Robinson Aviation (RVA), Inc.

FINAL REPORT

NATUNA ISLANDS AIR TRAFFIC CONTROL AND AIRSPACE MANAGEMENT PROJECT FOR INDONESIA

September 2006

Prepared for:

Directorate General of Civil Aviation of the Republic of Indonesia

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This report was funded by the U.S. Trade and Development Agency (USTDA), an agency of the U.S. Government. The opinions, findings, conclusions, or recommendations expressed in this document are those of the author(s) and do not necessarily represent the official position or policies of USTDA. USTDA makes no representation about, nor does it accept responsibility for, the accuracy or completeness of the information contained in this report.

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Natuna Islands Air Traffic Control and Airspace Management Project for the Republic of Indonesia

Task 1

Review of the Existing Air Traffic Control, Air Navigation and Airspace Management System in Indonesia

Prepared for
Directorate General of Air Communications of the Republic of Indonesia

By
Robinson Aviation (RVA), Inc.

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Appendix 1, ICAO Doc 9613, Required Navigation Performance 4 (RNP-4)

Appendix 2, Area Navigation/Required Navigation Performance

Appendix 3, Acronyms

1.0 Overview

The Republic of Indonesia, recognizing the need to upgrade its Air Navigation Service Provider (ANSP) facilities and services, requested and received support for this feasibility study from the United States Trade and Development Agency (USTDA). Subsequently, Robinson Aviation (RVA), Inc., of Falls Church, Virginia, USA, was selected to carry out the work.

a. Leading Indonesia's efforts in this project are the Director General of Air Communication (DGAC) within The Ministry of Transport, Communications, and Post. Historically, Indonesia's air navigation system has not kept pace with technology. Consequently, as leading subject matter experts and the responsible point of contact, DGAC's Office of System and Procedure for Air Navigation on behalf of the Republic's government has recognized the need to make significant improvements to become a world-class ANSP. Along that path, the DGAC is undergoing serious review of the current ANSP system as well as developing plans to put it on a par with its neighbors such as Malaysia, Singapore and Thailand.

b. Indonesia's improvement program includes assuring its readiness to resume ANSP responsibilities for Indonesia's sovereign airspace over Natuna Islands often referred to as Area C airspace. Other organizations that provide these services will be discussed later in this report.

2.0 Background

Currently, the authority for air navigation services including the systems and procedures of the airspace over Natuna Islands has been delegated to Singapore and Malaysia in accordance with the agreement reached at the International Civil Aviation Organization (ICAO) Regional Meeting in Honolulu, Hawaii, in 1973. Under the agreement, both the rights over airspace and obligations of the parties must comply with applicable international law and regulation. According to the 1st article of International Civil Aviation Convention, every State that contracts out a portion or all of its airspace to another State for management still holds full authority on the airspace over its territory. This provision is also adopted by Indonesian decree number 15 1992 regarding General Aviation which affirms that Indonesia has full sovereign authority over the airspace above Indonesian territory. Annex 11 of the International Civil Aviation Convention requires that each ICAO contracting State is obliged to provide air navigation services within the airspace over its territory.

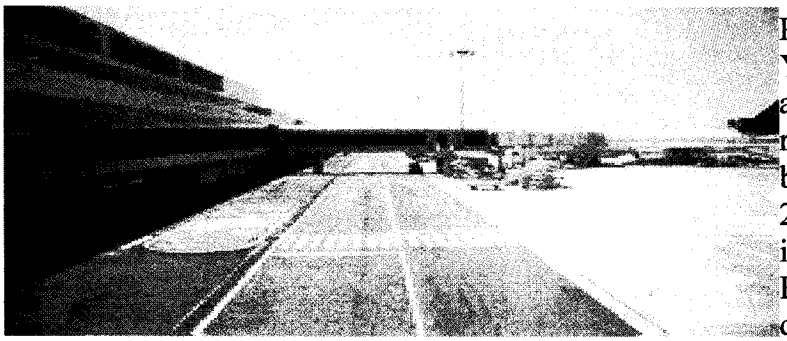
The boundary of the Flight Information Region (FIR) above the Natuna Islands is defined in the Asia Pacific Regional Air Navigation Meeting I (RAN Meeting), 1973. According to the RAN provisions, the authority of air navigation services in the airspace over Natuna Islands is divided into three sectors which are referred to as sectors A, B and C. Indonesia has delegated the provision of air navigation services in all of these sectors to Singapore and Malaysia. Over time, the intention of the Government of Indonesia is to assert their sovereign rights and fulfill their obligations for the provision of services for the airspace above Natuna Islands.

NATUNA ISLANDS is the site of an Air Route Surveillance Radar (ARSR) installed by Indonesia. While the namesakes of the airspace, discussions with DGAC indicate ATM services would most likely be provided from the present Area Control Center (ACC) in Jakarta.

Ranai, which is also called Natuna Besar, is the biggest island of the group. There is an airstrip near the village Ranai that offers flight to and from Tanjungpinang.

HANG NADIM INTERNATIONAL AIRPORT

Batam Island's Hang Nadim International Airport has recently enjoyed a multi-million dollar extension and renovations. It is a first-class facility which can handle Boeing 747-400 flights nonstop to Europe, as well as numerous domestic flights to all parts of Indonesia in wide- and narrow-body jets. The terminal facility is modern and efficient, and it is set amidst tastefully landscaped grounds. The airport is served by Garuda Indonesia and other regional carriers (Merpati and Bouraq). Soon European, Asia and Australia air carriers are expected to operate services through Hang Nadim. It is also an important air freight terminal.



President Susilo Bambang Yudhoyono has launched an aggressive program of economic reforms aimed at improving the business and investment climate. The 2004 GDP growth reached 5.1%, an increase from 4.1%, in 2003. However, the earthquake and tsunami disaster in Aceh and North Sumarta caused the Government of Indonesia (GOI) to reconsider its priorities. 2005 GDP growth is projected at 5%, down one-half percent from pre-tsunami projection.

Starting in 2000, the aviation industry in Indonesia experienced tremendous development. In 1999, there were only five airline companies. Currently, there are 22 scheduled and 35 chartered airlines operating in Indonesia, with a total fleet of 450 aircraft operating on more than 300 routes. Compared with 6.9 million in 1999, domestic passenger traffic increased to 17.4 million and 21.7 million in 2003 and 2004 respectively. In addition, cargo and chartered airlines also enjoyed 10-15 percent revenue increase in 2004, especially during the general and presidential elections.

The airline industry is predicted to remain attractive. Many airline companies have announced their plans to expand their routes and aircraft fleets. Among scheduled airlines, Lion Air is growing the fastest and may have a larger aircraft fleet than national flag carrier Garuda in the near future (both attended the user meeting as noted later in Task 1). Two new airline companies, Lintas Airlines and Trans Wisata Airlines, have announced their plans to start operations.

3.0 Feasibility Study Goal and Objective

3.1 Primary Goal

The primary goal of this feasibility study is to assist the DGAC in the identification of the technical and financial requirements for recapturing airspace management control over the Indonesian (Natuna) Islands, which are located in the South China Sea.

3.2 Study Objective

The study objective is to determine the *training*, *technical* and *financial* requirements of the project and for its implementation.

The Feasibility Study shall:

1. Assess the Technical requirements for Indonesia to be able to provide air traffic management in the airspace over the Natuna Islands and in neighboring areas called sectors A and B which are both currently under the Singapore Flight Information Region (FIR).

2. Develop estimates of system and equipment requirements and investments needed.

3. Develop human resource and training requirements for establishing a brand new Area Control Facility (ACC) at Natuna.

4. Include financial analysis of the project and recommended financing options.

4.0 Service Provider Organizations

Three organizations have various responsibilities for ANSP activities. They are:

a- Indonesia's DGAC is a Department under the Ministry of Transportation, with responsibility for ANSP activities at select locations not receiving services from AP I or AP II. DGAC also has responsibility for this feasibility study.

b- Angkasa Pura I, limited company, is one of the Government companies under the Transportation Department. In 1964, Angkasa Pura I limited company was named Negara Angkasa Pura "Kemayoran" Company, and since 1965 the name changed to Negara Angkasa Pura Company. In 1974, its name changed to Public company (or called PERUM) Angkasa Pura.

After Soekarno-Hatta Airport in Cengkareng started to operate in 1985, it was followed by the closing of operating activity Kemayoran airport. This caused the division of Angkasa Pura into two parts; those were Angkasa Pura I Public Company

with headquarters at the former Kemayoran Airport and Angkasa Pura II, a Public Company which is managing Soekarno-Hatta Airport at Cengkareng.

In 1993, the corporation of Angkasa Pura I Public Company changed to Angkasa Pura I Limited Company (Ltd). Until 1993, Angkasa Pura I Ltd was to mange 10 airports. Those are Ngurah Rai-Bali, Polonia-Medan, Juanda-Surabaya, Hasanuddin-Ujung Pandang, Sepinggan-Balikpapan, Frans Kaisiepo-Biak, Sam Ratulangi-Manado, Adisutjipto-Yogyakarta, Adisumarmo-Surakarta and Syamsuddin Noor-Banjarmasin.

c- Angkasa Pura II is a State-owned company engaged in the provision of airport management and air traffic services. Established on August 13, 1984, under the name of Perum Pelabuhan Udara Jakarta Cengkareng (PPUJC), the Company managed the Jakarta International Airport Cengkareng, the Halim Perdanakusuma Airport, and Jakarta FIR (Flight Information Region). On January 2, 1993, PPUJC was transformed into PT (Persero) Angkasa Pura II, which provides Aeronautical services for Jakarta FIR, as well as non-aeronautical services for the management of 10 airports in the western region of Indonesia.

Additional associated ATM service providers and interested parties are:

The Civil Aviation Authority of Singapore (CAAS)

The Civil Aviation Authority of Singapore (CAAS) is a statutory board under the Ministry of Transport. It represents the government in the negotiation of air services agreements as well as advises on matters related to civil aviation. The CAAS Air Traffic Control Service ensures the safe and expeditious flow of civilian air traffic at Singapore's airports and throughout the Singapore FIR.

Malaysia's Directorate of Civil Aviation (DCA)

Established in 1976, Malaysia's Directorate of Civil Aviation (DCA) became a self-accounting department under the Ministry of Transport. DCA is responsible for administering 20 airports including 4 international airports and the Kuala Lumpur and Kota Kinabalu FIRs. It provides ATC Primary Radar Service for Area Control within the Kuala Lumpur FIR.

DGAC Study Representatives

The following are principal DGAC Study representatives:

Cucuk Suryo Suprojo, Director General

Capt. Christian Bisara, Director of Aviation Safety

Ir. Suprasetyo, Deputy Director of Security and Safety and also Chief of the Committee of all USTDA Project

Ir. Nanang Swastya Taruf, Deputy Director of System and Procedure for Air Navigation and also Chief of the evaluation team of Air Traffic Control (ATC) program

Ir. Novie Riyanto, Manager of System and Procedure for Air Navigation and also senior member of the ATC program for the USTDA Project

Ir. Nanang Swastya Taruf is the principal contact while the latter two are points of contact for details in their respective areas of expertise.

Study Initial Information and Sources

Information on existing CNS equipment planned for the provision of air traffic control in the study airspace was provided by the office of the DGAC. Site visits were conducted on similar type surveillance and navigation facilities in the Jakarta area. The objective of these onsite visits was to review what was reported to be a representative segment of the present air navigation system. The proposed use of this information is to establish a baseline which establishes CNS/ATM status, needs and requirements.

- Status and average age of equipment employed in managing navigation and air traffic control services;
- Status of support infrastructure and physical facilities housing ATM related equipment and services;
- Site-specific environmental characteristics; and
- Staffing, training needs, and training capacity.

General information regarding this study:

- System includes 10 major airports.
- Air traffic has grown between 10 and 15% annually for the last 3 years.
- Passenger traffic grew 57% from 1999 to 2002.
- In 1973, the authority for air navigation services over the Natuna Islands was delegated to Singapore and Malaysia in accordance with an agreement reached with ICAO.
- Indonesia continues to maintain full authority (sovereignty) of the airspace over its territory

5.0 Methodology

In conducting this assessment, the team used the methodology listed below. The conclusions and observations presented in this report are based mostly on data collected using this methodology

and are predicated on the assumption that the facilities visited are representative of the entire system.

The methodology includes:

- Visits to select sites in the Jakarta area considered as a small representation of the types of facilities that will be used to provide air traffic management in the Natuna airspace. These facilities include: Jakarta ACC, Cengkareng Hatta Air Traffic Control Tower, Cengkareng ARSR, and Cengkareng VOR/DME facilities.

Air Traffic Management (ATM) as well as Equipment Operations and Maintenance (O&M) information was provided by the appropriate one of three service providers; PT (Persero) Angkasa I, PT (Persero) Angkasa II, and directly by the DGAC.

Upon arrival, RVA met with Director General Cucuk Suryo Suprojo, Captain Christian, and Pak Nanang, receiving the approval of and guidance for the project from Director General Cucuk Suryo Suprojo. Subsequently, RVA met with the members of the staff for a review of the workplan submitted and developing an agreeable work schedule. The approach and workplan for Tasks 2-6 can be found in Section 4 of RVA's original submission to Indonesia and USTDA.

Based on the information provided in the Request for Proposal (RFP), RVA had determined there were several key issues to be addressed and resolved in this study. One issue is to assist representatives of the Government of Indonesia in determining whether there should be a combined implementation of Air Traffic Services (ATS), CNS/ATM, and facility development similar to a regional implementation, or an individual state implementation. It was discussed that ICAO had already indicated that such matters should be implemented in concert with regional planning groups, but ultimately, ATS and CNS/ATM implementation is the State's responsibility. DGAC and RVA discussed our experience which has shown that working within the concept of regional implementation works very well. While noting that such an approach is consistent with ICAO and IATA policies, it was also noted that regional implementation does not impede the State's implementation of additional ATS and CNS/ATM initiatives on their own. Collectively, we agreed that our objective would be to identify the benefits, costs, and other implementation issues for both regional and Indonesian implementation, and to format them in a manner so that project members can clearly see the differences. RVA's expert team members were able to meet their project counterparts at this time.

Team members agreed that the plan must ensure a smooth transition from a ground-based system to a satellite-based system. The recommended system will be in line with guidelines provided by ICAO and other organizations that are subscribed to by the Government of Indonesia and are in accordance with national laws.

Another issue addressed is the requirement to ensure that present assets and resources are used for maximum efficiency and redundant systems are kept to a minimum. The equipment recommended needs to be cost-effective and meet Indonesian requirements while supporting regional plans to the maximum extent possible.

A significant amount of time was expended reviewing the present and future airspace envisioned by the DGAC. These discussions continued in a mutually supportive effort between DGAC and RVA in order to gain clarity. The airspace described later in Task 1 is the result of those discussions.

DGAC shared its view of the role of Singapore and Malaysia in the provision of ANSP services in Indonesia's sovereign airspace. Representatives of RVA and the DGAC scheduled and traveled to Singapore in an effort to further the information-sharing between the two states. Singapore could not accommodate its visitors and promised to provide requested data at a later date. Efforts to conclude the objective of this meeting continue.

Onsite visits to familiarize the team with the status of the needs giving rise to this Technical Assessment (TA) as well as ATS and CNS/ATM development to establish a baseline of services were conducted during the first week. While visiting various sites, the RVA representatives discussed current operations, policies, and equipment including structures, overflight traffic flows, and airports to determine the present state of aviation in Indonesia with ANSP representatives. RVA's team also studied the system's strengths and weaknesses and what improvements need to be made while establishing new airspace and a new ATS system.

In the data-gathering phase of Task 1, the RVA team requested assistance from the Government of Indonesia to provide statistical data and information on the overall system. DGAC was very supportive from the standpoint of those issues under their control. Obviously, due to dependency on other ANSPs, the delivery of some critical information is still pending delivery.

RVA and DGAC representatives reviewed the present operational characteristics of the air traffic system to include current procedures; use of airspace including Danger Areas, Restricted or Prohibited airspace, sectorization, routings, staffing, use of personnel, training, quality assurance, and system limitations and restrictions. We reviewed the navigational aid infrastructure, both en route and terminal, for condition, age, and coverage. An examination of equipment condition and age of the various air-ground and ground-ground communications links and equipment including VHF communication coverage was discussed in the early days and subsequently through onsite visits. Additional reviews of the various maintenance programs, servicing of equipment and maintenance training programs were made.

During the second week of the onsite, RVA's team met with experts in the financial, legal, and regulatory area to better understand related policies and procedures which could impact this plan. Tangential to the finance meetings, discussions were held with ATC experts and supervisors, airspace specialists, training specialists, and other specialists who provided information for the development of manpower figures, evaluating and recommending improvements in training, if necessary, and planning a transition scenario. During the onsite visits, RVA reviewed the layout of selected airports, looking for possible environmental hazards, reviewing runway configurations, and determining other factors that may affect CNS/ATM.

All of the above activities provided a backdrop for the project objective, i.e., restoration of Indonesia's sovereign airspace over the Natuna Islands and Indonesia's commitment to provide the best of CNS/ATM systems in support of ANSP and airspace transition.

6.0 Assessment of the Existing System

6.1 Airspace

a. An analysis of Indonesia, Malaysia, and Singapore airspace, defined by FIRs, UIRs, UTAs, MOUs and/or Letters of Agreement, was made as required to assist in determining the most cost effective and user beneficial plan for providing air traffic control service in the airspace described as Sector C within the Singapore FIR. Traffic flow through Sector C was determined by a review of the routes currently published in the Singapore AIP ENR 3.1-17 dated 20 JAN 05 and the Indonesia High/Low En Route Charts dated 23 September 2005. It was noted that although the Indonesia En Route Charts were dated approximately 8 months later than the Singapore AIP, two RNP routes (L625 & L644) that transit Sector C that are depicted on the Singapore Air Traffic System Chart were not shown on the Indonesian En Route Charts.

The airspace analysis studied the following currently established areas of responsibility:

1. Indonesia

a. Jakarta FIR	Class F	GND-FL245
b. Jakarta UIR	Class F	FL245-UNL
c. Jakarta UTA	Class A	FL245-FL460

2. Malaysia

a. Kuala Lumpur FIR	Class G	Below FL250
b. Kota Kinabalu FIR	Class A	FL250-FL460

3. Singapore

a. Singapore FIR	(No Class Shown)	GND-UNL

4. Airspace Delegated by MOU's

a. South China Sea Corridor	GND/SEA-FL200 and FL240 East of 105E GND/SEA-FL150 and FL240 West of 105E Currently delegated to Kuala Lumpur. Proposal to remain delegated to Malaysia.
b. Sector A	Sea Level to 37,000 ft. Currently delegated to Singapore. Proposal to remain delegated to Singapore
b. Sector B	Sea Level to Unlimited Currently delegated to Singapore
c. Sector C	Above FL200 over the South China Sea Corridor and FL245 and above is currently within Singapore FIR. Proposal to delegate to Indonesia (Jakarta FIR)

b. Traffic Flows/Routes

1. One Directional RNP 10 Routes **Through Sector C** of Singapore FIR
   - a. L625 Singapore to Taipei/Japan
   - b. N884 Singapore to Manila
   - c. M767 Manila/Japan to Singapore
   - d. L644 Hong Kong to Jakarta

2. Bi-Directional Routes **Through Sector C** between FIRs
   - a. G580* Singapore FIR/Kota Kinabalu FIR
   - b. M761* Singapore FIR/Kota Kinabalu FIR
   - c. M758* Singapore FIR/Kota Kinabalu FIR
   - d. B348* Singapore FIR/Kota Kinabalu FIR
   - e. G334* Singapore FIR/Kota Kinabalu FIR
   - f. A576 Singapore FIR/Jakarta FIR
   - g. A464 Singapore FIR/Jakarta FIR
   - h. N875 Singapore FIR/Jakarta FIR

* **Note**: Routes do not indicate if they are contained within the South China Sea Corridor airspace that is delegated to Malaysia.

c. Singapore SIDs/STARs with transitions to routes to and from Sector C airspace

1. SIDs
   - a. Mersing (VMR 2A and VMR 3B) to Manila
   - b. Tango India (TAN 2A & TAN 3B) to Bali/Darwin
   - c. Hosba (HOS 2A & HOS 3B) Taipei/Japan

2. STARs
   - a. HOSBA (HOS 4A & HOS 4B) from Manila/Japan
   - b. TANGO INDIA (TAN 4A & TAN 4B) Darwin/Bali

d. Indonesia SIDs and STARs with transitions to routes to and from Sector C airspace

1. SIDs – Batam, Hang Nadim Airport
   - a. HOSBA 1C and 1D to G580
   - b. TANGO INDA 1C and 1D to W36

2. STARs – Batam, Hang Nadim Airport
   - a. TANGO INDIA 1C and 1D from W36/Pontianak/Tanjung Pinang

Note: None of the SIDs and STARs serving the Jakarta Intl Airport have transitions to or from Sector C airspace.

e. Reference Data

1. AIP Singapore ENR 3-1-17 20 Jan 05 Air Traffic System Chart
2. High/Low Altitude En Route Charts INA-1 & INA-2
3. MOU Between Government of the Republic of Indonesia and the Government of the Republic of Singapore on the Realignment of the Boundary Between Singapore FIR and Jakarta FIR, signed in Singapore on 21 September 1995
4. GNC 13, 14 and 15 global navigation charts
5. Charts depicting theoretical CNS coverage of Sectors A, B and C.
6. Republic of Indonesia AIP, Volume II, AD International

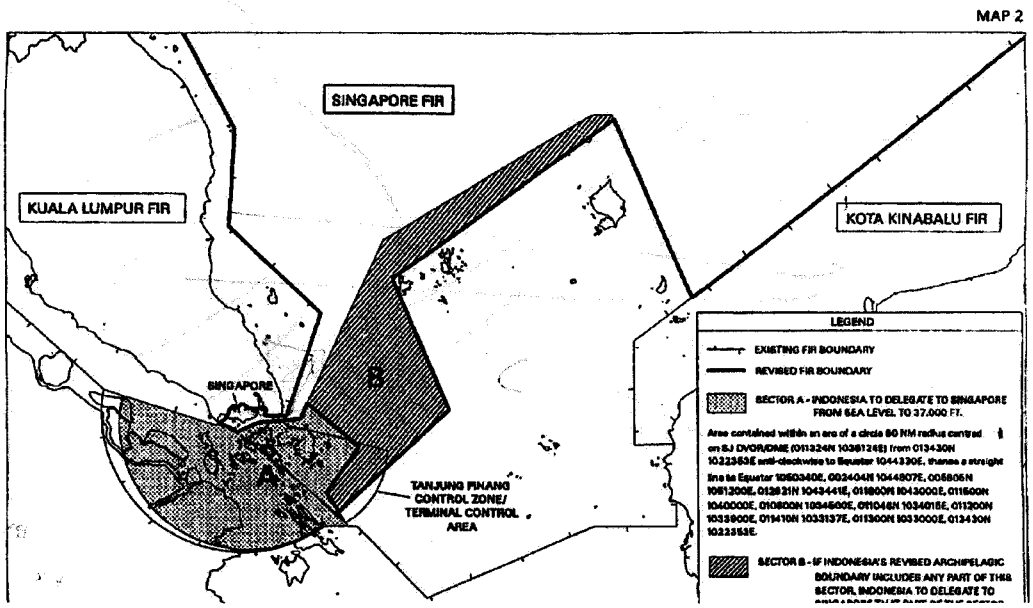
Discussion of Airspace. According to the Singapore AIP, Sectors 1 and 2, as described in the above paragraphs, are within Kuala Lumpur FIR and as stated are delegated to Singapore ACC. FL200 and below in the South China Sea Corridor falls within the Area of Responsibility of Kuala Lumpur ACC. Outside of the corridor and within the lateral boundaries of the Singapore FIR, Singapore ACC provides air traffic control services to flights within controlled airspace. The lower limits of controlled airspace usually start at FL140. Any aircraft operating in this corridor would be provided basic flight following if they are below controlled airspace. International flights generally operate above the corridor and are under the control of Singapore ACC. Singapore arrivals generally plan for the beginning of their descent at approximately 100 NM. Flights continue with Singapore ACC until around 40 NM when they are transferred to Singapore Approach Control for descent and sequencing for landing.

Normal ATC coordination is required for departures from Jakarta northbound. The letter of agreement allows flights to depart without prior coordination provided the minimum longitudinal separation is maintained. Current separation is 10 minutes for flights on the same level. Only an estimate for the boundary is required. Similar procedures are followed for departures from Singapore for destinations to the south going into Jakarta FIR. A system of unidirectional routes is in place which currently handles the heavy traffic flow. Batam departures procedures allow an automatic release to 3,000 feet which is within the Batam Control Zone and a higher altitude is assigned once a radar handoff is made from Tanjong Pinang (Note: Batam does not have radar. Tanjong Pinang Approach, located on a nearby island, handles coordination for Batam flights.) to Singapore. Singapore and Jakarta have differing views as to the timeliness of departures releases at Batam.

During the review, it was noted that Kuala Lumpur Sectors 1 and 2 are subdivided into subsectors B, D, F and A, C, E, H respectively. These airspace segments are delegated to Singapore for the purpose of providing ATC. Sector 1 (BDF) upper limits are FL245 and the lower limits get lower as aircraft come nearer to Singapore. This procedure facilitates descent, as well as the climb phase. The altitudes in use appear excessively low in light of the highly efficient air carrier fleet of today. Sector 2 is equally inefficient. Kuala Lumpur ACC controls above FL245 and FL380 in Sectors 1 and 2. Such airspace allocation appears to cause overflights, for example, from Jakarta to Bangkok at FL250 or higher, to be transferred to KL as soon as they cross the Singapore Island. Procedures for Sector 2 are similar to Sector 1. Transfer of control generally occurs at the lateral boundaries; therefore, traffic regardless of the upper levels gets handed over at the boundary, i.e., 50DME. Again Sector 2 has similar

procedures. Traffic in Sector 2 eastbound out of KL gets transferred to Singapore ACC at PK, which is 20 NM from the boundary of the delegated airspace.

1996 Airspace Map



MAP NOTATIONS ARE TRANSFERRED WITHOUT EDIT.

MAP2
ISINGAPOREFIR I "
~.
IKUALALUMPURFIR I I)KOTAKINABALUFIR I
LEGEND
EXISTING FIR BOUNDARY
REVISED FIR BOUNDARY
fJ
SECTORA .'NDONESIA TO DELEGATETO SINGAPORE
FROM SEA LEVELTO 37.000 FT.
N88 c:ont8Ined within 8ft.re of . drde 80 NM redlul centred I
on 8J DVORIDME 1011324N 103&124EI frem 013430N
10223&3E entl.clockwll. to Equetor 104-4330E.1h8l'lC88 8IrIIDht
In. to EqU8tor10&034OE. oo2404N 104-4807E. 00&806N
10&12OOE.012821N 1043441E, 011800N 1043OOOE.011&OON
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Yv
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BOUNDARY INCLUDES ANY PARTOFTHIS
&EcrOR,INDONE8IA TO DELEGATETO
SINGAPORE THAT PARTOFTHE SEcrOR
FROM SEA IEVEL TO UNUMITED HEIGHT.
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oo68O&N 10612OOE.012821N 1043441E. 033000N 1063000E.
060000N 108ooooE. 060000H 1081600E. 046700N 1081818E.
030200N 1063826E. 0124&oN 1081848E. 001030N 1046868E.

6.2 Traffic

DGAC and RVA are collaborating on the development of traffic statistics. The most available traffic statistics will be presented in Task 2.

Industry indicators continue to show Southeast Asia as a top growth market as highlighted in the following examples:

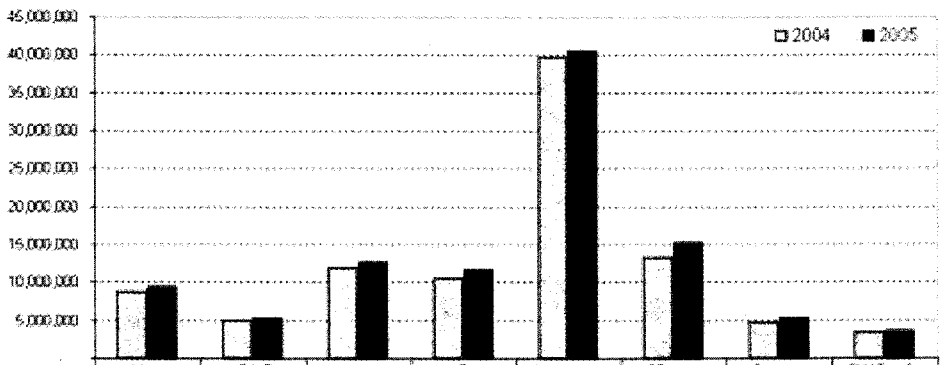
2005 - 2009 Forecast Summary:

International Air Traffic Growth by Key Route Area

	AAGR 2005-09	
	Passenger	Freight
North Atlantic	5.3%	4.6%
Trans Pacific	5.8%	6.0%
Within Europe	5.1%	4.1%
Within Asia Pacific	6.8%	8.5%
Europe to Asia Pacific	5.9%	5.7%
Europe to Africa	5.7%	4.5%
Middle East to Europe	6.6%	5.1%
Middle East to Asia Pacific	6.7%	8.8%
N America to Latin America	4.6%	3.7%
Within Latin America	4.2%	5.0%
All International Routes	5.6%	6.3%

Note the following percentile of growth relative to other markets.

Europe to the World Booking Analysis
Aug 03-Jul 04 Versus Aug 04-Jul 05



	Africa	JP/KE	Lat America	M. East	N America	SE Asia	Subcont	SW Pacific
2004	8883310	5090670	11907830	10588832	39749792	13415658	4848047	3608887
2005	9425273	5341624	12604868	11699249	40615171	15291619	5414620	3841999

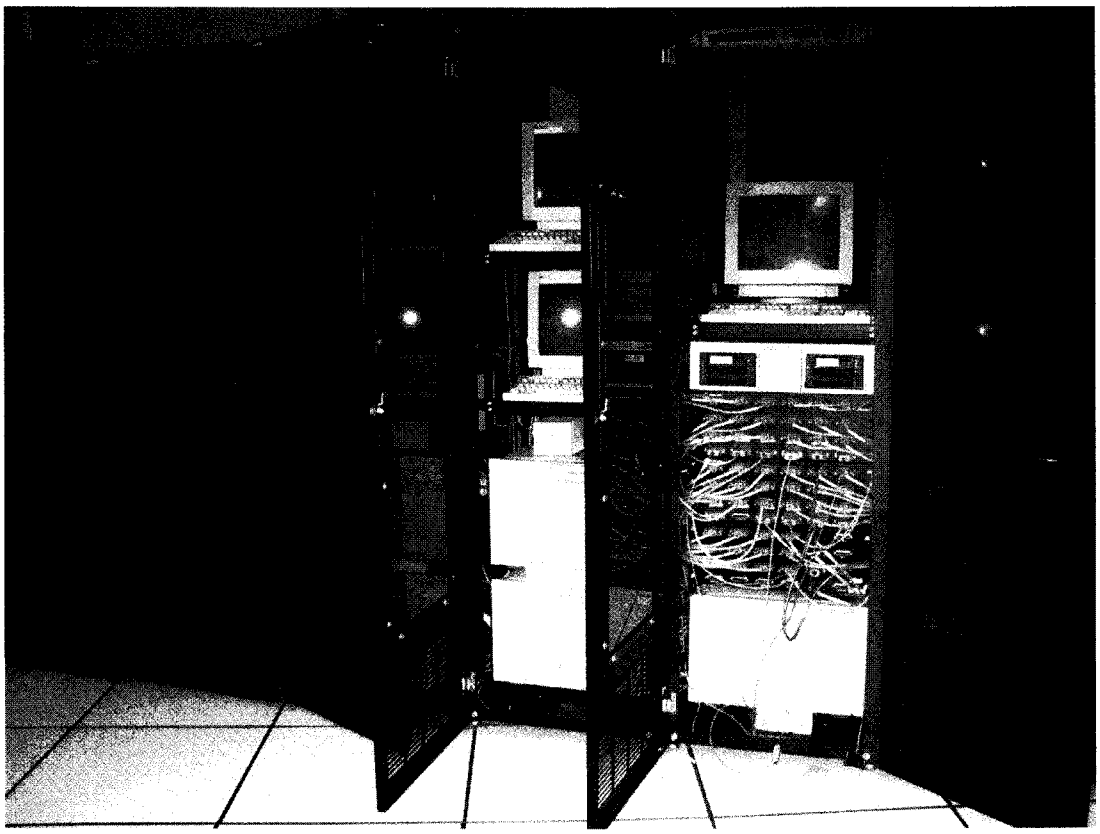
Figures based on bookings made not actual flown passengers

Direct bookings over the internet are not included hence low-cost carrier data is minimal
JP/KE = Japan and Korea
Sub Continent = India / Pakistan / Sri Lanka (Western Asia)

6.3 Facilities

a. Jakarta Area Control Center (ACC)

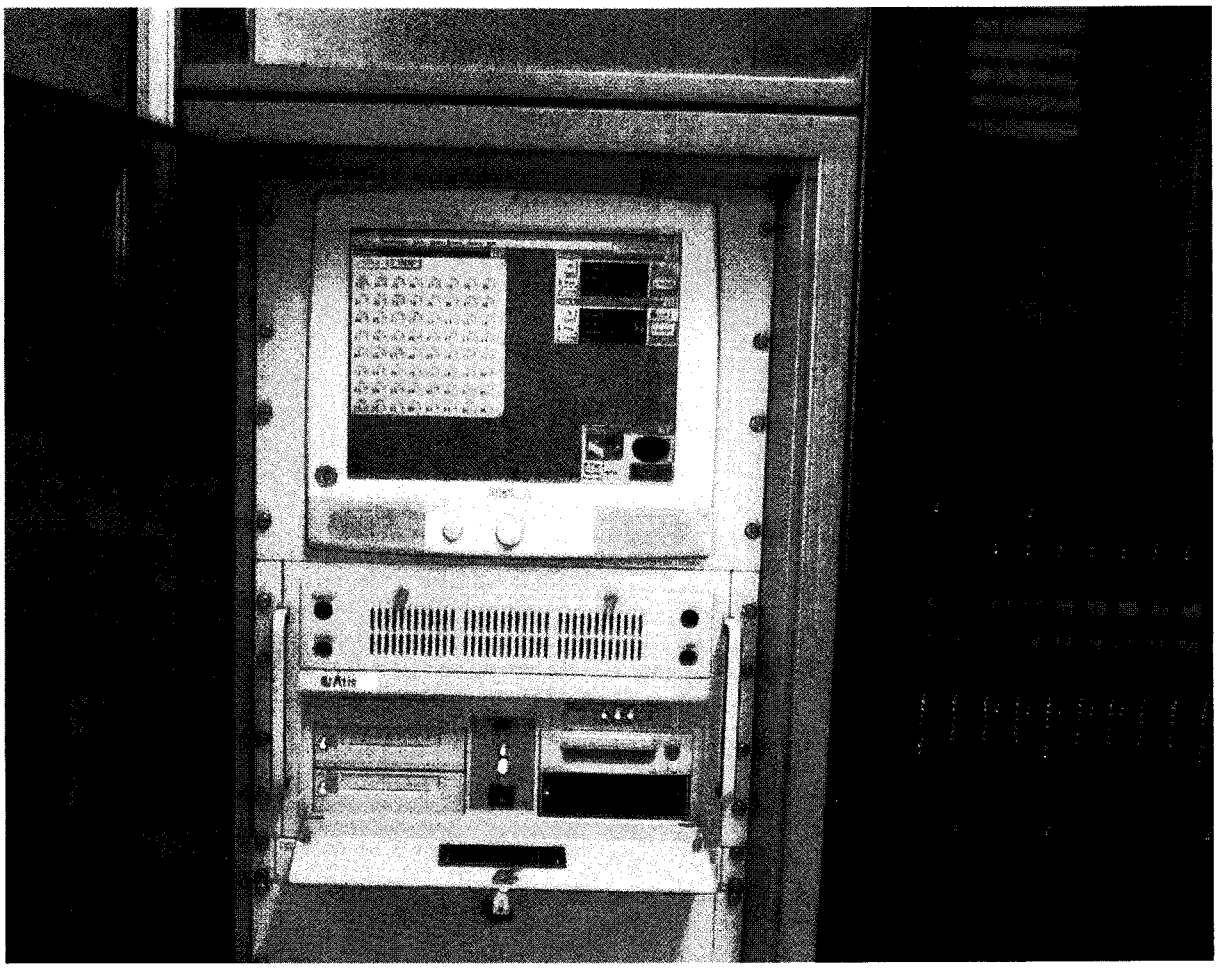
Automation and Display. Raytheon system installed in 1997. Local maintenance personnel have the capability to develop local patches for any changes to maps and upgrades. The system has Main and Standby Radar Data Processing and Flight Data Processing plus a Spare. There is no automatic handoff capability to adjacent ATC facilities or to the Makassar ACC. Displays are American Hughes color digital displays which provide more than adequate presentation. A position has been established and ATC staffing available to cover the proposed Natuna airspace. In effect, the Natuna Sector is in place within the Jakarta ACC. The position includes all automation programming and mapping, connectivity of existing remote communications frequencies and radar sensors, and any other functional requirements to begin control of the Sector C, Natuna airspace. A training simulator is available onsite to provide air traffic control procedural training. Although the equipment is reliable, a zero spare policy for all major electronic systems in the air traffic control system equipment leaves a greater potential for extended loss of service due to equipment failure, and the lack of automatic handoff capability limits the quality of ATC services provided.



Jakarta ACC Display Automation Equipment

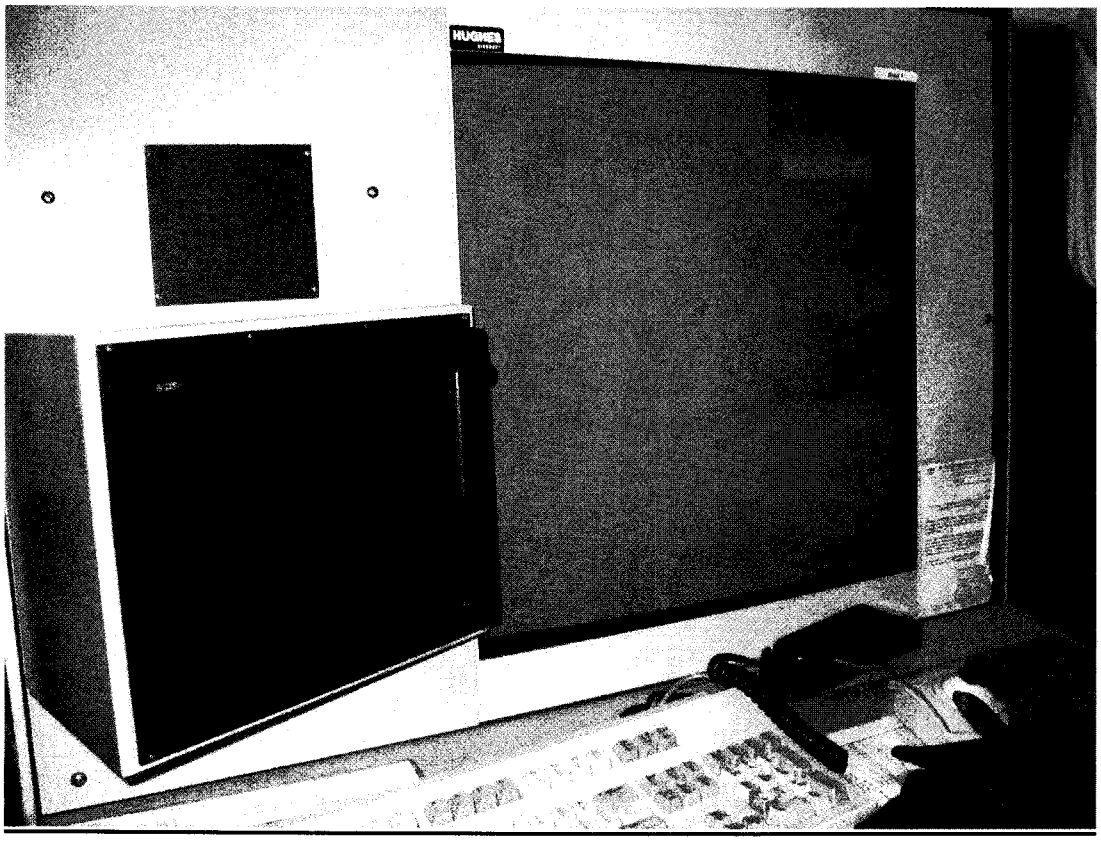
Communications A new Swiss made GAREX voice switch and control system installed in 2002 services the ACC and the co-located Cengkareng-Hatta International Airport Air Traffic

Control Tower. The system is reliable, flexible, and meets the needs of the ACC including the additional capability needed to support the Natuna airspace. Voice Recording System (VRS) is a recent model of the German manufactured ATIS 128 channel digital system. Currently 123 channels are in use including frequencies to support the Natuna airspace and all ACC, ATCT, and other facilities interphone communication operational needs. External CNS facilities are connected to the ACC via PCSI Clarity series Very Small Aperture Terminal (VSAT) network installed in 1997. The VSAT equipment is contractor maintained by Information Communications at a specified 97% availability level leaving certain vulnerability for extended failures having a serious impact on air traffic control.



Jakarta ACC Voice Recording System

Power Systems and Infrastructure. There is a critical power bus with Primary commercial and Standby power generating equipment providing parallel power through French made MGA "No-Break" Power Conditioning System to provide uninterruptible power source to all critical equipment in the ACC.



Jakarta ACC Natuna Sector
(Installed but not operational)

Jakarta ACC Natuna Sector
(Closeup view of the two positions pictured above)

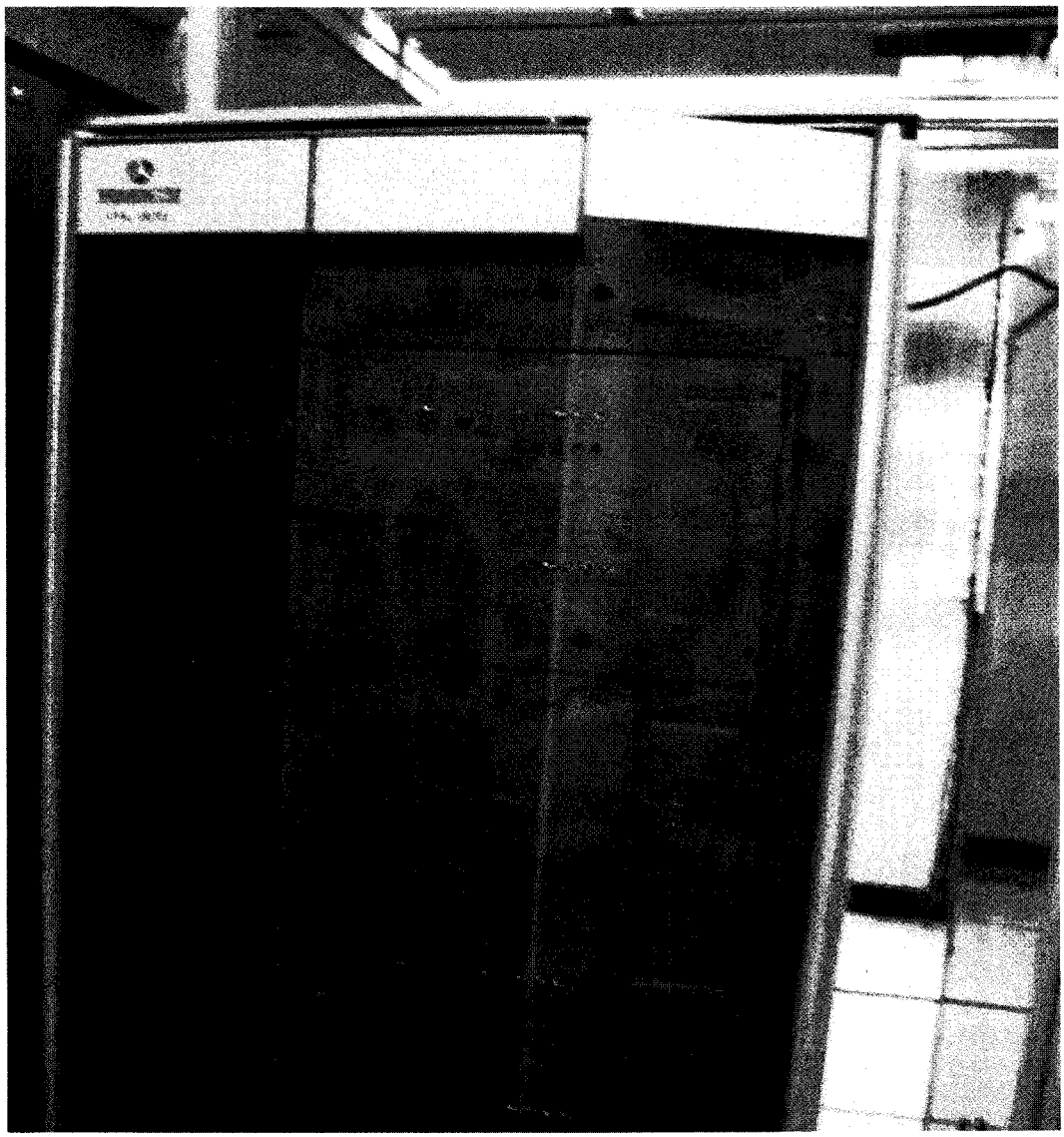
ATC Training/Certification. Training and certification at the Jakarta ACC are provided after thorough initial training at the Singapore ATC training facility. Jakarta has a radar training simulator for follow-on training. While DGAC presently conducts limited training, it is studying alternatives to increase the quantity and quality of ATC and Traffic Flow Management training. Training will be discussed in detail in Task 2. In Task 2, a specific training issue to be pursued is Mach Speed Control Procedures including the alternative of sending Indonesian controllers to Singapore ACC for familiarization with the procedures and control techniques used by Singapore controllers in the Natuna airspace.

Technicians/Engineers. DGAC has stated that it has an adequate number of technicians assigned to equipment maintenance and operation. Training is provided on initial purchase of new equipment. Technicians interviewed during site visits were able to communicate at a high level of technical expertise on their assigned systems. During our site visits, all facilities appeared to be professionally maintained, clean, neat, and operationally satisfactory. Task 2 deals with this issue in greater detail.

b. Cengkareng ARSR Facility Visit

The Cengkareng Radar facility is located on the Cengkareng-Hatta airport compound with 24-hour guard service. Cengkareng ARSR equipment consists of Thompson CSF series extended

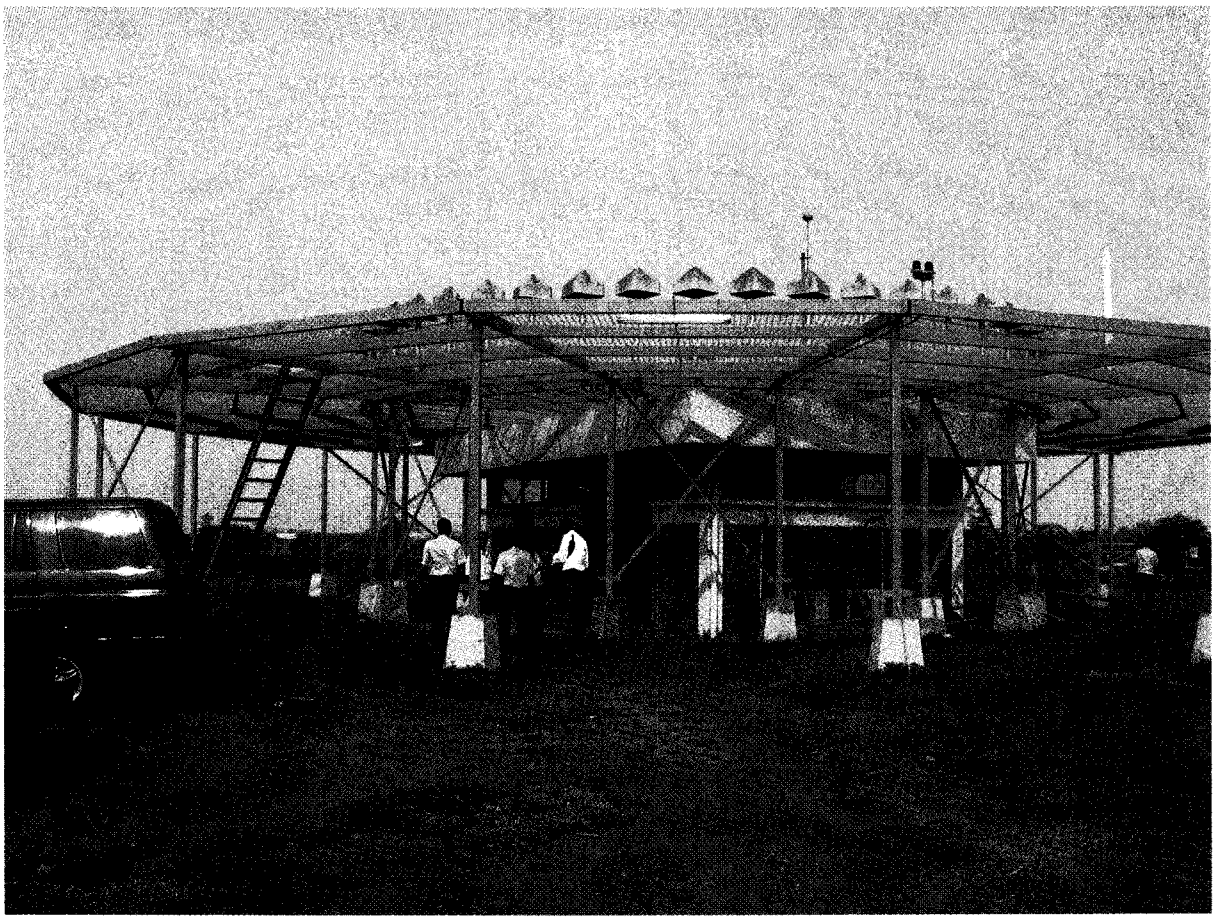
range ER850, RS77B, and TPL800 cabinets installed in 1985. The antenna turns at 8 RPM and the entire system is connected to the centralized ACC critical power bus with uninterruptible power system. The primary channel operates in Diversity mode while the secondary is dual channel. The system normally provides a 250 nautical mile coverage. There are 12 technicians providing 24-hour watch coverage. A zero spare policy, lack of remote maintenance and monitoring capability, and age of equipment result in higher maintenance costs and greater risk of extended service interruptions. The physical aspect of the facility was clean and neat with the building in good condition.



Cengkareng Radar Facility

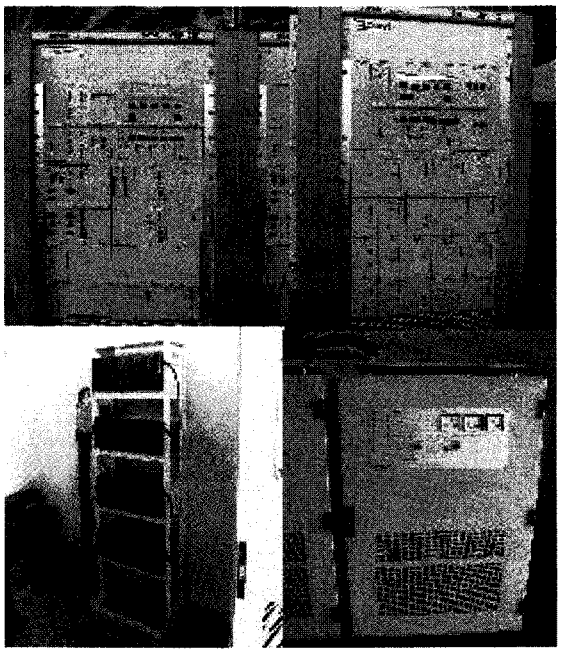
c. Cengkareng VOR/DME Facility Visit

The Cengkareng VOR/DME facility is located some 60 kilometers from the Cengkareng-Hatta airport. The Doppler VOR equipment is AWA/Australia Model VRB52B operating at 113.6 MHz providing a 150 NM radius coverage without restrictions. The DME equipment is AWA/Australia Model LDB 102 operating on Channel 83X. This is the same equipment suite as located at Natuna Islands.



Cengkareng Doppler VOR/DME Facility

The site has a standby power generator and a Victron UPS system with battery backup systems for both the VOR and DME. The VOR/DME facility is maintained by technicians assigned to the airport Navaids Unit, and the physical structure and grounds are maintained by a contract person who lives on the facility property and keeps the building clean and in good general repair and maintains the grounds in good condition. Both VOR and DME were found to be in good working order. System performance and maintenance checks are manually documented in a facility log. No review of the facility log was performed for performance history; however, it was a repeat message throughout our visit that the flight inspection program was lacking in timeliness and integrity.



Cengkareng DVOR/DME and UPS Equipment

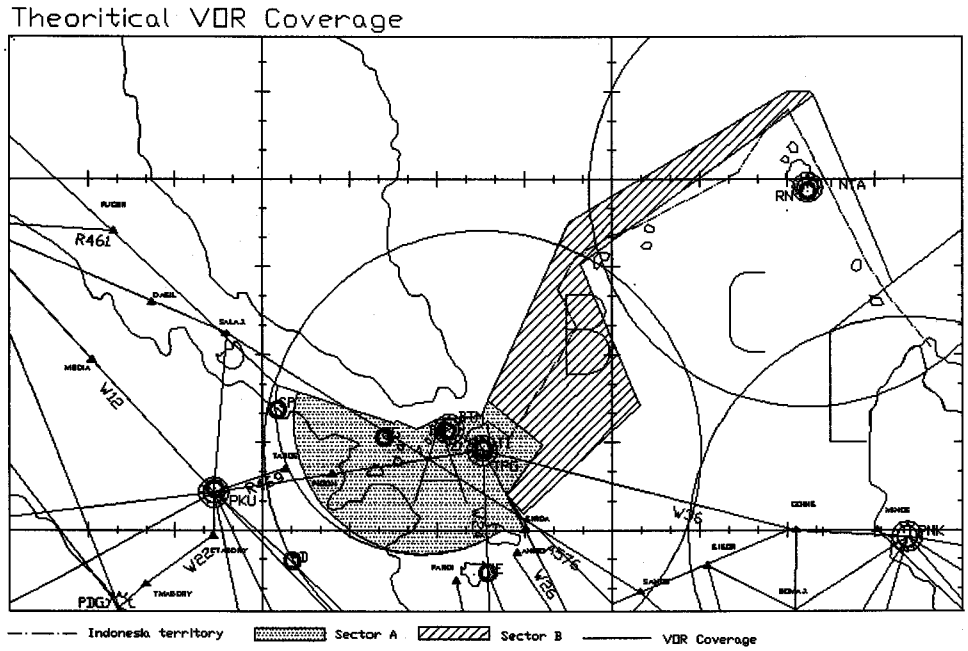
Navigational Aids to Support Natuna Airspace

Angkasa Pura II operates three Doppler VOR/DME facilities to provide VOR/DME navigation coverage throughout the Natuna airspace. These facilities form a triangle with three sides of approximately 250 NM each with Natuna/Ranai (NTA) on Natuna Islands at the northern peak southeast 250 nautical miles to Pontianak (PNK), Borneo, and southwest 280 nautical miles to Tanjung Pinang (TPG), off the central eastern coast of Sumatra. Monitor and control functions are provided to the Jakarta ACC via PCSI Clarity VSAT equipment.

VHF Omni-Range and Distance Measuring Equipment

Facility	City/Aerodrome	Manufacturer	Model	Installed	Identifier	Coverage
DVOR	Natuna, Ranai	AWA/Australia	VRB52B	1996	NTA	150 NM
DME	Natuna, Ranai	AWA/Australia	LDB102	1996	NTA	150 NM
DVOR	Pontianak, Supadio	AWA/Australia	VRB52D	1997	PNK	150 NM
DME	Pontianak, Supadio	American	ASI I	1997	PNK	150 NM
DVOR	Tanjung Pinang, Kijang	AWA/Australia	VRB51D	1992	TPG	150 NM
DME	Tanjung Pinang, Kijang	AWA/Australia	LDB101	1992	TPG	150 NM

VOR/DME Coverage Chart



Radar Surveillance to Support Natuna Airspace

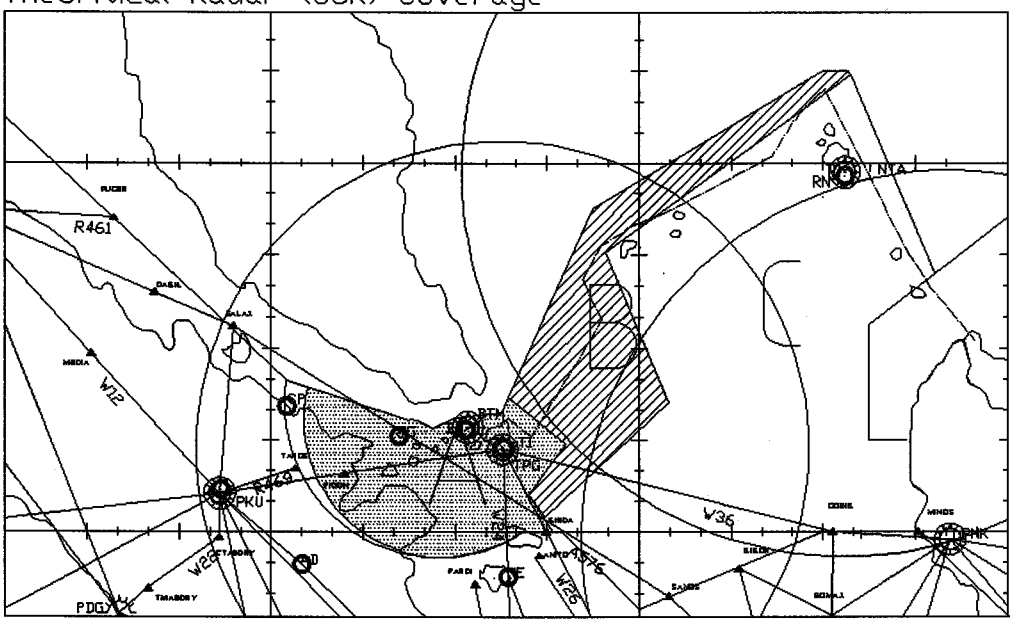
Angkasa Pura II operates three dual channel secondary surveillance radar facilities to provide radar surveillance throughout the Natuna airspace. These facilities form a triangle with sides of approximately 250 NM each with Natuna/Ranai (NTA) on Natuna Islands at the northern peak southeast 250 nautical miles to Pontianak (PNK), Borneo, and southwest 280 nautical miles to Tanjung Pinang (TPG), off the central eastern coast of Sumatra. Currently, monitor and limited control functions are provided to the Jakarta ACC via PCSI Clarity VSAT equipment. Natuna has good radar coverage as indicated below.

Natuna Island Airspace Surveillance Equipment

Type	City/Aerodrome	Manufacturer	Model	Date	Code	Range NM
MSSR	Natuna, Ranai	Cardion		1997	WION	240
SSR	Pontianak, Supadio	Thomson CSF	RS-870	1990	WIOO	240
PSR	Pontianak, Supadio	Thomson CSF	ER-23K	1990	WIOO	200
SSR	Tanjung Pinang, Kijang	Thomson CSF	EV-760	1990	WIKN	200
PSR	Tanjung Pinang, Kijang	Thomson CSF	TPL-800	1990	WIKN	140

SSR Radar Coverage Chart

Theoritical Radar (SSR) Coverage



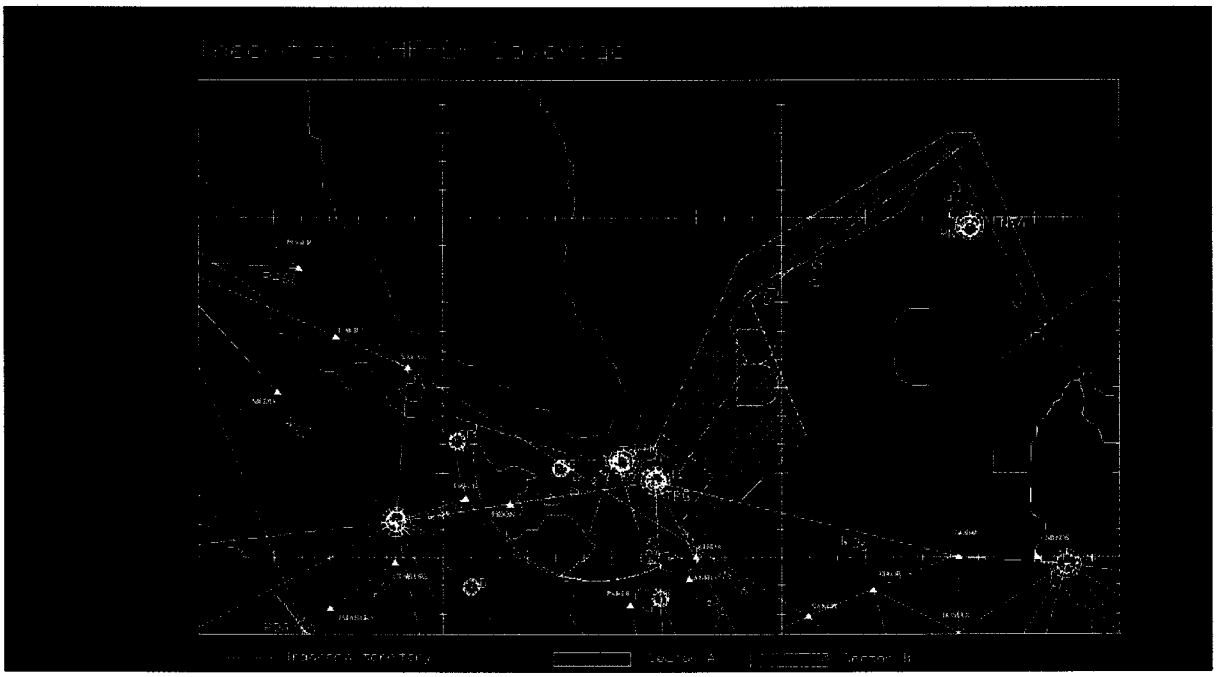
Communications - VHF and HF to Support Natuna Airspace

Angkasa Pura II operates VHF and HF frequencies to provide air-ground communications coverage to service the Natuna airspace. There are existing VHF communications facilities located at Natuna Islands, to the southeast at Pontianak, Borneo, and southwest at Pekanbaru, Sumatra. PCSI Clarity Very Small Aperture Terminals (VSAT) have been installed at the facilities and the Jakarta ACC. Communication upgrades in the Master plan for the 2007-2008 timeframe include digital voice communications to replace the aging 52 elements of the VSAT network. The DGAC also has nine proposed new frequencies to better service the Natuna airspace area; three VHF and six HF as listed in the chart below. Seven of the new frequencies will be located at Batam, just to the South of Singapore. The addition of the new frequencies at Batam along with existing frequencies should provide adequate coverage in the Natuna Islands airspace. Currently, communications coverage is limited.

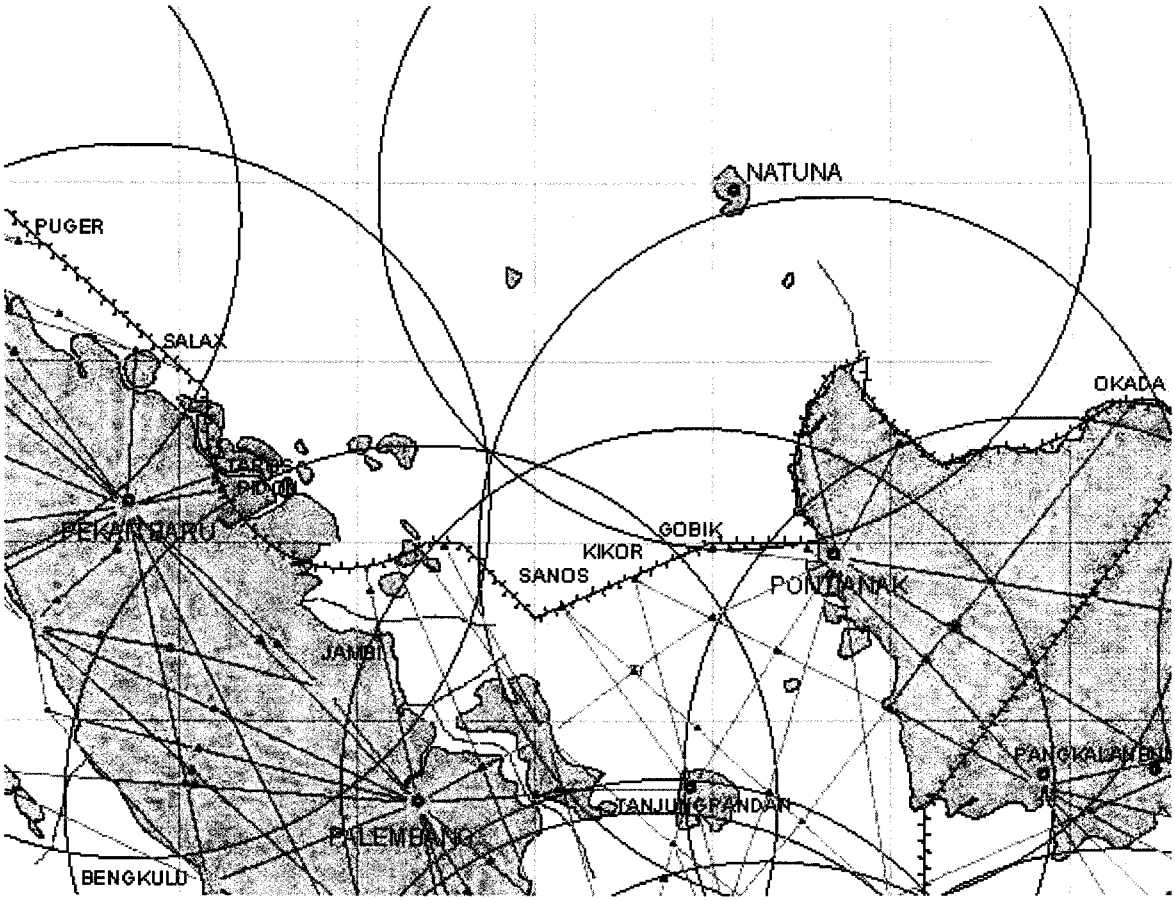
Proposed VHF/HF Communications

Location	Use	Band	Manufacturer	Frequency	Range
Natuna	Upper Control UTA	VHF	TBD	119.5 MHz	200 NM
Batam	Proposed	VHF	TBD	120.5 MHz	200 NM
Tanjung Pandan	Proposed	VHF	TBD	122.2 MHz	200 NM
Batam	Proposed	HF	TBD	3416 KHz	
Batam	Proposed	HF	TBD	6595 KHz	
Batam	Proposed	HF	TBD	3470 KHz	
Batam	Proposed	HF	TBD	5630 KHz	
Batam	Proposed	HF	TBD	5670 KHz	
Batam	Proposed	HF	TBD	11309 KHz	

VHF Extended Range Communications Coverage Chart



VHF Frequency Coverage Chart



In general, all facilities visited were in excellent condition. The buildings were in excellent shape even though several were dated by more than 20 years.

7.0 CNS/ATM Trends

The objective of this section is to identify and document the international trends in the implementation of Communications, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) as proposed by International Civil Aviation Organization (ICAO), IATA, EUROCONTROL, Airservices Australia, and other Air Navigation Service Providers (ANSP) involved in CNS/ATM. The following discussion of international trends in CNS/ATM will focus on the various components and technologies of CNS/ATM including the Global Navigation Satellite System (GNSS) and its augmentations, data link, Aeronautical Telecommunications Network (ATN), radar, automatic dependent surveillance (ADS), and air traffic management (ATM) systems. This discussion will also address the progress in the development of Standards and Recommended Practices (SARPs) and other guidance material. RVA will identify the technical and non-technical barriers associated with CNS/ATM implementation and will indicate how some civil aviation authorities are overcoming them.

7.1 Introduction

In this report, we will examine several topics concerning the implementation of CNS/ATM concepts including institutional, technical, operational, and economic issues, barriers to implementation, funding mechanisms, trends in global acceptance, and projected time schedules when CNS/ATM technology will be available for public use. It is very important to be keenly aware of the fluid nature of CNS/ATM. Constant change and evolution are the hallmark of the emerging CNS/ATM world. We will address the communications, navigation, and surveillance functions of CNS/ATM and show how users and providers are preparing for the transition to these new technologies. Although the operational procedures that will provide the benefits of ATM are still being developed and validated, we will highlight the benefits that will be available through ATM.

We intend to identify and discuss several important institutional issues to CNS/ATM implementation including barriers to the implementation and how provider states are overcoming them. For example, the fact that GNSS may be built around a satellite system owned and operated by a foreign government has been a volatile issue in the international community. We will discuss actions that have been taken or that are being taken aimed at reducing this concern. We also intend to show how the results of many trials and demonstrations are being used to provide early CNS/ATM benefits to users and operators.

Finally, we will provide information on the trends in CNS/ATM worldwide citing individual air navigation services (ANS) providers only because of their notoriety in this field. EUROCONTROL is a leader in CNS/ATM implementation and has developed several planning documents relating to the implementation. We will discuss how states are accepting and using CNS/ATM technology, and how they are responding to many of the issues mentioned in this report. We also will provide some insight into the future of CNS/ATM and, where possible, provide details on when the full benefits of the future air navigation system will be available.

7.2 Status of CNS/ATM Systems

7.2.1 Background

In order to provide an overview of CNS/ATM trends, it is important to fully understand the components of CNS/ATM, their functions, and the benefits they may provide. This section identifies new technologies (equipment) and how they may be used by Indonesia in CNS/ATM implementation. These technologies are being considered by regional and international airlines that are in the process of upgrading their aircraft to take advantage of the early benefits of CNS/ATM. However, due to the financial state of the industry and expenses involved in the whole process of upgrading aircraft (taking an aircraft off the line, training, spare parts, lost revenue, etc.), much of the suggested technology may be in use before all aircraft are upgraded. All air carriers realize the advantages to CNS/ATM, but most will not upgrade their aircraft until they can realize a benefit from the cost of equipage. There has also been a history of failed promises from some ANSPs. Most air carriers are using 12 months as a payback time to install new avionics. Such a short timeline makes establishing a positive business case very challenging. Further, we will point out the need for harmonization, compatibility, and interoperability, and the

need for users to see an early payback. Airlines and ANSPs both clearly understand the need that equipage is directly related to delivering prioritized "enablers," that is, solutions that will solve system deficiencies.

There is widespread agreement among ANS providers that the rationale strategy for CNS/ATM is a phased approach such as indicated below:

- Phase 1: Maintain current status and services while new CNS/ATM system infrastructure, hardware, and software architecture enhancements are implemented;

- Phase 2: Deployment of CNS/ATM capabilities and integration of CNS/ATM technologies into the new technologies; as legacy infrastructure is phased out at the end of its life cycle and as aircraft equipage reaches a level that allows the ANS provider to bring the CNS technology into the operation; and

- Phase 3: Complete deployment of CNS/ATM capabilities and integration of CNS/ATM technologies into the new architecture.

7.2.2 Communications

7.2.2.1 Aeronautical Telecommunications Network (ATN)

General

It was clear to the Future Air Navigation System (FANS) committee that the civil aviation community needed a global data Internet to interconnect an ever-widening variety of aircraft and ground-based computers. They recommended the ATN, which has since been developed under the sponsorship of the ICAO, to provide the internetworking infrastructure for the CNS/ATM environment.

The ATN system is being designed to operate as a single, cooperative, data network using a variety of physical sub-networks, both air-ground and ground-ground, to be connected by computers running standardized inter-networking protocols. The ATN will utilize the Aeronautical Mobile Satellite System (AMSS), Very High Frequency (VHF), High Frequency (HF), Mode S, or other acceptable sub-networks to transmit data or voice from one-end system to another utilizing a common Internet protocol. Any ATN host computer will be able to communicate with any other ATN computer over the network without any direct physical link between them. ICAO has submitted SARPs to the states that will ensure the international interoperability by use of agreed protocols and services that fulfill operational requirements. The end-state system will feature a fully digitized voice and data network. Even though all communication links will be sub-networks of the ATN, we will describe them separately.

7.2.2.2 Aeronautical Message Handling Service (AMHS)

The AMHS is a high capacity, high-speed internet system that is fully compliant with ICAO ATN standards. It provides for the exchange and distribution of message-oriented traffic

between ATC units. It replaces the non-ATN compliant Aeronautical Fixed Telecommunications Network (AFTN). The AMHS is now operational and should be considered for implementation. In the initial implementation, the AMHS may require an AMHS/AFTN gateway to connect the air traffic service (ATS) message server if the AFTN co-exists with AMHS, but only an ATS message server is required for the AMHS.

7.2.2.3 ATS Interfacility Data Link Communications (AIDC)

Another sub-network of the ATN is AIDC. AIDC is a digital application that supports the exchange of ATC-related information between ATS units in support of critical ATC functions. This exchange includes the notification of flights approaching a Flight Information Region (FIR) boundary, coordination of boundary crossings, and the transfer of control. Other AIDC messages support ancillary ATC data exchanges between ATS units such as ATC restrictions, change in trajectories, etc. Although AIDC is considered a sub-network of the ATN, almost all AIDC applications will be initiated by an air traffic management (ATM) system or an Automated Flight Data Processor (AFDP), but will pass through the ATN. The AIDC specification requirements are: Integrity-10-7, Availability-99.996, Realibility-99.9, and Continuity-99.9. The AIDC will supplant the present CIDIN (Common ICAO Data Interchange Network) and the AFTN.

7.2.2.4 Voice Communications

Voice communications that include VHF, VHF-ER (Extended Range), HF, and AMSS will continue to support air traffic services for the foreseeable future. VHF will continue as the primary voice sub-network to provide voice communications within domestic airspace with the exception of that portion of domestic airspace that lies over remote areas, jungles, mountains and deserts which may require AMSS or HF voice. Many of the international air carrier aircraft are equipped with or are being equipped with AMSS. AMSS is superior to HF in both quality and cost; however, it does not have polar coverage. HF has polar coverage, but is inferior to AMSS in cost and quality. Therefore, HF may be used as a backup to AMSS and to provide polar coverage. HF voice will be gradually supplanted over the next few years, but may continue to be used for interfacility communications between adjacent ATC facilities. Both VHF and AMSS voice have the capability to provide all of the potential CNS/ATM benefits in the en route environment, but only VHF can provide these benefits in and around terminal areas. However, it is expected that VHF voice will be used for many years to come, and later, when the ATN is fully operational, to provide backup for controller-pilot data link communications (CPDLC) and emergency communications.

7.2.2.5 Data Communications

VHF Data Link Mode 2 (VDL M2)

VDL M2 features VHF data link using "Carrier Switching, Multiple Access (CSMA)" protocols, which operate at a baud rate of 31.5 Kbps. VDL M2 is an operational, high-speed data link that is capable of providing pre-departure clearances (PDC), digital-automatic terminal information service (D-ATIS), CPDLC, automatic dependent surveillance-contract (ADS-C), Aeronautical

Information Service (AIS), and any other ATC data application that requires fast response times, but it will not support ADS-B. VDL M2, as with other VHF links, has the limitation of line-of-sight with a range of approximately 240 NM at more than 30,000 feet. At present, VDL M2 is being used for PDC, D-ATIS, and CPDLC services.

VHF Data Link Mode 3 (VDL M3)

VDL M3 will feature both voice and data using four different channels operating on the same frequency using "Time Division, Multiple Access (TDMA)" protocols with a baud rate of 31.5 Kbps. VDL M3 is still in development status and is not yet operational. VDL M3 will provide both data and voice on the same frequency using a "slot" protocol. VDL M3, like all other VHF links, is only available within line-of-sight, but will require considerable ground-based equipment, namely timing stations. It will provide VHF voice and data services similar to VDL M2, but will not support airlines operation control (AOC) operations. SARPs are available for VDL M3.

VHF Data Link Mode 4 (VDL M4)

VDL M4 is a multi-purpose data link that can combine several services and applications. It can mix them on a single 25 kHz channel (frequency) or use several channels for improved redundancy, integrity and capacity. It is the only known data link suitable for time-critical applications, and is characterized by a very high delivery probability based on its unique data link protocol. Its FM modulation scheme (GFSK) gives the data link long range (200 NM) at low power including very good transmission characteristics on the ground, e.g., at airports. The core function of VDL M4 is automatic dependant surveillance broadcast (ADS-B). VDL M4 features a modulation technique using "Self-organizing, Time Division, Multiple Access (STDMA)" protocols and is being developed by Swedevia (Sweden CAA). VDL M4 is a surveillance link only, which means an additional link is required for CPDLC. VDL M4 is presently receiving considerable attention from the Russian community. SARPs are available. Earlier in 2004, ICAO's council approved the removal of a restrictive note in the SARPs for VDL-4 which limited VDL-4 to surveillance applications.

7.2.2.6 Universal Access Transceiver (UAT)

UAT is a wide-band, broadcast concept that is presently undergoing trials in the continental United States and Alaska with the Capstone project. UAT is presently being used for ADS-B applications. At present, UAT applications have experienced similar problems as VDL M4. UAT will require an additional link for CPDLC, but is still an immature link and has only been used in the USA. Thus far, it has only been used as a demonstration system and has not been developed to an adequate level for commercial availability, but it is considered a promising system as a surveillance broadcast link. Although all UAT applications have not been defined, it may be used as a gap-filler by some countries until all aircraft are equipped with Mode S.

7.2.2.7 Aircraft Communications and Reporting System (ACARS)

ACARS, which was developed by ARINC (Aeronautical Radio, Inc.), provides cost-effective, highly reliable data link services throughout all of North and Central America and most of Europe and Asia. SITA provides these services in those parts of the world where ARINC is absent. ACARS was originally developed for AOC, but now provides many data link benefits. It expands the global data link capabilities with real-time reporting of departures, arrivals, movement times, engine parameters, delays, aircraft position, maintenance and winds aloft. It also enables crisp, clear crew and passenger voice communications from the aircraft.

PDC and D-ATIS via ACARS is being used at 59 airports in the United States and at several airports in Europe, Asia, and Australia. Although ACARS is currently being utilized in the PDC and ATIS programs in the United States and Europe, it is being supplanted by or upgraded to VDL M2 in those areas where higher integrity and greater data rates are essential. ACARS is a non-compliant ATN data service, but is being used as gap filler until VDL M2 becomes more widely available.

7.2.2.8 ACARS over VHF Data Link (AOA)

While VHF data link (VDL) was designed to transport ATN air-ground communications, it can also transport ACARS communications as well. In the VDL AOA architecture, the aircraft uses the ACARS air-ground protocol over the ICAO VDL M2 link (Aviation VHF Link Control - AVLC) increasing the capacity over the VHF link. In the AOA architecture, aircraft use AVLC to transport binary data over the VDL M2 link to ground stations. AVLC provides a connection to a VDL sub-network that provides the aircraft access to the ATN, thus permitting ACARS to be compatible with the ATN.

AOA is an interim step towards ATN in Latin America.

7.2.2.9 HF Data Link (HFDL)

HFDL is becoming a cost-effective, long-range link that provides global data communications and is the only data link capable of polar coverage. SARPs have been approved and distributed for this link. HFDL can be used as a backup for satellite communications or as a low-cost alternative for data communications in remote and oceanic airspace. It is expected to play a larger role in ATC communications due to the fact that several of the negative characteristics that plagued HF voice have been eliminated. However, HF does not provide separate channels for voice and data, and during trials it appeared that one blocked the other. When certified for ATC applications, it may be used mostly in a backup mode. The delay or response time (90 sec) is too high for many applications like ATC. There are more than 11 global HFDL ground stations in operation with each station having radius coverage of more than 2,700 NM.

7.2.2.10 Mode Select (Mode S)

Mode S is an operational link and has several potential applications, which include broadcast capability. At present, Mode S is being used for air-air applications for TCAS (Traffic Collision and Avoidance System-USA) and for ACAS (Aircraft Collision and Avoidance System-Europe). It has two links known as the extended squitter, 1090 MHz for the downlink and 1030 MHz for

the uplink. Mode S is being upgraded for broadcast surveillance applications (ADS-B) and is planned for near-term applications.

Boeing is upgrading its Mode S Transponder installation to ARINC 718 transponders, which are compliant with ICAO Annex 10, amendment 77. This will form a foundation for Mode S and ADS-B upgrades. Airbus is likewise working several similar projects.

7.2.2.11 Aeronautical Mobile Satellite System (AMSS) Data Link (Satellite Data)

Satellite data link is an operational data link that can be used in most ATC applications. Satellite communications are being used in remote and oceanic airspace for the provision of air traffic services and AOC services. Satellite communications have global capability and Inmarsat provides the service. Inmarsat services are supported by three systems: Aero-L, Aero-I, and Aero-H. Aero-L provides low-speed (600 bits/sec) real-time data communications. This service is mainly used for airline, ATC, and operational and administrative purposes. Aero-I allows aircraft flying within spot-beam coverage to receive multi-channel voice, fax, and data services. Aero-H provides high-speed (up to 10.5 Kbit/sec) service supporting multi-channel voice, fax and data communications in the global beam for passengers, operations, administrative, and safety services applications.

The delay in response time of up to 15 seconds may prove to be too lengthy for broadcast surveillance and some reduced separation standards where rapid position updates are required. AMSS has high potential for the reduction of oceanic separation standards and for the reduction of separation standards over remote, jungle, mountainous, and desert areas. AMSS is currently the most expensive form of aviation communications and unavailable in Polar Regions. This may make it an undesirable link for some aircraft, but most international aircraft are equipping for AMSS.

7.2.2.12 Controller-Pilot Data Link Communications (CPDLC)

CPDLC is a VHF data link communication concept that permits the controllers and pilots to have two-way communications for a variety of ATC applications. CPDLC will be the principal application of data link technology. CPDLC, as defined by ICAO in CNS/ATM-1 SARPs, is being implemented by the United States, EUROCONTROL and other countries. CPDLC is expected to replace most voice communications in the future system. Operational trials and full-scale implementation of data link communications including CPDLC have been very successful in many regions of the world. Although CPDLC will initially be via VHF, it is expected to be available with both HF and AMSS communications. Likewise, the limited number of message sets will expand as CPDLC is phased into service.

7.2.2.13 Very Small Aperture Terminal (VSAT)

VSAT systems are satellite communication systems and, although not actually considered as a CNS/ATM system, offer great potential in remote areas such as the mountainous regions. VSATs first appeared in the United States in the 1970's, but only in the last 10 years have they appeared in the European/Asia region. VSAT offers a direct, low-cost link between facilities and

aircraft for fax, voice, and data transmissions. VSATs operate with a form of CSMA (carrier sensing, multiple access) or TDMA (time division, multiple access) modulation using various networks. The most notable modulation techniques are SCPC (single-channel-per-carrier) and DAMA (demand-assigned-multiple-access). DAMA seems to be leading the field now due to the reduction in cost, the optimization of satellite resources, and the increased provider revenues it offers.

A VSAT with an antenna diameter of 1.2 meters (4 feet) gives full access to a private network involving multiple locations. VSATs use C-band and Ku-band transponders. In a VSAT network, a user can view the satellite as a router in the sky, eliminating the need for local loops and/or public telephone switching infrastructure. In a star arrangement, a VSAT provides two-way communications from remote locations in the same manner as the terrestrial telephone network. International Telecommunication Satellite Consortium (INTELSAT) provides satellite coverage in most parts of the world.

7.2.2.14 Communications Summary

VHF voice will be used for all domestic operations supplemented with AMSS and HF where required. The candidate VHF data link will be VDL M2 with the exception of providing ADS broadcast. VDL M2, AMSS data and HFDL are all addressable data links which eliminate them from being used for broadcast links. VDL M2 is superior to AMSS and HF data due to the short response time and cost. AMSS and HF data have applications in remote, jungle, mountainous, and desert areas where response time is not so critical and the topography limits antenna sitings. VDL M2 is preferable for ADS-A, PDC, D-ATIS, AIS, CPDLC and other addressable applications. The candidate link for broadcast (ADS-B) will be Mode S or VDL M4, but UAT has potential as a backup and gap-filler if it becomes certified and approved. We believe that VDL M3 will prove to be too expensive for use and may not support a cost benefit analysis. Augmented GPS with an appropriate data link will provide ADS-C for en route and terminal applications, and ADS-B will provide ground surveillance applications and airborne situational awareness (per ICAO). ADS-B has numerous applications beyond surfaces operations. ADS-B may eventually have applications involving self-managed separation during approach and landing maneuvers. Australia is making wide use of ADS-B for surveillance in vast remote areas and the FAA has designated ADS-B as its next generation surveillance system. ACARS is not ATN compliant; therefore, its applications may be limited. We believe VDL M2, HFDL, Mode S, or VDL M4 may satisfy the requirements of Indonesia with UAT as a gap-filler for ADS until all aircraft are equipped with Mode S.

7.2.3 Navigation

7.2.3.1 Global Positioning System (GPS)

GPS is the primary candidate for the positioning constellation that will drive the Global Navigation Satellite System (GNSS). It is an all-weather, day/night navigation system that provides position and velocity in three dimensions in a worldwide common grid reference and can accept an unlimited number of users. At present, GPS consists of 29 satellites in six orbits of four or more satellites that orbit the earth every 11 hours and 58 minutes and are positioned at a

distance of 10,900 miles from earth. The satellites are spaced in orbit so that a minimum of 5 satellites are in view at all times. The satellites provide continuous ranging signals on two different frequencies although only one frequency, the Standard Positioning Service (SPS) at L1, is available for civil use. The Precise Positioning Service (PPS) at L2 provides a more accurate position, but it is reserved for the US military and allies of the United States. The SPS provides accuracies that satisfy the accuracy requirements for oceanic, domestic en route, and non-precision approach phases of flight. Since the removal of selective availability in May 2000, users can expect continuous accuracies near 13 meters. GPS was approved by ICAO as a candidate positioning system for GNSS in 1994. SARPs are available for GPS.

Many improvements have been made with GPS in the last few years. In 1996, the President of the United States created a "Civil GPS Advisory Committee" to provide more civil input in the management of GPS that further reduced the military control of the system. Several of the Block IIR replacement satellites have been launched and the US has already procured 12 Block IIF satellites, which will replace the Block IIR replacement satellites in 2006. There will be two additional ranging frequencies added to the replacement satellites to further improve the civil capability of GPS. On January 18, 2004, the first Block IIR satellite with an additional L2 frequency for civil use was declared operational, although this frequency is a "non-safety-of-life" frequency. The third ranging frequency (L5), which is a "safety-of-life" frequency, will be added to the first Block IIF satellite scheduled for launch in 2006. As indicated above, the accuracy of GPS without selective availability is near 13 meters or less, but the accuracy using two ranging frequencies will be near 8 meters or less.

GPS by itself does not meet the stringent requirements for sole means navigation. Therefore, these requirements or certification parameters must be met by means of augmentation in order for GPS to reach its full potential as the positioning constellation for GNSS. GPS receivers that are certified under Technical Standard Order (TSO) C129 or TSO C129a are used to augment GPS for supplemental and primary means of flight. The Wide Area Augmentation System (WAAS), a satellite-based augmentation system (SBAS) based on GPS, has been certified for sole means navigation for aircraft using an approved GPS receiver (TSO C145).

7.2.3.2 Global Orbiting Navigational Satellite System (GLONASS)

GLONASS was developed by the Russian Federation Government and is managed by the Russian Space Forces. It was offered to the world through ICAO in January 1996, the same time that it was declared operational by the Russian Federation. ICAO formally accepted this offer in September 1996. The offer was generally the same as GPS except that it was offered for a minimum of 15 years. GLONASS accuracy, which is approximately 70 meters with a 95 percent probability, was at the time somewhat better than GPS in that GLONASS did not introduce "selective availability". However, now that selective availability has been removed from GPS, GPS accuracy exceeds that of GLONASS.

GLONASS is a global timing and position system that works in a similar manner to GPS in how it develops a position solution, but differs in how the satellite is acquired and how the signal is transmitted. However, GLONASS is not yet a mature system. The satellites that made up the original system only had a 3-year lifespan and not much is known of the replacement satellites.

Seven replacement satellites have been successfully put into orbit, but only six satellites are providing ranging signals. GLONASS is also based on the SGS-90 datum; also know as the PZ-90 datum, which is approximately 15 meters different in the horizontal plane from WGS-84. It appears that the two systems could be brought substantially into coincidence by a small rotation of the Z-axis of either system, but no action has been taken on that issue.

The potential of GLONASS to be an active candidate for GNSS continues to be in doubt. Only seven replacement satellites have been launched since 1996; only six are operating. The political situation in Russia has created a shortage of funds and GLONASS has had severe funding problems. The Russian Federation has publicly made it known that they are willing to accept outside funding.

7.2.3.3 Galileo

Galileo will be Europe's own GNSS, providing a highly accurate, guaranteed global positioning service under civilian control. It will be interoperable with GPS and a user will be able to determine a position from any of the satellite positioning systems or a combination thereof. Galileo is the European Union's GNSS-2 initiative for a satellite-based navigation and positioning system. The European Union agreed to make its proposed Galileo system compatible with the U.S. GPS system.

The fully deployed Galileo system will consist of 30 satellites (27 operational + 3 active spares), positioned in three circular Medium Earth Orbit (MEO) planes at an altitude of 23,616 km above the Earth, at an inclination of 56 degrees with reference to the equatorial plane. The system would include a ground control system and would provide integrity over the European area. Galileo will perform very similar to GPS in that the satellites will provide a ranging signal and aircraft will use a second-generation receiver to ascertain their position. Galileo will provide both sole means navigation for all phases of flight and a precision approach capability.

Galileo will offer dual frequencies as standard, which will deliver real-time positioning accuracy down to the meter range, which is unprecedented for a publicly available system. It will guarantee availability of the service under all but the most extreme circumstances and will inform users within seconds of a failure of any satellite. This will make it suitable for applications where safety is crucial, such as running trains, guiding cars, and landing aircraft.

The first experimental satellite, part of the Galileo System Test Bed (GSTB), was launched in December 2005. The objective of this experimental satellite is to characterize the critical technologies, which are already under development under ESA contracts, thereafter up to four operational satellites will be launched in the timeframe 2005-2006 to validate the basic Galileo space and related ground segment. Once this In-Orbit Validation (IOV) phase has been completed, the remaining satellites will be installed to reach the Full Operational Capability (FOC).

On January 12, 2006, The Galileo In-Orbit Validation Element (GIOVE-A) satellite started transmitting the first Galileo signals from medium earth orbit (MEO). GIOVE-A was placed in orbit (altitude 23,260 km) by a Soyuz-Fregat rocket operated by Starsem on December 28, 2005,

from the Baikonur cosmodrome. The prime contractor, Surrey Satellite Technology Limited, then successfully deployed the 7-metre solar array panels, commissioned the satellite platform, and prepared the payload for tests from its Mission Control Center. These activities on GIOVE-A drew on the joint efforts of ground stations deployed at RAL (UK), Bangalore (India) and Kuala Lumpur (Malaysia) for uploading of the onboard computer software,deployment of the two solar panels, and placing of the satellite in sun-acquisition mode.

All the platform systems underwent functional checks and the satellite was then put in its nominal Earth-pointing attitude and orbit control mode. This platform commissioning phase was successfully completed by January 9. On January 10, payload commissioning started from the SSTL Mission Control Center with the objective of verifying that all the units in the navigation payload were functioning properly.

On January 12, the first Galileo navigation signals were transmitted by GIOVE-A. These were received and analyzed by the Galileo receivers using the 25-metre diameter dish of the Chilbolton Observatory Facilities for Atmospheric and Radio Research (UK) and the ESA Station in Redu (Belgium). The various Galileo signal modes will now be generated sequentially using the various GIOVE-A payload chains. Payload commissioning activities are planned to be completed by mid-February 2006.

Additional measurement campaigns will then be carried out to assess the medium earth orbit radiation environment, characterize the performance of the onboard clocks and perform signal-in-space experimentation.

GIOVE-A is the first element of the Galileo In-Orbit Validation phase. The pilot satellite marks the very first step towards full operability of Europe's new global navigation satellite system, a partnership project involving the European Space Agency and the European Commission. GIOVE-A's mission is to secure use of the frequencies allocated by the International Telecommunications Union for the Galileo system, demonstrate critical technologies for the navigation payloads of future operational Galileo satellites, characterize the radiation environment of the orbits planned for the Galileo constellation, and test the receivers on the ground.

Formerly known as GSTB-V2/A, the GIOVE-A satellite has two redundant, small-size rubidium atomic clocks built by Temex Neuchatel Time (Switzerland), each with a stability of 10 nanoseconds per day, and two signal generation units built by Alcatel Alenia Space (Italy) and SSTL (UK) respectively. This mission will be followed by that of the second satellite, GIOVE-B, which is to be built by Galileo Industries (Germany) in 2006.

2.7.3.4 Global Navigation Satellite System (GNSS)

GNSS is a worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers, ground monitor stations and system integrity monitoring augmented as necessary to support the requirements of Required Navigation Performance (RNP) for the actual phase of operation. It uses a satellite positioning and timing constellation to provide highly accurate positioning information and to provide a highly precise time transfer

system. In 2002, GLONASS had 7 satellites of its full 21 satellite constellation in orbit and only 6 of those satellites were operating. The launching of any other GLONASS satellites is not known. The future of GLONASS is unclear and cannot be counted on to provide the operational data that is presently supplied by GPS. GPS has been approved for instrument flight and for supplemental and primary means of navigation. GNSS must be augmented to achieve sole means performance.

In its present concept, GNSS, using the un-augmented GPS constellation, has been approved for supplemental and primary means of navigation. In laymen terms, GNSS can be used for all phases of navigation except for precision approaches. GNSS can be used by itself for most phases of flight as long as the aircraft carries avionics that meet the standards for sole means navigation and its GPS receiver meets the standards of TSO C129 or TSO C129a. GNSS has been approved for both GNSS non-precision (NPA) and precision (PA) approaches. SARPs are available for GNSS.

7.2.3.5 Satellite-Based Augmentation Systems (SBAS)

General

An SBAS augments core navigation satellites by providing ranging, integrity and correction information via geostationary satellites. The system comprises:

- a network of ground reference stations that monitor satellite signals;
- master stations that collect and process reference station data and generate SBAS messages;
- uplink stations that send the messages to geostationary satellites; and
- transponders on these satellites that broadcast the SBAS messages on the GPS frequency.

By providing differential corrections, extra ranging signals via geostationary satellites, and integrity information for each navigation satellite, SBAS delivers much higher availability of service than the core satellite constellations. SBAS, in certain configurations, can support approaches with vertical guidance (APV) and Category I precision approach operations. SBAS can support all en route RNAV operations. This will allow States to reorganize airspace for maximum efficiency and capacity, allowing aircraft to follow the most efficient flight path between airports. There are several SBAS systems in operation or development today which are discussed below.

7.2.3.6 Wide Area Augmentation System (WAAS) (An SBAS)

WAAS was developed to meet the worldwide requirements for sole means navigation for civil aviation by the Federal Aviation Administration (FAA). GPS by itself cannot meet the certification parameters of integrity, availability, accuracy, and continuity of function required for sole means navigation for all phases of flight. Therefore, the system must be augmented to meet those requirements. The WAAS will provide three functions. It will serve as a Ground Integrity Channel (GIC) that will provide the integrity to meet RNP requirements for all phases of flight. It will also provide differential corrections including ionospheric corrections that will

meet the RNP accuracy requirements for all phases of flight down to and including precision approaches. And finally, WAAS, utilizing the capability of the Inmarsat III geostationary satellites, will provide a GPS "look alike" ranging function that will provide additional availability required by RNP for all phases of flight including precision approaches. The WAAS was certified on July 10, 2003.

The WAAS, for initial implementation, is composed of a network of 24 wide area reference stations (WRM) located at surveyed locations, capable of comparing a surveyed position with a GPS position and then transmitting a correction factor to a master control station (MCS). Initially, there will be two master control stations associated with the WAAS that will formulate correction messages and transmit them to two ground earth stations (GES) that will uplink the messages via C band to a geostationary satellite (GEO). Then via a "bent pipe" technique, the correction messages will be transmitted via the L1 band to GPS receivers that will use the correction messages to provide integrity, increase the availability of GNSS, and provide a more accurate aircraft position near the 7-10 meter range or lower. Reference stations also serve as monitor stations to ensure the accuracy of corrections. The WAAS will improve basic GPS accuracy to less than 7 meters in the vertical plane and possibly less in the horizontal plane, improve system availability through the use of GEOs carrying navigation payloads, and provide important integrity information about the entire GPS constellation.

7.2.3.7 European Geostationary Navigation Overlay System (EGNOS)

EGNOS is a joint project of the European Space Agency (ESA), the European Commission (EC) and EUROCONTROL. It is Europe's contribution to the first stage of GNSS and is a precursor to Galileo, the full global satellite navigation system presently under development.

The EGNOS system, which has been labeled GNSS-1 by ESA, is basically an overlay of the GPS and GLONASS systems when it becomes operational. EGNOS is an augmentation system, which operates very similar to the WAAS. Both systems rely on the Inmarsat III geostationary satellites, which have a small navigation payload or ranging signal. The EGNOS also relies on Artemis, ESA's private geostationary satellite, and on a group of specially sited, ground earth stations. For EGNOS, the exact location of the geostationary satellites must be known, and that is ensured by continual measurements from the earth stations. Phase I of GNSS-1 will provide accuracy and integrity for en route and terminal operations, and Phase II will provide sufficient accuracy for precision approaches. In 2004, Phase II, a wide area differential service, will be tested to provide sufficient accuracy for precision approaches and give the system a sole means navigation capability. EGNOS is primarily intended for use within the European community, but can be expanded within the footprint of the Inmarsat and Artemis satellite coverage area. This en route system was expected to be operational in 2004, but it will be late 2006 before the precision approach capability is added. SARPs are available for EGNOS.

The initial EGNOS will be composed of 2 Inmarsat III satellites and 1 private satellite (Artemis); 4 Reference Integrity Monitoring Stations (RIM); 1 Mission Control Center (MCC); and 2 Navigation Land Earth Stations (NLES). However, the final configuration will consist of 30 RIMS; 4 MCCs; and 6 NLES that include Artemis. The first stage of the EGNOS Advanced Operational Capability architecture foresees 7 NLES, 5 of which will uplink EGNOS messages

to the Inmarsat III Atlantic Ocean Region – East (AOR-E) and Indian Ocean Region (IOR) satellites, and 2 of which will uplink EGNOS messages to the Artemis satellite.

7.2.3.8 Multi-Function Satellite Augmentation System (MSAS)

Throughout Asia, MSAS provides satellite navigation correction and validation, making SBAS-enabled receivers at least three times more accurate than standard devices. MSAS relay stations have been set at known positions throughout Asia.

SBAS-enabled receivers do not require any additional equipment to use MSAS correction signals and, as with satellite navigation signals, there are no setup or subscription fees. Providing accuracy to within 5 meters or less, MSAS was scheduled for full operation in 2005 and will expand safety and air traffic capacity in the Asia Pacific regions.

The Multi-Functional Satellite-Based Augmentation System (MSAS) is based on the Multi-Functional Transport Satellite (MTSAT) of Japan.

MSAS is also an augmentation system that operates very similar to the WAAS and EGNOS and will be interoperable with both of them. The accuracy of MSAS is expected to be near 2-3 meters and capable of precision approaches. The coverage area of MSAS extends from the mid-Pacific to the Seychelles and from the northern tip of Alaska to just north of Antarctica. MSAS will use K-band transmissions from the GES to the MTSAT and then L-band to the users.

7.2.3.9 Lockheed Regional Position System (RPS)

Lockheed Martin is developing a commercial spaced-based system to augment or supplement an SBAS, which will be known as the Regional Positioning System (RPS). The Lockheed system is a proposed 12 geostationary satellite system with two satellites in six different orbital locations. The RPS is global in concept serving three major regions: the Americas, Europe/Asia, and Asia/Pacific. RPS will carry SBAS transponders and will have the capability to broadcast SBAS messages from various augmentation systems such as the WAAS, Japan's MSAS, and Europe's EGNOS. This system was expected in 2005, but since Lockheed has been awarded the contract to build the new GPS III system, this initiative may be combined with the new GPS III system which is not expected until 2010.

7.2.3.10 Boeing Positioning System (BPS)

The Boeing Positioning System is a 16-satellite system being developed by the Boeing Space and Defense Group. This system will be capable of carrying SBAS transponders, which could provide alternative methods of SBAS transmissions. This system will provide radio-navigation services, but will not use geosynchronous satellites. It will use low earth orbit (LEO) satellites. It has the potential to be used for a wider array of CNS/ATM services. This system is still in the planning stages and is not expected to be operational until the 2005 timeframe or later. Boeing is a partner with Lockheed in building the new GPS III system and it is expected that this initiative may be delayed to ensure interoperability between the new GPS III system and Boeing's new satellite positioning system.

7.2.3.11 Ground-Based Augmentation Systems (GBAS)

General

The GBAS is a ground-based installation that monitors GPS and/or GLONASS signals at an aerodrome and broadcasts locally relevant integrity messages, pseudo range corrections and approach data via a VHF Data Broadcast (VDB) to aircraft within a nominal range of 23 NM. GBAS has the potential to support Category I through III precision approach operations and some surface movement operations. A single GBAS ground installation may provide guidance for up to 49 precision approaches within its VDB coverage, serving several runways and possibly more than one aerodrome. The only candidate GBAS at this time is the Local Area Augmentation System.

7.2.3.12 Local Area Augmentation System (LAAS)

The United States is presently developing standards and criteria for a Local Area Augmentation System (LAAS). The LAAS will be used to provide precision approach capability to those areas not covered by the WAAS or EGNOS such as mountainous terrain and other areas outside the coverage of a geostationary satellite (GEO). It will also be used to provide CAT I-CAT III capability where required. The LAAS is basically a reference station that uses differential technology to measure the difference between a surveyed position with that of a satellite position and then transmits a correction factor (time) directly to the aircraft via data link. The accuracy of the LAAS is expected to be near 3 meters, if not lower. The range of this capability is estimated to be nearly 50 nautical miles; therefore, one differential could basically support more than one airport. SARPs are available.

The first operational system is planned for deployment in mid-2006. While LAAS units are still priced above what was originally expected, they are still considerably cheaper than a CAT III ILS and are expected to be in the range of approximately $800,000 USD at the time of deployment. LAAS is expected to attract a very large market in the international arena.

7.2.3.13 Special Category 1 (SCAT-1)

SCAT-1 is a special designated Category I instrument approach that uses differential GPS technology whose equipment and installation cost would be borne by the user. It was developed by the FAA to give both provider and user an opportunity to gain experience with precision approaches using differential GPS (DGPS) and is the forerunner to LAAS. SCAT-1 is a concept that can be used until a system such as the LAAS is available to provide precision approach capability for all airports. The FAA and Industry have been involved in the development of SCAT-1 for more than 5 years and there are presently seven vendors who have obtained FAA type approval. SCAT-1 systems have been deployed and certified at several sites in the United States, Australia, and the Philippines. With the deployment of the LAAS, the SCAT-1 program should fade, but most SCAT-1 systems can be upgraded to meet LAAS requirements.

7.2.3.14 Ground Regional Augmentation System (GRAS)

The GRAS works similar to an SBAS, but can also provide precision approach capability to a broader range of airports similar to an LAAS. The system is based on a GRAS Master Station (GMS), a series of reference stations known as GRS (GRAS Reference Station), and any number of VHF transmitter sites known as GRAS VHF Stations (GVS). The GRS collects GPS data and sends it to the GMS via satellite link or ground-links (telephone lines). The GMS processes GPS data in real time and then transmits correction and integrity data to the GVSs. Each GVS performs a verification check, formats the information into a GBAS-like signal, and then transmits it at one second intervals in TDMA-managed time slots via a GBAS VDB (VHF Data Broadcast) protocol. This broadcast provides aircraft with error corrections for accurate navigation and a "warning signal" should the GPS system fail or provide unusable data. This system is becoming widely accepted as a viable, cost-effective navigation solution. This system is limited only to the line-of-sight limitations of VHF and the number of GVS sites that a country chooses to install. Each site provides SBAS data in a GBAS format within a range of more than 200 NM.

7.2.3.15 Airborne-Based Augmentation System (ABAS)

The purpose of ABAS is to augment and/or integrate information obtained from GNSS elements with onboard aircraft information. This augmentation or integration is required to ensure that technical performance (in terms of accuracy, integrity, continuity and availability) meets the requirements of Annex 10 Chapter 3, Section A.2.4. ABAS requires use of one of the following two processing schemes; (1) Receiver autonomous integrity monitoring (RAIM) which uses GNSS information exclusively; or (2) Aircraft autonomous integrity monitoring (AAIM) which uses information from additional onboard sensors such as barometric altimeter, multi-sensor RNAV, inertial navigation, and/or a precise clock plus the GNSS information.

Integrity is achieved through the availability of sufficient redundancy in position solutions. RAIM relies only on the estimation of residual errors derived from the multiple combinations of GNSS ranging sources. AAIM uses the redundancy of position estimates from multiple sensor sources including GNSS.

The minimum RAIM function described in avionics certification standards only requires the detection of a failure or fault detection. With the minimum RAIM function, following fault detection, GNSS navigation is terminated. RAIM functionality beyond the required minimum includes exclusion of the failed satellite. This is called fault detection and exclusion or FDE. This functionality may permit the continuation of GNSS navigation following exclusion of the failed satellite. AAIM implementations are required to provide performance that is at least equivalent to RAIM. TSO-C129 requires either RAIM or AAIM, and TSO C129a adds an additional requirement for FDE.

7.2.3.16 Non-Precision Approaches (NPA) with Vertical Guidance (APV-1/2)

APV approaches are NPAs with vertical guidance that have the potential for lower minimums than conventional NPAs, and in many cases, minimums that are near or equal to what is known

as CAT I precision approaches today. APV-1 approach is a GNSS NPA with vertical guidance that uses only GNSS and APV-2 is a GNSS NPA with vertical guidance that uses an SBAS and can generate minimums near that of CAT I. These approaches, given the vertical and horizontal accuracy they can generate, can provide a near precision approach capability that could eliminate the need for CAT I ILS at many airports.

The APV approaches are new approaches and are in the ICAO approval process at this time. The following table indicates the vertical and horizontal accuracies available with this system.

	Vertical	**Horizontal**	**Requirement**
NPA	More than 40 meters	80 meters	GNSS
APV-1	20-39 meters	40 meters	GNSS
APV-2	12-20 meters	Less than 40 meters	SBAS(satellite based augmentation sys.
CAT I	10 meters	Less than 40 meters	ILS

7.2.3.17 Navigation System Certification Standards

There are three standards of certification for navigational systems and their associated avionics that are recognized by ICAO. These standards are based on how a system meets the four navigational system performance parameters (integrity, accuracy, availability, and continuity) for sole means navigation. These standards are as follows:

- Supplemental Means - A navigation system that meets only the integrity and accuracy requirements for sole means and has been approved for use with another navigational system that has been certified and approved as a sole means of navigation. GPS has been approved for use without the necessary monitoring of the sole means system, but the sole means system must be capable of operating should GPS fail.

- Primary Means – A navigation system that meets the integrity and accuracy requirements for sole means for a given phase of flight, but does not meet all four certification parameters for sole means navigation. Safety is achieved through operational procedures and requirements. This means that for specified phases of flight that have been approved for primary means, no other navigational system is required.

- Sole Means - A navigation system that meets the navigational system performance requirements (integrity, accuracy, availability, and continuity of function) for all phases of flight.

7.2.3.18 Navigational Summary

GNSS, without augmentation, will support operations for only supplemental and primary means, but still provide many benefits. GNSS, without augmentation, can be used as a gap-filler until an SBAS, which will provide sole means navigation, becomes operational. In order to achieve the potential benefits of GNSS, the system must be augmented for sole means navigation. Therefore, Indonesia must subscribe to an SBAS in order to achieve these benefits. EGNOS appears to be the most logical, most convenient, and most cost-effective SBAS. With an SBAS, all navigational benefits including precision approaches to most airports will be available. GBAS will be required for CAT I in those areas that have a lack of, or weak, SBAS signals, but is required for all airports that require CAT II or CAT III approaches. However, APV-1/2 approaches will be available as an alternative to precision approaches.

7.2.4 Surveillance

7.2.4.1 Radar

Surveillance is the basic tool of ATS to provide separation services as well as a number of other ATS-related services. Radar has always been the number one surveillance tool for air traffic control and will continue in that regard for many years to come. There have been several new features applied to the new generation of monopulse secondary surveillance radar (MSSR) systems. The latest air traffic control radars are modular, solid state, and incorporate the latest in electronic surveillance technology. They are equipped with ATM functionality and highly advanced moving target detectors that improve aircraft detection in weather and clutter. The latest terminal radars, the Airport Surveillance Radar (ASR-11) manufactured by Raytheon and the ASR-12 manufactured by Northrop, were the first fully digitized American radar systems.

The ASR-11 and the ASR-12, although called by different names by European manufacturers, were designed as the latest in advance terminal radar surveillance systems, but both can easily be modified for en route surveillance. The ASR-11 and ASR-12 are on the cutting edge of solid-state technology. They are modular, fully solid-state, primary radar systems that incorporate the latest technology in airport surveillance radar systems with secondary coverage out to 250 NM. Both systems provide very accurate aircraft position information under the most extreme conditions of weather, ground clutter, natural and man-made interference, and ground vehicular traffic. The ASR-12 is equipped with an MTD-IV, a highly advanced Moving Target Detector (MTD), that improves aircraft detection in weather and other clutter phenomena. Both systems are equipped with a separate weather-processing channel and define the weather in six different levels of intensity.

7.2.4.2 Automatic Dependent Surveillance (ADS)

General

Although radar will be an important part of the advanced navigation system, the future surveillance system will be characterized by the integration of current surveillance techniques using Automatic Dependent Surveillance. The term ADS reflects that surveillance information

is dependent on another system such as the onboard avionics of the aircraft to provide its position information. There are two forms of ADS, addressed or contract (ADS-C) and broadcast (ADS-B). Both have approved SARPs.

7.2.4.3 ADS-C

ADS-C, which used to be called ADS-A, develops a contract with the provider on what reports it will make. These three different reporting contracts include: (1) Periodic - reports at specific intervals; (2) Events - reports certain events such as leaving an altitude, reaching an altitude, position reports; and (3) On-demand - when requested by the ground station. ADS-C provides surveillance using positioning information derived from GNSS onboard avionics and transmitting that information to a ground receiver via an appropriate data link. At present VDL M2, AMSS and HFDL are addressable links and have the capability to transmit this information to ground stations. However, as previously explained, AMSS is expensive, unavailable in Polar Regions, and has up to a 15-second delay in response time. HFDL has a delay in response time up to 90 seconds and has not yet been certified for ATC operations. AMSS cannot be used as an ADS link for reduced separation that may be based on a rapid response time. VDL M2 is the choice for ADS-C with AMSS and HFDL used as backup. ADS-C can be used as a gap-filler for surveillance in those areas that eventually will require radar until radar becomes available and/or affordable.

7.2.4.4 ADS-B

ADS-B is an automatic, periodic broadcast of flight Information that includes aircraft ID, GPS position, altitude, velocity, intent, acceleration, etc. ADS-B requires a broadcast link, and several links are being examined such as VHF, HF, or Mode S (1090 MHz broadcast-1030 MHz receive). The most logical choice appears to be Mode S. It appears to be the least expensive and aircraft are beginning to equip with the Mode S extended squitter upgrade. Other links that are being demonstrated are UAT and VDL M4. Both have ADS-B potential, but only VDL M4 has approved standards. ADS-B has applications for surface or ground surveillance and for surveillance within the terminal area such as departure surveillance. It is presently being displayed by means of a Cockpit Display of Traffic Information (CDTI), and has high yet controversial potential for Airborne Collision Avoidance System (ACAS), Traffic Collision Avoidance System (TCAS), and for surface surveillance. At present, power is limited to about 40 NM and the transmission rate is approximately once per second.

7.2.4.5 Mode Select Extended Squitter

Every aircraft equipped with a Mode S transponder radiates its unique Mode S address once per second on 1090 MHz which is known as the extended squitter. The GPS squitter adds two additional 112-bit messages. One message is radiated every half second and contains GPS position and barometric altitude when the aircraft is on the surface; or position, heading, and speed when the aircraft is airborne. The other message is radiated every 5 seconds and contains flight number Flight number (registry number or tail number for general aviation). The potential benefits of the Mode S extended squitter include improved TCAS, a single system for positioning and identification for both airborne and surface aircraft; augmentation or replacement

of secondary surveillance; and the provision of an additional data link air-ground sub-network. The Mode S SARPs were approved in May 1999 and published in 2001.

7.2.4.6 Multilateration

Multilateration is being developed under different names by different companies, but the technology is a transponder-based Multilateration system that uses multiple receivers to capture aircraft transponder pulses and calculate position and identification. The system is configured with multiple low-cost, non-rotating sensors strategically placed in the surveillance area. Targets must be within "line of sight" of a minimum of three sensors or antennas at all times to be tracked. Each sensor receives, decodes, times stamps, and transmits the data from the transponder to a target processor (TP). The TP compares the reports from multiple sensors to derive the target position based on the time of receipt of the signals at each sensor. The Multilateration process, with its typical update rate of once per second, allows the system to provide an accuracy of 5 meters or less for surface surveillance, and 30 meters or less for wide area surveillance. Multilateration can work with any transponder-equipped aircraft without additional avionics. Additionally, Multilateration supports simultaneous reception of ADS-B extended squitter messages with no equipment modifications. Unlike traditional radar, the Multilateration system relies on small equipment enclosures and non-rotating antennas that are installed on existing communication towers, terminals and other structures. Additionally, Multilateration sensors can communicate with the TP via a wide variety of communication options.

A Multilateration system offers an ideal solution for the complexity of airport surface surveillance. At larger airports, this system complements the existing surface movement radar system, providing improved and more reliable data than that from a single surveillance sensor. For smaller airports that rely on visual surveillance, Multilateration provides a cost-effective surveillance system to enhance safety. Multilateration can also be used in the en route environment, but it is line-of-sight which will therefore require a number of strategically placed antennas or sensors to cover large areas of airspace. The ability to interface Multilateration with traditional radar systems is still under study.

7.2.4.7 Surveillance Summary

MSSR is the surveillance tool of choice for high frequency traffic areas, for complex traffic areas, and for enhanced safety. Although not mentioned in this document, Airport Surface Detection Equipment (ASDE-radar) is also available for ground surveillance, but will eventually be replaced by ADS-B. Radar is an expensive surveillance system that provides considerable benefits; and where surveillance is required, it is the candidate choice. However, for those areas where enhanced surveillance is required and radar is either too expensive or not available such as remote and oceanic areas, ADS is an excellent alternative. ADS-C is available for oceanic and remote areas and domestic en route areas where radar is too expensive or not available. ADS-B is a broadcast means of surveillance and is applicable for ground or surface surveillance and surveillance as a departure enhancement. ASDE can fill the ground surveillance gap until ADS-B is certified and available.

Multilateration is a new technology that has not been fully developed but has potential for terminal area surveillance. It is being demonstrated in the en route environment, but since it is a line-of-sight technology, it will require several strategically placed sensors/antennas to provide surveillance over a large area. Since the planned accuracy of Multilateration appears to be 5 meters on the ground and 30 meters in the air, the accuracy of Multilateration may be less than ADS-B, SBAS, and GBAS.

7.2.5 Air Traffic Management (ATM)

7.2.5.1 Functions of ATM

The most basic function of ATM remains the safe and orderly flow of air traffic. Functions of ATM should enable aircraft operators to meet their planned times of departure and arrival, and adhere to their preferred flight path with minimum constraints and without compromising agreed levels of safety. ATM includes the air traffic services to be provided, the airspace organization, the associated facilities and equipment, and the required communications, navigation and surveillance performance that facilitate the provisions of CNS/ATM benefits.

Benefits derived from CNS/ATM concepts will drive the evolution of CNS/ATM. ATM is basically a product of the new tools (benefits) associated with CNS/ATM, which permits controllers to manage their airspace more efficiently. Airspace managers can use these tools to promote system efficiency without overly controlling it.

7.2.5.2 Airspace Management

The air traffic system should include a network of ATS routes established so as to enable aircraft to operate along or as near as practicable to the preferred flight path, in both the horizontal and vertical planes, from the departure airport to the destination airport. ATS routes based on area navigation should be recommended when and where available. Standard terminal arrival routes (STAR) should be established when the density of air traffic justifies their application in a terminal area and to facilitate the description of the route and procedure in air traffic control clearances.

Whenever circumstances warrant, the airspace organization should be designated to support the ultimate goal of allowing each aircraft to fly its own optimized flight path. Airspace management is being practiced in the South Pacific where properly equipped aircraft operating between the west coast of the United States, Australia, and New Zealand are allowed to fly their optimized routes, generally at their requested altitude, and are permitted to change routes based on revised wind forecasts while en route.

The FAA has used the "National Route Program" for several years in which aircraft were permitted to fly user trajectories above Flight Level 330 within the domestic United States from a point 200 NM from their departure airports to a point 200 NM from their destinations. This program, which is being applied at lower levels and at points closer to the airport, has provided users considerable cost savings as well as providing data collections to support a new concept

called "Free Flight". The Free Route Program being initiated by EUROCONTROL is very similar in operation as the FAA's National Route Program.

7.2.5.3 Traffic Flow Management (TFM)

The final ingredient to ATM is traffic flow management or what is commonly known as "flow control." This concept, which was originated in the United States almost 30 years ago, has saved considerable amounts of money and has increased safety in unaccountable terms and numbers. No longer are arriving aircraft held at approach fixes or in delay absorption patterns; nor are en route or terminal sectors inundated at various periods of time with unmanageable air traffic flows. Aircraft demand levels are managed in light of real capacity, which reduces the overall delay, saves time and fuel, and eases the controller workload.

Information exchange and collaboration continue to be critical components of traffic management. Improved information exchange among users and service providers enable shared insight about weather, demand, and capacity conditions, and allows for improved understanding of CNS/ATM system status and TFM initiatives. Users are key participants in the planning process of traffic flow initiatives. As users receive better knowledge of the intent of traffic flow initiatives, they may arrange their own resources to help solve the flow problems.

Increasingly, regional and local TFM service providers adapt to an environment of increased user flexibility, collaborative partnership, and information sharing among themselves and with the airspace users. During the first few years of the 21st century, users and service providers alike will begin to experience the benefits of increased automated exchange of information between users and service providers. Timely and consistent information across the CNS/ATM system will be made available for both user and service provider planning purposes.

Increased collaboration among local facilities, regional TFM, and CNS/ATM system users is augmented by decision support systems that enable a shared view of traffic and weather with all parties. Additional to this is the "what if" tools that will be used by both the service provider and the CNS/ATM system user to evaluate proposed strategies. Since CNS/ATM system users have increased flexibility in planning routes and schedules, and because the CNS/ATM system relies less on routine restrictions and fixed routes to structure traffic, the management of CNS/ATM system resources becomes more dynamic and adaptive. Improved decision support systems will help service providers visualize demand and manage the more complex traffic flows. In addition, decision support systems that evaluate CNS/ATM system performance in real-time enables the service provider to be more responsive and develop more effective traffic management strategies.

More and more providers are beginning to effectively manage their airspace and air traffic by using the flow management tools that are becoming available. Flow management programs that reduce delays, improve capacity, and expedite traffic are becoming more common through advanced automation and collaborative decision making.

7.2.6 Performance-Based Initiatives

General

The future air traffic system will be characterized by performance-based technology. This performance-based technology includes Required Communications Performance (RCP), Required Surveillance Performance (RSP), Required Navigation Performance (RNP), and Required Total System Performance (RTSP). This means that flight will be based on the performance capabilities of the aircraft for flight in different areas of airspace. Aircraft will have to satisfy certain communications, navigation, and surveillance performance requirements that eventually will result in a total system performance capability. These requirements will be satisfied by the performance capabilities of onboard equipment. Future flight will specify certain aircraft performance requirements and it is up to the aircraft as to how it meets those requirements as long as the aircraft is certified for flight in that airspace.

7.2.6.1 Required Surveillance Performance (RSP)

Required surveillance performance (RSP) is that specified monitoring capability describing one or more of the pertinent monitoring parameters necessary to ensure the safe separation of an aircraft over a particular area, airspace, route, procedure, or operation. Monitoring performance relates to an aircraft function that provides a capability in the monitoring of aircraft position and intent. This capability may be used to assure safe separation of aircraft in the en route and terminal environment (radar, automatic dependent surveillance, etc.). Required surveillance performance applies to the capability associated with each individual aircraft rather than a population of aircraft. It is closely linked with RNP and RCP. Failure of an aircraft's navigation or communication system will adversely affect RSP. SARPs for RSP have been approved and distributed.

Although RSP applies to a capability associated with each individual aircraft rather than a population of aircraft, it also may pertain to a variety of airborne or ground system features such as TCAS/ACAS, altitude alerting, ground proximity warning system, minimum safe altitude warning, conflict alert, conflict probe, or other techniques or systems. Required monitoring performance is generally categorized in terms of performance, availability, and integrity. Required monitoring performance is generally specified according to the two broad areas described as follows:

- Ground System Methods: ATS monitoring includes features such as conflict probe, conflict alert, minimum safe altitude warning, or other such features that may be used by ATC in the separation of aircraft. Airborne and ground system methods or techniques may require systems such as automatic dependent surveillance, radar surveillance transponders, communication position reports, or other techniques to support RSP.

- Airborne System Methods: Airborne methods include monitoring provided by systems like TCAS/ACAS, vertical or altitude alerting, ground proximity warning systems, Engine Indication and Crew Alerting System (EICAS), Electronic Centralize Aircraft Monitoring (ECAM), Flight Management System (FMS) alerting, or other such features.

7.2.6.2 Required Communications Performance (RCP)

Required communications performance is gaining considerable acceptance in the aviation industry. The ICAO All-weather Operations Panel (AWOP), the FAA, and EUROCONTROL are still evaluating it in conjunction with RNP, RSP, and RTSP. RCP is a specified communication capability of an aircraft describing one or more of the pertinent performance parameters of an airborne communication system necessary for use in a particular area, airspace, route, procedure, or operation. RCP addresses communication system performance, integrity and availability and may address normal, rare normal, and non-normal performance. The following types of required communication performance are generally specified for a particular airspace, operation, procedure, or route:

- No communication capability required.
- VHF communication transmitter/receiver (single or dual).
- UHF communication transmitter/receiver (single or dual).
- HF communication transmitter/receiver (single or dual).
- Data link (ACARS).
- Data link, Mode S (single or dual).
- Data link, ARINC 622 or later specification (single or dual).
- Data link, ATN-compatible or later specification (single or dual).
- VHF data link (single or dual).
- SATCOM (AMSS) voice capability (single or dual).

The above capabilities may be specified individually or in combination for various airspace, areas, routes, procedures, or operations. Other communication capability may subsequently be specified as other international criteria are developed. When new methods of communication capability are introduced such as data link, the new method of communication capability should provide at least the equivalent safety features of the communication capability it is meant to replace unless otherwise specified by an authority. If exclusive dependence is to be placed on a means of communication not previously operationally validated, appropriate levels of performance, integrity and availability must be demonstrated. SARPs have been approved for RCP.

7.2.6.3 Required Navigation Performance (RNP)

RNP is a generic term that allows the requirements of the airspace to be defined without specific reference to a navigation system. RNP is a statement of the navigation performance necessary within a defined airspace and is a product of CNS/ATM. A specified type of RNP is intended to define the navigation performance of each individual aircraft within the airspace commensurate with the navigation requirements for that airspace.

RNP is a fundamental parameter in the determination of separation when used with intervention, traffic density, and route configuration. Providers are already assigning RNP values to particular routes and areas in order to take advantage of the benefits of GNSS. The Informal South Pacific Air Traffic Coordinating Group (ISPACG) has already assigned RNP-10 for routes and tracks in

the South Pacific. The use of RNP permits a reduction in separation from 10 minutes horizontally and 100 NM laterally to 50 NM both laterally and horizontally. The goal is to assign RNP-4 for all South Pacific routes and further reduce the separation to 30 NM both horizontally and laterally. FAA began 30 X 30 on Pacific routes in December 2005.

At present, there are basically two lateral containment areas associated with RNP: a 95% containment area (inner) where the aircraft can be expected to remain 95% of the time during any particular phase of flight, and a containment area (outer) where the probability that the aircraft will not exceed that area is one in every 500,000 operations per flight hour. At present, the containment areas are a function of the RNP value. RNP values determine the lateral confines of both containment areas. The RNP value for en route operations is the 95% inner containment value and the outer containment area is twice the RNP. For example, an RNP-5 value indicates that the 95% inner containment area for en route operations will be 5 NM either side of the centerline, and that the outer containment area will be twice the RNP or 10 NM. Operationally, this means that there must be at least 20 NM between centerlines of two parallel RNP-5 airways. Approach containment areas have been developed for the various categories of approaches. The RNP will determine the containment area. Improvements to RNP and its associated containment areas are occurring everyday.

RNP types approved by ICAO include RNP-1, RNP-4, RNP-12.6, and RNP-20, but other RNP types such as RNP-0.1, RNP-0.3, and RNP-0.5 are already being used for instrument approaches. It is expected that an RNP between 0.003 and 0.015 will eventually be used for GNSS CAT III approaches. Transition routes over Alaska between Canada and the North Pacific Route Structure (NOPACS) have been assigned RNP-20 to permit better use of airspace. RNP-4 has been assigned to a new RNAV route between Miami, Florida, and San Juan, Puerto Rico. RNP-10 will be assigned to the oceanic tracks between the United States and Hawaii and between Hawaii and Japan later this year. Other RNP values are also being assigned to instrument approaches. ICAO Circular 267-AN/159 indicates that other RNP values will be used in various types of airspace, especially during the initial phase of RNP. EUROCONTROL has been using RNP-5 for their Basic-RNAV program for several years.

7.2.6.4 Required Total System Performance (RTSP)

Required Total System Performance is a statement of the total system performance needed to operate in various areas of airspace or to use a specific procedure. RTSP may permit an aircraft to operate in airspace when one of the components of RTSP (RCP, RNP, or RSP) by itself does not meet the minimum requirements for operation in that airspace. This is based on the assumption that when all the components of RTSP are combined, the total performance may outweigh the performance capability of one. An example of this is the navigational term used in GNSS known as Total System Error (TSE). TSE is a combination of Flight Technical Error (FTE) and Navigational Sensor Error (NSE). By using TSE, flight in specific airspace can be accomplished when the individual performance parameters of FTE or NSE may be larger than would be permitted if using one of the component performance parameters by itself. The MASPS (Minimum Aviation System Performance Standards) for the use of RTSP is completed and the SARPs are being developed and should be available soon.

7.2.7 Certifications and Approvals

7.2.7.1 Certification of Systems/Avionics

While most countries have depended on the FAA to provide certification standards and criteria for the certification of systems/avionics, that task has now been passed on to the Joint Aviation Authority (JAA). The JAA is a multinational authority composed of the United States, England, Canada, and other countries that now provide a global certification standard. Even though one country may develop the standards, those standards are adopted by the JAA and then become acceptable to most ICAO countries to use for certification purposes. At the present time, TSO C129, TSO C129a, as amended, and TSO C145 (TSO for WAAS receivers) have been adopted. Almost all states that have approved GPS as a supplemental or primary means of navigation have used TSO C129a as their standard. Airworthiness requirements for the installation of GPS receivers are defined in FAA's Advisory Circulars AC-20-138 and AC-20-130A. These circulars have also been adopted by the JAA and most provider states.

7.2.7.2 Operational Approvals

The operational approval authority is a state responsibility. Each state must determine to what degree they will approve the use of CNS/ATM technology within their borders. They must determine the standards they will accept and then develop the operational procedures, either for visual or instrument flight rules, or both. They also must determine the operational approvals for any ground equipment used such as differentials, monitors, reference stations, etc. The approval documents should contain any requirements that the approving state deems necessary for a safe implementation, and then the documents should be published in an appropriate manner. For example, both Australia and Fiji require pilots to be recertified to conduct a GNSS instrument approach.

Operational approvals are also based on operational procedures being in place and ready to use. This is primarily an air traffic responsibility, but other units are also involved, particularly the Flight Standards organizations. Air traffic must develop the procedures to be used to provide the benefits available from any CNS/ATM implementation; Flight Standards units must have their procedures in place for both flight and avionics inspectors and for flight inspection units. The aeronautical information unit must be ready to prepare and disseminate GNSS Notice to Airmen (NOTAM) based on GNSS satellite outages or the outage of any other component of the GNSS system for which an approval has been received.

7.2.8 Barriers to Implementation

General

When the Future Air Navigation Committee developed the Future Air Navigation System (FANS), now known as CNS/ATM, the system was primarily conceptual based on advanced CNS technology. Many of the concepts appeared feasible but had not been proven. Additionally, these concepts were developed in part around GPS, a satellite positioning system owned and operated by the United States Department of Defense (DoD), and GLONASS, a

satellite positioning system owned and operated by the Russian Federation, both of which did not permit international control. Consequently, there were institutional and political issues that had to be resolved as well as establishing the technical feasibility and operational benefits of CNS/ATM. The first issues to emerge were with the positioning systems that provided the navigational capability for CNS/ATM. As the development of CNS/ATM continued, other issues began to arise and have become important to every provider state. Several of these issues have been considered as barriers to implementation. Regardless of the extent of these issues, they have the potential to delay the full implementation of CNS/ATM. In subsequent Task, we will identify several of those issues and offer comments on how they are being resolved by the provider states.

7.2.8.1 Institutional Issues

Ownership and Control

The ownership and control of GPS and GLONASS have been an institutional issue since GPS and GLONASS were first proposed as a candidate for GNSS. The fact that foreign military establishments own and operate both positioning systems is not acceptable to many who feel that the system could be used as leverage in many international and political disputes. It was also felt that no one could accept a system for international use that could be turned on and off at a foreign government's whim. The United States has taken special actions to relieve provider concerns over GPS, to impress provider states that GPS is an international resource, and that the system will be available for the foreseeable future.

The move toward further civil control of GPS was exemplified by the establishment of a "Civil GPS Users Advisory Council." This council is composed of both users and the provider of GPS services. This council actively participates in the management of GPS by participating in the activities of the Interagency GPS Executive Board. Additionally, the President of the United States has approved two additional GPS ranging frequencies to be installed on GPS Block IIR replacement satellites that have not already been launched and Block IIF satellites that are scheduled for launch in 2006.

To further demonstrate the efforts of the United States on the global acceptance of GPS, the FAA has signed bilateral cooperative agreements with more than 20 countries. These agreements cover the full spectrum of FAA activities including the development of independent technical aspects of GPS augmentation services, surface management, and the combining of WAAS networks to form a seamless global system.

In summary, the United States has made every effort to meet the concerns of the international aviation community about GPS. Additionally, positioning satellites that will carry GPS through the next 20 years are already being designed, procured, and in some cases, launched. For the most part, world providers have accepted these concessions and are using GPS for present and future needs, including the development of an integrity system. The use of GLONASS is still being debated since there is not sufficient information on the system to make future intelligent decisions.

User Charges for GPS

User fees or service charges have also been an institutional issue since GPS was first offered for worldwide use. When GPS was offered to ICAO, the offer included "free of all direct user charges." The United States has lived up to that agreement, and as long as GPS is controlled by the United States, there will be no user charges assessed. However, the offer did not include user charges for augmentations to the GPS system such as differential GPS or integrity channels similar to those that are being developed as part of the WAAS, EGNOS, or MSAS. The FAA is developing the WAAS, and international participation has been included in the development specifications. There have been no discussions or decisions made as to whether user charges will be applied to those who wish to use the WAAS; however, since the WAAS was developed for use by civil aviation, a user charge is not expected to be imposed on those countries that anticipate using the WAAS. For example, the South American Planning Group, GREPECAS, has been transmitting correction signals from their satellite test bed through the FAA's Master Control Stations (MCS) for relay back to South America for several months at no charge. However, international providers will be expected to fund the cost of getting their integrity data to the FAA's MCS. It is expected that there will be user charges for EGNOS's wide area differential service (GNSS-2) since a consortium of countries and manufacturers is developing it for profit.

Legal

There are various ICAO articles that obligate states to provide radio-navigation services throughout their country. ICAO has already issued a legal opinion on their authority to implement the positioning capability of GNSS under Article 48 of the Chicago Convention. However, an issue has been raised as to the legal responsibility for a country using a navigation system that is owned and operated by another country. The legal committee for ICAO and other legal experts are presently working these issues. Integrity for the legal framework for the implementation of GNSS requires observance of fundamental principles that need to be outlined in a charter. That charter, "Charter on the Rights and Obligations of States Relating to GNSS Services (AR32-19)," is in final draft copy after almost 10 years of work, but has not yet been approved or disseminated.

ICAO has issued appropriate guidance for states to follow to legally use the GPS system until the legal committee issues its decision, which is expected to support a state's right to use GPS. It appears that countries are using the advice issued by ICAO as they demonstrate CNS/ATM initiatives in their country today.

7.2.8.2 Technical Issues

General

The technical issues associated with CNS/ATM implementation are being resolved almost on a daily basis. The FAA's Satellite Operational Implementation Team (SOIT) has been the leader in this area, especially in the areas of GNSS receiver certification, development of GNSS approach criteria, and the overlay program. They have also been involved in WAAS and LAAS

receiver certifications, WAAS/EGNOS interoperability, GPS interference, and operational implementations. Canada and several countries from EUROCONTROL who attend and participate in SOIT meetings have also been very active in resolving many technical issues as well. While many issues have been resolved, there are others, some of which are indicated below, that are still being resolved.

GNSS Receiver Certifications

TSO C129 and TSO C129a were developed to certify GPS receivers for instrument flight, and have been used to certify GPS for supplemental and primary means of navigation for oceanic, en route, and non-precision approach in several countries. TSO C145 and TSO C146a have been developed to certify GNSS receivers for sole means utilizing the WAAS or EGNOS. Now the main focus is aimed at developing the standards and certification criteria for the second-generation receivers; those that will receive and process augmented data, e.g., WAAS, EGNOS, and LAAS.

Additional GPS Frequencies

The GPS Executive Board recommended that a second GPS frequency be added to the new Block IIR satellites due to be launched in 2004. The board felt that a second GPS frequency would expand the base of civil GPS users worldwide and send a strong message to the international community that the United States intends to maintain a long-term commitment to providing GPS services. Moreover, the WAAS system could provide improved services with a second frequency, and the addition of a second frequency would allow for independent civil and military applications.

In January 1999, the vice president of the United States announced the addition of a third ranging frequency that would be installed onboard the Block IIF future replacement satellites. The addition of these two ranging frequencies will greatly improve the availability of GPS. The first Block IIR satellite with the new ranging frequency (L2) was declared operational on January 10, 2004. This is not the same L2 frequency used by the US military; however, this frequency is a "non-safety-of-life" frequency. This means the frequency is usable but not protected from other frequency disturbance or interference. The new "safety of life" frequency (L5) will be available with the Block IIF satellites to be launched in 2006. It is expected that all Block IIF satellites will have three ranging frequencies (L1, L2, L5), although only two of these frequencies (L1, L5) will be protected.

7.2.8.3 Operational Issues

General

PANS-OPS criteria (SARPs for GNSS approaches) have been approved and distributed. GNSS approaches offer an exciting capability and benefit to the user and provider. There are more than 3400 GNSS non-precision approaches available for public use today. GNSS precision approaches are just beginning to be developed and used. The issues here are whether the three

categories of precision approaches (CAT I-III) will remain the same in relationship to GNSS approaches given the minimums now available with GNSS.

Systems Monitoring

One of the operational issues facing CNS/ATM implementation is the monitoring of the systems used to provide the benefits of CNS/ATM such as the positioning constellations, ground-based augmentation systems, etc. In order for the ATS provider to provide a safe and expeditious service, it is necessary that they are kept informed on the status of the navigational aids on which any procedure is predicated (Annex 11). At present, GNSS is monitored by the FAA and ESA, as well as the US military. Individual states that have approved GPS for use have set up a number of GPS monitors to verify and validate GPS signals. Each provider state should have a monitor or series of monitors to ensure the validity of the system so that users can be notified immediately if the signals are corrupt or if a satellite is inoperative. At present, international GPS NOTAM information on the GPS constellation is published on a daily basis.

Even though the United States (GPS) and the Russian Federation (GLONASS) have committed to ICAO to provide certain positioning accuracies, it is incumbent upon user states to ensure for their own safety and protection that the systems are performing within advertised parameters. Additionally, ICAO requires navigational aids that are used by international and domestic aviation to be monitored. GNSS is no exception. Neither GPS nor GLONASS were developed with integrity. At the present time, the only method that provides any integrity for GPS is GPS receivers that are certified to TSO C129 or TSO C129a and the WAAS. The GPS receiver with RAIM or AAIM currently provides GPS integrity, but that might not continue to be the case as GNSS is approved for all phases of flight. Therefore, a limited network of ground monitor stations should be employed to monitor the GPS constellation. Personnel who could initiate a NOTAM if the system fell below published parameters should monitor these reference stations. Additionally, as GNSS is approved as a sole means of navigation, these monitors can be upgraded to SBAS Reference Stations that will support the WAAS and, to some degree, the EGNOS.

Procedures

The procedures for all CNS/ATM applications have not been fully developed as of yet. However, most SARPs have been completed and approved. Operational procedures for air traffic control using CNS/ATM components were developed for trials and demonstrations, and in most cases have now been validated. For example, air traffic control procedures for ADS that were developed for the Fiji demonstration have weathered the test of time and are still being used after 8 years. Accordingly, as soon as all the SARPs are completed, many of the air traffic procedures that were developed for trials and demonstrations can be modified to meet the SARPs criteria.

Some procedures are already in use in various countries. Fiji has been experimenting with 10 NM longitudinal separation using GPS for distance information. GPS distance information is "along track distance (ATD)" which is distance without slant range, so the distance between aircraft is more exact. The FAA has adopted longitudinal and lateral separation standards using

GPS along track distance for longitudinal separation between RNAV aircraft and DME equipped aircraft. Canada is also working with the FAA to adopt the same standards so as to create a seamless airspace between the two countries.

It is extremely important that in areas where GPS has been approved for supplemental or primary means of navigation, procedures must be developed to provide an acceptable target level of safety for operational initiatives and for the dissemination of GPS satellite outages. Integrity of the system is dependent on the satellites being in service. When a satellite is out of service, it could have an adverse effect on integrity for different phases of flight.

In an effort to disseminate satellite outages and integrity information to the users, the FAA established the GPS Aeronautical Information System. The RAIM algorithm is used to compute the integrity at various airports within the United States. GPS almanac data and satellite health information are input into the RAIM algorithm and processed against the database of airfields to determine satellite coverage at specific locations. With this information, GPS integrity can be predicted for many airports worldwide. EUROCONTROL also uses this technique to predict integrity within the European area. The outage and integrity information is then distributed to aviators via NOTAMs. Therefore, any state that is using GNSS as a supplemental or primary means of navigation should be providing satellite integrity information outages to their users.

7.2.9 Evaluation of Key Technology Functions

General

The predicted growth in aviation has created the need to immediately begin the process of modernizing the CNS/ATM system. To achieve these objectives requires the development of new paradigms and the use of new technology. This section focuses on the evaluation of key technologies that are available to support the modernization of the CNS/ATM system.

7.2.9.1 Voice Communications

General

The world's voice communications for civil aviation in domestic airspace, like the majority of the world's civil domestic aviation voice communications systems, are predominantly Very High Frequency (VHF) based; communications for oceanic/remote area communications are usually High Frequency (HF) based. Voice communications will remain predominantly analog throughout the transition to digital systems. However, in concert with the worldwide adoption of the CNS/ATM concept, analog voice communication will be used for non-routine communications, with more routine communications provided through digital communications services.

VHF Voice

Characteristics

- Amplitude modulation
- Uses VHF spectrum
- Line of sight

Strengths

- Currently operating, reliable, mature
- Used by air carrier, general aviation, and military

Weaknesses

- Line of sight
- Subject to interference

HF Voice

Characteristics

- Over the horizon communications
- Propagation influenced by time of day, season, weather, and ionospheric disturbances
- Uses HF communication spectrum

Strengths

- Equipment currently installed in many aircraft
- Very long propagation distances
- Supports both voice and data communications
- SARPs available
- Potential use as complementary means of voice and data communications

Weaknesses

- Communications reliability dependent on variable propagation conditions
- Not designed to support time-critical CNS/ATM system services

7.2.9.2 Aeronautical Mobile Satellite System (AMSS)

Characteristics

- Service provided by Inmarsat
- Four satellites in geosynchronous orbit

- Supports Voice, ATN (Data 3 packet mode) and non-ATN (circuit mode) services
- Connection to PSTN
- A-BPSK modulation scheme for up to 2.4 Kbps and A-QPSK for greater bit rates

Strengths

- ICAO standards currently exist
- Already operational for Airline Operational Control (AOC) purposes
- Supports both voice and data communications
- Wide coverage

Weaknesses

- High operating costs
- High installation costs
- High transmission power
- Significant transmission delays
- Coverage problems at high latitudes
- Service Provider dependent

7.2.9.3 Data Communications

General

The most promising means of achieving many of the needed CNS/ATM system improvements is to use various forms of data communications to enhance the flow of data between pilots and controllers, and between pilots and their operational control centers. Data communications will enhance safety by:

- Reducing the risk of controller-pilot misunderstanding thereby enhancing safety.
- Reducing the congestion on voice communication channels.
- Providing pilots and controllers with more accurate, error-free information.
- Providing a complementary means of communications.
- Permitting the implementation of new air traffic management and flight operations capabilities.
- Reducing pilot and controller workload per flight.
- Allowing resectorization.
- Reducing long-term infrastructure cost.
- Allowing use on new generation aircraft (for example, B777 and new Airbus aircraft) to download aircraft performance data.

Data links will improve spectrum efficiency by increasing the flow of information over each communication channel and reduce the voice channel loading.

VHF Data Communication

Note: Mode 2, 3, 4 and any attendant equipage must be established as a global solution because of the requirement that there be no duplicate equipage requirements levied on users.

The selected solution must satisfy the requirement of technology enabler at the lowest cost to the user. Cost factors include the enabling device, added weight to the aircraft, aircraft out-of-service installation time as well as direct install cost, and training for air crews and mechanics.

A-BPSK (Aviation Binary Phase Shift Keying) modulation scheme for up to 2.4 Kbps and A-QPSK (Aviation Quadrature Phase Shift Keying) for greater bit rates.

VHF Data Link Mode 2 (VDL Mode 2)

Characteristics

- Uses the spectrum currently allocated for VHF communications
- VHF bit oriented data communication system
- CSMA protocol (p-persistent)
- D8PSK modulation at 31.5 Kbps

Strengths

- SARPs available
- Uses VHF spectrum
- Supports both ATN and non-ATN data services
- Favored by general aviation

Weaknesses

- Lack of an acceptable prioritization scheme
- Non-deterministic transfer time
- Poor frequency reuse and spectrum utilization
- **Note**: See ACARS AOA applications below for a further discussion of VDLM2 applications

VHF Data Link Mode 3 (VDL Mode 3)

Characteristics

- VHF bit oriented communication system
- Supports both digital voice and data communication services
- TDMA scheme (4 channels in a 25 kHz bandwidth assignment for either voice or data)
- D8PSK modulation at 31.5 Kbps
- Vocoder modulates at 4.8 Kbps

Strengths

- Supports time-critical communications
- Integrated voice and data services in a single radio on a single frequency
- Uses VHF spectrum
- SARPs available

Weaknesses

- Not compatible with existing analog voice communications equipment
- Not compatible with EUROCONTROL voice communications requirements
- Interference analysis needs to be completed
- Complicated with timing stations

VHF Data Link Mode 4 (VDL Mode 4)

Characteristics

- VHF bit oriented data communication system
- Supports broadcast and air-to-air services
- Supports both ATN and non-ATN data services
- D8PSK modulation at 31.5 Kbps or GFSK at 19.2 Kbps
- TDMA scheme (up to 6,540 slots per minute depending on the modulation scheme)

Strengths

- Uses the VHF spectrum
- Supports time-critical applications
- Supports both broadcast and air-to-air applications
- Provides integrated surveillance and communication services
- SARPs available

Weaknesses

- Standards are immature. I think "immature" means not developed
- Limited acceptance by airspace users. However, acceptance of VDL-4 is improving rapidly.
- Assessment of the avionics and aircraft integration issues is not yet completed
- VDL-4 is not globally accepted. The area of greatest acceptance is in Scandinavian countries and Russia.

Mode S

Characteristics

- Supports two-way data link (squitter)
- Selective interrogation

Strengths

- Provides surveillance data integrity
- Overcomes Mode A code shortage
- Reduces radio frequency interference

Weaknesses

- Does not meet transit delay and coverage requirements for some applications
- DCL, A-SMGCS, Pushback/Taxi clearance, D-ATIS, NOTAMs, RVR applications are not supported due to limited ground coverage

Controller-Pilot Data Link Communications (CPDLC)

CPDLC will be a functional enhancement to the CNS/ATM system with enhanced capabilities for both en route and arrival/departure control domains. Within these domestic airspace domains, the enhanced capabilities will be fully integrated into the future controller workstations. CPDLC will provide an additional means for two-way dialogue between controllers and pilots for ATC clearances, requests, instructions and pilot reports. CPDLC will be implemented as a digital computer-to-computer communications network. The network will consist of both ground-to-ground and air-to-ground components that will provide communication services to aircraft equipped with appropriate avionics. The decision-making process will incorporate ground and avionics systems as they evolve.

Characteristics

- Bit-oriented applications
- Used for all routine controller-pilot communications, i.e., non-control instructions
- Predetermined message sets, easily selectable easy in the laboratory not in the actual trials, this involves a new way of flying for pilots and under pressure there are problems, this is not to say CPDLC is bad it just has a long way to go. The critical issue is how to handle a mixed fleet

Strengths

- ATN compliant
- Can support critical ATC communications
- Compatible with many frequency Spectrum Options

Weaknesses

- Limited applications in high workload, time-critical situations, such as communications within the terminal area where radar vectoring is primary controller tool
- Requires a separate display in an already crowded display panel
- Can divert attention from other tasks if used in very high workload situations which create a safety issue
- Difficult to use in emergency situations which create a safety issue
- Requires the continued carriage of voice radios
- Loss of the common frequency "party line" is a safety issue yet to be decided

Aircraft Communications and Reporting System (ACARS)

The Aircraft Communications and Reporting System (ACARS) is currently fitted in most air carrier aircraft as the primary means of providing Aircraft Operations Control (AOC) communications. ACARS is also being used to provide a very limited set of CNS/ATM data link capabilities under tightly controlled conditions in a few areas of the world.

Characteristics

- Uses the VHF communication spectrum for most services
- VHF character-oriented data communications system
- CSMA Protocol (non-persistent)
- AM-MSK modulation at 2.4 Kbps

Strengths

- Currently in operational use throughout the world
- Use the VHF spectrum currently allocated for communication purposes
- Installed in many air carrier aircraft
- Strategic, non-critical air traffic services are currently being provided in limited areas (such as Pre-departure Clearances, which save pilots and controllers workload)

Weaknesses

- Not compatible with the Aeronautical Telecommunication Network (ATN)
- Very low bit rate
- Designed for AOC communication, not time-critical ATC/ATM services
- Messages are not prioritized
- Not suitable for time-critical communications
- Very few channels available in the VHF spectrum
- Only two major service providers, SITA and ARINC (who, on the positive side, do provide quality worldwide service)

ACARS over AVLC (AOA)

ACARS is not ATN compliant; therefore, it is not an acceptable future data link. However, technology has developed a technique that can make the ACARS link ATN compliant. In the VDL AVLC architecture (commonly called AOA), the aircraft uses the ACARS air/ground protocol over the ICAO VDL Mode 2 link Aviation VHF Link Control (AVLC) increasing the capacity over the VHF link. In the AVLC architecture, aircraft use the AVLC to transport binary data over the VDL Mode 2 link to ground stations. The AVLC provides a connection to a VDL sub-network that provides the aircraft access to the ATN, thus permitting ACARS to be compatible with the ATN. This has high potential for all VDL M2 applications.

Characteristics

- Uses the VHF communication spectrum for most services
- VHF character-oriented data communications system
- CSMA Protocol (non-persistent)
- AM-MSK modulation at 2.4 Kbps

Strengths

- Currently in operational use on a limited basis
- Use the VHF spectrum currently allocated for communication purposes
- Equipment in many air carrier aircraft
- Strategic, time-critical air traffic services are currently being provided in limited areas
- Compatible with the Aeronautical Telecommunication Network (ATN)
- Designed for time-critical ATC/ATM services

Weaknesses

- Immature
- Not fully developed or accepted
- SARPs not yet available
- Aircraft ACARS suites must be upgraded

Universal Access Transceiver (UAT)

Characteristics

- VHF bit oriented data communication system
- Supports broadcast and air-to-air services
- Supports both ATN and non-ATN data service

Strengths

- Multi-purpose broadcast link
- Low-cost link

- High bandwidth
- High potential for broadcast services (ADS-B)

Weaknesses

- Presently in demonstrational use only in Capstone Project
- No SARPs as of yet

HF Data

Characteristics

- Over the horizon communications
- Propagation influenced by time of day, season, weather, and ionospheric disturbances
- Uses HF communication spectrum

Strengths

- Equipment currently installed in many aircraft
- Very long propagation distances
- Supports both voice and data communications
- SARPs available
- Potential use as complementary means of voice and data communications

Weaknesses

- Communications reliability dependent on variable propagation conditions
- Not designed to support time-critical CNS/ATM system services

Aeronautical Mobile Satellite System (AMSS) Data

Characteristics

- Service provided by Inmarsat
- Four satellites in geosynchronous orbit
- Supports data, ATN (Data 3 packet mode) and non-ATN (circuit mode) services
- Connection to PSTN
- A-BPSK modulation scheme for up to 2.4 Kbps and A-QPSK for greater bit rates

Strengths

- ICAO standards currently exist
- Already operational for AOC purposes
- Supports both voice and data communications
- Wide coverage

Weaknesses

- High operating costs
- High installation costs
- High transmission power
- Significant transmission delays
- Coverage problems at high latitudes
- Service Provider dependent

7.2.9.4 GNSS Navigation

Global Positioning System (GPS)

Characteristics

- Uses L band spectrum
- Medium earth orbit satellites
- Accurate positioning system
- Worldwide navigation applications
- Spaced-based system

Strengths

- Worldwide use
- Accurate positioning system
- Impervious to weather
- En route/oceanic/terminal/precision approach applications (when augmented)
- Free of direct user charges
- No provider expenses
- Certified for IFR operations
- Mature, reliable system
- No position ambiguities
- Certified for primary mean of navigation in oceanic and remote areas

Weaknesses

- National Asset operated and maintained by US military, but managed by civilian authority
- No built-in integrity
- Susceptible to intermittent masking of buildings/mountains
- Does not support sole means operations without augmentation

Global Orbiting Navigation Satellite System (GLONASS)

Characteristics

- Uses L band spectrum
- Medium earth orbit satellites
- Accurate positioning system
- Worldwide navigation applications
- Spaced-based system

Strengths

- Worldwide use to surface of the earth
- Accurate positioning system
- Impervious to weather
- En route/oceanic/terminal/precision approach applications
- Free of direct user charges

Weaknesses

- Not certified for IFR operations
- Only 9 of 21 required satellites operational
- Not a mature proven system
- Owned by Russian Space Forces
- Poor performance history

Galileo

Galileo is being developed by the European Space Agency (ESA) and is the European Union's (EU) GNSS-2 initiative for a satellite-based navigation and positioning system. Galileo will perform very similar to GPS in that the satellites will provide a ranging signal, and aircraft will use a second-generation receiver to ascertain their position. At first, integrity will be provided only over Europe, but it may be provided wherever there are sufficient ground stations that provide differential corrections. At present, ground stations are planned only for Europe, but additional stations will probably be installed in other areas outside of the planned European coverage.

Characteristics

- Uses L band spectrum
- Medium earth orbit satellites
- Accurate positioning system
- Worldwide navigation applications
- Spaced-based system

Strengths (potential)

- Worldwide use to surface of earth
- Accurate positioning system
- Impervious to weather
- En route/oceanic/terminal/precision approach applications
- Free of direct user charges for GNSS 1
- No provider expenses
- Certified for IFR operations

Weaknesses (potential)

- In development stage
- Not operational until 2008 earliest date

Area Navigation (RNAV) and Required Navigation Performance (RNP)

See reader's quick reference papers (Appendix 1 and Appendix 2) prepared by ICAO and FAA with some modification for use in this TA.

Spaced-Based Augmentation System (SBAS)

Wide Area Augmentation System (WAAS)

The chosen mode of differential correction and availability enhancement of the United States National Airspace System is the Wide Area Augmentation System (WAAS). The WAAS was commissioned in May 2003, and provides adequate availability of the Global Positioning System with an accuracy of less than 10 meters throughout the world. It serves as a Ground Integrity Channel (GIC) that provides integrity to meet RNP requirements for all phases of flight; provides differential corrections including ionospheric corrections that will meet the accuracy requirements for RNP and for all phases of flight down to and including CAT I precision approaches; and through its geostationary satellite, provides an embedded, GPS-like ranging function that will provide additional availability.

Characteristics

- Augmentation to GPS
- Ground-based monitoring network
- Integrity for GPS
- Enhancement to GPS (more ranging signals, better accuracy)
- Ionospheric corrections

Strengths

- Sole means navigation system for all phases of flight to CAT I precision approach

- International participation encouraged

Weakness

- Requires regional coverage to realize benefits that are cost productive

European Global Navigational Overlay System

The European Space Agency (ESA), in cooperation with the European Satellite Commission, and EUROCONTROL will develop and implement the European Global Navigation Overlay System (EGNOS). EGNOS will be deployed in two phases, GNSS-1 and GNSS-2. GNSS-1 is similar to the Wide Area Augmentation System (WAAS) and the Multi-Function Satellite Augmentation System (MSAS). GNSS-2 is a civilian satellite system known as Galileo.

The concept of EGNOS is very similar to WAAS and requires a series of reference stations to provide corrections to a master control station that in turn uplinks the data to the GEO for re-broadcast to the users. The reference stations also gather the correction data transmitted from the GEO and compares it to the data sent thereby providing integrity in the system.

Characteristics

- Augmentation to GPS
- Ground-based monitoring network
- Integrity for GPS
- Enhancement to GPS (more ranging signals, better accuracy)
- Ionospheric corrections

Strengths (potential)

- Sole means navigation system for all phases of flight when operational
- CAT I precision approach when operational
- International participation
- Has an additional GEO to provide signals

Weakness (potential)

- Requires regional coverage to realize benefits that are cost productive
- Not expected to be operational until 2004 for en route
- Not expected to be operational until 2005 for precision

Ground-Based Augmentation System (GBAS)

Local Area Augmentation System

The Local Area Augmentation System (LAAS) is a system designed to augment and differentially correct the signal of GPS satellites for landing and surface phases of flight. The

differential corrections will enable suitably equipped users to perform precision approach and landing (Category I/II/III) throughout rollout and then surface navigation on the surface of the airport area.

Characteristics

- Broadcast corrections over VHF digital link
- Accuracy in centimeters
- Site specific (50 NM radius)

Strengths

- High accuracy, high availability
- CAT I, II, III capability
- Used for more than one airport or runway
- Surface navigation
- Arrival/Departure navigation

Weaknesses

- Limited range
- Line of sight

7.2.9.5 Surveillance

Monopulse Surveillance Secondary Radar (MSSR)

Characteristics

- Primary radar based on "skin paint"
- Secondary radar based on "transponder signals"
- Line of sight

Strengths

- Currently operational
- Meets ICAO Standards
- Mature, reliable system

Weaknesses

- Limited coverage (250 NM)
- Line of sight
- Expensive ($12-15 million US)

Automatic Dependent Surveillance

Automatic Dependent Surveillance (ADS) is both contract and broadcast. ADS-C (contract) has applications for surveillance in the en route and terminal environment and ADS-B (broadcast) has applications for surveillance in the departure/arrival areas, airport surface, and air-air (TCAS). ADS-C is applied on a contract basis with the controllers and provides "events" or "periodic" reports. ADS-B is a continual broadcast of position and any one who is tuned to the proper frequency can receive the positions.

ADS-C

Characteristics

- Periodic/events broadcasts
- "Line-of-sight" coverage (each antenna)
- Operates with several receivers

Strengths

- ICAO SARPs available
- Uses existing VHF spectrum
- Supports all domestic applications
- Low-cost surveillance for service provider
- Low-cost VHF antenna/receiver can increase coverage
- ATN compliant
- Available with VDL M2

Weaknesses

- Line-of-sight coverage (additional VHF antenna will increase coverage)
- Requires upgrade to radios
- Requires onboard avionics
- En route/terminal applications only
- User installation, training, and added weight of aircraft cost

ADS-B

Characteristics

- Continual broadcast
- Special data link frequency
- Cover area depends on antennas

Strengths

- ICAO SARPs available
- Compatible with EUROCONTROL
- Uses existing VHF spectrum
- Supports all domestic applications
- Low-cost surveillance for service providers
- Low-cost VHF antenna/receiver can increase coverage
- ATN compliant

Weaknesses

- Line-of-sight coverage (additional VHF antenna will increase coverage)
- Requires upgrade to radios
- Requires onboard avionics
- Surface, air-air, immediate terminal area applications only
- Does not work with VDL M2
- User installation, training, and added weight of aircraft cost

Multilateration

Multilateration is a transponder-based cross lateration system that uses multiple receivers to capture aircraft transponder pulses and calculate position and identification.

Strengths

- Low cost
- Non-rotating sensors simplify maintenance
- Typical update rate of once per second
- Work with any transponder-equipped aircraft without additional avionics
- Supports simultaneous reception of ADS-B extended squitter messages with no equipment modifications.
- Small equipment enclosures and non-rotating antennas that are installed on existing communication towers, terminals and other structures

Weaknesses

- Line-of-sight
- Minimum of three sensors or antennas at all times
- Accuracy of 5 meters or less for surface surveillance, and 30 meters or less for wide area surveillance

- No ability to interface Multilateration with traditional radar systems

7.2.9.6 Radar Data Processing

ATM Surveillance Tracker and Server (ARTAS)

Five more European air traffic control centers (Brussels, Dublin, Geneva, Shannon and Zurich) have gone operational using ARTAS, the state-of-the-art radar data processing technology.

Already in operational use at the Maastricht Upper Area Control Centre, Schiphol and Lisbon, this technology is designed specifically to achieve surveillance integration by fusing together all types of surveillance data from different sensors into a seamless and accurate situation picture.

With its interfaces to various sensor systems, ARTAS will not only improve the efficiency and reliability of ATM surveillance systems across Europe, but it will also provide a means for States to readily exploit new surveillance technology such as Mode S radar and Automatic Dependent Surveillance (ADS) by processing down linked aircraft parameters. "Modern air traffic management" depends on reliable and accurate surveillance data.

Loss of surveillance data due to sensor failure in one part of the airspace can increase risk in the short term and create a major temporary reduction in ATC capacity in a specific part of European airspace," stated Jacky Pouzet, ARTAS Product Manager at EUROCONTROL.

"The optimum use of all available sensor data and the system reliability and contingency arrangements provide the basis for improved safety." The development of ARTAS dates back to 1993. All successive versions of ARTAS systems have undergone extended trials at a large number of pilot sites.

Following the prototyping phase, ARTAS V3U was the first version to be used in operational service at Schiphol (the Netherlands ACC/APP) in 1998 with classical sensors. Also in 1998 EUROCONTROL established a Centralized ARTAS Maintenance and Operational Support (CAMOS) to support users with implementation. ARTAS V4 was then developed to allow remote supervision. In 2001, ARTAS V4 entered operational service at the Maastricht Upper Area Control Centre (UAC), Lisbon and Schiphol.

ARTAS V6b2 is the first version of the system having the capacity to process Mode S radar elementary information. This version is currently in operational use at the Maastricht Upper Area Control Centre, Schiphol and Lisbon. This baseline version has also been recently introduced at the centers of Brussels, Dublin, Geneva, Shannon and Zurich.

The next step is the development of ARTAS V7 which will allow the processing of enhanced surveillance sensor information (Mode S and ADS). The first ARTAS V7A0 Unix version will be delivered in September 2004 and this will be followed by a version on the LINUX operating system by mid-2005.

7.2.9.7 Technology Conclusions

General

This section is devoted to the conclusions that are based on the evaluations provided in the previous sections.

Data Communications Conclusions

VDL Mode 2

- Currently being implemented for AOC communications
- VDL Mode 2 ICAO SARPs currently exist
- VDL Mode 2 avionics are available
- Two frequencies are required to handle heavy traffic demands
- Transfer delay could be a limiting factor, if traffic and only one frequency is used
- ADS-B is not supported (not envisioned in the design)
- Frequency allocation rules need to be defined
- A-SMGCS is not supported (requires more throughput and shorter transfer times)
- Does not support ADS-B

VDL Mode 3

- SARPs available
- Both voice and data on same frequency
- Vocoder presently being tested
- Supports time-critical communications
- Does not support ADS-B
- Not yet operational

VDL Mode 4

- VDL Mode 4 supports all of the candidate ATN Data Link applications
- VDL Mode 4 also supports ADS-B, A-SMGCS,
- Two frequencies are required for ATN services in high-density airspace
- Three frequencies are required for ATN and Specific Services in high-density airspace
- VDL Mode 4 ICAO SARPs approved

Mode S

- Mode S does not meet transit delay and coverage requirements for some applications
- DCL, A-SMGCS, Pushback/Taxi clearance, D-ATIS, NOTAMs, RVR applications are not supported due to limited ground coverage
- Flight Plan Consistency checking and Dynamic Route Availability applications are not available due to limited transfer time

- Institutional and security issues prevent the use of Mode S for AOC communications

AMSS

- ADS in terminal areas is not supported due to transfer time limitations
- ADS-B is not supported
- A-SMGCS is not supported
- Expensive for routine operations

HF Data Link

- Supports most en route services, but requires larger separation standards
- Not suitable for "time-critical" applications due to unpredictable propagation disturbances
- ADS in terminal areas is not supported due to unpredictable propagation disturbances
- ADS-B is not supported
- A-SMGCS is not supported

CPDLC

- Can reduce workload associated with routine communications
- Reduces voice channel congestion
- Relieves misunderstanding, especially when English is not the routine language
- ATN compliant
- Useable over wide areas
- Needs cost/benefit study to determine real usefulness

Voice Communications Conclusions

VHF

- Useable for routine and emergency communications for the foreseeable future
- Mature, reliable communications

HF

- Supports most en route services, but requires larger separation standards
- Not suitable for "time-critical" applications due to unpredictable propagation disturbances

Navigation Conclusions

GPS

- Supports primary means navigation worldwide

- Supports sole means in all areas when properly augmented
- Supports precision approaches when properly augmented
- Mature, seasoned constellation
- Has no integrity; must be provided by airborne or ground-based system
- Presently certified for IMC flight for oceanic en route, terminal, and non-precision approaches as a primary means of navigation

GLONASS

- Is not certified for IFR flight
- Not a mature system
- Only 9 of 24 needed satellites operational
- Satellites have 3-year life span; only 6 replacements launched

Galileo

- Controlled by the European Space Agency
- Not scheduled for deployment until 2008
- Provides same services as GPS
- Charges for Differential use (SBAS)

WAAS

- Certified for sole means navigation for en route and CAT I precision approach in May 2003.
- Encourages international participation

EGNOS

- Integrity (GIC) scheduled for 2004 (en route sole means)
- Differential scheduled for 2005 (precision approach)
- Will provide sole means to CAT I when differential added
- Charges for precision capability not established

LAAS

- Precision approach capability CAT I through CAT III for LAAS
- High availability, high accuracy
- Serves more the one airport

Surveillance Conclusions

MSSR

- Mature, reliable, accepted

- Usable for all domestic separation standards
- Expensive

ADS C

- Most cost effective of surveillance technologies
- Use is limited to oceanic/remote areas
- Used as a base service
- Requires data link to transmit position
- ATN compliant

ADS B

- Supports all domestic applications
- ATN compliant
- Very accurate
- SARPs approved, not distributed
- Requires data link to transmit position

7.2.10 Technology Advantages and Shortcomings

General

7.2.10.1 Data Communications

VDL Mode 2

- Currently being implemented for AOC communications
- VDL Mode 2 ICAO SARPs currently exist
- VDL Mode 2 avionics are available
- Two frequencies are required to handle heavy traffic demands
- Transfer delay could be a limiting factor, if traffic and only one frequency is used
- ADS-B is not supported (not envisioned in the design)
- Frequency allocation rules need to be defined
- A-SMGCS is not supported (requires more throughput and shorter transfer times)
- Does not support ADS-B

VDL Mode 3

- SARPs available
- Both voice and data on same frequency
- Vocoder presently being tested
- Supports time-critical communications
- Does not support ADS-B
- Not yet operational

VDL Mode 4

- VDL Mode 4 supports all of the candidate ATN Data Link applications
- VDL Mode 4 also supports ADS-B, A-SMGCS
- Two frequencies are required for ATN services in high-density airspace
- Three frequencies are required for ATN and Specific Services in high-density airspace
- VDL Mode 4 ICAO SARPs approved

Mode S

- Mode S does not meet transit delay and coverage requirements for some applications
- DCL, A-SMGCS, Pushback/Taxi clearance, D-ATIS, NOTAMs, RVR applications are not supported due to limited ground coverage
- Flight Plan Consistency checking and Dynamic Route Availability applications are not available due to limited transfer time
- Institutional and security issues prevent the use of Mode S for AOC communications

AMSS

- ADS in terminal areas is not supported due to transfer time limitations
- ADS-B is not supported
- A-SMGCS is not supported
- Expensive for routine operations

HF Data Link

- Supports most en route services, but requires larger separation standards
- Not suitable for "time-critical" applications due to unpredictable propagation disturbances
- ADS in terminal areas is not supported due to unpredictable propagation disturbances
- ADS-B is not supported
- A-SMGCS is not supported

CPDLC

- Can reduce workload associated with routine communications
- Reduces voice channel congestion
- Relieves misunderstanding, especially when English is not the routine language
- ATN compliant
- Useable over wide areas
- Needs cost/benefit study to determine real usefulness

7.2.10.2 Voice Communications Conclusions

VHF

- Useable for routine and emergency communications for the foreseeable future
- Mature, reliable communications

HF

- Supports most en route services, but requires larger separation standards
- Not suitable for "time-critical" applications due to unpredictable propagation disturbances

7.2.10.3 Navigation

GPS

- Supports primary means navigation worldwide
- Supports sole means in all areas when properly augmented
- Supports precision approaches when properly augmented
- Mature, seasoned constellation
- Has no integrity; must be provided by airborne or ground-based system
- Presently certified for IMC flight for oceanic en route, terminal, and non-precision approaches as a primary means of navigation

GLONASS

- Is not certified for IFR flight
- Not a mature system
- Only 9 of 24 needed satellites operational
- Satellites have 3 year life span; only 6 replacements launched

Galileo

- Controlled by the European Space Agency
- Scheduled for deployment until 2008
- Provides same services as GPS claims are made for slight accuracy improvements
- Charges for Differential use (SBAS)

WAAS

- Certified for sole means navigation for en route and CAT I precision approach in May 2003.
- Encourages international participation

EGNOS

- Integrity (GIC) scheduled for 2004 (en route sole means)
- Differential scheduled for 2005 (precision approach)
- Will provide sole means to CAT I when differential added
- Charges for precision capability not established

LAAS

- Precision approach capability CAT I through CAT III for LAAS
- High availability, high accuracy
- Serves more the one airport

7.2.10.4 Surveillance Conclusions

MSSR

- Mature, reliable, accepted
- Usable for all domestic separation standards
- Expensive

ADS-C

- Most cost effective of surveillance technologies
- Use is limited to oceanic/remote areas
- Used as a base service
- Requires data link to transmit position
- ATN compliant

ADS-B

- Supports all domestic applications
- ATN compliant
- Very accurate
- SARPs approved, not distributed
- Requires data link to transmit position

7.2.11 International Trends

General

ICAO has provided a Global Plan for use by regional planning groups and states. The Asia Pacific Planning Group has taken a leadership roll with ICAO and IATA in pulling together invested parties for a regional approach to CNS/ATM. EUROCONTROL, in association with European Civil Aviation Conference (ECAC), has taken the plan and is using it for reference and

guidance as they prepare for CNS/ATM implementation within the EUROCONTROL arena. EUROCONTROL is both demonstrating and formally using CNS/ATM technologies as they move toward a full CNS/ATM implementation in the next few years. Voice communications continue to remain the most effective means of communications, but will be enhanced, and in some cases supplanted, by data communications. The navigation trend by EUROCONTROL continues to be the development of EGNOS, which is an augmentation of GPS, and Galileo, a EUROCONTROL satellite positioning and ranging constellation. The trend in surveillance continues to be improved radar, but is now moving toward ADS as an enhancement to radar and as a sole surveillance system in others. ATM trends continue to be the reduction in aircraft separation and the elimination of aircraft delays.

There are several other global initiatives that formulate a trend in CNS/ATM implementation that have been discussed in detail in other sections of this document, for example, the Integrated Initial Flight Plan System (IFPS), which has standardized, formalized, and centralized the flight plan filing process. ICAO has adopted an airspace classification system. RVSM is being implemented across the globe. We have reviewed several of the planning documents being used to fulfill the expectations for this implementation and will identify several initiatives (trends) that are being undertaken, as well as other states in adjacent areas, as they prepare for a full implementation.

7.2.11.1 Communications

Data Link

The EUROCONTROL trend in communications is toward a data link capability as indicated in the Link 2000+ Program. EUROCONTROL and its ATM partners have already demonstrated the feasibility of data link services through pre-operational trial projects such as the Preliminary EUROCONTROL Trial on Air/Ground Data Link (PETAL II), the Prototype ATN (PROATN), and the European Pre-Operational Data Link Applications (EOLIA). The operational requirements for this first generation of data link services have been developed and defined. The Link 2000+ Program will maximize the use of the results of these projects and will build on the achievements to coordinate the implementation of operational air-ground data link services for ATC throughout the EUROCONTROL states. The Link 2000+ Program is aimed at implementing seamless data link services in the core area of Europe within the 2002-2007 timeframe.

News reports from Maastricht, Netherlands, during 2004 and 2005 reported exchanges between the cockpit and the ground using CPDLC. These reports showed an increase in both numbers of messages and types of clearances and services used at EUROCONTROL's Maastricht Upper Area Control Center.

The number of CPDLC operations in 2005 stood at over 1600 operational exchanges per month. In total, over 9000 operational data link messages have been exchanged with over 4000 CPDLC flights in a 12-month period. CPDLC capability is expected to increase further, resulting in over 100,000 CPDLC flights per year by 2006.

Messages between pilots and controllers are also now fully implemented by aeronautical telecommunications network (ATN) over VHF Data Link (VDL-2), ensuring a faster and more reliable link than analogue ACARS based messages.

CPDLC at Maastricht UAC is used on a daily basis by an international team of air traffic controllers to exchange routine ATC messages with the cockpit. The feedback from the controllers using this menu-based messaging system is positive. They see savings in voice communication time and greater potential for a better workload distribution between planning and the executive controllers. The use of CPDLC also helps aircrew and controllers reduce misunderstandings that can sometimes occur with traditional voice communications.

Continued daily operation is also giving rise to suggestions as to how to use CPDLC even more extensively and how to replace some of the more complex voice communications currently being used.

Maastricht UAC is the pioneer air traffic control centre for CPDLC within the EUROCONTROL Link 2000+ Programme. Controller-pilot data link is scheduled for implementation at 15 air traffic control centers in Belgium, the Netherlands, Germany, Austria, Switzerland, Italy, Spain, Portugal and France by 2007. Link 2000+ is expected to deliver an 11 percent capacity gain and is part of a series of the programs that EUROCONTROL is driving to improve the efficiency of Europe's air traffic management system. The programs are all aimed at allowing more passengers to travel safely and with minimal delays.

The introduction of this technology is highly dependent on sufficient aircraft equipage rates to achieve the expected benefits in terms of safety and capacity enhancement. Airlines have expressed their support for the introduction of data link operation. Data link services are regarded as an essential tool in solving the capacity problems of the coming decade and are an integral part of EUROCONTROL's CNS/ATM implementation. Having said that, it is also true that data link is an excellent choice in many high altitude sectors servicing overflight traffic. The users of such airspace almost always will be equipped with the necessary data link technology. Users are anxious to use the equipment that they have already invested in.

In order to further the data link implementation, the Link 2000+ Strategy offers financial and integration testing support to the first 100 aircraft that add ATN/CPDLC to their VDL M2 installation. The objective of such a scheme is to accelerate the introduction of data link in the en route airspace so as to have 75% of the flights and all centers in Link 2000+ airspace data link equipped. A real incentive for the air carriers is that EUROCONTROL proposes to reduce the route charges for aircraft that voluntarily equip with data link.

8.33 kHz Spacing

In order to expand their communications structure and overcome a frequency congestion problem, EUROCONTROL implemented 8.33 kHz spacing in 1996. The States that initially implemented 8.33 kHz channel spacing above FL245 are Austria, Belgium, Germany, Luxembourg, Netherlands and Switzerland. France implemented 8.33 above FL195. In 2002, Bosnia Herzegovina, Czech Republic, Croatia, Denmark, Estonia, Finland, Hungary, Ireland,

Italy, Latvia, Lithuania, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Slovakia, Yugoslavia, and the United Kingdom implemented 8.33 kHz spacing. The 8.33 kHz Program has benefited CNS/ATM providers who will be able to offer an increased airspace capacity. This in turn will benefit the airspace users, whose increased traffic requirements will be met by the increase in airspace capacity. The bottom line issue with 8.33 kHz is that it "buys time" while the ANSP community and users seek a long-term solution to the diminishing frequency spectrum.

Controller-Pilot Data Link Communications (CPDLC)

EUROCONTROL has awarded a contract to deploy a network of 12 VDL M2 ground stations to support CPDLC communications above Flight Level 245 in the skies over Belgium, The Netherlands, Luxembourg, and northern Germany--some of Europe's busiest airspace. The Maastricht Upper Air Center (UAC) was the first facility to receive this initiative as part of EUROCONTROL's Link 2000+ program.

The Link 2000+ Program started with a limited set of CPDLC messages and expand the message sets as appropriate. Scandinavian Airlines System, American Airlines, and Lufthansa were the first operators to participate in the Link 2000+ Program. CPDLC has long been anticipated as a key element of future air traffic control. It allows controllers to reduce their dependence on voice radio, replacing it with faster, more reliable text messaging between the controller and pilots. This should lead to a reduction in delays, an increase in the margin of safety, and a reduction in aircraft operating costs. Actual results are being studied at this time.

Separately, EUROCONTROL has initiated a contract to install and maintain an ATN/VDL M2 Air/Ground Test Station (AGTS) at its experimental center at Bretigny, France. The station is used to support internal testing, avionics testing, and interoperability testing of the major functionality of ATN/VDL M2 for VHF, VDL and ATN services. The AGTS was conceived and developed as a stand-alone network that will enable EUROCONTROL to perform a variety of scenario-based tests, without the constraints associated with being connected to a live network.

7.2.11.2 Navigation

Basic Area Navigation (B-RNAV)

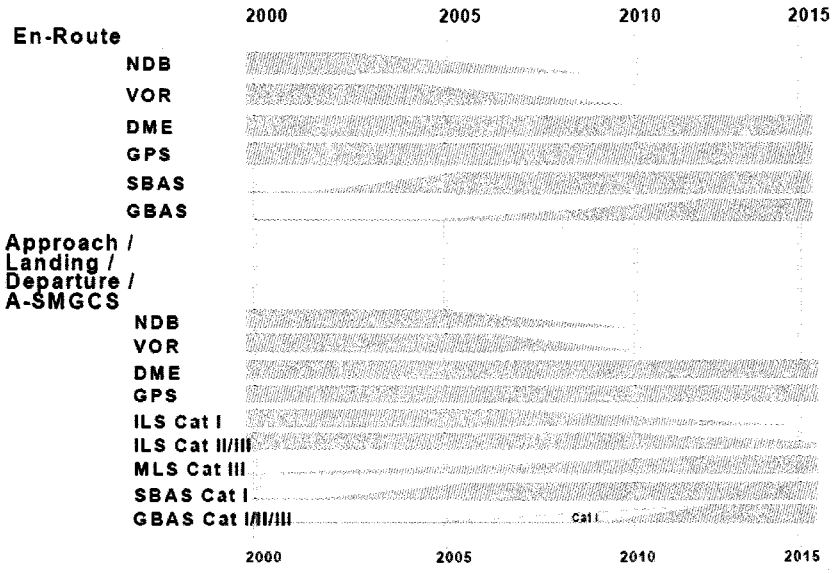
EUROCONTROL has adopted a navigation initiative known as Basic Area Navigation (B-RNAV). It is known as the RNAV concept for European airspace. B-RNAV was developed and implemented by the ECAC in conjunction with EUROCONTROL for use in the ECAC route network (33 countries). B-RNAV requires the aircraft to be certified in accordance with JAA standards for RNP-5. The implementation date was April 23, 1998, and calls for RNP-5 above FL 100, which has significantly increased capacity. Although RNP-5 can be achieved with VOR/DME, DME/DME, Inertial Navigation System (INS), etc., the trend is toward satellite navigation using the EGNOS and in the future, Galileo. This has created a trend toward RNP-1 which is what primary RNAV will try to achieve.

Primary Area Navigation (P-RNAV)

P-RNAV is an advanced navigation initiative proposed by EUROCONTROL and ECAC. It requires aircraft to be certified for primary RNAV through JAA TGL-10 which certifies the aircraft to RNP-1. Many aircraft are already certified, although most of them are high-end aircraft. P-RNAV is presently in effect in some European terminals for flight below the minimum safe altitude (MSA) or minimum vectoring altitude (MVA). At present, RNP-1 can be achieved through DME/DME, SBAS, and/or GBAS. RNP-1 should be available with Galileo in the future. The ECAC states have agreed that P-RNAV is an important element in the achievement of more consistency in the requirements and procedures for the safe operation of RNAV in ECAC terminal airspace. Therefore, by November 2004, all procedures in major ECAC terminal airspace will either be conventional (non-RNAV) or will be RNAV procedures that require P-RNAV approval. However, some B-RNAV procedures may continue to exist, but only under the stringent requirement that they will be limited to procedures above the MSA and MVA, and designed according to en route RNAV principles.

7.2.11.3 Equipment

The graphic below, which was derived from the ECAC navigational strategy, indicates the trend in navigational equipment planned for use by the ECAC in EUROCONTROL and ECAC airspace along with the implementation and decommissioning timeframes. In effect this is a notional depiction of plans.



7.2.11.4 Surveillance

Mandatory Mode S

EUROCONTROL has made the decision to move forward on Mode S and as a result has mandated the inclusion of Mode S equipment aboard aircraft. The mandated date for IFR

aircraft for the carriage and operation of Mode S Elementary Surveillance airborne equipment in designated airspace is as follows:

In brief, the latest date for aircraft compliance with Mode S Elementary Surveillance (ELS) and Enhanced Surveillance (EHS) is 31 March 2007. In the case of EHS, this is subject to operators applying for an exemption from the Mode S Exemption Coordination Cell (ECC). Exceptionally, an exemption may be granted for a small proportion of an operator's EHS applicable fleet until 31 March 2009. Separate comparable exemption arrangements apply for State aircraft. (See ref. ICAO Annex 10 Amendment 77.)

The mandate for VFR aircraft flying in designated airspace is to carry and operate Mode S Elementary Surveillance airborne equipment by 31 March 2005. There are some exemption timeframes; some until 2007. But the important thing is that EUROCONTROL has made the decision to use Mode S as a surveillance enhancement and is requiring aircraft to be equipped with the airborne equipment if flying in Mode S required airspace.

ADS-B

Although ADS-C is a surveillance initiative, the trend in the ECAC states is ADS-B. Therefore, we will address only ADS-B. FAA has been the leader for ADS-B in its Capstone project and ongoing projects at Memphis, Tennessee; Dayton, Ohio; and Louisville, Kentucky.

Airservices Australia has the following projects in progress: Airservices Australia is expanding its Automatic Dependent Surveillance Broadcast (ADS-B) activities in order to promote and exploit the safety and operational benefits made possible by the new data link technology. Five correlated ADS-B programs are in various stages of development. A brief synopsis of each program is outlined below.

a. Burnett Basin Operational Trial is a pilot program to gain technical and operational knowledge and experience in ADS-B technology. Includes installation of a single ADS-B ground station, integration of ADS-B functions in Australia's air traffic management system, and equipping a number of aircraft with ADS-B avionics

b. Upper Airspace Program is a program aimed at providing near-term safety and operational benefits in high-level, non-radar airspace. Includes installation of approximately 28 ADS-B ground stations, strategically located across Australia to provide air traffic surveillance above 30,000 feet in continental airspace outside of radar coverage.

c. Australian Transition to Satellite Technology. This is a major, longer term program designed to make ADS-B the primary means of ground-to-air and air-to-air surveillance in Australian en route airspace. It includes installation of additional ADS-B ground stations to provide air traffic surveillance in airspace currently covered by en route radar facilities. The program is intended to lead to the decommissioning of a number of radar sites. Mandatory aircraft ADS-B equipment requirements will apply--funding options to support general aviation operators will be explored.

d. Research and Development Programs in Australia. R&D activities are to facilitate the Lower Airspace ADS-B Programs. Activities include development of low-cost ADS-B transmitters for general aviation aircraft, air-to-air ADS-B receivers and cockpit displays to provide airborne traffic information to pilots.

e. International Activities Conducted by Air Services Australia. Airservices Australia on behalf of Australia is participating in a number of international forums and panels developing standards and procedures for the implementation of ADS-B technology for air traffic control. Airservices Australia also provides consultancy services in support of ADS-B programs in other States.

EUROCONTROL has established the ADS Validation Test Bed (AVT) to start the validation of ADS-B for use in the airspace of EUROCONTROL and ECAC member states. The ADS Program will comprise three stages:

- Stage 1- Stage 1 is to be concluded with the development of a business case for pre-operational development of ADS. Stage 1 aims to complete the functional and performance specifications and assess the various ADS subsystems. This is achieved through a variety of techniques, including studies, prototyping, and trials. It will also cover an assessment of ADS-B data link technologies.

- Stage 2 - Stage 2 will result in a business case to proceed to Stage 3. Stage 2 focuses on pre-operational development in order to validate both technical and operational aspects of the proposed European ADS infrastructure. Early in this stage, detailed and fully elaborated convergence and implementation program objectives will be produced and ADS functional and performance specifications will be validated.

- Stage 3 - Stage 3 consists of local implementation and will be the responsibility of the national administrations and organizations, together with common maintenance and support as a centralized activity.

ATM Surveillance Tracker and Server (ARTAS)

ARTAS is designed specifically to achieve surveillance integration by fusing together all types of surveillance data from different sensors into a seamless and accurate situation picture. ARTAS is already in operational use at the Maastricht Upper Area Control (UAC) Center and in area control centers (ACC) at Schiphol, Lisbon, Brussels, Dublin, Geneva, Shannon, and Zurich.

With its interfaces to various sensor systems, ARTAS will not only improve the efficiency and reliability of ATM surveillance systems across Europe, but it will also provide a means for states to readily exploit new surveillance technology such as Mode S radar and ADS by processing down linked aircraft parameters. Modern air traffic management depends on reliable and accurate surveillance data. Loss of surveillance data due to sensor failure in one part of the airspace can increase risk in the short term and create a major temporary reduction in ATC capacity in a specific part of European airspace. The optimum use of all available sensor data and the system reliability and contingency arrangements provide the basis for improved safety.

Following the prototyping phase, ARTAS V3U, using classical sensors, was the first version to be used in operational service at Schiphol (the Netherlands ACC/APP) in 1998. Also in 1998 EUROCONTROL established a Centralized ARTAS Maintenance and Operational Support (CAMOS) to support users with implementation. ARTAS V4 was then developed to allow remote supervision. In 2001, ARTAS V4 entered operational service at Maastricht, Lisbon, and Schiphol, and was expanded to the other five ACCs in 2002.

The next step is the development of ARTAS V7 which will allow the processing of enhanced surveillance sensor information (Mode S and ADS). The first ARTAS V7A0 Unix version will be delivered in September 2004 and this will be followed by a version on the LINUX operating system by mid-2005. This particular radar data processing seems to be the trend for EUROCONTROL radars.

7.2.11.5 Air Traffic Management

Reduced Vertical Separation Minima (RVSM)

The implementation of Reduced Vertical Separation Minimum (RVSM) on 24 January 2002 provided six additional flight levels in the European RVSM Airspace between FL 290 and FL 410 inclusive. This has been achieved by reducing the vertical separation minima between aircraft from 2000 feet to 1000 feet. RVSM has been implemented in the airspace of 41 European and North African countries. The switchover to RVSM across the whole European RVSM airspace was conducted very smoothly within both core and transition areas. The only portion of the market that probably is not showing overall savings in fuel as a result of RVSM implementation is that small element that made the commercial decision not to equip for RVSM operations and is now operating at less efficient flight levels.

Free Routes Airspace Program (FRAP)

This is one of EUROCONTROL new airspace initiative that will allow aircraft to fly on more direct routes other than fixed airway routes. The Free Routes Airspace Program (FRAP) is an emerging program whose objective is the introduction of the Free Routes Concept in upper airspace (FL 295 to FL 435) of the participating States. Free Route Airspace is defined as a specific airspace within which airspace users may freely plan their routes between an entry point and exit point without reference to the ATS route network. Flights remain subject to ATC and the responsibility for separation remains with the ground ATC system. The geographical area involved encompasses the upper airspace of Belgium, Denmark, Finland, Germany, Luxembourg, Netherlands, Norway, Sweden, and EUROCONTROL's Maastricht UAC.

The initial feasibility study indicated that implementation of Free Routes Airspace offered the following potential benefits:

- Significant decrease in the number of potential conflicts (approximately 30% less conflicts). Has the potential to increase airspace capacity provided the required ATC systems support tools are implemented;

- Increased flexibility and efficiency for airspace users resulting from operations at more optimal horizontal and vertical profiles, with corresponding additional fuel savings; and

- Cost reduction to airspace users (flight distance/time reduced by some 2 percent).

Cascade

EUROCONTROL and its stakeholders have started a new cooperative program designed to exploit the synergies of two important emerging technologies and to speed their implementation. The new program, known as Cascade, is essentially the fusion of ADS-B and cooperative air-ground traffic management, made possible by advanced CPDLC and data-linked flight information.

Along with its stakeholders, EUROCONTROL says it plans to implement Cascade's improvements in two phases. The first phase, which will start in 2008 following operational trials between 2005 and 2007, will address the limitations of radar-based surveillance, and how CPDLC can improve air traffic control over its present voice-based system.

The second phase, which should start in 2010, will introduce new ATM concepts where pilots, using new onboard surveillance systems, will perform specific maneuvers that previously would have required a controller's direct intervention. This phase will also investigate the potential for ATM improvements based on the controller's better knowledge of an aircraft's future trajectory that is provided automatically from aircraft and to speed their implementation, which is a main element of EUROCONTROL's ATM systems. EUROCONTROL sees Cascade as a way to exploit the synergies of these technologies.

Airborne Separation Assistance System (ASAS)

ASAS is a EUROCONTROL initiative that is derived from the ATM 2000+ Strategy that identifies a strategic line of action on a progressive, but limited, transfer of separation responsibility from the ground to the cockpit. This is similar to the "bubble concept" which is being explored in the United States that permits the aircraft to use its own avionics to provide some limited separation responsibility. This initiative indicates that operational improvements in en route and terminal ATC could be achieved by transfer of separation responsibility with ASAS as an enabler. This initiative is expected to be used on a limited basis by 2008 and be fully operational near 2015. Although this is a new initiative, the following benefits could be derived from this initiative:

- Safety: Enhanced cockpit situation awareness, with the possibility to better understand surrounding traffic; this would not replace ACAS, but can help to avoid being in situations where this safety net would be useful by reducing exposure to risk of judgment error in planning traffic situation.

- Capacity & flight efficiency: ASAS applications should reduce controller workload (e.g., long monitoring situations). Depending on traffic conditions, airspace constraints, and controller's options, ASAS can be converted into capacity and/or flight efficiency.

- Cost reductions: Cost reduction may come from reduced delays attached to capacity/flight efficiency gains. However, it is not anticipated that this will lead to a reduction of ATC infrastructure costs.

This initiative is being tested in a project known as the Mediterranean Free Flight program. This program is a pre-operational program aimed at defining, testing, and validating free flight applications and procedures within selected Mediterranean scenarios that involve Airborne Separation Assurance (ASA). ASA is a fundamental concept introduced by Free Flight and the Airborne Separation Assurance System is the main enabler. This concept is investigating:

- Traffic situational awareness;
- Cooperative ASAS (including airborne spacing assurance and airborne separation assurance) in managed airspace; and
- Airborne self-separation assurance in free flight airspace.

Training

In order to have a successful transition to a CNS/ATM environment, it is critical that the various disciplines be trained on the new technology. The CNS/ATM concept is relatively new and many people within each discipline who will have some responsibility for CNS/ATM development have little knowledge of CNS/ATM or the elements that comprise the concept. Each discipline must determine to what level they must become knowledgeable in CNS/ATM and then be provided the opportunity to receive the necessary training to attain that level. It will be very difficult to develop benefits that result from a CNS/ATM environment if one does not understand the system and how it works. Academic training and application training are also a necessity. It is no different than ATC; to know the rules is one thing, but to apply them is another. Training is available from a variety of sources that include ICAO's Trainair, industry, private contractors, manufacturers, and others. Many states have developed their own CNS/ATM training programs and are raising the knowledge level of all their aviation employees. At the onset, DGAC and user leadership should receive a specially designed CNS/ATM seminar. The objective would be to provide a condensed version of the materials contained herein, which would include system costs and benefits as well as system planning information. Such training in the form of a CNS/ATM Seminar would prepare DGAC's leadership as they guide the organization forward.

There are several options available to Indonesia to prepare controllers who will be providing air traffic services in the airspace over the Natuna Islands. We recognize the ATC simulator at Jakarta ACC could be used to provide Natuna area training to current controllers. This could include radar and flow management training. Another option would be to contract for airspace specific training (Natuna Islands area) radar training from an organization such as the Singapore Aviation Academy (SAA). Newly hired controllers could receive their initial training (non-radar and radar) from SAA as an example, and area specific radar training on Indonesia's radar simulator. Training on the Natuna sector(s) could also be provided by SAA.

The availability of the various types of training needed prior to the transfer of the airspace to Indonesia is dependent on the capabilities of Indonesia's ATC simulator to provide realistic traffic scenarios. Additionally, the ability of contract training organizations to provide realistic traffic scenarios in airspace identified by the client is crucial.

To provide the best training environment will require the development of air traffic procedures and airspace design within the Natuna Islands area prior to the airspace transfers so that any training conducted will be as realistic as possible. We must be mindful of the training required for technicians and engineers. Task 2 will deal with Training in detail.

8.0 System Issues

In the arena of CNS/ATM, all ANSP's have areas requiring attention, i.e., shortcomings. Indonesia's DGAC, in concert with RVA, has set about addressing the following:

During the previous 10 years, several studies on various portions of Indonesia's air transport sector have been conducted.

- The National ATC Master Plan (SOFREAVIA, 1995)
- Transport Sector Strategy Study (Halcrow Fox and Associates, 2000)
- The Implementation Plan for CNS/ATM System in Indonesia and Harmonization with Asia-Pacific Regional Plans (DGCA, 2001, Update version of The National ATC Master Plan)
- The Phase-I Study on Integrated Modernization Plan for Air Transport in Eastern Indonesia (Swedevia, 2001)
- The Asian Regional Navigation Feasibility Study, by USTDA, MITRE, Indonesia and others.

The contents of these existing studies were obsolete. Due to time and/or the studies covered only limited issues of new CNS/ATM systems, a comprehensive master plan was required. At the request of the Government of the Republic of Indonesia in 2003, the Government of Japan conducted the Master Plan Study on the Strategic Policy of the Air Transport Sector in the Republic of Indonesia. Japan International Cooperation Agency, the official agency responsible for the implementation of technical cooperation programs of the Government of Japan, conducted the study. The Study took 14 months to complete and ended in June 2004 with the submission of the Draft Final Report. Indonesia has adopted this Study as their Master Plan.

The goal of the Study was to achieve safer and more efficient air transport services in Indonesia. One of the objectives was to provide recommendations on improvements in safety regulation of Indonesian ATS providers. In Chapter 8 of the Study, two specific areas of problems (ATM and CNS) have been identified. For purposes of the Natuna Islands Airspace feasibility study, Task 1 and this report only identify problems with airspace, CNS facilities, training and safety and are listed:

<u>Airspace</u>

- Redesign of control airspace by area control centers of Indonesia is required

- Rearrangement of airspace with military in Central Java is required to efficiently operate civil aircraft
- Rearrangement of control boundary between Jakarta and Singapore FIR is required

Training

- Air traffic controllers' training manuals are available but need to be updated
- No established training program for CNS/ATM

CNS facilities

- Radar operators cannot rely on radars because of insufficient radar performance (double targets, no position data)
- VHF coverage for air routes in Indonesia FIR is not complete
- Poor voice quality in some areas
- Experience interference, low quality, and low reliability with HF
- VSAT availability is low
- Ground-based facilities are maintained by three different organizations; DGAC, AP-1, AP-2
- Maintenance performance level is different in the three organizations
- Budget is different for each organization
- Zero stock policy is inadequate

Safety

- Toy kites on the final approach were reported to the authority as a safety hazard and response was less than prompt
- Air traffic controllers' quality of speaking (Indonesian accent) is difficult to understand and voice ATC communication is not clear
- ATC VHF background noise is a source of distraction and irritation to pilots especially on the arrival, approach/departure, tower and ground frequencies
- Many aircraft near-misses or the loss of separation cases reported are attributed to the inadequate communications either between air traffic controllers and pilots or between controllers of the different ATC units; e.g., between Indonesian and Australian units

The Japanese Study also identifies a unique issue. There are three air traffic services organizations (AP-1, AP-2, and DGAC) in Indonesia that interact daily air traffic control operations. Although these three organizations have worked together for more than 10 years, there are different cultures in each organization and different procedures and manner of operating air traffic services. RVA has also identified this organizational structure as a serious institutional issue which will be discussed in a subsequent task.

The Indonesian Government has studied the issue and concluded that the transition of air traffic control jurisdiction by private companies is not legally justified and the execution of air traffic services by a private company under existing law is against the will of the law. The government

has proposed a bill to congress that will enable the formation of a new single air traffic control organization.

During our interviews in Indonesia, we also heard many of the items listed above. A suggestion for the DGAC might be to develop a plan to address the shortcomings identified in the Master Plan and provide periodic written or verbal updates on plans to correct these shortcomings to staff and system operators.

Discussions with service user groups

The following reflects user discussion point during Listening sessions.

User comments

- 91 percent of the operators in Indonesian airspace have TSO-C129 compliant GPS
- Operational communications is a problem for users (explained as effective radio coverage)

While all airlines were invited, only representatives from Garuda Indonesia and Lion Air were present. Lion Air is a private company serving domestic routes only. Garuda competes domestically with Lion Air and also has an international route structure. Neither company is in the air freight business.

- Airline representatives urged the use of RNP-10 routes in Sector C.
- Users complained that due to the airspace design around Singapore and Batam numerous frequency changes are required to arrive and depart Batam. Delays of 10-15" to obtain release from Singapore to depart Batam are not uncommon.
- Need better communications in Natuna area. The complaint was directed at Singapore's radio system.
- Several NAVAIDs have been awaiting flight calibration for some time and are considered unreliable and used with a great deal of caution.
- To depart CGK to the north requires a release and altitude approval from Singapore. Delays occur from this procedure.
- There is a need for a direct route from Jakarta to Hong Kong.
- Gouda's growth is controlled by the government. Approval of expansion plans is very slow.
- Garuda aircraft are equipped with IRS. They use FANS and ACARS for ADS downlink.
- DGAC has a zero spares policy and repairs on NAVAIDs are too lengthy, further exasperating the user's complaints regarding navigational aids.
- Need more real-time coordination between the military and the commercial operators. The present coordination process for flights through the "Danger Areas" is inefficient and causes delays

9.0 Planning for Service Upgrades

This report will discuss the application of emerging CNS/ATM technologies in subsequent Tasks (2 and 6). It is premature at this point to engage in detailed CNS/ATM discussions. However, it is right to say that technologies, such as ADS-B, RNP, GNSS, and a modern coordination mechanism between ATC facilities are high value issues that must be carefully considered. Further, training, airspace redesign, organizational restructuring, and a careful review of traffic flow management processes also require comment.

APPENDIX 1

ICAO DOC 9613, REQUIRED NAVIGATION PERFORMANCE-4 (RNP-4)

The material in this appendix is found in ICAO DOC 9613 Manual on Required Navigation Performance (RNP), Manual on Airspace Planning Methodology for the Determination of Separation Minima. This material, developed by ICAO is provided here in part and is provided solely for ease of reference. Readers are urged to refer to a full, current and complete copy. DOC 9613, Appendix F follows.

Appendix F

GUIDANCE FOR A REQUIRED NAVIGATION PERFORMANCE 4 (RNP 4) OPERATIONAL APPROVAL PROCESS – FOR INITIAL APPLICATION IN OCEANIC OR REMOTE AREA AIRSPACE

Section 1

INTRODUCTION

1.1 PURPOSE

1.1.1 *Annex 6 — Operation of Aircraft* specifies that an operator must obtain required navigation performance (RNP) operational approval from the State of the Operator (for international commercial air transport operations) or the State of Registry (for international general aviation operations) before conducting flights in defined portions of airspace or on routes where RNP types have been prescribed.

1.1.2 The safe, efficient and expeditious implementation of RNP requires a uniform approach by all States to the issuance of these approvals. Guidance material on implementing an RNP 10 operational approval process has already been published. This guidance material has been produced to assist States in developing their approval procedures for RNP 4. To ensure consistency with the approval process for other RNP types, these guidelines generally follow the structure of the guidance material for the RNP 10 operational approval process described in Appendix E of the *Manual on Required Navigation Performance (RNP)* (Doc 9613).

1.2 BACKGROUND AND SCOPE

1.2.1 This guidance material was developed by the Separation and Airspace Safety Panel (SASP), to support the implementation of the 30 NM lateral and the 30 NM longitudinal distance-based separation minima for use in conjunction with RNP 4, which are described in paragraph 3.4.1 e) of Attachment B to Annex 11—*Air Traffic Services* and Section 5.4 of the *Procedures for Air Navigation Services – Air Traffic Management* (PANS–ATM, Doc 4444).

1.2.2 The approval process described in this document does not incorporate all of the equipment functionalities described in the minimum aviation system performance standards (MASPS) for RNP 4, which are contained in RTCA Document DO-236B and EUROCAE

Document ED 75B. The existing 30 NM separation minima which this approval process is designed to support require RNP 4 navigation performance as specified in Doc 9613, but do not require compliance with certain additional requirements specified in the MASPS.

1.2.3 The approval process described herein is limited to aircraft which have received airworthiness certification indicating that the installed navigation systems meet the performance requirements for RNP 4. This certification may have been issued at the time of manufacture, or where aircraft have been retrofitted in order to meet the requirements for RNP 4, by the granting of an appropriate supplemental type certificate (STC).

1.2.4 While this guidance material has been developed to support the 30 NM lateral and longitudinal separation minimum based on RNP 4, it should be noted that it addresses only the navigation requirements associated with these standards. It does not address the communications or surveillance requirements. Aeronautical Information Publications (AIP) and Regional Supplementary Procedures (Doc 7030) are the appropriate documents for promulgation of the communications and surveillance requirements for specific airspace or ATS routes.

Note 1. – The provisions relating to these separation minima, including the communications and surveillance requirements, can be found in paragraph 3.4.1 e) of Attachment B to Annex 11 and Section 5.4 of the PANS-ATM. Provided that they can support the increased reporting rate required, CPDLC and ADS systems which meet the requirements for application of the 50 NM lateral and longitudinal minima based on RNP 10 will also meet the requirements for the application of the 30 NM lateral and longitudinal minima.

Note 2. – Although this RNP 4 operational approval has been developed to support the application of reduced separation minima in oceanic or remote area airspace, it could also be used to support other future RNAV separation minima smaller than 30 NM (e.g. in non-radar continental airspace) if the navigation performance requirements are the same. However, the communications and surveillance requirements associated with such minima may be quite different. For example, direct voice communications might be required instead of CPDLC, and an increase in the ADS reporting rate might be necessary.

1.2.5 While this operational approval document deals only with the navigation element (RNP 4), flight crews must be aware that different airspaces may have other operational requirements that need to be considered when they are flight planning into RNP airspace. The need to verify compliance with any such additional requirements is noted in the guidelines provided for flight crew training, which can be found in section 5 of this document.

1.3 RNP 4 REQUIREMENTS

1.3.1 The navigation accuracy requirement for issuance of an RNP 4 approval requires that the aircraft navigate with a cross-track Total System Error (TSE) no greater than ±7.4 km (±4NM) for 95 per cent of the total flight time. The aircraft along-track TSE must also be no greater than ±7.4 km (±4 NM) for 95 per cent of the flight time.

Note. – For the definition of TSE and its components, see Appendix A

1.3.2 The technical capabilities of the equipment leading to the navigation solution must be presented by the operator to the appropriate State's airworthiness authority and must be certified by the State prior to the grant of a full operational approval. For commercial operators, this equipment approval should be reflected in Operations Specifications forming part of an Air Operator Certificate (AOC), and for non-commercial operators, in the form of a flight manual supplement. This, in combination with operational considerations, forms an RNP 4 operational approval.

1.3.3 The required and recommended equipment functionalities for RNP 4 operations are listed in Section 3.

1.3.4 In addition to the aircraft having the appropriate RNP certification, the issuance of an RNP 4 operational approval requires consideration of issues related to continuing airworthiness, operational procedures, and training for the flight crew and other operational staff.

1.3.5 Sources of additional information on RNP are listed in the Appendix.

1.3.6 Operators and flight crews must also comply with the relevant requirements of *Annex 2 — Rules of the Air*.

Section 2

RNP 4 OPERATIONAL APPROVAL PROCESS

2.1 GENERAL

2.1.1 The following steps must be completed before an RNP 4 operational approval can be issued to an operator:

a) eligibility of aircraft and certification of its navigation equipment for RNP 4 must be determined by the State of Design and State of Registry;

b) flight crew training and operating procedures for the navigation systems to be used must be identified by the operator; and

c) the operator database used, flight crew training, and operating procedures must be evaluated by the State of the Operator or State of Registry.

2.1.2 When these steps have been successfully completed an RNP 4 operational approval, letter of authorization, appropriate operations specifications, special authorization, or equivalent, can be issued by the State.

2.1.3 This guidance material addresses only the approval of aircraft for which the certification of RNP 4 navigation capability for operations in oceanic or remote airspace is based upon the use of GNSS or equivalent systems as either stand-alone navigation systems, or as one of the navigation inputs to a multi-sensor system. GNSS ensures that there is no time limit imposed upon the RNP 4 approval.

2.2 STARTING THE APPROVAL PROCESS

2.2.1 Operators should contact their aviation/regulatory authority to discuss the aviation authority's airworthiness and operational requirements. Topics for discussion include the:

a) contents of the operator's application;

b) aviation authority's review and evaluation of the application;

c) limitations (if any) on the approval; and

d) conditions under which the operational approval may be cancelled.

2.3 CONTENTS OF AN APPLICATION FOR AN RNP 4 OPERATIONAL APPROVAL

Aircraft eligibility

2.3.1 Operators must provide relevant documentation (e.g. the flight manual) to establish that the aircraft is equipped with navigation equipment that satisfies the requirements of RNP 4. Operational approval is based upon the equipment listed in the appropriate documents having been approved by the aviation authority of the State of Design. Additional details regarding aircraft eligibility are given in Section 3 below.

2.3.2 Operators must provide a detailed list of the equipment and components to be used for long-range navigation and RNP 4 operations. Installed equipment must be identical to that certified in the flight manual and must be operational unless exceptions are listed in the Minimum Equipment List (MEL) for specific non-standard conditions.

Training documentation

2.3.3 Operators that are required to have an approved training programme under the terms of their operating certificate must submit training syllabi and training material (e.g computer based training, simulator training) to the aviation authority to show that the operational practices and procedures and training items related to RNP 4 operations have been incorporated in training programmes (e.g. initial, upgrade or recurrent training for flight crew, dispatchers or maintenance personnel). Practices and procedures in the following areas must be standardized:

- flight planning;
- pre-flight procedures at the aircraft for each flight;
- procedures before entry into an RNP 4 route or airspace;
- in-flight contingency and
- flight crew qualification procedures.

2.3.4 Operators that are not required to have an approved training programme (e.g. non-commercial operators) must accept responsibility for training flight crew in accordance with the practices and procedures described in Section 5 of this Appendix.

Operations manuals and checklists

2.3.5 Commercial operators must revise their operations manuals and checklists to include information/guidance on the standard operating procedures detailed in Section 5. The appropriate manuals should contain navigation system operating instructions and contingency procedures where specified (e.g. weather deviation procedures). Commercial operators must submit manuals and checklists for review as part of the application process.

2.3.6 Non-commercial operators must create appropriate instructions containing navigation operating instructions and contingency procedures. This information must be available to crews in flight and should be entered into the Operations Manual or Pilot Operating Handbook, as appropriate. These manuals and manufacturer's instructions for operation of the aircraft navigation equipment, as appropriate, must be submitted for review as part of the application process.

Past performance

2.3.7 Operators must include a company 'operating history' in their application. The 'operating history' must address any events or incidents related to navigation errors (e.g. as reported on a

State's navigation error investigation form) and the means by which the operator addressed those events or incidents through new or revised training programmes procedures, maintenance, or modifications to the aircraft.

Minimum equipment list (MEL)

2.3.8 For commercial operations, the appropriate State aviation authority must approve any MEL revisions necessary to address the RNP 4 provisions in this manual. For non-commercial operations, installed navigation equipment, listed in the flight manual as required for RNP 4 operations must be operational.

Maintenance and continuing airworthiness

2.3.9 All operators/owners must submit their maintenance programme, including a reliability programme for monitoring the equipment, for approval at the time of application. The holder of the design approval, including either the type certificate (TC) or supplemental type certificate (STC) for each individual navigation system installation, must furnish at least one set of complete instructions for continuing airworthiness.

2.4 EVALUATION, INVESTIGATION AND CANCELLATION

Review and evaluation of applications

2.4.1 After an operator submits an application, the aviation authority will begin the process of review and evaluation. If the contents of the application are deficient the approving authority will request additional information from the operator. When all the certification, airworthiness and operational requirements of the application have been met, the RNP 4 approval will be issued.

2.4.2 An RNP 4 operational approval should be issued in an appropriate form (e.g. a certificate indicating an RNP 4 operational approval, operations specifications, special authorization or letter of authorization). It should identify any conditions or limitations on operations in RNP 4 airspace or on an RNP 4 route (e.g. required navigation systems or procedures, routes or areas of operation).

Monitoring and investigation of navigation and system errors

2.4.3 Demonstrated navigation accuracy provides the basis for determining the lateral route spacing and separation minima necessary for traffic operating on a given route. Accordingly, lateral and longitudinal navigation errors are monitored through monitoring programmes. Radar observations of each aircraft's proximity to track and altitude, before coming into coverage of short-range navaids at the end of the oceanic route segment, are noted by ATS facilities. If an observation indicates that an aircraft is not within the established limit, a navigation error report is submitted, and an investigation undertaken to determine the reason for the apparent deviation from track or altitude, in order that steps may be taken to prevent a recurrence.

Cancellation of RNP 4 approval

2.4.4 An aviation authority may consider any navigation error reports in determining remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment or operational procedure may result in cancellation of the operational approval pending replacement or modifications on the navigation equipment or changes in the operator's operational procedures.

2.4.5 Information that indicates the potential for repeated errors may require modification of an operator's training programme, maintenance programme or specific equipment certification. Information that attributes multiple errors to a particular pilot crew may necessitate remedial training or crew licence review.

Section 3

AIRCRAFT ELIGIBILITY GROUPS, TECHNICAL REQUIREMENTS AND EXPLANATION OF TERMS

3.1 AIRCRAFT ELIGIBILITY GROUPS

Group 1: RNP certification

3.1.1 Group 1 aircraft are those with formal certification and approval of RNP integration in the aircraft. RNP compliance is documented in the aircraft's flight manual.

3.1.2 The certification will not necessarily be limited to a specific RNP type. The flight manual must address the RNP levels that have been demonstrated and any related provisions applicable to their use (e.g. navaid sensor requirements). Operational approval is based upon the performance stated in the flight manual.

3.1.3 This method also applies in the case where certification is received through a supplemental type certificate (STC) issued to cover retrofitting of equipment, such as GNSS receivers, to enable the aircraft to meet RNP 4 requirements in oceanic and remote area airspace.

Group 2: Prior navigation system certification

3.1.4 Group 2 aircraft are those that can equate their certified level of performance, given under previous standards, to RNP 4 criteria. Those standards listed below in sub-paragraphs a) to c) can be used to qualify aircraft under Group 2.

a) *Global Navigation Satellite Systems (GNSS).* Aircraft fitted with GNSS as an approved long-range navigation system for oceanic and remote airspace operations must meet the technical requirements specified in Section 3.2. The flight manual must indicate that dual GNSS equipment approved under an appropriate standard is required. Appropriate standards are FAA Technical Standard Orders (TSO) C129a or C146, and JAA Joint Technical Standard Orders (JTSO) C129a or C146. In addition, an approved dispatch fault detection and exclusion (FDE) availability prediction program must be used. The maximum allowable time for which FDE capability is projected to be unavailable is 25 minutes. This maximum outage time must be included as a condition of the RNP 4 operational approval. If predictions indicate that the maximum allowable FDE outage will be exceeded the operation must be rescheduled to a time when FDE is available.

b) *Multi-Sensor Systems Integrating GNSS with integrity provided by Receiver Autonomous Integrity Monitoring (RAIM).* Multi-sensor systems incorporating Global Positioning System (GPS) with RAIM or FDE that are approved under FAA AC20-130A, or other equivalent documents, meet the technical requirements specified in Section 3.2.

c) *Aircraft Autonomous Integrity Monitoring (AAIM).* AAIM uses the redundancy of position estimates from multiple sensors, including GNSS, to provide integrity performance that is at least equivalent to RAIM. These airborne augmentations must be certified in accordance with TSO C-115b, JTSO C-115b or other equivalent

documents. An example is the use of an inertial navigation system or other navigation sensors as an integrity check on GNSS data when RAIM is unavailable but GNSS positioning information continues to be valid.

Group 3: New technology

3.1.5 This group has been provided to cover new navigation systems that meet the technical requirements for operations in airspace where RNP 4 is specified.

3.2 TECHNICAL REQUIREMENT

Navigation accuracy

3.2.1 Accuracy is defined relative to a geodesic path along a route or defined procedure. RNP 4 operations require that aircraft navigate with a cross-track navigation error no greater than ±7.4 km (±4NM) for 95 per cent of the total flight time. This includes position estimation error (PEE), flight technical error (FTE), path definition error (PDE) and display error. The aircraft along-track positioning error must be no greater than ±7.4 km (±4 NM) for 95 per cent of the flight time.

GNSS monitor

3.2.2 The GNSS navigation system must detect satellite failures before they cause the aircraft to exceed the defined airspace limits. This requirement is derived from the overall effect of a GNSS failure, and applies to all navigational uses of GNSS. The probability of missed detection of satellite failures must be less than or equal to 10^{-3}, and the effective monitor limit for these failures on the navigation solution, known as the horizontal alert limit (HAL), must consider the other normal errors that may exist during the satellite fault, the latency of the alert, the crew reaction time to an alert and the aircraft response. An acceptable means of compliance is to use a HAL as follows: Oceanic (RNP 4): 4NM.

Required functionalities

3.2.3 The following functionalities are mandatory:

a) CDI in pilot's "Field of Vision" (FOV);

b) track to fix (TF);

c) direct to fix (DF);

d) direct - to function;

e) course to fix (CF);

f) parallel offset;

g) fly-by transition criteria;

h) user interface displays;

i) flight planning path selection;

j) flight planning fix sequencing;

k) user defined course to fix;

l) path steering;

m) alerting requirements;

n) navigation data base access; and

o) WGS 84 geodetic reference system.

Recommended functionalities

3.2.4 The following additional functionalities are recommended:

a) display cross-track error on the CDU;

b) display present position in distance/bearing to selected waypoints;

c) provide time to waypoints on the CDU;

d) along track distance to the next waypoint;

e) display ground speed;

f) indicated track angle;

g) provide automatic navigation aids selection;

h) purge radio updates;

i) manually inhibit a navaid facility;

j) automatic selection and tuning of DME and/or VOR;

k) estimate of position uncertainty;

l) current RNP type;

m) flight plan discontinuity; and

n) navigation sensor in use and display of degraded navigation.

Automatic radio position updating

3.2.5 Automatic updating is the only method acceptable for the update of an aircraft's position.

3.3 EXPLANATION OF TERMS

CDI in pilot's Field of View (FOV)

3.3.8 A course deviation indicator (CDI) located in the pilot's primary field of view along the forward flight path, enabling the pilot to perform a natural crosscheck, is required. These displays must be visible to the pilot in the primary field of view. A scalable electronic map cannot

substitute for a CDI. A fixed scale CDI is acceptable as long as the CDI demonstrates appropriate scaling and sensitivity for the intended RNP type. Differences in CDI scales from one RNP type to another may require operational procedures to check and affirm the CDI scale against the RNP type. With a scalable CDI, the scale must derive from the selection of RNP, not from a separate selection of CDI scale. Alerting and annunciation limits must match scaling values. If the equipment uses default RNP types to describe the operational mode (e.g. en route, terminal area and approach), then displaying the operational mode is an acceptable means from which the flight crew may derive the CDI scale sensitivity. The course selector of the deviation display must have a full-scale deflection required for the flight procedure and track keeping accuracy.

Track to fix (TF)

3.3.9 The TF leg is a geodesic path between two fixes. The first fix is either the previous leg termination or an IF leg. The termination fix is normally provided by the navigation database, but may also be a user-defined fix.

Direct to fix (DF)

3.3.10 The DF leg is a geodesic path starting near the area of initiation and terminating at a fix.

Direct-To function

3.3.11 The Direct-To function must be able to be activated at any time by the flight crew, when required. The Direct-To function must be available to any fix. The system must be capable of generating a geodesic path to the designated "To" fix. The aircraft must capture this path without "S-turning" and without undue delay.

Course to fix (CF)

3.3.12 The CF leg is a geodesic path terminating at a fix with a specified course at that fix. The inbound course at the termination fix and the fix are provided by the navigation database. If the inbound course is defined as a magnetic course, the source of the magnetic variation needed to convert magnetic courses to true courses is required.

Parallel offset

3.3.13 The system must have the capability to fly parallel tracks at a selected offset distance. When executing a parallel offset, the RNP type and all performance requirements of the original route in the active flight plan must be applicable to the offset route. The system must provide for entry of offset distances in increments of 1 nautical mile, left or right of course. The system must be capable of offsets of at least 20 nautical miles. When in use, system offset mode operation must be clearly indicated to the flight crew. When in offset mode, the system must provide reference parameters (for example, cross-track deviation, distance-to-go, time-to-go) relative to the offset path and offset reference points. An offset must not be propagated through route discontinuities, unreasonable path geometries, or beyond the initial approach fix. Annunciation must be given to the flight crew prior to the end of the offset path, with sufficient time to return to the original path. Once a parallel offset is activated, the offset must remain active for all flight plan route segments until removed automatically, until the flight crew enters a Direct-To routing, or until flight crew (manual) cancellation. The parallel offset function must be available for en route TF and geodesic portion of DF leg types.

Fly-by transition criteria

3.3.14 The navigation system must be capable of accomplishing fly-by transitions. No predictable and repeatable path is specified, because the optimum path varies with airspeed and bank angle. However, predictable and repeatable boundaries of the transition area are defined. Path definition error is defined as the difference between the defined path and the theoretical

transition area. If the path lies within the transition area, there is no path definition error. Fly-by transitions must be the default transition when the transition type is not specified. The theoretical transition area requirements are applicable for the following assumptions:

a) course changes do not exceed 120 degrees for low altitude transitions (referred as when the aircraft barometric altitude is less than FL 195); and

b) course changes do not exceed 70 degrees for high altitude transitions (referred as when the aircraft barometric altitude is equal to or greater than FL 195).

User interface displays

3.3.15 General user interface display features must provide for presentation of information, provide situational awareness and be designed and implemented to accommodate human factors considerations. Essential design considerations include:

a) minimizing reliance on flight crew memory for any system operating procedure or task;

b) developing a clear and unambiguous display of system modes/sub modes and navigational data with emphasis on enhanced situational awareness requirements for any automatic mode changes if provided;

c) use of context sensitive help capability and error messages (for example, invalid inputs or invalid data entry messages should provide a simple means to determine how to enter "valid" data);

d) fault tolerant data entry methods rather than rigid rule based concepts;

e) placing particular emphasis on the number of steps and minimizing the time required to accomplish flight plan modifications to accommodate ATS clearances, holding procedures, runway and instrument approach changes, missed approaches and diversions to alternate destinations; and

f) minimizing the number of nuisance alerts so the flight crew will recognize and react appropriately when required.

Displays and controls.

3.3.16 Each display element used as a primary flight instrument in the guidance and control of the aircraft, for manoeuvre anticipation, or for failure/status/integrity annunciation, must be located where it is clearly visible to the pilot (in the pilot's primary field of view) with the least practicable deviation from the pilot's normal position and line of vision when looking forward along the flight path. For those aircraft meeting the requirements of FAR/JAR 25, it is intended that provisions of certification documents such as AC 25-11, AMJ 25-11 and other applicable documents should be satisfied.

3.3.17 All system displays, controls and annunciations must be readable under normal cockpit conditions and expected ambient light conditions. Night lighting provisions must be compatible with other cockpit lighting. All displays and controls must be arranged to facilitate flight crew accessibility and usage. Controls that are normally adjusted in flight must be readily accessible with standardized labelling as to their function. System controls and displays must be designed to

maximize operational suitability and minimize pilot workload. Controls intended for use during flight must be designed to minimize errors, and when operated in all possible combinations and sequences, must not result in a condition whose presence or continuation would be detrimental to the continued performance of the system. System controls must be arranged to provide adequate protection against inadvertent system shutdown.

Flight planning path selection

3.3.18 The system must provide the capability for the crew to create, review and activate a flight plan. The system must provide the capability for modification (for example, deletion and addition of fixes and creation of along-track fixes), review and user acceptance of changes to the flight plans. When this capability is exercised, guidance outputs must not be affected until modification(s) is/are activated. Activation of any flight plan modification must require positive action by the flight crew after input and verification by the flight crew.

Flight planning fix sequencing

3.3.19 The system must provide the capability for automatic sequencing of fixes.

User-defined course to fix

3.3.20 The system must provide the capability to define a user-defined course to a fix. The pilot must be able to intercept the user-defined course.

Path steering

3.321 The system must provide data to enable the generation of command signals for autopilot/flight director/CDI, as applicable. In all cases a Path Steering Error (PSE) must be defined at the time of certification, which will meet the requirements of the desired RNP operation in combination with the other system errors. During the certification process, the ability of the crew to operate the aircraft within the specified PSE must be demonstrated. Aircraft type, operating envelope, displays, autopilot performance, and leg transitioning guidance (specifically between arc legs) should be accounted for in the demonstration of PSE compliance. A measured value of PSE may be used to monitor system compliance to RNP requirements. For operation on all leg types, this value must be the distance to the defined path. For cross-track containment compliance, any inaccuracies in the cross-track error computation (for example, resolution) must be accounted for in the total system error.

Alerting requirements

3.3.22 The system must also provide an annunciation when the manually entered RNP type is larger than the RNP type associated with the current airspace as defined in the navigation database. Any subsequent reduction of the RNP type must reinstate this annunciation. When approaching RNP airspace from non-RNP airspace, alerting must be enabled when the cross-track to the desired path is equal to or less than one-half (1/2) the RNP value and the aircraft has passed the first fix in the RNP airspace.

Navigation database access

3.3.23 The navigation database must provide access to navigation information in support of the navigation systems reference and flight planning features. Manual modification of the navigation database data must not be possible. This requirement does not preclude the storage of "user defined data" within the equipment. When data are recalled from storage they must also be retained in storage. The system must provide a means to identify the navigation database version and valid operating period.

WGS-84 geodetic reference system

3.3.24 WGS-84 or an equivalent earth reference model must be the reference earth model for error determination. If WGS-84 is not employed, any differences between the selected earth model and the WGS-84 earth model must be included as part of the path definition error. Errors induced by data resolution must also be considered.

Section 4

OPERATIONAL REQUIREMENTS

4.1 NAVIGATION ACCURACY

4.1.1 For RNP 4 operations, an aircraft must meet a cross-track keeping accuracy and along-track positioning accuracy of no greater than ±7.4km (4 NM) for 95 per cent of the flight time.

4.2 NAVIGATION EQUIPAGE

4.2.1 For RNP 4 operations in oceanic or remote airspace, at least two fully serviceable independent long-range navigation systems (LRNSs), with integrity such that the navigation system does not provide misleading information, must be fitted to the aircraft and form part of the basis upon which RNP 4 operational approval is granted.

4.2.2 For aircraft incorporating GPS, United States FAA Advisory Circular AC 20-138 and Australian CAAP 35-1, or equivalent documents, provide an acceptable means of complying with installation requirements for aircraft that use but do not integrate the GNSS output with that of other sensors. FAA AC 20-130A describes an acceptable means of compliance for multi-sensor navigation systems that incorporate GPS.

4.2.3 The equipment configuration used to demonstrate the required accuracy must be identical to the configuration specified in the MEL or flight manual.

4.2.4 The design of the installation must comply with the design standards that are applicable to the aircraft being modified and changes must be reflected in the flight manual prior to commencing operations requiring an RNP 4 navigation approval.

4.3 FLIGHT PLAN DESIGNATION

4.3.1 Operators must indicate the ability to meet RNP 4 for the route or airspace in accordance with the PANS- ATM, Appendix 2, which requires the insertion of "R" in Item 10: (Equipment), of the ICAO flight plan. Operators must also comply with any additional flight planning requirements specified in Regional Supplementary Procedures (Doc 7030) and State AIP.

4.3.2 Insertion of the letter "R" indicates that the pilot has:

a) reviewed the planned route of flight, including the routes to any alternate aerodromes, to identify the types of RNP involved;

b) confirmed that the aircraft and the operator have been approved (i.e. airworthiness and operational approval obtained) by the aviation authority for RNP 4 operations; and

c) confirmed that the aircraft can comply with all conditions of the approval for the planned route of flight, within airspace or on routes requiring RNP 4.

4.4 AVAILABILITY OF GNSS

4.4.1.1 Before the commencement of flight, the operator must ensure that the GNSS availability requirements on which the operator's approval is based, will be met for the full length of the flight.

4.5 NAVIGATION DATA BASE

4.5.1 The standards for navigation databases are contained in RTCA document DO-200A and EUROCAE document DO-76. Given that not all current suppliers of navigation databases meet these standards, the operator, as a minimum, must implement navigation database integrity checks using appropriate software tools or approved manual procedures to verify data relating to all waypoints in the subject RNP-4 airspace or routes. These checks are in addition to any checks previously performed by the Aeronautical Information Services, unapproved navigation database suppliers, or navigation equipment manufacturers. The integrity checks need to identify any discrepancies between the navigation database and the published charts/procedures. An approved third party may perform integrity checks. Discrepancies that invalidate a procedure must be reported to the navigation database supplier and affected procedures must be prohibited by an operator's notice to its flight crew. Aircraft operators should consider the need to continue their own database checks even for products obtained from approved suppliers.

Section 5

TRAINING PROGRAMMES AND OPERATING PRACTICES AND PROCEDURES

5.1 INTRODUCTION

5.1.1 The following items (5.2 through 5.5) should be standardized and incorporated into training programmes, operating practices and procedures. Certain items may already be adequately standardized in existing operator programmes and procedures. New technologies may also eliminate the need for certain crew actions. If this is found to be the case, then the intent of this material can be regarded as having been met.

Note. – This guidance material has been written for a wide variety of operator types and therefore certain items may not apply to all operators.

5.2 FLIGHT PLANNING

5.2.1 During flight planning, the flight crew should pay particular attention to conditions that may affect operations in RNP 4 airspace or on RNP 4 routes. These include, but may not be limited to:

a) verification that the aircraft has been approved for RNP 4 operations;

b) verification that the letter "R" has been inserted in "Item 10: Equipment" of the ICAO flight plan;

c) verification that any additional flight planning requirements specified in Regional Supplementary Procedures (Doc 7030) or State AIP have been met;

d) verification of the requirements for GNSS, such as FDE, if appropriate for the operation; and

e) account for any operating restriction related to the RNP 4 approval, if required.

5.3 PRE-FLIGHT PROCEDURES

5.3.1 The flight crew must:

a) review maintenance logs and forms to ascertain the condition of the equipment required for flight in RNP 4 airspace or on routes requiring RNP 4 navigation capability;

b) ensure that maintenance action has been taken to correct defects in the required equipment;

c) during the external inspection of an aircraft, check the condition of the navigation antennas and the condition of the fuselage skin in the vicinity of each of these antennas. In addition to the pilot, this inspection may be accomplished by a qualified and/or authorized person such as a maintenance or flight engineer; and

d) review the contingency procedures for operations in RNP 4 airspace or on routes requiring an RNP 4 navigation capability. These are no different than normal oceanic contingency procedures with one exception; crews must be able to recognize and ATC must be advised when the aircraft is no longer able to navigate to its RNP 4 navigational capability.

5.4 EN ROUTE

5.4.1 At least two LRNSs, capable of navigating to RNP 4, and listed in the flight manual, must be operational at the entry point of the RNP airspace. If an item of equipment required for RNP 4 operations is unserviceable, then the pilot should consider an alternate routing, or diversion for repairs.

5.4.2 In-flight operating procedures must include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent inadvertent deviation from ATC-cleared routes.

5.4.3 Crews must advise ATC of any deterioration or failure of the navigation equipment that causes navigation performance to fall below the required level, and/or any deviations required for a contingency procedure.

5.5 FLIGHT CREW KNOWLEDGE

5.5.1 Operators/owners must ensure that flight crews have been trained and that they have appropriate knowledge of the topics contained in this guidance material, the limits of their RNP 4 navigation capabilities, the effects of updating, and RNP 4 contingency procedures.

5.5.2 In determining whether training is adequate, an approving authority might:

a) evaluate a training course before accepting a training centre certificate from a specific centre;

b) accept a statement in the operator's/owner's application for an RNP 4 approval that the operator has ensured and will continue to ensure that flight crews are familiar with the RNP 4 operating practices and procedures contained in documents similar to FAA Order 8700.1 and the contents of this manual; or

c) accept a statement by the operator that it has conducted or will conduct an RNP 4 training programme utilizing the guidance contained in this document.

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Attachment 1 to Appendix F

SOURCES OF ADDITIONAL INFORMATION

1. WEB SITES

- Federal Aviation Administration (FAA), United States
  - http://www.faa.gov/ats/ato/rnp.htm
- Civil Aviation Safety Authority (CASA), Australia
  - http://www.casa.gov.au/avreg/rules/caap.htm

2. RELATED PUBLICATIONS

- Federal Aviation Administration (FAA), United States
  - FAA Order 8400.12A (as amended)
  - Code of Federal Regulations (CFR), Part 121, Appendix G
  - Advisory Circular (AC) 20-130. Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors
  - AC20-138. Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for use as a VFR and IFR Supplemental Navigation System
  - FAA Order 7110.82. Monitoring of Navigation/Altitude Performance in Oceanic Airspace
- Civil Aviation Safety Authority (CASA), Australia
  - Civil Aviation Advisory Publication (CAAP) 35-1

    (Copies may be obtained from Airservices Australia Publications Centre, Locked Bag 8500, Canberra 2601, ACT, Australia.)
- International Civil Aviation Organization (ICAO)
  - *Manual on Required Navigation Performance (RNP)* (Doc 9613-AN/937)

    (Copies may be obtained from the Document Sales Unit, ICAO, 999 University St, Montreal, Quebec, Canada H3C 5H7)
- RTCA
  - Minimum Aviation System Performance Standards (MASPS): Required Navigation Performance for Area Navigation (DO 236B), RTCA
  - Minimum Operational Performance Standards (MOPS) for Required Navigation Performance for Area Navigation (DO 283), RTCA

    (Copies may be obtained from RTCA, Inc., 1828 L Street NW, Suite 805, Washington, DC 20036, United States.)

APPENDIX 2, AREA NAVIGATION/REQUIRED NAVIGATION PERFORMANCE

The term RNP, in the case of Natuna/Sector C, is applied as a descriptor for airspace and routes. RNAV/RNP is an enabler that allows greater access to Sector C and the most efficient use of airspace. RNAV/RNP applies to navigation performance within an airspace and therefore includes the capability of both the available infrastructure (navigation aids) and the aircraft. RNP type is used to specify navigation requirements for the airspace. ICAO has standardized the following RNP Types, RNP-1, RNP-2, RNP-12.6 and RNP-20. The required performance is obtained through a combination of aircraft capability and the level of service provided by the corresponding navigation infrastructure. From a broad perspective:

Aircraft capability + level of service = access.

Note: Access means, aircraft without the required navigation capability may be denied entry into the airspace where in effect they would be incompatible with properly equipped aircraft.

In this context, aircraft navigation capability refers to the airworthiness certification and operational approval elements (including avionics, maintenance, database, human factors, pilot procedures, training, and other issues). The level of service element refers to the ANSP provided airspace system infrastructure (including published routes, signal-in-space performance and availability; and air traffic management). When considered collectively, these elements result in providing access. *Access provides the desired benefit* (airspace, procedures, routes of flight, etc.).

RNP cannot be sensor-generic; this goal is unachievable as long as the aircraft capability is in any way dependent on external signals. The aircraft navigation system always consists of specific sensors or sensor combinations, and the navigation infrastructure consists of specific systems. In addition, flight inspection and maintenance personnel ensure the quality of specific navigation systems. Sensor independent operations (where pilot does not have to be concerned about what sensors are being used) could be established when the airborne equipment provides the protections and system alerting based upon specific navigation systems.

The sensor-specific options available for any given route, or airspace depend on the available infrastructure (level of service) and the requirements (aircraft capabilities) that promote access to a given airspace or procedure.

RNP types specify the minimum navigation performance accuracy required in an airspace. Normally, aircraft not meeting the RNP type are excluded from RNP airspace. If appropriately equipped, an aircraft with a level of navigation performance more accurate than that specified can fly in the airspace concerned (e.g., RNP-1 certified aircraft in RNP-4 airspace).

Note that when an aircraft's capability meets the requirements of a more stringent RNP airspace, based on upon specific infrastructure, this capability might not meet the requirements of a less stringent RNP airspace (due to the lack of supporting infrastructure appropriate to its navigation

equipment fit), e.g., RNP-1 (DME/DME only) certified aircraft is not capable of operation in RNP-10 (oceanic) airspace.

FIGURE 1. Evolutionary Path for Implementation

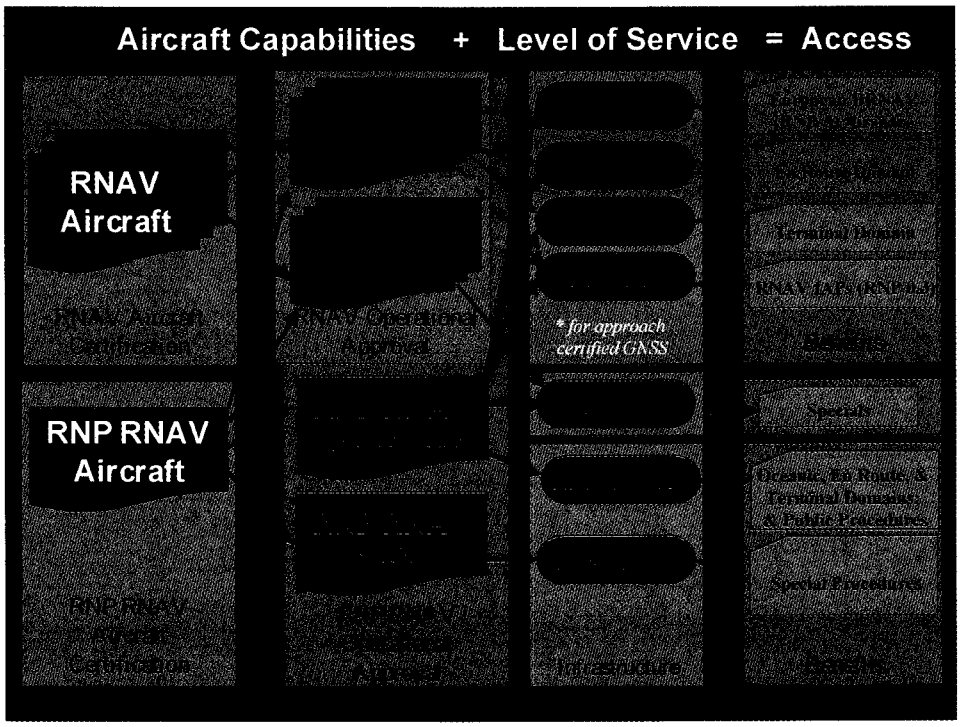

Figure 1 shows the U.S. plan for how the elements of certification, operational approval, and level of service relate to access. The first column represents the airworthiness certification. The second column addresses the operational approval (this includes operational approval, continuing airworthiness, training, etc.). Combining the first and second column collectively represent the aircraft capability component of the equation. The third column represents the level of service (requirement for navigation performance accuracy) independent of the navigation source, and the fourth column represents access. Access in this case denotes the ability to operate within specific airspace domains and/or to conduct an operation. Access relates directly to the benefits addressed in the introduction.

Where airspace is designated as RNP-x, the required performance is an accuracy value met by using an appropriate RNAV system. The accuracy requirement is that the total system error (TSE) does not exceed the specified RNP value ('x') for 95 percent of the flight time in either cross-track or along track.

Note: Precision approaches are based upon specific sensors and not upon navigation performance for an operations/airspace.

3.0 The RNP RNAV Concept (see RTCA DO-236A).

3.1 RTCA DO-236A/EUROCAE ED-75A, Minimum Aviation System Performance Standards (MASPS): Required Navigation Performance for Area Navigation (RNP RNAV) contains system requirements for operations in an RNP RNAV environment.

3.2 It is important to distinguish between RNP and RNP RNAV operations. There is no requirement for airborne monitoring of the achieve accuracy; instead, accuracy is ensured operationally by qualifying specific sensors or through ATM. These parameters (accuracy, integrity, and continuity) are defined and quantified by RNP RNAV.

Where airspace is designated as RNP-x RNAV, performance requirements include containment (see Figures 2 and 3). Containment is a set of interrelated parameters used to define the performance of an RNP RNAV navigation system. These parameters are containment integrity, containment continuity, and containment region. The accuracy requirement is the 95th percentile of TSE (same as RNP). Integrity and continuity are specified relative to a containment region, whose limit is equal to twice the RNP value (e.g., for RNP-0.3 RNAV the containment region is 0.6 NM). RNP RNAV has additional functional requirements beyond those of RNP, i.e., alerting of the loss of RNP capability must occur in the flight crew's primary field of view. RNP RNAV avionics assume the ATS service provider ensures their navigation infrastructure meets desired performance requirements. These assumptions should be listed in the AFM. However, since all ATS service providers may not provide identical performance from their navigation infrastructure, the operator must ensure the service provider's existing infrastructure supports the desired RNP RNAV operation.

The containment region (see Figure 3 below) quantifies the navigation performance where the probability of an unannunciated deviation greater than 2 x RNP is less than 1×10^{-5}. This means that the crew will be alerted when the Total System Error (TSE) can be greater than the containment limit. This performance assurance is intended to facilitate the assessment of operational risk and safety for applications where ATC intervention is not feasible or timely (e.g., instrument procedure). The RNP RNAV containment region (the area defined by 2 times the RNP value) could help with safety assessments for separation and obstacle clearance in the development of routes, areas, and procedures.

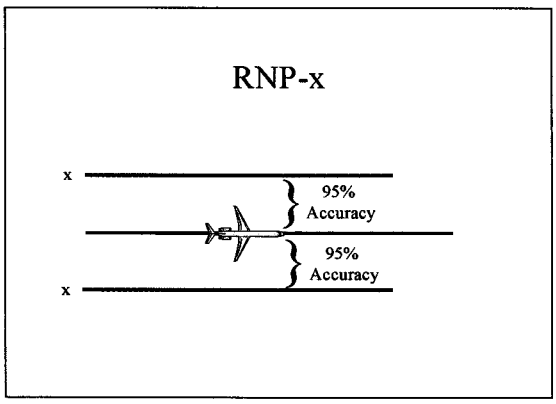

FIGURE 2. RNP

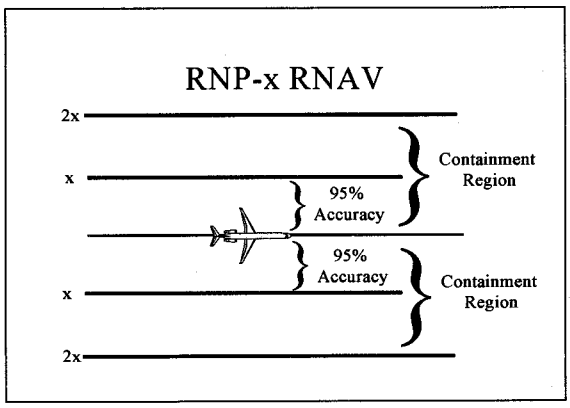

FIGURE 3. RNP RNAV

Figure 2 depicts the lateral region defined by an RNP. Figure 3 depicts the lateral containment region for an RNP-x RNAV.

Containment in this case is not equal to required obstacle clearance surfaces or aircraft-to-aircraft separation. It is a tool to support obstacle clearance and separation although the methods to use the tool have not been defined.

Containment integrity for RNP RNAV is the basis for user confidence in the correctness and reliability of the navigation capability including the monitoring and alerting for the RNP. The 2 x RNP containment limit represents a 99.999% percent or better probability per flight hour level of assurance that an undetected fault or condition leading to misleading RNP status has not occurred (e.g., aircraft is outside of 2 x RNP when indications are that it is within 2 x RNP, and no alert is issued).

Containment continuity is the capability of the total system to satisfy the containment integrity requirement without unscheduled interruption during the intended operation. The 2 x RNP containment continuity limit is a 99.99 percent or better probability that the navigation performance is satisfied without unscheduled interruptions during the intended operation. Containment continuity helps prevent unnecessary interruptions and false warnings of a loss of navigation capability.

Normally, the loss of a single aircraft radio navigation/self-contained navigation in the national airspace system is classified as a minor hazard with a continuity requirement of 99.99 percent probability and misleading navigation is classified as a major hazard with a containment integrity of 99.999 percent probability. This is what the RNP RNAV 2 x RNP continuity values is based on. However, there are many operations where continuity and integrity requirements are ***more*** stringent that those specified for RNP RNAV. In the conduct of RNAV operations, specifically terminal and approach operations predicated upon an RNP RNAV capability, a continuity probability of 99.99 percent may also be inadequate in an obstacle rich environment (ORE). In such an ORE, this issue may be resolved by increased equipment redundancy/availability, operational performance requirements/limitations, or some other mitigation of risk. If no solution exists, these operations will be prohibited.

Based upon their mean time between outage, many single system/sensor installations may not qualify for RNP RNAV operations when there is not an underlying navigation infrastructure available or when an ORE requires increased RNP RNAV containment continuity.

APPENDIX 3. ACRONYMS

ABAS	Airborne-based Augmentation System
ACC	Area Control Center
ACF	Area Control Facility
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AFDP	Automatic Flight Data Processor
AFTM	Air Traffic Flow Management
AFTN	Aeronautical Fixed Telecommunication Network
AIC	Aeronautical Information Circular
AIDC	ATS Interfacility Data Communications
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMHS	Aeronautical Message Handling Service
AMSS	Aeronautical Mobile Satellite Services
ANSP	Air Navigation Service Provider
AP I & II	Angkasa Pura I & II
ARINC	Aeronautical Radio, Inc.
ARSR	Air Route Surveillance Radar
ASEAN	Association of South East Asian Nations
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management

ATIS	Airport Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATO	Air Traffic Operations
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
ATSU	Air Traffic Services Unit
B-RNAV	Basic Area Navigation
CA	Conflict Alert
CAA	Civil Aeronautics Administration
CAAS	Civil Aviation Authority of Singapore
CATCC	Central Air Traffic Command Center
CDM	Collaborative Decision-Making
CNS/ATM	Communications, Navigation, Surveillance/Air Traffic Management
CPDLC	Controller-Pilot Data Link Communications
CSFP	Center Stored Flight Plan
CY	Calendar Year
DATIS	Digital Airport Terminal Information Service
DCA	Directorate of Civil Aviation (Malaysia)
DGAC	Director General of Communications
DGPS	Differential Global Positioning System
DME	Distance Measuring Equipment
DOC	Document

DVOR	Doppler VOR
E-MSAW	En Route Minimum Safe Altitude Warning
ENR	En Route
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIR	Flight Information Region
FIS	Flight Information Service
FTP	File Transfer Protocol
FUA	Flexible Use of Airspace
GBAS	Ground-Based Augmentation System
GDP	Gross Domestic Product
GMS	GPS Monitoring System
GNSS	Global Navigation Satellite System
GOI	Government of Indonesia
GPS	Global Positioning System
GRAS	Ground Regional Plans (APANPIRG Agreements) Augmentation System
GRS	Ground Reference Station
HF	High Frequency
HFDL	HF Data Link
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots Association
IFATCA	International Federation of Air Traffic Controllers' Associations

IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
ISPACG	Informal South Pacific ATC Coordinating Group
JCAB	Japanese Civil Aviation Bureau
LAAS	Local Area Augmentation System
LOA	Letters of Agreement
M2	Mode 2 (two)
MCS	Master Control Station
MITRE/CAASD	MITRE Corporation's Center for Advanced Aviation System Development
MNT	Mach Number Training
MOU	Memorandum of Understanding
MRS	Master Reference Station
MSAS	Multi-Functional Transport Satellite-Based Augmentation System
MSSR	Monopulse Secondary Surveillance Radar
MTSAT	Multi-Functional Transport Satellite
NDB	Non-Directional Beacon
NOTAM	Notice to Airmen
O&M	Operations and Maintenance
OLDI	Online Data Interchange
ORDD	Operational Readiness Demonstration Date
PDC	Pre-Departure Clearance

PIREP	Pilot Reports (weather)
PMS	Precipitation Map Service
QA	Quality Assurance
RAN	Regional Air Navigation
RASMAG	Airspace Safety Monitoring Advisory Group
RDP	Radar Data Processing
RFI	Radio Frequency Interference
RFP	Request for Proposals
RLRS	Reduced Lateral Route System
RNAV	Area Navigation
RNP	Required Navigation Performance
RVA	Robinson Aviation (RVA), Inc.
RVSM	Reduced Vertical Separation Minima
SADIS	Satellite Distribution
SATNAV	Satellite Navigation
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
SIGMET	Significant Meteorological Conditions
SOIT	Satellite Operational Implementation Team
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
TA	Technical Assessment
TFM	Traffic Flow Management

TIS	Traffic Information System
TSO	Technical Standard Order
TWS	Terminal Weather Service
UAT	Universal Access Transmitter
UIR	Upper Information Region
URET	User Request Evaluation Tool
USTDA	U.S. Trade and Development Agency
VDL M2	Very High Frequency Data Link Mode 2
VDL	VHF Data Link
VHF	Very High Frequency
VOR	VHF Omni-Directional Range
VOR/DME	VHF Omni-Directional Range/Distance Measuring Equipment
VSAT	Very Small Aperture Terminal
WAAS	Wide Area Augmentation System
WAFS	World Area Forecast System
WGS-84	World Geodetic Survey –84

Natuna Islands Air Traffic Control and Airspace Management Project for the Republic of Indonesia

Task 2

Develop Specific Aviation Infrastructure System Requirements for Air Traffic Control and Airspace Management

Prepared for
Directorate General of Air Communications of the Republic of Indonesia

By
Robinson Aviation (RVA), Inc.

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1.0 Goal and Objective

1.1 Primary Goal

Assist the Director General Air Communications (DGAC) to identify the technical and financial requirements for resuming Air Navigation Service Provider (ANSP) responsibilities over the Republic of Indonesian sovereign airspace, referred to as Sector C and/or the Natuna Islands.

1.2 Objective

Determine the *training*, *technical* and *financial* requirements of the project for its implementation.

This Technical Assessment (TA) shall:

1. Assess the technical requirements for Indonesia to provide air traffic management in the airspace over the Natuna Islands referred to as Sector C. Neighboring airspace is called Sectors A and B. All three sectors are currently in the Singapore Flight Information Region (FIR). Only Sector C is the subject of this TA.
2. Develop estimates of system and equipment requirements and investments needed.
3. Develop human resource and training requirements for establishing a brand new Area Control Facility (ACF) at the Natuna Islands.
4. Include financial analysis of the project and recommended financing options.

Note: Number 1, of the above four points, has been adjusted following meetings with representatives of the DGAC. Specifically, the original No.1 referred to Sectors A and B as part of this TA. In actuality, only Sector C is subject to Indonesia's reclaiming as sovereign airspace. Additionally, DGAC representative stated that building an Area Control Center (ACC) on Natuna was a metaphor to indicate the ACC should be constructed at an appropriate location.

In order to establish the information base necessary to make an informed decision, Robinson Aviation (RVA), Inc., will include in Task 2 the specific requirements necessary to address the following:

1. Establishment of an ACC capable of providing ANSP services in the Natuna (Islands) airspace, Sector C, per DGAC representatives.
2. System and Procedure for Air Navigation Services.
3. Supporting Facilities.
4. Human Resources, Capacity Building, and Training Requirements.

2.0 Overview

Task 1 provided a detailed report reflecting the current state of CNS/ATM, the background of Indonesia's quest to resume control of Sector C, which is the airspace overlying the Natuna

Islands, and the current state of affairs with Sector C and associated service areas. Further, Task 1 related the political and technical background of today's situation.

In essence, authority for air navigation services over the Natuna Islands was delegated to Singapore in 1973. Yet, under the International Civil Aviation Organization (ICAO) convention, Indonesia has retained sovereign authority of the airspace over its territory, despite having contracted part of its airspace management to another state (Singapore). The political processes are not part of this project. Task 2 identifies the operational and technical requirements for transition of Sector C/Natuna Islands airspace and ANSP responsibilities back to Indonesia referred to here as the DGAC.

The origin of Sector C, i.e., the airspace Indonesia is in the process of reclaiming, is found in the "Agreement between the Government of the Republic of Indonesia and the Government of the Republic of Singapore on the realignment of the boundary between the Singapore Flight Information Region and the Jakarta Flight Information Region", which is graphically depicted in map 2 in the agreement. In the instant study, no effort is made to change airspace boundaries due to the 1995 agreement between the states. Analysis of present traffic routing within the confines of Sector C reveals that routes are generally long established and serve the user community with the caveat that more direct routes are always welcome. Issues of services are addressed later in this TA.

3.0 Task 2 Issues

In Task 2, we will focus on issues detailed in the following sections below. This layout allows the Indonesian DGAC to readily see the progressive correlation between the Terms of Reference and this TA.

3.1 Regional Plans (APANPIRG Agreements) ANSPs. Singapore and Malaysia are the most involved ANSPs and are recognized in Task 1, section 1.4.

3.1.1 The Civil Aviation Authority of Singapore (CAAS). The CAAS is a statutory board under the Ministry of Transport. It represents the government in the negotiation of air services agreements and also advises on matters related to civil aviation.

3.1.2 Malaysia's Directorate of Civil Aviation (DCA). Established in 1976, DCA became a self-accounting department under the Ministry of Transport.

3.2 Regional Plans (APANPIRG Agreements) and Global Plans. Plans having impact on Indonesia's Natuna airspace are as follows:

- The National ATC Master Plan (SOFREAVIA, 1995).
- Transport Sector Strategy Study (Halcrow Fox and Associates, 2000).
- The Implementation Plan for CNS/ATM System in Indonesia and Harmonization with Asia-Pacific Regional Plans (APANPIRG Agreements) (DGCA, 2001, Update version of The National ATC Master Plan).
- The Phase-I Study on Integrated Modernization Plan for Air Transport in Eastern Indonesia (Swedevia, 2001).

- The Asian Regional Plans (APANPIRG Agreements) Navigation Feasibility Study, by USTDA, MITRE, Indonesia and others.
- The Master Plan Study on the strategic policy of the air transport sector in the Republic of Indonesia, Draft Final report, Volume 1/5, Summary Report, June 2004, JICA, Pacific Consultants International.
- Global plans developed by the following organizations: (Upon review one would not find significant differences in any CNS/ATM plan.) ASEAN, ASIA/PAC Air Navigation Planning and Implementation Regional Plans (APANPIRG Agreements) Group (APANPIRG), IATA, ICAO, EUROCONTROL, FAA.

In actuality, all the plans are similar calling for harmonious procedures, interoperability of equipage, safety, efficiency, and capacity gains with no adverse effect on the environment.

4.0 Major Tenets of the Natuna Islands Airspace TA

4.1 Evolvability, Capacity and Access. The actions discussed and ultimately recommended for the Republic of Indonesia's DGAC in its resumption of ANSP responsibilities will have, at its core, a system capable of evolving with future demand and changing technology. Evolvability, Capacity and Access are seen in the totality of system change commensurate with need, proven technology, and benefit cost analysis. This TA recommends a progression from a remediated legacy infrastructure to a state-of-the-art CNS/ATM system commensurate with documented need and in accord with sustainable cost.

4.2 Communications. This is first of the Communication, Navigation, and Surveillance (CNS) technology trilogy. Communication systems are rapidly evolving to digital systems. Coincidently, Indonesia's Master Plan reflects transitioning to advanced digital communication systems. The most obvious example of such evolvability issues is Controller to Pilot Data Link Communications (CPDLC) and Future Air Navigation System (FANS), a system in use today. The question to be decided is this: "Is CPDLC an appropriate application for Sector C?" The answer is driven by customer needs, decisions of the ANSPs managing airspace surrounding Sector C and the non- commercial customer. In other words, if other states use a workable CPDLC system and FANS-1a customer use CPDLC, then Natuna should also do so, for the sake of the customer and harmonious operations in the region. However, Natuna should remember that CPDLC is an evolving system that bears close monitoring. CPDLC is justified, in large measure, by issues of frequency congestion and the needs of high altitude CPDLC plays an important part in the ATC operation. While there is no communication congestion problem in Sector C at the present time future considerations should consider less expensive alternatives for operators of small "general aviation" and military aircraft, alternatives such as such as the 8.33 kHz frequency spacing.

In summary, the DGAC is urged to proceed with the regional plans (APANPIRG agreements) approach to CPDLC AND FANS for the long-haul International operator and to seriously consider an alternative frequency congestion program such as an 8.33 kHz program. An 8.33 kHz is more economical for all concerned in the short-haul operation and for ANSP organizations that must weigh the benefit-cost issues of government budgets.

4.3 Navigation. In the area of navigation, evolution is driven by the use of the Global Positioning System (GPS) also known as part of the Global Navigation Satellite System (GNSS) which will be addressed throughout this report. Additionally, this TA encourages the DGAC to support regional plans (APANPIRG agreements) for greater use of area navigation (RNAV) as well as the appropriate utilization of required navigation performance (RNP). By virtue of the Natuna Airspace, this TA will focus on Oceanic/Remote En Route RNP, RNP 10 and RNP 4.

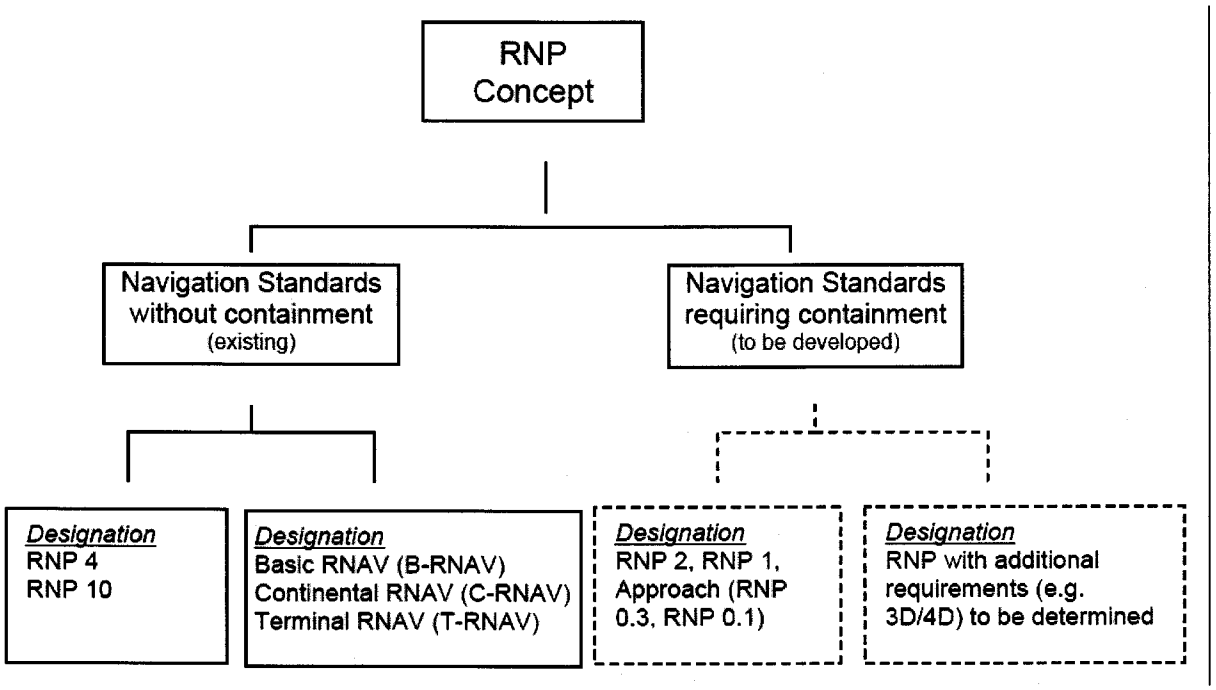


Figure 1. RNP Concept (ICAO)

RNP Navigational Performance Requirements

RNP-4
All aircraft must meet an along track and across track keeping accuracy equal to or better than ± 4 NM (±7.4 km) for 95% of the flight time in RNP-4 airspace.

RNP-5
RNP 5 means that an aircraft must be able to navigate within 5 NM of its intended position (both across track and along track) for at least 95% of its total flying time.

RNP-10
All aircraft shall meet a track keeping accuracy equal to or better than ±10 NM for 95% of the flight time in RNP-10 airspace. All aircraft shall meet along-track positioning accuracy of ±10 NM for 95% of the flight time in RNP-10 airspace.

4.4 Surveillance. Surveillance will be enhanced with the Natuna Secondary Surveillance Radar (SSR) being integrated into the air traffic services (ATS) system. This surveillance system must include the capability to depict convective weather for controllers and traffic flow managers. Further, the Natuna MSSR should be equipped with En Route Minimum Safe Altitude Warning (E-MSAW) and later evolve to a system that will be augmented by Automatic Dependent

Surveillance-Broadcast (ADS-B). ADS-B is a cooperative surveillance system having many applications including the ability to function as gap filler in non-radar areas. Another surveillance system that is receiving considerable attention today is Multilateration. Multilateration is a surveillance system available at a relatively low cost. These systems were discussed in Task 1. The installation requirements of Multilateration, however, make it unsuitable for the Natuna Islands airspace.

5.0 Methodology

In conducting this assessment, the RVA team used the methodology articulated in Task 1 and partially restated here. The conclusions and observations presented in this report are based on information and data collected using this methodology.

RVA's methodology included visits to select sites in the Jakarta area considered representative of the type of facility required to provide air traffic management in the Natuna airspace. These facilities include: the Jakarta ACC, Cengkareng Hatta Air Traffic Control Tower, Cengkareng ARSR, Cengkareng VOR/DME facilities and those at Batam.

Air Traffic Management (ATM) as well as Equipment Operations and Maintenance (O&M) information was provided by one of three service providers, as appropriate; PT (Persero) Angkasa I, PT (Persero) Angkasa II, and directly by the DGAC.

Based on the information provided in the Request for Proposal (RFP), RVA determined there were several key issues to be addressed and resolved in this study. One issue is to assist representatives of the Government of Indonesia in determining whether there should be a combined implementation of ATS, CNS/ATM, and facility development in accord with a regional plans (APANPIRG agreements) implementation, or an individual state implementation. It was discussed that the ICAO had already indicated that such matters should be implemented in concert with regional plans (APANPIRG agreements) planning groups, but ultimately, ATS and CNS/ATM implementation is the State's responsibility. RVA's experience has shown that working within the concept of regional plans (APANPIRG agreements) implementation is the best approach. In discussions with the DGAC, we noted that such an approach is consistent with ICAO and International Air Transport Association (IATA) policies, and also that regional plans (APANPIRG agreements) implementation does not impede the State's implementation of additional ATS and CNS/ATM initiatives on their own.

Another issue addressed and agreed to in Task 1 is the requirement to ensure that present assets and resources are used for maximum efficiency and redundant systems are kept to a minimum. The equipment recommended by RVA will be shown to be cost effective thus meeting Indonesia's requirements, while still supporting regional plans (APANPIRG agreements) /global plans.

A significant amount of time was devoted to reviewing the present and future airspace envisioned by the DGAC. These discussions continued in a mutually supportive effort between DGAC and RVA in order to gain clarity. The airspace described herein is the result of those discussions. We reached consensus that the DGAC's intention is to prepare for the resumption of ANSP responsibilities in the Natuna Islands airspace, also known as Sector C.

DGAC shared its view of the role of Singapore and Malaysia in the provision of ANSP services in and adjacent to Indonesia's sovereign airspace. In light of the importance of the ICAO and IATA policy that regional plans (APANPIRG agreements) CNS/ATM systems best serve all involved, representatives of RVA and the DGAC scheduled and traveled to Singapore. The purpose of this travel was to further the information-sharing between the two most involved states and to obtain important information regarding traffic volume and flows from Singapore. Indonesia and Singapore continue their cooperative effort to develop data that specifically reflects the activity of the Natuna airspace.

The Team made onsite visits to become more familiar with the status of CNS/ATM support facilities in the Jakarta area. While visiting various sites, the RVA representatives discussed ATS and CNS/ATM developments and current operations, policies, and equipment including structures, overflight traffic flows, and airports to determine the present state of aviation in Indonesia relevant to the Sector C airspace. Our Team also studied the system's strengths and weaknesses, and what improvements need to be made relevant to resumption of control of Sector C.

In the data-gathering phase of Task 1, the RVA Team requested assistance from the Government of Indonesia to provide statistical data and information on the overall system. Some obstacles with information deliveries were due the dependency on other ANSPs, most notably Singapore. Information requested of Singapore is still pending.

RVA and DGAC representatives reviewed the present operational characteristics of the air traffic system. These included available information regarding current procedures, the use of airspace such as Danger Areas, Restricted or Prohibited airspace, sectorization, routings, staffing, use of personnel, training, quality assurance, and system limitations and restrictions. We reviewed the navigational aid infrastructure, particularly en route equipage for condition, age, and area coverage. Information was gathered through onsite visits, analysis of existing reports, and interviews of technical personnel. Equipment condition, age of the various air-ground and ground-ground communications links and equipment, including VHF communication coverage, were discussed early on and subsequently observed through onsite visits. Additional reviews and discussions of the various maintenance programs, servicing of equipment, and maintenance training programs were held with DGAC staff.

During the second week of the onsite visit, RVA's Team met with experts in the financial, legal, and regulatory area to better understand related policies and procedures which could impact this plan. With regard to the finance meetings, discussions were held with ATC experts and supervisors, airspace specialists, training specialists, and other specialists to receive their input. These discussions provided us with information for the development of manpower figures and the ability to evaluate and recommend any necessary improvements in training, and further, to plan a transition scenario.

All of the above activities provided a backdrop for the project objective, the restoration of DGAC control of Indonesia's sovereign airspace over the Natuna Islands. Further, this background information helped the team appreciate Indonesia's commitment to provide the best CNS/ATM systems in support of its ANSP responsibilities.

5.1 Traffic Activity Terms

As a guide to assessing traffic activity and the amount of traffic, the following terms and definitions are used:

Traffic Load. The number of movements handled by an ATS unit or part thereof during a given period of time.

Weekly Traffic Load. The traffic load handled during a 7-day period from July 1 to 7 inclusive, or other 7-day period more appropriate to a specific Contracting State, when a common period is not necessary by the nature of the task.

Peak Hourly Traffic. The traffic load handled during that clock hour in the period from July 1 to 7 inclusive, or any other 7-day period more appropriate to a specific Contracting State when a common period is not necessary by nature of the task, during which the highest number of movements occurs.

Maximum Instantaneous Traffic Load. The traffic load at the busiest instant within the peak hour as defined in the above paragraph.

The use of the above-described terms and definitions make it possible to compare data obtained for assessment purposes with data provided for traffic forecasting in specific parts of the region.

5.2 Natuna in Perspective

Having used the above methodology to gather required information to develop suggestions and options for the resumption of control of the Natuna airspace, the relationship of Natuna to the entirety of Indonesia's airspace as well as the regional plans (APANPIRG agreements) airspace was necessary. It is **important** that a **perspective** of Natuna Islands and Sector C be maintained. Sector C is, relative to the entire Indonesian airspace, a very small area receiving Indonesian ANSP services.

Notwithstanding these information-gathering issues, Natuna/Indonesian officials fully understand their responsibilities in the provision of services and cooperated to the best of their on their resources.

6.0 Evolving Leadership Role

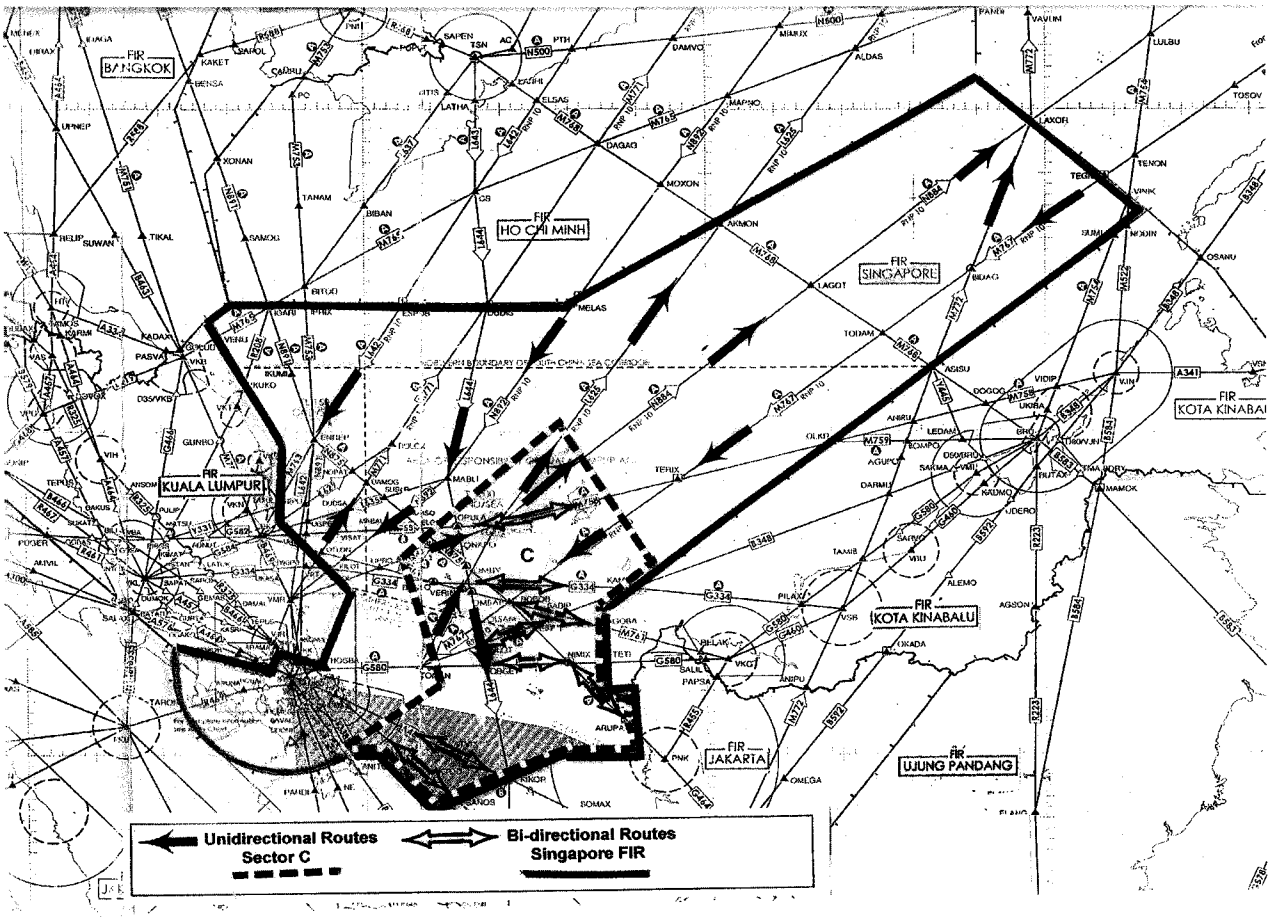
Indonesia, as a key ANSP in the South China Sea, should immediately begin preparation for significant traffic growth and changing technologies. Its strategic location is highly impacted by traffic flows between Asia and the growing markets of China, Australia, Europe, and the United States. It is our assertion that Indonesia can reasonably expect a minimum 5-percent annual growth for the next 15 years. This is documented in many professional reports, most recently in ICAO document 9853, Asia/Pacific Area Traffic Forecasts 2004-2020.

7.0 System Requirements Discussion

DGAC, in concert with RVA and as part of Task 1, chaired a meeting with industry representatives to facilitate open discussions on this project. Additionally, RVA representatives visited facilities in Batam and Singapore. In this report, information regarding requirements for the development of new systems requirements will be addressed. Central to all information gathered and the outcomes presented, we address issues such as the system access, capacity, and "evolvability" required to accommodate expected traffic growth. We discussed safety and security to determine and articulate the requirements of the airspace management system. Task 2 establishes the rationale for future requirements and includes, but is not limited to, addressing the following types of needs:

7.1 Airspace Configuration. The predominant factors to consider when configuring airspace are the following:

- Traffic statistics and forecast
- Aircraft types/fleet mix (wake turbulence category)
- Altitudes used by type aircraft and volume
- Number of ATS routes served
- Number of intersections of ATS routes
- Proportions of aircraft in level flight and in climb and descent
- Significant aircraft group by varying airspeed



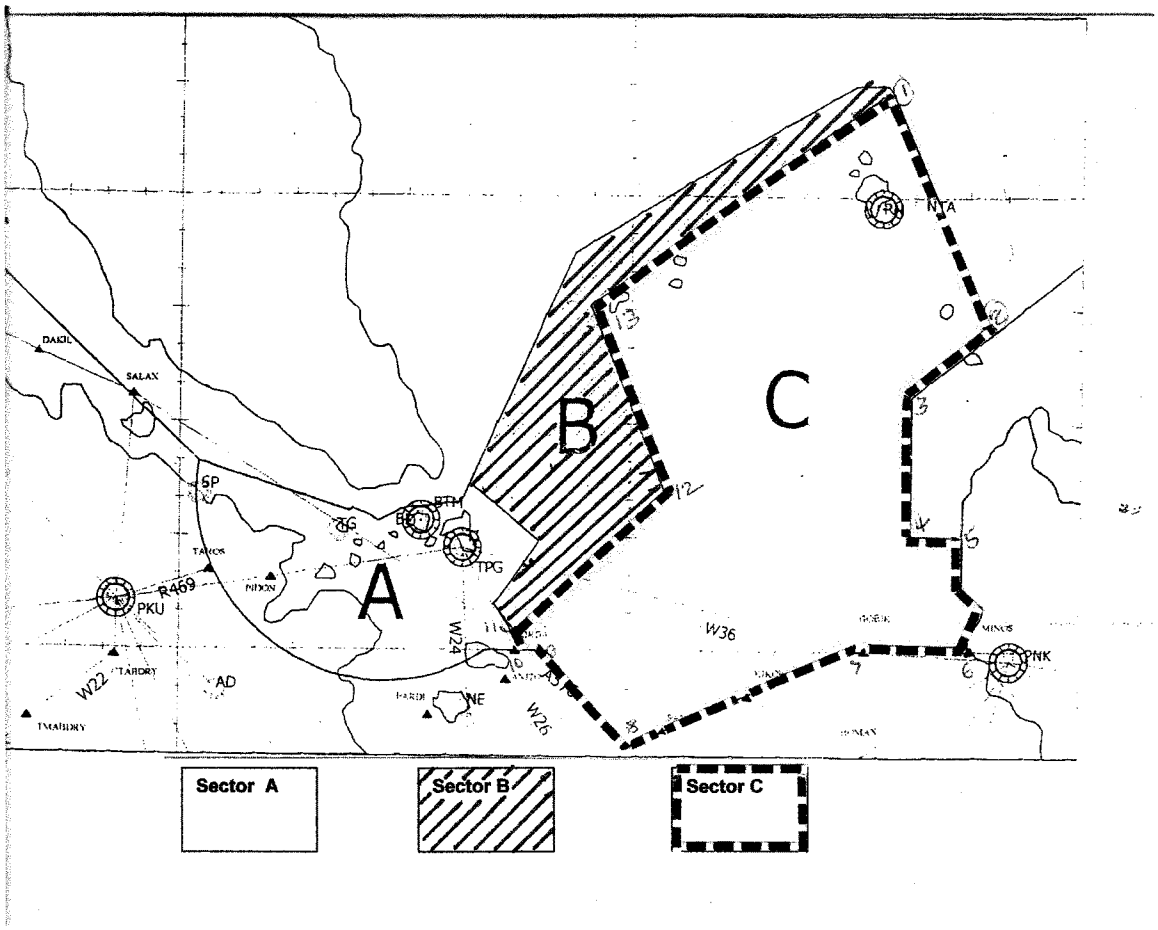
Map 1. Example of Uni-Directional Routes

Note: In August 2004, States concerned agreed to establish two uni-directional routes to cater for traffic flows between Jakarta and Hong Kong. The northbound route, M772, and the southbound route, L644, were established on January 20, 2005. This has reduced travel distance between the two countries and saved fuel for the airlines.

7.2 Airspace. In 2005, Indonesia reorganized their four flight information regions (FIR) into two FIRs--Jakarta FIR and Makassar FIR with the Natuna airspace contained within the Jakarta FIR. The Republic of Indonesia requested this review of the Natuna airspace and its assignment to what has been referred to as the Natuna Area Control Center (ACC). Additionally, the sovereign Indonesian airspace, referred to as Sector C, has been studied with the intent of offering the DGAC options when contemplating resumption of ANSP responsibilities. In Task 2, consideration is given to division of Sector C into sub-sectors based on the characteristics of air traffic, flight routes, and volume. Nothing justifying significant changes in Sector alignment has surfaced. It is prudent that the transition to Indonesian control be a well managed evolution that progressively initiates a building block series of CNS/ATM program improvements.

In the past there have been discussions that the Natuna Airspace be subdivided with different organizations responsible for unnamed sub-sectors. While such a scheme could be developed, RVA makes no such recommendation. Firstly, even with clearly defined boundaries and procedures, such a scheme would be rife with safety concerns with no comparative gains in capacity or efficiency. Specifically, subdividing would create increased controller coordination and, therefore, safety and efficiency concerns.

RVA suggests implementing a deliberate plan for airspace sub sectors and for service improvement after the workforce is thoroughly familiar with their new duties. An action plan aimed at implementing a continuous improvement program through renewed programs for quality control, individual skill building, assuring infrastructure reliability, and addressing customer services (for example, more routes) should be announced not later than 3 months after Operational Readiness Demonstration Date (ORDD). Such a program will demonstrate to users that system improvement will continue in the Natuna Islands airspace.



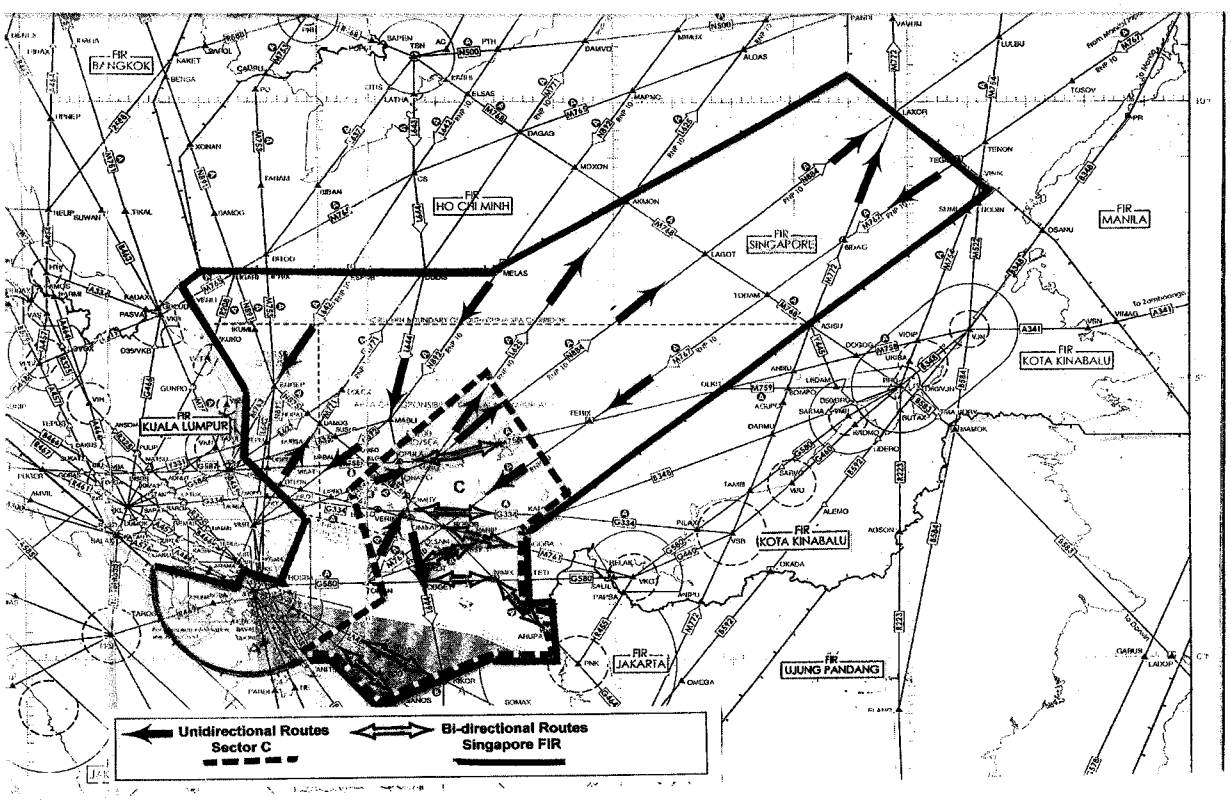
Map 2. Sectors A, B, and C

7.3 Sector C – Sectorization. Air Traffic Service (ATS) in Sector C airspace is currently provided by Singapore ACC. Two sectors (Sector 1 and Sector 3) at the Singapore ACC

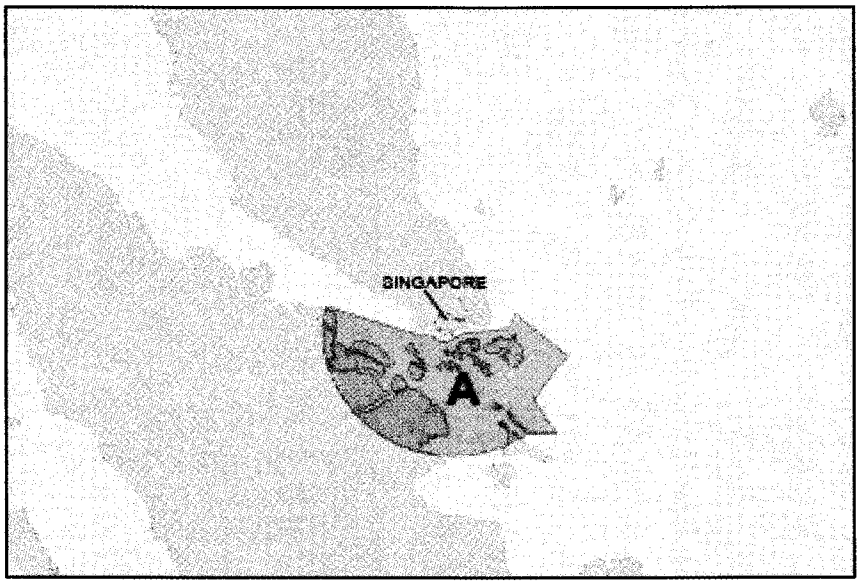
straddle Sector C airspace. Singapore ACC sector boundaries are described in proprietary Singapore ACC ATS manuals.

It is approximately 100 NM from the southwest boundary of Sector C to the arrival fix for Singapore/Changi International Airport (Hobsa STAR 11,000 ft. transitional altitude). In the future, when Sector C is under control of Jakarta ACC, radar service could be provided to aircraft entering Sector C from the northeast and until transfer to Singapore ACC at the southwest boundary of Sector C. The application of radar separation rather than non-radar and/or ICAO oceanic procedures will significantly increase capacity (by at least a factor of 3) by reduction of the required procedural airspace protection on individual routes and at the route crossing points. Use of radar would increase safety and provide greater efficiencies in service to the users through approval of direct routes, deviations requested, altitude changes, emergency services, etc. As with all procedures related to this transition, a Letter of Agreement (LOA) between Jakarta ACC and Singapore would be required to establish responsibilities and procedures for radar services.

Sector C currently overlies the South China Sea Corridor which is delegated to Kuala Lumpur ACC.



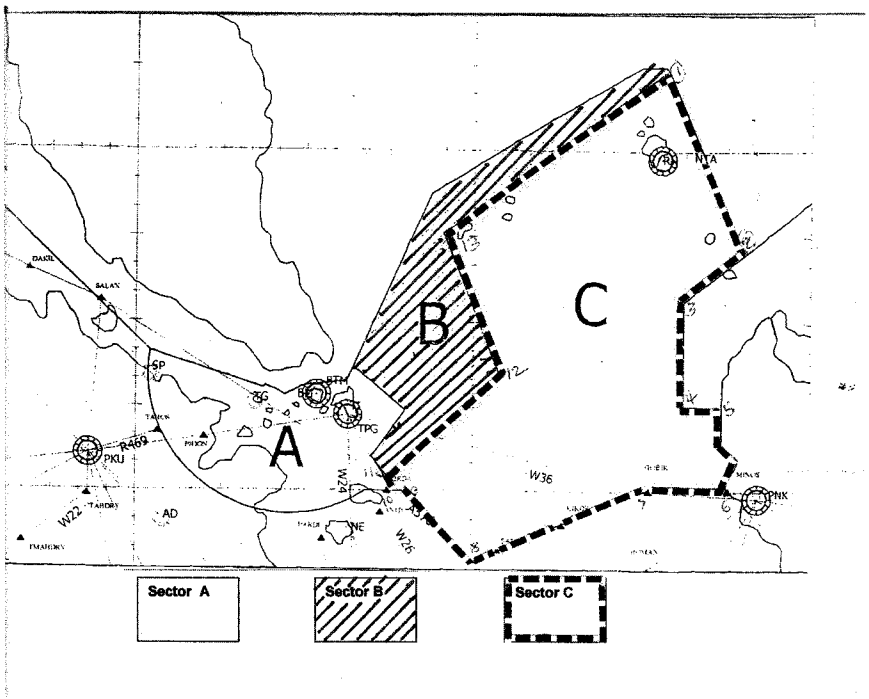
Map 3. Sector C (South China Sea corridor with yellow highlight)



Sector A - from sea level to 37,000ft

Area contained within an arc of a circle 90 NM radius centred on SINJON (011324N 1035124E); from 013430N 1022353E anti-clockwise to Equator 1044330E, thence a straight line to Equator 1050340E, 002404N 1044807E, 005606N 1051200E, 012921N 1043441E, 011800N 1043000E, 011500N 1040000E, 010800N 1034500E, 011046N 1034015E, 011200N 1033900E, 011410N 1033137E, 011300N 1033000E, 013430N 1022353E.

Map 4. Sector A and Coordinates



Map 5. Sectors A, B, and C

Procedures for ATS, Air Traffic Management (ATM) procedures, LOA, and interfacility coordination procedures will remain unchanged in basic content. At the time of transition, Jakarta would assume the role of responsible primary ANSP and dominant airspace manager for Sector C with Singapore ACC's and Kota Kinabalu ACC's continued involvement as supporting organizations. Certainly the needs of adjacent ACCs would be properly addressed creating a workable environment for all.

7.4 Sector C – Traffic Flow. The primary traffic flow through Sector C is via two one-way air routes from Singapore/Changi International Airport to Manila (N884), Formosa and Japan (L625) and a one-way route (M767) from Manila/Japan. A single one-way route (L644) from Hong Kong to Jakarta crosses Sector C. There are six bi-directional routes between Singapore FIR and Kinabalu FIR. These routes are also in the South China Sea Corridor which is controlled by Kuala Lumpur ACC at FL200 and below. Two bi-directional routes between Singapore FIR and Jakarta FIR cross the southern end of Sector C. Routes through Sector C are depicted in Map 1 and Map 3.

Indonesia should continue the fine work begun in August 2004 when it was agreed with other States to establish two uni-directional routes to cater for traffic flows between Jakarta and Hong Kong. The northbound route, M772, and the southbound route, L644, which were established on January 20, 2005, have resulted in the reduction of the travelling distance between the two countries and saved fuel for the airlines while creating options for air traffic control and traffic management staff. If the DGAC initiates radar service, as recommended, one-way routes should become uni-directional routes.

Natuna ACC cannot initiate some actions by itself and should join with the DGAC and Regional entities in pursuing more CNS/ATM issues. Examples of operational improvements requiring the efforts of service providers beyond those of the Natuna ACC are as follows:

- Natuna Island's airspace focuses on RNP-10 and RNP-4. However, adoption of Indonesian RNP procedures that expand route capacity are recommended to optimize usage of airspace.

- RNP-4 should be inaugurated at the earliest date. Parallel to the development of RNP-4 infrastructure, Natuna ACC airspace specialist should develop prototype RNP-4 routes taking full advantage of available airspace. It is recommended that Natuna ACC actively participate in the ATS Route Network Review Task Force seeking improved routing options through their airspace.

- Direct routes with optimum altitudes should be developed through Sector C between Australian/Indonesian FIR boundaries to Singapore.

- Sector C should have the capacity of harmoniously responding to adjacent service providers who allow flex routes.

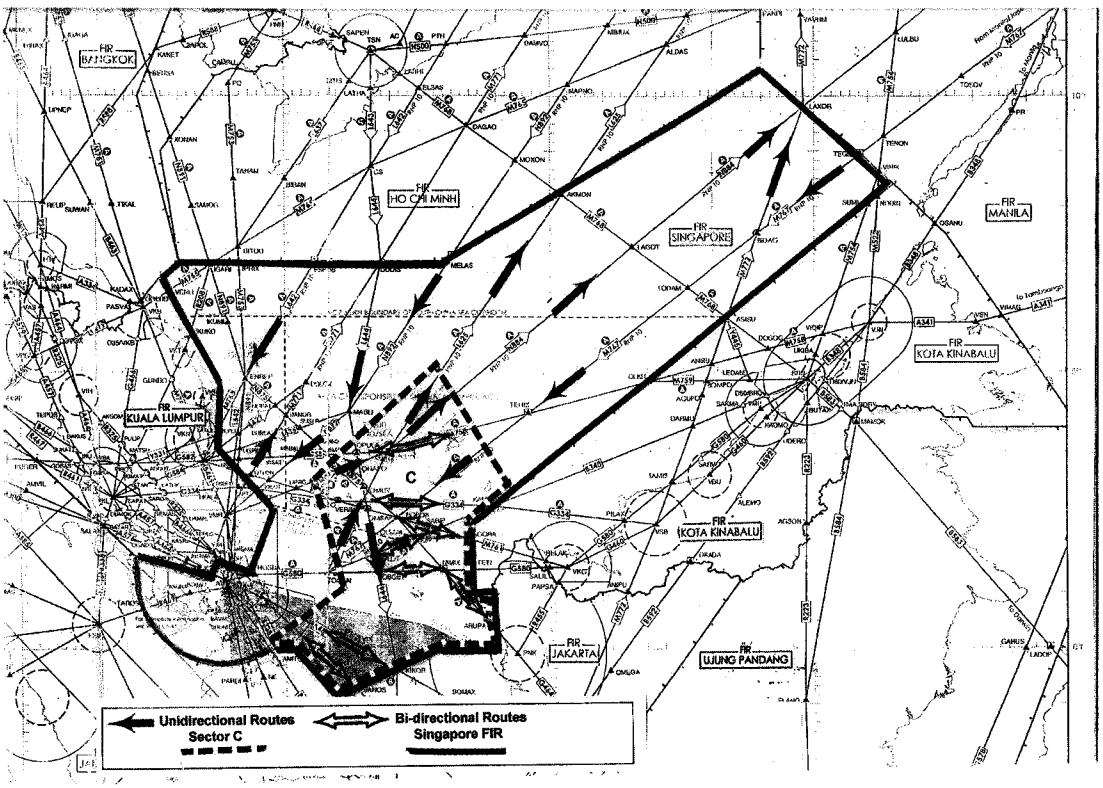
- Continue to create routes where feasible as done in November 2004; Rahim Yar Khan was further extended to Kandahar and this made P628.

- Develop viable alternative airways using Global Positioning System (GPS) such as when P628 was extended from ASOPO to Rahin Yar Khan. The needed alternatives should be created and identified after consultations with users and neighbouring ANSPs.

- Develop continuous or profile descent procedures combing use of Natuna and Singapore airspace.

Note 1: The above recommendations alternately address the issues of capacity, efficiency and system access; as such have the potential to improve service to the user.

Note 2: All airspace actions recommended in this TA are aimed at Sector C and must be in harmony with adjacent airspace.



Map 6. Example of Uni-Directional Routes

7.5 Methods of Control. Information regarding these considerations was provided DGAC representatives. When assessing the methods of control used, it is necessary to differentiate between the following:

- Procedural control;
- Primarily procedural control supported by varying degrees of use of primary radar;
- Radar control based on the use of primary radar;
- Radar control based on the use of SSR without Mode C;
- Radar control based on the use of SSR with Mode C;
- Use of automatic equipment by the ATS radio control position; and
- Use of automatic equipment between ATS units.

Presently, air traffic control is procedural control with radar used to monitor flights. Automation is not used to electronically pass flight data information, boundary times, or to initiate handoffs to the next air traffic control facility.

8.0 Systems and Procedures of Air Navigation/Supporting Facilities

8.1 Harmonious ATS/ATM Processes. Indonesia's ATS/ATM processes must be harmonious with its neighboring ANSPs. For example, The Civil Aviation Authority of Singapore has recently chosen a vendor to help manage arrival flows. This arrival management software is a classic example of technologies wherein neighboring ANSPs must assure compatibility. Such an application will be customized to meet the specific operational requirements and procedures of the Singapore airspace. The basic philosophy is to solve predictable congestions over sequencing points for traffic already within the ACC and thus to avoid problems in the Approach and Terminal Centers. The software in use automatically determines arrival sequences based on preferred arrival times. The defined separation minima and local operational procedures are taken into account as constraints. The program provides advisories in order to achieve the suggested arrival times. The actual traffic evolution is monitored continuously, and proposed sequences are updated dynamically. We offer no endorsement of this program as there are many other software programs that accomplish the same result. (Recommendations will, also, be listed in the final report which will include a list of potential vendors.) The point is that if one ANSP initiates a new tool, especially one that reaches into the en route system, there is a high probability that procedures of both states will change. More importantly, both ANSP's systems must be compatible if data is to be exchanged. The lack of coordination between ANSPs is a common thread in both complaints from users and the reports of system deficiencies.

ATFM programs are excellent tools for controlling the workload and movement of aircraft through complex airspace. The programs account for and predict the positions of hundreds of aircraft both entering and transiting large segments of airspace. Unfortunately, the Natuna airspace is too small by itself for the application of these programs. It is suggested that an ATFM program be applied to the entire Jakarta ACC and related ACC sectors.

8.2 Navigational Systems and Aids. The Global Navigation Satellite System (GNSS) is the preferred concept of navigation system for the future. Satellite navigation comes in many forms with the only operational system being GPS. All of these systems were detailed in Task 1.

8.2.1 Discussion. Recently, Australia approved the use of GPS as a primary means of navigation in Australian airspace. For properly equipped aircraft, this allows GPS to be used as the sole means of navigation. The reliability and availability of GPS make it the best choice for Sat/NAV operations. GPS is recommended as part of this TA.

In keeping with global and as described in the MITRE Corporation's Center for Advanced Aviation System Development (MITRE/CAASD) study, Satellite Navigation (SATNAV) will become the primary means of navigation in the region. As part of that planning effort, Australia, a regional leader in ANSP services, has approved the use of GPS as a primary means of navigation in Australian airspace. For some types of aircraft and operations, this allows GPS to be used as the only means of navigation. It is noted that our review of aircraft in Indonesia shows almost 100 percent GPS equipage. Accordingly, pilots of appropriately equipped aircraft can plan and conduct instrument flight rule (IFR) operations without backup ground navigation aid, such as a non-directional radio beacon (NDB), VHF omni-directional range (VOR), or instrument landing system (ILS). Elimination of legacy navigational devices represents significant saving to services providers. Proliferation of GPS throughout the region is expected in the immediate future, 5+ years according to existing plans. With the 21 monitor station configuration, the average GPS availability with Multi-Functional Transport Satellite-Based Augmentation System (MSAS), a subsystem of the Multi-Functional Transport Satellite (MTSAT) (a Japanese system due 1 year after launch of the MTSAT) is estimated to be at least 0.99999. With the 14 monitor station configuration, GPS availability is lower than with the 21 monitor station configuration and is no worse than 0.9999 in portions of Indonesia, Malaysia, and Vietnam. Certainly, the availability of signal coverage is not a problem. It is important to remember that elimination of legacy navigational devices and subsequent savings refer to future benefits. As recommended in this TA, the timing of facility elimination depends on the customers' capability to transition to GNSS.

The locations of Ground Reference Stations (GRS) will be a subset of the airport locations for the Economies that are presented. The five GRSs for Indonesia are located at the following airports: Banda Aceh; HPKI; Bali; Jayapura; and Tarakan. HPKI will be co-located with an MCS.

8.3 Present Situation. In gathering information, RVA held meetings with DGAC representatives focused on the technical resources currently in place that could allow Indonesia to provide ATM in the airspace over Natuna Islands <u>and</u> in the neighboring areas called Sectors A and B, which are both currently controlled within the Singapore Flight Information Region (FIR). Sectors A, B and C were delegated by Indonesia to Singapore and Malaysia for the provision of air navigation services. In these discussions, Indonesia pointed out that Sector A of the FIR is currently managed by Singapore by agreement between Indonesia and Singapore. Singapore transfers all overflight charges (about $300,000 per month) to Indonesia. Indonesia noted that at present Sector C users receive services from Singapore without incurring any charges. Sector B is dedicated to military operations and managed by Singapore. Only Sector C is the focus of this TA.

8.4 Organizational Aspects and a Perspective for Air Traffic Services above the Natuna Islands. In all airspace and ATS/ATM programs aimed at change, it is important to maintain a perspective of the larger issues involved. There are three major points for

consideration in Indonesia's resumption of ANSP responsibilities over the Natuna Islands. They are:

1) Natuna Islands' airspace is extremely small in relation to the totality of Indonesian airspace and the South China Sea ANSP service area (less than 40,000 square kilometers). Natuna Islands airspace is situated between Malaysia and Singapore. This location requires thoughtful, integrated and well-coordinated planning.

2) Natuna Islands' airspace (Sector C) cannot stand alone as an initiator of, or as the provider of, many costly CNS/ATM services.

3) An ACC dedicated solely to airspace the size of the Natuna airspace is difficult to rationalize and requires thoughtful review of all alternatives. Such a facility would be extremely inefficient in terms of cost and expenditure of resources in relation to services provided and revenue collected.

   This is not to say CNS/ATM initiatives are inappropriate in this airspace. Rather, it is to say CNS/ATM technology installations solely for the Natuna Islands airspace are inappropriate. DGAC is strongly encouraged to go forward with CNS/ATM programs as part of the regional plans (APANPIRG agreements) and state ANSP programs. Under that scheme, Natuna would enjoy the attributes of CNS/ATM thereby benefiting the DGAC and system users. Review of the most recent record reveals the DGAC has recently initiated action on many Regional plans.

8.5 Sector C – Supporting Facilities. Present-day facilities have a well-documented need for improvement, in some case, immediate improvement and certification. However, DGAC reports significant progress in assuring proper certification of facilities. Further, DGAC has stated that this TA and appropriate sections of the Master Plan will guide system improvements in the future.

Indonesia (Jakarta ACC), following the initial plan for system improvements set forth in this TA, could provide an excellent level of ATS in Sector C for the near term (5 years). Further system improvements through continued use of this TA in the institution of CNS/ATM modernization would satisfy the user community needs for decades to come assuring safe and efficient service. Yet, given that it would take a minimum of 5 to 10 years to create any meaningful change, action is required now.

Prior to assuming the initial transition to Indonesian control, numerous system upgrades, referenced herein, must be accomplished in the interest of all concerned.

9.0 ANSP Activity Growth Projections

9.1 Indonesia and Singapore Forecast

While Indonesia and Singapore continue the development of traffic activity data, reasonable conclusions can be developed through review of ICAO data and traffic flows. ICAO, IATA, and industry sources reveal a consensus that traffic growth in this part of Southeast Asia is

among the highest in the world. Further, the main routes between countries and city pairs are likewise growing. Therefore, the following is offered as background information to support the conclusion that a reasonable expectation of 5 percent growth is consistent with regional growth.

Traffic growth indicators for Transpacific traffic, the region, and select city pairs that would traverse Sector C all reflect increases in traffic. The following is presented as a means of demonstrating growth over the study period. The major source of data is ICAO as outlined below.

TABLE 6

TRANSPACIFIC AIRCRAFT MOVEMENT FORECAST

Year	Passenger Aircraft Movements					Total Movements Forecast		
	Low	Most Likely	High	Cargo	Others	Low	Most Likely	High
Historical								
2000	112,283			24,810	8,000		145,093	
2001	107,692			22,857	8,000		138,549	
2002	97,444			25,413	8,000		130,857	
2003	90,762			23,900	8,000		122,662	
Forecasts								
2004	102,036	103,324	105,378	21,970	8,000	132,006	133,294	135,348
2005	109,844	114,776	120,218	24,771	8,000	142,615	147,547	152,989
2006	118,630	125,330	132,837	27,049	8,000	153,679	160,379	167,885
2007	124,262	132,789	142,487	28,659	8,000	160,921	169,448	179,145
2008	128,048	138,405	150,355	29,871	8,000	165,919	176,276	188,226
2009	132,946	145,347	159,858	31,369	8,000	172,315	184,716	199,227
2010	137,682	152,247	169,532	32,696	8,000	178,378	192,943	210,228
2011	142,867	159,787	180,147	34,316	8,000	185,182	202,103	222,463
2012	148,177	167,619	191,337	35,998	8,000	192,174	211,617	235,334
2013	151,590	173,436	200,454	37,247	8,000	196,837	218,683	245,701
2014	157,076	181,759	212,705	39,034	8,000	204,110	228,793	259,739
2015	162,683	190,388	225,599	40,887	8,000	211,571	239,276	274,487
2016	168,025	198,876	238,621	42,287	8,000	218,313	249,163	288,908
2017	173,462	207,641	252,277	44,151	8,000	225,613	259,793	304,428
2018	178,990	216,688	266,591	46,075	8,000	233,065	270,763	320,666
2019	184,608	226,020	281,587	48,059	8,000	240,667	282,079	337,646
2020	190,313	235,640	297,288	50,105	8,000	248,418	293,745	355,393
Average Annual Percentage Growth Rates								
2002-2005	4.1	5.6	7.3	-0.8	0.0	2.9	4.1	5.3
2005-2010	4.6	5.8	7.1	5.7	0.0	4.6	5.5	6.6
2010-2015	3.4	4.6	5.9	4.6	0.0	3.5	4.4	5.5
2015-2020	3.2	4.4	5.7	4.1	0.0	3.3	4.2	5.3
2002-2020	3.8	5.0	6.4	3.8	0.0	3.6	4.6	5.7

Passenger aircraft movements are forecast to increase at the average annual rate of 5.0 percent for the period 2002-2020. The intermediate forecasts for the periods 2002-2005, 2005-2010,

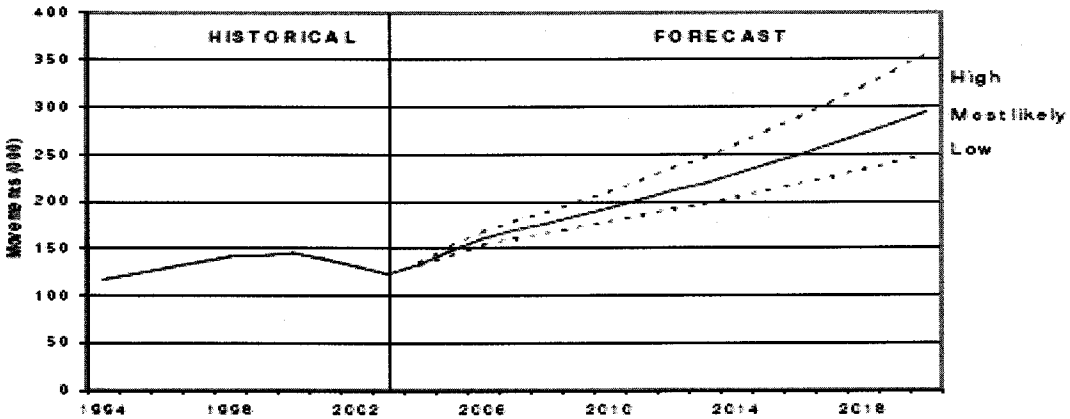
2010-2015, and 2015-2020 are projected to be around rates of 5.6, 5.8, 4.6, and 4.4 percent, respectively.

All-cargo flights are projected to decrease at 0.8 percent annually to the year 2005, and then increase at 5.7 percent per year until 2010. The average annual forecast growth rate for the period 2010-2015 is to be 4.6 percent and 4.1 percent for the period 2015-2020. The all-cargo flights are forecast to increase from some 25.4 thousand in 2002 to some 50.1 thousand flights by the year 2020 at an average annual growth rate of 3.8 percent. Other aircraft movements were estimated based on an analysis of sample week traffic supplemented by data from Tokyo/Naha ACC and expected to remain at around 8 thousand flights per year. The total aircraft movement forecasts for the Transpacific market are given in Table 6 above and shown graphically in Figure 7 below.

NOTE: Table 6 above and Figure 7 below are extracts from ICAO Doc 9853, Asia/Pacific area traffic forecast 2004-2020 and retain the original Doc 9853 identifications.

FIGURE 7

TRANSPACIFIC AIRCRAFT MOVEMENT FORECAST



2.10 **Analysis of Sample Week Traffic (Historical and Forecast)**

2.10.1 Transpacific aircraft movements records for the period July 1-7 were provided by the Anchorage and Oakland Air Traffic Control Centres and the Tokyo/Naha Air Traffic Control Centre for each year from 1989 to 2003. The analysis of these peak week records is summarized in **Appendix B. Tables B-1 to B-6.**

Prior to the events of September 2001, conflict in the Middle East, and world health issues, Asia/Pacific traffic growth fluctuated between 6 and 8 percent as noted by the Asia/Pacific area traffic forecasting group. While these events had a short-term negative impact, traffic now is back to these levels.

Continued Asia/Pacific growth was recognized at the Asia/Pacific Air Navigation Planning and Implementation Group (APANPIRG/16) held in Bangkok, Thailand, from August 22 to 26, 2005. There was steady growth of the aviation industry, such as the existence of 812 air

carriers worldwide by the end of 2004, and a growth of about 32 percent in the last 10 years in terms of aircraft numbers. The financial commitment in terms of jet aircraft orders placed with major aircraft manufacturers in 2004 was estimated to be about $65 billion. But these figures were very conservative compared to industry predictions--Boeing projection was that the next 20 years would see a $2.1 trillion market with Asia/Pacific region enjoying the largest share of 36 percent.

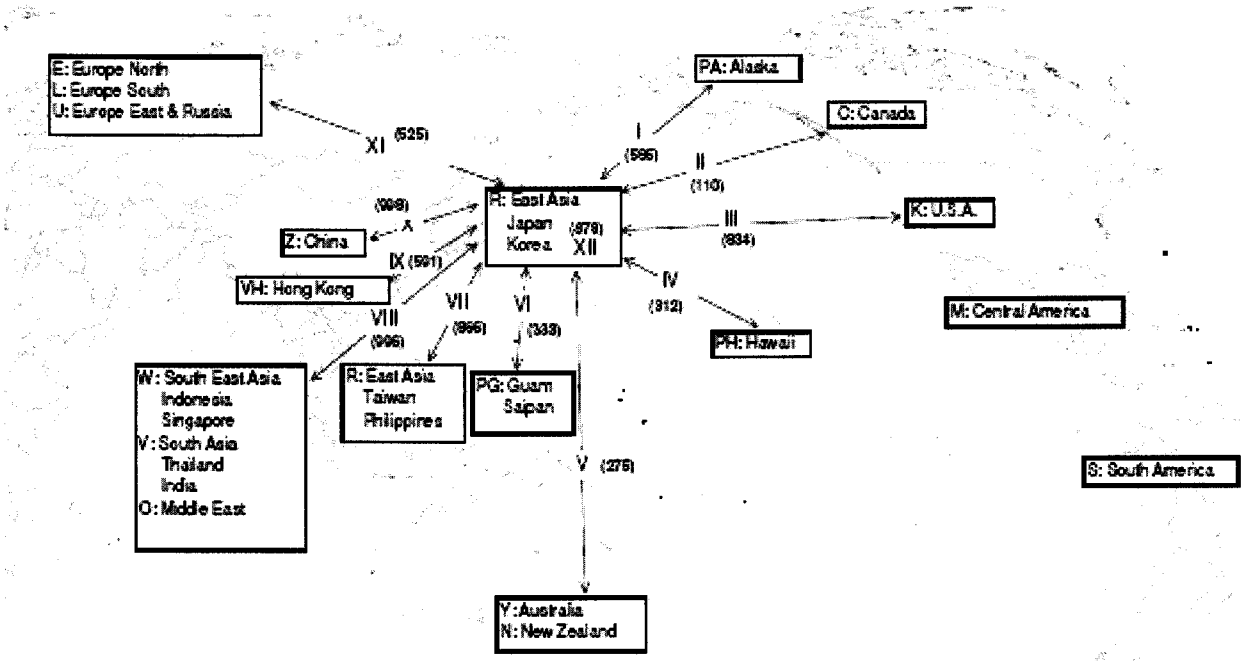
9.2 Intra-Asian Forecast. This presents the most meaningful information and is set forth below.

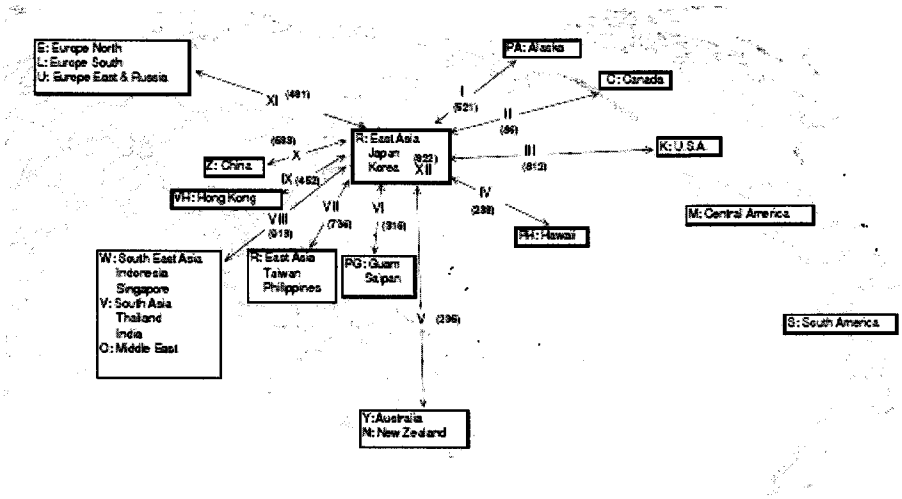
Intra-Asia passenger aircraft movements were forecast to increase from 662 thousand in 2002 to some 766.6 in 2005, equivalent to an average annual growth rate of 5.0 percent. For the period 2002 to 2020, aircraft movements are forecast to increase at an average annual growth rate of 4.6 percent.

The top 41 city-pairs in terms of numbers of passengers in the Asia/Pacific and Transpacific are expected to show traffic increases in aggregate terms of passenger flow at an average annual growth rate of 4.9 percent from 2002 to 2007. This growth will result in an increase in passenger traffic on the routes concerned from some 46.6 million passengers in 2002 to 59.2 million passengers in the year 2007 (Table 12).

Note: The following four maps/figures/tables originated in ICAO Doc ASIA/Pacific Area Traffic Forecasts 2004-2020.

ZONE PAIR TRAFFIC MOVEMENTS
(To/from/through Tokyo Naha FIR, from July 1 to July 7, 2002)




E: Europe North
L: Europe South
U: Europe East & Russia
PA: Alaska
C: Canada
R: East Asia
Japan
Korea
K: U.S.A.
Z: China
VH: Hong Kong
M: Central America
PH: Hawaii
W: South East Asia
Indonesia
Singapore
V: South Asia
Thailand
India
O: Middle East
R: East Asia
Taiwan
Philippines
PG: Guam
Saipan
S: South America
Y: Australia
N: New Zealand

TOP 41 CITY-PAIRS
INTRA ASIA/PACIFIC AND TRANSPACIFIC

City-Pairs	1984	1994	1995	1996	1997	1998	1999	2000	2001	2002	Average Annual Growth (%) 1984-1994	Average Annual Growth (%) 1994-2002	Passenger Forecast 2007	Average Annual Growth (%) 2002-2007
LONG HAUL CITY PAIRS														
Tokyo-Sydney	144,609	484,063	449,489	459,760	444,943	416,230	424,600	435,884	426,670	475,909	12.8	-0.2	512,689	1.5
Hong Kong-Sydney	179,077	395,433	468,561	507,044	513,448	562,716	584,048	485,792	607,290	599,699	8.2	5.3	913,940	6.3
Singapore-Sydney	225,185	449,662	473,706	497,062	549,189	622,026	702,500	955,525	1,003,607	1,042,987	7.2	11.1	1,483,466	7.3
Singapore-Melbourne	147,848	311,462	334,714	335,520	363,138	453,635	519,168	569,924	669,349	726,487	7.7	11.2	1,028,494	7.2
Tokyo-Singapore	328,380	1,106,410	1,163,384	1,208,699	1,188,226	1,035,429	1,400,114	1,275,903	1,136,324	1,155,667	12.9	0.5	1,307,531	2.5
Singapore-Osaka	166,046	396,170	522,481	565,173	550,937	476,218	480,181	504,965	431,091	401,626	9.1	0.2	430,536	1.4
Tokyo-Bangkok	264,691	881,147	1,049,392	1,172,964	1,227,528	1,254,049	1,435,434	1,607,319	1,512,283	1,675,610	12.8	8.4	2,242,344	6.0
Singapore-Perth	162,811	431,925	439,395	417,339	470,573	524,126	549,846	635,704	745,961	779,347	10.2	7.7	1,106,484	7.3
Singapore-Taipei	113,227	325,002	339,766	351,957	340,637	528,127	342,085	754,447	620,669	621,149	11.1	8.4	879,366	7.2
Tokyo-Manila	494,323	680,963	655,574	684,605	668,399	729,057	665,523	983,931	959,492	936,846	3.3	4.1	1,173,079	4.6
MEDIUM HAUL CITY PAIRS														
Hong Kong-Tokyo	1,242,588	1,881,383	2,042,946	2,323,710	1,890,076	1,680,856	1,851,299	2,037,093	1,968,033	1,972,643	4.2	0.6	2,354,221	3.6
Hong Kong-Singapore	705,752	1,382,533	1,355,247	1,552,893	1,439,631	1,449,774	1,476,200	1,899,685	1,859,566	1,823,950	7.0	3.5	2,383,630	5.5
Hong Kong-Kuala Lumpur	133,173	399,709	410,977	426,233	455,590	449,260	514,642	569,717	525,655	647,710	11.6	6.2	908,447	7.0
Bangkok-Taipei	56,463	371,654	418,009	398,001	395,095	429,414	472,341	530,173	529,802	463,696	20.7	2.9	575,093	4.4
Hong Kong-Osaka	440,932	667,753	707,908	958,546	723,938	658,533	613,998	717,036	541,655	606,027	4.2	-1.2	702,551	3.0
Tokyo-Saipan	115,902	505,732	526,470	539,673	496,394	413,235	479,252	487,904	411,735	421,992	15.9	-2.2	520,866	4.3
Tokyo-Taipei	780,554	1,033,441	965,328	966,169	990,073	976,126	1,042,776	1,148,199	1,449,833	1,661,509	2.8	6.1	2,233,981	6.1
Tokyo-Beijing	132,947	502,946	546,462	718,095	718,671	640,479	744,193	722,943	796,773	756,934	14.2	5.2	1,076,606	7.3
Sydney-Auckland	479,470	661,607	729,899	761,023	749,137	738,759	780,370	937,056	1,011,430	1,016,695	3.3	5.5	1,360,554	6.0
Seoul-Hong Kong	270,530	979,681	1,027,093	1,077,145	1,040,657	1,115,635	1,256,849	1,326,504	1,407,756	1,379,683	13.7	4.4	1,735,852	4.7

City-Pairs	1984	1994	1995	1996	1997	1998	1999	2000	2001	2002	Average Annual Growth (%) 1984-1994	Average Annual Growth (%) 1994-2002	Passenger Forecast 2007	Average Annual Growth (%) 2002-2007
SHORT HAUL CITY PAIRS														
Hong Kong-Bangkok	933,472	1,796,119	1,845,993	2,142,767	1,965,020	1,977,001	2,131,137	2,036,646	1,996,351	2,068,146	7	2	2,492,114	3.8
Seoul-Taipei	239,573	595,425	522,925	459,411	411,553	350,846	369,444	418,119	479,085	475,928	9.6	-2.8	517,781	1.7
Singapore-Bangkok	665,235	1,493,357	1,498,115	1,617,474	1,596,352	1,734,973	1,860,183	2,131,251	2,265,875	2,506,383	8.4	6.7	3,515,332	7.9
Tokyo-Seoul	836,516	2,189,367	1,909,898	1,897,946	2,037,653	2,046,135	2,274,812	2,496,117	2,601,310	2,437,427	10.1	1.4	2,994,899	3.5
Hong Kong-Manila	584,655	1,206,597	1,344,499	1,460,368	1,402,990	1,426,405	1,430,977	977,161	789,995	740,736	7.5	-5.9	950,411	2.8
Singapore-Jakarta	584,457	1,615,182	2,043,976	2,154,659	2,205,236	1,141,702	1,353,264	1,509,493	1,867,706	1,956,691	10.7	2.4	2,936,166	5.9
Seoul-Osaka	360,634	545,528	637,612	922,536	1,090,874	1,113,023	1,308,409	1,522,414	1,447,360	1,632,622	3.7	14.7	1,920,360	3.3
Hong Kong-Taipei	663,696	2,462,816	2,556,230	2,436,237	2,343,355	2,383,717	2,466,867	2,759,426	2,622,293	2,696,445	11.0	1.1	3,346,694	4.4
Singapore-Penang	331,379	650,528	611,463	657,403	643,718	543,662	590,267	620,614	615,343	572,117	7.0	-1.6	647,299	2.5
Singapore-Kuala Lumpur	1,316,148	2,319,779	2,394,079	2,541,516	2,607,266	2,131,269	2,065,162	2,180,393	2,190,116	2,027,229	5.6	-1.7	2,262,454	2.4
TRANSPACIFIC CITY PAIRS														
Tokyo-Honolulu	979,715	2,149,991	2,264,427	2,292,193	2,207,626	1,912,596	1,973,916	1,776,673	1,538,565	1,664,602	9.3	-3.1	2124756	5.0
Tokyo-Los Angeles	677,653	1,023,293	1,112,397	1,282,234	1,339,942	1,203,679	1,603,926	1,659,323	1,393,749	1,560,999	4.2	5.4	2138704	6.5
Tokyo-Guam	382,042	957,834	859,986	829,222	949,943	912,310	892,998	993,439	781,023	923,733	9.4	-0.5	1076896	5.5
Tokyo-San Francisco	419,664	744,399	799,694	842,579	824,339	743,696	930,265	905,590	859,598	953,169	5.9	3.1	1251869	5.6
Honolulu-Osaka	458,639	810,346	915,818	1,071,668	1,059,377	946,292	753,771	946,995	640,386	740,927	5.9	-1.1	897125	3.9
Tokyo-New York	400,631	698,230	752,085	714,745	742,693	714,435	699,623	937,721	841,236	1,026,869	5.7	5.0	1,353,859	5.6
Hong Kong-San Francisco	183,433	424,746	524,953	574,435	514,000	362,461	452,254	493,199	572,607	634,841	9.8	5.2	761,335	3.7
Tokyo-Chicago	215,601	439,782	445,446	467,894	462,607	549,146	679,347	759,332	669,677	706,797	7.4	6.1	954,611	6.2
Los Angeles-Seoul	205,628	675,521	667,126	693,658	782,979	700,390	794,669	868,968	780,346	773,832	12.6	1.7	884,095	2.7
Los Angeles-Sydney	125,778	564,416	584,170	635,657	793,281	792,705	763,731	804,572	719,970	731,490	16.2	3.3	942,512	5.2
Hong Kong-Vancouver	113,579	423,387	339,039	471,402	520,629	512,799	499,658	525,675	614,093	732,511	14.1	6.5	935,692	5.9
TOTAL ALL ROUTES	17,443,255	33,135,435	39,316,021	42,976,892	41,616,084	39,244,166	42,637,523	45,227,525	44,740,336	46,603,635	9	2.9	59,223,523	4.9

While individual city pairs can reflect a growth of less than 5 percent, the cumulative effect remains at 5 percent.

10.0 Alternatives for Resumption of ANSP Responsibilities

Having determined the overall objective, airspace, traffic flows, and demands, two transition alternatives are possible and they are as follows:

10.1 Alternative 1. The *early resumption of Sector C responsibility to be accomplished by* using the present infrastructure and procedures. This is possible only after all Natuna infrastructure and support activities have been returned to ICAO and regional plans (APANPIRG agreements) standards.

10.2 Alternative 2. The resumption of control in Sector C to be accomplished by following Alternative 1 activities immediately with implementation of CNS/ATM programs.

11.0 Alternatives: Discussion and Recommendation

Actions necessary for transition to Indonesian ANSP responsibilities for the Natuna Islands Airspace.

11.1 Alternative Number 1

11.1.1 Early Resumption Term Meaning

Actions needed prior to *early resumption* of Sector C responsibility. "Early resumption" is a possible alternative wherein Indonesia first assures the integrity of the infrastructure, procedures, staff capabilities and organization supporting the Natuna Airspace with only minimal development of a state-of-the-art CNS/ATM system. The effect of Alternative 1 is to resume control of the Natuna Islands airspace as quickly as possible doing nothing more that assuring the integrity of the support systems. No substantive change CNS/ATM programs would be implemented.

11.1.2 Alternative 1 Objective

The objective of Alternative 1 is to make the earliest transition to DGAC responsibility for the Natuna Islands airspace. This early transition would be accomplished by restoring certification status to all components of the Natuna Islands support infrastructure, training and introducing DGAC staff to their new duties, allowing a period of system component "burn in" and experience for staff prior to the introduction of greater change and new CNS/ATM systems. (Exception = introduction of Digital ATIS and Pre-Departure Clearance.)

11.1.3 Discussion

Prior to assuming ANSP responsibilities for the Natuna airspace, at a minimum, the following actions must be accomplished. The ORDD is the date when these pre-transition actions are complete and Indonesia DGAC starts providing the full range of ANSP services. The ORDD will be set after careful study of the work required, consultation with all stakeholders, and approval by appropriate authority in the Republic of Indonesia.

The proposed timeline is purposefully aggressive in order to demonstrate the importance of the goal as well as to underscore the critical need for remedial action detailed in a number of steps. For example, it is of the utmost importance that the integrity of navigational aids is properly documented through certification after flight inspection and accurate information is disseminated to system users.

11.2 Preparations for Sector C Airspace Transfer and Resumption of ANSP Duties by the Republic of Indonesia

11.2.1 Step 1 to be Accomplished in CY- 2007

11.2.1.1 Executive Direction

DGAC should issue a written statement to subordinate offices outlining the task objective. It will cite the purpose of the transition, the goal Indonesia wishes to accomplish, and the supporting activities to be accomplished with the resumption of ANSP responsibilities for Natuna Island's airspace. The office of principal responsibility must be identified and this will be accomplished with the release of the statement.

Other DGAC offices must be directed to provide needed support. Inter-office cooperation is essential in all matters and will be closely monitored. Program success is based on action not just planning. Therefore, every office is expected to support the Airspace transition; accordingly the completion date should be a "millennium type date", i.e., there will be no sliding the date forward. The Director General is encouraged to direct his staff to ensure that all members of the DGAC organization understand the national interest and benefit associated with the resumption of Indonesia's sovereign airspace.

The management and planning staff should be directed to accomplish as many tasks in parallel as possible rather than in sequence. Such scheduling allows many tasks to be accomplished at the same time rather than waiting for sequential completion of each task.

11.2.1.2 Formulate a Transition Team Dealing Solely with Operational Issues

The DGAC transition team is an internal work group comprised of a small number, six members or less, of responsible managers dedicated to the successful completion of this transition. Their responsibilities would include but not be limited to:

A. Begin briefings and coordination with all parties/stakeholders:

1. Neighboring states--Singapore and Malaysia.
2. ICAO, IATA, IFALPA, IFATCA.
3. APII, user community.

B. Develop an action plan showing all tasks, timelines, and those accountable.

C. Establish rules for meetings, schedule for meetings, and the keeping of minutes.

D. Regular information sharing with all stakeholders is essential. An office responsible for the regular dissemination of project information is identified at the outset.

11.2.1.3 CNS Infrastructure Actions Include:

Project leadership should be clarified at the outset thereby resolving problems inherent in organizations having multiple and uncoordinated management systems.

NOTE: The present management structure dividing responsibilities among AP 1, 2, and the DGAC does not appear to be working to the benefit of all involved and we strongly recommend that a change be made to a single technically competent and administratively strong organization. For simplicity's sake, the following assumes DGAC in the leadership role of that organization.

1. The DGAC office responsible for the maintenance of CNS facilities should, as a first action, establish an aggressive schedule to inspect and ensure all facilities supporting the Natuna airspace operate at the required levels. **Note:** APANPIRG/15 developed regional plans (APANPIRG agreements) procedures that would establish a data base of navigational aids requiring attention.

2. The zero spares policy should be reviewed and modified to ensure critical spares are stocked and the most outage prone items are readily available. Continuation of absolute adherence to a zero spares policy exposes Indonesia to significant criticism. Appendix 1 cites a specific list of spare parts most likely to suffer failure as well as average market prices of these parts.

3. DGAC should assume the lead for a CNS facilities' quality assurance (QA) team representing all maintenance disciplines. This team of subject matter experts, engineers, and technicians is formed for the purpose of ensuring the integrity and availability of all CNS facilities serving Natuna airspace.

4. Flight inspections should be accomplished on a priority basis of all CNS facilities serving Natuna airspace. These flight inspection and certification reports should be expedited for the use of the QA team for any additional refurbishment required.

5. CNS and automation equipment systems requiring onsite reviews and renovation include:

- 3 VORs
- 3 radars
- VSAT systems
- All inter- and intra-facility communication systems serving Sector C
- VHF communication equipment – frequencies published as serving Sector C
- Backup communication systems
- Power conditioning systems
- Emergency radios

11.3 Natuna ACC Automation Systems In general, it can be said that the required ATM Automation System will consist of an Air Traffic Management function, Weather Information Analysis and Display function, E-MSAW, CA, Traffic Flow Management programs such as TMA, and Controller's Training and Backup functions if not already in place. Each of these automation systems will be discussed later in Task 2. It is suggested that during any Quality Assurance review of ACC automation equipment special attention be paid to the documentation of abnormal automation failures. Additionally, all references to air traffic automation problems involving operational errors or service interruptions should be included. Appropriate follow-up would then, of course, be taken.

Specific nomenclature for software is dependent on the individual vendor's product.

11.4 Natuna Airspace Transition Activities

11.4.1 Documentation

Prior to the ORDD, the following information should be recorded: document /validate traffic flow, i.e., volume, speed, separation standards applied, and any other information necessary for the documentation of a base case. This information may be necessary if accusations of inefficient service arise.

11.4.2 Validation

Early emphasis should be put on the quality of AIP information, regarding Natuna and Sector C. All published aeronautical information should be verified and publications updated. Special attention should subsequently be given to the continued currency of the Indonesian AIP information.

11.4.3 Timeline and Exception

In order to expedite DGAC's resumption of ANSP responsibility for the Natuna Islands airspace, construction and/or relocation of a new ACC and/or Central Air Traffic Command Center (CATCC) are not considered in Alternative 1. Further, a complete CNS/ATM transition is not considered. Both of these actions would add significantly to the timeline. DGAC should, however, Implement Pre-Departure Clearance (PDC) and Digital ATIS equipment and procedures.

11.4.5 Timeline

The timeline used in this TA coincides with the Indonesian Master Plan with the exception of the initial period dedicated to restoration of systems serving the Natuna Airspace. CNS/ATM development policy for Indonesia is; in the short term present time to 2009, mid term is 2010 to 2015 and long term is 2016 to 2025. It is important that common timelines be used in the development of Indonesia's Master Plan, regional plans (APANPIRG agreements) and all other CNS/ATM programs.

11.5 CNS/ATM Actions in Concert with Regional Plans (APANPIRG Agreements) and Neighboring ANSP Plans

11.5.1 Communication

11.5.2 Communication Requirement Determination

The basic element involved in the determination of the need for ATS air-ground communications channels is based on the time a controller has available for issuance of ATC instructions. It is generally accepted that, when a frequency exceeds 60 percent use of available time, it is saturated and another frequency/operating position is required.

ATS radio control positions are that part of an ATS unit performing a specific ATS function requiring the direct and unrestricted access to VHF air-ground communications channel. At present, this is met by the assignment of a discrete channel per ATS radio control position. Specifically, the DGAC has addressed this need when it established two operating positions in the Jakarta ACC solely for the Natuna Islands airspace.

Further consideration of communication requirements raises the question of what constitutes a Sector and how is that need resolved. A sector is defined portion of airspace within which air traffic services are provided by one or more ATS radio control positions. Again, the DGAC has addressed this need when it established two operating positions in the Jakarta ACC solely for the Natuna Islands airspace.

Further, when studying the need for establishment of new sectors requiring ATS communications (Sector discrete frequencies), the following factors should be and were considered:

- amount of traffic;
- configuration of the airspace;
- method of control used; e.g., radar or procedural;
- effects on the total communication load resulting from systematic reduction of air-ground communications;
- special national requirements; and
- average capability of the control personnel.

11.5.3 Communications Equipage in Place

- The VHF communications facility is already located on Natuna Islands and should be commissioned as a VHF-ER facility.

- Assumption #1 – frequency 119.5 MHz has frequency protection and main/standby redundancy

- Assumption #2 – extended range frequency 119.0 MHz located at Pontianak also provides coverage throughout most of Sector C airspace South of Natuna.

- A proposed additional extended range VHF frequency 122.2 MHz at Tanjungpandan will also provide communications coverage in the Southwestern area of Sector C.

- High Frequency (HF) communications are required; the HF facilities proposed on Batam could be commissioned or a new HF facility could be co-located with VHF facility on Natuna.

- An additional VHF frequency will not be needed if a single sector is used for ATS in Sector C.

- Aeronautical Fixed Telecommunication Network (AFTN) circuits or its successor technology will not be required according to discussions with DGAC.

- CPDLC and ADS data link are currently used by Singapore ACC to provide service to FANS-1 equipped aircraft over the South China Sea beyond the range of their existing radar and VHF voice communications.

11.5.4 Spectrum Saturation

Communication frequency spectrum saturation is not a problem at this time and there is an option of utilizing 8.33 MHz spacing. This is a viable option until the business case for data link improves or the operation requires CPDLC.

11.5.5 Very Small Aperture Terminal (VSAT) is the fundamental means for the transfer of data/information to and from the facilities involved in the operation of Sector C. Therefore, the immediate upgrade of VSAT is a priority issue notwithstanding the need to upgrade the entire Indonesian VSAT system.

VSAT is an earthbound station used in satellite communication of data and voice. A VSAT consists of two parts, a transceiver that is placed outdoors in direct line of sight to the satellite and a device that is placed indoors to interface the transceiver with the system user's communications device, such as a PC. The transceiver receives or sends a signal to a satellite transponder in the sky. The satellite sends and receives signals from a ground station computer that acts as a hub for the system. Each end user is interconnected with the hub station via the satellite, forming a star topology. The hub controls the entire operation of the network. For one end user to communicate with another, each transmission has to first go to the hub station that then retransmits it via the satellite to the other end user's VSAT. VSAT can handle up to 56 Kbps.

11.5.6 Aeronautical Information Publication (AIP) information, regarding Natuna, should be verified and publications updated accordingly. Special attention should be given to the currency of AIP information as a first order of business.

11.6 Navigation Systems

11.6.1 Legacy Navigation Systems

- Angkasa Pura II operate three Doppler VOR/DME facilities providing VOR/DME navigation coverage throughout the Sector C airspace. The facilities are located at Natuna/Ranai (NTA) in the Natuna Islands, Pontianak (PNK), Borneo and Tanjung Pinang (TPG), off the central Eastern coast of Sumatra.

- These legacy facilities should continue to be maintained into the foreseeable future in order to serve the transitioning user community. Legacy navigation systems should be phased out of service as soon as the user fleet equipage will allow. The user community should be incentivized to speed the progress to closure since serious cost avoidance economies are to be had through the proliferation of GPS systems.

- Aircraft equipped with RNAV systems are currently allowed to operate on the RNAV routes in the revised South China Sea ATS route structure. Ten of these routes are through Sector C airspace.

- All navigation systems must be maintained in accord with ICAO standards if RNP procedures are to be used. RNP en route is outlined in ICAO Annexes 2, 4, 6, 11, 15 and PANS-ATM. Doc 9613, Manual on Required Navigation Performance, also provides guidance.

11.7 Surveillance. The "gold standard" in surveillance is radar. There are new surveillance innovations, which in time may be operationally effective and cost efficient. However, traditional radar remains the recommended choice until systems such as ADS are fully available. At the forefront of new systems is ADS-B. DGAC has initiated an ADS-B evaluation with Airservices Australia and SITA.

In the case of this TA, Natuna's MSSR can fill the surveillance gap presently in Sector C providing Indonesia a tremendous strategic ANSP position. The Natuna MSSR could provide the missing link of a radar chain from north of Natuna to Singapore and later on to Jakarta.

11.7.1 Surveillance issues relevant to Sector C:

- Angkasa Pura II operates three dual channel secondary surveillance radar facilities providing radar coverage throughout Sector C airspace. They are at the same general locations as the VOR/DME facilities.

- Radar data from Natuna/Ranai MSSR is sent to Jakarta ACC via PCSI Clarity VSAT. Since this MSSR is not currently being used for air traffic control, certification is required.

- Air Traffic Services currently provided by Singapore ACC in Sector C are primarily procedural control.

- The addition of Natuna/Ranai MSSR will give Jakarta ACC the opportunity to provide radar service throughout Sector C.

- The long range radar facilities at Potianak, Borneo and Tanjung Pinang, and Sumatra are SSRs.

- An MSSR is presently contracted for Batam will provide additional overlap and assurance of Sector C coverage.

11.8 ATS/ATM Actions and Discussion

The following is recommended in support of Alternative 1.

1. Open discussions with Singapore ANSP authorities regarding how Singapore manages air traffic through Sector C.

2. Establish a clear understanding of resources and procedures involved.

3. Confirm the use made of radar by Singapore air traffic controllers. If radar is used solely for monitoring traffic flows, no change should be initiated. If radar monitoring of traffic is the norm, DGAC should begin radar training for air traffic controllers.

4. Indonesian controller and engineering staff would be required to make visits to Singapore in order to meet their counterparts and observe the Singapore operation and management systems. These observation visits should be guided by a checklist of information required, such as staffing levels, operational issues with other service providers, etc. Indonesia's observation of the Singapore ACC, focusing on Sector C, must include all hours of the operation so that a comprehensive understanding is achieved.

5. Draft procedures and Letters of Agreement (LOAs) must be developed to replace all present documents dealing with Natuna. In addition to procedures and LOAs, controller staff must be thoroughly conversant with new frequencies and equipment at new operating positions. Emergency/security and administrative procedures must be revamped as necessary. These documents, when consensus is reached among the signatory organizations, should be tentatively initialed as acceptable awaiting final approval by higher authority. Initially, these documents should have no changes other than revisions due to Indonesia assuming authority for its sovereign airspace. The transition should be kept as simple as possible. System improvements can be made after a successful transition and stabilization of new equipment and the workforce.

6. Begin controller and engineer training on technical issues (new procedures for controllers, equipment for engineers) as soon as possible. This training includes the revised procedures noted above and the appropriate training issues cited below.

7. ANSP staff should be provided sufficient time to familiarize themselves with new equipment. Eight hours orientation and the use of a checklist documenting all required items are suggested.

8. All controller staff, including supervisors, must be tested on new procedures and airspace. Those scoring less than 100 percent must receive additional training.

9. Flow control procedures and authority should remain unchanged since flow control is a regional plans (APANPIRG agreements) issue and should be managed accordingly. Differences on flow control decisions regarding "local" airports and sectors should be resolved through existing procedures. For example, if departure delays from Batam do not appear to be equitable, those directly involved should try to resolve the problem.

10. ATS/ATM automation support activities require review, updates, and testing.

11. All staff must be briefed on emergency, alternate airport, and security procedures.

12. Reference and emergency binders should be developed and made readily available to all staff in their respective work areas.

13. Control room supervisors should enforce a policy of professional decorum in the operating quarters; also a policy requiring the proper use and wearing of headsets should be enforced.

14. All aeronautical engineers and electrical technicians should be licensed and subsequently provided regular training.

11.9 Pre-ORDD (Operational Readiness Demonstration Date) Activities

1. Confirm charting dates support the planned (some charts will include the name of the new control facility and other operational information).

2. Ensure all aeronautical information publication (AIP) and aeronautical information is current and publication dates are in concert with the proposed start date.

3. Ensure all parties are briefed.

4. Arrange for the temporary assignment of Singapore controller staff to the Jakarta ACC for a period of 2 weeks after the transition. This would be preceded by, at least, one day of observation time for the Singapore staff prior to ORDD.

11.10 Assumption of ANSP Responsibilities Schedule

- **3 months prior**
  Publish Public Relations notices.

- **One month prior**
  As able, document/validate traffic flow, i.e., volume, speed, separation standards applied, and any other information necessary for the documentation of a base case. This information may be necessary if accusations of inefficient service arise.

- **One week prior**
  Verify all equipment frequencies and coordination circuits and backup equipment are operational.

  Verify all backup power sources are operational.

  Issue informational notices of the ORDD to remind all stakeholders.

- **48 hours prior**
  Issue NOTAMs.

  Parallel to the changeover time, Singapore monitors the operation while Indonesia actually controls Sector C traffic.

  Singapore stands down after 48 hours.

  Indonesia is solely operating with no infrastructure backup from Singapore.

- **Weekly for 2 months after ORDD**
  Weekly Quality Assurance reports

11.11 Summary of Alternative 1

In summary, Alternative 1 includes those actions required for the earliest possible resumption of Indonesia's ANSP authority over its sovereign airspace. Alternative 1 would provide greater reliability in Natuna's ANSP facilities and satisfy the user's expectations. These enhancements would provide a level of service allowing a seamless transition of service providers (for Natuna/Sector C) and general improvement in overall CNS/ATM expertise.

12.0 Alternative Number 2

Resumption of Sector C responsibility - *based on new CNS/ATM technologies and procedure.*

12.1 Objective

The objective of Alternative 2 is to re-establish the Republic of Indonesia as the ANSP for the Natuna Islands airspace. This transition would be accomplished by first, as outlined in Alternative 1, restoring certification status to all components of the Natuna Islands support infrastructure, training and introducing DGAC staff to their new duties, allowing a period of system component "burn in" and experience for staff while simultaneously introducing the new full range of CNS/ATM systems in concert with neighboring ANSPs. Advanced CNS/ATM systems and procedures would be initiated following restoration of Natuna facilities and staff to regional plans (APANPIRG agreements) standards where required.

12.2 Discussion

Prior to assuming ANSP responsibilities for the Natuna airspace, at a minimum, the following certain actions (see Alternative 1) must be accomplished. The ORDD is the date when these pre-transition actions are complete and Indonesia DGAC starts providing the full range of ANSP services. The ORDD will be set after careful study of the work required, consultation with all stakeholders, and approval by appropriate authority in the Republic of Indonesia.

12.3 Preparations for Sector C Airspace Transfer and Resumption of ANSP Duties by the Republic of Indonesia

12.4 Actions to be accomplished in CY- 2007

12.4.1 Executive Direction

DGAC should issue a written statement to subordinate offices outlining the task objective to be accomplished with the resumption of ANSP responsibilities for the airspace over Natuna Islands. The office of principal responsibility must be identified and this will be accomplished with the release of the statement.

Other DGAC offices must be directed to provide needed support. Inter-office cooperation is essential in all matters and will be closely monitored. Program success is based on action not just planning. Therefore, every office is expected to support the Airspace transition; accordingly the completion date should be a "millennium type date", i.e., there will be no sliding the date forward. The Director General is encouraged to direct his staff to ensure that all members of the DGAC organization understand the national interest and benefit associated with the resumption of Indonesia's sovereign airspace.

The staff should be directed to accomplish as many tasks in parallel as possible rather than in sequence. That is, many tasks can and should be accomplished simultaneously rather than waiting for each task to be completed before beginning the next.

12.4.2 Formulate a Transition Team Dealing Solely with Operational Issues

The DGAC transition team is an internal work group comprised of a small number, six or less, of managers responsible for the successful completion of this transition. Their responsibilities would include but not be limited to:

A. Begin briefings and coordination with all parties/stakeholders:

1. Neighboring states—Singapore and Malaysia.
2. ICAO, IATA, IFALPA, IFATCA.
3. AP II and the user community.

B. Develop an action plan showing all tasks, timelines, and those accountable.

C. Establish rules for meetings, schedule for meetings, and the keeping of minutes.

D. Regular information to all stakeholders is essential. An office responsible for the regular dissemination of project information is identified at the outset.

12.4.3 CNS Infrastructure Remedial Actions Include:

NOTE: The present management structure dividing responsibilities among AP 1, 2, and the DGAC does not appear to be working to the benefit of all involved and we strongly recommend that a change be made to a single technically competent and administratively strong organization. For simplicity's sake, the following assumes DGAC in the leadership role of that organization.

1. The DGAC office responsible for the maintenance of existing CNS facilities should establish an aggressive schedule to inspect and ensure all CNS facilities supporting the Natuna airspace operate at required levels of integrity.

2. The zero spares policy should be reviewed and modified to ensure critical spares are stocked and the most outage prone items are readily available. Appendix 1 cites a specific list of spare parts most likely to suffer failure as well as average market prices of these parts.

3. DGAC should assume the lead for a CNS facilities' QA team representing all maintenance providers. This team of subject matter expert engineers and technicians is formed for the purpose of restoring, as necessary, all CNS facilities serving Natuna airspace.

4. Flight inspections should be accomplished on a priority basis of all CNS facilities serving Natuna airspace. These flight inspection and certification reports should be expedited for the use of the QA team for any remediation required.

5. CNS/Automation Equipment/systems requiring onsite reviews and restoration include:

- 3 VORs
- 3 radars
- VSAT systems
- All inter- and intra-facility communication systems serving Natuna
- VHF communication equipment – frequencies published as serving Natuna
- Backup communication systems
- Power conditioning systems
- Emergency radios

12.5 Jakarta ACC Software/Automation Systems. In general, it can be said that the required ATM Automation System will consist of an Air Traffic Management function, Weather Information Analysis and Display function, URET, E-MSAW, CA, ATM data recording, and Controller's Training and Backup functions if not already in place. Each of these automation systems will be discussed later in Task 2. It is suggested that during the Quality Assurance review of the Jakarta ACC equipment special attention be paid to the

documentation of abnormal automation failures. Appropriate followup would then, of course, be taken.

Specific nomenclature for software is dependent on the individual vendor's product.

12.6 Transition Actions, Documentation and Validation

12.6.1 Documentation

Prior to ORDD, the following information should be recorded: document/validate traffic flow, i.e., volume, speed, separation standards applied, and any other information necessary for the documentation of a base case. This information may be necessary if accusations of inefficient service arise.

12.6.2 Validation

Early emphasis should be put on the quality of AIP information, regarding Natuna and Sector C. All published aeronautical information should be verified and publications updated. Special attention should subsequently, after verifying the Natuna information, be given and ensure the currency of the Indonesian AIP information.

12.7 CNS/ATM Actions in Concert with Regional Plans (APANPIRG Agreements) and Neighboring ANSP Plans

12.7.1 Communication

12.7.2 Communication Requirement Determination

The basic element involved in the determination of the need for ATS air-ground communications channels is based on the time a controller has available for issuance of ATC instructions. It is generally accepted that, when a frequency exceeds 60 percent use of available time, it is saturated and another frequency/operating position is required.

ATS radio control positions are that part of an ATS unit performing a specific ATS function requiring the direct and unrestricted access to VHF air-ground communications channel. At present, this is met by the assignment of a discrete channel per ATS radio control position. Specifically, the DGAC has addressed this need when it established two operating positions in the Jakarta ACC solely for the Natuna Islands airspace.

Further consideration of communication requirements raises the question of what constitutes a Sector and how is that need resolved. A sector is defined portion of airspace within which air traffic services are provided by one or more ATS radio control positions. Again, the DGAC has addressed this need when it established two operating positions in the Jakarta ACC solely for the Natuna Islands airspace.

Further, when studying the need for establishment of new sectors requiring ATS communications (Sector discrete frequencies), the following factors should be and were considered:

- amount of traffic;
- configuration of the airspace;
- method of control used; e.g., radar or procedural;
- effects on the total communication load resulting from systematic reduction of air-ground communications;
- special national requirements; and
- average capability of the control personnel.

12.7.3 Communications Equipage in Place

- The VHF communications facility already located on Natuna Island should be commissioned.

- Assumption #1 – frequency 119.5 MHz has frequency protection and main/standby redundancy

- Assumption #2 – extended range frequency 119.0 MHz located at Pontianak also provides coverage throughout most of Sector C airspace South of Natuna.

- A proposed additional VHF-ER frequency 122.2 MHz at Tanjungpandan will also provide communications coverage in the Southwestern area of Sector C.

- High Frequency (HF) communications are required; the HF facilities proposed on Batam could be commissioned or a new HF facility could be co-located with VHF facility on Natuna.

- An additional VHF frequency will not be needed if a single sector is used for ATS in Sector C.

- Aeronautical Fixed Telecommunication Network (AFTN) circuits will not be required according to DGAC officials.
- CPDLC (a data link is commonly referred to as CPDLC) and ADS data link are currently used by Singapore ACC to provide service to FANS-1 equipped aircraft over the South China Sea beyond the range of their existing radar and VHF voice communications.

Communication frequency spectrum saturation is not a problem at this time and there is an option of 8.33 MHz spacing. This is a viable option until the business case for data link improves or the operation requires CPDLC (that data link beyond FANS-1).

12.7.4 Very Small Aperture Terminal (VSAT) is the fundamental means for the transfer of data/information to and from the facilities involved in the operation of Sector C. Therefore, the immediate upgrade of the Natuna Islands VSAT is a priority issue notwithstanding the need to

upgrade the entire Indonesian VSAT system to meet the performance requirements for data link application. Recent discussions with DGAC representatives indicate the improved status of the VSAT system. Further agreement was reached calling for more quality assurance audits of the VSATs assuring operation within specifications.

12.7.5 Aeronautical Information Publication (AIP) information, regarding Natuna, should be verified and publications updated accordingly. Special attention should be given to the currency of AIP information.

These services are available via Inmarsat-3 Satellites and provide voice and data for Natuna's ADS-C communication link. AMSS Data 2 (nominally 600 or 10,500 bps) is part of the surveillance system backup with the Natuna MSSR being primary. If Natuna were to require the backup surveillance system, AMSS-2 could provide voice or data with approximately 2000 air carrier aircraft equipped to send Aircraft Communications, Addressing, and Reporting System (ACARS) data link using AMSS-2. This is the only satellite service currently approved for ATS use supporting FANS-1/A services. It is recommended that AMSS be used as the ADS-C communication system when Natuna surveillance and HF comm is out of service.

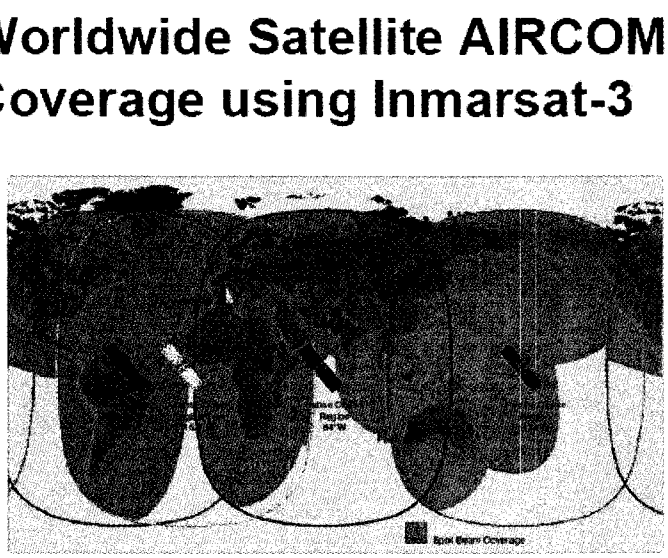


Figure 2. Inmarsat

12.8 Navigation Systems

12.8.1 Legacy Navigation Systems

- Angkasa Pura II operate three Doppler VOR/DME facilities providing

VOR/DME navigation coverage throughout the Sector C airspace. The facilities are located at Natuna/Ranai (NTA) in the Natuna Islands, Pontianak (PNK), Borneo and Tanjung Pinang (TPG), off the central Eastern coast of Sumatra.

- These legacy facilities should continue to be maintained into the foreseeable future in order to serve the transitioning user community. Legacy navigation systems should be phased out of service as soon as the user fleet equipage will allow. The user community should be incentivized to speed the progress to closure since serious cost avoidance economies are to be had through the proliferation of GPS systems.

- Aircraft equipped with RNAV systems are currently allowed to operate on the RNAV routes in the revised South China Sea ATS route structure. Ten of these routes are through Sector C airspace.

- All navigation systems must be maintained in accord with ICAO standards if RNAV/RNP procedures are to be used.

12.8.2 Global Positioning System (GPS). Indonesia is already deeply involved with its regional plans (APANPIRG agreements) ANSP neighbors establishing the Global Navigation Satellite System (GNSS). Indonesia's task is the establishment of a Ground Monitor Station (GMS) and a Master Control Station (MCS) in Jakarta at Latitude (deg) -6.17 N, Longitude 106.80 E.

- In keeping with regional plans (APANPIRG agreements) and as described in the USTDA/MITRE study, SATNAV will become the primary means of navigation in the region. As part of that planning effort, Australia, a regional leader in ANSP services, has approved the use of GPS as a primary means of navigation in Australian airspace. For some types of aircraft and operations, this allows GPS to be used as the only means of navigation. Accordingly, pilots of appropriately equipped aircraft plan and conduct IFR flights without requiring any ground navigation aid, such as NDB, VOR (VHF Omni-Directional Range), or ILS. Elimination of legacy navigational devices represents significant savings to services providers. Proliferation of GPS throughout the region is expected in the immediate future. The following table (Table B1) from The Asian Regional Plans Navigation Feasibility Study, by USTDA, MITRE, Indonesia and others, highlights the value of making the transition to GNSS.

- A future alternative could be through the Japanese MSAS (Multi-Functional Transport Satellite-Based Augmentation System). However, that system is presently not operational.

Table B.1. Summary of GNSS NPV and Internal Rates of Return (IRR), by Economy

Economy	NPV ($000)			IRR		
	GPS	SBAS	GRAS	GPS	SBAS	GRAS
Thailand	$ 998,138	$ (838)	$ (48,023)	+	2.6%	-
Korea	$ 886,280	$ (1,050)	$ (57,010)	+	2.8%	-
Malaysia	$ 615,275	$ (769)	$ (44,738)	+	1.3%	-
Indonesia	$ 1,042,338	$ 7,518	$ (75,119)	+	31.3%	-
Philippines	$ 265,740	$ (2,383)	NA	+	-	NA
Vietnam	$ 191,964	$ (1,265)	$ (56,804)	+	-	-
Chinese Taipei	$ 642,891	$ (1,737)	$ (40,255)	+	-	-
Singapore	$ 431,303	$ (2,791)	NA	+	-	NA
Hong Kong	$ 530,702	$ (2,812)	NA	+	-	NA

GRAS was not considered for the Philippines, Singapore, or Hong Kong. The "+" under GPS indicate that IRR could not be calculated (no positive IRR) since benefits always exceed costs. The "-" under GRAS indicate that IRR could not be calculated since costs always exceed benefits, unless benefits not modeled in this study are included. For SBAS, "-" for the Philippines, Chinese Taipei, Vietnam, Singapore, and Hong Kong also imply negative returns (no positive discount rate sets the NPV of SBAS to 0).

The use of SBAS without installing ground stations, as discussed in Sections 3, 7, and 13, will incur costs similar to GPS, but benefits similar to SBAS. The effect of implementing SBAS without installing a ground station can be seen in the Tornado diagrams presented later in this appendix for each Economy.

B-1

Table 2. MITRE GNSS Asia Pacific Study

Reduced dependence on legacy navigational facilities will bring significant cost reductions to Indonesia and system users. Special consideration should be given for operation of military aircraft in all aspects of CNS.

Economies are also achieved by the user community who are required to carry onboard less equipment. Avionics that comply with Technical Standard Order (TSO) C145a/146a are sufficient; there is no longer a requirement to carry a ground-based navigational system. TSO C-145 refers to airborne navigation sensors that use GPS augmented by Wide Area Augmentation System (WAAS). TSO C-146 refers to stand-alone airborne navigation equipment that uses GPS augmented by WAAS.

12.8.3 Regional Plans for GPS. Indonesia's planning is for the inauguration of GPS navigation consistent with global and regional plans (APANPIRG agreements). Accordingly, Natuna will benefit from these regional plans. Indonesia is expected to carry out its commitment for the GPS plan as agreed with neighboring States. Accordingly, Indonesia will have a Ground Monitor Station (GMS) and a Master Control Station (MCS) in Jakarta. While Natuna management need not initiate an independent GNSS program, a strong working knowledge of this and other CNS/ATM programs is needed.

12.8.4 The new **Ground-Based Regional Augmentation System (GRAS)** will utilize a network of very high frequency (VHF) radio stations that will transmit radio signals that correct for inherent GPS navigation errors. While an aircraft is in the en route phase of flight, the GRAS signal improves navigation accuracy, integrity and overall safety. A GRAS reference station compares information transmitted by GPS satellites with the station's surveyed location, then links that information to the VHF transmitters for broadcast to airplanes. The aircraft's navigation system uses this information to correct its data output.

12.8.5 Airborne-Based Augmentation System (ABAS). This augmentation strategy is restated here from Task 1 because global airlines have taken the position that they do not believe there is an advantage in investing in ground or space-based augmentation systems given they have this capability onboard their aircraft today. That decision reduces an ANSP's cost, requires no action on the part of the ANSP, and causes our recommendation of ABAS.

The purpose of ABAS is to augment and/or integrate information obtained from GNSS elements with onboard aircraft information. This augmentation or integration is required to ensure that technical performance (in terms of accuracy, integrity, continuity and availability) meets the requirements of Annex 10 Chapter 3, Section A.2.4. ABAS requires use of one of the following two processing schemes: (1) Receiver autonomous integrity monitoring (RAIM) which uses GNSS information exclusively; or (2) Aircraft autonomous integrity monitoring (AAIM) which uses information from additional onboard sensors such as barometric altimeter, multi-sensor RNAV, inertial navigation, and/or a precise clock plus the GNSS information.

Integrity is achieved through the availability of sufficient redundancy in position solutions. RAIM relies only on the estimation of residual errors derived from the multiple combinations of GNSS ranging sources. AAIM uses the redundancy of position estimates from multiple sensor sources including GNSS.

The minimum RAIM function described in avionics certification standards only requires the detection of a failure or fault detection. With the minimum RAIM function, following fault detection, GNSS navigation is terminated. RAIM functionality beyond the required minimum includes exclusion of the failed satellite. This is called fault detection and exclusion or FDE. This functionality may permit the continuation of GNSS navigation following exclusion of the failed satellite. AAIM implementations are required to provide performance that is at least equivalent to RAIM. TSO-C129 requires either RAIM or AAIM, and TSO C129a adds an additional requirement for FDE.

12.8.6 GNSS Interference and Jamming. In a world of high tech terrorists, ANSPs rightfully express concern about interference and jamming. It was known from the beginning that GPS was susceptible to potential frequency interference and anomalies. The FAA and the United States Department of Defense have taken steps to reduce potential interference and anomalies to the GPS signal. The Satellite Operational Implementation Team (SOIT) has established an anomaly working group to pursue reported anomalies with GPS signals. This group uses both civil and military resources to investigate and resolve reported anomalies in the system. The reporting of detected interference has been a problem, and the FAA is investigating new methods for its interference reporting system.

There are several sources from which Radio Frequency Interference (RFI) can emanate including VHF transmissions (harmonics), television transmissions, airframe shielding, antenna location, and others. The FAA has taken a number of steps to reduce RFI. During the operational testing of GPS, it was discovered that harmonic interference from VHF transmissions could adversely affect GPS signals. Consequently, AC 20-138 was amended to include installation testing on frequencies 121.50, 121.75, 121.200, 131.250, 131.275, and 131.300. This interference was eventually overcome with filters and shunts. The FAA, in concert with Ohio University, has developed two instruments to locate RFI with GPS, one is airborne and the other is ground-based. Additionally, the U.S. National Transportation Safety Center (Volpe Center) has developed two new RFI location systems that depart from the traditional RFI location systems by emphasizing reaction speed and rapid location. The FAA is also actively involved in GPS/WAAS receiver susceptibility testing, investigating environmental sources of interference, and analyzing broadcast television spectrums. Many new initiatives have been developed to reduce RFI, and most are included in various certification and installation criteria.

It has been decided that the intentional interference or jamming of the GPS signal or an augmented signal cannot be stopped just as the intentional interference or jamming of ground-based navigational signals cannot be stopped. Attempts are being made to negate the effects of jamming with adaptive null-seeking antennas, although they may be too expensive for general aviation aircraft. Other attempts, such as monitors to cause an alarm if a new signal is detected, are also being examined. However, one must assume the same condition with GPS as with other navigational systems such as ILS, VOR, etc.; none of those have ever been jammed. It does appear, however, that intentional jamming will be a local problem, and provider states must take precautions and develop strategies to deal with intentional jamming.

12.9 Surveillance. The trend in surveillance had been to be improved radar. However, surveillance is now moving toward ADS-B as an enhancement to radar and as the primary surveillance system in remote or oceanic areas. Some ANSPs are installing ADS-B as a sole surveillance system. Alternative modes of surveillance include Monopulse Secondary Surveillance Radar (MSSR), Automatic Dependent Surveillance-Contract (ADS-C) or Multilateration. These and more were thoroughly discussed in Task 1.

Surveillance issues relevant to Sector C:

- Angkasa Pura II operates three dual channel secondary surveillance radar facilities providing radar coverage throughout Sector C airspace. They are at the same general locations as the VOR/DME facilities.

- Radar data from Natuna/Ranai MSSR is sent to Jakarta ACC via PCSI Clarity VSAT. Since this MSSR is not currently being used for air traffic control, certification is required.

- Air Traffic Services currently provided by Singapore ACC in Sector C are primarily procedural control.

- The addition of Natuna/Ranai MSSR will give Jakarta ACC the opportunity

to provide radar service throughout Sector C.

- The long range radar facilities at Potianak, Borneo and Tanjung Pinang, and Sumatra are SSR's.

- An MSSR has been reported by DGAC as contracted for Batam and the new TRACON location.

Throughout the world, ANSPs are developing the infrastructure to provide ADS-B capabilities. An example referred to earlier is ADS-B services across Australia's entire upper-level airspace. This system is to be completed by early 2007. Airservices Australia's high altitude project continues to progress satisfactorily. However, the low altitude ADS-B project ahs been suspended (summer of 2006). This will also add credence to Indonesia's DGAC ADS-B trial. DGAC's trial will consist of up to five ADS-B receivers deployed at SITA sites "that will maximize the value of the received ADS-B data providing coverage across the Flight Information Region's boundaries, thus allowing the received data to be made available to adjacent ANSPs." Regional plans urge the sharing of resources which is consistent with ICAO and IATA policy. The sharing of surveillance data is particularly encouraged.

12.10 ATS/ATM Actions

1. Open discussions must be initiated with Singapore ANSP authorities regarding how air traffic is managed through Sector C and establish a clear understanding of resources and procedures involved.

2. Visitors to the Singapore ACC should determine the use made of radar by Singapore air traffic controllers. If radar is used solely for monitoring traffic flows, no change should be initiated by Indonesia DGAC at this time. Implementation of radar services may be phased into service after all controllers have been fully trained, certified and have no less than 3 months experience monitoring traffic flows.

3. Indonesian controller and engineering staff should make visits to Singapore in order to meet their counterparts and observe the Singapore operation. These observation visits should be guided by a checklist documenting the required information, such as staffing levels, operational issues with other service providers, etc. Indonesia's observation of the Singapore ACC, focusing on Sector C, must include all hours of the operation so that a comprehensive understanding of the operational requirements is achieved.

4. Draft procedures and LOAs must be developed. In addition to procedures and LOAs, controller staff must be thoroughly conversant with new frequencies and equipment at new working positions. Emergency/security procedures must be revamped as necessary. These documents should be tentatively initialed as acceptable by the parties waiting final approval by higher authority. Initially, there should be no changes other than revisions due to Indonesia assuming authority for its sovereign airspace.

5. At the earliest possible date, DGAC should begin controller and engineer training on technical issues (new procedures for controllers and equipment for engineers/technicians). This

training includes the revised procedures noted above and the appropriate training issues cited below.

6. ANSP staff should be provided sufficient time to familiarize themselves with new equipment. Eight hours of orientation and the use of a checklist of required items are suggested.

7. All controller staff, including supervisors, must be tested on new procedures and airspace. Those scoring less than 100 percent must receive additional qualification training.

8. Flow control authority should remain unchanged since flow control is a regional issue and should be managed accordingly. Differences on flow control decisions regarding "local" airports and sectors should be decided through existing procedures.

9. ATS/ATM automation support activities require review, updates, and testing.

10. All staff must be briefed on emergency, alternate airport, and security procedure.

11. Reference and emergency binders should be developed and made readily available to all staff in their respective work areas.

12.11 Facilities Support Facilities & Systems

12.11.1 Establishment of an Air Traffic Control Center (Natuna Islands)

At the outset of this TA, Indonesia sought guidance regarding the establishment of an ACC. This ACC should be capable of servicing Sector C airspace. Central to that recommendation is an assessment of the size and workload associated with Sector C. As discussed in this TA, Sector C is quite small, approximately 250+/- miles in length, less than one hour at cruise for an airliner. Observation and review of route structure show traffic to be quite organized. The following options based on known facts and expectations for responsible expenditure of capital should be considered.

12.11.2 ACC Facility Alternatives

DGAC has a number of ACC facility alternatives including:

1- As cited in the USTDA Terms of Reference, "**construct an ACC on Natuna Islands**". The cons for this option include extra cost of construction on a remote site, difficulty enticing staff to relocate to the location, human relations and compensation issues, security, and clearly unacceptable benefit cost ratios. After extensive discussions with DGAC staff, we do not believe the government has this identified as a "must do alternative".

2- **Construct a new ACC on Batam Island**. Batam would not have all the remote location shortcomings of Natuna due to the thriving economy found there. Batam would, however, suffer many difficulties such as attracting sufficient

skilled specialists in the many disciplines required to operate a modern ACC. The government of Batam does, however, create a very positive environment for an alternate ACC to be constructed as an expansion of the planned TRACON.

3- **Construct an all new and separate ACC in Jakarta** (approx. 3,864 m2, 2-storey), and Power Plant Building (approx. 660m2, 1-storey, reinforced concrete structures).

4- **Upgrade the existing Jakarta ACC**. In 2005, the Jakarta ACC established operational positions with the installation of consoles and hardware. This established two sectors dedicated to the provision of air traffic service when Sector C airspace is reacquired from Singapore. Two sectors will be sufficient for the next 5 to 10 years. DGAC should closely monitor the operation of Sector C for significant changes in traffic volume and or routing requiring additional operating positions.

12.11.2.1 Natuna Capital Investment ACC Construction Recommendation. Alternative 4 should serve the Natuna Airspace through year 2020. In the interim, traffic demand, available technology/software, and Global CNS/ATM plans will mature. As suggested in 2 above, the Batam TRACON should be considered as an alternate ACC to be used in the event a disabling occurrence should impact the Jakarta ACC.

12.11.3 Air Traffic Flow Management Center. The RFP calls for an evaluation traffic flow management facility which initially appears to be in conflict with the Master Plan by the Japanese Civil Aviation Bureau (JCAB). The JCAB suggests establishment of an Air Traffic Flow Management Center which would be called Indonesia's CATCC which would be the focal point of all command and control activities for the DGAC.

This TA is to focus on the Natuna Airspace/Sector C and it is recognized that flow management is interconnected to all areas of Indonesia's airspace. Accordingly, establishing an independent CATCC or flow management facility for the Natuna ACC would be counterproductive and not cost effective. Therefore, our recommendation is the establishment of one Coordination/Flow Control desk within the CATCC ATFN section. This workgroup of subject matter experts would provide the point of contact for the Natuna ACC.

Traffic Management for the Natuna Airspace is needed, as evidenced by user feedback. Work is in progress to develop an air traffic flow management (ATFM) tool throughout the region and the Natuna ACC management should be directly involved as representative of their airspace. Among the issues is the user's complaint that during peak periods help is needed with the reduction of ground delays and rerouting of flights due to congestion. When viewed in context, the references to volume delays are directed outside of the Natuna operation. In order to address these issues, the future Natuna ACC should be represented by one Coordination/Flow Control desk within the regional ATFM facility.

Indonesia does not have sufficient trained and experienced staff at this time to assume the duties of developing and managing a regional ATFM facility. Training of this staff should start not less than 6 months prior to commissioning the CATCC flow control function.

Specific reasons for Indonesia's consideration of building a traffic management facility include growing traffic, the governmental leadership on Batam Island offering property and construction funding, and ATC delays particularly at Batam Island. Resolution of the latter is a matter of local leadership and follow-up on specific incidents.

The construction of the Batam TRACON offers an opportunity to combine the CATCC (emergency operation control room, flow control, etc., all as a backup to the primary facility). This new opportunity should receive serious consideration in recognition of Indonesia's seismic activity and possible utility disruption in Jakarta.

12.11.3.1 Recommendation: Construction of a Dedicated Air Traffic Management Facility

DGAC, in recognition of the Natuna Island's airspace size and volume of traffic, should:

1. Refrain from construction of a dedicated Natuna ATM facility.

2. Natuna management should support establishing the CATCC in proximity of the Jakarta ACC.

3. Develop ATM staff and procedures that serve their needs as a regional participant.

4. Select a permanent staff position that serves as the DGAC subject matter expert, regularly representing the DGAC at regional ATM meetings.

5. Hold the selected ATFM staff member responsible for resolving all incidents of poor ATFM service.

6. Assign the ATFM staff person to work an operational schedule that coincides with the heaviest traffic flows while occasionally working other shifts as assigned by upper management.

7. Develop a backup CATCC at Batam capable of handling ATFM responsibilities as well as natural disaster coordination.

12.12 Capacity Enhancing Procedures

12.12.1 Area Navigation (RNAV)/Required Navigation Performance (RNP). Indonesia already provides for RNAV. The present VOR/DME system permits RNP-5.

RNP RNAV is a navigation requirement and is only one factor to be used in the determination of required separation minima. RNP RNAV alone cannot and should not imply or express any separation standard or minima. When establishing air traffic route spacing and aircraft separation minima, in addition to the navigation element, one must also consider the supporting airspace infrastructure, including surveillance and communications. Additionally, the parameters of ATM, such as intervention capability, capacity, airspace structure, and occupancy

or passing frequency (exposure), must be evaluated. A general methodology for determining separation minima has been developed by the ICAO (see Determination of Separation Minima (Doc 9689). The general methodology is to conduct an operational safety assessment that considers all CNS/ATM elements.

RNP RNAV is defined in RTCA DO-235A/EUROCAE ED-75.

A reasonable planning goal can be summarized as: **RNAV everywhere, RNP where needed.**

12.12.2 Reduced Vertical Separation Minima (RVSM). RVSM was implemented in 2005. The only partial implementation of RVSM flight level allocation (only FL350-FL390) is causing inefficient operation and costs to airlines and operators. Early acceptance of the full flight level band between FL290-FL410 will alleviate this problem.

12.12.3 Digital Airport Terminal Information Service (D-ATIS). This is both equipment and a procedure. While D-ATIS is an airport operations-related initiative, the service (i.e., preprogrammed departure and arrival information) is used by all arriving aircraft. It is therefore addressed in this Sector C project. Digital Automatic Terminal Information Service is one initiative where Very High Frequency Data Link Mode 2 (VDL M2) expedites flight information, reduces the workload of both the controller and the pilot, and increases efficiency and safety. D-ATIS is recommended for international airports. SARPs are available for this data link initiative and it is inexpensive to implement. More than 80 airports worldwide now provide D-ATIS. D-ATIS is recommended by ICAO. D-ATIS demonstrates Indonesia's movement to CNS/ATM and reduces the safety risk associated with communications to the issuance on route clearances.

12.12.4 Standard Instrument Departure (SID)/Standard Terminal Arrival Route (STAR). SIDs and STARs could continue to be used based on VOR/DME, but should progressively transition through RNAV and GNSS. GNSS SIDs/STARs need to be developed and used under a primary means approval, but the VOR/DME minimums must not be decreased until GNSS is approved for sole means navigation if the GNSS procedure overlays the VOR/DME procedure. SIDs and STARs contribute to the efficiency of Sector C by increasing the accuracy and efficiency while increasing the safety of operations. Safety is increased by reducing errors in communications and adherence to delegated airspace.

12.12.5 Collaborative Decision-Making (CDM). CDM is a program of dialogue and collaboration between both ATC and the users. Its objective is to develop and maintain an ATFM service that provides the best utilization of airspace, avoids congestion, and minimizes user delays. Sector C operations benefit by offering a less stringent and officious dialogue between those responsible for operations.

12.12.6 ATS Interfacility Data Communications (AIDC). AIDC will automatically exchange ATC information between the Air Traffic Services Unit (ATSU) in support of the ATC functions:

- Notification of flights approaching the boundary.
- Notification of boundary crossing coordinates.

- Transfer of control at the boundary.
- Flight progress information sharing.

Recommend: AFTN based AIDC be migrated to ATN based AIDC.

12.12.7 Aeronautical Message Handling System AMHS). AMHS and ATN router support the ATN transition plan for ground-ground communications. (See Task 1.)

12.12.8 Route Development. Natuna ACC should offer its expertise and airspace planning staff to assist ICAO, IATA and users in the development of more efficient routes across the Natuna Airspace.

12.12.9 RNAV Offset Routes. Offset Routes offer the capacity enhancing option of moving traffic off the routes for the purpose of using speed differential to pass another aircraft or to avoid costly speed reductions.

12.12.10 URET User Request Evaluation Tool. This controller tool (software) is capable of evaluating traffic conflicts 20 minutes ahead and then advising the controller of options.

12.12.11 Convective Weather Information. Natuna should ensure the timeliness and accuracy of severe weather information in support of safety, capacity and access objectives.

12.13 Related Access/Efficiency Issues.

12.13.1 Aeronautical Information Services (AIS) Discussion. System users transiting Sector C must be able to rely on the quality of aeronautical information published by Indonesia. Therefore, Indonesia's ACC (we suggest the Jakarta ACC) should be physically expanded to accommodate a new Aeronautical Information facility capable of issuing digitally formatted information in a timely manner. (AIS data base: NOTAM and other aeronautical information.) A new AIS system must use upgraded software in order to correct defects of data storage, archiving, quality standards, retrieval, etc. It is recommended that a new AIS system having processing capability of digital AIP and AIC in addition to the function of NOTAM data processing be collocated in the Jakarta ACC.

Numerous reported errors in WGS-84 coordinates should be corrected immediately. It is recommended that contractors be used in order to expedite this type work.

A transition from the Aeronautical Fixed Telecommunication Network (AFTN) network to an Aeronautical Telecommunications Network (ATN) VDL M2 network should be planned in concert with regional plans.

12.13.2 Aeronautical Information Service (AIS)/Flight Information Service (FIS). AIS will provide aeronautical information concerning Aeronautical Information Publications (AIP), AIP Supplements, Notices to Airmen (NOTAM), Aeronautical Information Circulars (AIC), and real-time flight information such as meteorology, airport information, flow restrictions, and a host of other aeronautical services. FIS will provide a variety of services via data link including Precipitation Map Service (PMS), Terminal Weather Service (TWS), Windshear

Advisory Service (WAS), Pilot Report (PIREP) service, and Runway Visual Range (RVR) service. It is recommended that this system migrate to a digital format and to ATN as ATN replaces the AFTN system which should be a priority project. Both paragraph (s) 12.13.1 and .2 should be in the Jakarta ACC for efficiency and quality control reasons.

12.13.3 Satellite Distribution (SADIS). The new (SADIS upgraded) SADIS 2G service was launched in September 2004. It is expected that SADIS users will have moved onto this system by December 31, 2007. It is recommended that Indonesia consider resumption of this ICAO-endorsed program upgrade. SADIS is a high-quality, cost-effective, and error-free satellite data distribution system that brings vital flight information to aviation users around the world. It provides a point to multi-point service in real-time on a 24-hour basis via satellite.

- Uses an Intelsat 904 satellite located over the Indian Ocean.
- Distributes World Area Forecast System (WAFS) products and global OPMET.
- Enables WAFC London to distribute data to more than 90 ICAO states.
- Has coverage of around 60 percent of the earth's land surface.
- Two similar satellites over the Atlantic and the Pacific Oceans provide the complementary ISCS service, which covers the rest of the world.
- Access to the internet-based SADIS FTP Service.
- Highly cost effective.

12.13.4 Flight Data Processing (FDP). Automatic Flight Data Processor (AFDP) is used for the processing of flight data and the preparation, coordination, and dissemination of control strips. The processor will process flight plan information from the AFTN or the Aeronautical Message Handling Service (AMHS), record all overflight aircraft as they enter/exit the FIR, provide strips for each control position, perform coordination functions, etc. It will reduce excessive coordination and eliminate the errors and workload associated with manual processing and the counting of strips and aircraft movements. EUROCAT 1000 is one version of FDP and has adopted the Online Data Interchange (OLDI) as the interface for flight data dissemination, and will transition to AIDC as it is planned by the Europeans. EUROCONTROL recently announced their intention to continue with OLDI in lieu of ATS Interfacility Data Communications (AIDC) (see12.12.6 above), but EUROCONTROL will consider interfacing with AIDC at a later date. It is recommended that AIDC be utilized since it will automatically exchange ATC information between the Air Traffic Services Unit (ATSU) in support of the ATC functions:

- Notification of flights approaching the boundary.
- Notification of boundary crossing coordinates.
- Transfer of control at the boundary.
- Flight progress information sharing.

12.13.5 Initial Integrated Flight Plan Processing System (IFPS). EUROCONTROL is improving this system to provide data exchange between ACCs and between adjacent FIRs. Indonesia will need to adopt the Sysco level I interface to provide this ATFM option. Additionally, the IFPS will process "Center Stored Flight Plans (CSFP)", which will be used by the ACC should the need arise. An efficient Flight Data Processing System must be established

between ACCs, particularly to allow efficient transfer of traffic between Jakarta ACC and Ujung Pandang ACC which has been the subject of earlier problems.

13.0 ORDD Activities

1. Ensure all AIP's and updates of all aeronautical information are current and publication dates are in concert with the actual start date.

2. Ensure all parties/stakeholders are briefed.

3. Arrange for the temporary assignment of Singapore controller staff to the Jakarta ACC for a period of 2 weeks after the transition of responsibility. This would be preceded by one day of observation time for the Singapore staff prior to ORDD.

4. Confirm charting dates (some will include the name of the control facility and the correct frequency).

13.1 Assumption of ANSP Responsibilities Schedule

- **3 months prior**
  Public Relations notices.

- **One month prior**
  As able, document/validate traffic flow, i.e., volume, speed, separation standards applied and any other information necessary for the documentation of a base case. This information may be necessary if accusations of inefficient service arise.

- **One week prior**
  Verify all equipment frequencies and coordination circuits are operational.

  Verify all backup power sources are operational.

  Issue informational notices of the ORDD again to remind all stakeholders.

- **48 hours prior**
  Issue NOTAMs.

13.2 Changeover and Beyond

- Parallel to the changeover time, Singapore monitors the operation while Indonesia actually controls Sector C traffic.

- Singapore stands down after 48 hours.

- Indonesia is solely operating with no infrastructure backup from Singapore.

- Weekly for 2 months after ORDD. Weekly Quality Assurance reports.

14.0 Human Resource Issues

14.1 Staffing. Coordination visits to the Singapore ACC will clarify the present number of operational positions and staffing dedicated to Sector C. Indonesia has already installed two operational positions and the staffing level should not be lower than that experienced by Singapore. As a general planning guide, the formula of multiplying operational positions by a factor of 1.6 will yield a comfortable staffing level as the full Natuna operation begins. Specific numbers of operational staff i.e., air traffic controllers, depends on established work rules. Experience and careful staff studies on traffic growth and complexity will aid management in making staffing adjustments.

CNS/ATM innovations such as GPS, Data Link, CPDLC, RNAV, RNP, enhanced traffic management flow control and the other controller tools referenced in this TA do not require additional staffing. A standard radar position staffed with one radar controller and one assistant will be sufficient. Additional staff positions as previously cited, such as procedure development and training specialist, will be required, as will additional automation/software specialist. A sufficient number of operationally qualified controller supervisors is required for immediate action as the expanded operation begins. Supervisors must be available if corrective action or controller support is needed.

14.2 Management Structure/Organization. Management or overhead positions should be kept to a level where there is only one layer between the facility manager and the operation and that layer would be the operational supervisors. Support staff such as training and procedure development would report to the assistant manager. Quality Assurance would report directly to the facility manager. Likewise the Air Traffic Manager has a counterpart directing the engineering staff. A key principle is to keep the top management official knowledgeable of the service provided. Natuna's Quality Assurance should use, as a base document in their work, the guidance material reported at APANPIRG/16. It is recommended that Natuna ACC supplement that document with guidance specific to Natuna ACC.

14.3 Training. Jakarta ATS reported having a radar simulator. This training aid needs to be updated to show Sector C and its airway structure. Staff should develop representative Sector C flow problems in order to demonstrate potential problems. Controller personnel should receive 16 hours of radar each on Sector C procedures. During these training sessions, controllers must demonstrate knowledge of airspace, routes, procedures, and frequency assignments.

It is of the utmost importance that the radar simulator be of world class quality because of the risk involved in having less than the best trained radar controllers; therefore, it is recommended that the radar simulator facility be state of the art.

14.4 Language Training. The ICAO designated language of aviation is English. Indonesia should, in the near term, assure the English language proficiency of engineers and air traffic controllers responsible for Sector C. The ICAO regional Office is to conduct a survey of all

Asia/Pacific States for the purposes of ascertaining States' readiness by March 2008 with ICAO provisions of Operational Level 4 language proficiency. Sector C personnel must be a priority in order to prepare both equipment and for controllers to reach the required proficiency prior to reassuming responsibility for Sector C.

14.5 MACH Number Technique (MNT). MNT is currently used on ATS routes in Sector C by Singapore ACC. Singapore's AIP, ENR 1.8-13, paragraph 2, describes Singapore's Mach Number Technique (MNT). A table listing entry and exit points for the application of MNT is also contained in this chapter of the AIP.

MNT training of Jakarta ACC controllers who have not had experience applying MNT will be required to achieve a working level of proficiency. When applied correctly, MNT is a valuable tool for maximizing altitude use on the same route of flight. Application of the faster aircraft following MNT is also being applied worldwide and is fully endorsed by ICAO. MNT procedures between states shall be covered in LOAs in accordance with ICAO ATS Planning manual (Doc 9426).

14.6 Average Staff Capability Observation of a cross section of staff was time limited yet insightful due the intensity of the work. The average (in terms of organizational rank) staff personnel appeared motivated and competent in their own area of responsibilities. Technicians in the equipment room were well versed in their specialties. Controllers were competent and attuned to their work. The control room supervisor was very knowledgeable regarding the overall operation.

General observations are impractical and it is more important to continuously strive for improvement and establish methods of regular review which will be informative and allow for recommendations for specific improvements as needed. Review of existing records shows that regular reviews are being made and they point to current areas needing improvement. A professional development program is part of the Sector C airspace transition plan.

15.0 Associated Operational and Management Issues

15.1 Search and Rescue (SAR). Indonesia is a signatory to an agreement between members of the Association of South East Asian Nations (ASEAN) concerning the facilitation of search for aircraft in distress and rescue of survivors of aircraft accidents. Sectors A, B, and C are currently within the Singapore FIR, and primary responsibility for SAR is with Singapore. With the acquisition of Sector C by Indonesia, primary responsibility for Sector C may revert to Indonesia. We recommend the SAR Agreement be reviewed to ensure the primary SAR responsibility for Sector C is clearly defined and understood by all signatories.

15.2 Capacity. Developing System Capacity is dependent on the DGAC execution of a plan including CNS/ATM technologies and procedures that are harmonious with regional plans (APANPIRG agreements)/Global ANSP and user community plans as cited earlier. Indonesia supports ICAO/IATA initiatives, and Indonesian plans parallel these global initiatives. All programs, CNS/ATM, training, human resources, Quality Assurance, etc., discussed herein contribute to increased capacity.

15.3 Quality Assurance (QA). The Natuna Islands airspace project requires pre- and post-transition quality assurance reports validating the quality of the services provided. Indonesia should coordinate with ICAO or RVA for assistance in developing a QA program that will address shortcomings mentioned in several recent studies. This QA program should develop a plan to address the shortcomings mentioned in the Master Plan. A schedule for addressing these shortcomings should be developed with milestones and scheduled progress reports. Additionally, facility evaluations covering administration and operational activities for both air traffic services and maintenance should be held on a scheduled basis. The initiation of new CNS/ATM systems and procedures requires QA followup.

The Asia/Pacific Regional Plans (APANPIRG Agreements) Airspace Safety Monitoring Advisory Group (RASMAG) is supported by Indonesia's DGAC. The role of RASMAG would not only facilitate the implementation of RNP, ADS, CPDLC, RVSM, etc., but would ensure continuous monitoring of safety requirements associated with these initiatives. Indonesia will reduce its risk and liability by vigorous application of the RASMAG evaluation and reporting model.

It is recommended that, as a safety imperative, the Natuna ACC establish a clear policy requiring that written reports be submitted on any RVSM altitude deviation.

16.0 Summary of Recommendations

16.1 Discussion

The following presents most, but not all, recommendations divided into categories for ease of reference. This TA recommends a progression from a remediated legacy infrastructure to a state-of-the- art CNS/ATM system commensurate with documented need and in accord with sustainable cost. It is noted that some activities should be accomplished before others and some are of greater importance; these activities are identified by an asterisk (*) at the end of the particular item. Recommendations address the issues of capacity, efficiency and system access; as such have the potential to improve service to the user. It is noted that Natuna cannot initiate some actions by itself but should join with the DGAC in pursuing more CNS/ATM issues. These are generally regional issues and are identified accordingly.

This listing of issues could be a resource when briefing executive management as this list is divided into project categories.

16.2 Leadership

DGAC should issue a written statement to subordinate offices outlining the task objective. It will cite the purpose of the transition, the goal Indonesia wishes to accomplish, and the supporting activities to be accomplished with the resumption of ANSP responsibilities for Natuna Islands airspace.

16.3 Normalization of Present Infrastructure

All facilities must be maintained to ICAO or other appropriate standards. *

VSAT facilities should be restored to their required operating specifications. *

All Communication, Navigation and Surveillance facilities should be restored to their required operating specifications. *

The validation of all AIP information is a first order of business. *

HF ER facilities on Natuna Islands should be accessed for possible needed restoration. *

A budget and dedicated staff should be established for restoration activities. *

16.4 CNS Technologies

A transition from the Aeronautical Fixed Telecommunication Network (AFTN) to an Aeronautical Telecommunications Network (ATN) VDL M2 should be planned in concert with regional plans (APANPIRG agreements).

16.5 Communications

16.5.1 Flight Information Service (FIS). FIS will provide a variety of services via data link including Precipitation Map Service (PMS), Terminal Weather Service (TWS), Windshear Advisory Service (WAS), Pilot Report (PIREP) service, and Runway Visual Range (RVR) service. It is recommended that this system migrate to a digital format and to ATN as ATN replaces the AFTN system which should be a priority project. Both paragraphs 12.13.1 and .2 should be in the Jakarta ACC for efficiency and quality control reasons. It is recommended that a new AIS system, having processing capability of digital AIP and AIC in addition to the function of NOTAM data processing, be co-located in the Jakarta ACC.

16.5.2 Aeronautical Information Services (AIS) System. AIS users transiting Sector C must be able to rely on the quality of aeronautical information published by Indonesia. Therefore, Indonesia's ACC (we suggest the Jakarta ACC) should be physically expanded to accommodate a new Aeronautical Information facility capable of issuing digitally formatted information in a timely manner. (AIS data base: NOTAM and other aeronautical information.) A new AIS system must use upgraded software in order to correct defects of data storage, archiving, quality standards, retrieval, etc. It is recommended that a new AIS system having processing capability of digital AIP and AIC in addition to the function of NOTAM data processing be co-located in the Jakarta ACC.

16.5.3 Satellite Distribution (SADIS). The new (SADIS upgraded) SADIS 2G service was launched in September 2004. It is expected that SADIS users will have moved onto this system by December 31, 2007. It is recommended that Indonesia consider resumption of this ICAO-endorsed program upgrade. SADIS is a high-quality, cost-effective, and error-free satellite data distribution system that brings vital flight information to aviation users around the world. It provides a point to multi-point service in real-time on a 24-hour basis via satellite.

16.5.4 Flight Data Processing (FDP). Automatic Flight Data Processor (AFDP) is used for the processing of flight data and the preparation, coordination, and dissemination of control strips. The processor will process flight plan information from the AFTN or the Aeronautical Message Handling Service (AMHS), record all overflight aircraft as they enter/exit the FIR, provide strips for each control position, perform coordination functions, etc. It will reduce excessive coordination and eliminate the errors and workload associated with manual processing and the counting of strips and aircraft movements. EUROCAT 1000 is one version of FDP and has adopted the Online Data Interchange (OLDI) as the interface for flight data dissemination, and will transition to AIDC as it is planned by the Europeans. EUROCONTROL recently announced their intention to continue with OLDI in lieu of ATS Interfacility Data Communications (AIDC), but would consider interfacing AIDC at a later date. It is recommended that AIDC be utilized since it will automatically exchange ATC information between the Air Traffic Services Unit (ATSU) in support of the ATC functions.

16.5.5 Initial Integrated Flight Plan Processing System (IFPS). EUROCONTROL is improving this system to provide data exchange between ACCs and between adjacent FIRs. Indonesia will need to adopt the Sysco Level I interface to provide this ATFM option. Additionally, the IFPS will process "Center Stored Flight Plans (CSFP)", which will be used by the ACC should the need arise. An efficient Flight Data Processing System must be established between ACCs, particularly to allow efficient transfer of traffic between Jakarta ACC and Ujung Pandang ACC, which has been the subject of earlier concerns. At the present and near term levels of traffic there is no need for IFPS.

16.6 Navigation

Natuna Islands airspace focuses on RNP-10 and RNP-4. However, Indonesian RNP-5 infrastructure is not constrained in the placement of sensors and should be upgraded to Required Navigation Performance (RNP) 5 as soon as possible so as to optimize usage of airspace.

RNP-4 should be inaugurated at the earliest date. Parallel to the development of RNP-4 infrastructure, Natuna ACC airspace specialists should develop prototype RNP-4 routes taking full advantage of available airspace. It is recommended that Natuna ACC actively participate in the ATS Route Network Review Task Force seeking improved routing options through their airspace.

Numerous reported errors in WGS-84 coordinates should be corrected immediately. It is recommended that contractors be used in order to expedite the completion of this task. This recommendation is made notwithstanding the recent report by the DGAC that most WGS-84 coordinates are now current.

The transition to GPS should be made in concert with the Regional GNSS plan.

NDB's should be deactivated following coordination with system users.

16.7 Surveillance

16.7.1 ADS. ADS-B is recommended as the supplemental system to RADAR. ADS-C is suggested as a backup and supplemental surveillance system to Natuna MSSR only if the ADS-B project fails. Funding should not be established for ADS-C at this time since ADS-B has a high success record. Boeing is upgrading its Mode S Transponder installation to ARINC 718 transponders, which are compliant with ICAO Annex 10, amendment 77. This will form a recommended foundation for Mode S and ADS-B upgrades. Airbus is likewise working several similar projects.

Natuna's and Batam's MSSR should be activated at the earliest date. *

16.7.2 Software/Automation Systems. In general, it can be said that the required ATM Automation System will consist of an Air Traffic Management function, Weather Information Analysis and Display function, URET, E-MSAW, CA, ATM data recording, an emergency/alternate airport map and Controller's Training and Backup functions. These software programs are recommended and discussions with DGAC indicate that all are in use except the emergency map and URET. FAA could be of assistance with the emergency map while the MITRE Corporation should be contacted regarding URET. MITRE does not generally sell software. Instead, they would more typically work with an ANSP to solve the complex issues of adapting such an application to their particular operations, etc. Given that, equipment requirements or price are not relevant.

16.8 Coordination and Information Sharing

Draft procedures and Letters of Agreement (LOAs) must be developed to replace all present documents dealing with Natuna. In addition to procedures and LOAs, controller staff must be thoroughly conversant with new frequencies and equipment at new operating positions. Emergency/security and administrative procedures must be revamped as necessary. This is a particularly sensitive issue with the introduction of new technologies such as ADS-B and in recognition of the requirement to have alternate procedures established in the event of equipment failures of operational exigencies.

When consensus is reached among the signatory organizations, these documents should be tentatively initialed as acceptable awaiting final approval by higher authority. Initially, these documents should have no changes other than revisions due to Indonesia assuming authority for its sovereign airspace. The transition should be kept as simple as possible. System improvements can be made after a successful transition and stabilization of new equipment and the workforce.

SAR Agreement should be reviewed to ensure the primary SAR responsibility for Sector C is clearly defined and understood by all signatories.

Reference and emergency binders should be developed and made readily available to all staff in their respective work areas.

RVA reiterated to DGAC that a review of agreements and or procedures was desired. English language copies should be supplied.

16.8.1 Convective Weather Information. Natuna should insure the timeliness and accuracy of severe weather information in support of safety, capacity and access objectives. Use of existing radar systems and the recommended flight information systems will accomplish this objective.

16.8.2 Collaborative Decision-Making (CDM). CDM is a program that is provided to both ATC and the users to develop and maintain an ATFM service that provides the best utilization of airspace, avoids congestion, and minimizes user delays. Sector C operations will benefit by offering a less stringent and officious dialogue between those responsible for operations.

16.8.3 ATS Interfacility Data Communications (AIDC). AIDC will automatically exchange ATC information between the Air Traffic Services Unit (ATSU) in support of the ATC functions:

- Notification of flights approaching the boundary.
- Notification of boundary crossing coordinates.
- Transfer of control at the boundary.
- Flight progress information sharing.

Recommend: AFTN based AIDC be migrated to ATN based AIDC.

16.8.4 Aeronautical Message Handling System AMHS) AMHS and ATN router support the ATN transition plan for ground – ground communications.

16.8.5 Project Discussions with Singapore.

1. Open discussions with Singapore ANSP authorities regarding how Singapore manages air traffic through Sector C.

2. Establish a clear understanding of resources and procedures involved.

3. Confirm the use made of radar by Singapore air traffic controllers. If radar is used solely for monitoring traffic flows, no change should be initiated. If radar monitoring of traffic is the norm, DGAC should begin radar training for air traffic controllers.

4. Indonesian controller and engineering staff would be required to make visits to Singapore in order to meet their counterparts and observe the Singapore operation and management systems. These observation visits should be guided by a checklist of information required, such as staffing levels, operational issues with other service providers, etc. Indonesia's observation of the Singapore ACC, focusing on Sector C, must include all hours of the operation so that a comprehensive understanding is achieved.

16.9 Airspace

All airspace actions recommended in this TA are aimed at Sector C and must be in harmony with adjacent airspace.

It is recommended that Natuna ACC actively participate in the ATS Route Network Review Task Force seeking improved routing options through their airspace.

16.10 Capacity Enhancements

16.10.1 Area Navigation (RNAV)/Required Navigation Performance (RNP). Indonesia already provides for RNAV. The present VOR/DME system permits RNP-5.

RNP RNAV is a navigation requirement and is only one factor to be used in the determination of required separation minima. RNP RNAV alone cannot and should not imply or express any separation standard or minima. When establishing air traffic route spacing and aircraft separation minima, in addition to the navigation element, one must also consider the supporting airspace infrastructure, including surveillance and communications. Additionally, the parameters of ATM, such as intervention capability, capacity, airspace structure, and occupancy or passing frequency (exposure) must be evaluated. A general methodology for determining separation minima has been developed by the ICAO (see Determination of Separation Minima (Doc 9689)). The general methodology is to conduct an operational safety assessment that considers all CNS/ATM elements.

16.10.2 Reduced Vertical Separation Minima (RVSM). RVSM was implemented in 2005. The only partial implementation of RVSM flight level allocation (only FL350-FL390) is causing inefficient operation and costs to airlines and operators. Early acceptance of the full flight level band between FL290-FL410 will alleviate this problem.

16.10.3 Digital Airport Terminal Information Service (D-ATIS). This is both equipment and a procedure. While D-ATIS is an airport operations-related initiative, the service (i.e., preprogrammed departure and arrival information) is used by all arriving aircraft. It is therefore addressed in this Sector C project. Digital Automatic Terminal Information Service is one initiative where Very High Frequency Data Link Mode 2 (VDL M2) expedites flight information, reduces the workload of both the controller and the pilot, and increases efficiency and safety. D-ATIS is recommended for international airports. SARPs are available for this data link initiative and it is inexpensive to implement. More than 80 airports worldwide now provide D-ATIS. D-ATIS is recommended by ICAO. D-ATIS demonstrates Indonesia's movement to CNS/ATM and reduces the safety risk associated with communications to the issuance on route clearances.

16.10.4 Standard Instrument Departure (SID)/Standard Terminal Arrival Route (STAR). SIDs and STARs could continue to be used based on VOR/DME, but should progressively transition through RNAV and GNSS. GNSS SIDs/STARs need to be developed and used under a primary means approval, but the VOR/DME minimums must not be decreased until GNSS is approved for sole means navigation if the GNSS procedure overlays the VOR/DME procedure. SIDs and STARs contribute to the efficiency of Sector C by increasing the accuracy, efficiency while increasing the safety of operations. Safety is increased by reducing errors in communications and adherence to delegated airspace.

16.10.5 RNAV Offset Routes. Offset Routes offer the capacity enhancing option of moving traffic off the routes for the purpose of using speed differential to pass another aircraft or to avoid costly speed reductions.

16.11 Efficiency

16.11.1 Uninterrupted Descent. Develop continuous or profile descent procedures combining use of Natuna and Singapore airspace.

16.11.2 Coordination. Automation should be used to electronically pass flight data information, boundary times, or to initiate handoffs to the next air traffic control facility. See 16.8.3

16.11.3 Step Altitude Changes. The introduction of improved infrastructure and procedures will lead to capacity and efficiency improvements through step climbs and descents that allow the user to reach optimum altitudes.

16.11.4 URET User Request Evaluation Tool. This controller tool (software) is capable of evaluating traffic conflicts 20 minutes ahead and then advising the controller of options. This changes the today's situation where controllers have a view of the airspace that is bounded by the sector that they control. Fixed airspace structures used to organize flows and create predictable intersections are necessary for moment-to-moment control. These structural limitations can, in some cases, result in inefficiencies, and loss of capacity and denied system access. URET provides the controller an automated tool for a more strategic look across multiple sectors leading to a quick response to the user's request.

16.12 Access

16.12.1 Flow Management. Flow control procedures and authority should remain unchanged since flow control is a regional issue and should be managed accordingly. Differences on flow control decisions regarding "local" airports and sectors should be resolved through existing procedures. For example, if departure delays from Batam do not appear to be equitable, those directly involved should try to resolve the problem.

16.12.2 Efficient Routes. Direct routes with optimum altitudes should be developed through Sector C based on user request and system capability.

16.12.3 Regional Cooperation. Sector C should have the capacity of harmoniously responding to adjacent service providers who allow flex routes.

16.12.4 Increase Access. Continue to create routes where feasible as done in November 2004; Rahim Yar Khan was further extended to Kandahar and this made P628.

16.12.5 GPS. Develop viable alternative airways using GPS such as when P628 was extended from ASOPO to Rahin Yar Khan. The needed alternatives should be created and identified after consultations with users and neighbouring ANSPs.

16.12.6 Customer Service. Natuna ACC should offer its expertise and airspace planning staff to assist ICAO, IATA and users in the development of more efficient routes across the Natuna Airspace.

16.12.7 Increasing General Aviation Activities. Natuna develop RNAV RNP routes that would serve the soon-to-emerge private aircraft community in the South China Sea region. RVA believes this is a segment of the user community that will grow in excess of the commercial aircraft community in the next 5 years.

16.13 Administration

16.13.1 Equipment Spares. The equipment spares should be changed. A specific listing can be found in Appendix 1.*

16.13.2 Flight Inspections. Flight inspections should be brought up to date.*

16.13.3 Aeronautical Information. Current facility information should be published on a priority basis.*

16.14 Establishment of an Air Traffic Control Center (ACC) (Natuna Islands).

16.14.1 Natuna Capital Investment ACC Construction Recommendation. It is suggested that a dedicated ACC is not built solely for Natuna. Rather, establish one Coordination/Flow Control desk within the CATCC. This subject matter expert would provide the point of contact for the Natuna ACC and should serve the Natuna Airspace through year 2020. In the interim, traffic demand, available technology/software, and Global CNS/ATM plans will mature.

16.15 Construction of a Dedicated Air Traffic Flow Management Facility. It is recommended that DGAC, in recognition of the Natuna Island airspace size and volume of traffic, do the following:

1. Refrain from construction of a dedicated Natuna ATM facility;

2. Natuna management should support establishing the CATCC in proximity of the Jakarta ACC;

3. Develop ATM staff and procedures that serve their needs as a regional plans (APANPIRG agreements) participant;

4. Select a permanent staff position that serves as the DGAC subject matter expert, regularly representing the DGAC at regional plans (APANPIRG agreements) ATM meetings;

5. Hold the selected ATFM staff member responsible for resoling all incidents of poor ATFM service; and

6. Assign the ATFM staff person to work an operational schedule that coincides with the heaviest traffic flows while occasionally working other shifts as assigned by upper management.

16.16 Management Structure

The present management structure dividing responsibilities among AP 1, 2, and the DGAC does not appear to be working to the benefit of all involved and we strongly recommend that a change be made to a single technically competent and administratively strong organization. For ease of discussion, we assume DGAC in the leadership role of that organization.

Management or overhead positions should be kept to a minimum level preferably where there is only one layer between the facility manager and the operation and that layer would be the operational supervisors.

16.17 Training

All staff must be briefed on emergency, alternate airport, and security procedures.

All engineers and electrical technicians should be licensed and subsequently provided regular training.

A professional development program for all staff members in their work specialty and management training for supervisors and above should be provided.

Begin controller and engineer training on technical issues (new procedures for controllers) as soon as possible. This training includes the revised procedures noted above and the appropriate training issues cited below.

ANSP staff should be provided sufficient time to familiarize themselves with new equipment. Eight hours orientation and the use of a checklist documenting all required items are suggested.

All controller staff, including supervisors, must be tested on new procedures and airspace. Those scoring less than 100 percent must receive additional training.

16.18 MACH Number Technique (MNT)

MNT is currently used on ATS routes in Sector C by Singapore ACC. Jakarta ACC controllers who have not had experience applying MNT will be required to achieve to achieve a working level of proficiency.

16.19 Radar Simulation & Airspace Modeling

Radar simulation should be the best available. Additionally, the device should also be capable of airspace modeling.

16.20 Language

States are required to attain readiness by March 2008 with ICAO provisions of Operational Level 4 language proficiency.

16.21 Staffing

Coordination visits to the Singapore ACC are required in order to clarify the present number of operational positions and staffing dedicated to Sector C. A general planning guide using the formula of multiplying operational positions by a factor of 1.6 will yield a comfortable staffing level.

16.22 Quality Assurance (QA) and Metrics

The Natuna Islands airspace project requires pre- and post-transition quality assurance reports validating the quality of the services provided. Indonesia should coordinate with ICAO or RVA for assistance in developing a QA program.

16.23 Supervision

Control room supervisors should enforce a policy of professional decorum in the operating quarters, also a policy requiring the proper use and wearing of headsets should be enforced.

17.0 Task 2 Conclusions

1. Indonesia is capable of resuming ANSP responsibilities of their sovereign airspace over Natuna Islands after assuring system integrity as outlined above.

2. Indonesia is capable of providing quality and efficient services after completion of the action described in this TA.

3. The time and cost for this activity depend on the option selected.

4. More feedback and data from DGAC is required in order to fully develop this TA.

5. Task 3 will be influenced by the quality and timeliness of feedback on Task 2.

APPENDIX 1. EQUIPMENT SPARES

CNS Equipment Spare Parts Lists The prudent complement of onsite spare parts varies by equipment manufacturer, equipment type, age, condition, and criticality to the Airspace System. The primary equipment servicing Natuna airspace centers around the Natuna (NTA) MSSR, VOR and Communications equipment all located on Natuna Islands. A limited degree of coverage overlap and redundancy is provided by CNS equipment located at Tanjung Pinang (TPG) and Pontianak (PNK). With the Natuna equipment critical and essential to providing CNS services, appropriate numbers and kinds of onsite spares should be available to prevent equipment failures and to reduce time out of service when unscheduled failures occur. The table below lists the types of typical onsite spare parts for similar equipment. Quantity of part based on sparing all three locations and on average part failure rate in similar CNS equipment, the cost is based on U.S. Dollars.

System	Part Description	Unit Cost	Qty	Total Cost
SSR/MSSR	Power Module	$ 18,045	6	$ 108,270
SSR/MSSR	Power Supply Pre-Amp Assembly	$ 3,305	6	$ 19,830
SSR/MSSR	Power Supply Collector	$ 6,743	6	$ 40,458
SSR/MSSR	Power Pre-Amplifier Switch	$ 2,650	6	$ 15,900
SSR/MSSR	Power Supply Multiplier	$ 9,757	6	$ 58,542
SSR/MSSR	Blower Master Assembly	$ 3,252	3	$ 9,756
SSR.MSSR	Serial Controller Assembly	$ 5,953	6	$ 35,718
SSR/MSSR	Phase Control Module	$ 2,605	3	$ 15,630
SSR/MSSR	Hybrid Line Amplifier	$ 15,514	6	$ 93,078
SSR/MSSR	Barometric Switch	$ 19,810	3	$ 59,430
SSR/MSSR	Antenna Motor Drive Assembly	$ 51,480	3	$ 308,880
SSR/MSSR	Splitter 1:3 Assembly	$ 2,395	6	$ 14, 370
SSR/MSSR	Splitter 1:4 Assembly	$ 15,872	3	$ 95,232
SSR/MSSR	Other spare Module/Card Assemblies	$ 5,000	18	$ 93,600
VOR	Voltage Regulator Assembly	$ 620	3	$ 1,860
VOR	Analog Circuit Card Assembly	$ 1,252	3	$ 3,756
VOR	Digital Circuit Card Assembly	$ 998	3	$ 2,994
VOR	Measurement Assembly	$ 876	3	$ 2,628
VOR	Antenna Control Assembly	$ 2, 685	3	$ 8,055
VOR	Monitor Detector Assembly	$ 900	3	$ 2,700
VOR	Peak Power Assembly	$ 617	3	$ 1,851
VOR	Doppler Antenna Assembly	$ 3, 916	3	$ 11,748
VOR	Other Spare Modules/Card Assemblies	$ 1,000	15	$ 15,000
COMM	Power Supply Assembly	$ 1,656	6	$ 9,936
COMM	Power Amplifier	$ 845	6	$ 5,070
COMM	VHF Cavity	$ 3,294	6	$ 19,764
COMM	Communications Modem	$ 351	6	$ 2,106
COMM	VHF Antenna	$ 1,803	6	$ 10,818
COMM	VHF Amplifier	$ 426	6	$ 2,556
COMM	Fan Assembly	$ 537	6	$ 3,222
COMM	Other Spare Modules/Card Assemblies	$ 1,000	15	$ 15,000
Total				**$1,073,388**

APPENDIX 2. TRAINING

A3.0 Overview

Training is the foundation of a successful Air Navigation Service Provider and an essential part of managing the inherent risk involved in all ANSP programs. In times of restricted budgets, too often only essential initial certification training is accomplished leading to poor service and increasing the risk of serious incidents. Organized training makes the most of limited resources by assuring specifically targeted issues are accomplished. Therefore, a structured and well managed training program is essential to the success of all ANSP organizations.

Training air traffic controllers, systems engineers and staff should be a continuous process that ensures all, ANSP and user alike, benefit from a thorough and well-documented training program. A detailed and specific discussion on the training program Indonesia requires is too extensive for this document but the essentials for the Natuna airspace will be discussed and a citation to the FAA program is offered. The FAA Training program and its link are listed below. We cite some of the attributes of a good training program in the following suggestions.

Understanding and use of different types of training will lead to operational quality improvements as well as better representation of the ANSP policy. Therefore definitions are important and provide order in training program management.

A3.1 Definitions

1. **Supplemental Training.** Training conducted when changes occur pertaining to new/revised procedures, regulations, or equipment.

2. **On-the-Job Training (OJT).** Training conducted by a supervisor On-the-Job-Training-Instructor (OJTI) that provides direct experience in the work environment.

3. **Proficiency Training.** Training conducted to maintain and update the knowledge and skills necessary to apply air traffic procedures in a safe and efficient manner.

4. **Qualification Training.** Training conducted to develop the knowledge and skills required to qualify specialists for certification on positions of operation within an air traffic facility.

5. **Refresher Training.** Training conducted to maintain and update previously learned knowledge and skills.

6. **Remedial Training.** Training provided to correct specific identified operational deficiencies.

7. **Self-Study.** Training situation wherein the study/learning is accomplished by the individual.

8. **Simulation Training.** Training conducted in a classroom/laboratory environment designed to allow the developmental to apply basic skills and knowledge.

9. **Supplemental Training.** Training conducted when changes occur pertaining to new/revised procedures, regulations, or equipment.

A3.2 Proficiency Training

Of the many types of training listed above, Refresher, Supplemental, Skill Enhancement, and Remedial are under the umbrella of Proficiency Training.

A3.2.1 Proficiency Training Application

Proficiency training is required for all personnel who maintain operational currency. The purpose of this training is to maintain and upgrade the knowledge and skills necessary to apply air traffic procedures in a safe and efficient manner.

(1) Proficiency training needs will differ from facility to facility and, therefore, should be tailored to meet identified requirements.

(2) Proficiency training may include mandatory briefing items distributed by DGAC headquarters.

A3.3 Refresher Training

DGAC headquarters will establish in writing an annual refresher training program based on recurring operational needs or a cycle designed to remind personnel of important issues. Additional topics for the annual refresher training program may be added locally in order to meet each facility's needs. Managers shall stress that refresher training is for proficiency improvement, not performance evaluation.

Natuna Islands Refresher program could include the following topics:

(1) Unusual situations, such as unplanned equipment outages, aircraft equipment failure, hijacking, and other types of emergencies. (Training on emergency situations should be based on real life incidents and aircraft accidents, stressing a lesson learned approach.)

(2) Seldom used procedures, such as transitioning to and applying nonradar separation and procedures for special flight handling during natural disasters.

(3) Weather and other conditions that affect flight (e.g., Typhoons, Thunderstorms, etc.) within the facility's airspace.

(4) Other topics designated by the DGAC headquarters.

Natuna personnel should review the following items in the annual refresher training program:

(1) Safety alerts and traffic advisories.

(2) Wake turbulence information and application.

(3) En Route Minimum Safe Altitude Warning (E MSAW) procedures.

(4) Procedures and responsibilities for Special Military Missions.

(5) Training on lost aircraft orientations and SAR procedures.

(6) Airspace intruder refresher training annually. This training shall include:

(a) Tracked and untracked targets.

(b) Airspace violators who have established two-way radio communications and violators who have not established two-way radio communications.

(c) Mode C and non-Mode C equipped targets.

A3.4 Natuna ACC Contingency Plan

The Natuna ACC Contingency Plan shall be reviewed annually to ensure familiarity with procedures and airspace based on the facility contingency plans (e.g., extended period of time when the building is not available for use, facility loss of radar, communication failure, etc.).

A3.5 Initial Controller Training

A3.5.1 Phase 1. We suggest a training program for new controllers that begins with approximately 8 weeks of basic weather, aircraft characteristics, ATC phraseology, ICAO DOC 4444 and Rules of the Air, basic departure and arrival nonradar separation control problems using a simulated environment. The control area including sector boundaries, airways, navigation fixes/frequencies, mileages, published altitudes, sector radio frequencies, etc., should be memorized and tested prior to moving to the next phase of training. Testing and high passing grades of 90 percent are encouraged. Some materials require absolute knowledge due the nature of the subject.

A3.5.2 Phase 2. Flight Data is the next phase, lasting approximately 6 months and should consist of working in the operational quarters passing and receiving flight plans from within Indonesia and surrounding FIRs. This will allow the developmentals to become more comfortable with ATC equipment, control room decorum, phraseology and their control area.

A3.5.3 Phase 3. Nonradar is a six- week course of nonradar separation exercises. Course problem difficulty will vary with problems consisting of five basic level problems, five medium level problems and three certification problems. The actual length of the course will depend on the number of students in the class. Successful completion of the certification problems should be followed by a structured OJT period of approximately 2 months on each sector where the individual is to be certified as a planning controller.

Note: Class should be small enough to allow sufficient time for student de-briefing and remedial instruction.

A3.5.4 Phase 4. This phase occurs nine months after certification as a planning controller. The student returns to the classroom to begin a 3 week course on radar separation. This course should include a review of radar equipment and procedures followed by completion of a series of radar control problems of varying difficulty. After successful completion of the radar problems, a 2 month OJT period will be given on each radar sector in the certification process.

A3.5.5 Natuna Radar Simulation

Natuna radar simulation capabilities shall be used to accomplish the following:

> Personnel required to maintain radar currency shall receive refresher training annually on the use of the primary backup mode. This training shall include:
> (a) Transitioning to and from normal operations to backup operations.
> (b) The unique radar/flight data processing used while operating in the backup configuration(s)
> (c) Control and communication procedures associated with operation in the backup mode.

A3.5.6 Advanced Simulation Training

It is recognized that Indonesia has simulation capabilities. However, it is strongly suggested that advanced simulation capabilities be investigated. In the next 10 years, Indonesia will be required to provide continuous radar control skill training as traffic levels grow to record levels. Radar simulation will be the key to a successful program. Advanced Simulation Training assistance is available from Adacel Systems Inc. Adacel Systems offers a full range of simulation capabilities including ATC, ATM and airspace simulation. More information is available on the net at Adacel.com

A3.6 Specific Training for Evolving Systems

With the advent of CNS/ATM, there will be specific, continuing training needs for both technicians and controllers. This training will consist of academic, simulation and hands-on training; some being provided in the ATC facilities and some provided by the manufacturers of CNS/ATM equipment at their sites. It is normal that any training required for hardware or Software equipment is provided by the manufacturer and should be included in any contract when purchasing new equipment. The following are examples of CNS/ATM training.

A3.6.1 CNS/ATM

An overview general knowledge of CNS/ATM is of great value to all personnel. A CNS/ATM Overview course could give a perspective of how all CNS/ATM elements are related. In order to have a successful transition to CNS/ATM, the new technologies must be understood as they relate to each other and to the intended objective. The CNS/ATM concept is relatively new and

many people do not have the necessary knowledge of CNS/ATM as a system of systems. Each organization needs to determine to what level they must become knowledgeable of CNS/ATM in order to accomplish its mission.

A3.6.2 CNS/ATM Training Course(s) Availability

Management and line operational personnel first need a clear understanding of emerging CNS/ATM systems they will encounter in the immediate future. Everyone must understand these new technologies will be the backbone of future ANSP systems. Creating a foundation of knowledge prepares an organization for future growth and excellence in customer service.

Conducting this training requires a unique skill sets, knowledge and experiences. RVA has all those attributes gained over decades and around the world. RVA can provide a very understandable and sufficiently detailed course on CNS/ATM, utilizing world class subject matter experts who are aware of DGAC's programs and needs. RVA's course provides the participant with a complete understanding of CNS/ATM including why it was developed and the benefits expected from it. It also discusses the supporting satellite systems including GPS, GLONASS, Galileo, Multi-Functional Transport Satellite (MTSAT) system and their augmentations including SBAS (WAAS and EGNOS), MTSAT Satellite Augmentation System (MSAS), a subsystem of the previously mentioned Multi-Functional Transport Satellite (MTSAT) and ABAS; communications that include the various data link technologies; surveillance, including radar and ADS; principles of air traffic management, RVSM, and much more. We believe that, with this course, participants will become more knowledgeable in CNS/ATM and thereby make more informed decisions.

A3.6.3 Communications

The future air navigation system calls for less reliance on ground-based systems and greater use of satellite-based navigation and communication systems. We have already discussed the various forms of both voice and data communications required in the future air navigation environment, including the Aeronautical Telecommunications Network (ATN) and its sub-networks. These are new concepts requiring both the technicians and controllers be educated. Communication training requirements for CNS/ATM would include classroom, simulation and on-the-job training for the various forms of voice and data communications, ATN implementation and operation, and specific operations for CPDLC and ADS. Some communication manufacturers provide limited training. Therefore, most countries conduct communications training classes on the local level using competent communications specialists as instructors. Here again RVA can bring a complete CAN/ATM training course or a competent vender.

A3.6.4 Navigation

For the most part, engineer/technician training for GNSS will be somewhat constrained because of the dual roll they play assuring the continued certification of legacy equipment while learning GNSS systems. Technicians will require both classroom and field training, which can be obtained from the manufacturer and through the FAA if requested.

Controllers will require classroom training on procedures and how to make full use of CNS equipage. ICAO, through TRAINAIR, and FAA can recommend training and training materials in these areas. It is suggested Indonesia continue to participate in all procedure development working groups. The application of RNAV, RNP, off sets and closer separation, and how they will be used, are examples of required training.

A3.6.5 Surveillance

Radar training on both hardware and software for technicians and controllers should be provided by the manufacturer. Controller radar training can be provided on a local level (within country) or by other training providers. Neighboring ANSP's such as Singapore, Thailand and others have training academies that provide controller training. ADCEL, a world leader in Radar simulation and Pan American Flight Academy both are well known for providing controller radar and nonradar training.

Both technicians and controllers will require training on ADS-B training on hardware and software as well as data link communications. Controllers will require limited hardware training, and on ADS, after obtaining certification on radar. Technicians will require academic training as well as hands-on training.

A3.7 Management Training

In addition to specialists training, management or supervisory training should be a requirement. The supervisory workforce is the backbone for the management and operation of the system. Supervisors must be trained in the principles of organizational management before they can be expected to manage a group of workers. An Air Traffic Service (ATS) supervisor is responsible for the control room and the controllers. The supervisor is in charge of the facility during his tour of duty. He is the link between the DGAC and the workforce, a key person in helping the staff understand the organizations decisions and plans.

A3.7.1 Airspace Management/Staff Specialists

CNS/ATM implementation will require the development and validation of air traffic procedures and the redesign of airspace to provide and permit the benefits associated with CNS/ATM. These assignments are accomplished by a cadre of specialists who have been trained on these matters. Although most of the ATM procedural work will be developed by regional groups, DGCA must have procedure specialists to tailor and validate these new procedures. Training for these specialists is available through TRAINAIR and the FAA Academy, as well as qualified venders who will be listed in the final report. It is worth noting that the FAA Academy welcomes international students in the FAA airspace course. This is accomplished through coordination with the US Embassy. Airspace management training (flow control specialists) may also be required and that training is also available through the FAA.

A3.8 Documentation

Documentation is almost as important as the training. In the event of an incident, an ANSP, who is unable to provide documentation of having accomplished required courses and thorough

training, incurs the risk of increased liability while defending its actions. Therefore, specific documentation guidelines should be adopted at the outset. Natuna ACC should clearly track all actions in preparation for the restoration of ANSP responsibilities, remembering the actions of system engineers/maintenance personnel and air traffic controllers are equally important.

A3.9 Training Recommendation Summary

Successful implementation of CNS/ATM requires having sufficient trained technicians and air traffic controllers to establish, maintain, and operate the system. It is suggested the present training, certification, and documentation methods be improved to meet the complex challenges that are required to support a successful CNS/ATM transition. In order to meet this challenge, it is suggested that:

- Natuna ACC management oversee their training responsibilities, taking these recommendations into consideration, while adhering to DGAC direction;
- the controller training program be revised to teach modern technologies procedures, and techniques; and
- full use of the wide array of training types outlined in this Appendix and CNS/ATM* training be conducted.

*When new technologies/equipment are introduced into an ATC system, part of the purchase agreement should include a requirement that the manufacturer provide training for controllers and technicians. Additional training may also be gained from Regional ANSP organization, ICAO or other organizations that are currently using the new equipment.

FAA's Training Program is a world class model for such programs. It is available on the net by searching FAA Order 3120.4L or using HTTP://INET.ATCTRAINING.FAA.GOV

APPENDIX 3. ACRONYMS

ABAS	Airborne-based Augmentation System
ACC	Area Control Center
ACF	Area Control Facility
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AFDP	Automatic Flight Data Processor
AFTM	Air Traffic Flow Management
AFTN	Aeronautical Fixed Telecommunications Network
AIC	Aeronautical Information Circular
AIDC	ATS Interfacility Data Communications
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMHS	Aeronautical Message Handling Service
AMSS	Aeronautical Mobile Satellite Services
ANSP	Air Navigation Service Provider
AP I & II	Angkasa Pura I & II
APANPIRG	ICAO's Asia-Pacific Air Navigation Planning and Implementation Regional Plans (APANPIRG Agreements) Group
ARINC	Aeronautical Radio, Inc.
ARSR	Air Route Surveillance Radar
ASEAN	Association of South East Asian Nations
ATC	Air Traffic Control

ATFM	Air Traffic Flow Management
ATIS	Airport Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATO	Air Traffic Operations
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
ATSU	Air Traffic Services Unit
B-RNAV	Basic Area Navigation
CA	Conflict Alert
CAA	Civil Aeronautics Administration
CATCC	Central Air Traffic Command Center
CDM	Collaborative Decision-Making
CNS/ATM	Communications, Navigation, Surveillance/Air Traffic Management
CPDLC	Controller-Pilot Data Link Communications
CSFP	Center Stored Flight Plan
CY	Calendar Year
DATIS	Digital Airport Terminal Information Service
DCA	Directorate of Civil Aviation (Malaysia)
DGPS	Differential Global Positioning System
DME	Distance Measuring Equipment
DOC	Document
DVOR	Doppler VOR

E-MSAW	En Route Minimum Safe Altitude Warning
ENR	En Route
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIR	Flight Information Region
FIS	Flight Information Service
FTP	File Transfer Protocol
FUA	Flexible Use of Airspace
GBAS	Ground-Based Augmentation System
GMS	GPS Monitoring System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRAS	Ground Regional Plans (APANPIRG Agreements) Augmentation System
GRS	Ground Reference Station
HF	High Frequency
HFDL	HF Data Link
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots Association
IFATCA	International Federation of Air Traffic Controllers' Associations
IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules
ILS	Instrument Landing System

ISPACG	Informal South Pacific ATC Coordinating Group
JCAB	Japanese Civil Aviation Bureau
LAAS	Local Area Augmentation System
LOA	Letters of Agreement
M2	Mode 2 (two)
MCS	Master Control Station
MITRE/CAASD	MITRE Corporation's Center for Advanced Aviation System Development
MNT	Mach Number Training
MRS	Master Reference Station
MSAS	Multi-Functional Transport Satellite-Based Augmentation System
MSSR	Monopulse Secondary Surveillance Radar
MTSAT	Multi-Functional Transport Satellite
NDB	Non-Directional Beacon
NOTAM	Notice to Airmen
O&M	Operations and Maintenance
OLDI	Online Data Interchange
ORDD	Operational Readiness Demonstration Date
PDC	Pre-Departure Clearance
PIREP	Pilot Reports (weather)
PMS	Precipitation Map Service
QA	Quality Assurance
RASMAG	Asia/Pacific Regional Plans (APANPIRG Agreements) Airspace Safety Monitoring Advisory Group

RDP	Radar Data Processing
RFI	Radio Frequency Interference
RFP	Request for Proposals
RLRS	Reduced Lateral Route System
RNAV	Area Navigation
RNP	Required Navigation Performance
RVA	Robinson Aviation (RVA), Inc.
RVSM	Reduced Vertical Separation Minima
SADIS	Satellite Distribution
SATNAV	Satellite Navigation
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
SIGMET	Significant Meteorological Conditions
SOIT	Satellite Operational Implementation Team
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
TA	Technical Assessment
TFM	Traffic Flow Management
TIS	Traffic Information System
TSO	Technical Standard Order
TWS	Terminal Weather Service
URET	User Request Evaluation Tool
USTDA	U.S. Trade and Development Agency

VDL M2	Very High Frequency Data Link Mode 2
VDL	VHF Data Link
VHF	Very High Frequency
VOR	VHF Omni-Directional Range
VOR/DME	VHF Omni-Directional Range/Distance Measuring Equipment
VSAT	Very Small Aperture Terminal
WAAS	Wide Area Augmentation System
WAFS	World Area Forecast System
WGS-84	World Geodetic Survey –84

Natuna Islands Air Traffic Control and Airspace Management Project for the Republic of Indonesia

Task 3

Develop an Investment Plan

Prepared for:
Directorate General of Air Communications of the Republic of Indonesia

By:
Robinson Aviation (RVA), Inc.

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1.0 Introduction

The objective of Task 3 is to identify the first order costs (capital and annual recurring operations and maintenance) necessary to satisfy the technical and human resources required to provide CNS/ATM coverage and air traffic services for the Natuna Sector C airspace. Task 3 develops the Total First Order Cost of providing these ANSP services. The total cost includes a level of initial investment and a recurring annual operating cost. The initial capital investment is difficult to determine since most of the CNS/ATM equipment requirements are met with existing equipment. Therefore, an estimated initial investment cost to replace the equipment is listed and used as a depreciation basis included as part of the annual recurring cost. The annual recurring costs will be used in conjunction with the estimated Route Air Navigation Services (RANS) charges (revenues) developed in Task 5 to complete the economic and financial analysis. In order to determine the financial requirements for Sector C air traffic services, an assessment of the existing Communications, Navigation, and Surveillance (CNS), Area Control Center (ACC), and Air Traffic Management (ATM) capabilities was completed with a number of alternatives discussed in Task 2. This section of Task 3 will address those alternatives and associate a cost to each. Financing options vary with the type of expense, the extent of the investment, and the expected rates of return on the investment. Potential sources of financing will be identified later in this Task.

2.0 Background

The primary focus of this study is to assist the Directorate General of Air Communications (DGAC) to identify the requirements of resuming Air Navigation Service Provider (ANSP) responsibilities for the Natuna Sector C airspace. Earlier tasks defined the airspace in question, described the existing CNS/ATM conditions, assessed the technical requirements, and provided alternatives to accomplish this objective. Additionally, in Task 1 and Task 2, discussions with the primary stakeholders were outlined. Further, through the designated DGAC representative, the contents of Task 3 were shared with stakeholders and input was encouraged. Direct face-to-face meeting(s) are scheduled in Jakarta prior to presentation of the final report. Any particular input from stakeholders will be accepted at that meeting for inclusion in the final report. This later coordination gave them another opportunity to know of and understand the magnitude of future investments.

In summary, this task addresses the financial aspects of the project and addresses the most operationally acceptable and economically feasible way to resume ANSP responsibilities for Natuna Sector C airspace.

2.1 CNS Resources. CNS coverage throughout Sector C is currently provided by existing communications, navigation, and surveillance equipment located on Natuna Islands with a significant amount of coverage overlap from Tanjung Pinang and Pontianak. With the new MSSR Surveillance equipment installation currently in progress on Batam Island to replace Tanjung Pinang SSR, that equipment should continue to provide adequately reliable surveillance for the next 10 years. The Natuna (NTA) MSSR is operational and remoted to the Jakarta ACC; however, it is not currently being used for air traffic control. Although the equipment is in place and operational, the initial cost to clear

critical issues[1] regarding equipment spares, flight calibration, VSAT reliability, and technical personnel training as well as to provide ongoing operations and maintenance activities, is included in this investment plan.

A cost basis is provided for the option of immediately replacing the existing equipment and an estimated depreciation expense is also listed to provide a cost basis for using the existing equipment during initial transition of the airspace and allow a longer term transition to new CNS equipment or space based technology. The specific cost for acquisition and implementation of new equipment is extremely variable depending on the manufacturer, specifications of the equipment, and the range of options purchased (quantity, specific configuration, number of spares, training, shipping, site preparation, installation packages, etc.). The costs used in this section are the best estimates available. A list of United States suppliers of CNS/ATM and ATC related equipment is provided in Appendix 4.

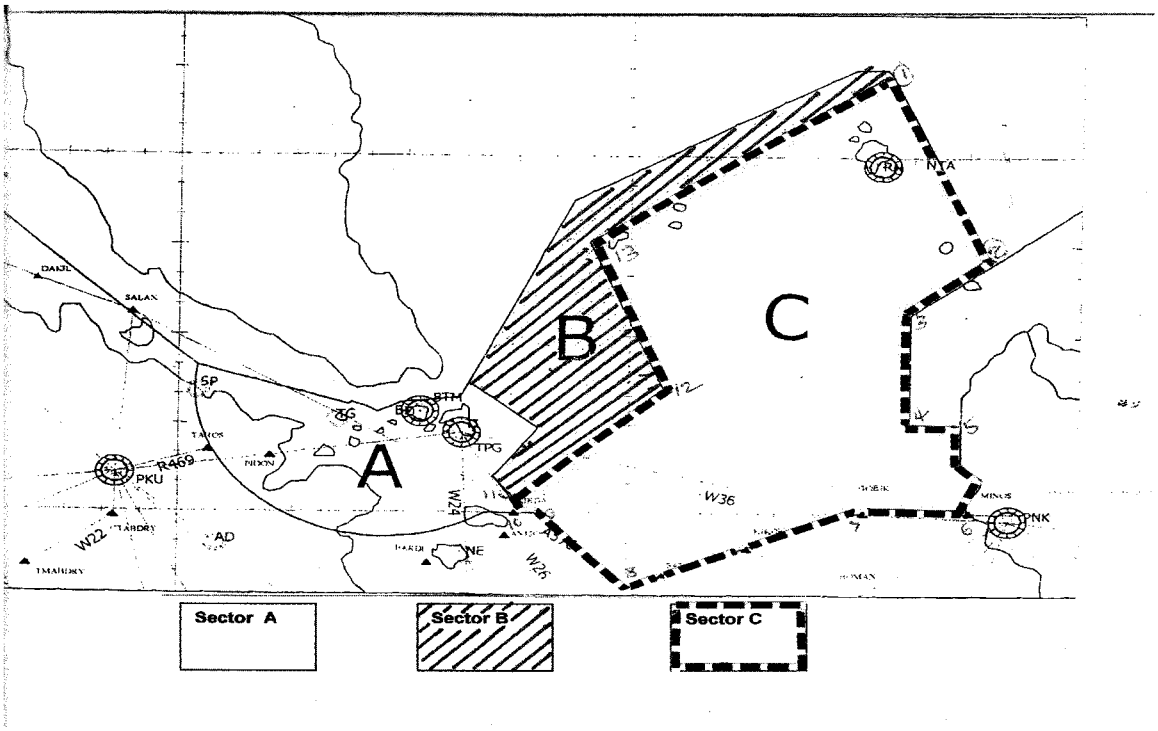


Figure 2.1. Natuna Sector C Airspace

2.2 ATM Resources. The most critical and essential services provided by any ANSP are to provide a reliable infrastructure and a system capable of assuring safe operations and efficient routing throughout the Flight Information Region. In addition to the technical skill requirements, air traffic controllers and technicians need appropriate language skills. ATS procedures must be well prepared, properly documented, and controllers adequately

[1] *The Master Plan Study on the Strategic Policy of the Air Transport Sector in The Republic of Indonesia,* (June 2004 final draft, Volume 1, Chapter 8, Table 8.2.2 - Problems in existing CNS)

trained. Additionally, the cost to resolve any identified outstanding Air Traffic Management issues[2] are included in the investment plan.

3.0 Area Control Center (ACC) Cost Considerations

ACC facility options for control of Natuna Sector C airspace range from constructing a dedicated ACC on Natuna Islands or in Jakarta, consolidating Sector C air traffic control function into the new Batam terminal approach control facility, to upgrading the existing Jakarta ACC. Some basic considerations for the construction of a new ACC, particularly in the relatively remote location of Natuna Islands, are:

- **Land Acquisition/Lease.** The real estate options available will determine the exact location of a new ACC. It is assumed that if the ACC were constructed on Natuna Islands, it would be on government-owned property and there would be no purchase or lease costs involved and that adequate power and water supply is available. If the new facility is not located on government property, an arbitrary estimate is not suggested as this cost can range dramatically.

- **Site Preparation.** In addition to the land lease or purchase costs, there are site preparation and building infrastructure costs. Estimates for these costs represent a wide range of possibilities depending on the location of the building and proximity to utility services and highway access, level of quality of assets desired, and availability of qualified contractors to successfully complete the work. Some of the major costs to be considered are:

  Clearing, grubbing and grading
  Heating, air conditioning, and ventilation systems
  Environmental control systems
  Water and Sewer
  Electrical power
  Power Conditioning and Standby power systems
  Access roads and parking
  Security and fencing
  General building landscaping and aesthetics
  Telecommunications equipment and services
  Office automation and administrative support equipment
  Furniture

  All of these costs will be escalated by approximately thirty percent (30%) if this facility were to be constructed on Natuna Islands due to its remote location. In an average urban environment, apart from land lease/purchase costs, the above listed cost areas could conservatively approach more than $3 million USD.

- **Building Construction.** Building construction has two different costs aspects.

[2] *The Master Plan Study on the Strategic Policy of the Air Transport Sector in The Republic of Indonesia,* (Volume 1, Chapter 8, Table 8.2.1 - Problems in the existing ATM)

(1) Technical space has a higher cost due to the special environmental preparations to accommodate electronics equipment and control room operational areas.

(2) A lower rate is applied to administrative space.

The ACC cost is based on 800 square meters of technical space for equipment and operations and 200 square meters of administrative space including training and operational support use. Seismic reinforcement is recommended which will add to the cost. Typical seismically reinforced building cost per square meter for technical space is estimated at $4,000 USD and $3,000 USD for administrative space. Estimated total cost for 1,000 square meter ACC building alone is $3.8 million U.S. Dollars (USD) (not considering the shipping of materials and the additional importation of skilled workers in remote locations).

- **Operations Equipment.** Operational systems purchase, installation, sparing, and training are other significant contributions to the total investment cost of the ACC. These costs would be well into the millions in USD. A listing of the primary equipment and systems required include:

  - Remote control and monitoring for CNS equipment
  - Automation systems, hardware and software, to process data and operate in harmony with adjacent centers
  - Display equipment and controller consoles with CPDLC/data link capability and IDS-5 controller information displays
  - Intrafacility communications equipment
  - Voice switch and recording equipment
  - Power conditioning systems
  - Aeronautical information distribution system

- **Staffing and Training.** Another major cost consideration is the initial and continued cost of staffing the facility with trained and qualified air traffic controllers and technical operations specialists plus management, operations, and administrative support staffs. At the current level of Sector C traffic, one ATC sector would be required (one full performance level (FPL) plus one associate controller). One ATC sector normally requires a controller staffing of one supervisor, four certified FPL radar (tactical) controllers, and four associate (planning) controllers. Technical operations staffing will vary depending on equipment complement and required level of coverage, i.e., 24/7, 16/7, etc. It is as costly to operate and maintain a small facility that requires all of the same equipment as a much larger facility with only a fraction of the utilization rate – Sector C. In summary, the cost is the same but the revenue is much less.

- **Recurring Building Maintenance**. The recurring cost of building maintenance including rent, administrative communications, utilities, facility maintenance and repair, daily upkeep of the building systems, grounds, and security must be considered.

3.1 Area Control Center Options

- **Natuna Islands ACC.** Constructing, equipping, staffing, and operating a new ACC on Natuna Islands dedicated exclusively to service the approximate 40,000 square kilometers of Sector C airspace is initially not considered an economically nor operationally feasible option from a cost benefit perspective; serious considerations are the size of the airspace, its isolated geographic location with limited access to workers, services, and the related added construction cost.

  To put this airspace size in perspective, in the U.S., the Indianapolis and Cleveland Air Route Traffic Control Centers control more than six times that amount of airspace with 243,800 square kilometers and 237,100 respectively. In Europe, the Maastricht Area Control Center covers 261,400 square kilometers, Barcelona 265,800, London 328,000, and Rome almost 11 times the size of Natuna at 433,800. In addition to the air traffic control and technically qualified human resource deficit on Natuna Islands, the initial capital investment for the site preparation, physical plant, and equipment assets leave this as an unattractive alternative.

- **Batam Island ACC.** Alternatively, it may be economically feasible, from an initial investment perspective, to establish a new ACC facility at a location such as the new privately funded approach control facility under construction in Batam. Private funding for the construction and possibly the equipping of the facility make this option financially attractive. Although this option alleviates some of the remoteness issues with Natuna, the issues and investments remain concerning equipping, CNS remoting, and staffing the facility with sufficiently qualified resources required to operate a modern ACC. The global trend is to consolidate Area Control Centers to gain efficiencies and economies of scale. Separation of one element of the Jakarta FIR poses serious operational deficiencies and is not recommended.

- **Jakarta ACC.** A significantly more cost-effective alternative to constructing, equipping, and staffing a new ACC facility on Natuna Islands, or to co-locate into the Batam approach control facility, is possible through upgrade of the existing Jakarta ACC. The Natuna operational position is presently established in the control room. Additionally, operational and technical staffing is available to assume ATC operations once all required remedial actions and training are completed. Jakarta ACC has in place all of the Natuna, Pontianak, and Tanjung Pinang CNS sensor information and communications data flow and other hardware and software systems necessary to control Sector C. The economies gained by consolidation of ACCs and availability of a qualified labor pool overshadow the benefit of possible low initial construction cost at an alternate location.

3.2 ACC Recommendation. It is the recommendation of this study to make the appropriate investments as outlined in the remaining parts of Task 3, to commission and certify the Sector C air traffic control position as established in the Jakarta ACC. The

benefits of this option are multiple. Aside from the technical and human resource considerations, consideration was given to the proximity to the DGAC Headquarters allowing more effective oversight and use of subject matter experts and crisis management. Incorporating Natuna Sector C airspace management in Jakarta ACC has the following benefits over the other options:

- Allows efficient utilization of existing and future ATS/ATM human and capital resources
- Gains economic efficiency implementing new CNS/ATM technology
    - Less equipment to purchase
    - Fewer connectivity costs to remote sensors
    - Allows integration of surveillance data (radar and ADS) into one database
- Facilitates future CNS/ATM technologies integration
- More centralized transition to space based technology
- Improves Customer Service with better flow control and fewer transitions
- Provides ready access for DCAG resources
- Consistent with other regional practices; i.e., Thailand and the Philippines

4.0 Transition Team

A Transition Team should be established to provide leadership throughout the transition process. This team should perform all of the activities necessary for proper coordination and consultation with all parties and organizations affected by the transfer. It is anticipated that the transition team will provide a temporary function and will be terminated following successful transfer of airspace control.

5.0 Human Resource Requirements

Human resources include temporary transition team and the ongoing dedicated air traffic control and technical operations staffing to provide air traffic control and operations and maintenance of the equipment for the Natuna Sector C airspace.

5.1 Transition Team Staffing. The transition team will provide oversight to ensure that all of the required actions necessary for a successful transfer are completed. The roles and responsibilities are outlined in Task 2, Paragraph 11.2.1.2.

In addition to the coordinating activities, the team must ensure the accuracy of all air traffic procedures and that training is completed, and further that all CNS/ATM equipment is properly operating, certified by flight inspection, and properly spared to provide the required level of performance. Table 5.1 lists suggested transition team staffing.

Table 5.1 - Transition Team

Position	Function	Number of Positions
Team Lead	Executive Leadership	1
Coordinator	External and Internal Coordination	1
Air Traffic Control Readiness	Operational Readiness of ATC	1
ACC Internal Integration	Assure CNS integration within ACC Sector C Position	1
CNS Technical External Sites	Assure CNS remote sensors operational readiness	1

5.2 Air Traffic Control Staffing. Based on information acquired during the in-country assessment, Natuna Sector C can be managed by a single ACC position with 24 hour/7 day coverage requirements. The position has provisions for radar and associate radar air traffic control (ATC) specialists as well as operational supervisors. In addition to the radar controllers on position, there is a need for a variety of ATC staff specialists to support air safety and the efficiency of aircraft movement. The support staff types of duties performed by these specialists are contained in Appendix 2. Table 5.2 identifies the proposed Natuna Area Control Center air traffic control staffing.

Table 5.2 - Natuna Sector C Airspace Air Traffic Control Staffing

Position	Function	Number of Controllers
Air Traffic Control	Radar Controller	7
Air Traffic Control	Radar Associate Controller	3
Air Traffic Control	Operational Supervisor	3
Support Specialist	Training	1
Support Specialist	Airspace Procedures /Airman Information	1
Support Specialist	Quality Assurance	1
Support Specialist	Automation	1

5.3 Technical Operations Staffing. Equipment supporting air navigation services over Natuna Sector C will rely on CNS equipment currently installed at three locations: Natuna Island (NTA), Pontianak (PNK), and Tanjung Pinang (TPG). Three specialists at each location provide the level of equipment Operations and Maintenance (O&M) response to equipment failures, and cover vacation and training time. Typical O&M activities performed are listed in Appendix 2. Where actual cost information is not available, the allocation of total annual O&M labor costs to CNS equipment is based on equipment type staffing standard values, and is shown here as a percentage of total labor for these equipment types.

- VHF-ER Communications equipment 6.9% of total
- VSAT Communications equipment 10.5% of total
- SSR/MSSR Surveillance equipment 61.2% of total
- DVOR/DME Navigation equipment 21.4% of total

Operations and Maintenance (O&M) support for all of these facilities is currently provided by PT Angkasa Pura II (AP-II). Table 5.3 illustrates the technical operations staffing requirements to provide O&M on the CNS systems and ACC integration in support of Natuna airspace.

Table 5.3 - Natuna Sector C Airspace Technical Operations Support

Position	Function	Number of Specialists
Engineering Specialist	Natuna (NTA) CNS equipment O&M	3
Engineering Specialist	Pontianak (PNK) CNS equipment O&M	3
Engineering Specialist	Tanjung Pinang (TPG) CNS equipment O&M	3
Engineering Specialist	Jakarta ACC equipment O&M	3
Engineering Supervisor	Supervise Engineering Specialists	1
Coordinator	Coordinate O&M between ACC and Remote Sites	1

6.0 Annual Recurring Costs

This section identifies the categories of annual recurring costs that are included in the development of the total cost to provide air traffic control radar services in the Natuna Sector C airspace. Recurrent costs are those yearly costs that are required to provide ANSP services in Sector C. They include Air Traffic Management (ATM) as well as Technical Operations CNS costs to meet training and staffing requirements and to meet CNS operational and maintenance and facility support requirements. These costs are incurred whether the existing equipment is used or replaced with new equipment. Equipment depreciation expense is listed separately, although it is also considered as an annual recurring cost to offset the life cycle of the equipment. All cost figures are expressed in U.S. dollars (USD). Where applicable, the 365-day average exchange rate for the period 01 August 2005 to 31 July 2006 of 9,568.96170 Rupiah (IDR) per $1 USD was used. [3]

6.1 Personnel Compensation (Labor). The air traffic control and technical operations personnel compensation (labor) cost data include gross wages and salaries (paid labor) plus a twenty-two percent (22%) margin for employer contributions to retirement systems or pensions, employment taxes, health and life insurance, and other benefits with an associated employer cost. An additional twenty percent (20%) is added to include the corporate (AP-II) General and Administrative (G&A) support cost for items such as administrative and second level engineering support. The resulting rate is the "Fully Loaded" cost of employment. The calculated average "Fully Loaded" annual cost of employment is based on reported average compensation for air traffic control and engineering technician employees performing these functions. Average base compensation costs by employment category were provided by the DGAC.

- ATC Specialist - $11,990
- ATC Operational Supervisor - $13,478
- ATC Support Specialist - $13,478

[3] FXHistory copyright 1997-2005 by OANDA Corp

- Engineering Technician - $10,277
- Engineering Supervisor/Coordinator - $11,990

6.2 Facility Support. Facility support costs include costs to support the infrastructure and the upkeep and maintenance of buildings structures and systems to house, service, and support CNS equipment. Support costs include:

- Physical plant electrical, plumbing, heating, and cooling
- Building Systems – fire alarm, chillers, control systems
- Power generating, conditioning, and switching systems
- Test Equipment purchase and calibration
- Building Security or Guard services
- Custodial services, pest control, and trash pickup
- Vehicles and mobile equipment for site access
- Telephone interfacility and switching system
- Grounds, roads, and entrance maintenance and parking
- Utilities – Gas, electric, water, sewer

The cost for infrastructure support varies with each estimate due to conditions depending on location of the equipment and level of support required. Utilities costs vary depending on equipment and utility rates charged for usage. For communications and navaids equipment, this cost is relatively small in comparison to operating surveillance equipment and associated infrastructure where stringent power requirements and power conditioning cause utility costs to be significant.[4] Therefore, utility costs for surveillance (SSR/MSSR) sites are listed separate from facility support costs.

Based on analysis of cost reports for similar ANSP service providers, facility support costs are expressed as a percentage (35%) of the Operations and Maintenance costs.

6.3 Remoting (Telecommunications). An integral part of providing ATC services is for the control location to reliably receive the information provided by the remote sensors – Surveillance and Communications information. Very Small Aperture Terminal (VSAT) systems provide radar data and VHF-ER voice information from each CNS component to the ACC. Remoting cost for one line of VSAT services from a remote location to the ACC is based on reported costs of approximately $4,000 per month.

6.4 Training. CNS/ATM training costs include the cost of training all of the controllers identified in section 2.2 working Sector C. Training costs include initial and recurrent training to gain and maintain job proficiency in the performance of air traffic control activities and in equipment O&M activities. Training costs include things such as course development and delivery, reproduction of training materials, and equipment or simulation lab exercise time. Training costs are based on expected number of hours of training per ATC employee times an average rate of $90 USD for the type of training needed.[5]

[4] Average U.S. ARSR-4 radar facility electricity 2004 annual cost is approximately $40,000

[5] MITRE Corporation *The Asia-Pacific Regional Navigation Feasibility Study (ARNFS),* May 2005

Controller initial training requirements depend on the degree of controller familiarity with the proposed Natuna procedures. It is estimated that each controller and supervisor working the Natuna Sector will require 80 hours of initial radar and procedural control training and 8 hours per month recurrent training. These costs do not include a continuation of the DGAC reported effort to provide refresher English language training.

The technical operations (engineering) segment of the workforce will not require initial training if the current systems are used. However, several technical shortcomings have been identified in previous studies and these issues must be dealt with in a timely manner. Manufacturer initial technical training on new equipment should be included in the acquisition cost of the equipment. Technical refresh training is required as systems develop and modernization efforts occur. For technical operations, recurrent and technical refresh training varies depending on equipment type and upgrade or modernization efforts. Engineering technician technical refresh training is calculated at 5% of the annual labor cost to support the system.[6]

6.5 Site Spares. Site spares costs include the average annual cost of replenishment of site spares used during the course of routine and corrective equipment maintenance. Appendix 3 contains a listing of typical spare parts for CNS equipment. Spare parts cost will vary by equipment manufacturer, arrangements made at the time of purchase, equipment location and weather conditions, technician's level of expertise, and level of equipment redundancy and reliability mandated. Surveillance equipment components, such as antenna rotary joint replacement parts, and installation are extremely expensive ($1.5 Million USD each) and therefore are not included in the spares cost, since it is not prudent to store these parts. Initial and annual recurring cost of spare parts was determined by analysis of similar CNS equipment spare usage by specific part numbers and cost averages for one year of usage.[7]

6.6 Flight Inspection. Flight inspection to assure the flight integrity of certain equipment is required on a periodic basis and on surveillance equipment as conditions warrant. Flight inspection costs are based on expected number of hours of inspection time required for routine periodic quality assurance checks at the reported average total rate of $3,600 USD per flight inspection hour. An initial flight inspection should be performed on all navigation equipment supporting Natuna airspace and on the Natuna MSSR to assure proper operation on all airborne performance parameters–estimate eight hours per site. Following the initial inspection, navigation equipment should have a minimum of annual inspections at approximately four hours per facility and surveillance as echoes or other conditions warrant.

6.7 Depreciation. Depreciation is a non-cash expense that reduces the value of an asset due to wear and tear, age or obsolescence. Assets lose their value over time and must be replaced once the end of their useful life is reached. Whether new equipment is purchased or existing equipment is used, a capital cost recovery plan should be included in the cost recovery formula for providing ANSP services. Although listed separately, it is

[6] Training percentages based on Federal Aviation Administration 2005 Cost of Services figures.
[7] Site spares average annual replenish cost based on similar CNS systems in FAA

part of the annual recurring CNS expense to support Natuna airspace. Depreciation was determined by calculating a twenty (20) year asset straight-line depreciation schedule with zero salvage value at the end of the life cycle using the cost of acquisition and installation of the equipment based on manufacturer's quotes when actual cost data is not available.

7.0 Sector C Airspace Cost Development

This section identifies the cost elements considered in identifying one-time and annual recurring costs to provide CNS/ATM radar separation air navigation services in the Natuna Sector C airspace. Cost categories include "Initial One Time" and "Annual Recurring" costs and are appropriately labeled in the following tables.

The initial one time costs for CNS equipment show the manufacturer's quotes for the type of equipment listed (equipment baseline), the initial site spare cost to ensure the equipment meets the reliability, availability, and mean time to repair requirements for global quality air navigation service providers. An estimated cost to conduct a formal on-site technical evaluation, arranged by the transition team, is included to ensure all equipment technical parameters are operating in compliance with the manufacturer's specifications. Although a functional Transition Team is critical to successfully coordinate all of the actions required, the ordinary costs such as salary and benefits are not included in the cost estimate.

Annual recurring costs are identified as costs incurred for all aspects of operations and maintenance and facility support needed for CNS equipment servicing Sector C and the ATM staff compensation recurrent training required to provide air traffic control services.

Adequate technical resources (CNS/ATM equipment) are in place and adequate human resources (controllers and technicians) are available to resume ANSP responsibilities for Natuna Sector C. The most economical, efficient, and expedient way to provide air traffic control in this area is to ensure the operability of the existing CNS/ATM infrastructure and to develop procedures and train controllers in Sector C air traffic management. This approach allows a baseline of the annual recurring and depreciation costs to be used with the calculated Sector C Route Air Navigation Services (RANS) charges revenues in subsequent cost analysis. New equipment cost estimates, along with a list of equipment manufacturers listed in appendix 4, are provided to allow the option of purchasing new or upgrading the existing equipment.

7.1 Communications (C). Communications systems are evolving to digital and the Indonesian Master Plan reflects transitioning to digital systems throughout the Indonesian airspace and in conjunction with Regional plans. In the current environment, communications coverage for Natuna Sector C can be provided by the existing Very High Frequency (VHF) extended range (ER) frequencies located at three remote locations: Natuna Islands, Pontianak, and Tanjung Pinang, which are of the same technology as communications outlets in adjacent airspaces. The existing communications frequencies are connected to the Jakarta Area Control Center (ACC) via reliable Very Small Aperture Terminal (VSAT) equipment and associated leased services. Table 7.1A shows the Communications "One Time" investment and Table 7.1B shows the Annual Recurring cost by location and equipment type. All costs presented are in United States Dollars (USD).

Table 7.1A - Communications "One Time" Investment

Equipment Location	Equipment Type	Equipment Baseline	Initial Spares	Technical Evaluation	Total
Natuna Island	VHF-ER	215,000	18,000	2,000	$235,000
Pontianak	VHF-ER	215,000	18,000	2,000	$235,000
Tanjung Pinang	VHF-ER	215,000	18,000	2,000	$235,000
Natuna Island	VSAT	180,000	6,000		$186,000
Pontianak	VSAT	180,000	6,000		$186,000
Tanjung Pinang	VSAT	180,000	6,000		$186,000
Jakarta ACC	VSAT	180,000	6,000	2,000	$ 188,000
Total		**$1,365,000**	**$ 78,000**	**$8,000**	**$1,451,000**

Table 7.1B - Communications Annual Recurring Cost

Equipment Location	Equip Type	Depreciation Expense	Operations (O&M)	Facility Support	Site Spares	Remoting (telecom)	Total Recurring
Natuna Island	VHF-ER	10,750	3,088	1,081	10,000		$24,919
Pontianak	VHF-ER	10,750	3,088	1,081	10,000		$24,919
Tanjung Pinang	VHF-ER	10,750	3,088	1,081	10,000		$24,919
Natuna Island	VSAT	9,000	4,699	1,645		48,000	$63,344
Pontianak	VSAT	9,000	4,699	1,645		48,000	$63,344
Tanjung Pinang	VSAT	9,000	4,699	1,645		48,000	$63,344
Jakarta ACC	VSAT	9,000	13,666	4,678	5,000		$ 32,344
Total		**$ 68,250**	**$37,027**	**$12,854**	**$35,000**	**$ 144,000**	**$297,133**

7.2 Navigation (N). Ground-based navigation systems will ultimately be replaced with space based technology like Global Positioning Systems. Several studies have been conducted and are the subject of several meetings and agreements. Space based technology must be installed in accordance with regional planning and is not suitable for Natuna Sector C in itself. Consequently, like communications, navigational coverage for Natuna Sector C can be provided by relatively new extended range Doppler VHF Omni-directional Range (DVOR) and Distance Measuring Equipment (DME) located at the same three remote locations: Natuna Island, Pontianak, and Tanjung Pinang. The existing navigational aids provide a theoretical coverage throughout the control area. Table 7.2A shows the Navigation "One Time" investment and Table 7.2B shows the Annual Recurring cost by location and equipment type.

Note: As discussed in Task 2, Indonesia is participating in a regional plan to transition to GPS. No additional equipment beyond the regional agreement is required.

Table 7.2A - Navigation "One Time" Investment

Equipment Location	Equipment Type	Equipment Baseline	Initial Spares	Tech Evaluation Flight Inspection	Total
Natuna Island	DVOR/DME	625,000	20,000	30,800	$675,800
Pontianak	DVOR/DME	625,000	20,000	30,800	$675,800
Tanjung Pinang	DVOR/DME	625,000	20,000	30,800	$675,800
Total		**$1,875,000**	**$60,000**	**$92,400**	**$2,027,400**

Table 7.2B - Navigation Annual Recurring Cost

Location	Equip Type	Depreciation Expense	Operations (O&M)	Facility Support	Site Spares	Flight Inspection	Total Recurring
Natuna Island	DVOR DME	31,250	9,577	3,352	20,000	14,400	$78,579
Pontianak	DVOR DME	31,250	9,577	3,352	20,000	14,400	$78,579
Tanjung Pinang	DVOR DME	31,250	9,577	3,352	20,000	14,400	$78,579
Total		**$ 93,750**	**$28,731**	**$10,056**	**$60,000**	**$ 43,200**	**$235.737**

7.3 Surveillance (S). Surveillance (Radar) coverage is primarily provided by a relatively new MSSR system installed on Natuna Islands. Two adjacent facilities at Pontianal and Tanjung Pinang fill the gaps and provide overlap coverage to provide redundancy in the event of Natuna MSSR failure. A new state-of-the-art MSSR system is currently under construction at Batam which will supersede the aging Tanjung Pinang SSR and is expected to provide an even larger degree of Sector C overlap coverage. Table 7.3A shows the Surveillance "One Time" investment and Table 7.3B shows the Annual Recurring cost by location and equipment type.

Table 7.3A - Surveillance "One Time" Investment

Equipment Location	Equipment Type	Equipment Baseline	Initial Spares	Tech Evaluation	Total
Natuna Island	MSSR	4,500,000	190,000	4,000	$ 4,694,000
Pontianak	SSR	4,500,000	190,000	4,000	$ 4,694,000
Tanjung Pinang	SSR	4,500,000	190,000	4,000	$ 4,694,000
Batam Island	MSSR				
Total		**$13,500,000**	**$570,000**	**$12,000**	**$ 14,082,000**

Table 7.3B - Surveillance Annual Recurring Cost

Location	Equip Type	Depreciation Expense	Operations (O&M)	Facility Support	Site Spares	Utilities (Electric)	Total Recurring
Natuna Island	MSSR	225,000	44,751	15,663	180,000	43,000	$508,414
Pontianak	SSR	225,000	44,751	15,663	180,000	43,000	$508,414
Tanjung Pinang	SSR	225,000	44,751	15,663	180,000	43,000	$508,414
Batam Island	MSSR						
Total		**$675,000**	**$134,253**	**$46,989**	**$540,000**	**$129,000**	**$1,525,242**

7.4 Air Traffic Management (ATM). Table 7.4A shows the Air Traffic Management "One Time" investment and Table 7.4B is a summary of ATM costs including initial and recurrent training and annual operations to provide ATM services at the Jakarta ACC Natuna position.

Table 7.4A - Air Traffic Management "One Time" Investment

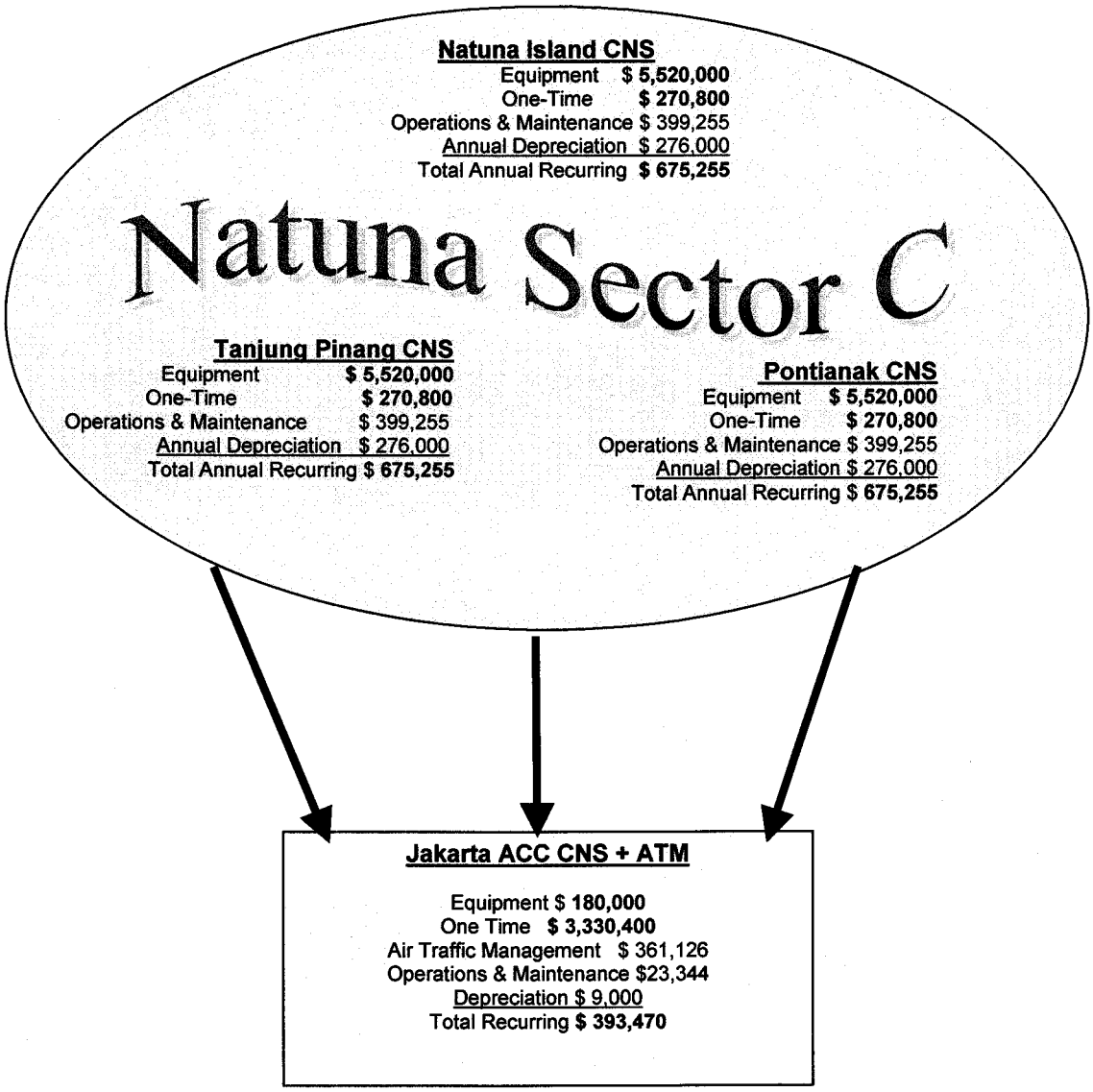
ATM Function	ATM system	
Traffic management	Air Traffic Management	$3.0M
Controller position	Controller information displays	$0.2M
Total		**$3.2 M**

Table 7.4B - ATM Initial Training and Annual Recurring Cost

Position	Initial Training	Annual Operations	Recurrent Training	Total Recurring	Total ATM Cost
Air Traffic Control	93,600	160,334	112,320	272,654	$ 366,254
ATC Support	28,800	53,912	34,560	88,472	$ 117,272
Total	**$122,400**	**$214,246**	**$146,880**	**$361,126**	**$ 483,526**

7.5 Summary of Costs. Figure 7.5A and Table 7.5B show the summary of equipment investment, one-time, and annual recurring costs to provide air traffic control services in the Natuna Sector C airspace from the Jakarta ACC. Details are included in Appendix 5. Cost for salaries and travel for the Transition Team are not included. Figure 7.5A shows costs by geographic location.

Figure 7.5A - Cost by Location



All costs in USD

Table 7.5B - Summary of Costs

Service	Equipment	One time	Operations	Annual Depreciation	Total Recurring	Recurring + Depreciation
Communications	1,365,000	86,000	228,881	68,250	297,131	$382,131
Navigation	1,875,000	152,400	141,987	93,750	235,737	$388,137
Surveillance	13,500,000	582,000	850,242	675,000	1,525,242	$2,107,242
Air Traffic Mgmt		122,400	361,126		361,126	$483,526
Total	**$16,740,000**	**$942,800**	**$1,582,236**	**$ 837,000**	**$2,419,236**	**$3,362,036**

8.0 Conclusions

1. State-of-the art CNS/ATM systems would benefit Sector C operations.

2. Remediation of systems and procedures should be the first priority.

3. DGAC reported many projects in progress, such as ADS-B and GPS, which will benefit system users and reduce recurring cost for Indonesia. Accordingly these CNS/ATM systems are not included in Task cost projections.

4. State-of-the-art CNS/ATM systems must be instituted in harmony with neighboring states and adjacent Air Navigation Service Providers (ANSP).

5. Resuming control of Sector C will allow full CNS coverage utilizing three surveillance systems, multiple VHF/HF frequencies, and three VOR/DME facilities. Full CNS coverage, with GPS, will allow improved, i.e., closer, RNP separation standards.

6. Closer RNP tolerance will facilitate more accurate separation standards, greater system access, and increased capacity while assuring the same or greater levels of safety.

7. Capital investment in technologically advanced CNS/ATM systems is recommended for wider application than found in Sector C and must be in concert with regional planning and agreements.

8. Installation of CNS/ATM systems such as CPDLC, ADS-B, GPS and Regional traffic flow management will benefit Sector C but must be initiated for larger areas than Sector C.

9. Studies, such as ARNFS, SOFREAVIA, and JICCA – adopted as the Indonesian Master Plan, all reference the need for Regional planning and implement timeframes and regional agreements for demonstrations for various space based systems and future technologies.

10. A policy to develop regional and global plans is endorsed by ICAO, IATA, and the majority of ANSPs.

11. Air navigation services providing radar separation for the Natuna Sector C airspace can be provided from the Jakarta Area Control Center using the existing CNS/ATM equipment with a relatively small amount of initial investment in transition planning, procedures development and training and technical quality assurance.

12. The primary equipment providing CNS coverage for Sector C is relatively new and is located at Natuna Islands.

13. The Natuna MSSR is the strategic key to radar coverage in the South China Sea.

14. A high degree of overlap surveillance coverage is provided by a brand new MSSR at Batam (replaces Tanjung Pinang SSR).

15. Additional CNS overlap is provided by equipment located at Pontianak. Although not recommended, an initial investment of an estimated $16,740,000 USD is required to replace the existing CNS equipment used to provide CNS coverage throughout Sector C.

16. Singapore ACC currently provides procedural air traffic services over Natuna Islands Sector C airspace; controlling this airspace from Jakarta ACC with existing CNS equipment will provide full CNS coverage while creating at least double the present capacity.

17. Air traffic control can be provided by one position at the Jakarta ACC staffed with 10 full performance level air traffic controllers, 3 operational supervisors and 4 support staff personnel. Reliable CNS coverage with redundancy, overlap, and adequate equipment performance and restoration requirements can be provided with existing CNS equipment by 12 engineering technicians, three each located at Natuna, Pontianak, Tanjung Pinang, and Jakarta ACC along with one supervisor and one facility coordinator located at the Jakarta ACC.

18. New CNS equipment estimates are included as information on which to base decisions to replace or retain existing equipment. Baseline costs are also used in the calculation of depreciation expense for full cost recovery.

19. One-time costs to assure equipment readiness and capability to support ATC services at the required level of performance, provide controller training, and support transition team requirements are estimated at approximately $1 million USD. An additional one-time cost of $3.2 million USD will provide a traffic management system compatible with Singapore ACC and Controller information displays.

20. A complete listing of equipment and systems manufacturers is provided in Appendix 4. This listing includes equipment and sources that address needs beyond this

particular TA. The sources listed are known creditable providers of excellent CNS/ATM systems worthy of serious consideration.

21. The estimated total annual recurring operating costs to provide Sector C ANSP, with the current level of CNS equipment is $1.6 million USD operating cost, with $0.8 million USD annual depreciation expense, for a total annual recurrent cost of $2.4 million USD based on 2006 cost estimates.

9.0 Project Financing

Sources of financing vary greatly depending on a multitude of factors including size, scope, and nature of the project and how it will contribute to the economic development of the area. Many potential lenders have a vested interest in economic development. Every indicator is that Southeast Asia is expected to continue its recent trend toward economic growth with air transportation a key element in that growth. A project, such as providing radar separation air traffic control in a critical crossroads of the Region, will reflect well as a capital venture.

The cost of financing will vary depending on market conditions and other factors affecting the expected rate of return and the favorability of the project. Ground-based systems providing CNS/ATM types of services are constantly being evaluated against transition to less cost intensive and much more far reaching space-based technologies. The development of space-based global air navigation systems will impact on the level and investment in aging 20th century CNS technology.

9.1 Financing Outlook. In a recent study, *The Asia-Pacific Regional Navigation Feasibility Study (ARNFS),* the MITRE Corporation noted the following observation on public versus private funding opportunities:

> Historically, infrastructure modernization projects in the Asia-Pacific region have been financed with public funds. *International Finance Statistics* of the International Monetary Fund (IMF) suggests that public funding of infrastructure projects ranged from somewhere between 2.1% to 3.2% of the gross domestic product (GDP) of the upper middle income to lower income countries, respectively (Estache 2004), during the last decade. Official Development Assistance (ODA) has been the second largest source of financing infrastructure. Recently, however, the advantages of private sector involvement have been recognized, and a trend has emerged toward greater reliance on private funds. Whenever private funds have been involved, projects have been found to be economically viable and contributed more productively than alternatives. In addition, private financing has often been found to effectively mitigate numerous risks

in complex projects when proper care is taken in designing contracting and scheduling options.[8]

10.0 Financing Options for CNS/ATM Infrastructure Investments

10.1 General. This section explains the lending option initiatives and provides for the actions to be taken when applying for a loan to provide CNS/ATM equipment. There are multiple sources for financing of CNS/ATM capabilities. A limited range of commercial sources of finance is available for CNS/ATM investments. Conversely, sources of concessionary financing traditionally available to developing economies become a viable option. Selection of financing vehicles is best done as part of the contract negotiation process with the selected vendor. Vendors with established relationships with commercial and bilateral concessionary lenders are able to structure financing arrangements that reflect the goals and objectives of the vendor and the borrower. The most significant issues regarding financing of CNS/ATM capabilities are the mitigation of default and currency risks.

10.2 Commercial Financing. Each State has a speculative grade credit rating that supports use of a limited range of financial services for the acquisition of CNS/ATM capabilities. Identification of potential financial intermediaries should be based on current relationships between the State's government and/or seller of the subject goods and services. Use of seller-based relationships moves the transaction into a vendor financing process; use of buyer-based relationships becomes a lender financing process. Both pathways can result in the consummation of a deal. The choice becomes one of the relative passivity/activity of the buyer and seller. An active buyer role militates toward lender financing; a more passive buyer role leads to vendor financing.

10.3 Vendor Financing. Vendors obviously have a strong interest in arranging the financing of major system acquisitions as an integral component of their negotiations with buyers. In cases where the resulting note is secured by the seller, each state's speculative grade status may require additional collateral to secure the necessary financing requirements. This trend would be further reinforced if debt servicing were managed through a mechanism such as the IATA clearing house.

10.4 Lender Financing. International lender interest in providing financing for CNS/ATM development should be high despite the speculative grade rating. However, lenders might be less enthusiastic about financing such a package given the relatively small size of the total acquisition. Direct lending for infrastructure projects in the international market is usually in the USD $1 billion magnitude. Substantially smaller sums can be financed, but loan origination fees can increase the total cost of the financing significantly above the nominal interest rate. When compared to the benefits noted above regarding vendor financing, international lender financing of a CNS/ATM modernization program is less attractive.

[8] MITRE Corporation *The Asia-Pacific Regional Navigation Feasibility Study (ARNFS) Chapter 11 Economic Feasibility Sources of Funding, and Financial Options* May 2005

A second source of lender financing for CNS/ATM might be found in the domestic market. Given the collateralization of such a loan in US$-denominated cash flows, such a lending opportunity would be very attractive to lenders whose alternative uses of funds are tied to the activities of each state activities. However, borrowing to finance a CNS/ATM modernization might adversely distort the domestic capital market as states compete with other private borrowers for a limited pool of investment funds. Further, since most of the outlays are US dollars-denominated, use of the State's local currency might adversely distort the foreign exchange market. Liquidity in both the capital and foreign exchange markets seems to be sufficient to make this a minor consideration.

10.5 Concessional Financing. Concessional financing is that form of financial intermediation where loan terms do not fully reflect the economic value of the transaction being financed. Such financing is the province of State agencies and/or multilateral authorities. Access to financing through either mechanism is the product of non-economic decisions. Use of either mechanism to support the acquisition of CNS/ATM capabilities could be highly advantageous to some applications.

Such arrangements can be used in concert with vendor and lender financing approaches outlined above. Traditionally, multilateral financing has been used in situations where the commercial market is unwilling to provide financing in its absence. Further, multilateral lending authorities have not been active in providing financing support to air traffic control modernization programs except where sufficient linkage can be made to the social development objectives of the lenders. Thus, depending on reactions from vendor and lender institutions, multilateral financing should be viewed as a consideration.

10.6 Bilateral Financing. In contrast to the situation with multilateral lending agencies discussed above, bilateral lending is based upon policy decisions by State authorities regarding their application of industrial policy considerations. Many States follow an export promotion policy. Technically oriented products such as air traffic control systems are seen as highly desirable financing opportunities by lenders.

A second area of consideration is the use of bilateral financing as a foreign policy tool by the exporting State. Governments seeking to extend their national influence through economic ties are highly motivated to provide financial support. A third area of consideration is the use of bilateral financing as a means to support other industries. A final area of consideration is the use of bilateral financing as a means to encourage other air traffic service providers in the region to equip with similar capabilities. This motive reinforces the three considerations mentioned previously.

Two primary sources of CNS/ATM financing are the Export-Import Bank of the United States (Ex-Im) and the European Bank for Reconstruction and Development (EBRD).

11.0 Potential Sources of Financing

Potential sources of financing may be available through government or private enterprise with a vested interest in developing air navigation capabilities and fostering economic growth in the area. Special financing may be available for certain kinds of technology. Potential sources of financial assistance are:

- The Export-Import Bank of the United States – Ex-Im can assist with financing for export sales of U. S. air traffic control equipment. The Ex-Im Bank has experience in providing loan guarantees based on revenues collected from overflight (RANS) fees. Ex-Im Bank may negotiate flexible terms to allow for project implementation. Complete details on the Ex-Im CNS loan process are explained in Appendix 5.

- European Bank for Reconstruction and Development (EBRD). The EBRD uses the tools of investment to help build market economies and democracies in 27 countries from central Europe to central Asia. The policy and criteria for EBRD loans are listed in Appendix 6.

- The Asian Development Bank (ADB) is a multilateral financial institution that promotes economic and social development in the Asia-Pacific region. Indonesian Development Funding (IDF)

- The Islamic Development Bank (IsDB) is a multilateral development financial institution. The functions of the Bank are to participate in equity capital and grant loans for productive projects and enterprises besides providing financial assistance to member countries in other forms for economic and social development.

- World Bank – IBRD and IDA. The World Bank is a vital source of financial and technical assistance to developing countries around the world. They are made up of two unique development institutions owned by 184 member countries—the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA).

- Overseas Private Investment Corporation (OPIC). OPIC helps U.S. businesses invest overseas, fosters economic development in new and emerging markets, complements the private sector in managing risks associated with foreign direct investment, and supports U.S. foreign policy.

- Japan Bank for International Cooperation (JBIC). The purpose of Japan Bank for International Cooperation shall be to contribute to the sound development of Japan and the international economy and community through undertaking lending and other financial operations: for the promotion of Japanese exports, imports or Japanese economic activities overseas; for the stability of international financial order; and for economic and social development or economic stability in developing areas; in accordance with the principle that it shall not compete with commercial financial institutions. (Note: JBIC financed the New Bangkok International Airport NBIC.)

12.0 Risk Assessment

Under any circumstances, financial institutions are faced with certain risks associated with lending money. To optimize opportunity for potential CNS infrastructure investment loans, a brief explanation of risk mitigation strategies in provided in Appendix 7, "Risk Assessment and Considerations by Financial Institutions."

APPENDIX 1. DESCRIPTION OF ATC SUPPORT STAFF DUTIES

Type Position	Position Title	Position Summary
Air Traffic Control	Training Specialist	Plans, develops, maintains and conducts training including classroom instruction, simulator training, proficiency training, and counseling. Develops lesson plans, visual aids, and simulated laboratory problems, and examinations. Studies proposed changes to policies and procedures to determine training needs. Reviews incidents to determine if proficiency or supplemental training is required. Maintains facility training records. Spends sufficient time in observation of operational activities to assure familiarity with all phases of operations.
Air Traffic Control	Airspace & Procedures Specialist/Airman Information	Analyze and evaluate all DGAC, AP-II, ICAO, and other policy statements, regulations, manual revisions, criteria and reports on new equipment and procedures to determine effects on ACC airspace and procedures. Studies air traffic characteristics within the ACC to determine the need for alternate airways, preferential routings, additional or changed holding patterns, new or relocated CNS equipment. Develops and recommends modifications to procedures such as climb corridors and coded arrival/departure procedures, assuring that they meet systemwide criteria, provide for ease of operation, and present minimum interference with existing traffic patterns. Develop Letters of Agreement between the ACC and other entities. Develop substitute routes and procedures in the event of CNS equipment failure. Assures that all publications are current, reflect actual operational procedures and processes, and are published and disseminated in the appropriate time cycle.
Air Traffic Control	Quality Assurance Specialist	Makes a complete analysis of all phases of air traffic incidents occurring in the ACC airspace control, makes an initial evaluation of the incident to determine factors involved including ATC specialist error, procedural deficiencies, pilot error to comply with instructions, equipment malfunction, breakdown in coordination, and makes recommendations for corrective actions regarding specialist re-training or procedural changes. Provides overall review of accident and incident patterns and trends to determine if specific procedures, equipment layout, specialists habits, or control techniques appear to be fundamental causes and recommends changes as required. Investigates and evaluates all Unsatisfactory Condition Reports. Maintains information on employee progress, certification, failure, related experience and education, and rate of proficiency including English language proficiency development. Conducts facility evaluations.
Air Traffic Control	Automation Specialist	Identifies and develops software system patches to ensure sectorization and mapping presentations on ATC controller displays accurately reflect the airspace configuration in accordance with published procedures and to ensure automated hand-off processing internal and external to the facility are in accordance with approved directives. Ensures adequate testing of all changes and modifications prior to implementing in the live ATC environment.
Technical Operations	Engineering Specialist	Perform all aspects related to the operations and maintenance (O&M) of electronic communications, navigational, or surveillance equipment and supporting standby power and power conditioning systems and telecommunications equipment providing connectivity from the remote sensor to the controlling ACC. Duties include performing Periodic maintenance tasks for scheduled performance checks to hardware and software systems, System Certification, corrective maintenance for system restoration following unscheduled failure or to correct system deficiencies discovered during routine use, and to perform equipment modifications to upgrade equipment to a higher technological level or to correct inherent equipment deficiencies.

APPENDIX 2. OPERATIONS AND MAINTENANCE ACTIVITIES

Operations & Maintenance (O&M) costs include - All labor costs associated with performance of periodic and corrective maintenance, equipment modifications and AP-II administrative Support.

Periodic maintenance - All labor and benefits costs associated with scheduled performance checks to hardware and software systems including activities specific to certification.

Corrective maintenance - All labor and benefits costs associated with service restoration and equipment repairs of hardware and software.

Equipment modifications - All labor and benefits cost associated with alterations to hardware and software CAS Labor allocation assigns the value of Remaining Labor Workload for CAS Facilities.

Administrative support - All non-technical AP-II labor and benefits costs associated to activities that include training coordination, time and attendance processing, office administration, budgeting, etc.

Support (Non Labor) costs include - All costs associated with equipment or service connectivity, flight inspection, site sparing, utilities, and training.

Infrastructure – All buildings and grounds infrastructure support costs such as security, janitorial, and pest control services, upkeep of the buildings, roads, parking lots, grounds, fences, and building systems, and utilities.

Connectivity – Also called "Remoting" or "Telecommunications" Costs associated with leased satellite or ground cable connection of remote sensors and frequencies to the Area Control Center.

Flight Inspection - Costs identified by flight inspection office that are associated to ensure the safety and compliance of electronic navigation equipment and procedures.

Site Spares - Costs associated with maintaining stocks and stores of spare parts for issuance to the field performing facility refurbishment services and providing on-site repair services.

Training – Costs associated with ATC Controller and Technical Operations personnel English proficiency and technical training.

APPENDIX 3. CNS EQUIPMENT SPARE PARTS LISTS

The prudent complement of on-site spare parts vary by equipment manufacturer, equipment type, age, condition, and criticality to the National Airspace System. The table below lists the types of typical on-site spare parts for CNS equipment. Quantity of parts based on sparing three CNS locations and on average part failure rate in similar equipment. The cost is based on U.S. Dollars.

System	Part Description	Unit Cost	Qty	Total Cost
SSR/MSSR	Power Module	$ 18,045	6	$ 108,270
SSR/MSSR	Power Supply Pre-Amp Assembly	$ 3,305	6	$ 19,830
SSR/MSSR	Power Supply Collector	$ 6,743	6	$ 40,458
SSR/MSSR	Power Pre-Amplifier Switch	$ 2,650	6	$ 15,900
SSR/MSSR	Power Supply Multiplier	$ 9,757	6	$ 58,542
SSR/MSSR	Blower Master Assembly	$ 3,252	3	$ 9,756
SSR.MSSR	Serial Controller Assembly	$ 5,953	6	$ 35,718
SSR/MSSR	Phase Control Module	$ 2,605	3	$ 15,630
SSR/MSSR	Hybrid Line Amplifier	$ 15,514	6	$ 93,078
SSR/MSSR	Barometric Switch	$ 19,810	3	$ 59,430
SSR/MSSR	Antenna Motor Drive Assembly	$ 51,480	3	$ 308,880
SSR/MSSR	Splitter 1:3 Assembly	$ 2,395	6	$ 14, 370
SSR/MSSR	Splitter 1:4 Assembly	$ 15,872	3	$ 95,232
SSR/MSSR	Other spare Module/Card Assemblies	$ 5,000	18	$ 93,600
VOR	Voltage Regulator Assembly	$ 620	3	$ 1,860
VOR	Analog Circuit Card Assembly	$ 1,252	3	$ 3,756
VOR	Digital Circuit Card Assembly	$ 998	3	$ 2,994
VOR	Measurement Assembly	$ 876	3	$ 2,628
VOR	Antenna Control Assembly	$ 2, 685	3	$ 8,055
VOR	Monitor Detector Assembly	$ 900	3	$ 2,700
VOR	Peak Power Assembly	$ 617	3	$ 1,851
VOR	Doppler Antenna Assembly	$ 3, 916	3	$ 11,748
VOR	Other Spare Modules/Card Assemblies	$ 1,000	15	$ 15,000
COMM	Power Supply Assembly	$ 1,656	6	$ 9,936
COMM	Power Amplifier	$ 845	6	$ 5,070
COMM	VHF Cavity	$ 3,294	6	$ 19,764
COMM	Communications Modem	$ 351	6	$ 2,106
COMM	VHF Antenna	$ 1,803	6	$ 10,818
COMM	VHF Amplifier	$ 426	6	$ 2,556
COMM	Fan Assembly	$ 537	6	$ 3,222
COMM	Other Spare Modules/Card Assemblies	$ 1,000	15	$ 15,000
Total				**$1,073,388**

APPENDIX 4. UNITED STATES SUPPLIERS OF CNS/ATM AND ATC RELATED EQUIPMENT

Controller Displays:

Tech-Source
442 S. North Lake Boulevard
Altamonte Springs, FL 32701
USA
Tel: +1 407 262 7100
Fax: +1 407 339 2554
Email: info@techsource.com
Web: www.techsource.com

- Graphics controllers and controller display processors.
- Tech-Source is most widely known for its Raptor PCI and GXTRA Bus family of graphics accelerators. A new line of STARS PCI graphics accelerators is used by Air Traffic Management Systems Integrators around the world. The STARS 2K will be used to upgrade air traffic control throughout the United States over the next ten years!

Systems Atlanta, Inc.
405 Toonigh Rd.
Woodstock, GA 30188 USA
Contact: Judy Davis, Director, Business Development
Telephone: (770) 928-0240
Fax: (770) 928-9396

Systems Atlanta is an industry leader in development if integrated Information Display Systems (IDS) for ATC and the aviation industry. Systems Atlanta's IDS product line is operational in some 500 ATC/aviation facilities, including towers, radar approach, flight service, en route, military, airlines and airport operations. These systems display real-time data from multiple NAS sources consolidated with aeronautical reference data on a common integration platform. IDS data distribution networks link diverse ATC/aviation environments for shared situational awareness. Current Systems Atlanta programs and projects include the FAA's ACE-IDS and SA-IDS4 programs, the US Air Force's Airfield Automation System (AFAS) program, and IDS5-Airport Information Management (IDS5-AIM) for airport operations centers/emergency management facilities, among others.

Communications (Recorders):

Advanced Integrated Recorders

121 Whittendale Drive
Building 1
Moorestown, NJ 08057
USA
Tel: +1 856 234 5020
Fax: +1 856 234 5242
Email: danc@air.formation.com
Web: http://air2000.formation.com/

- Integrated data and voice recording and playback systems.
- AIR2000 synchronously records, plays-back, archives, and restores various types of information, such as: voice, radar, workstation screen, and TCP/IP socket (i.e., LAN) data. Scale ability, expandability, and enhance ability are three key requirements of the product architecture. Product configurations range from a single system with as few as 16 channels to a multi-node, multiple-archive storage device installation, capable of supporting over 1,000 channels of recorded information.
- AIR2000 can be used by Air Traffic Control Centers, Financial Centers, and Call Centers as a powerful tool for event analysis, performance evaluation, training, and risk management.

Comverse USA
234 Crossways Park Drive
Woodbury, NY 11797
USA
Tel: +1 516 677 7400
Fax: +1 516 677 7197
Email: marketing@cominfosys.com
Web: www.cominfosys.com/usa

- Digital voice and data recording and playback systems.
- ULTRA™ is the flagship product with a unique single platform for running multiple applications. These applications include: full-time recording of all calls; quality monitoring for agent evaluation and training; and on-demand monitoring for transaction recordings (such as sales centers); all on a single, client-server platform. This flexible and scalable design allows businesses to modularly start with one application and add additional applications without costly purchases of additional systems. A true multimedia platform, ULTRA can simultaneously record voice, data and video (screen capture), as well as fax. Comverse's unique Virtual Playback and Review feature, utilizing LAN, LAN/WAN or Internet, allows access to multiple supervisors from any desktop or telephone, anywhere in the enterprise. IP-ready, its advanced technology enables recording of voice over IP for Internet Call Centers, as well as LAN and LAN/WAN-based recording to support the next generation of PC-based and work-at-home agents.

Dictaphone Corporation

3191 Broadbridge Avenue
Stratford, CT 06614-2559
USA
Tel: +1 203 381 7000
Fax: +1 203 386 8597
Web: www.dictaphone.com/index.htm

- Digital recording and playback systems.
- Dictaphone's Enterprise Express improves customer's document creation processes by uniting leading edge technologies (speech recognition, digital mobile voice recorders, server based dictation / transcription job administration, document life cycle management, etc.).

Lanier Worldwide

2300 Parklake Drive NE
Atlanta, GA 30345
USA
Tel: +1 770 496 9500
Fax: +1 770 491 1534
Web: www.lanier.com

- Recording and playback systems.
- Advocate V recorder is a four-channel recorder, providing up to six hours of unattended recording time on standard cassettes. The reliable and economical Advocate V is perfect for recording courts of record, various legal proceedings, business and professional conferences. When used with the optional VOR/Time Injector, the Advocate V recorder can record telephone and/or radio traffic. It will also provide the date and time for each call.

Communications (Radios):

ARINC Incorporated

2551 Riva Road
Annapolis, MD 21401-7465
USA
Tel: +1 410 266 4000
Web: www.arinc.com

- Air/Ground Communications:
  ARINC engineers, implements, and manages voice and data communications services that provide aviation operational and safety communications for aircraft throughout the world.

- Airport Systems:
  ARINC provides airports worldwide with integrated information, communications, and management systems that improve operations and enhance passenger service.
- Systems Engineering, Development, and Integration:
  ARINC delivers systems engineering, software development, and systems integration solutions to defense, government, and commercial customers.

Aydin Telemetry

47 Friends Lane
PO Box 328
Newtown, PA 18940-0328
USA
Tel: +1 215 968 4271
Fax: +1 215 968 3214
Email: telemetry@aydin.com
Web: www.aydin.com

- Air-ground radios.

Baker Audio-Telecom

2195 Norcross Tucker Road
Norcross, GA 30071
USA
Tel: +1 770 441 2000
Fax: +1 770 449 7719
Email: aamy@bakeraudio.com
Web: www.dispatchworks.com

- Voice communications and switching systems.
- DISPATCHWorks is a comprehensive, integrated, communications system provided by Baker Integrated Technologies. Baker has been providing these systems for over twelve years in mission critical applications including airline operations centers.

Harris Corporation (RF Communications)

1025 West NASA Boulevard
Melbourne, Florida 32919-0001
USA
Tel: +1 321 727 9207
Web: www.harris.com

- Turnkey air-ground radio systems featuring both analogue (VHF, UHF, HF) and digital (VDL multimode).
- VDL Mode 4
- VSAT

- All Communications

Motorola

1303 E. Algonquin Road
Schaumburg, IL 60196
USA
Tel: +1 847 576 5000
Web: www.mot.com/GSS/SSTG/RSO/Air_Traffic.html

- VHF and UHF air-ground radio systems.

GPS Products
- The Oncore family of Global Positioning System (GPS) products features modules, chipsets, and antennas ideal for a variety of GPS applications.

Satellite Communications
- Communication solutions for government and commercial space missions.
- UHF Satellite secure voice/data terminals for worldwide communications
- Satellite Communications Products: portable phones, pagers, mobile phones, portable docks, accessories and L-band transceivers.

Rockwell Collins

400 Collins Road NE
Cedar Rapids, IA 52498
USA
Tel: +1 319 295 1000
Fax: +1 319 295 5429
Email: mktgsvcs@collins.rockwell.com
Web: www.collins.rockwell.com

- Cockpit avionics including collision-avoidance, radio communications, and weather radar.

SATCOM 906

- The Collins SATCOM 906 is the world's first six-channel voice and data satellite communication system. This integrated system provides support for cockpit data and voice, as well as revenue-generating passenger telephone, fax and PC links.

HF Data Link

- Collins HF Data Link (HFDL) maximizes Aircraft Communications, Addressing and Reporting Systems (ACARS) messages, such as air traffic management, weather and airline operational communications. Collins HFDL is the basis for Automatic Dependent Surveillance (ADS) reporting and other services. Automated information transfer minimizes time delays and operational shortcomings inherent in conventional long-range voice communications.

- The Collins HFDL upgrade brings existing ARINC 719 HF voice radios into compliance with ARINC 753 and ARINC 635, enabling operators to realize the potential benefits and capabilities of the evolving CNS/ATM environment - at the lowest possible retrofit cost. The upgrade system, which meets or exceeds all the latest industry characteristics, includes data link provisions for the Aeronautical Telecommunications Network (ATN), the Future Air Navigation System (FANS), the Communications Navigation Surveillance System (CNSS), and other CNS/ATM operational applications.

Sensis Corporation

5793 Widewaters Parkway
DeWitt, NY 13214
USA
Tel: +1 315 445 0550
Fax: +1 315 445 9401
Email: info@sensis.com
Web: www.sensis.com

- The Sensis Air Traffic Systems group develops surveillance sensors and information systems aimed at increasing aviation safety, capacity and efficiency through improved situational awareness. The group focuses on advanced, low-cost sensors and real-time data communications that provide high accuracy, high update rate surveillance data for Advanced Surface Movement Guidance and Control Systems (A-SMGCS), Precision Runway Monitoring (PRM), Cockpit Display of Traffic Information (CDTI) via Traffic Information System - Broadcast (TIS-B), and Automatic Dependent Surveillance - Broadcast (ADS-B).

Telephonics

815 Broad Hollow Road
Farmingdale, NY 11735
USA
Tel: +1 516 755 7000
Fax: +1 516 755 7010
Web: www.telephonics.com/

- Telephonics integrates sophisticated multi-radar fusion tracking (MRT) and a highly efficient controller interface into the system for optimal performance. Aircraft identification, communication, command, control, data processing, flight training and simulation are all vital features of the "complete" Traffic Management System.
- Telephonics' AeroTrac™ Air Traffic Management System is an advanced en route and terminal automation system that features unparalleled radar capacity, tracking accuracy and flight information processing. Telephonics' AeroTrac has been proven in large scale Air Traffic Control (ATC) systems by tracking over 3000 aircraft, simultaneously processing over thirty radar sensors, and covering over nine million square miles of airspace.

- SkySearch-2000 is a low cost, high performance solution for adding new or expanded secondary surveillance radar coverage in terminal and en route areas. SkySearch-2000 SSR is a complete, turnkey SSR for terminal and en route radar applications.
- Suitable for Air Traffic Control in demanding environments, the ADP-2000 is an easy to use, completely self contained controller display and radar processing system.
- Telephonics' AeroTrac™ Simulator (SIM) is a flexible tool for training controllers in all phases of traffic control procedures.

Communications – Aeronautical Mobile Satellite System (AMSS):

Intelsat

3400 International Drive, NW
Washington, DC 20008-3006
USA
Tel: +1 202 944 6800
Fax: +1 202 944 7898
Web: www.intelsat.int/index.htm

- CLASS: The INTELSAT ground network and mission team has supported the launch of over 60 satellites for external customers.
- Voice and Data Services: Our telephone, fax, videoconferencing and multimedia traffic reaches virtually every country in the world. IBS, IDR, TDMA, DAMA, Internet, VSATs.

Navigation:

Wide Area Augmentation System (WAAS)

Raytheon Company

141 Spring Street
Lexington, MA 02421
USA
Tel: +1 781 862 6600
Web: www.raytheon.com

- Raytheon offers a complete turnkey, low risk transition solution for CNS/ATM.
- We present Multi-Mode VHF Radio System (MMVRS) for ground-air services.
- For Aeronautical Telecommunication Networks of the future Raytheon has developed an AtN Router, Radio Interface Unit (RUI), ground Network Interface unit (GNI), and Data Link applications Processor (DLAP).

- Raytheon has worldwide installations of SATCOM/VHF/H and aeronautical telecommunications networks, DGPS/WAAS/LAAS navigation systems and air traffic management automation systems.
- The Communication Systems unit designs, develops, manufactures, and supports communication products, systems and software to provide critical voice, data, imagery and telemetry communications for ship, aircraft, satellite and ground station applications. Integrated Systems specializes in flight simulations, modeling and simulation, air traffic control, and command and control systems. Imagery and Geospatial Systems designs, develops, installs and supports real-time and near-real-time hardware/software systems, high-performance computing, advanced architectures and open systems employed in information handling, digital imaging applications and signal processing. Strategic Systems designs, develops, produces and supports advanced hardware and software systems including systems engineering and integration for automated signal processing systems, electronic countermeasures systems, unmanned vehicle payload systems and remotely controlled reconnaissance systems.

Local Area Augmentation System (LAAS)

Honeywell Airport Systems

5353 West Bell Road
Glendale, AZ 85308
USA
Tel: +1 602 436 4808
Fax: +1 602 561 4777
Email: Hilary.King@cas.honeywell.com
Web: www.cas.honeywell.com/airport_systems

- Satellite-based precision-landing systems.
- LAAS and E-LAAS

Raytheon Company

141 Spring Street
Lexington, MA 02421
USA
Tel: +1 781 862 6600
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Surveillance:

Radar

Northrop Grumman Corporation

1840 Century Park East
Los Angeles, CA 90067-2199
USA
Tel: +1 310 553 6262
Web: www.northgrum.com

- Air Traffic Control Systems: In ground-based radar technology, the company is one of the world's leading producers of airspace management systems for both commercial air traffic control (ATC) and military air defense systems. It has developed and produced the ASR-12 primary surveillance radar for international customers. The ASR-12 is the solid-state derivative of the ASR-9, the primary surveillance radar in use at 140 airports in the United States and at 17 international sites. In addition, its wholly owned British subsidiary, Park Air Electronics Ltd., has installed ATC communications equipment in more than 150 countries.
- ASR-12 Primary Surveillance radar and MSSR are derived from the ASR-9 and Mode S, the most advanced terminal radars in the world.
- Advanced surface movement guidance and control systems
- ARSR-4: high performance with low operating cost long-rang, 3-D, joint-use surveillance.

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Lexington, MA 02421
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- SkySearch-2000 is a low cost, high performance solution for adding new or expanded secondary surveillance radar coverage in terminal and en route areas. SkySearch-2000 SSR is a complete, turnkey SSR for terminal and en route radar applications.
- Suitable for Air Traffic Control in demanding environments, the ADP-2000 is an easy to use, completely self contained controller display and radar processing system.
- Telephonics' AeroTrac™ Simulator (SIM) is a flexible tool for training controllers in all phases of traffic control procedures.

Automatic Dependent Surveillance (ADS)

ARINC Incorporated

2551 Riva Road
Annapolis, MD 21401-7465
USA
Tel: +1 410 266 4000
Web: www.arinc.com

- Air/Ground Communications:
  ARINC engineers, implements, and manages voice and data communications services that provide aviation operational and safety communications for aircraft throughout the world.
- Airport Systems:
  ARINC provides airports worldwide with integrated information, communications, and management systems that improve operations and enhance passenger service.
- Systems Engineering, Development, and Integration:
  ARINC delivers systems engineering, software development, and systems integration solutions to defense, government, and commercial customers.

Harris Corporation

1025 West NASA Boulevard
Melbourne, Florida 32919-0001
USA
Tel: +1 321 727 9207
Web: www.harris.com

- Harris RF Communications is focusing its technical expertise and innovation in radio communications on providing the worldwide air traffic control (ATC) communications industry with next-level HF, VHF, and UHF digital radio products and systems for civil and defense aviation agencies. These multimode voice and data radios meet both current and future global operational needs of ATC customers, protecting their investment well into the future.

- VDR 2404D-1 ATC Operator Panel
  VDR 2404D-1 Operator Panel provides the ATC operator with remote audio, keyline, and control of the system radios. It may be connected to a full main/standby transceiver set via VDR-2403D-1/2 Switching Units or directly to a non-redundant transceiver set. Location may be over 300 meters from the radio equipment.

- VLR-4141 & VLR-4201 Transmitter and Receiver
  The VLR-4141 Transmitter and VLR-4201 Monitor Receiver form a radio data broadcast subsystem for use in ground based augmentation systems such as LAAS. The radio transmits data in compliance with the LAAS Signal-in-Space Interface Control Document (DO-246), with real-time monitoring and demodulation of the transmitted signal, station transmitter and monitor receiver.

- Series 3000 Voice & Data Ground-to-Air Radio System
  The VDR-3205 and VDR-3135 represent a new generation of ground-to-air VHF multi-mode radio equipment to meet the changing and demanding needs for air traffic control communications (ATCC). The Series 3000 radio system is a simple and cost-effective solution for analog AM voice ATCC applications including both 25 kHz and 8.33 kHz channels. These units are also available with the new digital waveforms (defined by ICAO and the US FAA) ensuring a "Future Proof" solution addressing today's and tomorrow's requirements.

- Series 2000 Voice & Data Ground-to-Air Radio System
  The VDR-2205 and VDR-2135 represent a new generation of ground-to-air VHF multimode radio equipment to meet the changing and demanding needs for air traffic control communications (ATCC). The Series 2000 radio system is a simple and cost-effective solution for analog AM voice ATCC applications including both 25 kHz and 8.33 kHz channels. These units are also available with the new digital waveforms (defined by ICAO and the US FAA) ensuring a "Future Proof" solution addressing today's and tomorrow's requirements.

Lockheed Martin ATM

9221 Corporate Boulevard
Rockville, MD 20850
USA
Tel: +1 301 640 2460
Fax: +1 301 640 3416
Web: www.lmco.com/atm/

- Turnkey en route and terminal air traffic management automation systems.
- Lockheed Martin is a full service provider. To meet the growth of global air traffic, Lockheed Martin is developing advanced automation and infrastructure systems. Lockheed Martin will leverage its experience with commercial-off-the-shelf product integration, advanced capabilities with open architecture solutions, and other applications to provide a wide range of non-developmental alternatives to meet air traffic control customers' specific requirements.

- Lockheed Martin can provide total system solutions, including financing. These solutions can range from individual air traffic management (ATM) products to long-term national level air navigation service upgrades.

Northrop Grumman Corporation

1840 Century Park East
Los Angeles, CA 90067-2199
USA
Tel: +1 310 553 6262
Web: www.northgrum.com

- Air Traffic Control Systems: In ground-based radar technology, the company is one of the world's leading producers of airspace management systems for both commercial air traffic control (ATC) and military air defense systems. It has developed and produced the ASR-12 primary surveillance radar for international customers. The ASR-12 is the solid-state derivative of the ASR-9, the primary surveillance radar in use at 140 airports in the United States and at 17 international sites. In addition, its wholly owned British subsidiary, Park Air Electronics Ltd., has installed ATC communications equipment in more than 150 countries.
- ASR-12 Primary Surveillance radar and MSSR are derived from the ASR-9 and Mode S, the most advanced terminal radars in the world.
- Advanced surface movement guidance and control systems
- ARSR-4: high performance with low operating cost long-rang, 3-D, joint-use surveillance.

Raytheon Company

141 Spring Street
Lexington, MA 02421
USA
Tel: +1 781 862 6600
Web: www.raytheon.com

- Raytheon offers a complete turnkey, low risk transition solution for CNS/ATM.
- We present Multi-Mode VHF Radio System (MMVRS) for ground-air services.
- For Aeronautical Telecommunication Networks of the future Raytheon has developed an AtN Router, Radio Interface Unit (RUI), ground Network Interface unit (GNI), and Data Link applications Processor (DLAP).
- Raytheon has worldwide installations of SATCOM/VHF/H and aeronautical telecommunications networks, DGPS/WAAS/LAAS navigation systems and air traffic management automation systems.

The Communication Systems unit designs, develops, manufactures, and supports communication products, systems and software to provide critical voice, data, imagery and telemetry communications for ship, aircraft, satellite and ground station applications. Integrated Systems specializes in flight simulations, modeling and simulation, air traffic control, and command and control systems. Imagery and Geospatial Systems designs,

develops, installs and supports real-time and near-real-time hardware/software systems, high-performance computing, advanced architectures and open systems employed in information handling, digital imaging applications and signal processing. Strategic Systems designs, develops, produces and supports advanced hardware and software systems including systems engineering and integration for automated signal processing systems, electronic countermeasures systems, unmanned vehicle payload systems and remotely controlled reconnaissance systems.

Telephonics

815 Broad Hollow Road
Farmingdale, NY 11735
USA
Tel: +1 516 755 7000
Fax: +1 516 755 7010
Web: www.telephonics.com/

- Telephonics integrates sophisticated multi-radar fusion tracking (MRT) and a highly efficient controller interface into the system for optimal performance. Aircraft identification, communication, command, control, data processing, flight training and simulation are all vital features of the "complete" Traffic Management System.
- Telephonics' AeroTrac™ Air Traffic Management System is an advanced en route and terminal automation system that features unparalleled radar capacity, tracking accuracy and flight information processing. Telephonics' AeroTrac has been proven in large scale Air Traffic Control (ATC) systems by tracking over 3000 aircraft, simultaneously processing over thirty radar sensors, and covering over nine million square miles of airspace.
- SkySearch-2000 is a low cost, high performance solution for adding new or expanded secondary surveillance radar coverage in terminal and en route areas. SkySearch-2000 SSR is a complete, turnkey SSR for terminal and en route radar applications.
- Suitable for Air Traffic Control in demanding environments, the ADP-2000 is an easy to use, completely self-contained controller display and radar processing system.

Rannoch Corporation,
1800 Diagonal Road, Suite 430
Alexandria, VA 22314
TEL: 703-838-9780
FAX: 703-838-3676

Aircraft Multilateration ADS-B Surveillance System (SY-400)

The SY-400 series combines Rannoch's SSR decoding and time tagging systems with data communications and central processing to provide a comprehensive surveillance system. Using 3 or 4 remotely sited receiver decoders, the system can accurately track aircraft position and provide aircraft identification details. The system can use either the PC-based

decoders or the VME-based decoders, depending on performance requirements. Data communications are handled via dial up modem, leased line, RF modem or ethernet.

Power Systems:

TSi Power Corporation

Since 1992, TSi Power has supplied several thousand **AC power conditioner, AVR (automatic voltage regulator), UPS, DC to AC inverter & ATS (automatic transfer switch)** systems.

OutdoorXUPS-600/1000/1500/2200/3000 (new 420~2100 watt output capacity UPS systems with 1~8 hour battery runtime in outdoor rated metal cabinets) are also new - shipment started in September 2005. Outdoor UPS systems can protect smaller repeater & BTS equipment shelters, perimeter security monitoring (using CCTV, motion/heat detectors, etc) and othe communication systems which must operate even during long power outage periods. Brochures & price quotation will be provided upon your request.

VRp-1000/2000/3000/5500/7500/10000/15000/20000 (1 to 20 Kwatt single-phase precision voltage regulators) and **VRp-3000/6000/9000/15000/22500/30000** (3 to 30 Kwatt three-phase precision voltage regulators) provide very tightly regulated output voltage (nominal value +/-3% even if AC input varies by +/-20%) by using 10~20KHz microprocessor-controlled IGBT switching technology. VRp provides all the functions & benefits of a UPS (except battery backup) at about **1/3 of the cost of an equivalent UPS for sensitive instruments, analyzers and test/measurement systems.**

SLC-600/1200/1800 are 600/1200/1800 watt capacity automatic voltage regulators with operating AC input voltage range of 75~150V (47~63Hz) and regulated output voltage of 105~130V. For countries with 230V mains, **SLC-600E/1200E/1800E** are equivalent models. They are very compact and lightweight (4 to 7 kg) and low-cost.

ILC-240/600B/1000B/1800/2400/3600/4400/5500/12000/15000/24K/36K/45K/75K/100K/150K are phase isolation line conditioners with very good lightning & surge protection, noise filtering and neutral-to-ground bonded output from built-in isolation transformers. Capacities range from 240VA to 150KVA (single, dual or three phase input/output models are available). Nearly 30,000 ILC line conditioners are in operation worldwide since 1995 with most customers reporting dramatic improvements in the reliability and lifetime of connected equipment such as VSAT satellite phone terminals, modems, computers, cash registers, printers copiers, UPS and AC to DC rectifier/battery banks, and AC to DC power systems.

Siemens (USA and Germany), ABB Automation, Rockwell Automation, ViaSat, Scientific Atlanta, Motorola, Ericsson Wireless, Mobile Telephone Network (MTN) in Uganda, Heidelberg Engineering (Germany), CIBA Vision (part of Norvatis Group)

are some of our long-term customers since 1993. Completed projects include **FAA LINCS, FAA Airport Fiber Loop, MAXIS cable TV inverter project (in Malaysia), Colonial Pipeline, LINCS and Fiber Loop Carrier projects in most major US airports (by FAA) and 2002 Salt Lake City Winter Olympics.**

For additional information please contact:
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APPENDIX 5. EXPORT-IMPORT BANK OF THE UNITED STATES

General. Task 3 required RVA to list different financing options available for the acquisition of CNS/ATM technologies to include the necessary steps to apply for and/or secure financing, as well as a summary of the conditions of potential loans from various sources. RVA chose the US-based Export-Import Bank to outline the necessary stages of securing a loan for CNS/ATM equipment.

The principal potential source of US-based bilateral financing is through the Export-Import Bank of the United States (Ex-Im). The Ex-Im is committed to having a world-class program in limited recourse project finance. As developing nations turn away from sovereign-guaranteed borrowing, Ex-Im's project financing program is assisting U.S. exporters to compete in new international growth industries such as the development of private power and other infrastructure. While such a financing structure has been used successfully in the past for oil and gas, mining, and power projects, the move towards "privatization" by sovereign entities has created new opportunities for U.S. exporters in telecommunications, transportation and other sectors.

Exports of capital goods and related services may be supported by Ex-Im's long-term loans and guarantees of commercial bank financing (up to 10 years repayment), or medium-term loans, guarantees, and insurance (up to 7-year repayment terms). For private-sector transactions, Ex-Im may require an acceptable financial institution to act as either guarantor or obligor. Alternatively, Ex-Im will accept private obligors which are creditworthy as demonstrated by their financial statements, commercial track record and credit history. The Ministry of Finance must be the obligor or guarantor on medium-and long-term sales to public sector entities.

Ex-Im may also be interested in considering acceptable forms of limited recourse project finance in States where reasonable assurance of repayment is based on the project's cash flow rather than on a guarantor.

Application Process for the Ex-Im Bank. An introductory meeting with Ex-Im Bank and the State's Business Development Division or their financial office is strongly recommended. The meeting should focus on Ex-Im's policies and procedures and include a thorough explanation of the application process and the requirements for Ex-Im support.

- A Project Finance Letter of Interest (LI) is an indication of Ex-Im's willingness to consider financing a given export transaction. To apply, interested parties must complete the Ex-Im LI application and clearly indicate Limited Recourse Project Finance. The non-refundable processing fee for an LI is US$100. The applicant should attach an executive summary of the project which identifies the type of project, location of the project, parties to the transaction, status of the project, total project cost, U.S. cost, and the anticipated project timeframe. The Project Finance LI differs from Ex-Im's traditional LI; therefore, each interested state should contact the Business Development Office of Ex-Im for an LI application.

- The Final Commitment application submitted to Ex-Im must include the standard Ex-Im Preliminary Commitment/Final Commitment Application Form.

- The Project Finance Division will review the material submitted within 5 to 10 business days from the date that the application is received to determine if it includes the required information to proceed with an evaluation.

- If the application presented is determined to be incomplete by the Project Finance Division, it will be returned to the applicant with an explanation of its deficiencies. If the application is not determined to be suitable for limited recourse project financing but could still be considered for another form of Ex-Im financing, it will be forwarded to the appropriate division and the applicant will be notified.

- For applications proceeding to an evaluation, a financial advisor will be selected by Ex-Im from the pre-approved group. Determination of the specific financial advisor will depend on several factors including geographic and sector expertise and availability to meet project deadlines.

- Before the financial advisor begins the review (Phase I of due diligence), the applicant will be required to pay an evaluation fee and execute a contract with Ex-Im. In addition, the applicant will need to execute an indemnity agreement with the financial advisor. No evaluation by the financial advisor will commence without payment of the financial advisor fee, execution of the contract and the indemnity agreement, and the arrangement between Ex-Im and the financial advisor. The indemnity agreement is not negotiable. If Ex-Im agrees to proceed with the project after completion of the Phase I due diligence, the applicant will be required to pay additional related fees for the Phase II due diligence. The application will be returned to the applicant if the arrangements for the financial advisor are not completed within 30 days.

- For all projects, Ex-Im will require, either in conjunction with other lenders or for its own use, the advice of independent outside legal counsel, independent engineers, and insurance advisors. In addition, there may be other fees associated with conducting proper due diligence. Payment for these and any other fees will be the responsibility of the project sponsors or the applicant.

- Preliminary Project Letter (PPL) (Phase I). Upon satisfactory completion of the evaluation process, the Project Finance Division will issue a PPL within 45 days from the date evaluation begins by the financial advisor. The PPL will indicate if Ex-Im is prepared to move forward on a financing offer and the corresponding general terms and conditions based upon the information available at the time of application.

- Evaluation Post-PPL (Phase II). After issuance of the PPL, Ex-Im will work with the applicant to proceed to a Final Commitment. Please note that Ex-Im does not issue preliminary commitments for project finance transactions. Ex-Im will continue to utilize the financial advisor for Phase II of the due diligence process.

Project Criteria and Application Information. The project should have long-term contracts from creditworthy entities for the purchase of the project's output and the purchase of the project's major project inputs such as fuel, raw materials, and operations and maintenance. Such contracts should extend beyond the term of the requested Ex-Im financing. In sectors such as telecommunications and petrochemicals if long-term contracts are not available, Ex-Im will evaluate the transactions on a case-by-case basis, looking for economically compelling business rationale. Modernization of CNS/ATM presents additional considerations and would likely be addressed with different factors.

- The project should contain an appropriate allocation of risk to the parties best suited to manage those risks. Sensitivity analysis should result in a sufficient debt service coverage ration to ensure uninterrupted debt servicing for the term of the debt.

- Total project cost should be comparable to projects of similar type and size for a particular market. Product unit pricing and costs should reflect market based pricing. Devaluation risk needs to be substantially mitigated through revenues denominated in hard currencies; revenue adjustment formulas based on changing currency relationships, or other structural mechanisms.

Information Required. The following information is required for all applications:

a) A summary of all aspects of the project, as contained in an independently prepared feasibility study and/or a detailed information memorandum, prepared by a qualified party. The study or memorandum should include the project description, location, legal status, ownership, and background and status of key elements of the project structure, such as agreements, licenses, local partner participation and financing.

b) In regards to agreements for key elements of the project, Ex-Im considers key agreements to include all contracts necessary for the project to be built and operate. This includes contracts relating to infrastructure as well as supply and off-take agreements. These agreements should be in substantially final form. Ex-Im will not accept summaries or outlines of these agreements.

c) A breakdown of anticipated project costs through commissioning, including interest during construction and working capital requirement, by major cost category and country of origin. This information should also include a breakdown of any "soft cost" such as development cost, development fees, owner's contingencies and other similar items. A breakdown of the proposed coverage for interest during construction and the method of calculation should also be included.

d) A summary of the anticipated project financing plan and security package, including the proposed source, amount, currency and terms of the debt and equity investments; the sources of finance in the event of project cost overruns; and description of escrow accounts. Information on the terms, security requirements, and status of financing commitments of other lenders to the project, if applicable, should be provided. All other sources approached for financing (multinational

development banks, other export credit agencies, commercial banks, capital markets and private investors) must be disclosed.

e) Projected annual financial statements covering the period from project development through final maturity of the proposed Ex-Im financing, to include balance sheet, profit and loss, source and application of funds statements, and debt service ratios. Projections should include a sensitivity analysis for not only the expected scenario, but pessimistic and optimistic cases as well. This information should also be provided in electronic format with the project's financial model in Spreadsheet format such as Excel. The structure of the financial model should be in a format that is user friendly. Ex-Im must be able to review and adjust the assumptions in the model.

f) Assumptions for the financial projections, including but not limited to the basis for sales volume and prices; operating and administrative cost; depreciation, amortization and tax rates; and local government policy on price regulation.

g) Market information to include 10 years of historical price and volume data; present and projected capacity of industry; product demand forecast with assumptions; description of competition and projected market share of the project as compared to the shares of the competition; identity and location of customers; and marketing and distribution strategy.

h) A description of the principal risks and benefits of the project to the sponsors, lenders, and host government.

i) A description of the types of insurance coverage to be purchased for both the pre- and post-completion phases of the project.

j) Information on infrastructure required for the project to operate; specifically information pertaining to the timing, status and development plans must be provided.

k) A clear articulation of the need for Ex-Im coverage.

Requirements of the Participants in the Project.

- Project sponsors, off-take purchasers, contractors, operators, and suppliers must be able to demonstrate the technical, managerial and financial capabilities to perform their respective obligations within the project.

- Sponsors must provide in English a brief history and description of their operations, a description of their relevant experience in similar projects, and 3 years of audited financial statements.

- If the sponsors are part of a joint venture or consortium, information should be provided for all the participants. A shareholders agreement should also be provided. All documents pertaining to this area (joint venture agreement, management and service agreements) should be in substantially final form.

- Off-take purchasers and suppliers should provide in English a history and description of operations, at least 3 years of audited financial statements, and a description of how the project fits in their long-term strategic plan. If the project utilizes raw materials (oil, gas, coal, ethane, etc.), copies of contracts that have been reviewed by legal counsel for appropriateness and in adherence with local law should be provided.

- Contractors and operators must provide resumes indicating experience with similar projects and recent historical financial information on the contractor.

Technical Considerations. The following technical considerations need to be addressed:

a) Project technology must be proven and reliable, and licensing arrangements must be contractually secured for a period extending beyond the term of the Ex-Im financing.

b) A technical feasibility study or sufficient detailed engineering information needs to be provided to demonstrate technical feasibility of the project. In the case of CNS/ATM modernization, the requirement may be waived.

c) Technical description and a process flow diagram for each project.

d) Detailed estimate of operating costs.

e) Arrangement for supply of raw materials and utilities.

f) Draft turnkey construction contract and description of sources of possible cost increases and delays during construction, including detailed description of liquidated damage provisions and performance bond requirements.

g) Project implementation schedule, showing target dates for achieving essential project milestones (see Task 5).

h) A site-specific environmental assessment, highlighting concerns, requirements and solutions. These documents should demonstrate compliance with Ex-Im's environmental guidelines. All applicants must submit a Preliminary Environmental Assessment report conducted by a third party expert prior to an application for final commitment.

Host Country Legal/Regulatory Framework & Government Role. The host government commitment to proceeding with the project must be demonstrated. Legal and regulatory analysis must demonstrate that the country conditions and the project structure are sufficient to support long-term debt exposure for the project through enforceable contractual relationships.

Ex-Im's relationship with the host government will be addressed on a case-by-case basis. An Ex-Im Project Incentive Agreement (PIA) with the host government may be required. The PIA addresses certain political risks and Ex-Im's method of resolution of conflict with the host government pertaining to these issues. Only certain markets will require a PIA.

Information Required. A description of the host government's role in the project, and progress made toward obtaining essential government commitments, including authorizations from appropriate government entities to proceed with the project. Copies of all permits, licenses, concession agreements and approvals are required in addition to a description of all permits necessary to complete the project and their status. This information is critical for Ex-Im application consideration.

A definition of the control, if any, that the government will have in the management and operation of the project, and status of any assurances that the government will not interfere in the project's operation. If the government is also a project sponsor, these issues will be of particular importance.

Evidence of the government's current and historical commitment and policies for availability and convertibility of foreign currency.

Status and strategy for obtaining government undertakings to support any government parties involved in the project, to the extent that such undertakings are needed to provide adequate credit support for such entities.

Multilateral Financing. Multilateral financing comes from "member owned" institutions that provide loans for a variety of projects at reasonable rates of interests. These banks provide low-interest loans, interest-free credit, and grants to developing countries. The majority of these loans are for lower-middle and middle-income countries that are only able to generate private financing at very high rates of interest.

APPENDIX 6. EUROPEAN BANK FOR RECONSTRUCTION AND DEVELOPMENT

General. A likely source of multilateral financing is through the European Bank for Reconstruction and Development (EBRD). The EBRD is the principal source of multilateral financing for economic, social, and institutional development projects in Europe, Asia, and Africa. These include policy and sector reform programs and support for public and private investment. These investments should be consistent with the growth and development model of each country, its needs for physical integration, and its transportation requirements, both in the national sphere and in the sphere of regional integration.

Emphasis will be placed on the institutional aspects, programming, planning and maintenance, as well as on rehabilitation and expansion of existing systems. Projects for new construction will also be considered. The EBRD may finance projects for transportation by land, river, air, sea or pipeline. However, due to the limited resources assigned by the EBRD to the transportation sector, EBRD's participation in large transport projects primarily may be catalytic in nature so as to encourage more massive financial assistance from other sources and to provide financing in those areas where other resources are less likely to be available.

EBRD General Lending Policy Issues. EBRD's policy will cover financing of loans and technical cooperation for:

1) Collaboration in the institutional strengthening of the transportation sector in the member countries, including training and manpower development;

2) The organization, rationalization and/or improvement of transportation services for the movement of passengers and freight to and from the various human settlements, production centers and consumption centers; and

3) Maintenance, rehabilitation and expansion of existing infrastructure with a view to the utilization, in the best possible way, of those modes of transport that will best support the economic development process of the Bank's member countries as well as new transportation projects necessary for the process of socioeconomic development.

EBRD Lending Policies. For all modes of transportation, the EBRD may finance the purchase of materials, equipment and vehicle needs that enhance construction of transportation projects, and the Bank may also finance other materials and equipment that clearly complement physical infrastructure such as: cranes and loaders for freight stations, ports and airports, navigation aids and other equipment for the operation of land, air and maritime terminals with greater security and efficiency for the movement of passengers and freight. Provision of EBRD financing for these items would take into account the availability of private sources of financing, which, in the opinion of the EBRD, are reasonable for the borrower.

EBRD Air Transportation Policy. The EBRD should not support investments which contribute to an increase in the handling capacity of airports in the region as air traffic contributes to major environmental problems, including the depletion of the ozone layer and an increase in harmful noise levels. **The EBRD should instead shift its attention into improving safety and air traffic control systems.**

In this sub-sector the EBRD may extend financing for:

1) Institutional strengthening;

2) Rationalization, maintenance, rehabilitation, remodeling or expansion of existing airports and their aerial navigation and safety systems;

3) Construction and/or expansion of aerial navigation and safety system; and,

4) Construction of new airports and their aerial navigation and safety systems, with preference for local traffic.

Basic Criteria. In addition to applying the general criteria set forth in the Operations Policies Manual, the EBRD will take into account that the programs and projects submitted for its consideration will:

1) Be part of short, medium or long-term investment plans for financing the transportation sector or its sub-sectors as well as being integrated with the socioeconomic planning at the national level;

2) Have the capacity to provide a speedy and efficient transportation service that makes it possible to link up the different areas of each member country and helps to facilitate foreign trade; consider investments that make it possible to combine and complement the various modes of transport that can be efficiently exploited in each member country;

3) Contribute to rationalization of the consumption of energy, promoting especially the saving of energy generated with nonrenewable resources;

4) Offer possibilities to promote new socioeconomic benefits for the population; and

5) Ensure the utilization technologies, with emphasis on intensive use of labor and local materials in the execution and maintenance of infrastructure projects.

APPENDIX 7. RISK ASSESSMENT AND CONSIDERATIONS BY FINANCING INSTITUTIONS

Default Risk. The default risk of debt securities, regardless of the currency in which they are denominated, is of central interest to lenders. Any interruption of debt service, including unscheduled payments arrears and unilateral changes by the issuer of repayments of interest and principal, can constitute default under the terms of a debt issue. However, the default risk of an issuer's local currency debt may differ markedly from that of its foreign currency debt.

A sovereign government's ability and willingness to service local currency debt is supported by its taxing power and control of the domestic financial system, which give it potentially unlimited access to local currency resources. To service foreign currency debt, the sovereign also must secure foreign exchange, usually by purchasing it in the currency markets. That can be a binding constraint on sovereigns at the lower end of the rating spectrum, and it accounts for the lower frequency of local versus foreign currency sovereign default.

Currency Risk. Lenders face a number of risks associated with local currency-denominated debt that distinguish them from foreign currency debt. Whether based locally or offshore, lenders must first consider the default or credit risk of local currency obligations. Second, cross-border lenders are affected by the risk that the value of debt service may be impaired by a depreciation of the local currency in terms of foreign exchange (currency risk). A third consideration is that cross-border lenders may be unable to freely convert the local currency proceeds of debt service into U.S. dollars or other foreign currencies (transfer or convertibility risk).

Currency risk is a consideration for cross-border lenders when they hold debt denominated in a currency other than their own. Even if debt service is timely, its value may still be impaired by a depreciation of the exchange rate in terms of investors' own currency. Yet, for most issuers, the impact of exchange rate changes on the foreign currency value of their local currency debt instruments is only weakly correlated with fundamental credit trends. Other factors, such as differences in interest rates and inflation across countries, also influence exchange rates and often overshadow credit considerations.

Still, drastic currency depreciation over short time horizons—in terms of real purchasing power or in relation to nominal values of one or more of the world's key currencies—always signal weakening creditworthiness because sovereigns ultimately control the value of money. For example, declines on the order of 40%-60% during 1996 in the value of the currencies of Turkey and Venezuela versus the U.S. dollar reflected sharp deterioration in public finances and the balance of payments--though both governments have continued to service local currency obligations (as well as rated foreign currency debt, which in both instances were downgraded to B+) without interruption. Such cases aside, however, the currency risk of local currency debt instruments is similar to other market risks. As a result, currency risk is incorporated in local currency ratings only to the extent that it reflects the potential default risk of the debt instruments.

Sovereign Risk. Sovereign risk is a collage of risk factors that are intertwined with one another and the characteristics of the country at issue. While the risk elements can be treated apart, they are assessed as a whole to evaluate the risk of default by a sovereign entity. Those risk elements, and their underlying considerations, include:

Political Risk.

- Form of government and adaptability of political institutions
- Extent of popular participation
- Orderliness of leadership succession
- Degree of consensus on economic policy objectives
- Integration in global trade and financial system
- Internal and external security risks

Income and Economic Structure.

- Living standards, income, and wealth distribution
- Market, non-market economy
- Resource endowments, degree of diversification

Economic Growth Prospects.

- Size and composition of savings, and investment
- Rate and pattern of economic growth

Fiscal Flexibility.

- General government operating a total budget balance
- Tax competitiveness and tax-raising flexibility
- Spending pressures

Public Debt Burden.

- General government financial assets
- Public debt and interest burden
- Currency composition, structure of public debt
- Pension liabilities
- Contingent liabilities

Price Stability.

- Trends in price inflation
- Rates of money and credit growth
- Exchange rate policy

Balance of Payments Flexibility.

- Impact on external accounts of fiscal and monetary policies
- Structure of the currency account
- Composition of capital flows
- External Debt and Liquidity
- Size and currency composition of public external debt
- Importance of banks and other public and private entities as contingent liabilities of the sovereign
- Maturity structure and debt service burden
- Debt service track record
- Level, composition of reserves and other public external assets

Risk Mitigation Strategies.

Default Risk. As noted above, default risk is measured by the past performance of a borrower. Available research indicated past performances are acceptable. Further means of addressing concerns of default risk is through the use of mechanisms such as the IATA clearing house.

Currency Risk. Project financing for infrastructure facilities has become more prevalent for much of the global emerging markets. With capital needs for projects such as power facilities, toll roads, and pipelines in the tens of billions of dollars through 2000, projects are increasingly looking to borrow in developed capital markets, where terms and tenor may enhance feasibility. However, when offshore debt is used, an important factor in the credit risk profile of that project is its ability to mitigate or manage the ensuing currency risk. The sudden devaluation of the Mexican peso in 1994 illustrates this point. Currency management is critical; without the proper mechanisms, a mismatch between project revenues and project expenses can rapidly occur. More importantly, the ability to service debt may be impaired. The need to manage currency risk is more crucial for a project than for a sovereign or corporate credit because projects, by definition, have very limited abilities to create other streams of revenue and they typically have high debt payment requirements.

Exchange-rate risk—the changes in the value of one currency relative to another—is a more difficult issue. Exchange-rate risk is a project-specific risk that must be evaluated accordingly. Exchange rates rarely remain stable over long periods and are often volatile. Since infrastructure projects typically have long amortization terms, the exposure to currency movements add to the projects credit risk profile. This compounding effect would cause problems for most utility and infrastructure projects. However, in many transactions, there are ways exchange-rate risk can be managed or mitigated so the project's credit profile is not adversely affected.

Sovereign Risk. Sovereign credit ratings are an assessment of each government's capacity and willingness to repay debt according to its terms. The appraisal of the sovereign's overall creditworthiness is both quantitative and qualitative. The quantitative aspects of the analysis incorporate a number of measures of economic and

financial performance as outlined below. The analysis is qualitative because of the importance of political and policy developments in the analytical process, and because ratings indicate future debt service capacity. Each aspect relates to two key aspects of credit risk—economic risk and political risk.

- Economic risk addresses the government's ability to repay its obligations on time and is a function of both quantitative and qualitative factors. Mitigation strategies for the economic elements of sovereign risk are explored as part of the default risk analysis above.

- Political risk addresses the sovereign's willingness to repay debt. Willingness to pay is a qualitative issue distinguishing sovereigns from most other types of issuers. Partly because creditors have only limited legal redress, a government can default on some or all of its obligations for political reasons, even when it possesses the financial capacity for timely debt service. In practice, of course, political and economic risks are related. A government that is unwilling to repay debt usually is pursuing economic policies that weaken its ability to do so. Willingness to pay, therefore, encompasses the range of economic and political factors influencing government policy.

APPENDIX 8. ACRONYMS

ABAS	Airborne-Based Augmentation System
ACC	Area Control Center
ACF	Area Control Facility
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AFDP	Automatic Flight Data Processor
AFTM	Air Traffic Flow Management
AFTN	Aeronautical Fixed Telecommunications Network
AIC	Aeronautical Information Circular
AIDC	ATS Interfacility Data Communications
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMHS	Aeronautical Message Handling Service
AMSS	Aeronautical Mobile Satellite Services
ANSP	Air Navigation Service Provider
AP I & II	Angkasa Pura I & II
APANPIRG	ICAO's Asia-Pacific Air Navigation Planning and Implementation Regional Plans (APANPIRG Agreements) Group
ARINC	Aeronautical Radio, Inc.
ARSR	Air Route Surveillance Radar
ASEAN	Association of South East Asian Nations
ADB	Asian Development Bank
ATC	Air Traffic Control

ATFM	Air Traffic Flow Management
ATIS	Airport Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATO	Air Traffic Operations
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
ATSU	Air Traffic Services Unit
B-RNAV	Basic Area Navigation
CA	Conflict Alert
CAA	Civil Aeronautics Administration
CATCC	Central Air Traffic Command Center
CDM	Collaborative Decision-Making
CNS/ATM	Communications, Navigation, Surveillance/Air Traffic Management
CPDLC	Controller-Pilot Data Link Communications
CSFP	Center Stored Flight Plan
CY	Calendar Year
DATIS	Digital Airport Terminal Information Service
DCA	Directorate of Civil Aviation (Malaysia)
DGPS	Differential Global Positioning System
DME	Distance Measuring Equipment
DOC	Document
DVOR	Doppler VOR
EBRD	European Bank for Reconstruction and Development

E-MSAW	En Route Minimum Safe Altitude Warning
ENR	En Route European
Ex-Im	Export-Import Bank of the United States
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIR	Flight Information Region
FIS	Flight Information Service
FTP	File Transfer Protocol
FUA	Flexible Use of Airspace
GBAS	Ground-Based Augmentation System
GMS	GPS Monitoring System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRAS	Ground Regional Plans (APANPIRG Agreements) Augmentation System
GRS	Ground Reference Station
HF	High Frequency
HFDL	HF Data Link
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots Association
IFATCA	International Federation of Air Traffic Controllers' Associations
IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules

ILS	Instrument Landing System
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
ISPACG	Informal South Pacific ATC Coordinating Group
JCAB	Japanese Civil Aviation Bureau
JBIC	Japan Bank for International Cooperation
LAAS	Local Area Augmentation System
LI	Letter of Interest
LOA	Letters of Agreement
M2	Mode 2 (two)
MCS	Master Control Station
MITRE/CAASD	MITRE Corporation's Center for Advanced Aviation System Development
MNT	Mach Number Training
MRS	Master Reference Station
MSAS	Multi-Functional Transport Satellite-Based Augmentation System
MSSR	Monopulse Secondary Surveillance Radar
MTSAT	Multi-Functional Transport Satellite
NBIC	New Bangkok International Airport
NDB	Non-Directional Beacon
NOTAM	Notice to Airmen
ODA	Official Development Assistance
O&M	Operations and Maintenance
OLDI	Online Data Interchange

ORDD	Operational Readiness Demonstration Date
PDC	Pre-Departure Clearance
PIREP	Pilot Reports (weather)
PMS	Precipitation Map Service
PPL	Preliminary Project Letter
PIA	Project Incentive Agreement
QA	Quality Assurance
OPIC	Overseas Private Investment Corporation
RASMAG	Asia/Pacific Regional Plans (APANPIRG Agreements) Airspace Safety Monitoring Advisory Group
RDP	Radar Data Processing
RFI	Radio Frequency Interference
RFP	Request for Proposals
RLRS	Reduced Lateral Route System
RNAV	Area Navigation
RNP	Required Navigation Performance
RVA	Robinson Aviation (RVA), Inc.
RVSM	Reduced Vertical Separation Minima
SADIS	Satellite Distribution
SATNAV	Satellite Navigation
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
SIGMET	Significant Meteorological Conditions
SOIT	Satellite Operational Implementation Team
SPS	Standard Positioning Service

SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
TA	Technical Assessment
TFM	Traffic Flow Management
TIS	Traffic Information System
TSO	Technical Standard Order
TWS	Terminal Weather Service
URET	User Request Evaluation Tool
USTDA	U.S. Trade and Development Agency
VDL M2	Very High Frequency Data Link Mode 2
VDL	VHF Data Link
VHF	Very High Frequency
VOR	VHF Omni-Directional Range
VOR/DME	VHF Omni-Directional Range/Distance Measuring Equipment
VSAT	Very Small Aperture Terminal
WAAS	Wide Area Augmentation System
WAFS	World Area Forecast System
WGS-84	World Geodetic Survey –84
World Bank	IBRD and IDA. The World Bank is a vital source of financial and technical assistance to developing countries

Natuna Islands Air Traffic Control and Airspace Management Project for the Republic of Indonesia

Task 4

Assess Environmental Implications

Prepared for:
Directorate General of Air Communications of the Republic of Indonesia

By:
Robinson Aviation (RVA), Inc.

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Appendix 1, FAA Paper "CNS/ATM Enhancements to Reduce Aircraft Emissions"

Appendix 2, ICAO Paper "Agenda Item 3: CNS/ATM Implementation and Related Activities"

Appendix 3, Acronyms

1.0 Objective

The objective of Task 4 is to assess environmental implications of the proposed project.

Accordingly, Robinson Aviation (RVA), Inc., identified and acknowledged key environmental issues that needed to be incorporated as part of the proposed Technical Assessment (TA). These issues included consideration of land use impacts, noise pollution, new waste water impacts from discharges, disposal of fluids, batteries, and any toxic substances resulting from new initiatives involving the operation of equipment, etc. RVA also considered the extent to which the identified environmental issues, if found, could be mitigated. These factors were explicitly studied and any potential cost impact was considered a potential cost factor for inclusion in the project investment analysis.

1.1 Scope

The scope of this TA involves the application of Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM) systems (equipment and procedures) to the task of providing for the return of Natuna Islands/Sector C Airspace Air Navigation Service Provider (ANSP) responsibilities from Singapore to Indonesia. Tasks 1, 2, and 3 discussed these issues in detail. Review of these previous tasks clearly establishes that this TA encompasses only high altitude operations and airspace areas; no new routings, no airport operations, no establishment of new facilities, and no revision of airspace boundaries are involved in this TA.

1.2 Methodology

Task 4 considered the legal requirements set forth in the Republic of Indonesia Environmental Management Act (Government Act No. 23 of 1997), its required considerations as outlined below, and the technical and procedural recommendations of Tasks 1, 2, and 3.

2.0 Legal Framework for Environmental Management

2.1 Government Policy on the Environment

The new Environmental Management Act (Government Act No. 23 of 1997) was enacted in 1997, which has been the basic law concerning the environmental management. This Act aims to implement environmentally sustainable development, which means preserving and developing the environmental capacity in a harmonious and balanced manner in utilizing natural resources to enhance the public welfare. This is in accordance with the increasing global awareness of the environment and the responsibility of each country to carry out environmental management based upon an integrated and comprehensive national policy.

2.2 Targets of Environmental Management

The targets for the environmental management, as stated in the Act, are as follows:

- Achievement of harmony, compatibility, and balance between human beings and the environment.
- Formation of the environmental consciousness of the Indonesians, in order to preserve and foster the environment.
- Guaranteeing the interests of present and future generations.
- Achievement of the preservations of environmental functions.
- Prudent control of the utilization of natural resources.

2.3 Environmental Impact Assessment System (AMDAL)

Act No. 23 of 1997 prescribes that every activity/ project, which is considered likely to have a significant impact on the environment, must be accompanied by an environmental impact assessment (EIA). An environmental impact assessment system (AMDAL: analysis Menganai Dampak Lingkungan) has been established accordingly in Indonesia to meet this requirement. The necessary processes of AMDAL are specified in the new Government Regulation No. 27 of 1999, amendment of No.51 of 1993), which promotes decentralization of AMDAL commissions. The type of businesses and activities for which AMDAL is required are specified in the decree of the State Minister of Environment No. KEP-17/2001 according to the scale of the activity/project.

The objectives of environmental impact assessment (AMDAL), stated in Government Regulation No. 27 of 1999, are as follows:

- To understand the present condition of the environment in the project area;
- To identify the particular activities of the project; this may induce a significant impact on the environment;
- To predict the environmental impacts and evaluate their magnitudes;
- To propose countermeasures for mitigation of the envisaged negative impacts; and
- To formulate plans for environmental management and monitoring.

3.0 CNS/ATM Environmental History

Indonesia's progressive planning to apply CNS/ATM technologies and procedures is consistent with global aviation leadership. The growing demand for further air traffic capacity is constrained not just by safety requirements, but also by increasing pressures to integrate environmental requirements into ATM policy-making. Already complex ATM decision-making processes are being made responsive to these concerns. Different ways of managing flights using state-of-the-art technologies and new concepts are being explored which help to mitigate the environmental impact of air transport operations. Implementation of CNS/ATM is thought likely to provide the largest potential sources of fuel and emissions savings over time. Recent International Civil Aviation Organization (ICAO) modeling of CNS/ATM implementation in Europe and the United States points to a 5% reduction in global carbon dioxide (CO2) emissions by 2015. This is consistent with an evaluation carried out for the International Air Transport Association (IATA) by the National Aerospace Laboratory, Netherlands (NLR) which showed that speedier implementation of CNS/ATM could lead to a 9% improvement in CO2 emissions worldwide. It could also reduce aircraft emissions of oxides of nitrogen (NOx) by 8% and carbon monoxide (CO) and unburned hydrocarbons (HC) by 15-20%. An earlier ICAO Intergovernmental Panel on Climate Change (IPCC) assessment similarly concluded that CNS/ATM implementation could lead to reductions of 6-12% in global aviation-related CO2 emissions. The aviation industry strongly supports States' actions to improve CNS/ATM that:

- Generate extra capacity to meet demand;
- Increase safety levels;
- Reduce costs; and
- Provide environmental benefits.

3.1 Relationship CNS/ATM, Fuel Burn and Emissions

Fuel conservation and environmental protection have been long-standing objectives of many countries and is one of the U.S.'s national priorities. Recent U.S. analysis provides evidence to suggest that the modernization of the American National Airspace System can make a significant contribution to the realization of these national goals. The key findings from this study indicate that aircraft could potentially reduce fuel burn by about 10 billion pounds by the year 2015, representing a 6% reduction in the amount of fuel that would have been burned without the NAS modernization. The 10 billion-pound fuel saving converts into reductions of over 209 million pounds of NOx, 211 million pounds of CO, and 59 million pounds of HC, representing reduced emission levels of 9%, 12% and 18%, respectively. Finally, the economic value of the fuel savings on an annual basis is estimated to have a potential worth of about a billion dollars to the aviation users. While the traffic loads and airspace are different with Indonesian airspace, the projected results cited are consistent with worldwide studies. In effect, CNS/ATM programs/systems are aimed at the reduction of fuel burn and aircraft, i.e., engine run time. Scientist and common sense have established a connection between these two factors and the reduction of emissions.

3.2 Appendix 1

The above information, in part, represents conclusions of the Federal Aviation Administration (FAA) paper titled ***"CNS/ATM Enhancements to Reduce Aircraft Emissions"*** which is provided as Appendix 1 for the reader's ease of reference.

4.0 Environmental Benefits Associated with the Implementation of CNS/ATM Systems

The following refers, in part, to the ICAO report on CNS/ATM and the environment, specifically the results of the Intergovernmental Panel on Climate Change (IPCC):

> The following is an extract from the IPCC special report on the effects of aviation on the global atmosphere, in relation to operational aspects:
>
> "*Improvements in air traffic management (ATM) and other operational procedures could reduce aviation fuel burn by between 8 and 18%. The large majority (6 to 12%) of these reductions comes from ATM improvements which it is anticipated will be fully implemented in the next 20 years. All aviation emissions will be reduced as a consequence. In all aviation emission scenarios considered in this report the reductions from ATM improvements have already been taken into account. The rate of introduction of improved ATM will depend on the implementation of the essential institutional arrangements at an international level.*
>
> "Air traffic management systems are used for the guidance, separation, coordination, and control of aircraft movements. Existing national and international air traffic management systems have limitations which result, for example, in holding (aircraft flying in a fixed pattern waiting for permission to land), inefficient routings, and sub-optimal flight profiles. These limitations result in excess fuel burn and consequently excess emissions.
>
> "For the current aircraft fleet and operations, addressing the above-mentioned limitations in air traffic management systems could reduce fuel burned in the range of 6 to 12%. It is anticipated that the improvement needed for these fuel burn reductions will be fully implemented in the next 20 years, provided that the necessary institutional and regulatory arrangements have been put in place in time. The scenarios developed in this report assume the timely implementation of these ATM improvements, when estimating fuel use."

4.1 Appendix 2

The full text of the above information is included for the reader's ease of reference in Appendix 2. *International Civil Aviation Organization:*

TENTH MEETING OF THE
ASIA/PACIFIC AIR NAVIGATION PLANNING AND
IMPLEMENTATION REGIONAL GROUP (APANPIRG/10)
Bangkok, Thailand, 30 August to 3 September 1999
Agenda Item 3: CNS/ATM Implementation and Related Activities

5.0 Impact Areas Considered

The following impact areas were considered in relation to the TA suggestions:

- Ambient Air Quality Standards
- Water Quality Standards
- Effluent Standards
- Noise Level Standards
- Air Pollution
- Waste Water Treatment
- Solid Water Management
- Bird Hazards (Bird Strikes)

5.1 Impact Area Results

No significant impact will occur in the above-listed areas because the operations will have no more than minimal change and only at high altitudes. The only changes will be in terms of improvements in reduced fuel burn, reduced emissions, and reduced operating cost to the user and the Republic of Indonesia.

6.0 Conclusions

1. The new Environmental Management Act (Government Act No. 23 of 1997) was enacted in 1997. This Act has been the basic law concerning the environmental management.

2. The governmental policy on an environment is the implementation of environmentally sustainable development.

3. This Act is acknowledged and was followed in the development of this TA.

4. It is understood that activities and projects, which are considered likely to have a significant impact on the environment, must be accompanied by an environmental impact assessment (AMDAL) in Act No. 23 of 1997. This TA does not contain any airport projects.

5. All of the operations in this TA occur above 1000m with the vast majority occurring at cruse altitudes.

6. 99+ percent of the resulting operations occur over the open sea.

7. No new facilities are introduced, only replacement equipment.

8. If the proposed expansion of the Jakarta Area Control Center (ACC) is adopted, that action would be the subject of a separate environmental review.

9. No equipment is recommended that could cause a toxic effect.

10. No operations are envisioned causing changes in airspace boundaries.

11. Application of CNS/ATM systems and procedures as recommended in this TA will benefit Indonesia and have no negative impact in the areas cited in the Task 3 objective.

12. There is no introduction of actions causing a significant impact on the environment.

APPENDIX 1. FAA PAPER "CNS/ATM ENHANCEMENTS TO REDUCE AIRCRAFT EMISSIONS"

FAA paper is attached.

2nd USA/EUROPE AIR TRAFFIC MANAGEMENT R&D SEMINAR, Orlando, Fl, 1st - 4th December 1998

CNS/ATM Enhancements to Reduce Aircraft Emissions

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In support of the Free Flight paradigm, the Federal Aviation Administration (FAA) is investing billions of dollars to introduce new Communication, Surveillance, Navigation/Air Traffic Management (CNS/ATM) technologies into the National Airspace System (NAS). It is expected that with the deployment of these new capabilities, users will get better services, such as more wind-optimized cruise trajectories and altitudes and more efficient surface traffic operations.

This paper summarizes our study on CNS/ATM enhancements by extending the measurement of fuel savings to NAS users to also include Free Flight's associated environmental benefits. In essence, if the Free Flight paradigm results in lower fuel burn by users, a corollary benefit is less pollution - a clear environmental benefit that is often overlooked. In particular, the study analyzed the fuel and emission benefits by aircraft type and phase of flight. Calculations for aircraft emissions were made specifically for oxides of nitrogen (NOx), hydrocarbons (HC) and carbon monoxide (CO).

The key findings from this study indicate that aircraft flying in U.S. airspace could potentially reduce fuel burn by about 10 billion pounds in the year 2015, representing a 6% reduction in the amount of fuel that would have been burned without the NAS modernization. The 10 billion-pound fuel saving converts into reductions of over 209 million pounds of NOx, 211 million pounds of CO, and 59 million pounds of HC, representing reduced emission levels of 9%, 12% and 18%, respectively.

Introduction

The ICAO Committee on Aviation Environmental Protection (CAEP) is charged with the development of international standards and recommended practices for measuring and controlling aircraft noise and engine emissions. Historically CAEP activities have been directed at improvements in methods for measuring gaseous emissions and at considering increases in stringency of the standards. More recently, the CAEP has expanded their consideration to include operational measures that have the potential to reduce aviation emissions, including CNS/ATM implementation.

Worldwide there is a considerable amount of unnecessary fuel burn and emissions released into the atmosphere due to air traffic control delays. Significant inefficiencies in the present air traffic system can impede the ongoing efforts to meet internationally agreed environmental objectives, such as those established in the Worldwide Environmental Conference held in Kyoto, Japan in December 1997. Increased emissions levels could compromise the ability of aviation interests to meet environmental obligations.

To a significant extent, the FAA's NAS Architecture responds to this dual mantra of fuel conservation and protection of the environment. This study was undertaken to evaluate the potential fuel and emission savings that represent the benefits from the planned implementation of various capabilities in the NAS architecture. Findings from this study were presented by the FAA delegation at the ICAO Worldwide CNS/ATM Systems Implementation Conference in May 1998.

Free Flight

There is a realization shared between the government and the aviation industry that free flight will revolutionize air transportation in the 21st century in the United States, as well as internationally. In October 31, 1995, the RTCA Task Force 3 on Free Flight Implementation published a final report that defined the Free Flight operational concept, evaluated the Free Flight architecture and technology needs, and identified an incremental transition to Free Flight (RTCA, 1995).

"Free Flight is defined as the safe and efficient flight operating capability under instrument flight rules in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are imposed only to ensure separation, to preclude exceeding airport capability, to prevent unauthorized flights through special use airspace, and to ensure safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity that removes restrictions represents a move towards Free Flight."

In simple terms, free flight will enable aviation users to select routes, speed, altitudes and schedules in real-time. It is also anticipated that pilots will be able to make more dynamic in-flight changes to their routes, speed or altitudes in order to maximize their aircraft performance. Combining with the flexibility of visual flight rules and the safety (traffic separation capabilities) of instrument flight rules, free flight will offer substantial savings in time, fuel and emissions to users.

Concept of Operations

In September 1997, FAA Air Traffic Services (ATS) published a concept of operations, which reflects the joint efforts of the FAA and industry, through RTCA, to implement Free Flight (FAA/ATS, 1997). This document describes the evolutionary changes that are needed to meet the emerging user needs for greater flexibility in planning and predictability in flight operations. It describes the transition from a wholly ground-based system to one based on Free Flight concepts, which also embodies the International Civil Aviation Organization's CNS/ATM concept.

Before this operational concept can be implemented, technologies and procedures must be developed and validated, with an emphasis on human-factor considerations. Essentially, the concept of operations serves as the basis for procedural, investment and architectural decisions on the operational capabilities to achieve the Free Flight maxim.

NAS Architecture

With collaboration from the U.S. aviation community and international organizations, the FAA has outlined an 18-year plan to modernize the national airspace system (FAA/ASD, 1997). The NAS Architecture is the roadmap for modernizing the nation's air traffic control system to support the free flight capabilities sought by aviation user groups. It provides a high-level description of the NAS capabilities and services, the functions to be performed, their dependencies and interactions, and the flow and integration of information among the functions.

The NAS Architecture provides a logical framework to support investment analysis and acquisition decisions by the FAA's Joint Resources Council (JRC). It provides a starting point with initial functional requirements, costs and schedules and also highlights the interdependencies of functions and capabilities for a more systematic and comprehensive investment analysis of alternatives. It is also the intent of the NAS Architecture to be used by the aviation community to plan for avionics transitions.

The NAS Architecture is not an end-state document. It represents an evolving process that incorporates new technology into the NAS in an appropriate timeframe to satisfy the requirements of the users and service providers. Service providers refer to anyone who provides separation assurances, navigation/landing services, aviation information, search and rescue, or other assistance to NAS users. NAS users refer to anyone who uses the air traffic system, such as air carriers, general aviation and the Department of Defense

An overview of the interrelationships between the Concept of Operations, Architecture and Investment Analysis in the FAA's acquisition process cycle is illustrated in Figure 1.

Study Scope

The scope of this evaluation covered the planned CNS/ATM improvements in the U.S. controlled oceanic, en route and terminal airspace, including airport surface operations. The analysis used concepts and technologies that are outlined in the NAS Architecture draft version 3.0 for the period between 1996 and 2015. Participants in this FAA study effort included NASA, the Air Transport Association (ATA) and three member airlines.

Approach

An analytical framework was used to create two scenarios that reflect the current operations (baseline scenario) and the future concept of operations (enhanced scenario) in the NAS. Using 1996 as the base year, the baseline scenario (essentially a no-modernization NAS) consists of meeting projected traffic growth with today's NAS capacity, adjusted for committed near-term funded airport capacity expansion programs.

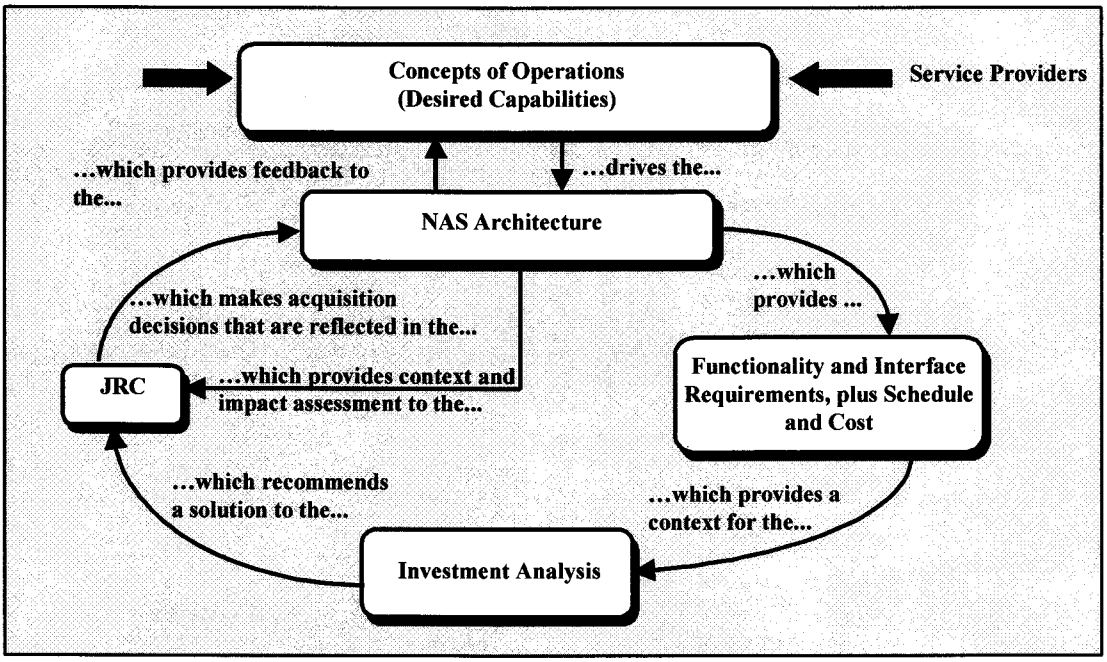

Figure 1. Interrelationships of the Concept of Operations, NAS Architecture and Investment Analysis in the FAA Acquisition Process

From this base case, three future scenarios for the time intervals 2005, 2010, and 2015 are developed. In a sense, each of these scenarios represent a time frame when key technologies and operational capabilities are introduced into the NAS to deliver new services to users, such as direct routes, optimal climb and descent and expedited taxi clearances. Simulated fuel estimates of users operating in a NAS with no modernization versus what could be achieved in a NAS with the planned CNS/ATM capabilities are then developed for each of the three scenarios. Comparison of the NAS scenarios, with and without modernization, yields incremental estimates of the fuel savings by phase of flight (below 3000', above 3000' and surface) for the years 2005, 2010, and 2015. Using ICAO and Boeing conversion algorithms, the fuel savings were then transformed into the various emission levels.

An overview of the modeling approach, based on the phased-in implementation of new operational capabilities, is illustrated below in Figure 2.

To establish the base year traffic count, standard databases like the Official Airline

Guide (OAG) and Enhance Traffic Management System (ETMS), were used to determine flights that were filed and flown, respectively. Traffic activity and fleet mix forecasts from FAA, ICAO and industry were then incorporated into the future demand generator of the National Airspace System Performance Analysis Capability (NASPAC) model to generate demand profiles for 2005, 2010 and 2015 (Millner, 1993). Airport capacity measures were incrementally augmented into NASPAC to account for planned airport and procedural improvements.

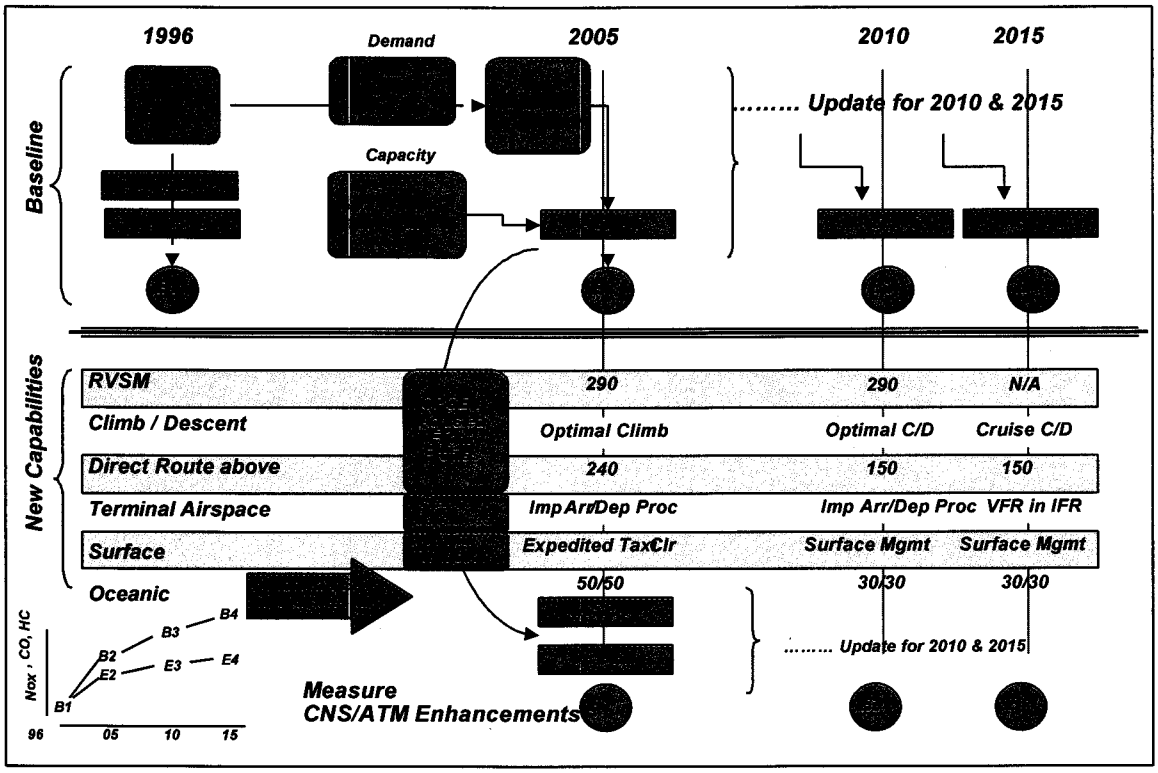

Figure 2. Overview of Modeling Scenarios

Against this baseline, new capabilities that facilitate reduced aviation fuel use and corresponding lower emission levels are analyzed. These new services are made possible by the introduction of new technologies and systems such as pilot-controller datalink, air-to-ground digital communications, automatic dependence surveillance, and satellite-based navigation and landing. In addition, a sequence of advanced automation decision support tools will improve conflict detection and resolution, facilitate more precise separation assurances and optimize traffic sequencing.

In turn, users are expected to benefit from these new capabilities. In the en route environment, new capabilities are expected to lead to reduced vertical separation minima (RVSM), optimal climb and descent profiles and more wind-optimized direct routes above flight level 240 and dropping to 15,000' by 2010. In the terminal environment, the airspace throughput will be maximized with improved arrival and departure procedures, more accurate final metering and approach spacing tools, with the eventual goal of conducting instrument

flight rule operations under visual flight rule conditions. On the airport surface, more efficient traffic management practices are expected to reduce aircraft taxi times, improve gate availability and departure sequencing functions on the airport surface. In the oceanic airspace, lateral and longitudinal separations are expected to close to 50 nautical miles (nm) by 2005 and to 30 nm by 2010.

The time and fuel savings calculations were generated primarily by three FAA simulation models. The Optimal Trajectory Generator (OPGEN) and the National Airspace System Performance Analysis Capability (NASPAC) were used to derive the benefits of the modernization associated with airspace improvements while the Performance Monitoring and Analysis Capability (PMAC) was used to derive the benefits to users from surface improvements. A MITRE simulation model was used to generate the benefits attendant with the planned oceanic improvements.

Future Fleet Mix

One of the key assumptions is the future aircraft fleet composition. An accurate projection of the fleet mix is necessary in order to account for the fact that the airlines will order newer aircraft to replace their aging fleet over the next two decades irrespective of CNS/ATM enhancements. These newer high performance airplanes will be equipped with more fuel-efficient engines than their predecessors will. As a result, there is a propensity of certain aircraft types in the future fleet to consume less fuel that is not directly attributable to planned CNS/ATM enhancements.

The U.S. baseline fleet mix was developed using data obtained from ATA and NASA. The ICAO world fleet forecast was used as the primary source of information to derive the future fleet mix. Using ICAO's forecast, and the U.S. baseline fleet, the U.S. forecast for each class of aircraft was extrapolated from the world forecast (assuming that the proportion of U.S. aircraft in the world fleet would remain constant).

This forecast was validated and updated using the U.S. forecast from the FAA's Office of Aviation Policy and Planning's (APO) forecast for Stage II/III aircraft. This resulted in reduction of the future inventory for aircraft that currently are out of production (such as 727 and 737-100/200). Other aircraft in the same class were increased to compensate. The resulting U.S. forecast is shown in Figure 3.

Conversion of Fuel Burn into Emissions

In order to convert fuel burn into oxides of nitrogen (NOx), hydrocarbons (HC) and carbon monoxide (CO) emissions, the following formula was used (Anderson, 1997 and EPA, 1985).

*Emissions (lbs.) = Time (min) * Fuel Flow (1000 lbs/min) * Emission Index (lbs emission/1000 lbs fuel)*

One of the main factors in the equation above is the emission index. The emission index is a function of the engine type, phase of flight (or engine thrust), and pollutant. The emission indices are based on information provided by the engine manufacturers and documented by the FAA and ICAO (EPA, 1985). These indices were used in the calculations for emissions released during taxi/idle and operations below 3000'. However, because these indices are not representative of emissions above 3,000 feet Boeing developed indices for operations above 3000' by incorporating the

ICAO indices and several other factors (Baughcum, 1996). If these indices were not available for a specific engine type, the ICAO index for the approach phase was used in its place.

Claas (Generic)	Type	1996	2005	2010	2015
20-40 seats					
1	DHC6	64	108	131	155
1	DHC8	144	244	296	349
1	D328	37	63	76	90
1	Embr120	237	402	488	576
1	J31	87	148	180	212
1	J32	83	141	171	202
1	J41	39	66	80	95
>40 seats					
1	ATP	12	36	48	61
1	ATR-42	100	299	400	506
1	ATR-72	51	153	204	258
1	CV-580	18	54	72	91
1	CRJ	36	108	144	182
1	DHC7	29	87	116	147
1	F27	14	42	56	71
Total (1)		**951**	**1950**	**2462**	**2994**
2	BAE146	41	47	52	57
2	BAC111				
2	A320	109	187	267	306
2	DC8	102	119	131	143
2	DC9	454	408	328	328
2	737-100	11	0	0	0
2	727/100-2	680	147	0	0
2	707/720	2	2	3	3
2	737-200	312	90	5	0
2	737-500	160	459	600	658
2	737-400	94	123	135	147
2	737-300	482	561	618	673
2	MD-81/8	615	775	915	1010
2	MD-90	11	13	14	16
2	F-100	130	151	166	181
2	F-28	70	81	90	97
Total (2)		**3273**	**3163**	**3324**	**3618**
3	757	660	1803	2294	2592
3	A310	41	79	99	115
Total (3)		**701**	**1882**	**2393**	**2707**
4	747-SP	4	0	0	0
4	L1011	101	49	53	53
4	DC10	176	205	175	175
4	767	224	483	611	854
4	777	12	159	218	251
4	A300	73	225	298	431
Total (4)		**591**	**1121**	**1355**	**1764**
5	MD11	55	70	93	117
5	747-400	47	91	126	161
5	747-100	59	50	50	50
5	747-200	62	60	53	52
Total (5)		**223**	**271**	**322**	**380**
6	XX		39	80	133
Total (6)		**0**	**39**	**80**	**133**
7	747-SR	0	19	92	144
Total (7)		**0**	**19**	**92**	**144**
TOTAL (class 2-7)		**4787**	**6494**	**7566**	**8745**

Class	# of Seats
1	0-80
2	81-150
3	151-210
4	211-300
5	301-400
6	401-500
7	501-600

Figure 3. U.S. Fleet Forecast

Because the emission indices are engine specific, it was necessary to map the aircraft types from the scenarios to specific engine types. The first step in the mapping process was to map all of the aircraft types to "default" aircraft types using the characteristics of the aircraft (i.e., size, jet vs. turboprop, number of engines, etc.). In many cases, the aircraft type was the same as the default. Once the default aircraft type was assigned, the default engine for each aircraft type was extracted from both the ICAO and Boeing documentation (Baughcum, 1996 and EPA, 1998). Where there was no default engine specified in either document, then the default engine from FAA's Office of Environment and Energy's (AEE) Emissions and Dispersion

Modeling System (EDMS) was used (Anderson, 1997). Once the default engine was determined, the appropriate emission index could be used for each aircraft type.

In addition, the phases of flight used for emission calculations are slightly different from those used for conventional phases of flight. This is due to the fact that emission dissipation acts differently closer to the ground than higher in the atmosphere. Therefore, the climb-out phase is considered to be from 1000 feet and 3,000 feet instead of continuing until the aircraft levels off. In addition to the change in climb out altitude, the cruise indices are separated out into two altitude levels (0-9 km and 9-13 km) to reflect more accurately the difference in emissions between lower cruise levels and higher cruise levels. A summary of the levels of emission calculations by phase of flight is depicted in Figure 4.

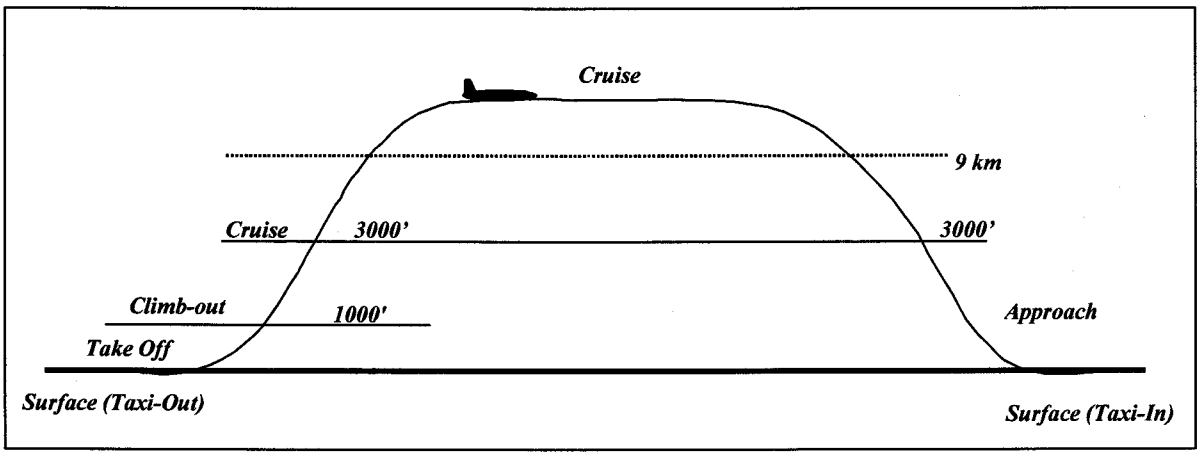

Figure 4. Calculations of Emissions by Phase of Flight

Results

A summary of the fuel and emission estimates is shown in Table 1. The numbers reported here represent fuel and emmitant levels that were simulated for a day of instrument flights in the National Airspace System for each of the respective time frames.

As a function of altitude, the phase of flight above 3,000 feet consumes the most fuel (approx. 83%) and generates the maximum levels of oxides of nitrogen (NOx), carbon dioxide (CO) and unburned hydrocarbon (HC) pollutants. Peak fuel burn and NOx emissions occur during cruise altitudes since most of the flight time occurs at these altitudes.

The next largest level of fuel use occurs for flights below 3,000 feet to the surface (the take-off and climb phases). While surface operations account for the least amount of fuel use, it has the highest proportionate output of CO and HC to fuel burn on a per pound basis. This is because carbon monoxide and unburned hydrocarbon emissions are highest at low power settings where the temperature within the engine is relatively low and combustion is less efficient.

		Baseline Case				CNS/ATM Improvements							
Year	Mode	Fuel	NOx	CO	HC	Fuel		NOx		CO		HC	
1996	Total	305,805	3,712	3,772	754								
	Above 3000	253,195	3,100	2,926	569								
	Below 3000	33,380	547	200	19								
	Surface	19,231	65	647	166								
2005	Total	351,964	4,708	4,373	854	339,240	-3.6%	4,377	-7.0%	3,974	-9.1%	758	-11.2%
	Above 3000	292,604	3,935	3,431	657	280,656		3,609		3,041		563	
	Below 3000	38,346	702	195	19	37,824		698		191		18	
	Surface	21,013	72	747	177	20,759		71		742		176	
2010	Total	380,176	5,126	4,607	919	359,263	-5.5%	4,636	-9.5%	4,059	-11.9%	773	-15.9%
	Above 3000	317,224	4,292	3,595	713	297,424		3,810		3,074		572	
	Below 3000	40,414	757	194	19	40,041		752		192		18	
	Surface	22,538	77	817	188	21,797		75		793		183	
2015	Total	399,157	5,399	4,706	937	374,953	-6.1%	4,867	-9.9%	4,109	-12.7%	768	-18.0%
	Above 3000	333,192	4,513	3,666	727	310,633		3,996		3,110		568	
	Below 3000	42,756	806	198	19	42,132		795		195		19	
	Surface	23,209	80	842	191	22,188		76		804		182	

Table 1. Fuel and Emission Results by Phase of Flight (1,000 lbs./Day)

As expected, the phased implementation of the planned CNS/ATM capabilities are estimated to produce an incremental impact on aviation fuel usage. In particular, the fuel savings are estimated to grow from 3.6 % in 2005 to 5.5 % in 2010. When all the planned CNS/ATM enhancements to the NAS are completed by 2015, the potential daily fuel savings is estimated to be 6.1% compared to the fuel that would otherwise be consumed without modernization.

Annual Benefits

Given the projected fuel and emission levels listed in Table 1, the next step in the study involved extrapolating the numbers from a daily count to an annual basis. This was accomplished by examining the pattern of traffic for the base year 1996 to adjust for operational differences between weekday and weekend traffic as well as seasonal differences. The annualized fuel and emission savings are shown in Table 2.

	Fuel	NOx	CO	HC
Above 3,000	9,683	204.3	197.1	56.7
Below 3,000	219	4.0	1.1	0.1
Surface	358	1.2	13.2	3.1
Total	**10,259**	**209.5**	**211.4**	**59.9**
% Savings	**6.1%**	**9.9%**	**12.7%**	**18.0%**

Table 2. Annual Fuel and Emission Savings in 2015 (in Millions of Pounds)

The summary numbers indicate that the CNS/ATM enhancements to the NAS have a potential annual fuel savings of 10.3 billion pounds by the year 2015, which represents a savings of 6.1% from what would have been used without NAS modernization. The phase of flight above 3,000 feet accounts for 94% of the savings, with remaining savings accruing to greater efficiency in surface operations and approach and take-off phases

of flight. These fuel savings translate to an annual reduction in emissions of over 200 million pounds for both oxides of nitrogen (NOx) and carbon monoxide (CO), and 60 million pounds of unburned hydrocarbon (HC), representing savings of approximately 10%, 13%, and 18%, respectively.

From an economic standpoint, these physical units of fuel savings were converted into monetary values using inputs from the Air Transportation Association and the FAA. The monetary estimates of fuel benefits for air carriers and general aviation users are summarized in Table 3. It is projected that aviation users could gain potential savings in fuel of about a billion dollars in 2015.

Almost 87% of the estimated annual fuel savings are expected to accrue to the air carriers.

	Air Carriers	GA	Total
Lbs. of Fuel Savings	9,897	362	10,259
Gallons of Fuel Savings	1,477	54	1,531
Dollars of Savings	**$886**	**$135**	**$1,021**

Table 3. 2015 Annual Fuel Cost Savings (in millions of 1998 dollars)

Summary

Fuel conservation and environmental protection have been long standing U.S. national priorities. This analysis provides evidence to suggest that the modernization of the National Airspace System can make a significant contribution to the realization of these national goals.

The key findings from this study indicate that aircraft flying in U.S. airspace could potentially reduce fuel burn by about 10 billion pounds by the year 2015, representing a 6% reduction in the amount of fuel that would have been burned without the NAS modernization.

The 10 billion-pound fuel saving converts into reductions of over 209 million pounds of NOx, 211 million pounds of CO, and 59 million pounds of HC, representing reduced emission levels of 9%, 12% and 18%, respectively. Finally, the economic value of the fuel savings on an annual basis is estimated to have a potential worth of about a billion dollars to the aviation users.

Acknowledgements

The authors gratefully acknowledge the participation, and support of several individuals and organizations. We especially like to recognize the significant contributions made by the following individuals: Fran Melone, Dan Citrenbaum and Doug Baart, FAA; Donna Middleton and Madelyn Harp, TRW; Joe Smith and Marie Pollard, SAIC; Art Tastet, JTA; and, Stephen Mondoloni, Bill Colligan and Willie Weiss, CSSI.

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APPENDIX 2. ICAO PAPER "AGENDA ITEM 3: CNS/ATM IMPLEMENTATION AND RELATED ACTIVITIES"

ICAO paper is attached.

International Civil Aviation Organization

**TENTH MEETING OF THE
ASIA/PACIFIC AIR NAVIGATION PLANNING AND
IMPLEMENTATION REGIONAL GROUP (APANPIRG/10)
Bangkok, Thailand, 30 August to 3 September 1999**

Agenda Item 3: CNS/ATM Implementation and Related Activities

Environmental benefits associated with the implementation of CNS/ATM systems

(Presented by the Secretariat)

SUMMARY

This paper discusses the importance of environmental issues while defining the CNS/ATM system implementation strategies. The paper further reports the ongoing efforts within CAEP's work programme in establishing a common methodology for assessing environmental benefits of CNS/ATM system implementation.

Action by the meeting is proposed at paragraph 8.

1. INTRODUCTION

1.1 Against a background of increasing concerns regarding the impact of aircraft engine emissions on the environment, ICAO has been considering what steps can be taken by the international aviation community to control emissions.

1.2 The ICAO Committee on Aviation Environmental Protection (CAEP), during its fourth meeting (CAEP/4, April 1998), noted that CNS/ATM systems, which were conceived to improve flight safety and reduce flying times and delays, could potentially reduce fuel consumption, thereby reducing aircraft emissions. In order to increase awareness of the possibilities of reducing emissions in this way, CAEP/4 adopted Recommendation 1/1 – Environmental benefits of CNS/ATM, which was subsequently approved in an amended form by the Council. The recommendation calls for the attention of Contracting States and relevant international organizations to be drawn to the environmental benefit, as one of the benefits that would accrue from the early implementation of CNS/ATM systems (State letter AN 1/17-99/27, dated 5 March 1999 refers).

1.3 As a result of the delays experienced with the present systems limitations, aircraft are burning additional fuel and are thereby generating additional emissions. The early implementation of CNS/ATM systems offers an effective means of reducing fuel burn and avoiding unnecessary emissions, helping to minimize civil aviation's environmental impact.

2. CAEP WORK PROGRAMME

2.1 CAEP established a new work programme in the emissions field, taking into account the outcome of the third session of the Conference of the Parties to the United Framework Convention on Climate Change (Kyoto, Japan, December 1997), which recognized ICAO as the forum in which developed countries should pursue the limitation or reduction of greenhouse gas emissions from aviation bunker fuels. CAEP has established three working groups to consider:

a) the reduction of emissions at source;

b) emissions reduction derived from operational measures, including studies to estimate savings expected from the implementation of CNS/ATM systems; and

c) the market-based options for emissions reduction, such as emissions-related levies (charges or taxes) and emissions trading,

and CAEP has agreed that an action plan on emissions should be prepared. Work on this action plan is currently under way.

2.2 The Council, in noting the CAEP/4 recommendation that representatives of CAEP be permitted to participate in regional meetings dealing with the implementation of CNS/ATM systems, indicated that CAEP representatives could follow the implementation of CNS/ATM systems in the regions by direct participation in their respective State's delegation.

3. RESULTS OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

3.1 The following is an extract from the IPCC special report on the effects of aviation on the global atmosphere, in relation to operational aspects:

"*Improvements in air traffic management (ATM) and other operational procedures could reduce aviation fuel burn by between 8 and 18%. The large majority(6 to 12%) of these reductions comes from ATM improvements which it is anticipated will be fully implemented in the next 20 years. All aviation emissions will be reduced as a consequence. In all aviation emission scenarios considered in this report the reductions from ATM improvements have already been taken into account. The rate of introduction of improved ATM will depend on the implementation of the essential institutional arrangements at an international level.*

"Air traffic management systems are used for the guidance, separation, coordination, and control of aircraft movements. Existing national and international air traffic management systems have limitations which result, for example, in holding (aircraft flying in a fixed pattern waiting for permission to land)., inefficient routings, and sub-optimal flight profiles. These limitations result in excess fuel burn and consequently excess emissions.

"For the current aircraft fleet and operations, addressing the above-mentioned limitations in air traffic management systems could reduce fuel burned in the range of 6 to 12%. It is anticipated that the improvement needed for these fuel burn reductions will be fully implemented n the next 20 years, provided that the necessary institutional and regulatory arrangements have been put in place in time. The scenarios developed in this report assume the timely implementation of these ATM improvements, when estimating fuel use.

"Other operational measures to reduce the amount of fuel burned per passenger-km include increasing load factors (carrying more passengers or freight on a given aircraft), eliminating non-essential weight, optimizing aircraft speed, limiting the use of auxiliary power (e.g., for heating, ventilation), and reducing taxiing. The potential improvements in these operational measures could reduce fuel burned, and emissions, in the range 2 to 6%.

"Improved operational efficiency may result in attracting additional air traffic, although no studies providing evidence on the existence of this effect have been identified."

4. FURTHER DEVELOPMENTS

4.1 Since CAEP/4, the various working groups have been progressing their tasks and Working Group 4 (WG4) – Emissions – Operational Issues has been involved primarily in the quantification of the environmental benefits that accrue from the implementation of CNS/ATM systems.

4.2 During the discussions at the second meeting of WG4 (Seville, 2 to 4 March 1999), attention was drawn to the need to establish a common methodology to assess the environmental benefits of CNS/ATM systems implementation worldwide, as a means of avoiding a proliferation of different methodologies. The meeting also addressed the importance of having the environmental aspects included among the relevant considerations to be taken into account when defining the implementation of CNS/ATM systems, i.e. in the business cases. To date, environmental considerations have been included in the *Global Air Navigation Plan for CNS/ATM Systems* only as an indirect benefit from the systems implementation. It was also noted that the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation does not include environmental issues within its precepts.

4.3 Based on the recommendations arising from the second meeting of WG4, the third meeting of the ALLPIRG/Advisory Group (ALLPIRG/3, Montreal, 6 to 8 April 1999) was presented with a working paper on the need to adopt a uniform methodology for the assessment of environmental benefits associated with the implementation of CNS/ATM systems. The meeting, in endorsing the conclusion, invited ICAO to take the necessary follow-up action (ALLPIRG/3 Conclusion 3/14 refers).

5. ACTION TAKEN BY THE AIR NAVIGATION COMMISSION AND COUNCIL

5.1 On 11 June 1999, in approving report of the third meeting of the ALLPIRG/Advisory Group, the Council called upon CAEP to expedite its work on the development of a preliminary methodology for the assessment of the environmental benefits associated with the implementation of CNS/ATM systems. This preliminary methodology is to be applied by PIRGs at the earliest opportunity in the analysis of the business cases, until the final methodology is incorporated as part of a new chapter into Volume I of the *Global Air Navigation Plan for CNS/ATM Systems*.

6. BENEFIT ASSESSMENT METHODOLOGY

6.1 The development of a common methodology for the assessment of the environmental benefits of CNS/ATM systems implementation will be based on a Federal Aviation Administration study that was done for ICAO's Global CNS/ATM Systems Implementation Conference held in 1998 that evaluate the potential of CNS/ATM procedural enhancements to reduce environmental emissions by reducing fuel burn.

6.2 As the need to incorporate the environmental aspects during the consideration of the regional business cases is more immediate, steps are being taken to adopt a preliminary methodology (which is expected to be presented to the Air Navigation Commission in November 1999) while awaiting the final methodology.

6.3 The final methodology is expected to be presented to the fifth meeting of the CAEP, which is scheduled for last quarter of 2000 or the first quarter of 2001, for approval.

7. FOLLOW-UP BY STATES

7.1 In light of the above, the APANPIRG may wish to urge States, through the following conclusion, to take environmental benefits into account in the development of business cases for the implementation of CNS/ATM systems.

Conclusion 10/X – Environmental benefits of CNS/ATM systems

That States take the environmental benefits, among other considerations, into account in the development of business cases for the implementation of CNS/ATM systems.

8. ACTION BY THE MEETING

8.1 The APANPIRG is invited to:

a) note the importance of considering the environmental issues when defining CNS/ATM systems implementation strategies;

b) note the importance of establishing a common methodology to assess the environmental benefits of CNS/ATM systems implementation, as a means of avoiding a proliferation of different methodologies;

c) note that there are ongoing efforts within CAEP's work programme towards such an approach; and

d) endorse Conclusion 10/X in paragraph 7 above.

– END –

APPENDIX 3. ACRONYMS

ABAS	Airborne-Based Augmentation System
ACC	Area Control Center
ACF	Area Control Facility
ADB	Asian Development Bank
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AFDP	Automatic Flight Data Processor
AFTM	Air Traffic Flow Management
AFTN	Aeronautical Fixed Telecommunications Network
AIC	Aeronautical Information Circular
AIDC	ATS Interfacility Data Communications
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMDAL	Environmental Impact Assessment System
AMHS	Aeronautical Message Handling Service
AMSS	Aeronautical Mobile Satellite Services
ANSP	Air Navigation Service Provider
AP I & II	Angkasa Pura I & II
APANPIRG	ICAO's Asia-Pacific Air Navigation Planning and Implementation Regional Plans (APANPIRG Agreements) Group
ARINC	Aeronautical Radio, Inc.
ARSR	Air Route Surveillance Radar

ASEAN	Association of South East Asian Nations
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATIS	Airport Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATO	Air Traffic Operations
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
ATSU	Air Traffic Services Unit
BRD	International Bank for Reconstruction and Development
B-RNAV	Basic Area Navigation
CA	Conflict Alert
CAA	Civil Aeronautics Administration
CAEP	Committee on Aviation Environmental Protection
CATCC	Central Air Traffic Command Center
CDM	Collaborative Decision-Making
CNS/ATM	Communications, Navigation, Surveillance/Air Traffic Management
CO	carbon monoxide
CO2	carbon dioxide
CPDLC	Controller-Pilot Data Link Communications
CSFP	Center Stored Flight Plan
CY	Calendar Year

DATIS	Digital Airport Terminal Information Service
DCA	Directorate of Civil Aviation (Malaysia)
DGPS	Differential Global Positioning System
DME	Distance Measuring Equipment
DOC	Document
DVOR	Doppler VOR
E-MSAW	En Route Minimum Safe Altitude Warning
ENR	En Route European
EBRD	Bank for Reconstruction and Development
Ex-Im	Export-Import Bank of the United States
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIR	Flight Information Region
FIS	Flight Information Service
FTP	File Transfer Protocol
FUA	Flexible Use of Airspace
GBAS	Ground-Based Augmentation System
GMS	GPS Monitoring System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRAS	Ground Regional Plans (APANPIRG Agreements) Augmentation System
GRS	Ground Reference Station
HC	hydrocarbons

HF	High Frequency
HFDL	HF Data Link
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDA	International Development Association
IFALPA	International Federation of Air Line Pilots Association
IFATCA	International Federation of Air Traffic Controllers' Associations
IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules
IIPC	Intergovernmental Panel on Climate Change
ILS	Instrument Landing System
ISPACG	Informal South Pacific ATC Coordinating Group
JCAB	Japanese Civil Aviation Bureau
JBIC	Japan Bank for International Cooperation
LAAS	Local Area Augmentation System
LI	Letter of Interest
LOA	Letters of Agreement
M2	Mode 2 (two)
MCS	Master Control Station
MITRE/CAASD	MITRE Corporation's Center for Advanced Aviation System Development
MNT	Mach Number Training
MRS	Master Reference Station

MSAS	Multi-Functional Transport Satellite-Based Augmentation System
MSSR	Monopulse Secondary Surveillance Radar
MTSAT	Multi-Functional Transport Satellite
NBIC	New Bangkok International Airport
NDB	Non-Directional Beacon
NLR	National Aerospace Laboratory, Netherlands
NOTAM	Notice to Airmen
NOx	oxides of nitrogen
ODA	Official Development Assistance
O&M	Operations and Maintenance
OLDI	Online Data Interchange
ORDD	Operational Readiness Demonstration Date
PDC	Pre-Departure Clearance
PIREP	Pilot Reports (weather)
PMS	Precipitation Map Service
PIA	Project Incentive Agreement
PPL	Preliminary Project Letter
QA	Quality Assurance
OPIC	Overseas Private Investment Corporation
RASMAG	Asia/Pacific Regional Plans (APANPIRG Agreements) Airspace Safety Monitoring Advisory Group
RDP	Radar Data Processing
RFI	Radio Frequency Interference
RFP	Request for Proposals

RLRS	Reduced Lateral Route System
RNAV	Area Navigation
RNP	Required Navigation Performance
RVA	Robinson Aviation (RVA), Inc.
RVSM	Reduced Vertical Separation Minima
SADIS	Satellite Distribution
SATNAV	Satellite Navigation
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
SIGMET	Significant Meteorological Conditions
SOIT	Satellite Operational Implementation Team
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
TA	Technical Assessment
TFM	Traffic Flow Management
TIS	Traffic Information System
TSO	Technical Standard Order
TWS	Terminal Weather Service
URET	User Request Evaluation Tool
USTDA	U.S. Trade and Development Agency
VDL M2	Very High Frequency Data Link Mode 2
VDL	VHF Data Link

VHF	Very High Frequency
VOR	VHF Omni-Directional Range
VOR/DME	VHF Omni-Directional Range/Distance Measuring Equipment
VSAT	Very Small Aperture Terminal
WAAS	Wide Area Augmentation System
WAFS	World Area Forecast System
WGS-84	World Geodetic Survey –84
World Bank	IBRD and IDA. The World Bank is a vital source of financial and technical assistance to developing countries

Natuna Islands Air Traffic Control and Airspace Management Project for the Republic of Indonesia

Task 5

Revenues and Financial and Economic Analysis

Prepared for:
Directorate General of Air Communications of the Republic of Indonesia

By:
Robinson Aviation (RVA), Inc.

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1.0 Introduction

The objective of Task 5 is to develop the Financial and Economic Analysis of the Proposed Investment Plans as established in the previous task. Task 3 provides the cost involved in development of the CNS/ATM plan set forth in Task 2. These costs are now, in Task 5, compared to estimates of revenues from overflight charges and a revenue stream generated through the implementation of the Investment Plan developed in Task 3.

Estimated Route Air Navigation Service (RANS) charges (revenues) developed in Task 5 complete the economic and financial analysis. In order to determine the financial requirements for Sector C air traffic services, an assessment of the existing Communications, Navigation, and Surveillance (CNS), Area Control Center (ACC), and Air Traffic Management (ATM) capabilities was completed with a number of alternatives discussed in Task 2.

RVA's Financial and Economic analysis presented here in Task 5 provides the DGAC a detailed analysis of the financial consequences of the suggested Sector C CNS/ATM plan. Specifically, the results of this work resulted in RVA providing a projected revenue stream generated from implementation of RANS charges earned from the DGAC's resumption of ANSP services. These revenues were then compared to the cost of providing CNS/ATM services to the users of the Natunna Airspace Sector C.

Based on these estimates for investment costs and revenues, RVA carried out a financial review of the proposed airspace management project including calculation of the financial internal rate of returns (FIRR). Further information is provided in the form of FIRR for 10 different scenarios consisting of changes in anticipated air traffic growth over Natuna and within the Indonesian airspace, inflationary costs of Operations and Management, and timing of implementing a graduated scale of RANS unit rate.

RVA also completed sensitivity analysis for the same 10 scenarios based on potential variations in unit rate implementation schedules, traffic pattern changes, and inflationary cost.

Decision making requires consideration of a multitude of different factors. In order to provide the DGAC a broad range of information, the following areas were considered and commented on. The net result is that the preponderance of information indicated the proposed investment in the project will have a positive impact on the Indonesian economy.

2.0 Route Air Navigation Service (RANS) Charges

The International Civil Aviation Organization (ICAO) recognizes the right of each member contracting state to provide air navigation services within the airspace over its territorial land and seas. Furthermore, ICAO permits its member states to collect air navigation service fees to recover the expenses incurred in providing such services and for the improvement of aviation and airport facilities within the state. Revenue collections should be used to evaluate and improve the quality of air navigation services provided, to improve ATC infrastructure, to transition to satellite-based CNS systems, and to implement ATM systems providing full service

over the sovereign airspace. Prior to attempting to implement any new RANS charges, it is imperative to consult the latest edition of ICAO's Policies on Charges for Airports and Air Navigation Services (Sixth Edition 2001) Sections I and III and Appendix 2 http://www.icao.int/icaonet/dcs/9082_6ed.pdf.

2.1 ICAO's Policies. Reference ICAO Document 9082/6, ICAO policies on charges for Air Navigation Services as adapted 08 December 2000; in particular, paragraphs 36 through 46 and Appendix 2. The ICAO council considers as a general principle, where navigation services are provided for international use, the providers may require the users to pay for their share of the related costs. An equitable cost recovery system could proceed from an accounting of total air navigation services costs incurred on behalf of aeronautical users (as developed by Task 3) to an allocation of these costs among categories of users, and finally to the development of a charging or pricing policy system (cited here in Task 5).

2.2 Cost Recovery Principles. The systematic approach used in Task 3 to develop costs is consistent with Council recommendations that, when establishing a cost basis for RANS charges, the following principles apply:

- The cost is the full cost of providing the air navigation services, including appropriate amounts for cost of capital and depreciation of assets, as well as the costs of operations, maintenance, and General and Administrative costs.

- The costs to be taken included those assessed in relation to the ATM which is divided into Air Traffic Services (ATS), air traffic flow management (ATFM), and airspace management (ASM).

- Ground and/or satellite-based aeronautical communications (including satellite lease service costs), navigation (including Global Navigation Satellite System (GNSS) and associated augmentation systems), and surveillance systems (including primary/secondary surveillance radars and other facilities supporting the Automatic Dependence Surveillance (ADS) or ADS-B Broadcast) necessary for safety and regularity of flights.

- Any excessive construction, operation, or maintenance expenditures should be excluded.

- Air navigation services may produce sufficient revenues to exceed all direct and indirect operating costs and so provide for a return on assets to contribute towards necessary capital improvements (new technology).

- States may choose to recover less than full costs.

- Each State should decide for itself when and at what level any air navigation services charges should be imposed.

- The approach toward the recovery of full costs should be a gradual process.

2.3 Cost Allocation Process[1]**.** The allocation of costs of air navigation services among users should be carried out in a manner equitable to all users; the proportion of costs should be determined in such a way as to ensure that no user is burdened with costs not properly allocated to them according to sound accounting principles. The Council recommends that States should acquire basic utilization data in respect of air navigation services, including the number of flights by category of user (i.e., air transport, general aviation, and other) in both domestic and international operations, and other data such as the distance flown and aircraft type or weight, where such information is relevant to the allocation of costs and the cost recovery system.

2.4 Natuna Sector C Air Navigation Services. The Indonesian goals in this effort are to begin a process to resume control of airspace over its territory and to generate revenue to subsidize its air traffic control system to continue providing air traffic management. The revenue would be used not only for Sector C ATC, but also to help modernize ground-based systems, particularly at Pontianak and Tanjung Pinang, and to help finance the transition from ground-based to space-based technologies to better accommodate the projected 5.0% annual air traffic growth rate in the region. The improved margin of safety by providing radar procedural control and an increased level of services are key elements for ICAO approval and economic development. It must be noted that Sector C is a small area of airspace wholly contained within the Singapore Flight Information Region (FIR). Transfer of control for this airspace will create additional complexity for traffic crossing this area; therefore, development of viable procedures is critical to its success.

Ultimately, Singapore FIR Sector C air traffic management activities will be transferred from the Singapore ACC to the Indonesian air traffic control facility wherein RANS charges will be implemented. RANS charges are currently implemented in Sector A of the Singapore FIR which is controlled by the Singapore ACC. Fees are collected by Singapore on behalf of the Indonesian government per agreement made 22 January 1999 between representatives of the Singapore (CAAS) and Indonesia (DGAC) and reaffirmed at a followup meeting on 9 October 2003. The document concerning Route Air Navigation Service (RANS) Charges in Sector A Airspace also concludes that collection of fees is a matter outside of the Agreement on the Realignment of the Boundary between the Singapore FIR and the Jakarta FIR, signed on 21 September 1995. Therefore, it is concluded that implementing RANS charges in Sector C is also a matter outside of the Agreement on the Realignment of the Boundary between the Singapore FIR and the Jakarta FIR.

2.5 Coordination. ICAO's ***Policies on Charges for Airports and Air Navigation Services*** Seventh Edition "emphasizes the importance of consultation with users before changes in charging systems or levels of charges are introduced." This consultation should provide the users of the system with an understanding of how the charges will be determined. It is also to allow the users to detail the effect the changes will have on them. A review of this ICAO document is an important step in the development of a charging system.

[1] Guidance on cost allocation is contained in the *Manual on Air Navigation Services Economics* (Doc 9161), and the *Airport Economics Manual* (Doc 9562), although States use any accounting approach they consider meets their particular requirements.

3.0 Revenues

3.1 Route Air Navigation Service (RANS) Charges. RANS charges for Sector C are expected to be implemented similar to the fee implementation structure agreed for collection of Sector A RANS charges. Sector A fee collection procedures are described in Singapore AIP GEN 4.2, Air Navigation Service Charges, resulting from an agreement made between representatives of the Civil Aviation Authority Singapore (CAAS) and the Directorate General of Air Communication (DGAC) of Indonesia held at Changi Airport on 22 January 1999. Further discussions were held between the CAAS, DGAC, and PT Angkasa Pura II on collection of RANS charges on October 2003 which proposed and adopted increasing the Sector A rates in equal steps over the ensuing 5 years after consultation with the International Air Transport Association (IATA).

Sector A RANS charges originated at a low rate of $0.15 in 1999 per ICAO General Council recommendations, then are progressively increased on a yearly basis on 01 July over a 9-year period to a maximum equal to the current Indonesian rate of $0.65 per unit which will be effective 01 July 2008. The net proceeds of Sector A charges are collected by Singapore CAAS, then remitted to PT Angkasa Pura II on a monthly basis.

It is assumed that Sector C RANS fees would be collected by the DGAC of Indonesia. Implementation of Sector C RANS charges would follow the same guidelines as Sector A and imposition of any other new fee per ICAO recommendations.

3.2 Sector C Traffic Profile. A comprehensive review of the Singapore Civil Aviation Authority (CAAS) AIP, ENR 3.1-17, ***Air Traffic System*** Chart dated 20 January 2005, was completed to determine the routes that go through Sector C. The chart depicts all routes that go through Sector C and specifies the unidirectional required navigation performance (RNP) routes to be used to or from Singapore Changi International Airport. Overflight traffic routes that transverse Sector C to Jakarta International Soekarno-Hatta Airport were also identified. After identifying the routes, an analysis of the Changi International Airport and Jakarta International Soekarno-Hatta Airport departing and arriving traffic was completed considering origin and destination of the flights to determine routes used. The traffic analysis considered only international flights and excluded all non-civil flights, General Aviation, and all flights that may be related to the intra-Malaysian corridor. Appendix 1 contains a complete listing of air traffic used for this analysis.

3.3 Determining the RANS Rate. The formula used for computing RANS charges is composed of three numbers: Unit Rate, Distance Factor (DF), and Weight Factor (WF) where the DF and WF are combined in a figure called the "Route Unit" resulting in the formula: RANS Charge = Unit Rate x Route Unit.

3.3.1 Route Unit. The computation of the Route Unit is as follows:

Route Unit = Distance Factor (DF) x Weight Factor (WF)

- **Distance Factor (DF)** calculations where:

  DF = 0 Between 1.0 km (0 nm) and 49.9 km (27 nm)
  DF = 1 Between 50.0 km (27 nm) and 159.9 km (81 nm)
  DF = 2 Between 150.0 km (81 nm) and 249.9 km (135 nm)
  DF = 3 Between 250.0 km (135 nm) and 349.9 km (189 nm)
  DF = 4 Between 350.0 km (189 nm) and 449.9 km (243 nm)
  DF = 5 Between 450.0 km (243 nm) and 549.9 km (297 nm)
  Thereafter, for every subsequent 100 km (54 nm) or part thereof, DF shall increase by 1.

Nautical mile (NM) distances were determined using Indonesia High/Low Altitude Enroute Chart, effective 8 April 2005. Route Distance Factors (DF), Table 3.3.1A, shows the routes through Sector C and the approximate distance resulting in the distance factor used in all calculations.

Route:	A464	A576	B348	G334	G580	L625	L644	M767	N884	W 36
NM:	120	100	188	201	152	218	238	212	204	233
DF:	2	2	3	4	3	4	5	4	4	4

Table 3.3.1A - Route Distance Factors (DF)

- **Weight Factor (WF)** is based on aircraft type Mean Take-Off Weight (MTOW)[2] as it relates to the weight factor (WF) listed on the ***Weight Factor Table*** attached as Appendix 2. A listing of all aircraft types for flights identified as potential RANS charges is shown in Table 3.3.1B below.

Aircraft Type	MTOW	MTOW in Kg	Weight Factor
A319	75,500 kg	75.50	32
A320	77,000 kg	77.0	33
A330	217,000 kg	217.0	74
A340-200[3]	260,000 kg	260.0	86
B727	95,030 kg	95.03	39
B737-800	79,015 kg	79.02	33
B747-400 ER	412,770 kg	412.77	124
B767-400	204,120 kg	204.12	71
B777	341,105 kg	341.11	107

Table 3.3.1B - Weight Factor (WF)

3.3.2 Unit Rate. The appropriate unit rate used on implementation of RANS charges is an issue for careful consideration and coordination. Consistency with past practices in the region

[2] http://www.airliners.net
[3] Philippine Air http:www.aircraft-info.net/aircraft/jet_aircraft/airbus/A340-200/

and close coordination with ICAO, IATA, and the customer community is a critical issue to be resolved well in advance of RANS implementation.

3.4 Expected Revenues. Two options for a schedule of RANS fee implementation are presented. Both options show the projected monthly and annual revenues under conditions of constant traffic and with 5% annual traffic growth. The options are implementing $0.17 versus $0.29 in Year 1. Implementing a higher rate at the beginning of the cycle increases the overall revenues during the 15-year period analyzed and will result in a better rate of return; the negative side is the impact on users and their willingness to pay the higher rate at the onset of RANS fees.

3.4.1 Implementing a Year 1 Unit Rate of $0.17. Option one implements a unit rate of $0.17 in Year 1 with yearly increases in $0.06 increments reaching the current Indonesian rate of $0.65 in Year 9. Table 3.4.1, Estimated RANS Revenues $0.17 Year 1, shows the expected revenues.

Year Rate implemented	RANS Rate in $ USD	Constant Traffic		5 % Annual Traffic Growth	
		Monthly Revenue *	Annual Revenue *	Monthly Revenue*	Annual Revenue *
1	0.17	$135,838	$1,630,059	$135,838	$1,630,059
2	0.23	$183,782	$2,205,386	$192,971	$2,315,656
3	0.29	$231,725	$2,780,704	$243,312	$2,919,740
4	0.35	$279,669	$3,356,023	$293,652	$3,523,824
5	0.41	$327,612	$3,931,338	$343,992	$4,127,905
6	0.47	$375,555	$4,506,659	$394,333	$4,731,992
7	0.53	$423,498	$5,081,977	$444,673	$5,336,076
8	0.59	$471,441	$5,657,295	$495,013	$5,940,160
9	0.65	$519,384	$6,232,613	$545,354	$6,544,244
10	0.65	$519,384	$6,232,613	$572,621	$6,871,456
11	0.65	$519,384	$6,232,613	$601,252	$7,215,029
12	0.65	$519,384	$6,232,613	$631,315	$7,575,781
13	0.65	$519,384	$6,232,613	$662,881	$7,954,570
14	0.65	$519,384	$6,232,613	$696,025	$8,352,298
15	0.65	$519,384	$6,232,613	$730,826	$8,769,913

* In constant 2006 US Dollars

Table 3.4.1 - Estimated RANS Revenues $0.17 Year 1

3.4.2 Implementing a Year 1 Unit Rate of $0.29. The second option implements a unit rate of $0.29 in Year 1 with annual incremental increases of $0.06 reaching the current Indonesian rate of $0.65 in Year 7. Table 3.4.2, Estimated RANS Revenues $0.29 Year 1, shows the expected revenues.

Year Rate Implemented	RANS Rate in $ USD	Constant Traffic		5 % Annual Traffic Growth	
		Monthly Revenue *	Annual Revenue *	Monthly Revenue *	Annual Revenue *
1	0.29	$231,725	$2,780,704	$243,312	$2,919,740
2	0.35	$279,669	$3,356,023	$293,652	$3,523,824
3	0.41	$327,612	$3,931,338	$343,992	$4,127,905
4	0.47	$375,555	$4,506,659	$394,333	$4,731,992
5	0.53	$423,498	$5,081,977	$444,673	$5,336,076
6	0.59	$471,441	$5,657,295	$495,013	$5,940,160
7	0.65	$519,384	$6,232,613	$545,354	$6,544,244
8	0.65	$519,384	$6,232,613	$572,621	$6,871,456
9	0.65	$519,384	$6,232,613	$601,252	$7,215,029
10	0.65	$519,384	$6,232,613	$631,315	$7,575,781
11	0.65	$519,384	$6,232,613	$662,881	$7,954,570
12	0.65	$519,384	$6,232,613	$696,025	$8,352,298
13	0.65	$519,384	$6,232,613	$730,826	$8,769,913
14	0.65	$519,384	$6,232,613	$767,367	$9,208,409
15	0.65	$519,384	$6,232,613	$805,736	$9,668,829

* In constant 2006 US Dollars

Table 3.4.2 - Estimated RANS Revenues $0.29 Year 1

3.4.3 Monthly and Annual RANS Revenue. Figures 3.4.3A and 3.4.3B below graphically represent the summarized expected RANS Revenues monthly and annually respectively for Years 1 through 15 for the information in the tables above. Each graph shows the rates for implementation at $0.17 and $0.29 and for constant versus 5% increase in traffic.

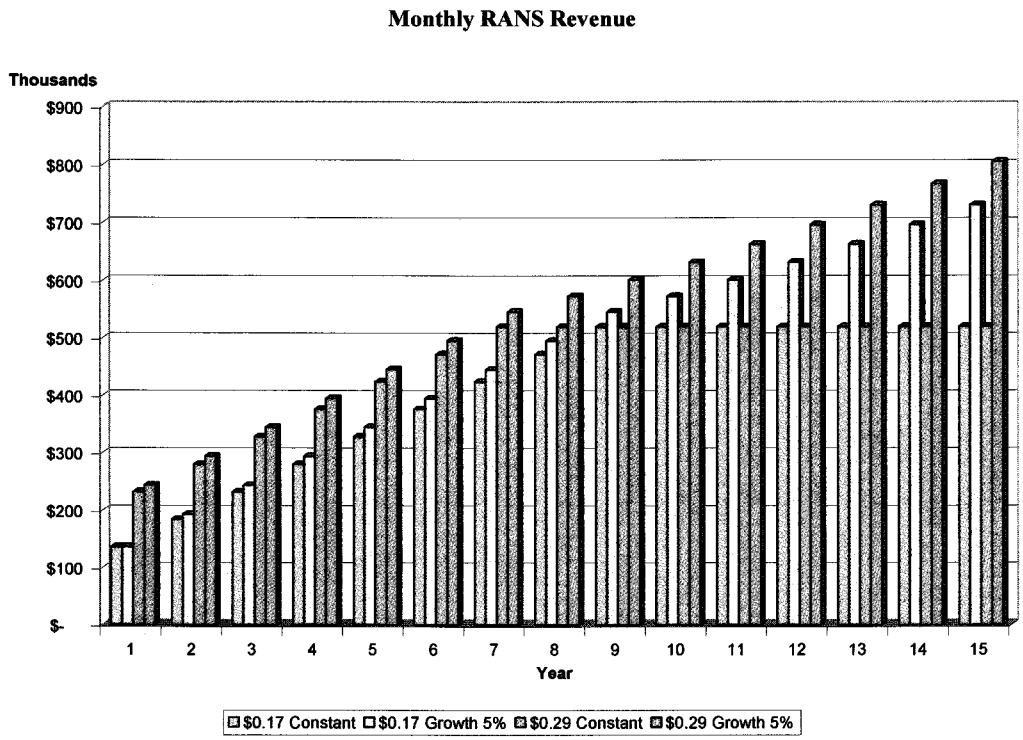

Figure 3.4 .3A - Projected Monthly RANS Revenue

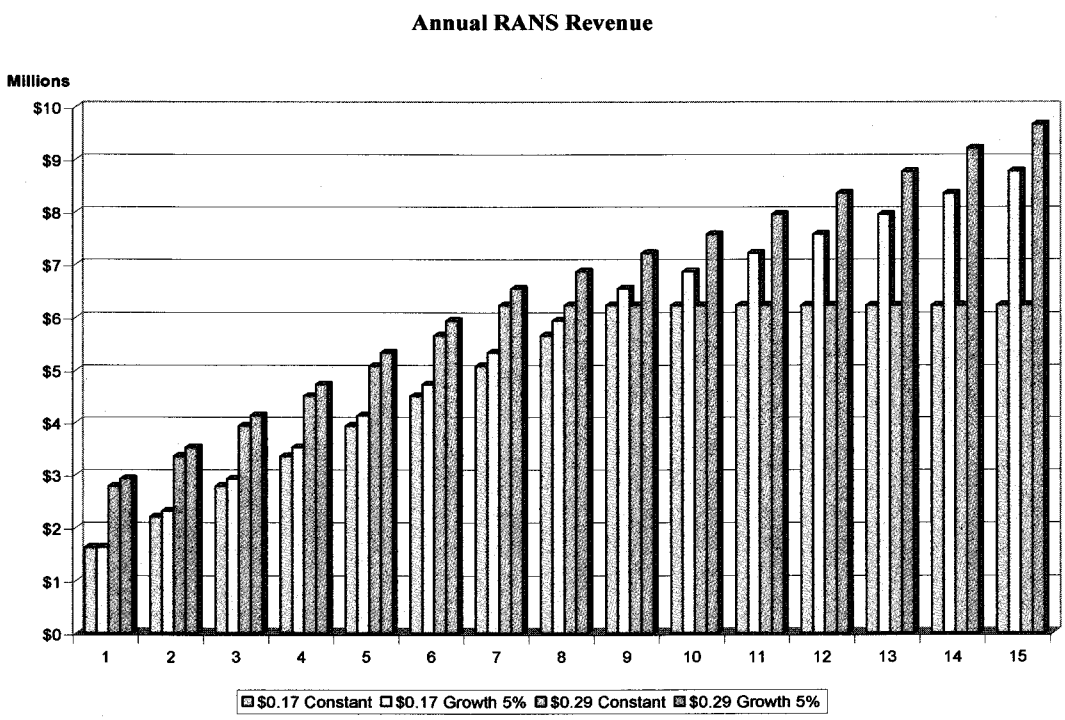

Figure 3.4.3B - Projected Annual RANS Revenue

4.0 Financial and Economic Internal Rate of Return (FIRR/EIRR)

4.1 Internal Rate of Return (IRR). The Internal Rate of Return is a measure of the worth of an investment. The financial IRR is the interest rate that makes the present value of the investment's income stream add up to zero. The net present value (NPV) of an investment is the value of its future cash flows (benefits minus costs) discounted by a factor that reflects the time value of money. If the risks are equal, investments with higher internal rates of return pay better. Effectively, IRR is the value that would make an investor indifferent between receiving net benefits today versus in accordance with a projected schedule of revenue streams. The income stream (revenue minus costs) used in this analysis is determined by the projected Sector C revenue (RANS charges) minus the initial or "one-time" costs plus the annual recurring costs of providing ANSP services from the Jakarta Area Control Center (ACC). The following scenarios present a cash flow analysis showing program costs and expected revenues over a 15-year CNS life cycle. Assumptions involved in any economic analysis have a considerable degree of uncertainty. The following analysis is based on the best information available at the time of the analysis. Because the project involves a relatively small initial investment at numerous locations, the relative economic impact on any one economy is negligible. Therefore, this analysis primarily focuses on the Financial Internal Rate of Return.

The IRR for each scenario below is calculated by determining the annual discount rate that makes the net present value (NPV) of the income stream add to zero at the end of the projected 15-year life cycle of the investment period.

Revenue is generated by phasing incremental RANS charges for the estimated Natuna Sector C air traffic. Costs include the Sector C ANSP initial "one-time" costs initiated in Year 0 plus the annual recurring CNS Operations and Maintenance, Air Traffic Management, and equipment depreciation costs. Revenues and costs are projected over the 15-year life cycle of the investment indicated by years 1 through 15. Note that with the assumption that the existing CNS equipment will be used and Air Traffic Management done from the Jakarta ACC, new equipment investment cost was not used in the IRR analysis. In lieu of initial equipment costs, the applicable CNS equipment depreciation expense is included in the annual recurring costs for financial analysis.

All IRR scenarios presented are based on several assumptions concerning the initial development of one-time and recurring annual costs and in developing RANS charges (revenues) based on the Natuna Sector C traffic profile and implementing fees at rates and phased in schedule consistent with past practices associated with Singapore Sector A. In addition to these assumptions, revenues and costs vary with rates and inflation.

4.2 Revenue Variations. Revenue variations are caused by two primary factors; unit rate and traffic volume. Initial revenue and cost figures are based on the best flight information available and the assumption that RANS charges will be implemented at a lower rate in Year 1 and escalate at an incremental yearly rate of $0.06 to a maximum unit rate equal to the Indonesian rate of $0.65.

The unit rate can be implemented at a level that is consistent with past practices and will be endorsed by IATA and ICAO. It is assumed that the unit rate will be implemented at an initial rate lower than the final rate. Following the example of Sector A implementation, calculations are performed against two options to illustrate the net effect on cumulative revenues and on the overall internal rate of return. The two options in the scenarios begin in Year 1 with a unit rate of $0.17 or in Year 1 with a rate of $0.29.

Traffic growth predictions for the next 15 years vary considerably. Intra Asia/Pacific and Transpacific air transportation annual cumulative growth rate is projected to center around 5.0%[4]. World events such as September 11, SARS, Bird Flu, and natural disasters have a resounding effect on air traffic demands and in the past 2 years resulted in lower than expected growth rates. The IRR scenarios presented evaluate two traffic conditions; a constant traffic (no-growth) rate and an annual traffic growth rate of 5.0%.

4.3 Cost Variations. Cost variations in these scenarios are calculated based on the expected increase in Operations and Maintenance (O&M) and Air Traffic Management (ATM) costs primarily due to the expected level of inflation over the life cycle of the analysis. The Indonesian Government, in coordination with the Bank Indonesia, has developed an "Inflation Targeting" plan setting the inflation target for 2005 and 2006 at 6.0 +/-1%, and 5.5 +/-1% respectively[5]. Figure 4.3 below graphically depicts the 2004 and 2005 2-year average inflation rate of 8.23%[6]. Using this information as a reference, IRR scenarios with cost variations were calculated using a flat rate inflation index of 5.0% and 8.23% applied to the total annual recurring cost.

[4] Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG)
[5] Bank of Indonesia web site www.bi.go.id
[6] Disclaimer: The AsianBondsOnline team employs its best efforts to obtain the most accurate information available from various sources which are believed to be reliable. Although care has been taken in preparing and updating the database of the Asia Bond Indicators, the AsianBondsOnline team and Asian-Development Bank will have no obligation or liability of any kind in the event of inaccuracies, errors, or omissions.

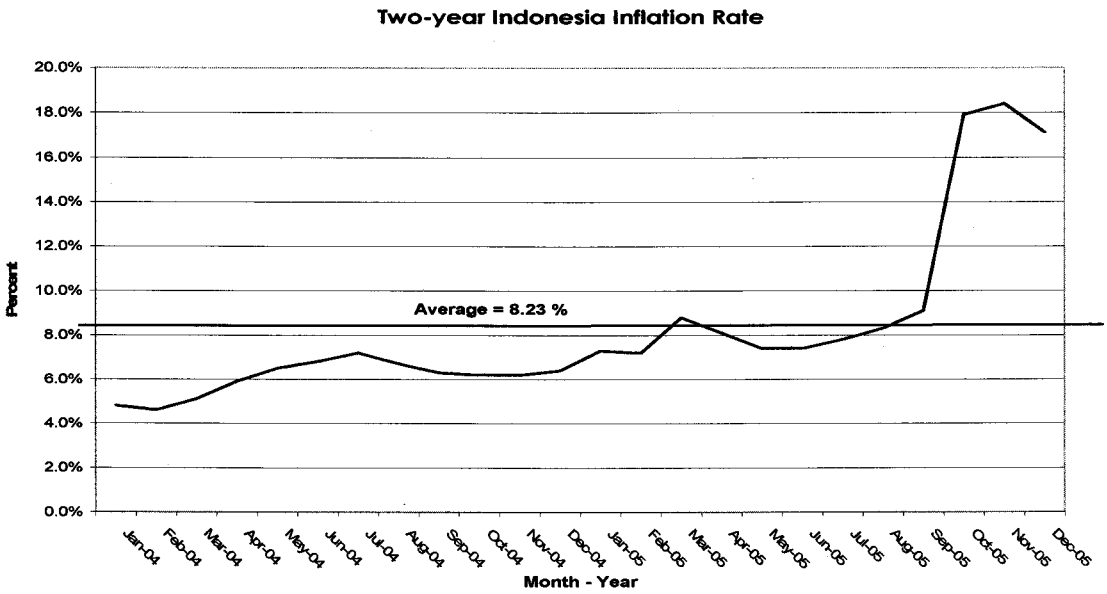

Figure 4.3 - Two-Year Indonesia Inflation Rate

4.4 Cost/Revenue IRR Scenarios. Ten scenarios are presented showing combinations of variations in revenue and cost. In all cases, the RANS charges are phased in beginning at a lower rate in Year 1 then progressively increasing at $0.06 each year until reaching the Indonesian rate of $0.65. In all scenarios, revenues are calculated considering both the rate increase for the appropriate number of years and the revenue (traffic) growth and/or cost increase (inflation) in years 1 through 15. For the scenarios, two conditions are evaluated; one condition is initial implementation of a $0.17 rate in Year 1, the second is initial implementation of $0.29 in Year 1. For each condition, calculations were made to reflect a 5.0% increase in revenue (traffic growth) and either a 5.0% or 8.23% (2004 and 2005 2-year Indonesian average) increase in cost (inflation). For each of the scenarios, the annual revenues, costs, net income, and effective IRR are calculated and presented in the respective tables[7] and graphs that follow. Table 4.4, Scenario Conditions, shown below lists the 10 scenario conditions.

[7] All values in thousand $USD Costs reflect one-time plus annual recurring

Scenario	Rate at Year 1	Traffic (Revenue)	Cost
1	$ 0.17	Constant	Constant
2	$ 0.17	5.0% Annual Growth	Constant
3	$ 0.17	Constant	5.0 % Annual Growth
4	$ 0.17	5.0% Annual Growth	5.0% Annual Growth
5	$ 0.17	5.0% Annual Growth	8.23% Annual Growth
6	$ 0.29	Constant	Constant
7	$ 0.29	5.0% Annual Growth	Constant
8	$ 0.29	Constant	5.0% Annual Growth
9	$ 0.29	5.0% Annual Growth	5.0% Annual Growth
10	$ 0.29	5.0% Annual Growth	8.23% Annual Growth

Table 4.4 - Scenario Conditions

4.4.1 Scenario 1. Implement RANS charges beginning with a unit rate of $0.17 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 9. This scenario assumes that traffic will not increase and will remain constant at the same level as Year 1; therefore, the only increases in revenues are due to the phased unit rate increases until peaking out in Year 9 at which time the revenue levels off and remains constant.

Costs for this scenario are assumed to be constant at the Year 1 calculated annual recurring level with no changes throughout the period of analysis. Table 4.4.1, Scenario 1 Traffic and Costs, depicts the values resulting from Scenario 1 and Figure 4.4.1 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic Constant	Annual Recurring Cost: Constant	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.17	$ 1,630	$ 2,419	**$ (789)**
2	$0.23	$ 2,205	$ 2,419	**$ (214)**
3	$0.29	$ 2,781	$ 2,419	$ 361
4	$0.35	$ 3,356	$ 2,419	$ 937
5	$0.41	$ 3,931	$ 2,419	$ 1,512
6	$0.47	$ 4,507	$ 2,419	$ 2,087
7	$0.53	$ 5,082	$ 2,419	$ 2,663
8	$0.59	$ 5,657	$ 2,419	$ 3,238
9	$0.65	$ 6,233	$ 2,419	$ 3,813
10	$0.65	$ 6,233	$ 2,419	$ 3,813
11	$0.65	$ 6,233	$ 2,419	$ 3,813
12	$0.65	$ 6,233	$ 2,419	$ 3,813
13	$0.65	$ 6,233	$ 2,419	$ 3,813
14	$0.65	$ 6,233	$ 2,419	$ 3,813
15	$0.65	$ 6,233	$ 2,419	$ 3,813

Table 4.4.1 - Scenario 1: Traffic: Constant; Cost: Constant
RANS Phased Beginning at $0.17 Year 1 to $0.65 Year 9

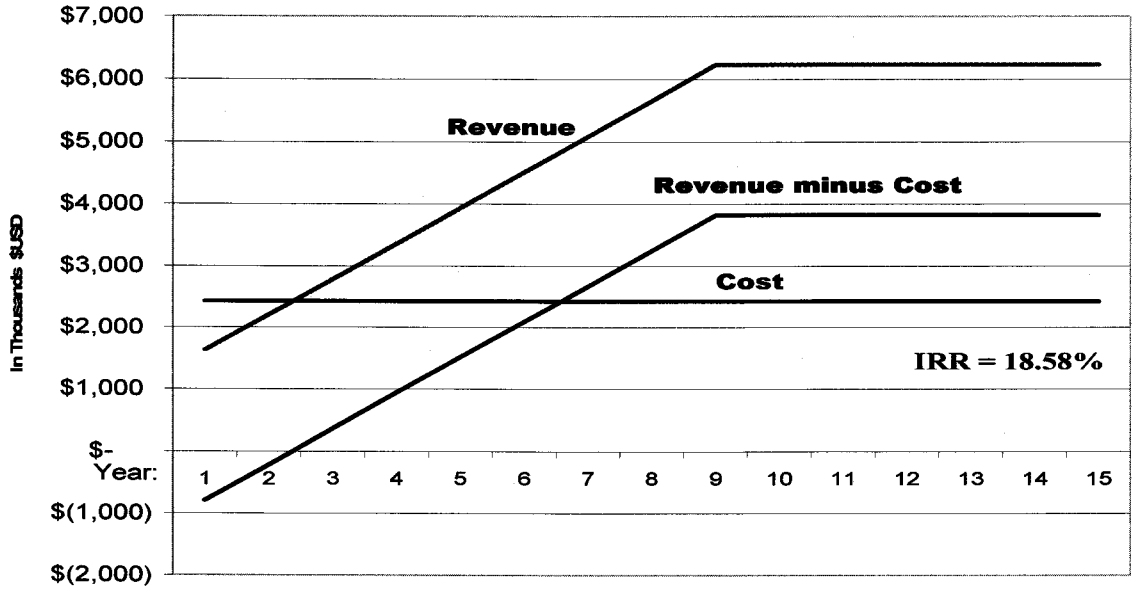

Figure 4.4.1 - Scenario 1 Revenue, Cost, and IRR

4.4.2 Scenario 2. Implement RANS charges beginning with a unit rate of $0.17 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 9. This scenario assumes that traffic will increase at a growth rate of 5.0% annually; therefore, the first 9 years will be compound revenue growth with 5.0% increases in traffic and $0.06 yearly increases in the unit rate until peaking in Year 9. After Year 9, revenue increases will solely be due to a 5.0% increase in traffic.

Costs for this scenario are assumed to be constant at the Year 1 calculated annual recurring level with no changes throughout the period of analysis. Table 4.4.2, Scenario 2 Traffic and Costs, depicts the values resulting from Scenario 2 and Figure 4.4.2 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: 5% Growth	Annual Recurring Cost: Constant	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.17	$ 1,630	$ 2,419	**$ (789)**
2	$0.23	$ 2,316	$ 2,419	**$ (104)**
3	$0.29	$ 2,920	$ 2,419	$ 500
4	$0.35	$ 3,524	$ 2,419	$ 1,105
5	$0.41	$ 4,128	$ 2,419	$ 1,709
6	$0.47	$ 4,732	$ 2,419	$ 2,313
7	$0.53	$ 5,336	$ 2,419	$ 2,917
8	$0.59	$ 5,940	$ 2,419	$ 3,521
9	$0.65	$ 6,544	$ 2,419	$ 4,125
10	$0.65	$ 6,871	$ 2,419	$ 4,452
11	$0.65	$ 7,215	$ 2,419	$ 4,796
12	$0.65	$ 7,576	$ 2,419	$ 5,157
13	$0.65	$ 7,955	$ 2,419	$ 5,535
14	$0.65	$ 8,352	$ 2,419	$ 5,933
15	$0.65	$ 8,770	$ 2,419	$ 6,351

Table 4.4.2 - Scenario 2: Traffic: Growth 5% Annually; Cost: Constant RANS Phased Beginning at $0.17 Year 1 to $0.65 Year 9

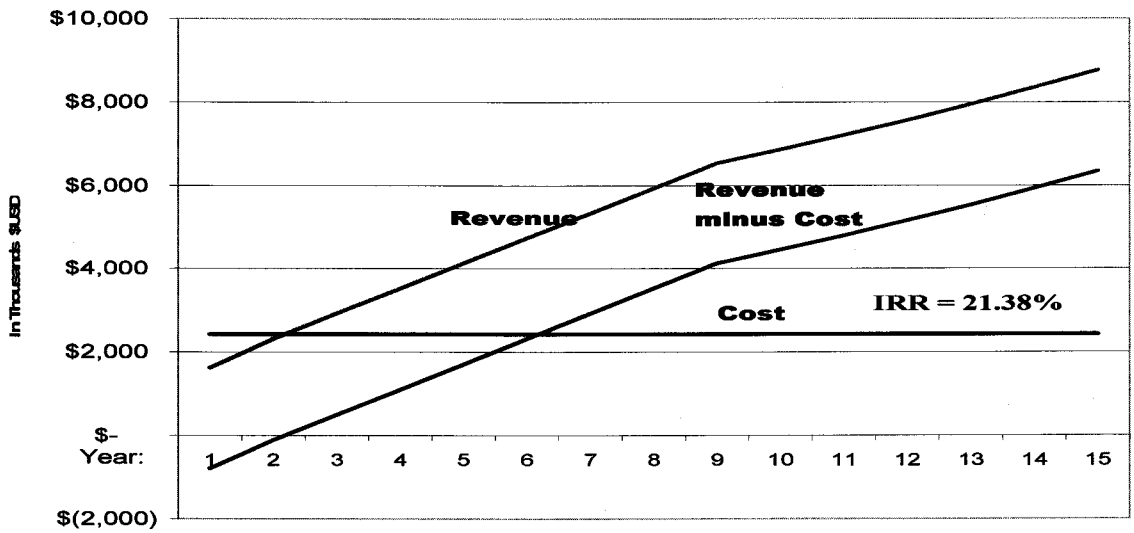

Figure 4.4.2 - Scenario 2 Revenue, Cost, and IRR

4.4.3 Scenario 3. Implement RANS charges beginning with a unit rate of $0.17 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 9. This scenario assumes that traffic will not increase and will remain constant at the same level as Year 1; therefore, the only increases in revenues are due to the phased unit rate increases until peaking out in Year 9 at which time the revenue levels off and remains constant.

Costs for this scenario are assumed to increase 5.0% annually due to inflation beginning with Year 1. Table 4.4.3, Scenario 3 Traffic and Costs, depicts the values resulting from Scenario 3 and Figure 4.4.3 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: Constant	Annual Recurring Cost: 5% Growth	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.17	$ 1,630	$ 2,540	**$ (910)**
2	$0.23	$ 2,205	$ 2,667	**$ (462)**
3	$0.29	$ 2,781	$ 2,801	**$ (20)**
4	$0.35	$ 3,356	$ 2,941	$ 415
5	$0.41	$ 3,931	$ 3,088	$ 844
6	$0.47	$ 4,507	$ 3,242	$ 1,265
7	$0.53	$ 5,082	$ 3,404	$ 1,678
8	$0.59	$ 5,657	$ 3,574	$ 2,083
9	$0.65	$ 6,233	$ 3,753	$ 2,480
10	$0.65	$ 6,233	$ 3,941	$ 2,292
11	$0.65	$ 6,233	$ 4,138	$ 2,095
12	$0.65	$ 6,233	$ 4,345	$ 1,888
13	$0.65	$ 6,233	$ 4,562	$ 1,671
14	$0.65	$ 6,233	$ 4,790	$ 1,433
15	$0.65	$ 6,233	$ 5,029	$ 1,203

Table 4.4.3 - Scenario 3: Traffic: Constant; Cost: Growth 5% Annually RANS Phased Beginning at $0.17 Year 1 to $0.65 Year 9

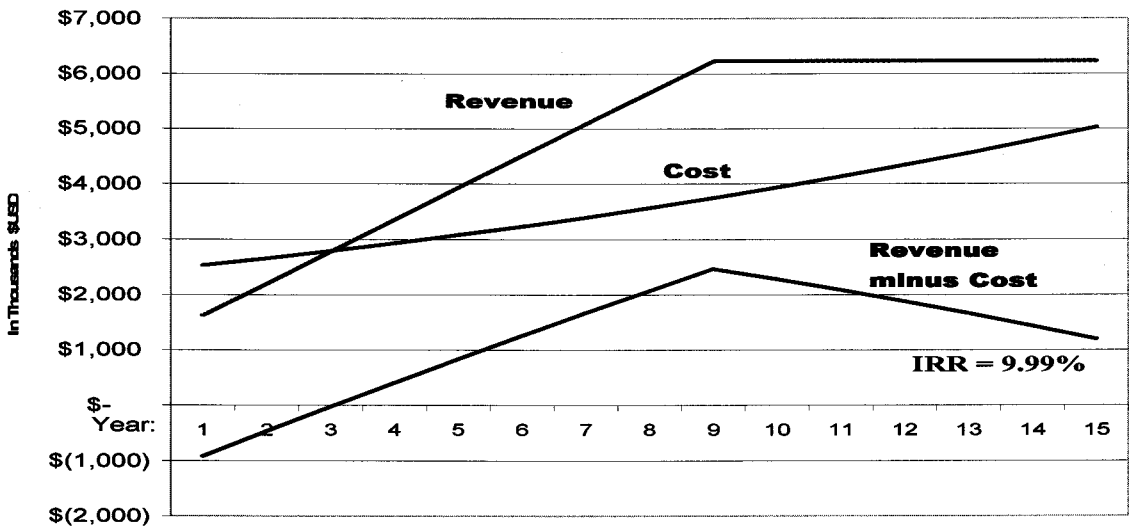

Figure 4.4.3 - Scenario 3 Revenue, Cost, and IRR

4.4.4 Scenario 4. Implement RANS charges beginning with a unit rate of $0.17 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 9. This scenario assumes that traffic will increase at a growth rate of 5.0% annually; therefore, the first 9 years will be compound revenue growth with 5.0% increases in traffic and $0.06 yearly

increases in the unit rate until peaking in Year 9. After Year 9, revenue increases will solely be due to a 5.0% increase in traffic.

Costs for this scenario are assumed to increase 5.0% annually due to inflation beginning with Year 1. Table 4.4.4, Scenario 4 Traffic and Costs, depicts the values resulting from Scenario 4 and Figure 4.4.4 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: 5% Growth	Annual Recurring Cost: 5% Growth	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.17	$ 1,630	$ 2,540	**$ (794)**
2	$0.23	$ 2,316	$ 2,667	**$ (268)**
3	$0.29	$ 2,920	$ 2,801	$ 79
4	$0.35	$ 3,524	$ 2,941	$ 338
5	$0.41	$ 4,128	$ 3,088	$ 527
6	$0.47	$ 4,732	$ 3,242	$ 658
7	$0.53	$ 5,336	$ 3,404	$ 745
8	$0.59	$ 5,940	$ 3,574	$ 796
9	$0.65	$ 6,544	$ 3,753	$ 819
10	$0.65	$ 6,871	$ 3,941	$ 751
11	$0.65	$ 7,215	$ 4,138	$ 688
12	$0.65	$ 7,576	$ 4,345	$ 630
13	$0.65	$ 7,955	$ 4,562	$ 578
14	$0.65	$ 8,352	$ 4,790	$ 529
15	$0.65	$ 8,770	$ 5,029	$ 485

Table 4.4.4 - Scenario 4: Traffic: Growth 5%; Cost: Growth 5% Annually RANS Phased Beginning at $0.17 Year 1 to $0.65 Year 9

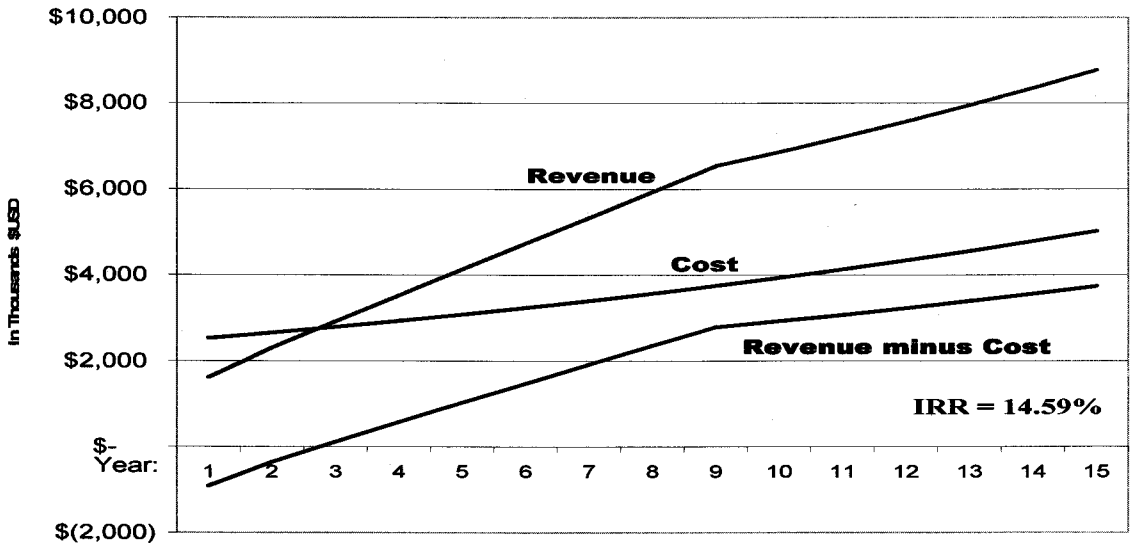

Figure 4.4.4 - Scenario 4 Revenue, Cost, and IRR

4.4.5 Scenario 5. Implement RANS charges beginning with a unit rate of $0.17 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 9. This scenario assumes that traffic will increase at a growth rate of 5.0% annually; therefore, the first 9 years will be compound revenue growth with 5.0 % increases in traffic and $0.06 yearly increases in the unit rate until peaking in Year 9. After Year 9, revenue increases will solely be due to a 5.0 % increase in traffic.

Costs for this scenario are assumed to increase 8.23% annually due to inflation beginning with Year 1. Table 4.4.5, Scenario 5 Traffic and Costs, depicts the values resulting from Scenario 5 and Figure 4.4.5 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: 5% Growth	Annual Recurring Cost: 8.23% Growth	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.17	$ 1,630	$ 2,618	**$ (988)**
2	$0.23	$ 2,316	$ 2,834	**$ (518)**
3	$0.29	$ 2,920	$ 3,067	**$ (147)**
4	$0.35	$ 3,524	$ 3,319	$ 204
5	$0.41	$ 4,128	$ 3,593	$ 535
6	$0.47	$ 4,732	$ 3,888	$ 844
7	$0.53	$ 5,336	$ 4,208	$ 1,128
8	$0.59	$ 5,940	$ 4,555	$ 1,385
9	$0.65	$ 6,544	$ 4,930	$ 1,615
10	$0.65	$ 6,871	$ 5,335	$ 1,536
11	$0.65	$ 7,215	$ 5,774	$ 1,441
12	$0.65	$ 7,576	$ 6,250	$ 1,326
13	$0.65	$ 7,955	$ 6,764	$ 1,191
14	$0.65	$ 8,352	$ 7,321	$ 1,032
15	$0.65	$ 8,770	$ 7,923	$ 847

Table 4.4.5 - Scenario 5: Traffic: Growth 5%; Cost: Growth 8.23% Annually RANS Phased Beginning at $0.17 Year 1 to $0.65 Year 9

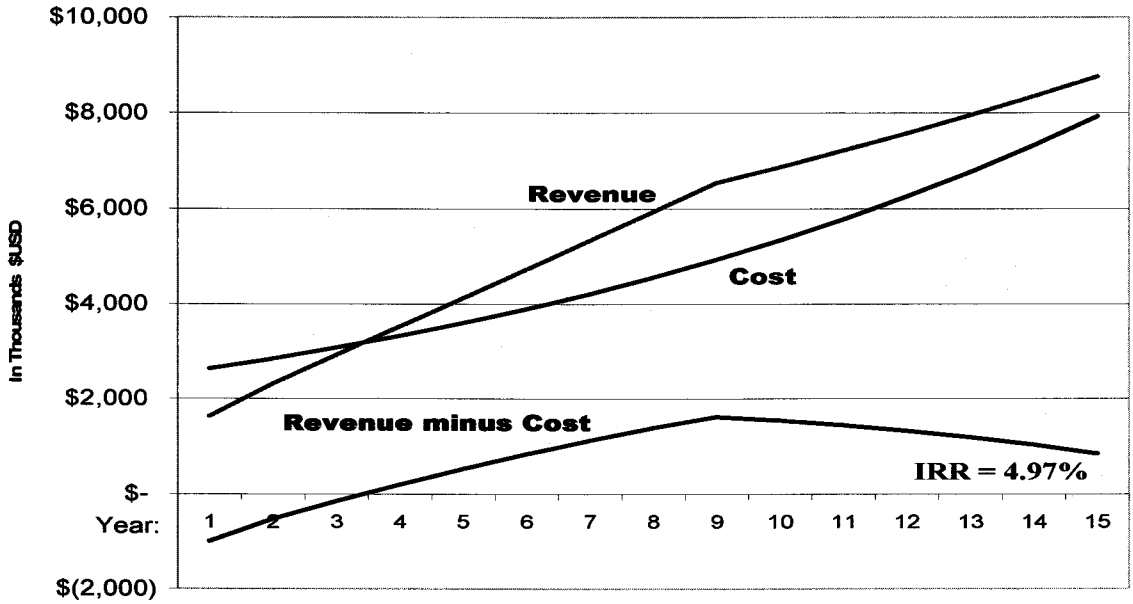

Figure 4.4.5 - Scenario 5 Revenue, Cost, and IRR

4.4.6 Scenario 6. Implement RANS charges beginning with a unit rate of $0.29 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 7. This scenario assumes that traffic will not increase and will remain constant at the same level as Year 1; therefore, the only increases in revenues are due to the phased unit rate increases until peaking out in Year 7 at which time the revenue levels off and remains constant.

Costs for this scenario are assumed to be constant at the Year 1 calculated annual recurring level with no changes throughout the period of analysis. Table 4.4.6, Scenario 6 Traffic and Costs, depicts the values resulting from Scenario 6 and Figure 4.4.6 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: Constant	Annual Recurring Cost: Constant	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.29	$ 2,781	$ 2,419	$ 362
2	$0.35	$ 3,356	$ 2,419	$ 937
3	$0.41	$ 3,931	$ 2,419	$ 1,512
4	$0.47	$ 4,507	$ 2,419	$ 2,087
5	$0.53	$ 5,082	$ 2,419	$ 2,663
6	$0.59	$ 5,657	$ 2,419	$ 3,238
7	$0.65	$ 6,233	$ 2,419	$ 3,813
8	$0.65	$ 6,233	$ 2,419	$ 3,813
9	$0.65	$ 6,233	$ 2,419	$ 3,813
10	$0.65	$ 6,233	$ 2,419	$ 3,813
11	$0.65	$ 6,233	$ 2,419	$ 3,813
12	$0.65	$ 6,233	$ 2,419	$ 3,813
13	$0.65	$ 6,233	$ 2,419	$ 3,813
14	$0.65	$ 6,233	$ 2,419	$ 3,813
15	$0.65	$ 6,233	$ 2,419	$ 3,813

Table 4.4.6 - Scenario 6: Traffic: Constant; Cost: Constant RANS Phased Beginning at $0.29 Year 1 to $0.65 Year 7

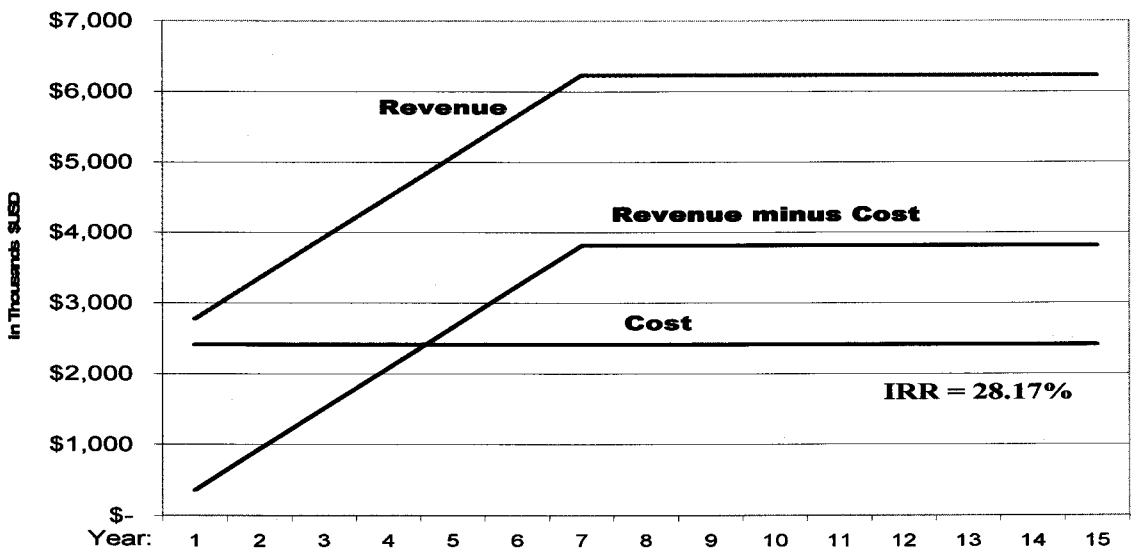

Figure 4.4.6 - Scenario 6 Revenue, Cost, and IRR

4.4.7 Scenario 7. Implement RANS charges beginning with a unit rate of $0.29 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 7. This scenario assumes that traffic will increase at a growth rate of 5.0% annually; therefore, the first 7 years will be compound revenue growth with 5.0% increases in traffic and $0.06 yearly increases in the unit rate until peaking in Year 7. After Year 7, revenue increases will solely be due to a 5.0% increase in traffic.

Costs for this scenario are assumed to be constant at the Year 1 calculated annual recurring level with no changes throughout the period of analysis. Table 4.4.7, Scenario 7 Traffic and Costs, depicts the values resulting from Scenario 7 and Figure 4.4.7 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: 5% Growth	Annual Recurring Cost: Constant	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.29	$ 2,920	$ 2,419	$ 501
2	$0.35	$ 3,524	$ 2,419	$ 1,105
3	$0.41	$ 4,128	$ 2,419	$ 1,709
4	$0.47	$ 4,732	$ 2,419	$ 2,313
5	$0.53	$ 5,336	$ 2,419	$ 2,917
6	$0.59	$ 5,940	$ 2,419	$ 3,521
7	$0.65	$ 6,544	$ 2,419	$ 4,125,
8	$0.65	$ 6,871	$ 2,419	$ 4,452
9	$0.65	$ 7,215	$ 2,419	$ 4,796
10	$0.65	$ 7,576	$ 2,419	$ 5,157
11	$0.65	$ 7,955	$ 2,419	$ 5,535
12	$0.65	$ 8,352	$ 2,419	$ 5,933
13	$0.65	$ 8,770	$ 2,419	$ 6,351
14	$0.65	$ 9,208	$ 2,419	$ 6,789
15	$0.65	$ 9,669	$ 2,419	$ 7,250

Table 4.4.7 - Scenario 7: Traffic: Growth 5%; Cost: Constant RANS Phased Beginning at $0.29 Year 1 to $0.65 Year 7

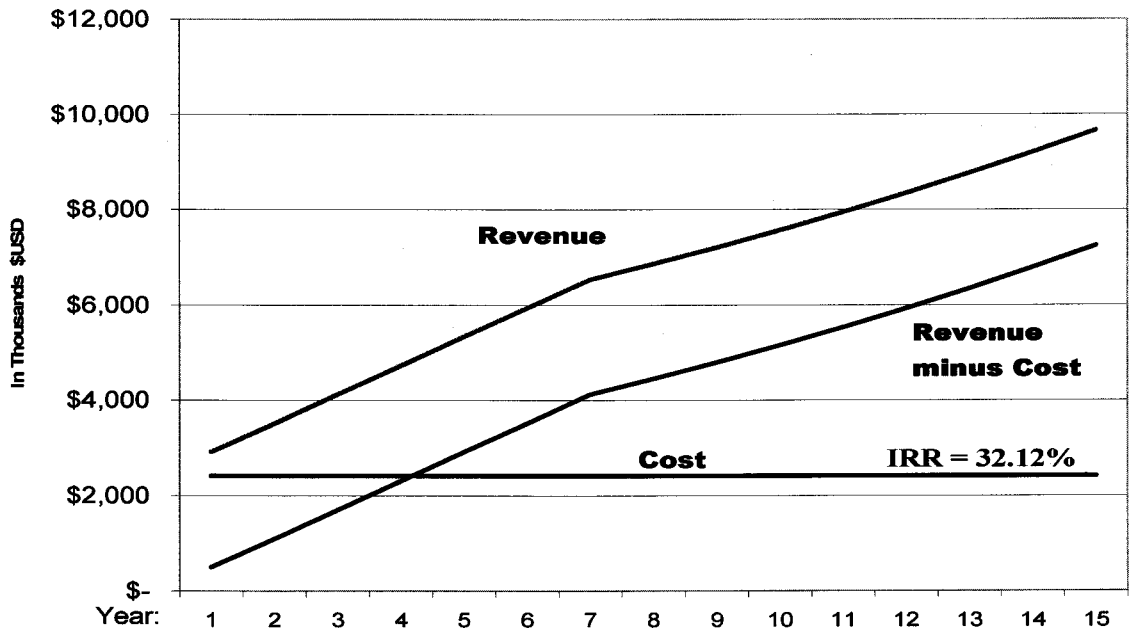

Figure 4.4.7 - Scenario 7 Revenue, Cost, and IRR

4.4.8 Scenario 8. Implement RANS charges beginning with a unit rate of $0.29 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 7. This scenario assumes that traffic will not increase and will remain constant at the same level as Year 1; therefore, the only increases in revenues are due to the phased unit rate increases until peaking out in Year 7 at which time the revenue levels off and remains constant.

Costs for this scenario are assumed to increase 5.0% annually due to inflation beginning with Year 1. Table 4.4.8, Scenario 8 Traffic and Costs, depicts the values resulting from Scenario 8 and Figure 4.4.8 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: Constant	Annual Recurring Cost: 5% Growth	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.29	$ 2,781	$ 2,540	$ 241
2	$0.35	$ 3,356	$ 2,667	$ 689
3	$0.41	$ 3,931	$ 2,801	$ 1,131
4	$0.47	$ 4,507	$ 2,941	$ 1,566
5	$0.53	$ 5,082	$ 3,088	$ 1,994
6	$0.59	$ 5,657	$ 3,242	$ 2,415
7	$0.65	$ 6,233	$ 3,404	$ 2,828
8	$0.65	$ 6,233	$ 3,574	$ 2,658
9	$0.65	$ 6,233	$ 3,753	$ 2,480
10	$0.65	$ 6,233	$ 3,941	$ 2,292
11	$0.65	$ 6,233	$ 4,138	$ 2,095
12	$0.65	$ 6,233	$ 4,345	$ 1,888
13	$0.65	$ 6,233	$ 4,562	$ 1,671
14	$0.65	$ 6,233	$ 4,790	$ 1,443
15	$0.65	$ 6,233	$ 5,029	$ 1,203

Table 4.4.8 - Scenario 8: Traffic: Constant; Cost: Growth 5% Annually RANS Phased Beginning at $0.29 Year 1 to $0.65 Year 7

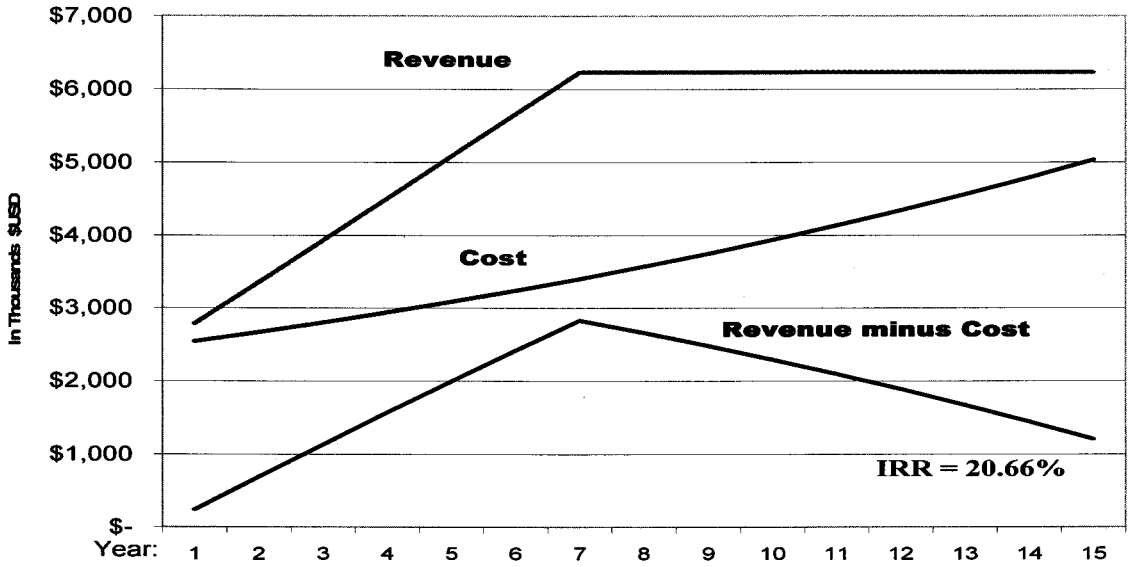

Figure 4.4.8 - Scenario 8 Revenue, Cost, and IRR

4.4.9 Scenario 9. Implement RANS charges beginning with a unit rate of $0.29 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 7. This scenario assumes that traffic will increase at a growth rate of 5.0% annually; therefore, the first 7 years will be compound revenue growth with 5.0% increases in traffic and $0.06 yearly increases in the unit rate until peaking in Year 7. After Year 7, revenue increases will solely be due to a 5.0 % increase in traffic.

Costs for this scenario are assumed to increase 5.0% annually due to inflation beginning with Year 1. Table 4.4.9, Scenario 9 Traffic and Costs, depicts the values resulting from Scenario 9 and Figure 4.4.9 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: 5% Growth	Annual Recurring Cost: 5% Growth	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	**$ (6,562)**
1	$0.29	$ 2,920	$ 2,540	$ 380
2	$0.35	$ 3,524	$ 2,667	$ 857
3	$0.41	$ 4,128	$ 2,801	$ 1,327
4	$0.47	$ 4,732	$ 2,941	$ 1,791
5	$0.53	$ 5,336	$ 3,088	$ 2,248
6	$0.59	$ 5,940	$ 3,242	$ 2,698
7	$0.65	$ 6,544	$ 3,404	$ 3,140
8	$0.65	$ 6,871	$ 3,574	$ 3,297
9	$0.65	$ 7,215	$ 3,753	$ 3,462
10	$0.65	$ 7,576	$ 3,941	$ 3,635
11	$0.65	$ 7,955	$ 4,138	$ 3,817
12	$0.65	$ 8,352	$ 4,345	$ 4,008
13	$0.65	$ 8,770	$ 4,562	$ 4,208
14	$0.65	$ 9,208	$ 4,790	$ 4,418
15	$0.65	$ 9,669	$ 5,029	$ 4,639

Table 4.4.9 - Scenario 9: Traffic: Growth 5%; Cost: Growth 5% Annually RANS Phased Beginning at $0.29 Year 1 to $0.65 Year 7

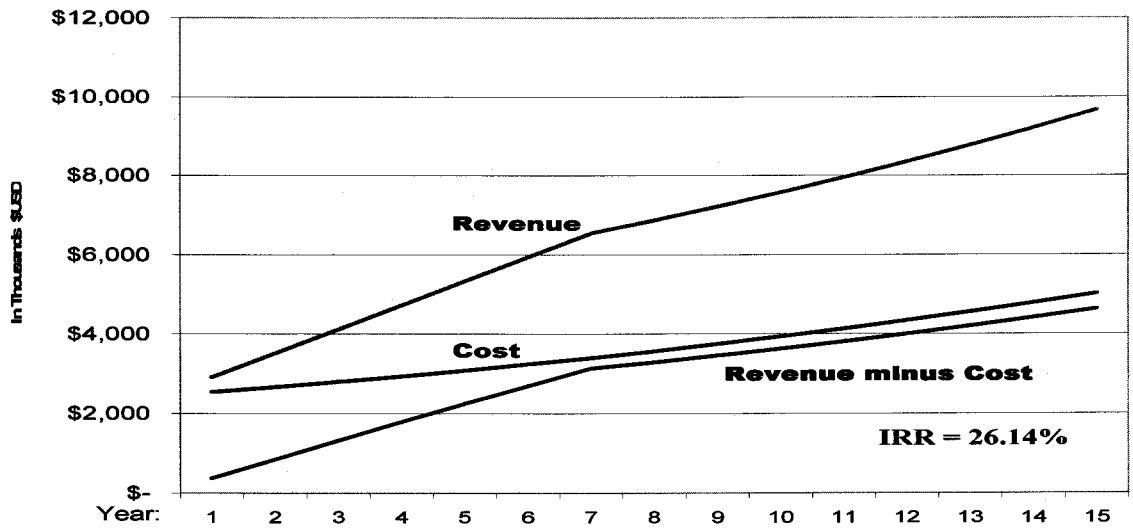

Figure 4.4.9 - Scenario 9 Revenue, Cost, and IRR

4.4.10 Scenario 10. Implement RANS charges beginning with a unit rate of $0.29 in Year 1 then progressively increase on a yearly basis until reaching the Indonesian rate of $0.65 in Year 7. This scenario assumes that traffic will increase at a growth rate of 5.0% annually; therefore, the first 7 years will be compound revenue growth with 5.0% increases in traffic and $0.06

yearly increases in the unit rate until peaking in Year 7. After Year 7, revenue increases will solely be due to a 5.0% increase in traffic.

Costs for this scenario are assumed to increase 8.23% annually due to inflation beginning with Year 1. Table 4.4.10, Scenario 10 Traffic and Costs, depicts the values resulting from Scenario 10 and Figure 4.4.10 graphically represents revenues, costs, and revenue minus costs.

Year Rate Implemented	RANS Unit Rate	Revenue: Traffic: 5% Growth	Annual Recurring Cost: 8.23% Growth	Revenue minus Cost
0	$0.00	$ 0	$ 6,562	$ (6,562)
1	$0.29	$ 2,920	$ 2,618	$ 302
2	$0.35	$ 3,524	$ 2,834	$ 690
3	$0.41	$ 4,128	$ 3,067	$ 1,061
4	$0.47	$ 4,732	$ 3,319	$ 1,413
5	$0.53	$ 5,336	$ 3,593	$ 1,743
6	$0.59	$ 5,940	$ 3,888	$ 2,052
7	$0.65	$ 6,544	$ 4,208	$ 2,336
8	$0.65	$ 6,871	$ 4,555	$ 2,317
9	$0.65	$ 7,215	$ 4,930	$ 2,285
10	$0.65	$ 7,576	$ 5,335	$ 2,240
11	$0.65	$ 7,955	$ 5,774	$ 2,180
12	$0.65	$ 8,352	$ 6,250	$ 2,103
13	$0.65	$ 8,770	$ 6,764	$ 2,006
14	$0.65	$ 9,208	$ 7,321	$ 1,888
15	$0.65	$ 9,669	$ 7,923	$ 1,746

Table 4.4.10 - Scenario 10: Traffic: Growth 5%; Cost: Growth 8.23% Annually RANS Phased Beginning at $0.29 Year 1 to $0.65 Year 7

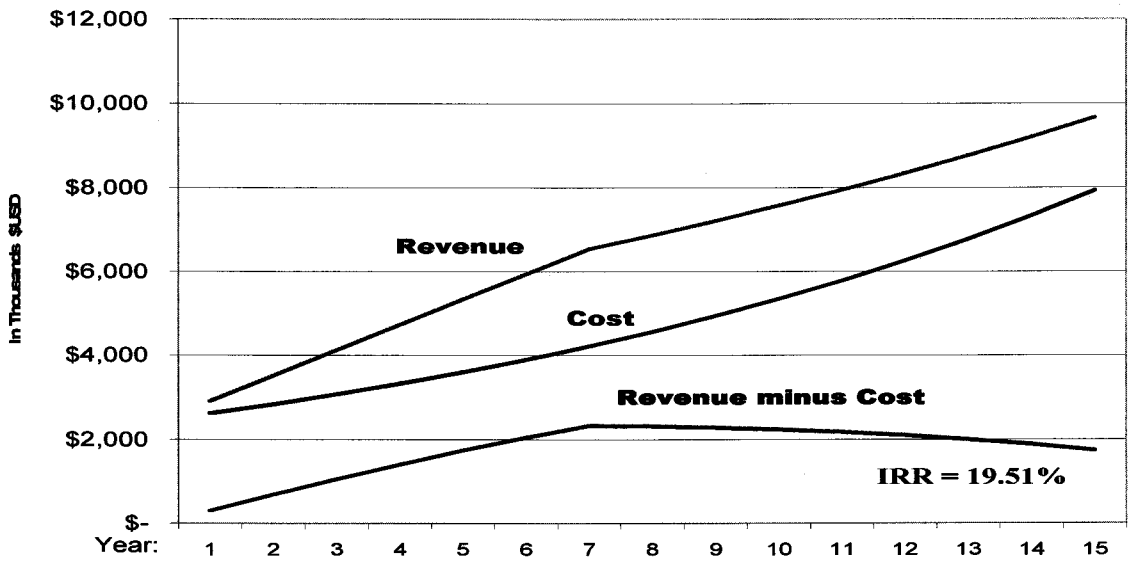

Figure 4.4.10 - Scenario 10 Revenue, Cost, and IRR

4.4.11 Summary of Internal Rates of Return. The IRR will vary depending on the initial rate implemented in Year 1 and on the events that affect traffic and recurring annual costs. Naturally, the higher initial implementation rate, the greater the rate of return; however, past practices in implementing these type of fees dictate that prudence is the best approach for ICAO and IATA concurrences. Starting with a unit rate too low will not allow recovery of initial investment and recurring costs. In Year 15, the CNS assets will reach the end of their useful life and depreciation expense will be used up. Assets will need replacement, retro-fit, or upgrading to newer space-based technology. Several plans and tests are underway to accommodate ADS-B, CPDLC, and GNSS technology. The RANS revenue stream should play a significant role in financing the new services addressed in Regional planning and in the Master Plan. Figure 4.4.11 shows a summary of the IRR for the various implementation scenarios.

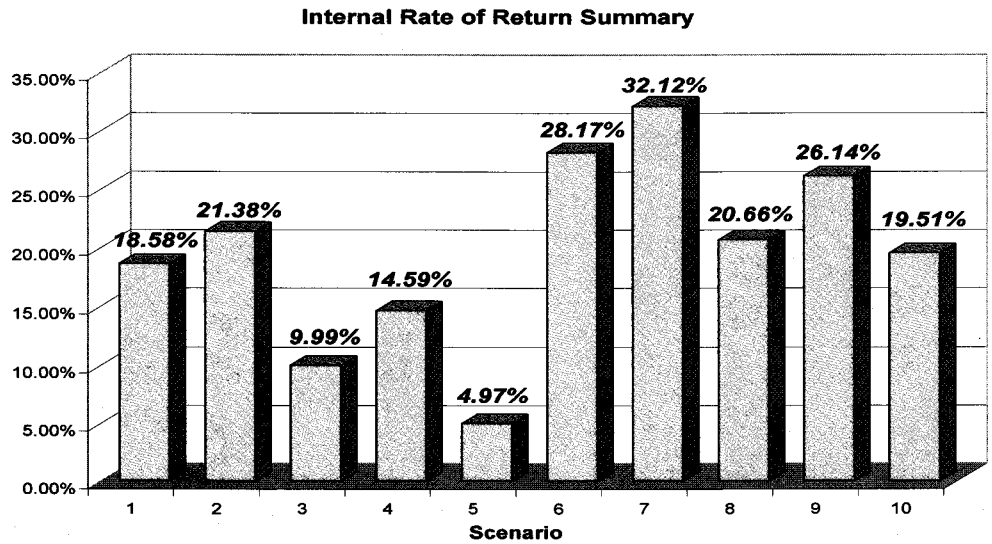

Figure 4.4.11 - Internal Rate of Return Summary

5.0 Sensitivity Analysis

In Scenarios 1 through 10, the values affecting the potential outcome of the project were varied and financial internal rates of return (FIRR) recalculated. The three variables that are most measurable and have the biggest impact on the estimated revenues are the initial unit rate implemented in Year 1, the inflationary cost of Operations and Maintenance, and the amount of Sector C traffic. The assumptions were based on the best information available which indicate that traffic will grow at a rate of 5% and that costs will be inflationary at a rate of between 5.0 and 8.23%. The scenarios were developed considering those values. In each case, the Sensitivity Indicator (SI) and Switching Value (SV) were calculated with the results presented in Figure 5.0A, Sensitivity Analysis for Year 1 Unit Rate $0.17, and Figure 5.0B, Sensitivity Analysis for Year 1 Unit Rate $0.29.

Year 1 Unit Rate	Scenario	Conditions	Changes	Change from Base	FIRR	SI	SV
$0.17	2	Traffic + 5.0 % Cost constant	Best Case Base	N/A	21.38%	N/A	N/A
$0.17	1	Traffic constant Cost constant	Traffic - 5.0 %	5.00%	18.58%	2.62	38.18%
$0.17	4	Traffic + 5.0 % Cost + 5.0 %	Cost + 5.0 %	5.00%	14.59%	6.35	15.74%
$0.17	3	Traffic constant Cost + 5.0 %	Traffic - 5.0 % Cost + 5.0 %	10.00%	9.90%	5.37	18.62%
$0.17	5	Traffic + 5.0 % Cost + 8.23 %	Cost + 8.23 %	8.23%	4.97%	9.33	10.72%

Figure 5.0A - Sensitivity Analysis for Year 1 Unit Rate of $0.17

	Scenario	Conditions	Changes	Change from Base	FIRR	SI	SV
$0.29	7	Traffic + 5.0 % Cost constant	Best Case Base	N/A	32.12%	N/A	N/A
$0.29	6	Traffic constant Cost constant	Traffic - 5.0 %	5.00%	28.17%	2.46	40.66%
$0.29	9	Traffic + 5.0 % Cost + 5.0 %	Cost + 5.0 %	5.00%	26.14%	3.72	26.86%
$0.29	8	Traffic constant Cost + 5.0 %	Traffic - 5.0 % Cost + 5.0 %	10.00%	20.66%	3.57	28.03%
$0.29	10	Traffic + 5.0 % Cost + 8.23 %	Cost + 8.23 %	8.23%	19.51%	4.77	20.96%

Figure 5.0B - Sensitivity Analysis for Year 1 Unit Rate of $0.29

The Sensitivity Indicator compares percentage changes in the FIRR with percentage changes in either or both the traffic and the O&M cost input variables. The Switching Value is an indicator of how a percentage changes in one of the input variables (traffic or O&M cost) or combinations of both reduce the FIRR to the discount rate. In all cases, the discount rate was considered 0, i.e., no alternative investment opportunities were evaluated.

6.0 Conclusions

1. Task 5 recommendations are in compliance with ICAO Doc 9082/6.

2. RVA's recommendations provide options and demonstrate outcomes.

3. Task 5 aims at managing IRR and cost.

4. These recommendations support Cost containment.

5. This plan's gradual increase of charges is consistent with ICAO policy.

6. RVA's recommendations make best use of existing resources, both operationally and financially.

7. A minimal investment scheme and development of a capital cash flow model for future technology investment is consistent with ICAO policy.

8. Investments in un-required facilities and systems have a negative effect on the positive IRR.

9. Investments in un-required facilities and systems are against ICAO policy.

10. Early accumulations of funds ensure against future uncertainties.

11. Premature expenditures create fixed cost revenue drains.

12. Use of depreciation paves the way for future CNS capital investments.

13. Without use of depreciation and making full use of existing assets, a positive IRR would be significantly diminished

14. Recommendations establish a valid RANS charges base.

15. RVA's plan avoids accusations of excessive construction and other expenditures.

16. The Remediation project and changing the spares policy are arguably a chargeable one-time event in compliance with ICAO's reliability requirement for new service provider facilities.

17. This plan's gradual new equipment investment pace allows maturing of CNS systems.

18. The Republic of Indonesia's objective of doubling the Gross Domestic Product (GDP) is supported by these recommendations through conservative investments, maximum use of assets, creation of hi tech career positions, creation of a positive image of the Republic of Indonesia DGAC activities, and generation of cash reserves for future investments.

7.0 Summary of Developmental Impact

Adoption of the recommendations in this Technical Assistance (TA), drawn from the preceding Tasks, will have positive impact as detailed above and capsulated in the following synopsis:

7.1 Infrastructure/Industry. This TA will create a modern Area Control Center (ACC) capable of providing state-of-the-art air navigation services (ANS) through Indonesia's sovereign airspace over the Natuna Islands. Such a facility will facilitate the Republic of Indonesia's objective of resuming its rightful role as the area service provider. Commensurate with resumption of this role, new facilities and technologies will be implemented. The Indonesian staff will gain new skills while generating additional revenue sources for the Republic. The amount of revenue is dependent on the option selected as detailed in Task 5.

7.1.1 The new technologies to be implemented include data link communications, satellite navigation, and modern surveillance systems as well as numerous support systems including aeronautical and meteorological information systems. Recommended systems and plans will provide improved safety through such measures as the inauguration of surveillance systems in areas having none now and by aggressively improving air traffic controller skills where studies have identified need. One of the specific financial improvements contained in this task (Task 5) is the identification of how to achieve an Internal Rate of Return (IRR) of more than 30 percent. A detailed briefing on this entire TA, as well as its financial conclusions (Task 5), was provided to all stakeholders in person by RVA in Jakarta.

7.1.2 Indonesia rightfully takes pride in being a good steward of the environment. Accordingly, care was taken to address such issues in this TA. No negative environmental impact was found as a consequence of implementing the Natuna Islands Airspace Management Project. Our environmental work was in accord with Indonesia's Environmental Management Act (Government Act No. 23 of 1997).

7.2 Human Capacity Building. The Natuna Islands Air Traffic Control and Airspace Management Project created new job opportunities, enhanced the skills for existing employees, and provided advanced training to upgrade the capability of the DGAC workforce.

7.2.1 DGAC air traffic controllers, supervisors, and engineers associated with the Natuna Islands airspace at Jakarta, Natuna, and Batam will all require specialized training on the use, installation, and maintenance of the new equipage cited in 7.1 above and detailed in this TA. Staffing for the new Natuna Islands airspace operation will require 10 additional air traffic controllers, 3 air traffic supervisors, and 4 support engineers of varying electronic disciplines. Staff support may be as many as 14 Air Navigation Service specialists with new skills ranging from procedures development specialists to training instructors. The average annual salary of these positions is a minimum of $13,000 USD.

7.2.2 Engineers will learn to deal with the latest in air navigation, surveillance, and data link communication equipment. Air traffic controller staff will learn the application of these technologies thereby supporting Indonesia's quest to resume authority in its sovereign airspace and to assume a leadership position in Southeast Asia's aviation community. Application of the

preceding will provide improved safety, efficiency, and capacity within the Natuna Islands area for both National and International flights.

7.3 Technology Transfer and Productivity Improvement. The Natuna Islands Air Traffic Control and Airspace Management TA will result in the introduction of advanced technologies and improved processes as well as systems that stimulate greater individual productivity and allow more efficient use of resources (human, territorial, and hardware).

7.3.1 State-of-the-art air navigation service systems are to be implemented as part of this TA. These new equipage systems and air traffic control processes will bring Indonesia's ANSP on a par with the most advanced in the world. Further, growing Regional demand for air service (RVA estimated 5 percent annual growth) will be accommodated by the resulting threefold capacity increase brought by implementation of this TA. System safety will increase with the important consequence of moderating Indonesia's liability due to incidents and/or accidents.

7.3.1.1 Recommended state-of-the-art CNS/ATM systems recommended will be in harmony with neighboring states and adjacent Air Navigation Service Providers (ANSP).

7.3.2 The recommended transition path to the new Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) systems, recommended herein, makes the most cost-effective use of existing equipment during its present life cycle prior to purchasing new systems. This strategy is detailed in TA sub-tasks 3 and 6.

7.3.3 Recommendations are consistent with the ICAO policy of gradual increases in overflight fees as well as Indonesia's cost containment policy. Task 5 recommendations are in compliance with ICAO Document 9082/6.

7.3.4 Ten different cost-benefit type scenarios were developed for this TA. Scenario 7 is identified as the suggested scenario with an IRR of 32.2 percent.

7.3.5 Task 2, 3 and 5 provide details citing how the Republic of Indonesia's objectives of doubling the GDP are supported by these recommendations through conservative investments, maximum use of assets, creation of hi-tech career positions, creation of a positive image of the Republic of Indonesia DGAC activities, and generation of cash reserves for future investments.

7.4 Market-Oriented Reforms. The Natuna Islands Air Traffic Control and Airspace Management Project does not have any primary or secondary objective focusing on facilitation of market-oriented reforms. Reforms encouraging more transparent regulatory systems and institutions were not an issue nor were privatizations of state-owned economic entities. To the contrary, Indonesia is in the process of consolidating the air traffic control (ATC) and air navigation services (ANS) responsibilities to the office of the Director General of Civil Aviation (DGCA). Air traffic control (ATC) and air navigation services (ANS) responsibilities are not considered by the Indonesian government subjects for promotion of competition at this time.

APPENDIX 1. NATUNA SECTOR C TRAFFIC

Weekday - Monday 13 March 2006

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
0:25	AA5836	NRT	M767	B777	341,105
0:55	OZ6787	SFO/ICN	M767	A330	217,000
1:30	AA8397	LAX/NRT	M767	B777	341,105
4:30	KE361	ICN	M767	B777	341,105
5:35	QR639	CBU	M767	A330	217,000
6:05	MI547	CBU	M767	A320	77,000
6:20	SQ19	LAX	M767	B747	412,770
11:45	SQ141	BAJ	A576	B777	341,105
11:50	SQ71	MNL	M767	B777	341,105
12:00	PR503	MNL	M767	A340	260,000
12:45	SQ5421	BWN	B348	A319	75,500
12:50	SQ5221	SUB	A576	A320	77,000
13:25	GA846	BPN	W36	B737	79,015
14:15	VF532	SUB	A576	A320	77,000
14:30	BI3181	BWN	B348	A319	75,500
15:35	SQ143	BAJ	A576	B777	341,105
15:50	NH6271	FUK	M767	B777	341,105
15:55	NH6269	NGO	M767	B777	341,105
16:15	3K562	MNL	M767	B727	95,030
17:00	NH6263	KIX	M767	B777	341,105
17:25	GA840	BAJ	A576	B737	79,015

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
17:35	JL719	NRT	M767	B777	341,105
17:45	SQ73	MNL	M767	B777	341,105
18:00	NH6253	NRT	M767	B777	341,105
18:25	PR501	MNL	M767	A330	217,000
18:40	JL721	KIX	M767	B777	341,105
18:50	KE641	ICN	M767	B747	412,770
19:10	MI566	CBU/DVO	M767	A320	77,000
19:25	QF81	MEL/DRW	A464	A330	217,000
20:15	TR503	MFM/Clark	M767	A320	77,000
22:00	OZ6783	ICN	M767	A330	217,000
22:35	SQ147	BAJ	A576	B777	341,105
22:35	NH6265	KIX	M767	B777	341,105
22:50	SQ5901	NRT	M767	B747	412,770
23:05	SQ5427	BWN	B348	B777	341,105
23:50	NH7051	IAD//NRT	M767	B777	341,105
23:50	SQ5227	SUB	A576	B777	341,105
9:20	CX777	HKG/CGK	L644	A330	217,000
15:50	GA863	HKG/CGK	L644	A330	217,000
16:00	CX719	HKG/CGK	L644	A330	217,000
8:10	CI679	HKG/CGK	L644	B737	79,015
0:05	SQ255	BNE	A576	B777	341,105
0:20	SQ231	SYD	A576	B747	412,770

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
1:10	NH6264	KIX	L625	B777	341,105
1:15	SQ990	FUK	L625	B747	412,770
6:00	NW6	PDX/NRT	L625	A330	217,000
7:15	UA890	IAD/NRT	L625	B777	341,105
7:20	MI222	SUB	A576	A319	75,500
7:45	SQ5428	BWN	B348	B777	341,105
8:00	SQ886	ICN	L625	B747	412,770
8:10	CI662	TPE	L625	B737	79,015
8:15	AA5837	NRT	L625	B777	341,105
8:20	3K561	MNL	N884	B727	95,030
8:35	SQ872	TPE	L625	B777	341,105
8:40	VF531	SUB	A576	A320	77,000
9:05	MI588	CBU/DVO	B348	A319	75,500
9:05	OZ6788	SFO/ICN	L625	A330	217,000
9:35	SQ142	BAJ	A576	B777	341,105
9:40	NH6252	LAX/NRT	L625	B777	341,105
9:40	PR502	MNL	N884	A340	260,000
9:45	SQ72	MNL	N884	B777	341,105
9:55	SQ245	BNE	A464	B777	341,105
11:20	GA855	SUB	A576	B737	79,015
12:10	TR502	MFM/Clark	N884	A320	77,000
13:00	3K521	TPE	L625	B727	95,030

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
13:05	PR504	MNL	N884	A340	260,000
13:10	BR226	TPE	L625	B777	341,105
13:40	SQ5422	BWN	B348	B777	341,105
13:45	SQ74	MNL	N884	B777	341,105
13:50	GA849	BPN	W36	B737	79,015
15:35	SQ5226	SUB	A576	B777	341,105
16:00	SQ20	LAX/NRT	L625	B747	412,770
16:40	SQ146	BAJ	A576	B777	341,105
17:10	MI9330	BKI	G334	A320	77,000
17:10	SQ76	MNL	N884	B777	341,105
18:25	GA841	BAJ	A576	B737	79,015
19:00	SQ148	BAJ	A576	B777	341,105
21:05	UL2432	AKL/BNE	A464	B777	341,105
21:10	QF52	BNE	A464	A330	217,000
21:15	SQ235	BNE	A464	B777	341,105
22:35	KE642	ICN	L625	B747	412,770
22:45	QF82	ADL/DRW	A464	A330	217,000
23:00	SQ5752	ICN	L625	B747	412,770
23:15	JL710	NRT	L625	B767	204,120
23:35	JL722	KIX	L625	B767	204,120
23:40	NH6254	NRT	L625	B777	341,105
23:55	SQ5902	NRT	L625	B777	341,105

Weekend Day - Saturday 25 March 2006

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
0:25	AA5836	NRT	M767	B777	341,105
0:55	OZ6787	SFO/ICN	M767	A330	217,000
1:30	NH6255	LAV/NRT	M767	B777	341,105
1:50	UL2433	AKL/BNE	A464	B777	341,105
4:30	KE357	ICN	M767	B777	341,105
5:40	SQ246	BNE	A464	B777	341,105
6:20	SQ19	LAX	M767	B747	412,770
9:10	TR701	DRW	A464	A320	77,000
10:10	GA842	SUB	A576	B737	79,015
11:45	SQ141	BAJ	A576	B777	341,105
11:50	SQ71	MNL	M767	B777	341,105
12:00	PR503	MNL	M767	A340	260,000
12:50	SQ5221	SUB	A576	A320	77,000
13:20	SQ5421	BWN	B348	B777	341,105
13:25	GA846	BPN	W36	B737	79,015
14:30	BI3181	BWN	B348	A319	75,500
14:35	OZ6781	ICN	M767	A330	217,000
15:35	SQ143	BAJ	A576	B777	341,105
15:50	SQ256	BNE	A464	B777	341,105
15:50	NH6271	FUK	M767	B777	341,105
15:55	NH6269	NGO	M767	B777	341,105
16:15	3K562	MNL	M767	B727	95,030

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
16:20	SQ5631	BKI	G334	B777	341,105
17:00	NH6263	KIX	M767	B777	341,105
17:10	SQ5273	MDC	W36	B777	341,105
17:25	GA840	BAJ	A576	B737	79,015
17:35	JL719	NRT	M767	B777	341,105
17:45	SQ73	MNL	M767	B777	341,105
18:00	NH6253	NRT	M767	B777	341,105
18:25	PR501	MNL	M767	A330	217,000
18:40	JL721	KIX	M767	B777	341,105
18:50	KE641	ICN	M767	B747	412,770
19:10	MI566	CBU/DVO	M767	A320	77,000
19:30	QF51	BNE	A464	A330	217,000
20:15	TR503	MFM/Clark	M767	A320	77,000
20:50	SQ236	BNE	A464	B777	341,105
21:05	SQ5225	SUB	A576	B777	341,105
21:30	QF9	ICN	A464	A330	217,000
21:45	SQ75	MNL	M767	B777	341,105
21:50	SQ5751	ICN	M767	B777	341,105
22:00	OZ6783	ICN	M767	A330	217,000
22:35	SQ147	BAJ	A576	B777	341,105
22:35	NH6265	KIX	M767	B777	341,105
22:50	SQ5901	NRT	M767	B747	412,770

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
23:50	NH7051	IAD/LAX/NRT	M767	B777	341,105
0:05	SQ255	BNE	A464	B777	341,105
9:20	CX777	HKG to CGK	L644	A330	217,000
15:50	GA863	HKG to CGK	L644	A330	217,000
16:00	CX719	HKG to CGK	L644	A330	217,000
8:10	CI679	HKG to CGK	L644	B737	79,015
1:05	NH6268	NGO	L625	B777	341,105
1:10	NH6264	KIX	L625	B777	341,105
1:15	SQ990	FUK	L625	B747	412,770
6:00	NW6	PDX/NRT	L625	A330	217,000
7:15	UA890	IAD/NRT	L625	B777	341,105
7:20	MI222	SUB	A576	A319	75,500
7:55	MI847	BPN	W36	A319	75,500
8:00	SQ886	ICN	L625	B747	412,770
8:10	CI662	TPE	L625	B737	79,015
8:15	AA5837	NRT	L625	B777	341,105
8:20	3K561	MNL	N884	B727	95,030
8:35	SQ872	TPE	L625	B777	341,105
8:40	VF531	SUB	A576	A320	77,000
9:05	MI566	DVO/CBU	B348	A319	75,500
9:05	OZ6788	SFO/ICN	L625	A330	217,000
9:35	SQ142	Bali	A576	B777	341,105

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
9:40	NH6252	LAX/NRT	L625	B777	341,105
9:40	PR502	MNL	N884	A340	260,000
9:45	SQ72	MNL	N884	B777	341,105
9:55	SQ245	BNE	A464	B777	341,105
9:55	OZ6786	YVR/ICN	L625	B777	341,105
11:20	GA855	SUB	A576	B737	79,015
12:10	TR502	MFM/Clark	N884	A320	77,000
13:00	3K521	TPE	L625	B727	95,030
13:05	PR504	MNL	N884	A340	260,000
13:10	BR226	TPE	L625	B777	341,105
13:45	SQ74	MNL	N884	B777	341,105
14:15	BI422	BWN	B348	A319	75,500
15:35	SQ5226	SUB	A576	B777	341,105
16:00	SQ20	NRT/LAX	L625	B747	412,770
16:40	SQ146	BAJ	A576	B777	341,105
17:10	MI9330	BKI	G334	A320	77,000
17:10	SQ76	MNL	N884	B777	341,105
17:15	AI8030	TPE/LAX	L625	B777	341,105
18:10	GA843	SUB	A576	B737	79,015
18:25	GA841	BAJ	A576	B737	79,015
19:00	SQ148	BAJ	A576	B777	341,105
21:05	UL2432	AKL/BNE	A464	B777	341,105

Arr/Dep Time	Flight Number	DEP/ARR Airport	Sector C Route	Aircraft Type	MTOW kilograms
21:10	QF52	BNE	A464	A330	217,000
21:15	SQ235	BNE	A464	B777	341,105
22:35	KE642	ICN	L625	B747	412,770
22:45	QF82	ADL/DRW	A464	A330	217,000
23:15	JL710	NRT	L625	B767	204,120
23:35	JL722	KIX	L625	B767	204,120
23:40	NH6254	NRT	L625	B777	341,105
23:45	OZ6782	ICN	L625	A330	217,000

APPENDIX 2. WEIGHT FACTOR TABLE

Aircraft Weight (1,000kg)	Weight Factor	Aircraft Weight (1,000kg)	Weight Factor
0 - 1	1	166.99 - 170.48	61
1 - 2.38	2	170.48 - 173.98	62
2.38 - 3.95	3	173.98 - 177.49	63
3.95 - 5.66	4	177.49 - 181.02	64
5.66 - 7.48	5	181.02 - 184.56	65
7.48 - 9.39	6	184.56 - 188.12	66
9.39 - 11.39	7	188.12 - 191.69	67
11.39 - 13.45	8	191.69 - 195.27	68
13.45 - 15.59	9	195.27 - 198.87	69
15.59 - 17.78	10	198.87 - 202.48	70
17.78 - 20.03	11	202.48 - 206.10	71
20.03 - 22.33	12	206.10 - 209.73	72
22.33 - 24.68	13	209.73 - 213.38	73
24.68 - 27.08	14	213.38 - 217.04	74
27.08 - 29.52	15	217.04 - 220.71	75
29.52 - 32.00	16	220.71 - 224.40	76
32.00 - 34.52	17	224.40 - 228.09	77
34.52 - 37.08	18	228.09 - 231.80	78
37.08 - 39.67	19	231.80 - 235.52	79
39.67 - 42.49	20	235.52 - 239.26	80
42.49 - 44.95	21	239.26 - 245.00	81
44.95 - 47.65	22	245.00 - 246.76	82
47.65 - 50.37	23	246.76 - 250.52	83
50.37 - 53.12	24	250.52 - 254.30	84
53.12 - 55.90	25	254.30 - 258.09	85
55.90 - 58.71	26	258.09 - 261.89	86
58.71 - 61.55	27	261.89 - 265.70	87
61.55 - 64.41	28	265.70 - 269.53	88
64.41 - 67.30	29	269.53 - 273.36	89
67.30 - 70.21	30	273.36 - 277.21	90
70.21 - 73.15	31	277.21 - 281.06	91
73.15 - 76.11	32	281.06 - 284.93	92
76.11 - 79.09	33	284.93 - 288.80	93
79.09 - 82.10	34	288.80 - 292.69	94
82.10 - 85.13	35	292.69 - 296.59	95
85.13 - 88.15	36	296.59 - 300.50	96
88.15 - 91.25	37	300.50 - 304.41	97
91.25 - 94.35	38	304.41 - 308.34	98
94.35 - 97.46	39	308.34 - 312.28	99
97.46 - 100.59	40	312.28 - 316.26	100
100.59 - 103.75	41	316.26 - 320.19	101
103.75 - 106.92	42	320.19 - 324.15	102
106.92 - 110.11	43	324.15 - 328.13	103
110.11 - 113.32	44	328.13 - 332.12	104
113.32 - 116.55	45	332.12 - 336.11	105
116.55 - 119.80	46	336.11 - 340.12	106
119.80 - 123.06	47	340.12 - 344.14	107
123.06 - 126.34	48	344.14 - 348.16	108
126.34 - 129.64	49	348.16 - 352.19	109
129.64 - 132.96	50	352.19 - 356.24	110
132.96 - 136.29	51	356.24 - 360.29	111
136.29 - 139.64	52	360.29 - 364.36	112
139.64 - 143.00	53	364.36 - 368.43	113
143.00 - 146.38	54	368.43 - 372.50	114
146.38 - 149.78	55	372.50 - 376.60	115
149.78 - 153.19	56	376.60 - 380.69	116
153.19 - 156.62	57	380.69 - 384.80	117
156.62 - 160.06	58	384.80 - 388.91	118
160.06 - 163.62	59	388.91 - 393.04	119
163.62 - 166.99	60	393.04 - 397.17	120

APPENDIX 3. INTERNATIONAL AIRPORT CODES

City, Location	Country	Airport Identifier
Adelaide	Australia	ADL
Auckland	New Zealand	AKL
Bali	Papua New Guinea	BAJ
Kota Kinabalu	Malaysia	BKI
Brisbane	Australia	BNE
Balikpapan	Indonesia	BPN
Brunei	Brunei Darussalam	BWN
Cebu	Philippines	CBU
Jakarta	Indonesia	CGK
Darwin	Australia	DRW
Davao	Philippines	DVO
Fukuoka	Japan	FUK
Hong Kong	China	HKG
Washington- Dulles	United States	IAD
Incheon	Korea	ICN
Osaka	Japan	KIX
Los Angeles, CA	United States	LAX
Manado	Indonesia	MDC
Melbourne - Tullamarine	Australia	MEL
Macau	Macau China SAR	MFM
Manila	Philippines	MNL
Nagoya	Japan	NGO
Tokyo-Narita	Japan	NRT
Portland, OR	United States	PDX
San Francisco, CA	United States	SFO
Surabaya	Indonesia	SUB
Sydney - Kingsford Smith	Australia	SYD
Taipei Chiang Kai Shek	Taiwan	TPE
Vancouver	Canada	YVR

APPENDIX 4. ACRONYMS

ACC	Area Control Center
ADS	Automatic Dependence Surveillance
ADS-B	Automatic Dependence Surveillance-Broadcast
ANSP	Air Navigation Service Provider
ASM	Airspace Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
CAAS	Civil Aviation Authority Singapore
CNS	Communications, Navigation, Surveillance
CPDLC	Controller-Pilot Data Link Communications
DF	Distance Factor
DGAC	Directorate General of Air Communication
EIRR	Economic Internal Rate of Return
FIR	Flight Information Region
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IRR	Internal Rate of Return
MTOW	Mean Take-Off Weight

NM	Nautical Mile
NPV	Net Present Value
O&M	Operations and Maintenance
RANS	Route Air Navigation Service
RNP	Required Navigation Performance
SI	Sensitivity Indicator
SV	Switching Value
WF	Weight Factor

APPENDIX 5. IMPLEMENTATION SCHEDULE

Implementation schedule

Year:	0	1	1	1	1	2	2	3	4	5	6	7	8
	Base 2006	2007 Qtr 1	2007 Qtr 2	2007 Qtr 3	2007 Qtr 4	2008 Qtr 1	2008 Qtr 2	2009 -	2010 -	2011 -	2012 -	2013 -	2014 - 2021
System Enhancement:													
1- Executive Direction	X												
2- DGAC transition team		X	—	—	—	—	—						
2a- Involve stake holders		X											
2b- Develop action plan -- what, who, when (APANPRIG)		X											
2c- Validate existing traffic Singapore procedures & traffic flows			X										
2d- Develop LOA's as required				X									
3- Inspect all CNS facilities supporting (activity + travel)			X	—	—	—	—						
4- Modify zero spares policy	X												
5- Q/A team purpose = restoring all CNS fac./ Natuna		X	—	—	—	—							
6 - Flight inspection and certification		X	—	—	—	—	—	→	→	→	→	→	→
7- Jakarta ACC Software/Automation Sys(see line 38)				X	—	—	—						
8- Aeronautical information should be verified	X	—	—	—	—	—	—	→	→	→	→	→	→
9- Charting dates validates and charting assured						X							
Human Resource activities:													
1- Controller procedure training			X	—	—	—	—	→	→	→	→	→	→
2- Controller radar skills training					X	—	—	→	→	→	→	→	→
3- Engineer Technician training			X	—	—	—	—	→	→	→	→	→	→
4- ICAO language training			—	—	—	—	—						
5- Additional staff				X	—	—	—						
6- Emergency services training					X	—	—						
Investment for new equip. or If audit proves need:													
1- ATM flow program Barco (Lordas II / O'SYRIS)				X	—	—	—	→	→	→	→	→	→
2- MSSR @Batam (replace Tanjung Pinang SSR)		X	—	—	—	—	—	→	→	→	→	→	→
Resumption of ANSP Responsibilities Schedule	ORDD						X						

APPENDIX 5. IMPLEMENTATION SCHEDULE

Implementation schedule	Base 2006	2007 Qtr 1	2007 Qtr 2	2007 Qtr 3	2007 Qtr 4	2008 Qtr 1	2008 Qtr 2	2009 -	2010 -	2011 -	2012 -	2013 -	2014 - 2021
Investment for new equip. or **if audit proves need**													
1- ADS-B integration w radar			X	→	→	→	→	→	→	→	→	→	→
1a- Mode S 1090 ES			X	→	→	→	→	→	→	→	→	→	→
2-VHF-ER co-locate @ Batam w HF-ER			X										
3- HF-ER			X										
4-VHF-ER @ Tanjunpandan			X										
4-four radio (8.33KHz)											X		
7-AMHS router for ATN									X				
8-ATN subnetwork for 2nd stage									X				
9- GPS												X	
9a-Ground Monitor Station												X	
9b- Master Control Station												X	
10- VOR-ER										X			
11- FDP								X					
12- VDL Mode 2			X										
12a- PDC			X										
12b- Digital ATIS			X										
13- Controller Information Dispays (Systems Atlanta)							X						
14- Adacel Controller Simulator installation				X									
New or Modified Facility construction													
1- Jakarta ACC expansion								X					
2- Batam TRACON expansion									X				
3- Power Conditioning Unit housing								X					
4- CATCC in Jakarta (AT Flow Management)									X				
5- Backup CATCC in Batam									X				

APPENDIX 5. IMPLEMENTATION SCHEDULE

Implementation schedule	Base 2006	2007 Qtr 1	2007 Qtr 2	2007 Qtr 3	2007 Qtr 4	2008 Qtr 1	2008 Qtr 2	2009 -	2010 -	2011 -	2012 -	2013 -	2014 - 2021
Air Traffic Management													
1- FDP (QA upgrade)									X				
2- FDP (OLDI)									X				
3- FDP (AIDC)									X				
4- RVSM	X												
5- RNAV/RNP present	X												
6- RNAAV/RNP expan.										X			
7- Continious Descent procedures										X			
8- AIS/FIS restore					X								
9- AIS/FIS limited					X								
10- AIS/FIS full imple.					X								
11- Center Stored Flt Pln								X					
12- CFMU (regional)	X												

Natuna Islands Air Traffic Control and Airspace Management Project for the Republic of Indonesia

Task 6

Final Report

Prepared for:
Directorate General of Civil Aviation of the Republic of Indonesia

By:
Robinson Aviation (RVA), Inc.

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1.0 Task 6 - The Final Report

1.0.1 Task 6 Overview

1.0.2 Task 6 – The Final Report Requirements. Task 6 calls for the submission of a Final Report; specifically the Final Report must fully document the results of all tasks for submission to the Director General of Civil Aviation (DGCA). The Final Report must be and is in accordance with Clause I of Annex II of the Grant Agreement. Additionally, an appendix is affixed identifying prospective U.S. Sources of CNS/ATM equipment.

1.1 Study Primary Goal. The primary goal of this feasibility study is to assist the DGCA in the identification of the technical and financial requirements for resumption of ANSP authority for airspace management over the Indonesian (Natuna) Islands, often referred to as Sector C, located in the South China Sea.

1.2 Study Objective. The Study Objective is to determine the *training*, *technical* and *financial* requirements of the project and for its implementation.

1.3 Study Accomplishments. This Feasibility Study accomplished the following:

1. Assessed the technical requirements for Indonesia to be able to provide air traffic management in the airspace over the Natuna Islands while recognizing neighboring areas called sector A and B which are both currently under the Singapore Flight Information Region (FIR).

2. Developed estimates of system and equipment requirements and investments needed.

3. Developed human resource and training requirements necessary for the administration of ANSP responsibilities in Sector C, the Natuna Islands airspace.

4. Assessed the environmental implications of actions proposed in this TA.

5. Provided a financial analysis of the project and recommended financing options.

2.0 Sub Task

The Natuna Airspace project is divided into six Tasks. These separate tasks are building blocks of information leading from the present system assessment to recommendations for consideration in the resumption of ANSP responsibilities for Sector C.

This final report discusses each task in turn as follows:

2.1 Sub Task 1. Task 1: Review of the Existing Air Traffic Control, Air Navigation and Airspace Management System in Indonesia airspace overlying the Natuna Islands.

2.1.1 Initial Assessment. Under this task, the RVA was required to make an initial assessment of the existing system. RVA's experts were also tasked to visit the Natuna Area Control Center (ACC) to inspect the current system and hold discussions with key aviation officials. Further, RVA was required to document the findings of the system and equipment in terms of vintage, specifications, operating conditions, maintenance records and procedures, etc. All of this is reported in the original Task 2 report.

2.1.2 Technology Trends. As part of Task 2, RVA also assessed current technology trends and state-of-the-art systems and procedures in air traffic control and airspace management worldwide. Consideration was given to the use of Global Navigation Satellite Systems (GNSS), data link, aeronautical telecommunications, air traffic decision support systems, and other modern trends in aviation systems to develop a profile of technologies applicable to Indonesia. An evaluation of Indonesia's existing infrastructure and operations for areas where improvement is under consideration was conducted.

2.1.3 Institutional Capabilities. RVA assessed the institutional capabilities and human resources management systems, documenting areas where further enhancement is needed. Specific training requirements for air traffic control (ATC) and airspace management personnel, engineers and staff were recorded in Task 1 as well as in subsequent tasks.

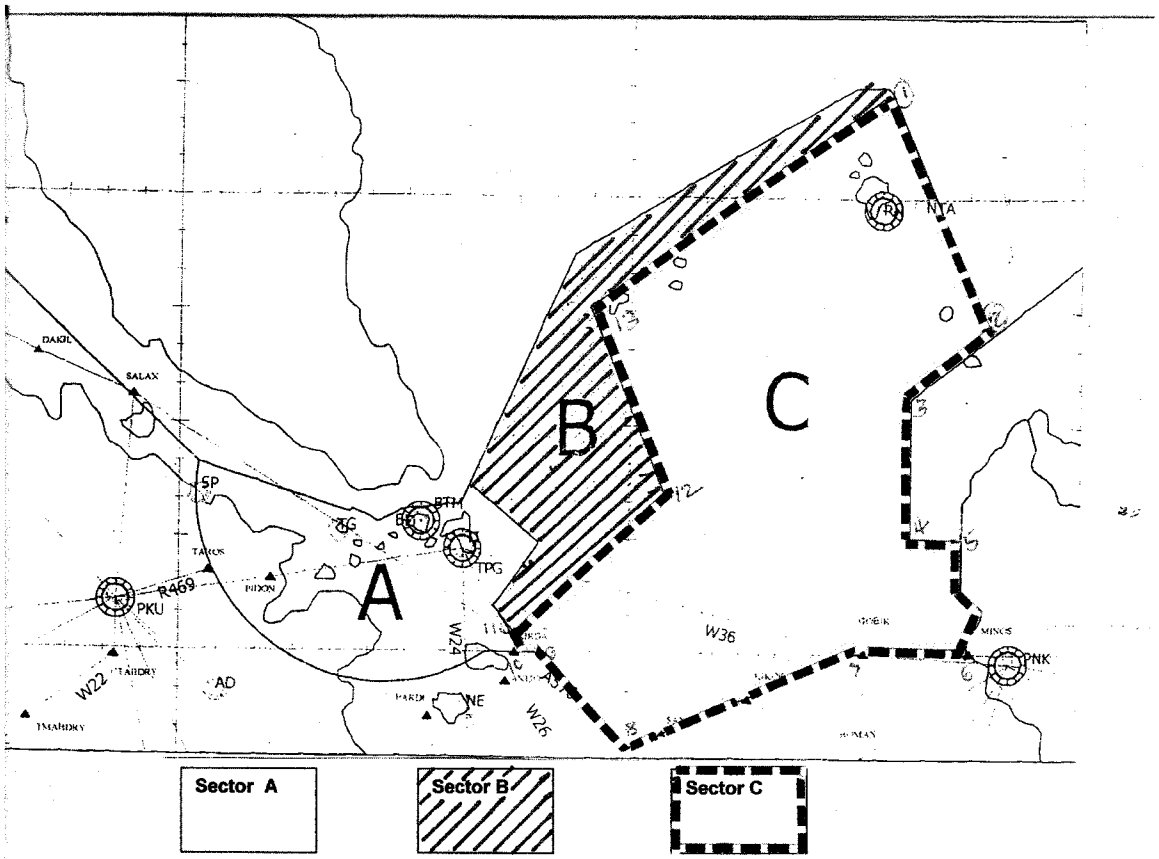
2.1.4 Methodology. In this, the final report, we will begin with Task 1 and subsequently progress through the entire Task list. In the process, we will address and comment on material provided for each previous task. It is important to note that while conducting this assessment, the team of RVA and DGCA representatives used a methodology that included reviews of information resources, interviews, and site visits. Local infrastructure site visits allowed RVA to observe facilities first hand.

2.1.4.1 On-Site Work. During the preliminary activity prior to the onsite assessment, RVA developed a work schedule with appropriate start and finish dates, assigned personnel to complete each of the 6 tasks, and reviewed applicable DGCA and ICAO (International Civil Aviation Organization) documents. This review was of documents that could provide information into the development and completion of this study. In addition to these documents, RVA also reviewed a variety of papers including Indonesia's AIP (Aeronautical Information Publication).

2.1.5 Organization Structure. In review of the organizational structure which includes three ANSP entities, it became apparent that such a structure created road blocks to coherent planning. Reasons for difficulty are varied and ranged from different CNS/ATM requirements to differences in priorities, facility size, financial capabilities, and the volume of traffic. No matter the reason, this is an issue that needs to be resolved at the outset of any significant organizational change. In summary, the present management structure dividing responsibilities among AP 1, 2, and the DGCA, does not appear to be working to the benefit of all involved, and we strongly recommend that a change be made to a single technically competent and administratively strong organization. For ease of discussion, in this report, we use the name DGCA in the leadership role of that future state organization.

2.1.6 Best Use of Facilities. Another issue addressed at the beginning of this TA is the requirement to ensure that present assets and resources are used for maximum efficiency and redundant systems are justified and kept to a minimum. The equipment recommended herein is judged in terms of clearly fulfilling an operational need and is cost effective while in concert with regional plans, to the maximum extent possible.

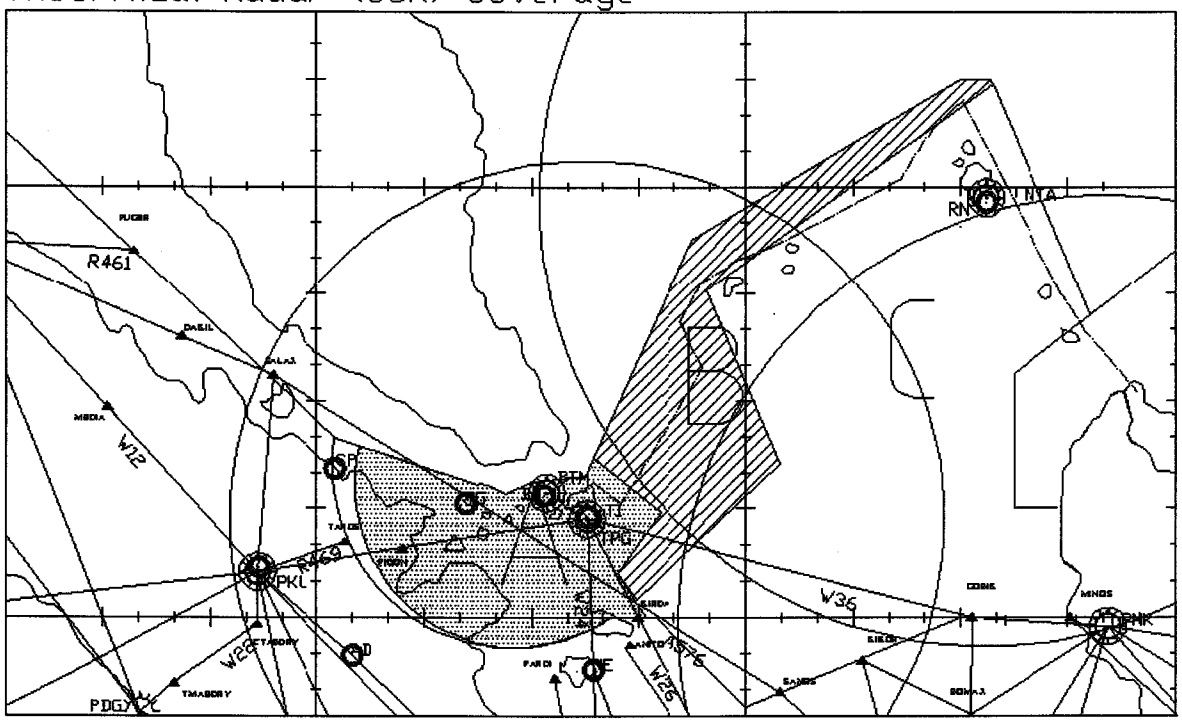
2.1.7 Airspace Assessment. RVA conducted an assessment of the existing Airspace and Air Traffic Management System for the Natuna Islands airspace/Sector C. This analysis was made of the Indonesia, Malaysia and Singapore airspace, defined by FIRs, UIRs, UTAs, in MOUs and/or Letters of Agreement. The analysis was made to determine the most cost effective and user beneficial plan for providing air traffic control service in the airspace described as Sector C. This sovereign Indonesian airspace is temporarily delegated to Singapore. Among the findings, two are particularly important: 1) the Natuna airspace is very small as noted below, and 2) for all practical purposes, the entire airspace lays over water and is predominantly at high altitudes.



Sectors A, B, C

2.1.8 Traffic Flow. Traffic flow through Sector C was determined by review of all airways, STARs and SIDs. Traffic routings and flows were not found to be particularly complex or inefficient considering the terrestrial based navigation facilities presently in use. The most important finding during this review of airspace boundaries and routing is the fact that Sector C is quite small in terms of consideration being given to a dedicated ACC facility and possible implementation of state-of-the-art CNS/ATM systems. The potential ACC is planned to serve the needs of airspace of approximately 40,000 square kilometers which is more than 200,000 square kilometers smaller than normal sized airspace for ACCs. While the area to be serviced is relatively small, the location of both the airspace and the Natuna radar is great operational value to the Region at large. The airspace and potential radar intelligence is strategically of great importance to other ANSPs, the user community and Region in general. Specifically, Natuna fills the gap between Singapore, Jakarta and traffic transiting the South China Sea area.

Theoritical Radar (SSR) Coverage

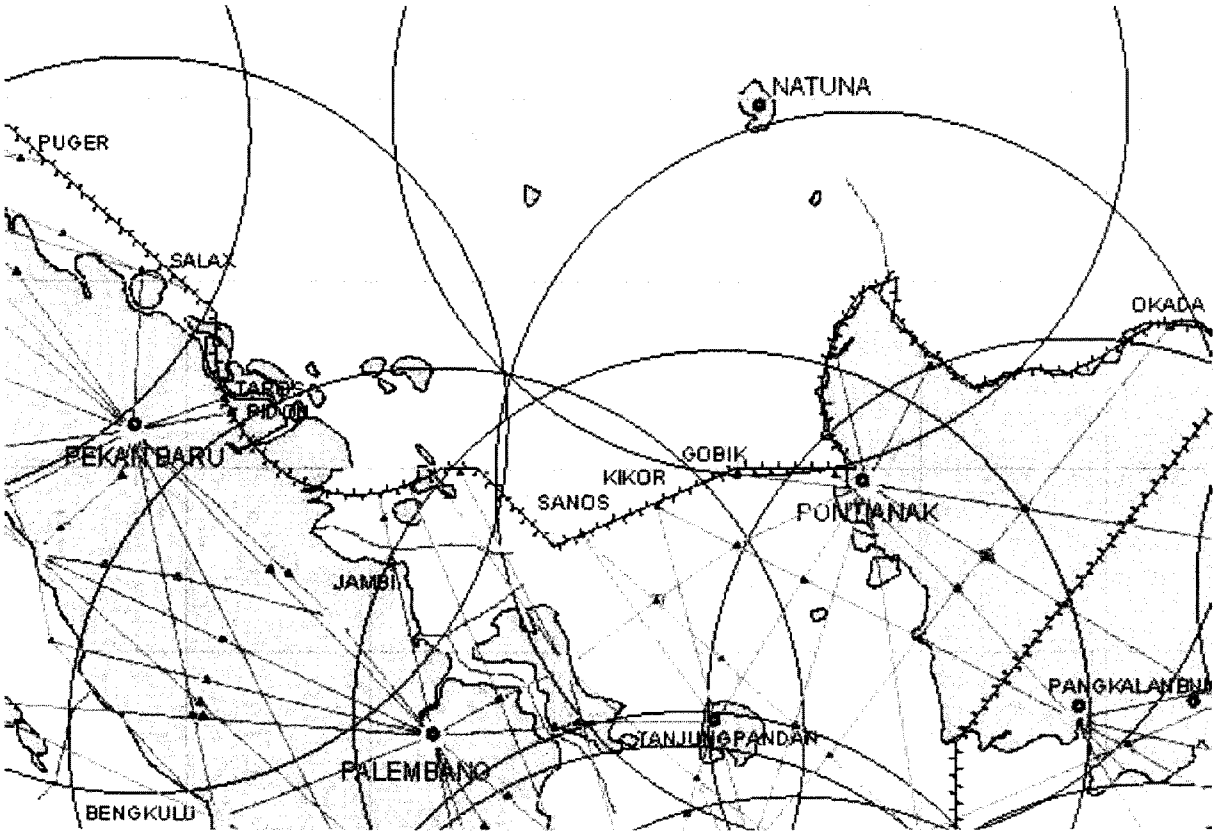


2.1.9 Traffic Growth and Growth. Traffic activity was developed using information from the DGCA and our own analysis of airline schedules and routings. It is important to remember that Sector C is presently serviced by Singapore ACC which considers actual traffic activity as proprietary information, thereby necessitating our development of traffic activity approximations after review of Regional activity with focus on city pairs and routes through Sector C. Activity growth is conservatively judged to be a minimum of 5% annually. History shows air traffic has grown between 10% and 15% annually for the last three years while passenger traffic grew 57% from 1999 to 2002. The events of these years caused unusual fluctuations up and down in traffic volume. A period of stable growth consistent with regional trends is now to be expected.

2.1.10 Singapore Procedures. Having developed traffic activity information, RVA reviewed known air traffic control procedures. Here again, Singapore ACC's internal procedures were considered proprietary. However, this was of no significant importance in light of universal application of ICAO rules and requirements. Therefore, the proposition of Indonesia resuming ANSP responsibilities in its sovereign airspace is a relatively straightforward issue.

3.0 Facilities

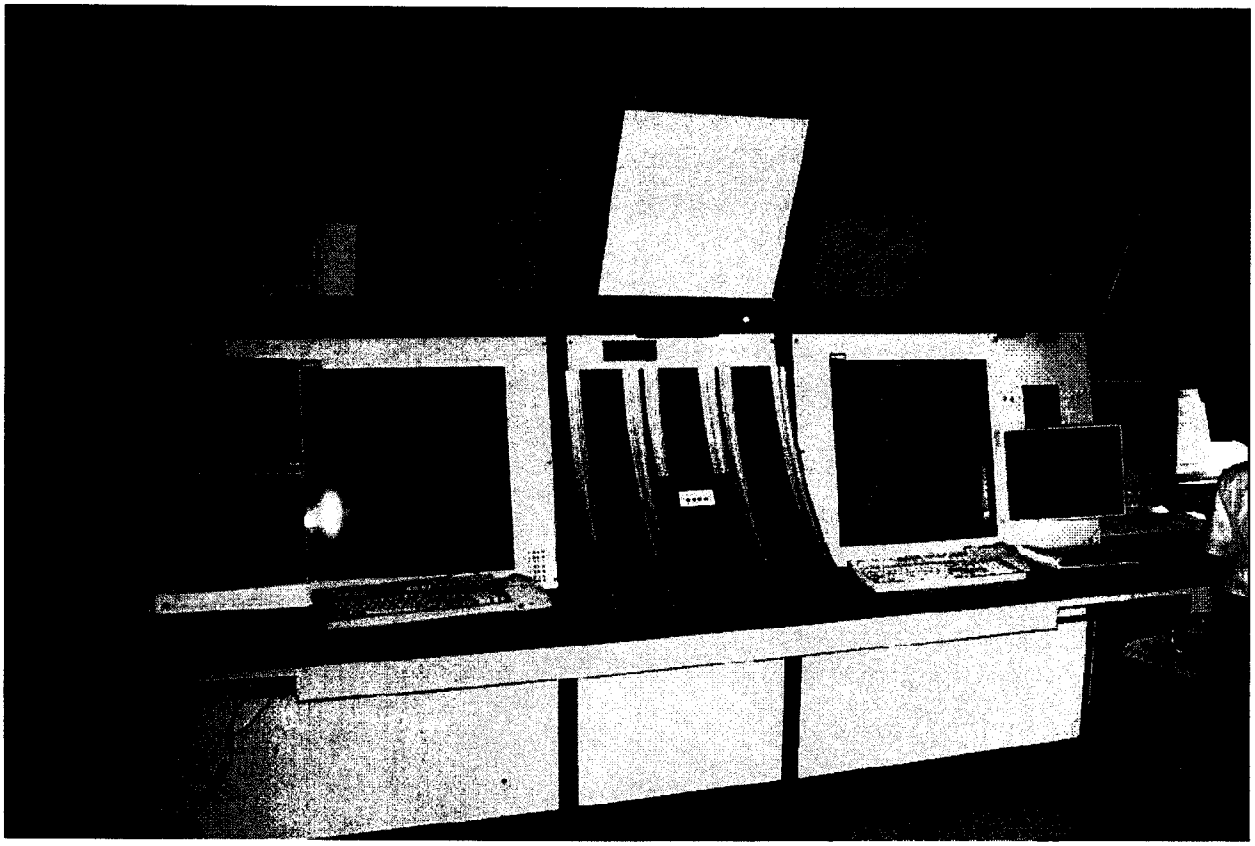
As part of the onsite facility review, the Communication, Surveillance and Navigation facilities in the local Jakarta area were visited. Additionally, AP Angkasa Pura II hosted an excellent visit and briefing at the Jakarta ACC. In both instances, facilities were found to be in good working order with a knowledgeable staff providing support. One system possibly needing further attention by onsite decision makers is the PCSI Clarity VSAT equipment. Due to the VSAT system's age, the need for expansion and new equipment that came to our attention in the later phase of the project, more time is needed for a thorough review.



VHF Coverage

3.1 Natuna Sector. The most remarkable aspect of the Jakarta ACC visit was to find an installed "Natuna Sector" already available for provision of air traffic services. Considering the information established to this point, i.e., a relatively small and fixed amount of airspace, reasonable traffic volumes using standardized routes and procedures, and operating CNS systems

well within their life cycle, the focus of the TA clearly centered on how to transition to Indonesian control of Sector C.



Natuna Sector Jakarta ACC

3.2 Radar Training. A fundamental driver of the provision of quality service is the training and certification of air traffic controllers. In this TA, we recommend a new state-of-the-art radar simulator. The response to this recommendation represents one of the most important decisions to be made in relation to resumption of ANSP responsibility for the Natuna airspace. Radar training in the future must address the initial, certification, and radar proficiency of controllers. A world class simulator capable of training air traffic controllers and simulating Traffic Flow Management initiatives is of the utmost importance. Consideration should be given to an Adacel MaxSim or a system of similar capabilities as addressed later in this report.

3.3 Technology Readiness. DGCA is aware of the need for newer and more efficient equipment and is preparing for the implementation of space based/digital-like CNS/ATM systems. Information regarding Indonesia's previously unannounced involvement in regional CNS projects came to light only in the last stage of this TA. DGCA is to be congratulated for these forward thinking projects. As the global community transitions to advanced CNS/ATM systems, many questions arise including the threshold question of what problem is to be solved. Central to these questions is "what is the payback?" Those questioning "payback" include not only the ANSP but also the user, who eventually must pay for new services and systems. These

questions are further expanded to include the need for harmonization, compatibility, and interoperability. Planners must understand the need for users to see an early payback especially in today's strained economic situation. RVA urged thoughtful consideration of investments and advised meeting attendees that many CNS/ATM systems lack the necessary maturity to justify investments. Reviewing the appropriateness of a given technology may even include questioning whether this is the correct technology for particular location, such as technologies that are only cost effective over large areas. In essence, potential system users and investors were warned that CNS/ATM technologies and systems must satisfy an operational need, delivering a service at the right time in history in order to be appropriate investments

3.4 Planning Recommendations. RVA recommended a rational strategy for assumption of control of the Natuna Islands airspace utilizing CNS/ATM systems. Specifically, the recommendation is for a general planning philosophy as follows:

- Phase 1: Maintain and invest in proven technologies, maintaining the limited status quo until proven new CNS/ATM systems are available for specific applications. During this phase, DGCA should replace end of life cycle legacy infrastructure systems while closely monitoring the evolution of CNS infrastructure, hardware, software, and architecture systems.

- Phase 2: Deployment of CNS/ATM capabilities and integration of CNS/ATM technologies into the new technologies. This is important as legacy infrastructure is phased out at the end of its life cycle and as aircraft equipage reaches a level that allows the ANSP to bring the CNS technology into the operation. In this period of time, dual systems should be maintained in order to service the operators who cannot equip. Reasons for the user not transitioning to CNS equipage must be acceptable to the national government. It is expected that the military will continue to have special requirements.

- Phase 3: Complete deployment of CNS/ATM capabilities and integration of CNS/ATM technologies into the new architecture when required and in concert with Regional plans.

3.5 CNS Task 1 Review. Our discussion of the CNS system covered each technology or system individually in Task 1.

3.5.1 Communications. This Communications section refers to voice and data as well as an appropriately timed transition to ATN. At the present, Natuna systems are sufficient and plans for additional equipage such as VHF-ER are in progress. Recommendations for state-of-the-art background noise canceling radios are included. This radio system could resolve user complaints of excess background noise compromising the safety of operations. Additionally, since spectrum congestion is not an issue for Sector C, a recommendation is made that a program of 8.33 kHz spacing be given consideration in light of the current maturity and cost of CPDLC.

3.5.2 Navigation. Navigation issues covered include GPS, which Indonesia is presently developing in concert with Regional ANSPs. GNSS augmentation or integration is required to

ensure that technical performance (in terms of accuracy, integrity, continuity and availability) meets ICAO requirements as detailed in Task 1. Our recommendation is for consideration of ABAS (Aircraft Based Augmentation System) which is favored by the user community. Until GNSS systems are fully matured and fielded to the entire user community, a basic system of VORs will continue to be required for many small operators.

3.5.3 Surveillance. Surveillance information provided in Task 1 can be summarized as advocating radar surveillance for the foreseeable future with ADS-B initially as a supplemental system. ADS-B is receiving much attention but caution must be exercised while this system matures. ADS-B has many attributes which we strongly support but the purchase of and reliance on these systems requires due diligence on the part of ANSPs. Many early pronouncements are now under serious review and final certification is yet to come. DGCA must have an explicit operational plan which clearly states the operational use to be made of ADS-B.

3.5.3.1 Surveillance Options. Presently MSSR is the surveillance tool of choice for high traffic volume areas, for complex traffic areas, and for enhanced safety. It brings considerable benefits where surveillance is required. ADS-C is available for oceanic and remote areas and domestic en route areas where radar installations are too expensive or site locations are not available. However, ADS-C's update rate is too low for modern Air Traffic operations. ADS-B, as mentioned, is an excellent, yet evolving surveillance tool. ADS-B is a broadcast means of surveillance which hopefully will, in the near term years, be certified and available for all of its advertised applications, such as the transfer of some separation responsibilities to the pilot.

3.5.3.2 Multilateration. Multilateration is a new technology that has not been fully developed but has potential in terms of operational capabilities and cost. It is being demonstrated in the terminal areas while demos in the en route environment have encountered line-of-sight problems. Multilateration will require several strategically placed sensors to provide surveillance over a large area. Since the planned accuracy of Multilateration appears to be 5 meters on the ground and 30 meters in the air, the accuracy of Multilateration may be less than ADS-B. Nonetheless, Multilateration has many positive attributes and should be monitored closely by DGCA for future use.

3.5.4 Radar Capacity Enhancer. The application of radar separation rather than non-radar and/or ICAO oceanic procedures will significantly increase capacity (by at least a factor of 3) by reducing the required procedural airspace protection on individual routes and at route crossing points. Use of radar would increase safety and provide greater efficiencies in service to the users through approval of direct routes, deviations requested, altitude changes, emergency services, etc.

3.5.4.1 Surveillance Expansion. When discussing surveillance systems with DGCA, RVA was told of Indonesia's involvement in an ADS-B system which could eventually evolve to a supplemental surveillance system. Additionally, information is now available pointing out the installation of an MSSR on Batam in support of the new approach control facility under construction. The new MSSR Surveillance equipment, replacing the Tanjung Pinang SSR,

should continue to provide reliable surveillance for the next 10+ years. This radar further enhances the surveillance capabilities in Sector C.

The Natuna (NTA) MSSR is currently operational and remoted to the Jakarta ACC.

3.6 ATM. Air Traffic Management (ATM) is a necessary area of involvement as future traffic growth taxes the system's capacity and the controller's ability to cope with system requirements of safety and efficiency.

3.7 Efficient Routes. The ATM system should include a network of ATS routes established to enable aircraft to operate along, or as near as practicable, to their preferred flight path, in both the horizontal and vertical planes, from the departure airport to the destination airport. ATS routes based on area navigation should be recommended when and where available. Standard instrument arrival routes (STAR) and standard instrument departures (SID) should be established when efficiency needs of air traffic or the user justifies their application in a terminal area and to facilitate the efficiency needs of the user.

3.8 ATM Software. Whenever circumstances warrant, the airspace organization should be designated to support the ultimate goal of allowing each aircraft to fly its own optimized flight path. Airspace management is being practiced in the South Pacific where properly equipped aircraft operating between the west coast of the United States, Australia, and New Zealand are allowed to fly their optimized routes, generally at their requested altitude, and are permitted to change routes based on revised wind forecasts while en route. Such concepts can be implemented through Sector C. Additionally, RVA recommended the inauguration of continuous descent procedures particularly for arrivals to Singapore and Jakarta

3.8.1 Software Specifics. In all traffic management initiatives, it is of the highest importance that compatible software programs be used by adjacent and interacting ANSPs. Later in this TA, RVA cites a specific compatible Flow Management program that reduces delays, improves capacity, and expedites traffic. It will be noted that such an investment is essential to the successful resumption of ANSP responsibilities in Sector C.

3.8.2 RNP. Additional capacity enhancing issues discussed in Task 1 include Required Navigation Performance (RNP). RNP is a generic term that allows the requirements of the airspace to be defined without specific reference to a navigation system. RNP is a statement of the navigation performance necessary within a defined airspace and is a product of CNS/ATM. A specified type or level of RNP is intended to define the navigation performance of each individual aircraft within the airspace commensurate with the navigation requirements for that airspace.

3.8.2.1 RNP General. RNP is a fundamental parameter in the determination of separation when used with intervention, traffic density, and route configuration. Providers are already assigning RNP values to particular routes and areas in order to take advantage of the benefits of GNSS. The Informal South Pacific Air Traffic Coordinating Group (ISPACG) has already assigned

RNP-10 for routes and tracks in the South Pacific. The use of RNP permits a reduction in separation from 10 minutes horizontally and 100 NM laterally to 50 NM both laterally and horizontally. The goal is to assign RNP-4 for all South Pacific Routes and further reduce the separation to 30 NM both horizontally and laterally.

3.8.3 GPS. Issues such as ownership of systems, certification, and uninterrupted availability are discussed in detail in Task 1. Attention is given the issue of GPS. To demonstrate the efforts of the United States on the global acceptance of GPS, the FAA has signed bilateral cooperative agreements with more than 20 countries. These agreements cover the full spectrum of FAA activities including the development of independent technical aspects of GPS augmentation services, surface management, and the combining of WAAS networks to form a seamless global system.

3.8.3.1 GPS Summary. In summary, the United States has made every effort to meet the concerns of the international aviation community about GPS. Additionally, positioning satellites that will carry GPS through the next 20 years are already being designed, procured, and in some cases, launched. For the most part, world providers have accepted these concessions and are using GPS (a free of charge system) for present and future needs, including the development of an integrity system. The use of GLONASS is still being debated as information on the system is insufficient.

3.9 Task 1 Resource Material. Task 1 covers a multitude of CNS/ATM issues including legalities, quality standards, certification, the strengths and weaknesses of each CNS/ATM system, and some of the new applications of RNAV and GPS routes aimed at expanding system access and capacity. The Task 1 section discussing the strengths and weaknesses of CNS/ATM systems is of particular value to system managers as it provides a quick and concise read. The section of Task 1 summarizing the values and best applications of CNS systems provides decision makers as well as planners an invaluable reference.

3.10 Task 2 Clarifications. In accord with the Terms of Reference, Task 2 requires development of specific CNS/ATM equipment and systems infrastructure requirements for air traffic control and airspace management. The objective was previously cited. Further discussion with the DGCA has clarified the following: the Natuna Islands airspace also referred to as Sector C is the target airspace, not Sectors A and B as listed in the original TA. In actuality, only Sector C is subject to Indonesia's reclaiming as sovereign airspace. Additionally, the DGCA representative stated that the mention of building an Area Control Center (ACC) on Natuna is only an illustration that the ACC should be located at an appropriate location. Based on the output of Task 1 and the passenger and cargo traffic anticipated to operate within the airspace over Natuna over the next 15 years, RVA made an assessment of the future demand for air traffic control and airspace management systems.

4.0 Task 2 Requirements

Task 2 has extensive requirements as detailed below. These requirements are then addressed individually. RVA's team met with DGCA officials and others involved as reported in Task 1.

Airline representatives and Angkasa Pura II officials discussed development of new CNS/ATM systems requirements with RVA. DGCA staff reported that 90+ % of the Sector C operators were GPS equipped. Throughout the development of this TA, RVA used measures such as access, capacity, "evolvability," and accommodation of expected traffic growth, safety, and security to determine and articulate the CNS/ATM requirements of the Natuna Islands airspace management system. The future requirements discussed herein included, but were not be limited to, the following types of needs:

- Organizational Aspects of Air Traffic Services above the Natuna Islands.
- A state-of-the-art Natuna Area Control Center.
- Systems and Procedures of Air Navigation (is there a need and what options should be considered).
- Supporting Facilities and Structures.
- Human Resources Preparation – Capacity Building and Training.

4.1 FIR Reorganization. Indonesia's DGCA has already completed reorganization of Indonesian airspace which was divided into 2 Flight Information Regions (FIRs)--Jakarta FIR and the Makassar FIR. The pending plan for airspace over Natuna Islands is to be the responsibility of the Natuna Area Control facility (ACC). It is important to recall that this airspace cannot be expanded. The Natuna Islands/Sector C airspace is set by international treaty.

4.2 Change Requirements. RVA developed a detailed listing of requirements for all systems, equipment, structures, training and management that may be needed over the next several years, assuming that Indonesia will be in a position to manage the entire airspace over the Natuna Islands. The specific requirements to be addressed as part of this TA shall include the following:

4.3 Proposed Natuna ACC. Construction of an Air Control Center on Natuna Islands is highlighted in this section and detailed in Task 2. Considering the future demand for airspace management, Indonesia's needs to establish an ATC Center with capability to control and manage air traffic within the airspace over the Natuna Islands was studied and is reported in Task 2 as unnecessary, because other effective alternatives are available. Specific recommendations to accomplish this are set forth in Task 2. Further, RVA recommended the optimum ATC system and the supporting infrastructure for resumption of ANSP responsibilities in Sector C.

4.4 Systems and Procedure for Air Navigation Services. The review began with discussions of DGCA's procedures for airspace management over the Natuna Islands which included (a) air traffic control and coordination procedures, (b) letters of agreement with related Air Traffic Service (ATS) units, and (c) local Standard Operating Procedures (SOPs). RVA evaluated the following in addition to many more:

- Mach Number Technique separation system.
- Reduced Vertical Separation Minima (RVSM).
- Required Navigation Performance (RNP): RNP-10 and RNP-4 procedures.
- Radar Separation.

- Automatic Dependence Surveillance–Broadcast (ADS-B) and Controller/Pilot Data Link Communication (CPDLC).
- Aeronautical Telecommunication Network (ATN) and Aeronautical Interchange Data Communication (AIDC).

With review of these systems and procedures, RVA makes specific recommendations which are contained in Task 2.

4.5 Facility Review. RVA, in accord with the TOR, reviewed the following supporting facilities for air navigation: (a) Very High Frequency Omni-directional Range/Distance Measuring Equipment (VOR/DME), Monopulse Secondary Surveillance Radar (MSSR), GNSS and VHF-ER Natuna; (b) VOR/DME, SSR and VHF-ER Tanjung Pinang; and (c) VOR/DME, SSR and VHF-ER Pontianak. RVA's TA actions also included a full range of communications and air navigation systems; the air-ground communication for supporting the air traffic control over Natuna. Supporting facilitie' review included a variety of surveillance systems. The required surveillance equipment included systems such as the MSSR, SSR, Primary Surveillance Radar (PSR), ADS, and Multilateration. The recommended system was required to be integrated with the existing ATC system.

4.6 Supplemental Requirements. As noted in Task 1, consideration of Human Resources, Capacity Building, and Training Requirements are considered central to the successful resumption of ANSP responsibilities in Sector C.

4.6.1 Human Resource Requirements. RVA developed the human resources requirements needed to undertake the new operations. These include radar controllers, engineers, and staff. In addition, RVA developed training requirements for the personnel needed to manage the airspace system over Natuna. Specifically, the training requirements include radar and traffic management simulation training.

The output of this part of Task 2 includes a detailed list of the following:

All equipment and system requirements for the proposed airspace management system.
Spare parts and maintenance equipment.
Training requirements.
Software systems requirements and specific recommendations.

4.7 Master Plan. Task 2 involved many issues including achieving coherence between the many reports and recommendation for CNS/ATM initiatives for the greater Indonesian airspace. Recently, Indonesia has adopted a Master Plan. This TA is consistent with the majority of the Master Plan, with consideration that this TA is restricted to Sector C. This restriction in affect is troublesome when considering some systems which, while needed for the greater Indonesian airspace, are inappropriate for the relatively small Sector C.

4.8 Tenets. Major tenets of the Natuna Islands Airspace TA include requirements for Evolvability, Capacity, Reliability, and Access. RVA has addressed these issues individually and in the totality of our recommended system changes, commensurate with need, proven

technology, and RVA's benefit cost analysis. This TA recommends a progression from a remediated legacy infrastructure to a state-of-the-art CNS/ATM system commensurate with documented need and in accord with sustainable cost. More detail on these points is in the remainder of this Task 2 outline.

4.9 Communication System Options. Communication systems are the first of the CNS concept. In summary, RVA urged DGCA to proceed with the regional plans (APANPIRG agreements) approach to CPDLC and FANS for the long-haul International operator and, when needed, to consider an alternative frequency congestion program such as an 8.33 kHz program. An 8.33 kHz is more economical for operators involved in short-haul operations and for ANSP organizations that must weigh the benefit-cost issues of government budgets. Communication coverage issues are being addressed with expansion and renovation of the VSAT and VHF ER facilities.

4.10 Nav/GPS. In the area of navigation, RVA recommended recognition of the evolution of Global Positioning System (GPS) also known as part of the Global Navigation Satellite System (GNSS), which is addressed throughout the report. Additionally, this TA encourages the DGCA to support regional plans (APANPIRG agreements) for greater use of area navigation (RNAV) as well as the appropriate utilization of required navigation performance (RNP). System users in particular want expansion of RNAV because it is a known technology that they have already invested in. A simple mantra for navigation planning in the immediate future is "RNAV everywhere and RNP where you need it". By virtue of the Natuna Airspace, this TA will focus on Oceanic/Remote En Route RNP, RNP 10 and RNP 4. DGCA has already joined in a GPS project and that project's completion should remain a priority. A basic VOR system should be retained until user requirements can be otherwise accommodated.

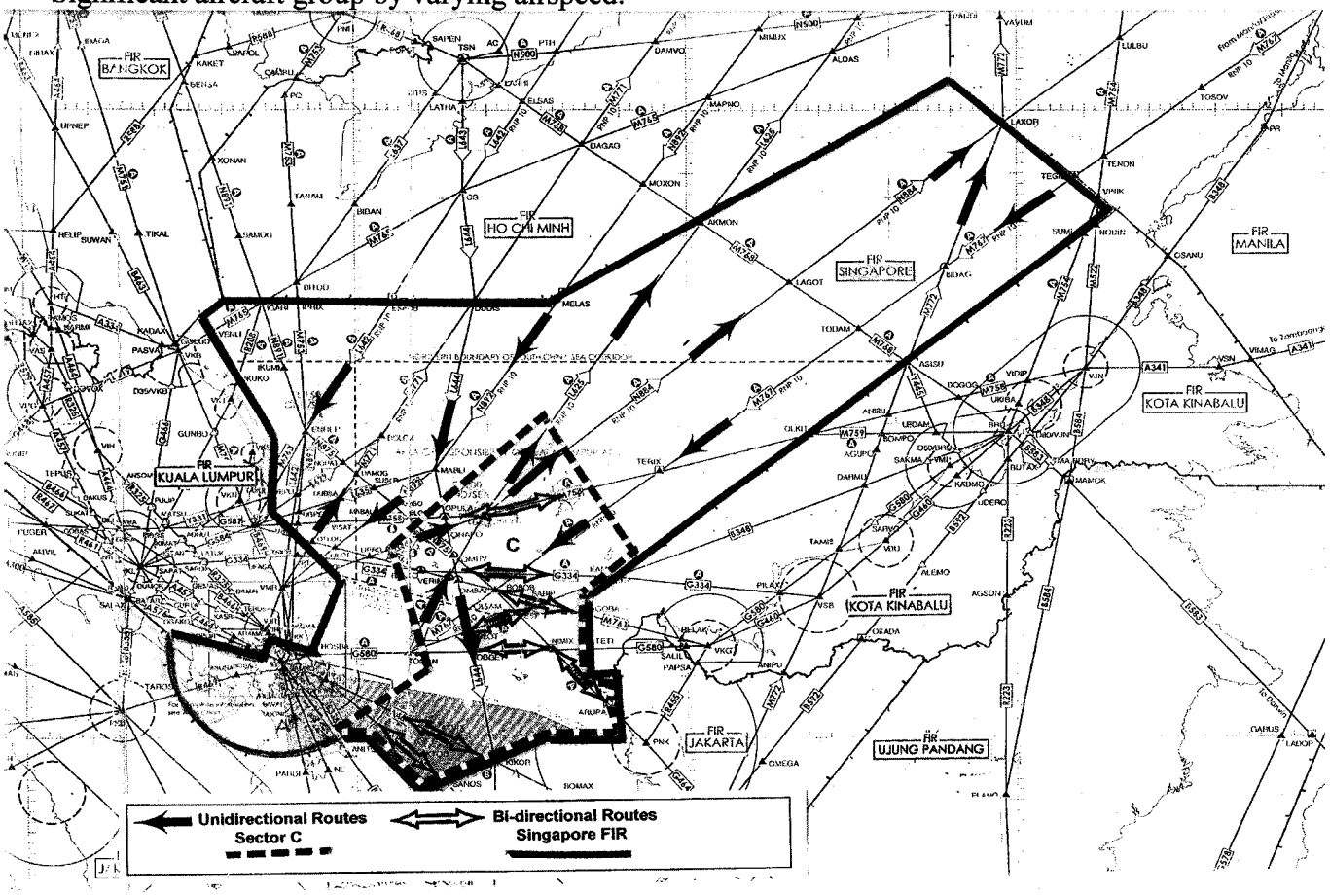
4.11 Surveillance. Surveillance in Sector C will be greatly enhanced with the Natuna Monopulse Secondary Surveillance Radar (MSSR) being integrated into the air traffic services (ATS) system. Additionally, the Natuna radar is in a most opportune and strategic location, filling a void in the ANSP system of the South China Sea. It is recommended that all surveillance systems include the capability to depict convective weather for the benefit of air traffic controllers and traffic flow managers. Further, the Natuna MSSR should be equipped with En Route Minimum Safe Altitude Warning (E-MSAW) and as soon as possible evolve to a system that will be augmented by Automatic Dependent Surveillance-Broadcast (ADS-B). ADS-B was recommended as a cooperative surveillance system, having the ability to function as gap filler in non-radar areas. In Task 2, another surveillance system RVA urges the DGCA to monitor is Multilateration.

4.12 Perspective. Having gathered information on possible CNS equipage and traffic statistics, RVA considered it timely to briefly discuss a perspective of the Natuna airspace and its impact on this TA. The discussion was between RVA and DGCA representatives. These discussions covered the resumption of control of the Natuna airspace, the relationship of Natuna to the entirety of Indonesia's airspace as well as the regional plans (APANPIRG agreements). It is important that a perspective of Natuna Islands and Sector C be maintained. Sector C is, relative to the entire Indonesian airspace, a very small area receiving Indonesian ANSP services.

4.13 Traffic Growth. Indonesia is evolving to be a key ANSP in the South East Asia and was urged to immediately begin preparation for significant traffic growth and changing technologies. Its strategic location is highly impacted by traffic flows between Asia and the growing markets of China, Australia, Europe, and the United States. It is our assertion that Indonesia can reasonably expect a minimum 5-percent annual growth for the next 15 years. This is documented in many professional reports, most recently in ICAO document 9853, Asia/Pacific Area Traffic Forecasts 2004-2020.

The predominant factors RVA considered when configuring airspace were the following:

- Traffic statistics and forecast.
- Aircraft types/fleet mix (wake turbulence category).
- Altitudes used by type aircraft and volume.
- Number of ATS routes served.
- Number of intersections of ATS routes.
- Proportions of aircraft in level flight and in climb and descent.
- Significant aircraft group by varying airspeed.



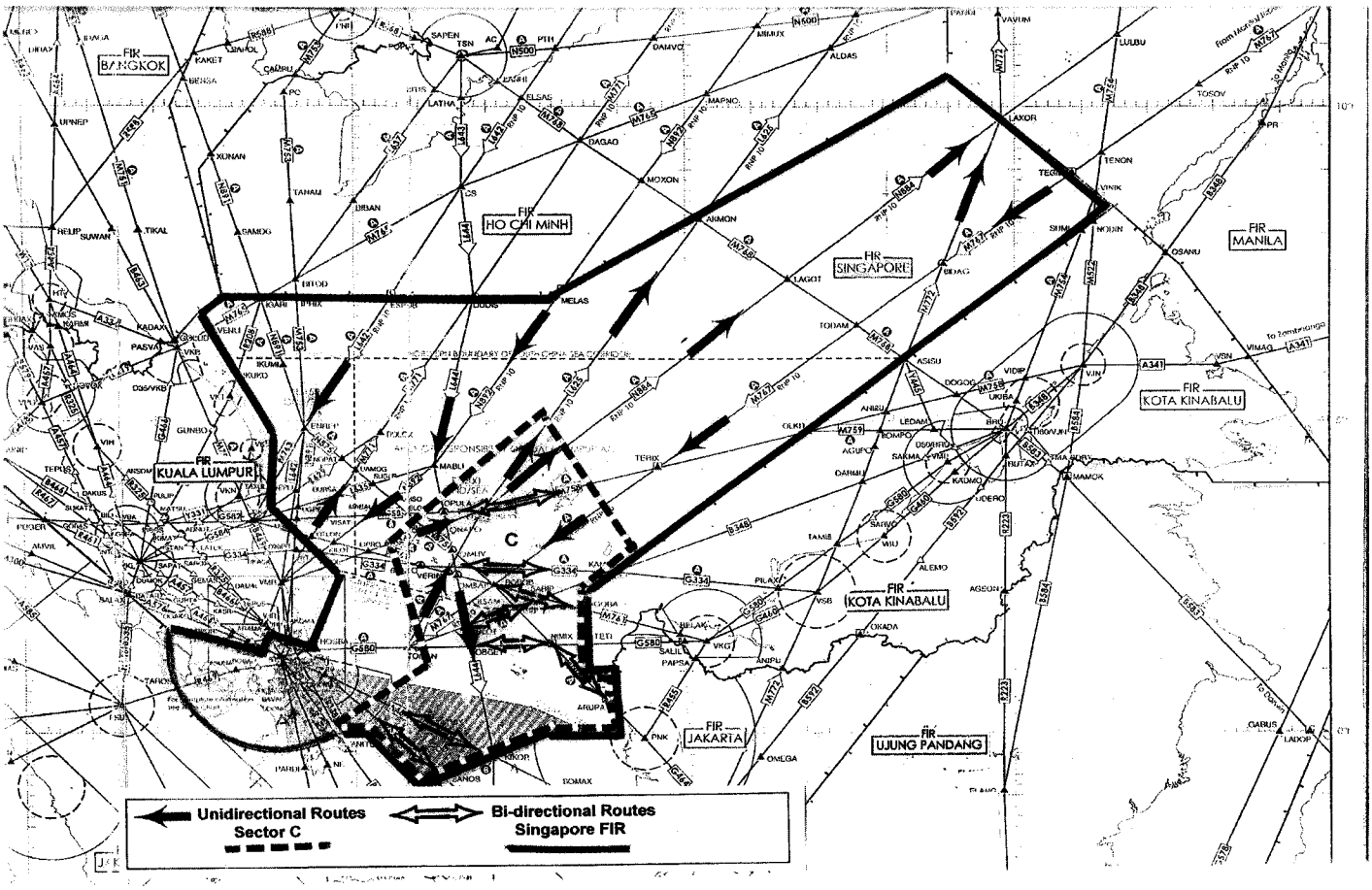
Example of Uni-Directional Routes

Note: In order to reduce travel distance and to reduce fuel burn, the expansion of uni-directional routes was recommended.

4.14 Sub Divide Sector. In the past, there have been discussions that the Natuna Airspace be subdivided with different organizations responsible for unnamed sub-sectors. While such a scheme could be developed, RVA makes no such recommendation. First, even with clearly defined boundaries and procedures, such a scheme would be rife with safety concerns. Specifically, subdividing would create increased controller coordination and therefore negatively impact safety and efficiency.

4.14.1 Future Airspace Changes. RVA suggested DGCA develop a deliberate plan for service improvement after the workforce is thoroughly familiar with their new duties. An action plan aimed at implementing a continuous improvement program through renewed programs for quality control, individual skill building, assuring infrastructure reliability, and addressing customer services (for example, more routes) should be announced after Operational Readiness Demonstration Date (ORDD). Such a program will demonstrate to users that programs aimed at system improvement will continue in the Natuna Islands airspace.

4.14.2 Bi-Directional Airways. The primary traffic flow through Sector C is via two one-way air routes from Singapore/Changi International Airport to Manila (N884), Formosa and Japan (L625) and a one-way route (M767) from Manila/Japan. A single one-way route (L644) from Hong Kong to Jakarta crosses Sector C. There are six bi-directional routes between Singapore FIR and Kinabalu FIR. These routes are also in the South China Sea Corridor which is controlled by Kuala Lumpur ACC at FL200 and below. Two bi-directional routes between Singapore FIR and Jakarta FIR cross the southern end of Sector C. Greater system access was recommended utilizing more accurate RNP minima, going from today's RNP 10 to RNP 4.



Note: In order to reduce travel distance and to reduce fuel burn the expansion of uni-directional routes was recommended.

4.15 Flow Management Software. RVA reviewed Air Traffic Flow Management initiatives involving the Natuna airspace and its neighboring ANSP in Singapore. The investigation determined details of this arrival management program. An understanding of Singapore's program software is important because of the eventual interaction of the two service providers. A strong recommendation is made that DGCA invest in the Osyris Traffic Management software. Details are continued in the Vender listing Appendix.

5.0 Transition Alternatives

5.1 Transition Alternative #1. RVA offered two alternative transition schemes to Indonesian for resumption of ANSP responsibilities for the Natuna Islands Airspace. Alternative 1 calls for remediation of present facilities and procedures. Additionally, Alternative 1 delays CNS equipage until a yet-to-be-determined date in the future, the exception being the inauguration of PDC and D-ATIS via VDL M2.

5.2 Transition Alternative #2. The second and recommended alternative has the same initial remediation action plan, beginning with establishing a leadership team eventually involving select stakeholders. Early on, the DGCA will provide executive direction citing the importance of resuming ANSP responsibilities over Natuna while charging the leadership with their responsibly for success.

5.3 System Remediation. Prior to assuming ANSP responsibilities for the Natuna airspace, the following actions must be accomplished prior to the Operational Readiness Demonstration Date (ORDD). ORDD is the date when these pre-transition actions are complete and Indonesia DGCA starts providing the full range of ANSP services. The ORDD will be set after careful study of the work required, consultation with all stakeholders, and approval by appropriate authority in the Republic of Indonesia. The ORDD should be managed as a "Millennium type date", that is, no change to the date.

5.4 Transition Action Plan. Within the suggested transition plans the following items should be included along with corresponding due dates and the designated accountable individuals:

1. Open discussions must be initiated with Singapore ANSP authorities regarding how air traffic is managed through Sector C. A clear understanding of resources and procedures involved must be established. Positive working relations between ATM operational staff leaders are critical.

2. Visitors to the Singapore ACC should clearly understand the use made of radar by Singapore air traffic controllers. If radar is used largely for monitoring traffic flows, no change should be initiated by Indonesia DGCA at the outset of this transition. Implementation of radar services may be phased into service after all controllers have been fully trained, certified and have no less than 3 months experience monitoring traffic flows.

3. Indonesian controller and engineering staff should make visits to Singapore in order to meet their counterparts and observe the Singapore operation. These observation visits should be guided by a checklist documenting the required information, such as staffing levels, operational issues with other service providers, etc. Indonesia's observation of the Singapore ACC, focusing on Sector C, must include all hours of the operation so that a comprehensive understanding of the operational requirements is achieved.

4. Draft procedures and LOAs must be developed. In addition to procedures and LOAs, controller staff must be thoroughly conversant with new frequencies and equipment at new working positions. Emergency/security procedures must be revamped as necessary. These documents should be tentatively initialed as acceptable by the parties awaiting final approval by higher political authority. Initially, there should be no changes other than revisions required to facilitate Indonesia assuming authority for its sovereign airspace.

5. At the earliest possible date, DGCA should begin controller and engineer training on technical issues (new procedures for controllers and equipment for engineers/technicians). This training includes the revised procedures and the appropriate training issues cited below.

6. ANSP staff should be provided sufficient time to familiarize themselves with new equipment. Eight hours of orientation and the use of training report forms are suggested. These training forms should become part of the individual records.

7. All controller staff, including supervisors, must be tested on new procedures and airspace.

8. Flow control authority should coordinate with adjacent facilities any anticipated changes since flow control is a regional issue and should be managed accordingly. Differences on flow control decisions regarding "local" airports and sectors should be decided through existing procedures.

9. ATS/ATM automation support activities require review, updates, and testing.

10. All staff must be briefed on emergency, alternate airport, and security procedure.

11. Reference and emergency binders should be developed and made readily available to all staff in their respective work areas.

5.5 ATS/ATM Action Timeline

The following ATS/ATM activities should be merged with 5.4 to form an action timeline for either alternative. Specific dates are not offered here since DGCA could offer no start date.

1. Open discussions with Singapore ANSP authorities regarding how Singapore manages air traffic through Sector C.

2. Establish a clear understanding of resources and procedures involved.

3. Confirm the use made of radar by Singapore air traffic controllers. If radar is used solely for monitoring traffic flows, no change should be initiated. If radar monitoring of traffic is the norm, DGCA should begin radar training for air traffic controllers.

4. Indonesian controller and engineering staff would be required to make visits to Singapore in order to meet their counterparts and observe the Singapore operation and management systems. These observation visits should be guided by a checklist of information required, such as staffing levels, operational issues with other service providers, etc. Indonesia's observation of the Singapore ACC, focusing on Sector C, must include all hours of the operation so that a comprehensive understanding is achieved.

5. Draft procedures and Letters of Agreement (LOA) must be developed to replace all present documents dealing with Natuna. In addition to procedures and LOAs, controller staff must be thoroughly conversant with new frequencies and equipment at new operating positions. Emergency/security and administrative procedures must be revamped as necessary. When consensus is reached among the signatory organizations, these draft documents should be tentatively initialed as acceptable awaiting final approval by higher political authority. Initially,

these documents should have no changes other than revisions due to Indonesia assuming authority for its sovereign airspace. The transition should be kept as simple as possible. System improvements can be made after a successful transition and stabilization of new equipment and the workforce.

6. Begin controller and engineer training on technical issues (new procedures for controllers, equipment for engineers) as soon as possible. This training includes the revised procedures noted above and the appropriate training issues cited below.

7. ANSP staff should be provided sufficient time to familiarize themselves with new equipment. Eight hours orientation and the use of a checklist documenting all required items are suggested.

8. All controller staff, including supervisors, must be tested on new procedures and airspace. Those scoring less than 100 percent must receive additional training.

9. Flow control procedures and authority should remain unchanged since flow control is a regional plans (APANPIRG agreements) issue and should be managed accordingly. Differences on flow control decisions regarding "local" airports and sectors should be resolved through existing procedures. For example, if departure delays from Batam do not appear to be equitable; those directly involved should try to resolve the problem.

10. ATS/ATM automation support activities require review, updates, and testing.

11. All staff must be briefed on emergency, alternate airport, and security procedures.

12. Reference and emergency binders should be developed and made readily available to all staff in their respective work areas.

13. Control room supervisors should enforce a policy of professional decorum in the operating quarters; also a policy requiring the proper use and wearing of headsets should be enforced.

14. All aeronautical engineers and electrical technicians should be licensed and subsequently provided regular training.

5.6 Pre-ORDD (Operational Readiness Demonstration Date) Activities

1. Confirm charting dates (some charts will include the name of any new control facility as well as other operational information).

2. Ensure all aeronautical information publication (AIP) and aeronautical information is accurate and publication dates are in concert with the proposed start date.

3. Ensure all parties are briefed.

4. Arrange for the temporary assignment of Singapore controller staff to the Jakarta ACC for a period of 2 weeks after the transition. This would be preceded by, at least, one day of observation time for the Singapore staff prior to ORDD.

5.7 Assumption of ANSP Responsibilities Schedule

- **3 months prior**
  Publish Public Relations notices.

- **One month prior**
  As able, document/validate traffic flow, i.e., volume, speed, separation standards applied, and any other information necessary for the documentation of a base case. This information may be necessary if accusations of inefficient service arise.

- **One week prior**
  Verify all equipment frequencies and coordination circuits and backup equipment are operational.

  Verify all backup power sources are operational.

  Issue informational notices of the ORDD as a reminder to all stakeholders.

- **48 hours prior**
  Issue NOTAMs.

  Parallel to the changeover time, Singapore monitors the operation while Indonesia actually controls Sector C traffic.

  Singapore stands down after 48 hours.

  Indonesia is solely operating with no infrastructure backup from Singapore.

- **Weekly for 2 months after ORDD**
  Weekly Quality Assurance reports

5.8 Future Operations. Managing the future of Natuna's operation includes: Aeronautical Information Publication (AIP) information, regarding Natuna, which should be verified and publications updated accordingly. Special attention should be given to the currency of AIP information. Aeronautical Information distribution services are recommended and are available via ARINC. ARINC systems and Inmarsat-3 Satellites are able to provide voice and data for Natuna's ADS-C communication link if ADS-C is used. AMSS Data 2 (nominally 600 or 10,500 bps) is part of the surveillance system backup with the Natuna MSSR being primary. If Natuna were to require the backup surveillance system, AMSS-2 could provide voice or data with approximately 2000 air carrier aircraft equipped to send Aircraft Communications, Addressing, and Reporting System (ACARS) data link using AMSS-2.

6.0 ACC Construction

Establishment of an Air Traffic Control Center (Natuna Islands) was established at the outset of this TA as an important issue. This ACC should be capable of servicing Sector C airspace. Central to developing such a recommendation was for RVA to conduct an assessment of need, recognizing the size and workload associated with Sector C. As discussed in this TA, Sector C is quite small, approximately 250+/- miles in length approximately 40,000 square kilometers, less than one hour at cruise for an airliner. Observation and review of route structure show traffic to be quite organized. The following options based on known facts and expectations for responsible expenditure of capital were considered as ACC Facility Alternatives.

6.1 ACC Alternatives. RVA articulated the following alternatives:

1. As cited in the USTDA Terms of Reference, "construct an ACC on Natuna Islands".
2. Construct a new ACC on Batam Island.
3. Construct an all new and separate ACC in Jakarta.
4. Upgrade the existing Jakarta ACC.

6.1.1 ACC Recommendations. After consideration of the above alternatives, RVA recommended use of the existing facilities in the Jakarta ACC. Alternative 4 should serve the Natuna Airspace through year 2020. In the interim, traffic demand, available technology/software, and Global CNS/ATM plans will mature. As previously suggested the Batam TRACON should be considered as an alternate ACC, only for the purpose of maintaining operations through Sector C. This alternate facility could be used in the event a disabling occurrence should impact the Jakarta ACC.

6.2 CATCC. The RFP calls for an evaluation traffic flow management facility which initially appears to be in conflict with the Master Plan by the Japanese Civil Aviation Bureau (JCAB). The JCAB suggests establishment of an Air Traffic Flow Management Center which would be called Indonesia's CATCC which would be the focal point of all command and control activities for the DGCA. In general, this is an excellent and much needed suggestion for servicing the whole of Indonesia. However, the purpose of this TA is to focus on the Natuna Airspace/Sector C. While it is recognized that flow management is interconnected to all areas and uses of Indonesia's airspace, a distinction is drawn between construction of a facility and the staffing and operation of a flow control facility. Accordingly, establishing an independent CATCC and co-flow management facility for the Natuna ACC would be counterproductive and not cost effective. Therefore, our recommendation is the establishment of one Coordination/Flow Control desk within the CATCC ATFN section. This workgroup of subject matter experts would provide the point of contact for the Natuna ACC.

6.2.1 Flow Management Need. Traffic Management for the Natuna Airspace is needed, as evidenced by user feedback. Work is in progress to develop an air traffic flow management (ATFM) tool throughout the region and the Natuna ACC management should be directly involved as representative of their airspace. Among the issues is the user's complaint that during peak periods help is needed with the reduction of ground delays and rerouting of flights due to

congestion. Further, users expressed a belief that the Jakarta ACC is put in a subservient position to Singapore. When viewed in this context, the references to volume delays are directed outside of the Natuna operation. In order to address these issues, the future Natuna ACC should be represented by one Coordination/Flow Control desk within the regional ATFM facility.

6.2.2 Flow Facility Staff. Indonesia does not have sufficient trained and experienced staff at this time to assume the duties of developing and managing a regional ATFM facility. Training of staff should start not less than 6 months prior to commissioning the CATCC flow control function.

6.3 Flow Backup Facility. The construction of the Batam TRACON offers an opportunity to combine the CATCC (emergency operation control room, flow control, etc., all as a backup to the primary facility). This new opportunity should receive consideration of Indonesia's seismic activity and possible utility disruption in Jakarta.

7.0 Capacity and Efficiency Enhancing Procedures

RVA recommended the following Capacity and Efficiency enhancing equipment or procedures:

Area Navigation (RNAV)/Required Navigation Performance (RNP).

Reduced Vertical Separation Minima (RVSM).

Digital Airport Terminal Information Service (D-ATIS).

Standard Instrument Departure (SID)/Standard Terminal Arrival Route (STAR).

Collaborative Decision-Making (CDM).

ATS Interfacility Data Communications (AIDC).

Aeronautical Message Handling System AMHS).

Route Development.

RNAV Offset Routes.

User Request Evaluation Tool (URET).

Convective Weather Information.

Aeronautical Information Services (AIS).

Aeronautical Information Service (AIS)/Flight Information Service (FIS).

Flight Data Processing (FDP).

Initial Integrated Flight Plan Processing System (IFPS).

7.1 Human Resource Review. The Natuna TOR calls for review of Human Resource Issues which include the following:

Staffing. Coordination visits to the Singapore ACC will clarify the present number of operational positions and staffing dedicated to Sector C. As a general planning guide, the formula of multiplying operational positions by a factor of 1.6 will yield a comfortable staffing level as the full Natuna operation begins.

CNS/ATM innovations such as GPS, Data Link, CPDLC, RNAV, RNP, enhanced traffic management flow control, and the other controller tools referenced in this TA do not require additional staffing.

Management or overhead positions should be kept to a level where there is only one Operational layer between the facility manager and the control room staff and that layer would be the operational supervisors. Quality Assurance would report directly to the facility manager. A key principle is to keep the top management official knowledgeable of the service provided.

Training. Jakarta ATS has radar simulator. This training aid needs to be updated. It is of the utmost importance that the radar simulator be of world class quality because of the risk involved in having less than the best trained radar controllers; therefore, it is recommended that the radar simulator facility be state of the art such as the Adacel MaxSim.

Language Training. The ICAO designated language of aviation is English. The ICAO regional office is to conduct a survey of all Asia/Pacific States for the purposes of ascertaining States' readiness by March 2008 with ICAO provisions of Operational Level 4 language proficiency.

MACH Number Technique (MNT). MNT is currently used on ATS routes in Sector C by Singapore ACC. MNT training of Jakarta ACC controllers who have not had experience applying MNT will be required to achieve a working level of proficiency.

7.2 Associated Operational and Management Issues

Associated Operational and Management Issues reviewed by RVA include:

1. Search and Rescue (SAR). Indonesia is a signatory to an agreement between members of the Association of South East Asian Nations (ASEAN) concerning the facilitation of search for aircraft in distress and rescue of survivors of aircraft accidents. Sectors A, B, and C are currently within the Singapore FIR, and primary responsibility for SAR is with Singapore. With the acquisition of Sector C by Indonesia, primary responsibility for Sector C may revert to Indonesia.

2. Capacity. Developing System Capacity is dependent on the DGCA execution of a plan including CNS/ATM technologies and procedures that are harmonious with regional plans (APANPIRG agreements)/Global ANSP and user community plans as cited earlier.

3. Quality Assurance (QA). The Natuna Islands airspace project requires pre- and post-transition quality assurance reports validating the quality of the services provided. This QA program should develop a plan to address the shortcomings mentioned in the Master Plan. A schedule for addressing these shortcomings should be developed with milestones and scheduled progress reports.

7.3 Summary of Task 2 Recommendations

Task 2 recommends a progression from a remediated legacy infrastructure to a state-of-the-art CNS/ATM system commensurate with documented need and in accord with sustainable cost. Recommendations address the issues of capacity, efficiency, and system access; as such have the potential to improve service to the user. It is stressed that Natuna cannot initiate some actions by itself but should join with the regional ANSPs in pursuing excellence in service. Among the first order of business are the following seven issues.

Leadership - DGCA is encouraged to issue a written directive to subordinate offices requiring implementation of this TA as is considered timely. The DGCA's outstanding leadership now being provided should continue with resumption of ANSP services in the Natuna Islands airspace and activation of Indonesia's Master Plan.

Normalization of Infrastructure - All facilities must be maintained to appropriate standards.

VSAT facilities should be restored to their required operating specifications.

All Communication, Navigation and Surveillance facilities should be remediated as necessary.

The validation of all AIP information is a first order of business.

HF ER facilities on Natuna Islands should be accessed for possible needed restoration.

A budget and dedicated staff should be established for restoration activities.

7.3.1 Technology Considerations. In summary, Task 2 CNS Technologies requiring consideration include but are not limited to:

A transition from the Aeronautical Fixed Telecommunication Network (AFTN) to an Aeronautical Telecommunications Network (ATN) VDL M2 should be planned in concert with regional plans (APANPIRG agreements).

Flight Information Service (FIS). FIS should be migrated to a digital format and to ATN as ATN replaces the AFTN system which should be a priority project.

Flight Data Processing (FDP). Automatic Flight Data Processor (AFDP) is used for the processing of flight data and the preparation, coordination, and dissemination of control strips.

Upgraded to Required Navigation Performance (RNP) 5 as soon as possible so as to optimize usage of airspace. RNP-4 should be inaugurated at the earliest date.

The transition to GPS should be made in concert with the Regional GNSS plan.

ADS-B is recommended as the supplemental system to RADAR.

Natuna's and Batam's MSSR should be activated at the earliest date.

ATM Automation System will consist of an Air Traffic Management function, Weather Information Analysis and Display function, IDS-5 controller information display, URET, E-MSAW, CA, ATM data recording, an emergency/alternate airport map and Controller's Training and Backup functions. The IDS-5 should a priority controller support tool.

7.4 Operational and Management Issues for Consideration

1. Establish one Coordination/Flow Control desk within the CATCC.

2. Natuna management should support establishing the CATCC in proximity of the Jakarta ACC and the advisability of a backup facility in the new Batam Approach Control facility.

3. Develop ATM staff and procedures that serve user needs through support of regional plans.

4. Transition to a single technically competent and administratively strong management organization.

5. Use only one layer of supervision between the facility manager and the operation.

6. All staff must be briefed on emergency, alternate airport and security procedures prior to assuming control of the Natuna airspace.

7. Institute a professional development program.

8. Begin controller and engineer training.

9. Familiarize staff with new equipment.

10. Test all controller staff on new procedures and airspace.

11. Train controller in the use of MACH Number Technique (MNT).

12. Radar simulation should be the best available. Additionally, the device should also be capable of airspace modeling.

13. Language readiness by March 2008 - ICAO Operational Level 4 language proficiency.

14. Support visits to Singapore to clarify issues associated with Sector C.

15. Institute a quality assurance program.

16. Control room supervisors should enforce a policy of professional decorum.

17. Draft procedures and Letters of Agreement (LOA) must be developed to replace all present documents dealing with Natuna.

18. Convective Weather Information. Natuna should ensure the timeliness and accuracy of severe weather information.

19. Implement a Collaborative Decision-Making (CDM) like program.

20. Institute Uninterrupted Descent procedures.

21. Modernize coordination procedures. Automation should be used to electronically pass flight data information, boundary times, or to initiate handoffs to the next air traffic control facility.

22. Implement User Request Evaluation Tool (URET).

23. Implement more Direct Routes and the use of Flexible airspace through Sector C based on user request and system capability.

24. Sector C should have the capacity of harmoniously responding to adjacent service providers who allow flex routes.

25. Develop viable alternative airways using GPS.

26. Natuna ACC should offer its expertise and airspace planning staff to assist ICAO, IATA and users in the development of more efficient routes across the Natuna Airspace.

27. Develop RNAV RNP routes that would serve the soon-to-emerge private aircraft community.

28. The equipment spares policy should be changed.

29. Flight inspections should be brought up to date.

30. Current facility information should be published on a priority basis.

31. Aeronautical Information Services (AIS) System. AIS users transiting Sector C must be able to rely on the quality of aeronautical information published by Indonesia.

32. Correct any remaining deficiencies in WGS-84 coordinates.

Task 2 Conclusion

1. Indonesia is capable of resuming ANSP responsibilities of their sovereign airspace over Natuna Islands after assuring system integrity.

2. Indonesia is capable of providing quality and efficient services after completion of the action described in this TA.

8.0 Task 3

Task 3 requires the following in the Development of an Investment Plan:

Estimates of first order engineering costs (capital and annual).

Human Resources and training requirements costs.

Develop an initial investment plan.

Working with the managers and engineers.

Ensure that these officials are fully supportive and understand the magnitude of the investments.

8.1 Task 3 Objective. The objective of Task 3 is to identify the first order costs (capital and annual recurring operations and maintenance) necessary to satisfy the technical and human resources required to provide CNS/ATM coverage and air traffic services for the Natuna Sector C airspace. The total cost includes a level of initial investment and a recurring annual operating cost. The initial capital investment is difficult to determine since most of the CNS/ATM equipment requirements are met with existing equipment.

8.2 Financial Aspects. In summary, this task addresses the financial aspects of the project and addresses the most operationally acceptable and economically feasible way to resume ANSP responsibilities for Natuna Sector C airspace. The annual recurring costs will be used in conjunction with the estimated Route Air Navigation Services (RANS) charges (revenues) developed in Task 5 to complete the economic and financial analysis.

8.3 Alternatives and Associated Cost. This section of Task 3 will address those alternatives and associate a cost to each. Financing options vary with the type of expense, the extent of the investment, and the expected rates of return on the investment. Potential sources of financing will be identified later in this Task.

8.4 Cost Immediate Replacement. A cost basis is provided for the option of immediately replacing the existing equipment, and an estimated depreciation expense is also listed to provide a cost basis for using the existing equipment during initial transition of the airspace and allow a longer term transition to new CNS equipment or space based technology. The specific cost for acquisition and implementation of new equipment is extremely variable depending on the manufacturer, specifications of the equipment, and the range of options purchased (quantity, specific configuration, number of spares, training, shipping, site preparation, installation packages, etc.). The costs used in this section are the best estimates available.

8.5 Supplier Sources. A list of United States suppliers of CNS/ATM and ATC related equipment is provided in Appendix 4 of Task 3.

8.6 Remediation Cost Listing. The costs for of remediation of the existing equipment and to resolve any identified outstanding Air Traffic Management issues are included in the investment plan.

9.0 Area Control Center (ACC) Cost Considerations

9.1 ACC Cost Considerations include:

Land Acquisition/Lease.
Site Preparation.
Building Construction.
Operations Equipment.
Staffing and Training.
Recurring Building Maintenance.

9.2 Area Control Center Options are:

1. Natuna Islands ACC.
2. Batam Island ACC.
3. Jakarta ACC.

9.3 ACC Recommendation. It is the recommendation of this study to make the appropriate investments as outlined in the remaining parts of Task 3, to commission and certify the Sector C air traffic control position as established in the Jakarta ACC. The Jakarta site proximity to the DGCA Headquarters allows more effective oversight and use of subject matter experts and crisis management. Incorporating Natuna Sector C airspace management in Jakarta ACC has the following benefits over the other options:

- Allows efficient utilization of existing and future ATS/ATM human and capital resources.
- Gains economic efficiency implementing new CNS/ATM technology.
- Less equipment to purchase.
- Fewer connectivity costs to remote sensors.
- Allows integration of surveillance data (radar and ADS) into one database.
- Facilitates future CNS/ATM technologies integration.
- More centralized transition to space based technology.
- Improves Customer Service with better flow control and fewer transitions.
- Provides ready access for DGCA resources.
- Consistent with other regional practices; i.e., Thailand and the Philippines.

10.0 Transition Team Staffing

The transition team will provide oversight to ensure that all of the required actions necessary for a successful transfer are completed.

Table 5.1 - Transition Team

Position	Function	Number of Positions
Team Lead	Executive Leadership	1
Coordinator	External and Internal Coordination	1
Air Traffic Control Readiness	Operational Readiness of ATC	1
ACC Internal Integration	Assure CNS integration within ACC Sector C Position	1
CNS Technical External Sites	Assure CNS remote sensors operational readiness	1

10.1 Air Traffic Control Staffing. Based on information acquired during the in-country assessment, Natuna Sector C can be managed by a single ACC position with 24 hour/7 day coverage requirements.

Table 5.2 – Air Traffic Control

Position	Function	Number of Controllers
Air Traffic Control	Radar Controller	7
Air Traffic Control	Radar Associate Controller	3
Air Traffic Control	Operational Supervisor	3
Support Specialist	Training	1
Support Specialist	Airspace Procedures /Airman Information	1
Support Specialist	Quality Assurance	1
Support Specialist	Automation	1

10.2 Technical Operations Staffing. Equipment supporting air navigation services over Natuna Sector C will rely on CNS equipment currently installed at three locations: Natuna Island (NTA), Pontianak (PNK), and Tanjung Pinang (TPG). Three specialists at each location provide the level of equipment Operations and Maintenance (O&M) response to equipment failures and cover vacation and training time.

Table 5.3 - Natuna Sector C Airspace Technical Operations Support		
Position	**Function**	**Number of Specialists**
Engineering Specialist	Natuna (NTA) CNS equipment O&M	3
Engineering Specialist	Pontianak (PNK) CNS equipment O&M	3
Engineering Specialist	Tanjung Pinang (TPG) CNS equipment O&M	3
Engineering Specialist	Jakarta ACC equipment O&M	3
Engineering Supervisor	Supervise Engineering Specialists	1
Coordinator	Coordinate O&M between ACC and Remote Sites	1

11.0 Annual Recurring Costs

This section identifies the categories of annual recurring costs that are included in the development of the total cost to provide air traffic control radar services in the Natuna Sector C airspace. Recurrent costs are those yearly costs that are required to provide ANSP services in Sector C. They include Air Traffic Management (ATM) as well as Technical Operations CNS costs to meet training and staffing requirements and to meet CNS operational and maintenance and facility support requirements. These costs are incurred whether the existing equipment is used or replaced with new equipment. Equipment depreciation expense is listed separately, although it is also considered as an annual recurring cost to offset the life cycle of the equipment.

11.1 Personnel Compensation (Labor). The air traffic control and technical operations personnel compensation (labor) cost data include gross wages and salaries (paid labor) plus a 22 percent (22%) margin for employer contributions to retirement systems or pensions, employment taxes, health and life insurance, and other benefits with an associated employer cost. An additional 20 percent (20%) is added to include the corporate (AP-II) General and Administrative (G&A) support cost for items such as administrative and second level engineering support. The resulting rate is the "Fully Loaded" cost of employment. The calculated average "Fully Loaded" annual cost of employment is based on reported average compensation for air traffic control and engineering technician employees performing these functions.

11.2 Facility Support. Facility support costs include costs to support the infrastructure and the upkeep and maintenance of buildings structures and systems to house, service, and support CNS equipment.

11.3 Remoting (Telecommunications). An integral part of providing ATC services is for the control location to reliably receive the information provided by the remote sensors.

11.4 Training Cost. Training costs include initial and recurrent training to gain and maintain job proficiency in the performance of air traffic control activities and in equipment O&M activities.

11.5 Site Spares. Site spares costs include the average annual cost of replenishment of site spares used during the course of routine and corrective equipment maintenance. Appendix 3 of Task 3 contains a listing of typical spare parts for CNS equipment.

11.6 Flight Inspection. Flight inspection to assure the flight integrity of certain equipment is required on a periodic basis and on surveillance equipment as conditions warrant.

11.7 Depreciation. Depreciation is a non-cash expense that reduces the value of an asset due to wear and tear, age or obsolescence. Assets lose their value over time and must be replaced once the end of their useful life is reached. Whether new equipment is purchased or existing equipment is used, a capital cost recovery plan should be included in the cost recovery formula for providing ANSP services. Although listed separately, it is part of the annual recurring CNS expense to support Natuna airspace. Depreciation was determined by calculating a 20-year asset straight-line depreciation schedule with zero salvage value at the end of the life cycle using the cost of acquisition and installation of the equipment based on manufacturer's quotes when actual cost data is not available.

12.0 Sector C Airspace Cost Development

This section identifies the cost elements considered in identifying one-time and annual recurring costs to provide CNS/ATM radar separation air navigation services in the Natuna Sector C airspace. Cost categories include "Initial One Time" and "Annual Recurring" costs and are appropriately labeled in Task 3 and briefly discussed in the following.

The initial one-time costs for CNS equipment show the manufacturer's quotes for the type of equipment listed (equipment baseline), the initial site spare cost to ensure the equipment meets the reliability, availability, and mean time to repair requirements for global quality air navigation service providers.

Annual recurring costs are identified as costs incurred for all aspects of operations and maintenance and facility support needed for CNS equipment servicing Sector C and the ATM staff compensation recurrent training required to provide air traffic control services.

Adequate technical resources (CNS/ATM equipment) are in place and adequate human resources (controllers and technicians) are available to resume ANSP responsibilities for Natuna Sector C. The most economical, efficient, and expedient way to provide air traffic control in this area is to ensure the operability of the existing CNS/ATM infrastructure and to develop procedures and train controllers in Sector C air traffic management. This approach allows a baseline of the annual recurring and depreciation costs to be used with the calculated Sector C Route Air Navigation Services (RANS) charges revenues in subsequent cost analysis. New equipment cost estimates, along with a list of equipment manufacturers listed in Appendix 4 of Task 3, are provided to allow the option of purchasing new or upgrading the existing equipment.

12.1 Air Traffic Management (ATM). Table 7.4A shows the Air Traffic Management "One Time" investment and Table 7.4B is a summary of ATM costs including initial and recurrent training and annual operations to provide ATM services at the Jakarta ACC Natuna position.

Table 7.4A - Air Traffic Management "One Time" Investment

ATM Function	ATM system	
Traffic management	Air Traffic Management	$3.0M
Controller position	Controller information displays	$0.2M
Total		**$3.2 M**

Table 7.4B - ATM Initial Training and Annual Recurring Cost

Position	Initial Training	Annual Operations	Recurrent Training	Total Recurring	Total ATM Cost
Air Traffic Control	93,600	160,334	112,320	272,654	$ 366,254
ATC Support	28,800	53,912	34,560	88,472	$ 117,272
Total	**$122,400**	**$214,246**	**$146,880**	**$361,126**	**$ 483,526**

12.2 Summary of Costs. Tables in Task 3 show the summary of equipment investment, one-time, and annual recurring costs to provide air traffic control services in the Natuna Sector C airspace from the Jakarta ACC. Details are included in Appendix 5 of Task 3. Cost for salaries and travel for the Transition Team are not included.

Natuna Island CNS
Equipment **$ 5,520,000**
One-Time **$ 270,800**
Operations & Maintenance $ 399,255
Annual Depreciation $ 276,000
Total Annual Recurring **$ 675,255**

Pontianak CNS
Equipment **$ 5,520,000**
One-Time **$ 270,800**
Operations & Maintenance $ 399,255
Annual Depreciation $ 276,000
Total Annual Recurring $ **675,255**

Tanjung Pinang CNS
Equipment **$ 5,520,000**
One-Time **$ 270,800**
Operations & Maintenance $ 399,255
Annual Depreciation $ 276,000
Total Annual Recurring $ **675,255**

Jakarta ACC CNS + ATM
Equipment $ **180,000**
One Time **$ 3,330,400**
Air Traffic Management $ 361,126
Operations & Maintenance $23,344
Depreciation $ 9,000
Total Recurring **$ 393,470**

Table 7.5B - Summary of Annual Recurring and One-Time Costs

Service Activity	Equipment Base	Annual Depreciation	Operations	One-Time	Total Recurring	Total Recurring + One-Time
Communications	1,363,000	68,250	228,881	86,000	297,131	$ 383,131
Navigation	1,875,000	93,750	141,947	152,400	235,737	$ 388,137
Surveillance	13,500,000	675,000	850,242	582,000	1,525,242	$ 2,107,242
Air Traffic Control	-	-	361,126	122,400	361,126	$ 483,526
Air Traffic Mgmt	-	-	-	3,200,000	-	$ 3,200,000
Total	**$16,740,000**	**$ 837,000**	**$1,582,236**	**$4,142,800**	**$2,419,236**	**$ 6,562,036**

Note: Suggested Air Traffic Management budget of $3.2M USD includes the following approximations based on direct discussions with equipment manufactures:

- $1M USD for ATFM software that is compatible with neighboring ANSP's
- Specific suggestion: Barco OSYRIS Arrival and Departure Management Tool
- $.6M USD for radar simulator
- $.3M USD if a tower simulator is desired
- $.2 M USD for IDS-5 controller information displays

13.0 Project Financing

Finance information is detailed in the Task 3 report. Task 3 includes the following subjects in detail:

Financing Outlook.

Financing Options for CNS/ATM Infrastructure Investments.

Commercial Financing.

Vendor Financing.

Lender Financing.

Concessional Financing.

Bilateral Financing.

Potential Sources of Financing.

Risk Assessment.

14.0 Task 3 Conclusions

State-of-the art CNS/ATM systems would benefit Sector C operations.

Remediation of systems and procedures should be the first priority.

DGCA reported many projects in progress, such as ADS-B and GPS, which will benefit system users and reduce recurring cost for Indonesia. Accordingly, these CNS/ATM systems are not included in Task cost projections.

State-of-the-art CNS/ATM systems must be instituted in harmony with neighboring states and adjacent Air Navigation Service Providers (ANSP).

Resuming control of Sector C will allow full CNS coverage utilizing three surveillance systems, multiple VHF/HF frequencies, and three VOR/DME facilities. Full CNS coverage, with GPS, will allow improved, i.e., closer, RNP separation standards.

Closer RNP tolerance will facilitate more accurate separation standards, greater system access, and increased capacity while assuring the same or greater levels of safety.

Capital investment in technologically advanced CNS/ATM systems is recommended for wider application than found in Sector C and must be in concert with regional planning and agreements.

Installation of CNS/ATM systems such as CPDLC, ADS-B, GPS and Regional traffic flow management will benefit Sector C but must be initiated for larger areas than Sector C.

Studies, such as ARNFS, SOFREAVIA, and JICCA – adopted as the Indonesian Master Plan, all reference the need for Regional planning and implement

timeframes and regional agreements for demonstrations for various space-based systems and future technologies.

A policy to develop regional and global plans is endorsed by ICAO, IATA, and the majority of ANSPs.

Air navigation services providing radar separation for the Natuna Sector C airspace can be provided from the Jakarta Area Control Center using the existing CNS/ATM equipment with a relatively small amount of initial investment in transition planning, procedures development and training and technical quality assurance.

The primary equipment providing CNS coverage for Sector C is relatively new and is located at Natuna Islands.

The Natuna MSSR is the strategic key to radar coverage in the South China Sea.

A high degree of overlap surveillance coverage is provided by a brand new MSSR at Batam (replaces Tanjung Pinang SSR).

Additional CNS overlap is provided by equipment located at Pontianak. Although not recommended, an initial investment of an estimated $16,740,000 USD is required to replace the existing CNS equipment used to provide CNS coverage throughout Sector C.

Singapore ACC currently provides procedural air traffic services over Natuna Islands Sector C airspace; controlling this airspace from Jakarta ACC with existing CNS equipment will provide full CNS coverage while creating at least double the present capacity.

Air traffic control can be provided by one position at the Jakarta ACC staffed with 10 full performance level air traffic controllers, 3 operational supervisors and 4 support staff personnel. Reliable CNS coverage with redundancy, overlap, and adequate equipment performance and restoration requirements can be provided with existing CNS equipment by 12 engineering technicians, three each located at Natuna, Pontianak, Tanjung Pinang, and Jakarta ACC, along with one supervisor and one facility coordinator located at the Jakarta ACC.

New CNS equipment estimates are included as information on which to base decisions to replace or retain existing equipment. Baseline costs are also used in the calculation of depreciation expense for full cost recovery.

One-time costs to assure equipment readiness and capability to support ATC services at the required level of performance, provide controller training, and support transition team requirements are estimated at approximately $1 million USD. An

additional one-time cost of $3.2 million USD will provide a traffic management system, compatible with Singapore ACC and Controller information displays.

A complete listing of equipment and systems manufacturers is provided in Appendix 4 of Task 3. This listing includes equipment and sources that address needs beyond this particular TA. The sources listed are known creditable providers of excellent CNS/ATM systems worthy of serious consideration.

The estimated total annual recurring operating costs to provide Sector C ANSP, with the current level of CNS equipment is $1.6 million USD operating cost, with $0.8 million USD annual depreciation expense, for a total annual recurrent cost of $2.4 million USD based on 2006 cost estimates.

15.0 Task 4 Assessment of the Environmental Implications

Task 4 deals with the Assessment of the Environmental Implications of the Proposed Project. RVA identified key environmental issues of the proposed Project for review in accord with appropriate Indonesian law and requirements. These included land use impacts, noise pollution, wastewater impacts from discharges from the airports, disposal of fluids, batteries, and any toxic substances resulting from equipment operations, etc. RVA also discussed the extent to which the identified environmental issues could be mitigated. These factors shall be explicitly studied and their cost impact considered for inclusion in the project investment analysis.

15.1 Environmental Scope. The scope of this TA involves the application of CNS/ATM systems (equipment and procedures) to the task of providing for the return of Natuna Islands/Sector C Airspace Air Navigations Service Provider (ANSP) responsibilities from Singapore to Indonesia. Tasks 1, 2, and 3 discussed these issues in detail. Review of these previous Tasks clearly establishes that this TA encompasses only high altitude operations and airspace over open oceanic areas; no new routings, no airport operations, no establishment of new facilities, and no revision of airspace boundaries are involved in this TA.

15.2 Legal Requirements. In Task 4, RVA considered the legal requirements set forth in Republic of Indonesia Environmental Management Act (Government Act No. 23 of 1997), its required considerations as outlined below, and the technical and procedural recommendations of Tasks 1, 2, and 3.

- Achievement of harmony, compatibility and balance with human-beings.
- Formation of the environmental consciousness of the Indonesians.
- Guaranteeing the interests of present and future generations.
- Achievement of the preservations of environmental functions.
- Prudent control of the utilization of natural resources.

15.3 Environmental Impact Assessment (EIA). It is further understood that every activity/ project, which is considered likely to have a significant impact on the environment, must be accompanied by an environmental impact assessment (EIA).

15.4 CNS/ATM Benefits Environment. Indonesia's progressive planning to apply CNS/ATM technologies and procedures is consistent with global aviation leadership in respect to environmental concerns. An evaluation carried out for IATA by the National Aerospace Laboratory, Netherlands (NLR) which showed that speedier implementation of CNS/ATM could lead to a 9% improvement in CO2 emissions worldwide. It could also reduce aircraft emissions of oxides of nitrogen (NOx) by 8%, carbon monoxide (CO) and unburned hydrocarbons (HC) by 15-20%.

15.5 EIA Objective. The objectives of environmental impact assessment (AMDAL), stated in Government Regulation No. 27 of 1999, are as follows:

- To understand the present condition of the environment in the project area;
- To identify the particular activities of the project, this may induce a significant impact on the environment;
- To predict the environmental impacts and evaluate their magnitudes;
- To propose countermeasures for mitigation of the envisaged negative impacts; and
- To formulate plans for environmental management and monitoring.

15.6 Indonesia's Progressive Planning to apply CNS/ATM technologies and procedures is consistent with global aviation leadership. Recent (ICAO) modeling of CNS/ATM implementation in Europe and the United States points to a 5% reduction in global carbon dioxide (CO2) emissions by 2015. This is consistent with an evaluation carried out for IATA by the National Aerospace Laboratory; Netherlands (NLR) which showed that speedier implementation of CNS/ATM could lead to a 9% improvement in CO2 emissions worldwide. It could also reduce aircraft emissions of oxides of nitrogen (NOx) by 8%, carbon monoxide (CO) and unburned hydrocarbons (HC) by 15-20%. An earlier ICAO Intergovernmental Panel on Climate Change (IPCC) assessment similarly concluded that CNS/ATM implementation could lead to reductions of 6-2 % in global aviation-related CO2 emissions. The aviation industry strongly supports States' actions to improve CNS/ATM that:

- generate extra capacity to meet demand;
- increase safety levels;
- reduce costs; and
- provide environmental benefits.

15.7 Task 4 Conclusions

Task 4 was completed in compliance with the new Environmental Management Act (Government Act No. 23 of 1997) which was enacted in 1997.

This Act is acknowledged and was followed in the development of this TA.

It is understood that every activity and project, which are considered likely to have a significant impact on the environment, must be accompanied by an environmental impact assessment.

All of the operations in this TA occur above 1000 m with the vast majority occurring at cruse altitudes.

99+ percent of the resulting operations occur over the open sea.

No new facilities are introduced, only replacement equipment.

If the proposed expansion of the Jakarta ACC is adopted, that action would be the subject of a separate environmental review.

No equipment is recommended that could cause a toxic effect.

No operations are envisioned causing changes in airspace boundaries.

Application of CNS/ATM systems and procedures as recommended in this TA will benefit Indonesia and have no negative impact.

There is no introduction of actions causing a significant impact on the environment.

16.0 Task 5 Economic and Financial Analysis of the Proposed Investment Plan

Task 5 requires an Economic and Financial Analysis of the Proposed Investment Plan. Accordingly, RVA developed estimates of revenues from overflight charges. Additionally, RVA developed a revenue stream generated through the implementation of the Investment Plan developed in Task 3. Specifically, RVA developed a revenue stream from the resumption of ANSP services in Sector C which cause improvements by new airspace management system and air traffic services.

16.1 Economic and Financial Analysis. Based on the estimates for investment costs and revenues, RVA carried out an economic and financial analysis of the proposed Natuna airspace management project. This analysis included the calculation of the financial internal rate of return (FIRR) for a number of different scenarios of anticipated air traffic over Natuna and within the Indonesian airspace of Sector C. RVA also completed a sensitivity analysis based on different revenue and cost inflation variations.

16.2 Task 5 Objective. The objective of Task 5 is to develop the Financial and Economic Analysis of the Proposed Investment Plans as established in previous task. Task 3 provides the cost involved in development of the CNS/ATM plan set forth in Task 2. These costs are now, in Task 5, compared to estimates of revenues from overflight charges and a revenue stream generated through the implementation of the Investment Plan developed in Task 3.

16.3 Financial Consequences. RVA's Financial and Economic analysis presented in Task 5 provides the DGCA a detailed analysis of the financial consequences of the suggested Sector C CNS/ATM plan. Specifically, the results of this work resulted in RVA providing a projected revenue stream generated from implementation of Route Air Navigation Service (RANS) charges earned from the DGCA's resumption of ANSP services. These revenues were then compared to the cost of providing CNS/ATM services to the users of the Natunna Airspace Sector C.

16.4 Ten Scenarios. Based on these estimates for investment costs and revenues, RVA carried out a financial review of the proposed airspace management project including calculation of the financial internal rate of returns (FIRR) in 10 different scenarios. Details are in Task 5.

16.5 Sensitivity Analysis. RVA also completed sensitivity analysis for the same 10 scenarios based on potential variations in unit rate implementation schedules, traffic pattern changes, and inflationary cost. Details are in Task 5.

16.6 Decision Information. Decision making requires consideration of a multitude of different factors. In order to provide the DGCA a broad range of information, the following areas were considered and commented on. The net result is that the preponderance of information indicated the proposed investment in the Project will have a positive impact on the Indonesian economy.

17.0 Cost Recovery Principles

The systematic approach used in Task 3 to develop costs is consistent with Council recommendations that when establishing a cost basis for RAN Service charges the following principles apply:

The cost is the full cost of providing the air navigation services, including appropriate amounts for cost of capital and depreciation of assets, as well as the costs of operations, maintenance, and General and Administrative costs.

The cost to be taken included those assessed in relation to the Air Traffic Management (ATM) which is divided into Air Traffic Services (ATS), air traffic flow management (ATFM), and airspace management (ASM).

Ground and/or Satellite based aeronautical communications (including satellite lease service costs), navigation (including Global Navigation Satellite System (GNSS) and associated augmentation systems), and surveillance systems (including primary/secondary surveillance radars and other facilities supporting the Automatic Dependence Surveillance (ADS) or ADS-B Broadcast) necessary for safety and regularity of flights.

Any excessive construction, operation, or maintenance expenditures should be excluded.

Air navigation services may produce sufficient revenues to exceed all direct and indirect operating costs and so provide for a return on assets to contribute towards necessary capital improvements (new technology).

States may choose to recover less than full costs.

Each State should decide for itself, when, and at what level any air navigation services charges should be imposed.

The approach toward the recovery of full costs should be a gradual process.

17.1 Route Air Navigation Services (RANS) Charges. The International Civil Aviation Organization (ICAO) recognizes the right of each member contracting state to provide air navigation services within the airspace over its territorial land and seas. Furthermore, ICAO permits its member states to collect air navigation service fees to recover the expenses incurred in providing such services and for the improvement of aviation and airport facilities within the state. Revenue collections should be used to evaluate and improve the quality of Air Navigation Services provided.

17.2 Route Air Navigation Service (RANS) Charges Continued. Route Air Navigation Service (RANS) charges for Sector C are expected to be implemented similar to the fee implementation structure agreed for collection of Sector A RANS charges. Sector A fee collection procedures are described in Singapore AIP GEN 4.2 Air Navigation Service Charges resulting from an agreement made between representatives of the Civil Aviation Authority Singapore (CAAS) and the Directorate General Civil Aviation (DGCA) of Indonesia.

17.3 RANS Historical Perspective. Sector A RANS charges originated at a low rate of $0.15 in 1999 per ICAO General Council recommendations then are progressively increased on a yearly basis on 01 July over a 9-year period to a maximum equal to the current Indonesian rate of $0.65 per unit which will be effective 01 July 2008.

17.4 Determining the RANS Rate. The formula used for computing RANS charges is composed of three numbers; Unit Rate, Distance Factor (DF), and Weight Factor (WF) where the DF and WF are combined in a figure called the "Route Unit" resulting in the formula: RANS Charge = Unit Rate x Route Unit.

17.5 Expected Revenues. Two Options for a schedule of RANS fee implementation are presented. Both options show the projected monthly and annual revenues under conditions of constant traffic or with 5% annual traffic growth and constant or inflationary costs. The options are implementing $0.17 versus $0.29 in Year 1. Implementing a higher rate at the beginning of the cycle increases the overall revenues during the 15-year period analyzed and will result in a better rate of return; the negative side is the impact on users and their willingness to pay the higher rate at the onset of RANS fees.

17.6 Implementing a Year 1 Unit Rate of $0.17. Option one implements a unit rate of $0.17 in Year 1 with yearly increases in $0.06 increments reaching the current Indonesian rate of $0.65 in Year 9. In Task 5, Table 3.4.1 - Estimated RANS Revenues $0.17 Year 1, shows the expected revenues.

17.7 Implementing a Year 1 Unit Rate of $0.29. The second option implements a unit rate of $0.29 in Year 1 with annual incremental increases of $0.06 reaching the current Indonesian rate of $0.65 in Year 7. In Task 5, Table 3.4.2 - Estimated RANS Revenues $0.29 Year 1, shows the expected revenues for this option.

18.0 Financial and Economic Internal Rate of Return (FIRR/EIRR)

18.1 Internal Rate of Return. The Internal Rate of Return is a measure of the worth of an investment. The financial IRR is the interest rate that makes the present value of the investment's income stream add up to zero. The net present value (NPV) of an investment is the value of its future cash flows (benefits minus costs) discounted by a factor that reflects the time value of money. If the risks are equal, investments with higher internal rates of return pay better. Effectively, IRR is the value that would make an investor indifferent between receiving net benefits today versus in accordance with a projected schedule of revenue streams. The income stream (revenue minus costs) used in this analysis is determined by the projected Sector C revenue (RANS charges) minus the initial or "one-time" costs plus the annual recurring costs of providing ANSP services from the Jakarta Area Control Center (ACC). Task 5 contains scenarios detailing the determination of IRR.

18.1.1 Scenario Assumptions. All IRR scenarios presented are based on several assumptions concerning the initial development of one-time and recurring annual costs with consideration for potential inflationary effects, and in developing RANS charges (revenues) based on the Natuna Sector C current and projected traffic profiles, and in implementing fess at rates and phased in schedule consistent with past practices associated with Singapore Sector A.

18.2 Revenue Variations. Revenues variations are caused by two primary factors; Unit rate and traffic volume. Initial revenue and cost figures are based on the best flight information available and the assumption that RANS charges will be implemented at a lower rate in Year 1 and escalate at an incremental yearly rate of $0.06 to a maximum unit rate equal to the Indonesian rate of $0.65.

18.3 Cost Variations. Cost variations in these scenarios are calculated based on the expected increase in Operations and Maintenance (O&M) and Air Traffic Management (ATM) costs primarily due to the expected level of inflation over the life cycle of the analysis. Using the information contained in the Bank Indonesia Inflation Targeting Plan as a reference to evaluate inflation rates, IRR scenarios with cost variations were calculated using a flat rate inflation index of 5.0% and 8.23.0% applied to the total annual recurring cost.

18.4 Cost Allocation Process: The allocation of costs of air navigation services among users should be carried out in a manner equitable to all users. The Indonesian goals in this effort are to begin a process to resume control of airspace over its territory and to generate revenue to

subsidize its air traffic control system to continue providing air traffic management and to help finance the transition from ground-based to space-based technologies to better accommodate the projected 5.0% annual air traffic growth rate. The improved margin of safety by providing radar control and an increased level of services are key elements for ICAO approval and economic development.

18.5 Cost/Revenue IRR Scenarios. Ten scenarios are presented in Task 5 showing combinations of variations in revenue and cost. In all cases, the RANS charges are phased in beginning at a lower rate in Year 1 then progressively increasing at $0.06 each year until reaching the Indonesian rate of $0.65. In all scenarios, revenues are calculated considering both the rate increase for the appropriate number of years and the revenue (traffic) growth and/or cost increase (inflation) in Years 1 through 15. For the scenarios, two conditions are evaluated, one condition is initial implementation of a $0.17 rate in Year 1, the second is initial implementation of $0.29 in Year 1. For each condition, calculations were made to reflect a 5.0 % increase in revenue (traffic growth) and either a 5.0% or 8.23% (2004 and 2005 two-year Indonesian average) increase in cost (inflation). For each of the scenarios, the annual revenues, costs, net income, and effective Internal Rate of Return (IRR) are calculated and presented in the respective tables and graphs that follow. Table 4.4 "Scenario Conditions" shown in Task 5 list the 10 scenario conditions.

Table 4.4 – Scenario Conditions

Scenario	Rate at Year 1	Traffic (Revenue)	Cost
1	$0.17	Constant	Constant
2	$0.17	5.0% Annual Growth	Constant
3	$0.17	Constant	5.0 % Annual Growth
4	$0.17	5.0% Annual Growth	5.0% Annual Growth
5	$0.17	5.0% Annual Growth	8.23% Annual Growth
6	$0.29	Constant	Constant
7	$0.29	5.0% Annual Growth	Constant
8	$0.29	Constant	5.0% Annual Growth
9	$0.29	5.0% Annual Growth	5.0% Annual Growth
10	$ 0.29	5.0% Annual Growth	8.23% Annual Growth

18.6 Summary of Internal Rates of Return. The IRR will vary depending on the initial rate implemented in Year 1 and on the events that affect traffic and recurring annual costs. Naturally, the higher initial implementation rate, the greater the rate of return; however, past practice in implementing these type of fees dictates that prudence is the best approach for ICAO and IATA concurrences. Starting with a unit rate too low will greatly diminish the rates of return and will not allow accumulation of revenues for reinvestment in capital assets at the end of the useful life of existing assets. In Year 15, the CNS assets will reach the end of their useful life and depreciation expense will be used up. Assets will need replacement, retro-fit, or upgrading to newer space-based technology. Several plans and tests are underway to accommodate ADS/B, CPDLC, and GNSS technology. The RANS revenue stream should play a significant role in financing the new services addressed in Regional planning and in the Master Plan. Figure 4.4.11 in Task 5 shows a summary of the IRR for the various implementation scenarios.

18.7 Sensitivity Analysis: In Scenarios 1 through 10, the values affecting the potential outcome of the project were varied and financial internal rates of return (FIRR) recalculated. The three variables that are most measurable and have the biggest impact on the estimated revenues are the initial unit rate implemented in Year 1, the inflationary cost of Operations & Maintenance, and the amount of Sector C traffic. The assumptions were based on the best information available which indicate that traffic will grow at a rate of 5% and that costs will be inflationary at a rate of between 5.0% and 8.23%. The scenarios were developed considering those values. In each case, the Sensitivity Indicator (SI) and Switching Value (SV) were calculated with the results presented in Task 5 in Figure 5.0A, ***Sensitivity Analysis for Year 1 Unit Rate $0.17,*** and Figure 5.0B, ***Sensitivity Analysis for Year 1 Unit Rate $0.29.***

18.8 Sensitivity Variables. The Sensitivity Indicator compares percentage changes in the FIRR with percentage changes in either or both the traffic and the O&M cost input variables. The Switching value is an indicator of how a percentage change in one of the input variables (traffic or O&M cost) or combinations of both reduce the FIRR to the discount rate. In all cases, the discount rate was considered 0, i.e., no alternative investment opportunities were evaluated.

Task 5 Conclusions

1. Task 5 recommendations are in compliance with ICAO Doc 9082/6.

2. RVA's recommendations provide options and demonstrate outcomes.

3. Task 5 aims at managing IRR and cost.

4. These recommendations support Cost containment.

5. This plans gradual increase of charges is consistent with ICAO policy.

6. RVA's recommendations make best use of existing resources, both operationally and financially.

7. A minimal investment scheme and development of a capital cash flow model for future technology investment is consistent with ICAO policy.

8. Investments in un-required facilities and systems have a negative effect on the positive IRR.

9. Investments in un-required facilities and systems are against ICAO policy.

10. Early accumulations of funds ensure against future uncertainties.

11. Premature expenditures create fixed cost revenue drains.

12. Use of depreciation paves the way for future CNS capital investments.

13. Without use of depreciation and making full use of existing assets, a positive IRR would be significantly diminished.

14. These Recommendations establish a valid base for RANS charges.

15. RVA's plan avoids accusations of excessive construction and other expenditures.

16. The Remediation project and changing the spares policy are arguably a chargeable one-time event in compliance with ICAO's reliability requirement for new service provider facilities.

17. This plan's gradual new equipment investment pace allows maturing of CNS systems.

18. The Republic of Indonesia's objective of doubling the GDP is supported by these recommendations through conservative investments, maximum use of assets, creation of hi tech career positions, creation of a positive image of the Republic of Indonesia DGCA activities, and generation of cash reserves for future investments.

APPENDIX 1. ACRONYMS

ABAS	Airborne-Based Augmentation System
ACC	Area Control Center
ACF	Area Control Facility
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AFDP	Automatic Flight Data Processor
AFTM	Air Traffic Flow Management
AFTN	Aeronautical Fixed Telecommunications Network
AIC	Aeronautical Information Circular
AIDC	ATS Interfacility Data Communications
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMHS	Aeronautical Message Handling Service
AMSS	Aeronautical Mobile Satellite Services
ANSP	Air Navigation Service Provider
AP I & II	Angkasa Pura I & II
APANPIRG	ICAO's Asia-Pacific Air Navigation Planning and Implementation Regional Plans (APANPIRG Agreements) Group
ARINC	Aeronautical Radio, Inc.
ARSR	Air Route Surveillance Radar
ASEAN	Association of South East Asian Nations
ADB	Asian Development Bank

ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATIS	Airport Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATO	Air Traffic Operations
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
ATSU	Air Traffic Services Unit
B-RNAV	Basic Area Navigation
CA	Conflict Alert
CAA	Civil Aeronautics Administration
CATCC	Central Air Traffic Command Center
CDM	Collaborative Decision-Making
CNS/ATM	Communications, Navigation, Surveillance/Air Traffic Management
CO	Carbon Monoxide
CPDLC	Controller-Pilot Data Link Communications
CSFP	Center Stored Flight Plan
CY	Calendar Year
DATIS	Digital Airport Terminal Information Service
DCA	Directorate of Civil Aviation (Malaysia)
DGCA	Directorate General Civil Aviation
DGPS	Differential Global Positioning System

DME	Distance Measuring Equipment
DOC	Document
DVOR	Doppler VOR
EBRD	European Bank for Reconstruction and Development
E-MSAW	En Route Minimum Safe Altitude Warning
ENR	En Route European
EIA	Environmental Impact Assessment (EIA)
EIRR	Economic Internal Rate of Return
Ex-Im	Export-Import Bank of the United States
DF	Distance Factor
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIR	Flight Information Region
FIRR	Financial Internal Rates of Return
FIS	Flight Information Service
FTP	File Transfer Protocol
FUA	Flexible Use of Airspace
GBAS	Ground-Based Augmentation System
GMS	GPS Monitoring System
GLONASS	Global Orbiting Navigational Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

GRAS	Ground Regional Plans (APANPIRG Agreements) Augmentation System
GRS	Ground Reference Station
HC	unburned hydrocarbons
HF	High Frequency
HF ER	High Frequency Extended Range
HFDL	HF Data Link
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDS 5	Information Display System --- version 5
IFALPA	International Federation of Air Line Pilots Association
IFATCA	International Federation of Air Traffic Controllers' Associations
IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IPCC	Panel on Climate Change
IRR	Internal Rate of Return
ISPACG	Informal South Pacific ATC Coordinating Group
JCAB	Japanese Civil Aviation Bureau
JBIC	Japan Bank for International Cooperation
kHz	Kilohertz

LAAS	Local Area Augmentation System
LI	Letter of Interest
LOA	Letters of Agreement
M2	Mode 2 (two)
NM	Nautical mile
JCAB	Japanese Civil Aviation Bureau
MITRE/CAASD	MITRE Corporation's Center for Advanced Aviation System Development
MHZ	Megahertz
MNT	Mach Number Technique
MRS	Master Reference Station
MSAS	Multi-Functional Transport Satellite-Based Augmentation System
MSSR	Monopulse Secondary Surveillance Radar
MTSAT	Multi-Functional Transport Satellite
MOU	Memorandum of Understanding
NBIC	New Bangkok International Airport
NDB	Non-Directional Beacon
NLR	Netherlands
NOTAM	Notice to Airmen
NOx	oxides of nitrogen
NPV	Net Present Value
NTA	Natuna Island
ODA	Official Development Assistance
O&M	Operations and Maintenance

OLDI	Online Data Interchange
ORDD	Operational Readiness Demonstration Date
PDC	Pre-Departure Clearance
PIREP	Pilot Reports (weather)
PMS	Precipitation Map Service
PPL	Preliminary Project Letter
PIA	Project Incentive Agreement
QA	Quality Assurance
OPIC	Overseas Private Investment Corporation
RANS	Route Air Navigation Services
RASMAG	Asia/Pacific Regional Plans (APANPIRG Agreements) Airspace Safety Monitoring Advisory Group
RDP	Radar Data Processing
RFI	Radio Frequency Interference
RFP	Request for Proposals
RLRS	Reduced Lateral Route System
RNAV	Area Navigation
RNP	Required Navigation Performance
RVA	Robinson Aviation (RVA), Inc.
RVSM	Reduced Vertical Separation Minima
SADIS	Satellite Distribution
SATNAV	Satellite Navigation
SBAS	Satellite-Based Augmentation System

SID	Standard Instrument Departure
SIGMET	Significant Meteorological Conditions
SOIT	Satellite Operational Implementation Team
SOP	Standard Operating Procedure
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
TA	Technical Assistance
TFM	Traffic Flow Management
TIS	Traffic Information System
TRACON	Terminal Radar Approach Control
TSO	Technical Standard Order
TWS	Terminal Weather Service
URET	User Request Evaluation Tool
UTA	Upper Control Area
USTDA	U.S. Trade and Development Agency
VDL M2	Very High Frequency Data Link Mode 2
VDL	VHF Data Link
VHF	Very High Frequency
VHF ER	Very High Frequency Extended Range
UIR	Upper Information Area
VOR	VHF Omni-Directional Range
VOR/DME	VHF Omni-Directional Range/Distance Measuring Equipment

VSAT	Very Small Aperture Terminal
WAAS	Wide Area Augmentation System
WAFS	World Area Forecast System
WF	Weight Factor
WGS-84	World Geodetic Survey –84
World Bank	IBRD and IDA. The World Bank is a vital source of financial and technical assistance to developing countries

APPENDIX 2. UNITED STATES SUPPLIERS OF CNS/ATM AND ATC RELATED EQUIPMENT

Controller Displays:

Tech-Source

442 S. North Lake Boulevard
Altamonte Springs, FL 32701
USA
Tel: +1 407 262 7100
Fax: +1 407 339 2554
Email: info@techsource.com
Web: www.techsource.com

- Graphics controllers and controller display processors.

Tech-Source is most widely known for its Raptor PCI and GXTRA Bus family of graphics accelerators. A new line of STARS PCI graphics accelerators is used by Air Traffic Management Systems Integrators around the world. The STARS 2K will be used to upgrade air traffic control throughout the United States over the next ten years!

Systems Atlanta, Inc.

405 Toonigh Rd.
Woodstock, GA 30188 USA
Contact: Judy Davis, Director, Business Development
Telephone: (770) 928-0240
Fax: (770) 928-9396

The IDS-5 is highly recommended for the needs described in the report. The IDS Display puts critical information at the controllers finger tips. Systems Atlanta is an industry leader in development if integrated Information Display Systems (IDS) for ATC and the aviation industry. Systems Atlanta's IDS product line is operational in some 500 ATC/aviation facilities, including towers, radar approach, flight service, en route, military, airlines and airport operations. These systems display real-time data from multiple NAS sources consolidated with aeronautical reference data on a common integration platform. IDS data distribution networks link diverse ATC/aviation environments for shared situational awareness. Current Systems Atlanta programs and projects include the FAA's ACE-IDS and SA-IDS4 programs, the US Air Force's Airfield Automation System (AFAS) program, and IDS5-Airport Information Management (IDS5-AIM) for airport operations centers/emergency management facilities, among others.

Communications (Recorders):

Advanced Integrated Recorders

121 Whittendale Drive
Building 1
Moorestown, NJ 08057
USA
Tel: +1 856 234 5020
Fax: +1 856 234 5242
Email: danc@air.formation.com
Web: http://air2000.formation.com/

- Integrated data and voice recording and playback systems.
- AIR2000 synchronously records, plays-back, archives, and restores various types of information, such as: voice, radar, workstation screen, and TCP/IP socket (i.e., LAN) data. Scale ability, expandability, and enhance ability are three key requirements of the product architecture. Product configurations range from a single system with as few as 16 channels to a multi-node, multiple-archive storage device installation, capable of supporting over 1,000 channels of recorded information.
- AIR2000 can be used by Air Traffic Control Centers, Financial Centers, and Call Centers as a powerful tool for event analysis, performance evaluation, training, and risk management.

Comverse USA

234 Crossways Park Drive
Woodbury, NY 11797
USA
Tel: +1 516 677 7400
Fax: +1 516 677 7197
Email: marketing@cominfosys.com
Web: www.cominfosys.com/usa

- Digital voice and data recording and playback systems.
- ULTRA™ is the flagship product with a unique single platform for running multiple applications. These applications include: full-time recording of all calls; quality monitoring for agent evaluation and training; and on-demand monitoring for transaction recordings (such as sales centers); all on a single, client-server platform. This flexible and scalable design allows businesses to modularly start with one application and add additional applications without costly purchases of additional systems. A true multimedia platform, ULTRA can simultaneously record voice, data and video (screen capture), as well as fax. Comverse's unique Virtual Playback and Review feature, utilizing LAN, LAN/WAN or Internet, allows access to multiple supervisors from any desktop or telephone, anywhere in the enterprise. IP-ready, its advanced technology enables recording of voice over IP for Internet Call Centers, as well as LAN and LAN/WAN-based recording to support the next generation of PC-based and work-at-home agents.

Dictaphone Corporation

3191 Broadbridge Avenue
Stratford, CT 06614-2559
USA
Tel: +1 203 381 7000
Fax: +1 203 386 8597
Web: www.dictaphone.com/index.htm

- Digital recording and playback systems.
- Dictaphone's Enterprise Express improves customer's document creation processes by uniting leading edge technologies (speech recognition, digital mobile voice recorders, server based dictation / transcription job administration, document life cycle management, etc.).

Lanier Worldwide

2300 Parklake Drive NE
Atlanta, GA 30345
USA
Tel: +1 770 496 9500
Fax: +1 770 491 1534
Web: www.lanier.com

- Recording and playback systems.
- Advocate V recorder is a four-channel recorder, providing up to six hours of unattended recording time on standard cassettes. The reliable and economical Advocate V is perfect for recording courts of record, various legal proceedings, business and professional conferences. When used with the optional VOR/Time Injector, the Advocate V recorder can record telephone and/or radio traffic. It will also provide the date and time for each call.

Communications (Radios):

ARINC Incorporated

Mr. Randy Pizzi
Singapore
Tel: 65 9848 36 10
or
Mr. Steve Means
USA
410 266 4276

Web: www.arinc.com
D-ATIS, PDC, GLOBAL, VDL-2, ADS-B

- Air/Ground Communications:
  ARINC engineers, implements, and manages voice and data communications services that provide aviation operational and safety communications for aircraft throughout the world.
- Airport Systems:
  ARINC provides airports worldwide with integrated information, communications, and management systems that improve operations and enhance passenger service.
- Systems Engineering, Development, and Integration:
  ARINC delivers systems engineering, software development, and systems integration solutions to defense, government, and commercial customers.

Aydin Telemetry

47 Friends Lane
PO Box 328
Newtown, PA 18940-0328
USA
Tel: +1 215 968 4271
Fax: +1 215 968 3214
Email: telemetry@aydin.com
Web: www.aydin.com

- Air-ground radios.

Baker Audio-Telecom

2195 Norcross Tucker Road
Norcross, GA 30071
USA
Tel: +1 770 441 2000
Fax: +1 770 449 7719
Email: aamy@bakeraudio.com
Web: www.dispatchworks.com

- Voice communications and switching systems.
- DISPATCHWorks is a comprehensive, integrated, communications system provided by Baker Integrated Technologies. Baker has been providing these systems for over twelve years in mission critical applications including airline operations centers.

Harris Corporation (RF Communications)

1025 West NASA Boulevard
Melbourne, Florida 32919-0001
USA
Tel: +1 321 727 9207
Web: www.harris.com

- Turnkey air-ground radio systems featuring both analogue (VHF, UHF, HF) and digital (VDL multimode).
- VDL Mode 4
- VSAT
- All Communications

Motorola

1303 E. Algonquin Road
Schaumburg, IL 60196
USA
Tel: +1 847 576 5000
Web: www.mot.com/GSS/SSTG/RSO/Air_Traffic.html

- VHF and UHF air-ground radio systems.

GPS Products
- The Oncore family of Global Positioning System (GPS) products features modules, chipsets, and antennas ideal for a variety of GPS applications.

Satellite Communications
- Communication solutions for government and commercial space missions.
- UHF Satellite secure voice/data terminals for worldwide communications
- Satellite Communications Products: portable phones, pagers, mobile phones, portable docks, accessories and L-band transceivers.

Rockwell Collins

400 Collins Road NE
Cedar Rapids, IA 52498
USA
Tel: +1 319 295 1000
Fax: +1 319 295 5429
Email: mktgsvcs@collins.rockwell.com
Web: www.collins.rockwell.com

- Cockpit avionics including collision-avoidance, radio communications, and weather radar.

SATCOM 906

- The Collins SATCOM 906 is the world's first six-channel voice and data satellite communication system. This integrated system provides support for cockpit data and voice, as well as revenue-generating passenger telephone, fax and PC links.

HF Data Link

- Collins HF Data Link (HFDL) maximizes Aircraft Communications, Addressing and Reporting Systems (ACARS) messages, such as air traffic management, weather and airline operational communications. Collins HFDL is the basis for Automatic Dependent Surveillance (ADS) reporting and other services. Automated information transfer minimizes time delays and operational shortcomings inherent in conventional long-range voice communications.
- The Collins HFDL upgrade brings existing ARINC 719 HF voice radios into compliance with ARINC 753 and ARINC 635, enabling operators to realize the potential benefits and capabilities of the evolving CNS/ATM environment - at the lowest possible retrofit cost. The upgrade system, which meets or exceeds all the latest industry characteristics, includes data link provisions for the Aeronautical Telecommunications Network (ATN), the Future Air Navigation System (FANS), the Communications Navigation Surveillance System (CNSS), and other CNS/ATM operational applications.

Sensis Corporation

5793 Widewaters Parkway
DeWitt, NY 13214
USA
Tel: +1 315 445 0550
Fax: +1 315 445 9401
Email: info@sensis.com
Web: www.sensis.com

- The Sensis Air Traffic Systems group develops surveillance sensors and information systems aimed at increasing aviation safety, capacity and efficiency through improved situational awareness. The group focuses on advanced, low-cost sensors and real-time data communications that provide high accuracy, high update rate surveillance data for Advanced Surface Movement Guidance and Control Systems (A-SMGCS), Precision Runway Monitoring (PRM), Cockpit Display of Traffic Information (CDTI) via Traffic Information System - Broadcast (TIS-B), and Automatic Dependent Surveillance - Broadcast (ADS-B).

Telephonics

815 Broad Hollow Road
Farmingdale, NY 11735
USA
Tel: +1 516 755 7000
Fax: +1 516 755 7010
Web: www.telephonics.com/

- Telephonics integrates sophisticated multi-radar fusion tracking (MRT) and a highly efficient controller interface into the system for optimal performance. Aircraft identification, communication, command, control, data processing, flight training and simulation are all vital features of the "complete" Traffic Management System.

- Telephonics' AeroTrac™ Air Traffic Management System is an advanced en route and terminal automation system that features unparalleled radar capacity, tracking accuracy and flight information processing. Telephonics' AeroTrac has been proven in large scale Air Traffic Control (ATC) systems by tracking over 3000 aircraft, simultaneously processing over thirty radar sensors, and covering over nine million square miles of airspace.
- SkySearch-2000 is a low cost, high performance solution for adding new or expanded secondary surveillance radar coverage in terminal and en route areas. SkySearch-2000 SSR is a complete, turnkey SSR for terminal and en route radar applications.
- Suitable for Air Traffic Control in demanding environments, the ADP-2000 is an easy to use, completely self contained controller display and radar processing system.
- Telephonics' AeroTrac™ Simulator (SIM) is a flexible tool for training controllers in all phases of traffic control procedures.

Communications – Aeronautical Mobile Satellite System (AMSS):

Intelsat

3400 International Drive, NW
Washington, DC 20008-3006
USA
Tel: +1 202 944 6800
Fax: +1 202 944 7898
Web: www.intelsat.int/index.htm

- CLASS: The INTELSAT ground network and mission team has supported the launch of over 60 satellites for external customers.
- Voice and Data Services: Our telephone, fax, videoconferencing and multimedia traffic reaches virtually every country in the world. IBS, IDR, TDMA, DAMA, Internet, VSATs.

Navigation:

Wide Area Augmentation System (WAAS)

Raytheon Company

141 Spring Street
Lexington, MA 02421
USA
Tel: +1 781 862 6600
Web: www.raytheon.com

- Raytheon offers a complete turnkey, low risk transition solution for CNS/ATM.
- We present Multi-Mode VHF Radio System (MMVRS) for ground-air services.
- For Aeronautical Telecommunication Networks of the future Raytheon has developed an AtN Router, Radio Interface Unit (RUI), ground Network Interface unit (GNI), and Data Link applications Processor (DLAP).

- Raytheon has worldwide installations of SATCOM/VHF/H and aeronautical telecommunications networks, DGPS/WAAS/LAAS navigation systems and air traffic management automation systems.
- The Communication Systems unit designs, develops, manufactures, and supports communication products, systems and software to provide critical voice, data, imagery and telemetry communications for ship, aircraft, satellite and ground station applications. Integrated Systems specializes in flight simulations, modeling and simulation, air traffic control, and command and control systems. Imagery and Geospatial Systems designs, develops, installs and supports real-time and near-real-time hardware/software systems, high-performance computing, advanced architectures and open systems employed in information handling, digital imaging applications and signal processing. Strategic Systems designs, develops, produces and supports advanced hardware and software systems including systems engineering and integration for automated signal processing systems, electronic countermeasures systems, unmanned vehicle payload systems and remotely controlled reconnaissance systems.

Local Area Augmentation System (LAAS)

Honeywell Airport Systems

5353 West Bell Road
Glendale, AZ 85308
USA
Tel: +1 602 436 4808
Fax: +1 602 561 4777
Email: Hilary.King@cas.honeywell.com
Web: www.cas.honeywell.com/airport_systems

- Satellite-based precision-landing systems.
- LAAS and E-LAAS

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Lexington, MA 02421
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Surveillance:

Radar

Northrop Grumman Corporation

1840 Century Park East
Los Angeles, CA 90067-2199
USA
Tel: +1 310 553 6262
Web: www.northgrum.com

- Air Traffic Control Systems: In ground-based radar technology, the company is one of the world's leading producers of airspace management systems for both commercial air traffic control (ATC) and military air defense systems. It has developed and produced the ASR-12 primary surveillance radar for international customers. The ASR-12 is the solid-state derivative of the ASR-9, the primary surveillance radar in use at 140 airports in the United States and at 17 international sites. In addition, its wholly owned British subsidiary, Park Air Electronics Ltd., has installed ATC communications equipment in more than 150 countries.
- ASR-12 Primary Surveillance radar and MSSR are derived from the ASR-9 and Mode S, the most advanced terminal radars in the world.
- Advanced surface movement guidance and control systems
- ARSR-4: high performance with low operating cost long-rang, 3-D, joint-use surveillance.

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Transtech

1011 Carlsesa drive
Aliquippa, Pa. 15001
USA
706 864 0121
e-mail: John Moffatt@aero-sci.com
www.transteck-solutions.com

Low cost, effective surveillance systems for ramp control and other unique applications.

Telephonics

815 Broad Hollow Road
Farmingdale, NY 11735
USA
Tel: +1 516 755 7000
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Web: www.telephonics.com/

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flight information processing. Telephonics' AeroTrac has been proven in large scale Air Traffic Control (ATC) systems by tracking over 3000 aircraft, simultaneously processing over thirty radar sensors, and covering over nine million square miles of airspace.

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- Suitable for Air Traffic Control in demanding environments, the ADP-2000 is an easy to use, completely self contained controller display and radar processing system.
- Telephonics' AeroTrac™ Simulator (SIM) is a flexible tool for training controllers in all phases of traffic control procedures.

Automatic Dependent Surveillance (ADS)

ARINC Incorporated

Mr. Randy Pizzi
Singapore
Tel: 65 9848 36 10
or
Mr. Steve Means
USA
410 266 4276

Web: www.arinc.com
or

2551 Riva Road
Annapolis, MD 21401-7465
USA
Tel: +1 410 266 4000
Web: www.arinc.com

- Air/Ground Communications:
  ARINC engineers, implements, and manages voice and data communications services that provide aviation operational and safety communications for aircraft throughout the world.
- Airport Systems:
  ARINC provides airports worldwide with integrated information, communications, and management systems that improve operations and enhance passenger service.
- Systems Engineering, Development, and Integration:
  ARINC delivers systems engineering, software development, and systems integration solutions to defense, government, and commercial customers.

Harris Corporation

1025 West NASA Boulevard
Melbourne, Florida 32919-0001
USA
Tel: +1 321 727 9207
Web: www.harris.com

- Harris RF Communications is focusing its technical expertise and innovation in radio communications on providing the worldwide air traffic control (ATC) communications industry with next-level HF, VHF, and UHF digital radio products and systems for civil and defense aviation agencies. These multimode voice and data radios meet both current and future global operational needs of ATC customers, protecting their investment well into the future.

VDR 2404D-1 ATC Operator Panel

VDR 2404D-1 Operator Panel provides the ATC operator with remote audio, keyline, and control of the system radios. It may be connected to a full main/standby transceiver set via VDR-2403D-1/2 Switching Units or directly to a non-redundant transceiver set. Location may be over 300 meters from the radio equipment.

- VLR-4141 & VLR-4201 Transmitter and Receiver
  The VLR-4141 Transmitter and VLR-4201 Monitor Receiver form a radio data broadcast subsystem for use in ground based augmentation systems such as LAAS. The radio transmits data in compliance with the LAAS Signal-in-Space Interface Control Document (DO-246), with real-time monitoring and demodulation of the transmitted signal, station transmitter and monitor receiver.

- Series 3000 Voice & Data Ground-to-Air Radio System
  The VDR-3205 and VDR-3135 represent a new generation of ground-to-air VHF multi-mode radio equipment to meet the changing and demanding needs for air traffic control communications (ATCC). The Series 3000 radio system is a simple and cost-effective solution for analog AM voice ATCC applications including both 25 kHz and 8.33 kHz channels. These units are also available with the new digital waveforms (defined by ICAO and the US FAA) ensuring a "Future Proof" solution addressing today's and tomorrow's requirements.

- Series 2000 Voice & Data Ground-to-Air Radio System
  The VDR-2205 and VDR-2135 represent a new generation of ground-to-air VHF multimode radio equipment to meet the changing and demanding needs for air traffic control communications (ATCC). The Series 2000 radio system is a simple and cost-effective solution for analog AM voice ATCC applications including both 25 kHz and 8.33 kHz channels. These units are also available with the new digital waveforms (defined by ICAO and the US FAA) ensuring a "Future Proof" solution addressing today's and tomorrow's requirements.

Lockheed Martin ATM

9221 Corporate Boulevard
Rockville, MD 20850
USA
Tel: +1 301 640 2460
Fax: +1 301 640 3416
Web: www.lmco.com/atm/

- Turnkey en route and terminal air traffic management automation systems.
- Lockheed Martin is a full service provider. To meet the growth of global air traffic, Lockheed Martin is developing advanced automation and infrastructure systems. Lockheed Martin will leverage its experience with commercial-off-the-shelf product integration, advanced capabilities with open architecture solutions, and other applications to provide a wide range of non-developmental alternatives to meet air traffic control customers' specific requirements.
- Lockheed Martin can provide total system solutions, including financing. These solutions can range from individual air traffic management (ATM) products to long-term national level air navigation service upgrades.

Northrop Grumman Corporation

1840 Century Park East
Los Angeles, CA 90067-2199
USA
Tel: +1 310 553 6262
Web: www.northgrum.com

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Metron Aviation

Metron Aviation, Inc.
131 Elden Street, Suite 200
Herndon, VA 20170

Voice: (703) 456-0123
Fax: (703) 456-0132

Jack Kies, CEO

Mr. Norm Fujisaki, President.

Metron Aviation fuses the principles of science and mathematics with unparalleled domain knowledge to provide dynamic and innovative solutions to airspace constraints in the advancement of Traffic Flow Management concepts. Metron Aviation staff work in conjunction with FAA, airlines, NASA, academia and private industry to ensure modernization of the National Airspace System accommodates increased demand while balancing the need for customers to be informed and safe. Building upon this experience, Metron Aviation has developed a heightened awareness for aviation initiatives and detailed understanding of airspace constraints to address challenges faced by Air Traffic Management. Metron Aviation key focus areas include:

System Operations
Metron Aviation provides assessment of air transportation issues and inefficiencies to identify

new procedures and technology requirements. Leveraging lessons learned, Metron Aviation applies domain knowledge and distributed planning sciences to synthesize future operational concepts and system wide solutions for clients.

Software Development
Metron Aviation has a proven track record in the development of prototype systems and is uniquely qualified to develop practical solutions for complex problems inherent to air transportation systems throughout the world.

Analysis
Vast collections of data combined with extensive knowledge of Traffic Flow Management concepts have kept Metron Aviation at the forefront of NAS analysis.

Research & Development
Transitioning viable ideas for improved operations from concept to implementation is the motivation behind Metron Aviation's Research and Development program.

Motivated by service to the flying public, Metron Aviation provides system solutions for Air Traffic Management and the Aviation Community.

Telephonics

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Farmingdale, NY 11735
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Rannoch Corporation,
1800 Diagonal Road, Suite 430
Alexandria, VA 22314
TEL: 703-838-9780
FAX: 703-838-3676

Aircraft Multilateration ADS-B Surveillance System (SY-400)

The SY-400 series combines Rannoch's SSR decoding and time tagging systems with data communications and central processing to provide a comprehensive surveillance system. Using 3 or 4 remotely sited receiver decoders, the system can accurately track aircraft position and provide aircraft identification details. The system can use either the PC-based decoders or the VME-based decoders, depending on performance requirements. Data communications are handled via dial up modem, leased line, RF modem or ethernet.

Power Systems:

TSi Power Corporation

Since 1992, TSi Power has supplied several thousand **AC power conditioner, AVR (automatic voltage regulator), UPS, DC to AC inverter & ATS (automatic transfer switch)** systems.

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