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FEASIBILITY STUDY FOR CENTRAL ASIA

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AIR TRAFFIC MANAGEMENT/ COMMUNICATIONS, NAVIGATION, SURVEILLANCE

FINAL REPORT
APRIL 2009

Clients: Kazaeronavigatsia

Contractor: DORS Incorporated

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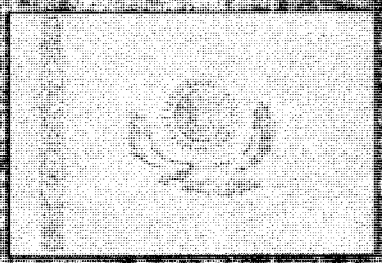
Central Asia Study
Final Report
CNS/ATM Regional Implementation

Prepared by DORS International



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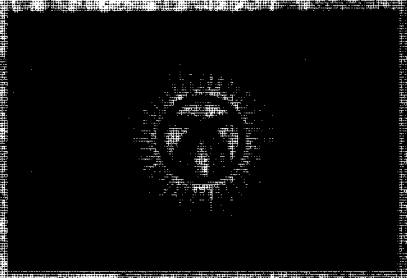

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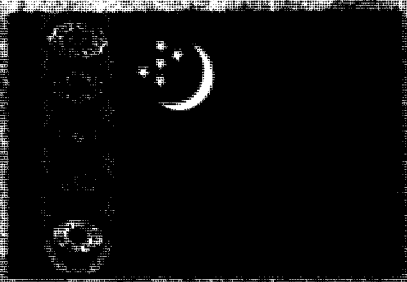

Turkmenistan

Uzbekistan

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Executive Summary

Background

In line with the latest global trend in Communications, Navigation, and Surveillance/Air Traffic Management (CNS/ATM), the Air Navigation Service Providers (ANSP) in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan obtained US Trade and Development Agency (USTDA) assistance in the development of a plan that will provide the guidance needed to achieve a successful transition from the traditional ground-based Air Navigation Services/Air Traffic Control (ANS/ATC) system to the new satellite-based CNS/ATM system.

To accomplish this goal, the five ANSPs have agreed to establish a Project Working Group (WG), consisting of a minimum of two participants from each ANSP, to represent the interests of their respective organizations. Each ANSP assigned one ATM operations specialist and one ATM technical expert to participate in the WG. Additionally, the ANSP from Kazakhstan was selected to act as the overall coordinator of the Study and was therefore responsible for assigning a National Project Coordinator (NPC), in addition to its two WG participants.

DORS Incorporated, a US based company, was selected via an open competition to conduct the study. Study funding was provided via the USTDA in accordance with the grant agreement.

The terms of reference of the grant agreement and subsequent contract contained fifteen tasks. The specific task descriptions are as follows:

- Task 1: Development of a Work Plan
- Task 2: Document Review
- Task 3: Site Visits
- Task 4: Identify the Status of CNS/ATM Implementation by ICAO in the Region
- Task 5: Working Group Seminar
- Task 6: Determine the Airspace User Requirements
- Task 7: Determine CNS/ATM Development Requirements
- Task 8: Working Group Meeting: A Regional Approach to CNS/ATM Transition Planning
- Task 9: Determine the Best Technology Options based on Operational Benefits vs. Cost
- Task 10: Preliminary Environmental Assessment

- Task 11: Develop Traffic Forecasts
- Task 12: Financial Evaluation and Identification of Potential Financing Sources
- Task 13: WG Workshop: Drafting the CNS/ATM Transition Plans
- Task 14: Promulgating the Draft CNS/ATM Transition Plan and Providing Technical Assistance for Consensus Building
- Task 15: Prepare a Final Regional CNS/ATM Transition Plan

The initial projected timeframe for completing these tasks was estimated to be approximately 18 months. Unfortunately, an unforeseen series of external events resulted in a prolonged study period. These events are briefly summarized as follows:

The Task 1 "kickoff meeting" was held in Almaty, Kazakhstan during the period 31 Jan-1 Feb 2005. The meeting was successful, and all parties enthusiastically supported the study objectives; Task 1 was completed 1 Feb 05. Task 2 was successfully completed in May 2005.

Task 3 data collection activities began in February 2005 and inputs from all States were received by July 2005. The information provided was reasonably complete and established a solid platform for conducting the on-site airport/air traffic control center surveys in the Region. Note: The participants refused to discuss pricing and revenue collection mechanisms; financial status, capabilities and commitments. These surveys were initially planned for August 2005, but due to difficulties in obtaining visas and availability of local site personnel the August date was not met. By October 2005 it was clear that Kazakhstan, Kyrgyzstan, and Tajikistan would provide the requisite support for the site surveys, but Turkmenistan and Uzbekistan remained a problem. A decision was made to proceed with the site surveys in Kazakhstan, Kyrgyzstan and Tajikistan. These surveys were conducted in November 2005 with full support of Kazaeronavigatsia personnel during the site visits at each of the locations in the three States. The site survey report for each of these sites was completed in January 2006.

Kazaeronavigatsia personnel continued the difficult task of obtaining permission from Uzbekistan and Turkmenistan officials for entry visas for DORS site survey personnel. In August 2006, Kazaeronavigatsia advised that the requisite coordination and visa permission had been obtained and a Uzbekistan/Turkmenistan site survey visit was planned for September 2006.

Kazaeronavigatsia personnel suggested it would be best for DORS personnel to travel to Almaty, obtain the visas while in Almaty and then proceed to locations in Uzbekistan and Turkmenistan. Due to the availability of flights to/from the survey locations in Uzbekistan and Turkmenistan it was also suggested that a minimum of twelve days be allocated for the visit. DORS personnel concurred with the Kazaeronavigatsia suggestions. In addition, DORS personnel suggested that a one day working group meeting be held in Almaty prior to beginning the site surveys. Although such a meeting was not required by the terms of reference, given the study delay and a request by USTDA to consider expanding the Central Asia Study to

include Afghanistan and Pakistan, it would be reasonable to meet with working group representatives. Kazaeronavigatsia personnel concurred and a working group meeting was planned for 6 Sep 2006.

DORS personnel made the requisite international travel arrangements (2-18 Sep 2006; Washington DC—Almaty; Ashgabat—Washington DC) and Kazaeronavigatsia personnel made local travel arrangements for locations in Uzbekistan and Turkmenistan. As with the site surveys conducted in November 2005, local travel arrangements for the sites to be visited were for both DORS and Kazaeronavigatsia representatives.

The 6 Sep 2006 working group was held at Kazaeronavigatsia offices and all meeting objectives were successfully completed. The addition of Afghanistan and Pakistan was supported.

Following the working group meeting DORS was informed by Kazaeronavigatsia that a visa had been obtained for Uzbekistan, but it would not be possible to obtain a visa for Turkmenistan. Flight arrangements to Uzbekistan were confirmed for the morning of 7 Sep. Approximately one hour later (1800 on 6 Sep 06), DORS personnel were informed that management had decided to withdraw Kazaeronavigatsia personnel support for the site visits to Uzbekistan and Turkmenistan, and that local travel arrangements had been canceled accordingly. No reason was provided for this decision.

DORS personnel returned to the US without conducting Task 3 site surveys in either Uzbekistan or Turkmenistan.

In October 2006 Kazaeronavigatsia informed DORS that their support would be available for conducting site surveys in Turkmenistan and Uzbekistan. DORS personnel completed the site surveys in Turkmenistan and Uzbekistan during the period 13-17 November 2006. The final draft report for Task 3 was completed in December 2006.

In early 2007 (Jan-Feb timeframe) DORS personnel were informed that the approval to amend the current contract to obtain Afghanistan and Pakistan has been requested and the outlook was positive. A key objective would be to include both Afghanistan and Pakistan in the overall regional CNS/ATM transition plan. To accomplish this objective it would be necessary to complete Task 1-3 activities for both Pakistan and Afghanistan. Kazaeronavigatsia supported delaying the continuation of the ongoing Central Asia study until a contract amendment had been drafted and approved by all appropriate parties.

DORS completed Task 4 for the five Central Asia countries in March 2007. The planned April 2007 Task 5 Working Group Seminar was delayed pending completion of the contract modification.

In preparation for Task 6, an airspace user questionnaire was prepared and provided for distribution by the Working Group. These questionnaires were distributed and

during the period Oct 2006—Jan 2007 DORS received the information required to complete Task 6 for the five Central Asia states.

The contract amendment for the addition of Afghanistan and Pakistan was sent to Kazaeronavigatsia for their approval on 6 July 07. In Sep 07 Kazaeronavigatsia notified USTDA that they would not approve the amendment to the contract.

Due to the lengthy delay since the onset of the study, DORS personnel believed it would be in the best interest of all participants to update the Task 2, 3 and 4 report data. The Central Asia participants were requested for updated information and DORS personnel re-evaluated and revised the Task reports accordingly. Working Group meetings were scheduled to resume in March 2008, but due to visa difficulties and Central Asia personnel availability, the meeting was postponed until 21-22 April 2008.

With the study activities for the five Central Asia states back on track, DORS personnel continued with the execution of the tasks. Some minor difficulties and delays were encountered, but they were considered normal for a regional study of this magnitude.

Summary

This Final Report is a compilation of the overall study task deliverables and provides the essential information and guidance for the participating Central Asia to evolve from a traditional CNS/ATM infrastructure to a next generation, satellite based architecture.

Site Visits and Survey Reports

KAZAKHSTAN
AIRPORTS
N
RUSSIA
MONGOLIA
Petropavlovsk
Soltustik Qazaqstan
Qostanay
Rudnyy
Pavlodar
Atbasar
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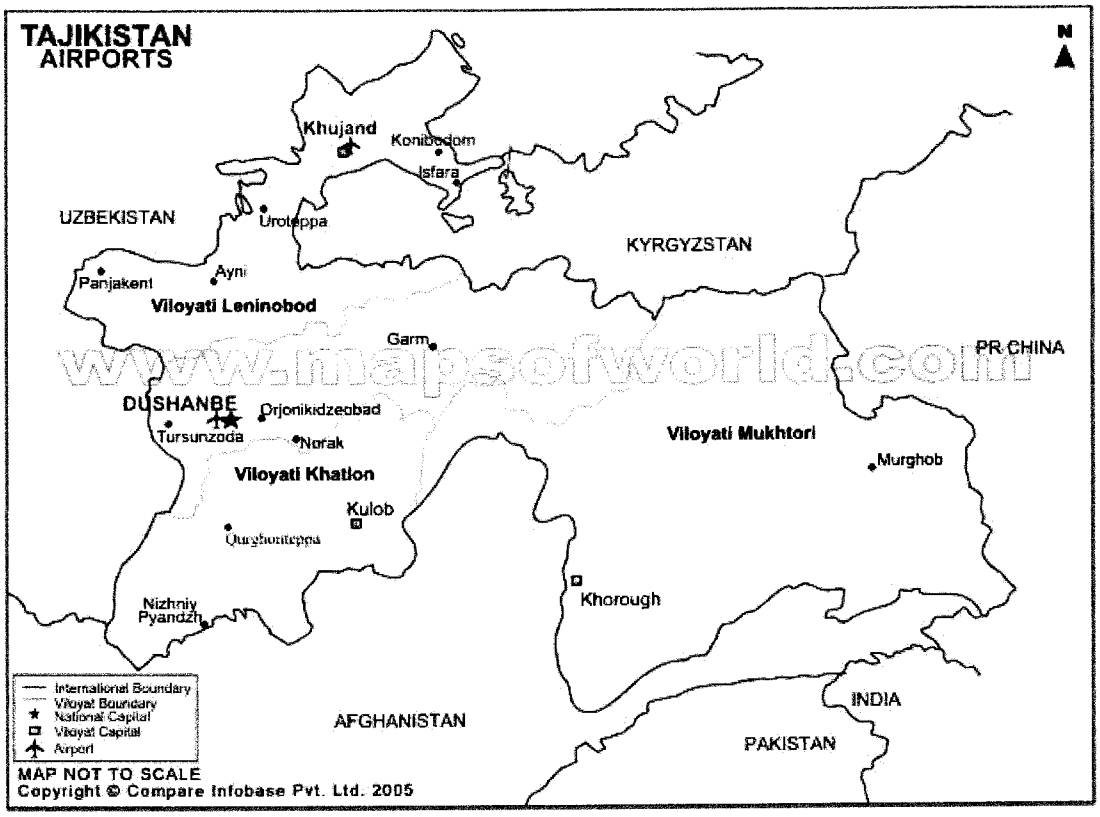
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Lebap Welayaty
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Quqon
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Nawaoiy
Samarqand
Farghona
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Bukhoro
TAJIKISTAN
Qashqadaryo
International Boundary
Republic Boundary
National Capital
Governorate Capital
Airport
A district has the same name as its capital except where mentioned separately.
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AFGHANISTAN

Introduction

In line with the latest global trend in Communications, Navigation, Surveillance and Air Traffic Management (CNS/ATM), the Air Navigation Service Providers (ANSP) in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan obtained US Trade and Development Agency assistance to conduct a Feasibility Study for the purpose of developing a plan that will provide the guidance needed to achieve a successful transition from the traditional ground-based Air Navigation Services/Air Traffic Control (ANS/ATC) systems to the new satellite-based CNS/ATM system.

To accomplish this goal, the five ANSPs agreed to establish a Project Working Group (WG), consisting of a minimum of two participants from each ANSP, to represent the interests of their respective organizations. The ANSP from Kazakhstan (Kazaeronavigatsia) was selected to act as the overall coordinator of the Study and would therefore be responsible for assigning a National Project Coordinator (NPC), in addition to its two WG participants.

A key task of this study is to conduct site surveys in order to determine the status of each country's ANS/ATC system, as well as the status of national development aims for the CNS/ATM system. Kazaeronavigatsia personnel and individual WG participants from each State accompanied DORS representatives during the completion of this task.

Site Survey Report

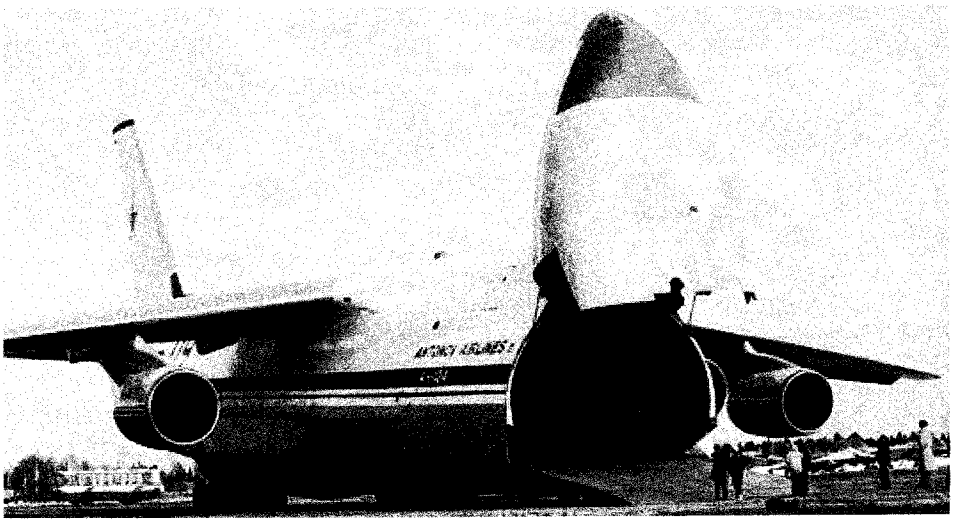
Area Control Center (ACC) Almaty, Kazakhstan

November 7, 2005

Overview

The principle airport servicing both domestic and international flight operations to/from Kazakhstan is the Almaty International Airport.

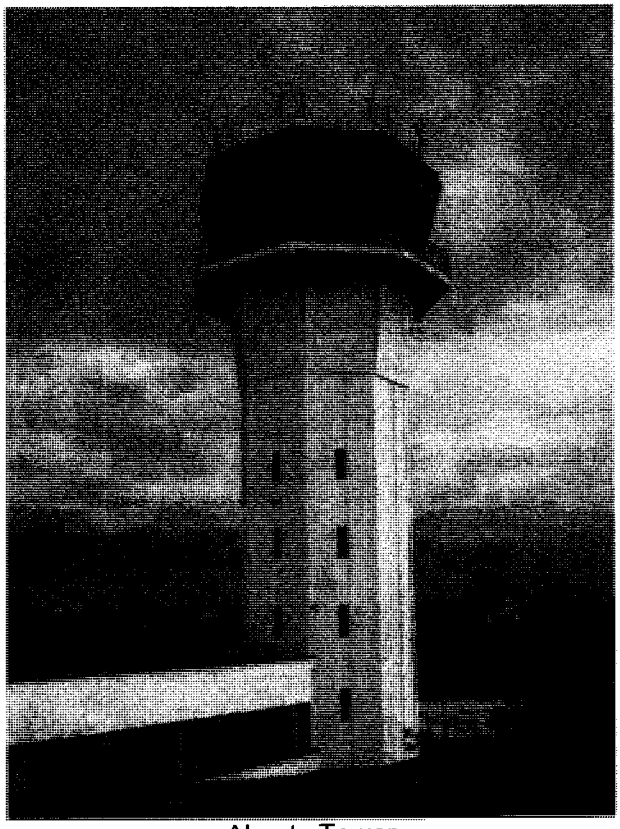
The Almaty airport has undergone significant expansion and modernization during the past five years. Most notably has been the opening of a new passenger terminal in 2003 and the installation of facilities that can support all classes of aircraft to include the world's largest aircraft, such as the Boeing 747 and Antonov 124 CONDOR (maximum weight 392 tons).



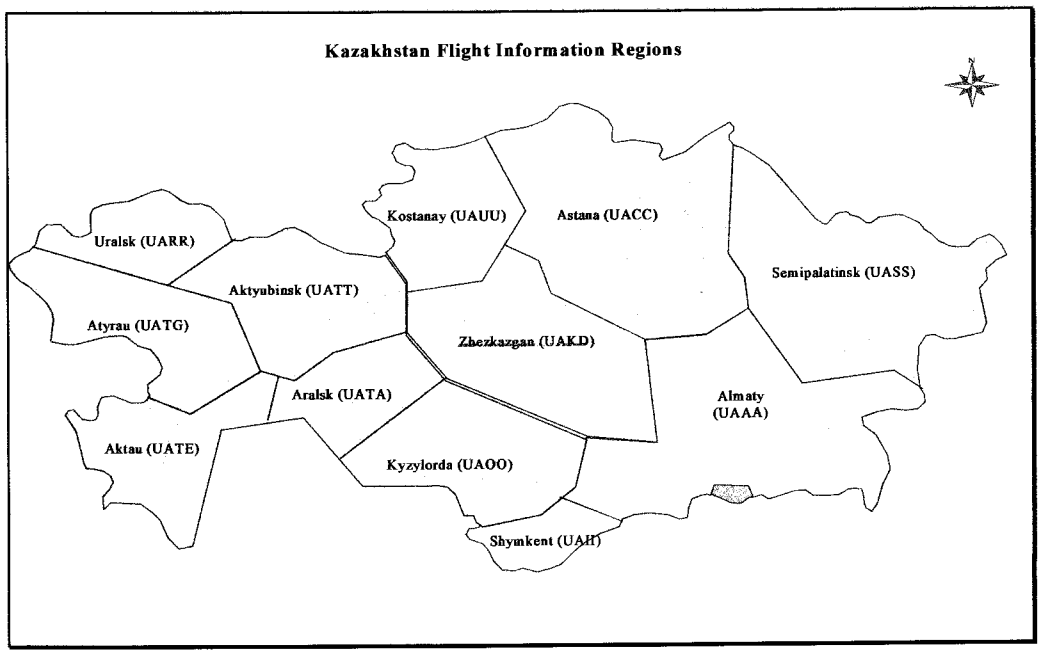
AN-124 CONDOR Long Range Heavy Transport Aircraft

Several leading foreign airlines have regularly scheduled flights to Almaty, to include Lufthansa, KLM, Korean Air, British Airways and Air France.

The Almaty Area Control Center (ACC) provides the requisite safe and efficient air traffic services for these airlines as well as all aircraft operating within the Almaty ACC area of responsibility. As one of the four major area control facilities providing air traffic services in the Kazakhstan flight information regions, the Almaty installation has been recently upgraded to state-of-the-art conditions. The new tower is fully equipped to house, maintain and operate modern communications, navigation and surveillance and air traffic management systems (CNS/ATM).



Almaty Tower

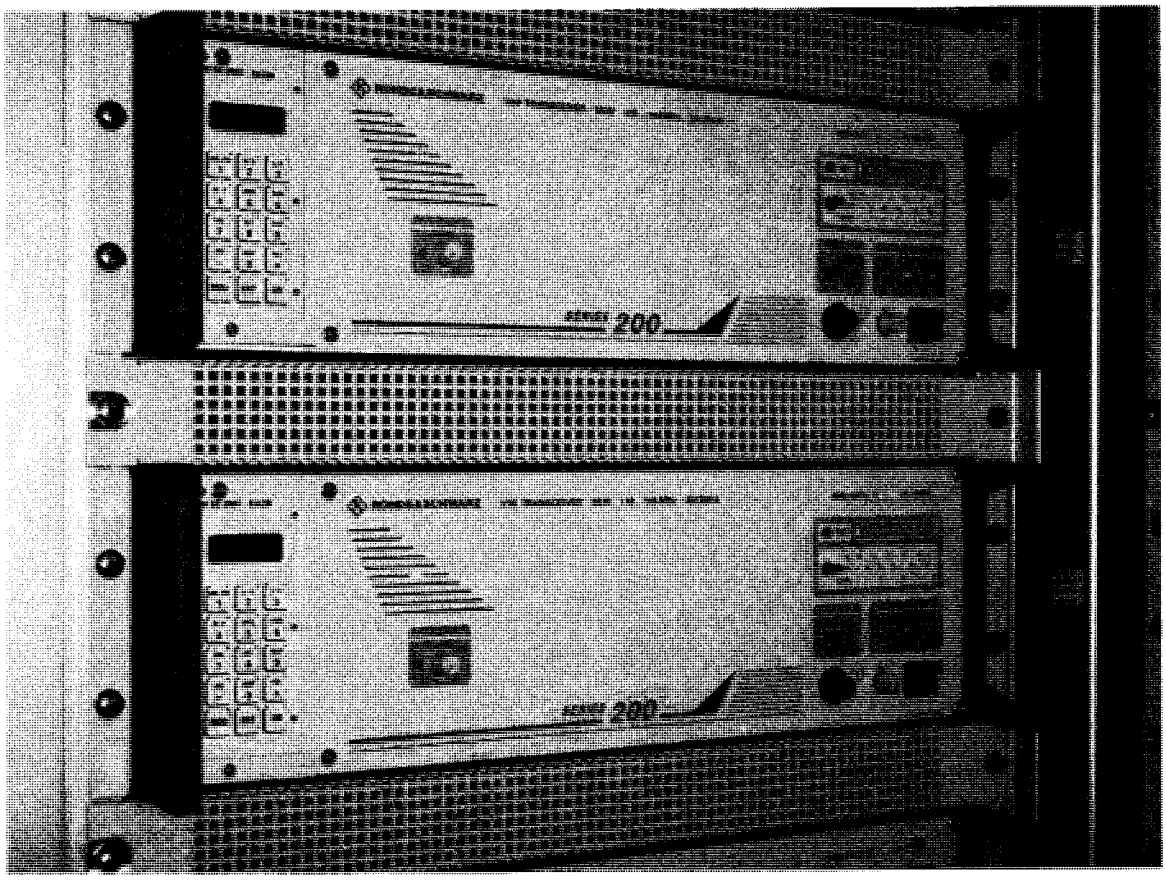


The remainder of this report provides a summary of the Almaty CNS/ATM equipment, systems and services as well as the comments and observations made during the site survey.

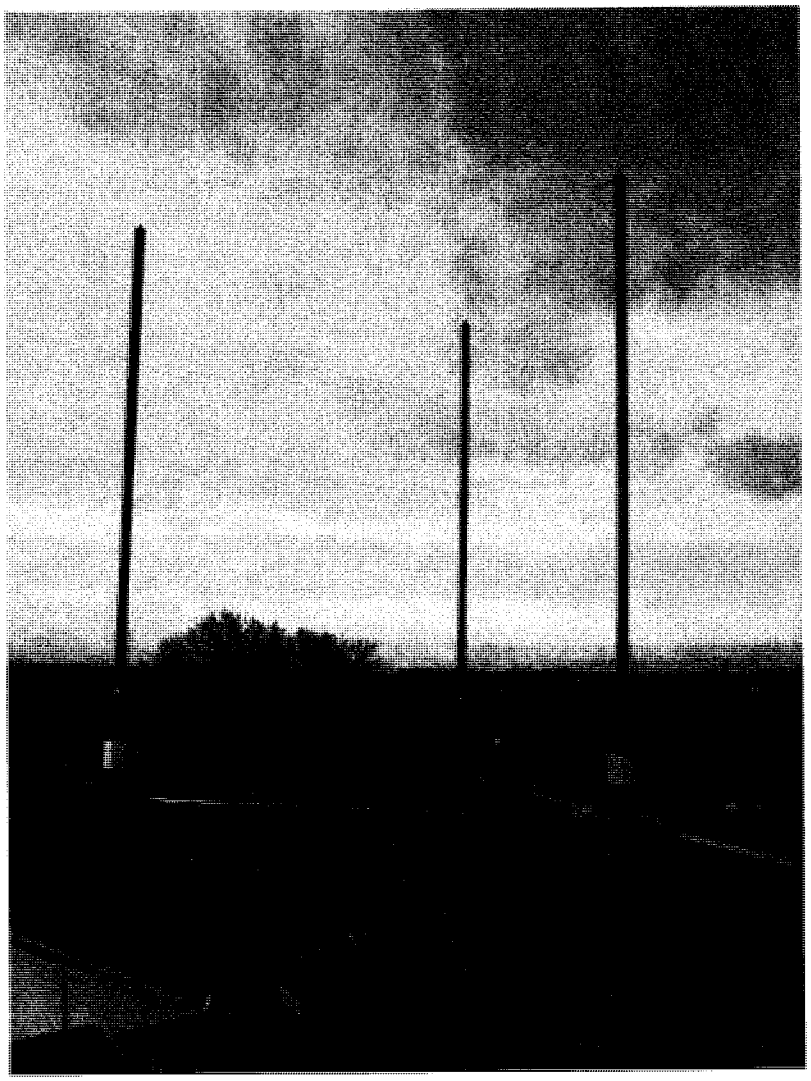
Communications

Principle ground-air communications services are provided by newly installed Rhode and Schwarz Series 200 transceivers. These radios, as well as the entire VHF system were modernized in 2005 to meet the ever increasing air traffic demands. The VHF system supports the following frequencies:

- Tower: 119.4 MHz
- Taxi: 121.7 MHz
- VHF Flight Operations: 120.8 MHz
- Approach Control: 131.6 MHz
- Area Control—primary: 132.9 MHz
- Sector Control: 135.4 MHz
- Small Aircraft/Backup: 132.0 MHz
- Emergency: 121.5 MHz



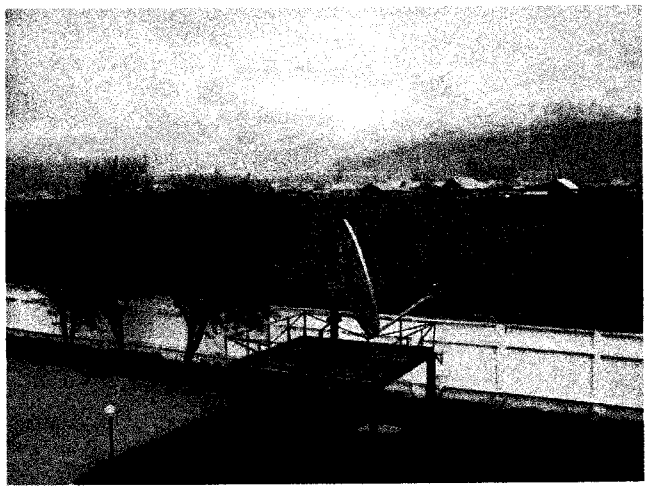
Rhode & Schwarz Series 200 Transceivers



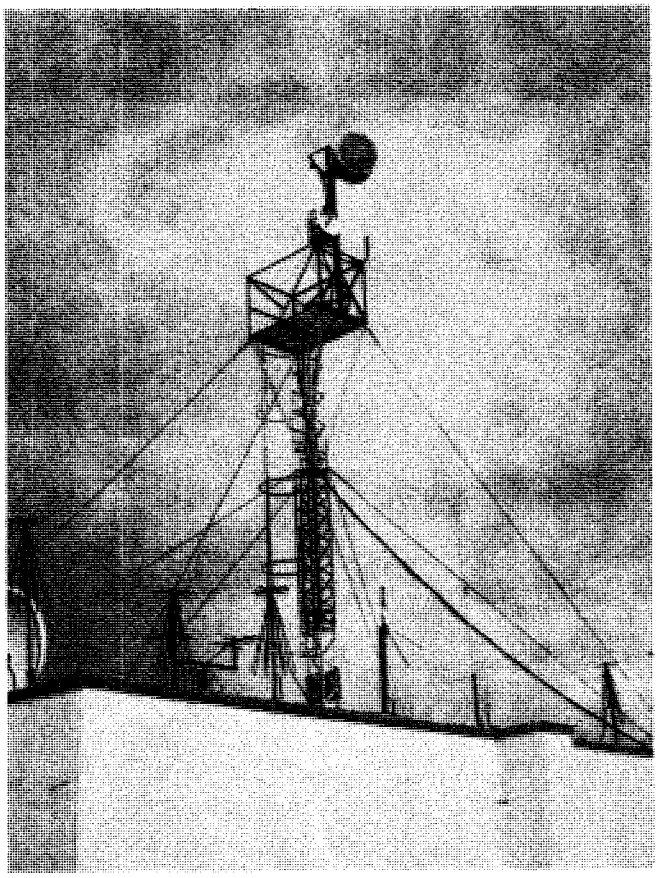
Rhode and Schwarz VHF Antennas—2005 Installation

Independent and separate discussions and interviews with area, approach, tower, ground operations and maintenance personnel indicated that the new VHF system is operating without problem and the services and support from the manufacturer, to include spare parts availability, has been outstanding. It must be noted that the system is less than one-year old and still in the initial warranty period.

Communication relays to/from the Almaty Telecom Center as well as to/from other facilities are provided via ground lines, microwave links and satellite communications. Essentially these point-to-point services are relatively new and operating reliably.



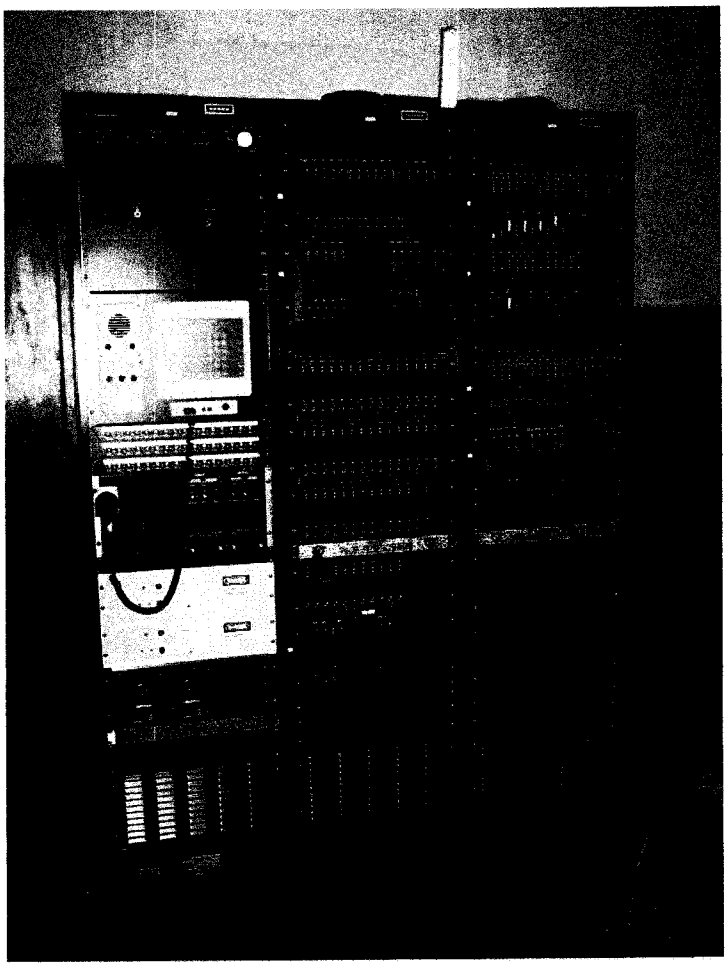
Satellite communication link antenna to Kyrgyzstan



Microwave Link to/from ACC—Telecom Center Almaty

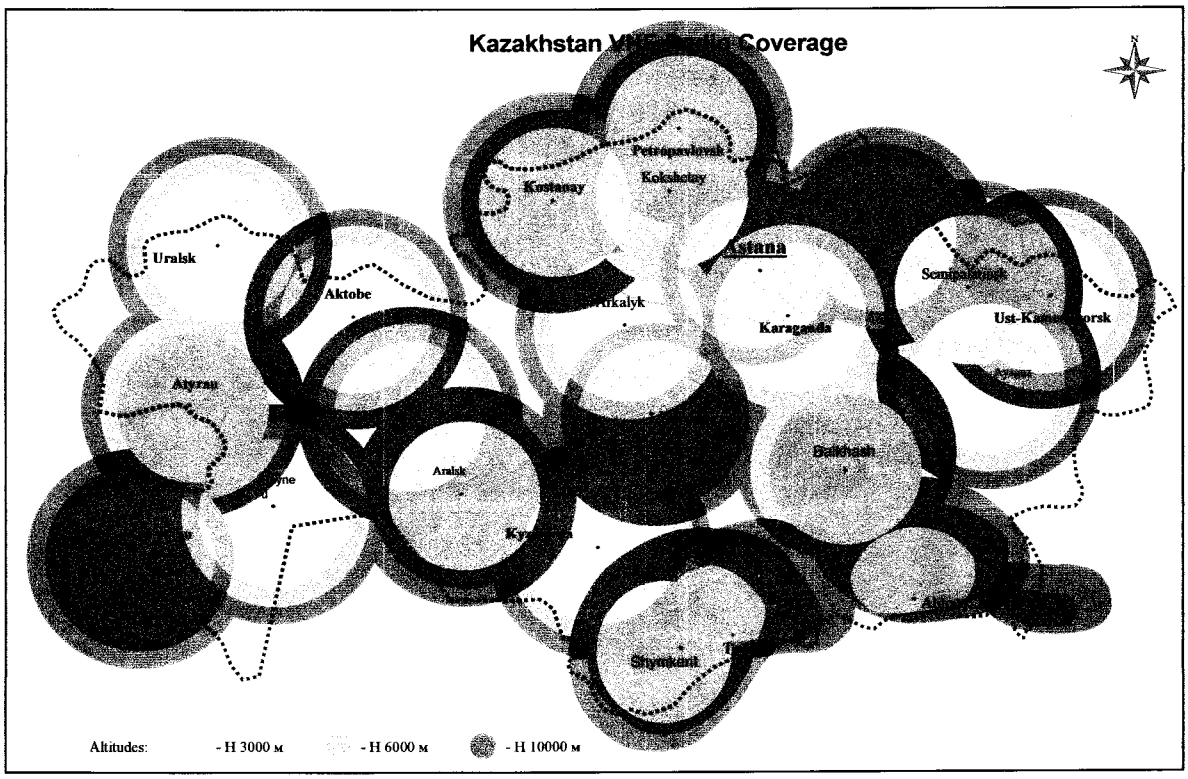
Communications switch and control is provided by a Northrop-Grumman DENRO manufactured switch. The switch is operating satisfactorily. Repair and maintenance of the switch has been on a regular basis and there have been no problems with the availability of

spare parts. However, it was noted that the current switch operational load is approaching the limit and given the age of the switch, that consideration should be given to either upgrading the current equipment or purchasing a new switch.



Northrop-Grumman DENRO Switch

Overall the VHF communication coverage services available for both the air traffic controllers and aircraft operating in Kazakhstan airspace is exceptionally designed and well structured to accommodate immediate needs as well as provide a solid foundation for future growth requirements.



Unfortunately, the HF equipment and systems are not as modern as their VHF counterpart. The transmitters and receivers are 1980 vintage Russian equipment (Bereza transmitters, Sosna receivers).

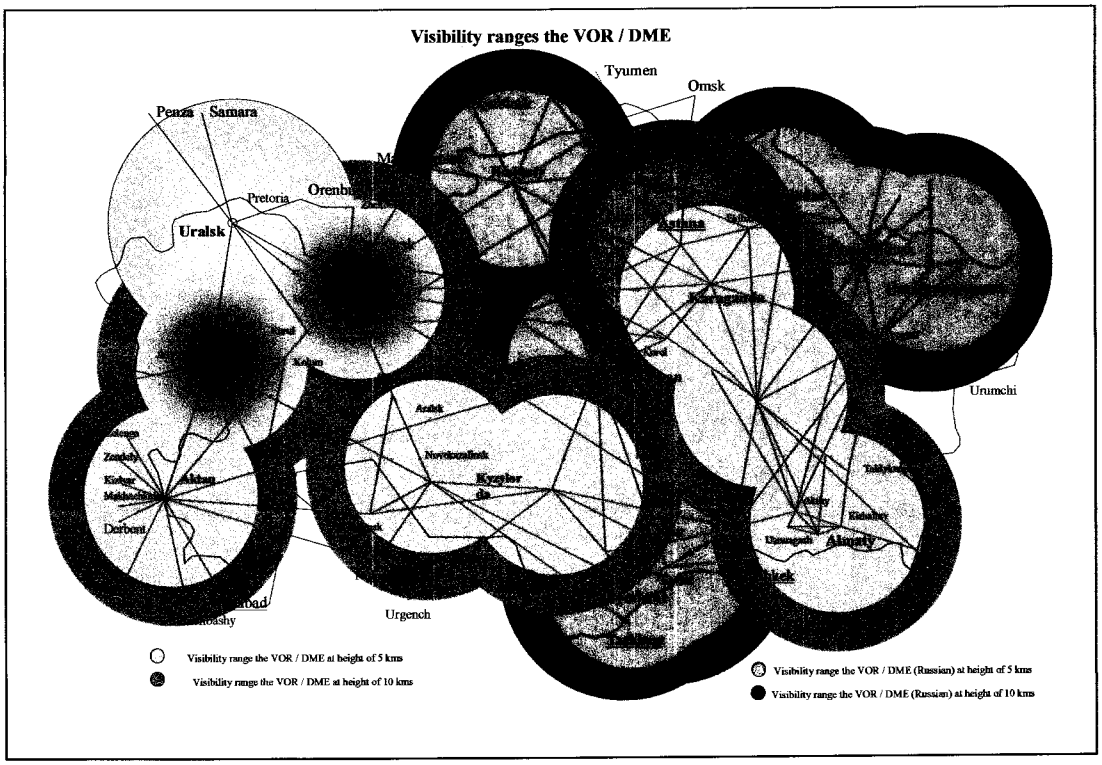
The HF systems are functional and can support air traffic services, but have clearly exceeded their life expectancy and are in need of replacement.

For all types of communication units there is a schedule of routine maintenance, daily, weekly, monthly, and quarterly in accordance with a standardized schedule.

Navigation

Navigation services at Almaty as well as throughout Kazakhstan are provided via traditional ground-based systems. The Russian manufactured Almaty VOR/DME is approximately 13 years old and reportedly is in good working condition. Spare parts are available and maintenance personnel indicated that there have been few problems effecting repairs on the system.

As indicated in the following chart, VOR/DME coverage throughout Kazakhstan is good and appears to be sufficient to support current and near-term air traffic demands.

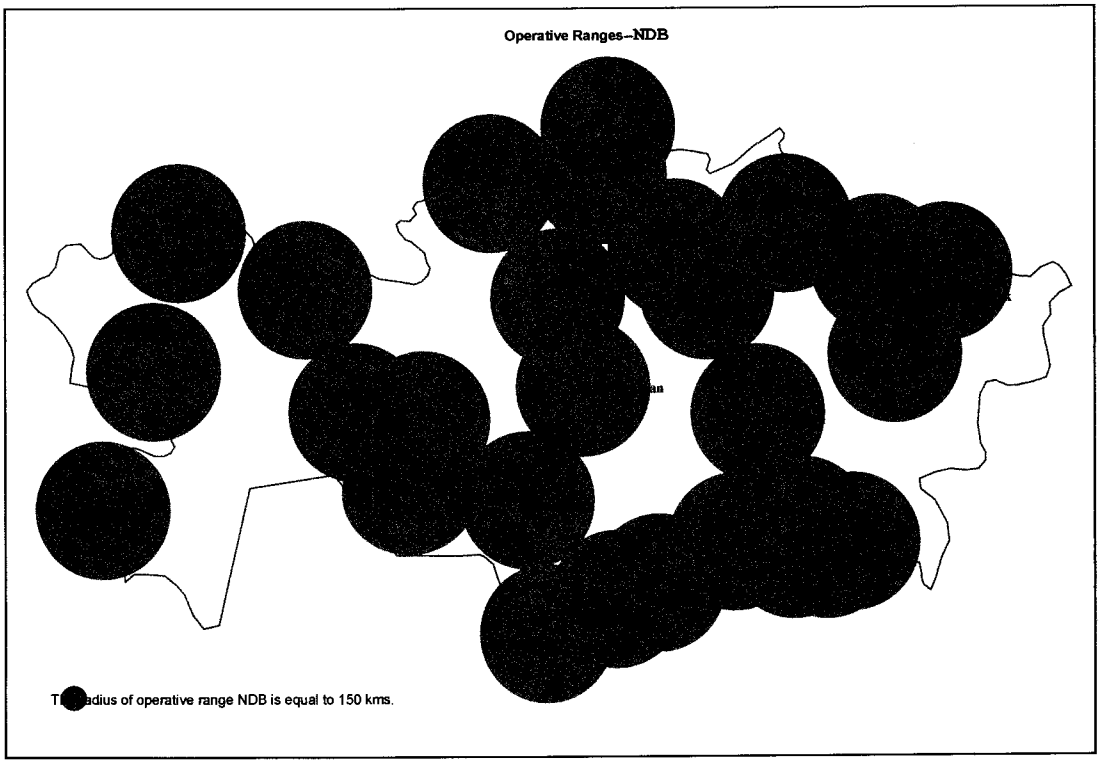


Most airport locations in Kazakhstan have four non-directional beacons (NDBs) per runway; two NDBs at each runway end, and the Almaty airport is no exception. The newest Almaty NDBs were acquired in 2000 and are reportedly operating with out difficulty.

The two NDBs at each runway end stems from an old Soviet Union requirement to provide a "beacon" at one kilometer and four kilometer positions. The justification for this requirement is to provide guidance for arriving aircraft.

The NDBs are relatively expensive to operate and maintain, and according to the air traffic personnel interviewed at several locations, very few aircraft have to rely on these NDBs as the only source of navigation guidance. In fact, many of the air traffic personnel could not recall the last time an aircraft actually had to use only the NDB system. Most modern aircraft have a VOR/DME capability or some other form of navigation guidance such as the instrument landing system (ILS), satellite navigation equipment (global positioning system (GPS)), and/or flight management/inertial navigation systems that can be used to support arrival operations. In fact, the performance of systems such as ILS, GPS, and VOR/DME provide more safe and accurate navigation guidance as compared to NDBs and can permit lower approach minimums for arriving aircraft.

Although the NDB coverage is very good throughout Kazakhstan as indicated in the following chart, it is recommended that the NDB system be considered for phase-out in the near-term.



The two instrument landing systems (ILS) installed at Almaty were acquired in 1998 and 2003, are reportedly in good operating condition and there appears to be no difficulty in obtaining spare parts or making timely repairs.

As mentioned in the beginning of this report, Almaty International Airport is the major airport supporting international flight operations to/from Kazakhstan. Weather conditions in Almaty can be severe during certain times of the year (e.g. freezing fog) resulting in low ceilings and effectively zero visibility for arriving aircraft.

Because the current ILSs installed at Almaty are not Category III systems, should weather minimums be below 100 foot ceilings and ¼ mile visibility, it is not possible for arriving aircraft to make a safe landing. Additionally since the Almaty area is mountainous, statistically there is an added threat to arriving aircraft attempting to land when the weather is near current landing minimums. Note: when operating in mountainous terrain in marginal weather conditions, the probability of a "controlled flight into the terrain" accident/incident is greater.

Consideration should be given to either upgrading or replacing the current ILS systems at Almaty to enable Category III operations.

The International Civil Aviation Organization (ICAO) Future Air Navigation Systems (FANS) was chartered to reassess the procedures and technologies that had so successfully served international civil aviation. FANS concluded that it was necessary to develop new systems that would overcome the limitations of conventional systems and allow the further growth of aviation on a global scale. These new systems would be expected to evolve and become more responsive to the needs of users and service providers whose economic health would be directly related to the efficiency of these systems. FANS concluded that satellite technology offered a viable solution to overcome the shortcomings of conventional ground-based systems and to meet the future needs of the international civil aviation community.

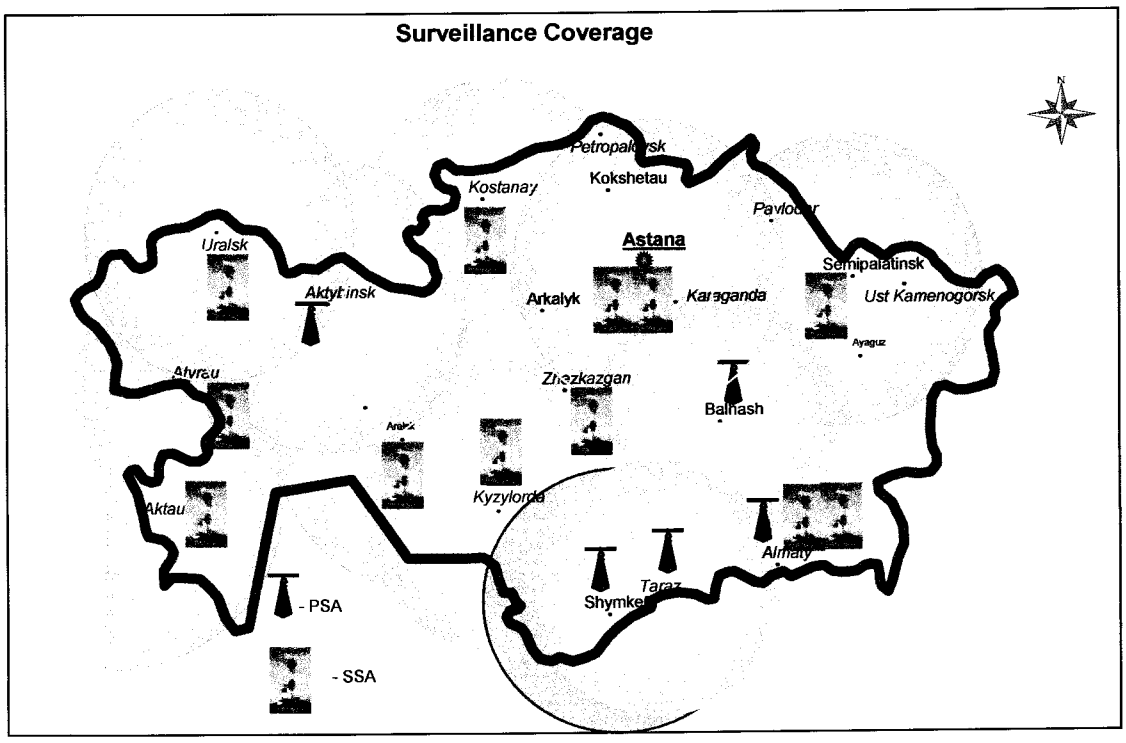
One of the first steps in evolving to satellite-based airspace operations is to develop and implement Global Navigation Satellite System (GNSS) procedures. For Almaty airport and other airfield locations in Kazakhstan, GNSS approach and departure procedures will enhance safety, improve the operational efficiency of the runway(s) and airport facilities, afford an opportunity for increasing revenues, and provide further justification for decommissioning existing ground-based systems such as NDBs.

It is recommended that a Kazaeronavigatsia program be established to develop and implement GNSS approach and departure procedures for Kazakhstan airports.

Surveillance

The primary and secondary radar systems providing service to the Almaty ACC are reportedly working satisfactorily. The dual Russian manufactured secondary surveillance systems are relatively new (2001, 2003 respectively) and sufficient spare parts are available to effect local repairs.

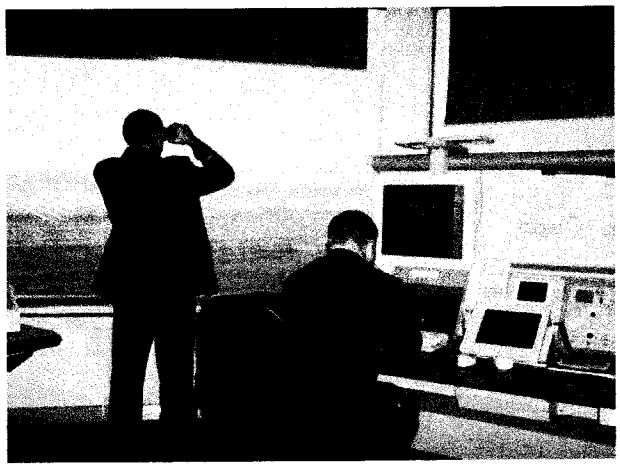
Overall surveillance coverage throughout Kazakhstan is generally provided by Russian manufactured radar systems. Some of these systems are more than twenty years old, and have exceeded their projected lifecycle. The following chart illustrates Kazakhstan surveillance coverage:



Air Traffic Management

Air traffic control personnel are very happy with their working environment and basically pleased with the functionality of the Siemens 2000 equipment being used for operations. As

mentioned previously, the Tower is new and the working facilities are excellent as illustrated in the following:



Almaty Tower Operations

During the interview process it was determined that the air traffic controllers would benefit by being able to replay the flight path information for arriving and departing aircraft as well as the actions taken by controllers to accommodate the safe and efficient movement of these aircraft. Such a capability would likely improve controller proficiency as well as provide a useful tool for analyzing controller working procedures and incorporating operational changes in the overall air traffic system. It was also determined that the existing Siemens 2000 equipment does not support the calculation of statistics to enable both the working controller and supervisors to evaluate operational effectiveness.

Upon further investigation it is apparent that there are mounting problems with both the hardware and software for the Siemens 2000 equipment, as well as the French manufactured Airsys ATM terminals. The following facts were noted during the survey process:

- Parts are old and difficult to obtain.
- No technical support is available and there is no original equipment manufacturer (OEM) maintenance contract.
- Mean time to repair varies depending upon the problem and can range in time from 1-2 days to 40 days or more.
- There is a service log indicating the failure rates and frequency. Based on a review of the service log it is apparent that the failure frequency has doubled since installation and the corrections often take the shape of "workarounds".
- The source code for the software is not available and it is not possible to make changes to the content of the displays as requested and needed by the air traffic controllers. For instance, they have requested the renaming of waypoints and changing of route/ flight paths. Although the basic "map" display can be changed, the underlying software programs used to manipulate the data cannot be changed. So, it is not possible to effectively make "global" changes. The controllers request these

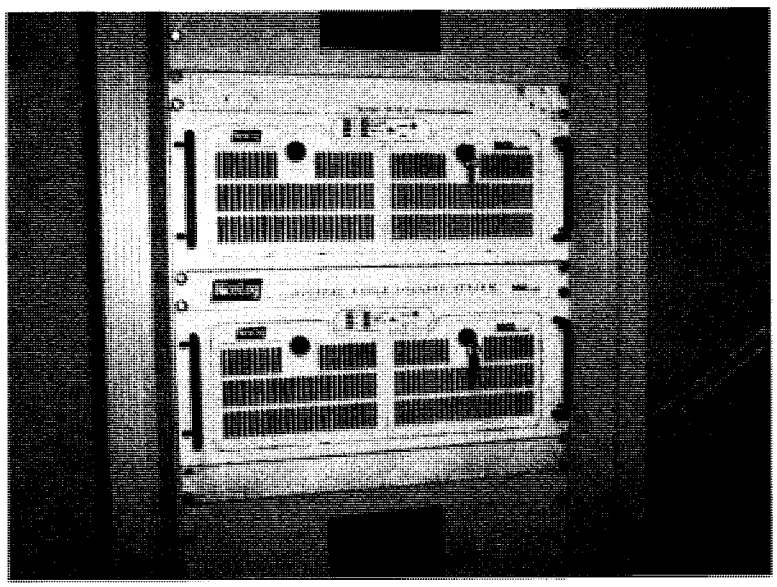
type of changes 3-5 time a year to improve their efficiency and effectiveness of control, but it is not possible to provide them the changes.

- Siemens has been contacted to obtain the software source code to be able to make the changes locally, but they will not provide the source code. Hence the software is not supportable to the degree needed for effective air traffic control.

- Power supplies: commercial, generator and uninterruptible power sources are in excellent condition and extremely reliable. There has never been a total power failure at the Almaty facilities.

It is recommended that serious consideration be given to upgrade or replace the Siemens 2000 equipment by the time it reaches the end of the 10 year lifecycle (2007).

While surveying the Almaty ACC infrastructure and evaluating component performance, it was determined that the Israeli manufactured Voice Communication recording equipment is 1997 vintage technology and has a seventy-two (72) channel recording capacity. A one hundred thirty-two (132) channel capacity is needed.



Current Voice Communication Recorders—72 Channel capacity

There also appears to be difficulty with the radar recording equipment. The Siemens manufactured radar recording equipment uses a DEC recording system. This DEC system relies on old technology tapes to record the data. There appear to be problems with this tape system and it does not support efficient archiving of data.

It is recommended that action be taken to replace both the voice recording and radar recording systems with equipment that can satisfy current and projected operational needs. Clearly a 132 channel voice recording capability is needed and current state-of-the-art recorders do not rely on tape system for storage of data—they are digital. Also, it is advisable to assess the availability and cost of a recording system capable of correlating both the voice and radar data to enable both to be seen and heard simultaneously.

Almaty Recommendation Summary

1. Upgrade the current DENRO communications switch or purchase a new switch.

2. Modernize the current HF radio system.

3. Plan and implement an NDB phase out program for all of Kazakhstan.

4. Upgrade or replace the current ILS to enable Category III operations. Note: should a Category III landing capability be provided at Almaty airport, then consideration must be given to providing surface guidance to the aircraft after it has landed. One such system is the Airport Surface Movement Guidance Control System (A-SMGCS).

5. Upgrade or replace the Siemens 2000 and Airsys equipment.

6. Replace the voice and radar recording equipment with systems that are digital and have expanded and possibly integrated capabilities.

Site Survey Report

Taraz Airport

November 11, 2005

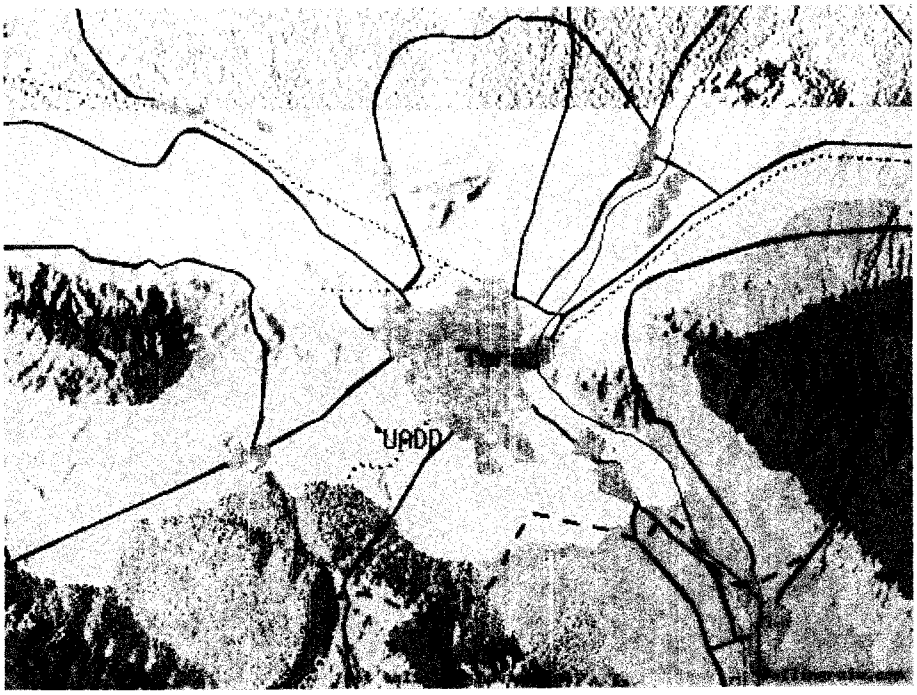
Overview

The Taraz Airport is located approximately 4 nautical miles southwest of the city of Taraz (note: Taraz Airport may also be referred to as Aulie Ata). With a population of approximately 300,000, the main air carrier is Air Kazakhstan. On average 100 aircraft operate out of Taraz airport each month on both a scheduled and non-scheduled basis. The primary aircraft are:

- Yak 40
- AN-24
- Fokker 50
- IL-76
- IL-62
- TU-154
- TU-134

Processed food, fertilizer, textiles, and metal products are manufactured in the city. In particular Taraz is known for their phosphorous industry and building of railroad tank cars. Typically, industry and people within a 70 kilometer radius rely on Taraz airport for air transportation and the import/export of goods by air. The relatively close airports located in Shymkent, Kazakhstan and Tashkent, Uzbekistan are recognized as major competitors for air services in the local area.

The Taraz airport facilities also provide back-up support for the Almaty Area Control Center and these as well as the communications, navigation and surveillance infrastructures are in the process of being modernized.



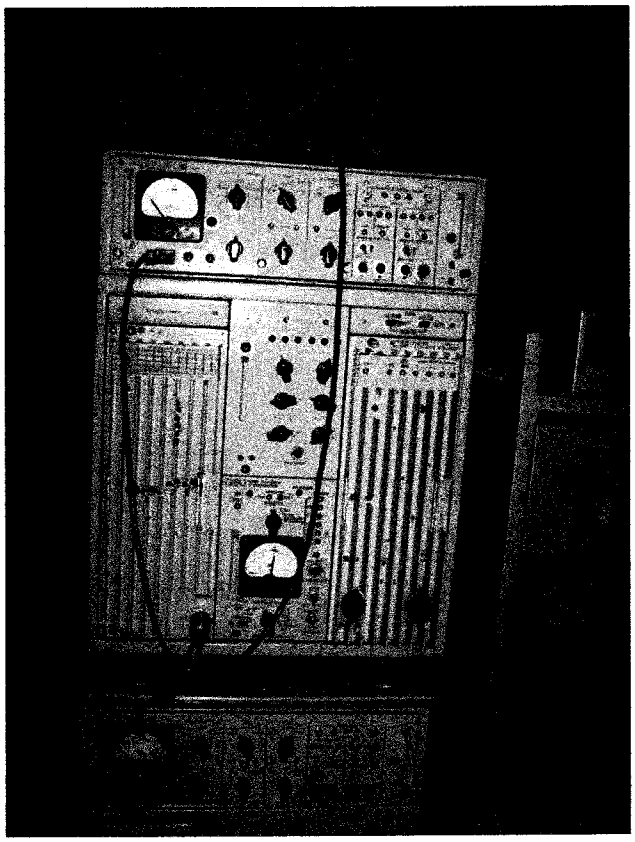
Taraz Airport (UADD)

The remainder of this report provides a summary of the Taraz CNS/ATM equipment, systems and services as well as the comments and observations made during the site survey.

Communications

The current VHF transmitters and receivers have reached the end of their life-cycle and are going to be replaced in Spring 2006 by new Rhode and Schwarz Series 200 transceivers. The new VHF communication system will be similar to the Almaty configuration and is expected to provide all the requisite services for enroute and terminal area operations.

However, HF communications remain a problem. The current 1980s vintage Russian manufactured HF radios have a limited service volume and cannot be used beyond a maximum of 60 kilometers. As a result of this limitation, small aircraft operating outside of 60 kilometers are either "out of radio contact" or the controller must rely on enroute aircraft within 60 kilometers to relay information to the aircraft outside of 60 kilometers. On average, this operational workaround is used to control 5 different aircraft per day. The controllers expressed concern regarding their ability to safely and reliably execute their duties because of the HF equipment limitation. It is recommended that the HF radio system be replaced as soon as possible.



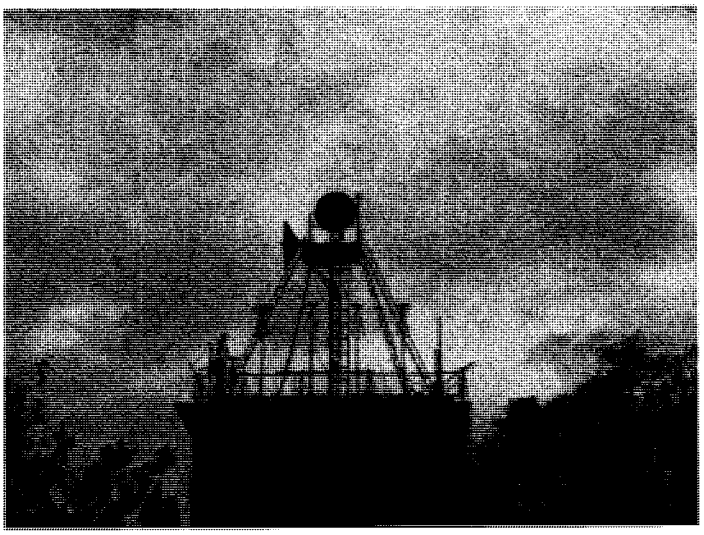
1980s Vintage Russian Manufactured HF Radios

Point-to-point communications are also a problem area. Due to the local terrain and climatic conditions, cable-based communications between the airport facilities can be difficult and unreliable. For instance, tower personnel encounter problems communicating with personnel and obtaining status information from the NDB facilities. Reliable two-way communications are frequently required because the NDB equipment is weather sensitive and must be periodically adjusted. The reason for this specific communication problem is because the current ground cable is underground and often underwater and the NDB facility is a relatively long way away from the tower.

It is recommended that consideration be given to purchasing and installing an alternative point-to-point communication system and/or modernizing the existing system. It appears as though a small microwave communication system capable of accommodating 5 channels would be operationally sufficient and likely be less expensive than replacing the old ground cable communication system. However, the availability of small microwave systems are unknown.

Point-to-point communications from/to Taraz and Airports and other airports in the local area such as Almaty and Shymkent are excellent. A combination of microwave links, fiber optic and digital satellite systems are have proven to be a powerful and reliable design configuration for satisfying intra system communications between all airport locations in Kazakhstan.

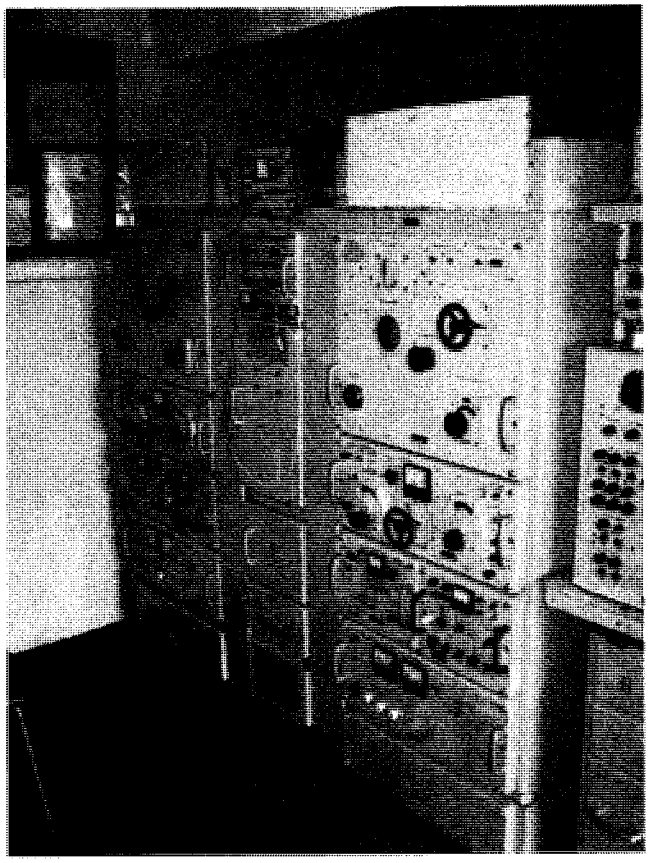
VSAT Antenna



Microwave Link Configuration on Top of Tower

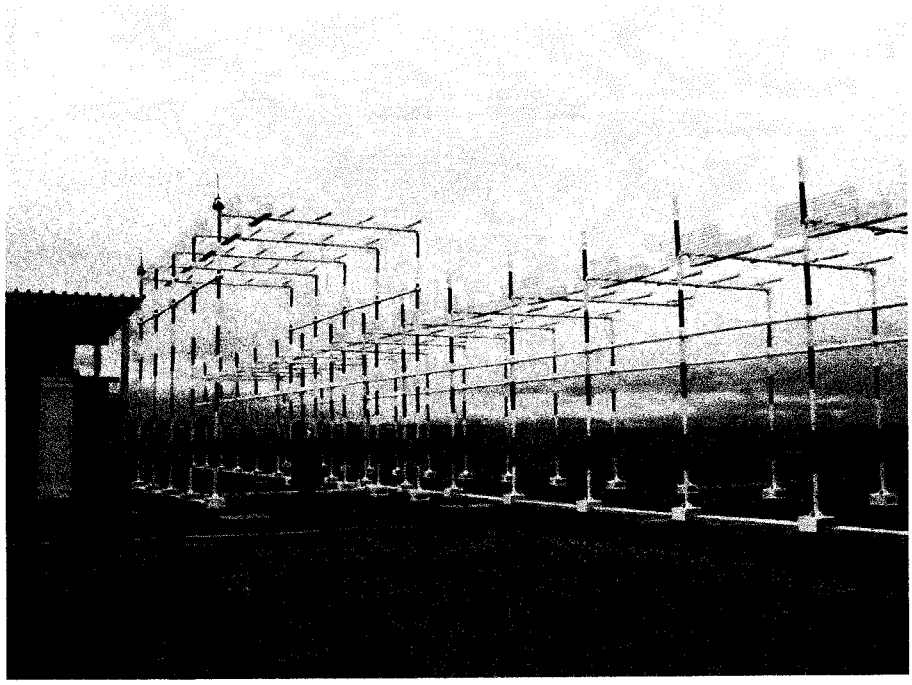
Navigation

Navigation services at Taraz are provided via traditional ground-based systems. The 1985 vintage Russian manufactured NDBs are reportedly reliable and operating without major difficulties except for the need to frequently adjust the systems due to local climatic conditions. There are ample NDB spare parts and the maintenance technicians are well qualified to affect local repairs which can be often due to weather associated problems with the systems.



NDB Main and Standby Systems

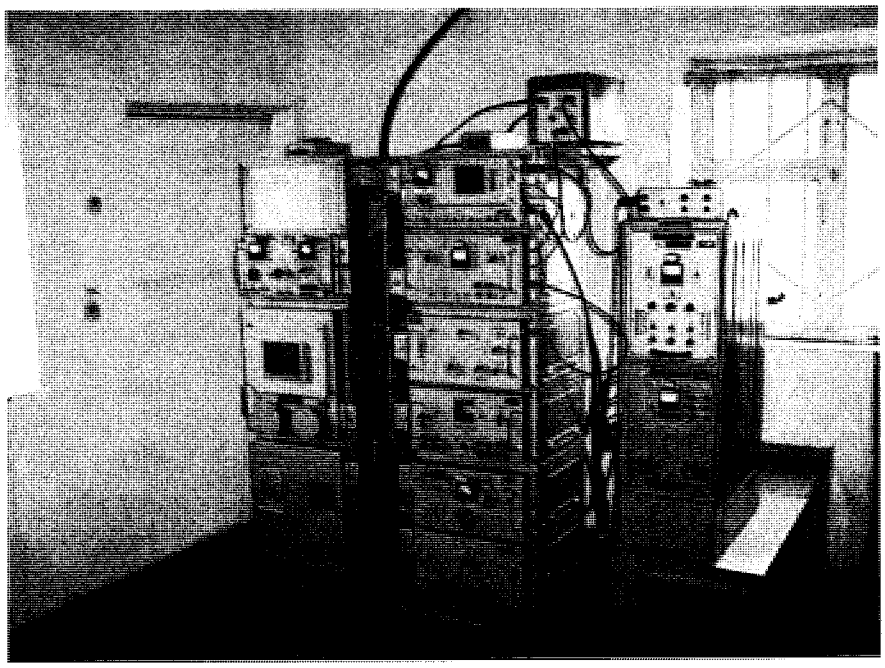
The Russian manufactured SP 90 Category I ILS system to Runway 13 was installed in 2005. The system is operating without problems, spare parts are available, and the maintenance personnel are confident they have been properly trained to affect repairs.



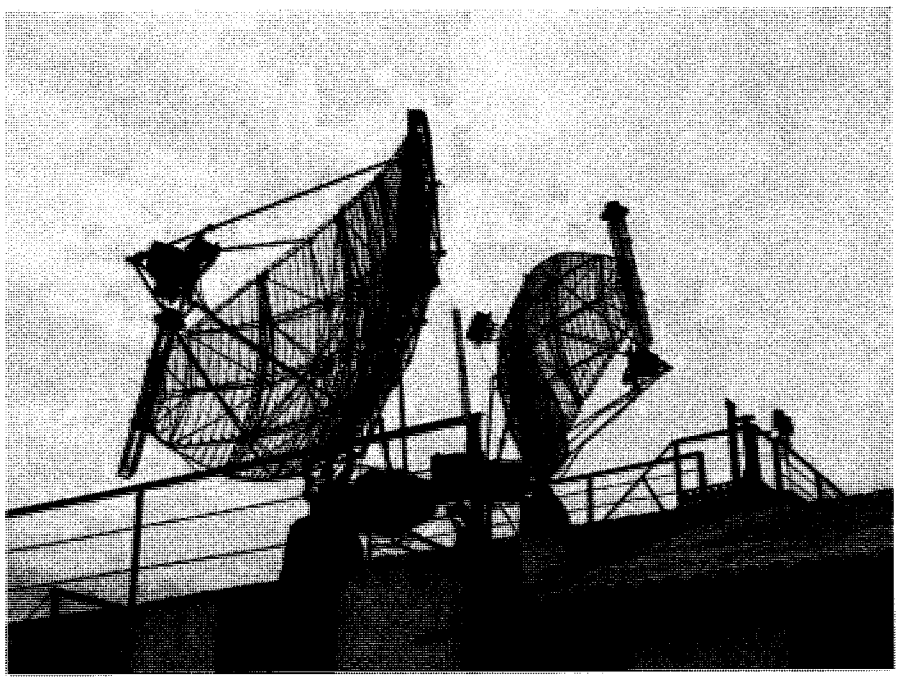
SP 90 Category I Localizer Antenna, Runway 13

Surveillance

The primary, secondary and approach control radar systems providing service in Taraz are Russian manufactured systems. A program began in 2005 to upgrade and modernize the 1995 vintage approach control radar to be ICAO compliant and support "squak" operations.



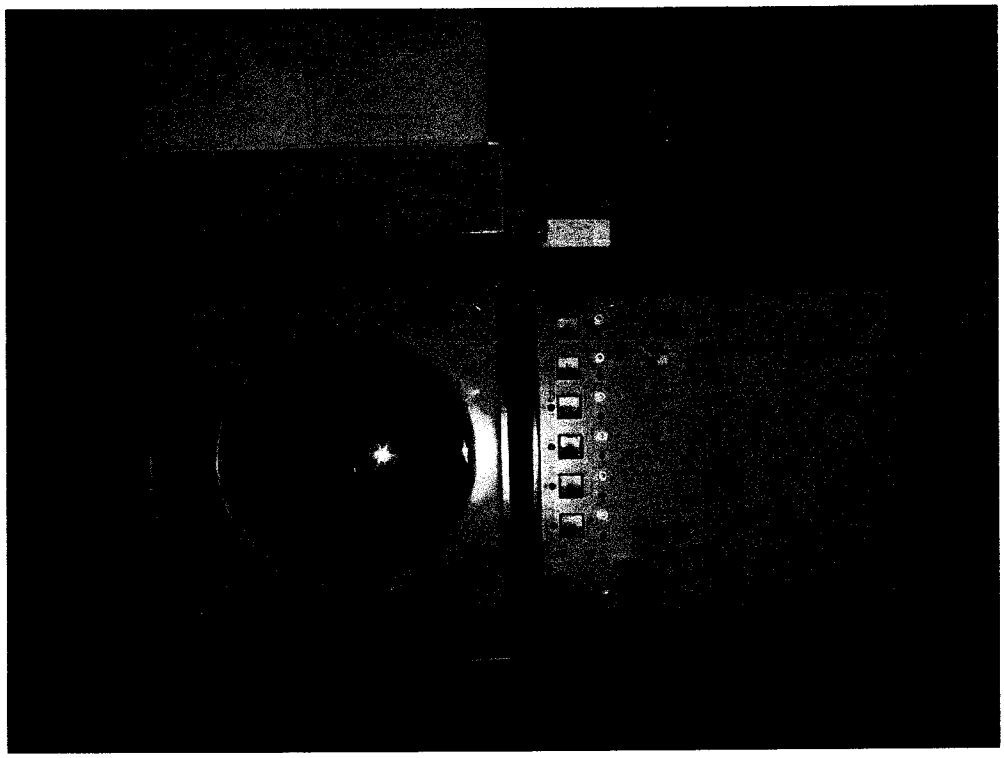
Modernized Approach Control Radar—one system shown



Approach Control Radar Antennas—note there are 2 systems

The approach control radar system is relatively reliable and the dual system configuration adequately meets current and future projected air traffic requirements. Statistically, the primary approach control system experiences problems once or twice per year and the backup second system will have to be used to provide radar services. Both systems are built on "tube" based technology and are not solid state.

The primary and secondary radar systems were manufactured in 1997 by Leonosiva (primary system) and Raduga (secondary system)—both Russian companies. The projected lifecycle for both systems is ten years and as the end approaches, Taraz maintenance personnel are experiencing an increase in the frequency of failures and number of necessary repairs. Of the two systems, the primary radar system creates a majority of the problems for the technicians. Spare parts are not locally available and the manufacturer has not been very responsive to requests for spare parts support. In some instances, repairs can take as long as 3 months due to an inability to obtain the requisite parts to affect repairs.

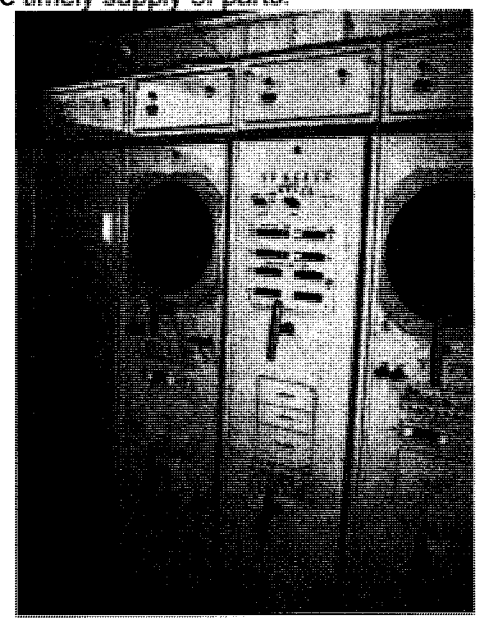


Primary Radar Display

Primary Radar Antenna

Specific problems with the secondary radar system includes failures with the processor, transmitter and receiver outages, and the slow process for obtaining spare parts. In addition

to a slow response from the manufacturer, the cumbersome shipping and customs procedures further delay the timely supply of parts.



Secondary Radar Equipment

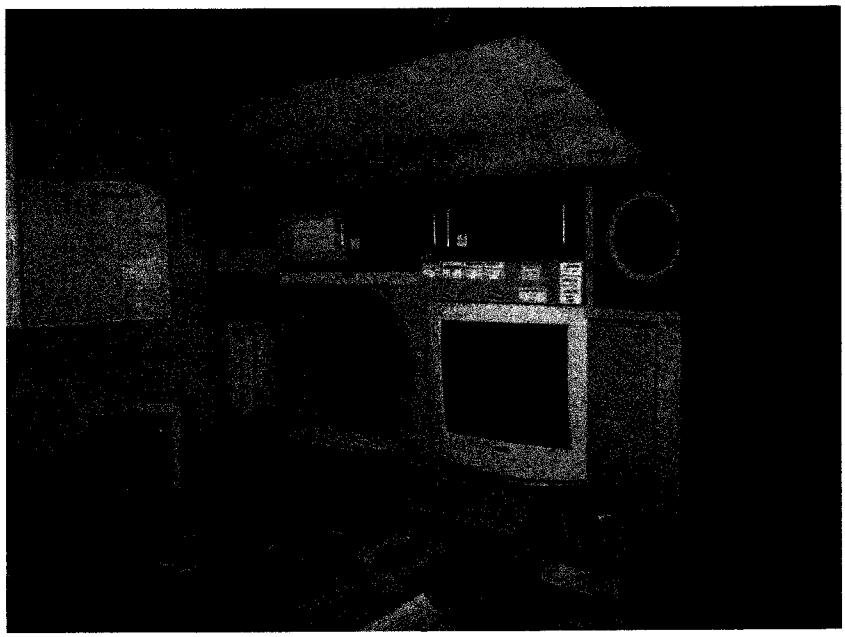
Secondary Radar Antenna

During the discussions with the maintenance technicians, they indicated that there is a need for a spare parts depot within Kazakhstan to be able to supply the needed spare parts for **all** communications, navigation, surveillance and air traffic management systems.

It is recommended that consideration be given to upgrading or replacing the primary and secondary radar systems in Taraz prior to exceeding their 2007 lifecycle. It is also recommended that Kazaeronavigatsia consider establishing a centralized depot facility to provide spare parts, diagnostics and training for all communications, navigation, surveillance and air traffic management (CNS/ATM) systems in Kazakhstan. Such a facility would also be capable of supporting CNS/ATM systems in the Central Asian region.

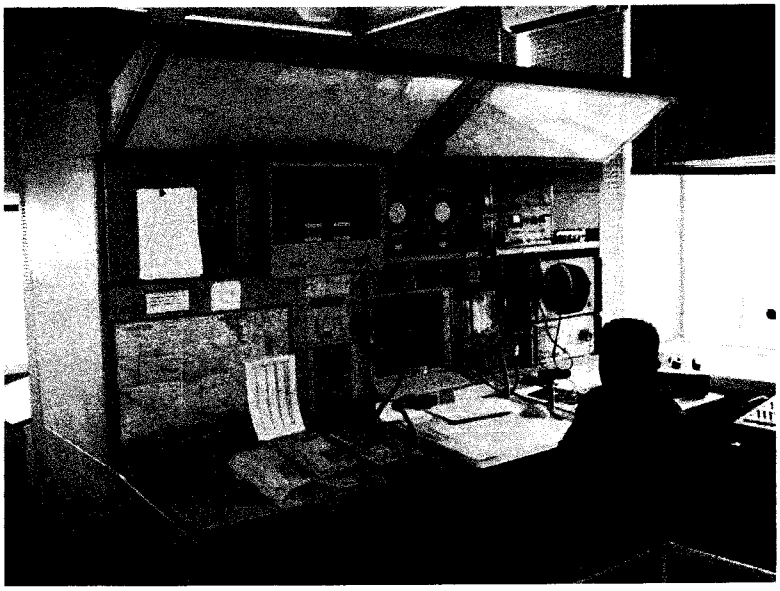
Air Traffic Management

Air traffic control personnel are able to adequately execute their duties and responsibilities with the existing equipment, however, much of the equipment is quite old. The back-up facility for the Almaty area control center appears to be a mix of old displays and equipment. Reportedly the control console at this position as well as the other controller positions in the tower and mobile unit are unreliable and the controllers frequently have problems.



Back-up for the Almaty ACC

In many airports the tower personnel have a virtually unrestricted view of the ramp, taxiways, runways and the airfield environment, but this is not the case in Taraz. Tower personnel have a limited view of the airfield and in fact only provide radar services to arriving and departing aircraft. Ground control and operations requiring an unrestricted view are performed by personnel in a mobile unit alongside of the runway.

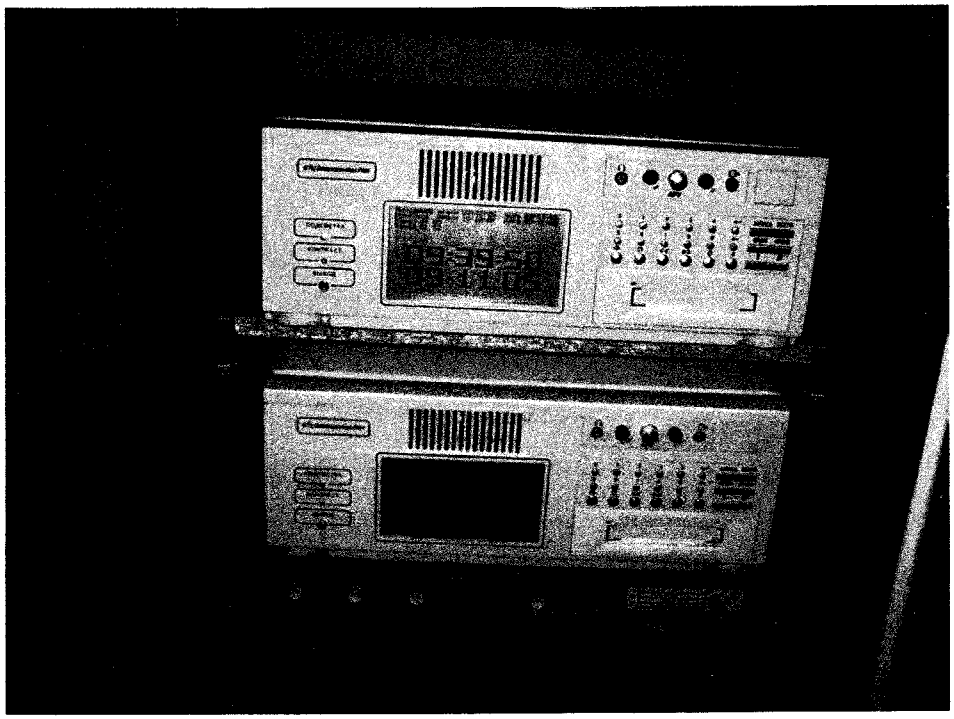


Tower Cab—Approach Control Radar Services Only

It is recommended that consideration be given to constructing a new tower at Taraz and/or modifying the current structure to permit an unrestricted view of the airfield environment. This will enable ground, runway, and approach control personnel to operate in a single facility, improve working efficiencies, reduce the probability of controller errors, improve safety, and likely reduce operating costs.

It is also recommended that consideration be given to modernizing the current controller consoles/working positions and associated equipment. During discussions with maintenance personnel they indicated that much of this older equipment is "old Soviet equipment based on old technology" and cannot accommodate the requisite technological changes. The Chief Technical Director indicated that there are 46 people in the technical branch responsible for maintaining all of the equipment and he believes it is possible to reduce the number of people to 23 if the old equipment is replaced.

Modernization and replacement of the older equipment and upgrading of the support infrastructure has been slowly occurring as evidenced in the previously sections of this report (e.g. new point-to-point communications systems and the new instrument landing system), and the purchase and installation of new digital recorders. The controllers are very pleased with this new equipment as well as the fact that the infrastructure improvements have virtually eliminated power supply interruptions.



New Russian manufactured 32 channel digital Recorders

Much of the credit for the infrastructure and working improvements as well as the maintenance and operation of the older equipment are a result of a dedicated and professional technical workforce. The maintenance facilities at Taraz, in particular the radar maintenance facility, are neat, orderly and operated with professional pride—the best we have ever surveyed.

Taraz Recommendation Summary

1. Modernize the current HF radio equipment/system.

2. Install an alternate point-to-point communication system for local area operations.

3. Plan and implement an NDB phase out program for Taraz and all of Kazakhstan.

4. Upgrade or replace the primary and secondary radar systems prior to exceeding their 2007 lifecycle.

5. Kazaeronavigatsia consider establishing a centralized depot facility to provide spare parts, diagnostics and training for all communications, navigation, surveillance and air traffic management (CNS/ATM) systems in Kazakhstan. Such a facility would also be capable of supporting CNS/ATM systems in the Central Asian region.

6. Upgrade or replace the current controllere consoles/working positions and associated equipment.

7. Modify the current structure or construct a new tower to provide an unrestricted view of the airfield environment.

Site Survey Report

Shymkent Airport

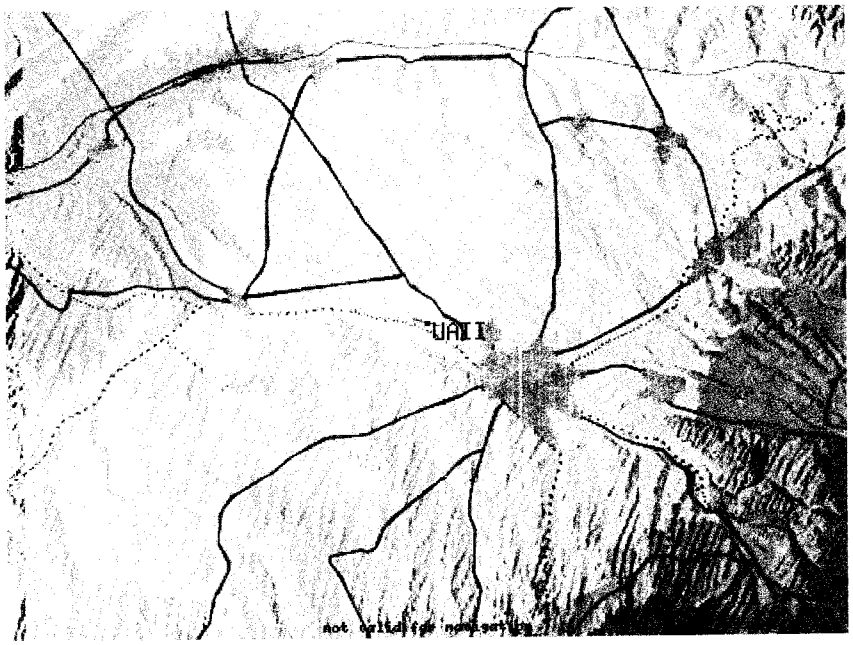
November 13, 2005

Overview

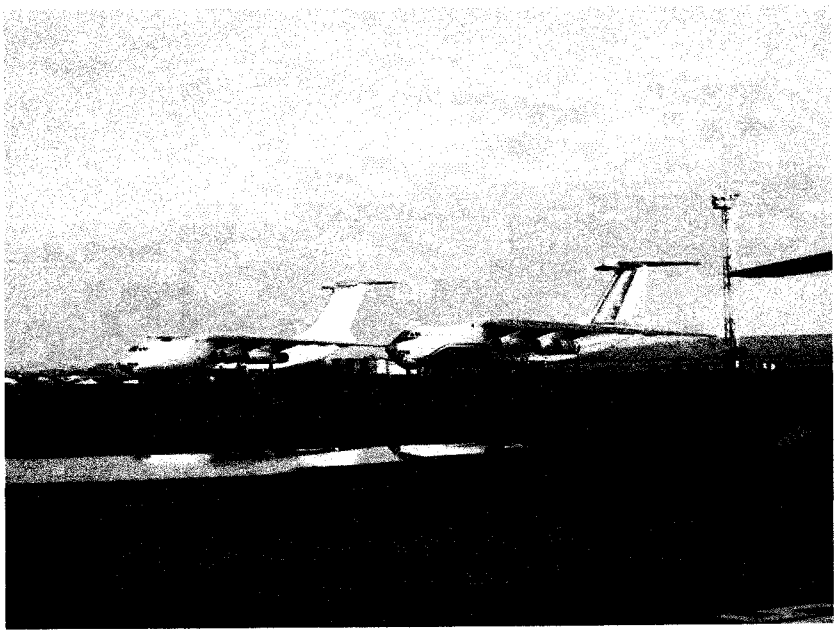
Shymkent airport is located in the southern part of Kazakhstan and is approximately 63 nautical miles north of the Tashkent Vostochny Airport.

The road to/from the Shymkent and Tashkent airports is in good repair, the border restrictions are not harsh for local personnel, and air transportation options from the Tashkent airport are greater than those from the Shymkent airport. Hence, many of the local 500,000 people drive and/or take a bus service to Tashkent for air transportation.

The Shymkent runway (10/28) is approximately 11,000 feet long, 144 feet wide and is concrete. It is capable of supporting the largest of aircraft and the taxiways and ramp areas are sufficiently large to accommodate multiple aircraft. On average, approximately 15 aircraft arrive/depart the Shymkent airport on a daily basis.



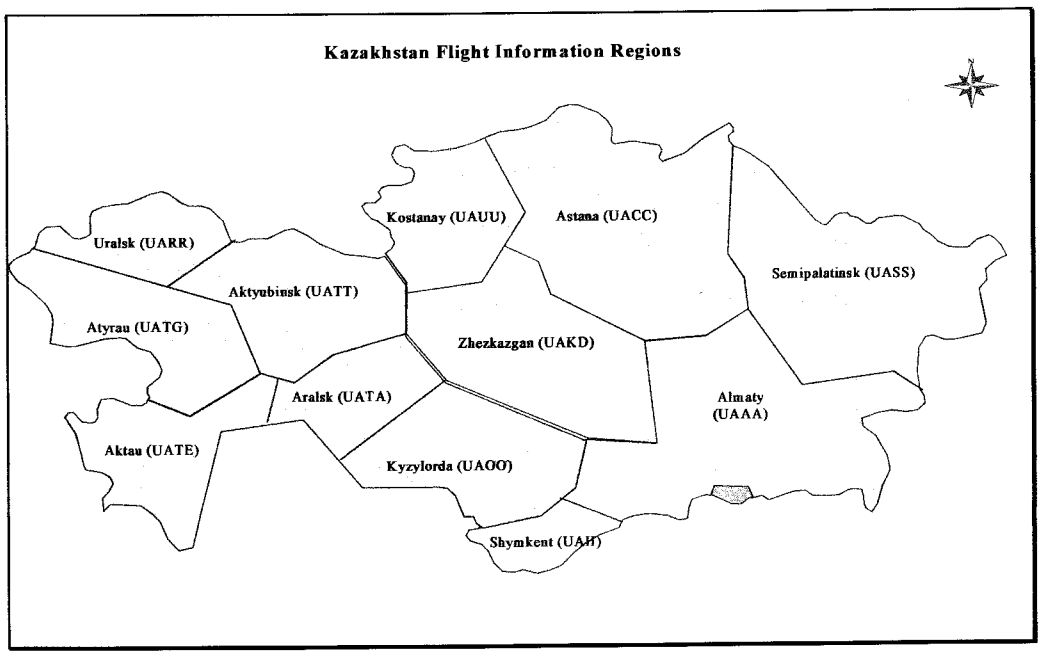
Shymkent Airport (UAII) is slightly Northwest of the town of Shymkent



Shymkent Airport Ramp

Shymkent Airport is also the site of the area control center for the Shymkent flight information region (FIR). There have been discussions regarding increasing the size of the Shymkent FIR but a firm decision has not yet been made.

The overall Kazakhstan vision is to have four area control centers responsible for all Kazakhstan airspace. Those area control centers would be located in Astana, Aktobe, Almaty, and Shymkent.



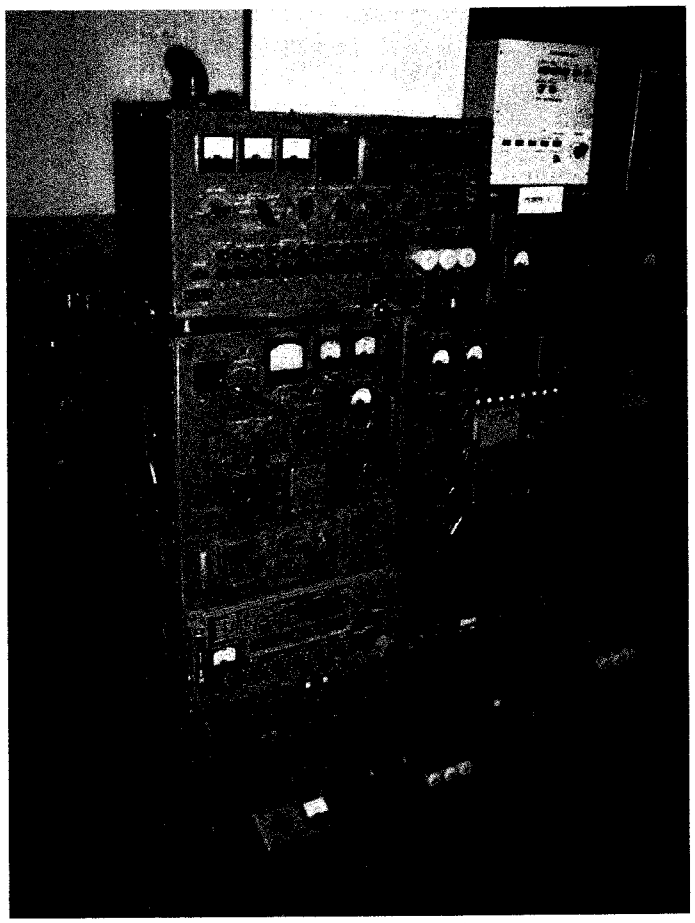
Current Kazakhstan Flight Information Regions

The remainder of this report provides a summary of the Shymkent CNS/ATM equipment, systems and services as well as the comments and observations made during the site survey.

Communications

Ground-air communications services are provided via HF and VHF radio systems. Both of these systems are old and have reached the end of their service life.

The HF radios are 20 year old Russian manufactured systems. Spare parts are currently available for these radios and the technicians are capable of affecting local repairs, but due to the frequency of repairs and age of the equipment there is concern that the radios will no longer be supportable in the near future. Additional, the power consumption of this system, which is based on tube technology, is relatively large as compared to the power usage of newer equipment.



HF Radios—Russian Manufactured

Power supplies can be a problem in Shymkent. Commercial power is available for all communications, navigation, surveillance and air traffic management equipment via either one or two independent power lines, but commercial power failures still occur. On average

commercial power is not available for 10 hours per year, with the maximum period of outage being approximately 3 hours or greater. Maintenance personnel spend a great deal of time keeping the 12 generators and 90 batteries in good operating condition. The generators and batteries are old and require a great deal of care and attention to ensure an overall reliable backup power system.

It is recommended that consideration be given to modernizing the HF radio system and modernizing the backup power supply systems (e.g. generators and batteries) for all CNS/ATM systems. Should a decision be made to replace the backup power supply systems, then it is suggested that the Tender be based on a functional capability and not merely a one-for-one replacement. Reason for this suggestion is as follows: the current backup power system design is based on older equipment with certain performance characteristics. Newer equipment performs better than older equipment and it appears that the backup power system design for Shymkent could be simplified and the number of generators and batteries necessary for a reliable power system could be reduced.

The VHF radio system is equally old and based on technology that is 25 years old or greater. Additionally there are problems with the point-to-point communications between tower, approach control the area control center and the displaced sites housing the communications, navigation, surveillance and air traffic management equipment. Currently the point-to-point system relies on ground cables that have reached their service life.

Plans are in place to replace the VHF technology 2006 with a system, similar to the Rhode and Schwarz Series 200 transceivers equipment installed in other locations, such as Almaty. This plan is fully supported.

Consideration should also be given for replacing the current point-to-point cable based communication system between airport locations with fiber optic and/or microwave technology. Should a decision be made to replace the point-to-point system, then it is recommended that a remote maintenance monitoring and control capability be included in the modernization plans. This remote system will provide the Shift Supervisor and controllers with the ability to determine the performance of the equipment as well as control the settings and functionality of the equipment to meet changing operational requirements. The remote system should be linked to both the HF and VHF systems as well as the navigation (e.g. ILS), surveillance (e.g. radars), generators, batteries and climate control systems.

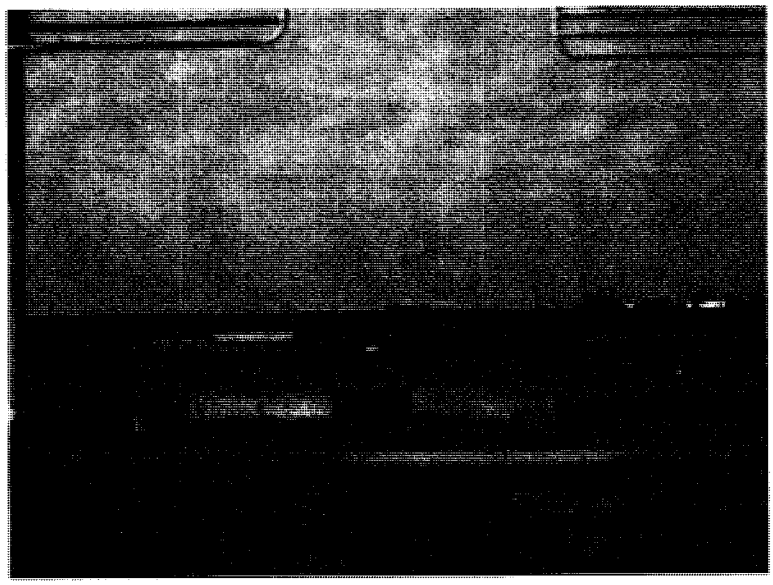
Since Shymkent is an area control center and responsible for airspace within their FIR with plans to evolve all of Kazakhstan airspace to be under the control of 4 area control centers, a reliable communications switching system is needed.
The current switches are analogue/mechanical devices and are unable to support the requisite communication requirements. Plans are underway to purchase and install a new communications switch at Shymkent to be operational in 2006. This plan is fully supported.

Navigation

Navigation services at Shymkent consist of 4 NDBs, a VOR/DME and a Category I ILS to a single runway end, Runway 10.

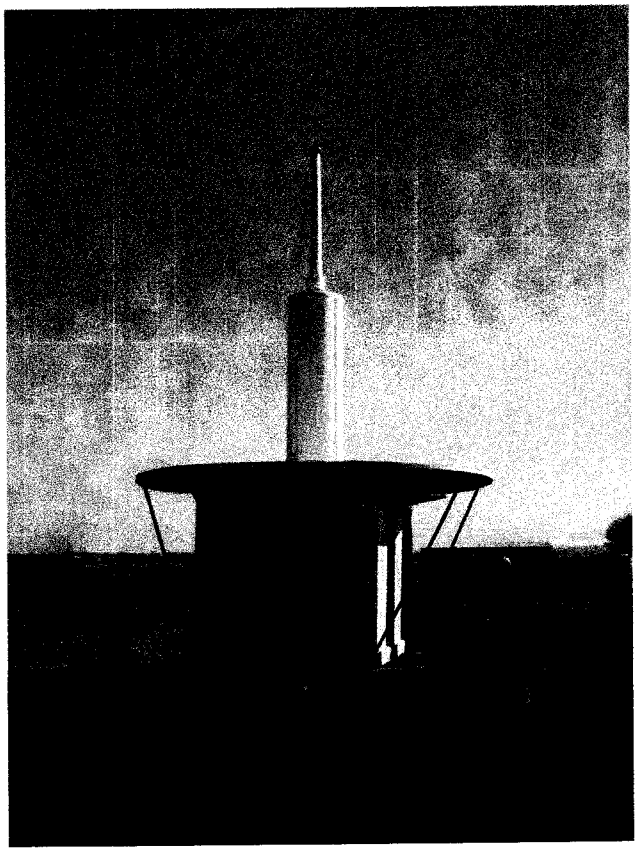
The NDBs are Russian manufactured and greater than 18 years old. They have reached the end of their service life. Many of the aircraft that operate in and out of Shymkent are older Russian aircraft, such as AN-24 and YAK-40. These older aircraft are not equipped with VOR/DME and local personnel believe that it is necessary to replace the existing NDBs to be

able to support these older aircraft. However, NDB procurement, maintenance, and operational costs are expensive. The current 4 NDBs are located at 1 and 4 kilometers from the approach end of each runway. This location requirement stems from Soviet Union navigation procedures that are decades old.



View of NDB site Runway 10

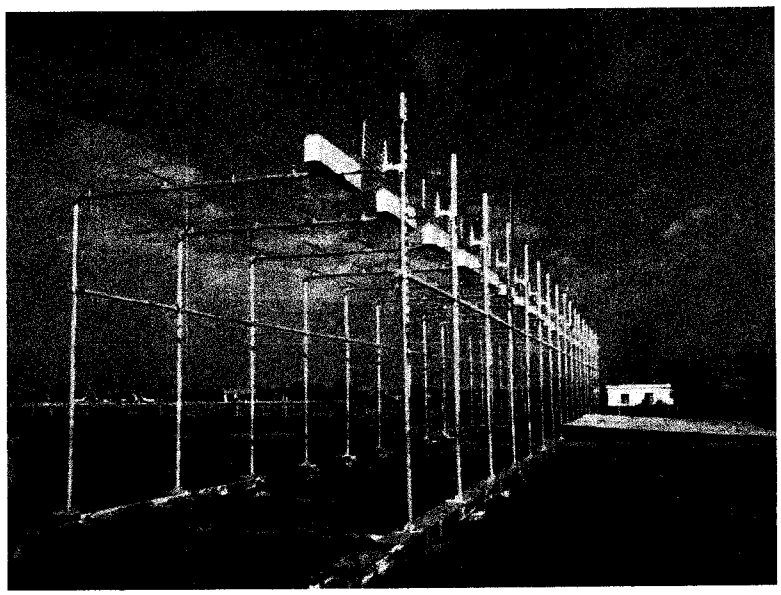
The VOR/DME is Russian manufactured and was newly installed in 2005. There have been no problems with the system and reportedly services have been excellent.



VOR/DME Installed in 2005

The current ILS to Runway 10 is a 15 year old Russian manufactured SP-80 system. Plans are in place to replace the existing ILS with a Russian manufactured SP-90 system and to purchase and install an SP-90 for Runway 28. It is anticipated that both system will be installed and operating in 2006. Although these systems are capable of supporting precision approach Category I operations, the runway lighting system is not ICAO compliant for Category I approaches. This presents a problem since the full benefit of these systems cannot be realized without the proper lighting and runway markings.

The plan to upgrade the current ILS, and purchase and install a new ILS is supported. Consideration should also be given to install the proper runway lighting system for both runway ends and ensure that all runway markings are ICAO compliant.



Runway 10 Localizer Antenna

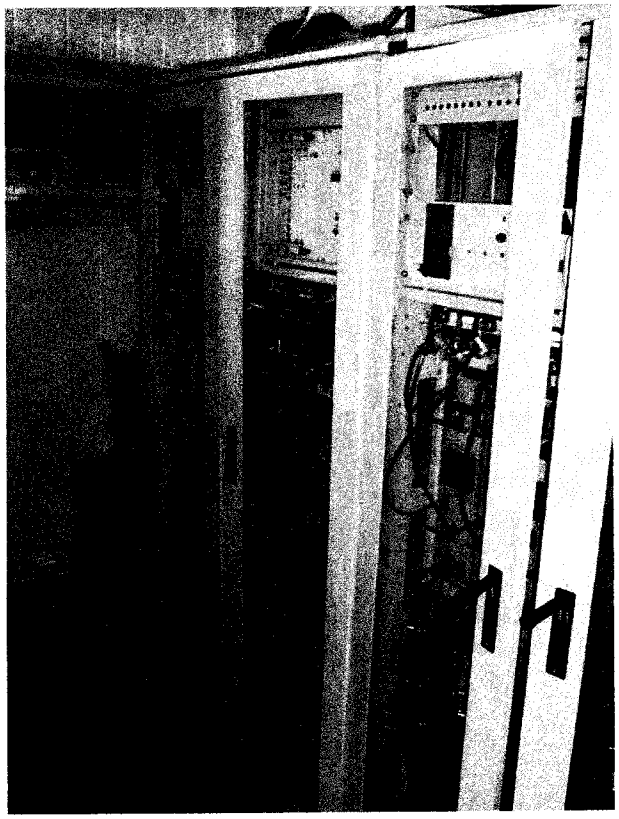
Recognizing that:

- ICAO supports the evolution to satellite-based navigation;
- Satellite navigation coverage is excellent in Kazakhstan;
- Modern aircraft are being equipped with satellite-navigation capabilities;
- Shymkent has a new VOR/DME—installed in 2005;
- Some of the aircraft operating in Shymkent have VOR/DME;
- There is a Cateory I ILS at the dominant runway and plans are in place to install a Category I ILS to the other runway end;
- New VHF communication systems will be installed and operating in 2006;
- Air traffic controllers have the necessary communication and radar equipment and facilities to provide radar vectors to non-VOR/DME equipped aircraft in order for them to use the ILS capabilities;
- NDB approach procedure minimums are above those minimums that can be realized by both satellite-navigation approaches and the ILS equipment even if Category I lighting is not available;
- The current NDBs have reached the end of their service life;
- New NDBs are relatively expensive to purchase, install, operate and maintain and;
- The Soviet Union requirements for using NDBs are outdated and appear not to be applicable for modern day airport operations.

It is recommended that consideration be given to phasing out the existing NDBs at Shymkent as they become non-supportable; conduct the necessary WGS-84 surveys to enable the development of satellite-navigation procedures; develop and implement satellite-navigation arrival, approach and departure procedures for both runway ends; establish a program to develop radar vector procedures to enable controllers to vector aircraft for a visual, satellite-navigation or ILS approach procedure; and establish the requisite training programming to ensure the controllers are fully qualified to use the new procedures and understand the operational use of satellite-navigation.

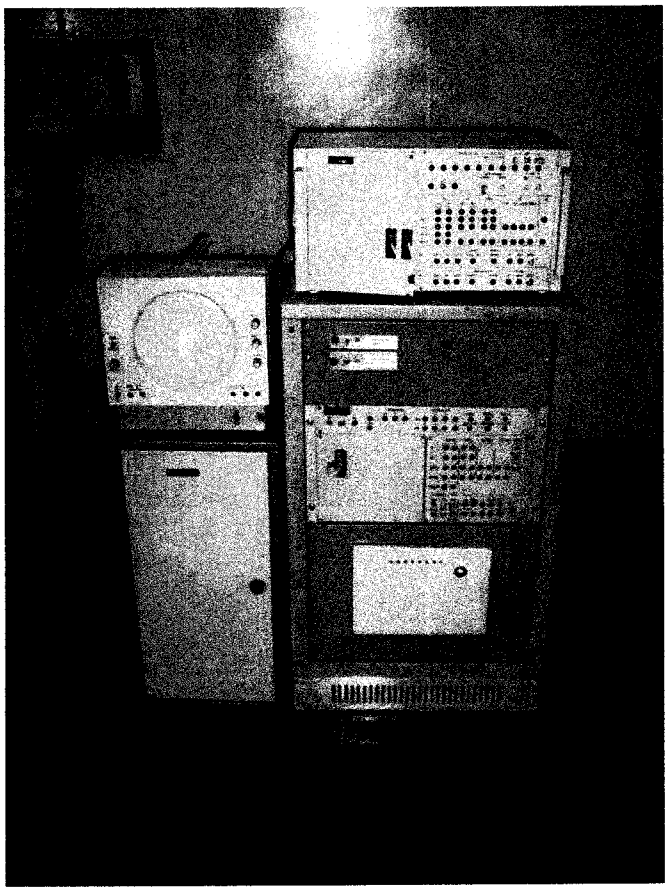
Surveillance

The primary and secondary radar systems are both relatively new. Both are Russian manufactured with a 12 year life cycle. The primary radar was installed in 1999 and the secondary radar was installed in 2003. Reportedly both system are operating without problems and are sufficient to accommodate Shymkent operational requirements. Spare parts are not a problem and the technicians responsible for maintaining the systems are satisfied with equipment performance.

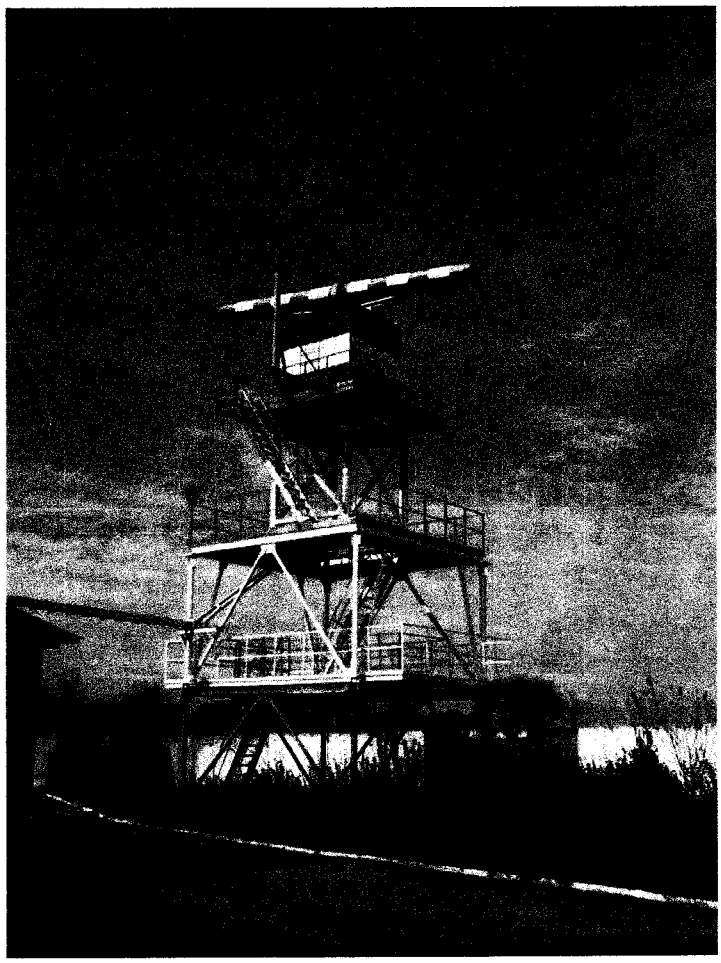


Primary Radar Equipment

Primary Radar Antenna



Secondary Radar Panel

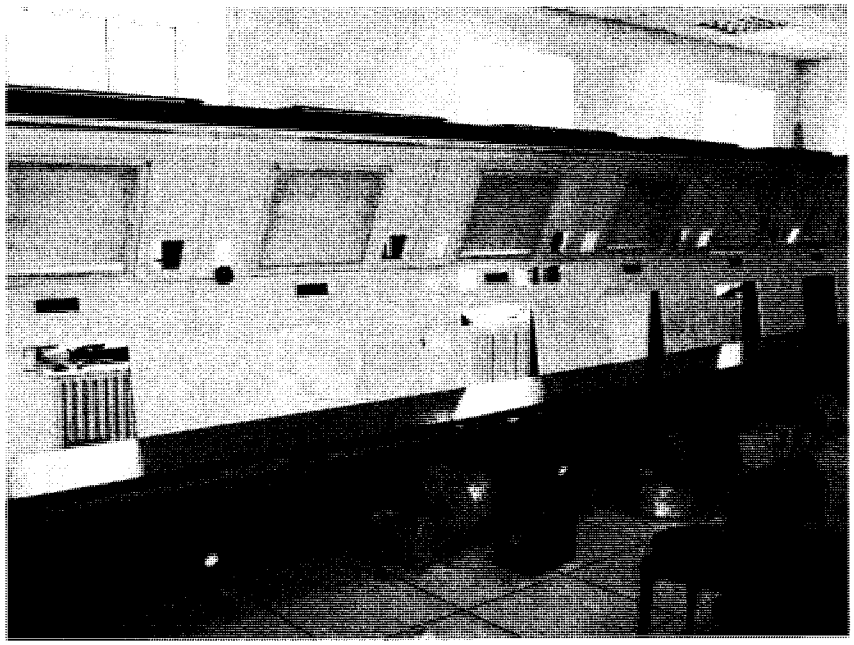


Secondary Radar Antenna

Air Traffic Management

Air traffic control personnel will be using a completely new air traffic control system in 2006. The area control center, approach and tower equipment are in the process of being modernized and are all scheduled for full system operation in 2006. The new equipment is Russian manufactured (VNIIRA-OVD) and reportedly the equipment and software have been properly matched and configured for Shymkent.

The area control center configuration is being expanded from its current 2 station design to 7 stations in order to accommodate the planned increase in area control responsibility at Shymkent.



New Shymkent ACC under construction-to be completed in 2006

Old Shymkent ACC Stations

Shymkent Tower Position—in modernization process

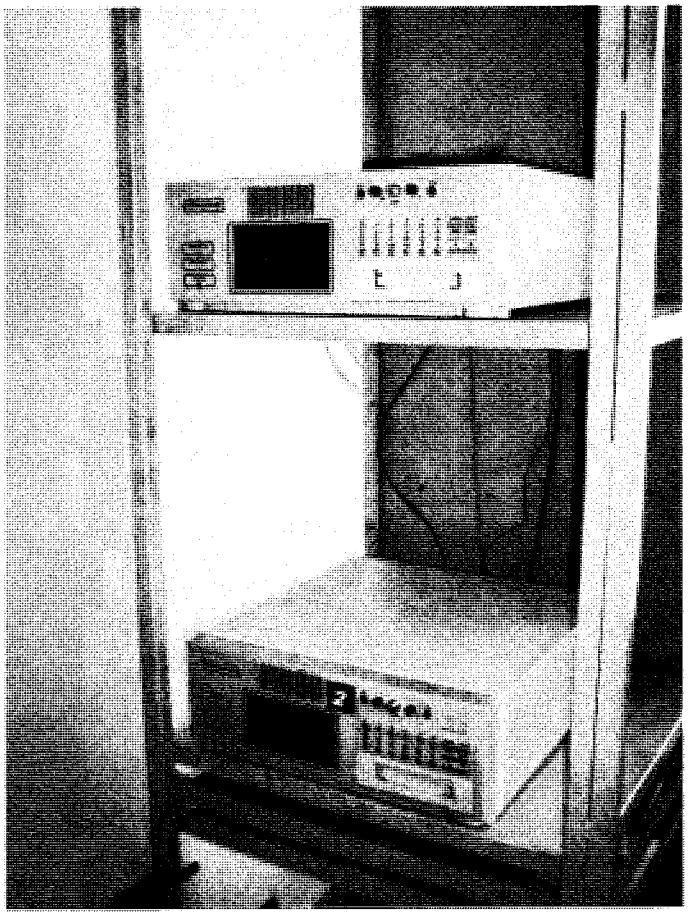
The controllers currently rely on new fiber optic and microwave link connected to facilities in the center of town. The system reportedly works satisfactorily and there are plans to install a satellite communication system that will be connected the internal Kazaeronavigatsia network to provide a backup capability in the event the commercial system fails.

It is recommended that consideration be given to installing the requisite system and equipment to be able to connect directly with the internal Kazaeronavigatsia network and not rely on the commercial communications infrastructure. In addition to reducing the risk of a commercial failure, it is likely that such a capability will be cost-effective as a result of eliminating the commercial communication costs.

Based on discussions with operational personnel, the importance of towers/airports within Kazakhstan to be able to communicate directly with one another. Such a capability would facilitate the safe and efficient of people and goods within all Kazakhstan airspace and improve operational safety. Technical personnel noted that the basic infrastructure was in place to be able to provide direct tower/airport communications via the Kazaeronavigatsia network, but it would be necessary to purchase and install the requisite number of "small" digital communication switches. The estimated number of these switches was 18.

It is recommended that consideration be given to enable the direct communication between all Kazakhstan towers/facilities using the internal Kazaeronavigatsia network.

The present digital recorders have a 32 channel capacity and are reportedly inadequate to support the higher communication requirements that will result from the expansion of the area control center and an increase in Shymkent provided air traffic control services.



Current 32 Channel Recorders

It is recommended that consideration be given to replacing the existing 32 channel recorder with digital recorders capable of supporting a minimum of 100 channels.

Shymkent Recommendation Summary

1. It is recommended that consideration be given to modernizing the HF radio system and modernizing the backup power supply systems (e.g. generators and batteries) for all CNS/ATM systems. Should a decision be made to replace the backup power supply systems, then it is suggested that the Tender be based on a functional capability and not merely a one-for-one replacement.

2. Consideration should be given for replacing the current point-to-point cable based communication system between airport locations with fiber optic and/or microwave technology. Should a decision be made to replace the point-to-point system, then it is recommended that a remote maintenance monitoring and control capability be included in the modernization plans for all CNS/ATM systems and the supporting infrastructure such as generators, batteries and climate control systems.

3. It is recommended that consideration be given to phasing out the existing NDBs at Shymkent as they become non-supportable; conduct the necessary WGS-84 surveys to enable the development of satellite-navigation procedures; develop and implement

satellite-navigation arrival, approach and departure procedures for both runway ends; establish a program to develop radar vector procedures to enable controllers to vector aircraft for a visual, satellite-navigation or ILS approach procedure; and establish the requisite training programming to ensure the controllers are fully qualified to use the new procedures and understand the operational use of satellite-navigation.

4. Consideration should be given to installing the proper runway lighting system for both runway ends and ensure that all runway markings are ICAO compliant to enable full Category I approach operations.

5. It is recommended that consideration be given to installing the requisite system and equipment to be able to connect directly with the internal Kazaeronavigatsia network and not rely on the commercial communication infrastructure.

6. It is recommended that consideration be given to enable the direct communication between all Kazakhstan towers/facilities using the internal Kazaeronavigatsia network.

7. It is recommended that consideration be given to replacing the existing 32 channel recorder with digital recorders capable of supporting a minimum of 100 channels.

8. Site Survey Report

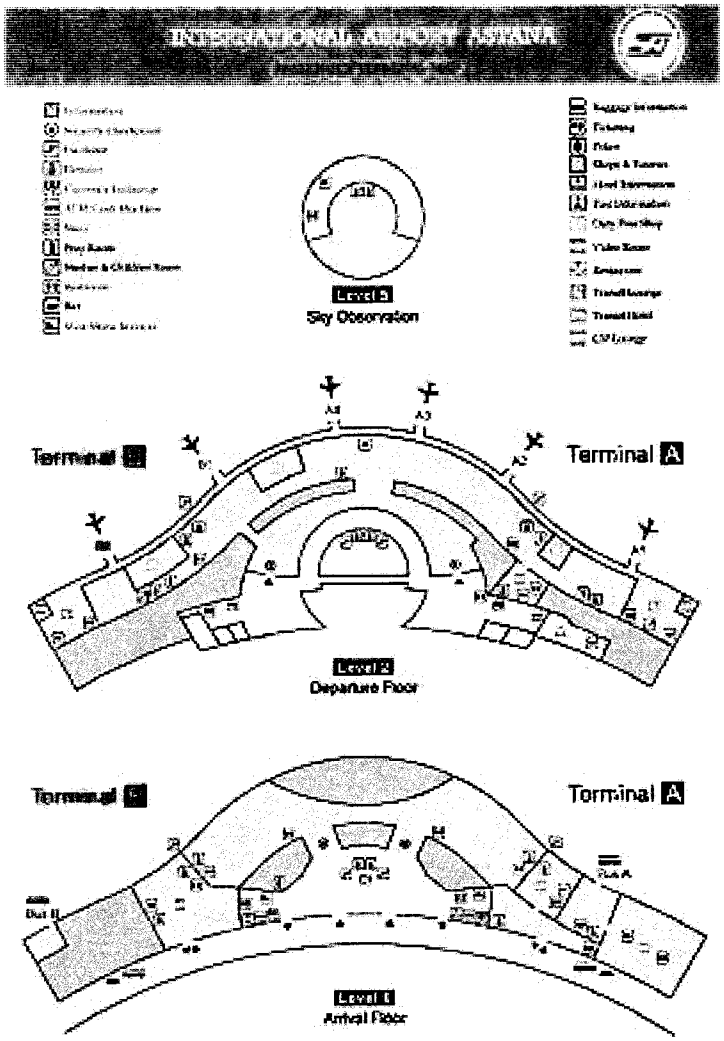
Airport and Area Control Center (ACC) Astana, Kazakhstan

November 15, 2005

Overview

The Astana International Airport and Area Control Center are very impressive. The buildings, offices, tower facilities, communications, navigation, surveillance, and air traffic management systems are relatively new, state-of-the-art technology, and the management personnel, workforce, and working conditions are outstanding.

Astana International Airport



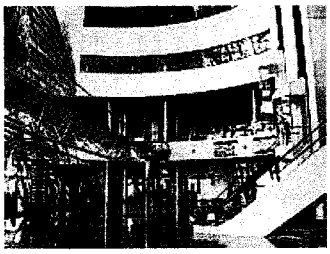
Astana Terminal Map

The Astana International Airport has undergone significant expansion and modernization during the past six years.

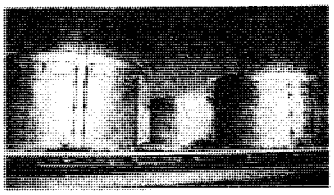
Modernization began in 1999 following receipt of a start-up loan of approximately $176,000,000 from the Japan Bank for International Cooperation (JBIC). The modernization project was all encompassing and included new facilities and equipment such as:

- Air Traffic Control buildings
- Warehouses
- Fuel distribution
- Heating and Cooling systems
- Power distribution facilities and systems
- Fire and rescue facilities and systems
- Maintenance facilities and equipment
- Supply lines (e.g. fuel, water, electric, etc.)
- Fiber optic, microwave and satellite communications systems

- Roads, fences, perimeter security
- Parallel and additional taxiways
- Reinforcement of the surfaces (e.g. ramp, apron, runways, etc.)
- Modern CNS/ATM equipment and systems
- New fleet of ground support vehicles and equipment

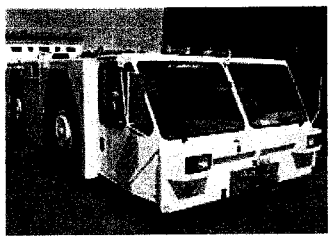


Passenger Terminal

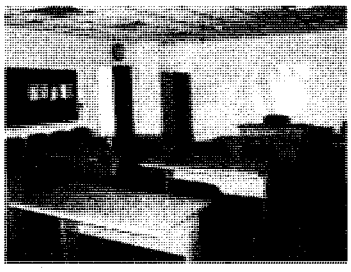


Fuel Storage and New Pipelines

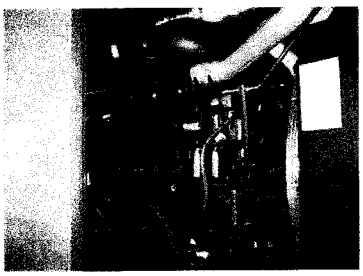
Fire and Rescue Equipment



Ground Service Vehicle



New Training Center



New 500 Kilo Watt Volvo Diesel Generator

The primary motivation for this effort was to transform the Kazakhstan capital airport into a modern cargo and passenger hub that would serve as a "gateway" for the movement of people and goods throughout Central Asia.

For three consecutive years Astana Airport has been recognized as the "Best Airport of the CIS States" and this trend is expected to continue. In particular, the new terminal is recognized as the premiere facility in the Region and can comfortably accommodate 750 passengers per hour.

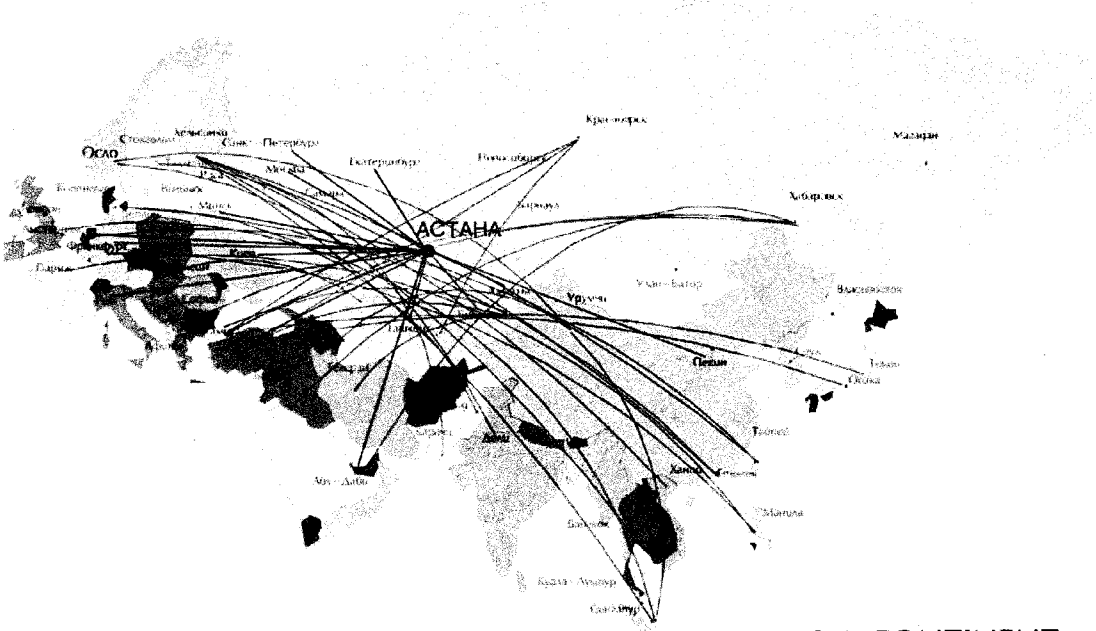
The following contractors had a major role in this reconstruction project:

- Japanese Consortium PCI (Pacific Consultants International) and KKAA (Kisho Kurokawa Architect & Associates)—general contractor
- Siemens (Germany),
- Marubeni (Japan),
- Laing (Great Britain)
- Alarko (Turkey).

The Astana International Airport is fully ICAO compliant and now capable of supporting aircraft of all types without weight restrictions, such as the largest of aircraft, the AN-124 and B747-400F. Additionally, the airport is certified to conform to ISO 9000-2000 for passenger handling and aircraft ground services.

The modernization vision for evolving Astana into a Central Asia gateway appears to be slowly taking hold as illustrated in the following Air Route Map (note Astana = АСТАНА).

ТРАНСЕВРАЗИЙСКИЕ АВИАЦИОННЫЕ МАРШРУТЫ, ПРОЛЕГАЮЩИЕ ЧЕРЕЗ ВОЗДУШНОЕ ПРОСТРАНСТВО КАЗАХСТАНА И АСТАНЫ



MAP OF MAIN AVIATION ROUTES ON THE EURASIA CONTINENT PASSING THROUGH THE TERRITORY OF KAZAKHSTAN AND ASTANA

The remainder of this report provides a summary of the Astana CNS/ATM equipment, systems and services as well as the comments and observations made during the site survey.

Communications

Principle ground-air communications services are provided by newly installed Rhode and Schwarz Series 200 transceivers. These radios, as well as the entire VHF system were

modernized in 2005 to meet the current and projected air traffic demands for the next several years. The transceivers are working well with no disruptions in service or system failures.

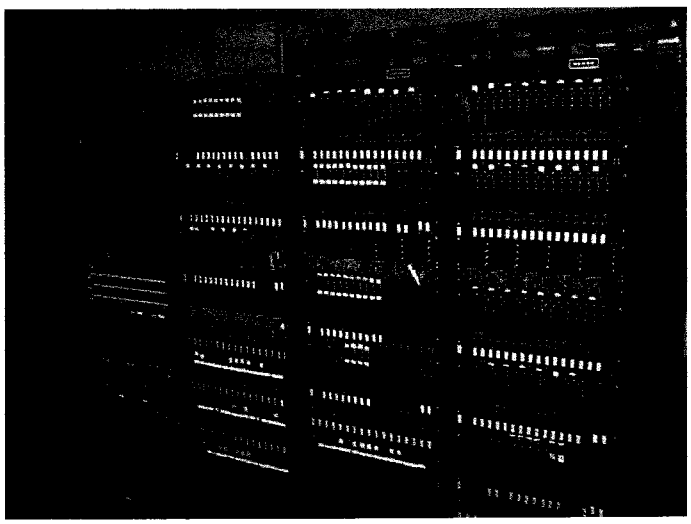
Rhode and Schwarz Series 200 transceivers—installed March 2005

The HF equipment and systems are vintage Russian manufactured, and reportedly work well. There are sufficient spare parts and the maintenance staff are comfortable with maintaining and repairing the equipment and systems in the event of problems. The HF operator indicated that the current HF capabilities satisfactorily meet daily requirements.

HF Work Station and Operator

Point-to-point communication services in Astana and between Astana and other Kazakhstan air traffic facilities are provided via ground lines, microwave links and satellite communications. Essentially these point-to-point services are relatively new and operating reliably.

Communications switching and control are provided by a Northrop-Grumman DENRO manufactured switch. The switch is less than one-year old and there have reportedly been no problems with the operation and maintenance of the system. A "fix all/repair all" service agreement for this switch will be in place in early 2006, similar to the agreements for the other Denro switches providing services at Kazakhstan facilities.



Denro Voice Communications Switch—installed Dec 2004

Navigation

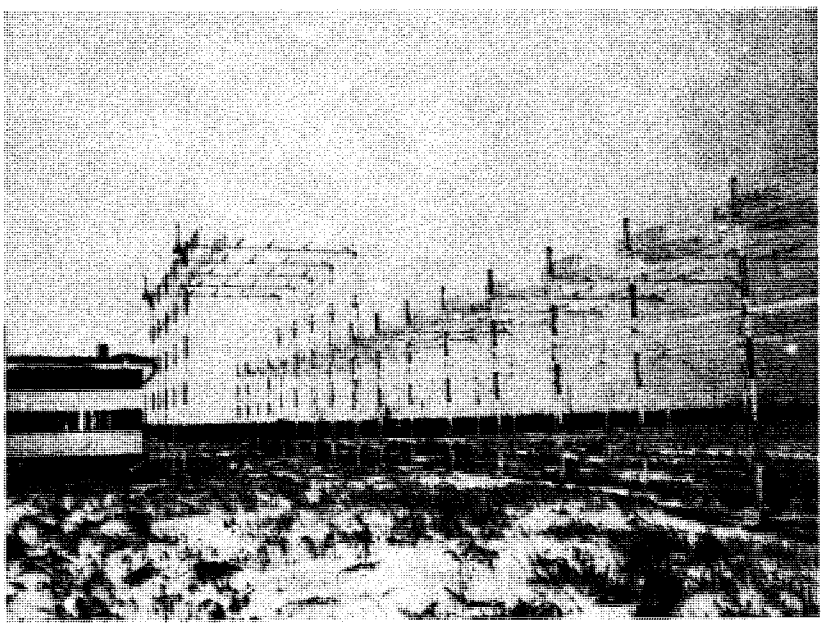
Navigation services at Astana as well as throughout Kazakhstan are provided via traditional ground-based systems.

Approximately 80 aircraft arrive/depart Astana on a daily basis. Approximately 98% of these aircraft rely on the VOR/DME and ILS systems for navigation services, with only 2% requiring radar vectors and/or the services of the NDBs.

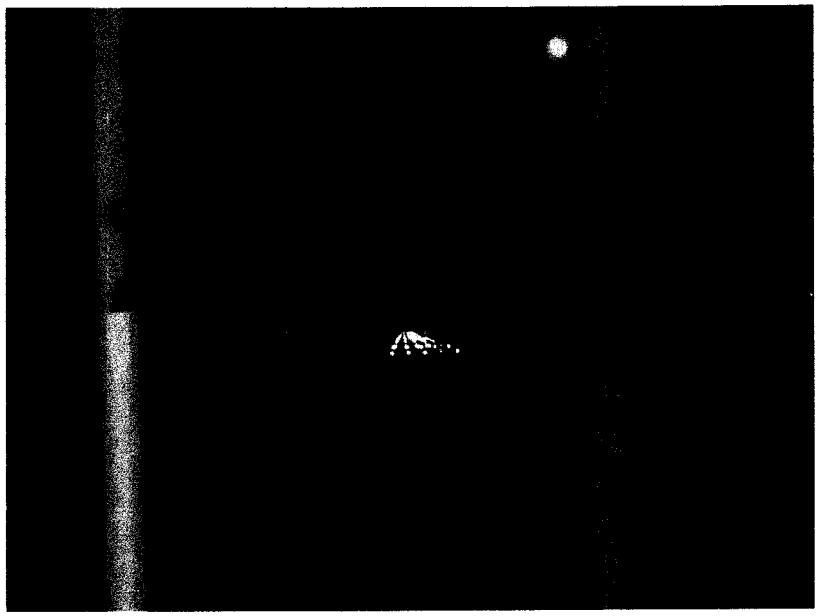
The Russian manufactured VOR/DME is located approximately 1.8 nautical miles from the runway and is reliably providing services without interruption. Adequate spare parts are available and reportedly the technical staff has no problem operating and maintaining the system.

The instrument landing system (ILS) is a Russian manufactured SP-90 Category 2 system. It was installed in 1997 and has a 15-year life cycle. The system is reportedly very reliable with an estimated mean time between failures of 3000 hours or greater. There are sufficient spare parts, the maintenance personnel have had no difficulties in making local repairs, and there is a service contract with the manufacturer. The manufacturer has reportedly been very responsive to requests for assistance with the SP-90 and there have been no problems in effecting timely repairs.

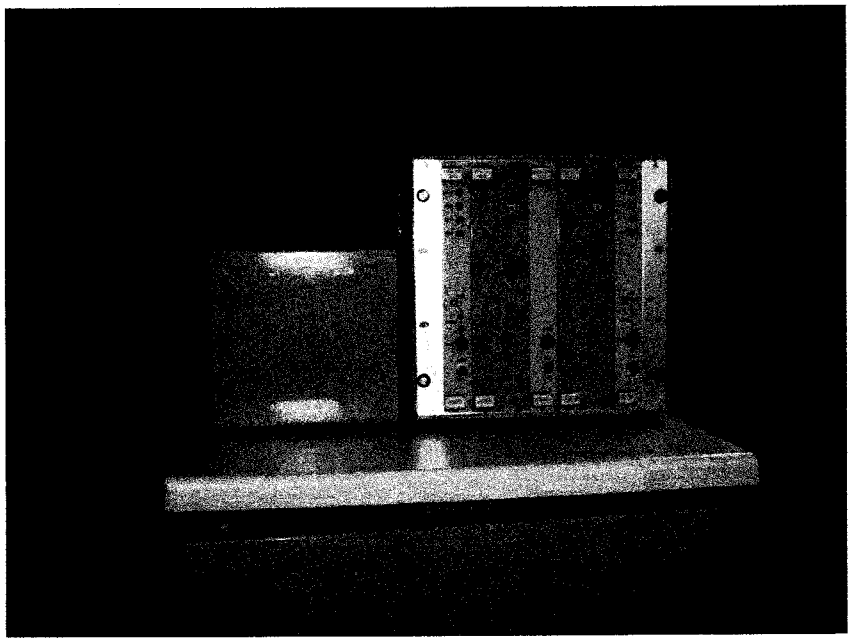
Weather conditions can be extreme at Astana and should the ceiling and visibility fall below Category 2 minimums, the navigation facilities will not permit arrival or departures. Such a condition is not desirable for scheduled airlines and will reduce the willingness to accept Astana International Airport as "gateway" facility.
It is recommended that consideration be given to either upgrading the current Category 2 ILS to a Category 3 ILS, or purchasing a new Category 3 ILS. In addition, is it recommended that consideration be given to acquiring and implementing a surface movement radar system to be able to safely handle aircraft ground traffic during limited visibility.



Category 2 ILS System—Localizer Antenna



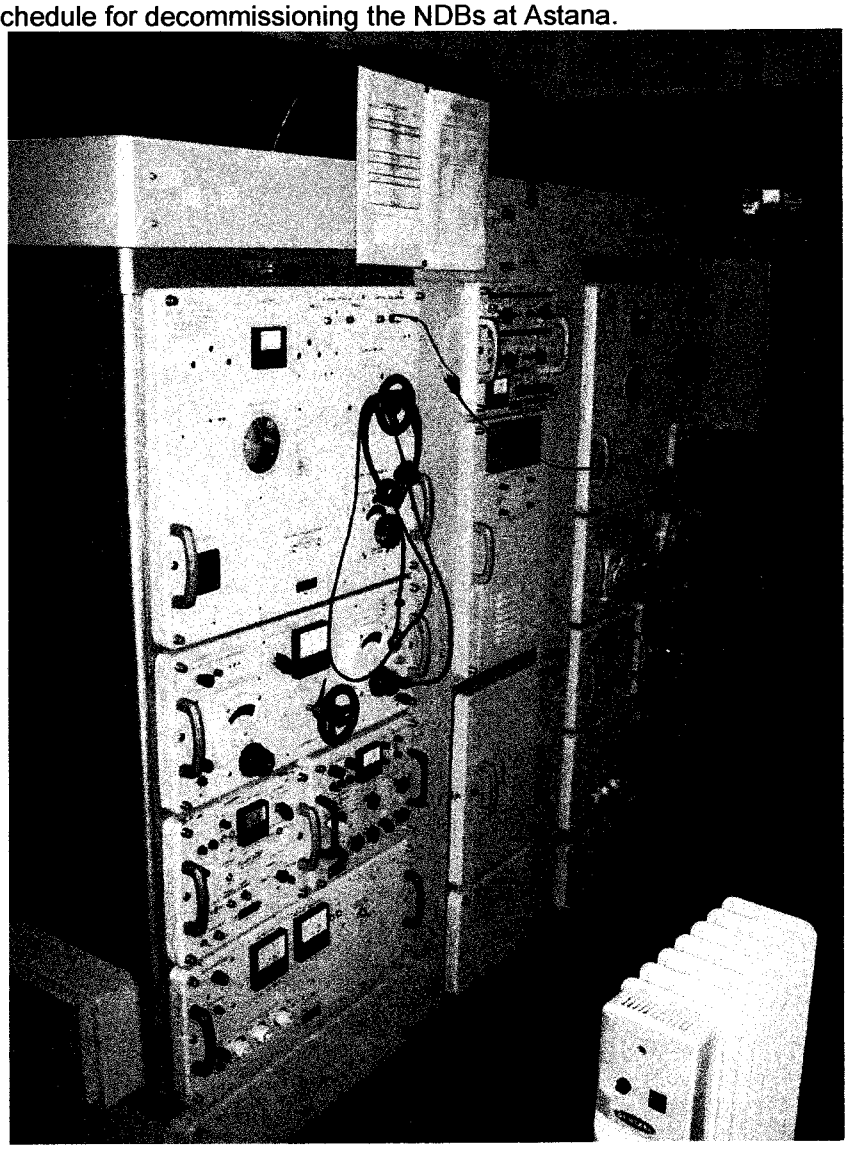
Category 2 Approach Lighting System, Runway 22



Category 2 ILS--Russian manufactured SP-90

The NDB systems are relatively new as compared to other NDB system throughout Kazakhstan. The Astana systems were purchased and installed in 1997-1998; are Russian manufactured and have a lifecycle of 15 years. The NDBs are reportedly very reliable and there are sufficient spare parts to effect repairs. It is estimated that the systems are offline 4-5 times per year. These down times are typically associated with weather induced problems such as frost on the antenna. Duration of the down time is typically 1 hour or less.

Given that fewer than 2% of the aircraft operating in Astana require the services of the NDBs and the as stated by an air traffic controller "if the NDBs were turned off today, it would not be a problem for tower operations", it is recommended that consideration be given to developing a plan and schedule for decommissioning the NDBs at Astana.



1997 Vintage NDB System

Surveillance

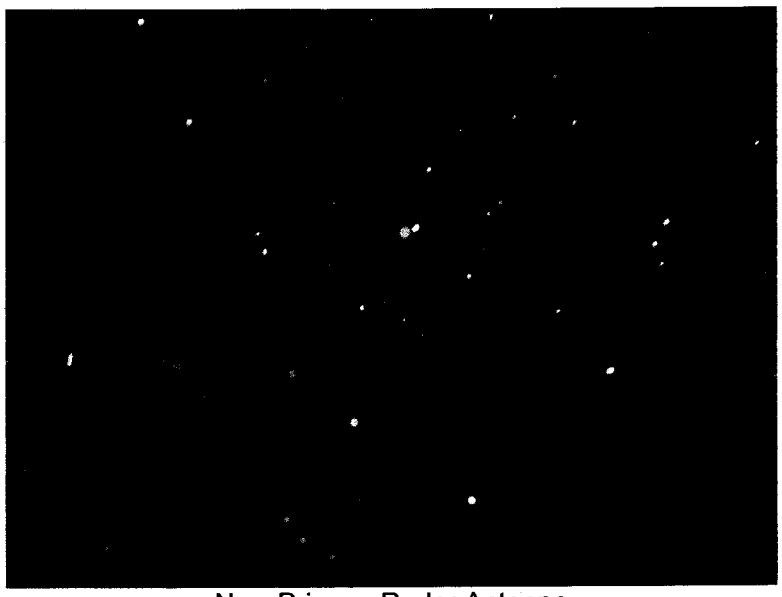
The primary, secondary and approach control radars are all reportedly working well with few problems.

The radar equipment is a mix of French and Russian manufactured systems. The primary radar is Russian manufactured and is used on as required. If the controller requests the primary radar to be "turned on", then the technician activities the system and within 1-2 minutes services are available for the controller. Reportedly, the primary radar is seldom "turned on".

The secondary radar system provides the main surveillance services for upper airspace control. The Thales Star 2000 system was installed in 1999; has a 15 year lifecycle; the mechanical system was upgraded in 2000; and rarely fails to operate. The technicians could not recall ever having an operational problem with the system. There are ample spare parts; a repair and service contract is in place with the manufacturer; and the manufacturer has been responsive to the technical requests for support.

Similarly, the approach control radar reliably provides a full range of services and is reportedly in excellent working condition. Approximately 5-6 aircraft per hour are vectored via the approach control radar and neither the technicians nor controllers could recall an operational failure of the system.

Primary and Secondary Radar Systems



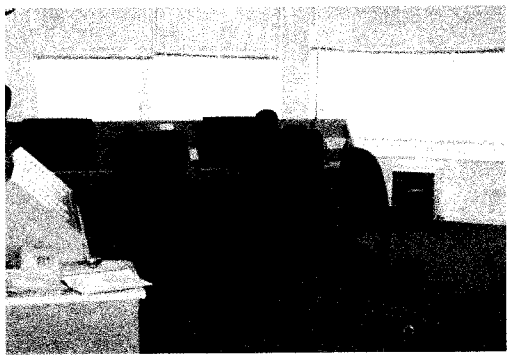
New Primary Radar Antenna

Air Traffic Management

Air traffic control personnel are very happy with their working environment and pleased with the functionality of the air traffic management equipment and supporting infrastructure. The new 44 meter tower—the highest in Kazakhstan-- is fully equipped with modern facilities and features. The new area control center is also fully equipped with state-of-the-art equipment to include the new Lockheed-Martin SkyLine air traffic management system.

SkyLine is an advanced system of complete Flight Data Processing (FDP) and Radar Data Processing (RDP). It provides tower, terminal area, procedural and flow monitoring system services. SkyLine is based on commercial-off-the-shelf hardware; provides ICAO compliant route processing, and is Lockheed Martin's offering for the mid-market international arena.

New 44 meter Tower



Tower Working Position

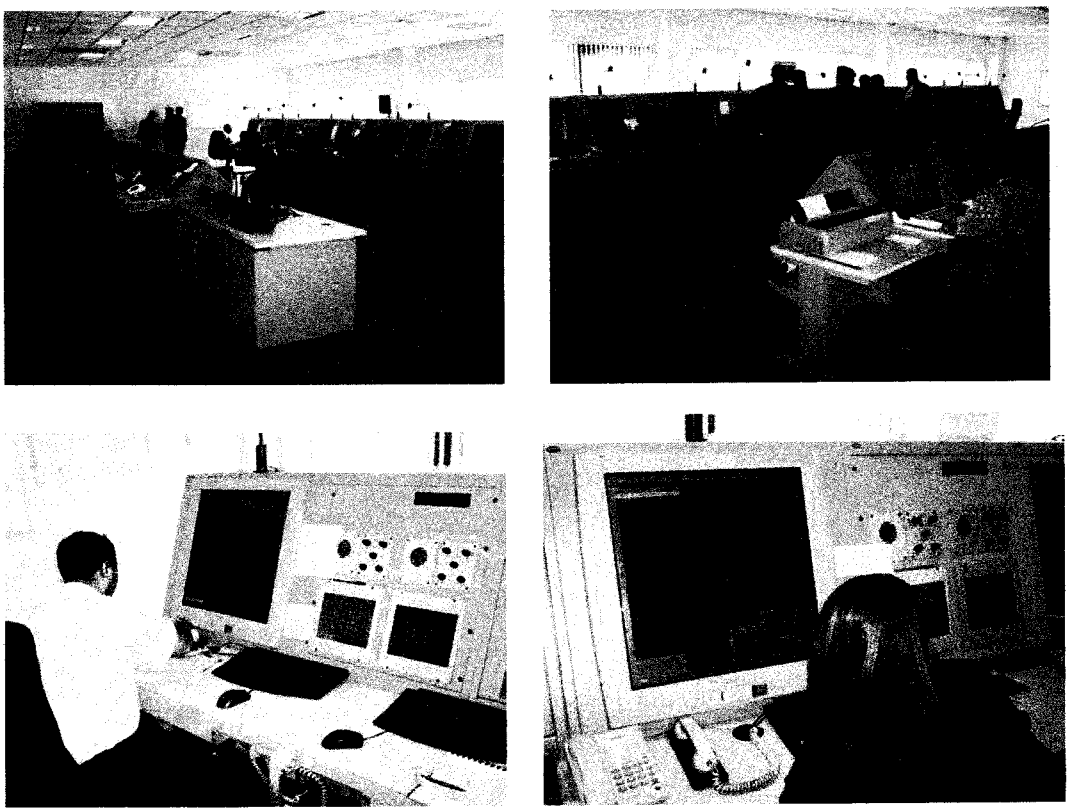
Since SkyLine was recently installed, the controllers are in the initial stages of becoming comfoirtable with the system and the myriad of features. There have been some minor

problems with the software, such as display errors in the relay of information from Balash secondary radar; false alarm warnings indicating dangerous vertical separation of aircraft; and scale display errors, but these problems have been corrected.

The plans for maintaining the SkyLine system beyond the one-year warranty period were unclear. The local maintenance people indicated that they did not have sufficient documentation and training to solve problems on their own without the support of Lockheed-Martin. However, if there is a failure of SkyLine and it cannot be repaired in a timely fashion, the old Russian manufactured air traffic management system is still in operation and will be used as a backup. This Russian was manufactured in 1999, it is reportedly very reliable and can be repaired by local personnel.

It is recommended that consideration be given to develop a post-warranty Skyline plan to ensure continued reliable operations and services from the system.

The area control center SkyLine equipment includes two workstations that are not being used and are not connect to a processor. The reason for this was unclear, but it was reported that these two workstations are not needed for the safe and efficient control of air traffic. It is recommended that consideration be given to obtaining a separate processor, run the SkyLine software on this new processor (reportedly this would be permitted at no additional cost), connect these two workstations to that processor, and use the two workstations for upgrades, testing and training.



New Area Control Center Facilities and SkyLine system

The 2001 vintage Russian manufactured voice recorders operate without difficulties. However, given the increase in the number of controller workstations and the anticipated air traffic growth in the Astana region, the current 64 channel recorders do not appear adequate to satisfy the recording requirements.

It is recommended consideration be given to obtaining and implementing 132-channel digital voice recorders for Astana. Additionally, the latest technology enables the coupling of voice data with radar data in order to have a clear simultaneous indication of the air traffic situation at any point in time. It is further recommended that the digital recorders be also capable of recording radar data with the voice data.

Astana Recommendation Summary

1. Either upgrade the current Category 2 ILS to a Category 3 ILS, or purchasing a new Category 3 ILS.

2. Acquiring and implementing a surface movement radar system to be able to safely handle aircraft ground traffic during limited visibility.

3. Develop a plan and schedule for decommissioning the NDBs.

4. Develop a post-warranty Skyline plan to ensure continued reliable operations and services from the system.

5. Obtain a separate processor, run the SkyLine software on this new processor (reportedly this would be permitted at no additional cost), connect the two unused workstations to that processor, and use these two workstations for upgrades, testing and training.

6. Acquire 132-channel digital voice recorders with the ability to also record radar data.

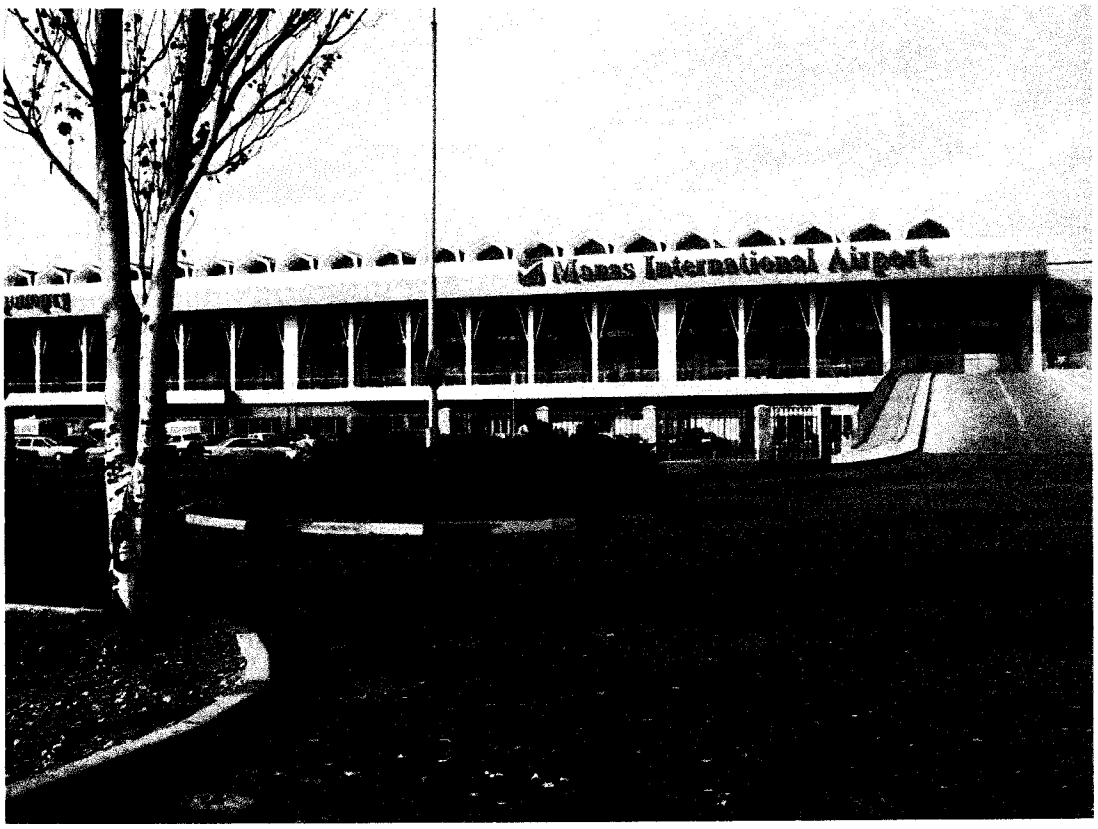
Site Survey Report

Manas International Airport and Area Control Center (ACC) Bishkek, Kyrgyzstan

November 9-10, 2005

Overview

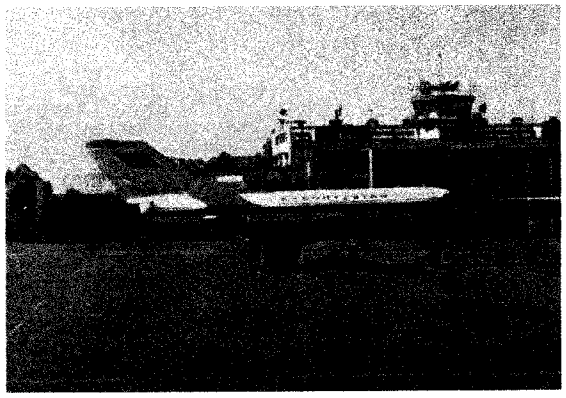
The Manas International Airport is approximately 35 kilometers from the Capital and the largest of the three airports in Kyrgyzstan. The other two airports Osh and Issyk-kul are domestic airports and have limited traffic. In addition to these airports, there are approximately twenty-five local fields that supplement local air services.



Manas International Airport

Manas International Airport--Interior

Osh Airport handles approximately 5-6 aircraft per day. There is also an air traffic control facility located nearby (Karakol) that provides both enroute and local air traffic service.



Osh Airport

The Issyk-kul Airport is a seasonal airport primarily for supporting tourism in the Issyk-kul lake region between June and October. The 1500 meter runway supports small aircraft operations to include YAK-40 and AN-2 platforms. In 2004 a project began to increase the runway length and improve the taxiways, ramp and terminal facilities to accommodate larger aircraft such as the TU-134 and Boeing airframes. The Issyk-kul lake region is the primary tourist attraction in Kyrgyzstan and reportedly generates approximately $50 million in annual revenues.

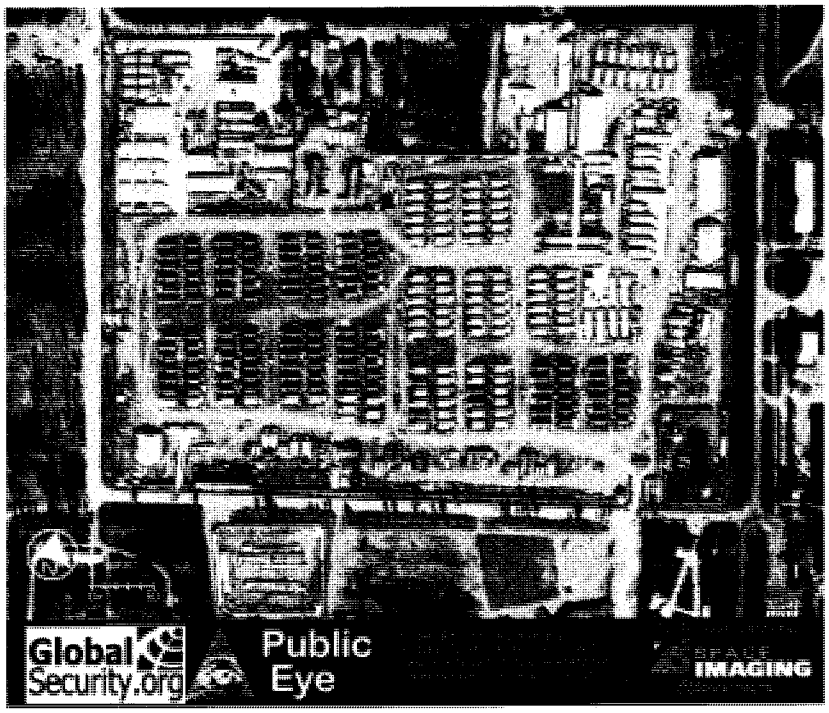
Air traffic control operations and exchange of controller information between Kyrgyzstan and their Central Asian neighbors Uzbekistan and Kazakhstan are working well. There are no problems with hand-offs, communications, and transfer of information between these area control centers.

However, there are problems with the bordering country to the southeast—China. There are difficulties transferring control operations between flight information regions and attempts to solve the local problems have not been successful. Apparently, local Chinese air traffic control officials cannot make changes or take corrective actions without receiving guidance and direction from Chinese Civil Aviation Authority headquarters in Beijing.

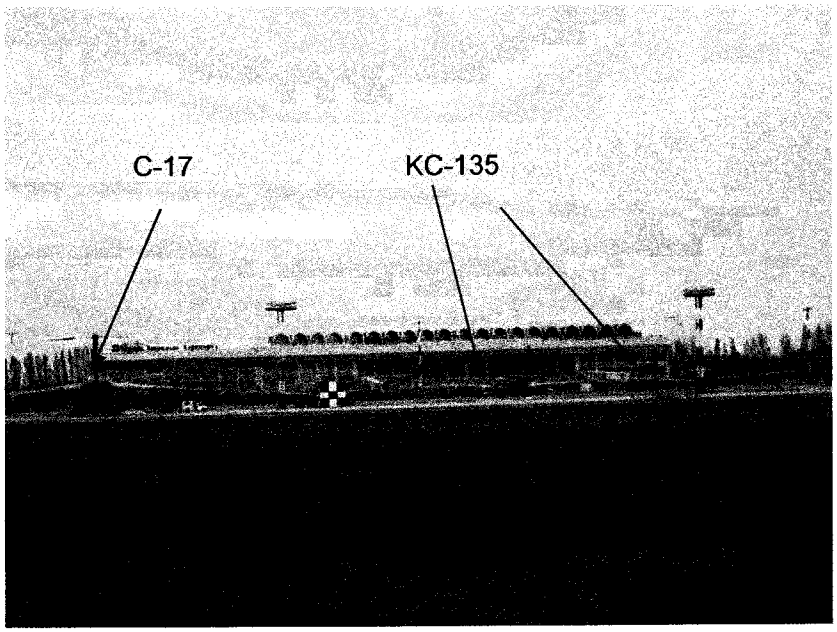
Since shortly after the September 11, 2001 terrorist attack in the US, the US established a military air base at Manas International Airport. This base, named Ganci Air Base, supports both military and humanitarian objectives in Afghanistan. Kandahar Afghanistan is approximately 1500 kilometers from Manas.

There are approximately 1000 troops assigned to the base and the US pays between 40 and 50 million dollars per year to operate the facilities. This expense fuels the Kyrgyzstan

economy and is in addition to the annual 10 million dollar US military aid program. In October 2005, the US finalized an agreement with the Kyrgyzstan government for open use of the air base for the foreseeable future.



Ganci Air Base (2003)



C-17 and KC-135 Aircraft on the Manas Ramp

The remainder of this report provides a summary of the Manas CNS/ATM equipment, systems and services as well as the comments and observations made during the site survey.

Communications

Principle ground-air communications services are provided by vintage Russian equipment. The transmitters and receivers are tube technology and were manufactured in the 1970-1980s. The diverse inventory of Russian manufactured communications equipment includes Sprut-200, Yasen-50, Balkan-RN, Polet 2A VHF transmitters and receivers and R-140, Beryoza, and Kashtan HF systems. The VHF radios support only 25 kHz channel spacing and 8.33 kHz spacing is desired.

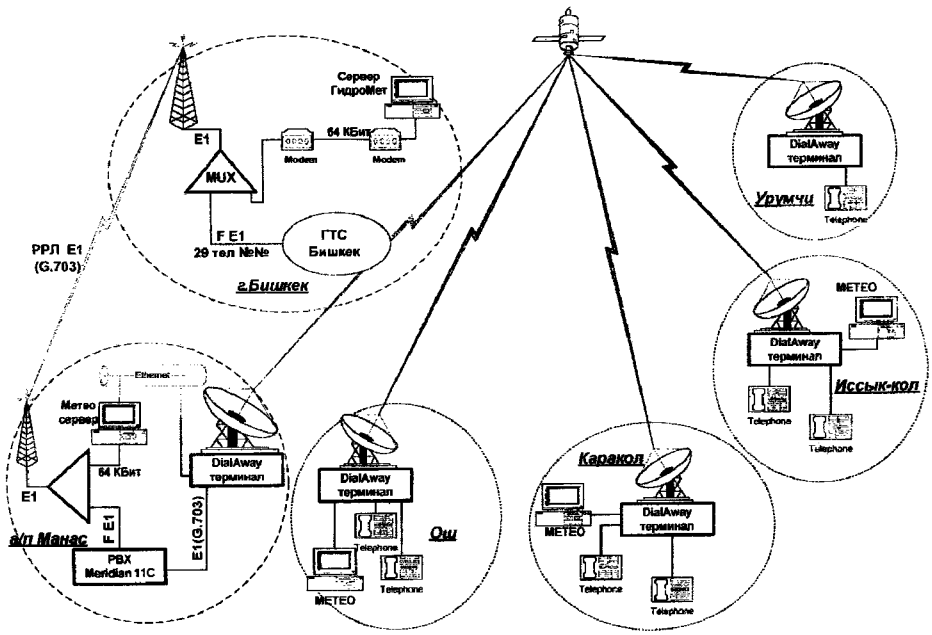
The VHF and HF transmitters and receivers are located in separate facilities. Due to the interference and reception characteristics of the signals the equipment must be separated by 4 kilometers. One site is located in the airport area and the other site is located near the center of a prosperous new housing area close to town. The high buildings in the town reportedly cause operational problems and the maintenance personnel staffing is greater than necessary due to the separate facilities.

Reportedly the ground-air communication system is reliable with an equipment problem once or twice per year. The local technicians are very familiar with the equipment and able to effect local repairs.

It is recommended that consideration be given to purchasing new digital VHF transmitters and receivers or transceivers that can be collocated in the same physical facility and use the same basic antenna systems; decommission the communications facility in town; and relocate all communications in a single Manas airport location. It is projected that this communications modernization will reduce the number of required maintenance personnel by approximately 30% and the revenue generated by the sale of the land and facility in town is projected to offset a reasonable portion of the cost of the new equipment.

HF Radio System at Manas

HF Antenna—Communication Facility Located in Housing Project



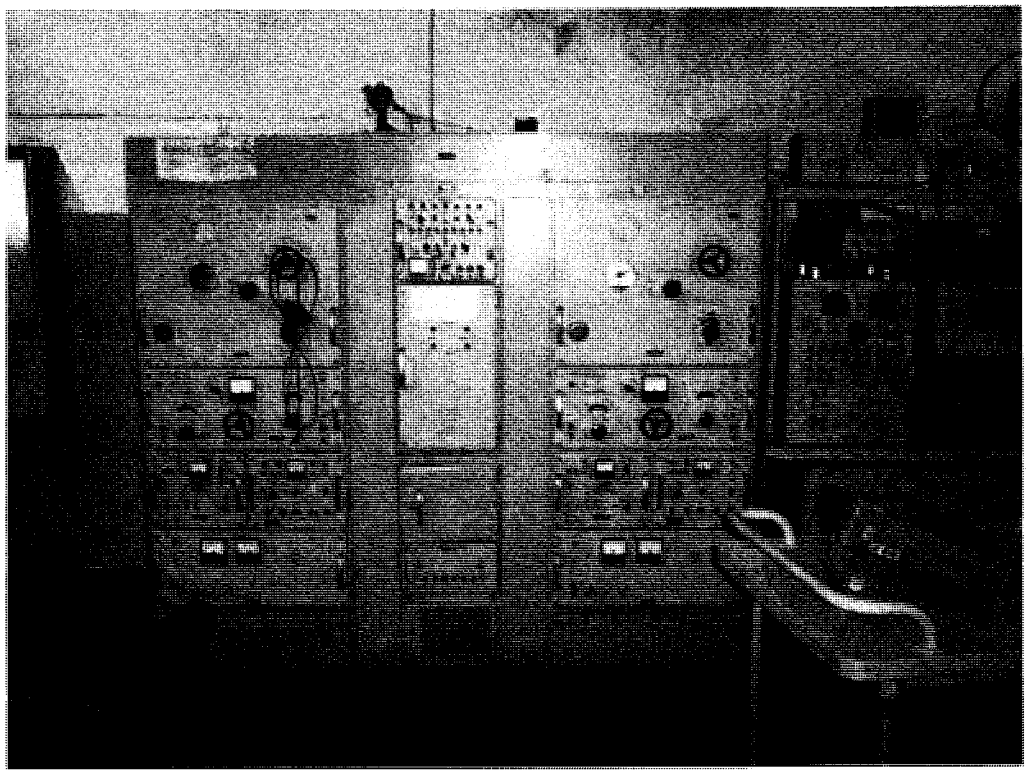
Kyrgyzstan Ground Communications Coverage

Navigation

Navigation services at Manas as well as throughout Kyrgyzstan are provided via traditional ground-based systems. As indicated in the following chart, the Kyrgyzstan ground-based navigation system consists mainly of NDBs.

Name	ID	Type
BALYKCHI	BL	NDB
BISHKEK	BI	NDB
BISHKEK	BK	NDB
BISHKEK	MN	NDB
BISHKEK	MNS	VOR-DME
BISHKEK MANAS	B	NDB
BISHKEK MANAS	M	NDB
CHALDOVAR	DW	NDB
IRISU	IR	NDB
KALINOVKA	KL	NDB
KANT	PD	NDB
KARAKOL	KA	NDB
KYZYL KIYA	KZ	NDB
MANAS	AFM	TACAN
NARYN-GES	NS	NDB
OSH	DZ	NDB
OSH	OU	NDB
ZHALAL ABAD	DA	NDB

The NDBs are Russian manufactured and in general reportedly work well with no operational problems. There are ample spare parts, the technicians are very familiar with the systems and have no problems with local repairs. The service life of the systems is typically 10 years and many of the operational NDBs in Kyrgyzstan have either reached or exceeded their service life.



Russian Manufactured NDB—produced in 1989

It is recommended that consideration be given to developing a plan to phase-out the NDBs in Kyrgyzstan and at the same time, initiate a program to develop and implement Global Navigation Satellite System (GNSS) enroute, terminal, arrival and departure procedures for those locations currently serviced by NDBs. Since Kalashnikov Vasily AIS Navigation Service develops procedures for Kyrgyzstan airspace operations and sends them to Rosjep for publication and distribution, it is recommended that both organizations be contacted to determine if they have the capability and experience to develop and publish GNSS procedures for domestic and international aviation users.

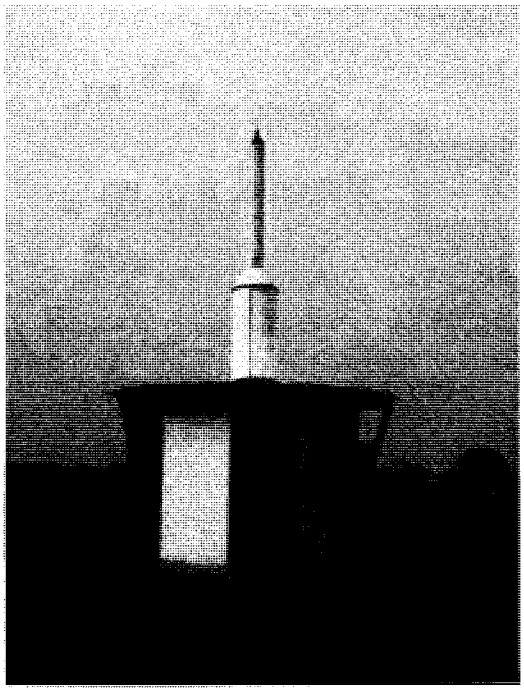
The VOR/DME at Manas International Airport was manufactured by Wilcox (Wilcox VOR 5858 and Wilcox DME 5960), a US company. Reportedly the system works very well, repairs and maintenance can be made locally and there are very few disruptions in service. In fact, in the last 10 years the local technicians could only recall one or two instances when the system experienced problems and could not be repaired locally.

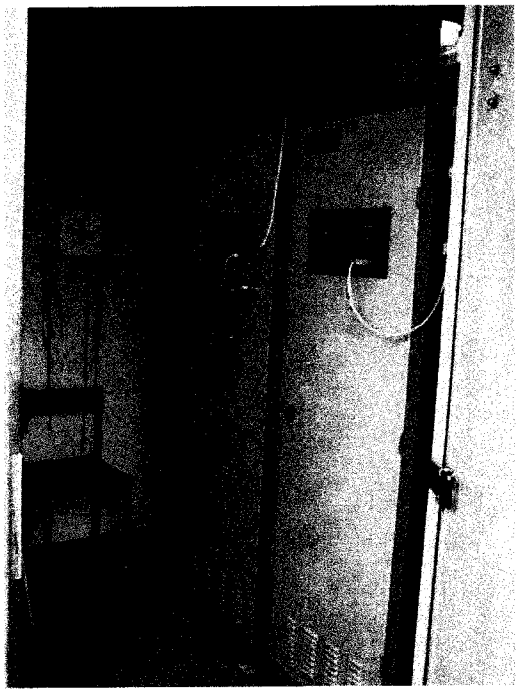
Recently it has been difficult to obtain spare parts for the system and there are concerns that service disruptions could increase if spare parts are not readily available.

There is no maintenance and repair contract with Wilcox and there has not been a contract since 1995. Thales has been available to effect repairs upon request, and apparently have been responsive.

Given the age of the VOR/DME equipment, the increasing difficult in obtaining spare parts, and the reported operational need for reliable VOR/DME services at Manas, it is recommended that near-term actions be taken to establish a repair and maintenance contract

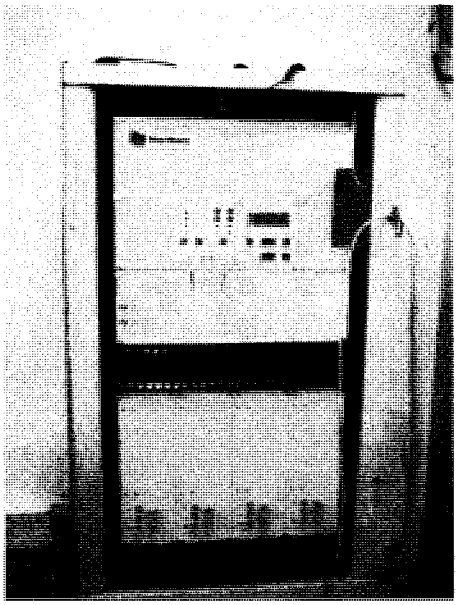
with Wilcox and a plan be developed to either upgrade or replace the existing system as it nears the end of its service life.

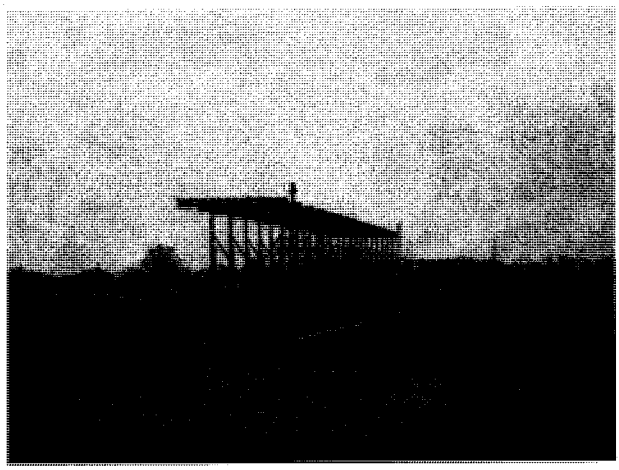




Manas VOR/DME System

The dual ILS systems at Manas are European manufactured and reportedly have low failure rates. Most of the instances when ILS services are not available are due to the failure of the power supply. Power failures at Manas occur approximately 20 times poer year with the time to restore power from 30 minutes to twelve hours. Similar problems are also experienced at Osh and Issyk-Kul airports where the average failure rates are estimated at 25 times per year. Back-up power is provided via generators at all locations and battery back-up power at Manas and Osh.





Manas ILS Components—Outer Marker and Localizer Antenna

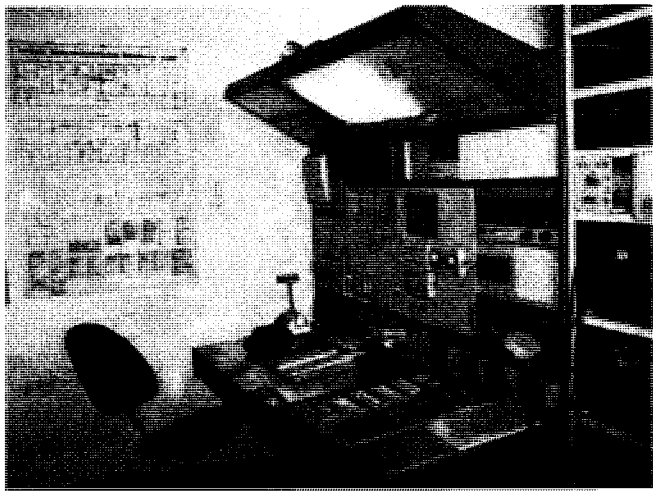
It is recommended that consideration be given to developing and implementing a plan for improving commercial power supply systems to all airport locations in Kyrgyzstan. In addition, to the commercial system, it is suggested that the current back up power systems be evaluated for performance and adequacy.

During the discussion about navigation equipment reliability, it was noted that there are concerns with being able to train and retain qualified people to ensure all CNS/ATM systems will provide optimum service. Apparently there is a qualified personnel retention problem because of the employee salary structure and the benefits of working elsewhere.

For instance: three years ago a new ILS was purchased and four people were sent to the factory for training. Two of those four people have already left the organization and the other two have plans to leave. Overall job satisfaction is high (7 on a 1-10 scale with 10 being high) but compensation satisfaction is low—a 2 on the 1-10 scale.

Currently, an average technician earns approximately $100.00/month and the maximum they can earn is $125.00/month. Many people have problems with routine expenses, such as rent and food, and find it very difficult to provide for their families. It is believed that the salary cap should be increased to at least $300.00/month. There are approximately 100 people currently in this situation.

Recognizing the growth in Kyrgyzstan air traffic terminal operations since 2001 has been approximately 20% per year and monthly overflight operation figures indicate a steady increase in traffic of approximately 20-30 additional flights per month, the necessity for having reliable CNS/ATM systems and a fully qualified staff to ensure continued operations will be essential. Therefore it is recommended that immediate consideration be given to modifying the pay scale to be able to retain qualified personnel.



VOR/DME, NDB, ILS Maintenance Station

Surveillance

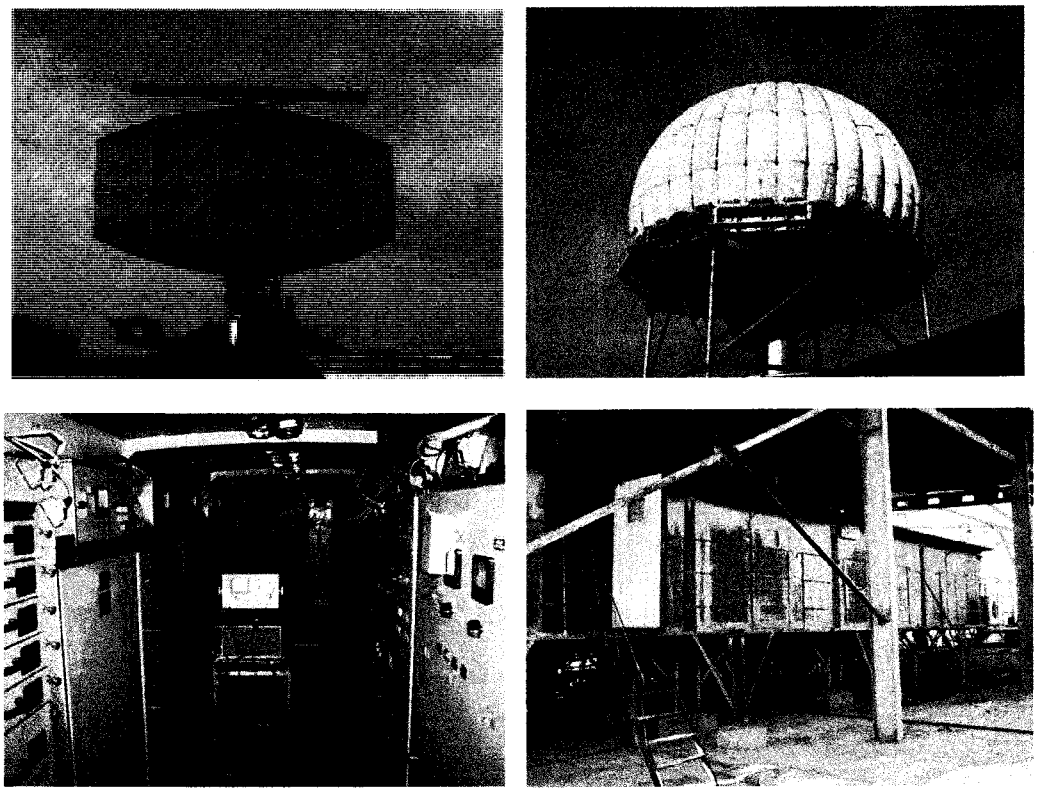
Overall surveillance coverage throughout Kyrgyzstan is provided by a mix of primary and secondary systems, most being Russian manufactured.

Some of these systems are more than twenty years old, and have exceeded their projected lifecycle. The dual Russian manufactured secondary surveillance systems at Manas are relatively new (2001, 2003 respectively) and sufficient spare parts are available to effect local repairs.

However, some systems have been in operation since 1951. For instance, the Manas approach radar has been in service for 24 years and has reached the end of its service life. Spare parts are not readily available consequently the equipment is becoming harder and harder to maintain.

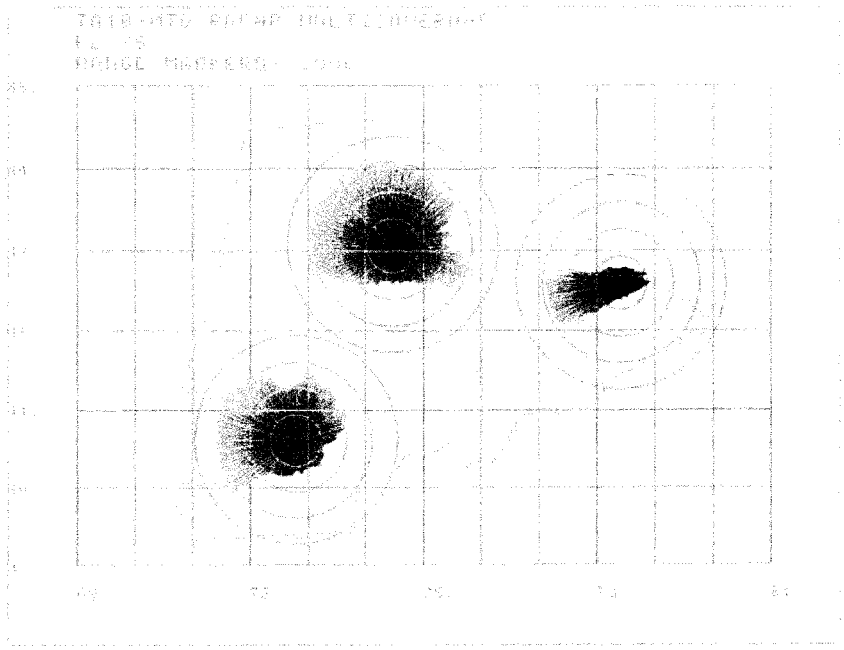
This old equipment cannot support an increase in flight operations. Currently overflights are approximately 300 per month and the maximum that can be supported with the old equipment is 400 per month. This limit will be reached within 12 months.

There are concerns about flight safety. The existing Russian radars are not ICAO compliant and cannot be used for radar separation services. Hence, the controllers use procedural separation for airspace operations. It is anticipated that the current radars will cease to function in 2-3 years due to the inability to keep them operating as a result of a lack of spare parts.

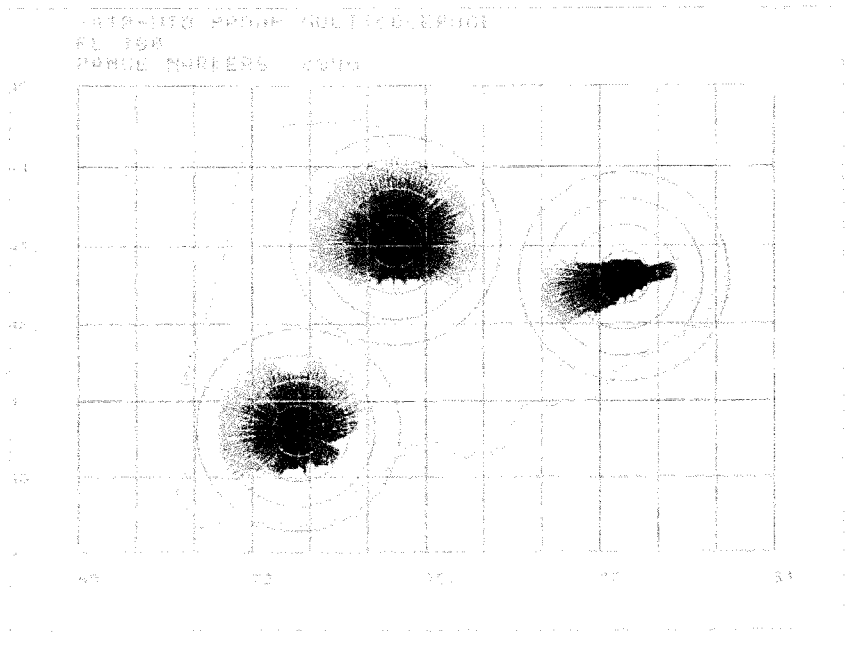


Manas Radar Equipment and Facilities

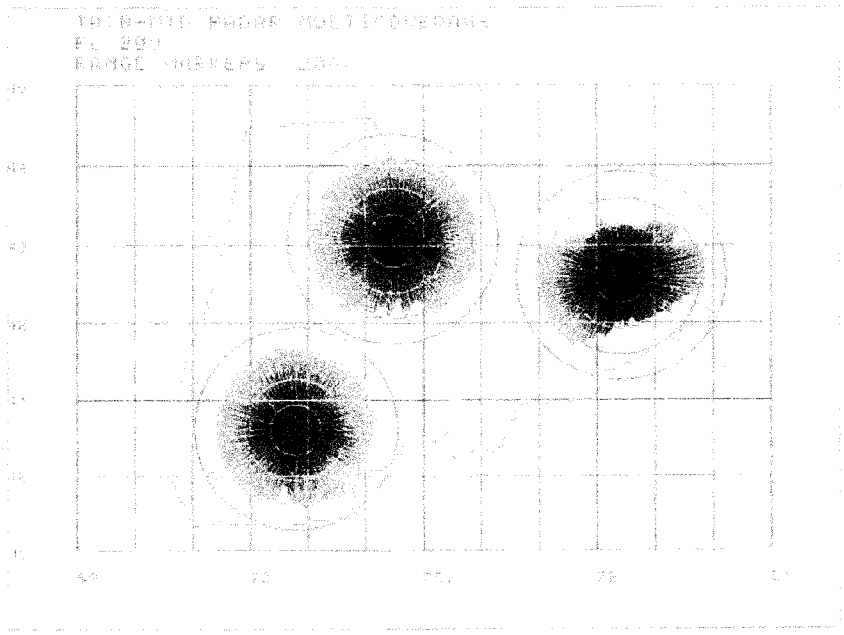
The following charts illustrate Kyrgyzstan surveillance coverage from the three equipment locations:



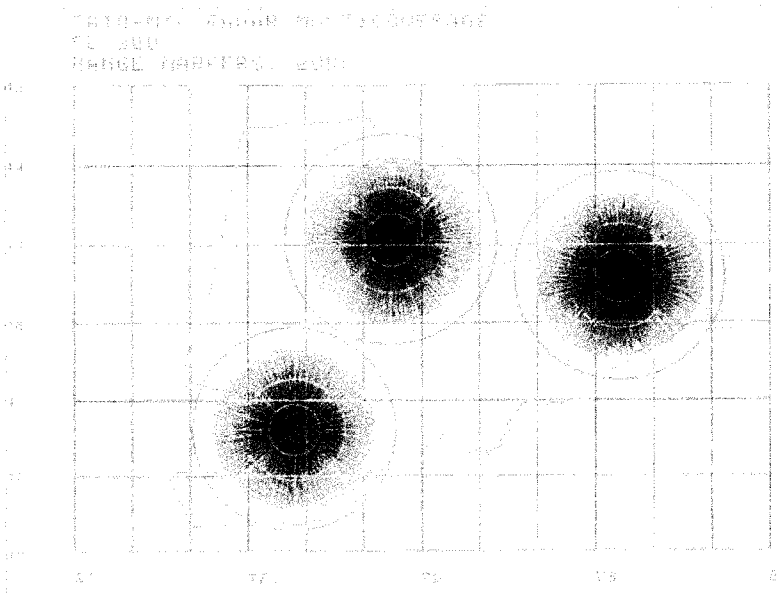
Primary Radar Coverage to FL 75



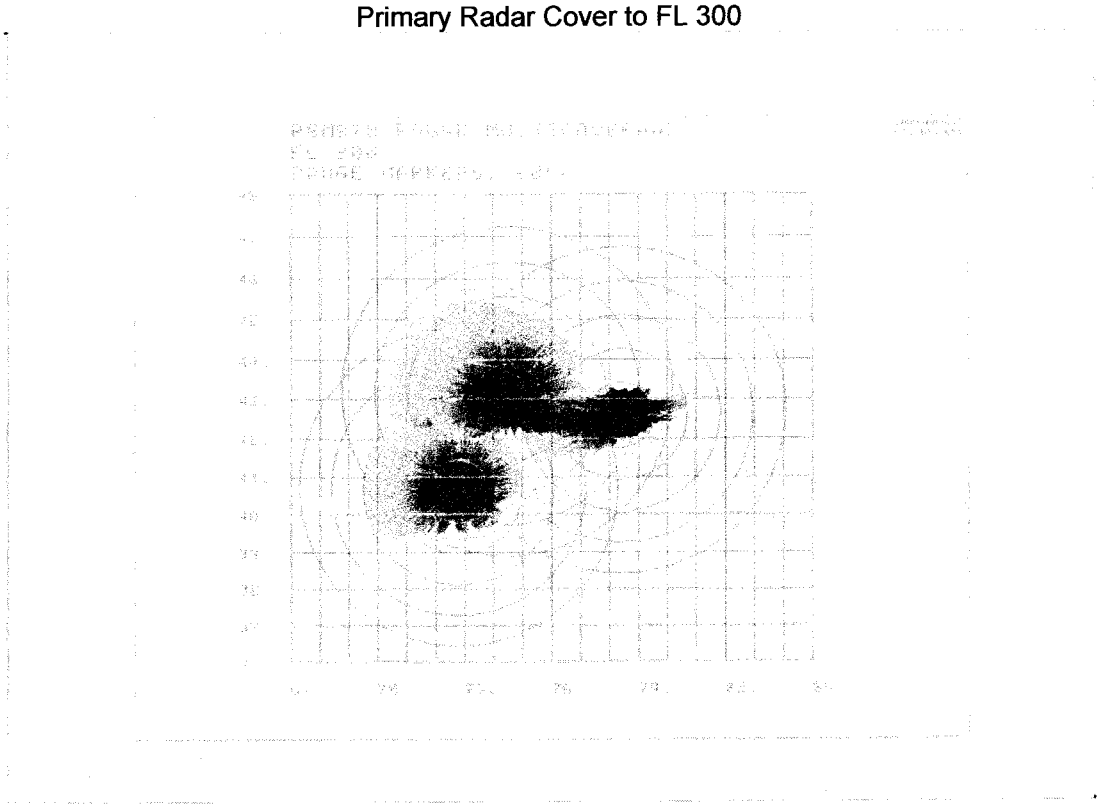
Primary Radar Coverage to FL 10



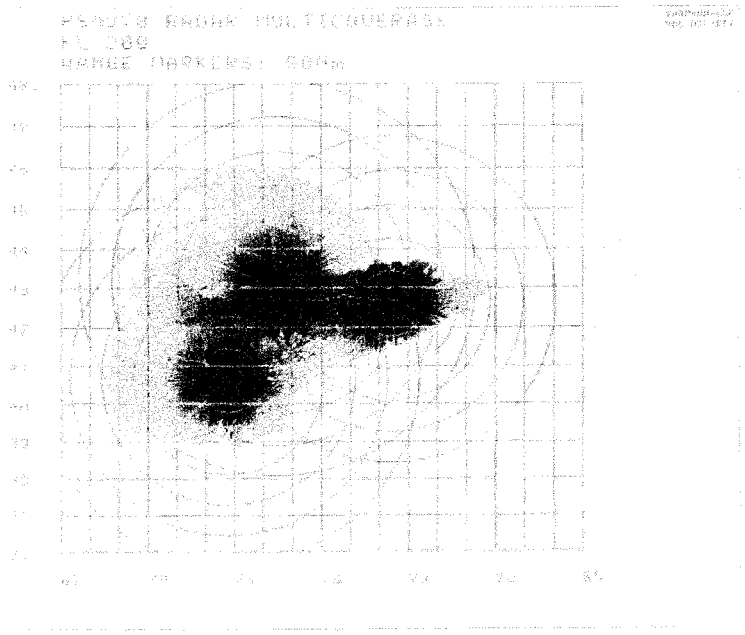
Primary Radar Coverage to FL 200



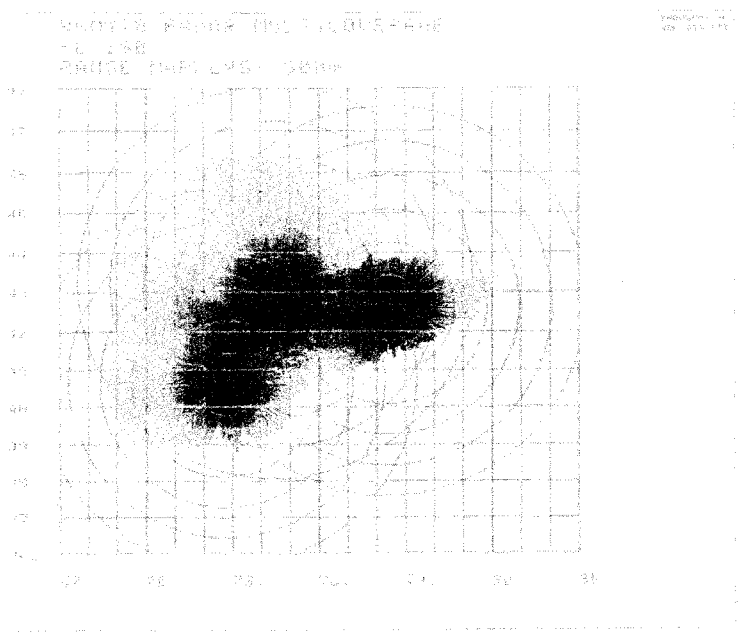
Primary Radar Cover to FL 300



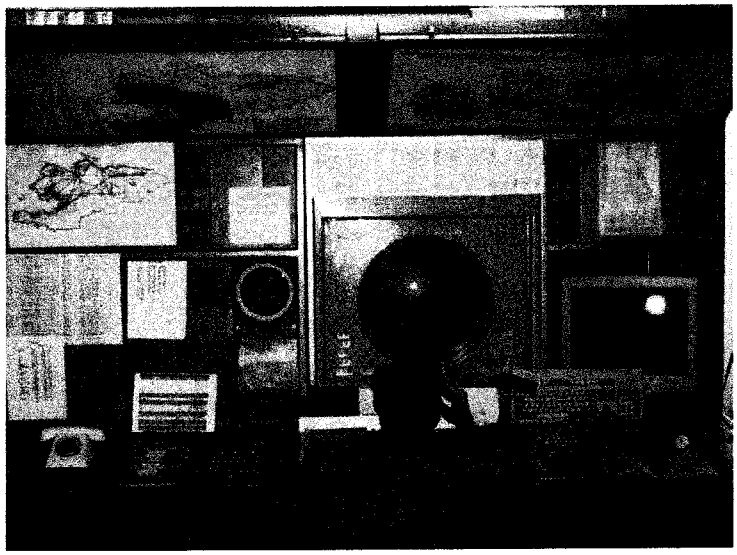
Secondary Radar Coverage to FL 200



Secondary Radar Coverage to FL 300



Secondary Radar Coverage to FL 350



Area Control Center Radar Scope/Working Position

It is recommended that consideration be given to upgrade or replace the current radar systems as soon as possible due to the age and increasing difficulty of obtaining spare parts for the current systems; the operational limitations imposed on the air traffic controllers because the current equipment is not ICAO compliant; flight safety concerns; and the need to provide reliable radar services to satisfy near-term and future airspace requirements.

Air Traffic Management

Air traffic control personnel job satisfaction is high and they are reasonably please with their work assignments. As with the technical personnel there are concerns about the monthly pay and benefits afforded controller personnel.

The area control center and approach control facilities are located in the same tower/building complex at Manas. The tower is actually part of the building complex as indicated in the following photo.

Tower/Building Complex

Tower personnel do not have a clear view of the runway, taxiways or ramp, consequently active control operations are performed by both personnel in the tower and controllers housed in a mobile unit adjacent to the runway. The controllers indicated that this dual coordination process works reasonably well and they do not believe there are any serious problems with safety and maintaining positive control. However, they stressed the importance of having runway and ground control personnel located in a single tower facility and strongly believed that the existing tower facility should either be modernized to permit a clear view of all airport operations or a new tower be constructed that would enable both runway and ground control personnel to be collocated in a single facility.

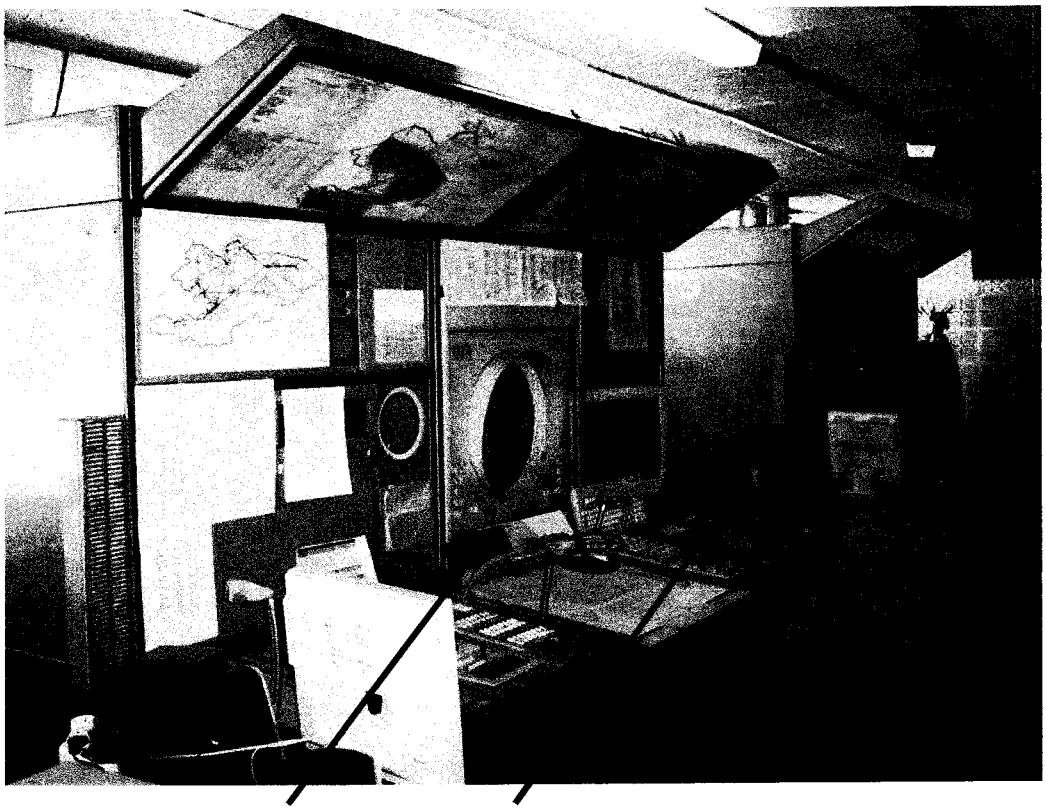
Adjacent Tower View

In addition to the Kyrgyzstan civilian controller personnel, there is also an English speaking military liaison person in the tower. This person assists with the control of military aircraft to/from the Manas Airport and designated Ganci Air Base facilities.

Manas Civil Tower Controllers and the Military Liaison

It is recommended that consideration be given to either modernizing the Manas tower or building a new tower to permit the collocation of runway and ground control personnel.

The area control center and approach control facilities are adjacent to each other in the tower/building complex. The personnel interviewed believed that the services provided are as good as possible given the type of radar equipment and displays that are available for their use. As noted in the surveillance section of this report, they also cited the limitations of the surveillance equipment and the inability to use radar data for aircraft separation. They believe that airspace operations and overall air traffic efficiencies would be significantly improved if ICAO compliant surveillance equipment and displays were available.

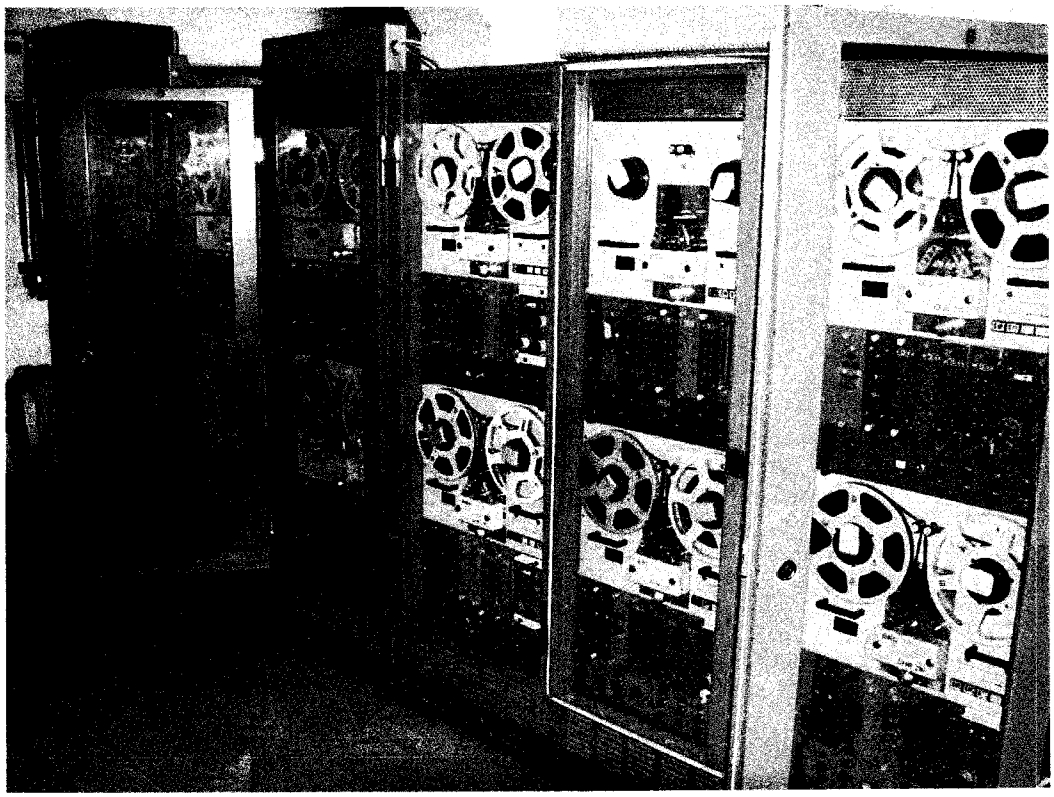


Area Control Center and Approach Control Work Stations

The communications switch is actually owned by the Manas Airport and Kyrgyzaeronavigatsia leases communications switch services. They indicated there are discussions regarding purchasing a switch for their use, but no definitive plans have been established.

It is recommended that consideration be given to purchasing a communications switch for the sole use of Kyrgyzaeronavigatsia.

The air traffic control recording equipment is a vintage tape drive system that reportedly works well, but has been cumbersome to operate and does not have the capabilities to satisfy all air traffic control requirements. During the interview process it was mentioned that arrangements have been made to replace the current recording equipment with a Russian manufactured digital system and installation should occur within 6 months or sooner.



Tape Drive Recording System

A satellite communications system to provide services between Kyrgyzstan and Kazakhstan area control centers has been installed, and is intended to provide better hand-offs and coordination between the two centers. However, the "phone" to enable the use of the system has not been installed, so controller hand-offs and coordination are via the ground-based "copper line" system.

It is recommended that the phone set be installed to permit the use of the satellite communications system.

Kyrgyzstan Recommendation Summary

1. Purchasing new digital VHF transmitters and receivers or transceivers that can be collocated in the same physical facility and use the same basic antenna systems; decommission the communications facility in town; and relocate all communications in a single Manas airport location.

2. Developing a plan to phase-out the NDBs in Kyrgyzstan and at the same time, initiate a program to develop and implement Global Navigation Satellite System (GNSS) enroute, terminal, arrival and departure procedures for those locations currently serviced by NDBs. Since Kalashnikov Vasily AIS Navigation Service develops procedures for Kyrgyzstan airspace operations and sends them to Rosjep for publication and distribution, it is recommended that both organizations be contacted to determine if they have the capability

and experience to develop and publish GNSS procedures for domestic and international aviation users.

3. Near-term actions be taken to establish a repair and maintenance contract with Wilcox and a plan be developed to either upgrade or replace the existing system as it nears the end of its service life.

4. Developing and implementing a plan for improving commercial power supply systems to all airport locations in Kyrgyzstan. In addition, to the commercial system, it is suggested that the current back up power systems be evaluated for performance and adequacy.

5. Immediate consideration be given to modifying the pay scale to be able to retain qualified personnel.

6. Upgrading or replacing the current radar systems as soon as possible due to the age and increasing difficulty of obtaining spare parts for the current systems; the operational limitations imposed on the air traffic controllers because the current equipment is not ICAO compliant; flight safety concerns; and the need to provide reliable radar services to satisfy near-term and future airspace requirements.

7. Either modernizing the Manas tower or building a new tower to permit the collocation of runway and ground control personnel.

8. Purchasing a communications switch for the sole use of Kyrgyzaeronavigatsia.

9. Install a phone set be to permit the use of the satellite communications system.

Site Survey Report

Dushanbe Airport Dushanbe, Tajikistan

November 18, 2005

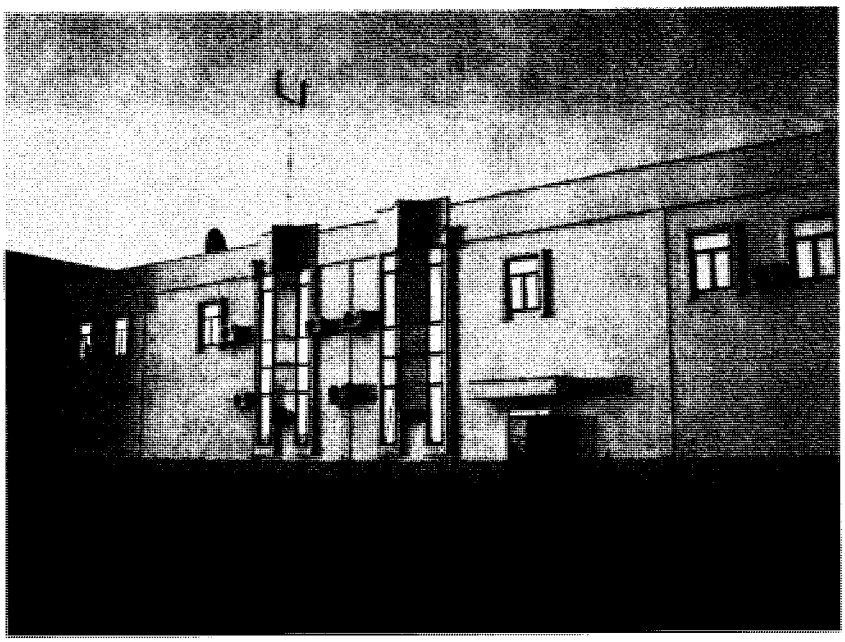
Overview

The principle airport servicing both domestic and international flight operations to/from Tajikistan is the Dushanbe International Airport. Dushanbe is one of 15 paved airports in Tajikistan, with the other prominent airports being:

- Gissar
- Isfara
- Khorog
- Hujand (Khudzhand)
- Kulyab
- Moskovskiy Pyandzh
- Murgab
- Parkhar South

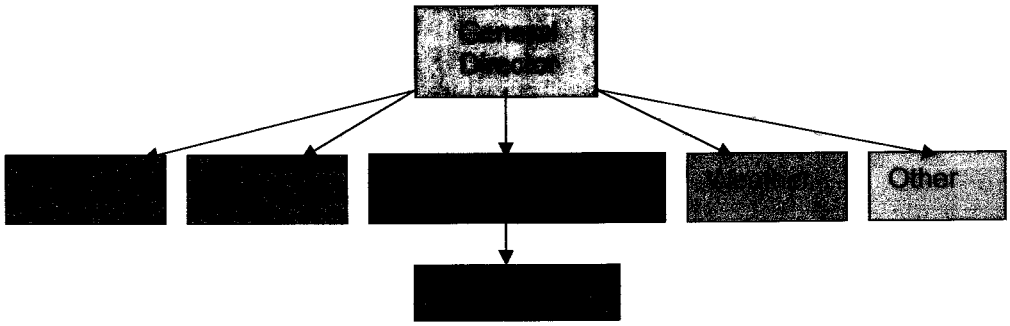
Of these airports, the two with ICAO identifiers are Dushanbe (UTDD) and Khudzhand (UTDL).

The Dushanbe airport air traffic control facilities have undergone significant modernization during the past three years and work is still ongoing. Most notably has been the construction of a consolidated area control center (ACC) for all of Tajikistan and building of new tower facilities.



Newly Constructed Area Control Facility

The State Air Company "Tochikiston" is responsible for all air operations in Tajikistan to include the Tajikistan airlines. Revenues generated by the aviation enterprises are under the control of a General Director and distribution of these funds is at the discretion of his office. The enterprises includes airports, air navigation, airlines, weather, and other "lesser" activities.



State Air Company "Tochikiston" Organization

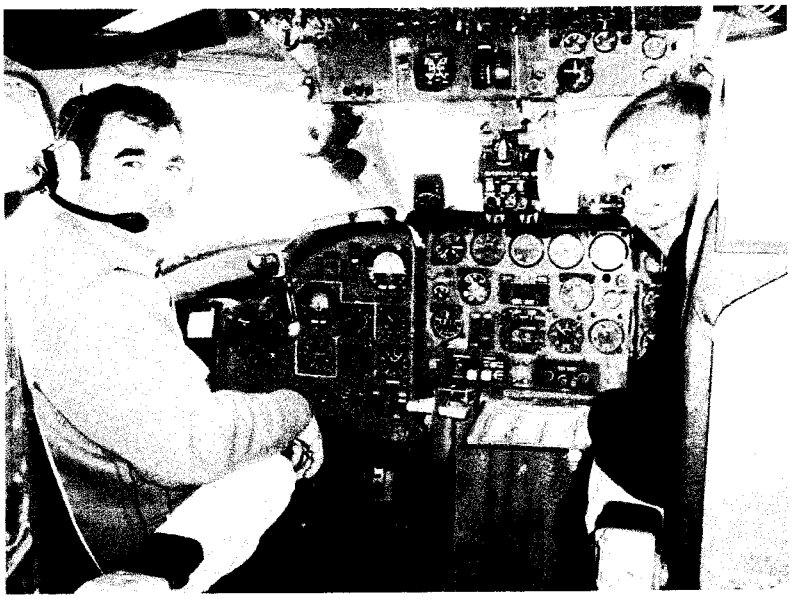
Funding for the recent Dushanbe modernization efforts was supported by a loan from the European Bank of Reconstruction. The actual tender package (valued at US $7,200,000.00) consisted of six activities, as follows:

1. New ATC consoles and radars.
2. New VHF radios, consoles and controllers.
3. Upgraded NDBs and an ILS.
4. Approach lights and a power supply.
5. New weather system.
6. Construction of the new area control center complex.

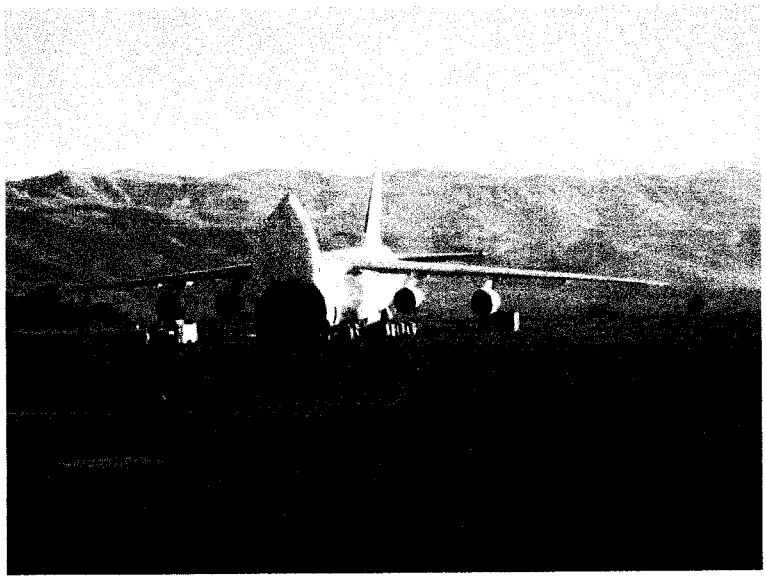
Approximately twenty companies submitted bids in response to the tenders. It was reported that no US companies submitted bids. Based on discussions with several personnel it appeared as though winner selection was based on the bottom-line price and not necessarily technical merit. The successful companies were a mixture of European and Russian vendors with workers from Turkey performing the actual area control center complex construction. It was noted that all of this equipment and construction seemed to be in excess of US $7,200.000.00, but personnel interviewed insisted that this was the actual cost.

Dushanbe International Airport is located approximately two miles from the city of Dushanbe. Shortly after the September 11, 2001 terrorist attack on the United States the Tajikistan government permitted the use of Tajikistan airspace and Dushanbe airport facilities in support of Operation Enduring Freedom. The French Air Force is currently operating C-130 and C-160 aircraft to/from the Dushanbe facilities. These operations have increased the demand on communications, navigation, surveillance and air traffic management systems and services. Reportedly this additional workload has not compromised safety or reduced the quality of services for civilian operations.

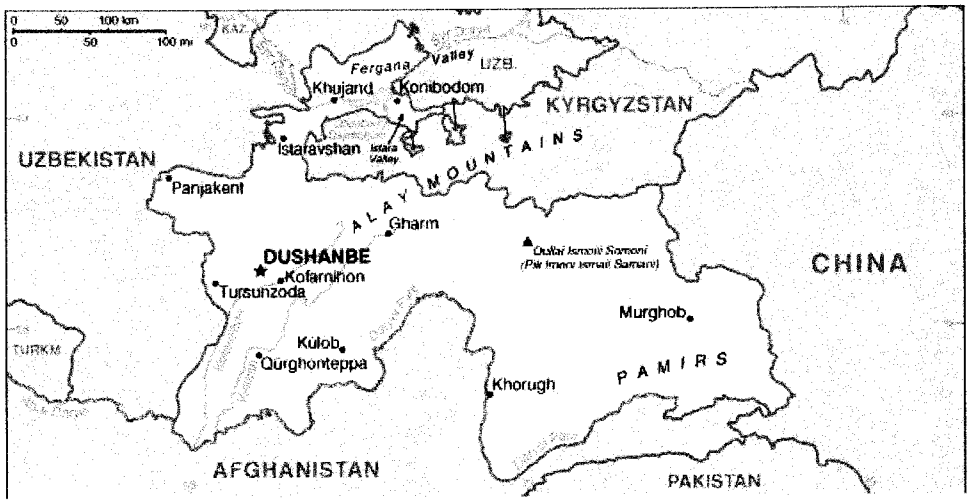
There are approximately 52 IFR and VFR civilian operations per day at Dushanbe. The majority of the civilian aircraft are Russian manufactured and include TU-154, TU-134, Yak-40, AN-28, aircraft and helicopters. The prominent airlines providing services at Dushanbe include: Iran Aseman Airlines, Kirghizia Airlines, Samara Airlines, Tajikistan Airlines.



Cockpit of a TU-134 Aircraft—Tajikistan Airlines



AN-124 Off Loading Cargo at Dushanbe International Airport



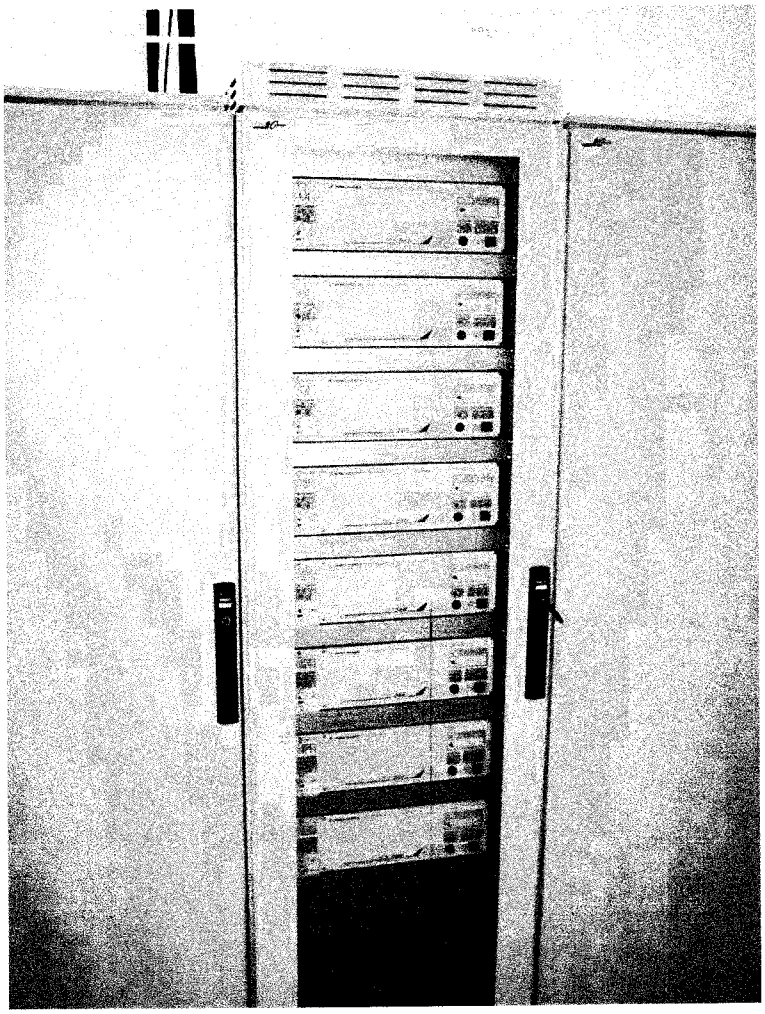
Map of Tajikistan

The remainder of this report provides a summary of the Tajikistan CNS/ATM equipment, systems and services as well as the comments and observations made during the site survey.

Communications

Principle ground-air communications services are provided by newly installed Rhode and Schwarz Series 200 transceivers. These radios, as well as the entire VHF system were modernized in 2005 to meet the ever increasing air traffic demands. The VHF system supports the following airport frequencies:

- Tower: 119.2 MHz
- Ground Control: 121.7 MHz
- VHF Flight Operations: 120.8 MHz
- Approach Control: 127.1 MHz
- Area Control—primary: 132.9 MHz
- ATIS: 126.2 MHz



Rhode & Schwarz Series 200 Transceivers

Independent and separate discussions and interviews with area, approach, tower, ground operations and maintenance personnel indicated that the new VHF system is operating without problem. It must be noted that the system is less than one-year old and still in the initial warranty period.

Communications switching and control is provided by a newly installed Russian (NITA) manufactured switch. The switch is operating satisfactorily. Again, it must be noted that the system is less than one-year old and still in the initial warranty period.

New Communications switch—primary and back-up; NITA St. Petersburg Russia

Given the extent of the new communications equipment and systems, the interview discussions focused on the post 1-year warranty period. The projection is that the equipment will have a 15-year life-cycle, but the relevant question is what provisions have been made to ensure reliable and continuous communications operations beyond the first year?

The head of the maintenance department indicated that all of the current repair technicians received proper training, but there are concerns about the availability of obtaining support from the manufacturer and the adequacy of spare parts to effect location repairs. Currently there is no repair and maintenance contract beyond the initial warranty period, funding has not been identified to obtain such a contract, and there are no immediate plans to take any action in this regard.

It is recommended that consideration be given to immediately begin the development of a plan to obtain post-warranty repair and maintenance support for all communications equipment and systems.

Unfortunately, the HF equipment and systems are not as modern as their VHF counterpart. The transmitters and receivers are 1980 vintage Russian equipment.

The HF systems are functional and can support air traffic services, but have clearly exceeded their life expectancy and are in need of replacement.

It is recommended that consideration be given to replacing or modernizing the vintage HF communications equipment and systems.

For all types of communication units there is a schedule of routine maintenance, daily, weekly, monthly, and quarterly in accordance with a standardized schedule.

Navigation

Navigation services throughout Tajikistan are provided via traditional ground-based systems. For the most part, navigation is via a system of non-directional beacons (NDBs) with a single VOR/DME located in Dushanbe.

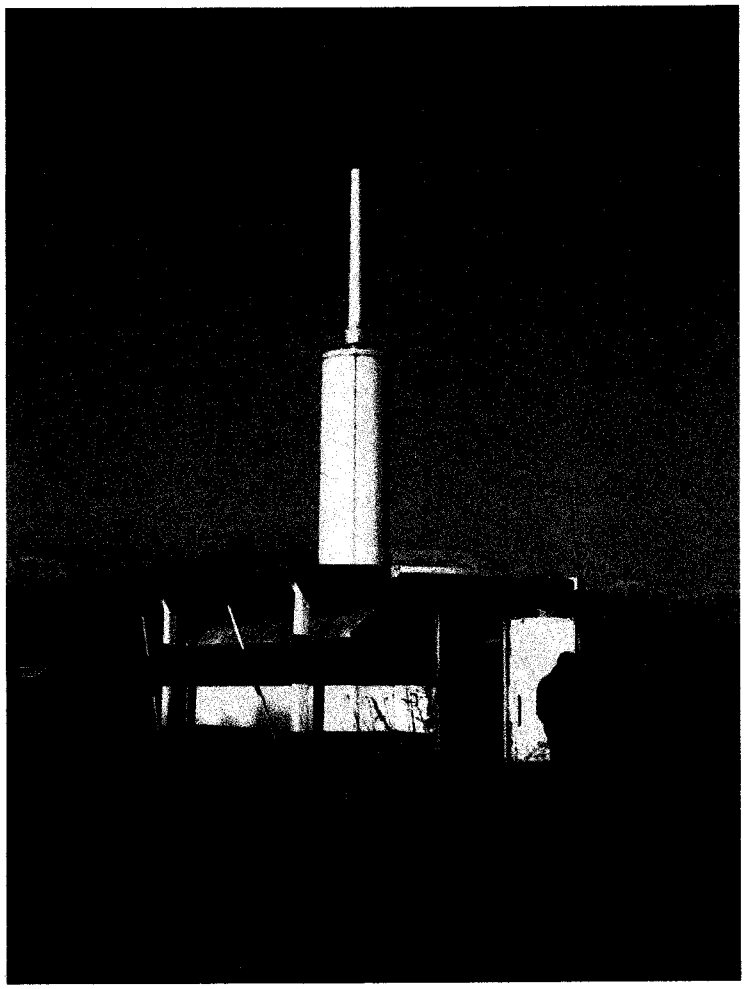
The current listing of all Tajikistan navigational aids that are suitable for operation indicate that there are 10 NDBs and one VOR/DME. The average age of the NDBs is approximately 20 years and their operation can be interrupted due to maintenance and repair activities.

Tajikistan Navigation Aids

Location	ID	Type
DANGARA	HU	NDB
DUSHANBE	DNB	VOR-DME
DUSHANBE	FN	NDB
DUSHANBE	WG	NDB
FAYZABAD	JD	NDB
KHUDZHAND	HD	NDB
KHUDZHAND	HV	NDB
KULYAB	CG	NDB
OKTYABRSKY	PR	NDB
PUGUS	SX	NDB
URA TYUBE	PF	NDB

The Russian made Dushanbe VOR/DME was manufactured in 1997 and installed in 1998. The VOR portion of the system fails approximately 10 times per year and the DME portion fails approximately 6-7 times per year. Repairs are generally made on-site by replacing "boards" and there is a service contract to repair and/or replace the failed parts.

Reportedly there is a plan being developed to modernize and/or replace the current VOR/DME system, but no specific date for releasing a tender has been determined.



Dushanbe VOR/DME

As indicated in the navigational aid chart many of the NDBs are located on airports and serve as outer or inner markers for instrument approaches and landings.

The requirement for NDBs at runway ends stems from an old Soviet Union requirement to provide a "beacon" at one kilometer and four kilometer positions. The justification for this requirement is to provide guidance for arriving aircraft.

The NDBs are relatively expensive to operate and maintain, particularly given the average age of the existing equipment and systems (20 years or more). Most modern aircraft have a VOR/DME capability or some other form of navigation guidance such as the instrument landing system (ILS), satellite navigation equipment (global positioning system (GPS)), and/or flight management/inertial navigation systems that can be used to support arrival operations. In fact, the performance of systems such as ILS, GPS, and VOR/DME provide more safe and

accurate navigation guidance as compared to NDBs and can permit lower approach minimums for arriving aircraft.

It is recognized that the primary aircraft operating to/from Tajikistan airports are vintage Russian manufactured TU and YAK aircraft, however, discussions with local aircrews indicated that many of these aircraft rely on GPS receivers for navigation.

It is recommended that consideration be given to developing an airspace restructuring plan based upon the use of satellite navigation positioning. Systems such as the Global Positioning System (US), GLONASS (Russian), and Galileo (Europe) will provide a robust navigation capability for Tajikistan and enable the reduction of ground-based navigation aids such as the NDBs. This airspace restructuring plan should also include a schedule for the decommissioning of the current NDBs.

The instrument landing systems (ILS) installed at Dushanbe is a category I system and was part of the recent purchase.

Regarding the outlook of the overall navigation architecture in Tajikistan, it is recommended that consideration be given to following the recommendation of the International Civil Aviation Organization (ICAO). The ICAO Future Air Navigation Systems (FANS) group was chartered to reassess the procedures and technologies that had so successfully served international civil aviation. FANS concluded that it was necessary to develop new systems that would overcome the limitations of conventional systems and allow the further growth of aviation on a global scale. These new systems would be expected to evolve and become more responsive to the needs of users and service providers whose economic health would be directly related to the efficiency of these systems. FANS concluded that satellite technology offered a viable solution to overcome the shortcomings of conventional ground-based systems and to meet the future needs of the international civil aviation community.

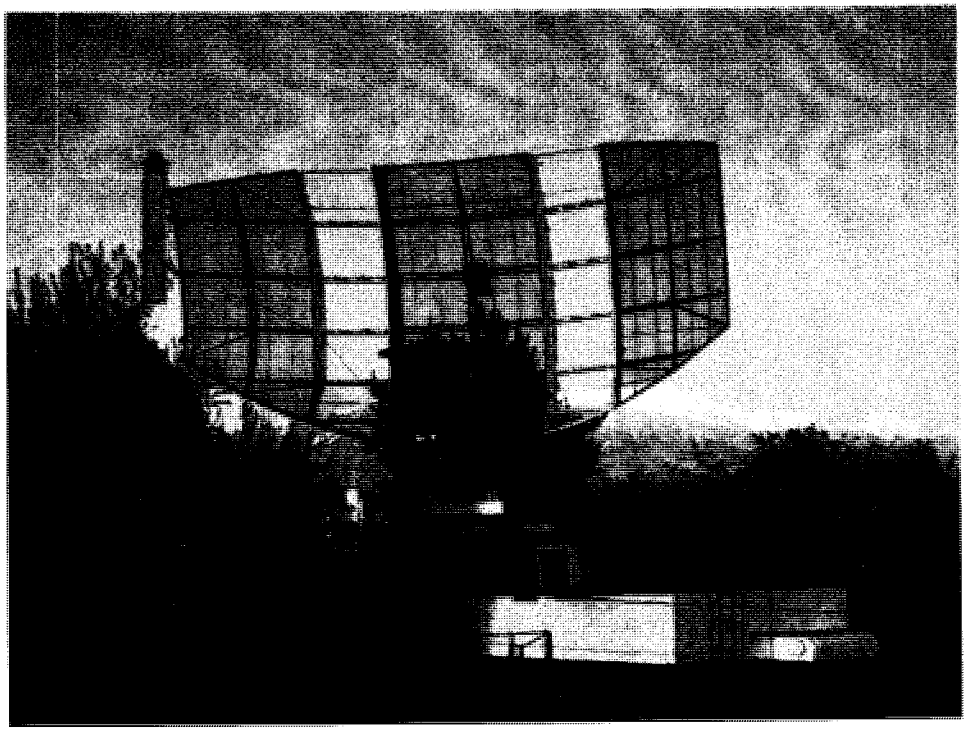
One of the first steps in evolving to satellite-based airspace operations is to develop and implement Global Navigation Satellite System (GNSS) procedures. For Dushanbe International Airport and other airfield locations in Tajikistan, GNSS approach and departure procedures will enhance safety, improve the operational efficiency of the runway(s) and airport facilities, afford an opportunity for increasing revenues, and provide further justification for decommissioning existing ground-based systems such as NDBs.

It is recommended that a country wide program be established to develop and implement GNSS approach and departure procedures for all Tajikistan airports.

Surveillance

The primary and secondary radar systems providing service to the Dushanbe ACC are reportedly working satisfactorily. The systems are Russian manufactured, twelve year old equipment that was modernized five years ago. Reportedly in this twelve year period there has never been a complete system failure.

Primary radar is seldom used, but secondary radar is continuously operating. Typically, when primary radar is needed the controller requests it be turned on for the requisite period of time.



Primary and Secondary Radar Site

The precision approach radar (PAR) system used for terminal area operations is a dual system configuration. They were purchased and installed in 1990 and reportedly have few operational problems. As with the communications and navigation equipment and systems, there is a regularly scheduled and executed maintenance program to ensure the operational readiness and performance of the systems.

Dual PAR Radars

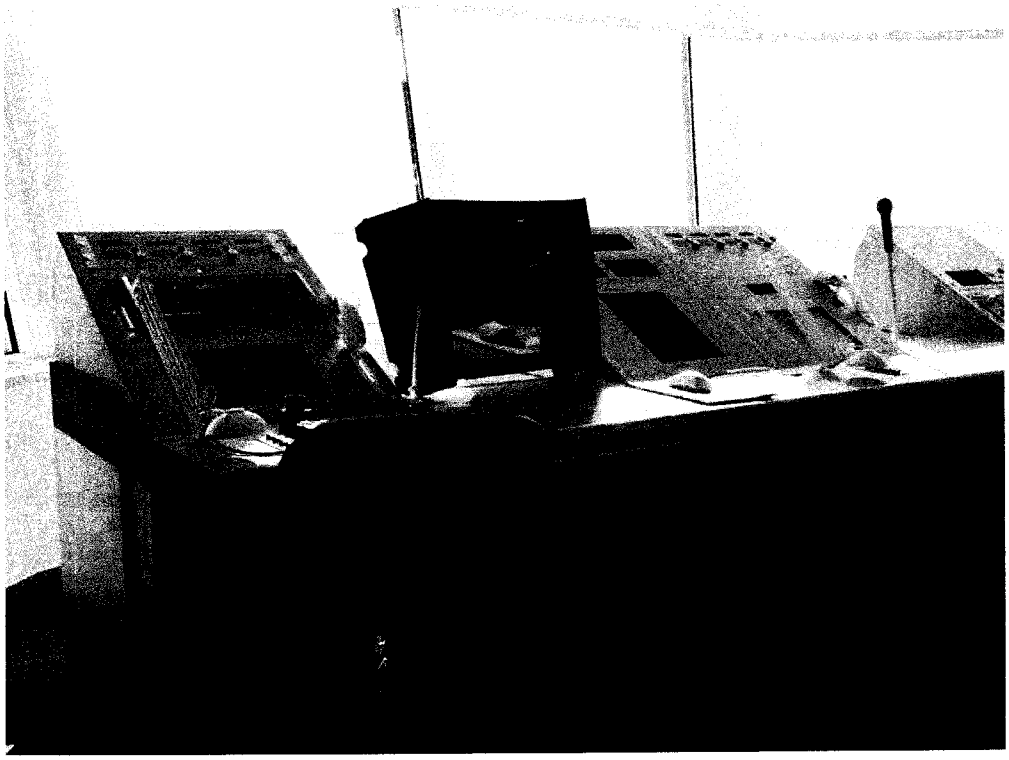
During discussions with radar maintenance personnel and their supervisors it was pointed out that there is a need for routine refresher training for the entire maintenance staff for all communication, navigation, surveillance and air traffic management (CNS/ATM) equipment and systems they have the responsibility for maintaining. They also indicated a need for information regarding current state-of-the-art equipment and systems, as well as a need for understanding the future modernization plans of other States and the position of ICAO regarding next generation CNS/ATM technologies.

It is recommended that consideration be given to developing an education and training program for all Tajikistan air traffic components; to include both maintenance and operational personnel. This program could include on and off-site classroom training; interactive computer training; establishing and maintaining an on-line and "hardcopy" library of technical manuals, ICAO publications, manufacturer literature, etc. Many of the documents and materials needed for such a program are readily available and they are either free-of-charge, or offered at a small price.

Air Traffic Management

Air traffic control personnel are very happy with their new working environment and are looking forward to begin using the new air traffic control equipment. As mentioned in the opening remarks, the area control center is new as well as the supporting ATC systems. The new tower facilities are nearly complete and appear to be capable of supporting current air traffic operations and being expanded to accommodate growing airspace user demands.

The old tower equipment will be moved to a new location to assist with ground control and ramp operations. It was noted that part of the ramp and the end of runway 09 are not visible from the tower.



New ATC Tower Equipment—Russian Manufactured

It is recommended that consideration be given to determine the options for either modifying the current tower or constructing a new facility to enable the full and unobstructed view of the entire ramp and the end of runway 09.

During the interview process it was determined that the air traffic controllers are facing a language challenge. In accordance with ICAO requirements it will be necessary for air traffic control personnel to achieve a level 4 English language skill by 2008. Currently there are no plans or programs to ensure the controller staff will be adequately trained to meet this language proficiency level by 2008.

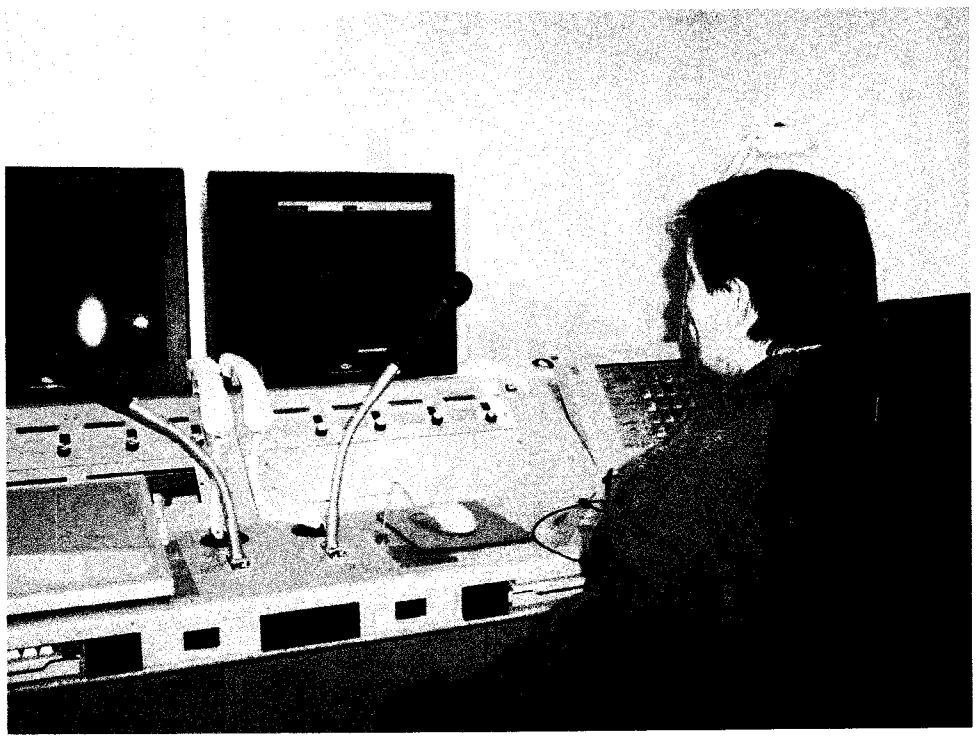
It is recommended that consideration be given to developing a plan and/or program to achieve the requisite level of English language proficiency. The program could be locally administered or a plan could be developed to schedule the controllers for training at a suitable facility within Central Asia. One such facility is operational in Almaty, Kazakhstan and discussions with Kazaeronavigatsia personnel indicated that arrangements could be made to accommodate the needs of all Tajikistan controllers.

It was noted during discussions with management representatives that technical personnel would also benefit from improving their English language skills. This would be particularly important to optimize their understanding of state-of-the-art CNS/ATM systems and services.

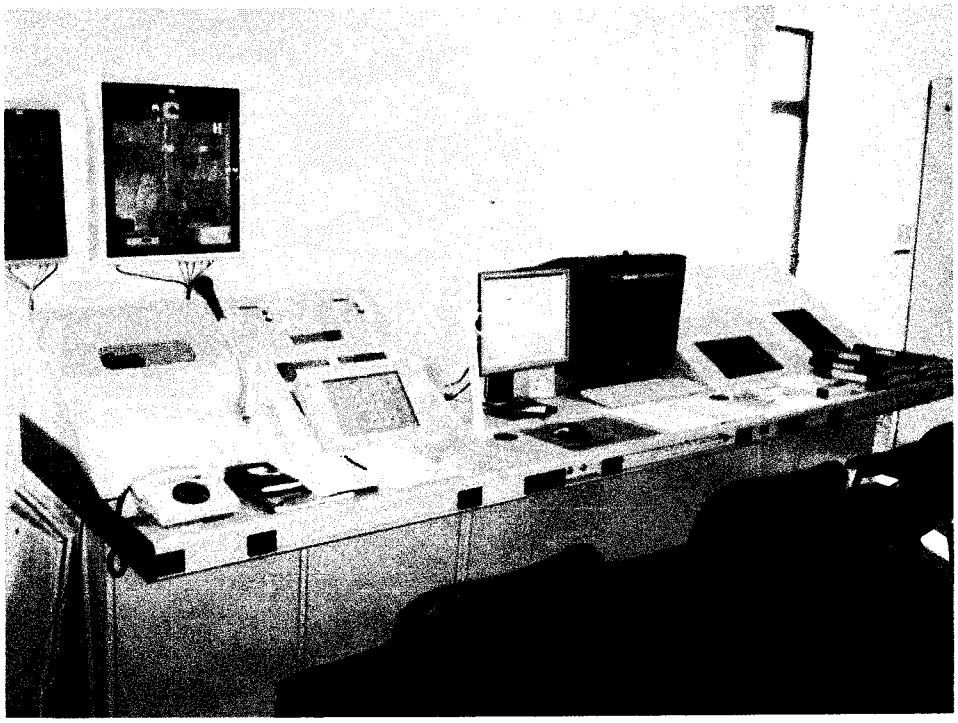
The new area control center consoles are operational and the controllers are pleased with their performance. Like all of the new equipment recently purchased, the consoles are still under the one-year warranty period and follow-up support for these systems after the one-year period remains a question. In addition, local personnel do not have access to the controlling software and are unable to maintain or modify the displays. For instance, when asked if it were possible to change a waypoint, the answer was no—only the manufacturer can make such a change.

It is recommended that consideration be given to investigating the software change and maintenance options for the new ATC equipment. The two potential options would be to either negotiate a general software maintenance and support contract with the manufacturer for a fixed annual cost or determining the impact of making arrangements with the manufacturer to effect software repairs and changes on a case-by-case basis.

Typically a general software maintenance and support contract is more cost-efficient as opposed to a "one at a time" repair strategy. It was suggested that future purchases of systems and equipment include a general maintenance and support contract option for the years following the initial warranty period for the life-cycle of the equipment/systems. Establishing such a contract option with the manufacturer prior to actually purchasing the equipment/systems generally results in a lower price when compared to the cost of such a contract after the actual purchase of the equipment/systems.



New Area Control Center Console



Shift Engineer Position—new and under construction to be completed Dec 05

The air traffic controllers also have a completely new weather reporting system to enable them to more accurately determine the effects of the current weather and better predict future conditions. Reportedly the system is state-of-the-art and fully capable of satisfying near-and far-term operational requirements.

Maintenance and follow-on support (both hardware and software) for this system are unclear at this time, but it is recognized that there is a need to make arrangements for full system support.

New Weather System

Dushanbe Recommendation Summary

1. Immediately begin the development of a plan to obtain post-warranty repair and maintenance support for all recently purchased CNS/ATM equipment prior to the end of the one-year manufacture warranty period.

2. Replacing or modernizing the vintage HF communications equipment and systems.

3. In accordance with ICAO recommendations, consideration be given to developing an airspace restructuring plan based upon the use of satellite navigation positioning. Systems such as the Global Positioning System (US), GLONASS (Russian), and Galileo (Europe) will provide a robust navigation capability for Tajikistan and enable the reduction of ground-based navigation aids such as the NDBs. This airspace restructuring plan should also include a schedule for the decommissioning of the current NDBs.

4. A country wide program be established to develop and implement GNSS approach and departure procedures for all Tajikistan airports.

5. Developing an education and training program for all Tajikistan air traffic components; to include both maintenance and operational personnel.

6. Determine the options for either modifying the current tower or constructing a new facility to enable the full and unobstructed view of the entire ramp and the end of runway 09.

7. Investigate the software change and maintenance options for the new ATC equipment.

Site Survey

Turkmenistan

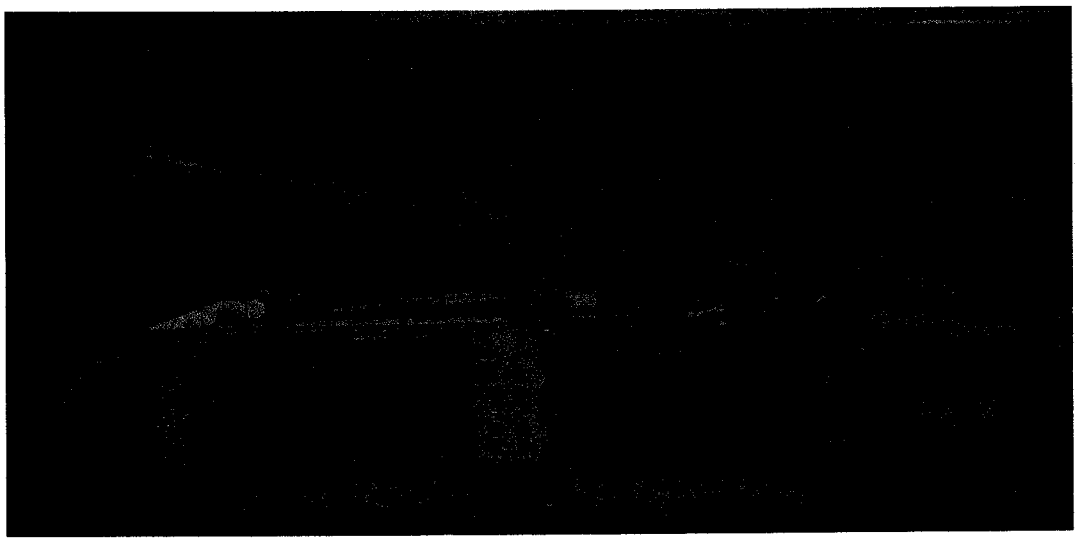
November 16-17, 2006

Turkmenhovayollary

Civil aviation in Turkmenistan, including the authority for the control of air traffic, is the responsibility of the National Civil Aviation Authority of Turkmenistan (Turkmenhovayollary). Turkmenhovayollary operates 5 towers and 4 ACCs (Area Control Center) in the Turkmenistan FIR (Flight Information Region). The towers include Ashgabat, Turkmendaashi, Turkmenabat, Mary, and Tashauz.

Ashgabat ACC

The Ashgabat ACC is in a 3-story building located on the airport proper. There is good security at both the airport and ACC building entrances. It is situated in a large room with work stations on both sides of the room. There is a supervisor's desk at the far end of the room in-between the work bays. There are 4 positions of operation in the ACC; en route control, approach control, radar, and a flight data monitor position. The radar position coordinates inbounds with the tower. All operational positions are located on the right side of the room with the exception of the radar position which is located on the left side.

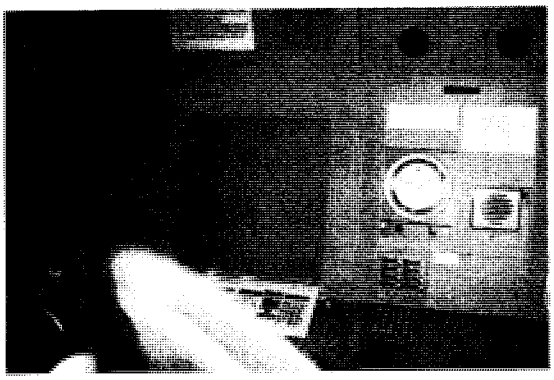


Ashgabat ACC Building From the ATC Tower

The ACC is powered by a Thompson EUROCAT 200 MSSR (Monopulse Secondary Surveillance System) radar system that was installed in 1996. The EUROCAT is a 2-channeled MSSR radar system with its own FDP (Flight Data Processor) which provides flight data processing for the ACC. Even though it was installed in 1996, it is considered by some to have reached the end of its life cycle.

The ACC receives flight plans from the AFTN (Aeronautical Fixed Telecommunications Network). The AFTN is used to disseminate flight plans and flight data throughout

There are presently 2 trainees training for certification in the ACC. Potential controllers are hired after completing 2 years of training at the Transport Institute and 2 years of academic training. When potential controllers are hired, they attend an ACC training school sponsored by Turkmenhovayollary for approximately 2 months and if successful, they are assigned an individual instructor at the ACC. The potential controller is afforded 350 hours of OJT (on-the-job training) in which to be certified in the ACC. If the trainee is not successful he is dismissed, or if a certain amount of promise was shown during training, he may be given additional hours to obtain certification.



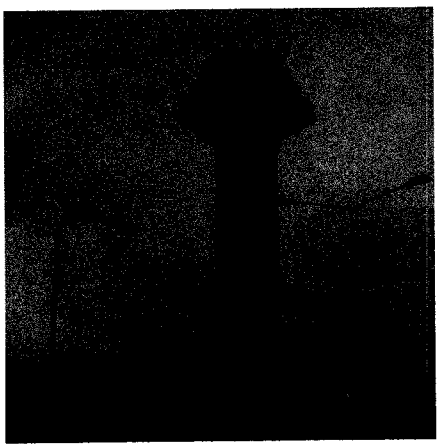
ACC Control Position

Power failures seem to be a problem at Ashgabat and at most Turkmenistan airports. Reports indicate at least 50 power failures per year at Ashgabat and sometimes downtime exceeds 3-4 hours. There is generator back-up power for the ACC, but the generators are older models and have to be hand started when there is a power failure. Clearly there is a need for UPS (Uninterrupted Power Supply) for the ACC and its equipment.

Navigation in Turkmenistan is still totally ground-based. VOR/DME (VHF Omni-directional Range/Distance Measuring Equipment) is used for en route navigation, backed-up by NDB (Non-directional Beacon). ILS (Instrument Landing System) units are used for precision approach landing. There are no plans to authorize satellite navigation, RNAV (Area Navigation), or RVSM (Reduced Vertical Separate Minima), although future plans call for RVSM to start in 2007. No airports have been re-surveyed to WGS-84 datum and at present, there are no plans to do so. There is also no ATIS (Automated Terminal Information Service) at any Turkmenistan airport.

Ashgabat ATC Tower

The Ashgabat Tower is approximately 200' across from the main entrance to the airport and rises 47 meters (141') above the ground. The tower is very large, especially for such a small volume airport, and there is a clear and unobstructed view of the airport. The tower was constructed in 1994 and is now in need of repair in some areas, especially replacing some of the inside roofing tiles. There are no slanted tower consoles with recessed equipment displays, only narrow flat consoles. The tower needs to be modernized with modern consoles and up-to-date tower equipment.

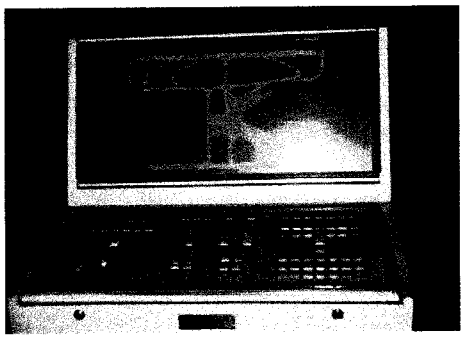


Ashgabat ATC Tower

Weather information is obtained from a Russian made AWOS which is similar to those manufactured in the west, but has a different method of display. There are 2 weather stations, one on each end of the runway which is common in Russia and in older Russian states. However, Turkmenistan uses only one local

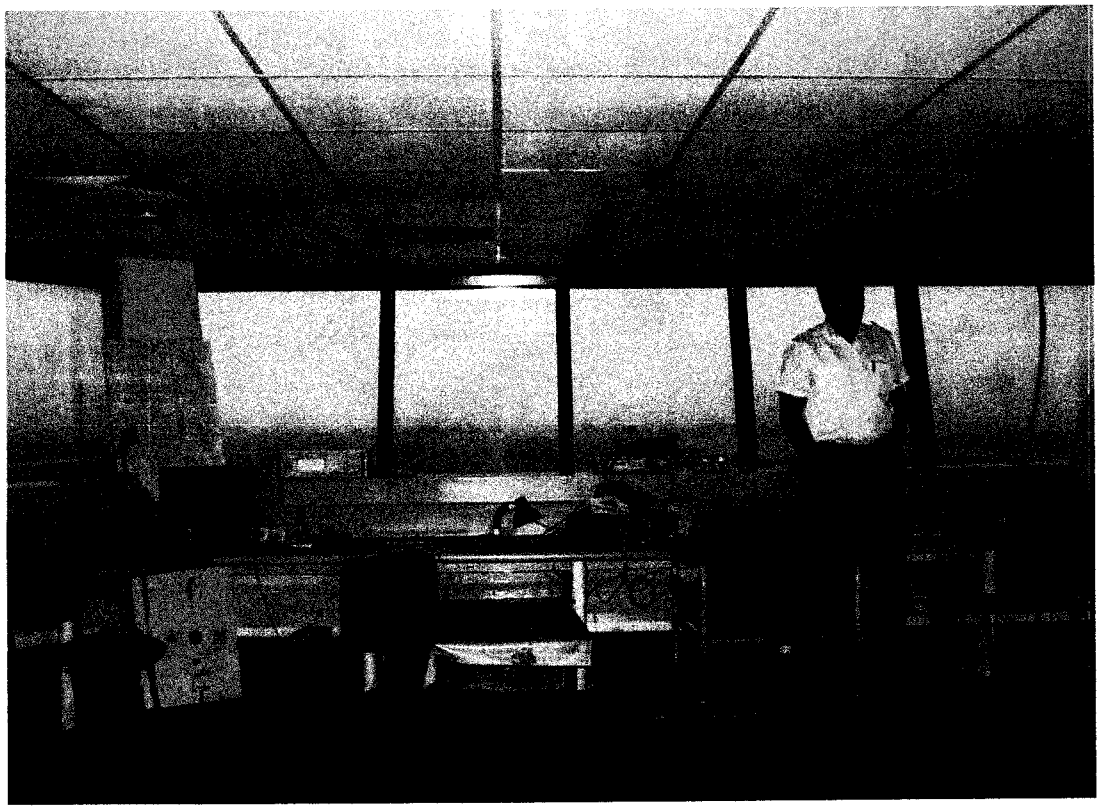
controller located in the tower in contrast to other older Russian states that still have a tower on each end of each runway. Weather is posted automatically on the AWOS display.

Flight plans are relayed to the tower from the ACC and are prepared manually. Arrival information is passed to the tower via the telephone from the radar position in the ACC. There is no radar monitor in the cab. Arrivals are switched to the tower approximately 6 NM from the airport. We noticed no RVR instruments in the cab. Airport lightning is controlled through a modern lighting panel.



Airport Lighting Panel

The local controller works on a pedestal or small raised section of the tower floor that is located in front of the glass in the far center of the tower. The ground controller's work station is a few feet to the left. There are 3 individuals on duty each shift. There are 3 frequencies in the cab; 118.1 MHz for local, 121.7 MHz for ground, and 121.5 MHz (Emergency Frequency) is monitored at both positions



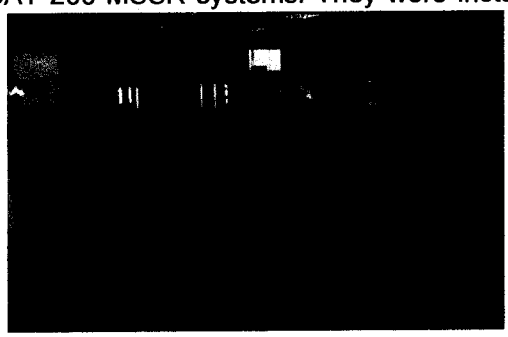
Ashgabat Tower Local Control Position

There are 2 parallel runways (12R/30L and 12L/30R). Runway 12R/30L is a newly constructed runway. There is a third runway (11/29) which is used primarily for helicopters.

MARY	MP	NDB
MARY	NS	NDB
SERDAR	RJ	NDB
TURKMENABAT	LBA	VOR-DME
TURKMENABAT	NQ	NDB
TURKMENABAT	UT	NDB
TURKMENBASHI	CO	NDB
TURKMENBASHI	KRS	VOR-DME
TURKMENBASHI	WZ	

Surveillance

We were not given much information on Turkmenistan's surveillance systems other than Turkmenistan has 3 Thompson-CSF EUROCAT 200 MSSR systems. They were installed in the 1996 timeframe and according to officials at the ACC, they have reached their lifecycle. As far as we know, there are no ASR (Airport Surveillance Radar) radar systems within Turkmenistan. We had the opportunity to view the EUROCAT 200 equipment located in the ACC building as well as a number of other items including some VHF communications and recorders. The equipment we viewed was kept in roomy and well ventilated quarters, and appeared to be in excellent condition. The EUROCAT flight data and radar data processors appeared almost new. The recorders are tape models and of Russian manufacturer.



EUROCAT 200 Data Processors

Ashgabat Airport

The Ashgabat airport is a large airport with a very modern terminal which has many conveniences generally associated with large terminal facilities. The airport has 2 parallel runways (one on either side of the terminal) and one shorter runway used for helicopters and small, light aircraft. The right parallel is a new runway with a full length parallel taxiway and equipped with CAT II at both ends. The left runway has no taxiway requiring an aircraft to back-taxi to use full length. This runway is equipped with CAT I at both ends.

Recommendations

1) Turkmenhovayollary should improve and upgrade their VHF and HF communications infrastructure. The present VHF and HF communications equipment and systems are older models and have frequent failures. VHF repeaters need to be replaced with additional frequencies and the VSATs repaired. Ashgabat ACC personnel indicated

that communications were a problem, but some improvement has been noted. The controllers seem to believe that communications would be a larger problem in the near future if not corrected now.

2) Satellite navigation is not authorized in Turkmenistan. GNSS could resolve most of their NAVAID problems. Action needs to be taken to begin the process to approve GNSS for use in Turkmenistan. Turkmenhovayollary has a limited number of navigational facilities and they are older models which are getting more difficult to maintain due to a lack of spare parts.

3) We recommend the implementation of the ATN that should begin with the implementation of AMHS (Aeronautical Message Handling Service). The AFTN is being replaced with AMHS and many countries have already started or completed implementing AMHS. There is no guarantee on how long the AFTN will remain in service.

4) Turkmenistan needs to implement RNAV procedures with RVSM. There are presently no RNAV or RVSM procedures in effect. RVSM would increase the useable altitudes above FL 290 thereby saving fuel and money for the air carriers. RNAV would provide more direct routes reducing flight time, fuel burn, and would also save money for the users.

5) Turkmenhovayollary should convert to the WGS-84 datum as soon as possible to meet an ICAO recommendation that all states convert to WGS-84 datum. At present there are no plans to convert.

6) The ACCs should consider the use of radar handoffs between facilities wherever possible to expedite traffic and keep aircraft in radar contact when possible.

7) Turkmenhovayollary needs to install ATIS at their major airports. This will relieve both controller and pilot workload.

8) Turkmenhovayollary needs to consider UPS at their major facilities. The generators we viewed were old and may not perform as well as required when needed.

9) It is also recommended that Turkmenhovayollary consider English training for their controllers. While we were in the ACC we noticed that the English used by controllers was broken at times and it was evident that some refresher language training may be needed.

Site Survey Report

Uzbekistan

November 13-15, 2006

Uzaeronavigatsia

Uzaeronavigatsia (Center for Airspace Usage and Air Traffic Control) is the responsible authority for air traffic services in Uzbekistan. The parent company of Uzaeronavigatsia is the National Air Company of the Republic of Uzbekistan (Uzbekistan Airways). Unfortunately, Uzbekistan Airways would not allow any photographs to be taken within or outside of their facilities whether they were on or off airport property. Accordingly, the only photograph in this report is the Tashkent ATC (Air Traffic Control) Tower taken from the Tashkent airport parking lot. Even though we did not have an opportunity to take photographs, we were given the opportunity to view the ACC (Area Control Center) and tower, as well as the equipment used to control air traffic on and off the airport property. Additionally, we were given a tour of the airport premises including the tarmac, runways, and taxiways. Uzbekistan Airways is also the parent company of State Enterprise Airports who controls the Uzbekistan airports. Uzaeronavigatsia manages 4 ACCs and several ATC towers. Uzaeronavigatsia is funded through user fees which are collected by Eurocontrol. These funds are then disseminated in accordance with the wishes of Uzaeronavigatsia. Uzaeronavigatsia is headquartered in Tashkent.

Tashkent ACC

The Tashkent ACC is located in a contemporary building inside the Tashkent airport property. The ACC itself is housed in a large room with modern work stations provide by Thompson-CSF, now known as Thales. Thompson-CSF also installed their EUROCAT 200 MSSR en route radar system (1997) in Tashkent which provides en route surveillance within their controlled airspace, as well as within their terminal airspace. In addition to the Thompson system, radar data from 3 other radar systems is imported to Tashkent via VSAT (Very Small Aperture Terminal) to provide full surveillance coverage within the Tashkent ACC airspace. A new ASR (Airport Surveillance Radar) system for terminal control is presently being installed on the airport. There are 3 positions of operation in the ACC; ACC control, approach control, and final approach control. Although there are only 3 positions of operation, there are several additional work stations available to accommodate any expansion in operational positions. There is a supervisor work station located behind the controller work stations to monitor and oversee the operation of the ACC. An additional work station is located next to the supervisor's desk to monitor the processing of flight data from the AFTN (Aeronautical Fixed Telecommunications Network) to the Thompson FDP (Flight Data Processor).

Aircraft are controlled in accordance with ICAO (International Civil Aviation Organization) rules and regulations and electronic strips are used eliminating the taxing burden of using paper strips and plastic strip holders. Aircraft are controlled using vertical and lateral separation standards. Vertical separation between aircraft is 1000' at FL (Flight Level) 290 and below, and 2000' above FL 290. Uzaeronavigatsia does not use RVSM (Reduced Vertical Separation Minima) within their sovereign airspace. Lateral separation between aircraft is provided by radar and is 15 NM (Nautical Miles) in the en route environment and 10 NM within terminal airspace. Separation is reduced to 3 NM on final unless an aircraft is following a heavy jet, then it is increased to 5 NM. Even though there is radar overlap between Tashkent and adjacent ACCs, radar handoffs are not conducted between facilities.

Aircraft are controlled using VHF (Very High Frequency) communications and coordination between facilities is effected using HF (High Frequency) and local land lines. There is VSAT communications between several adjoining countries. Navigation within the Tashkent ACC and other ACCs within Uzbekistan is provided by ground-based systems. There are 4 VOR/DME (VHFI Omni-directional Range/Distance Measuring Equipment) facilities, 1 stand-alone DME facility, 12 ILS (Instrument Landing Systems) facilities, and an assortment of NDB (Non-directional Beacons) facilities. GPS or GNSS has not been approved for use in Uzbekistan airspace.

The ACC receives flight plan information over the AFTN. The AFTN has been interfaced with the FDP provided by the Thompson MSSR which provides automated flight data processing. Flight plans are held in abeyance until called-up by the controller and then they are displayed as electronic strips on the radar display.

Since Tashkent is located very close to the Kazakhstan border, Kazakhstan has delegate an area of airspace north and northwest of Tashkent to Tashkent ACC to permit the climbing and descending of aircraft arriving and departing Tashkent. There is an Air Traffic Flow Management Unit (ATFMU-Flow Control) located in the Tashkent ACC that provides flow restrictions when required. However, radar is used to effectively manage the flow of aircraft in and out of Tashkent. There are no RNAV (Area Navigation) routes in Uzbekistan.

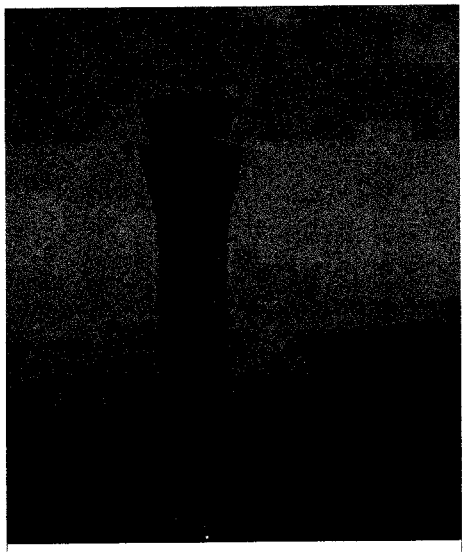
Tashkent has an ATC training school. Potential controllers enroll and complete an academic training program, and receive their basic ATC training at that time. Generally, it is a 1 year program. Then the controllers are sent to either a tower or ACC. In Tashkent, it takes about 6 months for a trainee to become qualified on all positions of operation in the Tashkent ACC. The ACC radar simulator provided by Thompson is used to reduce training time. There are approximately 75 controllers assigned to the Tashkent ACC and there are about 8 individuals in management positions. The manger of the ACC, who is also the manager of the tower, is an employee of and assigned to that position by Uzbekistan Airways.

Search and Rescue for the Uzbekistan FIR (Flight Information Region) is provided by the CAA (Civil Aviation Administration), the administration responsible for aviation matters in Uzbekistan, through the Civil Aviation Search and Rescue Service of the Republic of Uzbekistan. The CAA coordinates the combined efforts by all other ministries and departments. When the need arises, the CAA establishes an RCC (Rescue Coordination Center) to oversee and coordinate search plans.

Tashkent ATC Tower

The Tashkent Tower is a modern tower rising approximately 56 meters (120') above the ground. The tower building entrance is secure and entrance to the tower is controlled through a touch key-pad. The tower is large and offers a full and unobstructed view of the airport, including runways and taxiways. The tower has 3 positions of operation which include clearance delivery, ground-control, and local control, and is staffed by 4 individuals per shift. The tower has a wide range of equipment including an AWOS (Automated Weather Observation System) display, ILS monitor consoles, VHF radios consoles, a modern airport lighting panel, RVR (Runway Visual Range) monitors for both runways, and a Final Approach Course (FAC) radar to monitor arriving flights. Although the ATIS (Automated Terminal Information Service) is integrated with the FDP and therefore automated, controllers still have the option to add runway and approach information to the ATIS as well as NOTAMs (Notice to Airmen) and pertinent airport information

The local controller is responsible for separation of aircraft on the runways and within the tower airspace. The ground controller is responsible for the separation of aircraft on the taxiways and entrance in and out of the parking tarmac. The airport has 2 parallel runways (08R/26L and 08L/26R) and each runway is more than 12,000' in length. However, these runways are not separated by a sufficient distance to permit simultaneous approaches. Runways 08R/26L are CAT II runways and Runways 08L/26R are CAT I runways. Each ILS glide slope has collocated DME facilities.



Tashkent ATC Tower

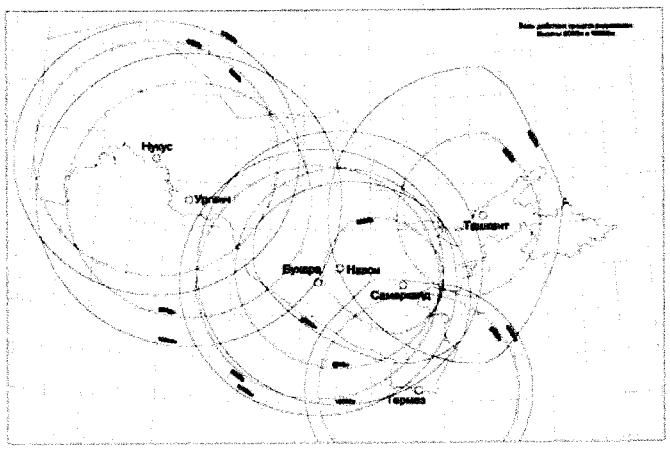
There are 71 controllers assigned to the Tashkent tower and they work 3 shifts that equate to 24 hours before receiving a 2-day break. Controllers work a 7 hour afternoon shift, followed by a 6 hour shift the next morning, and then an 11 hour shift that begins that evening at 9 PM and ends the next morning at 8 AM. Potential tower controllers attend the same air traffic training school as the potential ACC controllers. After successful completion of the school, they are assigned to a tower. Potential tower controllers train for approximately 4 months before obtaining full controller status.

Equipment

Uzaeronavigatsia has a full array of equipment for air traffic control. Although we were unable to take pictures of this equipment, we were able to view this equipment first hand and have identified this equipment according to its purpose. There are more than 500 technicians assigned to Uzaeronavigatsia to attend to their equipment.

Communications

Uzaeronavigatsia is presently improving their radio communications. Air-ground communications are provided by VHF units; however, more than 60% of the VHF units located throughout Uzbekistan are more than 16 years old, some more than 25 years old. However, all airports have at least one or two units that are less than 5 years old



The AMHS which is the replacement for the aging AFTN is considered as the first sub-network of the ATN and is presently being implemented by many countries and regions. There also doesn't seem to be any move toward the implementation

VHF Coverage Chart

Uzbekistan relies on HF frequencies for both air-ground and ground-ground, but most of these units are vintage models (1980s) with the majority of these units being Russian manufacture (Bereza, Kedr-C). Approximately 95% of the HF equipment is more than 15 years old. The AFTN is also used for ground-ground communications. It appears that no effort has been made toward the implementation of the ATN, or toward the implementation of AMHS (Aeronautical Message Handling Service). The AMHS, which is the replacement for the aging AFTN, is considered the first sub-network of the ATN and is presently being implemented by several countries and regions. There also doesn't appear to be any move toward the implementation of data link technology in Uzbekistan.

We visited the Communications Center at Tashkent where all the VHF and HF transmitters and receivers are collocated. The antennas are also located at this site. In the center is a Central Monitoring Office where all frequencies can be monitored on a daily basis including the ATIS frequency. There are direct speech circuits between Tashkent ACC and Germany, France, Pakistan, Iran, India, and Afghanistan using VSAT technology. VCCS (Voice Communication Control System) technology is also in use at Tashkent. All recorders at Tashkent are digital recorders.

Navigation

En route navigation within Uzbekistan is ground-based, either VOR/DME or NDB, although NDBs are used primarily in conjunction with markers associated with ILS units. There are 4 VOR/DME facilities and one stand alone DME in Uzbekistan for en route use. There is a DME collocated with each glide slope to determine distance from touchdown. All ILS systems also have NDBs collocated with all inner and outer markers. All VOR/DMEs are more than 10 years old and several of the ILS units are more than 15 years old. All ILS systems appear to be of Russian manufacturer. Flight inspection is performed by the Flight Inspection Department of USATSE ((Ukraine State Air Traffic Service Enterprise).

Outages are frequent, but are restored in minimum time unless a spare part is needed. There is difficulty in obtaining spare parts for VOR/DMEs which adds to downtime when these parts are needed. Spare parts are a problem.

We also visited several of the NDBs sites that are associated with the ILS systems as well as the localizer and glide slope for each runway. The equipment appeared to be well kept and each facility had UPS (Uninterrupted Power Supply). Most of the facilities in Uzbekistan including VOR/DMEs have UPS.

Satellite navigation has not been approved in Uzbekistan. It appears that the use of satellite navigation (GNSS) within Uzbekistan will require a complicated process to approve; one that will eventually require governmental intervention and approval. The navigational aids in Uzbekistan are as follows:

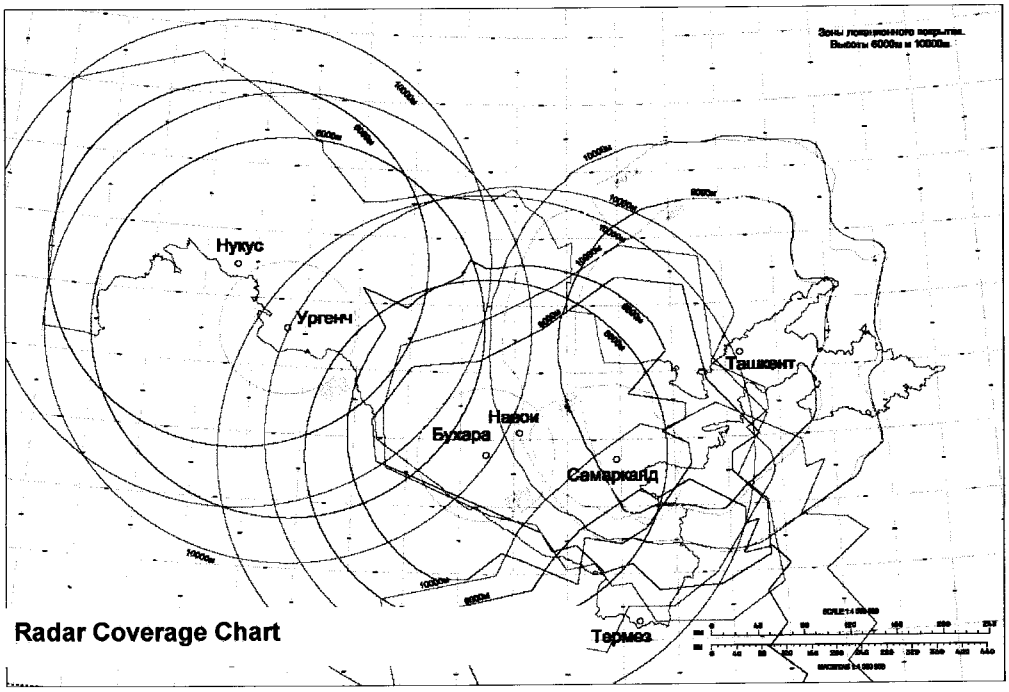
Name	ID	Type
ANDIZHAN	AD	NDB
ANDIZHAN	AN	NDB
BUKHARA	BR	NDB
BUKHARA	U	NDB
BUKHARA	UH	NDB
BULUNGUR	PD	NDB
DALVERZIN	FC	NDB
DZHIZAK	KA	NDB
FERGANA	ZU	NDB
GUZAR	GR	NDB
KAKAYDY	GZ	NDB
KAKAYDY	TD	NDB
KARAKHTAY	SW	NDB
KARSHI	UTV	TACAN
KASAN	YU	NDB
KOKAND	UP	NDB
MUYNAK	SO	NDB
NAGORNAYA	DY	NDB
NAMANGAN	SA	NDB
NURATA	HK	NDB
SAMARKAND	M	NDB
SAMARKAND	MZ	NDB
SERGELI	SR	NDB
SHERABAD	HA	NDB
SYRDARYA	CV	NDB
TAMDYBULAK	ST	NDB
TAMDYBULAK	TMD	VOR-DME
TASHKENT	FD	NDB
TASHKENT	NG	NDB
TASHKENT	TKT	VOR-DME
TASHKENT	ZW	NDB
TERMEZ	N	NDB
TERMEZ	NO	NDB
TERMEZ	TRZ	VOR-DME
TOYTEPA	UA	NDB
URGENCH	NU	NDB
URGENCH	RG	NDB
URGENCH	URG	VOR-DME
URGUT	DS	NDB
YUZHNY	F	NDB
YUZHNY	Z	NDB

Surveillance

Uzaeronavigatsia has 23 radar systems, most of which are 20 years old or older, and most are Russian manufacture. Many of these systems are not useable or not operating. However, Uzaeronavigatsia has 4 newer radar systems, one manufactured by Thompson-CSF, now known as Thales, and 3 manufactured by Allenia, an Italian manufacturer. The Allenia systems were installed in 2002 and the Thompson EUROCAT 200 system was installed in 1997. We were able to view the EUROCAT system as well as the construction site where the

new Thompson ASR system for the Tashkent terminal will be installed. All systems are based on GPS time. Radar data from the 3 Allenia systems is imported via VSAT to Tashkent and processed by the Thompson EUROCAT to provide full radar coverage over the Tashkent ACC airspace. There are 3 terminal radars of Russian manufacture (Krona) that were installed in 2002, but it is not known if these systems are in service.

We were able to visit the Thompson EUROCAT antenna site. This radar system has 4 primary channels (2 channels for backup) and 2 secondary channels (I channel for backup). This system has a Mode C antenna and provides secondary surveillance out to approximately 240 NM. The system is equipped with UPS and has 4 water cooling units that provide the cooling for the radar equipment.



Radar Coverage Chart

The Tashkent airport is the major airport in Uzbekistan. The ACC and tower as well as much of the ATC equipment are located on the airport premises. Airport security is provided by the Uzbekistan government and is very strict and rigidly enforced. There are armed guards stationed at each airport entrance and approximately every 2000' around the inside of the airport perimeter. The airport is managed by the State Enterprise Airport, a division of Uzbekistan Airways. Although it appeared the taxiways were maintained, the perimeter road and some parts of the tarmac were in need of resurfacing.

The largest user of the airport is Uzbekistan Airways accounting for approximately 65% of the airport traffic. The airport traffic count is approximately 60 operations per day with a peak hour of 6 operations.

The airport has a unique method of bird control. The airport maintains a flock of trained hawks that are individually caged in the grassy area between the parallel runways. The handlers use the hawks during daylight hours to ensure birds stay away from the runways. While touring

the AWOS site, we had the opportunity to view this operation first hand. A flock of birds appeared on the site and were quickly chased off by the hawks.

Recommendations

1. Uzaeronavigatsia needs to improve and upgrade their VHF and HF communications infrastructure. More than 60% of the VHF units are more than 16 years old and about 95% of the HF equipment is more than 15 years old or older. Tashkent personnel indicated that communications were a problem and would be a larger problem in the near future.

2. Action needs to be taken to begin the process to approve GNSS for use in Uzbekistan. Due to the lengthy process that was indicated in approving GNSS, action needs to begin quickly. The VOR/DME system is old and getting more difficult to maintain due to a lack of spare parts. New Doppler systems are expensive and will take a couple of years to install if new ones are procured. Most of the navigational concerns of Uzaeronavigatsia can be resolved with the approval of GNSS.

3. We recommend the implementation of the ATN that should begin with the implementation of AMHS. The AFTN is being replaced with AMHS and many countries have already started or completed implementing AMHS. There is no guarantee on how long that the AFTN will remain in service.

4. Uzaeronavigatsia needs to implement RNAV procedures with RVSM. There are presently no RNAV procedures in effect, but IATA is pushing for RNAV procedures through eastern and central Asian states. RVSM would increase the useable altitudes above FL 290 thereby saving fuel and money for the air carriers. RNAV would provide more direct routes reducing flight time, fuel burn, and save money for the users.

5. Uzaeronavigatsia should convert to the WGS-84 datum as soon as possible to meet an ICAO recommendation that all states convert to WGS-84 datum.

6. The ACCs should consider the use of radar handoffs between facilities wherever possible to expedite traffic and keep aircraft in radar contact when possible.

Central Asia Recommendation Summary

Almaty Recommendation Summary

1. Upgrade the current DENRO communications switch or purchase a new switch.

2. Modernize the current HF radio system.

3. Plan and implement an NDB phase out program for all of Kazakhstan.

4. Upgrade or replace the current ILS to enable Category III operations. Note: should a Category III landing capability be provided at Almaty airport, then consideration must be given to providing surface guidance to the aircraft after it has landed. One such system is the Airport Surface Movement Guidance Control System (A-SMGCS).

5. Upgrade or replace the Siemens 2000 and Airsys equipment.

6. Replace the voice and radar recording equipment with systems that are digital and have expanded and possibly integrated capabilities.

Taraz Recommendation Summary

1. Modernize the current HF radio equipment/system.

2. Install an alternate point-to-point communication system for local area operations.

3. Plan and implement an NDB phase out program for Taraz and all of Kazakhstan.

4. Upgrade or replace the primary and secondary radar systems prior to exceeding their 2007 lifecycle.

5. Kazaeronavigatsia consider establishing a centralized depot facility to provide spare parts, diagnostics and training for all communications, navigation, surveillance and air traffic management (CNS/ATM) systems in Kazakhstan. Such a facility would also be capable of supporting CNS/ATM systems in the Central Asian region.

6. Upgrade or replace the current controller consoles/working positions and associated equipment.

7. Modify the current structure or construct a new tower to provide an unrestricted view of the airfield environment.

Shymkent Recommendation Summary

1. It is recommended that consideration be given to modernizing the HF radio system and modernizing the backup power supply systems (e.g. generators and batteries) for all CNS/ATM systems. Should a decision be made to replace the backup power supply systems, then it is suggested that the Tender be based on a functional capability and not merely a one-for-one replacement.

2. Consideration should be given for replacing the current point-to-point cable based communication system between airport locations with fiber optic and/or microwave technology. Should a decision be made to replace the point-to-point system, then it is recommended that a remote maintenance monitoring and control capability be included in the modemization plans for all CNS/ATM systems and the supporting infrastructure such as generators, batteries and climate control systems.

3. It is recommended that consideration be given to phasing out the existing NDBs at Shymkent as they become non-supportable; conduct the necessary WGS-84 surveys to enable the development of satellite-navigation procedures; develop and implement satellite-navigation arrival, approach and departure procedures for both runway ends; establish a program to develop radar vector procedures to enable controllers to vector aircraft for a visual, satellite-navigation or ILS approach procedure; and establish the requisite training programming to ensure the controllers are fully qualified to use the new procedures and understand the operational use of satellite-navigation.

4. Consideration should be given to installing the proper runway lighting system for both runway ends and ensure that all runway markings are ICAO compliant to enable full Category I approach operations.

5. It is recommended that consideration be given to installing the requisite system and equipment to be able to connect directly with the internal Kazaeronavigatsia network and not rely on the commercial communication infrastructure.

6. It is recommended that consideration be given to enable the direct communication between all Kazakhstan towers/facilities using the internal Kazaeronavigatsia network.

7. It is recommended that consideration be given to replacing the existing 32 channel recorder with digital recorders capable of supporting a minimum of 100 channels.

Astana Recommendation Summary

1. Either upgrade the current Category 2 ILS to a Category 3 ILS, or purchasing a new Category 3 ILS.

2. Acquiring and implementing a surface movement radar system to be able to safely handle aircraft ground traffic during limited visibility.

3. Develop a plan and schedule for decommissioning the NDBs.

4. Develop a post-warranty Skyline plan to ensure continued reliable operations and services from the system.

5. Obtain a separate processor, run the SkyLine software on this new processor (reportedly this would be permitted at no additional cost), connect the two unused workstations to that processor, and use these two workstations for upgrades, testing and training.

6. Acquire 132-channel digital voice recorders with the ability to also record radar data.

Kyrgyzstan Recommendation Summary

1. Purchasing new digital VHF transmitters and receivers or transceivers that can be collocated in the same physical facility and use the same basic antenna systems; decommission the communications facility in town; and relocate all communications in a single Manas airport location.

2. Developing a plan to phase-out the NDBs in Kyrgyzstan and at the same time, initiate a program to develop and implement Global Navigation Satellite System (GNSS) enroute, terminal, arrival and departure procedures for those locations currently serviced by NDBs. Since Kalashnikov Vasily AIS Navigation Service develops procedures for Kyrgyzstan airspace operations and sends them to Rosjep for publication and distribution, it is recommended that both organizations be contacted to determine if they have the capability and experience to develop and publish GNSS procedures for domestic and international aviation users.

3. Near-term actions be taken to establish a repair and maintenance contract with Wilcox and a plan be developed to either upgrade or replace the existing system as it nears the end of its service life.

4. Developing and implementing a plan for improving commercial power supply systems to all airport locations in Kyrgyzstan. In addition, to the commercial system, it is suggested that the current back up power systems be evaluated for performance and adequacy.

5. Immediate consideration be given to modifying the pay scale to be able to retain qualified personnel.

6. Upgrading or replacing the current radar systems as soon as possible due to the age and increasing difficulty of obtaining spare parts for the current systems; the operational limitations imposed on the air traffic controllers because the current

equipment is not ICAO compliant; flight safety concerns; and the need to provide reliable radar services to satisfy near-term and future airspace requirements.

7. Either modernizing the Manas tower or building a new tower to permit the collocation of runway and ground control personnel.

8. Purchasing a communications switch for the sole use of Kyrgyzaeronavigatsia.

9. Install a phone set be to permit the use of the satellite communications system.

Tajikistan Recommendation Summary

1. Immediately begin the development of a plan to obtain post-warranty repair and maintenance support for all recently purchased CNS/ATM equipment prior to the end of the one-year manufacture warranty period.

2. Replacing or modernizing the vintage HF communications equipment and systems.

3. In accordance with ICAO recommendations, consideration be given to developing an airspace restructuring plan based upon the use of satellite navigation positioning. Systems such as the Global Positioning System (US), GLONASS (Russian), and Galileo (Europe) will provide a robust navigation capability for Tajikistan and enable the reduction of ground-based navigation aids such as the NDBs. This airspace restructuring plan should also include a schedule for the decommissioning of the current NDBs.

4. A country wide program be established to develop and implement GNSS approach and departure procedures for all Tajikistan airports.

5. Developing an education and training program for all Tajikistan air traffic components; to include both maintenance and operational personnel.

6. Determine the options for either modifying the current tower or constructing a new facility to enable the full and unobstructed view of the entire ramp and the end of runway 09.

7. Investigate the software change and maintenance options for the new ATC equipment.

Turkmenistan Recommendation Summary

1. Turkmenhovayollary needs to improve and upgrade their VHF and HF communications infrastructure. The present VHF and HF communications capability are older models and has frequent failures. VHF repeaters need to be replaced with additional frequencies and the VSATs repaired. Ashgabat ACC personnel indicated that communications were a problem, but some improvement has been noted. The controllers seem to believe that communications would be a larger problem in the near future if not corrected now.

2. Satellite navigation is not authorized in Turkmenistan. GNSS could resolve most of their NAVAID problems. Action needs to be taken to begin the process to approve

GNSS for use in Turkmenistan. Turkmenhovayollary has a limited number of navigational facilities and they are older models which are getting more difficult to maintain due to a lack of spare parts.

3. We recommend the implementation of the ATN that should begin with the implementation of AMHS (Aeronautical Message Handling Service). The AFTN is being replaced with AMHS and many countries have already started or completed implementing AMHS. There is no guarantee on how long that the AFTN will remain in service.

4. Turkmenistan needs to implement RNAV procedures with RVSM. There are presently no RNAV or RVSM procedures in effect. RVSM would increase the useable altitudes above FL 290 thereby saving fuel and money for the air carriers. RNAV would provide more direct routes reducing flight time, fuel burn, and would also save money for the users.

5. Turkmenhovayollary should convert to the WGS-84 datum as soon as possible to meet an ICAO recommendation that all states convert to WGS-84 datum. At present there are no plans to convert.

6. The ACCs should consider the use of radar handoffs between facilities wherever possible to expedite traffic and keep aircraft in radar contact when possible.

7. Turkmenhovayollary needs to install ATIS at their major airports. This will relieve both controller and pilot workload.

8. Turkmenhovayollary needs to consider UPS at their major facilities. The generators we viewed were old and may not perform as well as required when used.

9. It is also recommended that Turkmenhovayollary consider English training for their controllers. While we were in the ACC we noticed that the English used by controllers was broken at times and it was evident that some refresher language training may be needed.

Uzbekistan Recommendation Summary

1. Uzaeronavigatsia needs to improve and upgrade their VHF and HF communications infrastructure. More than 60% of the VHF units are more than 16 years old and about 95% of the HF equipment is more than 15 years old or older. Tashkent personnel indicated that communications were a problem and would be a larger problem in the near future.

2. Action needs to be taken to begin the process to approve GNSS for use in Uzbekistan. Due to the lengthy process that was indicated in approving GNSS, action needs to begin quickly. The VOR/DME system is old and getting more difficult to maintain due to a lack of spare parts. New Doppler systems are expensive and will take a couple of years to install if new ones are procured. Most of the navigational concerns of Uzaeronavigatsia can be resolved with the approval of GNSS..

3. We recommend the implementation of the ATN that should begin with the implementation of AMHS. The AFTN is being replaced with AMHS and many countries have already started or completed implementing AMHS. There is no guarantee on how long that the AFTN will remain in service.

4. Uzaeronavigatsia needs to implement RNAV procedures with RVSM. There are presently no RNAV procedures in effect, but IATA is pushing for RNAV procedures through eastern and central Asian states. RVSM would increase the useable altitudes above FL 290 thereby saving fuel and money for the air carriers. RNAV would provide more direct routes reducing flight time, fuel burn, and save money for the users.

5. Uzaeronavigatsia should convert to the WGS-84 datum as soon as possible to meet an ICAO recommendation that all states convert to WGS-84 datum.

6. The ACCs should consider the use of radar handoffs between facilities wherever possible to expedite traffic and keep aircraft in radar contact when possible.

CNS/ATM Implementation Trends

Introduction

The objective of this task is to identify the status of CNS/ATM implementation by ICAO in the region. Specifically the intent of this task is to identify and document international trends in implementing CNS/ATM technologies in the region through the review of ICAO and International Air Transport Association (IATA) planning documents, as well as other CNS/ATM-related implementation documents.

More specifically, the review will focus on the development status of appropriate components of the system, as well as ICAO's progress in establishing appropriate SARPs and other guidance documents for the operation and maintenance of the CNS/ATM system. Also, to provide examples of actions taken by other service providers around the world in overcoming the technical and non- technical barriers encountered in their organizations' transition from a ground-based to a satellite-based system.

Special emphasis will be given to the review of the methods employed by various air navigation service providers in identifying and acquiring financial resources for implementation activities, as well as the assumptions made and actions undertaken in establishing timelines for the integration of new technologies into their existing systems.

During the 7 September 2006 working group meeting in Almaty, Kazakhstan, the working group members supported the fact that there were no ICAO Regional CNS/ATM plan specifically designated for Central Asia. The working group discussed the idea of using the ICAO Regional Plan for Europe/Eastern Europe as a basis for this task. The working group formally accepted this approach for satisfying the requirements and believed that such an approach—from an historic, current and planning perspective--would provide the optimum benefit and proper balance for all participating States.

Hence, the remainder of this report addresses the ICAO structures and the past, present and future Regional planning and implementation processes for Europe and Eastern Europe.

ICAO AIR NAVIGATION PLANNING

1.1. Organizational Structure

The principal structures (organizational entities) involved in regional air navigation planning are the regional air navigation (RAN) meetings and regional planning groups.

The RAN meetings are comprehensive assemblies of the national aviation authorities of the region, convened by the Council of ICAO, having various committees and working groups. The regional planning groups are smaller gatherings, established by the Air Navigation Commission of ICAO, for specific planning purposes.

Technical experts from ICAO and its regional offices service these bodies and provide valuable assistance.

In some regions, certain large and influential sub-regional bodies or associations of States are involved in the planning process also.

Several regions also have specialized planning and implementation groups devoted to realization of the largely satellite-based communications, navigation and surveillance / air traffic management (CNS/ATM) systems.

1.2. The Planning Process

The basic step in the planning process is the making of a regional air navigation plan (ANP). This is done in RAN meetings or under the management of a regional planning group established by the Council of ICAO in response to the recommendation of a RAN meeting of that region. A subsequent step is the approval of the plan by the Council of ICAO.

More specifically, planning is done taking into account the ICAO global plan and the national plans of each State in the region (the State being ultimately responsible for the detailed planning and implementation of the facilities and services required). It is done by reaching a consensus between user States (those in which the aircraft using the facilities and services are registered) and provider States (those making available the facilities and services), in close consultation with the international associations of the aircraft operators which are liable to be charged with the costs of the facilities and services to be included in the relevant ANP.

This consensus aspect of the planning process underlies an important function of the ANP. Facilities and services provided for in the plan, as approved by the Council of ICAO, are globally accepted as necessary to the safety and efficiency of international civil aviation. Their providers are entitled to charge users to offset costs, however in general users are not expected to pay for costs other than those allocable to the facilities and services provided for by the approved plan. The costs of any other facilities and services (for example, those needed only by national civil or military aviation) should not be included in the cost basis for user charges.

The regional plan should be reviewed and updated periodically inline with the current operational requirements. Traditionally, infrequently held RAN meetings did this review and updating.

Plan amendments, by whoever drafted, are of course subject to the further process of approval by the Council of ICAO. This step is clearly necessary to ensure the coherence of the worldwide air navigation system and the conformity of such amendments with the ICAO worldwide SARPs. Approval is not pro-forma: if the Council believes that the facilities and services of a Contracting State are not reasonably adequate for the international air navigation requirements it consults, through the relevant ICAO regional office, with the State concerned and other States affected to find ways to remedy the situation.

The process of updating involves also forecast data on air transport and general aviation operations over the relevant air routes and airspace. It requires consideration of the general worldwide planning criteria established by ICAO.

1.3. The Regional Air Navigation Plan

A regional navigation plan is a detailed statement of the facilities and services to be provided to meet the needs of international civil aviation within a specified region.

The plan is an authoritative, internationally agreed and Council-approved reference document of benefit to both provider States and airspace users. It is an essential means to help ensure that the facilities and services provided, individually or collectively, by States in each region, form a coherent global air navigation system on a regionally integrated basis.

AIR NAVIGATION PLANNING IN THE ICAO EUROPEAN REGION

2.1. Organizational Structure in the Field of European Air Navigation

The European Air Navigation Planning Group (EANPG) is the regional body established in 1972. Additionally, the air navigation activities of four other intergovernmental organizations in the Western part of the EUR Region affect air navigation planning. These entities are:

- ECAC;
- EUROCONTROL;
- JAA;
- CANSO.

2.1.1. ECAC

The Council of Europe in association with ICAO established the European Civil Aviation Conference (ECAC) in 1955. The membership of ECAC comprises 41 European Contracting States of ICAO (totally there are 49 European Contracting States of ICAO).

To alleviate serious capacity problems that emerged during the late 1980s, ECAC, together with the European Commission, adopted stringent measures to harmonize the air traffic services of their Member States and jointly planned air traffic management within their respective areas of responsibility. Subsequently, the Ministers of Transport of the ECAC States endorsed the European Air Traffic Control Harmonization and Integration Program (EATCHIP) developed by ECAC, and gave EUROCONTROL a mandate to manage its implementation.

As a complement to EATCHIP, ECAC also established an Airport/Air Traffic System Interface (APATSI) Program to carry out aerodrome operations planning, particularly airport/ATC capacity aspects. ECAC also promoted the creation of the Joint Aviation Authorities (JAA) to deal mainly with airworthiness and the safety of air operations.

2.1.2. EUROCONTROL

The European Organization for the Safety of Air Navigation (EUROCONTROL), an organization governed by international public law, was constituted in 1960. EUROCONTROL currently numbers 31 Member States. The primary objective of EUROCONTROL is development of a seamless pan-European air traffic management (ATM) system.

EUROCONTROL develops, coordinates, and plans the implementation of short and long-term pan-European ATM strategies and their associated action plans in a collective effort involving national regulatory authorities, air navigation service providers, the airspace users, the military, industry and other European institutions.

2.1.3. JAA

The Joint Aviation Authorities (JAA) are an associated body of ECAC representing the civil aviation regulatory authorities of a number of European States which have agreed to co-operate in developing and implementing common safety regulatory standards and procedures. Nineteen ECAC Member States are now full members of the JAA.

2.1.4. CANSO

The Civil Air Navigation Service Organization (CANSO) is a quite young organization established in 1998. CANSO's mission is to provide a worldwide platform for customer and stakeholder driven civil ANS providers. The main fields of interest are: corporatization in air navigation domain, effectiveness of air navigation services and CNS/ATM implementation. CANSO includes 30 full members and 29 associated members.

Finally, among involved organizations, ICAO itself, through the EANPG and its European and North Atlantic Regional Office in Paris, is not only the sole entity with authority to manage the European Regional Air Navigation Plan, but also the only body embracing the entire EUR Region and thus able to approach planning on a truly regional basis. Given the existing situation, the role of ICAO in the European Region is to promote, co-ordinate and facilitate the harmonization of the relevant programs of the above-mentioned organizations in the Western part of the Region, as well as the activities of States and State groupings in the Central, Eastern and Far Eastern parts of the Region. It also manages the EUR Regional Air Navigation Plan to ensure a coherent air navigation system for the whole Region, and one that is compatible, at regional interfaces, with the air navigation systems of adjacent ICAO Regions (NAT, AFI, MID and Asia/Pacific).

2.2. Planning Processes

The activities of ECAC, EUROCONTROL, the JAA, CANSO and other organizations provide welcome support to develop the air navigation systems of Europe more rapidly. At the same time, the results of some specific aspects of their work can impact activities outside their respective territories. In particular, procedural aspects, the mandatory carriage of on-board equipment, and many other matters ought to be approved within the broader ICAO framework they affect, regionally, inter-regionally or worldwide.

Within the above framework, some aspects of air navigation planning, in particular detailed implementation planning, is now largely achieved through regional organizations, such as ECAC and EUROCONTROL, e.g. through the harmonization and integration program, EATMP (EATCHIP is the previous name), which embraces most of the ICAO Contracting States located in the Western part of the European Region. In the Eastern part of the EUR Region, especially that of the new Contracting States, ICAO, through the EANPG, will continue its full scale regional planning involvement to help States in discharging their related responsibilities.

ICAO, at the regional level, has always provided a forum for States in which pure air navigation planning was combined with detailed implementation planning.

Now, along with the EANPG, it takes into account what groups of States, or agencies (ECAC, EUROCONTROL, JAA and others) acting on their behalf, do within the Region in the fields of air traffic services harmonization, flow management, and aerodrome operations planning. At the same time, ICAO continues to provide a forum for all States in the Region for regional air navigation planning and to resolve contentious issues, issues of interface between sub-regions, or interface with other regions, of non-technical matters impacting on international civil aviation, and of contingencies and crises. The EANPG constitutes a mediating element and will continue to function as a catalyst for widely acceptable solutions.

In summary, collective air navigation planning and implementation initiatives undertaken by State groupings, irrespective of their constitutional nature (regional organizations, State associations and others), have proven efficient in harmonizing air traffic services and air traffic flow management, as well as aerodrome operations planning. ICAO and the EANPG retain the responsibility to ensure conformity of such initiatives with the Regional Air Navigation Plan (RANP) of the entire Region.

3. MEMBERSHIP IN AVIATION ORGANIZATIONS. SUB-REGIONAL ANALYSIS

To identify the international trends in communications, navigation, surveillance and air traffic management (CNS/ATM) technologies in the European region, specifically including countries with FIRs adjacent to Poland, let us consider a membership of the countries in aviation organizations.

Representing the membership we used names of the countries instead of the titles of corresponding institutions and enterprises to be short. To analyze a situation in the future we used only mass media published or politically declared intentions.

The current membership is represented in the figure 3.1 below.

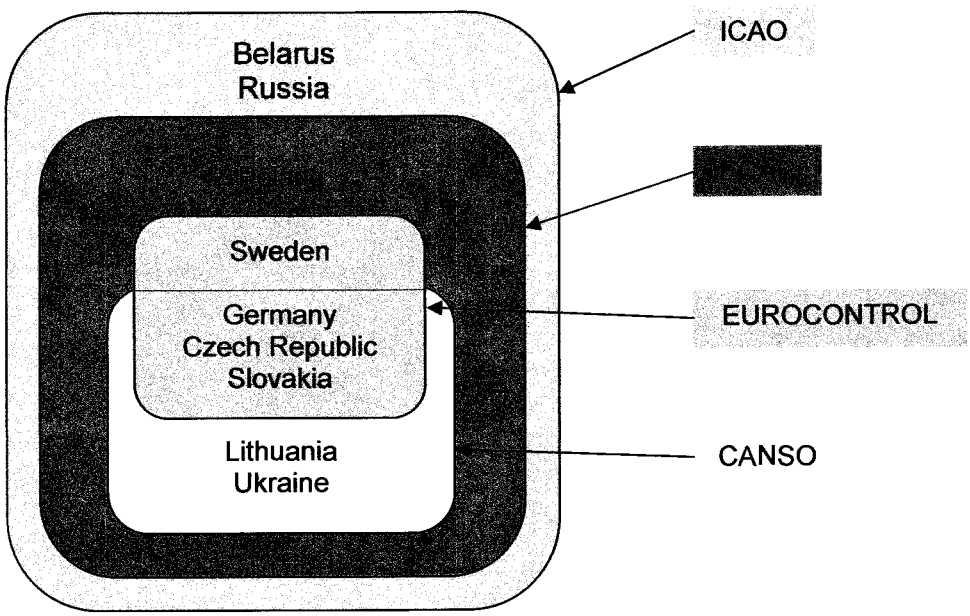


Fig. 3.1. Current membership

Taking into account political trend of Poland and the Baltic countries as well as the Agreement on Cooperation between Russian Federation and ECAC, it is possible to imagine a membership in some years as it is shown in the figure 3.2.

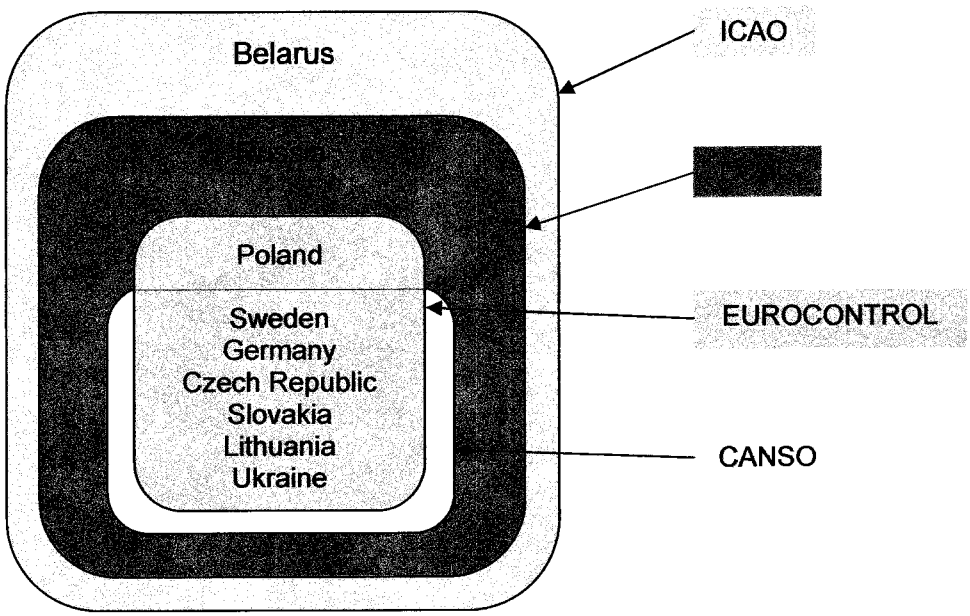


Fig. 3.2. Prospective membership

Figures 3.3 and 3.4 show current and prospective membership for the extended pool of countries. The prospective membership was drawn based on the same assumptions.

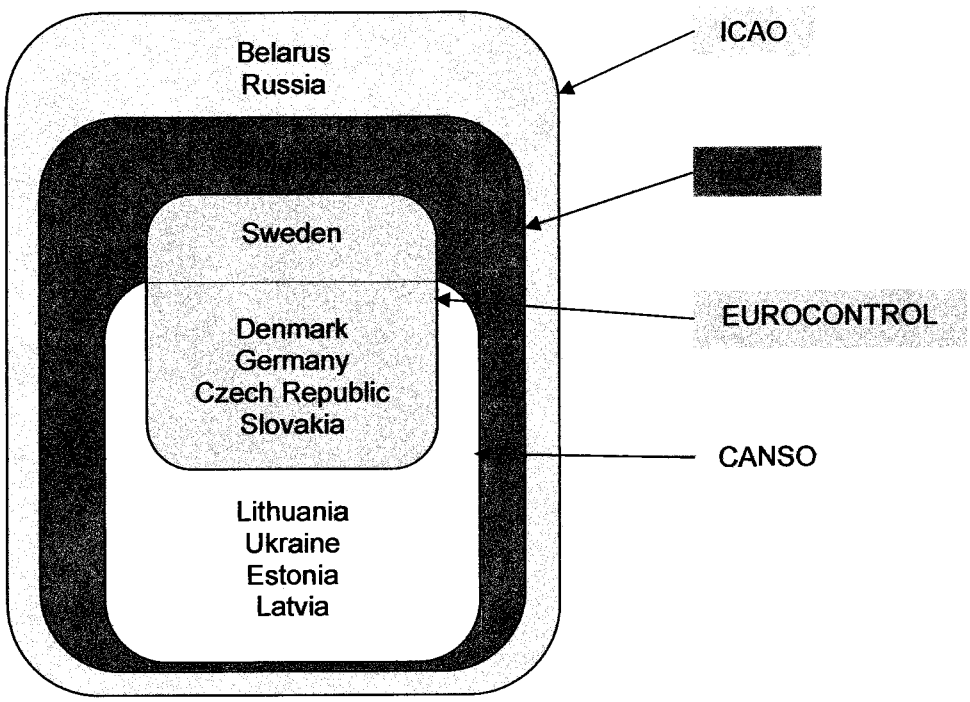


Fig. 3.3. Current membership. Extended pool of countries.

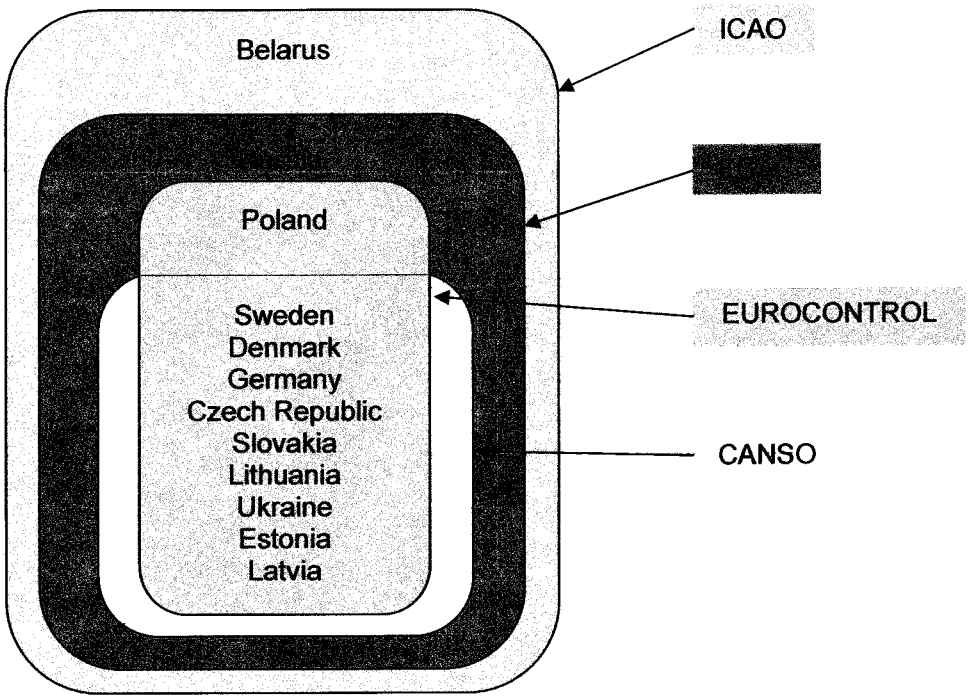


Fig. 3.4. Prospective membership. Extended pool of countries.

Taking into account an international character of aviation business, it is reasonable to use the extended pool of countries for analysis.

All countries of the pool are ICAO members. At the moment only Belarus and Russia are out of ECAC membership, however, Russia signed an Agreement on co-operation with ECAC recently, which is the first step on the way to ECAC.

At the moment 45% of the countries are EUROCONTROL members and more than 50% are CANSO members. Russia has developing relations with EUROCONTROL also. No doubt, Poland, Estonia, Latvia and Lithuania will join EUROCONTROL during next 2 – 3 years. So, it is evident, that absolute majority of the countries will belong to EUROCONTROL in some years.

CANSO is quite young, but very fast growing organization. Unfortunately, there is no information indicating country's intentions to join CANSO. Nevertheless, 2/3 of the countries are CANSO members now.

EUROCONTROL Agency has the most detailed and mature strategies, plans and programs in the European Region. CANSO just started to define its own position to CNS/ATM and has only one document on the matter published 3 years ago for the 5 years prospective ("Demystifying CNS/ATM". Report prepared by CANSO CNS/ATM Working Group, June 1999).

In general, EUROCONTROL recognizes a paramount role of ICAO. Taking into account that ICAO delegates the most complex and important tasks to EUROCONTROL (RVSM program is just recent example) and EUROCONTROL is managing agent on behalf of ECAC (ATM 2000+, Airspace, Communications,

Navigation, and Surveillance Strategies for ECAC), it is possible to consider that EUROCONTROL plans and programs are in line with those of ICAO and ECAC.

So, to understand international trends in the field of CNS/ATM, it is necessary to investigate mostly EUROCONTROL documents. It does not mean that we should not pay attention on ICAO documents. Intentions of Russia and Belarus require careful attention also.

ECAC & EUROCONTROL APPROACH TO CNS/ATM IMPLEMENTATION/TRANSITION

4.1. ATM 2000+ as an "Umbrella Strategy"

In January 2000 the Transport Ministers of the ECAC States adopted the EUROCONTROL Air Traffic Management Strategy for the years 2000+ (ATM 2000+ Strategy) as the vehicle for improving Air Traffic Management service provision in Europe and meeting the airspace users' needs' within the framework of a performance-driven and top-down European Convergence and Implementation Plan.

The ATM Strategy 2000+ follows on from the ECAC Strategies for the 1990's. It incorporates the on-going final phase of the European Air Traffic Control Harmonization and Integration Program (EATCHIP), and the scope of the former Airport/Air Traffic Services Interface Program (APATSI).

The ATM 2000+ Strategy is intended to provide an effective framework of change within which national plans can be developed. As such, it should be seen as an "umbrella" strategy that embraces and co-ordinates the more detailed individual strategies.

However, before the consideration of CNS/ATM trends it would be good to understand relationships between ATM 2000+ Strategy and ICAO Global Plan for CNS/ATM as well as ECAC Strategy and Commitment of the States.

To understand the relationships it is better to use pictures (see Fig. 4.1 and Fig 4.2).

Fig. 4.1. Interaction of ATM 2000+ Strategy with other Plans and Strategies.

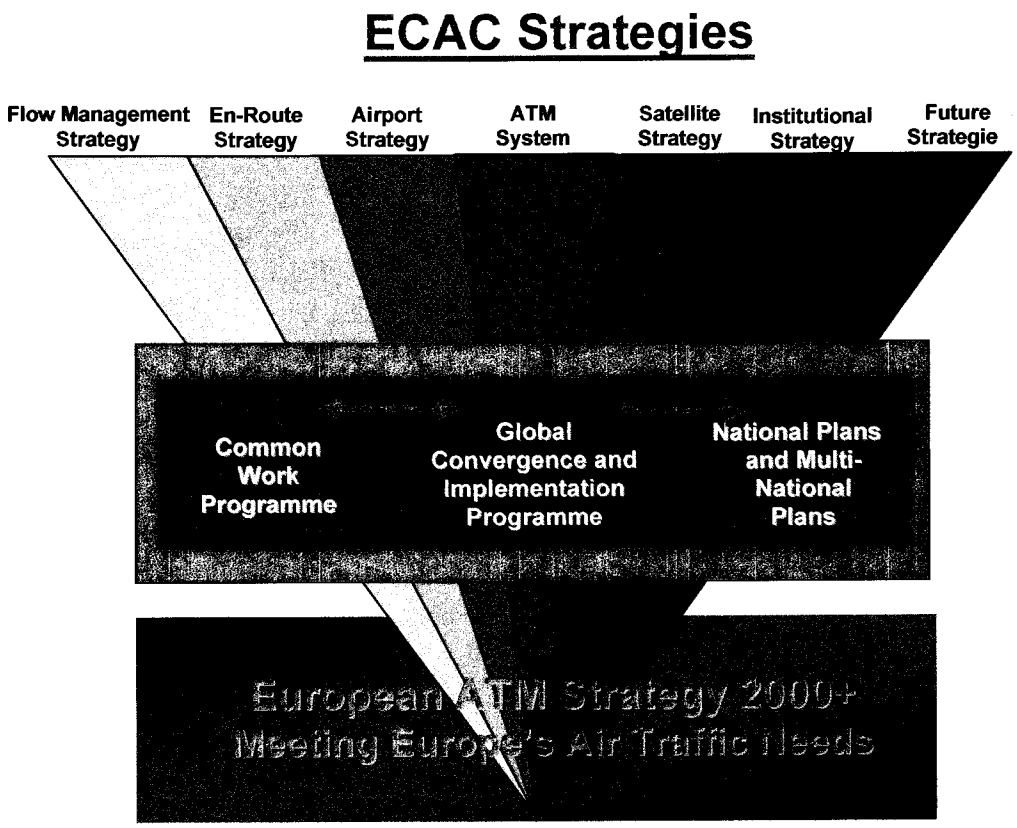


Fig. 4.2. ATM 2000+ and ECAC Strategies.

4.2. Commitment of States

The European Convergence and Implementation Plan describes the commonly agreed actions to be taken by the EUROCONTROL States and other ECAC States to meet the strategic principles and objectives set out in the EUROCONTROL ATM 2000+ Strategy. It is based on the EUROCONTROL Revised Convention, which sets out the requirement to achieve a uniform 'gate to gate' European ATM system, and takes as its foundation the need to set and realize quantifiable and measurable ATM Performance Targets for key ATM performance areas.

The European Convergence and Implementation Plan contains all necessary information on implementation objectives aiming at the harmonization and integration process within and between States.

The European Convergence and Implementation Plan (ECIP) provides a reference and a framework for national and multinational plans as well as, for plans for common projects to ensure that they remedy the identified deficiencies and that they converge to meet the strategic objectives of the ECAC, To that effect the ECIP contains objectives and milestones reflecting the commitment of States to achieve these objectives by agreed target dates.

The ECIP Implementation Objectives and Stakeholder Lines of Action flow down into Local CIP Documents (LCIPD) for each State. These set out the detailed national plans and actions needed to achieve the objectives and meet the national Performance Targets. The Local CIPs Documents constitute the medium-term implementation plans for the ECAC States and aviation stakeholders. So, LCIPD for each State provides their commitment.

Both plans show:

- Performance targets;
- Lines of Action;
- Implementation Objectives.

4.3. EATMP as an "Umbrella Program"

The EUROCONTROL ATM 2000+ Strategy sets out the strategic principles and objectives for enhancing ATM services in the ECAC States out to 2015.

The European Air Traffic Management Programme (EATMP) is the response to that strategy and represents the common work to be undertaken by all stakeholders to achieve the objectives of the ATM 2000+ Strategy. It is based on a top-down and performance-led approach that sets quantifiable and measurable performance targets in the four ATM key performance areas: Safety, Capacity, Cost-effectiveness and Environment.

The objectives of the EATMP are to:

- Improve ATM safety levels by reducing the number of ATM-related accidents and serious risk-bearing incidents in real terms as well as improve security;
- Provide sufficient ATM capacity to meet the demand of the airspace users under normal circumstances without imposing significant operational, economic or environmental penalties;
- Reduce Air Navigational Service (ANS) charges per unit of aircraft operation;
- Work with the International Civil Aviation Organization (ICAO) and its Member States to help protect the environment, particularly through the accelerated introduction of concepts, systems and procedures that mitigate the effect of aircraft operations.

EATMP is divided into domains, which are a functional sub-division of ATM. Each domain has its own programs. There are 10 domains in the EATMP:

- Airspace Management
- Airport Operations
- Air Traffic Flow and Capacity Management
- Air Traffic Control
- Aeronautical information Services
- Data Processing
- Communication

- Navigation
- Surveillance
- Human Resources

Figure 4.3 shows the top – down hierarchy/subordination between the Strategies – Domains – Programs discussed, where each program is developed under the umbrella of the respective Domain Strategy.

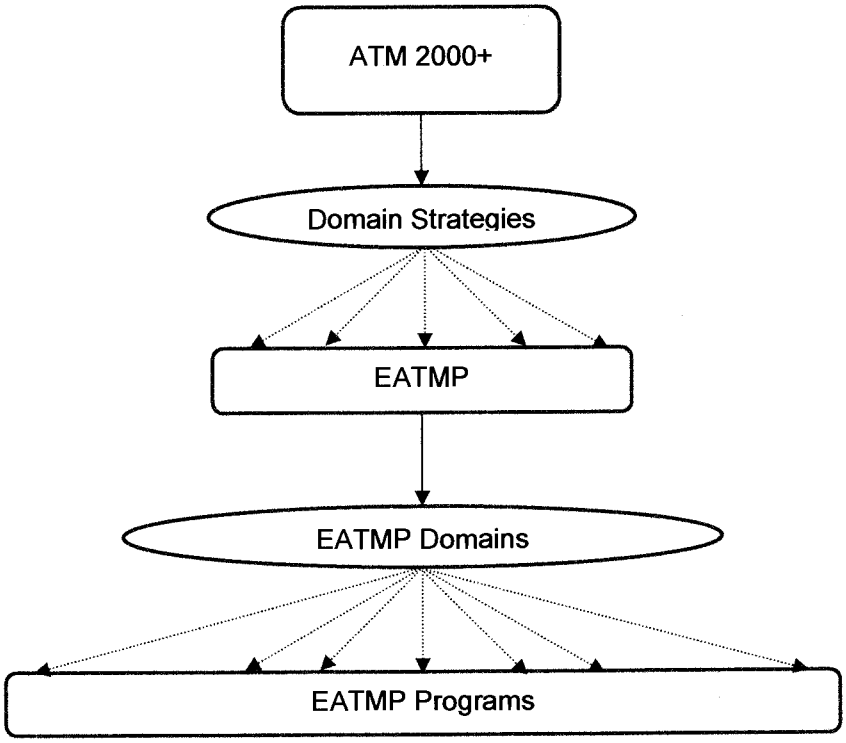


Fig. 4.3. European top – down implementation diagram.

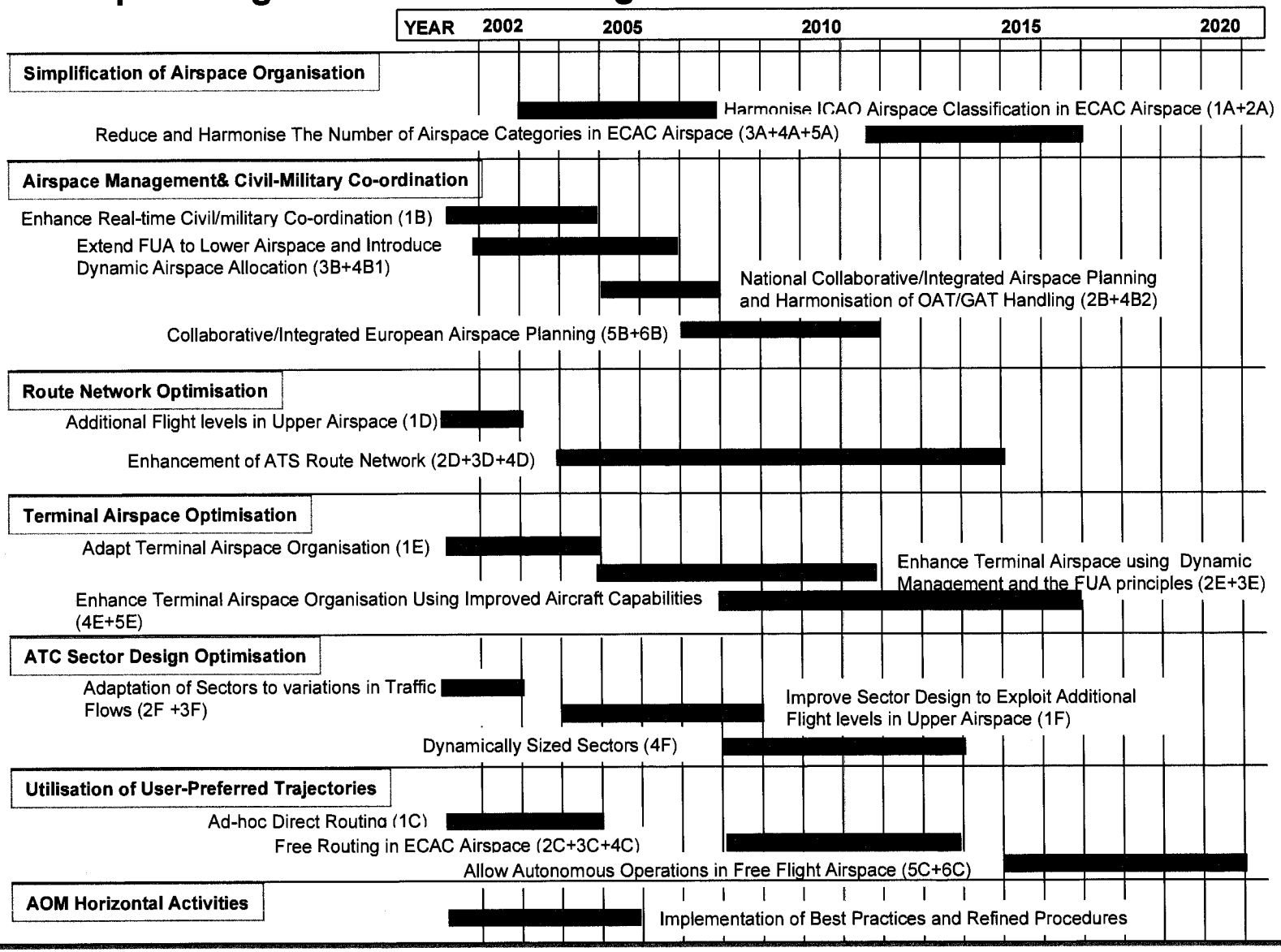
All the Domain Strategies as well as EATMP programs support the operational developments proposed by the ATM 2000+ Strategy towards the implementation of a uniform European Air Traffic Management system. It is in line with the implementation of the ICAO Global Air Navigation Plan for CNS/ATM systems in ECAC.

So, it is evident now that the levels of Domain Strategies and EATMP Programs are the right levels to consider CNS/ATM trends in the European Region as well as in the area of interest.

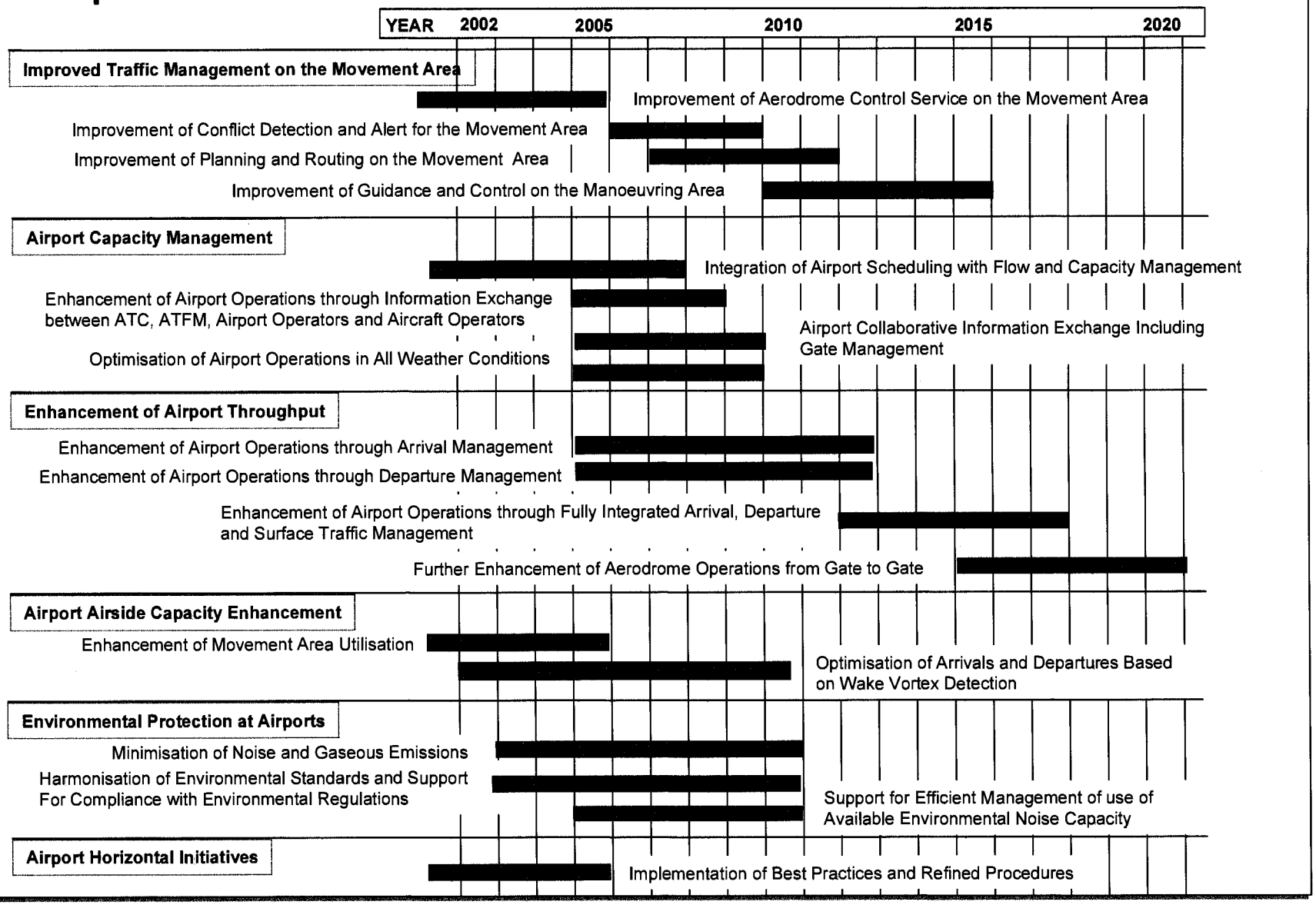
There is a big danger to repeat EATMP document describing CNS/ATM trends, especially in the fields of ATM. To avoid this, let us consider time charts for 7 main EATMP Domains mentioned above except of CNS Domains (to be consider later on). These charts present the main changes in the field of ATM in the most concentrated manner.

The Overall Road Map of Change will supplement these charts.

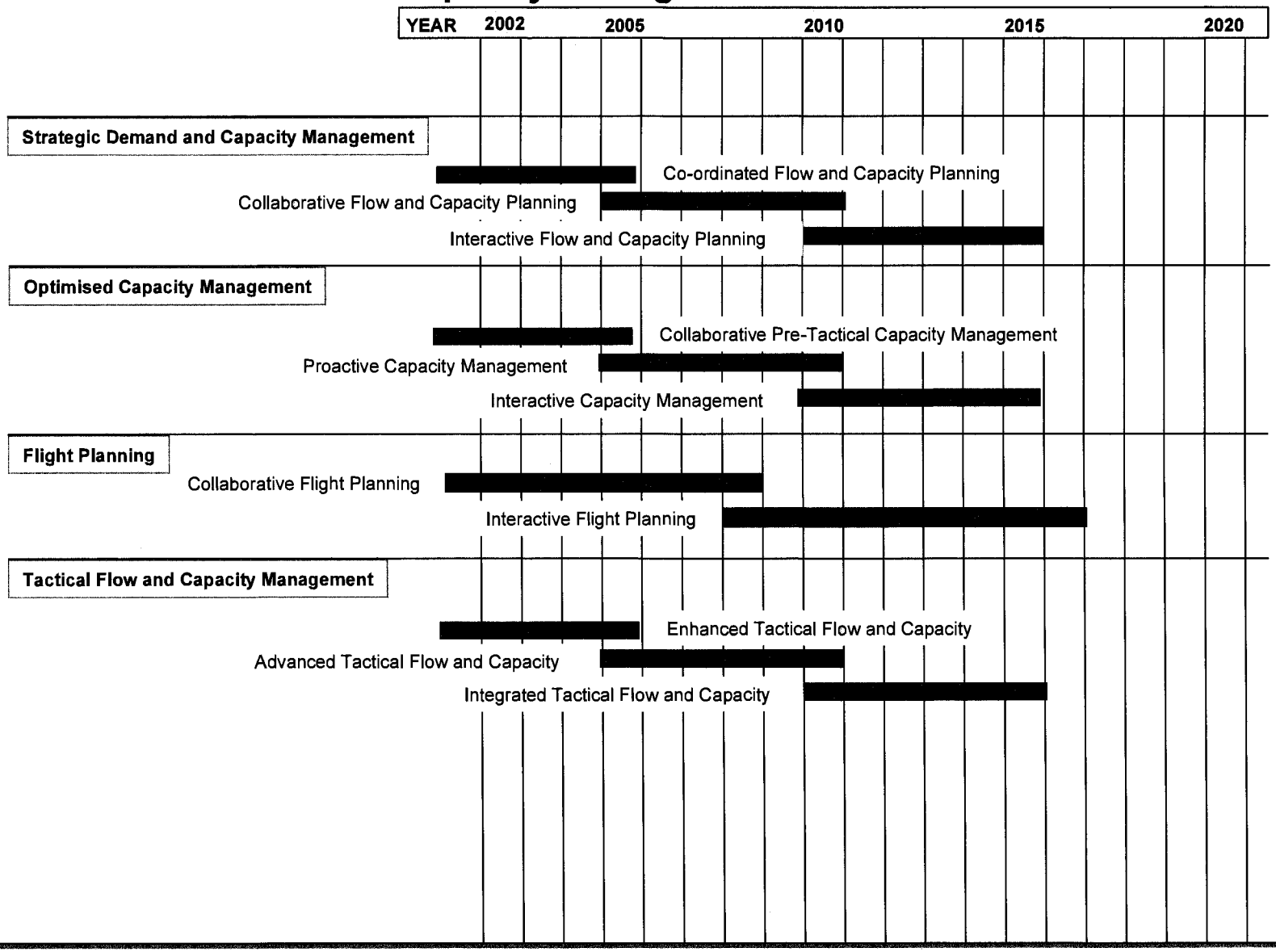
Airspace Organisation and Management



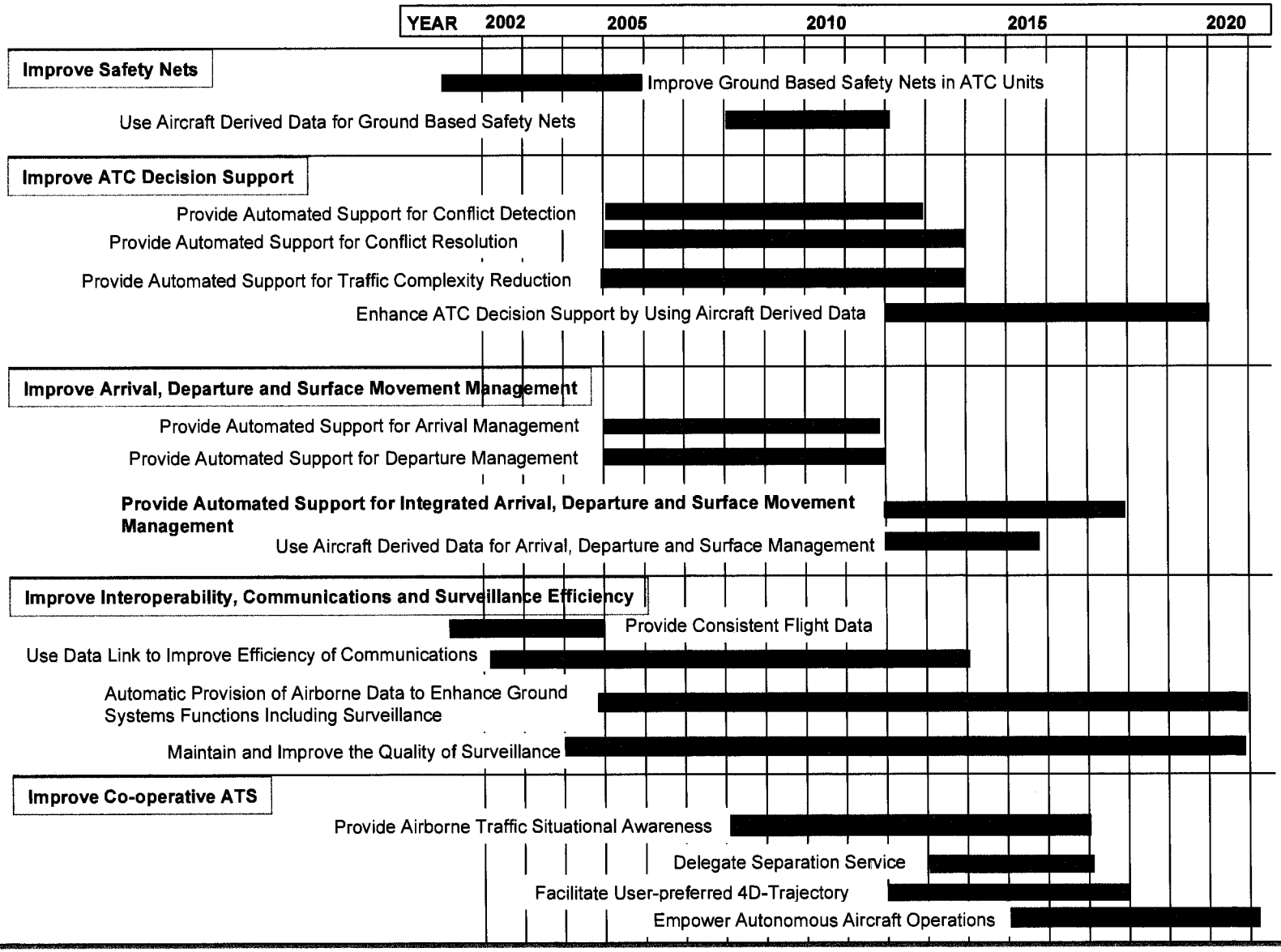
Airport ATC


YEAR
2002
2005
2010
2015
2020
Improved Traffic Management on the Movement Area
Improvement of Aerodrome Control Service on the Movement Area
Improvement of Conflict Detection and Alert for the Movement Area
Improvement of Planning and Routing on the Movement Area
Improvement of Guidance and Control on the Manoeuvring Area
Airport Capacity Management
Integration of Airport Scheduling with Flow and Capacity Management
Enhancement of Airport Operations through Information Exchange between ATC, ATFM, Airport Operators and Aircraft Operators
Airport Collaborative Information Exchange Including Gate Management
Optimisation of Airport Operations in All Weather Conditions
Enhancement of Airport Throughput
Enhancement of Airport Operations through Arrival Management
Enhancement of Airport Operations through Departure Management
Enhancement of Airport Operations through Fully Integrated Arrival, Departure and Surface Traffic Management
Further Enhancement of Aerodrome Operations from Gate to Gate
Airport Airside Capacity Enhancement
Enhancement of Movement Area Utilisation
Optimisation of Arrivals and Departures Based on Wake Vortex Detection
Environmental Protection at Airports
Minimisation of Noise and Gaseous Emissions
Harmonisation of Environmental Standards and Support For Compliance with Environmental Regulations
Support for Efficient Management of use of Available Environmental Noise Capacity
Airport Horizontal Initiatives
Implementation of Best Practices and Refined Procedures

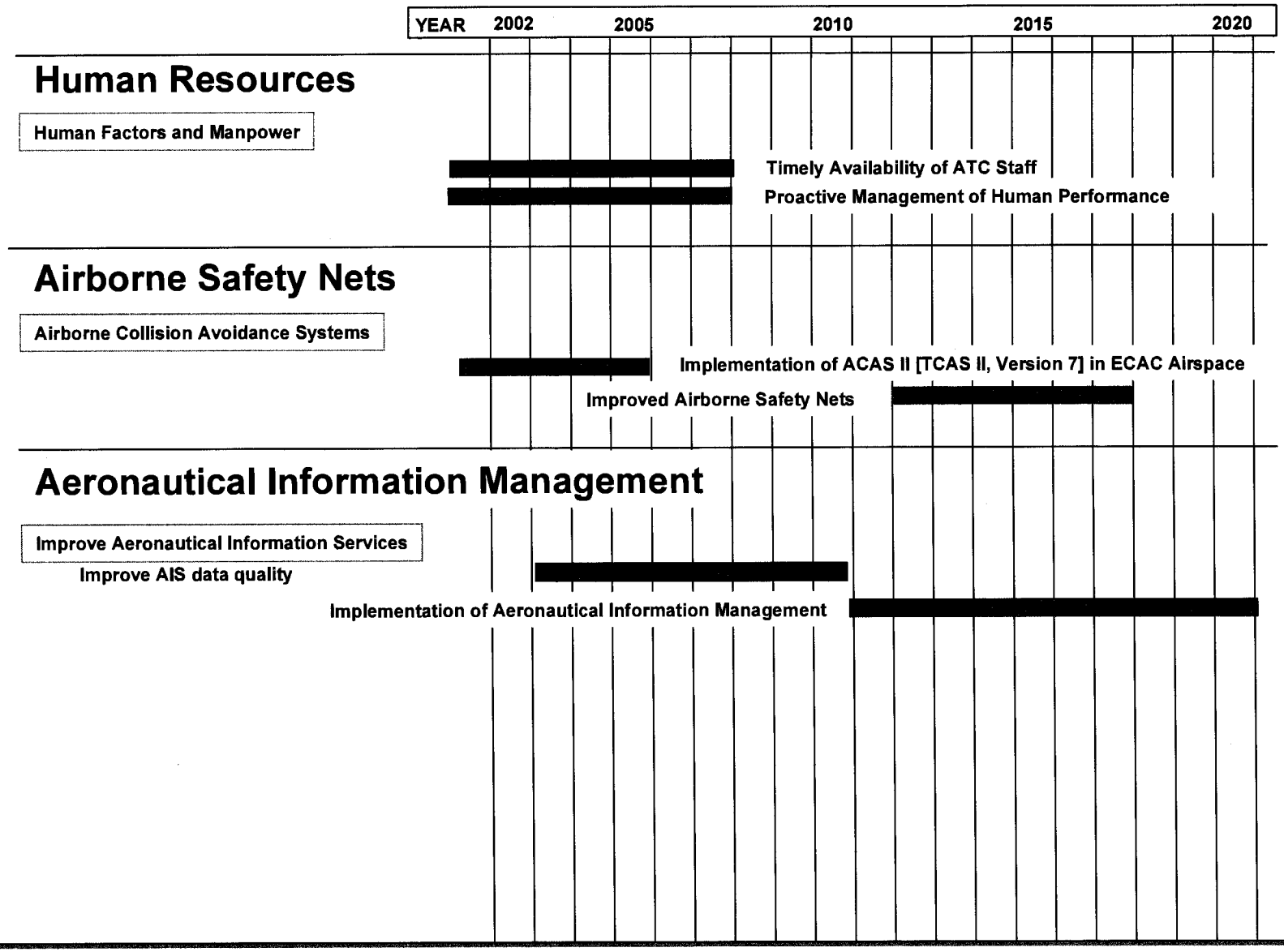
Air Traffic Flow and Capacity Management

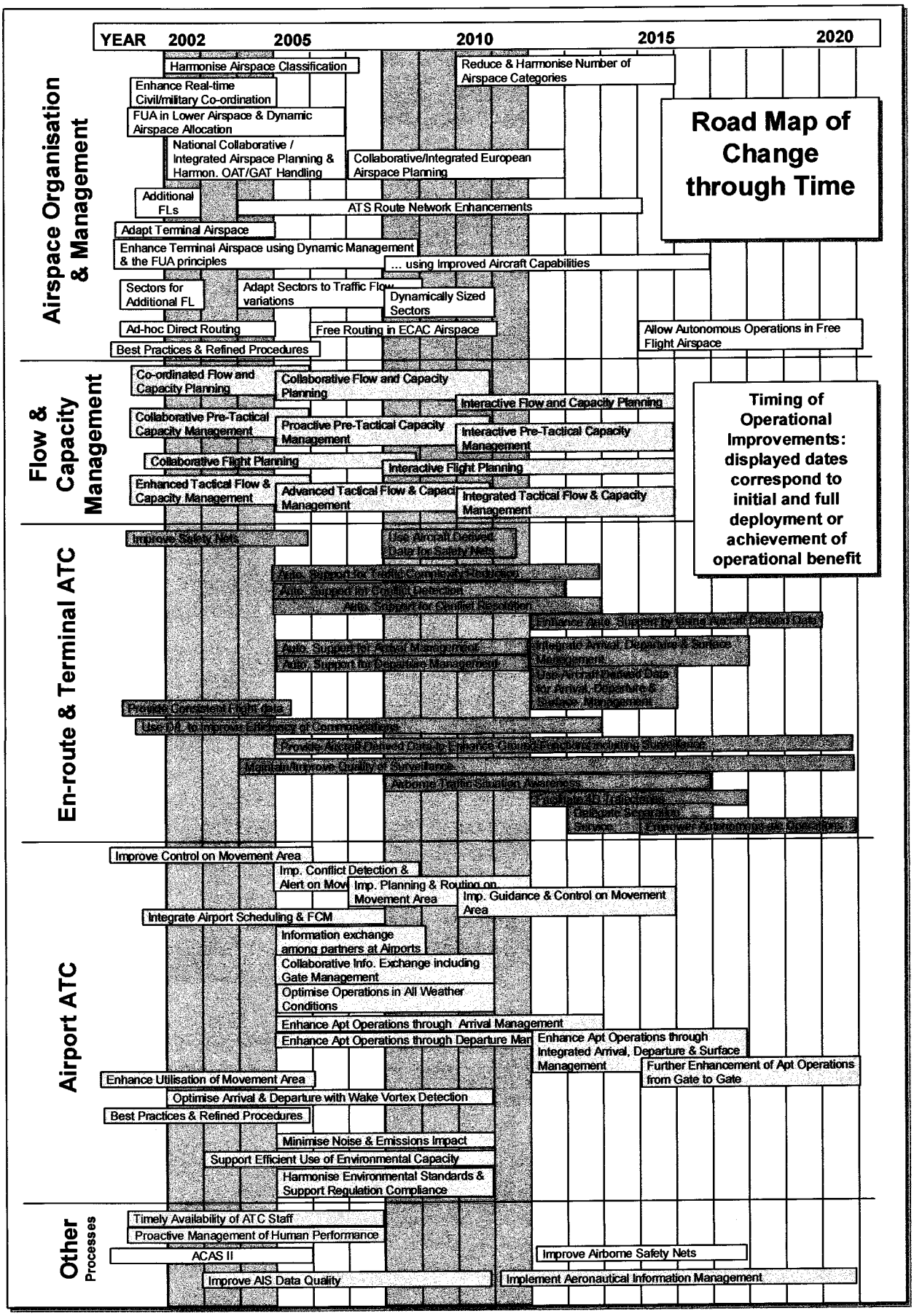


En-route and Terminal ATC



Other Processes




Road Map of Change through Time
YEAR 2002 2005 2010 2015 2020
Airspace Organisation & Management
Harmonise Airspace Classification
Reduce & Harmonise Number of Airspace Categories
Enhance Real-time Civil/military Co-ordination
FUA in Lower Airspace & Dynamic Airspace Allocation
National Collaborative / Integrated Airspace Planning & Harmon. OAT/GAT Handling
Collaborative/Integrated European Airspace Planning
Additional FLs
ATS Route Network Enhancements
Adapt Terminal Airspace
Enhance Terminal Airspace using Dynamic Management & the FUA principles
... using Improved Aircraft Capabilities
Sectors for Additional FL
Adapt Sectors to Traffic Flow variations
Dynamically Sized Sectors
Ad-hoc Direct Routing
Free Routing in ECAC Airspace
Allow Autonomous Operations in Free Flight Airspace
Best Practices & Refined Procedures
Flow & Capacity Management
Co-ordinated Flow and Capacity Planning
Collaborative Flow and Capacity Planning
Interactive Flow and Capacity Planning
Collaborative Pre-Tactical Capacity Management
Proactive Pre-Tactical Capacity Management
Interactive Pre-Tactical Capacity Management
Collaborative Flight Planning
Interactive Flight Planning
Enhanced Tactical Flow & Capacity Management
Advanced Tactical Flow & Capacity Management
Integrated Tactical Flow & Capacity Management
Timing of Operational Improvements: displayed dates correspond to initial and full deployment or achievement of operational benefit
En-route & Terminal ATC
Improve Safety Nets
Use Aircraft Derived Data for Safety Nets
Auto. Support for Traffic Synchronisation
Auto. Support for Conflict Detection
Auto. Support for Conflict Resolution
Enhance Auto. Support by Use of Aircraft Derived Data
Auto. Support for Arrival Management
Auto. Support for Departure Management
Integrate Arrival, Departure & Surface Management
Use Aircraft Derived Data for Arrival, Departure & Surface Management
Provide Consistent Flight Data
Use DLK to Improve Efficiency of Communications
Provide Aircraft Derived Data to Enhance Ground Surveillance
Maintain Improve Quality of Surveillance
Airborne Traffic Situation Awareness
Provide ATC Information
Delegate Separation Service
Enhance Autonomous Operations
Airport ATC
Improve Control on Movement Area
Imp. Conflict Detection & Alert on Mov
Imp. Planning & Routing on Movement Area
Imp. Guidance & Control on Movement Area
Integrate Airport Scheduling & FCM
Information exchange among partners at Airports
Collaborative Info. Exchange including Gate Management
Optimise Operations in All Weather Conditions
Enhance Apt Operations through Arrival Management
Enhance Apt Operations through Departure Man
Enhance Apt Operations through Integrated Arrival, Departure & Surface Management
Further Enhancement of Apt Operations from Gate to Gate
Enhance Utilisation of Movement Area
Optimise Arrival & Departure with Wake Vortex Detection
Best Practices & Refined Procedures
Minimise Noise & Emissions Impact
Support Efficient Use of Environmental Capacity
Harmonise Environmental Standards & Support Regulation Compliance
Other Processes
Timely Availability of ATC Staff
Proactive Management of Human Performance
ACAS II
Improve Airborne Safety Nets
Improve AIS Data Quality
Implement Aeronautical Information Management

CNS TRENDS IN ECAC

Let us consider CNS trends based on the ATM 2000+ Strategy.

CNS developments are not only driven by ATM needs, but also by the general evolution of technology. This enables the implementation of more cost-efficient infrastructures, and may also provide opportunities for ATM evolution.

CNS infrastructures need to be compliant with operational and general requirements. Operational requirements are directly derived from the supported ATM function and include safety requirements. General requirements apply to the entire infrastructure and are related to economical principles and the environment in which the CNS components are used. Important requirements include:

- the applied technology for CNS needs to be mature;
- whenever technically and economically feasible, new technology and CNS components should built on or integrate with existing CNS infrastructure;
- upgraded or new CNS infrastructures need to be scaleable in terms of performance and geographical coverage;
- CNS infrastructures involving airborne components need to be globally inter-operable.

6.1. Trends in the Field of Communications

The primary objective of the ECAC Communications Strategy will be to provide the framework for the development of a safe, efficient and cost-effective set of communications solutions which support, in a globally compatible manner and with due regard for backward compatibility, the evolution of European ATM and other identified air navigation services for the ECAC area to the year 2015. The strategy also recognizes that co-ordination will be necessary with external bodies such as EU, ICAO, FAA, and JAA etc.

The Communications Strategy Programme addresses the following communication areas:

- Data communications - supporting end-to-end connectivity (application to application) and broadcast capability for air-ground and ground-ground application purposes between ATS providers, airlines, airports and external organizations e.g. military.
- Voice communications - supporting the end-to-end and broadcast voice capability for ground-ground purposes between ATS providers, airlines, airports and external organizations.
- Pan-European Fixed Network Services (PENS) supporting the international telecommunications infrastructure and the interconnection of national infrastructures, including connections to airlines, airports and external organizations, for voice and for data. PENS scope includes network systems management, end-to-end integrity, switching and routing, multiplexing and message handling.

- System-wide: supporting the harmonized approach to systems management, directories, safety and security. Ensuring that the overall systems design for voice and data communications services meets operational requirements.
- EATMP Communication Gateway (ECG): The primary purpose of the ECG project is to provide a cost-effective implementation path for Air Traffic Service Providers (ATSPs), and other parties, who are considering migration to an Aeronautical Message Handling Systems (AMHS) or to an ATN-compliant environment. The ECG project is intended to provide ATSPs with a means of achieving commonality in European Ground Data Networks.

There are the following independent projects in the field of communications, which reflect the trends considered:

- Air – Ground segment:
  1. 8.33 kHz Channel Spacing;
  2. VDL Mode 2 Implementation;
  3. Link 2000+ (development of ATC oriented air – ground data link);
  4. VDL Mode 4 (development of VDL Mode 4 system for ADS and communications services).

- Ground – Ground segment:
  5. Flight Plan Data exchange (On Line Data Interchange network);
  6. Radar Data (All-purpose Structured EUROCONTROL Radar Information Exchange).

6.2. Trends in the Field of Navigation

The main objective of the ECAC Navigation Strategy is to provide a harmonized and integrated common framework, which will allow a cost-effective, customer-oriented evolution of the European air navigation systems during the period 2000-2015, in line with the ICAO Global Air Navigation Plan for ATM/CNS systems. The evolution of the air navigation systems is described in terms of performance, functionality and corresponding infrastructure, taking due account of the principle of global interoperability. It recognizes the users' requirements as the main driver in its development.

The main strategic streams are aimed at:

- achievement of a total RNAV environment with defined RNP values in designated airspace for all operations ECAC-wide;
- facilitating the implementation of the 'free routes' concept;
- supporting the continued operation of General Air Traffic of non-compliant State aircraft;
- implementation of 4D RNAV operations, to support the transition to a full gate-to-gate management of flight by 2015;

- judicious deployment and use of supporting ground- and space-based infrastructure for all phases of flight, ensuring the transition to Global Navigation Satellite Systems (GNSS) in the long-term, in line with ICAO recommendations;
- supporting the continued operations of aircraft with lower capabilities as long as operationally feasible and in full awareness of the impact of changes on this population.

The Road Map for Strategic Actions in the field of Navigation is presented in Fig. 6.1.

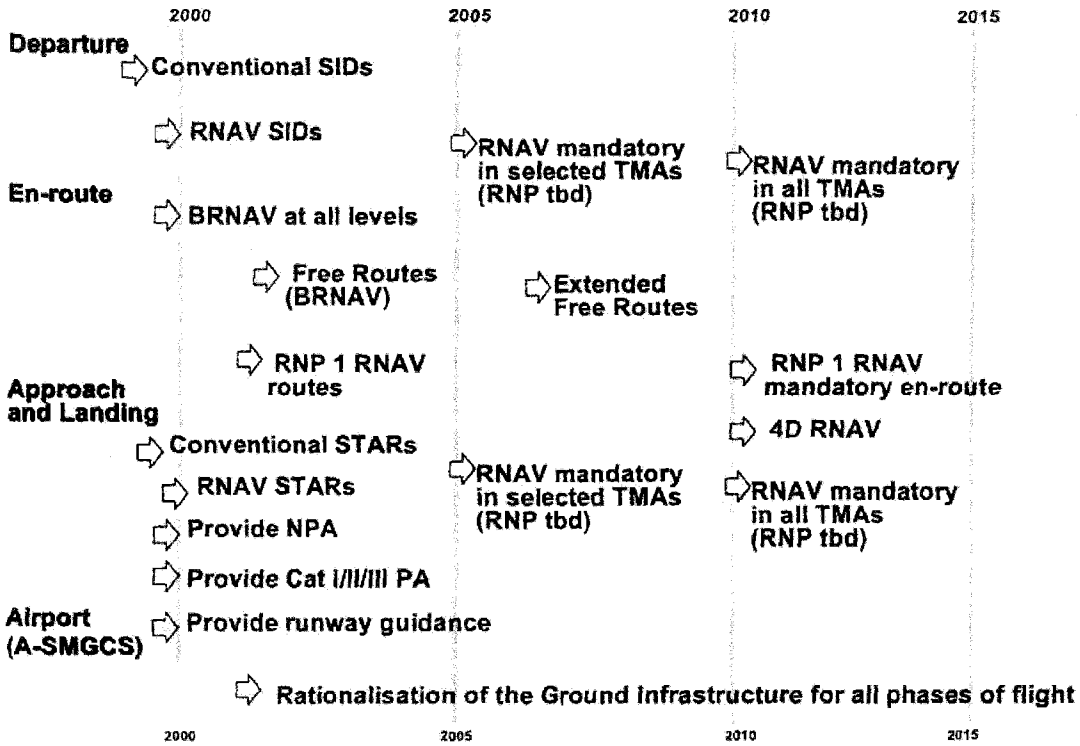


Fig. 6.1. Road Map for Strategic Actions in the field of Navigation

Advances in navigation functionality will be implemented to enable improvements in airspace design (structure, sectorisation, associated route network, applicable route spacing, separation minima and responsibilities, etc.), and allow for a high degree of flexibility for aircraft operations and for the navigational equipment used. Ultimately, all these elements, together with appropriate ATM tools, will enable operators to conduct their flights in accordance with their preferred trajectories, dynamically adjusted, in an optimum and cost-efficient manner.

The Navigation Strategy recognizes the emergence of satellite technology and its future role in the global navigation environment. However, it is expected (based on current knowledge) that the rate of technological development of the system, and the time needed for the resolution of institutional limitations, will result in the need for a ground-based back-up system for GNSS for the foreseeable future for all phases of flight. Therefore, the total number of ground navigation aids is expected to be reduced to that necessary to provide that back up.

Rationalization of navigation infrastructure (general trends) in accordance with the EUROCONTROL programs is shown on the Fig. 6.2.

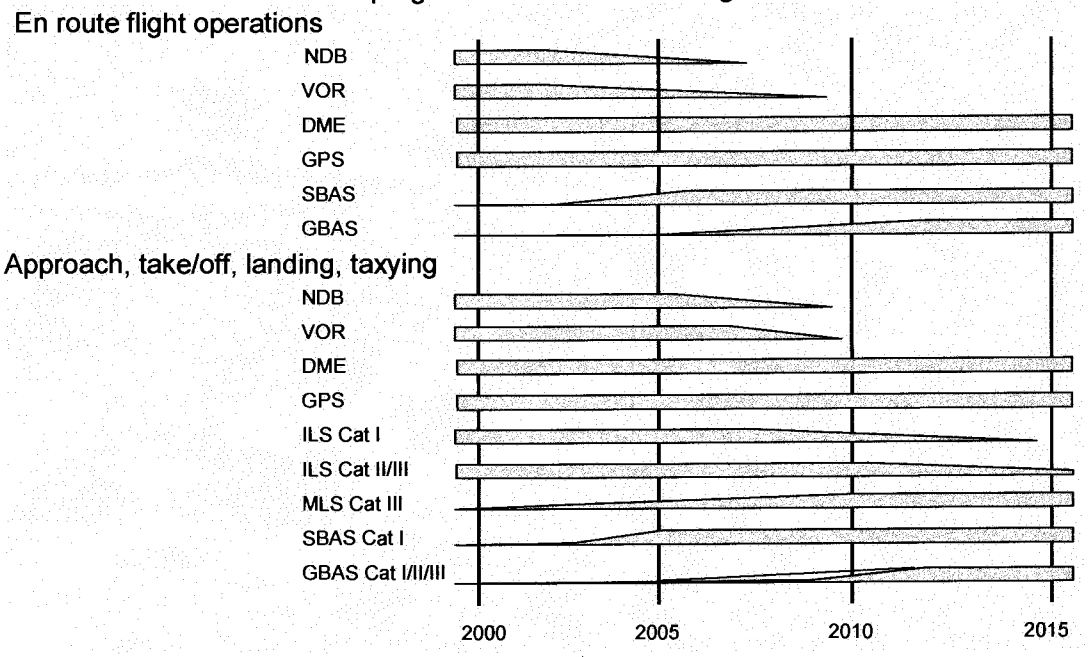


Fig. 6.2. Rationalization of the Ground Infrastructure.

Strategy of the navigation in the ECAC countries foresees that by the year 2010 VORs and NDBs will not be used for the en route flights. Strategy foresees that the national plans of the rationalization and putting the traditional equipment out of operation will be finalized not earlier than 2010 in order to support the traditional procedures at TMA for the state and non-equipped aircraft.

It is expected that in 2005 non-precision approach will be supported only by the satellite navigation systems. That will allow rejecting the procedures with the use of NDB with further complete rejection of the NDBs by the year 2010. The VORs will be used for the non-precision approach up to the year 2010.

National plans of the ground navigation infrastructure (VOR and NDB) starting with the year 2000 are formed in accordance with the "possibilities". Increase of the number of aircrafts of the RNP1 will make these plans obligatory.

It is foreseen that DMEs will stay in operation at less till year 2015 and will support the area navigation RNP 1 together with INS/IRS and GNSS. During the time period 2000-20001 area navigation RNP1 will be supported by the systems DME/DME.

It is expected that ILS Cat I will be gradually replaced by GNSS, however, ILS Cat I will not be completely put out of the operation before 2015.

It is recommended to use ILS cat II while it is cost efficient. It is supposed that ILS Cat III will stay in operation for the next 8-10 years. The main obstacles to use these systems in the future are the technical limitations. ILS Cat III will be replaced by MLS and ground augmentation elements of GNSS.

6.3. Trends in the Field of Surveillance

The Surveillance Strategy describes the evolution of surveillance infrastructure through the exploitation of the benefits of new technologies as they become available. The strategy is based on the use of various technological surveillance solutions allied to the anticipated context and performance requirements for particular geographical areas. It addresses the full scope of the gate-to-gate concept, and takes into consideration low cost solutions for general aviation and aerial work.

The objective of the Surveillance Strategy is to develop a safe, efficient and cost-effective surveillance solution for ECAC up to the year 2015. It embraces Primary Surveillance Radar, Monopulse Secondary Surveillance Radar, Mode S Secondary Surveillance Radar and Automatic Dependent Surveillance, which can be used separately or in combination.

There are two main programs in the field of surveillance: Mode S and ADS.

Other domain activities include:

- Surveillance Analysis Support System Tools (SASS-C and SASS-S);
- Centralized ARTAS (ATM surveillance Tracker And Server system);
- ASTERIX (All-Purpose Structured EUROCONTROL Surveillance Information Exchange).

7.1. Step 1 (up to 2004)

Human Resources

Associated changes to the management of human resources will comprise:

- development and introduction of methods and tools to analyze current and future tasks and the roles and responsibilities of operational staff;
- provision of strategic and tactical manpower planning data and tools to provide and maintain a sufficient number of qualified personnel;
- introduction of coordinated recruitment, selection, training and licensing procedures to provide a high ability profile of operational and technical staff;
- provision of resources and upgraded training for new human-machine interfaces and controller work positions;
- introduction of individual and team resource management practices to ensure the provision of safe, efficient and flexible operations;
- development and introduction of awareness and training programs for transitions and changes in tasks, roles and responsibilities of operational staff.

Ground Infrastructure

Associated enabling changes to the ground infrastructure will include:

- ATM Systems
  7. implementation of the Enhanced Tactical Flow Management System (ETFMS);
  8. upgraded human-machine interfaces and controller work positions;
  9. improved surface management systems and procedures at major airports;
  10. initial introduction of CDM applications.

- Communications
  11. introduction of ATN data communications infrastructure;
  12. introduction of mobile data communications at major airports to support departure clearances and ATIS;
  13. upgrading of the ground communication environment to create a more cost-effective infrastructure;
  14. expansion of 8.33 kHz spacing to create more RT channels.

- Navigation
  15. full exploitation of RVSM;
  16. increasing exploitation of satellite navigation.

- Surveillance
  17. introduction of Mode S Elementary surveillance in the Core Area.

Avionics

The accompanying avionics requirements, most of them already installed, and not necessarily for all users and all airspace, will be:

- Communication
  18. 8.33 KHz above FL245 has been mandated for implementation in 2002;
  19. VDL Mode2 has been nominated as an optional replacement for ACARS.

- Navigation
  20. Basic RNAV has been mandated since1998;
  21. Precision RNAV no ECAC wide mandate but being implemented in some ECAC States;
  22. RVSM above FL280 mandated and implemented in 2002.

- Surveillance
  23. ACAS II version 7.0 mandated since 2000;
  24. Mode S Elementary mandated from 2003.

7.2. Step 2 (2004 to 2007)

Human Resources

Associated changes to the management of human resources will expand the work done in the first period to achieve the human resources operational improvements proposed, thus creating by 2007 a sound nominal environment, where state-of-the-art methods and practices are in place and where the ATC controller shortage issue is solved.

Ground Infrastructure

Associated enabling changes to the ground infrastructure will include:

- ATM Systems
  25. FDPS upgrades to support advanced data processing and flexible route operations;
  26. initial deployment of conflict detection/resolution tools;
  27. progressive deployment of arrivals and departure management tools at major airports;
  28. provision of real-time data to facilitate civil/military collaborative use of airspace;
  29. ground-ground communications in support of proactive capacity management.

- Communications
  30. data link (improve communication efficiency) but with a limited capacity contribution due to the limited number of equipped a/c.

- Navigation
  31. enhanced guidance system for improvement of conflict detection and alert on the movement area.

- Surveillance
  32. full deployment of Mode S elementary Surveillance in core area
  33. first implementation of ADS-B;
  34. basic surveillance data acquisition of surface traffic.

Avionics

The accompanying avionics requirements will be similar to that of the first step, with a further deployment of data communication capabilities. The period will also see the initial introduction, on a voluntary basis, of ADS-B, SBAS/GBAS and wake vortex detection, to facilitate the acquisition of operational experience in selected sectors/airports and anticipate their wider use in the subsequent periods.

7.3. Step 3 (2008 to 2011)

Human Resources

The management of human resources will benefit from the achievement of the preceding periods in terms of staff numbers and quality, and proactive management of human performance. Regarding Human resources issues, the vigilant awareness of the ATM professionals and the daily use of methods and tools in place will facilitate the timely and adequate resolution of issues, and will simply need to be maintained at the state-of-the-art.

Ground Infrastructure

Associated enabling changes to the ground infrastructure will comprise:

- ATM Systems
  35. Implementation of a common, open architecture;
  36. Modular FDPS able to accommodate the assistance tools and the exchanges of data, compliant to interoperability requirements.

- Communications
  37. Infrastructure to support data communications and enhanced surveillance.

- Navigation
  38. Optimization of the ground navaids to take account of the existence of GNSS as prime means of navigation.

- Surveillance
  39. Means to implement Enhanced surveillance.

Avionics

The accompanying avionics requirements will support the required evolution of the ATM functions, but represent the beginning of a significant generation change in a number of areas. This third step will exploit the new required avionics and provide advantages to those equipped, but the full return will come in the following 4th period.

- Communication
  40. 8.33 KHz below FL245 - date for possible extension to below FL245 has yet to be determined but it is likely to be during this period;
  41. VDL mode2;
  42. Other communications modes and broad-band data link according to decisions made during 1st step.

- Navigation
  43. GNSS: from 2008 for GNSS is expected to be usable as prime means of navigation (but not sole means);
  44. RNP RNAV: mandate to be issued in 2003 for implementation in 2010.

- Surveillance
  45. ADS-B - optional according to operational requirements to be made.

7.4. Step 4 (2012 to 2020)

Human Resources

The management of human resources will benefit from the application of the principles and methods in place since the preceding periods and updated as necessary.

Ground Infrastructure

Associated enabling changes to the ground infrastructure will include:

- ATM Systems
  46. information structures compliant to the SWIM philosophy and interoperability requirements;
  47. Open, modular and interoperable FDPS.

- Communications
  48. High speed fixed and mobile links supporting the implementation of SWIM and providing the quality of service required for the most sophisticated applications.

- Navigation

- Surveillance
  49. Airborne Traffic Situational Awareness.

Avionics

The accompanying avionics requirements, will be:

- Communication
  50. Broad-band - possible mandate.

- Navigation
  51. 4D FMS - optional and unlikely to be mandated.

- Surveillance
  52. ADS-B.

7.5. Local Convergence and Implementation Plans

The Local CIP identifies the detailed plans and actions that the National ATM Stakeholders plan to undertake to achieve the General objectives of the ECIP within the framework of EATMP. LCIP constitutes the medium-term plan (2003-2007) for realizing the implementation objectives and the applicable performance targets in the ECIP in line with ATM Strategy 2000+.

Some objectives are on going or completed but some of them are planned for the future. So, we selected some objectives corresponding to ICAO CNS/ATM Concept from the Local CIPs.

The ATM objectives for Poland identified below are grouped according to their scope: Pan-European (PE), Multi-National (MN) and Harmonization (HO).

Area	Title of the Objectives	Level	LV	LT	EE	PL	SE
FCM	Implement enhanced Traffic Flow Management Services	PE	+/?	+	+	+	+
FCM	Implement Collaborative Flight Planning	PE	+/?	+	+/?	?	+
INF	Implement the European AIS database	HO	+	+/?	+/?	+	+
HUM	Implement the full integration of human factors into the lifecycle of ATM systems	HO	+/?	?	-	?	?
NAV	Assure SBAS navigation service for aviation needs	PE	-	?	-	+	?
NAV	Assure GBAS Cat I based precision approach.	HO	+	-	-	?	?
NAV	Implement approach procedures using RNAV with vertical guidance	HO	-	-	+/?	+	+
NAV	Implementation of P-RNAV an interim towards RNP RNAV	HO	-	-	+/?	+	+
AOM	Implement Collaborative civil-military airspace planning at National level	HO	++	?	+/?	?	?
ATC	Implement ATC air-ground data link services	HO	-	?	+/?	+	+

AOM - Airspace Management;
ATC - Air Traffic Control;
FCM - Flow and Capacity Management
HUM - Human Resources;
NAV - Navigation
SUR - surveillance
MIS - Miscellaneous.
INF - Information Management
\- - no planned
? - no information
\+ - planned
+/? - no Final Plan

++ - completed

New objectives, which were proposed, but not included into national CIPs at present, might be considered as causing an interest.

Area	Title	Level	Start	Finish
NAV	Rationalization of navigation infrastructure	PE	O6/2004	10/2010
NAV	Implementation of RNP-RNAV	PE	01/2001	03/2010
INF	Implement Integrated Briefing	HO	07/2002	12/2004

ICAO APPROACH TO CNS/ATM IMPLEMENTATION/TRANSITION

8.1. ICAO Approach to ATM Implementation/Transition

Current approach to the definition of the trends in ATM (in the framework of ICAO CNS/ATM Concept) is based on various existing plans released by international organizations in which Poland is the member.

The definition of ATM requirements and goals is considered as one of the major planning steps (in accordance with ICAO Global Plan). At bottom the goals and the objectives may be considered as the trends as they provide the direction for the changes in general.

More specific trends in ATM context are contained in the document "ICAO European Region Transition Plan to CNS/ATM" *(Released Version V1.0, January 2002).* The following Goals for the future ATM system in EUR Region are summarized as follows:

- maintain or increase the existing level of safety;
- increased system capacity and full utilization of capacity resources as required to meet traffic demand;
- dynamic accommodation of user-preferred three-dimensional and four-dimensional flight trajectories;
- accommodation of full range aircraft types and airborne capabilities;
- improve provision of information to the users such as weather conditions, traffic situation, availability of facilities;
- improve navigation and landing capabilities to support advanced approach and departure procedures;
- increase user involvement in ATM decision-making including air-ground computer dialogue for flight negotiation;
- creation, to the maximum extent possible, of a single continuum of airspace, where boundaries are transparent to users;
- organization of airspace in accordance with ATM provision and procedures;
- minimization of airborne delays and holding, coupled with adjustment of flight track schedules to achieve efficient traffic flows as well as efficient airspace and airport usage;
- integrate MET and AIS to the future ATM system, in order to improve the efficiency of the ATM and to provide real-time information to the users;
- improve ATS strategic planning to minimize future aircraft conflict and tactical conflict-resolution maneuvering by the ATS system.

Directions of change in ATM in the European Region are following:

- improved handling and transfer of information between operators, aircraft, and ATS units;
- extended surveillance by using aircraft positions derived from airborne systems (i.e. automatic dependent surveillance);
- advanced ground-based data processing systems, allowing for:

- the ability to take advantage of the navigation accuracy, in four dimensions, of modern aircraft;
- improved accommodation of user-preferred flight profiles in all phases of flight, based on the operator's objectives; and
- improvement in conflict detection and resolution, automated generation and transition of conflict-free clearances and rapid adaptation to changing traffic conditions.

8.2. ICAO Approach to CNS Implementation/Transition

To understand the ICAO view on CNS implementation/transition in the European region, let us consider the following consecution: ICAO characterization of the current status in respective domain, ICAO attention to the on-going projects in the respective domain and ICAO view on the relationship between ATM and CNS elements along with the benefit. The last item will show technologies/applications ICAO considers potentially suitable.

All data presented below relate to "ICAO European Region Transition Plan to CNS/ATM" *(Released Version V1.0, January 2002).*

Communications

The European Region is characterized by the use of:

- very high frequency (VHF) for voice and data communication in many continental and terminal areas; a shortage in the number of available VHF frequencies imposed the implementation 8.33 kHz channel spacing;
- AMSS for data and voice communication in some parts of the region;
- SSR Mode S data link, in the near future, in some high density airspace;
- ATN for the interchange of digital data over dissimilar ground-to-ground and air-ground communication links between end systems in the future.

On-going projects:

Project	Organization
ODIAC - Operational Requirements for ATM Air / Ground Data Communication Services	EUROCONTROL
Link 2000+ - Implementation of Operational Air-Ground Data Link Services in Europe (VDL Mode 2 and ATN)	EUROCONTROL
ASTERIX - All Purpose Structured EUROCONTROL Radar Information Exchange	EUROCONTROL
8.33 kHz - 8.33 kHz Channel Spacing	ICAO EUR/NAT + EUROCONTROL
PETAL II - Preliminary EUROCONTROL test of Air/Ground Data Link	EUROCONTROL
WACS – Wireless Airport Communication System	EUROCONTROL
MODE – S	EUROCONTROL

Navigation

The European Region is characterized by the:

- Progressive expansion of area navigation (RNAV) in conjunction with the ICAO Required Navigation Performance (RNP) Standards; B-RNAV (RNP5) was introduced starting with January 1998 in the entire ATS Route Network in the ECAC area;
- In addition to RNAV and inertial navigation system (INS), the use of global navigation satellite system(s) (GNSS) for navigation;
- World Geodetic System-1984 (WGS-84) is implemented in large areas of EUR Region; implementation in the whole area is on-going;
- Instrument landing systems (ILS) and limited number of Microwave landing systems (MLS) are used for approach and landing in accordance with the ICAO strategy;
- Current navigation aids (NDB and VOR) will be progressively withdrawn. DME is expected to remain in service for a longer time in order to support RNAV operations.

On-going projects:

Project	Organization
WGS-84 - World Geodetic System 1984	ICAO EUR/NAT + EUROCONTROL
B-RNAV - Basic RNAV	ICAO EUR/NAT + EUROCONTROL
P-RNAV - Precision RNAV	ICAO EUR/NAT + EUROCONTROL
EGNOS - European Geostationary Navigation Overlay Service	EU + others
GALILEO - European GNSS System	EU + others

Surveillance

The European Region is characterized by the use of:

- SSR Mode A, C and, in the near further, Mode S in some terminal and high-density continental airspace;
- ADS in some parts of the Region;
- the diminishing use of primary radar outside of terminal areas.

On-going projects:

Project	Organization
ARTAS - ATM Surveillance Tracker and Server System	EUROCONTROL
MODE-S	ICAO EUR/NAT + EUROCONTROL

ADS – Automatic Dependent Surveillance	EUROCONTROL
ADS-B - Automatic Dependent Surveillance Broadcast	Russian Federation

ICAO Scenarios

ICAO notes that the contents of the tables (Tables 8.1 and 8.2 below) are by no means all encompassing nor are they considered to be absolute requirements. These are no more than scenarios reflecting typical airspace and traffic level combinations and possibilities.

The tables presented below relate to the continental airspace with low-density traffic and terminal areas with low-density traffic. These parameters correspond to the FIRs in the area of interest.

Table 8-1. ATM • Oceanic / continental airspace with low-density traffic

Functions	Technical elements		Procedural aspects		ATM benefits
	Ground	Air	Structure	Procedures	
COM • AMSS voice and data • HF voice and data	• ATN connectivity to AMSS, HF • ATN end-systems (HMD • Voice AMSS, HF	• ATN connectivity to AMSS and HF avionics • Voice AMSS, HF	• RCP*	• Procedures for use of voice and data • Data link handling procedures • Message format	• Improved tactical control • Improved pilot/controller communications • Facilitate ATC/FMS dialogue
NAV • INS/IRS • GNSS	NIL	• INS/IRS • GNSS Receiver • FMS	• RNP • Airspace organization • RNP certification/ approval	• Navigation procedures	• Improved airspace utilization
SUR • ADS • ADS-B*	• ATN connectivity to AMSS and HF • Situation display for ADS and ADS-B*	• ATN connectivity with ADS and ADS-B* function and situation display • ADS, ADS-B* avionics	• Airspace organization • RSP*	• Surveillance procedures • Message format	• Reduction of R/T workload • Improved situational awareness*
AUTOMATION • Decision support systems	• Automated flight data processing • Conflict alert advisory prediction-resolution software	• FMS	• Airspace organization	• Automation procedures and algorithm development • Message format	• Increase in direct routings • Improved conflict prediction and resolution

Table 8-2. ATM • Terminal areas with low-density traffic

Functions	Technical elements		Procedural aspects		ATM benefits
	Ground	Air	Structure	Procedures	
COM • VHF voice and data	• ATN connectivity for VHF • ATN end-systems • Voice VHF	• ATN connectivity to VHF avionics • Voice VHF	• RCP*	• Procedures for voice of voice and data • Data link procedures • Message format	• Improved pilot/controller communications • Facilitate ATC/FMS dialogue • Complement VHF coverage
NAV • INS/IRS • GNSS	• Augmentation systems	• INS/IRS • GNSS receiver • FMS	• RNP certification approval	• Approach procedures	• Improved airspace utilization
SUR • ADS • ADS-B* • SSR	• ATN connectivity for VHF • Situation display for ADS and ADS-B*	• ATN connectivity with ADS and ADS-B* function and situation display • ADS, ADS-B' avionics	• RSP*	• Surveillance procedures	• Improved airspace utilization • Improved situational awareness* • Reduced need for PSR
AUTOMATION • Decision support systems	• Situation display • Automated flight data processing	• FMS		• Automation procedures and algorithm development • Message format	• Increase in user-preferred flight profiles • Improved traffic planning • Improved conflict prediction and resolution

CNS/ATM TRENDS IN RUSSIA

To evaluate CNS/ATM trends/developments in Russia the following documents were used:

1. Concept of Modernization and Development of United ATM System of the Russian Federation (approved by the Government of Russian Federation at 22/02/2000).
2. Federal Special Purpose Program "Modernization of the Transport System of Russia", Sub-program "United ATM System" (approved by the Government of Russian Federation at 05/12/2001).
3. Report of Mr. E. Falkov "Surveillance on a Grand Scale – Russia (first steps)". ADS Forum 25th –26th October 2001, Amsterdam.
4. The Concept (Project) of Russia ATM Technical modernization for the period till 2015 on the ICAO CNS/ATM Concept basis.

Two first and fourth documents are available in Russian only (source: www.gsga.ru). Further we will pay attention on plans of Russia in terms of future air navigation systems only (ICAO CNS/ATM Concept).

The Concept of Modernization declares as a long-term prospective implementation of ICAO CNS/ATM Concept. It is declared, that development of Russian ATM system should take into account development of European ATM system as well as ICAO strategic requirements for the European Region.

The Sub-program "United ATM System" consists of separate projects. Most of them are scheduled from 2003 up to 2015 (2019). The projects give ideas on the trends in Russia.

The Concept of Modernization declares scheduled CNS/ATM Plan.

Project #1
Modernization of Technical Provision of Current and Newly Opened International and Domestic Air Routes.

The Project intends a huge development of conventional ground based infrastructure. After 2005 the Project intends implementation of ADS and transition from procedural ATC to ADS based methods. Area of applicability: Oceanic, North and Far East regions of Russia.

Project #4
Implementation of Prospective ATM Applications on the basis of ADS.

This is one of the most ambitious projects. Goal of the Project is to provide ATC in the regions where utilization of conventional CNS technologies is impossible or unprofitable. The Project intends implementation of contract and broadcast versions of ADS. It is planned to use ADS-C for oceanic or remote regions (North and Far East of Russia). ADS-B will be used for the Trans-Siberian and Trans-Polar Routes. ATN is mentioned as a ground foundation for the ADS and VDL Mode 4 as a basis ADS-B.

ADS-B part consists of three stages:

- Phase 0 (2001 – 2002). Installation of five VDL Mode 4 ground stations in five airports in Tumen region (Siberia). Two airlines "Gasprom Avia" and "Yamal" equip their aircraft by VDL Mode 4 transponders. Field trials of the technology and applications.

- Phase 1 (2003 – 2005). Installation of 81 VDL Mode 4 ground stations to cover a continental part of Russian airspace. 30% of Russian aircraft will be equipped by VDL Mode 4 transponders. Operational use of ADS-B as a mean of surveillance.

- Phase 2 (2006 - 2010). Installation of 33 additional VDL Mode 4 ground stations. All Russian aircraft are equipped by VDL Mode 4 transponders. It is planned to restrict flying in some parts of the Russian airspace for aircraft, which are not equipped by ADS-B avionics. Application of VDL Mode 4 technology for ATIS-B, METAR-B, CPDLC.

The Project intends to provide Cat I precision approach for all major Russian airports on the basis of ADS-B technology and GNSS receiver onboard.

Project #5
Deployment of Ground Segment of Global CNS Systems for ATC on the Basis of Space Technology, Prospective Communications and Data Link Systems.

The Project intends:

- Joint utilization of GPS and GLONASS;
- Creation of Russian aviation fixed satellite communication service;
- Connection to the INMARSAT.

Project #10
Implementation of ICAO Programs for Russian ATM.

The Project intends harmonization of Russian ATM System with international ATM systems. The Project has two stages:

- Stage 1 (2002 – 2005)
  53. Creation of a Ground Collision/Proximity Warning System;
  54. Implementation of RVSM;
  55. Implementation of RNP;
  56. Implementation of Area Navigation;
  57. Implementation of ADS.

- Stage 2 (after 2005)
  58. Implementation of SSR Mode S;
  59. Implementation of 8.33 kHz frequency spacing.

CNS/ATM TRENDS IN BELARUS

Unfortunately, there are no available documents concerning CNS/ATM plans for Belarus. Belarus ANS provider "Belaeronavigatsia" has modernized VHF radios and radars recently. The new automated ATC system (ARSRIRE-Navigator, St. Petersburg) is established in 2003. Replacement and installation new navaids (VOR/DME) will be carried out in 2004-2005.

It is known that Belarus specialists were going to consider OLDI for interaction with neighboring countries. They considered development of special software to supplement current automated ATC system for interaction with neighboring countries. There are negotiations concerning OLDI connections with Kiev and Riga ACCs.

It is known also, that they considered implementation of satellite navigation on the basis of GLONASS and GPS and possible installation of GBAS in the future.

CNS/ATM TRENDS IN UKRAINE

An important landmark in the development of the air navigation system of Ukraine was Ukraine joining ECAC in 1999 and accepting its Constitution, together with the signing in December 2001 of the Cyprus Arrangements and the Protocol consolidating the EUROCONTROL International Convention relating to Co-operation for the Safety of Air Navigation with all the amendments which was signed on 13 December 1960. Additional obligations assumed vis-a-vis regional international organizations (ECAC, JAA, EUROCONTROL) also stimulated the transition to managing the airspace of Ukraine in accordance with ICAO Standards.
Ukraine is taking measures as part of the joint project of European States regarding implementation of the European Geostationary navigation service (EGNOS). Standard instrument departure (SID) and standard instrument arrival (STAR) procedures started to be implemented at the airports of Ukraine in 2001 using the modern software that it used for the design of similar procedures in the United Kingdom and Germany.

The functionality of the automated air traffic control systems of Ukraine, installed in all air traffic services area centers, meets the requirements of EUROCONTROL for systems with the functions of an advanced automated ATC system. ICAO cruising levels started to be used in the airspace of Ukraine in 2001, as was the reduced vertical separation minimum (RVSM).
In close cooperation with EUROCONTROL, a modern satellite voice communications system (VSAT) was developed for the interaction of the ATS control services of Ukraine, Turkey, Romania and Bulgaria. The requirements for the traffic service personnel of Ukraine were brought into line with the EUROCONTROL requirements. Ukraine started this year the phased introduction at the airports of Ukraine of pre-flight information services for aircraft crews, on the basis of the corresponding ICAO Standards and EUROCONTROL recommendations.

With respect to areas for further development, it should be noted that at the end of 2002, within the framework of the integrated civil/military air traffic management system, the Program for the development of the State system for the use of the airspace of Ukraine for 2002 to 2006 was adopted at the level of the Government of Ukraine. This Program contains a large number of far-reaching measures for the development of the technical aspects of modernization, the improvement of regulatory documents, etc. One of the consequences of the implementation of the Program has been the approval this year of the Rules of the Air and Air Traffic Services in the classified airspace of Ukraine. The Rules will be put into effect in 2004 and they provide for the classification of the airspace of Ukraine in accordance with the ICAO Standards and the Rules of the Air therein have been adapted to the international Standards. The next significant stage in the modernization of the air navigation system will be the construction and fit-up of the air traffic control center in the Dnepropetrovsk regional structural subdivision of the air navigation services provider (UKSATSE) and the reconstruction of the Simferopol air traffic control center. It is planned for this project to be completed by 2005.

In June 2002 in Baku, Azerbaijan, the air navigation services providers of Azerbaijan, Georgia, Kazakhstan, the Republic of Moldova and Ukraine signed an Agreement on cooperation (hereinafter called the Agreement) and a regional group was formed for cooperation among the air navigation services providers. The air navigation services provider of Armenia acceded to the Agreement in September 2002. The Regional Air Navigation Services Development Association (RADA) was created in 2003 on the basis of the regional group. The traditionally established historical ties between countries, the need for the practical implementation of solutions to problems related to the development of air navigation in the region, the creation of favorable conditions for the further growth of the economic efficiency of airspace use and the development of the safe and efficient Europe-Caucasus-Asia transport corridor led to the understanding of the expediency of developing common regional approaches to the implementation of the communications, navigation, and surveillance/air traffic management (CNS/ATM) concept and to the development of the air navigation services market in the region.

Main projects of the Association

1. Cooperation on regional aeronautical information management (RAIM)

The main task of the RAIM project is the development of AIS in RADA countries with a view to implementing such AIM functions as:

a. introduction of common operational/technical procedures for the collection, processing, use and dissemination of high-quality digital aeronautical information;

b. harmonization of the professional training of personnel, through the application of common standards in the training and qualification of the personnel involved in the provision of regional AIM services;

c. use of automated functions in the preparation and updating of national integrated aeronautical information packages (IAIP); and

d. implementation of integrated AIS/MET/ATM briefing services at the regional level.

2. Regional plan for the implementation of CNS/ATM systems in Ukraine

The development of the Plan is being funded by the United States Trade and Development Agency (USTDA).

A Grant Agreement was signed in July 2003 with regard to undertaking the technical/economic validation of the Regional plan for the implementation of CNS/ATM systems in Ukraine, Armenia, Azerbaijan, Georgia and the Republic of Moldova.

CNS/ATM TRENDS IN LITHUANIA

Lithuania participates in Baltic's CNS/ATM Transition Project. This Project develops detailed Transition Plan & Strategy options for next generation CNS/ATM systems and services for the Baltic Region. Summary of the Lithuanian Plan are presented below.

Communication

The Baltic States jointly committed on implementing, after 2002, 8.33 kHz channel spacing above FL245 (i.e. withdrawal of exemptions for airspace users), which will contribute to easier frequency management, throughout the ECAC region and neighboring FIRs. The possible date in Lithuania could be 31 October 2003. The formal decision on the date will take into account the needs of the flights between Kaliningrad and the main land of the Russian Federation, in parallel with the process of Lithuania accession to European Union. Vilnius ACC systems will be modified to accommodate 8.33 kHz, in due time. No UHF frequency channels are planned to be available in the Vilnius UIR/FIR. No frequency conversions from 25 to 8.33 kHz channel spacing are deemed necessary in the short term.

EUROCAT 200, presently operational, does not support OLDI. Baltic ATSO Network (BAN) will provide connectivity in the region. Digital connection with Riga ACC has already been implemented. It is planned with Warsaw ACC. ACT, ABI, LAM, PAC, REV and MAC messages are planned and they will to be supported by the new Vilnius ATM system by end 2005 with Riga ACC. Their operational use with Warsaw ACC will also depend on the suitability of the Polish end systems. No operational requirement today, for implementation with Malmo/Stockholm. Automated ground-ground co-ordination with Kaliningrad (Russian Federation) and Minsk (Belarus), will depend on possible future decisions by the respective National Authorities.

Navigation

Lithuania is planning that by the year 2010 VORs and NDBs will not be used for the en route flights. And also that the national plans of the rationalization and putting the traditional equipment out of operation will be finalized not earlier than 2010 in order to support the traditional procedures at TMA for the state and non-equipped aircraft.

It is expected that in 2005 non-precision approach will be supported only by the satellite navigation systems. That will allow rejecting the procedures with the use of NDB with further complete rejection of the NDBs by the year 2010. The VORs will be used for the non-precision approach up to the year 2010.National plans of the ground navigation infrastructure (VOR and NDB) starting with the year 2000 are formed in accordance with the "possibilities". It is foreseen that DMEs will stay in operation at less till year 2015 and will support the area navigation RNP 1 together with INS/IRS and GNSS.

It is expected that ILS Cat I will be gradually replaced by GNSS, however, ILS Cat I will not be completely put out of the operation before 2015.

Surveillance

The objective of the planning in Surveillance area is to develop a safe, efficient and cost-effective surveillance solution for Lithuania up to the year 2015. It embraces Primary Surveillance Radar, Monopulse Secondary Surveillance

Radar, Mode S Secondary Surveillance Radar and Automatic Dependent Surveillance, which can be used separately or in combination.

Additionally, to implement dual Secondary Surveillance Radar (SSR) Coverage on a portion over the high seas, where the coverage is single instead of dual. The intention of ON is to solve the problem through data sharing, from Gdansk radar station. The Baltic ATSO Network (BAN) will be an enabler to this action.

ATM

Lithuania is planning to implement a new ATM system. It is expecting that the current Eurocat 200 will be in operation until the end of 2005.

The current EUROCAT 200 system performs the following functions: Short Term Conflict Alert (STCA), Area Proximity Warning (APW), Minimum Safe Altitude Warning (MSAW) for En-route and Final Approach. The modernized Vilnius ATM system will also include these functions.

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Airspace User Requirements

Overview

In accordance with the terms of reference for the Central Asia study, this task objective is to determine the Airspace User Requirements. Specifically:

> *The Contractor shall research and identify the CNS/ATM applications and service provisions appropriate for the main users of the five country's airspace, through consultation with a minimum of six airlines (one from each country as well as two international airlines).*

In accordance with the above an airspace user questionnaire was prepared and distributed via the Central Asia working group to designated airlines operating in their airspace. Of the questionnaires distributed, Tajikistan Airlines, Uzbekistan Airways, Sayakhat Air Company and Air Astana responded with information regarding their respective flight capabilities. In addition, information was obtained from KLM and Lufthansa.

Based upon the information received it was determined that a sufficient number of representative airspace user data was obtained to be able to adequately determine the airspace user requirements and satisfy the objectives of Task 6.

METHODOLOGY

The below figure illustrates the sequence of the steps followed during the Task execution. This approach allows avoiding proposals of the solutions/services, which are not required by particular Users or Users group.

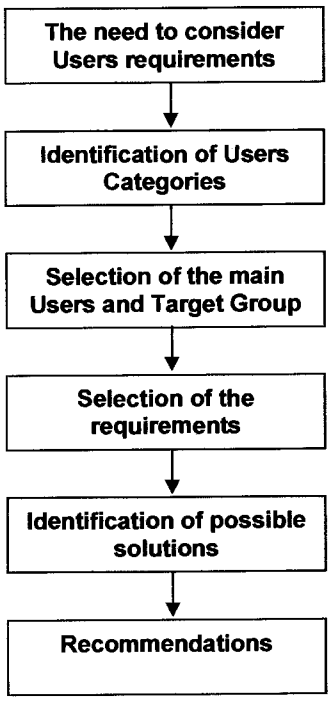


Fig. 1.1. The sequence of steps followed during the Task execution

SOURCES OF INFORMATION

The following sources of information were used to collect airspace Users requirements:

- Eurocontrol and IATA documents, containing User requirements;
- Respective Meetings and Workshop materials;
- Direct contacts with particular aircraft operators;
- Direct contacts with IATA representatives.

The Questionnaire "Determination of Airspace Users Requirements" was used to get information regarding specific needs of the airspace users operating within Central Asia airspace. This Questionnaire includes the questions regarding plans, priorities and on-board equipment. Attachment 2 provides the responses of Tajikistan Airlines, Uzbekistan Airways, Sayakhat Air Company and Air Astana to the distributed questionnaire.

GLOBAL AIR NAVIGATION PLAN FOR CNS/ATM SYSTEMS

The Global Air Navigation Plan for CNS/ATM Systems (Doc 9750-AN/963) recommends a consecution of steps and the Planning Methodology in respect of CNS/ATM. It is anticipated, that the planning process for any particular Region must begin with identification of specific homogeneous ATM areas and/or major traffic flows based on Users needs (requirements) followed by the development of an ATM plan for the Region.
The Global Plan is oriented to ATM objectives. It states, that in order to determine ATM objectives and to establish corresponding CNS facilities, the traffic forecast shall be performed and Users requirements shall be ascertained. Besides, CNS/ATM Concept foresees, that airborne segment will be included as an integral part of ATM. However, the document itself does not contain particular User requirements for CNS/ATM systems.

REGIONAL CNS/ATM PLANS

"ICAO European Region Transition Plan to CNS/ATM", (note: this plan was considered and supported by the Working Group as appropriate) does not contain airspace Users requirements (needs) for CNS/ATM systems or particular applications. However, it underlines in general, that airlines agree to incorporate new CNS/ATM systems on an evolutionary basis. The path, which airlines are taking in Global planning, follows the objective of achieving short and medium term goals, which provide improved airspace capacity and economy of operations. This path leads to the operational use of existing CNS technology on board and then, evolutionary, to the new aircraft systems compatible with CNS/ATM Global standards.
During the transition phase airlines plan to utilize existing well-developed data-link systems (ACARS) as the transitional means to enhance the development of operational ATN data-link systems in concert with the earliest implementation plans of ATC providers. This evolutionary approach is accepted as providing the airlines and ATC providers with a financially viable program for introducing new CNS/ATM systems. The requirement to take advantage of new technologies and procedures as they become available to provide benefits to airspace users as soon as possible is therefore a cornerstone of airline planning.
IATA publishes User Driven CNS/ATM Implementation Plans, which are intended to complement the ICAO Regional Planning Process.

ALGORITHM

Airspace user requirements related to ICAO CNS/ATM Concept and to the planning have been considered during this study.
In order to incorporate user requirements into the study in line with ICAO recommendations, some basic components were considered. These components are: traffic flows, main users categories, possible CNS/ATM applications etc.
Therefore the following approach was used to determine the user requirements:

- Step 1: Definition of the major traffic flows. Consideration of possible CNS/ATM Scenarios. (source: ICAO Documents, local FDP statistics)
- Step 2: Identification of Users Categories. Selection of the main Users. (source: ICAO Documents, local FDP statistics)
- Step 3: Selection of the requirements expressed by International Users Community related to ICAO CNS/ATM Concept.
- Step 4: Selection of the local Users requirements (source: direct interview and the questionnaire);
- Step 5: Grouping of the requirements depending on their category and transformation into the Operational requirements;

- Step 6: Preliminary analysis of the possibility to accommodate the Operational requirements based on Step 1 Scenarios.
  -

MAJOR TRAFFIC FLOWS IN THE CENTRAL ASIA REGION--SELECTION OF THE SCENARIOS.

The tables of Homogenous ATM areas and Major International Traffic Flows on the Global scale are listed in ICAO Doc.9750 (Chapter 4, page II-4-6). This ICAO document also recommends Scenarios (technical elements and procedural aspects) for various types of airspace. This is done in order to have a harmonized approach to the selection of CNS/ATM elements. According to this, the Central Asia region is considered as a Continental airspace with generally low-density traffic (note: AR-3 exception), which is corresponding to the local ANSP statistics (see table 1.1.below).

Table1.1. Major Traffic Flow through the airspace of Central Asia

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AR-3	Asia and Europe via north of the Himalayas	**Almaty,** Bangkok, Beijing, Guangzhou, Hanoi, Ho-Chi Minh, Hong Kong, Kathmandu, Kunming, Lanzhou, Naha, Phnom-Penh, Pyongyang, Shanghai, Shenyang, Taegu, Taipei, Tokyo, Ulaanbaatar, Urumqi, Vientiane, Wuhan, Yangon, and Russian/European FIRs	Continental high-density/ Continental low-density	Major traffic flow ASIA/EUR/MID
AR-7	Europe to Central and Southeast Asia via trans-Asian transit routes	Baltic States, Finland, **Kazakhstan,** Russian Federation, Mongolia, China	Continental low-density	Traffic flow via ATS routes linking European States with central and Southeast Asia, aligned south of ATS routes B159, A222, B200 and A310, including ATS route G3
AR-8	Europe to Middle Asia via Asian transit routes	Ukraine, **Turkmenistan, Kazakhstan,** Turkey, Armenia, Georgia, Azerbaijan, **Uzbekistan,** Russian Federation, Iran, Afghanistan	Continental low-density	Major traffic flow via ATS routes linking European States with Middle Asia, south of ATS route G3

The Scenario proposed by ICAO for low-density continental airspace is not universal and mainly generic (see Table 1.2 below), but it may be used as a basis for the current Study. It means that particular user requirements are considered in light of possible applications described in the Scenario. The following elements of CNS/ATM system were considered for Central Asia airspace:

Table 1.2. Proposed Scenario for Low-Density Continental airspace.

[illegible]	[illegible]	[illegible]	[illegible]
- AMSS (Voice and Data) - ATN - Datalink handling procedures	- GNSS (GPS) - RNP Certification and approval - RVSM - RNAV	ADS-C ADS-B	- Decision support systems - Digital MET information handling

The associated technical elements and procedural aspects necessary to realize these scenarios must take into account user capabilities both near and far term. Therefore the user requirements have been grouped accordingly to the domains, namely: the requirements for ATM, Communication, Navigation, Surveillance and planning.

In addition, there are air traffic control procedural aspects that effect overall user requirements and must be taken into consideration. For instance:

- a conventional non-ICAO metric system implemented in Kazakhstan, Kyrgyzstan, Uzbekistan and the Russian Federation;
- a conventional non-ICAO Chinese metric system implemented in China (and the Chinese RVSM system in the near future);
- the RVSM ICAO feet system implemented in Azerbaijan; and
- the conventional ICAO feet system implemented in Turkmenistan (and the ICAO RVSM feet system in the near future).

These procedural aspects create difficulties for the airspace users as well as the service providers and have a detrimental effect on determining user requirement "standards" applicable for aircraft operators. There are also safety implications one must take into consideration as a result of the above variations in airspace operations.

ICAO is aware of these problems and they are currently under investigation by the European Air Navigation Planning Group (EANPG). The Central Asia states are members of this group and a procedural resolution is currently being sought.

INTERNATIONAL OPERATORS REQUIREMENTS

The requirements, expressed by International Users Community are derived from the various Documents, Seminars and Workshop's Conclusions. These requirements are described in Attachment 2.

LOCAL OPERATORS REQUIREMENTS

The requirements of the local operators were received by direct interviews of their management staff and by questionnaires. Local Operators were informed regarding the Project goals in advance and were requested to express their requirements in line with ICAO CNS/ATM Concept. These requirements are described in Attachment 2.

AIRSPACE USERS CATEGORIES

The term "Airspace Users" refers to the aircraft Operators. Depending on the Users categorization method, the requirements may vary form Category to Category, what causes the changes in ATM objectives. The Categorization is required in order to identify, what User's Category requirements should be considered first, what possible applications may support the accommodation of the requirements and to establish Operational ATM Objectives. Therefore selection of the appropriate methodology for categorization of users has a high degree of importance. For the current Study the following basic definitions are used:

- User Category is a generic term describing the group of operators, which may be united by the mode or purpose of flight and/or specific in ATM Service provision from ANSP prospective.
- Target Group is the group of particular operators, who are considered as a main Users for more than one State and who belongs to more than one Category.

At present there are two commonly used approaches exists for users categorization: ICAO and Eurocontrol. Both approaches are universal but generic. In principle, both methods may be applicable for this Study but some modification is required in order to reflect local specifics. Below is described ICAO and Eurocontrol categorization of the Users.
ICAO method stipulates to categorize the Users as follows:

- **Commercial Aviation** (It comprises civil aircraft operators engaged in scheduled as well as unscheduled commercial air transport, i.e. passenger, mail and cargo services). This group of the Users is considered as a main as they perform about 95% of total flights.
- **General Aviation** (comprises civil aircraft operators engaged in commercial as well as non-commercial operations). The number of General Aviation flights in the Region is small percentage of the total number.
- **Military Aviation** (all those who are engaged in national security and public services and operate their aircraft in ICAO noncompliant modes). The number of military flights in the Region is small.
- **Aerial Work.** Note: The number of Aerial flights is very small and they conducted mainly in uncontrolled airspace.

Table1.3. ICAO recommended categories of Airspace users

Commercial Aviation	General Aviation	Military Aviation	Aerial Work
1. Scheduled airlines (international careers) 2. Scheduled airlines (regional careers) 3. Non-Scheduled airlines (Charters) 4. Air Taxis	1. Executive/Corporate 2. Private 3. Sporting and recreation aviation	1. OAT 2. Military A/C planned to have an access to controlled airspace 3. Military SAR	1. Surveying 2. SAR 3. Agriculture 4. Flying clubs 5. Police/customs

Assuming the above, it is clear that CNS/ATM objectives should be oriented to the Commercial aviation mainly (to the scheduled and non-scheduled international and local carriers) as they conduct about 95% of flights in the Region.
Basically this is correct in principle, but very generic as a Commercial aviation has their peculiarity from ANSP point of view (arriving/departing traffic, transit, supersonic etc), which should also be considered and specific requirements should be analyzed.

The Eurocontrol approach is to differentiate the users by their approach to ICAO rules and provisions, in particular:

- ICAO compliant flight operations (GAT -- General Air Traffic)
- ICAO non-compliant flight operations (OAT -- Operational Air Traffic)

<u>Note:</u> *All civil air traffic operates as GAT; part of the military traffic as OAT; and some military traffic as GAT.*

Such differentiation of the Users is also very generic as GAT includes a very wide spectrum of the users and does not enable a clear definition of CNS/ATM objectives.

Taking into consideration the above, it is evident that another (or adapted) Users Categorization method should be used for the current Study in order to reflect the peculiarity of the traffic environment in the Central Asia Region. This method should not contradict the ICAO approach as the current Study is based on ICAO recommendations and guidance. Therefore the ICAO method is used as a basis with minor modification to reflect the local traffic environment.

In accordance with the statistics provided by the participating States (Attachment 1), the overall traffic environment in the Central Asia Region has a transit nature. For instance, in the 2010 timeframe it is estimated that overflights will more than double local movements and includes both long and short-haul airlines. These aircraft will have differences in on-board equipment and, therefore, different levels of service may be provided to improve operations and decrease both workload and costs for the service providers (e.g. datalink, GNSS procedures, etc). It is also apparent that these aircraft primarily rely on upper airspace/en-route air traffic service.

There are number of local aircraft operators in the region that conduct local and/or short haul flights. They primarily rely on lower airspace/aerodrome facilities and services including Terminal Area service, ground service etc. Several of the Central Asia aerodromes have an international status and are also used by international airlines (long and short-haul). Therefore it appears more appropriate to divide all airspace users into two main Categories (Transit and Arriving traffic), which reflects the actual traffic environment.

The information and data obtained from the representative airspace user groups (Attachment 2) indicate that, for the most part, the TRANSIT traffic are capable of supporting area navigation/required navigation performance operations and have a data link capability.

The data provided for the ARRIVING aircraft category indicate that the capability of supporting area navigation/required navigation performance operations is less than that of the TRANSIT traffic and the same is true with data link availability. However, they have identified operational issues (i.e. choke points) and recognize the opportunities and subsequent benefits of next generation CNS/ATM equipment, systems and services.

SUMMARY

The DORS team examined, evaluated and analyzed the current and projected user requirements (ARRIVING and TRANSIT aircraft) within the Central Asia region. Based on this analysis, it was determined that the following should be considered as key for the planning and development of future CNS/ATM equipment and systems.

Airspace/Procedures

Restructure airspace procedures to improve transition and handoff processes between adjoining FIRs/sectors in order to avoid airspace user delays and conflicts such as flight level/altitude variations and the reduction of designated "choke points" etc. Specific user requirements/issues "choke points" include:

- Zuren-FN-Pinax
- Zuren-Sx-PR-Rapat
- Zenal-JD-Pinax
- Zenal-JD-Raman
- Mirzo-Ivnar-Egpan
- Mirzo-Topaz-Firuz
- Prona-JD-Pinax
- Prona-JD-PR
- Prona-Ivnar-Topaz
- Pinax-PR-Zulat
- Butra-SX-JD-Topaz

In addition, the following choke points and dog legs were identified as problematic:

Choke Points: CV, TMD, DODUR, SW, PF, UTSB, TRZ, UBENA, DAKLI, TUKRI, OGRIP.

Dog Legs: UA G3 DODUR A121 SMK (UAII), UA G3 DODUR A119 ARSUL, PF W75 BIGSO B116 DS.

Communications

The user's communications requirements include VHF (Very High Frequency) voice and data; however, they believe the continued development of various data link technologies will proliferate the VHF communication spectrum. Therefore, it is incumbent on the providers to consider the air carrier's view when determining communication links.

Users support the increase in VHF air-ground voice communications for aircraft operating above Flight Level (FL) 110. They also support the expanded use of VDL M2 (VHF Data Link Mode 2) for most data link services even thought the link has limitations. The users support the use of Mode S 1090ES (Mode Select 1090

Extended Squitter) as the most promising ADS (Automatic Dependent Surveillance) link, but are beginning to look more favorably on VDL M4 (Mode 4). The majority of the carriers believe that VDL M2 will increase the speed and capacity over ACARS without increasing band congestion.

Navigation

The users have expressed an adamant desire to use GNSS (Global Navigation Satellite System) to provide aircraft with accurate worldwide navigational capabilities while improving upon the present levels of safety performance. Several carriers as well as IATA expect GNSS supported by Galileo and GPS (Global Positioning System) to be the primary navigation system for all phases of flight from oceanic and domestic en route down to CAT I-III (Category I-III) minima.

The air carriers indicated they are expecting a seamless airspace which they believe is only attainable with GNSS using RNP (Required Navigation Performance). While the most important requirement for the carriers is RNAV (Area Navigation) routes, the potential benefits associated with RNAV routes will not reach their highest potential without the reduction of separation standards, which is only attainable with GNSS. Therefore, the carriers want a transition to GNSS and RNP as soon as practical. They also believe some type of redundancy for navigation in the form of a skeleton VOR/DME (VHF Omni-directional Range/Distance Measuring Equipment) system should remain. The use of RNP will also give some carriers the capability to receive navigational benefits using their present on-board avionics while transitioning their aircraft to a satellite-based environment. As a matter of priority and in the interest of safety and operational efficiencies, the users recognize a need for comprehensive and complete WGS-84 coordinate information and the publication of this information in the appropriate AIPs. The respective AIPs should also include a complete listing of operational airports with appropriate obstacle and geographical coordinate information.

Previously, the users preferred ILS for CAT I-III precision approaches due to the immaturity of GNSS to meet the more stringent requirements for these types of approaches; however, carriers are beginning to use GNSS precision approaches more each day. The carriers have also expressed a desire to have precision approach capability at all airports they serve. Most carriers believe that APV (Non-precision Approach with Vertical Guidance) approaches will be a cost-saving alternative to CAT I in those areas where ILSs are not cost efficient.

Surveillance Requirements

The carriers would like to see surveillance coverage in all areas of the region and believe that ADS can fill the gaps in most radar coverage schemes. They recommend ADS-C (Contract) for oceanic, domestic, remote, mountainous, and desert areas; ADS-B (Broadcast) for surface and terminal areas. Although the carriers have recommended ADS-C, they are putting special emphasis on ADS-B because of the accuracy and potential benefits it offers, and because it also has the potential as an en route surveillance enhancer. They expect the benefits from ADS-B to include surface and en route surveillance, reduced separation on departures, and other benefits in the terminal airspace. Although the carriers support the early

implementation of ADS, they want the states to implement this initiative in a cost effective and interoperable manner which includes limited ADS data links.

ATM (Air Traffic Management)

The users believe the management of aircraft should be a collaborative activity between the controller, the pilot and the airline operators. The aircraft should begin to have greater autonomy, particular in the area of providing their own separation, and the air traffic controller's tasks should take full advantage of automation and become one of more monitoring than actual controlling. Therefore, the user's requirements in this area are "seamless" flight operations, improved procedures, and the inserting of new technologies that are harmonized, interoperable, and compatible, regardless of national borders. There are several initiatives that the users want to continue and to expand on a global basis that are presently being provided on a limited basis.

- Greater use of RVSM (Reduced Vertical Separation Minima) which is the reduction of vertical separation to 1,000 feet between aircraft operating above FL 290.

- The application of RNP which will provide greater levels of airspace capacity and efficiency.

- The implementation of RNAV which permits aircraft operations on any desired flight path within the coverage of a self-contained navigation system (GNSS).

- The expansion of CDM (Collaborative Decision Making) which permits user interaction on cooperation with ATC on matters that affect the carriers. Collaboration is simply team work, which requires working together, sharing information, and the mutual understanding and acceptance of respective roles and responsibilities.

ATTACHMENT 1

ANSP Statistics from Questionnaire

Kyrgyzstan

The data is necessary to understand the current system, establish a baseline, and assess future capacity requirements. The predicted capacity requirements will drive the definition of infrastructure options. Also, this information will support the identification of financing options.

1. Please provide total aircraft movements by year for the last 5 years:

Year	2000	2001	2002	2003	2004
Arrivals	7559	5798	8441	9800	10725
Departures	75454	5800	8425	9802	10725

2. Please provide the total number of overflights per month for the past year.

Month	Jan 2004	Feb 2004	Mar 2004	Apr 2004	May 2004	Jun 2004
Number of Overflights	270	267	300	284	265	258
Month	Jul 2004	Aug 2004	Sep 2004	Oct 2004	Nov 2004	Dec 2004
Number of Overflights	272	297	312	316	349	371

3. Please provide the total number of aircraft movements forecasted for 2005, 2010, 2015:

Year	2005	2010	2015
Arrivals	10725	10725	10725
Departures	10725	10725	10725

Please explain the reasons for forecasted growth for each year:

4. Please provide the total number of overflights forecasted for 2005, 2010, 2015:

Year	2005	2010	2015
Number of Overflights	24584	24584	24584

Tajikistan

The data is necessary to understand the current system, establish a baseline, and assess future capacity requirements. The predicted capacity requirements will drive the definition of infrastructure options. Also, this information will support the identification of financing options.

5. Please provide total aircraft movements by year for the last 5 years:

Year	2000	2001	2002	2003	2004
Arrivals	4287	5432	7927	8631	8421
Departures	4298	5426	7930	8630	8421

6. Please provide the total number of overflights per month for the past year.

Month	Jan 2004	Feb 2004	Mar 2004	Apr 2004	May 2004	Jun 2004
Number of Overflights	713	782	914	975	1023	921
Month	Jul 2004	Aug 2004	Sep 2004	Oct 2004	Nov 2004	Dec 2004
Number of Overflights	901	874	1207	816	791	760

7. Please provide the total number of overflights forecasted for 2005, 2010, 2015:

Year	2005	2010	2015
Number of Overflights	8000	10000	12000

Please explain the reasons for forecasted growth for each year:

In future after finishing operation "Enduring Freedom" in Afghanistan and development of air travel from south-east Asia to Europe, and from former USSK and Europe to south-east of Asia number of transitional flights will be increased in 2000 total number of over flights was 9000.

Turkmenistan

The data is necessary to understand the current system, establish a baseline, and assess future capacity requirements. The predicted capacity requirements will drive the definition of infrastructure options. Also, this information will support the identification of financing options.

Response: This information is not relevant

Uzbekistan

The data is necessary to understand the current system, establish a baseline, and assess future capacity requirements. The predicted capacity requirements will drive the definition of infrastructure options. Also, this information will support the identification of financing options.

8. Please provide total aircraft movements by year for the last 5 years:

Year	2000	2001	2002	2003	2004
Arrivals	21740	16800	15002	15461	16449
Departures	21540	16860	15252	15464	16461

9. Please provide the total number of overflights per month for the past year.

Month	Jan 2004	Feb 2004	Mar 2004	Apr 2004	May 2004	Jun 2004
Number of Overflights	2170	2030	2215	2442	3270	2496
Month	Jul 2004	Aug 2004	Sep 2004	Oct 2004	Nov 2004	Dec 2004
Number of Overflights	2263	2242	2447	2614	2395	2630

10. Please provide the total number of aircraft movements forecasted for 2005, 2010, 2015:

Year	2005	2010	2015
Arrivals UTTT	17500	19500	20000
Departures UTTT	17400	19300	20000

Please explain the reasons for forecasted growth for each year:

11. Please provide the total number of over flights forecasted for 2005, 2010, 2015:

Year	2005	2010	2015
Number of Overflights UTTT	31200	33500	35500

Kazakhstan

12. Please provide the total number of aircraft movements forecasted for 2005, 2010, 2015:

Year	2005	2010	2015
Arrivals + Departures	105000	135000	160000

Please explain the reasons for forecasted growth for each year:

The increase of national and foreign flights, implemention of new routes

13. Please provide the total number of overflights forecasted for 2005, 2010, 2015:

Year	2005	2010	2015
Number of Overflights	340000	345000	350000

Please explain the reasons for forecasted growth for each year:

ATTACHMENT 2

Airspace User Information from Questionnaire

Sayakhat Air Company

1. General description of the Airspace User

a) "Sayakhat" Air company JSC
b) Republic of Kazakhstan, Almaty
c) Operations Department Manager, Gudz Yevgeniy +7 3272 70 62 60; 79 03 27 ;
e-mail: sayakhat@inbox.ru ; sah@itte.kz
d)

1) TU-154M , UN-85852
2) TU-154M, UN-85853
3) TU-154M, UN-85854
4) IL-76TD, UN-76442
5) IL-76TD, UN-76384
6) IL-76TD, UN-76385
7) IL-76TD, UN-76434

2. Current Aircraft Equipage by Aircraft Type

a) Communications Systems

Aircraft Type	Number of AC	VHF	HF	Satcom	Data Link
TU-154M	3	+	+	-	-
IL-76TD	4	+	+	-	-

б) Navigations Systems

Aircraft Type	Number of AC	VOR	DME	ILS	NDB	GPS	RNP	INS
Ту-154М	3	+	+	+	+	+	Level 5	-
Ил-76ТД	4	+	+	+	+	+	Level 5	+

c) Surveillance Systems

Aircraft Type	Number of AC	Mode A	Mode C	Mode S
Ту-154 М	3	-	-	+
Ил-76 ТД	4	-	-	+

3) **No** Aircraft Equipage Modernization Plans and Schedule by Aircraft Types

4) Airspace Operations

«Sayakhat» Air Company JSC operates charter passenger flights by Tu-154 M en-route:

- Almaty-Antaly-Almaty
- Almaty-Dalaman-Almaty
- Almaty-Bodrum-Almaty

- Almaty-Sharm-El-Sheikh-Almaty
- Domestic flights
- Other non-scheduled flights

«Sayakhat» Air Company JSC operates non-scheduled cargo flights by IL-76 TD to China and to other countries upon request.

Tajik Air

1. General Description of the Airspace User
a. State unitary airline "Tajik-Air"

2. Current Aircraft Equipage by Aircraft Type
a. Communication systems

Aircraft Type	Number of Aircraft	VHF	HF	Satcom	Data Link
TU-154 M	5	5+	5+	-	-
Yk-40	7	++	4+	-	-
TU-134	3	++	+	-	-
AN-26	2	++	+	-	-
AN-24	3	++	+	-	-
Mi-8T (helicopter)	1	+	+	-	-
Mi-8MTB (helicopter)	4	+	+	-	-
Mi-172 (helicopter)	1	+	+	-	-
AN-28	3	+	+	-	-

b. Navigation systems

Aircraft Type	Number of Aircraft	VOR	DME	ILS	NDB	GPS/GNSS	RNP Level	Inertial (INS
TU-154Б,M	5	5+	5+	5+	+	+		
Yk-40	7	4+	4+	7+	+	3+		
AN-24	3	++	+	++	+	-/-		
AN-26	2	++	+	++	+	-/-		
AN-28	3	-	-	-	+	-		
TU-134	3	++	+	++	+	+/-		
Mi-8T	1	-	-	-	+			
Mi-8MTB	4	2+	2+	2+	+	2+		
Mi-172	1	+	+	+	+	+		

c. Surveillance Systems

Aircraft Type	Number of Aircraft	Mode A	Mode C	Mode S
TU-154M	5	5+	5+	5+
Yk-40	7	2+	5+	2+
TU-134	3	+	+	+
AN-26	2	+	+	+
AN-24	3	+	+	-
AN-28	3	+	-	-
Mi-8T	1	-	-	-
Mi-8MTB	4	2+	-	-
Mi-172	1	+	+	-

3. Aircraft Equipage Modernization Plans and Schedule by Aircraft Types
a. Communication

Aircraft type	Number of aircraft	VHF/8.33	HF	Satcom	Data Link
TU-154Б,M	5	+	+	-	-
Yk-40	7	+	+	-	-
TU-134	3	+	-	-	-
AN-24	3	+	-	-	-
AN-26	2	+	-	-	-

b. Navigation

Aircraft type	Number of aircraft	VOR	DME	ILS	NDB	GPS/GNSS	RNP Level	Inertial (INS)
TU-154Б,M	5	+	+	+	+			
Yk-40	7							
TU-134	3	+	+	+	-	+/-		
AN-26	2	+	+	+	-	-		
AN-24	3	+	+	+	-	-		

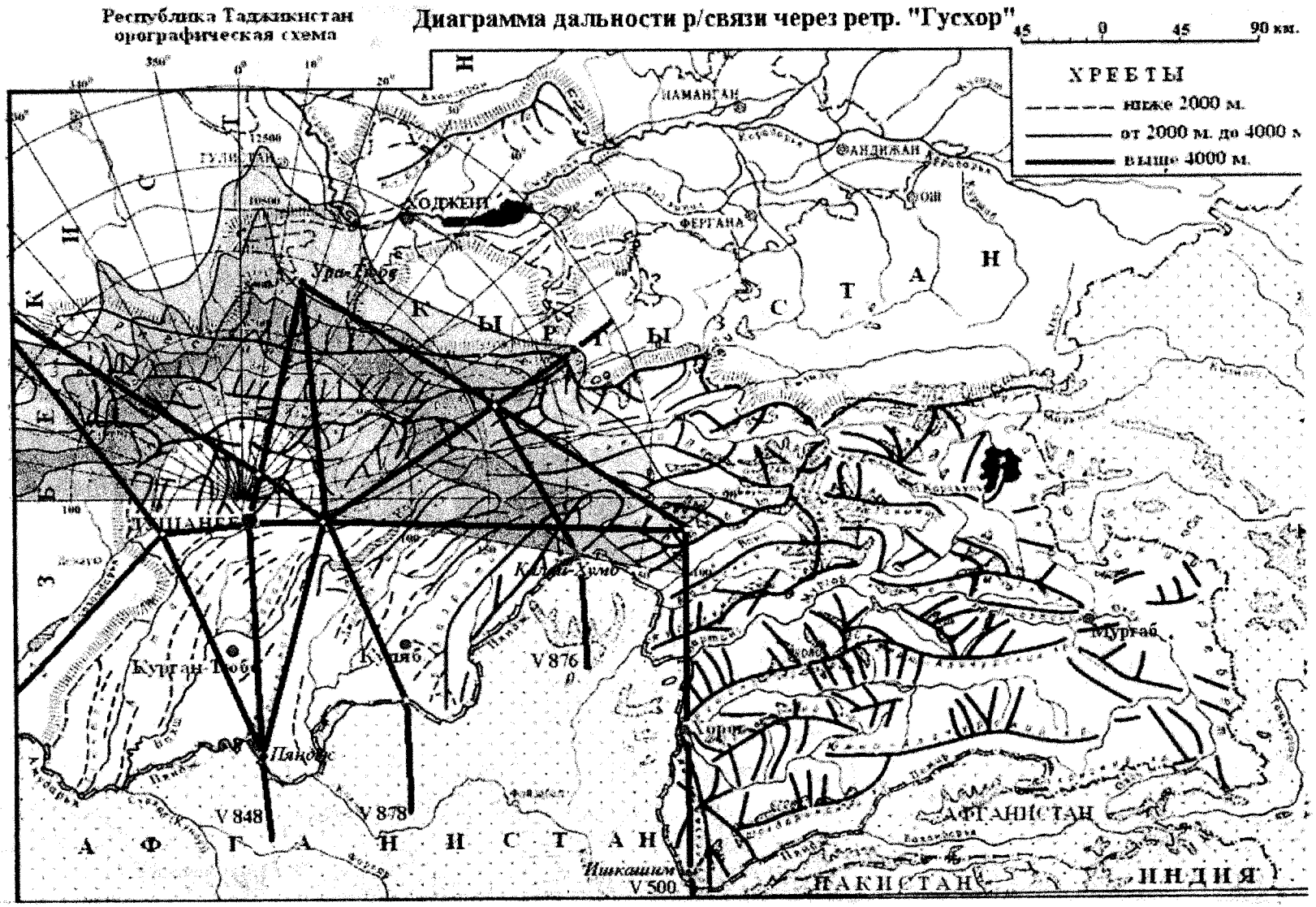
b. Operational Issues
Choke Points: lack since traffic is small.

Dog legs:
Zuren-FN-Pinax
Zuren-Sx-PR-Rapat
Zenal-JD-Pinax
Zenal-JD-Raman
Mirzo-Ivnar-Egpan
Mirzo-Topaz-Firuz
Prona-JD-Pinax
Prona-JD-PR
Prona-Ivnar-Topaz
Pinax-PR-Zulat
Butra-SX-JD-Topaz

Enroute delays/area avoidance: lack.

Handoff--clearance problems/efficiencies: lack.

5. Airspace user—Service Provider Interface Issues
a. Communication (diagram of communication cover is attached)


Республика Таджикистан
орографическая схема
Диаграмма дальности р/связи через ретр. "Гусхор"
45 0 45 90 км.
ХРЕБТЫ
ниже 2000 м.
от 2000 м. до 4000 м.
выше 4000 м.
НАМАНГАН
ФАНДИЖАН
ХОДЖЕНТ
ФЕРГАНА
ОШ
Ура-Тюбе
КЫРГЫЗСТАН
ТАДЖИКИСТАН
Курган-Тюбе
Куляб
Пенджикент
Калай-Хумб
Мургаб
Ишкашим
V 848
V 878
V 876
V 500
АФГАНИСТАН
ПАКИСТАН
ИНДИЯ

Uzbekistan Airways

3. General Description of the Airspace User
   a. Uzbekistan airways
   b. 41, Mavouronahr st., GSP 100060 Tashkent, Uzbekistan.
   c. Airline/organization personnel that were interviewed and provided data
   -Akil, Ruziev, Sinior navigator of Flight division.
   -Schedule department of Uzbekistan Airways

   d. Equipment (i.e. aircraft operated, to include specific aircraft types and the number of each aircraft)

4. Current Aircraft Equipage by Aircraft Type
   a. Communications Systems
      i. VHF
      ii. HF
      iii. Satcom
      iv. Data Link capabilities (e.g. CPDLC, PDC) and mode (e.g. HF, Satcom)

Aircraft Type	Number of Aircraft	VHF	HF	Satcom	Data Link
B767-300	4	+	+	-	-
B757-200	6	+	+	-	-
A310-324	3	+	+	-	-
RJ-85	3	+	+	-	-
TU-154	6	+	+	-	-
IL-114-100	1	+	+	-	-
AN-24	5	+	-	-	-
YAK-40	7	+	-	-	-
IL-76	5	+	+	-	-

Comments: (You can fill your answer in an offered table form or provide it in a "free" form)

   b. Navigation Systems
      i. VOR
      ii. VOR/DME
      iii. ILS
      iv. NDB
      v. GPS/GNSS
      vi. RNP performance level (as appropriate)

Aircraft Type	Number of Aircraft	VOR	DME	ILS	NDB	GPS/GNSS	RNP Level	Inertial (INS)
B767-300	4	+	+	+	+	+	RNP5	+
B757-200	6	+	+	+	+	+	RNP5	+
A310-324	3	+	+	+	+	-	RNP5	+
RJ-85	3	+	+	+	+	+	RNP5	+
TU-154	6	+	+	+	+	-		-
IL-114-100	1	+	+	+	+	+	RNP5	-
AN-24	5	-	-	+	+	-		-
YAK-40	7	-	-	+	+	-		-

IL-76	5	+	+	+	+	-	RNP5	+

Comments: (You can fill your answer in an offered table form or provide it in a "free" form)

c. Surveillance Systems
   i. Mode A
   ii. Mode C
   iii. Mode S

Aircraft Type	Number of Aircraft	Mode A	Mode C	Mode S
B767-300	4	+		+
B757-200	6	+		+
A310-324	3	+		+
RJ-85	3	+	+	
TU-154	6	+	+	
IL-114-100	1	+	+	
AN-24	5	+	+	
YAK-40	7	+	+	
IL-76	5	+	+	

Comments: (You can fill your answer in an offered table form or provide it in a "free" form)

5. Aircraft Equipage Modernization Plans and Schedule by Aircraft Types
   a. Communications
      i. Data Link—both Mode (e.g. Mode 2,3) and System (e.g. VHF, HF, Satcom)
      ii. VHF—8.33
      iii. Other
      iv.

Comments: answer in an provide it in a

Aircraft Type	Number of Aircraft	VHF/8.33	HF	Satcom	Data Link
B767-300	4	+	Modifications are not planned		
B757-200	6	+			
A310-324	3	+			
RJ-85	3	+			
TU-154	6	+			
IL-114-100	1	+			
AN-24	5	-			
YAK-40	7	-			
IL-76	5	+			

(You can fill your offered table form or "free" form)

   b. Navigation
      i. GPS/GNSS
      ii. Inertial
      iii. Other

Aircraft Type	Number of Aircraft	VOR	DME	ILS	NDB	GPS/GNSS	RNP Level	Inertial (INS)
B767-300	4	Modifications are not planned					RNP1	
B757-200	6						RNP1	
A310-324	3						RNP1	
RJ-85	3						RNP1	

TU-154	6			
IL-114-100	1			
AN-24	5			
YAK-40	7			
IL-76	5			

Comments: (You can fill your answer in an offered table form or provide it in a "free" form)

c. Surveillance
   i. Mode-S
   ii. ADS plans (e.g. VDL Mode 4)

Aircraft Type	Number of Aircraft	Mode A	Mode C	Mode S	ADS
B767-300	4	Modifications are not planned			
B757-200	6				
A310-324	3				
RJ-85	3				
TU-154	6				
IL-114-100	1				
AN-24	5				
YAK-40	7				
IL-76	5				

Comments: (You can fill your answer in an offered table form or provide it in a "free" form)

6. Airspace Operations
   a. Current Primary Routing
      i. City Pairs and current weekly frequency

Current City Pairs	Number of Flights per week
TAS-DME	14
TAS-LHR	3
TAS-BHX	3
TAS-FRA	2
TAS-CDG	2
TAS-FCO	2
TAS-ATH	1
TAS-IST	3
TAS-TLV	3
TAS-RIX-NYC	1
TAS-ATQ	6
TAS-DEL	3
TAS-BKK	3
TAS-ICN	2
TAS-BJS	2
TAS-KUL	2
TAS-LHE	3
TAS-NRT/KIX	2

TAS-SHJ	3
TAS-URC	2
TAS-ALA	7
TAS-ASB	1
TAS-CEK	1
TAS-FRU	3
TAS-GYD	2
TAS-KBP	1
TAS-KRR	1
TAS-KUF	1
TAS-KZN	1
TAS-MRV	1
TAS-OVB	1
TAS-SIP	1
TAS-SVX	1
TAS-TSE	2
TAS-UFA	1
TAS-LED	2
AZN-KJA	1
AZN-OMS	1
AZN-OVB	1
AZN-TJM	1
BHK-DME	3
FEG-DME	1
FEG-LED	1
KSQ-DME	1
NCU-DME	1
NMA-DME	1
NMA-SVX	0.5
SKD-DME	2
SKD-KZN	1
SKD-LED	1
UGC-DME	1
UGC-ROV	1

Comments: (You can fill your answer in an offered table form or provide it in a "free" form)

ii. Forecast city pair and frequency changes plans

Planned City Pairs	**Number of Flights per week**
TAS-DME	14
TAS-LHR	3
TAS-MIL	2
TAS-FRA	3
TAS-CDG	3
TAS-FCO	2
TAS-ATH	1
TAS-IST	4
TAS-TLV	3
TAS-RIX-NYC	2
TAS-ATQ	6
TAS-DEL	3

TAS-BKK	3
TAS-ICN	3
TAS-BJS	3
TAS-KUL	2
TAS-LHE	3
TAS-NRT/KIX	3
TAS-SHJ	3
TAS-URC	2
TAS-ALA	7
TAS-ASB	2
TAS-CEK	1
TAS-FRU	4
TAS-GYD	2
TAS-KBP	2
TAS-KRR	1
TAS-KUF	1
TAS-KZN	1
TAS-MRV	1
TAS-OVB	1
TAS-SIP	1
TAS-SVX	1
TAS-TSE	2
TAS-UFA	1
TAS-LED	2
AZN-KJA	1
AZN-OMS	1
AZN-OVB	1
AZN-TJM	1
BHK-DME	3
FEG-DME	1
FEG-LED	1
KSQ-DME	1
NCU-DME	1
NMA-DME	1
NMA-SVX	0.5
SKD-DME	3
SKD-KZN	1
SKD-LED	2
UGC-DME	1
UGC-ROV	1

Comments: (You can fill your answer in an offered table form or provide it in a "free" form)

b. Operational Issues

Choke Points: CV, TMD, DODUR, SW, PF, UTSB, TRZ, UBENA, DAKLI, TUKRI, OGRIP.

Dog Legs: UA G3 DODUR A121 SMK (UAII), UA G3 DODUR A119 ARSUL, PF W75 BIGSO B116 DS.

Air Astana

Since August 2007 all aircraft within the Air Astana fleet is equipped with EGPWS. This was done at a significant cost in support of flight safety as no aircraft equipped with EGPWS in the history of aviation suffered a CFIT accident (as you are no doubt aware CFIT accidents constitutes approximately half of all fatal hull loss accidents in commercial aviation).

However some airports (e.g. Petrapavlovsk, Kyzlorda and Zheskazghan) are not included in the AIP which denies the inclusion of the obstacles to the aircraft electronic obstacle database. The lack of data requires crew to de-activate the EGPWS terrain warning capability thereby effectively denying the use of a vital safety aid during critical phases of flight.

Additionally and unfortunately adding to the above risk is the lack of WGS-84 coordinates, as required by ICAO since 1999, for Kazakhstan airports and navigational facilities. This degrades the performance of sophisticated navigation equipment but more importantly denies optimal use of safety equipment (EGPWS) by any aircraft operating within Kazakhstan below safety altitude.

As a matter of safety urgency and in the interest of all aviation in Kazakhstan I respectfully request that:

- The airports not listed in the AIP are included with obstacle and appropriate geographical coordinates as a matter of priority.
- WGS-84 surveys with associated reference database be compiled and published in the AIP ASAP.

Gerhard Coetzee
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Air Astana avionics for all fleet aircraft

22 AUTO FLIGHT							
DESCRIPTION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
Flight Management Guide Computer	Thales/Pegasus ---------- C13042BA02	Thales/Smiths ---------- C13043BA02	Thales/Smiths ---------- C13043BA02	Thales/Pegasus ---------- C13042BA02	Thales/Pegasus ---------- C13042BA02		
Flight Augm. Computer	Thales ---------- B397BAM0513	Thales ---------- B397BAM0513	Thales ---------- B397BAM0617	Thales ---------- B397BAM0617	Thales ---------- B397BAM0617		
MCDU	Honeywell ---------- 4077880-982	Thales ---------- C19266AA01	Thales ---------- C19266AA01	Honeywell ---------- 4077880-982	Honeywell ---------- 4089740-961		
Flight Control Unit	Thales ---------- C12850AC02	Thales ---------- C12850AC02	Thales ---------- C12850BC02	Thales ---------- C12850BC02	Thales ---------- C12850AC02		

23 COMMUNICATIONS							
DESCRIP-TION	P4-PAS (2128)	P4-SAS (2016)	P4-TAS (2828)	P4-UAS (2987)	P4-VAS (3141)	P4-WAS (3484)	P4-XAS (3519)
	Manufacturer / Type / P/N / Quantity						
Audio Control Panel	Team ---------- ACP2788AB05	Team ---------- ACP2788AB04	Team ---------- ACP2788AB05	Team ---------- ACP2788AB05	Team ---------- ACP2788AB05		
Audio Management Unit	Team ---------- AMU4031SA110 101	Team ---------- AMU2790CB06	Team ---------- AMU4031SA110 101	Team ---------- AMU4031SA110 101	Team ---------- AMU4031SA140 204		
Panel Selcal	Team ---------- BC2065C	Team ---------- BC2065C	Team ---------- BC2065C	Team ---------- BC2065C	?		
CIDS Director	KID-SYSTEM ---------- Z010H000521 A	KID-SYSTEM ---------- Z010H000521 A	Airbus Deutchland GM ---------- Z014H000131 A	Airbus Deutchland GM ---------- Z014H000131 A	Airbus Deutchland GM ---------- Z014H000131 A		
CAM	?	?	?	?	?		
FAP	----------	----------	Airbus Deutchland GM ---------- Z133H031651 A	Airbus Deutchland GM ---------- Z133H031651 A	Airbus Deutchland GM ---------- Z133H031651 A		
Program and Test Panel (PTP)	KID-SYSTEM ---------- Z020H0001112	KID-SYSTEM ---------- Z020H0001112	----------	----------	----------		

23 COMMUNICATIONS							
DESCRIP-TION	P4-PAS (2128)	P4-SAS (2016)	P4-TAS (2828)	P4-UAS (2987)	P4-VAS (3141)	P4-WAS (3484)	P4-XAS (3519)
	Manufacturer / Type / P/N / Quantity						
HF Transceiver	Honeywell ---------- 964-0452-001	Collins ---------- 822-0330-20	Collins ---------- 822-0990-003	Collins ---------- 822-0990-003	Collins ---------- 822-0990-003 2		
VHF Transceiver	Honeywell ---------- 064-50000-0505	Collins ---------- 822-1047-030	Collins ---------- 822-1250-020	Collins ---------- 822-1047-030	Collins ---------- 822-1047-030 3		
Radio Management Panel (RMP)	Thales ---------- C12848CA01	Thales ---------- C12848CA01	Thales ---------- C12848CA01	Thales ---------- C12848CA01	Thales ---------- C12848CA01		
Cockpit Voice Recorder	Honeywell ---------- 980-6022-001	Honeywell ---------- 980-6022-001	L3 Communication ---------- 2100-1020-02	Honeywell ---------- 980-6022-001	Honeywell ---------- 980-6022-001		
PRAM	Panasonic ---------- RD-AX7675-51	Panasonic ---------- RD-AX7675-51	----------	----------	----------		
CD Player Seat Entertainment	Panasonic ---------- RD-AX7095-01	Panasonic ---------- RD-AX7095-01	Thales I2000	Panasonic ---------- RD-AX7095-01	?		

23 COMMUNICATIONS							
DESCRIP-TION	P4-PAS (2128)	P4-SAS (2016)	P4-TAS (2828)	P4-UAS (2987)	P4-VAS (3141)	P4-WAS (3484)	P4-XAS (3519)
	Manufacturer / Type / P/N / Quantity						
Airshow DIU	----------	Collins AS 420 921006	Thales I2000	Collins AS 420 921005	Collins AS 420 921006		
Main Multiplexer	Panasonic ---------- RDAX1301-5A	Panasonic ---------- RDAX1301-2E	Thales I2000	?	?		
Video System Control Unit	Panasonic ---------- RDAV3007-06	Panasonic ---------- RDAV3007-02	Thales I2000	Panasonic ---------- RDAV3007-06	?		
Video Player	Panasonic ---------- RDAV1216-01	Panasonic ---------- RDAV1216-01	Thales I2000	Panasonic ---------- RDAV1216-01	?		

27 FLIGHT CONTROLS							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
Spoiler Elevator Computer (SEC)	Thales ---------- B372BAM0511	Thales ---------- B372BAM0511	Thales ---------- B372BAM0511	Thales ---------- B372BAM0511	Thales ---------- B372BAM0511		
Flight Control Data Concentrator (FCDC)	Litef Litton ---------- 115370-1118	Litef Litton ---------- 115370-1016	Litef Litton ---------- 115370-1318	Litef Litton ---------- 115370-1318	Litef Litton ---------- 115370-1318		
SFCC	Liebherr ---------- 49-170-11	Liebherr ---------- 49-170-11	Liebherr ---------- 49-170-11	Liebherr ---------- 49-170-11	Liebherr ---------- 49-170-11		
Elevator Aileron Computer (ELAC)	Thales ---------- 3945128102	Thales ---------- 3945128102	Thales ---------- 3945128206	Thales ---------- 3945128206	Thales ---------- 3945128206		

28 FUEL							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
FQIC	Smith Aerospace ---------- SIC5059-11-0207	Smith Aerospace ---------- SIC5059-11-0207	Smith Aerospace ---------- SIC5059-13-10	Smith Aerospace ---------- SIC5059-13-10	Smith Aerospace ---------- SIC5059-13-10		
Control Unit Level Sensing	Simmonds Precision ---------- 30042-0000-	Simmonds Precision ---------- 30042-0000-	Simmonds Precision ---------- 30042-0000-	Simmonds Precision ---------- 30042-0000-	?		

	0501	0501	0501	0501			

31 INDICATING AND RECORDING							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
CFDIU	Thales ---------- C12860AA02	Thales ---------- C12860AA02	Thales ---------- C12860AA02	Thales ---------- C12860AA02	Thales ---------- C12860AA02		
FDIMU (FDIU)	SAGEM/SFIM ---------- ED48A100	SAGEM/SFIM ---------- ED48A100	Teledyne ---------- 2234320-01-01	SAGEM/SFIM ---------- ED48A200	SAGEM/SFIM ---------- ED48A200		
DMU	----------	----------	----------	----------	----------		
QAR	----------	----------	----------	----------	----------		
MDDU	SAGEM ---------- AC68A200	SAGEM ---------- AC68A200	SAGEM ---------- AC68A200	SAGEM ---------- AC68A200	SAGEM ---------- AC68A200		
Clock	Air Precision ---------- APE5100-1	Air Precision ---------- APE5100-1	Air Precision ---------- APE5100-1	Air Precision ---------- APE5100-1	Air Precision ---------- APE5100-1		
FWC	Airbus France ---------- 350E053020404	Airbus France ---------- 350E053020303	Airbus France ---------- 350E053020606	Airbus France ---------- 350E053020606	Airbus France ---------- 350E053020707		
SDAC	Airbus France ---------- 350E5500202	Airbus France ---------- 350E5500202	Airbus France ---------- 350E5500202	Airbus France ---------- 350E5500202	Airbus France ---------- 350E5500204		
	Thales	Thales	Thales	Thales	Thales		

Display Unit	---------- 3907130402	---------- 3907130402	---------- C19298AF05	---------- C19298AF05	---------- C19298AF05		

31 INDICATING AND RECORDING							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
Printer Multi Use	Honeywell ---------- 8055515-4501	Honeywell ---------- 8055515-4501	Honeywell ---------- 8055515-4501	Honeywell ---------- 8055515-4501	Honeywell ---------- 8055515-4501		
Display Management Computer (DMC)	Thales ---------- 9615325050	Thales ---------- 9615325040	Thales ---------- 1982660116	Thales ---------- 1982660116	Thales ---------- 1982660116		
Solid State FDR (SSFDR)	Honeywell ---------- 980-4700-042	Honeywell ---------- 980-4700-042	L3 Communication ---------- 2100-4043-02	Honeywell ---------- 980-4700-042	Honeywell ---------- 980-4700-042		

32 LANDING GEAR							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
Brake Steering Control Unit	Messier Bugatti ---------- E21327003	Messier ---------- C202163	Messier Bugatti ---------- E21327004	Messier Bugatti ---------- E21327004	Messier Bugatti ---------- E21327004		

34 NAVIGATION							
DESCRIP-TION	P4-PAS (2128)	P4-SAS (2016)	P4-TAS (2828)	P4-UAS (2987)	P4-VAS (3141)	P4-WAS (3484)	P4-XAS (3519)
	Manufacturer / Type / P/N / Quantity						
Antenna GPS active	Thales ---------- C17065AA	Collins ---------- 822-1330-001	Collins ---------- 822-1330-001	Collins ---------- 822-1330-001	Collins ---------- 822-1330-001		
MMR	Thales ---------- TLS755-01-0101B	Collins ---------- 822-1152-121	Collins ---------- 822-1152-121	Collins ---------- 822-1152-121	Collins ---------- 822-1152-121		
T2CAS	----------	----------	L3 Communication ---------- 9000000-10110	----------	----------		
TCAS II Computer	Honeywell ---------- 066-50000-2220	Collins ---------- 822-1293-321	----------	Collins ---------- 822-1293-322	Collins ---------- 822-1293-322		
Transponder Mode S	Honeywell ---------- 066-01127-1402	Collins ---------- 822-1338-021	L3 Communication ---------- 7517800-10005	Collins ---------- 822-1338-021	Collins ---------- 822-1338-021		
ATC-TCAS Control	Thales ----------	Thales ----------	Thales ----------	Collins ----------	Collins ----------		

Unit	C12404AB02	C12404AB02	C12404AB02	622-8974-118	622-8974-118		
ADF Receiver	Honeywell ---------- 066-50014-0202	Collins ---------- 822-0299-020	Collins ---------- 822-0299-020	Collins ---------- 822-0299-020	Collins ---------- 822-0299-020		

34 NAVIGATION							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
WX Radar Transceiver	Honeywell ---------- 066-50008-0407	Collins ---------- 622-5132-622	Collins ---------- 822-1710-202	Collins ---------- 822-1710-202	Collins ---------- 822-1710-202		
WX Radar Control Panel	Honeywell ---------- 2041220-0424	Collins ---------- 622-5130-021	Collins ---------- 622-5130-820	Collins ---------- 622-5130-820	Collins ---------- 622-5130-820		
DME Interrogator	Honeywell ---------- 066-50013-0202	Collins ---------- 822-0329-020	Collins ---------- 822-0329-020	Collins ---------- 822-0329-020	Collins ---------- 822-0329-020		
VOR Marker Receiver	Honeywell ---------- 066-50012-0202	Collins ---------- 822-0297-020	Collins ---------- 822-0297-020	Collins ---------- 822-0297-020	Collins ---------- 822-0297-020		
ADIRU	Honeywell ---------- HG2030AD11	Northrop Grumman ---------- 465020-0303-	Northrop Grumman ---------- 465020-0303-	Northrop Grumman ---------- 465020-0303-	Northrop Grumman ---------- 465020-0303-		

		0316	0316	0316	0316		
ADIRS CDU	Honeywell ---------- CG1151AC03	Northrop Grumman ---------- 465010-0300-0300	Northrop Grumman ---------- 465010-0300-0300	Northrop Grumman ---------- 465010-0300-0300	Northrop Grumman ---------- 465010-0300-0300		

34 NAVIGATION							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
DDRMI	Thales ---------- 63543-253-3	Collins ---------- 622-5001-504	Collins ---------- 622-5001-504	Collins ---------- 622-5001-504	Collins ---------- 622-5001-504		
Standby Altimeter	Thales ---------- 64141-590-1 1	Thales ---------- 64141-580-1 1	Not installed	Not installed	Not installed		
Standby Air Speed Indicator	Thales ---------- 64050-866-1 1	Thales ---------- 64050-866-1 1	Not installed	Not installed	Not installed		
Standby Horizon	Thales ---------- H321BHM1 1	Thales ---------- H321BHM1 1	Not installed	Not installed	Not installed		
ISIS	Not installed	Not installed	Thales ---------- C13221WB01	Thales ---------- C13221WB01	Thales ---------- C16221WB01		
Radio Altimeter	Honeywell ---------- 066-50007- 0212	Collins ---------- 822-0334-020	Collins ---------- 822-0334-020	Collins ---------- 822-0334-020	Collins ---------- 822-0334-020		
EGPWC	Honeywell ---------- 965-1676-001	Honeywell ---------- 965-1676-001	----------	Honeywell ---------- 965-1676-002	Honeywell ---------- 965-1676-002		

46 INFORMATION							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
ATSU	Airbus France ---------- LA2T0G20503 B050	Airbus France ---------- LA2T0G20503 B050	Airbus France ---------- LA2T0G20705 C070		Airbus France ---------- LA2T0G20705 C070		

52 DOORS							
DESCRIP-TION	**P4-PAS (2128)**	**P4-SAS (2016)**	**P4-TAS (2828)**	**P4-UAS (2987)**	**P4-VAS (3141)**	**P4-WAS (3484)**	**P4-XAS (3519)**
	Manufacturer / Type / P/N / Quantity						
Cockpit Door System Control	Adams Rite Aerospace ---------- AR4709-3		Adams Rite Aerospace ---------- AR4709-3	Adams Rite Aerospace ---------- AR4709-7	Adams Rite Aerospace ---------- AR4709-7		

22 AUTO FLIGHT					
DESCRIPTION	P4-EAS (29488)	P4-FAS (29489)	P4-GAS (28112)	P4-MAS (28833)	Notes
	Manufacturer / Type / P/N / Quantity				
FCC	Collins FCC-703 822-1261-101 3	Collins FCC-703 822-1261-101 3	Collins -------- 622-8757-105 3	Collins --------- 622-8757-106 3	
Thrust Management Computer (TMC)	M.Marietter ---------- 89954-948E414G2 1	M.Marietter ---------- 89954-948E474G2 1	Lockheed ---------- 89954-948E41462 1	Lockheed ---------- 948E414G2 S241T200-1414 1	
AP Control	Collins --------- 622-4717-004 1	Collins --------- 622-4717-004 1	Collins --------- 622-4717-004 1	Collins --------- 622-4717-004 1	
MCDP	Collins --------- 622-4593-508 1	Collins --------- 622-4593-508 1	Collins --------- 622-4593-507 1	Collins --------- 622-4593-507 1	

23 COMMUNICATIONS					
DESCRIPTION	P4-EAS (29488)	P4-FAS (29489)	P4-GAS (28112)	P4-MAS (28833)	Notes
	Manufacturer / Type / P/N / Quantity				
VHF TX/RX	Honeywell RTA44D 064-50000-0110 3	Honeywell RTA44D 064-50000-0110 3	Allied Signal RTA44D 064-50000-0110 3	Collins VHF-900B 822-1047-002 2	
VHF Control Panel	Gables --------- G7400-31 3	Gables --------- G7400-31 3	Gables --------- G7400-31 3	Gables --------- G7400-27 3	

23 COMMUNICATIONS					
DESCRIPTION	**P4-EAS (29488)**	**P4-FAS (29489)**	**P4-GAS (28112)**	**P4-MAS (28833)**	Notes
	Manufacturer / Type / P/N / Quantity				
HF Transceiver	Collins HFS-900D 822-0990-001 2	Collins HFS-900D 822-0990-001 2	Collins HFS-700 622-5272-001 2	Collins HFS-900 822-0330-001 2	
HF Control Panel	Gables --------- G7401-16 2	Gables --------- G7401-16 2	Gables --------- G7401-16 2	Gables --------- 622-6827-002 2	
SELCAL Decoder	Motorola --------- NA138-714B 1	Motorola --------- NA138-714B 1	Motorola --------- NA138-714B 1	Motorola --------- NA138-714B 1	
Airshow DIU	Rockwell Collins AS 210 910030 1	Rockwell Collins AS 210 910030 1	Rockwell Collins AS 210 910030 1	Rockwell Collins AS 420 921006 1	
Audio Reproducer	Panasonic (Matsushita) CD Player RD-AX7094-04 1	Matsushita CD Player RD-AX7094-04 1	Matsushita CD Player RD-AX7094-04 1	Panasonic (Matsushita) CD Reproducer RD-AX7095-01 + Tape reproducer	
Audio PA-Amp	Collins PES/PSS 622-5342-101(101) 1	Collins PES/PSS 622-5342-101(101) 1	Pacific Electro ------ 256-4 1	Pacific Electro ------ 256-4 1	
Video Player	Matsushita --------- RD-AV1113 2	Matsushita --------- RD-AV1113 2	Avicom -------- 493700-0001 2	Matsushita -------- RD-AV1216-01 2	

23 COMMUNICATIONS					
DESCRIPTION	**P4-EAS (29488)**	**P4-FAS (29489)**	**P4-GAS (28112)**	**P4-MAS (28833)**	Notes
	Manufacturer / Type / P/N / Quantity				
Main Multiplexer	Matsushita --------- RD-AX1017 1	Matsushita --------- RD-AX1017 1	Matsushita -------- RD-AX1017 1	Matsushita -------- RD-AX1017 1	
Audio Access Unit	Boeing ---------- 285T001-75 1	Boeing ---------- 285T001-75 1	Boeing ---------- 285T001-75 1	Boeing --------- 285T001-56 1	
Video System Control Unit	Matsushita --------- RD-AV3006-1 1	Matsushita --------- RD-AV3006-1 1	Avicom --------- 498020-0001 1	Matsushita --------- RD-AV3007-05 1	
ELT	Artex ELT 110-406 453-0004 1	Artex ELT 110-406 453-0004 1	Not installed	Not installed	Fixed 121.5/243/406 MHz
Cockpit Voice Recorder	Honeywell -------- 980-6022-001 1	Honeywell -------- 980-6022-001 1	Honeywell -------- 93-A100-80 1	Honeywell -------- 980-6020-001 1	

25 EQUIPMENT/FURNISHING					
DESCRIPTION	**P4-EAS (29488)**	**P4-FAS (29489)**	**P4-GAS (28112)**	**P4-MAS (28833)**	Notes
	Manufacturer / Type / P/N / Quantity				
ELT	Garret/Honeywell --------- 1151324-1M307 2	Garret/Honeywell --------- 1151324-1M307 2	Garret/Honeywell ---------- 1151324-1M218 2	ELTA A06V2 25N6088 1	Portable 121.5/243/406 MHz

31 INDICATING AND RECORDING

DESCRIPTION	P4-EAS (29488)	P4-FAS (29489)	P4-GAS (28112)	P4-MAS (28833)	Notes
	Manufacturer / Type / P/N / Quantity				
DFDAU	Honeywell -------- 967-0212-002 1	Honeywell -------- 967-0212-002 1	Teledine -------- 2233000-3A 1	Teledine -------- 2233000-3A 1	
SSFDR	Honeywell -------- 980-4700-042 1	Honeywell -------- 980-4700-042 1	Honeywell -------- 980-4120DXUS 1	Allied Signal -------- 980-4700-034 1	
EICAS CPTR	Collins EAP-703 822-1033-100 2	Collins EAP-703 822-1033-100 2	Collins EAP-703 822-1033-100 2	Collins EAP-703 822-1033-100 2	
Optical Quick Access Recorder (OQAR)	Not installed	Not installed	Not installed	Penny + Giles -------- D52000-62000 1	

34 NAVIGATION					
DESCRIPTION	P4-EAS (29488)	P4-FAS (29489)	P4-GAS (28112)	P4-MAS (28833)	Notes
	Manufacturer / Type / P/N / Quantity				
ADC	Honeywell -------- 4040800-912/-911 2	Honeywell -------- 4040800-911 2	Honeywell -------- 4040800-911 2	Honeywell -------- 4040800-911 (S242T210-211) 2	
IRU	Honeywell -------- HG1050AE11 3	Honeywell -------- HG1050AE11 3	Honeywell -------- HG1050AE11 3	Honeywell -------- HG1050AE11 3	

34 NAVIGATION					
DESCRIPTION	**P4-EAS (29488)**	**P4-FAS (29489)**	**P4-GAS (28112)**	**P4-MAS (28833)**	Notes
	Manufacturer / Type / P/N / Quantity				
EGPWS	Honeywell -------- 965-0976-020-216- 216 1	Honeywell -------- 965-0976-020-216- 216 1	Honeywell -------- 965-0976-020-216- 216 1	Honeywell MK V 965-0976-060-216- 216 1	
EFIS SG	Collins EFIP-701E 622-9436-101 3	Collins EFIP-701E 622-9436-101 3	Collins EFIP-701E 622-9436-101 3	Collins EFIP-701E 622-9436-101 3	
FMC	Honeywell -------- 4052506-955 (S242TN701-1001) 2	Honeywell -------- 4052506-955 2	Honeywell -------- 4052506-941 2	Honeywell -------- 4052500-962 (S242T102-331) 2	
MCDU	Honeywell -------- 4077880-908/903 2	Honeywell -------- 4077880-903 2	Honeywell -------- 4058650-931 2	Honeywell -------- 4038170-905 (S242T102-103) 2	
TCAS Computer	Honeywell TRA-81A 066-50000- 2120/2220 1	Honeywell TRA-81A 066-50000-2120 1	Honeywell TRA-81A 066-50000-2120 1	Collins TTR-920 622-8971-022 1	
MMR or ILS	Collins GLU920 822-1152-002/3 3	Collins GLU920 822-1152-002 3	Honeywell -------- 2041230-3531* 3	Collins ILS-700A 822-0282-102* 3	* ILS

34 NAVIGATION					
DESCRIPTION	**P4-EAS (29488)**	**P4-FAS (29489)**	**P4-GAS (28112)**	**P4-MAS (28833)**	Notes
	Manufacturer / Type / P/N / Quantity				
ADF Receiver	Honeywell DFA-75A 2041168-7510/12 2	Honeywell DFA-75A 2041168-7510 2	Honeywell DFA-75A 2041168-7510/12 2	Collins ADF-900 822-0299-001 2	
ADF Panel				Collins DFP-713 622-6830-001 1	
RDMI				Collins --------- 622-5001-109 2	
ATC Transponder	Honeywell TRA-67 066-01127-1602 2	Honeywell TRA-67A 066-01127-1602 2	Honeywell TRA-67A 066-01127-1602 2	Honeywell TRA-67 066-01127-1602 2	
DME Interrogator	Honeywell DMA-37A 2041167-3703/6 2	Honeywell DMA-37A 2041167-3706 2	Honeywell DMA-37A 2041167-3706 2	Collins --------- 822-0329-001 2	
RA-Transceiver	Honeywell ALA-52A 2041166-5204 3	Honeywell ALA-52A 2041166-5204/6 3	Honeywell ALA-52A 2041166-5203/4 3	Collins --------- 822-0334-002 3	
VOR/MKR Receiver	Honeywell RVA-36A 2041231-3617/18 2	Honeywell RVA-36A 2041231-3618/17 2	Honeywell RVA-36A 2041231-3618/17 2	Collins --------- 822-0297-001 2	

34 NAVIGATION					
DESCRIPTION	**P4-EAS (29488)**	**P4-FAS (29489)**	**P4-GAS (28112)**	**P4-MAS (28833)**	Notes
	Manufacturer / Type / P/N / Quantity				
Weather Radar Transceiver	Honeywell RDR-4A 2041217-0416 2	Honeywell RDR-4A 2041217-0416 2	Honeywell RDR-4A 2041217-0416 2	Collins WRT-701X 622-5132-106 1	
Panel WR				Collins ---------- 622-5129-108 1	
VS Indicator	Honeywell ---------- 4039893-902 2	Honeywell ---------- 4039893-902 2	Honeywell ---------- 4039893-902 2	Honeywell VS800 4039893-902 2	
FCC				Collins ---------- 622-8757-106 (S241T100-136) 2	
IND MACH SPEED				Honeywell ---------- 4039891-903 (S231T1001) 2	

22 AUTO FLIGHT			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
Flight Control Unit	Rockwell Collins ---------- 622-8757-106 3	Rockwell Collins ---------- 622-8757-106 3	
Autothrottle Computer	General Electric ---------- 948E310G2 1	General Electric ---------- 948E310G2 1	
MCDP	Rockwell Collins ---------- 622-4593-507 1	Rockwell Collins ---------- 622-4593-507 1	

23 COMMUNICATIONS			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
VHF COM Transceiver	Rockwell Collins ---------- 822-1047-003 3	Rockwell Collins ---------- 822-1047-003 3	
HF COM Transceiver	Rockwell Collins ---------- 622-5272-120 2	Rockwell Collins ---------- 622-5272-120 2	
VHF Control Panel	Boeing ---------- 285U0037-303 3	Boeing ---------- 285U0037-303 3	

23 COMMUNICATIONS			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
SELCAL Decoder	TEAM ---------- SC2253AD01 1	TEAM ---------- SC2253AD01 1	
Airshow DIU	Rockwell Collins AS 210 910030 1	Rockwell Collins AS 210 910030 1	
CD Player (Audio Entertainment)	Matsushita ---------- RDAX7095-01 1	Matsushita ---------- RDAX7095-01 1	
Audio PA-Amp	Rockwell Collins PES/PSS 622-5342-101 1	Rockwell Collins PES/PSS 622-5342-101 1	
Tape Reproducer (Video)	Matsushita ---------- 2002-03-012 (6ea) RDAV1115 (2ea) 8	Matsushita ---------- 2002-03-012 (6ea) RDAV1115 (2ea) 8	
Main Multiplexer	Matsushita ---------- RDAX1001A 1	Matsushita ---------- RDAX1001A 1	
Audio Access Unit	Boeing ---------- 285T0001-69 1	Boeing ---------- 285T0001-69 1	

23 COMMUNICATIONS			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
Video System Control Unit	Matsushita ---------- RDAV3006-03 1	Matsushita ---------- RDAV3006-03 1	
ACARS Management Unit	Honeywell ---------- 965-0758-001 1	Honeywell ---------- 965-0758-001 1	
Printer	Miltope ---------- 706300-211 1	Miltope ---------- 706300-211 1	
Cockpit Voice Recorder	L3 Communications ---------- S200-0012-00 1	L3 Communications ---------- S200-0012-00 1	

25 EQUIPMENT/FURNISHING			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
ELT	ELTA A06V2 95N6088 2 ea	ELTA A06V2 95N6088 2 ea	Portable 121.5 / 243 / 406 MHz

31 INDICATING AND RECORDING			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
DFDAU	Teledyne ---------- 2233000-45 1	Teledyne ---------- 2233000-45 1	
SSFDR	Honeywell ---------- 980-4700-003 1	Honeywell ---------- 980-4700-003 1	
EICAS CPTR	Rockwell Collins EAP-703 822-1033-100 2	Rockwell Collins EAP-703 822-1033-100 2	

34 NAVIGATION			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
Air Data Computer (ADC)	Honeywell ---------- 4040800-906 2	Honeywell ---------- 4040800-906 2	
Inertial Reference Unit (IRU)	Honeywell ---------- HG1050AE10 / HG1050AD10 3	Honeywell ---------- HG1050AE10 / HG1050AD10 3	

34 NAVIGATION			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
EGPWS	Honeywell ---------- 965-0976-003-212 1	Honeywell ---------- 965-0976-003-212 1	
Windshear System (via GPWS)	(X) Yes - Reactive	(X) Yes - Reactive	
EFIS SG	Rockwell Collins EFIP-701E 622-9436-101 3	Rockwell Collins EFIP-701E 622-9436-101 3	
Flight Management Computer (FMC)	Honeywell ---------- 4052506-955 (S242TN701-1001) 2	Honeywell ---------- 4052506-955 (S242TN701-1001) 2	
MCDU	Honeywell ---------- 4058650-931 2	Honeywell ---------- 4058650-931 2	
TCAS Computer	Honeywell ---------- 7517900-10003 1	Honeywell ---------- 7517900-10003 1	
ILS/GPS Multi-Mode Receiver	Rockwell Collins GLU920 822-1152-002 3	Rockwell Collins GLU920 822-1152-002 3	

34 NAVIGATION			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
ADF Receiver	Rockwell Collins ---------- 622-5222-120 2	Rockwell Collins ---------- 622-5222-120 2	
ATC Transponder	Rockwell Collins ---------- 622-7878-201 2	Rockwell Collins ---------- 622-7878-201 2	
DME Interrogator	Rockwell Collins ---------- 622-4540-122 2	Rockwell Collins ---------- 622-4540-122 2	
Radio Altimeter Transceiver	TRT ---------- 9599-607-14939 3	TRT ---------- 9599-607-14939 3	
VOR/MKR Receiver	Rockwell Collins ---------- 822-0726-120 2	Rockwell Collins ---------- 822-0726-120 2	
Weather Radar Transceiver	Rockwell Collins ---------- 622-5132-130 2	Rockwell Collins ---------- 622-5132-130 2	
Radio Distance Magnetic Indicator	Rockwell Collins ---------- 622-5001-111 2	Rockwell Collins ---------- 622-5001-111 2	

34 NAVIGATION			
DESCRIPTION	**P4-KCA (27612)**	**P4-KCB (27614)**	Notes
	Manufacturer / Type / P/N / Quantity		
Electronic Attitude Director Ind (EADI)	Rockwell Collins ---------- 622-7998-003 2	Rockwell Collins ---------- 622-7998-003 2	
Electronic Horizontal Situation (EHSI)	Rockwell Collins ---------- 622-7999-003 2	Rockwell Collins ---------- 622-7999-003 2	

22 AUTO FLIGHT						
DESCRIPTION	P4-HAS (20198)	P4-IAS (20188)	P4-JAS (20187)	P4-KAS (20193)	P4-LAS (20195)	Notes
	Manufacturer / Type / P/N / Quantity					
Computer Autopilot	Honeywell/Sperry SP-600 4029377-914 1	Honeywell/Sperry SP-600 4029377-914 1	Honeywell/Sperry SP-600 4029377-914 1	Honeywell/Sperry SP-600 4029377-914 1	Honeywell/Sperry SP-600 4029377-914 1	
Computer Stability Augmentation	Honeywell/Sperry SZ-601 7004187-903 1	Honeywell/Sperry SZ-601 7004187-903 1	Honeywell/Sperry SZ-601 7004187-903 1	Honeywell/Sperry SZ-601 7004187-903 1	Honeywell/Sperry SZ-601 7004187-903 1	

23 COMMUNICATIONS						
DESCRIPTION	P4-HAS (20198)	P4-IAS (20188)	P4-JAS (20187)	P4-KAS (20193)	P4-LAS (20195)	Notes
	Manufacturer / Type / P/N / Quantity					
Transceiver-VHF COM	Bendix/King VC-401B BPN 3614001-4001 KPN 064-1047-00 2	Bendix/King VC-401B BPN 3614001-4001 KPN 064-1047-00 2	Bendix/King VC-401B BPN 3614001-4001 KPN 064-1047-00 2	Bendix/King VC-401B BPN 3614001-4001 KPN 064-1047-00 2	Bendix/King VC-401B BPN 3614001-4001 KPN 064-1047-00 2	or 064-1047-32 or 3614001-4033
Decoder Selective Calling	Motorola ---------- N1335C 1	Motorola ---------- N1335C 1	Motorola ---------- N1335C 1	Motorola ---------- N1335C 1	Motorola ---------- N1335C 1	
Amplifier Passenger Address	Rockwell Collins 346D-2B 622-4096-001 1	Rockwell Collins 346D-2B 622-4096-001 1	Rockwell Collins 346D-2B 622-4096-001 1	Rockwell Collins 346D-2B 622-4096-001 1	Rockwell Collins 346D-2B 622-4096-001 1	
Reproducer Music	TEAM SA DPA S4 PAS3921AB02 1	TEAM SA DPA S4 PAS3921AB02 1	TEAM SA DPA S4 PAS3921AB02 1	TEAM SA DPA S4 PAS3921AB02 1	TEAM SA DPA S4 PAS3921AB02 1	

23 COMMUNICATIONS						
DESCRIPTION	**P4-HAS (20198)**	**P4-IAS (20188)**	**P4-JAS (20187)**	**P4-KAS (20193)**	**P4-LAS (20195)**	Notes
	Manufacturer / Type / P/N / Quantity					
Accessor Audio	Fokker ---------- F7941-024-413 1	Fokker ---------- F7941-024-413 1	Fokker ---------- F7941-024-413 1	Fokker ---------- F7941-024-413 1	Fokker ---------- F7941-024-413 1	
Recorder-Voice Solid State	Honeywell ---------- 980-6022-001 1	Honeywell ---------- 980-6022-001 1	Honeywell ---------- 980-6022-001 1	Honeywell ---------- 980-6022-001 1	Honeywell ---------- 980-6022-001 1	
ULB Recorder Voice	Dukane Corp. DK Series DK100, DK120 1	Dukane Corp. DK Series DK100, DK120 1	Dukane Corp. DK Series DK100, DK120 1	Dukane Corp. DK Series DK100, DK120 1	Dukane Corp. DK Series DK100, DK120 1	

25 EQUIPMENT & FURNISHING						
DESCRIPTION	**P4-HAS (20198)**	**P4-IAS (20188)**	**P4-JAS (20187)**	**P4-KAS (20193)**	**P4-LAS (20195)**	Notes
	Manufacturer / Type / P/N / Quantity					
Transmitter-Emergency Locator	AIL Systems ---------- DMELT8-1 1	AIL Systems ---------- DMELT8-1 1	AIL Systems ---------- DMELT8-1 1	AIL Systems ---------- DMELT8-1 1	AIL Systems ---------- DMELT8-1 1	Fixed 121.5 / 243 MHz
Transmitter-Emergency Locator	ELTA A06V02 95N6088 1	ELTA A06V02 95N6088 1	ELTA A06V02 95N6088 1	ELTA A06V02 95N6088 1	ELTA A06V02 95N6088 1	Portable 121.5/243/406 MHz

31 INDICATING & RECORDING						
DESCRIPTION	**P4-HAS (20198)**	**P4-IAS (20188)**	**P4-JAS (20187)**	**P4-KAS (20193)**	**P4-LAS (20195)**	Notes
	Manufacturer / Type / P/N / Quantity					
Recorder-Flight Data (SSFDR)	Allied Signal ---------- 980-4700-042 1	Allied Signal ---------- 980-4700-042 1	Allied Signal ---------- 980-4700-042 1	Allied Signal ---------- 980-4700-042 1	Allied Signal ---------- 980-4700-042 1	100 hrs recording
ACQ Unit-Flight Data	Teledyne 70-251 J 2229765-3A 1	Teledyne 70-251 J 2229765-3A 1	Teledyne 70-251 J 2229765-3A 1	Teledyne 70-251 J 2229765-3A 1	Teledyne 70-251 J 2229765-3A 1	
ACCLRMTR	Patriot Sensors & Controls ---------- 3001-01-111 1	Patriot Sensors & Controls ---------- 3001-01-111 1	Patriot Sensors & Controls ---------- 3001-01-111 1	Patriot Sensors & Controls ---------- 3001-01-111 1	Patriot Sensors & Controls ---------- 3001-01-111 1	
ULB Recorder-Flight Data	Dukane Corp. ---------- DK100 1	Dukane Corp. ---------- DK100 1	Dukane Corp. ---------- DK100 1	Dukane Corp. ---------- DK100 1	Dukane Corp. ---------- DK100 1	
Recorder-Quick Access	Penny & Giles ---------- D51434-1 1	Penny & Giles ---------- D51434-1 1	Penny & Giles ---------- D51434-1 1	Penny & Giles ---------- D51434-1 1	Penny & Giles ---------- D51434-1 1	
Alerter-Integrated	Grimes Aerospace ---------- 80-0590-3-5 1	Grimes Aerospace ---------- 80-0590-3-5 1	Grimes Aerospace ---------- 80-0590-3-5 1	Grimes Aerospace ---------- 80-0590-3-5 1	Grimes Aerospace ---------- 80-0590-3-5 1	

32 LANDING GEAR						
DESCRIPTION	P4-HAS (20198)	P4-IAS (20188)	P4-JAS (20187)	P4-KAS (20193)	P4-LAS (20195)	Notes
	Manufacturer / Type / P/N / Quantity					
Skid Control Unit	ABS ---------- 6004125-2 1	ABS ---------- 6004125-2 1	ABS ---------- 6004125-2 1	ABS ---------- 6004125-2 1	ABS ---------- 6004125-2 1	

34 NAVIGATION						
DESCRIPTION	P4-HAS (20198)	P4-IAS (20188)	P4-JAS (20187)	P4-KAS (20193)	P4-LAS (20195)	Notes
	Manufacturer / Type / P/N / Quantity					
Computer Air Data	Honeywell/Sperry AZ-800 Mod B,C 7000700-933 2	Honeywell/Sperry AZ-800 Mod B,C 7000700-933 2	Honeywell/Sperry AZ-800 Mod B,C 7000700-933 2	Honeywell/Sperry AZ-800 Mod B,C 7000700-933 2	Honeywell/Sperry AZ-800 Mod B,C 7000700-933 2	
REF Unit-Attitude and Heading	Litton Systems LTR81-01 460800-32-30 2	Litton Systems LTR81-01 460800-32-30 2	Litton Systems LTR81-01 460800-32-30 2	Litton Systems LTR81-01 460800-32-30 2	Litton Systems LTR81-01 460800-32-30 2	or 460800-32-31 but not together
Computer-Flight Director	Honeywell/Sperry FZ-500 4018369-905 2	Honeywell/Sperry FZ-500 4018369-905 2	Honeywell/Sperry FZ-500 4018369-905 2	Honeywell/Sperry FZ-500 4018369-905 2	Honeywell/Sperry FZ-500 4018369-905 2	
SW Unit-Instrument	Fokker ---------- F7941-108-428 1	Fokker ---------- F7941-108-428 1	Fokker ---------- F7941-108-428 1	Fokker ---------- F7941-108-428 1	Fokker ---------- F7941-108-428 1	

34 NAVIGATION						
DESCRIPTION	**P4-HAS (20198)**	**P4-IAS (20188)**	**P4-JAS (20187)**	**P4-KAS (20193)**	**P4-LAS (20195)**	Notes
	Manufacturer / Type / P/N / Quantity					
Display Unit (EFIS)	Honeywell/Sperry ED-800 7003110-901 4	Honeywell/Sperry ED-800 7003110-901 4	Honeywell/Sperry ED-800 7003110-901 4	Honeywell/Sperry ED-800 7003110-901 4	Honeywell/Sperry ED-800 7003110-901 4	
Generator-Symbol	Honeywell/Sperry SG-806 7013788-808 2	Honeywell/Sperry SG-806 7013788-808 2	Honeywell/Sperry SG-806 7013788-808 2	Honeywell/Sperry SG-806 7013788-808 2	Honeywell/Sperry SG-806 7013788-808 2	
Receiver-VHF Navigation	Bendix/King VN-411B KPN 066-1101-31FB BPN 3614004-4101FB 2	Bendix/King VN-411B KPN 066-1101-31FB BPN 3614004-4101FB 2	Bendix/King VN-411B KPN 066-1101-31FB BPN 3614004-4101FB 2	Bendix/King VN-411B KPN 066-1101-31FB BPN 3614004-4101FB 2	Bendix/King VN-411B KPN 066-1101-31FB BPN 3614004-4101FB 2	Or 066-1101-31 Mod 21 Or 3614004-4101 Mod 21
Transceiver-Weather Radar	Honeywell/Sperry WU-650 7008470-912 1	Honeywell/Sperry WU-650 7008470-912 1	Honeywell/Sperry WU-650 7008470-912 1	Honeywell/Sperry WU-650 7008470-912 1	Honeywell/Sperry WU-650 7008470-912 1	
Transceiver-Radio Altimeter	Thales Avionics AHV 539A 9599-607-14925 1	Thales Avionics AHV 539A 9599-607-14925 1	Thales Avionics AHV 539A 9599-607-14925 1	Thales Avionics AHV 539A 9599-607-14925 1	Thales Avionics AHV 539A 9599-607-14925 1	

34 NAVIGATION						
DESCRIPTION		P4-HAS (20198)	P4-IAS (20188)	P4-JAS (20187)	P4-KAS (20193)	P4-LAS (20195)	Notes
		Manufacturer / Type / P/N / Quantity					
TAWS		Universal Avionics / Class A / ------ / 1					
TAWS	Comp TAWS	3010-00-00 1	3010-00-00 1	3010-00-00 1	3010-00-00 1	3010-00-00 1	
TAWS	ACCY Assembly	331-91-4100-3 1	331-91-4100-3 1	331-91-4100-3 1	331-91-4100-3 1	331-91-4100-3 1	
TAWS	Config Module	30101 1	30101 1	30101 1	30101 1	30101 1	
Processor-TCAS		Bendix / King TCAS II Version 7 066-01146-1211 1	Bendix / King TCAS II Version 7 066-01146-1211 1	Bendix / King TCAS II Version 7 066-01146-1211 1	Bendix / King TCAS II Version 7 066-01146-1211 1	Bendix / King TCAS II Version 7 066-01146-1211 1	
Interrogator-DME		Bendix / King DM-441B Mod AA 3614019-4401 2	Bendix / King DM-441B Mod AA 3614019-4401 2	Bendix / King DM-441B Mod AA 3614019-4401 2	Bendix / King DM-441B Mod AA 3614019-4401 2	Bendix / King DM-441B Mod AA 3614019-4401 2	
Receiver-ADF		Bendix / King DF-431B Mod A 3614013-4301 2	Bendix / King DF-431B Mod A 3614013-4301 2	Bendix / King DF-431B Mod A 3614013-4301 2	Bendix / King DF-431B Mod A 3614013-4301 2	Bendix / King DF-431B Mod A 3614013-4301 2	
Transponder-ATC Mode S		Bendix / King MST 67A 066-01143-2101 2	Bendix / King MST 67A 066-01143-2101 2	Bendix / King MST 67A 066-01143-2101 2	Bendix / King MST 67A 066-01143-2101 2	Bendix / King MST 67A 066-01143-2101 2	

34 NAVIGATION							
DESCRIPTION		P4-HAS (20198)	P4-IAS (20188)	P4-JAS (20187)	P4-KAS (20193)	P4-LAS (20195)	Notes
		Manufacturer / Type / P/N / Quantity					
FMS Universal Avionics / UNS-1L / 1	Computer Navigation	2116-40-1116 1	2116-40-1116 1	2116-40-1116 1	2116-40-1116 1	2116-40-1116 1	
	Control Display Unit CDU 4"	1117-1-106 1	1117-1-106 1	1117-1-106 1	1117-1-106 1	1117-1-106 1	
	Config Module	11921 1	11921 1	11921 1	11921 1	11921 1	
	GPS/ Glonass Antenna	10706 1	10706 1	10706 1	10706 1	10706 1	
	Data Transfer Unit	DTU-100 1406-01-1 1	DTU-100 1406-01-1 1	DTU-100 1406-01-1 1	DTU-100 1406-01-1 1	DTU-100 1406-01-1 1	
	Relay Shelf Assembly	228-92-1100-5 1	228-92-1100-5 1	228-92-1100-5 1	228-92-1100-5 1	228-92-1100-5 1	
VSI		Honeywell / Grimes Aerospace IVA-81D, IVA-81A 066-01171-3404/ 8-5181-15-5 2	Honeywell / Grimes Aerospace IVA-81D, IVA-81A 066-01171-3404/ 8-5181-15-5 2	Honeywell / Grimes Aerospace IVA-81D, IVA-81A 066-01171-3404/ 8-5181-15-5 2	Honeywell / Grimes Aerospace IVA-81D, IVA-81A 066-01171-3404/ 8-5181-15-5 2	Honeywell / Grimes Aerospace IVA-81D, IVA-81A 066-01171-3404/ 8-5181-15-5 2	
ATC/TCAS Control Panel		Honeywell CTA-81A 071-01503-0201 1	Honeywell CTA-81A 071-01503-0201 1	Honeywell CTA-81A 071-01503-0201 1	Honeywell CTA-81A 071-01503-0201 1	Honeywell CTA-81A 071-01503-0201 1	
Radio Altimeter		Thales Avionics ----------	Thales Avionics ----------	Thales Avionics ----------	Thales Avionics ----------	Thales Avionics ----------	

Antenna	9599-607-12338 2	9599-607-12338 2	9599-607-12338 2	9599-607-12338 2	9599-607-12338 2	

22 AUTO FLIGHT				
DESCRIPTION	**A321** **P4-NAS** **(1042)**	**A321** **P4-OAS** **(1204)**	**A319** **P4-YAS** **(3614)**	Notes
	Manufacturer / Type / P/N / Quantity			
Flight Management Guide Computer	Thales/Smiths ---------- C13043BA03 2	Thales/Smiths ---------- C13043BA03 2		
Flight Augm. Computer	Thales ---------- B397BAM0515 2	Thales ---------- B397BAM0515 2		
MCDU	Thales ---------- C19266AA01	Thales ---------- C19266AA01		
Flight Control Unit	Sextant Avionique ---------- K217ABM11 1	Sextant Avionique ---------- K217ABM11 1		

23 COMMUNICATIONS				
DESCRIP-TION	**A321** **P4-NAS** **(1042)**	**A321** **P4-OAS** **(1204)**	**A319** **P4-YAS** **(3614)**	Notes
	Manufacturer / Type / P/N / Quantity			
Audio Control Panel	Team ---------- ACP2788AB04 3	Team ---------- ACP2788AB04 3		
Audio Management Unit	Team ---------- AMU2790CB06 1	Team ---------- AMU2790CB06 1		
Panel Selcal	?	?		
CIDS Director	---------- Z010H0005119 (8) 2	---------- Z010H0005119 (521A) 2		
CAM Cabin Assignment	Z050H6034040	Z050H6034040		
FAP		---------- Z130H0822110		
Program and Test Panel (PTP)	KID-SYSTEM ---------- Z020H0001112 1	KID-SYSTEM ---------- Z020H0001112 1		

23 COMMUNICATIONS				
DESCRIP-TION	**A321**	**A321**	**A319**	Notes
	P4-NAS (1042)	**P4-OAS (1204)**	**P4-YAS (3614)**	
	Manufacturer / Type / P/N / Quantity			
HF Transceiver	Collins ---------- 622-5272-020 1	Collins ---------- 622-5272-020 1		
VHF Transceiver	Collins ---------- 822-1047-020 3	Collins ---------- 822-1047-020 3		
Radio Management Panel (RMP)	Thales ---------- 899-0850-004 2	Thales ---------- 899-0850-004 3		
Cockpit Voice Recorder	Honeywell ---------- 980-6022-001 1	Honeywell ---------- 980-6022-001 1		
PRAM	Panasonic ---------- RD-AX7673-10	Panasonic ---------- RD-AX7673-10		
CD Player Seat Entertainment	Panasonic ---------- RDAX7095-01	Panasonic ---------- RDAX7095-01		

23 COMMUNICATIONS				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
Airshow DIU	----------	----------		
Main Multiplexer	Panasonic ---------- RDAX1301-1D 1	Panasonic ---------- RDAX1301-2E 1		
Video System Control Unit	Panasonic ---------- RDAV3007-02 1	Panasonic ---------- RDAV3007-02 1		
Video Player	Panasonic ---------- RDAV1216-01 1	Panasonic ---------- RDAV1216-01 1		

27 FLIGHT CONTROLS				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
Spoiler Elevator Computer (SEC)	Thales ---------- B372BAM0508 (9) 3	Thales ---------- B372BAM0509 3		
Flight Control Data Concentrator (FCDC)	Litef Litton ---------- 115370-0106 2	Litef Litton ---------- 115370-0106 2		
SFCC		Avionics Ltd. ---------- 49-170-11 GEC 49-117-07		
Elevator Aileron Computer (ELAC)	Thales ---------- 3945123608 2	Thales ---------- 3945123608 2		

28 FUEL				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
FQIC	BFG / Sextan / Simmonds ---------- B539AAM0307	BFG / Sextan / Simmonds ---------- B539AAM0206		
Control Unit Level	Simmonds Precision ---------- 30042-0000-0501	Simmonds Precision ---------- 30042-0000-0501		

Sensing	2	2		
31 INDICATING AND RECORDING				
DESCRIP-TION	**A321** **P4-NAS** **(1042)**	**A321** **P4-OAS** **(1204)**	**A319** **P4-YAS** **(3614)**	Notes
	Manufacturer / Type / P/N / Quantity			
CFDIU	Sfena ---------- B401ACM05-07	Sfena ---------- B401ACM05-07		
FDIMU (FDIU)	SAGEM/SFIM ---------- ED43A1D5	SAGEM/SFIM ---------- ED43A1D5		
DMU	Teledyne ---------- 795040-31-003	Teledyne ---------- 795040-31-003		
Digital Aid Recorder (QAR)	Penny & Giles ---------- D52000-62000 1	Penny & Giles ---------- D52000-62000 1		
MDDU		----------		
Clock	GMT4200 1	2610-13-1 1		
Flight Warning Computer (FWC)	Airbus France ---------- 350E018312020 2	Airbus France ---------- 350E018312020 2		
SDAC	Airbus France ---------- 350E5151331 2	Airbus France ---------- 350E5151331 2		
Display	Thales ----------	Thales ----------		

Unit	3907130402 6	3907130402 6		

31 INDICATING AND RECORDING				
DESCRIP-TION	**A321** **P4-NAS** **(1042)**	**A321** **P4-OAS** **(1204)**	**A319** **P4-YAS** **(3614)**	Notes
	Manufacturer / Type / P/N / Quantity			
Printer Multi Use	Honeywell ---------- 8055515-4501 1	Honeywell ---------- 8055515-4501 1		
Display Management Computer (DMC)	Thales ---------- 9615325032 3	Thales ---------- 9615325032 3		
Solid State FDR (SSFDR)	Honeywell ---------- 980-4700-003 1	Honeywell ---------- 980-4700-003 1		

32 LANDING GEAR				
DESCRIP-TION	**A321** **P4-NAS** **(1042)**	**A321** **P4-OAS** **(1204)**	**A319** **P4-YAS** **(3614)**	Notes
	Manufacturer / Type / P/N / Quantity			
Brake Steering Control Unit	Messier-Hispano-Bugatti ---------- C202163382D32 1	Messier-Hispano-Bugatti ---------- C202163382D32 1		

34 NAVIGATION				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
Antenna GPS active				
Multi Mode Receiver (MMR)	Collins ---------- 822-1152-121 2	Collins ---------- 822-1152-121 2		
T2CAS		----------		
TCAS II Computer	Honeywell ---------- 066-50000-2120 1	Honeywell ---------- 066-50000-2120 1		
Transponder Mode S	Collins ---------- 822-1338-021 2	Collins ---------- 822-1338-021 2		
ATC-TCAS Control Unit	Thales ---------- C12404AB02 1	Thales ---------- C12404AB02 1		
ADF Receiver	Honeywell ---------- 066-50014-0202	Honeywell ---------- 066-50014-0202		

	2	2		

34 NAVIGATION				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
WX Radar Transceiver	Honeywell ---------- 066-50008-0405 1	Honeywell ---------- 066-50008-0407 1		
WX Radar Control Panel	Honeywell ---------- 2041223-0424 1	Honeywell ---------- 2041223-0424 1		
DME Interrogator	Collins ---------- 622-4540-023 2	Collins ---------- 622-4540-023 2		
VOR Marker Receiver	Honeywell ---------- 066-50012-0212 2	Honeywell ---------- 066-50012-0212 2		
ADIRU	Northrop Grumman ---------- 465020-0303-0315 3	Northrop Grumman ---------- 465020-0303-0315 3		
Control Display Unit (CDU) ADIRS	Northrop Grumman ---------- 465010-0300-0300 1	Northrop Grumman ---------- 465010-0300-0300 1		

34 NAVIGATION				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
VOR / DME RMI	Thales ---------- 63543-150-4 1	Thales ---------- 63543-150-4 1		
Count / Point STBY Altimeter	Thales ---------- 64141-590-1 1	Thales ---------- 64141-590-1 1		
Air Speed Indicator	Thales ---------- 64050-866-1 1	Thales ---------- 64050-866-1 1		
STBY HORIZON Indicator	Thales ---------- H321BHM1 1	Thales ---------- H321BHM1 1		
ISIS	----------	----------		
Radio Altimeter	Thales ---------- 9599-607-14942 2	Thales ---------- 9599-607-14942 2		
EGPWC	Honeywell ---------- 965-0976-003-206-206 1	Honeywell ---------- 965-0976-003-206-206 1		

46 INFORMATION				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
ATSU				

52 DOORS				
DESCRIP-TION	A321 P4-NAS (1042)	A321 P4-OAS (1204)	A319 P4-YAS (3614)	Notes
	Manufacturer / Type / P/N / Quantity			
Cockpit Door System Control				

KLM Aircraft

Aircraft Type	Number	Data Link	RNAV/RNP
B 747-400	22	X	X
B 747-400ER Freighter	3	X	X
B 777-300ER	2	X	X
B 777-200ER	15	X	X
MD 11	10		X
A 330-200	10	X	X
B 737-900	5	X	X
B 737-800	21	X	X
B 737 400/300	13		X
Fokker 100/70	20		X
Fokker 50	14		X

Lufthansa Aircraft

Aircraft Type	Number	Data Link	RNAV/RNP
B 747-400	30	X	X
A 340-600	20	X	X
A 340-300	28	X	X
A 330-300	14	X	X
A 300-600	13	X	X
A 321	31	X	X
A 320	36	X	X
A 319	20	X	X
B 737-300	33	X	X
B 737-500	30	X	X
Avro RJ 85	18		X
CRJ 900	12		X
CRJ 700	20		X
CRJ 100/200	22		X
MD 11F	19	X	X

ATTACHMENT 3

COMMON REQUIREMENTS FOR ANS PLANNING AND DEVELPOMENT

N	Requirement	Need description	Applies to service	Domain	To be addressed
1.	The Users see a need to provide a 'pull' strategy to provide the incentive for the shortest transition period possible (simultaneous support of old and new functionality)	The Users see a need to provide a "pull" strategy to provide the incentive for the shortest transition period possible.	ANS Planning & Development	Evolving	Ensure Cost Effective System Inter-Operability and Evolution Mandating versus Incentive
2.	Mandating avionic capabilities must be on the basis of global standards in order to cater for the interoperability of aircraft flying into or coming from regions outside Europe	Mandating avionic capabilities must be on the basis of global standards in order to cater for the interoperability of aircraft flying into or coming from regions outside Europe.	ANS Planning & Development	Inter-operability	General Uniformity
3.	Mandating should be in terms of capabilities and not in terms of equipment	The Users wish to see a policy in which all mandatory equipage requirements are replaced by mandatory capability required, such as RNP. *Note: The choice of equipment must be left with the Users, provided the equipment meets the required performance specifications. This is ensured by certification.*	ANS Planning & Development	Principles of Treatment	Mandating versus Incentive

4.	Mandatory capabilities at certain locations are accepted if a clear plan is available and adequate C/B ratio benefits have been demonstrated	Care must be taken by the service providers to avoid unnecessary mandating. *Note: Mandatory capabilities at certain locations are accepted if a clear plan is available and adequate C/B ratio benefits have been demonstrated. Users must be kept informed of all developments and timescales to enable them to tailor their equipage programmes to suit the particular needs for particular routes/destinations.*	ANS Planning & Development	Principles of Treatment	Mandating versus Incentive
5.	CNS systems for wholly aviation use should be avoided where possible; this will allow costs to be shared by all Users. Cost recovery should occur as benefits are received	This requirement addresses specific charging issues raised by the implementation of CNS/ATM. Although this is a new environment, all basic IATA / ICAO principles such as non-discrimination, cost relationship, financial transparency, etc. should still be adhered to. It should be emphasized that the goal of CNS investment is an improved ATM that will result in operational efficiencies to the civil aviation community. Investments should be timed so that cost recovery will occur as benefits are received. Systems for wholly aviation use should be avoided where possible; this will allow costs to be shared by all Users. Since there are already systems in place that can provide a global service, no State, group of States or service provider, should MANDATE that airlines use	ANS Planning & Development	Principles of Treatment	Cost Reduction

		or pay for duplicate systems. *Note: IATA supports global or regional co-ordination in research and development to avoid unnecessary duplication of effort with associated costs.* *IATA supports competition between service providers. However, there may be circumstances where more than a single system will not be economically viable.* *IATA encourages States or providers of CNS/ATM services to carry out cost benefit studies to ensure the most cost effective option and implementation method. Airlines must be involved in all cost benefit studies. The IATA User Charges Panel (UCP) ICAO / FANS Working Group is still considering a number of issues which may have to be included in a more detailed supplementary paper to this policy statement.*			
6.	Communications, Navigation and Surveillance systems have to be developed within a single coherent framework to more aggressive timescales	None	ANS Planning & Development	Timeliness	Ensure Cost Effective System Inter-Operability and Evolution
7.	Decisions on mandating retrofit of airborne equipment capabilities must be based on cost/benefit analysis	Decisions on mandating retrofit of airborne equipment capabilities must be based on cost/benefit analysis.	ANS Planning & Development	Evolving	Cost Reduction

8.	The combination of equipage requirements and benefits should be such that operators are naturally invited to upgrade. This is preferred over the method of imposing or mandating equipment/capabilities	The combination of equipage requirements and benefits should be such that operators are naturally invited to upgrade. This strategy is preferred over the method of imposing or mandating equipment/capabilities. *Note: The transition plan should create incentives (such as RNAV SIDS and trunk routes) for aircraft with advanced avionics capabilities.*	ANS Planning & Development	Evolving Principles of Treatment	Mandating versus Incentive
9.	Need for proper user guidance, public funding and professional implementation management for accelerated standardization and certification of available CNS technologies	Background: When the FANS Committee finalized its CNS definition task (1988) it could not assess the rapid developments and possibilities GNSS is offering today. One can for example mention the cellular CNS, which was derived from the FANS-GNSS concept by the Swedish government. Due to continued development, such an advanced technology may (in the long run) turn out to have better functionality and be more cost effective than say, TCAS and Mode S. The user community should not be deprived from the benefits of existing advanced CNS technologies due to a lack of standardization or certification. The accelerated standardization and certification of available technologies and interfaces is essential to bring their benefits in time and to safeguard the economic benefits of these technologies which have mostly been funded by taxpayers through the various	ANS Planning & Development	Standardization & Certification	Ensure the Availability of Common Standards

		defense budgets. Description: Proper user guidance, public funding and professional implementation management is needed to enable the accelerated standardization and certification of available advanced CNS technologies.			
10.	The ATM transition plan should be coordinated with the aircraft operator plans, such that new airborne capabilities are matched by corresponding ground system functionality in the same time frame	In certain cases, aircraft operators may take the lead in equipping their aircraft with advanced equipment. To let those users take advantage of their investment, it is essential that the transition plan should be coordinated with the aircraft operator plans, such that new airborne capabilities are matched by corresponding ground system functionality in the same time frame.	ANS Planning & Development	Evolving	Ensure Cost Effective System Inter-Operability and Evolution
11.	The development of a strategy and transition path towards the needs to be done cooperatively between service providers and airspace users	At this moment, the users find it difficult to identify milestones in detail. When asked which milestone would be the most significant one to them, the answer was: the application of data link for ATC purposes. The definition of milestones for the development of the future will need to be done when the development process is laid down in more detail in agreement between providers and users.	ANS Planning & Development	Evolving	Ensure Cost Effective System Inter-Operability and Evolution

THE REQUIREMENTS FOR ATM

#	Need	Need description	Applies to service	Domain	To be addressed
12.	The operators who have invested in advanced equipment for their aircraft shall be entitled to receive adequate benefits	The operators who have invested in advanced equipment for their aircraft shall be entitled to receive adequate benefits. The foregoing implies a certain preferential treatment of advanced users over conventional users (e.g. preferential trajectories for advanced users).	ATM (Air Traffic Management)	Principles of Treatment	Mandating versus Incentive
13.	The future ATM system has to be based on a benefit-driven approach supported by clear business cases and must incorporate measurable performance targets	None	Air Navigation Services	Quality Assurance	Economy Principle, Performance-Driven Approach
14.	Certain services like AIS, MET, ARO should be integrated to improve the efficiency of these services to the users.	Certain services like AIS, MET, ARO should be integrated to improve the efficiency of these services to the users.	AIS, MET & Flight Plan Processing Services	Integration	Ensure Cost Effective System Inter-Operability and Evolution. Information Dissemination Capabilities

THE REQUIREMENTS FOR COST RECOVERY

N	Need	Need description	Applies to service	Domain	To be addressed
15.	The long-term expectations regarding charging principles can be found in a number of ICAO and IATA documents.	The IATA long-term expectations regarding charging principles are contained in the applicable ICAO and IATA documents.	Cost recovery	Principles of Treatment	Pricing Management
16.	The charging system for CNS/ATM should be nondiscriminatory and cost related, containing a movement related element to cover fixed costs, and a time in the system element to cover variable costs	This requirement addresses specific charging issues raised by the implementation of CNS/ATM. Although this is new environment, all basic IATA / ICAO principles such as non-discrimination, cost relationship, financial transparency, etc. should still be adhered to. Aspects of CNS/ATM, such as the Global Navigation Satellite System (GNSS) basic signal, which provide benefits to a multitude of users are a public good and costs should be borne by States. The charging system for CNS/ATM should be non-discriminatory and cost related. Therefore, it is important that the charging system contain the following elements: - a movement related element to cover fixed costs. - a time in the system element to cover variable costs. Any change to the charging system should take into consideration the recognized ICAO principle of	Cost Recovery	Principles of Treatment	Pricing Management

		gradualism.			

COMMERCIAL AIR TRANSPORT NEEDS FOR ATM

N	Need	Need description	Applies to service	Domain	To be achieved
17.	A route and airspace structure must be established which is not affected by national borders but is derived solely from the airspace users' operational requirements.	The objective of ATM is to maximize, within a given airspace structure, the utilization of available airspace by dynamic time-sharing and, at times, segregation of airspace among various categories of users based on short-term needs. As a prerequisite for the efficient use of airspace, a route and airspace structure must be established which is not affected by national borders but is derived solely from the airspace users' operational requirements.	ATM	Efficiency	One Airspace Principle
18.	ATM should attempt to minimize the environmental impact of air traffic by providing flexibility which allows as many optimal trajectories, defined by the operator, as possible.	There should be an attempt to minimize the environmental impact of air traffic by providing a flexible system that allows as many optimal trajectories, defined by the operator, as possible.	ATM	Flexibility Optimization	Flight Efficiency Supplementary Environment Objectives
19.	ATM should be able to handle a mixture of aircraft equipment. However the lowest capability aircraft should not impose the Quality of Service (QoS) for all.	There should be specifically designed procedures to handle a mixture of aircraft equipment. However the lowest capability aircraft should not impose the Quality of Service (QoS) for all.	CNS/ATM	Principles of Treatment	Define a 'service levels' policy. Fair access to Airspace,

					airports, ATM Services.

COMMERCIAL AIR TRANSPORT NEEDS FOR COMMUNICATION

#	Need	Need description	Applies to service	Domain	To be addressed
20.	The principle of 'no routine voice' communications should apply to all flight phases (ground/ground and air/ground communications)	There is a user requirement to eliminate as much voice communication as possible. There should be no routine voice communications (the "silent cockpit"). The principle of "no routine voice" communications should apply to all flight phases (ground/ground and air/ground communications). *Note: In addition, the pilot wants as few frequency changes as possible and expects the ground ATC system to have total knowledge of his pre-departure and departure plans and requests.*	COM	Workload	Communication Capabilities. Human Involvement and Commitment
21.	The Users want mechanisms to ensure that emergency related message exchanges (on whatever communication medium) have priority over all other communications	The generic requirement is to accommodate the needs of the users to communicate emergency status and future aircraft intentions through various means such as voice (VHF/ HF), ADS, Datalink, etc. The users want mechanisms to ensure that emergency related message exchanges (on whatever communication medium) have priority over all other communications. Emergency related messages could be exchanged manually or	COM	Safety	Communication Capabilities. Information Acquisition Capabilities

		automatically. Users do not want all emergency warnings in the cockpit to reach ATC; they need a priority button, filter to request special service. The existing (manual) squawk capability (7700 code) should co-exist with electronic means to inform ATC of abnormal condition. All Users express the need for protection of the emergency VHF/HF frequency.			
22.	The Users would not like to see datalink as a simple substitution of current voice communication procedures	The Users would not like to see datalink as a simple substitution of current voice communication procedures. The real benefits will come from introducing new procedures taking advantage of the special capabilities of datalink.	COM	Efficiency	Information Acquisition Capabilities. Information Dissemination Capabilities
23.	Efficient coding and data compression techniques must be used for transferring weather data between air and ground	Air-ground data transfer must be minimized for reasons of cost and technology. Ensure that, without loss of effective information, the volume of the products, which have to be transmitted to aircraft, is reduced to a minimum. Note: Minimizing air ground data transfer is a necessity because that is the expensive part of the transmission. This could be improved (with regard to the present situation) by using binary codes in place of alphanumeric ones. Minimizing data transfer can be achieved by using a standard, efficient, binary code such as WMO GRIB.	COM	Optimization	Information Dissemination Capabilities

24.	Users express the desire to implement the 4D profile communication capability via datalink early in the ATM transition schedule	Users express the desire to implement the 4D profile communication capability via datalink early in the implementation programmed.	ANS Planning & Developme nt	Evolving	Ensure Cost Effective System Inter-Operability and Evolution

GENERAL AVIATION NEEDS FOR COMMUNICATION

N	Need	Need description	Applies to service	Domain	To be addressed
25.	Mandating should be in terms of capabilities and not in terms of equipment	The GA Users do not want equipment types imposed on them. Functional requirements should be not avionics (e.g. RNP).	CNS/ATM Services	Principles of Treatment	General Uniformity
26.	GA operators are seeking simple (low cost) communications means with ATM. A voice communications capability should always be available	GA operators are seeking simple (low cost) communications means. A voice communications capability should always be available.	COM	Efficiency	Communication Capabilities

COMMERCIAL AIR TRANSPORT NEEDS FOR NAVIGATION

N	Need	Need description	Applies to service	Domain	To be addressed
27.	Users regard the Global Navigation Satellite System (GNSS) as the future navigation infrastructure	Users regard the Global Navigation Satellite System (GNSS) as the future navigation infrastructure.	Navigation Services	Principles of Treatment	Navigation and Clock Synchronization Capabilities

COMMERCIAL AIR TRANSPORT NEEDS FOR SURVEILLANCE

N	Need	Need Description	Applies to service	Domain	To be satisfied
28.	A-SMGCS is needed at major airports.	The Users believe that the implementation of A-SMGCS at major airports will significantly improve the fluidity of traffic between airspace and the ground. The A-SMGCS should: - provide adequate situational awareness of aircraft, vehicles and personnel on the airport; - ensure safe operation of aircraft/vehicle by means of routing guidance and control to prevent runway incursion; - ensure efficient use of the airport movement area; - maintain capacity in all weather conditions that are operationally relevant, i.e. affecting regularity.	SUR	Capacity. Efficiency. Poor Weather Conditions. Safety. Situational Awareness.	Best Use of Available Airport Capacity
29.	From an information point of view, A-SMGCS should be fully integrated with the rest of the ATM system	An integration of A-SMGCS and ATM is required as a tool to keep the availability of a common flow of information exchange, in order to provide an efficient management of airport operations.	SUR	Integration	Ensure Cost Effective System Inter-Operability and Evolution. Information Acquisition

					Capabilities
30.	As much as possible, the pilot in command and the controller should have independent situational awareness (for flight safety reasons)	As much as possible, the pilot in command and the controller should have independent situational awareness (for flight safety reasons). In other words, scenarios should be avoided where ground and air exchange incorrect situation data and build upon each others errors.	ATC	Situational Awareness	ATM Information Pool Management
31.	Pilots want access to the right traffic information (onboard) in order to take emergency actions and avoid other traffic	The pilot needs access to the right traffic information (on-board) in order to take emergency actions and avoid other traffic. Note: Users see a benefit to TCAS/ACAS type of equipment or collision avoidance systems (CAS's) based on a cooperative approach as a safety net. TCAS/ACAS are essentially airborne. New CAS's (cooperative) can be envisaged taking advantage of any or more: - GNSS positioning; - broadcast of position information via a datalink; air/ground datalink that ensures consistency of information.	SUR, NAV	Safety. Situational Awareness	Responsivenes s to Information needs

COMMERCIAL AIR TRANSPORT AND GA METEOROLOGICAL NEEDS

N	Need	Need description	Applies to service	Domain	To be addressed
32.	Users ask for a capability to provide Met. information to aircraft in flight via datalink	Meteorological data are a key element to aircraft operations. They have a direct impact on: - safety - operational procedures - economic efficiency - regularity - passenger comfort Positive effects can be: - Flying an aircraft in tail wind conditions, at the optimum level. The reduction in fuel consumption and flight duration will provide for an immediate economic return. - Operating in smooth, good weather conditions will reduce the risk of damage to the aircraft and insure passenger comfort and safety giving commercial credit to the company. Adverse effects are unfortunately more common and cost companies even more: - A significant number of fatalities occurring in aviation take place in adverse weather conditions. - Weather effect is a factor in numerous equipment failures inducing extra maintenance cost. - The need for operational procedures and aircraft equipment to cope with all significant weather phenomena (meteors, icing,	MET, FIS	Accuracy, Availability, Integration, Meteorological Conditions, Standardization	Information Dissemination Capabilities

		crosswind, turbulence, windshear, low level temperature inversion, etc.) induces training, maintenance, operational costs (e.g. to deice an aircraft on the ground costs money, using on-board anti-ice systems during a flight encounter will increase fuel consumption). It is essential to know the value of all meteorological parameters, which need to be taken into account for a safe, profitable flight. At the moment this knowledge can be obtained at the early preparation stage and through periodical updates provided by the various AIS services. This leaves pilots with a sketchy perspective and sometimes with little time to plan alternative action in case of significant weather change at destination. In the context of the introduction of air/ground datalink there is an opportunity to increase pilots' situational awareness by sending MET data directly to the cockpit using uplink functions. Real time information on adverse weather conditions, wind strength and direction, outside temperature along the planned aircraft trajectory will be of great use to any pilot. Users should be provided with the necessary SIGMET information and aerodrome METARS and TAFS. If required by the operators, these should be available through data link. In order to provide the necessary accuracy, aircraft flight management systems may require an update of the upper air (wind and temperature) data. In this case the data should be in a form suitable for direct loading into the aircraft FMS.			
33.	GA operators without weather radar desire the in-flight	Some General Aviation Users want the capability of having weather data information on e.g. cumulonimbus formations (VOLMET,	FIS, MET	Integration	Information Dissemination

	capability to receive graphical weather information via datalink	SIGMET) transmitted from the ground to on-board weather display equipment (moving maps). There is a need for standards for such displays. This GA requirement differs from commercial air transport carriers which rather use their on-board weather radars. SIGMET/VOLMET information should be made available on voice for VFR pilots.			Capabilities

REQUIREMENTS, EXPRESSED BY IATA

During the annual IATA RTCs, the IATA members agreed on various requirements to CNS/ATM. Some of these requirements are included into the study as they are in-line with ICAO CNS/ATM Concept.

> *Note: The numbering of these requirements is continued from the previous paragraph.*

34.	To support the need for an urgent development of all necessary studies required to enable the development and implementation of GNSS based precision approach systems;
35.	To support the need for mandating RNAV in individual TMAs, only when and where it is proven to be beneficial;
36.	To urge all States to enable the full utilization of aircraft B-RNAV capabilities at all lower levels by implementing appropriate airspace structures;
37.	To support the need for the development, in close co-ordination with the airspace Users, of all studies required for the decision on a mandatory carriage of RNAV RNP 1 MASPS compliant equipment;
38.	That because of the complex nature of the 4D operations, to support the need for coordinated and synchronized development and implementation plans for all the elements of the ATM system;
39.	To support the need for the urgent development of navigation infrastructure rationalization plans to ensure a safe, short and cost-effective transition to GNSS systems in the long term
40.	To support the need for the urgent development of navigation infrastructure rationalization plans to ensure a safe, short and cost-effective transition to GNSS systems in the long term;
41.	That unique Regional requirements should be avoided
42.	That all be requested to work towards common implementation plans in conformance with ICAO standards
43.	That additional efforts be expended by the States and by IATA on CNS/ATM Implementation Plans, coordinated to bring about the necessary commonality.

CNS/ATM Development Requirements

BACKGROUND

Objective

The objective of Task 7 is to determine the CNS/ATM (Communications, Navigation, Surveillance, and Air Traffic Management) development requirements to satisfy current and future upper and lower airspace operations for the participating states and the region. In completing this task, DORS (DORS International) will identify the technologies and systems or combination of systems, to meet the airspace service provider and airspace user requirements as identified in previous Task reports.

DORS will analyze the capabilities of prospective systems, and provide an evaluation of the key technologies that are identified in this document. We also will identify requirements and provide a list of options for consideration. Equipment and system benefits that can be expected from implementing a regional approach will be highlighted. Finally, we will evaluate the CNS/ATM systems and equipment that are relevant for the region and will meet airspace user and service provider requirements.

FUTURE SYSTEMS

The contractor has been tasked to identify possible technologies, systems, or a combination of systems that fulfill future functional requirements for all airspace operations. Therefore, we have listed the potential CNS/ATM components that may be used in both a single state and regional approach. From these lists we have identified the possible technologies that meet the functional requirements and can be used both in the upper and lower airspace.

Communications

The following communication systems have been identified as options for the provision of services for all airspace operations:

- The use of VHF (Very High Frequency) communications in VHF coverage areas; Service that supports non-routine voice in areas outside VHF coverage (e.g. remote);
- Direct mobile communications (air-ground) for routine ATS (Air Traffic Service) communications including CPDLC (Controller-Pilot Data Link Communications) via VDL (VHF Data Link), AMSS (Aeronautical Mobile Satellite System), HF (High Frequency); and ADS (Automatic Dependent Surveillance);
- Fixed communications (Ground-Ground) coordination for adjacent FIR (Flight Information Region), Approach Control, Meteorology, etc;
- VCCS (Voice Communications Control System) for mobile and fixed communications – fully digital;
- VSAT (Very Small Aperture Terminal) Network;
- Mobile communications data integration for FANS (Future Air Navigation System)1/A; and

- ACC interface with X.25 interface to ACARS (Aircraft Communications Addressing and Reporting System) and to access ADS/CPDLC.

From the communication technologies outlined above, we have identified the following communication technologies that meet the lower airspace requirements:

VHF in the VHF coverage area – VHF communications are reliable two-way, air-ground communications that have been used in ATC (Air Traffic Control) for many years. It is a mature system and is in operation world-wide. Unfortunately, it is a line-of-sight system which means most states require several transmitter and receiver sites to maintain constant communications over their airspace. The lower altitude will require VHF communications for tower, approach control, and limited en route operations. It is necessary for aircraft to communicate with the ATC facilities in and around the airport. Constant two-way communications in the lower airspace is not an absolute requirement.

Mobile Communications (CPDLC, VDL, AMSS, HF, ADS) – Satellite and data link communications, while nice to have, are not a requirement in the lower airspace, with the exception of on and around major terminals. Satellite communications (AMSS) are not required in the lower airspace. HF communications have been in operation for many years and will probably remain there for several more years. HF is used both as an air-ground system and ground-ground system. For those ATC facilities that have limited en route VHF, HF provides a reasonable alternative air-ground system in non-VHF areas and can be used to back-up VHF communications when they fail.

CPDLC has not proven to be the time-saving communication system originally recommended by ICAO (International Civil Aviation Organization), although it has met with success on the airport to provide PDC (Pre-departure Clearance) and D-ATIS (Digital Automatic Terminal Information Service). Due to the improving VHF and radar coverage throughout the world, CPDLC is only being used occasionally in the en route environment for routine messaging. At present, PDC and D-ATIS are the only operational services being provided by CPDLC and they are in use at many of the major airports world-wide. CPDLC would not be recommended for the lower airspace operations. However, the use of data links for AIS (Aeronautical Information Service), FIS (Flight Information Service), and ADS would be highly recommended.

Fixed Communications for Adjacent FIRs, Approach Control, Meteorology, etc – The requirement for ground-ground communications is paramount in both the upper and the lower airspace. At present, most of the coordination is accomplished with HF, direct voice through the use of the VSAT network, and the public telephone network. The most logical ground-ground system would be an ATN (Aeronautical Telecommunications Network) interfaced with an ATM (Air Traffic Management) system, backed-up by the VSAT voice network. All inter- and intra-facility coordination can be accomplished with an ATM system.

Generally, a radar system has many of the capabilities of an ATM system particularly in the transfer of ATC information, clearances, and flight data. One ATM system, interfaced with the ATN, located at a central facility could provide flight plan data processing, inter- and intra-facility coordination, and the transfer of flight information between most ATC facilities within the region and between the central facility and adjacent FIRs, and between lower airspace ACCs (Area Control Center) and adjacent ACCs and FIRs.

Meteorological data can be disseminated between facilities in like manner. The ATN is slowly coming on line. An ATN routers have been developed and is in the marketplace now.

VCCS - The VCCS is a computer–controlled system that provides air traffic controllers with the means to establish all voice circuits necessary for ATC operations. The VCCS may not be required for all lower airspace ATC facilities, but consideration should be given for VCCS implementation at those major airports that provide radar approach control service and provide substantial ATC services to those aircraft transitioning to and from the upper airspace. Push button, direct communications is required in those facilities with moderate or above traffic conditions.

VSAT Network - The VSAT Network provides two essential services; ATS/Direct speech circuits with neighboring FIRs and AFTN (Aeronautical Fixed Telecommunications Network) interconnections with neighboring countries. The VSAT network can be designed as a carrier for all aeronautical services, both old and new, to include ATS/DS (Air Traffic Service/Direct speech), AFTN, VHF, Radar, ADS-B, ATN, and GNSS. A key function of a VSAT network could be remote VHF services in under-serviced areas.

Navigation

At present satellite navigation is emerging as a primary method of navigation throughout the world. The global trend is to move towards RNAV (Area Navigation) supported by DME/DME (Distance Measuring Equipment), GNSS (Global Navigation Satellite System), or FMS (Flight Management system) utilizing INS/IRS (Inertial Navigation System/Initial Reference System). VOR/DME (VHF Omni-directional Range/Distance Measuring Equipment) navigation will likely remain, but as satellite navigation matures, the ground-based aids will become a redundant navigational system. Low-end aircraft, i.e., small single engine and older twin-engine aircraft may continue to use ground-based aids for a few more years, but the majority of the aircraft will use satellite navigation and/or FMS navigation. Many aircraft have already transitioned to satellite navigation and/or have a satellite navigatioin capability to RNP .3.

There remains a policy to maintain and replace NDBs (Non-directional Beacons). NDBs have been a primary element of navigation for many years and appears to remain important to all states. NDBs are generally inexpensive, considerably easier to maintain, and are a part of the instrument landing system. NDBs can provide en route navigation to back-up VOR/DME navigation when the VOR/DME fails or to provide a non-precision approach to the neighboring airport. However, NDBs provide a low level of navigation (limited accuracy) and are being decommissioned in most countries. GNSS provides a more accurate navigation standard, requires no maintenance by the country, covers all airspace in each country, and cost the provider nothing.

The lower airspace must focus on the use of landing and departure aids for their airports to support the en route high end aircraft. Most major airports have ILS (Instrument Landing System) capability to provide precision approaches. Other non-precision approaches are provided by VOR/DME and NDB. However, many states are moving toward the ICAO recommendation for using GNSS. In general, GNSS non-precision approaches (NPAs) are more accurate then any other NPA, and require only the

development of the approach by the provider. The approach is flight inspected one time and then only a signal-in-space check is required. Additionally, states should consider the use of APV-I/II (NPA with Vertical Guidance) approaches which can provide a NPA with vertical guidance to any airport. These approaches have approved SARPS (Standards and Recommended Practices) and provide minimums near that of a CAT-I (Category I) precision approach.

The trend in en route navigation in the upper and lower airspace should be satellite navigation or GNSS. Today augmented GNSS has been approved as a sole means of navigation in many countries and should be approved for sole means in Central Asia. GNSS, supported by the GPS (Global Positioning System) is available over the entire region with more than 5 GPS satellites in view at any one time. There is no cost for this service and the cost of the receiver is borne by the user. The approval and use of GNSS will provide enhanced navigation in both en route and terminal areas, and reduce the cost to the service providers of providing ground-based navigation services within their airspace.

Non-precision approaches will likely continue to be provided by VOR/DME, NDB, and GNSS. However, as time moves on, the trend will be toward satellite navigation with lesser dependence on ground-based aids including ILS. NDBs have passed their time and a decommissioning process should begin for NDBs, especially if satellite navigation is used.

Surveillance

The primary surveillance system is radar. The current radar coverage is limited. For the most part, we believe that airspace operations could be provided the additional surveillance coverage they need with ADS-B (Broadcast). The number of aircraft transiting through each state's airspace below FL (Flight Level) 240 appears minimal and would not justify the expense of ADS-C (Contract); however, ADS-B could serve as a surveillance tool for both terminal airspace and for en route/terminal transitioning services, as well as to provide ground surveillance on and around the airport. Additionally, ADS-B may be used for limited en route services if and when it is certified for en route use. If additional radar systems are procured, ADS-B/C would continue to be used to enhanced radar coverage and as a back-up surveillance system when radar fails. With the improved VHF coverage pilot reports would continue to be the backup for both radar and ADS.

CAPABILITIES OF PROSPECTIVE SYSTEMS

Task 7 requires the contractor to identify and evaluate future technologies and systems, or combination of systems that fulfill operational airspace requirements. This will include a review of communications, navigation, and surveillance technology and systems, as well as air traffic management initiatives. Even though some of these initiatives may not be used initially by all states, they will likely be used in the future. The identification and analysis of these technologies now should help in preparing for future planning.

Communications

Aeronautical Telecommunications Network (ATN)

It was clear to the ICAO 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 ICAO to provide the inter-networking 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 AMSS, VHF, 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. ATN SARPs are available.

Air-ground ATN Applications

Context Management (CM)

Context Management provides a means to determine communications services within a given flight region, and for a ground system or controller to direct an aircraft's context management application to contact a different flight region. The CM application allows addressing capability for data link applications. The CM application provides the capability to establish a logon between peer ATS ground systems and ATS ground and aircraft systems. Once an appropriate connection is established, CM provides data link application information, the capability to log-on to another ground system, and the capability to update log-on information. Context Management is covered in sub-volume II of the ATN SARPs, and in the CNS/ATM-1 SARPs.

Controller-Pilot Data Link Communications (CPDLC)

The basic concept of CPDLC is to provide data link communication between controllers and pilots. The CPDLC application provides the capability to establish, manage, and terminate CPDLC dialogues between ATS ground and aircraft system peers. Once a

dialogue is established, CPDLC provides for controller/pilot message exchange. The CPDLC application also provides the capability to establish, manage, and terminate CPDLC dialogues between two ATS ground system peers for the purpose of ground/ground forwarding of a CPDLC message. Context management permits the logon and logoff by aircraft. CPDLC is covered under sub-volume II of the ATN SARPs and the CNS/ATM-1 SARPs.

Flight Information Service (FIS)

The FIS application allows a pilot to request and receive FIS from ground FIS systems. The FIS application is designed to enable FIS to be provided to a pilot via the exchange of messages between aircraft avionics and ground FIS systems. Two types of FIS contracts that may be established on request by the pilot are:

FIS Demand Contract - where the ground FIS system provides the information immediately, but once only. This function allows the airborne FIS system to establish a FIS demand contract with a ground FIS system. Realization of the contract involves the sending of a single FIS report from the ground FIS system to the aircraft, optionally after the sending of a positive acknowledgement. Multiple FIS demand contracts may be established in parallel with a ground FIS server. The airborne FIS system formats and sends to the ground FIS system an FIS-demand-contract message. This message identifies the type of FIS information requested and contains the parameters of the request.

FIS Update Contract - where the ground FIS system provides the information and any subsequent update of this information. This function allows the airborne FIS system to establish an update contract with a ground FIS system. Realization of the contract involves the sending of FIS reports from the ground FIS system to the aircraft each time the requested FIS information is modified.

Each of these services will be accessed and used independently of the others and are initiated by the aircraft avionics (and/or pilot). It will not be required that aircraft avionics include the capability for all of the FIS services. The following services and negotiation mechanisms will be incorporated in future packages, in addition to ATIS:

- Precipitation Map Service (PMS)
- Terminal Weather Service (TWS),
- Windshear Advisory Service (WAS),
- Pilot Report (PIREP) Service,
- Notice to Airmen (NOTAM) Service,
- Runway Visual Range (RVR) Service.

The SARPs fully define the communication aspects of each application but do not address implementation of each application, specific options or operational procedures that may be required to support the operational use of the application by a given State or organization. FIS SARPS are included in sub-volume II of the ATN SARPs and the CNS/ATM-1 SARPs.

Ground-ground ATN applications

The Aeronautical Message Handling Service (AMHS)

The AMHS is a high capacity, high speed internet system that is fully complaint with ICAO ATN standards. It provides for the exchange and distribution of message-oriented traffic between ATC units. It replaces the non-ATN compliant 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 ATS message server if the AFTN co-exists with AMHS, but only an ATS message server is required for the AMHS. AMHS SARPs are included in sub-volume II of the ATN SARPS and the CNS/ATM-1 SARPs.

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 an 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 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. AIDC SARPs are included in sub-volume II of the ATN SARPS and the CNS/ATM-1 SARPs.

ATN Infrastructure

Upper Layer Communications Service (ULCS)

The upper level communications service is based on the top three layers of the 7-layer Open System Interconnection (OSI) model. The layers include the Sessions Layer (Layer 5), the Presentation Layer (Layer 6), and the Applications Layer (Layer 7). The upper layers common functions are used for connection establishment and release, and for encoding messages. The ATN SARPs apply to these layers only. The more specific functions of the three upper layers are:

Application Layer - contains all the information that is exchanged between end systems and is the province for individual ATN applications (ADS, CM, CPDLC), and for the FIS specifications for air-ground applications. The application layer includes applications service elements (ASE), application control service elements (ACSE), and ACSE services that have the following functions:

- establishes communication channel;
- terminates communication channel; and
- releases after all data have been transferred.

Presentation Layer - provides the means to represent the information exchanged between the end systems without changing the semantics-presentation protocol. This includes:

- the ability to negotiate and use many different abstract syntax's (message specification) and concrete syntax (encoding messages);
- only one agreed syntax is used for air ground; and
- used only for AMHS

Session Layer - provides the means to mark significant parts of the information exchanges such as words, pages, units, and chapters, and is used only for the AMHS. The session layer contains:

Sessions and Presentation Fast Bytes which are used for:

- Air-ground applications
- AIDC
- ATN pass through service; and

Sessions and presentations functionalities which are used by AMHS and provide compatibility with the following existing X.400 services:

- Connection establishment
- Connection termination
- Checkpoint recovery
- Dialog control.

Internet Communication Service (ICS)

In order to provide ATM services, it was clear to ICAO that the civil aviation community needs a global data internet to provide those services. That global data internet is known as the ATN and the infrastructure required to support the interconnection of end systems and intermediate systems using a variety of sub-network types is the ICS.

The ICS includes routing domains, administrative domains, routing domain confederations, and ATN backbone. The ICS provides for communications protocols that support a total end-end system. The ICS provides for the various ground-ground and air-ground sub-networks of the ATN in order to ensure successful inter-operation of ATN intermediate systems and the sub-networks to which they are attached. The Upper Layer Communications Service is the basic component of the ICS.

The ICS provides for the incorporation of different air-ground sub-networks (e.g. SSR (Secondary Surveillance Radar), Mode S, AMSS, VDL, etc.) and different ground-ground sub-networks, resulting in a common data transfer service. The design of the ICS is such that user communications services can be introduced in an evolutionary manner. The operation of the ATN is not possible without the ICS. The ICS SARPS are contained in sub-volume V of the ATN SARPs.

Voice Communications

Voice communications that include VHF, VHF-ER (Extended Range), HF, and AMSS will continue to support air traffic services for decades to come. 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. However, AMSS does not have polar coverage, but has a high quality of reception. HF has polar coverage, but is inferior to AMSS in reception 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 inter-facility 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 VHF voice is preferred to 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 CPDLC and emergency communications.

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 PDC, D-ATIS, CPDLC, ADS-C, 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 (Nautical Miles) 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, synchronized to GPS time. 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. The FAA (Federal Aviation Administration) has selected it for use in their ATC system. There are several concerns for this equipment at present that need resolution before it is operational. VDL M3 was recently demonstrated in the Miami Air Route Traffic Control Center (ARTCC) in Miami, Florida using two American Airlines aircraft, but is not expected to be operational until the 2008-2010 timeframe. 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 AOC (Airlines Operation Control) 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 (frequency modulation) scheme GFSK (Gaussian-filtered Frequency Shift Keying) 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 was ADS-B; now it is available for most all data link technologies. VDL M4 features a modulation technique using "Self-organizing, Time Division, Multiple Access (STDMA)" protocols and is being developed by Swedavia (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.

Universal Access Transceiver (UAT)

UAT is a wide band, random squitter broadcast concept developed by MITRE that is presently undergoing trials in the continental United States and Alaska with the Capstone project. It operates at 960 MHz (Megahertz) with a bandwidth of 2-3MHz. UAT is presently being used for ADS-B applications. UAT will require an additional link for CPDLC, but is still an immature link and has only been used in the US (United States). 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. It supports both air-air and air-ground, and has up-link capability for weather and flight information. Although 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 (Mode Select). UAT may also be a competitor with Mode S 1090ES (Extended Squitter). SARPS have not yet been fully developed.

ACARS over VHF Data Link

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. SIT (Société Internationale de Télécommunications Aéronautiques) 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 are 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-complaint ATN data service, but is being used as a gap filler until VDL M2 becomes more widely available.

ACARS over VHF Data Link (AOA)

While VHF data link 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 AVLC (Aviation VHF Link Control) 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.

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) may be too high for many applications like ATC. There are more than 11 global HFDL ground stations in operation with each station having a radial coverage of more than 2,700 NM.

Mode Select (Mode S)

Mode S is an operational link and has several potential applications, which includes 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.

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.

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.

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. VSATs first appeared in the United States in the 1970's, but only in the last 12 years have they appeared in other regions. VSAT offers a direct, low cost link between facilities and aircraft for fax, voice, and data transmissions

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.

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-B. 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 sittings. VDL M2 is preferable for ADS-C, 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 back up and gap-filler if it becomes certified and approved. We believe that VDL M3 will prove to be too

expensive for use by all states and may not support a cost benefit analysis. ACARS is not ATN complaint; therefore, its applications may be limited. We believe VDL M2, HFDL, Mode S, or VDL M4 may satisfy the requirements of the states with consideration for using UAT as a gap-filler (if desired) for ADS until all aircraft are equipped with Mode S 1090ES.

Navigation

Global Positioning System (GPS)

GPS is the current primary candidate for the positioning constellation that will drive GNSS. It is an all-weather, day/night navigation system that enables 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 32 satellites in six planes of four or more satellites that orbit the earth approximately every 11 hours and 58 minutes and are positioned at a distance of 10,900 nautical miles from earth. The satellites are positioned so that a minimum of 5 satellites are in view at all times. The satellites provide continuous ranging signals on two different frequencies. The Standard Positioning Service (SPS) at L1 is most commonly used for civil aviation, 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 to 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 twelve Block IIF satellites, which replace the Block IIR 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, was added to the first Block IIF satellite. 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.

Global Orbiting Navigational Satellite System (GLONASS)

GLONASS was developed by the Russian Federation 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% 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 three-year life span 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.

Galileo

The European Union (EU) recognized the U.S. GPS dominance, the growing European reliance on the system, and the risk associated with using a satellite based system outside of their span of control. In the late 1990s, the EU and European Space Agency (ESA) embarked on a program to design and develop a global satellite-based positioning and timing infrastructure. This new system (Galileo) was intended primarily for civilian use, and the overall cost was estimated to be in the range of three billion Euros.

Since the 30 satellite Galileo constellation was basically for civil services, it was assumed that at least two-thirds of the cost would be obtainable from private companies and investors. The remaining one-third would be provided by the EU and ESA. This assumption proved to be a problem. Although the final Galileo design was agreed upon in 2003, the actual funding profile for the system was not determined until 2007 at which time the EU reallocated funds from their agriculture and administrative budgets.

The first Galileo satellite (Galileo In-Orbit Validation Element—GIOVE-A) was successful launched on 28 December 2005 and the second satellite (GIOVE-B) was launched on 27 April 2008.

The Galileo signals will be compatible with GPS and the intent is to provide the following types and levels of service:

- **Open Service**: intended for mass market applications, free of direct user charges, and no service guarantees for the user.
- **Safety of Life Services**: intended for users requiring service guarantees, signals will be encrypted and user charges may be imposed.

- **Commercial Service**: intended for market applications requiring a higher level of performance that that obtainable from the Open Service. Signals will be encrypted and user fees will be imposed.

- **Public Regulated Service**: intended for government authorized EU members and signals will be encrypted.

- **Search and Rescue Service**: intended for international humanitarian search and rescue efforts.

A fully operational date for Galileo remains uncertain. Clearly the program is moving forward and the outlook is positive. Public sector financing appears to be available. China, Israel, Ukraine, India, Morocco, Saudi Arabia and South Korea have all formally joined the Galileo project and are providing various levels of support.

Beidou/Compass

Although China joined the Galileo project, it is also developing a standalone satellite navigation system to provide global coverage. This system (Beidou or Compass) is envisioned to be a combination of 5 geostationary and 30 medium earth orbit satellites.

As with the other global systems, Bediou/Compass will provide a satellite signal free of direct user charges and reportedly will be compatible with other standalone systems such as GPS, GLONASS, and Galileo. Bediou/Compass will also transmit an encrypted signal. Although the specific service intended for this encrypted signal is unknown, it is assumed that it will be for the military.

To date China has launched four geostationary satellites and one medium earth orbit satellite. There are few details regarding their global deployment plans, but it is clear that their number one priority is to provide services over the Asia region.

Global Navigation Satellite System (GNSS)

GNSS is a world-wide 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. At the present time both GPS and GLONASS are the only two satellite constellations that are candidates for GNSS. However, GLONASS has only a portion of a fully operational satellite constellation in orbit. 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 unaugmented 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 appropriate certification standards. GNSS has been approved for both GNSS non-precision (NPA) and precision (PA) approaches. SARPS are available for GNSS.

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 higher availability of service than the core satellite constellations. SBAS, in certain configurations, can support approaches with vertical guidance (APV). SBAS can support all en route RNAV (area navigation) operations. There are several SBAS systems in operation or development today which are discussed below.

Wide Area Augmentation System (WAAS)

GPS as presently operated does not fully meet the current US certification parameters of integrity, availability, accuracy, and continuity of function required for sole means navigation for all phases of flight. Consequently the FAA developed the WAAS to augment GPS. 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 ionosphere 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 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. It must be noted that the next generation of GPS satellites will likely not require augmentation to fully satisfy sole means navigation.

The WAAS, for initial implementation, is composed of a network of 24 WRMs (Wide Area Reference Monitors) 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 MCSs (Master Control Stations) associated with the WAAS that will formulate correction messages and transmit them to two GESs (Ground Earth Stations) that will up-link the messages via C band to a GEO (Geostationary Satellite). 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.

European Geostationary Navigation Overlay System (EGNOS)

EGNOS is a joint project of the ESA, the European Commission (EC) and Eurocontrol (European Organization for the Safety of Air Navigation). 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. Europe is building the EGNOS system as an enhancement over GPS and GLONASS to provide, through a civil service, improved accuracy and integrity data. The ICAO international SBAS standards guarantee the interoperability of all these systems at the user level.

The EGNOS system, which has been labeled GNSS-1 by ESA, is basically an overlay of the GPS and GLONASS systems. EGNOS is a satellite-based augmentation system, which operates very similar to the WAAS.

Multi-function Transport Satellite-based Augmentation System (MSAS)

The Multi-functional Transport Satellite-based Augmentation System is based on the MTSAT (Multi-functional Transport Satellite) of Japan, which was scheduled for launch in late 1999. Unfortunately, an explosion on the launch pad destroyed the first MTSAT satellite and marred the initial satellite launch, but a new satellite was subsequently successfully placed in orbit. 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.

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 serve several runways and possibly more than one aerodrome. The only candidate GBAS at this time is the Local Area Augmentation System.

Local Area Augmentation System (LAAS)

The United States is presently developing standards and criteria for a Local Area Augmentation System. The LAAS will be used to provide precision approach capability. 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 directly to the aircraft via data link. The accuracy of the LAAS is expected to be near three 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.

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 (US Dollars) at the time of deployment. LAAS is expected to attract a very large market in the international arena.

Special Category I (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 DGPS (Differential GPS) 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 five 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 up-graded to meet LAAS requirements.

Ground-based Regional Augmentation System (GRAS)

The GRAS works similar to an SBAS, but may be capable of also providing precision approach capability to a broader range of airports similar to a 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 protocol. This broadcast provide 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.

Aircraft-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 (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.

Non-precision Approaches (NPAs) with Vertical Guidance (APV-1/2)

APV approaches are NPAs with vertical guidance provided by onboard avionics that have the potential for lower minimums than conventional NPAs, and in many cases, minimums that are near or equal to what we know 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. 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
CAT I	10 meters	Less than 40 meters	ILS

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 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.

Navigational Summary

GNSS, without augmentation, will support operations for only supplemental and primary means, but still provides many benefits. GNSS, without augmentation, can be used as a gap-filler until sole means navigation is made possible. States should consider the augmentation options when restructuring their airspace design for GNSS services.

Surveillance

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 radar such as MSSR (Monopulse Secondary Surveillance Radar) 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 advanced 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 a MTD (Moving Target Indicator) -IV, a highly 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.

Automatic Dependent Surveillance (ADS)

General

Although radar will be an important part of the airspace system, the future surveillance system will likely 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.

ADS-B

ADS-B is an automatic, periodic broadcast of flight information that includes aircraft identification, 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 1090ES. The link of choice is Mode S. It appears to be the least expensive and aircraft are beginning to equip with the Mode S 1090 ES (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 used for Cockpit Display of Traffic Information (CDTI), and has high potential for ACAS, TCAS, and for surface surveillance. At present, power is limited to about 40NM and the transmission rate is approximately once per second.

ADS-C

ADS-C, which used to be called ADS-A, develops a contract with the provider to specify what reports it will make. The 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 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 can not 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.

Mode Select 1090 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 Mode S squitter has 2 different squitters, a short squitter (56 bits) and a longer (extended) squitter (112 bits).The short squitter is radiated every five seconds and contains flight number, or tail number for general aviation. The extended squitter 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 potential benefits of the Mode S 1090ES include improved TCAS capability; 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.

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 five meters or less for surface surveillance, and thirty 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 long 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.

Surveillance Summary

MSSR is the surveillance tool of choice for high frequency traffic areas, for complex traffic areas, and for enhanced safety. Although not discussed further in this document, Airport Detection Surveillance Equipment (ADSE-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 potential for terminal area surveillance and is being demonstrated in the en route environment. It is transponder–based technology that has line-of-sight limitations; therefore 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. Multilateration systems are provided by several manufacturers and are operational in some areas.

Air Traffic Management (ATM)

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 safe and orderly flow of traffic.

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

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 used when and where available. STARs (Standard Terminal Arrival Routes) 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 has provided user's considerable cost savings as well as providing data collections to support a concept called "Free Flight". The Eurocontrol Free Route Program is very similar in operation as the FAA's National Route Program.

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 are now held on the ground and given expected departure times, 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 TFM initiatives 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 have experienced 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 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 available. Flow management programs that reduce delays, improve capacity, and expedite traffic are becoming more common through advanced automation and collaborative decision making.

Performance-based Initiatives

Performance-based technologies are being expanded to include RASP (Required Air Traffic Management System Performance) to form an ATM Operational Concept that will include RTSP (Required Total System Performance) and other performance related technologies. RASP is a new technological concept and is presently being finalized for

use by the ICAO ATMRPP (Air Traffic Management Requirement and Performance Panel) Working Group.

General

The future air traffic system will be characterized by performance-based technology. This performance-based technology includes RCP (Required Communications Performance), RSP (Required Surveillance Performance), RNP (Required Navigation Performance), RASP, and 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.

Required Surveillance Performance (RSP)

RSP is the specified monitoring capability that describes 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, EICAS (Engine Indication and Crew Alerting System), ECAM (Electronic Centralize Aircraft Monitoring), FMS alerting, or other such features.

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 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.

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 ATC 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.

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, and 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 NOPACS (North Pacific Route Structure) 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. Separations on the oceanic tracks between the United States and Hawaii, and between Hawaii and Japan, have been reduced to 50 NM, but requires the aircraft to be certified for RNP-10. 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 B-RNAV (Basic-RNAV) program for several years.

Required Air Traffic Management System Performance (RASP)

RASP is the newest performance-based technology and is a set of criteria, expressed in the form of performance parameters and values of these parameters that the ATM system needs to meet with a given probability, in order to support the approved quality of service specified for a particular environment. RASP refers to a requirement, however, initiative and choice will be left to the implementer provided the lower bounds of performance have been met.

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, RASP, 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 TSE (Total System Error). TSE is a combination of FTE (Flight Technical Error) and NSE (Navigation Sensor Error). 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.

ATM Operational Concept

The ATM Operational Concept as proposed by the ICAO ATMCP (Air Traffic Management Operational Concept Panel), which has been changed to the ATMRPP, provides a description of how emerging and future ATM systems should operate. The operational concept describes the services that will be required to operate the global air traffic system up to and beyond 2025. The operational concept addresses what is needed to increase user flexibility and maximize operating efficiencies in order to increase system capacity and improve safety levels in the future ATM system.

The ATM operational concept is a high-level description of ATM services necessary to accommodate traffic at a given time; a description of the anticipated level of performance required from and the interaction between the ATM services, as well as the objects they affect; and a description of the information to be provided to specialists in the ATM system and how that information is used for operational purposes.

The ATM operational concept document is large and covers many segments of aviation such as safety, technology, collaboration, continuity, etc. Although the concept has many underlying principals, it relies heavily on performance-based systems which include RTSP and RASP. These two performance-based technologies coincide with one of the guiding principals adopted from the concept by the ATMCP which states: "CNS systems, and advanced information management technology will functionally combine the ground-based and airborne system elements into a fully integrated, interoperable, and robust ATM system."

We have previously identified RTSP as a statement of the total system performance needed to operate in various areas of airspace, or to use a specific procedure. That definition can be expanded to the expression of performance parameters (operational and technical) that the ATM system needs to meet in order to deliver the approved quality of service and required ATM system performance (RASP) specified for that particular environment. RASP is the set of criteria, expressed in the form of performance parameters, and values of these parameters, that the ATM system needs to meet with a given probability, in order to support the approved quality of service specified for a particular environment. RASP refers to a required (mandated) ATM system performance whereas RTSP refers to a set of parameters for performance.

APPLICABILITY OF PROSPECTIVE SYSTEMS FOR REGIONAL AN STATE IMPLEMENTATION

We have identified and analyzed the capabilities of both present and prospective systems that are applicable for CNS/ATM implementation. Although some of these new technological systems may not be used by all states in the very near future due to the cost and marginal benefits, they may be implemented by some states and structured for regional benefits. We have reviewed and analyzed those technologies and systems, and have concluded the following for consideration:

- VDL Mode 3 – VDL Mode 3 is a VHF data link that can be used for both voice and data. The requirement for vocoders and timing stations compared to the capabilities of VDL Mode 2 and VDL Mode 4 makes this technology undesirable.

- UAT/AOA – These are data links that have potential for several data link related technologies. UAT is being demonstrated in the United States, and AOA is a form of ACARS transmitted over VDL Mode 2 which makes it ATN compliant. However, with the advent of VDL M4, VDL M2, and Mode S 1090ES, there is likely little need for them in the region.

- EGNOS – EGNOS is a European augmentation of the GPS constellation that can provide some marginal benefits. This is a "paid for" service and with the advent of Galileo, this technology would be too expensive and not be cost-beneficial.

- WAAS – WAAS is a United States augmentation to the GPS constellation, and although very similar to EGNOS, would require reference stations be installed in the states/region. Similar to EGNOS, this technology would be too expensive and not be cost-beneficial.

- MSAS – MSAS is a Japanese augmentation of the GPS constellation and not available for the region.

- GRAS – GRAS is a ground-based augmentation to the GPS constellation and has potential benefit for individual states. It is not considered as a regional technology. It also may have technical problems and likely would not be cost beneficial.

SELECTING THE ALTERNATIVES

Task 7 also requires the contractor to identify criteria for selecting the best alternative options. The alternative options become those options associated with equipment requirements for total (upper and lower) airspace control.

We have outlined the various phases of flight that are pertinent to the low altitude operation and have included the operational requirements or ICAO recommendations with future equipment solutions. Note that low airspace operations will likely compose the foundation for the provision of upper airspace services and therefore are considered critical path items.

The only criteria in the selection of alternatives are the compatibility of the selection with other equipment and the maximizing of benefits compatible with cost. Each piece of equipment listed can meet the requirement indicated, but some equipment can meet several requirements within that particular phase and in other phases of flight. It would be cost beneficial to select equipment that can provide more than one airspace service.

Both ICAO and the 11th ANC (Air Navigation commission) have recommended the use of similar or common equipment to further the seamless airspace continuum. In association with this recommendation, air carriers can not afford to carry on-board equipment to satisfy each countries selection of ground-based equipment. A good example of this is the data link to support ADS-B. There are several links that will support ADS-B. At present, the United States and Eurocontrol have selected Mode S 1090ES as their ADS-B link, Russia has selected VDL M4 as their link, and other countries are looking at AOA or UAT. The air carriers can not carry a variety of data links when one or two links will suffice. Providers need to consider the airborne side when considering the ground-based side. While we have provided a variety of equipment in the following options, we are recommending the use of similar equipment to meet both lower and upper airspace requirements.

The following tables outline each phase of flight within a low altitude or lower airspace environment. The ICAO recommendation or what can be considered an operational requirement for that phase of flight is also indicated. And finally, we have indicated the equipment options that will satisfy the requirements for that [redacted]

Low Airspace Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Airspace and Flight Planning	Flight Data Processing and Dissemination	AFTN, ATM, FPDP, AMHS, VSATs, AIDC, ATM System
	Aeronautical Information Service, NOTAMs	AFTN, ATM, AMHS, WAFS, Satellite Imagery, VSATs, ATM System
	Repetitive Flight Plan {ACC Stored)	FPDP, ATM System
	Meteorology	AIS, ATN, WAFS, Satellite Imagery

Flight Data Processing and Dissemination

Flight plans are typically distributed to providers via the AFTN. AFTN is being replaced by the AMHS which is ATN compliant. The AMHS software is available, but has been implemented in only a few states thus far. The United States has already begun the implementation of AMHS. States should maintain the AFTN until it is replaced by AMHS. This is the initial component of the ATN. Flight plan processing can be completed manually, but automation has reduced this time consuming task. The FPDP will process flight plan information, record all overflight aircraft as they enter/exit the FIR, process flight times and aircraft type for over flight fee collections, provide strips for each control position, perform coordination functions, reduce the excessive coordination requirements at the busier facilities and will eliminate the manual processing and counting of strips and aircraft movements. An ATM system can do all the things an FPDP can do and more. The ATM is both an FPDP and an RDP. Both provide flight progress strips and forwards a strip to the tower for clearance delivery to the aircraft. ICAO has recommended the filing of flight plans be a coordinated effort between the provider and the user so that the flight profile accommodates the user's preferred trajectory with minimum ATM constraints. The FPDP nor the ATM system are ICAO requirements. Only the processing of flight data is an ICAO recommendation. When the ATM is interfaced with the ATN equipped with AIDC, it will provide an interchange of flight data between ACCs such as the passing of estimates. VSATs are recommended as the medium to enhance voice and data communications between users and providers.

AIS/NOTAM Aeronautical information must be processed and disseminated to the users. NOTAM information, along with meteorological and airspace information (special use airspace), must be processed and disseminated as well. The AFTN and/or AMHS is the medium used to disseminate this information.

Use of Repetitive Flight Plans Another name for this is "stored flight plans" Aircraft operators that have aircraft departing from the same airport at the same time and going to the same place each day via the same route should have a

stored flight plan on file with the provider. This eliminates the need to file a flight plan every day. Both ICAO and Eurocontrol have recommended the use of center stored flight plans. Flight plans are stored via a computer and processed approximately 2 hours prio to scheduled departure. Repetitive flight plans can be stored via an FFDP or an ATM system.

Meteorology Meteorology and the passing of weather information is very important to all states. With the wide variety of climatic patterns, the weather changes constantly and airspace users/service providers need to be aware of the ever changing weather. ICAO has recommended the use of satellite imagery. Also, there is a need to obtain and disseminate automated global upper winds/temperature and SIGMETS (Significant Weather) forecasts.

Low Airspace Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Airport Surface And Taxi	Airport Ground Surveillance	VDL M4, Mode S1090ES, ASDE, ADS-B
	Airport Management	SMA, VDL M2, Mode S 1090ES, ADS-B
	Taxi – Tower Directed	VHF voice, ADS-B, VDL M4, A-SMGCS Tower Displays, SMA, Mode S 1090ES
	Taxi – Pilot Directed	Pilot Display, ADS-B, VDL M4, VHF Voice Mode S 1090ES
	ATC Clearances	VHF Voice, PDC, ATIS, VDL M2
	Surface Management Advisor	ASDE, ADS-B, SMA, VDL M4, Mode S ES
	Automatic Terminal Information Service	VDL M2, ATIS (tape/digital)

Airport Ground Surveillance. ICAO recommends the use of ground surveillance at major, high use, international airports. The present ground surveillance system is radar in the form of ASDE (Airport Surface Detection Equipment). However, the new technology is ADS-B. ADS-B has been tested and demonstrated, and SARPS have been developed. The problem at this point is what will be used as a unified data link. Mode S1090ES and VDL M4 are being used in demonstrations, but many aircraft have not yet been modified for the Mode S 112-bit address. VDL M4 is also a candidate for ADS-B and has recently been approved for public use.

Airport Management. At large airports, aircraft and vehicular traffic has been an on-going safety problem for aircraft utilizing the airport. Vehicular traffic on the airport has surpassed the number of aircraft using the airport. Ground surveillance provides a high degree of safety at some airports, but has limitations. Another automation tool to assist in airport management is Surface Manager Advisor which increases awareness of traffic flow into the airport, giving ramp control operators and controllers precise touchdown times. Informed of aircraft identification and position in the terminal airspace, gate and ramp operators using SMA have enhanced ability to reduce taxi delays. ICAO recommends that States should provide separation between arrival, departing, and taxing aircraft in and around the airport using airport management tools where possible.

Taxi Instructions – Tower Directed/Pilot Directed. The control of taxing aircraft on an airport surface is the responsibility of the ATC tower. At present controllers verbally transmit through VHF voice taxi instructions to aircraft ensuring their separation between other aircraft and structures. This is a time consuming operation at large airports. Surface surveillance through The use of ADS-B has the potential to relieve the controller's workload. With ADS-B, the pilot can see traffic from a CRT (cathode-ray tube)in the cockpit and provide his own separation

as he taxis to the runway or to the gate. As previously mentioned, there are several data link candidates for ADS-B including Mode S 1090ES, and VDL M4. In the options we present, we will recommend a definitive link for ADS-B. Pilot directed taxi through ADS-B is an improvement over the present standard. Another tool is the A-SMGCS). A-SMGCS identifies each aircraft, and provides surveillance and monitors taxing traffic continuously; it determines automatically conflict-free taxiway routes and guides aircraft and vehicles reliably through the use of optical signals; and in case of deviations, it warns pilots or drivers immediately. As such, this control and monitoring functionality provides controllers with tools to enhance safety, efficiency, and availability at the airport in all visibility conditions.

ATC Clearances. ATC departure clearances are a result of a flight plan request. At present, ATC clearances are delivered directly to the aircraft through VHF voice or by voice relay. The New technology to deliver an ATC clearance is via data link. An initial data link application is PDC. This technology is presently offered through ARINC or SITA via an ACARS link but is Being supplanted with VDL M2. PDC eliminates transposing errors and mis-read clearances. The use of PDC is quicker and relieves clearance delivery workload. In busy terminals, PDC would be a time-saving, man-power saving technology. PDC is not an ICAO or SADC requirement; only the issuing of an IMC clearance to international air carriers is an ICAO recommendation.

Surface Management Advisor. SMA is one the tools of the family of Surface Management System tools. SMA increases awareness of traffic flow in/out and around the airport, giving tower and ramp control operators more accurate taxi and arrival/departure times . This updated information helps airlines manage ground resources at the terminal more efficiently: gates, baggage handling, food services, refueling, and maintenance. SMA has enhanced the ability to reduce taxi delays and increase the flow of arrivals and departures.

ATIS The use of ATIS is both an ICAO and Eurocontrol recommendation. Most airports have it, but it is a taped message and aircraft monitor a frequency to hear it. The new technology for ATIS is digitized data link known as D-ATIS. It is presently being used as an ACARS application but is being converted to VDL M2 which is the preferred link.

Low Airspace Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Departure and Departure Transition	Standard Instrument Departures	VHF Voice, GBAS, MSSR, ADS-B, Mode S 1090 ES, VDL M4, RNP-1/2 Galileo when available
	Reduced Obstruction/Terrain Clearance	VHF Voice, GNSS, ADS-B, Galileo when available
	Transition Routes (Reduced Minima)	VHF Voice, MSSR, ADS-B, VDL M4, Mode S 1090ES, RNP , Galileo when available

Standard Instrument Departures. (SIDs) SIDs have the capability to increase capacity, reduce delays, and ease controller workload. Using augmented GNSS (GBAS) and Galileo when available, the route can now be developed to conform with traffic flow rather than position of ground-based aids. Procedures can be designed that permits SIDs to conform to noise abatement and traffic flow. Route widths can be reduced to make better use of airspace configurations and to expedite departures.

Reduced Obstruction/Terrain Clearances. GBAS and/or Galileo can narrow the RNP value to reduce the distance aircraft must stay from obstructions and high terrain. In the past we have depended on radar to vector aircraft when they passed near obstructions. Now using RNP, we can develop routes that permit aircraft, under procedural control, to fly closer to obstructions than previously would not have been possible. This increases the capacity and reduced delays. ADS, which can be made available in non-radar areas, can provide a surveillance monitor if required. The reduction of obstruction and terrain clearance limits is a high priority in ICAO, but the manner in which it is accomplished is a States decision.

Reduced Departure and Arrival Minima. GNSS and/or Galileo, enhanced by ADS and RNP, can improve the transition routes for departures and arrival. These routes are not limited as they are with ground-based facilities. Departure transitional routes can be reduced in width and be designed for any type of airspace. Arrival transition routes from the STAR to the initial approach fix and even to the immediate approach fix can be reduced and designed to fit the traffic flow rather than the location of ground-based aids. These routes can also eliminate reverse courses for non precision approaches. Electronic surveillance is required for any RNP below RNP-4.

Low Airspace Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
En route	Navigation	RNAV, VOR/DME,VHF, HF, & AMSS Voice/Data, GNSS, Galileo, RNP, CPDLC
	RVSM (aircraft certification)	VHF/AMSS Voice/Data, CPDLC
	Separation Reductions - 10 min/80 NM - 20 NM (longitudinal) - 10 NM (longitudinal) - 5 NM/4NM (lateral) - 2 NM (lateral)	 VHF/AMSS/HF Voice/Data, VSAT VHF/AMSS/HF Voice/Data, GNSS, MSSR VHF/AMSS Voice/Data, MSSR, ADS-C, VDL M2/4,Mode S ES, RNP VHF Voice/Data, ADS-C, RNP-5, MSSR, Mode S ES, VDL M2/4 VHF Voice, MSSR, ADS-B,RNP-2, VDL M2/4
	MEA/MRA/MOCA	GNSS/Galileo VHF Voice or Data, ADS-C, MSSR, RNP
	Surveillance	MSSR, ADS-B, Mode S ES, VDL M2/4
Oceanic	Navigation (RNAV)	GNSS, Galileo, ADS-C, VDL M2 or M4, HF voice/data, AMSS, CPDLC

Point-to-point (RNAV). Point-to-point or direct navigation is supported through GNSS and in the future Galileo. GNSS will support RNP-4 or higher but an SBAS or Galileo is required for an RNP lower than RNP-4. GBAS is required for lower RNPs which are generally associated with approaches and departures. VHF/AMSS voice/data will satisfy communications requirements for RNP-4 and higher, but for RNPs lower than RNP-4, VHF voice is required due to the need for a quicker intervention capability. ICAO and Eurocontrol recommend VHF coverage for ATS purposes to permit effective direct pilot-controller communications. Radar or ADS is optional for RNP-4 and higher, but is considered a requirement in areas of RNP-2 or lower.

RVSM. RVSM has been recommended for use by both ICAO and Eurocontrol. Certification and monitoring of RVSM aircraft certified through GPS requires no ground based equipment. The use of RVSM using height monitors units requires ground based equipment for aircraft certification. Our recommendations will focus on the most cost productive method which appears to be GPS; however, RVSM is an aircraft certification and most aircraft certification can be provided by other states. It is not necessary that RADA states provide a certification program for aircraft to offer this benefit.

Reduction of Separation Standards. In those areas where longitudinal separation of 20 minutes or 20NM (nautical miles) are used, the reduction to 10 NM or 80 NM would be considered a reduction in separation minima. ECAC and ICAO have recommend that each state implement this standard as quickly as possible to be in line with other ECAC states that have already implemented it. With the advent of GNSS (SBAS/GBAS) and RNP, the potential for further separation reductions are high. What has normally been 10 or 20 minutes, or 20 DME separation standards can now be drastically reduced. Galileo will provide the accuracy and integrity for lower separation standards.

With RNP, lateral standards can be reduced to as low as 2 NM and possibly lower. Longitudinal standards can be reduced from 10 minutes to 10 NM. VHF/AMSS voice/data is required for separation of 10 NM or less. Electronic surveillance is optional with the exception of using 2 or 5 NM lateral separation. Other standards can be reduced such as longitudinal separation between departures, between crossing courses, and between climbing and descending aircraft. VSATS will be used to provide enhanced VHF and data communications between the users and providers.

Reduction in MEA/MRA/MOCA. MEA, MRA, and MOCA are based on the reception range of ground based navigational aids. MRA determines the MEA since the MEA can not be lower than the reception altitude of the ground-based aid. MRAs are based on the reception range of the navigational aid, therefore they are higher in the mountainous and remote areas due to the height of mountains and the distance between aids. The MOCA is based on the MRA and MEA. With GNSS, reception of signals are worldwide which would allow the lowest MEA and MRA even when in mountainous ranges. This means aircraft could fly at lower altitudes and/or select better flight profiles.

Surveillance. ICAO and Eurocontrol have recommended each state provide electronic surveillance (radar/ADS) where and when possible. The potential of CNS/ATM can not be fully realized without enhanced surveillance. New separation standards require electronic surveillance. Radar/ADS may be optional in most of these initiatives, but radar increases capacity and safety, while reducing delays. Both ICAO and IATA have put ADS-B on a high priority. IATA is looking for a common data link to reduce cockpit avionics. Both the US and Eurocontrol have opted for Mode s 1090Es as the ADS-B link while Russian states have adopted VDL M4. SADC needs to agree on a common data link for ADS-B. VDL M2 seems the definitive choice for ADS-C.

Oceanic. Navigation in oceanic airspace will be RNAV supported by GNSS and Galileo. ADS-C should provide surveillance in the off-shore airspace and deeper ocean. Communications should be provided through HF voice /data, CPDLC, or AMSS.

Low Airspace Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Arrival Transition And Arrival	Reduced Obstruction/Terrain	VHF Voice, GBAS, ADS-B, ADS, RNP, Multilateration (ML)
	Reduced Departure & Approach Minima	VHF Voice/Data, GNSS/GBAS MSSR, ADS-B, Mode 1090ESS RNP, ML
	Standard Terminal Arrival Routes	VHF Voice/Data, GBAS, MSSR, ADS-B, RNP, ML
	Metering and Sequencing Tools	VHF Voice/Data, MSSR, ADS-B, CTAS, URET, P-fast
	Approach Aids	ILS, GNSS, GBAS, ML

Reduced Obstruction/Terrain Clearances. GNSS, augmented by GBAS, and Galileo when available, can narrow the RNP value to reduce the distance aircraft must stay from obstructions and high terrain. This has been previously discussed in the departure and departure transition phase. The reduction of obstruction and terrain clearance limits is a high priority in ICAO, but the manner in which it is accomplished is a States decision.

Reduced Departure and Arrival Minima. GNSS, or Galileo, when available, using ADS, RNP, and data link can reduce the minima required for arrival transition routes. This has been previously discussed in the departure and departure transition phase.

Standard Terminal Arrival Routes. (STARs) . The development of STARs is an ICAO recommendation. GNSS with augmentation provides the RNP for this profile from the beginning of the STAR to the immediate approach fix. Radar/ADS provides the surveillance, but surveillance is not a requirement for this initiative.

Metering and Spacing Tools. The use of metering and spacing tools is supported by ICAO in the ICAO. CTAS (Center/Tracon Automation System) , URET (User Request Evaluation Tool), and P-fast are metering and aircraft spacing tools. URET automatically predicts and notifies controllers of conflicts between aircraft or special activity airspace. The system also allows controllers to quickly determine whether proposed flight path changes will conflict with en route traffic or airspace. Radar is required for these tools.

Landing Aids. The use of landing aids is supported by both ICAO and Eurocontrol. Landing aids are not a product of CNS/ATM, but are necessary to increase capacity and eliminate any delay in the landing process. Precision Approach Path Indicator (PAPI), Visual Approach Slope Indicator (VASI), and Runway Approach Intensity Lighting System (RAIL) are the most appropriate landing aids.

Low Airspace Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Approach and Landing	Approach Aids	ILS, GNSS, GBAS, ML
	Landing Aids	PAPI, REILS, VASI,
	Non-Precision Approaches - GNSS - APV-1 - APV-2 - Curved	 GNSS, RNP, VHF Voice/Data GNSS, RNP, VHF Voice/Data GBAS, RNP, VHF voice Data GBAS (ADS-B & MSSR optional for all)
	Precision - CAT I - CAT II - CAT III - Parallel	 ILS, GBAS, ML ILS, GBAS ILS, GBAS ILS, (ADS-B & MSSR optional for all)
	Approach Development	Procedural

Approach Aids. The requirement is for an instrument approach and several pieces of equipment can satisfy that requirement. With the exception of GNSS, all of the equipment mentioned can satisfy precision approach requirements. Although VOR/DME can satisfy the non-precision requirements, those aids will start the decommissioning process within the next five years. Non-directional beacons are not mentioned as an approach aid in the future system. Multilateration has yet to be proven as a successful approach aid although the potential has been demonstrated.

Landing Aids. The use of landing aids is supported by both ICAO and Eurocontrol. As indicated previously, they are not a product of CNS/ATM, but are required to gain the minimums associated with the various types of approaches, and to increase capacity and reduce delays caused by missed approaches. PAPIs, VASIs, and RAILS are the most frequently used landing aids.

Non-precision Approaches. GNSS will be able to provide non-precision approaches in those areas where a precision approach is not possible or where precision approach lighting systems are not available. Approach minimums will be less than conventional non-precision approach minimums are today. If using GNSS, aircraft must be using Galileo or be equipped with AAIM or RAIM, or using an SBAS system

APV-1 non-precision approaches. APV-1 approaches are GNSS non-precision approaches

APV-1 non-precision approaches. APV-1 approaches are GNSS non-precision approaches that use an electronic glide-slope provided by onboard avionics. These are new approaches and have not received final ICAO approval, but have the capability of approach minimum below that of conventional approaches. RNP will be a requirement for APV-1 and it is expected to be lower than RNP-.03.

APV-2 Approach. APV-2 approaches are GNSS non-precision approaches that use an electronic glide-slope provided by on-board avionics. The approach also requires the use of a SBAS or GBAS for navigation to obtain the lower minimums. These are new approaches and have not received final approval from ICAO, but they have the potential for approach minimums near present CAT I minimums today. The use of this approach may invalidate a requirement for an ILS or precision approach at some airports.

Curved Approach. Using GNSS, curved approaches can be constructed that permit aircraft to make approaches to runways that may not be permitted now due to obstructions or terrain. These approaches are non-precision at this time due to the distance required for stabilizing the approach, but it is expected to be certified for precision approaches inn 2006.

ILS/MLS Approach. The ILS/MLS (Multi-landing System) approach are precision approaches that are based on ILS/MLS equipment and RNP is not a factor. The ILS/MLS are the only systems that provides precision approach capability other than GNSS (SBAS/GBAS) precision approaches. The ILS/MLS have a life span of about 12 years even with good maintenance principals. ILS/MLS has three levels of precision approach; CAT I, CAT II, and CAT III. Only MLS is capable of providing a curved approach capability. ICAO recommends that each country have at least one precision approach capability at their major international airport. An ILS monitor is required in the ATC tower so that controllers can advise the aircraft to execute a missed approach if the ILS fails during the approach. VHF communications are required so that controllers can advise the aircraft when the ILS fails. Electronic surveillance is not required but recommended.

GNSS Precision Approach. SARPS for the GNSS precision approach have been completed. GBAS can support GNSS precision approaches for CAT I-III. Each level of the approach will have a lower RNP associated with it. It is expected that the RNP for a GNSS Cat III approach will be near RNP-.015.

Parallel Approaches. Parallel, precision approaches can be developed for use. Parallel approaches can be executed with ILS, MLS, or GNSS; however, they require electronic surveillance, either radar or precision radar monitors. ADS is not authorized for this purpose.

Approach Development. Approach development is mentioned here as a requirement because without the approach procedures, no approaches can be made. This effort requires several procedures specialists and funding.

STRATEGIES FOR IMPROVING TRAFFIC FLOWS

We believe there are several strategies available to improve the traffic flow throughout the airspace in particular if the states adopt a regional approach and embrace next generation CNS/ATM technologies. These strategies are as follows:

1) RNAV through Satellite Navigation – The approval of GNSS as a primary navigational aid is crucial to improving traffic flows. With GNSS, RNAV capability becomes an enormous benefit to the users. With RNAV aircraft can fly direct courses reducing flight time, delays, coordination, and controller workload. RNAV routes can be established based on satellite navigation providing separate inbound and outbound routes that will allow aircraft unrestricted climbs and descents.

2) Strategic coordination capability through the ATN and AIDC – Coordination of real-time flight information at state boundaries is generally difficult due to communications between facilities, which has delayed aircraft in reaching requested flight levels and descents in accordance with flight profiles. The ATN has been 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 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; however, AIDC is required to pass real-time data between ACCs and between terminals. Inter-facility communications will expedite the flow of traffic. The ATN has been slow, but now that an ATN router has been developed and tested, the transition to the ATN should proceed a little faster. ACI, a European consortium, under contract to ATNSI, an American firm, has developed an ATN stack router which is presently being tested.

3) Regional Flight & Radar Data Processing – We have already recommended an ATM system for the area control centers which is capable of processing both flight data and radar data. This central processor will process radar data from several radar sites as well as process and disseminate flight data and flight information. It will be connected to all facilities so that all facilities will receive timely flight information. By having a system that is connected to all states and is capable of passing real time flight information, the ability to be able to permit aircraft to fly direct or requested routes and at their requested altitudes will be present.

4) Procurement and Use of CNS/ATM Systems – All satellite-based CNS/ATM systems are an improvement over tradition and ground-based systems. States that adopt satellite services will generally have more income with less recurrent costs for ground-based systems. This will allow them to equip more rapidly with cost effective equipment that is an improvement over present systems and will provide both user and provider benefits.

5) Seamless Airspace – Should a regional air traffic service be pursued, then it might be reasonable to consider the provision of upper airspace services from a consolidated facility—one that services the FIRs or one or more states. Should this be an option, then "seamless airspace" operations would be possible. This means controllers could provide the same services in the same manner with the same equipment and aircraft will be able

to use the same equipment without regard to crossing sovereign boundaries. Aircraft will not know when they cross state/international boundaries as far as air traffic control is concerned. Seamless airspace is one of the highest priorities of ICAO and IATA (International Air Transport Association).

6) Procedures – Probably the most important strategy for a smooth and non-troublesome transition between adjoining states and FIRs as well as for future operations is proper procedures. Procedures may also be the backbone or true interface between the high and the low airspace to make things come together in a safe and efficient manner.

7) RVSM (Reduced Vertical Separation Minima) – RVSM is the use of 1000' (300m) separation between FL 290 and FL 410 instead of the normal 2000' (600m). This initiative would be of considerable benefit for both controllers and air carriers alike, especially for long haul air carriers that need to get to or as close to their requested altitude for fuel conservation. The benefits of RVSM include:

- Greater availability of fuel-efficient routes and tracks;
- Increases the possibility of preferred routes or tracks; and
- Enhances controller flexibility to manage traffic through an increased number of available altitudes

COMPABILITY OF EQUIPMENT FOR UPPER AND LOWER AIRSPACE

It is incumbent to utilize equipment that can serve both upper and lower airspace requirements. In addition, one should procure equipment that can provide one or more ATC services. For example VDL M2 can provide a variety of data link services for both the upper and lower airspace that includes D-ATIS, PDC, ADS-C, AIS, and FIS. Satellite navigation can also provide several navigational services such as RNAV and precision and non-precision approaches. In any event, the equipment should be useable by the maximum number of service providers in the region. In the interests of minimizing costs and maximizing investments, plans should be developed that will permit the volume purchase of like equipment and systems for all possible states. It is suggested that the states form a Regional Planning Team to determine those systems that could be jointly procured.

In reviewing the present and future equipment requirements, it is apparent that an ATM system or FDP, extended range VHF communications, data link communications using additional VSATs, the ATN including AMHS, GNSS procedures development and radar systems are the areas where a Regional Planning Team could first consider for joint procurement cooperation.

As previously mentioned, an FDP is more associated with a single radar system whereas the ATM system can process flight data and radar data from a variety of sources. The automated processing of flight data is essential to a successful transition. Lockheed Martin and Raytheon, both US manufacturers, have developed excellent ATM systems that would meet all of the requirements.

Similar systems are also available from European manufacturers. It may not be possible for every state to be connected to the ATM system at the same time, but a progressive timetable will be necessary to assure that the manual processing of flight data is kept to a minimum. As previously indicated, the processing of flight data would reduce the cost of this service. If the radars can be interfaced with each other, the combined FDPs could provide services similar to an ATM system such as centralized flight data processing and flight information dissemination.

Fixed communications, the ability for each ACC and terminal to communicate with other ACCs and terminals is very important. The ATN can satisfy this requirement even though it may be in limited service. AMHS, which is the replacement for the AFTN, is already being implemented in many countries and is the first sub-network of the ATN. Other networks such as mobile and fixed communications can be added as appropriate.

Data link technology should be common for all airspace operations. There are several data link technologies and many can provide the same service. VDL Mode 2 can provide all data link services except ADS-B. ADS-B can be provided by VDL Mode 4 or Mode S 1090 ES. Each data link can provide the same service for all airspace operations. Each state should use the same link for the same service. For example, if the decision is to use VDL Mode 4 for ADS-B, all service providers should use the same link rather than Mode S 1090ES, or any other available link that is ADS-B capable.

The use of satellite navigation or GNSS should be a first priority. Due to the limited number of VOR/DME facilities and the lengthy and numerous cases of down-time, a more reliable form of navigation is recommended for the region. A large majority of commercial aircraft are GNSS equipped. One of the highest IATA requirements is the use of satellite navigation. At present, GNSS is not certified as a sole means of navigation, but it is certified for supplemental navigation and is being used by and providing navigational benefits to users and service providers world-wide.

States should evaluate their plans to purchase ground-based navigational aids with the exception of ILS systems. In the future there will likely be little if any need for ground-based navigational equipment other than that necessary to support a skeleton structure.

Another major investment that has regional applicability is the procurement of compatible radar systems. Each ASR system that is installed at any terminal facility can be modified for secondary coverage for en route operations out to 240NM from the antenna site. It will provide terminal and approach surveillance to the terminal facilities and en route surveillance.

Finally, we are recommending that the equipment purchased meet industry standards. ICAO, RTCA, and associated binding documents such as TSOs (Technical Standard Orders), MOPS (Minimum Operating Performance Standard), and MASPS (Minimum Aviation System Performance Standards) provide standards for industry to use in the development of and manufacture of CNS/ATM equipment. When providers purchase equipment that meets these industry standards they are assuring themselves of compatibility, certification, approval and interoperability with other systems, as well as facilitating integration with the overall design/architecture of CNS/ATM.

APPENDIX 1: VALUATION OF KEY TECHNOLOGIES

The predicted growth in aviation has created the need to immediately begin the process of modernizing the CNS/ATM system. Over the past 10 years, several new systems and technologies have been developed to promote the use of next generation CNS/ATM. This section focuses on the evaluation of key technologies and systems that are now available to support the modernization of the CNS/ATM system for all states. In addition to this evaluation, we will outline the criteria that may be used to select the best alternative for lower/upper airspace and identify the best strategy or strategies for improving traffic flows and loads through the integration process.

Communications

Voice Communications

General

The world's voice communications for civil aviation in domestic airspace are predominantly VHF based; communications for oceanic/remote area communications are predominately HF based. Voice communications will likely remain predominately analog throughout the transition to future digital systems. However, in concert with the worldwide adoption of the CNS/ATM concept, analog voice communications will be used for non-routine communications, with more routine communications provided through digital communications services. All communications will most likely be sub-networks of the ATN.

VHF Voice

Characteristics
- Amplitude modulation
- Uses VHF spectrum
- Line of sight

Strengths
- Currently operating, reliable, mature
- Used by air carrier, general aviation, and military
- Capacity increased with 8.33 kHz (Kilohertz) spacing

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 communication

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

Aeronautical Mobile Satellite System (AMSS)

Characteristics
- Service provided by companies such as INMARSAT
- Satellites in geosynchronous orbit
- Supports Voice, ATN (Data 3 packet mode) and non-ATN (circuit mode) services
- Connection to PSTN (Public Service Telephone Network)
- A-BPSK (Advanced-Binary Phase Shift Keying) modulation scheme for up to 2.4 Kbps and QPSK (Quadrature Phase Shift Keying) 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

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;
- Reducing the congestion on voice communication channels;
- Providing pilots and controllers with more accurate, error free information;
- Providing a complimentary means of communications;
- Permitting the implementation of new air traffic management and flight operations capabilities;
- Reducing pilot and controller workload per flight;
- Allowing re-sectorization;
- Reducing long term infrastructure cost; and
- Allowing the use on new generation aircraft (for example B-777 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 Link (VDL) Communication

Note: VDL Modes 2, 3, 4 and any attendant equipage should be established as a global solution because of the requirement that there be no duplicate equipage requirements levied on users. The selected solution should satisfy the requirement to provide the technology enabler at the lowest cost to the user. Cost factors for the users include the enabling device, added weight to the aircraft, aircraft out of service, installation time as well as direct installation cost, and training for air crews and mechanics.

VHF Data Link Mode 2 (VDL M2)

Characteristics

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

Strengths

- SARPs available
- Capable of critical ATC messaging
- 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

VHF Data Link Mode 3 (VDL M3)

Characteristics

- VHF bit oriented communication system

- Supports both digital voice and data communication services
- TDMA (Time Division, Multiple Access) 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 (European Organization for the Safety of Air Navigation) voice communications requirements
- Interference analysis needs to be completed
- Complicated with timing stations

VHF Data Link Mode 4 (VDL M4)

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
- STDMA scheme (up to 6,540 slots per minute depending on the modulation scheme)

Strengths
- Uses the VHF spectrum; high delivery probability
- Supports time critical applications
- Supports both broadcast and air-to-air applications
- Provides integrated surveillance and communication services
- SARPs available
- Accepted by international community

Weaknesses
- Limited acceptance by airspace users, but improving rapidly
- Not widely accepted outside the European/African/Asian arena

Mode Select 1090 Extended Squitter (Mode S 1090ES)

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

Strengths

- Provides surveillance data integrity
- Overcomes Mode C code shortage
- Reduces radio frequency interference
- SARPs available

Weaknesses

- Does not meet transit delay and coverage requirements for some applications
- Does not support A-SMGCS, PDC, D-ATIS

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. CPDLC will provide an additional means for two-way dialogue between controllers and pilots for ATC clearances, requests, instructions and pilot reports.

Characteristics

- Used for all routine controller-pilot communications
- Predetermined message sets, easily selectable

Strengths

- ATN compliant
- Can support critical ATC communications
- Compatible with many frequency spectrum options
- SARPs available

Weakness

- Limited applications in high workload, time-critical situations, such as communications within the terminal area where radar vectoring is primary controller tool
- Can divert attention from other tasks if used in very high workload situations
- Difficult to use in emergency situations
- Requires another communication means for non-verbal and emergency use

Aircraft Communications and Reporting System (ACARS)

ACARS is currently fitted in most air carrier aircraft as the primary means of providing 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 (Amplitude Modulation-Minimum Shift Keying) 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 current being provided in limited areas, such as PDC and D-ATIS which save pilots and controllers workload

Weaknesses

- Not compatible with the ATN without AOA (ACARS over VHF Data Link)
- Very low bit rate
- Designed for AOC communication, not time critical ATC or 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 at present, and ARINC

AOA (ACARS over VDL M2)

ACARS is not ATN compliant; therefore, it is not an acceptable future data link. In the VDL AOA architecture, the aircraft uses the ACARS air-ground protocol over the ICAO VDL M2 AVLC (Aviation VHF Link Control) 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. 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 operation 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 current being provided in limited areas
- Compatible with the ATN
- Designed for time critical ATC/ATM services

Weaknesses

- Immature; standards developed but not approved
- Not fully developed
- 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
- Operational in parts of Alaska, USA.

Weaknesses

- SARPs not available until 2007

HF Data Link (HFDL)

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 service

Aeronautical Mobile Satellite System (AMSS-Data)

Characteristics

- Service provided by INMARSAT and Iridium
- Four satellites in geosynchronous orbit (INMARTSAT); 68 MEO satellites (Iridium)
- Supports Data, ATN (Data 3 packet mode) and non-ATN (circuit mode) services
- Connection to PSTN
- BPSK (Binary Phase Shift Keying) modulation scheme for up to 2.4 Kbps and QPSK (Quadrature Phase Shift Keying) for greater bit rate

Strengths

- ICAO standards currently exist (INMARSAT);
- Operational for AOC purposes (both systems)
- Supports both voice and data communications
- Wide coverage

Weaknesses

- High operating costs (INMARSAT); Iridium lower cost
- High transmission power
- Significant transmission delays
- Coverage problems at high latitudes(INMARSAT); problems not incurred by Iridium

Navigation (Global Navigation Satellite System)

Global Positioning System (GPS)

Characteristics

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

Strengths

- World-wide 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 (Instrument Flight Rules) operations
- Mature, reliable system
- No position ambiguities
- Certified for primary means of navigation in some areas
- Replacement satellites available with additional "safety of life" ranging frequency

Weaknesses

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

Global Orbiting Navigation Satellite System (GLONASS)

Characteristics

- Uses L band spectrum
- Medium earth orbit satellites
- World wide navigation applications
- Spaced-based system

Strengths

- World-wide 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
- Limited number of satellites operational
- No available user equipment
- Owned by Russian Space Forces
- Poor performance history

Galileo

Galileo is being developed by the European Space Agency and is the European Union's (EU) GNSS-2 initiative for a satellite-based navigation and positioning system. At first, integrity will be provided only over Europe, but it may be provided wherever there are sufficient ground stations that provide differential corrections. Scheduled implementation date has been moving to the right.

Characteristics (potential)

- Uses L band spectrum
- Medium earth orbit satellites
- Accurate positioning system
- World wide navigation applications
- Spaced-based system
- Dual ranging frequencies

Strengths (potential)

- World-wide 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)

- Not operational
- No SARPs available

Satellite-Based Augmentation System (SBAS)

Wide Area Augmentation System (WAAS)

The WAAS was commissioned in May 2003. With WAAS, GPS will meet the accuracy requirements for RNP and for all phases of flight. GPS-like ranging functions from geostationary satellites provide additional availability.

Characteristics

- Augmentation to GPS
- Ground-based monitoring network
- Integrity for GPS
- Enhancement to GPS (more ranging signals, better availability of signals)
- Ionosphere corrections

Strengths

- Sole means navigation system
- Impervious to all weather phenomena
- Designed and developed for international participation

Weakness

- High cost
- Requires regional coverage to realize benefits that are cost productive

European Geostationary Navigational Overlay System (EGNOS)

EGNOS will be deployed in two phases, GNSS-1 and GNSS-2. GNSS-1 is an augmentation of GPS and is very similar to the WAAS.

Characteristics

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

Strengths (potential)

- Sole means navigation system for all phases of flight
- International participation considered
- Has an additional GEO (ARTEMIS) to provide ranging signals

Weakness (potential)

- High cost

- Requires regional coverage to realize benefits that are cost productive
- Has been delayed for more than 2 years; no firm operational date set

Ground-Based Augmentation Systems (GBAS)

Local Area Augmentation System (LAAS)

The LAAS is a GBAS system designed to differentially correct the signal of GPS satellites so that suitably equipped users can perform precision approach and landing (CAT I/II/III), and surface navigation in the airport area.

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

Strengths
- High accuracy, high availability
- CAT I-III capability
- Can support more than one airport or runway
- Surface navigation
- Arrival/Departure navigation

Weaknesses
- Limited range
- Line of sight

Ground-based Regional Augmentation System (GRAS)

The GRAS is a new innovation in satellite navigation and works similar to an SBAS, but may have the potential to also provide a precision approach capability to a broader range of airports similar to a LAAS. 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.

Characteristics
- Ground-based positioning system based on GPS
- SBAS message format
- Regional coverage

Strengths
- Can produce both SBAS and GBAS message formats
- Provider controls message text

Weaknesses
- Limited coverage, based on number of ground stations
- Line-of-sight limitation
- Interference

Surveillance

Monopulse Secondary Surveillance Radar (MSSR)

Characteristics

- Primary radar coverage to 60 NM
- Secondary radar based on "transponder signals" (250 NM coverage)
- 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 (ADS)

Automatic Dependent Surveillance is both contract and broadcast. ADS-C, formerly known as ADS-A, has applications for surveillance in the en route and terminal environment and ADS-B has applications for surveillance in the departure/arrival areas, airport surface, and air-air (TCAS-Traffic Collision and Avoidance System) .

ADS-C

Characteristics

- Periodic/demand/events broadcasts
- "Line of sight" coverage
- Operates with several receivers

Strengths

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

Weaknesses

- Line of sight coverage (additional VHF antenna will increase coverage)
- Requires up-grade to radios
- Requires on-board avionics
- En route/terminal applications only; not available for surface surveillance

ADS-B

Characteristics

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

Strengths

- SARPs are available
- Compatible with Eurocontrol strategy
- Uses existing VHF spectrum
- Supports all domestic applications
- Low cost surveillance for service providers
- Low cost VHF antenna/receiver can increase coverage
- ATN complaint

Weaknesses

- Line of sight coverage (additional VHF antenna will increase coverage)
- Requires up-grade to radios
- Requires on-board avionics
- Surface, air-air, immediate terminal area applications; en route use being tested
- Can not be supported by VDL M2

Multilateration

Multilateration is relatively new on the surveillance scene. The technology is a transponder-based Multilateration system that uses multiple receivers to capture aircraft transponder pulses to calculate position and identification. The system is configured with multiple low-cost, non-rotating sensors strategically placed in the surveillance area. The Multilateration process, with its typical update rate of once per second, allows the system to provide accuracy of 5 meters or less for surface surveillance, and 30 meters or less for wide area surveillance. 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.

Characteristics

- Transponder-based surveillance system
- Aircraft dependent (transponder)

Strengths

- Low cost
- Radar enhancement
- Potential for low activity airports

Weaknesses

- Primarily ground surveillance system
- Line-of-site limitation
- Coverage depends on ground sensors

- No maturity; recent development

Air Traffic Management

Surface Manager Advisor (SMA)

Characteristics
- Software upgrade to AIS
- Airport management tool
- Communications network

Strengths
- Dissemination of airport information
- Airport user network
- Reduces delays

Weaknesses
- All airport users need to be connected to network

Center TRACON Automation System (CTAS)

CTAS includes a family of automation tools used for planning and controlling arrival air traffic. CTAS generates air traffic advisories designed to increase fuel efficiency, reduce delays, and provide automation assistance to air traffic controllers in achieving acceptable aircraft sequencing and separation as well as improving airport capacity. CTAS accomplishes this without decreasing safety or increasing controller workload. Included in this family of spacing tools is URET, FAST (Final Approach Sequencing Tool), TMA (Traffic Management Advisor), and many others. This analysis concentrates on those tools recommended in Option 3 which includes CTAS, URET, TMA, and FAST.

Characteristics
- Computer-based predicting tool
- Radar inter-faced

Strengths
- Computes and predicts arrival sequences with accuracy
- Adapts to changing environment including controller constraints
- Integrates weather, flow control restrictions, aircraft characteristics

Weaknesses
- Can not compute pilot intent
- Dependent on controller input in some scenarios

User Request Evaluation Tool (URET)

Characteristics
- Controller prediction tool

- Performance based on flight plan and tracker

Strengths
- Predicts potential aircraft conflictions 20 minutes in advance
- Provides separation recommendations (route/altitude change)
- Supports flight data management
- Provides timely detections

Weaknesses
- Not fully matured; False alerts still above average; missed alerts still a problem

Final Approach Sequencing Tool (FAST)

Characteristics
- Controller sequencing tool
- Radar interfaced

Strengths
- Accurate controller prediction tool
- Conflict probe and resolution
- Runway selector

Weaknesses
- Non-arrival aircraft clutter radar display of arrival sequence
- Difficulty in association of advisories with correct aircraft

Traffic Management Advisor (TMA)

Characteristics
- Controller sequencing tool for traffic management
- Radar interfaced

Strengths
- Sequences and meters to the outer fixes
- Supports en route traffic management
- Provides an en route flow sequence
- Meters traffic up to 90 minutes

Weaknesses
- Oldest of the sequencing tools
- May be supplanted by other CTAS tools

Advanced Surface Movement Guidance and Control System (A-SMGCS)

Characteristics
- Advanced airport lighting system
- Computer driven

Strengths

- Eliminates runway incursions
- Identifies and monitors aircraft around the airport
- Determines conflict-free taxi routes
- Uses optical signals to guide aircraft
- Safety enhancer at airports

Weaknesses
- Requires several surface sensors

Collaborative Decision Making (CDM)

Characteristics
- User interaction
- Collaboration

Strengths
- User/provider team work
- Information sharing
- Mutual understanding
- Respect for roles and responsibilities

Weaknesses
- Not yet widely accepted by providers, but proven to be effective

Traffic Flow Management (TFM – Flow Control)

Characteristics
- Traffic management tool
- Computer driven
- Flow management initiatives

Strengths
- Distributes controller workload
- Decrease aircraft holding time
- Collaborative partnership
- Flexibility in traffic management
- Traffic visualization
- Reduces traffic restrictions
- Increase capacity

Weaknesses
- Some flow programs based on proposed flight plan; not real time
- Controller confidence
- Being supplanted by Enhanced Traffic Management Service (ETMS)

Technology Conclusions

General

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

Data Communications Conclusions

VDL Mode 2

- Currently being implemented for AOC communications.
- SARPs available.
- VDL M2 equipment is 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)

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 M4 supports all of the candidate ATN data link applications
- VDL M4 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
- SARPs available

Mode S

- Mode S does not meet transit delay and coverage requirements for some applications
- A-SMGCS, PDC, D-ATIS, AIS, FIS are not supported
- 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
- SARPs available

AMSS

- ADS-C is not supported in terminal area due to transfer time limitations

- ADS-B and A-SMGCS are not supported due to time transfer delay
- Expensive for routine operations
- SARPs available

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-C is not supported in terminal areas due to unpredictable propagation disturbances
- ADS-B and A-SMGCS are not supported
- SARPs available

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

Voice Communications Conclusions

VHF

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

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

AMSS
- Excessive time delay for ATC operations
- Non-polar coverage

Navigation Conclusions

GPS
- Supports primary means navigation worldwide
- Supports sole means in all areas when properly augmented
- Should support precision approaches when properly augmented
- Mature, seasoned constellation
- Has no integrity; must be provided by airborne or ground-based system

- Presently certified for IMC (instrument meteorological conditions) flight for oceanic en route, terminal, and non-precision approaches as a primary means of navigation
- SARPs available

GLONASS
- Is not certified for IFR flight
- Not a mature system
- Full constellation not operational
- Satellites have a limited life span
- Avionics not available
- SARPs available

Galileo
- Controlled by the European Space Agency
- Continuous program schedule delays
- Provides similar services as GPS
- Possible charges for use

WAAS
- Approved for sole means navigation
- Encourages international participation
- SARPs available

EGNOS
- Schedule delays and set backs
- Charges for precision capability not established
- SARPs available

LAAS
- Potential precision approach capability CAT I through CAT III for LAAS
- High availability, high accuracy
- May serve more than one airport
- SARPs available

GRAS
- Ground-based regional system based on GPS
- Can produce both SBAS and GBAS message formats
- Provider controls message text
- Limited coverage, based on number of ground stations
- No standards or SARPs
- Immature and interference issues

Surveillance Conclusions

MSSR
- Mature, reliable, accepted

- Usable for all domestic separation standards
- Expensive

ADS-C
- Most cost effective of data link surveillance technologies
- Use is limited to oceanic/remote areas
- Requires data link to transmit position
- ATN compliant
- SARPs available

ADS-B
- Supports all domestic applications
- ATN compliant
- Very accurate
- SARPS available
- Requires data link to transmit position

Multilateration
- Low cost surveillance technology
- Emerging technology with good potential

Air Traffic Management Conclusions

SMA
- Airport management tool
- Airport user network
- Dissemination of airport information
- Effective where used

CTAS
- Controller computer prediction tool/radar required
- Predicts aircraft arrival sequences
- Adapts to changing environment

URET
- Controller prediction tool/radar interfaced
- Predicts potential aircraft conflicts within a 20 minute parameter
- Recommends separation strategies
- Some false alerts and missed alerts still occur
- Has high controller approval

FAST
- Controller approach sequencing tool/radar interfaced
- Conflict probe and resolution
- High controller approval

TMA

- En Route controller sequencing and metering tool
- Meters up to 90 minutes
- Supports en route traffic management
- Older technology

A-SMGCS

- Advanced airport lighting system
- Identifies, tracks, and monitors aircraft around airport
- Uses optical signals
- Eliminates runway incursions

CDM

- Provider/user collaboration
- Information sharing
- Mutual understanding of roles and responsibilities

TFM

- Traffic management tool
- Distributes controller workload
- Flexibility in traffic management
- Reduces aircraft in-flight and holding times

Glossary

AAIM	Aircraft Autonomous Integrity Monitoring
ABAS	Airborne-Based Augmentation System
A-BPSK	A-Binary Phase Shift Keying
ACARS	Aircraft Communications Addressing and Reporting System
ACAS	Aircraft Collision and Avoidance System
ACC	Area Control Center
ACSE	Application Control Service Elements
ADS	Automatic Dependent Surveillance
ADS-C	Automatic Dependent Surveillance-Contract
ADS-B	ADS-Broadcast
AFDP	Automatic Flight Data Processor
AFTN	Aeronautical Fixed Telecommunications Network
AIDC	ATS Interfacility Data Link Communications
AFI	African-Indian Ocean
AIS	Aeronautical Information Service
AMHS	Aeronautical Message Handling Service
AMMSK	Advanced Modulation Minimum Shift Keying
AMSS	Aeronautical Mobile Satellite System
AOA	ACARS over VHF Data Link
AOC	Airlines Operational Control
AOR-E	Atlantic Ocean Region - East
APV	Non-precision Approach with Vertical Guidance
ARINC	Aeronautical Radio, Inc.
ARTCC	Air Route Traffic Control Center

ASDE	Airport Surface Detection Equipment
ASE	Application Service Elements
ASR	Airport Surveillance Radar
A-SMGCS	Advance - Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
ATK	Average Ton-Kilometer
AVLC	Aviation VHF Link Control
AWOP	All Weather Operations Panel (ICAO panel)
BPS	Boeing Positioning System
BPSK	Binary Phase Shift Keying
B-RNAV	Basic Area Navigation
CAEP	Committee on Aviation Environmental Protection
CAT I	Category I precision approach
CAT II	Category II precision approach
CAT III	Category III precision approach
CDTI	Cockpit Display of Traffic Information
CFC	Chloro-fluorocarbons
CIDIN	Common ICAO Data Interchange Network
CNS/ATM	Communications, Navigation, Surveillance/Air Traffic Management
CM	Context Management
CPDLC	Controller-Pilot Data Link Communications
CRT	Cathode Ray Tube

CSMA	Carrier Switching Multiple Access
CTAS	Center/Tracon Automation system
D8PSK	Differential 8 Phase Shift Keying
DAMA	Demand Assigned Multiple Access
DASR	Digital Airport Surveillance Radar
D-ATIS	Digital Automatic Terminal Information Service
DGPS	Differential GPS
DME	Distance Measuring Equipment
DORS	DORS International
EC	European Commission
ECAM	Electronic Centralize Aircraft Monitoring
EGNOS	European Geostationary Navigation Overlay System
EICAS	Engine Indication and Crew Alerting System
ESA	European Space Agency
EU	European Union
Eurocontrol	European Organization for the Safety of Air Navigation
FAA	U.S. Federal Aviation Administration
FANS	Future Air Navigation System
FAST	Final Approach Sequencing Tool
FDE	Fault Detection and Exclusion
FIR	Flight Information Region
FIS	Flight Information Service
FM	Frequency Modulation
FL	Flight Level
FMS	Flight Management System

FOC	Full Operational Capability
FTE	Flight Technical Error
GBAS	Ground-Based Augmentation System
GEO	Geostationary Satellite
GES	Ground Earth Station
GFSK	Gaussian-Filtered Frequency Shift Keying
GIC	Ground Integrity Channel
GLONASS	Global Orbiting Navigational System
GMS	GRAS Master Station
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRAS	Ground Regional Augmentation System
GRS	GRAS Reference Station
GSTB	Galileo System Test Bed
GVS	GRAS VHF Stations
HF	High Frequency
HFDL	HF Data Link
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICS	Internet Communication Service
ILS	Instrument Landing System
INS	Inertial Reference System
INTELSAT	International Telecommunication Satellite Consortium
IMARSAT	International Maritime Satellites
IMC	Instrument Meteorological Conditions
IOR	Indian Ocean Region

IOV	In Orbit Validation
IPCC	International Panel for Climate Change
IRR	Internal Rate of Return
IRS	Inertial Reference System
ISPACG	Informal South Pacific ATC Coordinating Group
KHz	Kilohertz
LAAS	Local Area Augmentation System
LEO	Low Earth Satellite
MCC	Master Control Center
MCS	Master Control Station
MEO	Medium Earth Orbit
MHz	Megahertz
ML	Multilateration
Mode S ES	Mode Select 1090 Extended Squitter
MSAS	Multi-Functional Transport Satellite-Based Augmentation System
MSSR	Monopulse Secondary Surveillance Radar
MTD	Moving Target Indicator
MTSAT	Multi-Functional Transport Satellite
NDB	Non-directional Beacon
NLES	Navigation Landing Earth Station
NM	Nautical Miles
NOPAC	North Pacific Route Structure
NOTAM	Notice to Airmen
NPA	Non-precision Approach
NSE	Navigation Sensor Error

OSI	Open System Interconnection
PDC	Pre-departure Clearances
PIREPS	Pilot Reports (weather)
PMS	Precipitation Map Service
PPS	Precise Positioning System
PSTN	Public Service Telephone Service
QPSK	Quadrature Phase Shift Keying
RAIM	Receiver Autonomous Integrity Monitoring
RCP	Required Communication Performance
RIMS	Ranging and Integrity Monitoring Station
RNAV	Area Navigation
RNP	Required Navigation Performance
RSP	Required Surveillance Performance
RSPS	Regional Satellite Positioning System (Lockheed)
RTSP	Required Total System Performance
RVR	Runway Visibility Range
RVSM	Reduced Vertical Separation Minima
SARPs	Standards and Recommended Practices
SBAS	Satellite-Based Augmentation System
SCAT-1	Special Category I Precision Approach
SID	Standard Instrument Departure
SITA	Societe Internationale de Telecommunications
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
STDMA	Self-Organizing Time Division Multiple access

TCAS	Traffic Collision and Avoidance System
TDMA	Time Division Multiple Access
TFM	Traffic Flow Management
TIS	Traffic Information System
TKP	Ton-kilometer Performed
TMA	Traffic Manager Advisor
TP	Target Processor
TSE	Total System Error
TSO	Technical Standard Order
TWS	Terminal Weather Service
UAT	Universal Access Transceiver
UNFCCC	United Nations Framework Committee on Climate Changes
ULCS	Upper Layer Communication Service
URET	User Request Evaluation Tool
US	United States
USD	United States Dollar
USOAP	Universal Safety Oversight Audit Program
VCCS	Voice Control Communications System
VDB	VHF Data Broadcast
VDL	VHF Data Link
VDL M2	VDL Mode 2
VDL M3	VDL Mode 3
VDL M4	VDL Mode 4
VHF	Very High Frequency
VHF ER	Very High Frequency - Extended Range

VOR/DME	VHF Omni-Directional Range/Distance Measuring Equipment
VSAT	Very Small Aperture Terminal
WAAS	Wide Area Augmentation System
WHO	World Health Organization
WSA	Wind Shear Advisory
WRM	Wide Area Reference Monitors

Technology Options

Objective

The objective of Task 9 is to *Determine the Best Technology Options based on Operational Benefits vs. Cost*

Using previous information and data DORS will shall prepare optional transition scenarios that will be considered by the five ANSPs in developing a plan for the implementation of the CNS/ATM systems.

DORS will determine the cost(s) versus benefit(s) of the options to determine the optimum method for implementing appropriate technologies for national and/or regional investments by one or more of the five service providers.

This analysis should consider a life cycle approach for phasing out existing technology and cost of installing, operating, and maintaining the new infrastructure. DORS will specifically address transition issues through the comparison of new technology options to cost-benefit trade-offs that would result from relying on current technologies. This analysis should also consider any investment required in upgrading the underlying support infrastructure.

The Plan should prioritize the recommendations pertaining to the introduction of new technologies for airspace and air traffic management under two implementation scenarios. The first shall provide a phased approach to the investments needed to implement the Plan's prioritized activities. The second should address the activities in the investment plan on a year-by-year basis, and the Contractor shall identify costs in the following categories: (i) technology, systems, and equipment; (ii) training; (iii) maintenance; and (iv) staffing needs.

Requirements Definition

ICAO has been promoting the future air navigation concept known as CNS/ATM for several years. This new concept has required the development and manufacture of new air navigation systems and equipment. Manufacturers of CNS/ATM systems and equipment have kept pace with the transition from the present ground-based air navigation system to one that employs both satellite-based and ground-based technologies. CNS/ATM systems and equipment are now available to provide the many benefits that are associated with a CNS/ATM environment and at affordable and competitive costs. Many states and regions have already purchased CNS/ATM equipment and are well into their CNS/ATM implementation plans, providing a variety of new benefits to their users on a daily basis.

The key to a successful CNS/ATM transition plan is clearly defining and understanding the requirements for all those involved. A lack of requirements knowledge will typically lead to poor, if not wrong, decisions and loss of resources.

The most important objective of CNS/ATM is to enable aircraft operators to expand system capacity through the implementation of technological and procedural enablers while maintaining or improving an equivalent level of safety. Indicators of success in CNS/ATM would be enabling operators to meet their planned times of departure and arrival, and to adhere to their preferred flight path with minimum constraints and without compromising levels of safety. Service providers must develop new and different requirements in order to meet these objectives.

There are four different types of requirements that providers need to address in a CNS/ATM environment in order to meet the objectives of CNS/ATM. Those requirements are operational, equipment, procedural, and system requirements.

Operational Requirements

Operational requirements are those services recommended or mandated by ICAO, or requirements that are derived from a system requirement or system objective. Such services permit aircraft operators to operate safely and more efficiently from departure to arrival that starts with flight plan filing and ends at the arrival gate. For example, ICAO has recommended and most states consider it a mandate, that all airports that service international flights have a precision approach capability. Therefore, the precision approach capability becomes an operational requirement. Additional services such as PDC (Pre-departure Clearance) are at present optional, but if the provider decides to provide PDC, then PDC becomes an operational requirement. Operational requirements must be determined before equipment and procedural requirements are considered. In effect, requirements must be benefits driven.

Equipment Requirements

Equipment requirements are those pieces of equipment that enable or in part satisfy operational requirements. In the previous example where the precision approach was the operational requirement, an ILS (Instrument Landing System) could satisfy the precision approach requirement; therefore, the ILS could be the equipment requirement. Equipment requirements should only be considered after an operational requirement has

been established. Equipment that does not satisfy an operational requirement is considered "nice to have", but cannot be supported by a cost benefit analysis.

Procedural Requirements

Procedural requirements are those written instructions which are required to permit air traffic controllers to meet operational requirements. In the previous example, procedures such as the instrument approach procedure and air traffic control procedures would be procedural requirements and must be developed in order to permit the controller to offer the precision approach to the user.

System Requirements

The term "system requirement" is generally considered as the combination of operational, equipment, and procedural requirements. A system requirement can also be considered as a concept for which operational requirements can be determined. For example, if a provider decides they want a "seamless airspace" concept, then the seamless airspace becomes the system requirement and from that the operational requirements can be determined.

Requirement Considerations

The resolutions for flight/airspace limitations provide the basis for determining operational and equipment requirements; however, there are other entities that affect the determination of requirements such as aircraft and provider characteristics. These characteristics must be taken into consideration when determining operational and equipment requirements as well as the characteristics of those providers that supply systems for ATC (Air Traffic Control) use. In addition to those already mentioned, we must also take into consideration user requirements (Chapter 4) when developing operational and equipment requirements.

Aircraft Characteristics

Aircraft characteristics must support operational capabilities and behaviors. This must be accomplished through on-board avionics, automation, communications equipment, and in some cases, through manual manipulations by pilots. The difference in aircraft performances will create potential complexities in which the ATC system must develop solutions and system requirements to support those solutions. However, the characteristics of the aircraft must be able to support the following:

- Maintain aircraft flight path in accordance with its flight plan;
- Maintain aircraft flight path in conformance with navigation and guidance capabilities consistent with airspace requirements;
- Receive and acknowledge clearance information from ATC using communications and performance functionalities consistent with procedures and minima;
- Inform ATC of the aircraft state and intent consistent with reporting functionalities, procedures, and minima; and
- Receive and acknowledge re-route information from both auto-load capabilities and/or ATC data link.

In the CNS/ATM environment, there is a greater appreciation of the fact that the operational requirements of users will drive the provision of air traffic services. Investment decisions in avionics and procedures will be driven by the business considerations of those users. The movement toward a global CNS/ATM system is based upon the realization that aircraft must operate seamlessly throughout the world. ANSPs (Air Navigation Service Providers) must conform to the realities of aircraft equipage and airspace user business considerations when developing operational requirements.

Air Traffic Service Characteristics

The characteristics of the air traffic service permit controllers to provide for the safe implementation of rules, procedures, and standards. These characteristics enable controllers to effectively monitor air traffic under their control with reasonable workloads, and may be realized through a number of combinations of automation tools including surveillance, displays, and manual methods. These characteristics are both operational and procedural, and some equipment is required for the controllers to effectively manage these characteristics. These characteristics include the capabilities to:

- Inform controllers of the state and intent of aircraft under their control;
- Assure separation between aircraft and obstructions;
- Modify a flight path or react to a flight plan change request due to weather or emergency;
- Coordinate control responsibilities and clearances;
- Distribute information to aircraft and/or pilots including adverse weather conditions;
- Monitor aircraft conformance to its published flight plan;
- Maintain records of clearances and clearance sequences;
- Determine potential conflict and conflict resolutions;
- Provide for dynamic reroutes;
- Measure, validate, and document the components of achieved total system performance; and
- Provide for an orderly flow of aircraft, permitting user trajectory when and where possible.

System Provider Characteristics

As the range and technical sophistication of air traffic management capabilities has expanded, airspace users and air traffic service providers have recognized that their ability to meet the full range of operational requirements for CNS/ATM is limited. Both sets of parties have recognized their mutual interest in externalizing the provision of some services. Traditionally, service providers, such as ARINC (Aeronautical Radio, Inc.) and SITA (Societe Internationale de Telecommunications) have gained wide acceptance as a communications service provider. They presently provide worldwide communication services such as oceanic communications in the form of HFDL (High Frequency Data Link) and AMSS (Aeronautical Mobile Satellite Service). They also provide PDC and ATIS (Automatic Terminal Information Service) through ACARS (Aircraft Communications and Reporting System), and may continue to provide other data link services in the future. Other providers such as Lockheed, Boeing, and IMARSAT are providing navigational services using various satellite combinations. With

the expansion of the CNS/ATM concept, a broader range of services will be provided by these service providers and other entities outside the control of the air traffic service providers. The provision of these services will be done on a global basis, reflecting the necessity for aircraft to be able to function seamlessly though global airspace. Likewise, communications and navigation service providers will be committed to the provision of a uniform capability throughout their service area. Therefore, the services provided by service providers, whether it be communications or navigation, must be considered when developing operational and equipment requirements.

User Requirements

In developing the operational and equipment requirements user concerns and desires must be considered. Although local and regional users provided comments during the on-site evaluations, IATA (International Air Transport Association) was able to supplement those comments with other comments from international airlines. While the users refer to these concerns as their requirements, they are not provider requirements until the provider decides to accept a concern as one of their requirements.

In light of the potential increase expected in air traffic within central Asia and the enormous expenditures that are anticipated for CNS/ATM, the airline industry as a whole must strive for efficiency while reducing cost and improving safety. Therefore, the users are interested in an aviation system that will enhance safety, reduce cost, and accommodate an increasing growth in air traffic. The airline industry is focusing on those initiatives that will produce an aviation system that accomplishes their goals.

Communication Requirements

The user's communications requirements include VHF (Very High Frequency) voice and data; however, they believe the continued development of various data link technologies will proliferate the VHF communication spectrum. Therefore, it is incumbent on the providers to consider the air carrier's view when determining communication links.

Users support the increase in VHF air-ground voice communications for aircraft operating above Flight Level (FL) 110. They also support the expanded use of VDL M2 (VHF Data Link Mode 2) for most data link services even thought the link has limitations. The users support the use of Mode S 1090ES (Mode Select 1090 Extended Squitter) as the most promising ADS (Automatic Dependent Surveillance) link, but are beginning to look more favorably on VDL M4 (Mode 4). The majority of the carriers believe that VDL M2 will increase the speed and capacity over ACARS without increasing band congestion.

Navigation Requirements

The users have expressed an adamant desire to use GNSS (Global Navigation Satellite System) to provide aircraft with accurate worldwide navigational capabilities while improving upon the present levels of safety performance. Several carriers as well as IATA expect GNSS to be the primary navigation system for all phases of flight from oceanic and domestic en route down to CAT I-III (Category I-III) minima.

The air carriers indicated they are expecting a seamless airspace which they believe is only attainable with GNSS using RNP (Required Navigation Performance). While the most important requirement for the carriers is RNAV (Area Navigation) routes, the potential benefits associated with RNAV routes will not reach their highest potential without the reduction of separation standards, which is only attainable with GNSS. Therefore, the carriers want a transition to GNSS and RNP as soon as practical. They also believe some type of redundancy for navigation in the form of a skeleton VOR/DME (VHF Omni-directional Range/Distance Measuring Equipment) system should remain. The use of RNP will also give some carriers the capability to receive navigational benefits using their present on-board avionics while transitioning their aircraft to a satellite-based environment.

Previously, the users preferred ILS for CAT I-III precision approaches due to the immaturity of GNSS to meet the more stringent requirements for these types of approaches; however, carriers are beginning to use GNSS precision approaches more each day. The carriers have also expressed a desire to have precision approach capability at all airports they serve. Most carriers believe that APV (Non-precision Approach with Vertical Guidance) approaches will be a cost-saving alternative to CAT I in those areas where ILSs are not cost efficient.

Surveillance Requirements

The carriers would like to see surveillance coverage in all areas of the world and believe that ADS can fill the gaps in most radar coverage schemes. They recommend ADS-C (Contract) for oceanic, domestic, remote, mountainous, and desert areas; ADS-B (Broadcast) for surface and terminal areas. Although the carriers have recommended ADS-C, they are putting special emphasis on ADS-B because of the accuracy and potential benefits it offers, and because it also has the potential as an en route surveillance enhancer. They expect the benefits from ADS-B to include surface and en route surveillance, reduced separation on departures, and other benefits in the terminal airspace. Although the carriers support the early implementation of ADS, they want the states to implement this initiative in a cost effective and interoperable manner which includes limited ADS data links.

ATM (Air Traffic Management)

The users believe the management of aircraft should be a collaborative activity between the controller, the pilot and the airline operators. The aircraft should begin to have greater autonomy, particular in the area of providing their own separation, and the air traffic controller's tasks should take full advantage of automation and become one of more monitoring than actual controlling. Therefore, the user's requirements in this area are "seamless" flight operations, improved procedures, and the inserting of new technologies that are harmonized, interoperable, and compatible, regardless of national borders. There are several initiatives that the users want to continue and to expand on a worldwide basis that are presently being provided on a limited basis.

- Greater use of RVSM (Reduced Vertical Separation Minima) which is the reduction of vertical separation to 1,000 feet between aircraft operating above FL 290.
- The worldwide application of RNP which will provide greater levels of airspace capacity and efficiency.
- The implementation of RNAV which permits aircraft operations on any desired flight path within the coverage of a self-contained navigation system (GNSS).
- The expansion of CDM (Collaborative Decision Making) which permits user interaction on cooperation with ATC on matters that affect the carriers. Collaboration is simply team work, which requires working together, sharing information, and the mutual understanding and acceptance of respective roles and responsibilities.

CNS/ATM Equipment Analysis

In this chapter, DORS will identify, analyze, and evaluate current and future CNS/ATM equipment and systems that may be used and considered for satisfying the requirements. There has been new equipment and many new systems developed in the CNS/ATM concept, but all are not germane to CNS/ATM implementation for the Central Asia states. Therefore, we will explore only those technologies that DORS will recommend for the CNS/ATM transition in the Central Asia region for the participating States.

Communications

ATN (Aeronautical Telecommunications Network)

The ATN system, which is a single, cooperative, data network that uses a variety of physical sub-networks, both air-ground and ground-based, connected by computers running standardized inter-networking protocols, is the standard for future communications. ATN will utilize satellite, VHF, HF (High Frequency), Mode S (Mode Select), or other acceptable sub-networks to transmit data from one end-system to another utilizing a common protocol similar to those used over the Internet. Any ATN host computer will be able to communicate with any other ATN computer over the network without any direct physical link.

The lack of ATN routers had previously delayed implementation of the ATN. Now ATN routers are being commercially marketed by ATNSI (ATN Systems Incorporated), Airtel, ACI (Aeronautical Communications International), OKI Electric, and Sofrevia. Several of these routers have already been installed and are being used in several states and regions. ICAO SARPs (Standards and Recommended Practices) are available for this technology and several countries have already started a transition to the ATN with the implementation of AMHS (Air Traffic Service Message Handling Service), the first sub-network of the ATN.

The primary disadvantage of the ATN is that it is not based on TCP/IP (Transmission Control Protocol/Internet Protocol) protocols, which are the communication's industry standard, and as such may not be thoroughly adaptable to smaller regional networks.

AMHS (Air Traffic Service Message Handling Service)

AMHS, a near term technology, is a high capacity, high-speed internet system that is fully compliant with ICAO ATN standards and will be the first sub-network of the ATN. AMHS is the standard for aeronautical ground-ground communications for the transmission of NOTAMs (Notice for Airmen), flight plans and/or meteorological data. It provides for the exchange and distribution of message oriented traffic between ATC units, users, and providers. It is replacing the non-ATN compliant AFTN (Aeronautical Fixed Telecommunications Network). Although AMHS is a sub-network of the ATN and is the replacement for the AFTN, AMHS can still be used with the AFTN utilizing an AFTN/AMHS gateway until the ATN is operational. The first operational AMHS system went into operation in Europe in February 2005 between Germany and Spain. The Republic of Korea and Taiwan implemented AMHS in 2005, with Australia, Philippines, Singapore, the Arabian Emirates, Hungary and Tunisia following in 2007.

AIDC (Air Traffic Service Inter-facility Data Link Communications)

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 an FIR (Flight Information Region) boundary, coordination of boundary crossings, and the transfer of control. Although AIDC is considered a sub-network of the ATN, almost all AIDC applications will be initiated by an ATM system or an automated FDP (Flight Data Processor), but will still pass through the ATN. At present, several countries including EUROCONTROL (European Organization for the Safety of Air Navigation) are using a non-ATN compliant data exchange program known as OLDI (Online Data Interchange). OLDI has been in use for several years in most European and Middle East countries and provides the same data exchange functions as AIDC. Now that AIDC is operational, several countries have already started the transition process from OLDI to AIDC. Even though AIDC is the ATN compliant data exchange application, it can be interfaced with an FDP or FDP network until the ATN is operational. EUROCONTROL plans to begin their transition in 2009 and be completed by 2012.

Voice Communications and Control System (VCCS)

A VCCS is a communications management system that is generally fiber optic and allows air traffic controllers to establish air-ground and ground-ground communications with pilots and other air traffic controllers. The system generally offers unprecedented voice quality, touch-screen technology, and dynamic reconfiguration capabilities to meet changing needs.

The VCCS integrates air-ground and ground-ground voice communications through an automated, software-driven switching system. The VCCS is designed to provide delay-free voice communications that are unaffected by traffic load, adverse weather conditions, or aircraft emergencies. The system is able to connect calls within 15 milliseconds and process peak traffic loads of more than 2,800 calls per minute.

Voice Communications

The on-site assessment indicated VHF communications are not optimum for all areas. Some existing VHF equipment is approaching the end of its anticipated life cycle. Spare parts are not easily obtained and/or readily available. VHF radio communications with pilots are reportedly poor in some instances, equipment should be upgraded, VHF frequencies sometimes interfere with each other, and range of the radios present problems. Similarly, airspace users indicate that VHF services can be intermittent and undependable in some locations.

However, VHF will continue to provide voice communications within Central Asia airspace. Other communication systems such as AMSS or HF voice may be used as backup voice communications. AMSS does not have polar coverage, but has a high quality of reception. HF has polar coverage, but is inferior to AMSS in reception quality.

Ground communications

The primary/current ground communications system is the AFTN. The AFTN is a worldwide system of aeronautical fixed circuits provided, as part of the aeronautical fixed

service, for the exchange of messages and/or digital data between aeronautical fixed stations having the same or compatible communications characteristics. AFTN comprises aviation entities including: ANS (Air Navigation Services) providers, aviation service providers, airport authorities and government agencies, to name a few. It exchanges vital information for aircraft operations such as distress messages, urgency messages, flight safety messages, meteorological messages, flight regularity messages and aeronautical administrative messages.

An evaluation of the ground-ground communications indicated that the AFTN is used as the primary vehicle for ground-ground communications.

Data Links

VDL M2 (VHF Data Link Mode 2)

VDL M2 features VHF data link using "Carrier Switching, Multiple Access (CSMA)" protocols, which operate at a baud rate of 31.5 Kbps (Kilo Bits Per Second). VDL M2 is an operational, high-speed data link that is capable of providing PDC, D-ATIS (Digital-Automatic Terminal Information Service), CPDLC (Controller-Pilot Data Link Communications), ADS-C, AIS (Aeronautical Information Service), 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 a line-of-sight limitation.

VDL M4 (VHF Data Link Mode 4)

VDL M4 is a multi-purpose data link that can combine several services and applications. It can mix them on a single 25 KHz (Kilohertz) channel 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 frequency modulation scheme GFSK (Gaussian-filtered Frequency Shift Keying) gives the data link long range at low power including very good transmission characteristics on the ground, e.g. at airports. VDL M4 is now available for most all data link technologies. VDL M4 features a modulation technique using STDMA (Self-organizing, Time Division, Multiple Access) protocols and was developed by Swedavia (Sweden CAA). SARPs are available.

ACARS (Aircraft Communications and Reporting System)

ACARS provides cost-effective, highly reliable data link services. ACARS was originally developed for AOC (Airlines Operational Control), 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.

PDC and D-ATIS via ACARS data link or VDL M2 are being used at more than 60 airports in the United States and at several airports in Europe, Asia, and Australia. ACARS is being supplanted by or upgraded to VDL M2 in those areas where higher integrity and greater data rates are essential, but will serve as a gap-filler until VDL M2 is operational. ACARS is not ATN compliant.

HFDL (HF Data Link)

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 of 90 seconds may be too high for many applications like ATC. In 2005, ARINC implemented their 14th global HFDL ground station with each station having a radial coverage of more than 2,700 NM (Nautical Miles).

Mode S (Mode Select)

Mode S is an operational link and has several potential applications, which includes 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 (Megahertz) for the downlink and 1030 MHz for the uplink. Mode S is being upgraded for broadcast surveillance (ADS-B) and is planned for near term applications. Both the United States and EUROCONTROL have selected Mode S 1090ES as their definitive link for the provisions of ADS-B.

CPDLC (Controller-Pilot-Data-Link-Communications)

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 and 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 data link, it is expected to be available with both HF and AMSS data links in the future. Likewise, the limited number of message sets now available will expand as CPDLC is phased into service.

VSAT (Very Small Aperture Terminal)

VSAT systems are satellite communication systems and although not actually considered as a CNS/ATM system, offer great potential in remote areas. VSAT offers a direct, low cost link between facilities and aircraft for fax, voice, and data transmissions. In a VSAT concept, the cost of messaging is in the length of the message not the distance between antennas as long as the distance is within the footprint of the satellite. This makes VSATs a very economical method for the reception and transmission of voice and data communications.

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.

Navigation

In this section we have identified the present and future navigational systems. Although reliable and mature ground-based navigational systems such as VOR/DME, ILS, and NDB (Non-directional Beacon) may be used near term, they will eventually be decommissioned as satellite technology becomes more mature, reliable, and available.

Present Ground-based Navigational Systems

The present ground-based navigational system includes VORs, DMEs, ILS, and NDBs.

The on-site assessment indicated that the ground-based navigation system is composed of older VORs that have been reported in several instances as unreliable. The VORs are also susceptible to failures particularly during severe weather conditions and can be inoperative for extended periods of time. Of more relevance are the observations and comments made by the airspace users who report that the present navigation aids are not fully reliable.

GPS (Global Positioning System)

GPS is the current primary candidate for the positioning constellation that will drive GNSS. GPS is an all-weather, day/night navigation system that enables 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 31 satellites (Block II/IIA/IIR/IIR-M) in six planes of four or more satellites that orbit the earth approximately every 11 hours and 58 minutes and are positioned at a distance of approximately 10,900 NM from earth. The satellites are positioned so that a minimum of 5 or more satellites are in view at all times. The satellites provide continuous ranging signals on two different frequencies. The SPS (Standard Positioning Service) at L1 is most commonly used for civil aviation. The PPS (Precise Positioning Service) at L2 provides a more accurate position, but it is reserved for the United States 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.

GPS is managed by the National Space-based Positioning, Navigation, and Timing (NSPNT) Executive Committee, supported by the NSPNT Executive Secretariat. The NSPNT manages GPS and U.S. Government augmentations to GPS, consistent with national policy, to support and enhance U.S. economic competitiveness and productivity while protecting national security and foreign policy interests.

Two additional ranging frequencies have been added to the Block IIR replacement satellites to further improve the civil capability of GPS. On January 18, 2004, the first Block IIR-M satellite with an additional L2C frequency for civil use was declared operational. Two additional Block IIR-M satellites with an additional L2C frequency were

launched in September 2005 and another Block IIR-M satellite was launched in November 2006. GPS modernization and improvements will continue. At present, the published accuracy of GPS for civil users is near 13 meters or less, but the accuracy using two ranging frequencies may be near 8 meters or less.

The new and improved GPS constellation, "GPS III", is scheduled for operational implementation in 2013 and is expected to be 400 times faster than the present GPS system.

GLONASS (Global Orbiting Navigational Satellite System)

GLONASS was developed by the Russian Federation and is managed by the Russian Space Agency. It was offered to the world through ICAO in January 1996, and accepted in September 1996. The offer was generally the same as GPS except that it was offered for a minimum of 15 years. 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. GLONASS is also based on the SGS-90 (Soviet Geodetic Survey, 1990) datum; also know as the PZ-90 (Parametri Zemli, 1990) datum, which is approximately 15 meters different in the horizontal plane from WGS-84 (World Geodetic Survey, 1984). Although GLONASS is being modernized to be received by a multi-modal receiver, the datum has not yet been converted to WGS-84.

In recent years, Russia has kept the satellite orbits optimized for navigating in Chechnya, increasing signal coverage there at the cost of degrading coverage in the rest of the world. As of July 2007, GLONASS availability in Russia was 37.7% and average availability worldwide was down to 28.8%.

Beginning in 2001, Russia committed to restoring the system by 2011, and in recent years has diversified, brought on the Indian government as a partner in 2004, and accelerated the program with a goal of launching 8 satellites for global coverage by 2009. An additional goal is to have 18 of the 24 required satellites in orbit by 2010. However, the potential of GLONASS to be an active candidate for GNSS continues to be in doubt since at the present time there are a few positioning satellites in operation with an additional satellite in orbit, but not yet operational. An additional concern is that the advertised accuracy of GLONASS is only 57-70 meters with a 95% probability.

Galileo

The Galileo program represents the objective of the European community of autonomy for this crucial technology. Alongside an open service similar to the GPS civilian service, the Galileo system will provide new features to improve and guarantee services, thereby creating the conditions for responding to obligations imposed by critical, safety of life, or commercial applications. Services based on the Galileo system are required to be fully compatible and interoperable at user level with other GNSS services, with no common failure mode between systems. This combined use of the Galileo system and other GNSS systems will offer better performances for all kinds of user communities all over the world.

The Galileo-based services will be provided worldwide and independently from other systems. Galileo, which is still in development, will be Europe's contribution to GNSS,

providing a highly accurate, guaranteed global positioning service under civilian control. It will be inter-operable 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 fully deployed Galileo system will consist of 30 satellites (27 operational + 3 active spares), positioned in three circular MEO (Medium Earth Orbit) planes at an altitude of 23,616 KMs (kilometer) 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 and elsewhere. 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 offer dual frequencies as standard, which will deliver real-time positioning accuracy to the meter range. 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.
Galileo was originally scheduled to be operational in 2008; however, the full operational capability (FOC) date continues to move to the right. FOC is now anticipated to be beyond 2012.

GNSS (Global Navigation Satellite System)

GNSS is a world-wide 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 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. At the present time both GPS and GLONASS are the only two satellite constellations that are candidates for GNSS.

Surveillance

Surveillance is the basic tool of ATC 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. Although en route radars are still manufactured, terminal radars are being manufactured to expand their surveillance coverage and are slowly replacing en route radars as long distance surveillance systems. Even so, en route radars such as the MSSR (Monopulse Secondary Surveillance Radar) are still being manufactured, have modern functionality, and are fully digitized.

The ASR (Airport Surveillance Radar) -11 and ASR-12 were designed as the latest in advanced terminal radar surveillance systems and are very similar in operation, 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 and were the first fully digitized American radar systems. They are modular, solid-state radar systems that incorporate the latest technology in airport surveillance radar systems with secondary coverage 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. Both systems are equipped with an MTI (Moving Target Indicator) that improves aircraft detection in weather and other clutter phenomena. Both systems are equipped with a separate weather-processing channel that defines the weather in six different levels of intensity.

ADS (Automatic Dependent Surveillance)

Although radar will be an important part of the airspace system, the future surveillance system will likely 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. The aircraft's position is determined by onboard avionics (GPS, FMS (Flight Management Systems), VOR/DME, etc) and transmitted to a ground receiver by the ADS avionics via a data link. The position information, provided in longitude and latitude coordinates, is sent to a processor at an ATC facility and displayed on a controller's workstation (radar display) as a target. The accuracy of the ADS information is totally dependent on the accuracy of the onboard avionics; therefore, the definitive position information should be derived from GNSS. There are two forms of ADS; ADS-B and ADS-C. Both technologies have approved SARPs.

ADS-B

ADS-B is an automatic, periodic broadcast of flight information that includes aircraft identification, position, altitude, velocity, intent, acceleration, etc. ADS-B requires a broadcast link and several links are being examined such as VDL M4, HFDL, or Mode S 1090ES. The links of choice are VDL M4 or Mode S 1090ES and many aircraft are beginning to equip with these two links. ADS-B has applications for surface or ground surveillance and for departure surveillance. It is presently being used for CDTI (Cockpit Display of Traffic Information), and has high potential for ACAS, TCAS, and for surface surveillance. At present, power is limited to about 40 NM and the transmission rate is approximately once per second.

ADS-C

ADS-C provides surveillance using positioning information derived from onboard avionics and transmits that information to a ground receiver via an appropriate data link. ADS-C develops a contract with the provider to specify what reports it will make. The 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.

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 can not 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.

Mode S 1090 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 Mode S squitter has 2 different squitters, a short squitter (56 bits) and a longer squitter (112 bits).The short squitter is radiated every five seconds and contains flight number, or tail number for general aviation. The extended squitter 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 potential benefits of the Mode S 1090ES include improved TCAS capability; 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.

ATM (Air Traffic Management)

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.

In this section we have identified several ATM functions, many of which are required functions for air traffic management and others that provide user benefits. Where necessary, we have identified the equipment or systems that may be needed to provide an ATM function.

Air Traffic Management System

Each air traffic facility must have a method of transmitting and processing flight information to another or adjacent ATC facility, particularly flight plan information. At present AFTN is used for flight plan and flight data dissemination. Although this has been satisfactory in some areas where traffic and coordination requirements are low, it is not a satisfactory condition in areas of average to moderate traffic conditions and/or where coordination requirements are higher. The automatic processing and dissemination of flight plans and flight data has been in operation in many regions for several years and is recommended for Central Asia.

An ATM system is the definitive answer for flight data and radar data processing. ATM systems generally contain the most advanced FDP and SDP (Surveillance Data Processor) available today. An ATM system has open architectural design and high performance characteristics that are fully adaptable and scalable to any ATM environment, ranging from a simple tower automation application to a fully integrated national multi-facility system. The system provides a low-cost, low-risk solution for the

complete spectrum of ATC automation that includes flight plan and flight data processing and radar data processing. Most ATM systems will integrate 9 or more radar systems including the integration of ADS and Multilateration information. ATM systems also include a comprehensive set of AIS support systems as well as a full meteorological data processing capability. The system supports an extensive range of data, message sets and interface protocols.

An ATM system is recommended as a requirement since it is a radar and data processing system that can use ADS, radar, ATN, satellite communications, GNSS, Multilateration, and aviation weather to integrate ground-based automation and airborne flight management systems. An ATM system is an integrator that supports the integration between flight data processing, data link, and multiple surveillance sources such as radar, ADS-B, and ADS-C. Most ATM systems will also support wide-area Multilateration.

FDP (Flight Data Processor)

As mentioned above, flight plan and flight data processing is an important requirement in air traffic control. When an ATM system is not available, an FDP is generally used to automate flight data processing. Almost all radar systems that have been manufactured since 1990 have an integrated RDP (Radar Data Processor) and FDP that processes radar and flight data. The difference in an SDP mentioned above and an RDP mentioned here is that an RDP processes radar data from a single radar system where as an SDP processes radar data from several radar systems. An FDP will process all flights that are inserted into the FDP system and distribute control strips within the area defined by the radar processor. When interfaced with other FDPs, they will provide a network for flight data processing. This type of networking is recommended for EAC as a gap-filler until an ATM system comes online.

Airspace Management

The air traffic system should include a network of ATS (Air Traffic Service) 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 developed and recommended when and where available. STARs (Standard Terminal Arrival Routes) and SIDs (Standard Instrument Departure) 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 most regions where the CNS/ATM transition has begun. Airspace management will permit properly equipped aircraft to fly their optimized routes, generally at their requested altitude, and be permitted to change routes based on revised wind forecasts while en route.

There are software tools that have been developed for airspace management, but the traffic in Central Asia airspace is not yet frequent or complex enough to warrant these expensive tools. There are also procedural tools for airspace management such as EDCT (Expect Departure Clearance Time), RNAV, RVSM, and performance-based tools

such as RNP, RSP (Required Surveillance Performance), RCP (Required Communications Performance), and RTSP (Required Total System Performance) that can be implemented at the discretion of the facilities.

TFM (Traffic Flow Management)

Traffic flow management originated in the United States several decades ago. This concept 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 are now held on the ground and given expected departure times, which reduces the overall delay, saves time and fuel, and eases the controller workload.

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. 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 enable 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.

RNAV (Area Navigation)

RNAV is an airspace management tool that provides a user benefit and is a result of the accurate navigation capability provided by satellite navigation. Satellite navigation (GNSS) permits aircraft to fly point-to-point and is not limited by ground-based technology. This user benefit is limited only by air traffic rules and procedures. RNAV route widths and buffer areas have already been determined and recommended by ICAO.

RVSM (Reduced Vertical Separation Minima)

RVSM is the application of reduced vertical separations above FL 290 to 1000' in lieu of the usual 2000'. The air carriers are responsible for the certification of their aircraft for RVSM operations. ANSPs have to develop procedures for its use and then implement it. It is an extremely helpful user benefit and provides more available altitudes for use by the provider and the carrier. The AFI (African-Indian Ocean) Region approved the use of RVSM in 2002, but will not begin RSVM operations until September 2008.

RNP (Required Navigation Performance)

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 performance-based technology that will permit the reduction of aircraft separation. Instead of requiring aircraft to carry certain avionics for flight in their airspace, providers will determine the RNP value for their region, area, or route, and it will be the aircraft's responsibility to determine the equipment they need to meet the RNP requirement.

At present, there are basically two lateral containment areas associated with RNP: a 95 percent containment area (inner) where the aircraft can be expected to remain 95 percent 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. Approach containment areas have been developed for the various categories of approaches.

RCP (Required Communications Performance)

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.

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.

RSP (Required Surveillance Performance)

RSP is the specified monitoring capability that describes 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 en route and terminal airspace. RSP 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.

RTSP (Required Total System Performance)

RTSP 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. SARPs are being developed and should be available soon.

CDM (Collaborative Decision Making)

CDM is one of the basic concepts of CNS/ATM, although it has not yet been fully realized. CDM recognizes the right of the aircraft operator to have a coordinated voice in the manner in which their aircraft are handled, particular in alternate routings, delays, etc. CDM should be implemented for all phases of flight starting from the initial airline planning months in advance, continuing with gate-to-gate flight operations and finishing with the performance registration and user charges calculation. CDM calls for close cooperation between aircraft and airport operators and air navigation service providers to realize the benefits that can be derived by a collaborative decision process.

AIS (Aeronautical Information Service)

ANNEX 15 to the Convention on International Civil Aviation requires states to provide aeronautical information services to users. AIS include AIPs (Aeronautical Information Publications), supplements, maps, charts, pre-flight briefings, NOTAMs, AICs (Aeronautical Information Circulars), meteorology, etc. Almost all AIS information is disseminated via the AFTN, but the improved method is via data link. AIS information in the future will be distributed via VDL M2 in concert with the ATN/ATM system. In Europe, the AIPs, AIP supplements, and AICs of all EUROCONTROL states are available in soft copy on the internet.

Operational Requirements & Solutions

In this chapter, we have outlined many of the operational requirements as they relate to the major areas of Communications, Navigation, Surveillance, and Air Traffic Management. Most of these requirements are applicable to both the upper and lower airspace. These broad requirements will later form the basis for the design of system transition options.

For each requirement, we have recommended a solution. There may be more than one solution available to satisfy each requirement and one solution may satisfy more than one requirement. When there is more than one solution to each requirement, we have identified the definitive solution, but have also listed the other solution options. We have also listed gap-filler solutions, i.e., solutions that will fill the void until a final or definitive solution can be procured or installed.

Communications

Although we will discuss various forms of communication requirements, the ATN is one of the most important communication requirements to be addressed and should be a near-term future requirement. The ATN has been designed to operate as a single, cooperative, data network that will be able to communicate with any other ATN computer over the network without any direct physical link between them. The ATN is a communications tool used to disseminate all types of data with primary emphasis on communications and flight data applications.

Another communication requirement is the implementation of a Voice Communications & Control System. A VCCS provides the integration between air-ground communications and ground-ground communications. It provides radio connections between controllers and aircraft that are communicating with each other through various forms of radio communications and provides connections between controllers and external users through dedicated landlines or lease communications services. From one work station controllers are able to communicate with each other, with aircraft, and with external facilities through a network of frequencies, public telephones links, voice links and intercom communications. While many states utilize a VCCS, it is not a mandatory requirement, but certainly is a helpful tool.

VSATs will be recommended in this document and DORS believes many problems associated with communications could be alleviated through the use of a VSAT network.

Ground-Ground Communications Requirements and Solutions

Requirement: A VCCS is needed to manage air-ground and ground-ground communications networks through dedicated landlines using private or leased switched networks A VCCS is a communications management system that permits controllers to have controllable, interchangeable, and immediate air-ground and ground-ground communication exchanges from their immediate work station with aircraft and other controllers/facilities/organizations. While A VCCSs is an inevitable product, it can be delayed until a future time.

Solution:. The VCCS is built upon a fully decentralized structure with no centralized switching unit and characterized by a distributed digital voice switching and processing

units. The VCCS integrates air-ground and ground-ground voice communications through an automated, software-driven switching system. The VCCS is designed to provide delay-free voice communications that are unaffected by traffic load, adverse weather conditions, or aircraft emergencies. The system generally offers unprecedented voice quality, touch-screen technology, and dynamic reconfiguration capabilities to meet changing needs.

Requirement. To provide direct speech circuits and AFTN or AMHS interconnections between facilities and adjacent FIRs in accordance with Annex 3 and 11. Provide direct voice to all adjacent ATC facilities, search and rescue, aircraft operators, military operators, meteorological facilities, terminal ATC facilities, for the purposes of transferring aircraft estimates and flight data revisions such as time, route, and altitudes.

Solution: VSATs or a VSAT network may be able to provide direct speech circuits with adjacent FIRs if public telephone circuits are not available or unreliable. The alternative to VSAT is telephone cabling which has not proven to be that stable in this region. Direct voice is available through VSAT, landlines, or PTN (Public Telephone Network) for ground-ground voice communications between adjacent ATC facilities and sectors, military and civil services, search and rescue, and meteorological services.

Requirement: Implement an ATN which is an internet-based data network that uses various communications sub-networks to provide for a data exchange that includes flight plans and flight data, aeronautical information, and to provide communications between dissimilar communications networks using common protocols. The ATN is a high visibility project instituted by ICAO for future communications networks and is presently being installed in several states and regions. While not an immediate requirement, it is being highly recommended by ICAO.

Solution: The ATN capability integrated with AMHS and AIDC, and interfaced with an ATM system to provide flight plan and flight data processing and to disseminate all types of data with primary emphasis on communications and flight data applications.

Requirement: A flight data processing system that processes and disseminates flight plans and flight data information as described in Annex 11. While the present system of flight plan processing is adequate for now, it will need upgrading in the near future to meet future capacity
Solution: An ATM system that is interfaced with AMHS. The AMHS is replacing the aging AFTN, but can be used with the AFTN with an AFTN/AMHS gateway until the ATN is operational. Although the AMHS is a sub-network of the ATN, it can also be interfaced directly with an ATM or used as a replacement for the AFTN. The ATM serves a variety of other functions and is identified further in Air Traffic Management.

Another flight data processing solution is an FDP network that could be used until the ATM is operational. All radar systems manufactured after 1990 have integrated RDP and FDP systems. An FDP processes flight plans for all flights entered into the RDP/FDP system. These FDPs can be linked together or networked together to form a flight plan processing network that can use the AFTN as the distribution system. The linking of FDPs will require the linking of the RDPs which can be accomplished using the ASTERIX (All Purpose Structured Eurocontrol Surveillance Information Exchange) protocol. This would provide a flight plan and flight data processing scheme for EAC until the ATN and ATM are operational. When the AMHS is installed, the FDP network can be

interfaced with the AMHS via an AFTN/AMHS gateway for distribution. Another alternative is a centrally located, stand-alone FPDP (Flight Plan Data Processor) that can process flight plans and flight data, but would need to be interfaced with the AFTN, AMHS, or ATN for dissemination to facilities.

Requirement: A method to gather, process, and disseminate aeronautical information that includes meteorological information, NOTAMs, airport information, delays, etc. as indicated in Annex 15. This requirement is presently being met, but a more improved method of distribution should be considered.

Solution: A VDL M2 and/or AFTN capability. Aeronautical information includes dissemination of AIPs, supplements, maps, charts, pre-flight briefings, NOTAMs, AICs, meteorology, etc. AIS information can be disseminated via the AFTN, but should migrate to VDL M2 as soon as possible. AIS information in the future will be distributed by the ATN in concert with the ATM system and eventually disseminated via the internet.

Requirement: A method to control and monitor remote equipment such as NAVAIDs (Navigational Aids), communication, VSATs, and other equipment.

Solution: A RCM (Remote Control and Monitoring) unit is needed at each equipment site to remotely monitor the various ANS (Air Navigation Service) facilities and systems. If communications equipment, a radar system, or navigational facilities are located at the same site, the RCM unit can be configured to monitor and report the status on all facilities. RCM is the most definitive method of control monitoring and should be centralized to the maximum extent possible.

Air-Ground Communications Requirements and Solutions

Requirement: Full VHF voice for direct pilot-controller communications.

Solution: The installation of additional VHF ER (Extended Range) transmitter/receiver units at specific locations to provide the requisite VHF coverage.

VSATs could be part of this solution and may be required to provide direct VHF communications between facilities and aircraft within the required coverage area. VSATs are preferred to cover long distances and can transmit and receive both data and voice.

Requirement: In consideration of assuring optimum services and seamless operations between adjoining airspaces, VHF voice is required for direct pilot-controller communications for primary and routine communications to the extent possible.

Solution: The implementation of additional VHF sites or additional VHF equipment may be required to provide the required coverage; use of VHF-ER equipment is recommended. The communications presently used at some locations should be upgraded.

Requirement: Backup voice communications for both primary and routine communications, and for non-routine and emergency situations.

Solution: Improve HF communications with new or upgraded HF equipment for extended use; Install additional HF units as necessary.

Requirement: Data link capability will be required to support CPDLC, ADS-B/C, AIS, FIS (Flight Information Service), D-ATIS and PDC when these products are available.

Solution: When required, procure and install the following data link capability;

- VDL M2 – for all data link requirements except for ADS-B by 2011;
- VDL M4 – for all data link requirements including ADS-B by 2013;
- Mode S 1090ES – for ADS-B by 2013; and
- HFDL – for oceanic and remote terrain areas as backup for voice by 2014

VDL M2 is the preferred data link for all applications except for ADS-B in which VDL M4 or Mode S 1090ES are the preferred links. VDL, HFDL, and Mode S 1090ES can support additional services such as ADS, AIS, FIS, D-ATIS, and PDC, and can be used for air-ground backup.

Requirement: The approval and use of Required Communications Performance when approved by ICAO.

Solution: Implement RCP when approved by ICAO.

Navigation

GNSS is a satellite-based navigation system relying on satellite positioning systems such as GPS, GLONASS, and Galileo when it becomes operational. GPS has been certified for instrument use and has been operational for more than 10 years. It is being used as a primary means of navigation worldwide. GLONASS does not have sufficient positioning satellites as of yet and is being used mostly in Russian providences. Galileo has been delayed until 2012 or later. It seems prudent that GNSS navigation be the definitive navigation system with a limited number of VOR/DMEs remaining for navigational backup.

En Route Navigation Requirements and Solutions

Requirement: To provide a ground-based navigational capability that meets the criteria for sole means navigation for an aircraft to successfully navigate through sovereign territories of Central Asia, and to successfully navigate to and from airports that includes departure (SIDs) and arrival transitions (STARs). This system is to be maintained until GNSS has been approved as a sole means navigation system.

Solution: Continued use of VOR/DME equipment for sole means navigation until GNSS is approved for sole means navigation, at which time GNSS should become the navigation system of choice. We do not recommend the procurement of any additional VOR/DME equipment.

Requirement: To provide a satellite-based navigational capability that meets the requirements for supplemental means of navigation and to upgrade to primary means. To approve and use GNSS as a supplemental means of navigation.

Solution: Continued use of existing VOR/DME equipment for sole means navigation until GNSS is approved. Continue to expand the present GNSS navigation system to include

more SIDS, STARs, NPAs, and RNAV routes. We suggest the current VOR/DME equipment be retained for redundancy after full GNSS implementation, but we do not recommend the procurement of any additional VOR/DME equipment.

Requirement: To designate RNAV routes as RNP-5 or RNP-10 and to approve the use of RNP in all airspace.

Solution: RNP-5 is presently being used in many parts of the world and should be implemented in all airspace. It is an important function for navigation in that it defines the requirements of the airspace, but permits the aircraft to determine the avionics to best meet those requirements. It is a first step in reduction of aircraft separation minima.

Surveillance

Surveillance Requirements and Solutions

Based on the topography of Central Asia, it is desirable to have surveillance in as much airspace as possible. Not only is surveillance a vital part of aircraft tracking and separation, but it is critical in the event of aircraft accidents. Without surveillance, and based on the mountainous conditions that covers some states, locating a downed aircraft would be lengthy and difficult at best.

Surveillance coverage could pinpoint the impact area reducing the time lost to finding the accident sites. With the successful implementation of ADS and Multilateration, achieving surveillance coverage over the entire airspace at a reasonable cost is highly attainable. The surveillance requirements outlined below would provide surveillance coverage over the majority of the airspace.

It is highly recommended by ICAO and they have approved the use of ADS to enhance radar surveillance and to use as a stand alone surveillance tool. The requirements are designed to ensure the majority of aircraft operating within each state are within surveillance coverage during the departure, en route, and arrival phases of flight. Surveillance requirements can be achieved through the use of existing or future radar systems augmented by ADS-B/C.

Requirement: Surveillance coverage recommended over Central Asia airspace to the maximum extent possible for safety, to avoid delays, to maximize utilization of airspace with vectors and radar separation standards.; Surveillance coverage recommended within 150 NM of major international airport (note: consideration of upper and lower airspace harmonization and seamless operations). This last requirement is consistent with ICAO policy guidelines.

Solution: Implement or maintain MSSRs, and/or ASRs that are sited at optimum coverage (strategic) locations modified to receive secondary transponder replies within 240 NM of radar site. ADS-C or ADS-B are recommended for surveillance in those areas not covered by radar for the en route phase of flight and for departure and arrival transitions. ADS-C can be used as an enhancement to a present radar scheme, or it can be used as a stand alone surveillance tool. Multilateration may also be used to fill en route surveillance gaps. Surveillance will eventually be a mixture of radar systems and ADS.

Air Traffic Management

Functions of ATM should enable aircraft operators to meet their planned times of departure and arrival, adhere to their preferred flight path and trajectory, with minimum constraints and without compromising agreed levels of safety. Airspace management should include a network of ATS routes that enable aircraft to operate along, or as near as practical, to the preferred flight path, in both the horizontal and vertical planes, from the departure point to the destination while maintaining a high level 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. These requirements are designed to improve the quality of ATS and resolve ATS deficiencies that may include but are not limited to a lack of adequate radar or surveillance coverage, direct routings constrained by availability of navigational aids, dissimilar standards, lack of full and complete coordination, quality of communications, and language skills.

The communication, navigation, and surveillance requirements previously outlined are all ATM requirements, but will not be outlined here to eliminate redundancy.

ATM Requirements and Solutions

Requirement: Traffic Flow Management when required.

Solution: Flow management may not be an immediate requirement today, but as over flight traffic continues to increase, it is reasonable to begin preparations for flow control operations. We suggest TFM be reviewed with a goal of implementing basic flow procedures, and then transition to a larger use of flow management as the traffic increases.

Requirement: Approval and use of GNSS to relieve an aging NAVAID system.

Solution: GNSS has been recommended as the predominate navigational capability. GNSS is currently capable of providing primary means of navigation for domestic and oceanic en route, terminal and arrival transitions, and for non-precision approaches.

Requirement: Immediate access to the SAR (Search and Rescue) Rescue Coordination Center

Solution: Search and Rescue services must be available to controllers for en route emergencies that require a search and rescue capability. Controllers or supervisors should have direct dial-up communications capability and a backup communications capability with the SAR unit.

Requirement: Aeronautical Information Service as required by Annex 15

Solution: Aeronautical Information Services must be available for ATC. AIS includes aeronautical information concerning AIPs, AIP supplements, NOTAMs, AICs, charts, and real-time flight information such as meteorology, airport information, flow restrictions, and a host of other aeronautical services. Individual states will retain their responsibility as the provider and source for many of the various AIS documents such as the AIPs.

Requirement: Implementation of Required Total System Performance to include RNP, RCP, and RSP.

Solution: Although the SARPS have been approved for these ATM initiatives, they have not been disseminated by ICAO. Implement RTSP and its subordinate performance parameters RNP, RSP, and RCP when approved by ICAO. RTSP 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. These technologies are in the immediate future and ANSPs need to begin training their personnel how to take advantage of them.

Requirement: Reduced Vertical Separation Minima.

Solution: RVSM is a user benefit presently being used successfully in many regions of the world and has reduced fuel burn, minimized delays, and created considerable savings for the users. It can be used by any aircraft certified to use RVSM. Certification for RVSM is the responsibility of the air carriers. ANSPs need to develop procedures for its use and begin using it.

Requirement: Area Navigation.

Solution: Develop and approved satellite-based RNAV routes and procedures throughout for airspace operations.

Requirement: Initiate Collaborative Decision Making (CDM).

Solution: Collaborative Decision Making is one of the basic concepts of CNS/ATM, although it has not yet been fully utilized. CDM should be implemented for all phases of flight starting from the initial airline planning that takes place months in advance, continuing with gate-to-gate flight operations and finishing with the performance registration and user charges calculations. CDM brings together airlines, civil aviation authorities and airports in an effort to improve air traffic management through information exchange, data sharing and improved automated decision support tools. CDM calls for close cooperation between aircraft operators and airports and ANSPs to realize the benefits that can be derived by a collaborative decision process. CDM is an important air carrier initiative that few ANSPs have taken into consideration.

This philosophy of collaboration promises to become the standard in aviation. CDM enables information sharing and facilitates decision making processes by ensuring that stakeholders are provided with timely and accurate information, essential for the planning of their operations. For example, accurate estimates of arrival and departure times improve aircraft handling, apron services, stand and gate management, ATC and Air Traffic Flow Management. By enabling decision making based on accurate shared information, CDM increases predictability in case of unforeseen events or disruption.

Critical Path from Present Conditions

Function	Present Requirement	Requirement Validation	Present Equipment	Critical Path Present	Critical Path Future	Future Time Time	Comment
Communication							
Flight plan processing and dissemination Flight data dissemination, real-time estimates, altitude/time revisions	Each facility must have least one reliable and accessible ground-ground communication system interfaced with all necessary ATC facilities and adjoining FIRs to forward flight plans and flight data as mandated by ICAO and facility policy or LOP	ANNEX 11 ANNEX 2 ANNEX 15	AFTN, HF VSAT, Telephone	AFTN, VSAT, HF, Telephone	ATN/AMHS, ATM system, FPDP interfacing of RDP/FDP radars VDL M2	2014	
AIS Services, NOTAMS, AIPs and AIP supplements, AICs			AFTN, HF VSAT, Telephone	AFTN, VSAT, HF, Telephone	ATN/AMHS, ATM System VDL M2	2014	
Two-way air-ground communications in The majority of airspace	Sites must have sufficient VHF frequencies and coverage to provide total or near total VHF communications to all aircraft Backup VHF on a one for one basis for all control frequencies, at minimum one per state	ANNEX 11, Chapter 6	VH, HF	VHF limited coverage, HF backup	VHF ER units stragetically sited to provide maximun coverage	2011	VHF ER, data link VDL M2 by 2012
Meteorology information	Provide current weather information to all ATC facilities including forecasts in a timely manner	ANNEX 3 ANNEX 11, Chap 7.1, 2.20	AFTN, HF VSAT, Telephone	AFTN, VSAT, HF, Telephone	ATN/AMHS, ATM System VDL M2	2010	improvements needed in MET communications between facilities and MET bureaus
Voice activated/hotline to all sectors especially SAR; Landlines to all adjoining sectors and facilities	Sector & facility landline communications required between ATC facilities and between sectors that connect with various facilities that interact with the facility including SAR	ANNEX 11, Chapter 2	Landlines not always operable; no radar handoff lines	Each position of operation should have a voice activated hotlines and landlines to all adjacent sectors/FIRs/ACCs/ SAR	Same path including radar handoff lines	2012	
Navigation							
En route navigation capability throughout the airspace at FL 145 and above.	Improve the navigation capability. Note: GNSS should be approved for all phases of flight through non-precision apchs (NPA). GNSS NPAs, RNAV Routes, SIDs, and STARs should be developed to relieve a burdensome VOR system.	Article 28, Chicago Convention	VOR/DME, limited To no use of GNSS	Limited use of VOR/DME and GNSS. Most aircraft that are capable use FMS	Improved VOR/DME, maximum use of GNSS pererred down to NPA. Improve RNAV routes, SID STARS, and RNP-5-10	2012	VORs old and unreliable, failures, considerable signal problems Limited GNSS RNAV, SIDs, and STARs. More needed
Surveillance							
Surveillance over all airspace with emphasis on coverage at FL 245 and above.	For upper airspace surveillance coverage from FL 245 and above over the majority of the airspace and surveillance coverage within 150NM of major cities. (There is no actual ICAO requirement for radar, just recommendation	Safety, Reduce flight time/fuel, ICAO recom-mendation	Radar, position reports	ICAO recommendation: surveillance within 150NM of major cities;	Surveillance over the majority of airspace Use radar and/or ADS	2014	
Air Traffic Management							
Procedures RVSM (Reduce vertical sep. minima) CDM(Collaborative decision making) RNP (Required Navigation Performance) TFM (Traffic Flow Management)	Improve and update procedures not in use not in use not in use These ATM initiatives are not required presently, but are available to provide improved ATC services	DOC 9750	ACC procedures need updating	Procedures based on traditional operations, ground-based equip and systems	New procedures to include RNAV, RVSM, etc	2010 2008 2010 2010 2011	Procedures are needed for use of GNSS separation standards, LOPs, MOUs, preferential routes local ATC procedures, equipment use, emergency/SAR, etc.
Radar Interface procedures	not in use	Annex 11 DOC 4444	Not available	Capability for intrafacility and adjoining radar handoffs point out, etc	Same as present	2009	

Requirements Methodology

Background: The successful movement of people and goods in Central Asia airspace has been ongoing for decades. For the most part, communication, navigation, surveillance and air traffic management (CNS/ATM) systems used for airspace operations rely primarily on traditional ground-based technologies. With the advent of satellite based technology the systems and services available for controlling aircraft have broadened the range of available CNS/ATM tools. These new capabilities are being implemented throughout the world and are fully supported by the International Civil Aviation Organization (ICAO).

The challenge is to determine the optimum combination of traditional and new CNS/ATM systems/services and phase-in their use based on clearly defined operational requirements. Hence, real world operational requirements are the starting point for understanding and selecting the optimum combination of air traffic control tools.

The purpose of this paper and accompanying diagram is to present a structured methodology for determining the best combination of CNS/ATM systems and services for operations.

Discussion: Airspace operational requirements are governed by safety, security, international and regional standards and recommended practices, airspace user desires and capabilities, economic factors, and the levels of service deemed appropriate by the airspace service providers. There will likely be a broad range of operational requirements as direct routing, optimum separation, airspace/air traffic conflict avoidance, smooth flow, etc.

The initial step towards determining the best mix of CNS/ATM systems and services will be to clearly define the desired set of operational requirements without regard to when these requirements will actually be made available. As indicated in the attached diagram, these requirements will determine the "drawers" of the illustrated cube. Note that the illustration contains only 9 drawers, in reality there will likely be more than 9 desired operational requirements.

Each of the operational requirements will have an accompanying set of CNS/ATM options. For instance, in the forecasting of routes/airspace conflicts requirement (reference diagram: drawer C) the options include:

- Communications: voice and/or data link
- Navigation: aircraft position knowledge
- Surveillance: radar and/or automatic dependent surveillance
- ATM: visual displays and accompanying forecasting capabilities such as aircraft vectors, conflict identification/resolution, etc.

Following completion of each operational requirement, the next step will be to separate each of the drawers in accordance with the individual CNS/ATM elements as illustrated in the figures for the "Total Communication Requirements" and "Total Navigation Requirements".

Each of these CNS/ATM elements will have an option set. For instance, all of the red cubes in the "Total Navigation Requirements" figure are individual navigation options associated with each of the operational requirements in drawers A, B, C, D, etc. It is possible that the navigation options in each of the individual red cubes will contain one or more of the following: VOR, VOR/DME, NDB, GNSS (i.e. GPS, Galileo, GLONASS) without augmentation, GNSS with augmentation, etc.

In this navigation example, the objective will be to group as many of the navigation options together as possible. For instance, it may be that the navigation cubes for drawers A, B, C, D, E, F and G can be satisfied by GNSS without augmentation and the navigation cubes for drawers H and I cannot. Should this be the case, then the decision maker will be able to weigh the benefits associated by moving forward with airspace operations based on using GNSS without augmentation and understand those operational requirements that cannot be satisfied.

From an economic perspective such information provides a realistic picture of cost versus benefit and will likely be a compelling factor for making the initial upper airspace navigation decision.

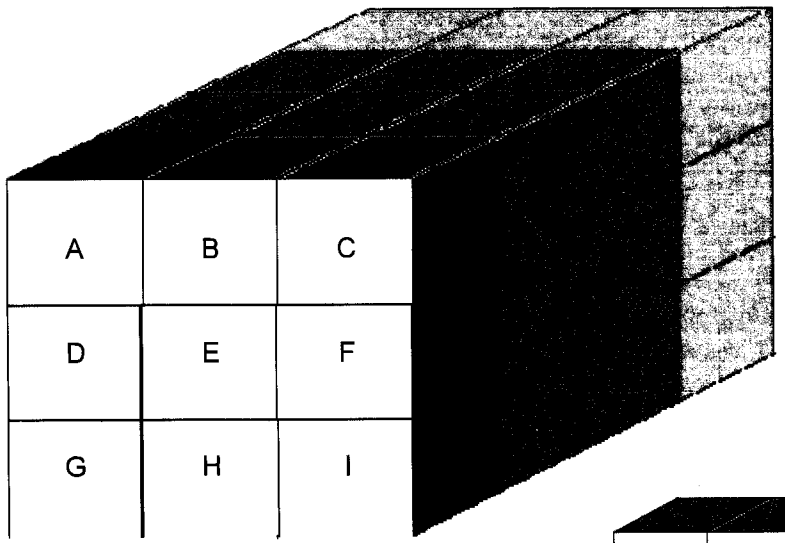
With respect to timing (e.g. when to implement a particular system or service such as GNSS without augmentation), based on experience with the above mentioned methodology, the timing question is typically answered by the cost versus benefit ratio. As a guide, the initial set of CNS/ATM systems selected should provide a return on investment within two years from initial operation.

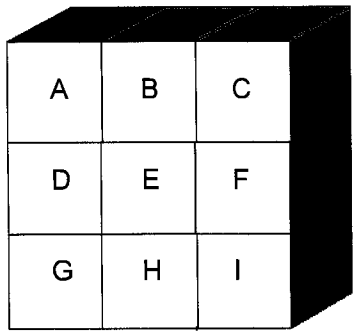
Summary: Operational requirements are the key for success. At first glance the described Requirements Methodology may likely appear either too complex or intuitively obvious/trivial. However, experience has proven that clearly understanding real world operational requirements (both airspace user and service provider) and cost versus benefit ratios will determine the economic success and/or failure of even the best intentions.

Case in point: the US Federal Aviation Administration (FAA) has invested hundreds of millions of dollars in a GNSS augmentation system (GPS Wide Area Augmentation System--WAAS) under an assumption that WAAS would provide significant operational benefits for the airspace users as well the FAA. Unfortunately, this assumption was not an accurate assessment of real world operational requirements and to date, the envisioned benefits have not been realized.

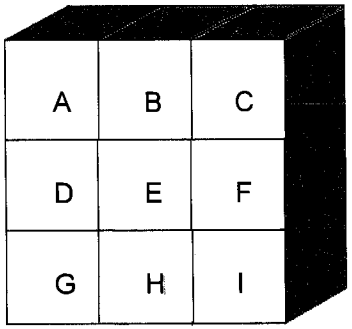
Requirements Methodology

Operational Requirement
Drawer A: Direct routing
Drawer B: Optimized separation
Drawer C: Forecast routes/airspace conflicts
Drawer D: Positive handoff procedures/smooth flow
Drawer E: etc.





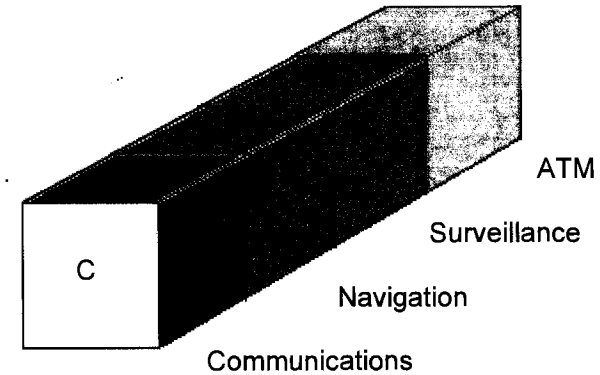
Total Comm. Requirements



Total Nav. Requirements

Color Coding

- **Communications**
- **Navigation**
- **Surveillance**
- **ATM**



CNS/ATM Requirements for Drawer C
(Forecast routes/airspace conflicts)

- **Communications: Voice/Data Link, min delay**
- **Navigation: Aircraft knows position**
- **Surveillance: Radar/ADS**
- **ATM: Visual displays, vectors, warnings**

Cost versus Benefit Considerations

The main criteria for the selection of equipment and systems are the compatibility of the selection with other equipment and the maximizing of benefits compatible with cost. The description of the requirements and solutions provided in chapter 6 offer options (e.g. Radar versus ADS) and the decision as to what and when to implement the solution must take into consideration the overall investment and return on those investments. For instance, it is suggested that a return on an investment should be realized within a two year period, otherwise the investment should be postponed.

Each piece of equipment listed in Chapter 6 can meet the requirement indicated, but some equipment can meet several requirements. It would be cost beneficial to select equipment that can provide more than one service.

Both ICAO and the 11th ANC (Air Navigation commission) have recommended the use of similar or common equipment to further the seamless airspace continuum. In association with this recommendation, air carriers can not afford to carry on-board equipment to satisfy each State's selection of ground-based equipment. A good example of this is the data link to support ADS-B. There are several links that will support ADS-B. At present, the United States and Eurocontrol have selected Mode S 1090ES as their ADS-B link, Russia has selected VDL M4 as their link, and other countries are looking at AOA or UAT. The air carriers can not carry a variety of data links when one or two links will suffice. Providers need to consider the airborne side when considering the ground-based side. While we have provided a variety of equipment in the options, we are recommending the use of similar equipment to meet regional airspace requirements.

Based upon the data provided by the air navigation service provider (ANSP) organizations from each State and the information obtained during the actual site surveys, the following State and Regional recommendations were compiled by the DORS team:

Almaty Recommendation Summary

- Upgrade the current DENRO communications switch or purchase a new switch.
- Modernize the current HF radio system.
- Plan and implement an NDB phase out program for all of Kazakhstan.
- Upgrade or replace the current ILS to enable Category III operations. Note: should a Category III landing capability be provided at Almaty airport, then consideration must be given to providing surface guidance to the aircraft after it has landed. One such system is the Airport Surface Movement Guidance Control System (A-SMGCS).
- Upgrade or replace the Siemens 2000 and Airsys equipment.
- Replace the voice and radar recording equipment with systems that are digital and have expanded and possibly integrated capabilities.

Taraz Recommendation Summary

- Modernize the current HF radio equipment/system.
- Install an alternate point-to-point communication system for local area operations.

- Plan and implement an NDB phase out program for Taraz and all of Kazakhstan.

- Upgrade or replace the primary and secondary radar systems prior to exceeding their 2007 lifecycle.

- Kazaeronavigatsia consider establishing a centralized depot facility to provide spare parts, diagnostics and training for all communications, navigation, surveillance and air traffic management (CNS/ATM) systems in Kazakhstan. Such a facility would also be capable of supporting CNS/ATM systems in the Central Asian region.

- Upgrade or replace the current controller consoles/working positions and associated equipment.

- Modify the current structure or construct a new tower to provide an unrestricted view of the airfield environment.

Shymkent Recommendation Summary

- It is recommended that consideration be given to modernizing the HF radio system and modernizing the backup power supply systems (e.g. generators and batteries) for all CNS/ATM systems. Should a decision be made to replace the backup power supply systems, then it is suggested that the Tender be based on a functional capability and not merely a one-for-one replacement.

- Consideration should be given for replacing the current point-to-point cable based communication system between airport locations with fiber optic and/or microwave technology. Should a decision be made to replace the point-to-point system, then it is recommended that a remote maintenance monitoring and control capability be included in the modernization plans for all CNS/ATM systems and the supporting infrastructure such as generators, batteries and climate control systems.

- It is recommended that consideration be given to phasing out the existing NDBs at Shymkent as they become non-supportable; conduct the necessary WGS-84 surveys to enable the development of satellite-navigation procedures; develop and implement satellite-navigation arrival, approach and departure procedures for both runway ends; establish a program to develop radar vector procedures to enable controllers to vector aircraft for a visual, satellite-navigation or ILS approach procedure; and establish the requisite training programming to ensure the controllers are fully qualified to use the new procedures and understand the operational use of satellite-navigation.

- Consideration should be given to installing the proper runway lighting system for both runway ends and ensure that all runway markings are ICAO compliant to enable full Category I approach operations.

- It is recommended that consideration be given to installing the requisite system and equipment to be able to connect directly with the internal Kazaeronavigatsia network and not rely on the commercial communication infrastructure.

- It is recommended that consideration be given to enable the direct communication between all Kazakhstan towers/facilities using the internal Kazaeronavigatsia network.

- It is recommended that consideration be given to replacing the existing 32 channel recorder with digital recorders capable of supporting a minimum of 100 channels.

Astana Recommendation Summary

- Either upgrade the current Category 2 ILS to a Category 3 ILS, or purchasing a new Category 3 ILS.

- Acquiring and implementing a surface movement radar system to be able to safely handle aircraft ground traffic during limited visibility.

- Develop a plan and schedule for decommissioning the NDBs.

- Develop a post-warranty Skyline plan to ensure continued reliable operations and services from the system.

- Obtain a separate processor, run the SkyLine software on this new processor (reportedly this would be permitted at no additional cost), connect the two unused workstations to that processor, and use these two workstations for upgrades, testing and training.

- Acquire 132-channel digital voice recorders with the ability to also record radar data.

Kyrgyzstan Recommendation Summary

- Purchasing new digital VHF transmitters and receivers or transceivers that can be collocated in the same physical facility and use the same basic antenna systems; decommission the communications facility in town; and relocate all communications in a single Manas airport location.

- Developing a plan to phase-out the NDBs in Kyrgyzstan and at the same time, initiate a program to develop and implement Global Navigation Satellite System (GNSS) enroute, terminal, arrival and departure procedures for those locations currently serviced by NDBs. Since Kalashnikov Vasily AIS Navigation Service develops procedures for Kyrgyzstan airspace operations and sends them to Rosjep for publication and distribution, it is recommended that both organizations be contacted to determine if they have the capability and experience to develop and publish GNSS procedures for domestic and international aviation users.

- Near-term actions be taken to establish a repair and maintenance contract with Wilcox and a plan be developed to either upgrade or replace the existing system as it nears the end of its service life.

- Developing and implementing a plan for improving commercial power supply systems to all airport locations in Kyrgyzstan. In addition, to the commercial system, it is suggested that the current back up power systems be evaluated for performance and adequacy.

- Immediate consideration be given to modifying the pay scale to be able to retain qualified personnel.

- Upgrading or replacing the current radar systems as soon as possible due to the age and increasing difficulty of obtaining spare parts for the current systems; the operational limitations imposed on the air traffic controllers because the current

equipment is not ICAO compliant; flight safety concerns; and the need to provide reliable radar services to satisfy near-term and future airspace requirements.

- Either modernizing the Manas tower or building a new tower to permit the collocation of runway and ground control personnel.

- Purchasing a communications switch for the sole use of Kyrgyzaeronavigatsia.

- Install a phone set be to permit the use of the satellite communications system.

Tajikistan Recommendation Summary

- Immediately begin the development of a plan to obtain post-warranty repair and maintenance support for all recently purchased CNS/ATM equipment prior to the end of the one-year manufacture warranty period.

- Replacing or modernizing the vintage HF communications equipment and systems.

- In accordance with ICAO recommendations, consideration be given to developing an airspace restructuring plan based upon the use of satellite navigation positioning. Systems such as the Global Positioning System (US), GLONASS (Russian), and Galileo (Europe) will provide a robust navigation capability for Tajikistan and enable the reduction of ground-based navigation aids such as the NDBs. This airspace restructuring plan should also include a schedule for the decommissioning of the current NDBs.

- A country wide program be established to develop and implement GNSS approach and departure procedures for all Tajikistan airports.

- Developing an education and training program for all Tajikistan air traffic components; to include both maintenance and operational personnel.

- Determine the options for either modifying the current tower or constructing a new facility to enable the full and unobstructed view of the entire ramp and the end of runway 09.

- Investigate the software change and maintenance options for the new ATC equipment.

Turkmenistan Recommendation Summary

- Turkmenhovayollary needs to improve and upgrade their VHF and HF communications infrastructure. The present VHF and HF communications capability are older models and has frequent failures. VHF repeaters need to be replaced with additional frequencies and the VSATs repaired. Ashgabat ACC personnel indicated that communications were a problem, but some improvement has been noted. The controllers seem to believe that communications would be a larger problem in the near future if not corrected now.

- Satellite navigation is not authorized in Turkmenistan. GNSS could resolve most of their NAVAID problems. Action needs to be taken to begin the process to approve GNSS for use in Turkmenistan. Turkmenhovayollary has a limited number of

navigational facilities and they are older models which are getting more difficult to maintain due to a lack of spare parts.

- We recommend the implementation of the ATN that should begin with the implementation of AMHS (Aeronautical Message Handling Service). The AFTN is being replaced with AMHS and many countries have already started or completed implementing AMHS. There is no guarantee on how long that the AFTN will remain in service.

- Turkmenistan needs to implement RNAV procedures with RVSM. There are presently no RNAV or RVSM procedures in effect. RVSM would increase the useable altitudes above FL 290 thereby saving fuel and money for the air carriers. RNAV would provide more direct routes reducing flight time, fuel burn, and would also save money for the users.

- Turkmenhovayollary should convert to the WGS-84 datum as soon as possible to meet an ICAO recommendation that all states convert to WGS-84 datum. At present there are no plans to convert.

- The ACCs should consider the use of radar handoffs between facilities wherever possible to expedite traffic and keep aircraft in radar contact when possible.

- Turkmenhovayollary needs to install ATIS at their major airports. This will relieve both controller and pilot workload.

- Turkmenhovayollary needs to consider UPS at their major facilities. The generators we viewed were old and may not perform as well as required when used.

- It is also recommended that Turkmenhovayollary consider English training for their controllers. While we were in the ACC we noticed that the English used by controllers was broken at times and it was evident that some refresher language training may be needed.

Uzbekistan Recommendation Summary

- Uzaeronavigatsia needs to improve and upgrade their VHF and HF communications infrastructure. More than 60% of the VHF units are more than 16 years old and about 95% of the HF equipment is more than 15 years old or older. Tashkent personnel indicated that communications were a problem and would be a larger problem in the near future.

- Action needs to be taken to begin the process to approve GNSS for use in Uzbekistan. Due to the lengthy process that was indicated in approving GNSS, action needs to begin quickly. The VOR/DME system is old and getting more difficult to maintain due to a lack of spare parts. New Doppler systems are expensive and will take a couple of years to install if new ones are procured. Most of the navigational concerns of Uzaeronavigatsia can be resolved with the approval of GNSS..

- We recommend the implementation of the ATN that should begin with the implementation of AMHS. The AFTN is being replaced with AMHS and many countries have already started or completed implementing AMHS. There is no guarantee on how long that the AFTN will remain in service.

- Uzaeronavigatsia needs to implement RNAV procedures with RVSM. There are presently no RNAV procedures in effect, but IATA is pushing for RNAV procedures through eastern and central Asian states. RVSM would increase the useable altitudes above FL 290 thereby saving fuel and money for the air carriers. RNAV would provide more direct routes reducing flight time, fuel burn, and save money for the users.

- Uzaeronavigatsia should convert to the WGS-84 datum as soon as possible to meet an ICAO recommendation that all states convert to WGS-84 datum.

- The ACCs should consider the use of radar handoffs between facilities wherever possible to expedite traffic and keep aircraft in radar contact when possible.

As indicated in the recommendation summary, there is commonality across the region with respect to those equipment and systems that should be upgraded replaced or phased out.

For instance, the need to upgrade the VHF and HF communications capabilities; the approval and implementation of GNSS procedures; and overall airspace redesign to take advantage of modern/ICAO endorsed concepts (RVSM, RNP, etc.)

The following chart depicts an estimated per State CNS/ATM annual investment costs to modernize equipment and systems on both an individual State and regional basis. It must be noted that these figures were estimated based upon the data provided by the air navigation service provider (ANSP) organizations, information obtained during the actual site survey, and the subsequent recommendations as indicated previously. The cost figures indicated include both operational and maintenance for existing equipment and systems as well as those investments needed to replace and/or modernize aging equipment and systems.

O&M and Capital Investment--Present Requirements (0-5 years)
Note: these figures represent both O&M costs as well as replacement investments

State	Communications	Navigation	Surveillance	ATM	Total Cost Thousand USD
	Thousand USD	Thousand USD	Thousand USD	Thousand USD	Thousand USD
Kazakhstan	$2,550	$1,000	$2,200	$8,900	$14,650
Kyrgyzstan	$1,000	$600	$1,300	$1,900	$4,800
Tajikistan	$1,500	$800	$1,800	$1,800	$5,900
Turkmenistan	$1,650	$900	$1,700	$2,100	$6,350
Uzbekistan	$1,700	$800	$1,400	$2,100	$6,000
Total	$8,400	$4,100	$8,400	$16,800	$37,700

Implementation Scenarios

Regional Scenarios are focused on planned actions having regional applicability. In a sense, Regional Scenarios represent overlapping of National CNS/ATM Transition Plans.

Moreover, considering interaction required during implementation of regional items, it is possible to pick out two categories of interaction:

Cooperation assumes a coherent implementation of CNS/ATM systems or applications, which cannot be implemented by one side or one side implementation is not reasonable / beneficial. Cooperation assumes participation of at least two project stakeholders from different countries.

Coordination means interest to implement CNS/ATM systems or applications, which could be implemented by one project stakeholder. Coordination is required to provide seamless environment for customers, however, participants may plan the implementation for different terms. Coordination is important to be sure partner's intensions are properly addressed.

To build potential implementation scenarios it is critical to identify the needs of the airspace users and service providers with respect to the phases of flight. As mentioned previously, it is possible to implementation a system and/or service that will satisfy more than one operational requirements. The following charts depict the phases of flight and potential sets of equipment and systems that address the operational requirements for the Central Asia region.

Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Airspace and Flight Planning	Flight Data Processing and Dissemination	AFTN, ATN, FPDP, AMHS, VSATs, AIDO, ATM System
	Aeronautical Information Service, NOTAMs	AFTN, ATN, AMHS, WAFS, Satellite Imagery, VSATs, ATM System
	Repetitive Flight Plan (AGO Stored)	FPDP, ATM System
	Meteorology	AIS, ATh, WAFS, Satellite Imagery

Flight plans are distributed to providers via the AFTN. The AFTN is being replaced by the AMHS which is ATN compliant. The AMHS software is available, but has been implemented in only a few states thus far. The United States has already begun the implementation of AMHS. SADO states should maintain the AFTN until it is replaced by AMHS. This is the initial component of the ATN. Flight plan processing can be completed manually, but automation has reduced this time consuming task. The FPDP will process flight plan information, record all overflight aircraft as they enter/exit the FIR, process flight times and aircraft type for over flight fee collections, provide strips for each control position, perform coordination functions, reduce the excessive coordination requirements at the busier facilities and will eliminate the manual processing and counting of strips and aircraft movements. An ATM system can do all the things an FPDP can do and more. The ATM is both an FPDP and an RDP. Both provide flight progress strips and forwards a strip to the tower for clearance delivery to the aircraft. IGAO has recommended the filing of flight plans be a coordinated effort between the provider and the user so that the flight profile accommodates the user's preferred trajectory with minimum ATM constraints. The FPDP nor the ATM system are IGAO requirements. Only the processing of flight data is an IGAO recommendation. When the ATM is interface with the ATN equipped with AIDO, it will provide an interchange of flight data between AGOs such as the passing of estimates. VSATs are recommended as the medium to enhance voice and data communications between users and providers.
AIS/NOTAM Aeronautical information must be processed and disseminated to the users. NOTAM information, along with meteorological and airspace information (special use airspace), must be processed and disseminated as well. The AFTN and/or AMHS is the medium used to disseminate this information.
Use of Repetitive Flight Plans Another name for this is "stored flight plans". Aircraft operators that have aircraft departing from the same airport at the same time and going the same place each day via the same route should have a stored flight plan on file with the provider. This eliminates the need to file a flight plan every day. Both ICAO and Eurocontrol have recommended the use of center stored flight plans. Flight plans are stored via

a computer and processed approximately 2 hours prior to a scheduled departure. Repetitive flight plans can be stored via an FFDP or an ATM system.

Meteorology. Meteorology and the passing of weather information is very important to Central Asia states. With the wide variety of climatic patterns, the weather changes constantly and aviators need to be aware of the ever changing African weather. Additionally, ICAO has recommended the extensive use of satellite imagery. Also, there is a need to obtain and disseminate automated global upper wins/temperature and SIGMETS (Significant Weather) forecasts.

Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Airport Surface And Taxi	Airport Ground Surveillance	VDL M4, Mode S1090ES, ASDE, ADS-B
	Airport Management	SMA, VDL M2, Mode S 1090ES, ADS-B
	Taxi – Tower Directed	VHF voice, ADS-B, VDL M4, A-SMGCS Tower Displays, SMA, Mode S 1090ES
	Taxi – Pilot Directed	Pilot Display, ADS-B, VDL M4, VHF Voice Mode S 1090ES
	ATC Clearances	VHF Voice, PDC, ATIS, VDL M2
	Surface Management Advisor	ASDE, ADS-B, SMA, VDL M4, Mode S ES
	Automatic Terminal Information Service	VDL M2, ATIS (tape/digital)

Airport Ground Surveillance. ICAO recommends the use of ground surveillance at major, high use, international airports. The present ground surveillance system is radar in the form of ASDE (Airport Surface Detection Equipment). However, the new technology is ADS-B. ADS-B has been tested and demonstrated, and SARPS have been developed. The problem at this point is what will be used as a unified data link. Mode S1090ES and VDL M4 are being used in demonstrations, but many aircraft have not yet been modified for the Mode S 112-bit address. VDL M4 is also a candidate for ADS-B and has recently been approved for public use.

Airport Management. At large airports, aircraft and vehicular traffic has been an on-going safety problem for aircraft utilizing the airport. Vehicular traffic on the airport has surpassed the number of aircraft using the airport. Ground surveillance provides a high degree of safety at some airports, but has limitations. Another automation tool to assist in airport management is Surface Manager Advisor which increases awareness of traffic flow into the airport, giving ramp control operators and controllers precise touchdown times. Informed of aircraft identification and position in the terminal airspace, gate and ramp operators using SMA have enhanced ability to reduce taxi delays. ICAO recommends that States should provide separation between arrival, departing, and taxing aircraft in and around the airport using airport management tools where possible.

Taxi Instructions – Tower Directed/Pilot Directed. The control of taxing aircraft on an airport surface is the responsibility of the ATC tower. At present controllers verbally transmit through VHF voice taxi instructions to aircraft ensuring their separation between other aircraft and structures. This is a time consuming operation at large airports. Surface surveillance through The use of ADS-B has the potential to relieve the controller's workload. With ADS-B, the pilot can see traffic from a CRT (cathode-ray tube)in the cockpit and provide his own separation as he taxis to the runway or to the gate. As previously mentioned, there are several data link candidates for ADS-B including Mode S 1090ES, and VDL M4. In the options we present, we will recommend a definitive link for ADS-B. Pilot directed taxi through ADS-B is an improvement over the present standard. Another tool is the A-SMGCS). A-SMGCS identifies each aircraft, and provides surveillance and monitors taxing traffic continuously; it determines automatically conflict-free taxiway routes and guides aircraft and vehicles reliably through the use of optical signals; and in case of deviations, it warns pilots or drivers immediately. As such, this control and monitoring functionality provides controllers with tools to enhance safety, efficiency, and availability at the airport in all visibility conditions.

ATC Clearances. ATC departure clearances are a result of a flight plan request. At present, ATC clearances are delivered directly to the aircraft through VHF voice or by voice relay. The New technology to deliver an ATC clearance is via data link. An initial data link application is PDC. This technology is presently offered through ARINC or SITA via an ACARS link but is Being supplanted with VDL M2. PDC eliminates transposing errors and mis-read clearances. The use of PDC is quicker and relieves clearance delivery workload. In busy terminals, PDC would be a time-saving, man-power saving technology. PDC is not an ICAO or Central Asia requirement; only the issuing of an IMC clearance to international air carriers is an ICAO recommendation.

Surface Management Advisor. SMA is one the tools of the family of Surface Management System tools. SMA increases awareness of traffic flow in/out and around the airport, giving tower and ramp control operators more accurate taxi and arrival/departure times . This updated information helps airlines manage ground resources at the terminal more efficiently: gates, baggage handling, food services, refueling, and maintenance. SMA has enhanced the ability to reduce taxi delays and increase the flow of arrivals and departures.

ATIS The use of ATIS is both an ICAO and Eurocontrol recommendation. Most airports have it, but it is a taped message and aircraft monitor a frequency to hear it. The new technology for ATIS is digitized data link known as D-ATIS. It is presently being used as an ACARS application but is being converted to VDL M2 which is the preferred link.

Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Departure and Departure	Standard Instrument Departures	VHF Voice, GBAS, MSSR, ADS-B, Mode S 1090 ES, VDL M4, RNP-1/2 Galileo when

Transition		available
	Reduced Obstruction/Terrain Clearance	VHF Voice, GNSS, ADS-B, Galileo when available
	Transition Routes (Reduced Minima)	VHF Voice, MSSR, ADS-B, VDL M4, Mode S 1090ES, RNP , Galileo when available

Standard Instrument Departures. (SIDs) SIDs have the capability to increase capacity, reduce delays, and ease controller workload. Using augmented GNSS (GBAS) and Galileo when available, the route can now be developed to conform with traffic flow rather than position of ground-based aids. Procedures can be designed that permits SIDs to conform to noise abatement and traffic flow. Route widths can be reduced to make better use of airspace configurations and to expedite departures.

Reduced Obstruction/Terrain Clearances. GBAS and/or Galileo can narrow the RNP value to reduce the distance aircraft must stay from obstructions and high terrain. In the past we have depended on radar to vector aircraft when they passed near obstructions. Now using RNP, we can develop routes that permit aircraft, under procedural control, to fly closer to obstructions than previously would not have been possible. This increases the capacity and reduced delays. ADS, which can be made available in non-radar areas, can provide a surveillance monitor if required. The reduction of obstruction and terrain clearance limits is a high priority in ICAO, but the manner in which it is accomplished is a States decision.

Reduced Departure and Arrival Minima. GNSS and/or Galileo, enhanced by ADS and RNP, can improve the transition routes for departures and arrival. These routes are not limited as they are with ground-based facilities. Departure transitional routes can be reduced in width and be designed for any type of airspace. Arrival transition routes from the STAR to the initial approach fix and even to the immediate approach fix can be reduced and designed to fit the traffic flow rather than the location of ground-based aids. These routes can also eliminate reverse courses for non precision approaches. Electronic surveillance is required for any RNP below RNP-4.

Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
En route	Navigation	RNAV, VOR/DME,VHF, HF, & AMSS Voice/Data, GNSS, Galileo, RNP, CPDLC
	RVSM (aircraft certification)	VHF/AMSS Voice/Data, CPDLC
	Separation Reductions -10 min/80 NM -20 NM (longitudinal) -10 NM (longitudinal) -5 NM/4NM (lateral) -2 NM (lateral)	 VHF/AMSS/HF Voice/Data, VSAT VHF/AMSS/HF Voice/Data, GNSS, MSSR VHF/AMSS Voice/Data, MSSR, ADS-C, VDL M2/4,Mode S ES, RNP VHF Voice/Data, ADS-C, RNP-5, MSSR, Mode S ES, VDL M2/4 VHF Voice, MSSR, ADS-B,RNP-2, VDL M2/4
	MEA/MRA/MOCA	GNSS/Galileo VHF Voice or Data, ADS-CMSSR, RNP
	Surveillance	MSSR, ADS-B, Mode S ES, VDL M2/4
Oceanic	Navigation (RNAV)	GNSS, Galileo, ADS-C, VDL M2 or M4, HF voice/data, AMSS, CPDLC

Point-to-point (RNAV). Point-to-point or direct navigation is supported through GNSS and in the future Galileo. GNSS will support RNP-4 or higher but an SBAS or Galileo is required for an RNP lower than RNP-4. GBAS is required for lower RNPs which are generally associated with approaches and departures. VHF/AMSS voice/data will satisfy communications requirements for RNP-4 and higher, but for RNPs lower than RNP-4, VHF voice is required due to the need for a quicker intervention capability. ICAO and Eurocontrol recommend VHF coverage for ATS purposes to permit effective direct pilot-controller communications. Radar or ADS is optional for RNP-4 and higher, but is considered a requirement in areas of RNP-2 or lower.

RVSM. RVSM has been recommended for use by both ICAO and Eurocontrol. Certification and monitoring of RVSM aircraft certified through GPS requires no ground based equipment. The use of RVSM using height monitors units requires ground based equipment for aircraft certification. Our recommendations will focus on the most cost productive method which appears to be GPS; however, RVSM is an aircraft certification and most aircraft certification can be provided by other states. It is not necessary that RADA states provide a certification program for aircraft to offer this benefit.

Reduction of Separation Standards. In those areas where longitudinal separation of 20 minutes or 20NM (nautical miles) are used, the reduction to 10 NM or 80 NM would be considered a reduction in separation minima. ECAC and ICAO have recommend that each state implement this standard as quickly as possible to be in line with other ECAC states that have already implemented it. With the advent of GNSS (SBAS/GBAS) and RNP, the potential for further separation reductions are high. What has normally been 10 or 20 minutes, or 20 DME separation standards can now be drastically reduced. Galileo will provide the accuracy and integrity for lower separation standards.

With RNP, lateral standards can be reduced to as low as 2 NM and possibly lower. Longitudinal standards can be reduced from 10 minutes to 10 NM. VHF/AMSS voice/data is required for separation of 10 NM or less. Electronic surveillance is optional with the exception of using 2 or 5 NM lateral separation. Other standards can be reduced such as longitudinal separation between departures, between crossing courses, and between climbing and descending aircraft. VSATS will be used to provide enhanced VHF and data communications between the users and providers.

Reduction in MEA/MRA/MOCA. MEA, MRA, and MOCA are based on the reception range of ground based navigational aids. MRA determines the MEA since the MEA can not be lower than the reception altitude of the ground-based aid. MRAs are based on the reception range of the navigational aid, therefore they are higher in the mountainous and remote areas due to the height of mountains and the distance between aids. The MOCA is based on the MRA and MEA. With GNSS, reception of signals are worldwide which would allow the lowest MEA and MRA even when in mountainous ranges. This means aircraft could fly at lower altitudes and/or select better flight profiles.

Surveillance. ICAO and Eurocontrol have recommended each state provide electronic surveillance (radar/ADS) where and when possible. The potential of CNS/ATM can not be fully realized without enhanced surveillance. New separation standards require electronic surveillance. Radar/ADS may be optional in most of these initiatives, but radar increases capacity and safety, while reducing delays. Both ICAO and IATA have put ADS-B on a high priority. IATA is looking for a common data link to reduce cockpit avionics. Both the US and Eurocontrol have opted for Mode s 1090Es as the ADS-B link while Russian states have adopted VDL M4. Central Asia needs to agree on a common data link for ADS-B. VDL M2 seems the definitive choice for ADS-C.

Oceanic. Navigation in oceanic airspace will be RNAV supported by GNSS and Galileo. ADS-C should provide surveillance in the off-shore airspace and deeper ocean. Communications should be provided through HF voice /data, CPDLC, or AMSS. (Note: it is recognized that oceanic navigation is not a factor in Central Asia. Information is provided for completeness and in recognition of airspace user capabilities.)

Operational and Future Equipment Requirements		
Phase of Flight	Operational Requirement	Equipment Solutions
Arrival Transition And Arrival	Reduced Obstruction/Terrain	VHF Voice, GBAS, ADS-B, ADS, RNP, Multilateration (ML)
	Reduced Departure & Approach	Minima VHF Voice/Data, GNSS/GBAS MSSR, ADS-B, Mode 1090ESS RNP, ML
	Standard Terminal Arrival Routes	VHF Voice/Data, GBAS, MSSR, ADS-B, RNP, ML
	Metering and Sequencing Tools	VHF Voice/Data, MSSR, ADS-B, CTAS, URET, P-fast
	Approach Aids	ILS, GNSS, GBAS, ML
Reduced Obstruction/Terrain Clearances. GNSS, augmented by GBAS, and Galileo when available, can narrow the RNP value to reduce the distance aircraft must stay from obstructions and high terrain. This has been previously discussed in the departure and departure transition phase. The reduction of obstruction and terrain clearance limits is a high priority in ICAO, but the manner in which it is accomplished is a States decision. Reduced Departure and Arrival Minima. GNSS, or Galileo, when available, using ADS, RNP, and data link can reduce the minima required for arrival transition routes. This has been previously discussed in the departure and departure transition phase.		
Standard Terminal Arrival Routes. (STARs) . The development of STARs is an ICAO recommendation. GNSS with augmentation provides the RNP for this profile from the beginning of the STAR to the immediate approach fix. Radar/ADS provides the surveillance, but surveillance is not a requirement for this initiative. Metering and Spacing Tools. The use of metering and spacing tools is supported by ICAO in the ICAO. CTAS (Center/Tracon Automation System) , URET (User Request Evaluation Tool), and P-fast are metering and aircraft spacing tools. URET automatically predicts and notifies controllers of conflicts between aircraft or special activity airspace. The system also allows controllers to quickly determine whether proposed flight path changes will conflict with en route traffic or airspace. Radar is required for these tools. Landing Aids. The use of landing aids is supported by both ICAO and Eurocontrol. Landing aids are not a product of CNS/ATM, but are necessary to increase capacity and eliminate any delay in the landing process. Precision Approach Path Indicator (PAPI), Visual Approach Slope Indicator (VASI), and Runway Approach Intensity Lighting System (RAIL) are the most appropriate landing aids.		

In consideration of the above information/data, taking into account the airspace user and service provider capabilities (reference Tasks 3&6), the cost versus benefit considerations as described in Chapter 7 of this task and the respective recommendation summaries also included in Chapter 7 of this task, the DORS team evaluated the implementation scenario options. The common approach to implementing new equipment and systems is to determine what is needed (e.g. new VHF/HF radios, VOR/DME) and develop a Gantt chart for purchase, implementation, operation, maintenance etc. Although this methodology is standard, it is not the 'best' approach for addressing CNS/ATM modernization on a regional basis. The basic reason is because in a regional approach, there is more than one State/sovereign territory and in particular, for Central Asia, it is most important to harmonize operations prior to buying equipment/systems.

For this reason, the Central Asia implementation scenario must first address the airspace configuration and associated operations without reference to State boundaries. In effect, this first step is to develop, to the maximum extent possible, the ICAO vision of seamless airspace.

The basic concept of seamless airspace can be summed up as airspace without borders and is achievable using satellite-based technologies. When the ICAO Chicago Convention was adopted in 1944, the founding members likely could not have envisaged today's global airspace demands and the capabilities of satellite technology.

Traditional air law does not contain rules governing space operations, nor does it cover the use of the radio frequency system. Fortunately, space law and telecommunications law were developed to complement air law. New CNS/ATM systems, many of which rely on satellite technology, have confronted the Convention with a challenge that has far-reaching implications for the future.

Implementation of the new CNS/ATM systems implies the introduction of a seamless airspace embracing the jurisdictional territory of a multiplicity of states, which by necessity requires a defined relationship among the affected states. As was originally envisaged, the Convention was intended to regulate the legal relationship between states in international civil aviation and it clearly recognizes the value and need for aeronautical "arrangements".

As a result, the ICAO Council is charged with the responsibility of being the depository of all aeronautical arrangements and of making those arrangements public as soon as possible.

Arrangements can address a number of subjects/issues and several options are available for their categorization. The most common arrangements are categorized and/or described as being:

- Conventions/treaties
- Protocols
- Multi-lateral agreements
- Bi-lateral agreements
- Memorandums of Agreement/Understanding
- Letters of Agreement
- Letters of Procedures.

It has been generally agreed that there is no legal obstacle to the implementation of next generation CNS/ATM systems and their acceptance and use remains consistent and in line with the Chicago Convention.

With this understanding and recognizing the objective of seamless airspace, it is recommended that the first phase of the implementation scenario be structured to address the following tasks:

A. The first task is to define the operation concept for the regional upper airspace. Once the operational concept for the regional upper airspace has been defined, a similar exercise needs to be executed for the lower airspace in each of the participating States. This is to ensure that the interface between operations in the common upper airspace and the lower airspace is harmonized.

Three specific subtasks have been identified as follows, namely:

- Airspace types and descriptions - Structuring of airspace
- Operational concept for upper airspace
- Operational concept for lower airspace and interface definition.

B. The purpose of the task is to define the end state communication infrastructure requirements for the common upper airspace in accordance with the operational concept. It is assumed that all the required infrastructure will not be implemented at once, and it will therefore be necessary to develop a roll out plan for the communications infrastructure, together with cost estimates of capital investment, operational and maintenance costs, etc.

A prerequisite for this planning is knowing the boundaries of the upper airspace to be supported. Hence, planning can only be done after there is an agreement between the States.

Five subtasks have been identified, the first four of which are on the critical path. The subtasks are the following:

- Define end state communications infrastructure
- Develop communications infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification.

C. The next step will be to define communications infrastructure requirements for the lower airspace. This subtask entails a gap analysis to determine additional requirements in connection with a communication infrastructure that is not covered by the communications plan for the upper airspace.

Similarly, five subtasks have been defined, namely:

- Define end state infrastructure requirements
- Develop infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification.

D. Similar to the communications specification addressed above, the specification of an upper airspace navigation plan must be completed.

The specific subtasks are as follows:

- Define end state navigation infrastructure requirements
- Develop navigation infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification.

E. The specification of additional needs and requirements for lower airspace navigation will be done in a similar manner.

The specific subtasks are as follows:

- Define end state infrastructure requirements
- Develop infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification

F. Similar to the communications and navigation requirements, the specification of a surveillance plan will be required.

The specific subtasks are as follows:

- Define end state surveillance infrastructure requirements
- Develop surveillance infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification.

G. The specification of additional needs and requirements for lower airspace surveillance will be done in a similar manner as for the previous components.

The specific subtasks are as follows:

- Define end state surveillance infrastructure requirements
- Develop surveillance infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification.

H. Similar to the CNS specifications, an air traffic management (ATM) infrastructure is required. This infrastructure should be developed with from "Regional" perspective, that is, to maximize the implementation of similar equipment thereby reducing problems with operational compatibility, and providing the fiscal benefits of purchasing equipment/systems in volume.

The specification of the ATM system is broken down into two components, namely:

- The operational systems

- The training system(s) with simulators, and which could also serve as a backup system for operational purposes. Note: from a regional perspective the number of training systems could be reduced.

The specific subtasks are as follows:

- Define the end state ATM regional infrastructure requirements
- Develop ATM infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification.

I. The specification of additional needs and requirements for lower airspace air traffic management will be done in a similar manner as those for CNS.

The specific subtasks are as follows:

- Define end state ATM infrastructure requirements for each state
- Develop ATM infrastructure phase in plan
- Cost estimate and investment/financing plan
- Operational budget—repair, maintenance, etc.
- Detailed equipment/system specification.

Specific Implementation Scenarios for CNS/ATM

The following charts depict specific operational requirements as defined by ICAO; identifies the related issues, concerns, constraints, and provides a strategic resolution for implementing equipments, systems and services to resolve the problems—both on a regional and individual state basis.

Flight Planning Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
Provide aircraft operators with information that will enable them to plan flights for optimum profile/route/ trajectory and meet their planned departure times. This includes weather, AIS (Aeronautical Information Service) NOTAMs, etc Provide aeronautical information in a timely and accurate manner. Provide flight plan information to adjacent control facilities 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.	Flight Planning Lack of automation, accuracy, timeliness. Monitoring Performance Lack of availability, integrity updates, accuracy Nav/Guidance Performance Lack of accurate navigation system, availability of system, RNP (Required Navigation Performance) determinations, integrity and reliability of navigation signals Communications Performance Lack of availability, integrity, and latency of communication systems. Lack of a definitive data link capability Control Performance Lack of current procedures, control, and cockpit awareness. Lack of available flow control capability. Use of redundant and excessive separation procedures. Lack of seamless airspace configurations while control performance effects flight plan development, these sub-elements are resolved in the en route environment)	Integration of information on capacity constraints at ACCs and airports to provide optimum airport scheduling information Integration of ATC and ATFM (Air Traffic Flow Management) information together with decision-making tools to accommodate late flight plan changes Provide user access to interactive, integrated flight information to include real time data in AIS, MET (Meteorology), ASM (Air Traffic System Management), and ATFM for flight plan filing purposes Enhance FPDP (Flight Plan Data Processing) to access tactical ASM , ATC, ATN, and ATFM information to include the use of repetitive flight plans. Install AMHS. Provide ground communications that permit the filing, processing, and retention of flight plans Provide automated co-ordination and decision-making tools to support optimum profile planning Provide HMI (Human Machine Interface) to access the integrated system.

Table 1 - Flight Planning Phase

Airport Surface Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
Maximize runway and taxi-way utilization to ensure minimum taxi time between departure gate and take-off to meet planned departure times Maximize runway and taxi-way utilization to ensure minimum taxi time to enable operators to meet their planned arrival time Provide a safe and orderly flow around the airport from gate to runway and visa versa 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.	Taxiway Configuration Lack of adequate taxiways at some airports. Increased runway crossings Inadequate airport lighting Movement area congestion Control Performance Lack of adequate tower visibility and controller awareness. Lack of adequate cockpit visibility and pilot awareness. Inadequate decision making tools. Control integrity Communication Performance Frequency congestion Availability Integrity Intervention Aircraft Performance Speed Maneuverability Equipage Airport Visibility Cockpit visibility Weather Flow Control Congestion Monitoring Performance Inadequate airport surveillance Airport Information Lack of D-ATIS (Digital-Automated-Terminal Information Service) and PDC (Pre-Departure Clearance)	Optimize airport surveillance that improves pilot and controller awareness that includes ASDE (Airport Surface Detection Equipment), ADS-B (Automatic Dependent Surveillance – Broadcast), or A-SMGCS (Advanced-Surface Movement Guidance And Control System) where needed Optimize controller tools for airport management Improved airport management that includes most direct route between runway and gates; utilization of SMA (Surface Management Advisor) Improve airport lightning A-SMGCS Integration of arrival, apron, and departure managers Integration of ATC, ATFM, airports, and AOC (Airline Operational Control) information Implementation of ATIS and PDC

Table 2 - Airport Surface Phase

Initial Departure and Final Approach Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
To accommodate different landing priorities for a given operator to optimize in and out operations. To maximize runway utilization and provide a smooth and seamless transition to the final approach course. To provide adequate instrument approach aids and procedures. To provide for a smooth transition from the runway to the departure phase and from the arrival phase to the landing runway 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.	Runway Occupancy Concerns Length, high speed turnoffs, exits; runway surface conditions; braking actions; RVV (Runway Visibility Value) RVR (Runway Visual Range) Runway Operations Missed approaches Crossing/intersecting runways Parallel/converging flight paths Departures/arrivals same runway Acceptance rate/wake turbulence Control Performance Separation/metering Go-around decisions Runway incursion/detection blunders. Lack of CTAS (Center/ Terminal Automation System). Aircraft Performance Traffic mix Approach speeds Braking actions Monitoring Performance Lack of adequate surveillance in the immediate approach area. Lack of radar for vectoring to final at some airports. Communications Performance Lack of immediate intervention Approach Procedures Lack of accurate and reliable instrument approach procedures Navigation Performance Lack of accurate, reliable navigational equipment and signals (satellite navigation)	Optimize arrival and departure routes (SIDs - STARs) within an agreed environmental policy Integrate arrival/departure managers at adjacent/close airports Provide flight profile prediction and optimization tools Optimize airport instrumentation for local weather measurement Provide adequate surveillance that will expedite arrivals and departures in a safe and orderly manner. Provide the environmental and runway configurations that expedite arriving and departing aircraft. Optimize controller tools such as CTAS; P-FAST (Passive Final Approach Sequencing Tool), URET (User Request Evaluation Tool), and SMA to improve controller performance and decision making. Provide more accurate navigation capability that minimizes missed approaches, reduces terrain and obstruction minima, and provides more cockpit awareness.

Table 3 – Initial Departure and Final Approach Phase

Approach and Departure Transition Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
To provide for a smooth transition from departure phase to the en route phase so aircraft can adhere to their planned flight profiles To provide for a smooth and seamless transition from the en route phase to the arrival phase so aircraft can meet their planned times of arrival To 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.	Aircraft Performance Speed Maneuverability Equipage Climb capability Traffic mix Control Performance Lack of standardized arrival and departure procedures. Lack of ground automation. Obstacle and terrain clearance concerns Airport Flow Runway configurations NOTAMs Flow control Navigation Performance Galileo GBAS (Ground-base Augmentation System) availability Signal reliability RNP values Integrity/accuracy Monitoring Performance Lack of adequate surveillance. Communications Performance Lack of adequate two-way communications within 30 miles of the airport. Lack of adequate intervention capability	Optimize arrival and departure routes utilizing SIDs and STARs Improve the overall efficiency of airport operations and runway Optimize airport instrumentation for local weather measurement. Provide metering and sequencing tools (CTAS; P-FAST, URET) Provide equipment and procedures for departure and arrival navigation Improve methods of determining obstruction and terrain clearances. Optimize navigation capabilities and procedures in terminal areas Optimize surveillance capabilities Within terminal airspace

Table 4 – Approach and Departure Transition Phase

En Route Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
To make the en route phase of flight a seamless phase of flight and to provide an overall gate-to-gate approach To expedite aircraft between two points with minimum delay while maintaining an acceptable level of safety To 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.	Navigation Performance Lack of an accurate and available navigational system that has integrity and is not limited to line-of-sight reception. Airspace Configuration Inadequate airspace configuration Inadequate use of airspace Airspace too complex and dense for optimum use. Lack of seamless airspace Aircraft Performance Equipage Traffic mix Climb and descent characteristics Altitude performance Communication Performance Lack of complete two-way communications in operational airspace; saturation of communications environment or spectrum Monitoring Performance Lack of surveillance in complex and high density airspace; lack of adequate surveillance updates/ blind spots Control Performance Excessive separation standards Lack of optimum procedures Excessive coordination required	Revise institutional polices to facilitate gate-to-gate operations Inter-relate ASM, ATS, and ATFM polices and integrated information systems Use of compatible air and ground systems Develop and utilize procedures based on dynamic and real time air traffic Provide and utilize trajectory monitoring tools Develop and implement autonomous separation activities in specified areas Provide viable two-way communications in all areas of responsibility Develop procedures based on modern equipment and techniques that make use of aircraft avionics' capabilities. Develop joint-use military airspace for seamless phases of flight and for optimum use of airspace Implement navigation capability using satellite navigation to provide direct routes on a world wide basis that minimize flight time.

Table 5 – En Route Phase

Preliminary Environmental Assessment

Introduction

As the aviation industry grows more and more rapidly, the impact of air traffic operations on the global atmosphere becomes increasingly important in addition to the local effects of noise and air quality. Efforts to control or reduce the environmental impact of air traffic have identified a range of options that might reduce the impact of aircraft engine emissions.

In particular, it is expected that improvements in ATM could help reduce aviation fuel burn, and thereby reduce the levels of aircraft engine emissions. The object of this task is to address the environmental impact on the implementation of next generation equipment and systems in Central Asia. Accordingly, we have reviewed the environmental issues that CNS/ATM may have on airspace operations as well as the environmental requirements of the World Bank and ICAO, and offer the following assessment.

Environmental Problems Associated With Civil Aviation

Air transport brings substantial social and economic benefits and underpins the global economy, but it also has a local and global impact on the environment. Demand for air travel is rising, and airlines are responding to this growth by bringing more capacity on line. This is the natural role of airlines in an increasingly deregulated and open market, boosted by global competition. Moreover, airlines are expected to offer ever-lower prices and a higher quality of service, with a widening choice of destinations and frequencies.

The importance of noise and other environmental issues for the aviation industry has grown considerably since the late 1960s, when ICAO first got involved in environmental matters. The organization's current environmental activities are largely undertaken through its Committee on Aviation Environmental Protection (CAEP), which is composed of experts from States, major sectors of the aviation industry, and an environmental umbrella group. The Committee deals of course with the main environmental problems associated with civil aviation, namely aircraft noise and the impact of aircraft engine emissions. The guiding principles underlying its work are technical feasibility, economic reasonableness and environmental benefit. ICAO SARPs relating to environmental protection are contained in Annex 16 to the *Convention on International Civil Aviation* (1944), while ICAO policies in this area are contained in a resolution which was adopted by the 32nd ICAO Assembly in autumn 1991.

An inventory of environmental problems associated with civil aviation was recently compiled by a multidisciplinary group in the ICAO Secretariat. In compiling this inventory, it was assumed that "the environment" means all those natural and man-made surroundings which may be adversely affected by the presence of civil aviation, but which are not directly involved in aviation itself. The inventory therefore excludes problems concerning the conditions for passengers and crew, such as the effects of smoking, ozone, high altitude radiation or noise and vibration within the cabin, or problems concerning the working conditions of airline or airport employees. Aircraft manufacturing processes were also excluded.

In Table 1, the inventory of environmental problems is grouped into seven categories. For many years, aircraft noise was considered to be the most important environmental problem associated with civil aviation, particularly the noise levels in the vicinity of airports. These are subject to two opposing trends: the replacement of noisy aircraft by quieter ones, and the increasing number of aircraft movements. As a result, the problem of noise at airports is likely to decline in general terms in the next decade, but may eventually increase again.

Air pollution is a major environmental problem in many countries, especially in urban areas. The main pollutants of concern are sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (such as unburned hydrocarbons) and suspended particulate matter (such as smoke), which are mainly produced by power stations, manufacturing industries, ground transportation and heating systems. Although the air quality in the vicinity of airports is no worse and often better than that found in urban areas, it is nevertheless a cause of concern in some cases.

Long-range air pollution refers to the adverse effects which air pollution can create at considerable distance from the source. One such adverse effect is acid rain, caused by pollutants such as NO_x being "washed out" of the atmosphere. Aircraft engine emissions en route make a small contribution to long-range air pollution, although action aimed at resolving local air quality problems near airports has helped to reduce civil aviation's role. It is now generally accepted that the accumulation in the atmosphere of certain gases resulting from human activities is contributing to the "greenhouse" effect. Since "greenhouse" gases remain in the atmosphere for many years, the planet would continue to warm and our climate to change even if all emissions of greenhouse gases were stopped immediately. Carbon dioxide (CO_2) is the major greenhouse gas. Most CO_2 originates from the burning of fossil fuels (coal, oil and gas). The CO_2 produced when aircraft burn fuel contributes to this problem, although this contribution is considerably less than that of many other sources, such as energy production, manufacturing industries and road transport. However, the possible contribution to global warming of aircraft engine NO_x emissions in the troposphere is now also being studied.

Table 1 - Inventory of Environmental Problems Associated With Civil Aviation

AIRCRAFT NOISE
Noise in the vicinity of airports caused by aircraft operations.
Engine testing and other noise sources at airports.
Sonic boom caused by supersonic aircraft.
Noise caused by aircraft en route (other than sonic boom).

AIR POLLUTION NEAR AIRPORTS
Aircraft engine emissions.
Emissions from airport motor vehicles.
Emissions from access traffic.
Emissions from other airport sources.

GLOBAL PHENOMENA
Long-range air pollution (e.g. acid rain).
The "greenhouse" effect.
Depletion of the ozone layer.

AIRPORT/INFRASTRUCTURE CONSTRUCTION
Loss of land.
Soil erosion.
Impact on water tables, river courses and field drainage.
Impact on flora and fauna.

WATER/SOIL POLLUTION NEAR AIRPORTS
Water pollution caused by inadequate treatment of contaminants in airport waste water.
Water and soil pollution caused by leakage from storage tanks.

AIRPORT WASTE MANAGEMENT
Disposal of environmentally harmful materials used in aircraft servicing and maintenance.

Disposal of waste from the airport and incoming aircraft.

AIRCRAFT ACCIDENTS/INCIDENTS
Accidents or incidents involving dangerous goods carried as cargo.
Other environmental problems that might arise from aircraft accidents.
Emergency procedures involving fuel dumping.

In recent years, increasing attention has been focused on global environmental problems, such as "long range" air pollution, global warming (the "greenhouse" effect) and depletion of the ozone layer. It is generally recognized that these matters are of a very serious nature and could be life-threatening in the long term. Some of the causes have been identified, but others are not fully understood. An important but still unanswered question for civil aviation is the extent to which aircraft engine emissions or other aviation sources may be contributing to these problems.

In recent years, evidence has emerged that the ozone layer around the earth, which protects it from harmful ultraviolet radiation, is being depleted as a result of complex chemical reactions involving man-made gases. The principal cause of this problem is considered to be chloro-fluorocarbons (CFCs), which are primarily employed as aerosol propellants or as refrigerants. However, another possible contributor to ozone depletion is NO_x emitted by those aircraft that fly in the stratosphere.

The construction of a new airport and its associated infrastructure can give rise to environmental problems. As with any other large construction site, there is the inevitable loss of land and the possibility of soil erosion and adverse impact on water tables, river courses and field drainage, and on flora and fauna. The nature of the problems varies from one airport to another. While relatively few new airports are being developed, these problems may also arise when existing airport facilities are expanded. Among the facilities the Digital-Airport Surveillance Radar (DASR) is the most important for air traffic control purposes.

DASR consists of two electronic subsystems: primary surveillance radar and secondary surveillance radar, sometimes called the beacon. The primary surveillance radar uses a continually rotating antenna mounted on a tower to transmit electromagnetic waves that reflect or backscatter from the surface of aircraft up to 60 miles from the radar. The radar system measures the time required for a radar echo to return and the direction of the signal. From this data the system can then measure the distance of the aircraft from the radar antenna and the azimuth or direction of the aircraft from the antenna. The secondary radar uses a second radar antenna (Mode C or Mode S) attached to the top of the primary radar antenna to transmit and receive area aircraft data for barometric altitude, identification code, and emergency conditions. The primary radar of the ASR-11 (new digital technology radar) operates in the range of 2700 to 2900 MHz. The transmitter generates a peak effective power of 25 kW and an average power of 2.1 kW. The secondary radar operates in the range of 1030 to 1090 MHz. Transmitting power ranges from 160 to 1500 watts. Average power density signal decreases with distance from the antenna. At distances of more than 13.12 m (43 feet) from the antenna, the power density of the ASR-11 signal will fall below the maximum permissible exposure levels established by the WHO (World Health Organization). This could be the reason that electromagnetic factors are usually excluded from the list of obligatory environmental factors analysis for airport development planning (design and reconstruction).

Various chemicals are used by airport operators and by aircraft operators. Through the action of rainwater, these chemicals may cause water pollution. This pollution is created if the chemicals find their way to local watercourses or become part of airport waste water and

are not adequately treated. Examples include the chemicals used in aircraft de-icing and runway ice prevention or removal. In addition, water and soil pollution may be caused by leakage from storage tanks (for example, oil-saturated soils at fuel farms).

In aircraft servicing and maintenance, environmentally harmful materials are used (oils, cleaning fluids, paints). Once used, they need to be disposed of in a satisfactory manner such as recycling. Airports and incoming aircraft also generate large quantities of waste material which is capable of causing environmental damage if not disposed of properly. In this respect, however, airports and aircraft do not significantly differ from similar establishments such as large hotels.

Environmental problems that might arise from aircraft accidents and incidents involving dangerous goods carried as cargo are likely to occur only under exceptional circumstances. Action taken to improve aviation safety helps to reduce the likelihood of these problems arising. The quantities of dangerous goods carried on aircraft are such that they do not pose environmental hazards. In the event of accidents, fuel spills could be of environmental concern, but fire is a much greater risk.

Another problem in this category is fuel dumping during emergency procedures. Many aircraft are not structurally capable of withstanding a landing in the high-mass conditions of take-off. In the event of an emergency requiring an early landing it is sometimes necessary to dump fuel into the atmosphere, although this is a rare occurrence.

Globally, air transport's perceived role in climate change is driving the need for continued improvements in fuel consumption and emissions per passenger kilometer. This is likely to be achieved through improved air traffic management, adoption of new operating practices and the introduction of new, more sustainable technologies. CNS/ATM has the potential to achieve favorable environmental results. Airlines are taking all reasonable action to reduce their environmental impacts, consistent with meeting market requirements and avoiding unnecessary costs.

There is a direct link between improved environmental performance and sustainable growth. The continuity of air transport is at risk unless airlines continue to minimize and possibly reduce the environmental impacts of their operations. In the last quarter century, the environmental performance of air transport has continually improved, productivity (as measured in thousands of available ton-kilometers) has increased steadily over the years. Efficiency is an essential first step on the road to sustainability, and for most airlines it is the key to minimizing their environmental impact. Airlines have been consistent investors in clean technology, buying newer aircraft that produce less noise, use less fuel and emit fewer engine exhaust emissions.

Modern aircraft make up over 80 percent of the IATA commercial jet fleet. The average age of the fleet has been held constant at around 11 years even though the size of the IATA commercial jet fleet has tripled since 1975 (from 3,342 to 9,485), and aircraft in-service life has increased. Put another way, only 16.5 percent of the IATA commercial jet fleet is over 20 years old, and this proportion decreases as the noisier "Chapter 2" aircraft are phased out.

Airline Environmental Management

A survey of IATA members showed that 42 airlines around the world had some form of environmental management. Initially, this responded to the need for operational compliance with environmental rules and regulations (partly to limit exposure to litigation, penalties, and fines), although some major carriers had set out basic policies and medium term targets reflecting different concepts of "sustainability". Since then, regulatory pressure, competition

and "good neighbor" policies have encouraged more IATA member airlines to address the environmental aspects of their flight, cabin and ground operations.

This is shown by the adoption of comprehensive environmental policies, airline environmental audits, more extensive environmental reporting, and changes in company culture. The leaders in the field track their environmental impacts through the measurement and reporting of consumption of natural resources, and by setting targets and benchmarking indicators (which are reported publicly). One major airline alliance has recently delivered a joint environmental agreement in which all alliance partners have committed to a common environmental policy. In line with other industries, accreditation under one or other environmental management systems for specific ground-based activities, such as engineering and maintenance and in-flight catering, is also becoming more common. The trend is to make environmental management a natural extension of an airline's primary task – caring for passengers and cargo.

In-flight and Ground Operations

An airline's basic environmental goals are to continuously decrease consumption of natural resources, reduce waste and use energy more efficiently. Viewed in the aggregate, aircraft noise and aircraft engine emissions from flying are considerably greater than the environmental impacts from ground operations. The focus here is therefore on airline flight operations.

The Intergovernmental Panel on Climate Change (IPCC) special report, Aviation and the Global Atmosphere, has brought flight operations into focus. As can be seen from the report, air transport makes a relatively small but increasing contribution to climate change and the traditional industry responses do not and will not address this issue satisfactorily.

Essentially, there are three main ways of controlling the environmental impact of flight operations, whether aircraft noise or aircraft engine emissions. They are as follows: limit market growth (e.g. by reducing demand through taxes or charges or by reviewing business basics); improve system efficiency (e.g. by improving ATC systems and airport infrastructure); and improve aircraft efficiency (e.g. by reducing noise and emissions at source, and by increasing aircraft productivity).

Demand for air travel will continue to grow, reflecting economic trends (historical trends, however, show that the growth rate for aircraft emissions has lagged behind that of traffic). The use of air travel among the world's population, especially in the developing world, is still relatively low. Air transport is the core of travel and tourism on which many of the countries in the developing world depend and, for the most part, international air transport has no substitute. On short-haul routes the potential for replacing air transport with other modes seems unlikely to exceed 10 percent, although there is considerable scope for optimizing the special strengths of each transport mode at key connecting points.

The CAEP's work focused on two initiatives of operational practices to reduce emissions. The first is the development and dissemination of information on opportunities to reduce emissions through specific operational. The other focus of work on operational measures that reduce emissions was the potential offered by the early implementation of advanced CNS/ATM systems, which lead to more direct routings, hence lower fuel burn and fewer emissions. The results of a preliminary study of the environmental benefits associated with the CNS/ATM systems, as well as the methodology for calculating these benefits, were presented at the January meeting of CAEP, which recommended that the methodology be expanded upon. A summary of the methodology and its main results are included in ICAO's Global Air Navigation Plan for CNS/ATM Systems (Doc.9750).

Trends in Fuel Consumption

Increasing public concern over global warming (greenhouse effect) raises questions about the possible contribution of aircraft engine emissions to this problem. Since the most important greenhouse gas is carbon dioxide, an unavoidable by-product of the combustion of conventional fossil fuel, one of the key parameters in the assessment of civil aviation's contribution to this phenomenon is the quantity of fuel consumed by aircraft and the expected future growth in this consumption.

The world's civil aviation industry as a whole is estimated to have consumed 138 million tons of aviation fuel in 1990; of this total, nearly 99 percent was jet fuel. It is expected that annual consumption of jet fuel by the air carriers will increase by 65 percent from 133 million tons to 220 million tons by the year 2010 (in reality 243 million tons were consumed by civil aviation in 2000).

The forecast of fuel consumption reflects expected changes in the aircraft fleet, operational conditions and aircraft load factors. Of particular note is the effect of the replacement of ageing aircraft over the next 10 years. This is expected to contribute nearly 2 percentage points to the annual rate of improvement in fuel productivity, which compares with a contribution of about 1 percent per annum from this source in the past.

Although international services provided about 55 percent of total airline capacity, they account for only 47 percent of airline fuel consumption. The variations in fuel consumption per unit of capacity, as illustrated in Table 2, result from differences in route structures, aircraft types and operational procedures. The quantity of fuel per TKP (Ton-kilometer Performed) relates fuel consumption to the final output of the industry, i.e. traffic flow. The difference between fuels per ATK (Average Ton-Kilometer) and fuel per TKP is the load factor, which depends on the number of unfilled seats and quantity of unused cargo capacity on airline services. Commercial air carriers had an average weight load factor of 60 percent in 1990. On this basis, fuel productivity amounted to 510 grams per TKP for the global airline industry.

The reliability of the preceding estimates of fuel consumption has been evaluated by comparisons with estimates from other sources. For example, an alternative estimate of total jet fuel consumption by scheduled carriers was derived from information on the total aviation fuel bill and the average price per ton. All of ICAO's estimates of fuel consumption are derived from airlines and other civil aircraft operators.

New generations of aircraft engines are expected to bring opportunities for further fuel savings in the longer term. For example, there is the possibility of the eventual introduction of propjet aircraft with greatly improved fuel efficiency characteristics. However, following the large aircraft replacement program of the 1990s (which assumes that the current recession is a cyclical phenomenon), a younger fleet is likely to be in place by the year 2000, and the replacement rate in the first decade of the next century should be lower with a smaller impact on fuel efficiency. The rate of reduction in fuel consumed per ATK as a result of fleet development could be about 1 percent per annum between 2000 and 2010.

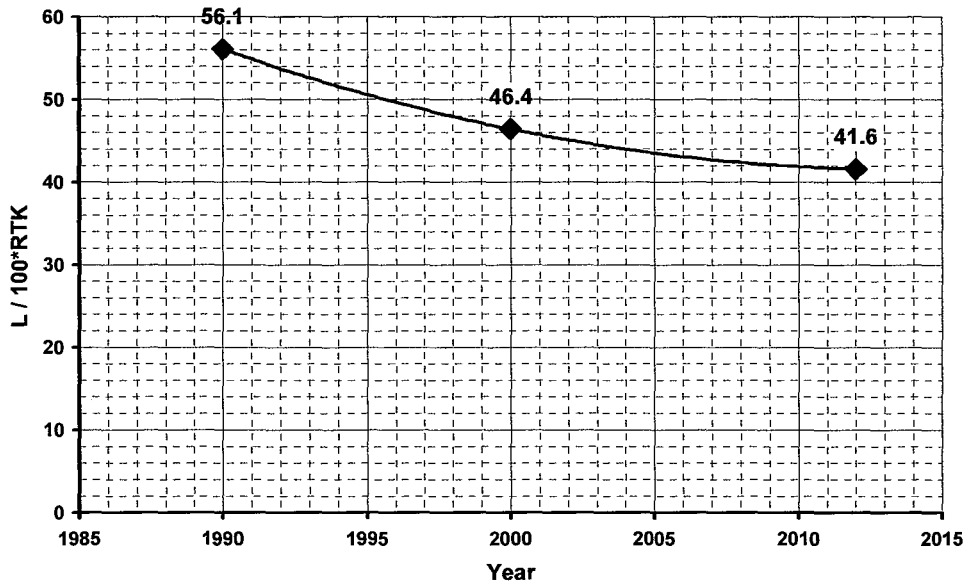
Table 2 Jet fuel consumption and air carrier capacity, 1990

	Total fuel consumption (million tons)
International services	
Scheduled	53
Non-scheduled	10
Domestic services	

United States	38
Russian Federation	15
Other States	17
World	133

Turning to the impact of operational factors, there are limits on the benefits from changes in procedures under the existing air navigation and ATC systems. Furthermore, airport and airspace congestion in some regions could have a cost in terms of fuel consumption. In the longer term, the implementation of the future CNS/ATM concept adopted by ICAO in 1991, could lead to renewed scope for fuel savings. These considerations, plus improvements to particular aircraft, suggest that fuel consumed per ATK could be reduced by 0.5 percent per annum over the 1990s and 1 percent per annum in the 2000 to 2010 period, Figure 1.

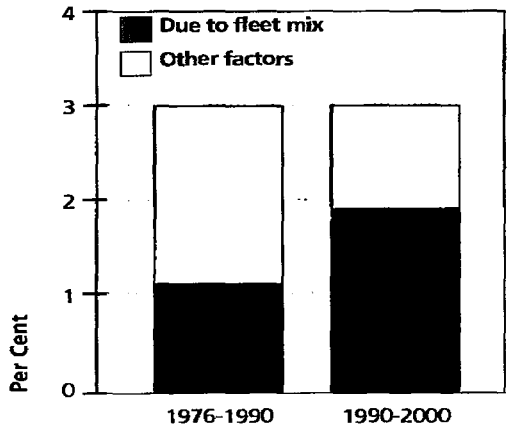
Figure 1 - Current/projected trends in overall fuel efficiency (Source: IATA)



Bringing together all the factors affecting the future trend in fuel consumption per ATK gives a rate of improvement of about 2.5 percent per annum in the 1990s and 2 percent per annum in the following decade. Some improvements in load factors are expected as marketing initiatives and yield management programs become more sophisticated. While the industry is gradually approaching upper limits for average load factors, there is probably more scope for improvement in weight load factors, which are lower than passenger load factors. With this additional source of productivity, the overall decline in fuel consumed per TKP is forecast at about 3 percent per annum in the 1990s and 2.5 percent per annum between 2000 and 2010.

The anticipated average rate of improvement in fuel productivity in the 1990s is similar to the estimated rate of improvement since 1976. However, the analysis of the impact of the evolving fleet mix suggests that the contribution to productivity improvement from this source will be significantly greater in the coming decade, as illustrated in Fig. 2.

Figure 2. Improvement in airline fuel productivity (average annual rate of improvement)



The growth in the total quantity of fuel consumed by the world civil air carrier industry is determined by the growth in traffic volumes offset by gains in fuel productivity. ICAO's latest forecasts of world scheduled passenger and freight traffic imply an average growth rate in TKP of 5.5 percent per annum during the 1990s. In line with the gradual decline in growth over the long term, a rate of 5 percent per annum is plausible for the period between 2000 and 2010. Taking into account the scenario outlined above for the reduction in fuel per TKP total aviation jet fuel consumption is therefore forecast to grow at an average annual rate of about 2.5 percent over the 20-year period between 1990 and 2010 (Table 3).

The IATA survey points out that environmental issues associated with direct impacts (e.g. aircraft noise control, emissions from aircraft, water and waste management), as well as the optimization of measures to minimize fuel use and improve energy efficiency, appear to be of the greatest importance to member air carriers. There are a number of different approaches being taken by airlines to minimize fuel consumption and associated emissions.

In much the same way as for noise reduction, the main policy and management approaches to minimizing fuel use and emissions are inextricably bound up with the development of aircraft and engine technology. Technology has enabled aviation to make impressive reductions in its emissions in the last 20 years. Today's world fleet is about 65 percent more efficient per passenger-kilometer than in 1970, and in the last decade fuel efficiency has improved by 17 percent owing to the continuing incorporation of the best available technologies in the global fleet.

Table 3 Contributions to growth in jet fuel consumption, 1990 to 2010 (Average percentage)

	1990 to 2000	2000 to 2010
1. Fleet mix	-1.9	-1.0
2. Operational changes (*)	-0.5	-1.0
3. Load factor	-0.7	-0.5
4. Fuel/TKP (= 1+2+3)	-.1	-2.5
5 Traffic	5.5	5.0
6. Fuel consumption (= 4+5)	2.4	2.□

The widespread adoption of accelerated fleet renewal policies will continue to play a major role in minimizing fuel use and emissions. However, the pace of this process has slowed because of the long product development cycles for new aircraft and engine technology. Typically, it takes 15 to 20 years from the time of development before new technologies translate into system-wide efficiency gains.

Although, there is confidence that the introduction of new, sustainable technologies will, in time, help to cut fuel consumption, this is unlikely to happen for some time. Within the last five years, it has become clear that emissions from aviation could be reduced significantly by using existing aircraft and infrastructure more efficiently.

An ICAO circular on operational opportunities for minimizing fuel consumption and reducing emissions provides important guidance to air carriers and airport operators. Working through ICAO's Committee on Aviation Environmental Protection, IATA coordinated — in consultation with States, airlines, airports and experts — the development of the circular and its guidance material for airport and airline best operational practices to reduce fuel burn. Essentially, the circular documents industry experience and the environmental benefits arising from the optimal use of aircraft and infrastructure. It evaluates each phase of flight (taxiing, take-off, climb, cruise, approach, landing and taxiing) and, where possible, quantifies the likely fuel savings.

Significantly, the ICAO circular underlines that an apparently small reduction in fuel use is worthwhile considering, particularly if applied on a global basis. Assuming total fuel use of 243 million tons for civil aviation in 2000, a reduction of 1 percent in fuel use represents 2.4 million tons which, if projected to the year 2015, equates to around 3.25 million tons of fuel.

The circular also makes clear those improvements in CNS/ATM systems are likely to provide the most significant fuel savings over time. It highlights the results of the parametric model developed by CAEP to estimate the environmental benefits arising from implementation of advanced CNS/ATM systems. The initial results, which cover in greater detail implementation of CNS/ATM systems in the United States and Europe, indicate a reduction of 5 percent in global carbon dioxide (CO_2) emissions by 2015. An earlier report by the Intergovernmental Panel on Climate Change estimated a reduction of global CO_2 in the order of 6 to 12 percent from CNS/ATM systems implementation. The IPCC report also estimated CO_2 reduction in the order of 2 to 6 percent from various other possible operational measures and a total reduction, from all operational measures together, of 8 to 18 percent.

A recent IATA study, Operational Measures to Improve Aircraft Fuel Efficiency and Reduce Emissions, which focuses on the possibilities of savings encountered in an accelerated implementation of the CNS/ATM systems, demonstrates that if implementation were achieved more quickly than planned, this could lead to a 9 percent improvement in system fuel efficiency worldwide by 2010. It could also reduce aircraft emissions of oxides of nitrogen by 8 percent and carbon monoxide and unburned hydrocarbons by 15 to 16 percent. Other operational measures could reduce NO_x, CO and HC emissions by 5 percent (Table 4).

Table 4 Projected fuel efficiency improvement in 2010 from accelerated implementation of CNS/ATM systems and other operational measures (% reduction)

Measures	Region	Fuel	NO_x	CO&HC
CNS/ATM-related	Africa	6	6	8 – 9
	Asia/Pacific	6	6	17 – 19
	Europe	10	10	14
	Latin America/Caribbean	8	8	8
	Middle East	4	4	4 – 5
	North America	10	9	16
Total CNS/ATM-related	Global	9	8	15 - 16
Other operational	Global	5	5	5
All operational	Global	14	13	20 - 21

For airport operations, the forthcoming ICAO circular identifies some 52 operational opportunities for minimizing fuel use and reducing emissions. These opportunities were identified by a comprehensive survey of airport air quality management techniques carried out by CAEP and published in May 2000. Some derive from changes to airport design and layout, others from the provision and operation of ground support equipment and transportation, while others derive from aircraft ground operations themselves. Ground transportation and ground support equipment generally contribute around 50 percent of the emissions produced at an airport, although this will vary from one airport to another.

At many airports special operating procedures, techniques and aircraft routings are in use to reduce the noise heard on the ground. These include noise abatement departure and approach procedures. These procedures usually involve careful selection of wing flap and engine power settings, and may include management of ground tracks, in order to reduce the noise below or to the side of aircraft during take-off or landing.

In parallel, airlines are increasing efforts to monitor their fuel use and improve fuel-monitoring and information systems so as to refine and build existing knowledge, thereby increasing the accuracy of airline fuel and emissions databases and improving management control. Some airlines have used such systems to improve the effectiveness of the aircraft loading process in optimizing fuel consumption or have introduced weight criteria into purchasing policies for in-flight products. Some airlines have introduced policies to minimize fuel tankering (the carrying of fuel for following or subsequent flights) in order to decrease aircraft weight and fuel consumption. More recently, a number of airlines have introduced policies encouraging the use of rail as a substitute for short-haul flights on certain sectors.

The use of operational approaches to maximize fuel efficiency can provide potential short-to-medium term benefits and may also present fewer of the legal, economic and technical difficulties (e.g. engine design, replacement or modification) associated with other approaches. In practice, their implementation will depend on safety, legal, environmental and other tradeoffs, such as the need to reduce noise or to respond to weather conditions.

On the ground, the use of low emissions and/or electrical ground support equipment is becoming more prevalent. A growing number of airlines have instituted measures to encourage the wider use of public transport, such as providing staff shuttle services, or interest - free loans for the purchase of public transport season tickets by airline staff.

As outlined above, the main fuel efficiency improvements in this category derive from fleet renewal and the general development and application of more accurate navigational technology. However, there have been many advances in avionics and flight deck automation design that are not yet fully utilized which could be used to improve the capacity and efficiency of the ATM system. This means that in practice the technical capabilities inherent in many aircraft may be under-utilized in some circumstances.

In the last decade there has been a steady increase in airline involvement in research projects. Some current projects seek to examine aviation's atmospheric effects, overcome air traffic congestion problems, measure emissions from engine exhausts, or match certified engine emissions data gathered in ground trials with actual emissions produced at cruising altitudes.

Additionally, research is ongoing into the effect of aircraft aging on fuel consumption and emissions, into the implications of differing levels of sulphur content in fuels, and on improving the monitoring accuracy of cruise performance. In 1998, the world's airlines carried over 1.4 billion passengers and more than 26 million tons of freight across the globe. By value, the airlines transported 40 percent of all manufactured exports. In carrying this traffic, the world's airlines consumed about 160 billion liters of fuel. This is equivalent to 4.8 liters for every passenger transported over a distance of 100 kilometers.

Against this background, IATA member airlines plan to achieve an additional 10 percent fuel efficiency improvement in their total fleet over the next 10 years. This could reduce the total release of CO_2 emissions into the atmosphere by almost 350 million tons for this period.

However, the fuel efficiency of aircraft is influenced by many factors, not all of which are under the airlines' direct control. Some, such as engine technology, route structure, air traffic control and airport capacity, depend on the availability of technology and infrastructure capacity and affect the potential to realize actual fuel efficiency gains. Others are market-driven (e.g. competition and alliances, aircraft size and frequency) and affect the potential for load factor improvement. Thus, the level of benefits to be derived from the foregoing initiatives is influenced by the regulatory and policy making framework, operating conditions and trade-offs between environmental performance objectives and the reduction or containing of local and global environmental effects. Each of these has implications for airline fuel performance and efficiency.

Environmental Benefits Associated with CNS/ATM Initiatives

Against a background of increasing concern regarding the impact of aircraft engine emissions on the environment, ICAO has been considering what steps could be taken by the international aviation community to control emissions. Aircraft engines burn fuel, producing emissions that are similar to other emissions resulting from fossil fuel combustion. However, aircraft emissions are unusual in that to a significant degree they are emitted at altitude. These emissions give rise to important environmental concerns regarding their global impact and their effect on local air quality.

At a global level, the principal concern is aviation's contribution to climate change. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) requires developed countries to reduce their collective emissions of greenhouse gases by approximately 5 percent by the period 2008–2012, compared to 1990. These targets do not apply to emissions from international aviation. Instead, Article 2, paragraph 2 of the Kyoto

Protocol states that the responsibility for limiting or reducing emissions from international aviation shall fall to the UNFCCC parties, working through ICAO.

Future concerns about aviation's role in both climate change and local air quality are largely due to the projected continued growth in this sector. While past technological improvements have reduced the growth rate of emissions and this progress is expected to continue in the future, total emissions will nevertheless continue to increase. For example, the IPCC's report projects growth in the sector of 5 percent per year between 1990 and 2015 with CO2 emissions growing at 3 percent annually over the same period.

Against this background, ICAO's Committee on Aviation Environmental Protection has been studying possible means to reduce aircraft engine emissions including the reduction at source, through operational measures or using market-based options. In addressing concerns associated with aircraft engine emissions, CAEP is guided by the following principles:

a) Measures to address emissions should take into account environmental need, technical feasibility and economic reasonableness;

b) Measures to address emissions should also take into account any potential implications for safety, which must not be compromised, and for aircraft noise. Measures aimed at one type of emission (for example, CO_2) or one emission-related problem (for example, climate change) should take into account any potential implications for other types of emissions or for other emission-related problems;

c) Measures to address emissions should be developed on a harmonized worldwide basis, wherever possible.

Environmental Summary

Within the time frame under consideration (2005–2015), global air traffic is expected to increase by approximately 61 percent. In the same time period, fuel consumption and CO_2 emissions are projected to increase by just 37 percent. Fuel burn and CO_2 emissions are growing less quickly than traffic because of the introduction of more efficient engine technology, aircraft retirement and fleet expansion. This reflects the already strong commitment of the aviation industry to fuel conservation and the consequent emission reductions.

The preliminary results of this study show that by 2015 there will be an additional benefit of approximately 5 percent fuel burn and CO_2 emission savings due to the introduction of planned CNS/ATM systems implementation measures within the United States and Europe. These results show the annual fuel and CO_2 savings for 2015 from CNS/ATM systems improvements for both the United States and the Europe Civil Aviation Conference States of the European Region. Preliminary results show savings of a similar order of magnitude for oxide of nitrogen (NO_X), unburned hydrocarbon (HC) and carbon monoxide (CO), but the work is subject to further analysis, verification and validation.

Conclusions

The report presents the results of environmental assessment executed for implementation of the CNS/ATM systems in Central Asia. The main environmental factors considered for this project were the fuel consumption and aircraft emission, which are dependent largely from the abilities of ATM to manage flights effectively. In this report it is shown that CNS/ATM will

provide the reduction of fuel consumption and aircraft emission as a result of more direct routes (less distances between the points of destination), optimization of aircraft load factor, aircraft weight, more preferred altitudes, and some other airport improvements. CNS/ATM has been found by several environmental assessments to be environmentally friendly and in fact, reduces the environmental intrusions associated with the present method of air traffic control and the aviation environment.

Traffic Forecasts

Introduction

The objective of Task 11 is to look towards the future and develop traffic forecasts for the number of flights for a fifteen (15) year period. The forecasts will be developed using three scenarios: worst case, most likely, and optimistic.

Forecasting and/or projecting future air traffic and growth rates is at best difficult. As evidenced during the aftermath of 9-11, air traffic growth declined on a global basis and was somewhat slow in recovery. The aviation and air traffic growth projections made prior to this incident clearly did not reflect the real-world post 9-11 environment.

The DORS Team recognizes the risk and potential criticism associated with forecasting the future and as indicated in the report, has taken several steps to minimize this risk. Essentially these steps equate to "casting a large net" by obtaining a cross section of information and data from various organizations/agencies knowledgeable about air traffic growth. This information and data is subsequently individually analyzed by the DORS team members and then discussed in group to reach a consensus.

The previous information and data used by the DORS team members to reach consensus regarding future air traffic growth rates were:

- Questionnaire Data provided by the States
- Current Traffic Flows and Loads data provided by the States
- Major Airline Operator Flight data
- Regional Aircraft Statistical data

The "weighting" of this data varied depending upon factors such as currency, completeness, relevancy, etc. The highest consideration was placed on the data provided by the States contained in the questionnaires.

Methodology

A uniform and standardized methodology will be essential in order to ensure the consistency and accuracy of air traffic management (ATM) data as well as data pertaining to the underlying communications, navigation, surveillance (CNS) infrastructure. A detailed understanding of this underlying infrastructure will be important for forecasting traffic volume as well as projecting the capability of the air navigation system to meet future air traffic growth.

During the kickoff meeting Central Asia representatives and DORS personnel discussed methodology options at length and concluded that the methodology must include both written surveys in the form of questionnaires and on-site visits to compile and validate the ATM data. In addition, each State would be requested to provide airline and flight data for each appropriate airport location. In turn, this data would also be validated during the site visits and compared to traffic flow and load data that is publicly available. One source of public information is the Official Airline Guide (OAG). The OAG is essentially an airlines schedule database providing details for approximately 1,000 airlines and more than 3,500 airports.

The content and scope of the questionnaires were concluded during the kickoff meeting. It was also determined that each of the questionnaire recipients must understand the importance and relevance of the questionnaire/site survey methodology. The following text accompanied each of the questionnaires:

"This questionnaire is aimed at obtaining data on Airspace, Facilities, Communication, Navigation, Surveillance, Information Distribution, Capacity, Modernization, Finance, Personnel and Simulation Data Requirements. The data obtained will support the Study findings and recommendations."

The data from this questionnaire and the information gathered during the site visits will provide two complementary sources of information for establishing a validated, accurate baseline. The accuracy of this baseline is critical in supporting the activities associated with the other tasks performed under the Study. The questionnaires and site surveys were successfully completed and the details of both are provided in the previous task reports.

Forecast Traffic Volumes

Central Asia Service Providers

The air navigation service providers (ANSPs) of each state were requested to provide data regarding the existing traffic conditions in each of their respective areas of responsibility as well as their projections of future traffic growth.

The following charts depict the data/information provided by each state:

Arrival and Departure Traffic

State	2005 Arrival	2005 Departure	2010 Arrival	2010 Departure	2015 Arrival	2015 Departure
Kazakhstan	52,500	52,500	67,500	67,500	80,000	80,000
Kyrgyzstan	24,584	24,584	24,584	24,584	24,584	24,584
Tajikistan	8,421	8,421	8,421	8,421	8,421	8,421
Turkmenistan	No data	No data	No data	No data	No data	No data
Uzbekistan	17,500	17,400	19,500	19,300	20,000	20,000

Overflights

State	2005	2010	2015
Kazakhstan	340,000	345,000	350,000
Kyrgyzstan	24,584	24,584	24,584
Tajikistan	8,000	10,000	12,000
Turkmenistan	No data	No data	No data
Uzbekistan	31,200	33,500	35,500

Note: Turkmenistan indicated that the request for this information was "not relevant". Apparently the traffic volume in their airspace is relatively low as compared to the other States.

An analysis of the data provided some interesting information and statistics with respect to the ANSP traffic forecast. Some of these are as follows:

1. Kyrgyzstan data indicates they do not believe there will be an increase in arrival and departure, and overflight traffic for the entire 10 year period.

2. Similarly, Tajikistan indicates there will be no increase in arrival and departure traffic for 10 years, but there will be overflight traffic growth. Specifically, they indicated that overflight traffic will grow a total of 25% between 2005 and 2010 and

20% between 2010 and 2015. Assuming a linear growth curve with equal distribution then the projected annual growth rate is approximately 4.56% for the years 2005-2010 and approximately 3.72% for the years 2010-2015.

3. Kazakhstan and Uzbekistan both project annual growth for arrival/departure and overflight traffic. The annual rate of growth for as forecasted by each of the States are:

Annual Percentage Growth Projections

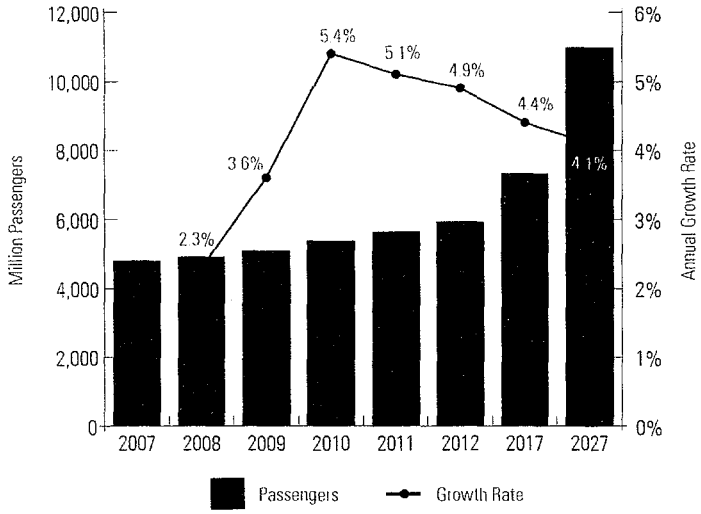
State	2005-2010 Arrival/Depart	2010-2015 Arrival/Depart	2005-2010 Overflight	2010-2015 Overflight
Kazakhstan	5.2	3.5	0.29	0.29
Uzbekistan	2.1	0.6	1.4	1.2
Tajikistan	0	0	4.56	3.72
Kyrgyzstan	0	0	0	0

Aviation Industry Organizations

During a 15-20 September 2008 ICAO Conference on the Economics of Airports and Air Navigation Services held in Montreal, Canada, **Airports Council International (ACI)** predicted that global passenger volumes will surpass the five (5) billion mark by 2009 and reaching eleven (11) billion by 2027. Consequently, over the next fifteen (15) years global air passenger traffic is projected to grow by 4% per year. ACI also predicted that air freight will increase at an even greater rate, of 5.1% per year.

Their overall predicted annual growth rate is not anticipated to be linear. At the onset it is estimated that annual growth will be somewhat slow as a result of external factors such as the economic crisis and fluctuating fuel prices. It was also noted that the actual degree and rate of growth will be influenced by the ability of the airports and aviation infrastructure (such as communications, navigation, surveillance and air traffic management) to accommodate the demands of the airspace operators. A graphic of their projection is illustrated in the following chart:

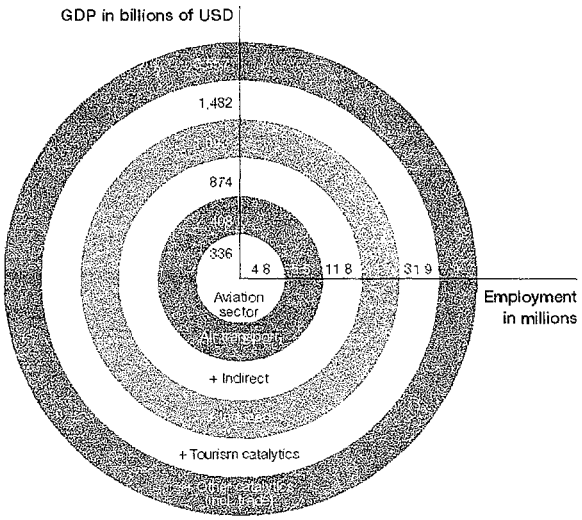
Global passenger traffic will reach 11 billion in 2027



The **International Air Transport Association (IATA)** 2008 report on *"The Economic and Social Benefits of Air Transport 2008"* highlighted the overall benefits associated with the aviation industry and also predicted the degree of air traffic growth on a global basis.

According to IATA, there are approximately two thousand (2,000) airlines around the world that operate a fleet of twenty-three thousand (23,000) aircraft. These aircraft service some three thousand seven hundred fifty (3,750) airports and transverse a route system of several million kilometers. Approximately one-hundred sixty air navigation service providers are responsible for the safe and efficient movement of these aircraft.

From a business perspective the GDP (gross domestic product) is an accepted measure of national income and outpit for a given State's economy. GDP is defined as the total market value of all final goods and services produced within the State in a given period of time (typically a calendar year). On a global level and in particular those regions of the world that do not have a well established surface transportation infrastructure, aviation is typically the cornerstone of international and in many cases domestic trade. The following IATA graphic is an estimate of the importance of the aviation section to the overall GDP



Source: Oxford Economics

IATA forecasts a 5.9% per year air traffic growth for the Asia-Pacific region of the world. This region includes the Central Asia States. According to IATA the Asia-Pacific region will be the largest aviation market in the world. To cope with the ever-increasing demands for aviation system capacity and cost-efficiency, IATA advises that the air traffic management sector must transition from its presently fragmented national arrangements to a regionally coordinated regulatory and operating environment.

This transition will require strong regional inter-governmental institutions to coordinate the harmonization of aviation regulations and infrastructure. Regionally harmonized air traffic management (ATM) systems should be put in-place to provide appropriate capacity, safety and efficiency levels. This will also contribute towards mitigating aviation's impact on the environment.

Strong regional coordination will enable new concepts in air traffic control technology to be implemented, thereby allowing aircraft to become less reliant upon expensive, ground-based infrastructure. A consistent approach, in-line with the ICAO Operational Concept will be necessary to facilitate the uniform implementation of ATM enhancements throughout the region. The future ATM system must be designed to fully utilize the standardized modern technology available on the aircraft. In addition, airspace restructuring is urgently required and careful and a responsible planned approach to improving the infrastructure.

Aviation Aircraft Industry Suppliers

As mentioned in the introduction, forecasting and/or projecting future air traffic and growth rates is at best difficult. Organizations such as those mentioned above (ACI, IATA) represent those groups and individuals that are performing direct services and support for day–to-day operations—airport owners and operators, airlines/airspace users. Because of the groups and individuals they represent, these Organizations must remain positive and have a solid outlook for the aviation industry as a whole.

The point is that these Organizations do not manufacture and/or sell products, hence, they do not have an upfront capital investment.

The same is not true for aviation industry manufactures and suppliers. They have to be extremely careful in forecasting air traffic growth and the subsequent demand for their products and services. The reason for this caution is the need for manufactures and suppliers to make an upfront capital investment in order to produce and market their equipment and systems. If they are wrong in predicting a near-term demand for their products and services, their upfront capital investment will be at risk, they will likely not have a positive cash flow, and will be operating at a loss. Another real-world factor is product shelf-life. Simply stated, no one wants to purchase "old" technology, systems and equipment. So if there is not a reasonable near-term need/sale of their products, then the products will lose their marketability and likely be an investment loss.

Consequently, the air traffic forecast views of the aviation industry suppliers (manufacturers) should be taken into consideration when predicting future growth. A small sampling of representative supplier views are provided for reference:

- **Boeing** (November 2008): Air transport is in a highly dynamic period. Challenges include a slowing world economy, high oil prices, and in some markets, slowing traffic growth. Current Market Outlook 2008-2027 is rooted in today's realities. Over the past 20 years, air travel grew by an average of 4.8 percent each year. This was despite two major world recessions, terrorist acts, the Asian financial crisis of 1997, the severe acute respiratory syndrome (SARS) outbreak in 2003 and two Gulf wars. During 40 years of producing the Current Market Outlook, we have learned that the resilience of air transport growth comes from its intrinsic importance to the livelihood of people around the world. On average over the next 20 years, passenger travel will grow at 5.0 percent and cargo at 5.8 percent. The fastest growing economies will lead the transformation into a more geographically balanced market. More productive, new airplanes will play a greater role, and there will be relentless pursuit of further environmental progress.

- **AIRBUS** (2007): Forecast global air transport growth is predicted to increase at an annual rate of 4.9%. In particular, for the Central Asia and Middle Eastern regions for the period 2007-2026 passenger traffic is projected to increase 5% annually whereas air freight annual growth is estimated to increase 3.9% annually.

- **Rockwell-Collins** (November 2008): Global air traffic in 2009 is now expected to be flat, compared with a prior forecast of 1% to 3% growth, because of the economic downturn, Jones said. Airlines already are pulling between 800 to 1,000 planes from the global fleet, but that could decline by an additional 400 planes before the end of the next year.

Aviation Agencies and Organizations

The **International Civil Aviation organization (ICAO)**, an agency of the United Nations, codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth.

The Central Asia States are contracting members of ICAO and are represented by the European and North Atlantic (EAC/NAT) Office located in Paris, France. The EAC/NAT office provides forecasts of air traffic growth within their region. The most recent projection (2008) provides an optimistic, baseline and pessimistic range for annual growth. A chart of these projections is as follows:

ICAO EUR/NAT Traffic Forecast (percentage)

Scenario	2009	2010	2015	2020
Optimistic	6.2	6.4	5.3	4.7
Baseline	5.0	4.9	4.4	4.0
Pessimistic	3.8	3.3	3.4	3.1

The **U.S. Federal Aviation Administration (FAA)** develops near, medium and long range traffic forecasts for both domestic and international operations. Their current belief is that on average through the year 2025 global air traffic will grow at a rate of 4.2% per year.

EUROCONTROL documents and data figures indicate a similar global air traffic growth rate as does independent assessments by organizations such as the German Aerospace Center. The optimistic annual growth rate is projected to be 4.9% per year through the year 2020, with a more conservative growth prediction of 2.5% to 3.0% per year.

Summary

The DORS team carefully reviewed and analyzed this broad range of traffic forecast data during the development of the three (3) prediction scenarios: worst case, most likely, and optimistic.

In addition, we took into account the fundamental drivers of air transportation such as projected future consumer/air traveler behavior and expectations, the stability of the political and social environment, the pace of liberalization, and the outlook with respect to airspace and airport congestion. The team also determined it would be prudent to cross reference the information obtained with an accounting of the number of aircraft in the region that are currently operating and the present conditions of the underlying infrastructure (reference Task 6 and Task 2/3 reports).

Based on these actions, the DORS Team developed the following traffic forecast predictions for the Central Asia Region:

Traffic Forecast-Annual Rate of Growth (percentage)

Scenario	2009-2015	2016-2020	2020-2025
Worse Case	1.8	2.3	2.4
Most Likely	3.2	3.4	3.5
Optimistic	4.6	4.8	5.0

Potential Financing Sources

Introduction

The objective of Task 12 is to develop a financial profile for CNS/ATM modernization and identify potential sources for financing.

Using the findings and conclusions from the previous task reports, a notional implementation schedule for a fifteen (15) year period was developed for the Central Asia region. During the development of this schedule the following assumptions were considered control factors and established the foundation for implementation:

1. Existing condition, status and capabilities of communications, navigation surveillance and air traffic management (CNS/ATM) systems and services as determined during the individual site surveys, personnel interviews, questionnaires and subsequent data provided by the participating states/working group members. This data and information are contained in the Task 3 report.

2. Remaining in-concert with international trends for implementing CNS/ATM technologies on a regional basis and consistent with ICAO and International Air Transport Association (IATA) planning documents, as well as other CNS/ATM-related implementation documents. This data and information are contained in the Task 4 report.

3. Ensuring consistency and compatibility between airspace user requirements and airspace service provider development requirements as detailed in the Task 6 and 7 reports.

4. Following the optional transition scenarios developed in Task 9 with particular emphasis being placed on the cost(s) versus benefit(s) of the options and the optimum method for implementing appropriate technologies for national and/or regional investments by one or more of the five service providers.

5. Remaining sensitive and appreciative of the positive and negative environmental impacts that result from the implementation and use of next generation CNS/ATM systems and services as described in the Task 10 report.

6. Forecast traffic volumes and the associated upper and lower airspace operational requirements to safely and efficiently control/managed aircraft movements. The forecast traffic volumes for each participating State and the Region are contained in the Task 11 report.

Modifications and/or changes to these control factors could impact the time line associated with implementation of one or more of the CNS/ATM systems.

Methodology

In addition to the control factors as outlined in the introduction, one must also remain aware of and take into consideration the following real world conditions:

1. The maturity of the technology, capabilities and services made available by the modernized CNS/ATM systems.

2. The willingness and ability of the airspace users to equip and operate with next generation systems.

3. The outlook for expanding and/or upgrading modernized systems commensurate with growing operational airspace demands.

4. Documented International Civil Aviation Organization (ICAO) constraints, concerns and limitations of existing systems and services with respect to phases of flight operations, and ICAO strategic resolutions for resolving these issues.

5. The extent to which airspace service provider and airspace user equipment can be "shared" to enhance overall operational safety and effectiveness.

The DORS Team determined that a realistic approach for CNS/ATM implementation must remain focused on the development and deployment of available technologies that yield immediate operational benefits while becoming the basis for future advances. This implementation approach includes, but is not limited to the following key considerations:

- The creation of user incentives to accomplish early equipage - the incentives should motivate users to embrace new technologies. The system should not exclude non-equippers, but recognizing that their operations may not be optimized.

- Capacity limitations should not affect user demand - the system must expand ahead of projected growth and accommodate all users. Artificial restrictions on the marketplace are unacceptable.

- Minimize the reliance on ground-based equipment - satellite and aircraft-to-aircraft technologies offer dramatically more operational flexibility at a fraction of the cost of today's system. The implementation should encourage the use of satellite communications and navigation with less reliance on ground-based technologies to the maximum extend possible.

- Make use of airborne and airborne-sharing equipment - the next generation of onboard communication, navigation and surveillance technologies will enable all aircraft and service providers to have total situational awareness, increasing safety on the ground and in the air. Users and providers can effectively be linked together to achieve this important enhancement. The implementation vision is to link the sharing of radar data, flight data

processing, and aeronautical flight information between the service provider and airspace user.

Notional Implementation Schedule

ICAO has identified the following operational requirements, constraints, concerns limitations and strategic resolutions associated with each phased of flight operations as highlighted in the following tables.

Flight Planning Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
Provide aircraft operators with information that will enable them to plan flights for optimum profile/route/ trajectory and meet their planned departure times. This includes weather, AIS (Aeronautical Information Service) NOTAMs, etc Provide aeronautical information in a timely and accurate manner. Provide flight plan information to adjacent control facilities 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.	Flight Planning Lack of automation, accuracy, timeliness. Lack of an adequate aeronautical information service (NOTAMs). Monitoring Performance Lack of availability, integrity updates, accuracy Nav/Guidance Performance Lack of accurate navigation system, availability of system, RNP (Required Navigation Performance) determinations, integrity and reliability of navigation signals Communications Performance Lack of availability, integrity, and latency of communication systems. Lack of a definitive data link capability Control Performance Lack of procedures, control, and cockpit awareness. Lack of a viable flow control capability. Use of redundant and excessive separation procedures. Lack of seamless airspace configurations (while control performance effects flight plan development, these sub-elements are resolved in the en route environment)	Integration of information on capacity constraints at ACCs and airports to provide optimum airport scheduling information Integration of ATC and ATFM (Air Traffic Flow Management) information together with decision-making tools to accommodate late flight plan changes Provide user access to interactive, integrated flight information to include real time data in AIS, MET (Meteorology), ASM (Air Traffic System Management), and ATFM for flight plan filing purposes Enhance FPDP (Flight Plan Data Processing) to access tactical ASM , ATC, ATN, and ATFM information to include the use of repetitive flight plans. Install AMHS. Provide ground communications that permit the filing, processing, and retention of flight plans Provide automated co-ordination and decision-making tools to support optimum profile planning Provide HMI (Human Machine Interface) to access the integrated system.

Table 1 - Flight Planning Phase

Airport Surface Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
Maximize runway and taxi-way utilization to ensure minimum taxi time between departure gate and take-off to meet planned departure times Maximize runway and taxi-way utilization to ensure minimum taxi time to enable operators to meet their planned arrival time Provide a safe and orderly flow around the airport from gate to runway and visa versa 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.	Taxiway Configuration Lack of adequate taxiways Increased runway crossings Inadequate airport lighting Movement area congestion Control Performance Lack of adequate tower visibility and controller awareness. Lack of adequate cockpit visibility and pilot awareness. Inadequate decision making tools. Control integrity Communication Performance Frequency congestion Availability Integrity Intervention Aircraft Performance Speed Maneuverability Equipage Airport Visibility Cockpit visibility Weather Flow Control Congestion Monitoring Performance Inadequate airport surveillance Airport Information Lack of ATIS (Automated Terminal Information Service) and PDC (Pre-Departure Clearance)	Optimize airport surveillance that improves pilot and controller awareness that includes ASDE (Airport Surface Detection Equipment), ADS-B (Automatic Dependent Surveillance – Broadcast), or A-SMGCS (Advanced-Surface Movement Guidance And Control System) where needed Optimize controller tools for airport management Improved airport management that includes most direct route between runway and gates; utilization of SMA (Surface Management Advisor) Improve airport lightning A-SMGCS Integration of arrival, apron, and departure managers Integration of ATC, ATFM, airports, and AOC (Airline Operational Control) information Implementation of ATIS and PDC

Table 2 - Airport Surface Phase

Initial Departure and Final Approach Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
To accommodate different landing priorities for a given operator to optimize in and out operations. To maximize runway utilization and provide a smooth and seamless transition to the final approach course. To provide adequate instrument approach aids and procedures. To provide for a smooth transition from the runway to the departure phase and from the arrival phase to the landing runway 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.	Runway Occupancy Concerns Length, high speed turnoffs, exits; runway surface conditions; braking actions; RVV (Runway Visibility Value) RVR (Runway Visual Range) Runway Operations Missed approaches Crossing/intersecting runways Parallel/converging flight paths Departures/arrivals same runway Acceptance rate/wake turbulence Control Performance Separation/metering Go-around decisions Runway incursion/detection blunders. Lack of CTAS (Center/ Terminal Automation System). Aircraft Performance Traffic mix Approach speeds Braking actions Monitoring Performance Lack of adequate surveillance in the immediate approach area. Lack of radar for vectoring to final. Communications Performance Lack of immediate intervention Approach Procedures Lack of accurate and reliable instrument approach procedures Navigation Performance Lack of accurate, reliable navigational equipment and signals (satellite navigation)	Optimize arrival and departure routes (SIDs - STARs) within an agreed environmental policy Integrate arrival/departure managers at adjacent/close airports Provide flight profile prediction and optimization tools Optimize airport instrumentation for local weather measurement Provide adequate surveillance that will expedite arrivals and departures in a safe and orderly manner. Provide the environmental and runway configurations that expedite arriving and departing aircraft. Optimize controller tools such as CTAS; P-FAST (Passive Final Approach Sequencing Tool), URET (User Request Evaluation Tool), and SMA to improve controller performance and decision making. Provide more accurate navigation capability that minimizes missed approaches, reduces terrain and obstruction minima, and provides more cockpit awareness.

Table 3 – Initial Departure and Final Approach Phase

Approach and Departure Transition Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
To provide for a smooth transition from departure phase to the en route phase so aircraft can adhere to their planned flight profiles To provide for a smooth and seamless transition from the en route phase to the arrival phase so aircraft can meet their planned times of arrival To 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.	Aircraft Performance Speed Maneuverability Equipage Climb capability Traffic mix Control Performance Lack of standardized arrival and departure procedures. Lack of ground automation. Obstacle and terrain clearance concerns Airport Flow Runway configurations NOTAMs Flow control Navigation Performance Galileo GBAS (Ground-base Augmentation System) availability Signal reliability RNP values Integrity/accuracy Monitoring Performance Lack of adequate surveillance. Communications Performance Lack of adequate two-way communications within 30 miles of the airport. Lack of adequate intervention capability	Optimize arrival and departure routes utilizing SIDs and STARs Improve the overall efficiency of airport operations and runway Optimize airport instrumentation for local weather measurement. Provide metering and sequencing tools (CTAS; P-FAST, URET) Provide equipment and procedures for departure and arrival navigation Improve methods of determining obstruction and terrain clearances. Optimize navigation capabilities and procedures in terminal areas Optimize surveillance capabilities Within terminal airspace

Table 4 – Approach and Departure Transition Phase

En Route Phase

ICAO Recommendation (Operational Requirement)	Constraint, Concern, or Limitation	Strategic Resolution of Constraint
To make the en route phase of flight a seamless phase of flight and to provide an overall gate-to-gate approach To expedite aircraft between two points with minimum delay while maintaining an acceptable level of safety To 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.	Navigation Performance Lack of an accurate and available navigational system that has integrity and is not limited to line-of-sight reception. Airspace Configuration Inadequate airspace configuration Inadequate use of airspace Airspace too complex and dense for optimum use. Lack of seamless airspace Aircraft Performance Equipage Traffic mix Climb and descent characteristics Altitude performance Communication Performance Lack of complete two-way communications in operational airspace; saturation of communications environment or spectrum Monitoring Performance Lack of surveillance in complex and high density airspace; lack of adequate surveillance updates/ blind spots Control Performance Excessive separation standards Lack of optimum procedures Excessive coordination required	Revise institutional polices to facilitate gate-to-gate operations Inter-relate ASM, ATS, and ATFM polices and integrated information systems Use of compatible air and ground systems Develop and utilize procedures based on dynamic and real time air traffic Provide and utilize trajectory monitoring tools Develop and implement autonomous separation activities in specified areas Provide viable two-way communications in all areas of responsibility Develop procedures based on modern equipment and techniques that make use of aircraft avionics' capabilities. Develop joint-use military airspace for seamless phases of flight and for optimum use of airspace Implement navigation capability using satellite navigation to provide direct routes on a world wide basis that minimize flight time.

Table 5 – En Route Phase

Each service provider organization was surveyed to determine their views and opinions regarding CNS/ATM implementation scheduling for a fifteen year period. Based on the information/data provided by the service provider organizations coupled with the aforementioned ICAO resolutions, control factors and real world conditions, the following notional implementation schedule was developed.

Communications Transition

ATN (Aeronautical Telecommunications Network)			
	0-5 Years	**5-10 Years**	**10-15 Years**
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan		X	
Uzbekistan		X	
AMHS (Air Traffic Service Message Handling Service)			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan			X
Uzbekistan		X	
AIDC (Air Traffic Service Inter-facility Data Link Communications)			
Kazakhstan			X
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
Voice Communications and Control System (VCCS)			
Kazakhstan	X		
Kyrgyzstan		X	
Tajikistan		X	
Turkmenistan			X
Uzbekistan		X	
Voice Communications--VHF			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan	X		
Uzbekistan	X		

	0-5 Years	5-10 Years	10-15 Years
Voice Communications-HF			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan	X		
Uzbekistan	X		
Data Links VDL M2 (VHF Data Link Mode 2)			
Kazakhstan	**Not planned for use all States**		
Kyrgyzstan			
Tajikistan			
Turkmenistan			
Uzbekistan			
Data Links VDL M2 (VHF Data Link Mode 4)			
Kazakhstan			X
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
Data Links ACARS (Aircraft Communications and Reporting System)			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan		X	
Uzbekistan		X	
Data Links HFDL (HF Data Link)			
Kazakhstan	**Not planned for use all States**		
Kyrgyzstan			
Tajikistan			
Turkmenistan			
Uzbekistan			

	0-5 Years	5-10 Years	10-15 Years
Data Links Mode S (Mode Select)			
Kazakhstan		X	
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
Data Links VSAT(Very Small Aperture Terminal)			
Kazakhstan	**Not planned for use all States**		
Kyrgyzstan			
Tajikistan			
Turkmenistan			
Uzbekistan			

Navigation Transition

VOR			
	0-5 Years	**5-10 Years**	**10-15 Years**
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan	X		
Uzbekistan	X		
DME			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan	X		
Uzbekistan	X		
ILS			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan	X		
Uzbekistan	X		
NDB			
Kazakhstan	**Remove 75%**		
Kyrgyzstan	**Remove 75%**		
Tajikistan	**Remove 50%**		
Turkmenistan	**Remove 30%**		
Uzbekistan	**Remove 30%**		
GNSS			
Kazakhstan		X	
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan		X	
Uzbekistan		X	

Surveillance Transition

ASR (Airport Surveillance Radar) -11 and ASR-12			
	0-5 Years	**5-10 Years**	**10-15 Years**
Kazakhstan	X		
Kyrgyzstan		X	
Tajikistan		X	
Turkmenistan			X
Uzbekistan		X	
ADS (Automatic Dependent Surveillance): ADS-B			
Kazakhstan		X	
Kyrgyzstan		X	
Tajikistan		X	
Turkmenistan			X
Uzbekistan		X	
ADS (Automatic Dependent Surveillance): ADS-C			
Kazakhstan		X	
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
Mode S 1090 Extended Squitter			
Kazakhstan		X	
Kyrgyzstan		X	
Tajikistan		X	
Turkmenistan			X
Uzbekistan		X	

ATM Transition

FDP (Flight Data Processor)			
	0-5 Years	**5-10 Years**	**10-15 Years**
Kazakhstan	X		
Kyrgyzstan		X	
Tajikistan	X		
Turkmenistan			X
Uzbekistan		X	
TFM (Traffic Flow Management)			
Kazakhstan	X		
Kyrgyzstan			X
Tajikistan		X	
Turkmenistan			X
Uzbekistan		X	
RNAV (Area Navigation)			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan		X	
Uzbekistan	X		
RVSM (Reduced Vertical Separation Minima)			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan	X		
Uzbekistan	X		
RNP (Required Navigation Performance)			
Kazakhstan	X		
Kyrgyzstan		X	
Tajikistan		X	
Turkmenistan		X	
Uzbekistan		X	

	0-5 Years	5-10 Years	10-15 Years
RCP (Required Communications Performance)			
Kazakhstan			X
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
RSP (Required Surveillance Performance)			
Kazakhstan			X
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
RTSP (Required Total System Performance)			
Kazakhstan			X
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
CDM (Collaborative Decision Making)			
Kazakhstan			X
Kyrgyzstan			X
Tajikistan			X
Turkmenistan			X
Uzbekistan			X
AIS (Aeronautical Information Service)			
Kazakhstan	X		
Kyrgyzstan	X		
Tajikistan	X		
Turkmenistan		X	
Uzbekistan	X		

Budgeting for modernization is always a difficult process from both a planning and execution perspective. The myriad of variables, such as market trends, technology improvements, quantities purchased, guarantees/warranties, spare parts, training, and maintenance can result in significant price differentials.

Purchasing next generation equipment, systems and services on a Regional basis should reduce the pricing for each individual state and afford the maximum opportunity for long-term systems guarantees and supportability. Hence, it is recommended that institutional measures and schedules be put in place to harmonize the purchase of new equipment, systems and services.

For instance, in the above communications transition chart Kazakhstan, Kyrgyzstan and Tajikistan plan to move forward with an Aeronautical Telecommunications Network (ATN) within the next five years. It would be beneficial for these states to work together as much as possible to procure the ATNs at the same time and collaborating to issue a single tender.

Recognizing the impact of the abovementioned variables and the transition schedules the DORS Team developed a rough order of magnitude estimate of the costs of the next generation sets of equipment, systems and services for which the participating states may find difficult to estimate. The participating states recognize the cost of traditional systems that have been "modernized", such as VOR, DME and ILS.

These figures should be considered as a starting point for the planning and budgeting process. The amounts indicated below were compiled based upon data obtained from global suppliers, information provided by civil aviation authorities that have recently obtained next generation equipment, systems and services, and in consideration of the 15 year transition charts in the previous pages of this document:

1. VHF clusters of radios (transmitters and receivers; 10 systems in each cluster) to include freight and installation on average should be approximately $200,000USD.

2. Communication towers, including land, site preparation, support building(s), cabling and power facilities should not exceed $350,000USD.

3. VDL-Mode 2 units (4 radios per state) to include freight and installation should be approximately $50,000 USD each.

4. It is suggested that GNSS monitors and data recorders be installed to alert air traffic personnel regarding the status of navigation signals and to record this data for further reference. The approximate cost of such a monitoring system should not exceed $50,000USD.

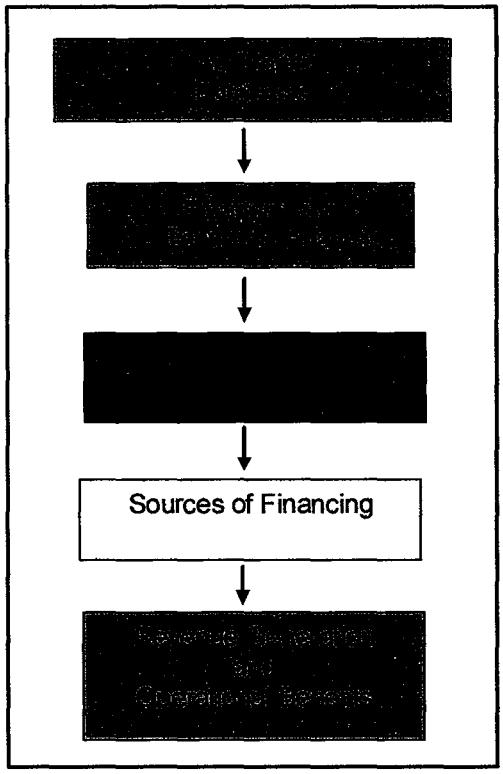
5. A "turn-key" ATM system to include the integration of ATN, AMHS and AIDC should be approximately $3,000,000USD. Note that fully equipped controller workstations including parallel controller positions may cost as much as $1,000,000USD each. These workstations include monitor equipment for ADS, CPDLC, displays capable of both ADS and radar monitoring, strip printers if required,

input/output devices etc. The cost of each workstation will be a function of the associated operational configuration.

6. For both surface and terminal surveillance with the potential of providing en route surveillance, and ADS-B station should cost approximately $150,000USD. Regarding an ADS-C station, the individual cost will likely be in the range of $200,000USD due to installation and cabling in the more remote areas.

Potential Sources for Financing

Prior to determining the best source for financing it is advisable to develop an accurate and complete financial plan. The basic steps for developing such a financial plan include air traffic forecasts, a financial and economic analysis, a comprehensive end-to-end plan, identification of sources for financing and revenue opportunities.



Basic Financial Steps

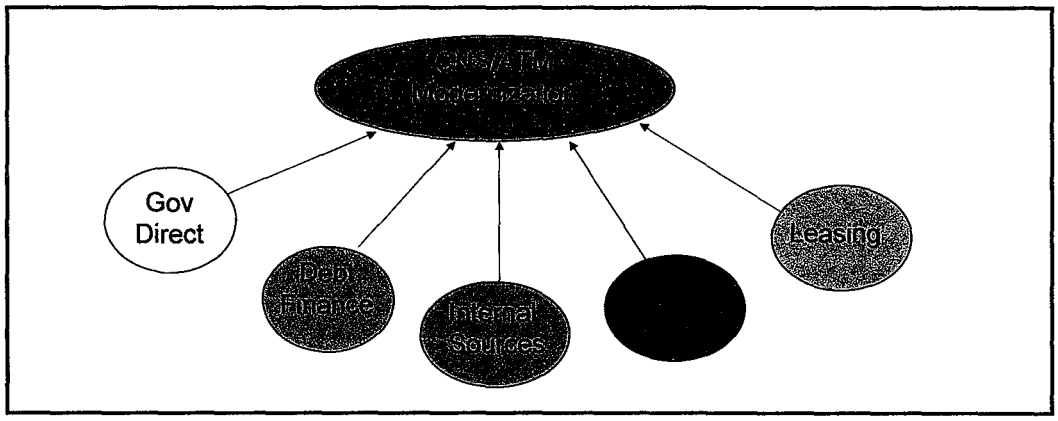
Direct financing of many basic components may not involve aviation at all, particularly where aviation is relatively minor user of a particular system (e.g. satellite navigation). In such situations, financing may be arranged by the system operator with aeronautical users paying for access through leases or charges, which would include an element to recover the costs of financing and repayment of capital.

Regarding the Basic Financial Steps, as outlined in the figure:

1. Air Traffic Forecasts: sound traffic forecasts are essential to any air navigation services infrastructure development project and it's financing. The main purpose of such forecasts is to identify traffic developments and to establish the associated capacity requirements of the air navigation facility or service involved. These forecasts are also important for carrying out financial and economic analyses and for preparing revenue estimates from charges on air traffic.

2. Financial and Economic Analysis: every major investment decision taken by a service provider should be supported by analyses to demonstrate cost and benefits to service providers, users and, as appropriate, the wider community. Such analyses are important when choosing between options for the implementation of CNS/ATM systems and when seeking government or private financing. Three types of analyses should be considered:
   a. Cost-benefit analyses to demonstrate financial viability and to identify the investment options that best conforms with the economic goal of maximizing net benefits and/or;
   b. Business cases study (financial evaluation) which deals with the direct costs, revenues and sources of funds and focuses on financial accounts and cash flows to demonstrate to a service provider of capital funds that loan obligations can be served;
   c. Economic impact study to assess the contribution of air navigation services to the overall economy.
3. End-to-end Planning: the purpose of end-to-end planning is to provide the following basic information:
   a. Estimates of the element costs (labor, materials, equipment, etc.) of each distinct part of the overall project;
   b. The funds required to make disbursements at various stages in the projects progress;
   c. The currencies in which payments are to be made (as appropriate);
   d. The sources from which funds are to be made available, such as
      i. Sources generated by the enterprise providing air navigation services, such as user charges, retained earnings, contractual payments, etc.
      ii. Other sources, such as loaning institutions, grants, aide programs, etc.

It is also important to make data available regarding the financial situation of the air navigation service provider over the recent years, as well as anticipated developments over a period of debt repayment. Of particular relevance is the recording of revenues and expenses by major item. Estimates regarding future financial developments would emanate from budgets and longer term financial plans. In the absence of such financial data, it would be much more difficult to decide whether or not the loan or financing sought should be granted.



Financing Options

A survey of potential sources of financing and which of them to seriously consider should be done as early as possible in the planning process.Potential sources of funds will vary considerably from project to project and State to State. The sources to be approached should be studied and decided upon individually for each project and can be grouped as follows: direct contributions from government sources, loans or debt financing; internally generated resources/revenues; equity financing; and leasing.

Direct contributions from governments: the extent to which direct contributions will be required from the government depends on a number of factors. Chief among these is the organizational form under which CNS/ATM systems services will be provided. For instance, will the government be directly involved, either alone, or in a joint effort with industry/other governments, or will it primarily involve a commercial corporation? Another factor is the type of CNS/ATM systems components involved. For instance, is funding being required for satellite elements or "national" ground-based faculties? Another factor is whether the traffic volume within the airspace concerned is sufficient to support CNS/ATM systems components in financial terms, including service debt. If such traffic is not sufficient, as in a situation where, for example, a local CNS/ATM facility would service one or more airports with very limited traffic, direct contributions from the government may be the only realistic alternative.

Debt financing: the feasibility of debt financing will depend on whether the traffic to be served by the CNS/ATM systems components to be financed is of sufficient volume and strength to service the debt, including interest and repayment of capital. Where an international agency or corporate entity would be providing basic CNS/ATM systems services, its cost of financing could be reduced if the State for which the basic services are being provided were to guarantee the servicing and repayment of the loans concerned. This in turn should reduce the costs.

Internally generated resources: depreciation and retained profits from the operation of air navigation services may become a supplementary source of financing for CNS/ATM systems and services. However, with regard to profits, an important qualification that needs to be recalled is the following principle: Air navigation services may produce sufficient revenues to exceed all direct and indirect operating

costs and so provide for a return on assets (before tax and cost of capital) to contribute towards necessary capital investments.

Equity financing: equity financing may be a viable alternative in some instances. For example, if a CNS/ATM systems component's services were acquired under contract from a commercial service provider, that operator could finance the investment required partially or completely through increased equity.

Leasing: leasing rather than outright ownership could become an important alternative in CNS/ATM systems provision. This could apply, for example, with regard to GNSS integrity monitoring and augmentation systems, where access may be effected in a less time and capital consuming manner that if the State(s) concerned were to operate these facilities themselves. The possibility could also be explored of applying leasing to local area augmentation units, possibly through the establishment of leasing companies, which would operate in a manner similar to those purchasing and leasing out, for example, computer systems, communications systems and/or aircraft under long term leases.

Examples of some of the specific alternative mechanisms for securing funding for modernization projects can be broadly classified as either Private or Public Sector options. A brief summary of these options are highlighted in the following sections. financial organizations (e.g. European Bank for Reconstruction and Development, US Export-Import Bank, OPIC, etc.).

Private Sector Options

Venture Capital

Venture capital is a type of private equity capital typically provided by professional, outside investors to new growth businesses. Generally made as cash in exchange for shares in the investee company, venture capital investments are usually high risk, but offer the potential for above-average returns.

A venture capital fund is a pooled investment vehicle (often a limited partnership) that primarily invests the financial capital of third-party investors in enterprises that are too risky for the standard capital markets or bank loans. Venture capital can also include managerial and technical expertise.

Most venture capital comes from a group of wealthy investors, investment banks and other financial institutions that pool such investments or partnerships. This form of raising capital is popular among new companies, or ventures, with limited operating history, which cannot raise funds through a debt issue. The downside for entrepreneurs is that venture capitalists usually get a say in company decisions, in addition to a portion of the equity.

Industry Investors/Consortiums

The operations, decisions, and day-to-day performance of the service providers will likely have an adverse impact on those aviation related industries and organizations with a vested interest in airspace performance. Specifically, these interest groups

are those that are capable of providing equipment, systems and/or services in support of flight operations and those that will pay for the airspace services provided.

The equipment, systems and/or services groups are global and include major corporations such as Thales, Lockheed-Martin, Raytheon, etc. For the most part, the vested airspace services "payer" is the International Air Transport Association (IATA).

Since the investors will have a interest in the services and operational performance within each State's airspace and the Region it would be in the best interest of potential suppliers and airspace operators (e.g. airlines) to invest in the infrastructure in order to "assist" with the organizational and operational decision making processes. From a suppliers point of view modernization will afford an opportunity to sell equipment, systems and services; from an IATA point of view the airspace user needs to ensure overflight and/or airspace user charges remain in the forefront of the decision making processes of the service providers.

Public Sector Options

Since the service provider functions and airspace operations will effect the general "public" as well as the wellbeing of the overall economic infrastructure of the States and Region, then funding options would include government agencies of participating states, and international lending bodies such as the IMF, the World Bank, various economic agencies of the UN, and development banks. The following paragraphs outline key aspects of the most likely lending institutions.

International Monetary Fund

The primary mission of the IMF is to provide financial assistance to countries that experience serious financial difficulties. Member states with balance of payments problems may request loans and/or organizational management of their national economies. In return, the countries are usually required to launch certain reforms, which have often been dubbed the "Washington Consensus". These reforms are generally required because countries with fixed exchange rate policies can engage in fiscal, monetary, and political practices which may lead to the crisis itself. For example, nations with severe budget deficits, rampant inflation, strict price controls, or significantly over-valued or under-valued currencies run the risk of facing balance of payment crises in their future. Thus, the structural adjustment programs are at least ostensibly intended to ensure that the IMF is actually helping to prevent financial crises rather than merely funding financial recklessness.

However, this approach is not without its critics, as described below. Many supporters of the IMF contend that some criticisms are the result of the fact that many people are not familiar with the operations and objectives of the IMF, and blame a lack of transparency within the IMF for this, as well as the dense nature of international finance in general. Suggestions for improving these understandings have included greater community outreach efforts, tighter accounting standards, possible regulatory oversight, and changes in the organizational structure of the IMF to include fewer economists, whom many fear are attempting to use developing countries as nothing more than lab rats. Some fear, however, that some of these

reforms to the IMF itself introduce political considerations rather than economic considerations, many of which may have resulted in the financial crises in the first place. According to Ulrich Beck, the International Monetary Fund is an international risk community combating the threat of a global financial crisis.

World Bank

The World Bank, as it is commonly referred to, consists of two agencies of the five that comprise the World Bank Group:

- The International Bank for Reconstruction and Development (IBRD)
- The International Development Association (IDA)

The International Bank for Reconstruction and Development (IBRD) is one of five institutions that comprise the World Bank Group. The IBRD is an international organization whose original mission was to finance the reconstruction of nations devastated by WWII. Now, its mission has expanded to fight poverty by means of financing states. Its operation is maintained through payments as regulated by member states. It came into existence on December 27, 1945 following international ratification of the agreements reached at the United Nations Monetary and Financial Conference of July 1 to July 22, 1944 in Bretton Woods, New Hampshire.

The IBRD provides loans to governments, and public enterprises, always with a government (or "sovereign") guarantee of repayment. The funds for this lending come primarily from the issuing of World Bank bonds on the global capital markets - typically $12-15 billion per year. These bonds are rated AAA (the highest possible) because they are backed by member states' share capital, as well as by borrowers' sovereign guarantees. (In addition, loans that are repaid are recycled (relent).) Because of the IBRD's credit rating, it is able to borrow at relatively low interest rates. As most developing countries have considerably lower credit ratings, the IBRD can lend to countries at interest rates that are usually quite attractive to them, even after adding a small margin (about 1%) to cover administrative overheads.

The International Development Association (IDA) is responsible for providing long-term interest-free loans to the world's 81 poorest countries. IDA provides grants and credits, with repayment periods of 35 to 40 years and no interest. Since its inception, IDA credits and grants have totaled $161 billion, averaging $7–$9 billion a year in recent years. IDA is part of the World Bank Group based in Washington, D.C. Kyrgyzstan, Tajikistan and Uzbekistan have all received loans from IDA.

IDA funds are allocated to the borrowing countries in relation to their income levels and record of success in managing their economies and their ongoing IDA projects. Nearly all IDA credits have no interest charge, but credits do carry a small service charge, currently 0.75 percent on funds paid out. IDA also provides grants, which are allocated that are at risk of debt distress. In fiscal year 2008 (which ended June 30, 2008), IDA commitments totaled US$11.2 billion, of which 28 percent was provided on grant terms. New commitments in FY08 comprised 199 new operations. Since 1960, IDA has provided US$193 billion to 108 countries. Annual commitments have increased steadily and averaged about US$11 billion over the last three years.

IDA-financed operations address primary education, basic health services, clean water and sanitation, environmental safeguards, business climate improvements, infrastructure and institutional reforms. These projects pave the way toward economic growth, job creation, higher incomes and better living conditions.

European Bank for Reconstruction and Development (EBRD)

The EBRD provides project financing for a wide range of markets to include infrastructure developments. Its initial "mission" was to support the former Soviet Union states for the development of establishing their private sectors. Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan have all been recipients of ERBD financing.

EBRD financing for private sector projects generally ranges from 5 million to 250 million Euros in the form of loans or equity. The average EBRD investment is €25 million. Smaller projects may be financed through financial intermediaries or through special programs for smaller direct investments in the less advanced countries.

To be eligible for EBRD funding, the project must:

- be located in an EBRD country of operations
- have strong commercial prospects
- involve significant equity contributions in-cash or in-kind from the project sponsor
- benefit the local economy and help develop the private sector
- satisfy banking and environmental standards.

The EBRD tailors each project to the needs of the client and to the specific situation of the country, region and sector. The EBRD typically funds up to 35 per cent of the total project cost for a greenfield project or 35 per cent of the long-term capitalization of the project company. The Bank requires significant equity contributions from the sponsors, which must equal or be greater than the EBRD's investment

U.S. Export-Import Bank

The U.S. Export-Import Bank (Ex-Im Bank) is the principal government agency responsible for aiding the export of American goods and services, and thereby creating and sustaining U.S. jobs, through a variety of loan, guarantee, and insurance programs. Generally, its programs are available to any American export firm regardless of size. Similar banks, or export credit agencies (ECAs), are operated by a number of foreign countries.

The Ex-Im Bank provides two types of loans: direct loans to foreign buyers of American exports and intermediary loans to responsible parties, such as foreign government lending agencies which relend to foreign buyers of capital goods and related services (for example, a maintenance contract for a jet passenger plane). Both programs cover up to 85 percent of the value of the exported goods and services, with repayment terms of one year or more

Overseas Private Investment Corporation (OPIC)

OPIC is an agency of the United States Government established in 1971 that helps U.S. businesses invest overseas and promotes economic development in new and emerging markets.

OPIC's mission is to "foster economic development in new and emerging markets, support U.S. foreign policy and create U.S. jobs by helping U.S. businesses to invest overseas." The agency provides political risk insurance against the risks of inconvertibility, political violence, or expropriation. OPIC also provides financing through direct loans and loan guarantees.

Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzebekistan have Investment Incentive Agreements with OPIC.

Annex I: Available US sources of supply

Communications

ACI - Aeronautical Communication International

Overview: ACI is an international joint venture provides various portable software products meeting the ATN infrastructure and application needs.

Key Products:

- ATN Router.
- Context Management (CM)
- Controller-Pilot Data Link Communications (CPDLC)
- Automatic Dependant Surveillance-Addressed (ADS-A)
- Flight Information Services (FIS)

Contact Info:
Honeywell Aerospace Electronic Systems (an ACI officer)
Avionics systems supplier based in Phoenix, Arizona & Redmond, Washington, USA, with offices worldwide

Contact: John Harvath
Tel: +1-425.885.8372
Fax: +1-425.885.8319

Website: http://www.aci-llc.com/

ARINC

Overview: Today, we're a $743 million, ISO 9001:2000 certified company that's recognized as the leading provider of transportation communications and systems engineering solutions for five major industries: aviation, airports, defense, government, and transportation.

Products:

- AeroMobile
- Air Traffic Management
- Aircraft Systems
- Airport Operations
- Airport Systems Integration Services
- Asset Management & Condition Monitoring
- Business Aviation Solutions
- Data Applications
- Engineering Services
- Homeland Defense
- Industrial and Manufacturing Engineering
- Integration Services
- Intelligent Transportation Systems
- Maritime Navigation
- Modeling and Simulation
- Naval Warfare Support
- Network Engineering
- Passenger Processing System
- Public Safety Systems and Wireless Data Networking
- Rail Control Center Integration
- Reliability, Maintainability, and Supportability Engineering
- Revenue Protection
- Satellite Services
- Security
- Space and Satellite Engineering
- Test and Evaluation
- Training
- Voice and Data Communications
- Weather

Contact Info:
2551 Riva Road
Annapolis, MD 21401-7465

Tel: 410-266-4000
Tel: 301-858-4000
Fax: 410-573-3300
Website: http://www.arinc.com

Ball Aerospace and Technologies Corp

Overview: Ball Aerospace & Technologies Corp's vision is to be a global leader providing advanced imaging, communications, and information solutions to the government and commercial aerospace markets

Products:

- Antennas
- Cameras / Video
- Remote Sensing
- Services
- Subsystems & Components

Contact Info:
1600 Commerce Street
Boulder, CO 80301

Tel: 303-939-4000
Tel: 303-939-6100
Email: info@ball.com

Website: http://www.ball.com/aerospace/batchp.html

Cubic Communications

CUBIC COMMUNICATIONS
A member of the Cubic Corporation family of companies

Overview: Cubic Communications, Inc. (CCI) provides high quality Radio Frequency (RF) and Digital Signal Processing (DSP)-based wireless communications equipment to Government and Commercial customers worldwide. Headquartered in San Diego, Calif., CCI has served the domestic and international communications and signal intelligence markets for more than four decades.

Products:

- Antennas
- Base station products in the air traffic control (ATM/CNS)
- Direction-finding equipment
- Exciters
- Maritime communication
- Receivers
- Signal monitoring
- Software definable transceiver
- Surveillance

Contact Info:
Cubic Communications, Inc.
9333 Balboa Avenue
San Diego, CA 92123

Tel: (858) 277-6780
Fax: (858) 505-1593

Website: http://www.cubic.com/

Denro (Under Northrop Grumman)

Overview: Advanced Systems is a major supplier of advanced telecommunications products for the Space, Electronic Warfare and Communications markets.

Products:

- C4I Switching System (C4ISS)
- Digital Voice Recording System
- Enhanced Terminal Voice Switch (ETVS)
- Litton Advanced Systems' Voice Communications Switching Systems
- Radio Control Equipment (RCE) Model 2001
- Rapid Deployment Voice Switch (RDVS)
- Shipboard Integrated Voice Communications System (SIVCS)
- Small Digital Voice Switch (SDVS)

Contact Info:
Northrop Grumman Advanced Systems
Mail Stop A-255
PO Box 17319
Baltimore, MD 21203-7319

Tel: (301) 864-5600
Fax: (301) 454-9803
General Information:
Email: ES_Communications@ngc.com

Website:
http://www.es.northropgrumman.com/es/pages/comms/denro_products.html

ECI TeleSystems Ltd

Overview: ECI Telecom (NASDAQ:ECIL) is a world leader in integrated network solutions. ECI Telecom provides leading edge digital telecommunications and data transmission systems to Network Service Providers around the globe.

Products:

- Broadband and Narrowband Access Solutions
- Business Systems
- Enavis Cross Connect Solutions
- Fixed Wireless Local Loop (InnoWave)
- Integrated Network Solutions
- LightScape Optical Networking Solutions
- Optical Transport
- NGTS (Next Generation Telephony Solutions)
- NGTS IP Solutions

Contact Info:
North American Headquarters (USA)
Herndon, VA

Tel: +1-703-456-3400
Fax: +1-703-456-3410

Website: http://www.ecitele.com

Global Weather Dynamics Inc

Overview: Global Weather Dynamics, Inc. has built its reputation by providing state-of-the-art communications and information management systems for the Aeronautical and Meteorological industries. GWDI offers a broad product line combining leading edge computer technology with an experienced and talented engineering and management staff.

Products:

- Aeronautical Information Management
- AFTN and CIDIN Message Switches
- ATC Integrated Information Display
- Automated Aeronautical Information Service Systems
- Flight Plan Management Systems
- Meteorological Information Management
- Meteorological Message Switches
- Operational Meteorology Database Systems.
- Pilot Self-Briefing
- Publishing and Cartography
- PC-based aeronautical and meteorological information terminals for message composition, transmission and reception.

Contact Info:
201-B Calle Del Oaks
Monterey, CA 93940

Tel: (831) 392-0430
Fax: (831) 392-0429
Email: info@gwdi.com

Website: http://www.gwdi.com/

Harris Corporation

Overview: Harris Corporation (NYSE: HRS) is an international communications equipment company focused on providing product, system, and service solutions for commercial and government customers. The company's five operating divisions serve markets for microwave, broadcast, network support, secure tactical radio, and government communications systems.

Products:

- Broadcast communications
- Government communications
- Microwave communications
- Network support

Contact Info:
1025 West NASA Boulevard
Melbourne, Florida

Contact: Sleighton Meyer (Sr. Manager of Marketing Comm.)
Tel: 321-727-6514
Fax: 321-727-4500

Website: http://www.harris.com/

L-3 Communications, ESSCO

Overview: Electronic Space Systems Corporation (ESSCO) and its subsidiary, ESSCO Collins Limited (ECL), are the worlds largest producers of ground based radomes and antenna products for a variety of user applications, providing secure communication systems, training systems, microwave components, avionics and ocean systems, telemetry, instrumentation, space and wireless products.

Key Products:

- High Data Rate Communications
- Space Communications & Satellite Control
- Military Communications & Tactical Security
- Information Security Systems
- Satellite Communication Terminals
- Simulation & Training Systems

Contact Info:
48 Old Powder Mill Rd.
Concord, MA 01742

Contact: Jeffrey S. Brown
Tel: 978-369-7200
Fax: 978-369-7641
E-mail: Info.essco@l-3com.com or Jeffrey.Brown@l-3com.com

Website: http://www.l-3com.com/ESSCO

Marconi Communications- (VHF Digital Radio)

Overview- Marconi is a multi-regional designer, manufacturer and supplier of telecommunications and information technology equipment and services. Our network technology and services enable our customers to evolve narrowband networks to next-generation broadband networks.

Key Products:

- Access Radio (AXR)
- Access WiMAX Radio (AWR) Product Family
- DMP - Distributed Multi-service Platform
- DTR 100 Radio
- MDMS - Marconi Digital Multipoint System
- Microwave Radio Antennas
- The MD202 1/0 Cross Connect
- TNX™210 and TNX1100
- XMP1 cross-connect system and flexible add/drop multiplexer

Contact:
CEO: Mike Parton
1000 Fore Drive
Warrendale, PA 15086-7502

Tel: (724) 742-4444
Fax: (724) 742-7700

Website: http://www.comms.marconi.com

Motorola

Overview: Motorola is a global leader in providing integrated communications solutions and embedded electronic solutions. Our Intelligence Everywhere™ solutions include: Software-enhanced wireless telephone and messaging, two-way radio products and systems, as well as networking and Internet-access products, for consumers, network operators, and commercial, government and industrial customers. End-to-end systems for the delivery of interactive digital video, voice and high-speed data solutions for broadband operators. Embedded semiconductor solutions for customers in wireless communications, networking and transportation markets. Integrated electronic systems for automotive, Telematics, industrial, telecommunications, computing and portable energy systems markets.

Key Products:
ASTRO and ASTRO 25 Network

- Computer Aided Dispatch (CAD)
- Delivery of interactive digital video, voice and high-speed data solutions for broadband.
- Embedded semiconductor solutions
- Integrated electronic systems for automotive, Telematics, industrial, telecommunications, computing and portable energy systems markets.
- Mobile Data Terminals
- MOTOBRIDGE Solutions
- Networking and Internet-access products
- Software-enhanced wireless telephone and messaging
- Two-way radio products and systems

Contact Info:
C&E Sales Office:
2501 San Pedro NE Suite 202
Albuquerque, NM 87110
Tel: 1-505-875-1999
Fax: 1-505-875-1888

Corporate:
1303 E. Algonquin Road
Schaumburg, IL 60196
Tel: 847-576-5000
Fax: 1-512-530-5509

Website: http://www.motorola.com/

NEC Corporation

Overview: With global operations, cutting-edge technology in numerous fields and over 100 years of business experience, NEC has emerged as a leading global Internet Solution Provider. In each of the three areas most important to the future of the Internet -- IT, networking and electron devices.

Key Products:

- BF200 series Switch
- Dterm Series Terminals
- NEAX 2000 IPS Communication system
- NEAX 2400 Internet Protocol eXchange (IPX)
- SB7000 series AFTN systems
- UNIVERAGE WL series Wireless LAN
- UNIVERGE IX1035/1036 Router
- UNIVERGE IX2010 Router
- WeDial Applications

Contact:
NEC USA:
101 East 52nd Street
New York, NY 10022, USA

Tel: 1-212-326-2400
Fax: 1-212-326-2419
Email: Webmaster@necus.com

NEC America:
6555 N. State Highway 161

Irving, TX 75039-2402, USA
Tel: 1-214-262-2000

Website: http://www.nec.com/

Park Air Systems

Overview: Park Air Systems is an international company focused on providing integrated communication, navigation and surveillance solutions for the world's airspace.

Key Products:

- GAREX Voice communication control systems
- NORMARC Instrument and satellite landing systems
- NOVA Approach and airport surveillance systems
- PAE Surface-to-air radio systems
- VHF/UHF Radios
- VHF Data Link

Contact:
Northfields
Market Deeping
Peterborough
England
PE6 8UE

Tel: +44 1778 345434
Fax: +44 1778 341286

Northrop Grumman Mission Systems
12011 Sunset Hills Road
Reston, VA 20190-3285

Website: http://www.parkairsystems.com/

Rockwell Collins

Overview: Rockwell Collins is a leader in aviation electronics and communications for government and commercial applications. Rockwell Collins is a global company providing aviation electronics for the world's aircraft manufacturers and more than 400 airline customers, as well as a major share of the world's military forces.

Key Products:

- Air Transport
- Business and Regional
- Collins Aviation Services
- Defense Electronics—Advanced
- EW-SIGINT
- Geophysical Sensors
- Head-Up Guidance Systems
- High Frequency Messenger
- Integrated Avionics
- Joint Tactical Radio System (JTRS)
- Propman 2000
- RT-1851(c) / BEAM

Contact Info:
400 Collins Road N.E.
Cedar Rapids, IA 52498

Tel: 319-295-1000
email: collins@rockwellcollins.com

Website: http://www.rockwellcollins.com/

RSI Technical Products (now under TriPoint Global)

Overview: RSI Technical Products designs, manufactures, integrates, installs and maintains a complete product line of high quality transmit and receive microwave antennas, antenna subsystems and/or turnkey earth station terminals for satellite communications, surveillance and radar applications.

Key Products:

- ATC/IFF Array Antennas
- HF-CPS
- HPA satellite communication
- Klystron Amplifiers
- LNA satellite communication
- Mobile SatCom Antennas
- Radar AntennasV
- SSPA satellite communication
- Synthesized Frequency Converters
- TACAN Antennas
- Towers and Support Structures
- TWT Amplifiers
- TWTA satellite communication
- VertexRSI Controls

Contact Info:
Dulles, Virginia 20166
Tel: (703) 450-5680
Email: RSISales@TriPointGlobal.com

Website: http://www.tripointglobal.com

SITA

Overview: SITA is the world's leading provider of global information and telecommunications solutions to the air transport industry. With over 50 years experience, it offers total service to around 740 air transport industry members and more than 1,800 customers, supporting them globally in over 220 countries and territories.

Key Products:

- AERORESA
- Aircraft Communications
- Aircraft Design & Maintenance
- Baggage Services and Handling
- Border Management
- E-business solutions for the aircraft lifecycle.
- Network Solutions
- Passenger and Travel Solutions
- Passenger Services

Contact Info:
3100 Cumberland Boulevard
Suite 200
Atlanta, GA 30339
Tel: 770- 850- 4500
Fax: 770- 612- 2265
E-mail: info.northamerica@sita.aero

Website: http://www.sita.com

Telegenix Inc

Overview: Telegenix, Inc., an Inductotherm Industries Company, provides systems and electronic devices for the following customer needs: ComElec Switches voice and data traffic for air traffic control and emergency dispatch operators. Products for air traffic control include computerized controlled voice and data switching systems utilizing proprietary software, a wide variety of network interfaces, and custom audio and visual operator display sub-stations.

Key Product:

- PROCOM-1400 Series Fixed Base Communication Systems
- PROCOM-2000 Series Digital Voice/Data Communication Switching System

Contact Info:

Telephone: 856-424-5220
Fax: 856-424-0889
E-mail: jdpeebles@telegenix.com

Website: http://www.telegenix.com

Telephonics

Overview: Welcome to Telephonics Corporation, a worldwide leader in Integrated Information and Communication Systems. Today, Telephonics continues to expand its business base by applying the technical know-how of its original defense communication and radar technologies to new electronic systems and products for a wide range of commercial and international customers.

Key Products:

- Aircraft Intercommunication Systems
- Audio Products.
- Communications Integration
- Integrated Transit Vehicle Communications
- Mass Transit Rail Communication Systems
- NIMROD MRA 4
- Secure Digital Intercommunication (SDI)
- STARCOM
- Digital Communications Management System (DCMS)
- Telephonic Communication Management System
- TRULINK

Contact Info:
815 Broad Hollow Road
Farmingdale, New York, 11735
Tel: 631- 755-7000
Fax: 631- 755-7200

Website: http://www.telephonics.com/

Navigation

AMS - Alenia Marconi Systems (ASI), Inc.

Overview: Alenia Marconi Systems (ASI), Inc. designs, manufactures, markets and installs ground based equipment to aid the in-flight navigation and ground movement of aircraft under all visibility conditions in various phases of a flight.

Key Products:

- Landing Aids
- Naval Radar
- Radio Navigation
- Visual Aid and Lighting Equipment

Contact Info:
11300 West 89th Street
Overland Park, Kansas USA 66214

Tel: 1-913-495-2600
Toll Free: 1-800-765-0861
Fax: 1-913-492-0870

Contact: John Wharton (Vice President, Sales & Marketing)
Tel: 1-913-495-2604
Email: Wharton@us-amsjv.com

Website: http://www.airportsystem.com/

ANPC - Advanced Navigation & Positioning Corporation

Overview: Advanced Navigation and Positioning Corporation, or ANPC, is an innovative aerospace company that designs and builds advanced precision aircraft navigation equipment.

Key Products:

- Firefly™ Transportable Transponder Landing System
- Rhino™ Mobile Surveillance and Guidance System
- Transponder Landing System (TLS)

Contact Info:
11 3rd Street
Hood River, OR, 97031

Contact: Renee Botts
Tel: (541) 386- 1747 x200
Tel: 1 (800) 228-1857
Email: marketing@anpc.com

Website: http://www.anpc.com/

Honeywell

Overview: Honeywell Aerospace delivers a diverse range of commercial and defense and space products, systems and services across the aerospace industry, from single-engine piston-powered airplanes to commercial applications to military and space vehicles applications.

Key Products:

- Aircraft landing systems
- Auxiliary power units
- Commercial avionics
- Engine systems and accessories
- Flight control systems
- Generation systems
- Ground proximity warning systems (EGPWS)
- Marine propulsion and ground power systems
- Power management
- Propulsion engines

Contact Info:
101 Columbia Road
Morristown, NJ 07962

General Contact Information:
Tel: (973) 455-2000
Fax: (973) 455-4807

Contact: Patrick Reines (Business Development Manager)
Tel: 301-948-4480
Fax: 301-947-3683
E-mail: Pat.reines@honewell.com

Website: http://www.honeywell.com/dses/products/dgps

Interstate Electronics Corporation

Overview: Interstate has led the industry in developing new technologies. Today, our staff of over 500 professionals develop, build, and maintain hundreds of systems around the globe.

communications

Interstate Electronics Corporation

Key Products:

- Displays
- Global Positioning System (GPS) solutions
- IMU Navigation
- Military GPS
- Satcom
- Strategic Weapon Systems
- SWS and Instrumentation Systems
- TruTrak
- Xfactor

Contact Info:
602 E. Vermont Avenue
P.O. Box 3117
Anaheim, California 92803-3117

Contact: Greg Martz
Phone: (714) 758-0500 or (800) 854-6979

Website: http://www.iechome.com

New Bedford Panoramex Corporation (NBP)

Overview: New Bedford Panoramex is a California-based corporation established in 1966, in response to the growing need for specialized automation and modernization of sophisticated electronic systems. The company has developed a diverse range of capabilities in design, development, engineering, high-volume state-of-the-art manufacturing, technical training and support services.

Key Products:

- Dual Mode High Intensity Approach
- Integrated Control and Monitoring System (ICMS)
- Lighting System (ALSF-2/SSALR)
- Medium Intensity Approach Lighting
- Precision Approach Path Indicator System (PAPI)
- Remote Monitoring Subsystem (MALSR RMS)
- Replacement Lamp Monitoring System (RLMS)
- System with Runway Alignment Indicator Lights

Contact Info:
1037 West 9th Street
Upland, CA 91786

Tel: 800-982-9806
Fax: 909-985-0798
Email: marketing@nbpcorp.com

Website: http://www.nbpcorp.com/

Northstar Avionics

Overview: Its entire line of diverse navigational products, including marine, avionics, and other land-based positioning equipment, is designed, manufactured, and sold from this location.

Key Products:

- 3300 Autopilot
- 491 Fishfinder
- 6000i Integrated Chartplotter
- Color GPS/Raster
- Digital Instruments
- NS100 marine VHF DSC radio
- Radar Equipment
- SmartCraft
- WAAS

Contact:
30 Sudbury Road
Acton, MA 01720

Tel:	978-897-6600
Toll Free:	1 800 628 4487
Fax:	978-897-7241
Email:	sales@bntmarine.com

Website: http://www.northstarcmc.com/

Raytheon

Overview: The Air Traffic Management Systems business area of Raytheon offers a range of automation and surveillance systems that are in use today countries around the world. The breadths of Raytheon's systems include Automation, Communication, Navigation, Surveillance, and Air Traffic Management with products supplied to both civil and military markets.

Key Products:

- Air Traffic Control Beacon Interrogator-6 (ATCBI-6)
- ASR-11 terminal area air traffic control radar
- Auto Trac flight data processing system
- Canadian Automated Air Traffic System (CAATS)
- GPS based Navigation systems
- Local Area Augmentation System (LAAS).
- Military Transporter
- Missile Seeker Applications
- Monopulse Secondary Surveillance Radar (MSSR)
- Precision Runway Monitor (PRM)
- Primary Surveillance Radar (PSR)
- Raytheon Advanced Surface Movement Radar (ASMR) runway surveillance
- Standard Terminal Automation Replacement System (STARS)
- Terminal Doppler Weather Radar.
- TracView air traffic management system
- Wide Area Augmentation Systems (WAAS)

Contact Info:
870 Winter Street
Waltham, MA 02451

Tel: 781-522-3000

Contact: Bob Meyer (Business Development)
Tel: 508-490-300
Fax: 508-490-3322
E-mail: rmeyer@raytheon.com

Website: http://www.raytheon.com/

Southern Avionics Company

Overview: Since 1962, Southern Avionics Company (SAC) has developed and installed dependable and durable Non-Directional Radio Beacons (NDB) in remotely harsh environments.

Key Product:

- Battery Charging Devices
- DS Series Transmitter Locator
- Monitor Receivers with Loop Antenna
- PC Series Antenna Coupler with Autotuner
- SA Series Digital Transmitters
- SC Series Differential GPS Reference Station

Contact Info:
P.O. Box 5345
Beaumont, Texas 77726

Tel:	409- 842-1717
Toll Free:	1-800-280-0322
Fax:	409-842-2987
Email:	Sales@southernavionics.com

Website: http://www.southernavionics.com/

Trimble Navigation Ltd

Overview: Trimble is a leading innovator of Global Positioning System (GPS) technology. In addition to providing advanced GPS components, Trimble augments GPS with other positioning technologies as well as wireless communications and software to create complete customer solutions.

Key Products:

- Dual Frequency RTK GPS
- Force 22
- GPS Boards and Chipsets
- Lassen Series GPS modules
- PPS Modules
- TA-12 Series SAASM-based Certified GPS Sensor
- The Cargo Utility GPS Receiver (CUGR™)

Contact Info:

935 Stewart Drive
Sunnyvale, CA 94085

Tel: 408 481 8000
Email: trimble_support@trimble.com.

Website: http://www.trimble.com

Surveillance

Image Systems Corporation

Changing the rules of business

Overview: Image Systems Corporation designs, manufactures, and sells displays and accessory products.

Products:

- 3D Image Solutions
- Color and Grayscale LCD flat Panel Displays
- Custom Displays Systems
- Display Calibration for Radiology Imagining
- Graphic Cards
- Grayscale CRTs
- MAX series Image Systems

Contact Info:
6103 Blue Circle Drive
Minnetonka, MN 55343

Contact: Dennis Stollenwerk
Tel: 952- 935-1171
Fax: 952-935-1386
Email: denniss@imagesystemscorp.com

Website: http://www.imagesystemscorp.com/

ITT Gilfillan

Overview: A unit of ITT Systems Division, Gilfillan develops, manufactures and services radar systems for air traffic control and tactical air defense systems.

Key Products:

- C- BAND T/R (Transmit/Recieve) Module
- Conceptual Circular Active Array
- GCA/PAR-2000
- MACS
- MDR (Multimode Digital Radio)
- MPN-14K
- MPN-25
- SPS-48e
- TASR

Contact Info:
7821 Orion Avenue
P.O. Box 7713
Van Nuys, CA

Contact: James Bunnell (Sr. Business Development Manager)
Tel: 818-908-2363
Fax: 818-908-4727
E-mail: james.bunnell@itt.com

Website: http://www.ittgil.com

Lockheed Martin ATM

Overview: Lockheed Martin capabilities include communications, navigation and surveillance/air traffic management; airport/terminal management; operations and flight services; satellite and ground weather systems; military and civilian aircraft; and air traffic control engineering, integration and support services.

Key Products:

- Active Matrix Liquid Crystal Display (AMLCD)
- Air Traffic Management/Air Traffic Control
- Area (En Route) Control Centers
- SkyLineÒ ATM external website
- SkyLineÒ ATM system
- Terminal Automation
- Tower Systems
- Weather and Radar Capabilities

Contact Info:
Rockville, MD

Contact:	Business Development
Tel:	301-640-2266
Fax:	301-640-3508
E-Mail:	bd.fc-tss@lmco.com

Website: www.lockheedmartin.com

Northrop Grumman Corporation

Overview: Northrop Grumman is a company defined by one word – technology. From under the sea to outer space and into cyberspace, Northrop Grumman technologies and products play a key role in the evolving defense environment of the 21st century.

Key Products:

- Airspace Management
- Combat Avionics
- Communications
- Defensive Systems
- Intelligence Surveillance and Reconnaissance
- Navigation Systems

Contact Info:
Mail Stop A-255
PO Box 17319
Baltimore, MD 21203-7319

Contact:	Steve Fisher
Tel:	703-620-8595
E-mail:	stephen.fisher@ngc.com

Website: http://www.northropgrumman.com

Palomar Display Products

Overview: Palomar Display Products is the recognized leader in the development and manufacture of commercial and military displays.

Key Products:

- ATM Monitors
- Sunlight Readable
- SunView 2000

Contact Info:
1945 Kellogg Avenue
Carlsbad, CA 92008

Tel:	760- 931-3200
Toll Free:	1-800- 700-1307
Fax:	760-931-5198

Website: http://www.palomardisplays.com/

Raytheon

Overview: The Air Traffic Management Systems business area of Raytheon offers a range of automation and surveillance systems that are in use today countries around the world. The breadths of Raytheon's systems include Automation, Communication, Navigation, Surveillance, and Air Traffic Management with products supplied to both civil and military markets.

- **Key Products:** Air Traffic Control Beacon Interrogator-6 (ATCBI-6)
- ASR-11 terminal area air traffic control radar
- Auto Trac flight data processing system
- Canadian Automated Air Traffic System (CAATS)
- GPS based Navigation systems
- Local Area Augmentation System (LAAS).
- Military Transporter
- Missile Seeker Applications
- Monopulse Secondary Surveillance Radar (MSSR)
- Precision Runway Monitor (PRM)
- Primary Surveillance Radar (PSR)
- Raytheon Advanced Surface Movement Radar (ASMR) runway surveillance
- Standard Terminal Automation Replacement System (STARS)
- Terminal Doppler Weather Radar.
- TracView air traffic management system
- Wide Area Augmentation Systems (WAAS)

Contact Info:
870 Winter Street
Waltham, MA 02451

Tel: 781-522-3000

Contact: Bob Meyer (Business Development)
Tel: 508-490-300
Fax: 508-490-3322
E-mail: rmeyer@raytheon.com

Website: http://www.raytheon.com/

Sensis Corporation

Overview: Sensis Corporation offers a broad array of sensors and information processing systems for Air Defense, Air Traffic Control, Airline & Airport Management and Data Distribution & Communication. The company serves a global client base and is actively involved in industry organizations and working groups worldwide, helping to address critical issues and develop innovative, real-world solutions..

Key Products:

- Advanced - Surface Movement Guidance and Control System (A-SMGCS)
- Aerobahn®
- Airport Surface Detection Equipment Model X (ASDE-X)
- Automatic Dependent Surveillance - Broadcast (ADS-B) Transceiver
- Automation Interface Unit (AIU)
- Communication Gateway (CGW)
- Expeditionary Mission Planner and Radar Optimizer (EMPRO)
- Multi-Scan Correlator (MSC)
- Multi-Sensor Data Processor (MSDP)
- Multistatic Dependent Surveillance (MDS)
- Radar Environment Simulator (RES)
- Signal Processor Enhancement (SPE-3000)
- System Interface Unit (SIU)
- Target Data Extractor (TDX)
- VeeLo®
- Weather Data Extractor (WDX)

Contact Info:
85 Collamer Crossings
East Syracuse, NY 13057

Contact: Beth Larson
Tel: 315-445-0550
Fax: 315-446-2209
E-mail: info@sensis.com

Website: http://www.sensis.com/

Air Traffic Management

Aerospace Engineering & Research Associates Inc.

Overview: Next generation air traffic control, air traffic management, airspace simulation and real time airline asset management systems; offer a complete range of aviation system/software development services and consulting experts; dedicated staff of scientists, engineers, and analysts specialize in real time aviation systems including 4D flight profiling, conflict prediction, and conflict resolution.

Products:

- AERALIB®, aviation system development tool
- AVID
- ATTILA
- AWSIM
- ATOM
- NOTAM Bene

Contact Info:

4550 Forbes Boulevard
Suite 310
Lanham, Maryland 20706

Tel: 301-459-7890
Fax: 301-459-8197
Email: aesupport@freeflight.com

Website: http://www.freeflight.com/

AIR - Advanced Integrated Recorders, Inc.

Overview: A leading supplier of integrated recording and replay solutions for Air Traffic Control, Call Centers, Public Safety, Security, and Financial Institutions.

Products:

- AIR2000
- Laser Body Scanner
- RAID Disk Systems
- Rugged Servers

Contact Info:
121 Whittendale Drive
Moorestown, NJ 08057

Tel: 856-234-5020
Fax: 856-234-5242

Website: http://air2000.formation.com

Amtech Systems (renamed as TransCore)

Overview: TransCore is recognized worldwide as the leader in automatic vehicle identification (AVI) systems. Our AVI systems provide control and tracking of commercial ground transportation vehicles at major airports.

Products:

- Amtech® Hardware Technology eGo™
- GeoSatellite
- GlobalWave Satellite
- Mobile Communication Devices
- MT2000
- XML Integration

Contact Info:
8158 Adams Drive
Liberty Centre - Bldg. 200
Hummelstown, PA 17036

Tel: 717.561.2400
Fax: 717.564.8439

Website: http://www.transcore.com/

Aydin Industrial Solutions

Overview: We are Aydin Industrial Solutions manufacturers of high quality rugged Rack Mount Flat Panels and CRT displays. We specialize in custom Industrial and Military LCD Flat Panels and Industrial CRT touch-screen monitors.

Products:

- AMLCD-based Flat Panels
- Color CRT monitors
- Computer Workstations

Contact Info:
3385 W. Hall Circle N.W.
Duluth, GA 30096

Tel: 770-623-9845
Fax: 770-623-9610
Email: sales@aydin-industrial.com

Website: http://www.aydindisplays.com

BAE Systems

Overview: BAE SYSTEMS' plays a leading role in designing and building both military and civil aircraft and systems. We are major partners in high-profile joint programs such as the Eurofighter Typhoon, F-22 and Joint Strike Fighter. Our Hawk is the world's most successful jet trainer. We are a world leader in mission planning systems, airborne communications and radar countermeasures.

Products:

- Air Systems
- Airborne Sensors
- Electro optics
- Airborne data systems
- Flight data recorders
- Airborne data links
- Countermeasures
- UAVs/Drones
- Processing/data highway

Contact Info:
1601 Research Boulevard
Rockville, MD 20850

Tel: 301-738-4000
Fax: 301-738-4643

8201 Greensboro Drive
McLean, Virginia 22102

Tel: 703-847-5820
Fax: 703-847-5880

Website: http://www.baesystems.com/

Dimensions International

Overview: Dimensions International is an award-winning international information technology company specializing in information integration, logistics management and air space management support.

Products:

- Automation Collection and Editing System (ACES)
- FAA/ANG Remote Radar Interface System (FARRIS)
- Mode-S Receiver/Logger
- Night Vision Technology
- Radar Analysis Display and Recording System (RADAR!)
- TAIU - AMASS/ARTS [Terminal Automation Interface Unit]

Contact Info:
2800 Eisenhower Avenue
Suite 300
Alexandria, VA 22314

Tel: (703) 998-0098
Fax: (703) 379-1695
Email: info@dimen-intl.com

Website: http://www.dimen-intl.com/

EDS - Electronic Data Systems

Overview: Founded in 1962 as Electronic Data Systems, EDS is the leading global information technology (IT) services company. We provide the right strategies, solutions, services and products to help our clients succeed in the digital economy.

Products: The company established a new European Air Transportation Centre of Excellence, announced two European aerospace industry client wins and released a new version of its aerospace industry-leading product design software -- strengthening its foothold as Europe's and the world's leading provider of information technology (IT) services to the airline industry.

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Website: http://www.eds.com/

Lockheed Martin ATM

Overview: Lockheed Martin capabilities include communications, navigation and surveillance/air traffic management; airport/terminal management; operations and flight services; satellite and ground weather systems; military and civilian aircraft; and air traffic control engineering, integration and support services.

Key Products:

- Active Matrix Liquid Crystal Display (AMLCD)
- Air Traffic Management/Air Traffic Control
- Area (En Route) Control Centers
- SkyLineÒ ATM system
- SkyLineÒ ATM external website
- Terminal Automation
- Tower Systems
- Weather and Radar Capabilities

Contact Info:

Rockville, MD

Contact:	Business Development
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Website:	www.lockheedmartin.com/tss

Raytheon

Overview: The Air Traffic Management Systems business area of Raytheon offers a range of automation and surveillance systems that are in use today countries around the world. The breadths of Raytheon's systems include Automation, Communication, Navigation, Surveillance, and Air Traffic Management with products supplied to both civil and military markets.

- **Key Products:** Air Traffic Control Beacon Interrogator-6 (ATCBI-6)
- ASR-11 terminal area air traffic control radar
- Auto Trac flight data processing system
- Canadian Automated Air Traffic System (CAATS)
- GPS based Navigation systems
- Local Area Augmentation System (LAAS).
- Military Transporter
- Missile Seeker Applications
- Monopulse Secondary Surveillance Radar (MSSR)
- Precision Runway Monitor (PRM)
- Primary Surveillance Radar (PSR)
- Raytheon Advanced Surface Movement Radar (ASMR) runway surveillance
- Standard Terminal Automation Replacement System (STARS)
- Terminal Doppler Weather Radar.
- TracView air traffic management system
- Wide Area Augmentation Systems (WAAS)

Contact Info:
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Website: http://www.raytheon.com/

SITA

Overview: SITA is the world's leading provider of global information and telecommunications solutions to the air transport industry. With over 50 years experience, it offers total service to around 740 air transport industry members and more than 1,800 customers, supporting them globally in over 220 countries and territories.

Key Products:

- AERORESA
- Aircraft Communications
- Aircraft Design & Maintenance
- Baggage Services and Handling
- Border Management
- E-business solutions for the aircraft lifecycle.
- Network Solutions
- Passenger and Travel Solutions
- Passenger Services

Contact Info:
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Website: http://www.sita.com

Systems Atlanta Inc

Overview: Systems Atlanta, Inc. designs, develops, and deploys high availability, decision support/ information display tools for the air traffic control environment including towers, radar approach, flight service, enroute, military, airlines and airport operations.

Key Products:

- ACE-IDS
- IDS4
- IDS5

Contact Info:

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Tech-Source Inc

Overview: Tech Source, Inc. is a leading manufacturer of high-resolution graphics accelerators for UNIX platforms.

Key Products:

- ATC Graphics
- EOL'd Products
- Medical Imagining
- Raptor 2000 Series
- Sun PCI Graphics

Contact Info:
442 S. North Lake Blvd.
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Contact: Richard Bendfelt (V.P. of Sales)
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Website: http://www.techsource.com

Meteorology

Global Weather Dynamics Inc

Overview: Global Weather Dynamics, Inc. has built its reputation by providing state-of-the-art communications and information management systems for the Aeronautical and Meteorological industries. GWDI offers a broad product line combining leading edge computer technology with an experienced and talented engineering and management staff.

Products:

- Aeronautical Information Management
- AFTN and CIDIN Message Switches
- ATC Integrated Information Display
- Automated Aeronautical Information Service Systems
- Flight Plan Management Systems
- Meteorological Information Management
- Meteorological Message Switches
- Operational Meteorology Database Systems.
- Pilot Self-Briefing
- Publishing and Cartography
- PC-based aeronautical and meteorological information terminals for message composition, transmission and reception.

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Northrop Grumman Corporation

Overview: Northrop Grumman is a company defined by one word – technology. From under the sea to outer space and into cyberspace, Northrop Grumman technologies and products play a key role in the evolving defense environment of the 21st century.

Key Products:

- Airspace Management
- Combat Avionics
- Communications
- Defensive Systems
- Intelligence Surveillance and Reconnaissance
- Navigation Systems

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Vaisala Oy

Overview: Vaisala develops, manufactures and markets products and services for environmental and industrial measurement for national meteorological services, aviation authorities, defense forces, road and rail authorities, land and water resource management agencies, research institutes, insurance companies, public utilities and industry worldwide.

Key Products:

- Carbon Monoxide Instruments
- Dewpoint Transmitter Series
- FD12P
- Flagship Humidity Transmitter Series
- Moisture Instruments
- PTB200 Series
- PTU200
- Visibility Equipment
- Weather Transmitter WXT510
- Wind Sensors

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Annex II: Prime Contractor and Subcontractors Performing Work on the Study

Prime Contractor:	**DORS Inc.** **211 North Union St. Suite 100** **Alexandria, VA 22314** **and** **1012 14th St. NW Suite 915** **Washington, DC 20005**
Contact:	**Joe Dorfler** **General Manager** **PH: 703 863-1092** **FAX: 703 323-8399** **e-mail: jdorfler@attglobal.net**
Sub-contractor:	**None**

ATTACHMENT 1

Study Work Plan

Background

The Air Navigation Service Providers (ANSPs) in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan sought USTDA's assistance in the development of a plan that will provide the guidance needed to achieve a successful transition from the traditional ground-based Air Navigation Services/Air Traffic Control (ANS/ATC) system to the new satellite-based CNS/ATM system. Their desire is to comply with an ICAO CNS/ATM recommendation thatevery State should have a national CNS/ATM implementation plan

From a Regional perspective, the ANSPs would like to coordinate modernization and create regional infrastructure segments, where appropriate. Individually and collectively, the Central Asia ANSPs are either preparing or making procurement decisions and this study will help refine the requirements and specifications for such procurements.

The underlying key issues are: improve safety and efficiencies, increase revenue opportunities, decrease operations and maintenance costs—both airspace user (airlines) and service providers.

Approach

The overall work approach will be to adhere to a logical/systematic process for developing realistic CNS/ATM implementation scenarios that will improve safety and efficiencies, increase revenue service, and decrease operations and maintenance costs. The specific work steps are as follows:

1. Establish the Central Asia Team/Working Group(s)

2. Determine the current CNS/ATM status for each State and the Region—both air navigation service providers and airspace users. Methodology includes:
    - Questionnaire
    - Site Surveys
    - Interviews

3. Assess current/future CNS/ATM technologies and implementation trends. The technologies include but are not limited to:
    - Analogue-Digital Comm (e.g. Mode 2,3,4)
    - GNSS (e.g. GPS, Glonass, Galileo)
    - SBAS (e.g. WAAS, EGNOS)
    - GBAS (e.g. LAAS)
    - GRAS (e.g. Australian System)
    - Automatic Dependent Surveillance (ADS)
    - Airspace optimization (e.g. RNP, GPS procedures)
    - Compliance; International Standards, developments in other countries/regions etc.

4. Identify and outline the CNS/ATM technology options with respect to providing airspace services for all phases of flight. Estimate future traffic forecasts.

5. Determine potential environmental impacts (as appropriate) and complete an environmental assessment.

6. Identify funding alternatives, opportunities, and potential financial sources. These include, but are limited to:
    - Self supporting/revenue generation (e.g. airline funded)
    - Grants
    - Loans

7. Develop CNS/ATM Architecture Alternatives tailored for the Region and each State.

8. Identify US Sources of Supply in accordance with USTDA requirements.