ATM Modernization Project Management Training Program

for the

Federal Air Traffic Control Authority (FATCA)

of

Serbia and Montenegro

Prepared by

The MITRE Corporation

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The purpose of MITRE's Center for Advanced Aviation System Development (CAASD), the FFRDC sponsored by the Administrator of the FAA, is to assist the FAA in addressing the long- and short-term evolutionary changes necessary to modernize the U. S. National Airspace System (NAS). CAASD's mission is to perform the studies, analysis, and concept formulation for continued advanced aviation research for the modernization and development of the NAS. In addition, CAASD, is encouraged to undertake engineering research and development efforts for foreign and international aviation authorities and similar organizations to advance, among other things, international harmonization of aviation and air traffic control standards and technology.

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EXECUTIVE SUMMARY

Under a United States Trade and Development Agency (TDA) grant agreement, the MITRE Corporation (MITRE) developed and conducted courses in project management and engineering management for the Serbia and Montenegro Federal Air Traffic Control Authority (FATCA). FATCA is responsible for the planning and implementation of a modernized Air Traffic Control (ATC) system.

MITRE performed the following work as part of this grant:

- Contacted FATCA, European Bank for Reconstruction and Development (EBRD), and the United States Embassy in Serbia and Montenegro to obtain background information regarding the FATCA organizational structure, current operations, modernization plans, EBRD bank procedures, rules, and guidelines, current project management and engineering management knowledge, and training needs.

- Visited FATCA in Belgrade, Serbia and Montenegro to discuss draft training outline, establish training requirements, obtain personnel education and experience, understand FATCA structure, review FATCA department capabilities and requirements, tour FATCA facilities, and finalize the course outline.

- Expanded course outline into detailed syllabus. Developed course materials for Session 1: Project Management. Materials included presentation slides, seminar exercises based on FATCA modernization effort, list of references, and a risk management tool kit.

- Arranged travel logistics for FATCA staff to attend training class in McLean, Virginia. Note that a planned site visit to an FAA facility was not possible due to the elevated terrorist threat level.

- Conducted Session 1: Project Management, June 13-20, 2003 at MITRE in McLean, Virginia. MITRE presented course segments on scope management, schedule management, risk management, acquisition management, cost management, finance, cost estimating, cost reporting, communication management, and project control. Course included exercises in work breakdown structure development, schedule development, risk identification, and acquisition strategy development.

- Prepared course materials for Session 2: Engineering Management. Materials included presentation slides, seminar exercises based on FATCA modernization, and list of references.

- Conducted Session 2: Engineering Management, September 8-14, 2003 in Belgrade, Serbia and Montenegro. MITRE presented course segments on system engineering, system safety, reliability and maintainability, system test and evaluation, configuration management, quality management, transition and training, maintenance strategy, and performance monitoring. Course included exercises in Functional Requirements Document development, modernization capabilities prioritization, configuration control board definition, performance monitoring and oversight product

development, risk analysis and response planning, and source selection approach development.

- Provided consulting services to FATCA for specific items of interests that could not be addressed during the time allotted for the training sessions. Items of interest included the following:
    - Develop a project charter
    - Discuss finance issues
    - Discuss the EBRD acquisition process and source selection methodology
    - Discuss the potential use of alternate work schedules
    - Review FATCA's draft risk management plan and modernization schedule
    - Review draft acquisition documents including statement of work and system level specification.
- Prepared Final Report.

Enclosed are the presentation slides developed for Session 1: Project Management, and Session 2: Engineering Management.

Project and Engineering Management
for the
Serbia and Montenegro Air Traffic Control Authority (SMATCA)

Monday June 16, 2003

9:00-12:00

- Welcome and Introductions
- Review of Material Presented April 18, 2003 in Belgrade
- Introduction to Project Management
  - Project Management Institute (www.pmi.org) and the Project Management Body of Knowledge (PMBOK)
  - Definition of project and project management
  - Project management knowledge areas (integration management, scope management, time management, cost management, quality management, human resource management, communications management, risk management, procurement management)
  - Project management process (initiating, planning, executing, controlling, closing)

- Scope Definition and the Work Breakdown Structure (WBS)

12:00-1:00

- Lunch and "National Airspace System Operational Evolution Plan" Presentation and Demonstration

1:00-4:00

- Seminar Exercise—FAMUS Project WBS Refinement

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Tuesday June 17, 2003

9:00-12:00[1]

- Project Time Management
  - Activity definition
  - Activity sequencing
    - Precedence diagramming method (PDM) including types of task dependencies (Finish-to-Start, Finish-to-Finish, Start-to-Start, Start-to-Finish)
    - Project network diagrams (PERT Chart)
  - Activity duration estimating including techniques (expert judgement, analogous estimating, quantitative estimating) and reserve time
  - Schedule development
    - Activity attributes (responsibility, resources, location, constraints, project calendar)
    - Schedule analysis (critical path method, PERT)
    - Duration compression techniques (crashing, fast tracking, concurrent engineering)
    - Simulation
  - Project schedule methods
    - Project network diagram with dates
    - Gantt chart
    - Milestone chart

12:00-1:00

- Lunch and "TARGETS" Demonstration

1:00-4:00[2]

- Complete Project Time Management Topics
- Seminar Exercise—FAMUS Schedule Refinement and Integration

4:00-4:30

- "Airport Operation Statistics" Presentation

[1] During this time period, Director General, Commercial Manager, and Procurement Manager will participate in a separate discussion regarding financial issues.
[2] From 1:00-2:00, Director General and FAMUS Project Manager will participate in a separate discussion regarding alternate work schedules.

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Wednesday June 18, 2003

9:00-12:00

- Risk Management
  - Risk Identification
  - Qualitative Risk Analysis
  - Quantitative Risk Analysis
  - Risk Response Planning including mitigation strategies

12:00-1:00

- Lunch and "Globalization: Implementation for Air Traffic Management" Presentation

1:00-4:00

- Seminar Exercise—FAMUS Risk Identification, Analysis, and Response Planning

4:00-5:00

- Reserved for Director General, FAMUS Project Manager, and MITRE discussions

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for the
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Thursday June 19, 2003

9:00-11:00[3]
- PIU Open Discussions

11:00-12:00
- MITRE Facilities and Lab Tour

12:00-1:00
- Lunch and "Integrated DSS Demonstration"

1:00-4:00[4]
- Project Tender Management
  - Procurement planning
    - Tender strategy
    - Contract type and risk
  - Tender planning
    - Tender documents
    - Evaluation criteria
  - Tender Process
  - Tender Evaluation and Award
  - Contract Administration
  - Contract Closeout

- Seminar Exercise—FAMUS Tender Management

4:00-4:30
- "Visualization" Demonstration

[3] Depending on the outcome of financial discussions on 6/17 and issues raised during the presentations and demonstrations, time is available for additional in-depth discussions on topics of particular interest to the Director General and selected team members.
[4] Director General and FAMUS Project Manager attend session at FAA Headquarters.

Friday June 20, 2003

10:00-11:00
- Communication Management

11:00-12:00
- Cost Management

12:00-1:00
- Lunch

1:00-3:00
- Project Control

3:00-4:30
- Wrap up
  - Questions
  - Feedback
  - Final planning for Session 2
  - Other

7:00
- Dinner—Angelo and Maxies, Reston Town Center

SESSION 2—DAY 1

- ACC, Tower, and Training Center Tours

SESSION 2—DAY 2

System Engineering *(Examples from different ATM-based programs will be used to illustrate the concepts)*

- What is System Engineering?
- Things to Consider During Implementation
  - Operational Concepts
  - Regulations and Standards
  - Strategic Plan
  - Life-cycle system engineering approach
    - Concept development and validation
    - Prototype development and deployment
    - Technical and Implementation Readiness
  - Participation of the airspace users
  - Integration
  - Benefits
  - Program Office Viewpoint
    - Role of System Engineering, Research and Development
    - Acquisition guidelines (example: FAA acquisition process)
  - Contractor Viewpoint
    - Requirements review
    - Critical design review
    - Program reviews
    - Other reviews

- Monitoring Versus Performing System Engineering
  - Roles and responsibilities of contractor (service provider) and FATCA (customer)
  - Discussion of collaboration, negotiation, trust
  - Keeping stable requirements
  - Monitoring the development process through "Problem Reports" (Tracking problem reports by opening, closing, counting)

- Modeling and Simulation
  - When it is used, why it is used, how it is used

- Functional Elements of Air Traffic Management
  - Discussion of surveillance processing, flight data processing, airspace design, automation functions, communication, display technologies

DAY 2—Continued

- Evaluating Designs
  - How to establish a common reference approach for evaluating designs (evaluation plan for source selection)

- Seminar Exercise—System Engineering
  - Define organizational roles, responsibilities, and goals regarding system engineering
  - Identify major system engineering stakeholders and points of contacts
  - Outline a basic Functional Requirements Document and identify who will be responsible for specific requirements areas
  - Review schedules, including plans and schedules for evaluating proposals
  - Identify qualitative and quantitative benefits, and how will they will be measured

SESSION 2—DAY 3

System Safety

- Overview of system safety
  - Summary of ICAO and RTCA guidelines
  - Definition of safety-critical programs, mission-critical programs
  - The role of certification (hardware, software, people)

- Establishing Requirements
  - Development approaches and requirements for different levels of safety
  - Case studies: Definition and Application of "Risk Ratio" and "Probability of Collision" metrics

- Operations and Support
  - How to maintain or ensure system safety
    - Automation functions to detect conflicts, function to alert supervisory personnel if aircraft violate safe standards
    - Approaches to training and maintaining proficiency (e.g., the use of scenario-based simulation).

- Seminar Exercise—System Safety
  - Identify level of safety and activities needed to validate that level of safety for specific FAMUS capabilities
  - Identify certification needs and FATCA's plan for ensuring those needs are met
  - Identify FATCA's System Safety organizational responsibilities

DAY 3—Continued

Reliability and Maintainability (R&M)

- Definitions
- Determining Minimum reliability and maintainability standards for specific systems
  - How to establish agreed-upon R & M requirements
    - What is needed versus what is desired?
    - The trade-off between R & M and cost

- Measuring R&M
  - Approaches and metrics for monitoring R&M

- Ensuring R&M Standards are Met
  - Approaches and requirements for ensuring that R&M levels are sustained

- Seminar Exercise—Reliability and Maintainability
  - Prioritize FAMUS capabilities according to desired reliability; i.e., what capability or function is most important, next important
  - Create a plan to research other ATM systems' R&M requirements and assign actions to FATCA representatives

SESSION 2—DAY 4

Configuration Management (CM)

- The definition of Configuration Management
- Configuration Items (i.e., what is controlled?)
  - Software
  - Data
  - Documentation

- Five levels of CM and examples of how they are applied
- Classical CM
  - Identification
  - Control
  - Status Accounting
  - Auditing
  - Process Improvement

- CM Reporting
  - Change Notices
  - Chronology Report for every release or update

- Lessons learned and examples of problems that occur without CM, and those that can occur with CM if proper oversight is not conducted

DAY 4--Continued

- Establishing and Managing the Configuration Control Board
  - CCB size, roles and responsibilities, positions, leadership, continuity
  - The significance of the Configuration Manager

- Proposing, Evaluating, and Approving System Changes
  - The significance of CM forms

- Technical Data Management
  - Creating and maintaining a central repository for information
  - Coordinating with the Configuration Management Function
  - Assigning Responsibilities (contractor and program office)

- Seminar Exercise—Configuration Management
  - Identify configuration items (e.g., system specification, statement of work, schedules) and where they will be located and archived
  - Define a Configuration Control Board and appoint a Configuration Manager
  - Create a list of the forms that will be needed

System Installation, Test and Evaluation, and Acceptance

- Definitions
  - The meaning of Test
  - The meaning of Evaluation
  - The meaning of Acceptance

- Establishing Installation and Test Procedures
  - Where in the System Life-Cycle do the procedures get developed?
  - Configuration Management of test and evaluation activities and data
  - The need for dedicated facilities and on-site support
    - Field facilities
    - Laboratory facilities that can be adapted

- Using Test and Evaluation to Monitor Progress
  - Collecting and Maintaining Problem Reports

- Defining Test Objectives and Requirements
  - Test Procedures
  - Pass/Fail Criteria
  - Factory Acceptance Testing
  - Final Acceptance Testing

DAY 4--Continued

- Case Study: Display System Replacement (DSR) Engineering and Test Processes
  - Hardware Factory Testing
  - Installation and Integration Testing
  - Development, Test, and Evaluation Subsystem Testing
  - Development, Test, and Evaluation System Testing
  - Acceptance Testing
  - Formal Operational Testing

- Seminar Exercise—System Installation, Test and Evaluation, and Acceptance
  - Identify test areas (functional, hardware, software)
  - Identify where and how various system components should be tested (e.g., inspection, simulation, analysis, observation, operations)
  - Determine general pass/fail criteria for FAMUS testing (e.g., 100% of requirements, 80%)

SESSION 2—DAY 5

Transition and Training

- Examples of Host replacement, DSR, User Request Evaluation Tool (Conflict Probe)
- Planning for System Installation and Cutover
- Planning and Managing Parallel Operations
- Planning for Training Management
  - Determining training objectives, training courses, participants, and timeframe
  - Determining recurring training needs on new and existing systems
  - Ensuring that the contractor "train the trainers."

- Equipment training versus proficiency training
- Seminar Exercise—Training
  - What are FATCA's training needs?
    - Location
    - Logistics (when, how, proximity)
    - Draft schedules based on desired deployment
    - Organizational Responsibilities
  - Identify Deployment Training Activities
  - Identify Frequency of Proficiency Training

DAY 5—Continued

Maintenance Strategy Options

- Maintenance alternatives (distributed versus centralized)
  - Descriptions
  - Examples
  - Benefits
- Organizing to Manage Operations and Support
- Allocating Responsibilities to Operating Entities
- Understanding Maintenance Levels and Functions
- Contracting for Operations and Support Functions
- Case Study: FAA Infrastructure Management Concept
- Seminar Exercise—Maintenance Strategy
  - Assess current maintenance strategy and identify areas of improvement
  - Itemize infrastructure areas that need *maintenance*: what are they and how frequently
  - Create a maintenance strategy for FAMUS infrastructure

Quality Management

- Quality Planning (including civil works, system standards, ICAO guidelines)
- Quality assurance vs. Quality control
- Role of Quality Manager (before and after program award)
  - References:
    - ICAO Doc 4444 Rules of the Air and Air Traffic chapter 2. ICAO
    - Annex 11 Air Traffic Services para 2.26 ED
  - Example application in Free Flight Program

- Seminar Exercise—Quality Management
  - Identify FATCA Quality Manager and outline roles and responsibilities (including review of risk management)
  - Outline steps that FATCA will take to evaluate and ensure quality assurance
    - Hardware and software
    - Operational (i.e., ensuring separation standards are met and that system throughput is maintained)

- Performance Monitoring
  - Program reviews
  - Monthly reports
  - Oversight briefings
  - Technical performance monitoring
  - Information distribution

- Potential Seminar Exercises—
  - FAMUS Performance Monitoring and Oversight Briefing

Project Management and Engineering Management

for the

Serbia and Montenegro Air Traffic Control Authority (SMATCA)

June 16-20, 2003

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Introduction to Project Management and Scope Definition

Monday June 16, 2003

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Monday June 16, 2003
Agenda

- Welcome, Introductions, and Logistics
- Project Management Institute (www.pmi.org) and the Project Management Body of Knowledge (PMBOK)
- Review of material presented April 18, 2003 in Belgrade
- Introduction to Project Management
  - Definition of project and project management
  - Project Management Knowledge Areas
  - Project Management Processes
- Scope Definition and the Work Breakdown Structure (WBS)
- Seminar Exercise—Outline FAMUS Project WBS

Lunch Presentation--National Airspace System Operational Evolution Plan (NAS OEP)

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Project Management Institute (PMI)

www.pmi.org

- Not-for-profit professional organization for Project Managers.
- Over 100,000 members in 125 countries. Over 200 chapters worldwide.
- PMI Goal--Advance the project management profession and to help new and established project managers gain the required skills.
- Publish "A Guide to the Project Management Body of Knowledge (PMBOK)".
- Established "Project Management Professional (PMP)" certification program.
- Provide education, training, and professional development opportunities.

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Project Management Institute (PMI)

www.pmi.org

Potential Chapter (per www.pmi.org)

FR Yugoslavia-Belgrade (US$10.00 Annually) 2001

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Project Management Body of Knowledge (PMBOK)

- "Sum of knowledge within the profession of project management" PMBOK 2000 Edition
- "A Guide to the Project Management Body of Knowledge" contains a subset of the knowledge that is generally accepted.
- Provides common terminology and framework for managing projects.

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Review of Material Presented April 18, 2003 in Belgrade

- Project Initiation
- Scope Planning
- Organization Planning
- Project Organization Structure
- Team Development
- Stakeholder Analysis and Communication Planning
- Project Management Approaches and Techniques

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Project Initiation

- Project Initiation is the process of formally authorizing a new project.
- The project sponsor drafts a project description to document the project's purpose and product or service to be undertaken.
- The project description is linked to and supported by the organization's key documents (e.g., Strategic Plan, Modernization Plan).
- Once a project is formally authorized, a Project Manager is assigned and a Project Charter is created to document the following:
  - Business need that must be met by project.
  - Project description.

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Scope Planning

- Scope planning involves the development of a scope statement that includes the project justification, major deliverables, project objectives, and criteria used to determine whether the project has been successfully completed.
- Scope statement should also include constraints and assumptions.
  - Constraints--Factors that limit the project team's options (e.g., predefined budget, EBRD procurement policies and procedures).
  - Assumptions--Factors that for planning purposes are assumed to be true or certain (e.g., external consultant will be under contract prior to the initiation of the tender preparation process).

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Organization Planning

- Organization planning involves the following:
  - Determining staff requirements--Competencies required by the project and corresponding timeframes.
  - Identifying, documenting, and assigning project roles, responsibilities, and reporting relationships.
  - Determining the staff management plan--Documents what, when, and how human resources will be brought into and taken off the project team.
- Organization planning tools include the following:
  - Responsibility Assignment Matrix
  - Resource histogram
  - Organization chart
- After organization planning is completed, the Project Manager acquires staff in accordance with the Staff Management Plan.

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Project Organization Structure

- Project organization structure is often constrained by the availability of resources. Type of structures include the following:
  - Functional--Project Manager and project staff reside in functional departments. Project Manager has limited authority and staff is assigned part time.
  - Matrix--Project Manager resides in department of project managers. Staff resides in functional departments. Project Manager has moderate authority and staff is assigned part time.
  - Projectized--Project Manager and staff reside in department whose sole purpose is the project. Project Manager has high authority and staff is assigned full time.
- As important as organizational structure is the ability of the Project Manager to influence staff performance appraisals.

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Team Development

- Team development involves the following:
  - Enhancing the ability of staff to contribute as individuals.
  - Enhancing the ability of the team to function together.
- Techniques include the following:
  - Team building activities
  - Reward and recognition
  - Collocation
  - Training

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Stakeholder Analysis and Communication Planning

- Stakeholder--Individual or organization who is actively involved in the project, whose interest may affect the project, or whose interest may be affected by the project.
- Stakeholder analysis--Assessment of stakeholder needs and procedures to meet those needs.
- Communication planning--Determining the information and communication needs of stakeholders (who needs what information, when they need the information, how will the information be delivered, and who will deliver the information).

It is important to determine stakeholders, analyze their information needs, and determine procedures to meet those needs as early as possible in the project. This analysis must be revisited throughout the life of the project.

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Project Management Approaches and Techniques

- After project initiation, the Project Manager must establish approaches and techniques to make project decisions and to inform members of the Project Implementation Unit (PIU) and key stakeholders of project status, deliverables, upcoming activities, responsibilities, issues, and risks.
- Potential approaches and techniques include weekly PIU meetings, regular status meetings with contractors or suppliers, project oversight briefings, and risk analysis meetings.

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What is a Project?

" A temporary endeavor undertaken to create a unique product or service"

Project Management Body of Knowledge (PMBOK) 2000 Edition

Temporary: Defined beginning and end.

Unique: Different from all other products or services.

Is providing ATM services to Serbia and Montenegro a project?

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What is Project Management?

" Application of knowledge, skills, tools, and techniques to project activities to meet project requirements"

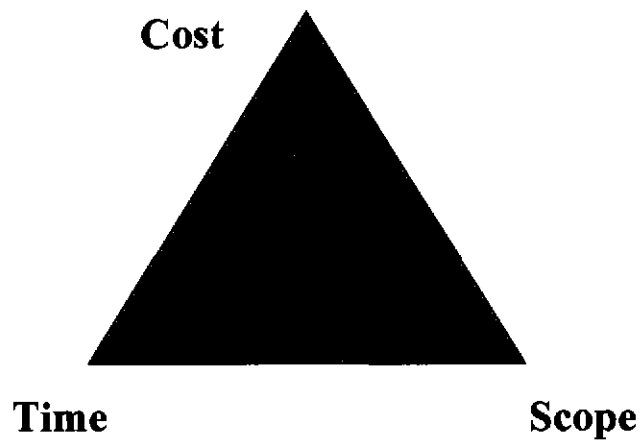
Project Management Body of Knowledge (PMBOK) 2000 Edition

PMI defines project requirements in terms of:

- Cost
- Time
- Scope (Technical, Performance)
- Quality

EBRD uses:
cost, time, and quality

The Triple Constraint



3 legs of a stool

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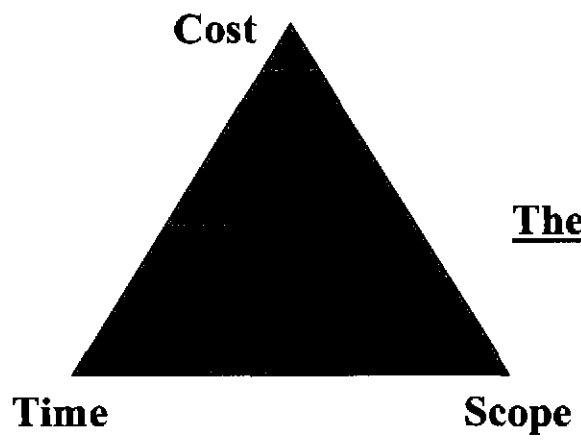
What is Project Management?
Triple Constraint

- It is important to analyze a project's "hard" constraints early in the project.
  - Is there a fixed budget?
  - Is there a "Finish-no-later-than" date?
  - Is there flexibility in the scope or requirements?



The Triple Constraint

What are FAMUS "Hard" Constraints ?

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Project Management Knowledge Areas

- Integration Management
- Scope Management
- Time Management
- Cost Management
- Quality Management
- Human Resource Management
- Communication Management
- Risk Management
- Procurement Management

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Project Management Processes

- Initiating--Authorizing the project.
- Planning--Defining objectives and course of action.
- Executing--Coordinating people and resources.
- Controlling--Ensuring objectives are met.
- Closing--Accepting project deliverables.

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Scope Definition

"Subdividing the major project deliverables into smaller, more manageable components to:

- Improve the accuracy of estimates.
- Define baseline for performance monitoring.
- Define project responsibilities." PMBOK 2000

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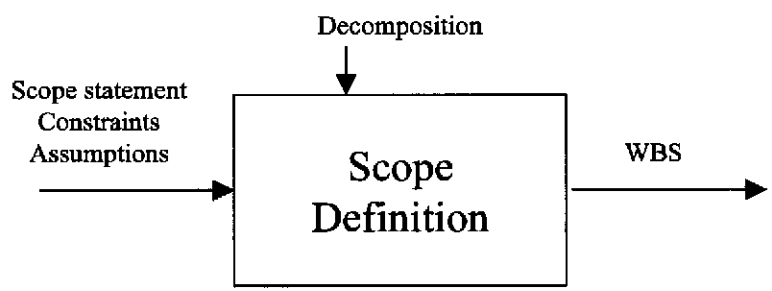
Scope Definition--continued

- Scope statement (justification, deliverables, objectives, and success criteria) constraints, and assumptions from Scope Planning are input to scope definition.
- Technique called "Decomposition" is used to further define project deliverables into smaller components.
- Decomposition is done until level of responsibility is reached and adequate estimates can be developed.
- The result of decomposition during scope definition is the Work Breakdown Structure (WBS).



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Scope Definition--continued
Work Breakdown Structure (WBS)

- "Deliverable-oriented grouping of project components that organizes and defines the total scope of the project." PMBOK 2000
- Work not documented in the WBS is outside the scope of the project.
- WBS can be displayed in table or chart form.
- Each item in a WBS is called a "Task"
- "Work Package"--Lowest level of WBS.
- "Cost Account"--Level above the Work Package.

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Work Breakdown Structure--Example
Table Form

Develop a New System to Facilitate the Hiring of New Employees

1.0 Document performance of current system
2.0 Determine business objectives of new system
3.0 Determine hardware, software, and process requirements
- 3.1 Determine high level requirements
- 3.2 Determine detailed requirements
- 3.3 Determine testing procedures and acceptance criteria
  - 3.3.1 Determine testing procedures for each requirement
  - 3.3.2 Determine expected outcomes for each testing procedure
  - 3.3.3 Determine acceptance criteria for each requirement

4.0 Develop System
5.0 Test System
6.0 Accept System
7.0 Prepare Organization for New System
8.0 Implement System

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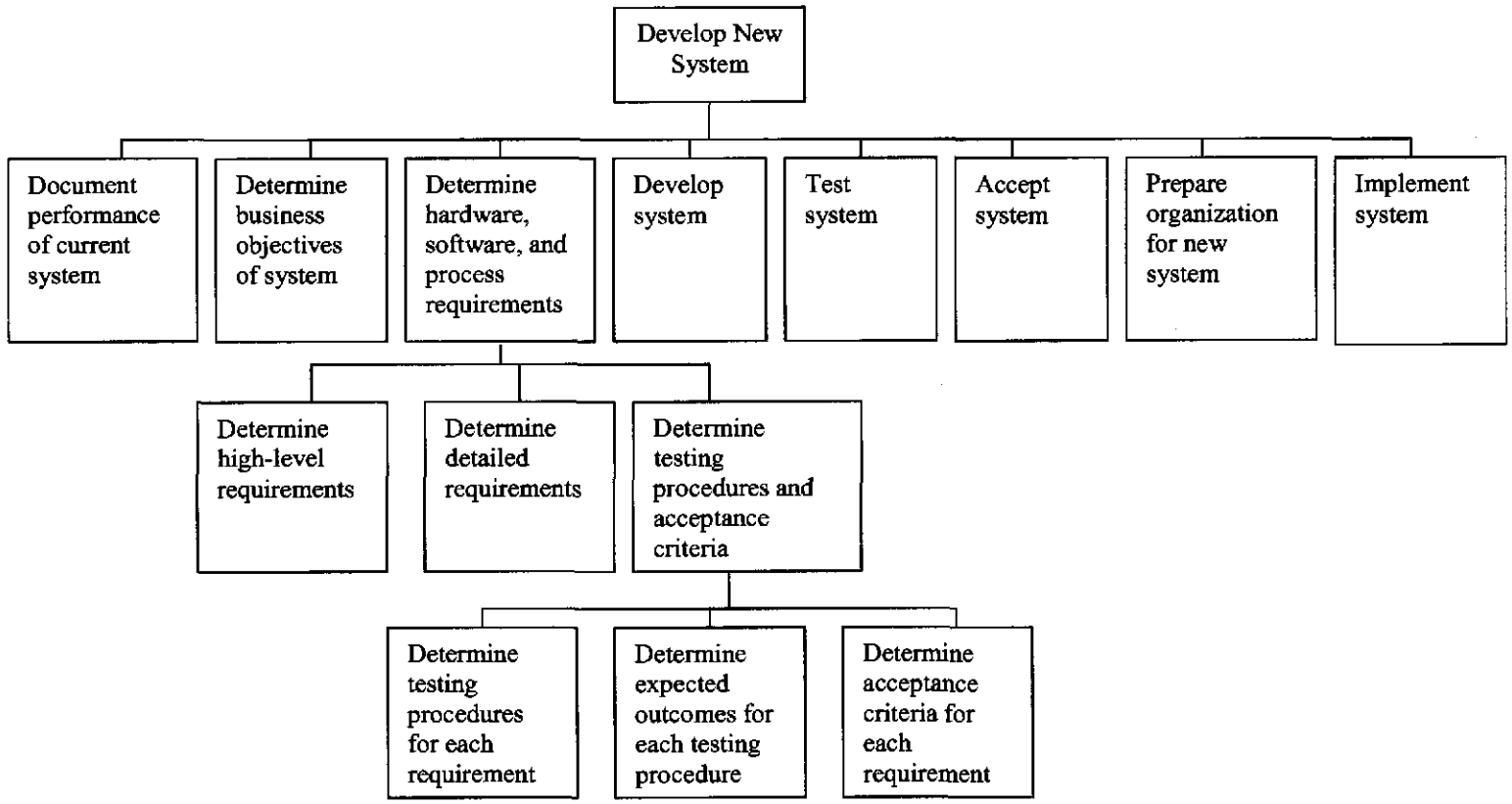
Work Breakdown Structure--Example

Chart Form

Develop a New System to Facilitate the Hiring of New Employees



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Work Breakdown Structure--concluded

- WBS Development Guidelines
  - Start each task with a verb.
  - Continue decomposition to the level of responsibility.
  - Ensure each task is a clear and discrete effort.
  - Ensure that the WBS as a whole includes all work required by the project.
  - Obtain necessary approvals and buy-in.

WBS is one of the most important project documents. It is an input to most project planning activities.

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Lunch Presentation

National Airspace System Operational Evolution Plan (NAS OEP)

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Seminar Exercise
Outline FAMUS WBS

- Plan overall project
- Decompose project scope into smaller manageable pieces
- Demonstrate integration points

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Project Time Management

Tuesday June 17, 2003

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Tuesday June 17, 2003
Agenda

- Project Time Management
  - Activity definition
  - Activity sequencing
  - Activity duration estimating
  - Schedule development
  - Project schedule methods
- Seminar Exercise—FAMUS Schedule Refinement and Integration

- Financial Discussions
(Director General, Commercial Manager, Procurement Manager)
- Alternate Work Schedule
(Director General, Project Manager)

Lunch Presentation--Targets
Afternoon Presentation--Operating Statistics

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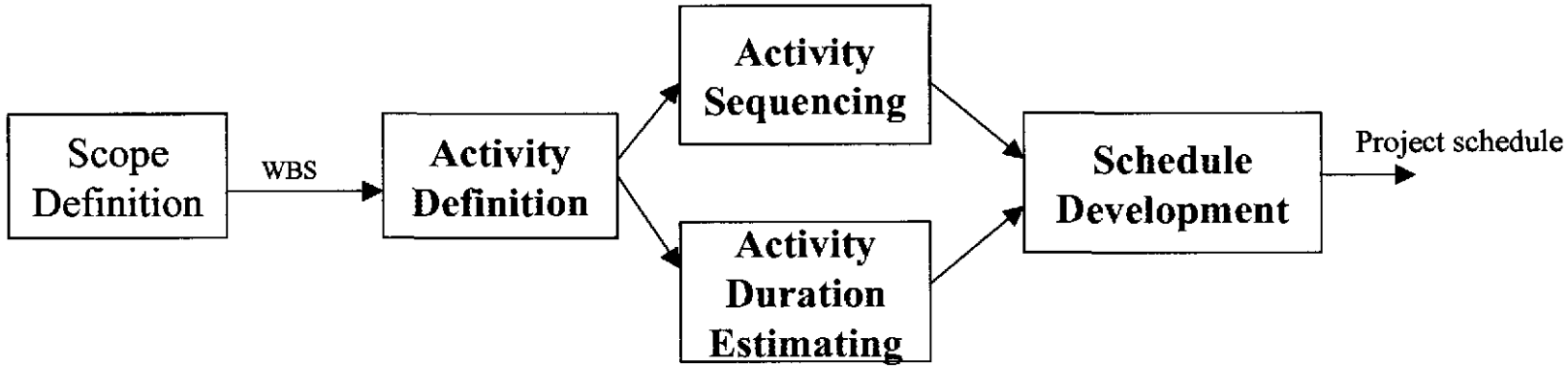
Project Time Management

Determination and control of activities required to plan for and ensure on time completion of the project.



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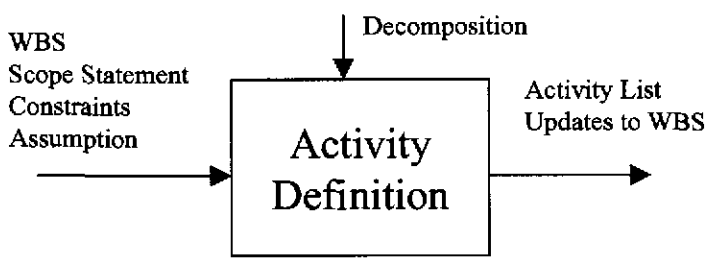
Project Time Management

Activity Definition

- Identifying specific activities that must be successfully completed to develop the deliverables or perform services documented in the WBS.
- Decomposing WBS beyond "level of responsibility" to all activities required to successfully complete the project.



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Project Time Management

Activity Definition--concluded

- Development of additional detail (descriptions, constraints, assumptions) for activities to ensure stakeholders understand the effort to be completed.
- Development of activities frequently leads to the need for clarification or even updates to the WBS.
- Documentation of activities needs to include links (e.g. task number or task name) to the work packages or cost accounts documented in the WBS.

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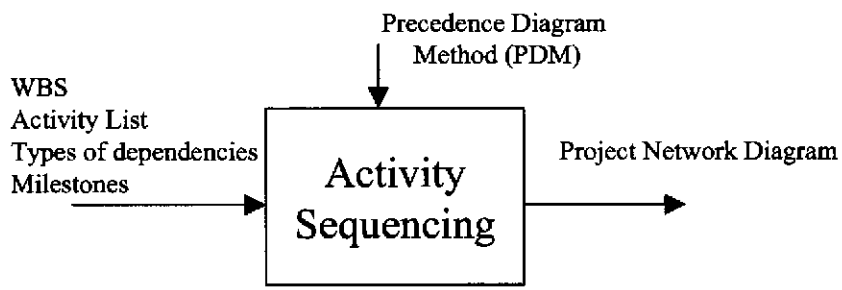
Project Time Management

Activity Sequencing

- "Identifying activity relationships."
- Supports the development of a realistic schedule.
- Uses the Precedence Diagram Method (PDM) to create a Project Network Diagram from the list of activities developed during Activity Definition.



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Project Time Management

Activity Sequencing--continued

Types of Dependencies

- Mandatory--driven by type of work (e.g., software development must occur before software testing).
- Discretionary--developed due to project team experience and knowledge (e.g., organizational change management to begin after the start of requirements definition).
- External--document relationship between project activity and non-project activity (e.g., milestone executive review completed prior to beginning next phase of work).

What are some SMATCA external dependencies?

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Project Time Management

Activity Sequencing--continued

Precedence Diagram Method (PDM)

- Boxes document activities.
- Arrows document dependencies. Four types of dependency relationships include:
  - Finish-to-Start (FS)
  - Finish-to-Finish (FF)
  - Start-to-Start (SS)
  - Start-to-Finish (SF)

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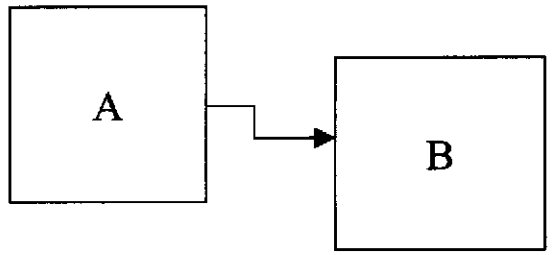
Project Time Management

Activity Sequencing--continued

Finish-to-Start (FS)

Start of Task B is dependent on the successful completion of Task A.



Example:
A-Develop software
B-Test software

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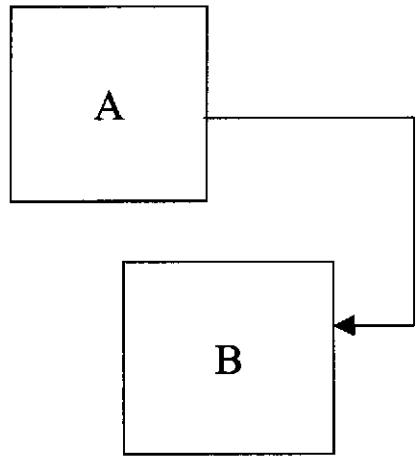
Project Time Management

Activity Sequencing--continued

Finish-to-Finish (FF)

Successful completion of Task B is dependent on the successful completion of Task A.



Example:
A-Award Contract
B-Allocate Funds

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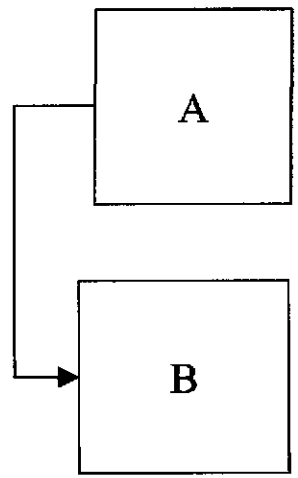
Project Time Management

Activity Sequencing--continued

Start-to-Start (SS)

Start of Task B is dependent on the start of Task A.



Example:
A-Define requirements
B-Begin Change Management

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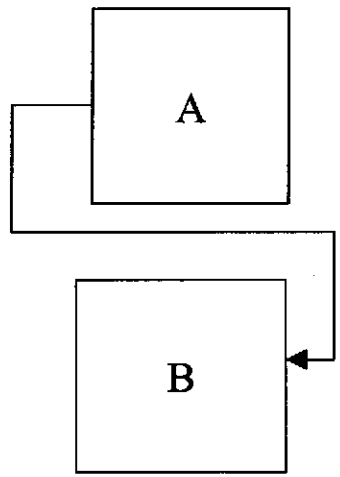
Project Time Management

Activity Sequencing--continued

Start-to-Finish (SF)

Task A must start before Task B can be completed.



Example:
A-Start anchor relay runner
B-Finish relay runner 3

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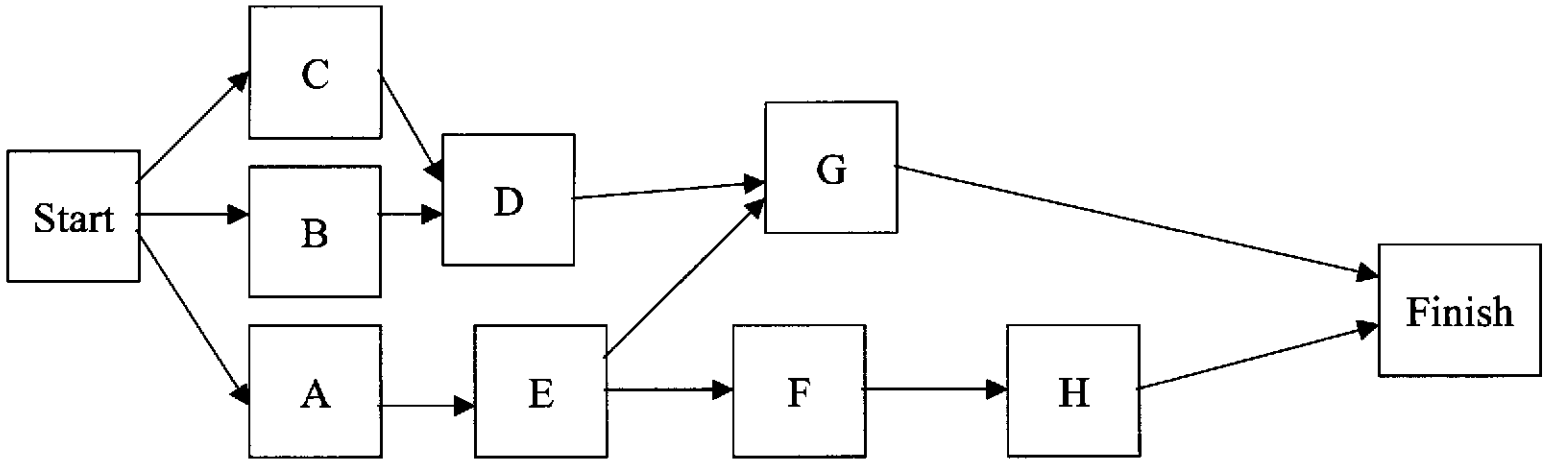
Project Time Management

Activity Sequencing--concluded

Project Network Diagram--Display of Project Activities documenting relationships. Sometimes called a PERT chart.



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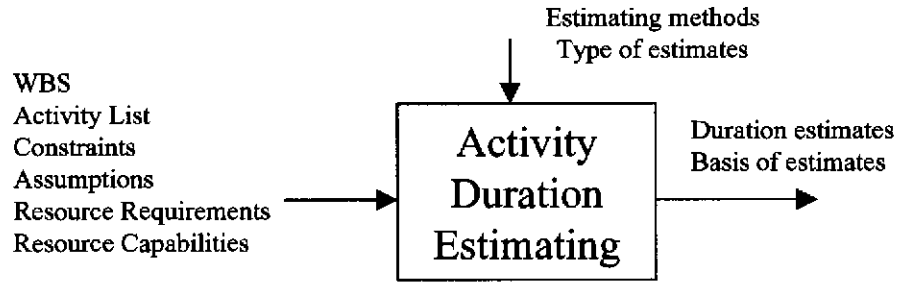
Project Time Management
Activity Duration Estimating

- Process of determining duration estimates for project activities.
- Estimates can be single point estimates, ranges, or PERT (Program Evaluation and Review Technique) estimates.
- It is extremely important to document the basis of estimates (methodology, assumptions).



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Project Time Management

Activity Duration Estimating--continued

Terminology to consider when determining estimates:

- **Working time**--Duration based on number of working hours (e.g., 48 working hours= 6 days). Used when staff is involved.
- **Elapsed time**--Duration based on number of hours during time period (e.g., 48 hours=2 days). Typically used when staff is not involved.
- **Effort hours**--Resource hours need to complete activity (e.g., 8 effort hours can be accomplished with 1 person-8 hours or 2 people-4 hours).

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Project Time Management

Activity Duration Estimating--continued

- Estimating Methods
  - Quantitatively based (e.g., bottom-up estimate of hours needed to complete subtasks, hours per line of software code)
  - Analogous (e.g., task for similar project took 6 working hours)
  - Expert Judgement (e.g., based on expertise, task will take 5 working hours)

- Types of estimates:
  - Single point (e.g., 5 working days)
  - Range (e.g., 5 working days +/- 1 day)
  - PERT = $\frac{\text{Optimistic} + (4 * \text{Most likely}) + \text{Pessimistic}}{6}$

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Project Time Management

Activity Duration Estimating--concluded

PERT Example: Optimistic=4 working hours

Most Likely=5 working hours

Pessimistic=8 working hours

PERT Estimate = [4 + (4 * 5) + 8] / 6

= 5.33 working hours

PERT Standard Deviation= (Pessimistic - Optimistic)/6

= (8 - 4) / 6

=.67

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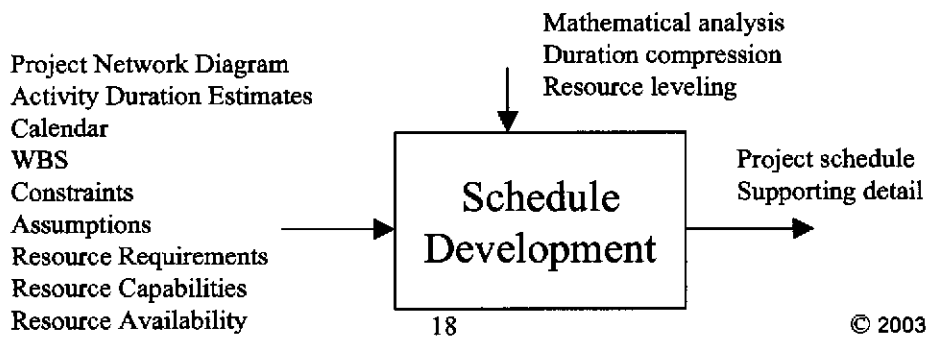
Project Time Management
Schedule Development

- Process of determining start and end dates for project activities.
- Important terminology:
  - Early Start (ES) & Early Finish (EF)--Earliest an activity can start and finish.
  - Late Start (LS) & Late Finish (LF)--Latest an activity can start and finish without extending the project end date.
  - Float--Amount of time an activity can be delayed without extending the project end date.
  - Free Float--Amount of time an activity can be delayed without delaying the next task.



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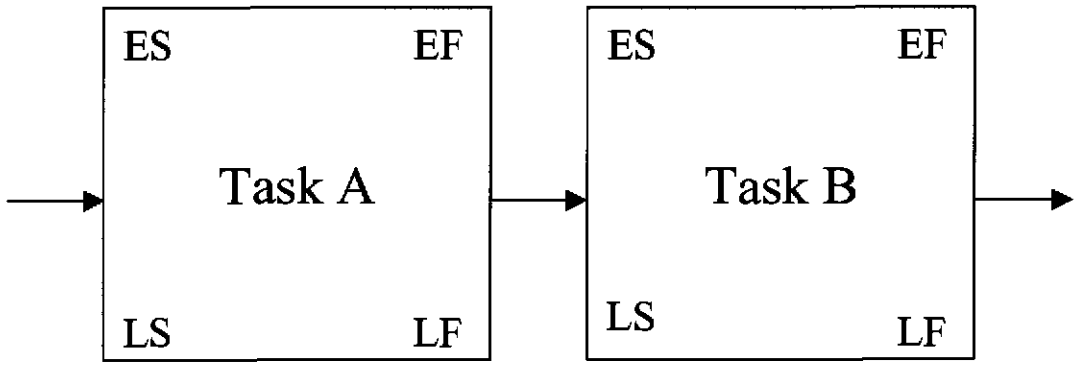
Project Time Management
Schedule Development--continued

Mathematical Analysis



Forward Pass is used to calculate ES and EF (displayed on top corners of box.).
ES=EF of previous task. EF=ES + task duration.

Backward Pass is used to calculate LS and LF(displayed on bottom corners of box).
LF=LS of next task. LS=LF - task duration.

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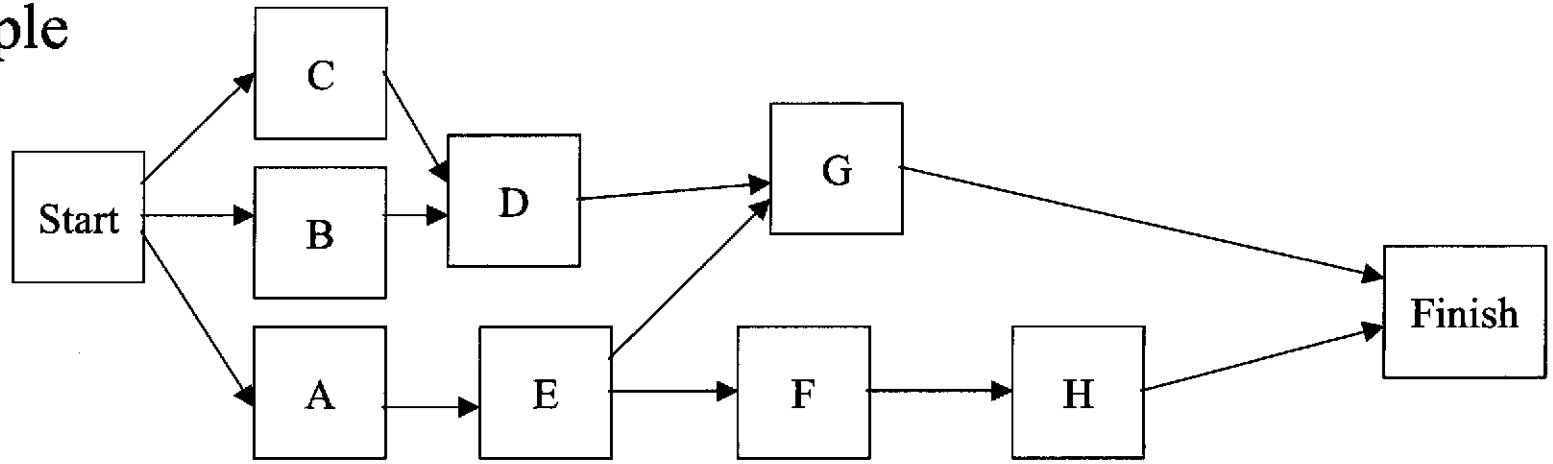
Project Time Management

Schedule Development--continued

Example



Task	Duration
A	3
B	4
C	2
D	4
E	1
F	4
G	3
H	2

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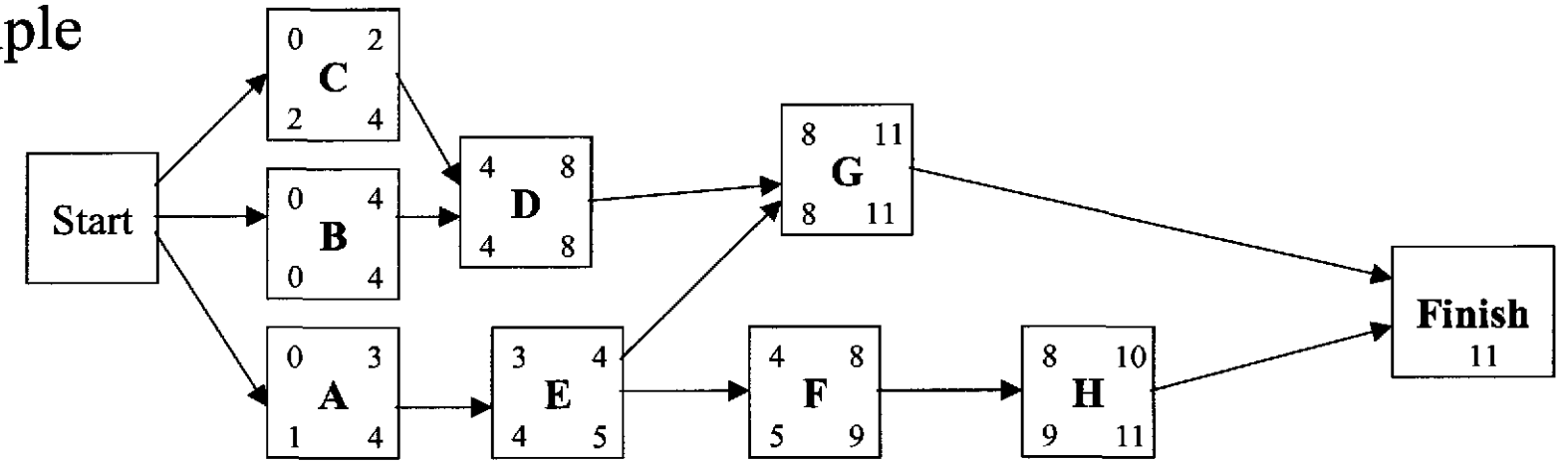
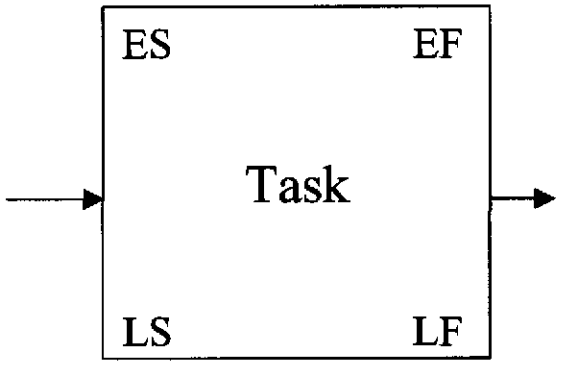
Project Time Management

Schedule Development--continued

Example



Task	Duration
A	3
B	4
C	2
D	4
E	1
F	4
G	3
H	2



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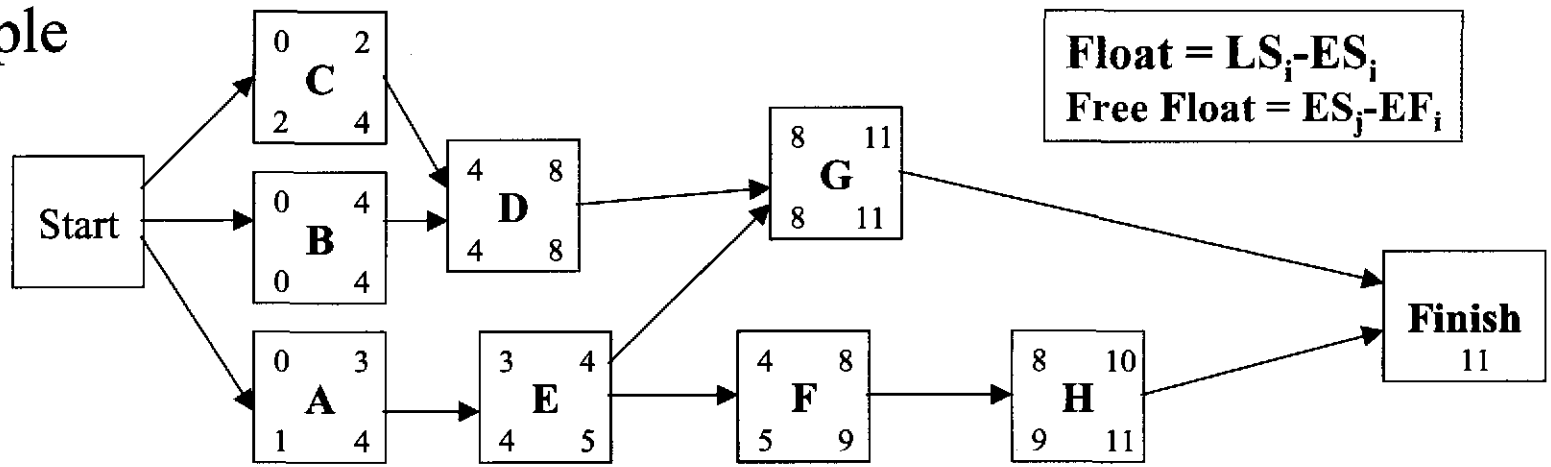
Project Time Management

Schedule Development--continued

Example



Float = LS_i-ES_i
Free Float = ES_j-EF_i

Task	Duration	Float	Free Float
A	3	1	0
B	4	0	0
C	2	2	2
D	4	0	0
E	1	1	0
F	4	1	0
G	3	0	0
H	2	1	1

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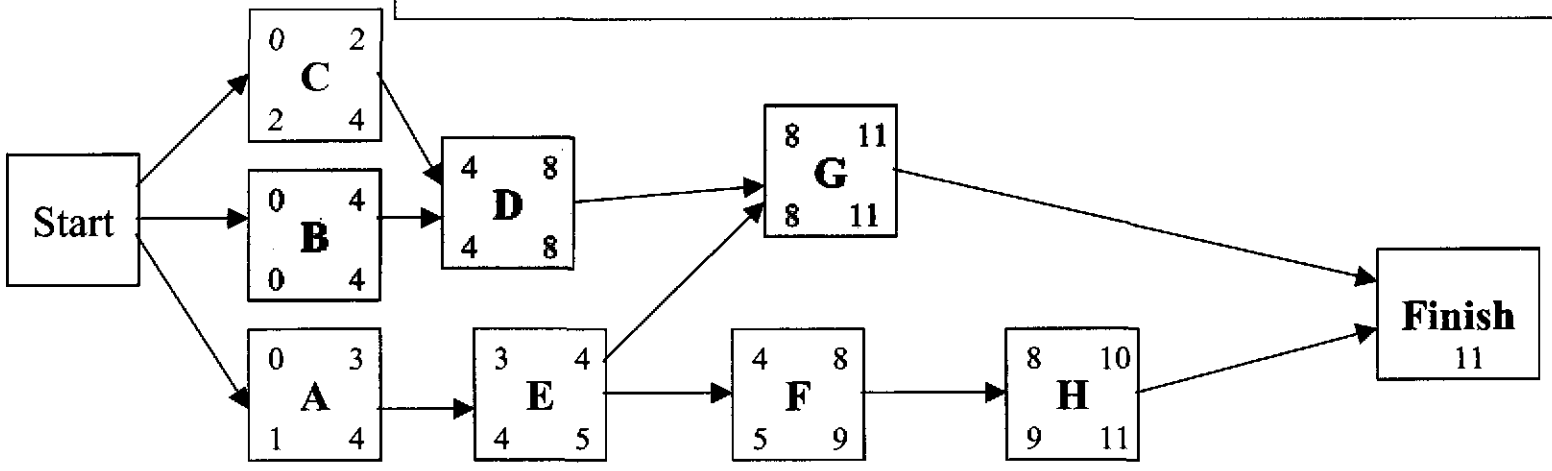
Project Time Management
Schedule Development--continued

Example

Critical Path: Series of activities that determine the earliest finish date. Activities with Float=0.



Task	Duration	Float	Free Float
A	3	1	0
B	4	0	0
C	2	2	2
D	4	0	0
E	1	1	0
F	4	1	0
G	3	0	0
H	2	1	1

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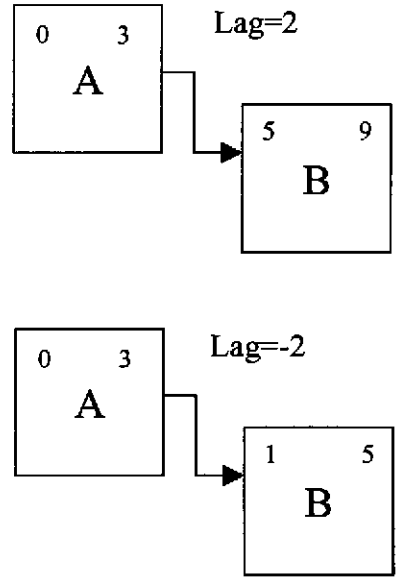
Project Time Management
Schedule Development--continued

Other key schedule development terminology

- Lag--Delay between activities.
- Lead--Starting an activity earlier (negative lag).
- Reserve time--Buffer added to duration estimate to reduce risk.
- Schedule constraints
  - Start no earlier than
  - Start no later than
  - Finish no earlier than
  - Finish no later than
- Milestone--task with zero duration. Signifies the end of a phase of work.



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Project Time Management
Schedule Development--continued

- Methods to shorten schedule
  - Crashing--Adding resources to an activity to shorten the duration. Also results in increased cost.
  - Fast Tracking--Performing activities in parallel that normally would be done sequentially. For example, Software testing begins during development.
- Resource Leveling
  - Frequently initial schedules produce resource conflicts. For example, a particular software engineer may be allocated 100% to development and 50% to testing during a particular time period.
  - In order to correct conflicts, the schedule may need to be extended to level out the planned effort for a resource.

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Project Time Management
Schedule Development--continued

- Project management software (e.g., Microsoft Project, Primavera) can be used to:
  - Perform mathematical analysis (ES, EF, LS, LF, float, free float).
  - Identify critical path.
  - Identify resource conflicts and assist in leveling.
  - Display and document project schedule.
  - Track schedule progress.
  - Determine effect of schedule delays.

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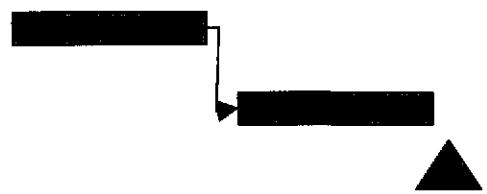
Project Time Management
Schedule Development--concluded

Project schedule

- Presents activities with planned start and planned finish dates.
- Displays activity relationships (FS, SS, FF, SF).
- Usually displayed in Gantt Chart form.
- For large projects, typically a Master Schedule or Summary Schedule is used in conjunction with more detailed schedules. Milestone schedules are frequently used to document the project's major milestones.

Example: Gantt Chart with Milestones

	Start Date	Finish Date
Task 1	June 1	June 15
Task 2	June 16	June 30
Milestone 1	June 30	June 30



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Lunch Presentation

TARGETS Demonstration

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Seminar Exercise
FAMUS Schedule

- Assess schedule realism
- Identify type of dependencies and task relationships
- Use duration estimation methods

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Afternoon Presentation

Airport Operation Statistics

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Risk Management

Wednesday June 18, 2003

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Agenda

- Risk Management Overview
- Planning for Risk Management
- Risk Identification
- Risk Analysis
- Risk Prioritization
- Risk Mitigation
- Risk Control

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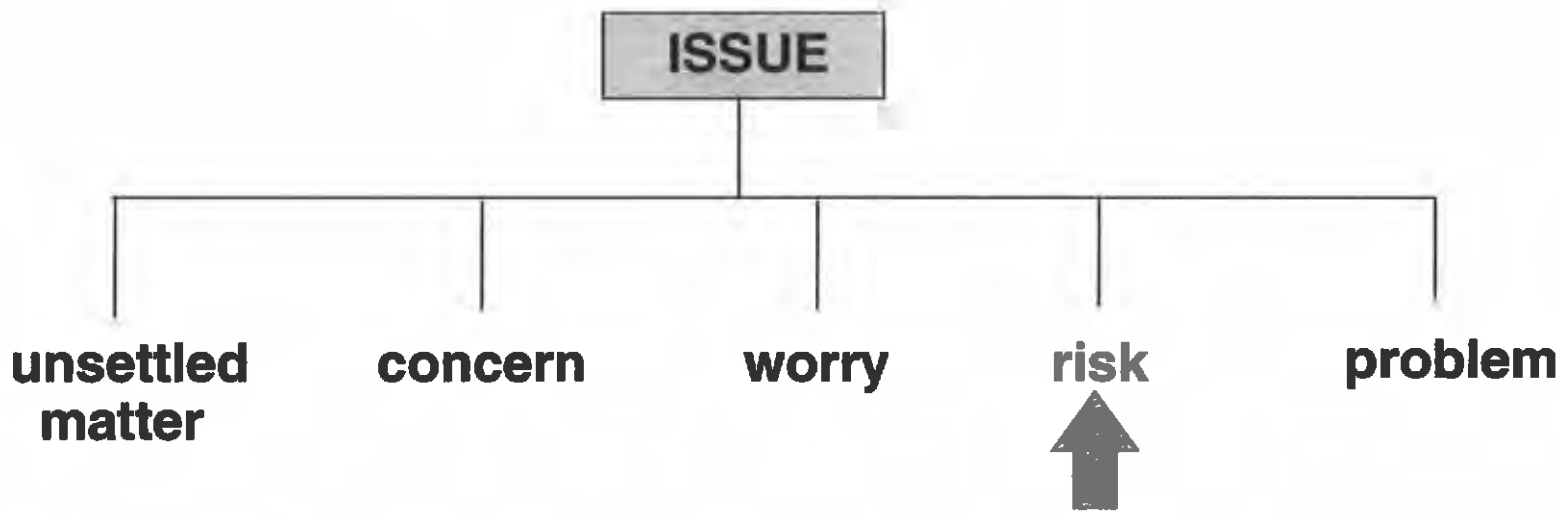
Risk Management Overview
Definitions

- **Issue: any item for discussion that the speaker or writer believes needs attention**
  - **Characteristics of issues:**
    - **not well defined; unsettled or unresolved**
    - **often the result of brainstorming**
  - **Risks need to be separated from other types of issues.**



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Risk Management Overview
Definitions

- **Risk: a possible problem**
  - **Risk has three parts:**
    - ***an event*** **that has unwanted consequences**
    - **the *probability that the event* will occur**
    - **the *severity of the unwanted consequences (impact)* if the event occurs**
  - **Risks change over time.**
  - **Has 2 degrees of management freedom:**
    - **Manage the probability of occurrence and/or Manage the severity of the impacts**

Risk: a possible problem

Key: The event has not yet occurred

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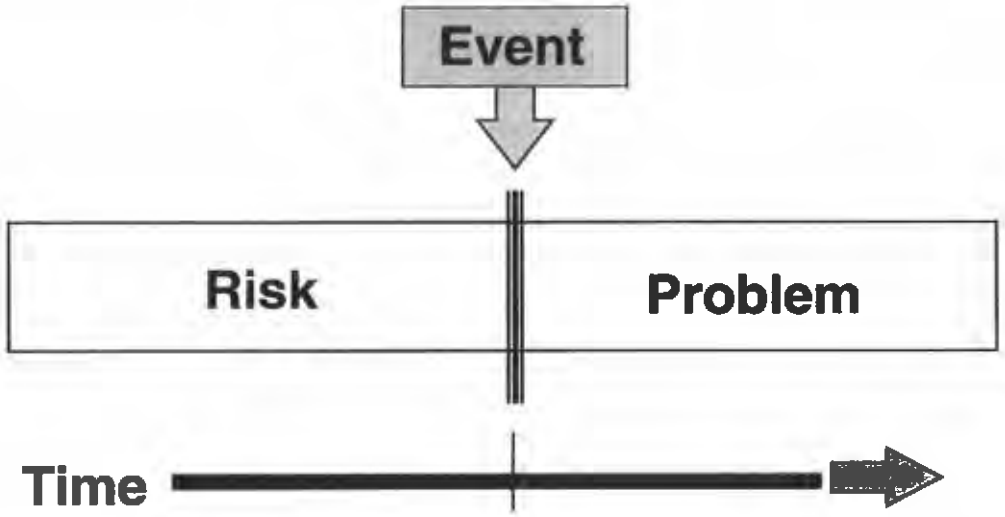
Risk Management Overview
Definitions

- **Problem**: a barrier to success
  - A risk whose event has occurred
  - Has only 1 degree of management freedom: Manage the impact



Relationship between a risk and a problem

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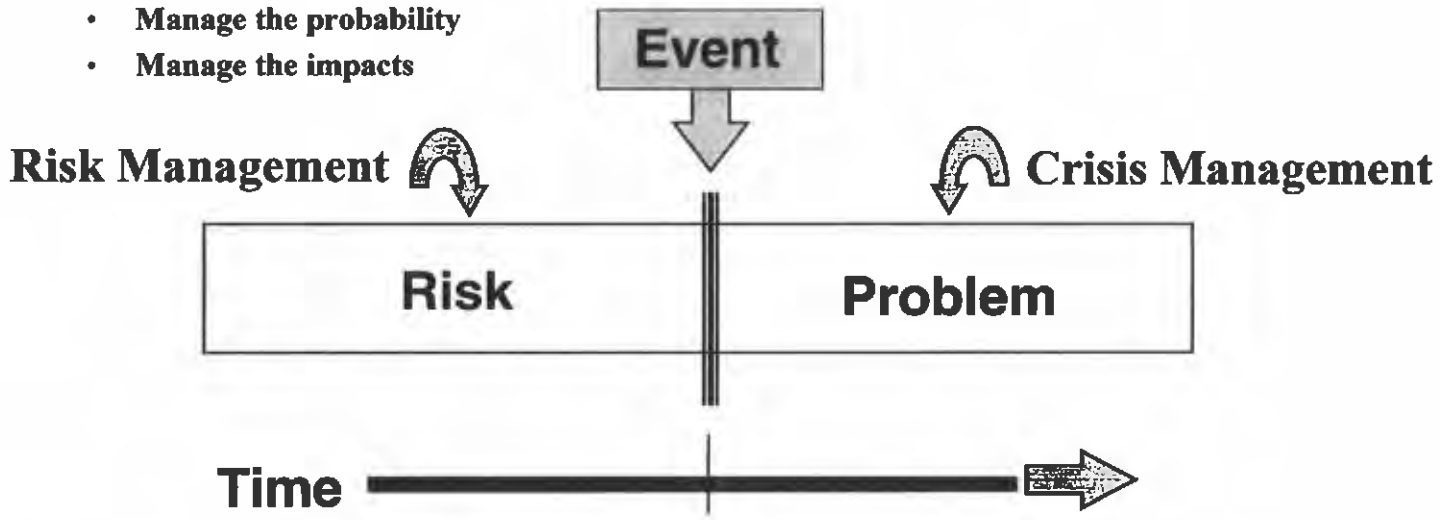
Risk Management Overview
Definitions Summary

- **Risk: a potential problem**
  - Risk has three parts:
    - an event
    - with a probability of occurrence
    - and unwanted consequences (impacts)
  - Risks change over time.
  - 2 Degree of freedom:
    - Manage the probability
    - Manage the impacts
- **Problem: a barrier to success**
  - A risk whose event has occurred
  - Has only 1 degree of freedom:
    - Manage the impacts



Relationship between a risk and a problem changes over time - when event occurs

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Risk Management
Overview

" Risk management is a method of managing that concentrates on identifying and controlling areas or events that have a potential of causing unwanted change ... it is no more and no less than informed management"

T.V. Carver, *Risk Management as a Means of Direction and Control,* Fact Sheet, Program Managers Notebook, Defense Systems Management College, No. 6.1, April 1985

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Risk Management
Overview

- Why?
  - Improve opportunity for success
    - Control cost
    - Deliver on time
    - Ensure expected level of technical performance
- How?
  - Management Team commitment
  - Planned and structured risk management process
  - Appropriate tools and methods

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Risk Management
Overview

- What does success look like?
  - Pro-active environment with wide-management participation
  - Close relationships with users, industry and other appropriate participants
  - Risks are continuously identified and analyzed for relative importance. Then they are mitigated, tracked, and controlled.
  - Defined set of success criteria for all cost, schedule, and performance elements
  - Metrics to monitor risk control strategies
  - Effective test and evaluation program
  - Anticipating then preventing problems before they occur
  - Cultural shift from "fire-fighting / crisis management" to pro-active decision-making

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Risk Management
Overview

- When is there not enough risk management?
  - Management feels surprised by an event
  - Feeling that program is in constant crisis ("fire fighting")
  - Decision-making with inadequate information or adequate knowledge of future consequences
- Does risk management guarantee success?
  - No
  - Effective risk management will improve chance for success
  - Helps avoid surprises
  - Improves decision-making

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Risk Management
Overview

- Types of Risk Assessments
  - Technical Risk Assessment
    - Develop solutions to solve technical program requirements
    - Integration of technical solutions
  - Programmatic Risk Assessment
    - Risks to contract vehicles
    - Requirements volatility
    - Contractor –Government relationships
    - Political issues (funding)
  - Cost and Schedule Risk Assessment
    - Executing the program within its constraints and requirements

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Planning for Risk Management
Activities

- Establish an overarching program strategy
  - Goals, objectives, milestones for key activities
- Identify risk management process participants
  - Establish roles and responsibilities for specific areas
  - Identify additional technical expertise that will be needed
- Decide methods, procedures, and tools
  - Communications plan
  - Documentation and Reporting methods (risk database)
- Establish and describe the risk assessment process
  - Define a risk assessment criteria and rating (prioritization) scheme
- Train the team
- Conduct Baseline Risk Assessments

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Planning for Risk Management
Baseline Risks Assessment

- Comprehensive look at the details of the program as early as possible
  - Lays the foundation for measuring progress and effectiveness of risk control activities
- When to begin?
  - Ideally before program execution begins
  - At other times such as:
    - Operational Requirements Documents is developed
    - Acquisition strategy development
    - Contract award
    - Significant requirements, budget, or schedule changes
    - Significant interface changes

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Planning for Risk Management
A Process Model

A suggested risk management model

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Planning for Risk Management
A Process Model

Two distinct phases to RM
Risk Analysis Phase and ***Risk Management Phase***

- **Risk Analysis Phase:**
  - **Responsibility of the functional or enterprise teams**
    - **Starts at Risk Identification**
    - **Ends at Develop Mgt Plans**
- **Risk Management Phase:**
  - **Responsibility of the Program Management Team**
    - **Starts at Develop Mgt Plans**
    - **Ends at Risk Exposure Reevaluation**

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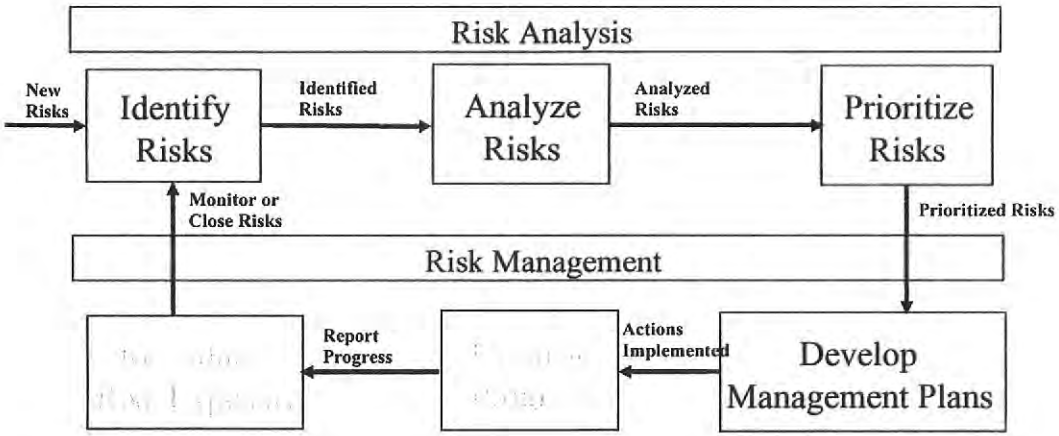
Planning for Risk Management
Risk Analysis Phase

A suggested approach: **Functional teams conduct risk assessments of their area.**



- **Each functional team will establish an internal risk analysis processes that identifies, analyzes, and establishes a risk mitigation plan for their risks.**

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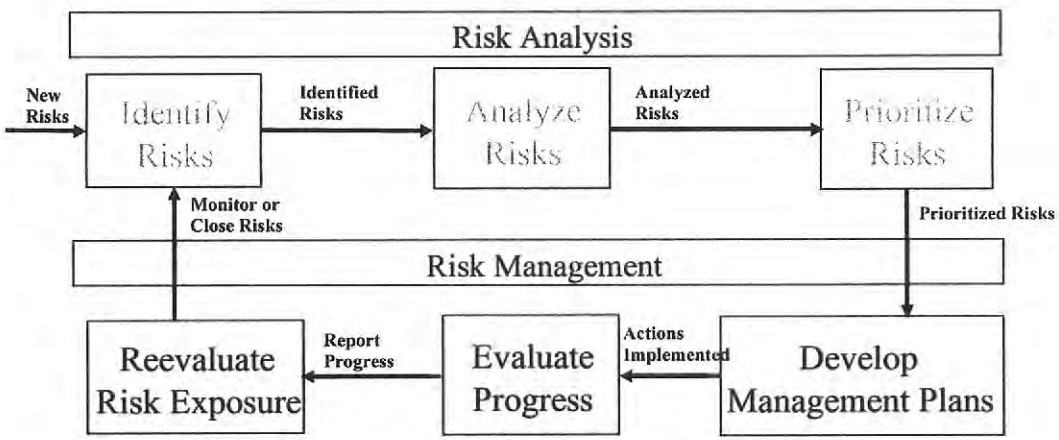
Planning for Risk Management
Risk Management Phase

A suggested approach: **Program Management Team integrates all program risk and approves mitigation plans and funding**



- **Program Management Team will review and coordinate all risk mitigation plans.**
- **Review and coordination would occur at regularly scheduled Risk Review Board sessions**
- **Risk Review Board would:**
  - **assess overall program priorities**
  - **approve mitigation plans**
  - **approve funding mitigation**

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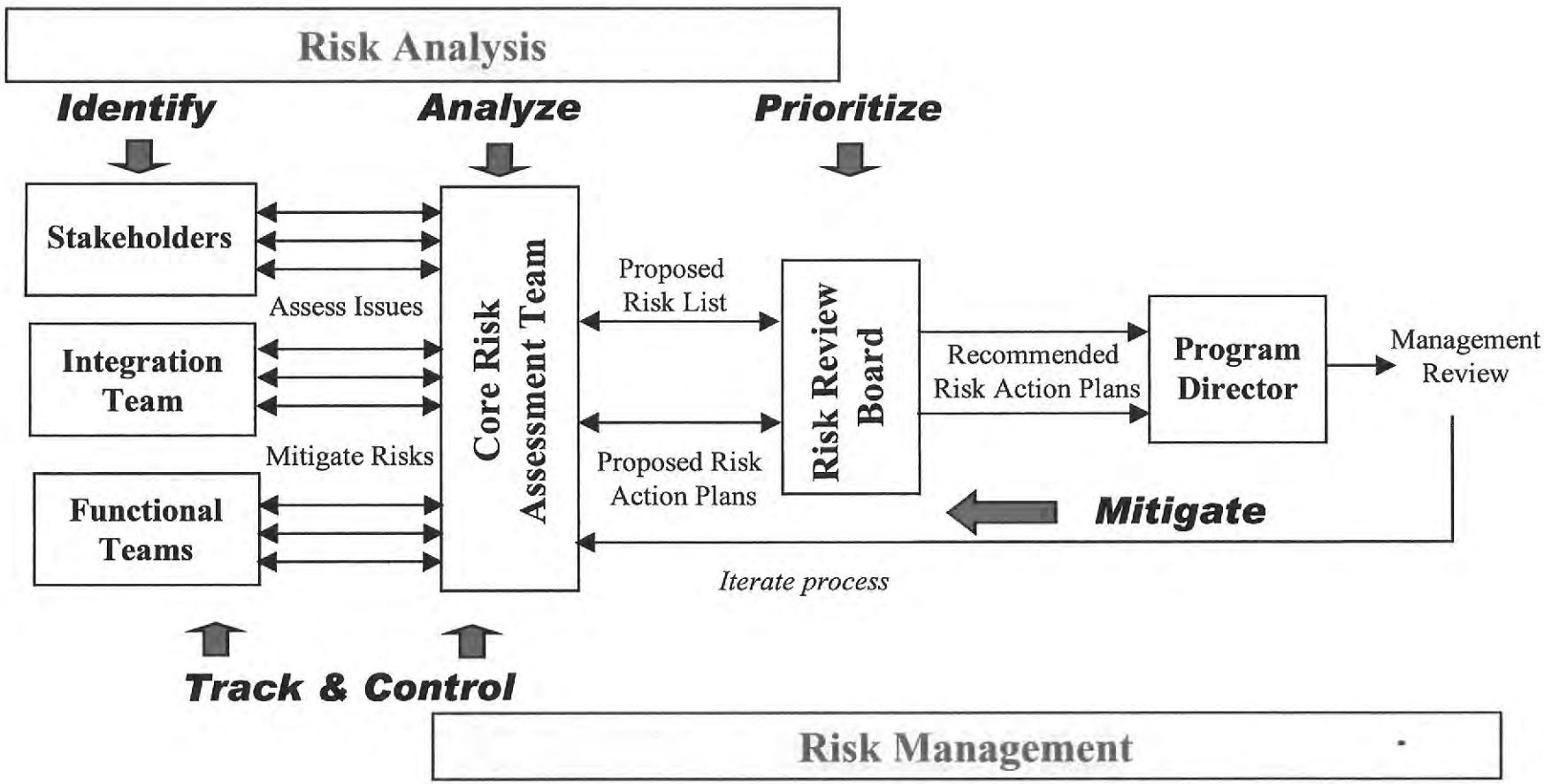
Planning for Risk Management
Suggested Risk Management Strategy



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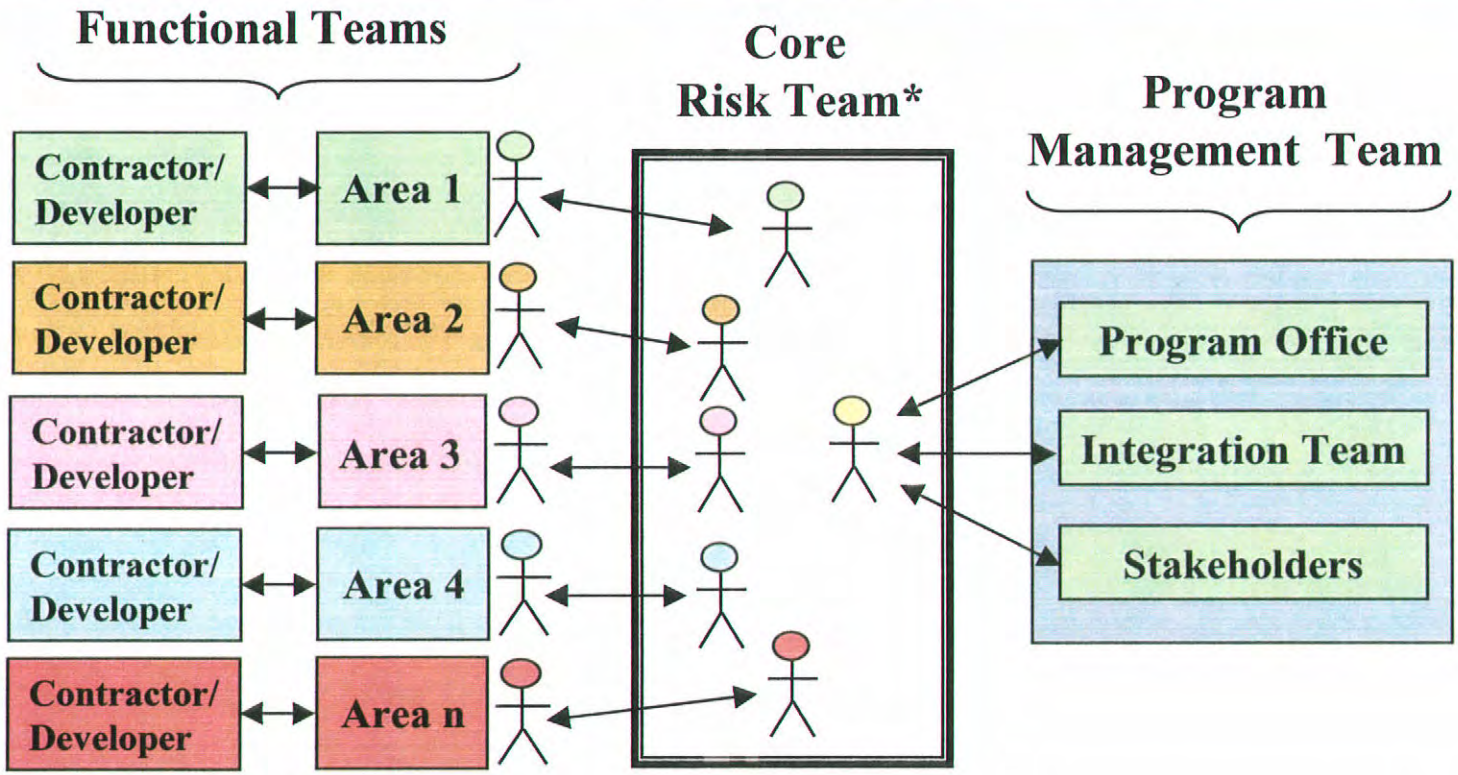
Planning for Risk Management
Suggested Risk Management Strategy



***Core Risk Team is a dedicated group that is highly trained in risk skills**

= specifically identified and trained risk staff

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Planning for Risk Management
Suggested Risk Review Board

- Who should participate?
  - Key program and functional managers
  - Support managers (budget, contracting, legal, labor relations)
  - Core risk team
- Charter
  - Validate risk prioritization across the entire program
  - Approve risk mitigation plans and modifications
  - Allocate resources to mitigation

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Risk Identification
Most Important Activity in Risk Management

- **Goal:**
  - No secrets, No Surprises
- **Time consuming and complex at times**
  - Requires careful methodology to be successful
- **How:**
  - Examine and assess program events to determine if they have risk events
  - Examining each Work Breakdown Schedule product and process has proven to be successful technique
  - Use supplemental checklists and functional area experts
  - Conduct interviews
  - Collaborate with industry

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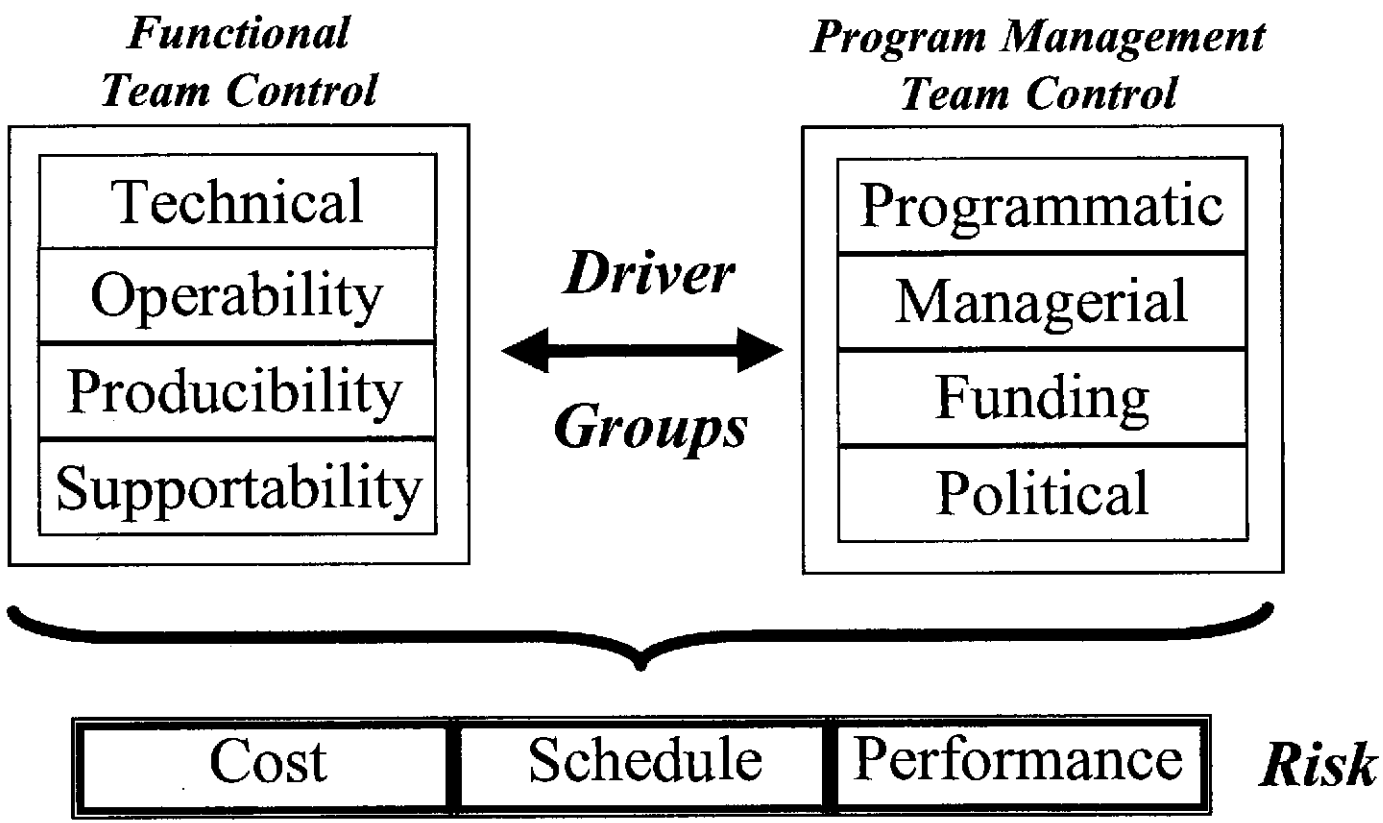
Risk Identification
Risk Groups



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Risk Identification
Risk Groups and Risk Drivers

DRIVER GROUP	SPECIFIC DRIVER TYPE
Technical	Technology - System Engineering - System Design - System Test - Tech Documentation
Operability	User/Operators - System Operation - System Interoperability -
Producibility	Design Production - Manufacturing - Parts & Materials - Testing & Documentation
Supportability	Operations & Maintenance - Logistics - Testing & Support - Support Docs - System Implementation
Programmatic	Schedule Estimations - Schedule Management - Operational Impact Dependencies Schedules & Influence
Managerial	Planning - Organization - Implementation - Control
Funding/Budget	Constraints - Support - Fiscal Management - Cost Estimating - Product Cost
Political	Congressional Influence - Stakeholders Influence - FAA Influence

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Risk Identification
Example Risk Drivers and Risk Events

Technical Risks

Adaptation
- Adaptation Complexity

System Engineering
- Technically incompatible with architecture
- Inadequate functional analysis
- Deficient functional allocation
- Incomplete integration
- Undefined internal interfaces
- Vague operational environment
- Insufficient requirements analysis
- Unstable requirements
- Immature requirements
- Weak Failure modes analysis
- Requirements difficult to trace
- Unidentified safety/security considerations

System Design
- Inadequate capacity
- Lack of design details
- Insufficient design margins
- Immature design
- Unsatisfactory growth potential
- Undefined physical properties
- Incomplete hardware design
- Incomplete software design
- Inadequate software tools
- Immature software language
- Ineffective fault detection
- Complex/incomplete CHI design
- Undefined technical approach

Programmatic Risks

Schedule Estimations
- Inadequate schedule estimation tools
- Erroneous estimations, Faulty basis
- Insufficient schedule margin
- Optimistic schedule duration

Schedule Management
- Unsatisfactory schedule controls
- Insufficient schedule monitoring
- Inadequate contractor/subcontractor schedule monitoring

Cross Cutting Dependencies
- Test scheduling dependencies
- Excessive task concurrency (deployment sites)
- Coinciding procedures development
- Coinciding regulations development
- Coinciding standards development
- Uncertain contractor processes
- Unavailability of: parts, facilities, personnel, funds, data

Funding Risks

Funding Constraint
- Unfavorable agency priorities
- Inadequate funding
- Unavailable funding
- Lengthy budget cycle

Funding Support
- Inadequate user support
- Ambiguous operator support
- Unclear political support
- Marginal cost/benefits
- Inconsistent government plans

Fiscal Management
- Insufficient funding requirements
- Insufficient fiscal controls
- Insufficient fiscal tools
- Insufficient funding plans
- Unrealistic funding profile

Cost Estimating
- Faulty basis for costing
- Estimation errors
- Insufficient margins
- Inadequate resourcing
- Undefined requirements

Product Cost
- Inadequate budget for hardware
- Undefined HW/SW costs

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Risk Analysis
Discussion

- Risks are generally assessed for two criteria:
  - The Probability (P) of the Risk Event occurring
  - The Impacts (I) or consequences to the program if it occurs
- Various methods are used to analyze risks
  - Probability and statistical modeling
  - Monte Carlo gaming methods
  - Lessons learned and comparisons to other studies or experience
  - Test results and other engineering data
  - Specialist and expert judgments
  - Modeling and simulation
- Numerous tools are available for all types of risk assessments: cost, schedule, and technical performance

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Risk Analysis

Suggested Probability and Impact Assessments

Probability Guidelines

Mean Value	Nominal Description	Code	Subjective Description
.9	Very Likely	VHI	80-100% Chance
.7	Probable	HI	60-80% Chance
.5	Improbable	MED	40-60% Chance
.3	Low	LO	20-40% Chance
.1	Very Low	VLO	0-20% Chance

Impact Guidelines

Nominal Value	Nominal Description	Code	Subjective Description
.8	Critical	VHI	Would cause program failure; Would not achieve minimum acceptable requirements
.4	Serious	HI	Would cause major cost/schedule increases; Would not achieve secondary benefits
.2	Moderate	MED	Would cause moderate cost/schedule increases; Important requirements can be achieved
.1	Minor	LO	Would cause only small cost/schedule increases; All requirements can be met with exception of few minor secondary requirements
.05	Negligible	VLO	May require that program reserves be exercised (schedule slack or budget reserves), but all requirements are met without exception

These tables help produce a consistent assessment of all risks.

The Core Risk Assessment Team is trained to facilitate this assessment

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Risk Analysis

Suggested Detailed Impact Assessments

Example of Expanded/Detailed Impact Rating (I)

Nominal Value	Nominal Description	Nominal Cost Description	Nominal Schedule Description	Nominal Performance Description
.8	Critical	Increase > 15%	Slip >12 months	Would not achieve minimum acceptable requirements
.4	Serious	Increase > 10% < 15%	Slip > 6-12 months	Would not achieve secondary performance requirements
.2	Moderate	Increase > 5%, < 10%	Slip 3-6 months	Most important requirements can be achieved. Would not achieve secondary performance requirements.
.1	Minor	Increase < 5%	Slip 1-3 months	All requirements can be met with exception of few minor secondary requirements
.05	Negligible	Increase Manageable	Slip Manageable	All requirements are met without exception

These would be adjusted to meet specific program goals

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Risk Analysis
Suggested Risk Rating Schema

A risk rating is generated by combining the Probability (P) and Impact (I) assessments

P x I = Risk Exposure

Impact Rating

Probability Rating

Description		VLO	LO	MED	HI	VHI
	Values	.05	.1	.2	.4	.8
VHI	.9	<.1	<.1	.18	.36	.72
HI	.7	<.1	<.1	.14	.28	.56
MED	.5	<.1	<.1	.10	.20	.40
LO	.3	<.1	<.1	<.1	.12	.24
VLO	.1	<.1	<.1	<.1	<.1	<.1

RE = 30-99%	Critical Program Risk	RED
RE = 1-29%	Significant Program Risk	YELLOW
RE = < 1%	Minimum Program Risk	GREEN
RE = 0	Mitigation Actions Complete	BLUE

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Risk Analysis
Suggested Procedure

Comprehensive risk assessment guidelines, should be used consistently to *analyze and assess all risks.*

This supports a disciplined structured risk management process.

Publishing the risk assessment guidelines helps communicate program objectives

RISK ASSESSMENT GUIDELINES
and
ANALYSIS SCHEMA

20 July 2001
Revision 5.0
(Replaces Rev 4.0, dated 1 December 2000)

Program Office
Integration Management Team

Prepared by
Risk Assessment Team

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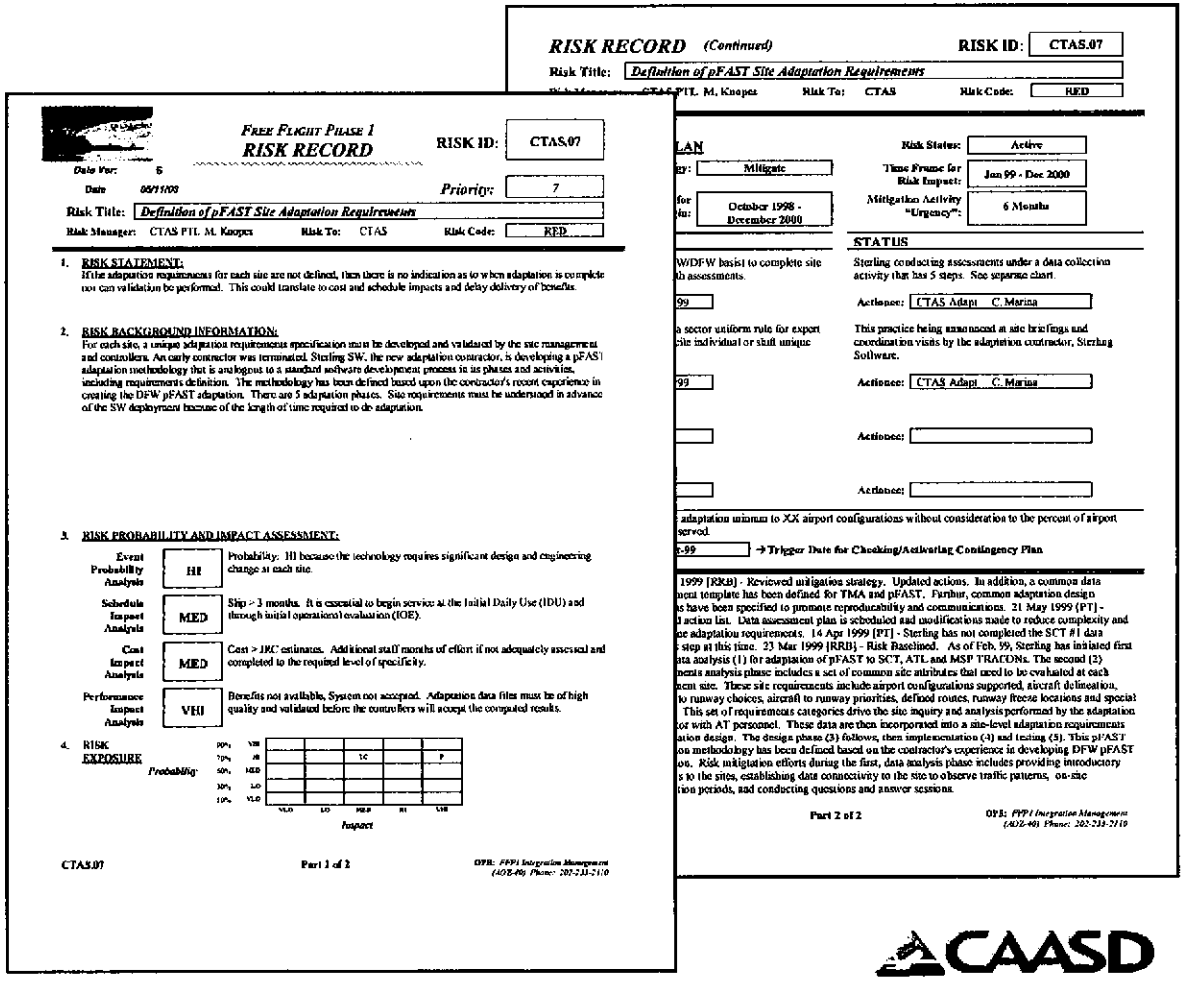
Risk Analysis
Risk Assessment Documentation

Risk Records contain description, assessment, action plan, & status details

Risk assessment data should be captured in a data base and be used to produce required program reports and conduct management oversight



FREE FLIGHT PHASE 1
RISK RECORD

RISK ID: CTAS.07

Date Ver: 6
Date 06/11/03
Priority: 7
Risk Title: *Definition of pFAST Site Adaptation Requirements*
Risk Manager: CTAS PTL M. Knopes Risk To: CTAS Risk Code: RED

1. RISK STATEMENT:
If the adaptation requirements for each site are not defined, then there is no indication as to when adaptation is complete nor can validation be performed. This could translate to cost and schedule impacts and delay delivery of benefits.

2. RISK BACKGROUND INFORMATION:
For each site, a unique adaptation requirements specification must be developed and validated by the site management and controllers. An early contractor was terminated. Sterling SW, the new adaptation contractor, is developing a pFAST adaptation methodology that is analogous to a standard software development process in its phases and activities, including requirements definition. The methodology has been defined based upon the contractor's recent experience in creating the DFW pFAST adaptation. There are 5 adaptation phases. Site requirements must be understood in advance of the SW deployment because of the length of time required to do adaptation.

3. RISK PROBABILITY AND IMPACT ASSESSMENT:

Event Probability Analysis	HI	Probability: HI because the technology requires significant design and engineering change at each site.
Schedule Impact Analysis	MED	Slip > 3 months. It is essential to begin service at the Initial Daily Use (IDU) and through initial operational evaluation (IOE).
Cost Impact Analysis	MED	Cost > IRC estimates. Additional staff months of effort if not adequately assessed and completed to the required level of specificity.
Performance Impact Analysis	VHI	Benefits not available, System not accepted. Adaptation data files must be of high quality and validated before the controllers will accept the computed results.

4. RISK EXPOSURE

Probability	VLO	LO	MED	HI	VHI
90% VHI					
70% HI			LC		P
50% MED					
30% LO					
10% VLO					

Impact

CTAS.07 Part 1 of 2 OPR: FFP1 Integration Management (AOZ-40) Phone: 202-233-2110

RISK RECORD (Continued) RISK ID: CTAS.07
Risk Title: *Definition of pFAST Site Adaptation Requirements*
Risk Manager: CTAS PTL M. Knopes Risk To: CTAS Risk Code: RED

LAN
Mitigate
October 1998 - December 2000
Risk Status: Active
Time Frame for Risk Impact: Jan 99 - Dec 2000
Mitigation Activity "Urgency": 6 Months

STATUS
Sterling conducting assessments under a data collection activity that has 5 steps. See separate chart.
Actionee: CTAS Adapt C. Marina
This practice being announced at site briefings and coordination visits by the adaptation contractor, Sterling Software.
Actionee: CTAS Adapt C. Marina
Actionee:
Actionee:

W/DFW basist to complete site h assessments.
99
a sector uniform rule for expert site individual or shift unique
99
adaptation minimum to XX airport configurations without consideration to the percent of airport served.
-99 → Trigger Date for Checking/Activating Contingency Plan

1999 [RRB] - Reviewed mitigation strategy. Updated actions. In addition, a common data ment template has been defined for TMA and pFAST. Further, common adaptation design s have been specified to promote reproducability and communications. 21 May 1999 [PT] - d action list. Data assessment plan is scheduled and modifications made to reduce complexity and he adaptation requirements. 14 Apr 1999 [PT] - Sterling has not completed the SCT #1 data step at this time. 23 Mar 1999 [RRB] - Risk Baselined. As of Feb. 99, Sterling has initiated first ata analysis (1) for adaptation of pFAST to SCT, ATL and MSP TRACONs. The second (2) ments analysis phase includes a set of common site attributes that need to be evaluated at each ent site. These site requirements include airport configurations supported, aircraft delineation, to runway choices, aircraft to runway priorities, defined routes, runway freeze locations and special This set of requirements categories drive the site inquiry and analysis performed by the adaptation tor with AT personnel. These data are then incorporated into a site-level adaptation requirements ation design. The design phase (3) follows, then implementation (4) and testing (5). This pFAST ion methodology has been defined based on the contractor's experience in developing DFW pFAST ion. Risk mitigation efforts during the first, data analysis phase includes providing introductory s to the sites, establishing data connectivity to the site to observe traffic patterns, on-site tion periods, and conducting questions and answer sessions.

Part 2 of 2 OPR: FFP1 Integration Management (AOZ-40) Phone: 202-233-2110

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Risk Prioritization
Discussion

- **Why is prioritization essential?**
  - To determine the risks that should be allocated resources in order to make a program successful
  - Usually more limited or constrained resources available to mitigate risks
  - Management must stay focused on those risks that pose greatest threat to program success
- **Timeframe of Risk Event Impact**
  - Emerging concept for prioritization
  - Two otherwise equally assessed risks can be differentiated by their timeframe of impact. "Sooner" has higher priority and requires more immediate attention from management than "later."
- **Tools are available that support prioritization**

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Risk Prioritization
Program Perspective

Risks can be plotted on the rating schema to provide a general perspective of program health with respect to risk

Impact Rating

Probability Rating

Description		VLO	LO	MED	HI	VHI
	Values	.05	.1	.2	.4	.8
VHI	.9	1	0	1	1	3
HI	.7	0	1	0	2	1
MED	.5	0	6	1	0	0
LO	.3	4	2	[illegible]	[illegible]	4
VLO	.1	2	1	[illegible]	3	3

Managers should focus on the upper right quadrant

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Risk Prioritization
Suggested Procedure

An example Risk List

INDEX NO	CURR RANK 3/00	PREV RANK 9/99	RISK TITLE	MANAGER	STRATEGY	CURRENT ACTIVITY	PROB	SCHED	COST	PERFORM
CTAS.02	1	4	pFAST Display Upgrades at MSP, STL, ATL	M. Knopes	Mitigate	In Progress: Research of options submitted to CTAS; Being assessed.				
XC.25	2	10	URET/TMA Dependency on Common Message Set	A. Taylor	Mitigate	On Track: Development reflowed; Numerous issues remain	↑		↑	
URET.25	3	6	URET CCLD Software Development	T. Spellerberg	Mitigate	On Track: Development reflowed; Additional Tech Transfer help provided.				
CTAS.45	4	0	CTAS Spiral 2 SW Development	M. Knopes	Mitigate	On Track: Coordination w/ CSC to facilitate work plan.	↑	↑	↑	↑
XC.17	5	12	Operational Acceptance by AT and NATCA	J. Phillips	Mitigate	In Progress: Nat'l AT User Teams actively involved	↓			
URET.26	6	0	URET CCLD Dev & Test Synch of Multiple Systems	T. Spellerberg	Mitigate	In Progress: Sync schedule being developed	↑	↑	↑	↑
XC.14	7	24	INFOSEC Requirements and Implementation	C. Holley	Mitigate	On Track: Plans written and in review. Follow up required on action items				
CTAS.14	8	26	FAA Visibility into CTAS Contractor's Efforts	M. Knopes	Mitigate	WATCH: Action Plan established, Status quarterly				
CTAS.30	9	27	CTAS Test Repeatability and Success Criteria	M. Knopes	Accept	Accept: Result of the nature of these.				
XC.23	10	15	Operational Acceptance by AF & PASS of FFP1	P. Baker	Mitigate	On Track: Nat'l team formed. FITs in development	↓		↓	
XC.26	11	1	FAA Acceptance of FFP1 Implementation Strategy	M. Gough	Mitigate	On Track: Roadshows continue with Regions	↓	↓	↓	↓
XC.04	12	28	Operational Performance Impacts Assessment	D. Knorr	Mitigate	On Track: Continuing to refine data presentations				
URET.29	13	0	Changes to Support Benefits Data Collection	T. Spellerberg	Mitigate	In Progress: Contractor report due Feb 2000	↑	↑	↑	↑
CTAS.15	14	13	TMA Operational Acceptability	M. Knopes	Mitigate	In Progress: Charter Teams developing and working action plan	↓	↓	↓	↓
XC.05	15	17	Co-location of URET-TMA Capabilities at ZTL	J. Phillips	Mitigate	On Track: Coordination team now includes ZTL		↓		↓
XC.20	16	21	Operational Safety Assessment	B.G. Smith	Mitigate	On Track: Safety Assessment initiated for all products.Process in place.	↑	↓	↓	
URET.04	17	33	URET CCLD May Be Designated As Safety-Critical	T. Spellerberg	Accept	ACCEPT: URET auto-coordination is issue		↓	↓	
CTAS.36	18	34	pFAST Benefits Dependence on Acceptable Wind Data	M. Knopes	Mitigate	In Progress: MIT/LL research submitted; Being assessed				
CTAS.07	19	7	Definition of pFAST Site Adaptation Requirements	M. Knopes	Accept	Accept: Sterling assessment complete; Scheduling activity underway.	↓			↓
URET.06	20	9	Operational Acceptance of URET CCLD	T. Spellerberg	Mitigate	On Track: Facility implementation teams are active.	↓	↓	↓	
XC.16	21	36	FFP1 Funding Requirements and Stability	G. Shapkin	Mitigate	WATCH: AOZ monitoring funding and budget requests		↓		
CTAS.35	22	40	Uncertain Operational Transition Strategy S1/B2	M. Knopes	Mitigate	In Progress: Action Plan in development				
CTAS.41	23	14	S3 Requirements Definition and Implementation	M. Knopes	Mitigate	On Track: Coordination w/CSC & Sterling; Green Team established	↓	↓		
XC.07	24	5	Clarification Needed for FFP1 Certification Req.'s	J. Thomas	Mitigate	WATCH: URET may need follow-up, Monitor	↓	↓	↓	↓
XC.09	25	11	Analysis of FFP1 Management Schedule	G. Shapkin	Mitigate	On Track: Site coordination in progress	↓	↓	↓	↓
XC.18	26	2	Gaps in User Expectations and Delivered Products	B.G. Smith	Mitigate	On Track: Completing	↓	↓	↓	↓

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Develop Management Plan
General 3-Step Process

1 **Decide the strategy**
- **Basically "Do Nothing" or "Do Something"**
- **"Accepting" a risk is a legitimate mitigation strategy, but a contingency plan should be considered**

Strategy	Strategy Description
AVOID	Change acquisition or deployment path to remove the risk completely.
MITIGATE	Take positive action to reduce probability, impact, or time frame of the risk.
WATCH	Mitigation actions complete, monitoring for effectiveness; or, contingency mitigation actions are available but not implemented pending evaluation of some program element.
ACCEPT	Take no action. Prepare a contingency plan to implement as required.
TRANSFER	Make another organization responsible for mitigating the risk.

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Develop Management Plan
General 3-Step Process

2 **Decide the approach**

- **Reduce the Probability, reduce the Impacts, or a blend of both**
- **Risks do not need to be mitigated to "0", only to an acceptable level**
- **Management needs to determine the acceptable level of risk**

Impact Rating

Probability Rating

Description		VLO	LO	MED	HI	VHI
	Values	.05	.1	.2	.4	.8
VHI	.9	<.1	[illegible]	.18	[illegible]	[illegible]
HI	.7	<.1	<.1	.14	.28	.56
MED	.5	<.1	<.1	.10	.20	.40
LO	.3	<.1	<.1	<.1	.12	.24
VLO	.1	<.1	<.1	<.1	<.1	[illegible]

● = Current Risk Exposure
→ = Mitigation Action Plan
◆ = Expected result of mitigation actions, i.e., *acceptable risk*

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Develop Management Plan
General 3-Step Process

3 **Decide specific mitigation actions**

- **Select a general mitigation activity, then detail the specific actions required to include milestone dates**

Example mitigation activities for risk group types

Risk Group	Example of Appropriate Mitigation Activities
Technical, Producibility	Analysis Modeling Simulation (without human in the loop, HITL) Lab and Field Tests
Operability, Supportability	Function, task, and procedure analysis Evaluation of part-task and laboratory prototypes HITL simulations Evaluation of fielded prototypes Operational demonstrations and evaluations
Programmatic, Management, Funding, Political	Cross-organizational consensus Guidelines, standards and recommended practices Memoranda of agreement Policy and management directives Legislative action Market and cost surveys Alternatives analyses Benefits assessments Cooperative research and development agreements Limited installation programs Streamlining certification and deregulation

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Develop Management Plan
More Thoughts

- Several acceptable mitigation plans may be possible for any given risk. Assess the characteristics of these options.
  - Mitigation plans cost program resources often at the expense of not mitigating other risks
  - There is usually a penalty to pay for delaying the start of mitigation. Accelerated or compressed mitigation can be costly.
- Mitigation plans due not have to be executed. Instead they could become contingency plans that will be executed when a triggering event is detected.
  - Triggering events are usually detected by monitoring metrics

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Evaluate Progress
Metrics and Risk Control Techniques

- **Metrics play an important role in risk management**
  - **Help identify new risks**
  - **Measure the effectiveness of mitigation actions of active risks**
  - **Flag triggering events that require activation of contingency plans**
- **Control Techniques**
  - **Effective Test & Evaluation Program:** Technical assessment labs
  - **Earned Value:** Cost/Schedule performance indicators
  - **Technical Performance Measurement**: Assesses essential performance parameters
  - **Program Metrics:** Wide array of formal periodic performance assessments for development and acquisition processes

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Evaluate Progress
Continuous Risk Management

- Effective risk management is continuous for the life of the program
  - Monitoring active risks, those with mitigation actions in progress, should be a regular management activity
- Routine monitoring of risks involves
  - Assessing environment changes that may require a risk to be reassessed. Risk exposures may have changed.
  - Effectiveness of mitigation actions and need for any adjustments
  - Program level events that may create new risk event opportunities
  - Program metrics to detect need for mitigation adjustments
- Communication is key to successful risk management
  - Actively engage and communicate risk program activity to the entire program team

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Lunch Presentation

Globalization: Implementation for Air Traffic Management

Stephen Welman
swelman@mitre.org
703-883-5280

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FAMUS Risk Management Exercise

- Walk through the risk management process to better understand the principles and methods involved.
- Identify and assess some risks in the FAMUS program using the provided tools to become familiar with their use.
- Develop risk mitigation plans for some risks to understand the concepts and principles in risk control.

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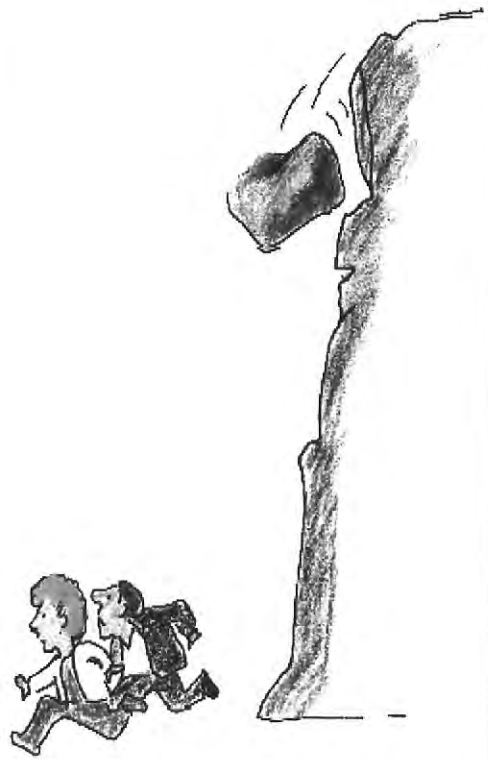
RISK MANAGEMENT EXERCISE
Tool Kit

18 June 2003

RISK
PERCEPTION

RISK
ASSESSMENT



RISK
MANAGEMENT

Risk Management Process

Step 1: Identify Risks: (Tables 1 through 3)

Risk identification involves thoroughly examining a program or product to identify and document potential issues that could impact cost, schedule or performance. Risk identification is a continuous process during the lifecycle of the program,.

Risks are classified, for identification purposes, by two factors: Risk Group and Specific Risk Type. This classification technique helps organize the findings, and later, to facilitate mitigation strategy development. These factors are shown in the following tables: .

Risk Groups

Technical	Operability	Produc-ibility	Support-ability	Programmatic	Manage-ment	Funding	Political
Adaptation Technology System Engineering System Design System Test Technical Documen-tation	User/ Operator System Operation Systems Inter-operability	Design Production Manufac-turing Parts & Materials Testing and Documen-tation	Operations & Maintenance Logistics Testing & Support Support Documen-tation System Implementa-tion	Schedule Estimations Schedule Management Cross Cutting Dependencies Benefit Identification Benefit Estimation	Planning Organiz-ation Imple-mention Control	Funding Constraint Funding Support Fiscal Manage-ment Cost Estimating Product Cost	Government-Based CAA Based Aviation Community Based

Each specific risk group has underlying risks associated with it. These risks are the result of historical program experience and represent a compilation of lessons learned. Not all risks are present in every program.

Risk Identification by Specific Risk Type

Technical Risks	Operability Risks	Producibility Risks
Adaptation • Adaptation Complexity **Technology** • Under reliance on currently unavailable or unproved technology • Possible better new technology may be available by time alternative is implemented **System Engineering** • Technically incompatible with NAS Architecture • Inadequate functional analysis • Deficient functional allocation • Incomplete integration • Undefined internal interfaces • Vague operational environment • Insufficient requirements analysis • Unstable requirements • Immature requirements • Weak Failure modes analysis • Requirements difficult to trace • Unidentified safety/security • Considerations **System Design** Inadequate capacity Highly complex • Lack of design details • Insufficient design margins • Immature design • Unsatisfactory growth potential • Undefined physical properties • Incomplete hardware design • Incomplete software design • Inadequate software tools • Difficulty of developing real-time, safety critical software • Immature software language Ineffective fault detection • Inordinate use of unique resources • Complex/incomplete CHI design • Undefined technical approach **System Test** • Inaccurate/simplistic modeling • Insufficient simulation • No or minimal prototype testing • Incomplete/inadequate test planning • Unsatisfactory OT&E results **Technical Documentation** • Inadequate design documentation • Insufficient test documentation • Ambiguous/incomplete requirements documentation Undocumented technical details	**User/Operator** • Uncertain operator requirements • Controversy over user acceptance • Increased/more complex aviation user workload • Increased/more complex FAA user workload **Excessive reliance on human reliability and performance System Operation** • Undefined external interfaces • Marginal availability • Insufficient reliability • Inadequate performance • Complex man/machine interface • Questionable usability • Unsatisfactory OT&E results **Systems Inter-operability** • Operationally incompatible with NAS Architecture • Incompatibilities with concept of operations • Insufficiently defined concept of operations • Difficult to change inter-operability characteristics if concept of operations changes • Incompatibilities with future NAS systems • Difficult to change inter-operability characteristics if other future NAS systems change • Places undue loads on other systems • Incompatible or inconsistent operation with existing systems or regulations • Unspecified operational interfaces • Marginal inter-operability	**Design Production** • Highly complex design • Undeveloped production requirements • Inadequate built-in test equipment • Non-standard remote maintenance monitoring • Novel/unproved technologies **Manufacturing** • Deficient manufacturing plan • Novel/unproved manufacturing technologies • Speculative manufacturing strategy • Custom design & manufacture required • Significant special tooling • Undefined tooling requirements • Unclear production requirements • Premature initiation of manufacturing • Unavailable or limited manufacturing facilities • Inadequate quality assurance program • Excessive standards • Unavailable equipment • Inexperienced contractor • Inadequate configuration management process • Insufficient skilled labor • Shallow industrial base **Parts & Materials** • Undefined long lead items • Unavailable gov't furnished equipment • Ineffective incoming materials handling • Unidentified hazardous materials • Unavailable parts **Testing and Documentation** • Inadequate consideration of special test equipment • Insufficient qualification testing • Deficient technical data package • Ineffective factory acceptance test program • Untested design changes

Risk Identification by Specific Risk Type (continued)

Supportability Risks	Programmatic Risks
Operations & Maintenance (O&M) • Inadequate O&M concept • Undeveloped O&M strategy • Specialized O&M equipment • Insufficient maintainability • Unsatisfactory maintenance interfaces • Inadequate maintenance procedures • Undeveloped maintenance plan • Configuration management not enforced • Deficient change process **Logistics** • Insufficient spares planning • Spares unavailability • Inaccessible site location • Inadequate training • Unclear Logistics Center responsibilities **Testing & Support** • Insufficient support equipment • Undeveloped support requirements • Inadequate automated test equipment (ATE) • Unidentified field support requirements • Poor diagnostics • Insufficient testing and support facilities • Unskilled/insufficient manpower **Support Documentation** • Deficient technical data • Faulty maintenance plan • Undefined data rights • Inappropriate release cycle **System Implementation** • Deficient implementation approach • Uncertain transition strategy • Unclear rules and procedures • Insufficient personnel/staffing • Unspecified/inappropriate standards	**Schedule Estimations** • Inadequate schedule estimation tools • Erroneous estimations, Faulty basis • Insufficient schedule margin • Optimistic schedule duration **Schedule Management** • Unsatisfactory schedule controls • Insufficient schedule monitoring • Inadequate contractor/subcontractor schedule monitoring **Cross Cutting Dependencies** • Test scheduling dependencies • Excessive task concurrency (deployment sites) • Coinciding procedures development • Coinciding regulations development • Coinciding standards development • Uncertain contractor processes • Unavailability of: parts, facilities, personnel, funds, data **Benefit Identification** • Same benefits claimed by other programs • Unidentified major benefits • Unrealistic identified benefits • Difficult to identify benefits **Benefit Estimation** • Benefits not quantifiable • Difficult to estimate benefits • Tenuous relationship to projected benefits • External forces may affect achieving benefits • Erroneous benefits estimations • Inaccurate inflation/discount rates • Speculative cost avoidance • Faulty basis of estimates • Inadequate estimating tools

Risk Identification by Specific Risk Type (concluded)

Management Risks	Funding Risks	Political Risks
Planning • Inadequate program plans • Incomplete contingency plans • Deficient risk management plans • Inadequate management approach • Unplanned slips in other programs • Adverse environmental impacts Unsubstantiated funding profile • Unsubstantiated manpower requirements • Unidentified personnel skills • Minimal resource alternatives • Excessive dependencies on other system • Unexpected acquisition regulation changes **Organizing** • Excessive span of control • Substantial integration or project activities • Inadequate authority • Undefined responsibilities • Unclear communications • Undefined integration responsibilities Ambiguous organizational interfaces • Inadequate contractor organization **Implementing** • Insufficient management tools • Inadequate program office staffing • Inadequate resource allocation • Lack of experience in managing this type of program • Lack of coordination • Tenuous top management support • Cumbersome contracting process Instability of contractor Uncertainties in procurement • Unavailable personnel • Deficient change implementation **Control** • Undefined or ineffective change management • Unsatisfactory configuration management • Insufficient contract evaluation • Large number of contractors to manage • Large number of substantial tasks to manage • Inadequate planning for contractor monitoring • Insufficient financial management • Irregular/unscheduled program reviews • Insufficient history/records • Undefined key metrics • Uncontrolled requirements changes • Requirements freeze not enforced Inadequate tracking systems	**Funding Constraint** • Unfavorable agency priorities • Inadequate funding • Unavailable funding • Lengthy budget cycle • Inadequate budget marks **Funding Support** • Inadequate user support • Ambiguous operator support • Unclear political support • Marginal cost/benefits • Inconsistent plans **Fiscal Management** • Insufficient funding requirements • Insufficient fiscal controls • Insufficient fiscal tools • Insufficient funding plans • Unrealistic funding profile **Cost Estimating** • Faulty basis for costing • Estimation errors • Insufficient margins • Inadequate resourcing • Undefined requirements **Product Cost** • Inadequate budget for hardware • Undefined HW/SW costs	**Governemnt- Based** • Impact of congressional mandates • Unfavorable congressional hearings on program • Critical government reports **CAA- Based** • Conflicting priorities • Many internal stakeholders • Diverse organizational needs • Conflicting organizational needs • Conflicting organizational priorities **Aviation Community Based** • Many different stakeholders • Diverse user community • Conflicting user demands • Conflicting user opinions • Conflicting user priorities • Inordinate pressure from user groups • Marginal user support • Strained relationships with users • Resistance to avionics equipage requirements • Inordinate media attention • Labor union concerns

Additional risk identification assistance is available by using the risk cue data shown below. These risk cues were developed from the analysis of many projects and represent specific examples of conditions that lead to low, moderate, or high risks to programs.

If the conditions shown in this table exist, they should be used as a guide for further analysis of the risk. Use the assessment tables described in these guidelines to determine specific probability and impacts of the risk.

Cues for Specific Risk Types

	Risk Types	Low Risk Cues	Medium Risk Cues	High Risk Cues
1	Project fit to Customer Organization	Directly supports customer organization mission and goals	Indirectly impacts one or more goals of customer	Does not support or relate to customer organization mission or goals
2	Project fit to provider Organization	Directly supports provider organization mission and goals	Indirectly impacts one or more goals of provider	Not support
3	Customer perception	Customer expects this organization to provide this product	Organization is working on project not expected by customer	Project is mismatch with prior products or services of this organization
4	Work flow	Little or no change to work flow	Will change some aspect or have small impact on work flow	Significantly change the work flow or method of organization
5	Goals conflict	Goals of projects are supportive of or complimentary to each other	Goals of projects do not conflict but provide little direct support	Goals of projects are in conflict, either directly or indirectly
6	Resource conflict	Projects within the program share resources without any conflict	Projects within the program schedule resources without any conflict	Projects within the program often need the same resources at the same time (or compete for the same budget)
7	Customer conflict	Multiple customers of the program have common needs	Multiple customers of the program have different needs, but do not conflict	Multiple customers of the program are trying to drive it in different directions
8	Directorship	Program has active major project director who coordinates projects	Program has person or team responsible for the program, but unable to spend enough time to lead effectively	Program has no director or major project director concept is not in use
9	Major project director experience	Major project director has deep experience in the domain	Major project director has some experience in the domain, is able to leverage subject experts	Major project director is new to the domain
10	Definition of the program	Program is well-defined, with a scope that is manageable by the organization	Program is well-defined but unlikely to be handled by this organization	Program is not well defined or carries conflicting objectives in the scope

Cues for Specific Risk Types (continued)

	Risk Type	Low Risk Cues	Medium Risk Cues	High Risk Cues
11	Political Issues	No particular politically-driven choices being made	Project has several politically motivated decisions, such as using a vendor selected for political reasons, rather than qualifications	Project has a variety of political influences or most decisions are made behind closed doors
12	Convenient date	Date for delivery has been set by reasonable project commitment process	Date is being partially driven by external influences or other mandate not related to technical estimate	Date is totally driven by external influences or other mandate; little consideration of project team estimates
13	Use of Attractive Technology	Technology selected has been in use for some time	Project is being done in sub-optimal way to leverage the purchase or development of new technology	Project is being done as a way to show a new technology or as an excuse to bring new technology into the organization
14	Short term solution	Project meets short term need without serious compromise to long-term outlook	Project focussed on short-term solution to a problem with little understanding of what is needed in the long term	Project has been explicitly directed to ignore the long term outlook and focus thee short term deliverable
15	Organizational stability	Little or no change in management or structure expected	Some management change or reorganization expected	Management or organization structure is continually or rapidly changing
16	Organizational roles and responsibilities	Individuals throughout the organization understand their roles and responsibilities and those of others	Individuals understand their roles and responsibilities, but are unsure who is responsible for work outside their immediate group	Many in the organization are unsure or unaware of who is responsible for many activities of the organization
17	Policies and standards	Development policies and standards are defined and carefully followed	Development policies and standards are in place, bur are weak or nor carefully followed	No policies or standards, or they are ill-defined and unused
18	Management support	Strongly committed to success of project	Some commitment, but not total	Little or no support
19	Executive involvement	Visible and strong support	Occasional support, provides help on issues when requested	No visible support; no help on unresolved issues
20	Project Objectives	Verifiable project objectives, reasonable requirements	Some project objectives, measures may be questionable	No established project objectives or objectives are not measurable
21	User involvement	Users highly involved with project team, provides significant input	Users play minor roles, moderate impact on system	Minimal or no user involvement; little user input
22	User experience	Users highly experienced in similar projects; have specific ideas of how needs can be met	Users have experience with similar projects and have needs in mind	Users have no previous experience with similar projects; unsure of how needs can be met

Cues for Specific Risk Types (continued)

	Risk Type	Low Risk Cues	Medium Risk Cues	High Risk Cues
23	User acceptance	Users accept concepts and details of system; process in place for user approvals	Users accept most of concepts and details of system; process in place for user approvals	Users do not accept any concepts or design details of system
24	User training needs	User training needs considered; training in progress or plan in place	User training needs considered; no training yet or training plan is in development	Requirements not identified or not addressed
25	User justification	User justification complete, accurate, sound	User justification provided, complete with some questions about applicability	No satisfactory justification for system
26	Project size	Small, non-complex, or easily decomposed	Medium, moderate complexity, decomposable	Large, highly complex, or not decomposable
27	Reusable components	Components available are compatible with approach	Components available, but need some revision	Components identified, need serious modification for use
28	Supplied components	Components available and directly usable	Components work under most circumstances	Components known to fail in certain cases, likely to be late, or incompatible with parts of approach
29	Budget size	Sufficient budget allocated	Questionable budget allocated	Doubtful budget is sufficient
30	Budget constraints	Funds allocated without constraints	Some questions about availability of funds	Allocation in doubt or subject to change without notice
31	Cost controls	Well established, in place	System in place, weak in areas	System lacking or nonexistent
32	Delivery commitment	Stable commitment dates	Some uncertain commitments	Unstable fluctuating commitments
33	Development schedule	Team agrees that schedule is acceptable and can be met	Team finds one phase of the plan to have a schedule that is too aggressive	Team agrees that two or more phases of schedule are unlikely to be met
34	Requirements stability	Little or no change expected to approved set (baseline)	Some change expected against approved set	Rapidly changing or no agreed-on baseline
35	Requirements completeness and clarity	All completely specified and clearly written	Some requirements incomplete or unclear	Some requirements only in the head of the customer
36	Testability	Product requirements easy to test, plans underway	Parts of product hard to test, or minimal planning being done	Most of product hard to test, or no test plans being made
37	Design difficulty	Well defined interfaces; design well understood	unclear how design, or aspects of design yet to be decided	Interfaces not well defined or controlled; subject to change
38	Implementation difficulty	Content is reasonable for this team to implement	Content has elements somewhat difficult for this team to implement	Content has components this team will find very difficult to implement

Cues for Specific Risk Types (continued)

	Risk Type	Low Risk Cues	Medium Risk Cues	High Risk Cues
39	System dependencies	Clearly defined dependencies of the project and other parts of the system	Some elements of the system are well understood and planned; others are not yet comprehended	No clear plan or schedule for how the whole system will come together
40	Response or other Performance factors	Readily fits boundaries needed; analysis has been done	Operates occasionally at the boundary	Operates continuously at boundary levels
41	Customer service impact	Requires little change to customer service	Requires minor change to customer service	Requires major changes to customer service approach or offering
43	Pilot approach	Pilot site (or team) available and interested in participating	Pilot needs to be done with several sites (who are willing) or with one who needs much help	Only available pilot sites are uncooperative or in crisis mode already
44	Alternatives analysis	Analysis of alternatives complete, all considered assumptions verifiable	Analysis of alternatives complete, some assumptions questionable or alternatives not fully considered	Analysis not completed, not all alternatives considered, or assumptions faulty
45	Commitment process	Changes to commitments in scope, content schedule are reviewed and approved by all involved	Changes to commitments are communicated to all involved	Changes to commitments are made without review or involvement of the team
46	Quality assurance approach	QA system established, followed, effective	Procedures established, but not well followed or effective	No QA process or established procedures
47	Development documentation	Correct and available	Some deficiencies, but available	Nonexistent
48	Use of defined Development process	Development process in place, established, effective, followed by team	Process established, but not followed or is ineffective	No formal process used
49	Early Identification of defects	Peer reviews are incorporated throughout	Peer reviews are used sporadically	Team expects to find all defects with testing
50	Defect tracking	Defect tracking defined, consistent, effective	Defect tracking process defined, but inconsistently used	No procedure in place to track defects
51	Change control for work products	Formal change control process in place, followed, effective	Change control process in place, not followed or is ineffective	No change control process used
52	Physical facilities	Little or no modification needed	Some modifications needed; some existent	Major modifications needed, or facilities nonexistent
53	Tool availability	In place, documented, validated	Available, validated, some development needed (or minimal documentation)	Not validated, propriety, or major development needed; no documentation

Cues for Specific Risk Types (continued)

	Risk Type	Low Risk Cues	Medium Risk Cues	High Risk Cues
54	Vendor support	Complete support at reasonable price and in needed time frame	Adequate support at contracted price, reasonable response time	Little or no support, high cost, and/or poor response time
55	Contract fit	Contract with customer has good terms, communications with team is good	Contract has some issues which could interrupt team work efforts	Contract has burdensome document requirements or causes extra work to comply
56	Disaster recovery	All areas following security guidelines; data backed up; disaster recovery system in place; procedures followed	Some security measures in place; backups done; disaster recovery considered, but procedures lacking or not followed	No security measures in place; backup lacking; disaster recovery not considered
57	PM approach	Product and process planning and monitoring in place	Planning and monitoring need enhancement	Weak or nonexistent planning and monitoring
58	PM experience	PM very experienced with similar projects	PM has moderate experience with different types of projects	PM has no experience with this type of project or is new to project management
59	PM authority		Has line management or official authority that enables project directorship effectiveness	Has little authority from location in the organization structure and little power to influence decision making resources
60	Support of the PM	Complete support by team and of management	Support by most of team, with some reservations	No visible support; manager in name only
61	Team member availability	In place, little turnover expected; few interrupts for fire fighting	Available, some turnover expected; some fire fighting	High turnover, not available; team spends most of time fighting fires
62	Mix of team skills	Good mix of disciplines	Some disciplines inadequately represented	Some disciplines not represented
63	Team communication	Clearly communicates goals and status between the team and rest of organization	Team communicates some of the information some of the time	Rarely communicates clearly within the team or to others who need to be informed
64	Application engineers	Extensive experience in team with projects like this	Some experience with similar projects	Little or no experience with similar projects
65	Experience with Application Area (Domain)	High experience	Average experience	Low experience
66	Experience with project tools	High experience	Average experience	Low experience
67	Experience with project process	High experience	Average experience	Low experience
68	Training of team	Training plan in place, training ongoing	Training for some areas not available or training planned for the future	No training plan or training not readily available

Cues for Specific Risk Types (continued)

	Risk Type	Low Risk Cues	Medium Risk Cues	High Risk Cues
69	Team spirit and attitude	Strongly committed to success of project; cooperative	Willing to do what it takes to get the job done	Little or no commitment to the project; not a cohesive team
70	Team productivity	All milestones met, deliverables on time, productivity high	Milestones met, some delays in deliverables, productivity acceptable	Productivity low, milestones not met, delays in deliverables
71	Technology match to project	Technology planned for project is good match to customers and problem	Some of the planned technology is not well suited to the problem or customer	Selected technology is a poor match to the problem or customer
72	Technology experience of team	Good level of experience with technology	Some experience with the technology	No experience with the technology
73	Availability of technology expertise	Technology experts readily available	Experts available elsewhere in organization	Will need to acquire help from outside organization
74	Maturity of technology	Technology has been in use in the industry for quite a while	Technology is well understood in the industry	Technology is leading edge, if not "bleeding edge" in nature
75	Design complexity	Easily maintained	Certain aspects difficult to maintain	Extremely difficult to maintain
76	Support personnel	In place, experienced, sufficient in number	Missing some areas of expertise	Significant discipline or expertise missing
77	Vendor support	Complete support at reasonable price and in the needed time frame	Adequate support at contracted price, reasonable response time	Little or no support, high cost, and/or poor response time

Step 2: Analyze Risks:

From a program management perspective, *risk* is a measure of a program's inability to achieve its objectives within predefined constraints. These constraints include *cost, schedule*, and *technical and operational performance* objectives.

Risk analysis is supported by use of *Probability* (P), *Impact* (I), and *Time Frame* (T) assessments as shown in Tables that follow.

Probability assessment (P)

Probability assessment (P) is the first step in assessing a risk.

Four basic components characterize probability assessment:

1. Maturity,
2. Complexity,
3. Dependency,
4. Stability.

Characterizing the Probability Rating (P)

VALUE	MATURITY	COMPLEXITY	DEPENDENCY	STABILITY
HIGH	State-of-the art, New Technology, Significant R&D hurdles, significant design and engineering required before use	Extremely, or significantly complex relative to existing environment	Depends on finding the solution from external organizations or on using new ideas from outside the organization	External factors drive constant changes because there are no established requirements baseline, or because external factors will make changes but the baseline is in development
MOD-ERATE	Technology available but requires major changes before use	Moderately complex relative to existing environment	Depends on modifications to existing factors or supply from outside organization	External factors will make major changes to established baseline
LOW	Technology exists but requires minor changes before use or it can be used "as is"	Minor complexity relative to existing environment	Depends on existing product supplied from outside the organization or is within program control.	External factors may make minor changes to established baseline

Generic Probability (P) Guidelines by Risk Group

Risk Group	LOW Probability	MODERATE Probability	HIGH Probability
Technical	Design is mature. Technology within state-of-the-art or off the shelf. Performance specifications are known.	Design is in development or prototype phases. Technology prototype or engineering model tested in relevant environment but not operated in fielded environment.	Design unknown. Approach to meet requirements carried only through conceptual design and analysis. Technology is only concept or experimental.
Operability	NAS or other interfaces are known and documented. Design approaches for the operational concept have been demonstrated or implemented. Will impact a few procedures but operational implementation is expected to be successful.	NAS or other interfaces somewhat known and partially documented. Operational concept has evolved to the point of a design baseline. Impacts are likely to several procedures, which may cause operational implementation to be unsuccessful.	NAS or other interfaces not fully known or documented. Operational concept or implementation of concept has yet to be established. Significant impacts are likely to procedures, which would cause operational implementation to be unsuccessful.
Producibility	Manufacturing and production capabilities known and available.	Manufacturing or production capabilities in state of change.	Manufacturing and production capabilities not known or unavailable.
Supportability	Similar items have been fielded & are currently being supported, or similar items have been demonstrated to be supportable during field-testing. Only minor changes to existing support technologies or procedures will be required. Transition of support to AF will be straightforward.	Items similar in concept have been supported as fielded systems or supported during test. Substantial modifications may be required to existing support technologies or procedures and transition of support to AF may be difficult.	New support technologies and procedures or substantial modifications to existing support technologies or procedures will be required which could prevent suitable transition of support to AF.
Programmatic	Benefits understood and based on or extrapolated from similar items in operation. Definition required for estimation is adequate. Direct relationship of alternative to benefits. Little likelihood of external forces affecting the achievement of the benefits.	Benefits not certain, but scope/definition required for estimation is adequate; slightly tenuous relationship of alternative to projected benefits; or possible external forces may have some affect on achieving benefits.	Major uncertainties exist related to benefit estimation; extremely tenuous relationship of alternative to projected benefits; or high likelihood external forces will affect achieving benefits.
Management, Funding, Political	Management, funding and stakeholder facets and environments known and stable.	Management, funding and stakeholder facets and environments in state of change but somewhat known.	Management, funding, and stakeholder facets and environments not known or unstable.

Impact assessment (I)

Impact assessment (I) is the second step in assessing a risk. It evaluates three factors for each risk :

1. Cost (Costing/Budget Baseline)
2. Schedule (Integrated Product and Site Deployment Schedules Baseline)
3. Technical and Operational Performance

Generic Impact Rating (I) Guidelines by Risk Group

Risk Group	VERY LOW & LOW Impact	MODERATE Impact	HIGH & VERY HIGH Impact
Technical	Performance and problem data indicate that only minor hardware/software design changes will be needed to meet full performance objectives.	Performance or problem data indicate that with current alternative design margins full performance objectives will only be met by: (1) significant modification to a design of a component or subsystem; or (2) reallocation of design margins among subsystems.	Performance or problem data indicate that with current alternative design margins, full performance would not be met and alternate systems are not available.
Operability	Technical operationally suitable solution is identified and readily available. Will impact a few procedures but operational implementation is expected to be successful.	Technical operationally suitable solutions partially identified. The solution is not readily available or will have significant impacts on the overall system performance. Will impact several procedures and may cause operational implementation to be only partially successful.	No operationally suitable solutions available without major impacts on the overall system performance. Will cause significant impact to existing procedures, which could cause operational implementation to be unsuccessful.
Producibility	Manufacturing and production capabilities known and available.	Manufacturing or production capabilities in state of change, and some uncertainty exists about when capabilities will be available.	Manufacturing and production capabilities not known or unavailable.
Supportability	System design characteristics & planned logistics and software support resources meet nearly all system utilization requirements. Only minor support procedures or technologies will be impacted, and transition of support to CAA highly likely to be successful.	System design characteristics & planned logistics and software support resources meet some but not all system utilization requirements. Some support procedures or technologies will be impacted and transition of support to CAA may be difficult.	System design characteristics & planned logistics and software support resources do not meet system utilization requirements. Support procedures or technologies will be significantly impacted and could prevent suitable transition of support to CAA.
Programmatic	At least 90% of the estimated benefits are expected to be achieved.	75 – 90% of the estimated benefits are expected to be achieved.	Less than 75% of the estimated benefits are expected to be achieved.
Management, Funding, Political	Insignificant impacts likely on management, funding, and stakeholder capabilities and support for which minor adjustments will be required.	Moderate impacts likely on management, funding, and stakeholder capabilities and support for which major adjustments will be required but will be doable.	Significant impacts likely on management, funding, and stakeholder capabilities and support for which adjustments cannot be made for all impacts.

Impact Guidelines

Nominal Value	Nominal Description	Code	Subjective Description
.8	Critical	VHI	Would cause program failure; Would not achieve minimum acceptable requirements
.4	Serious	HI	Would cause major cost/schedule increases; Would not achieve secondary benefits
.2	Moderate	MED	Would cause moderate cost/schedule increases; Important requirements can be achieved
.1	Minor	LO	Would cause only small cost/schedule increases; All requirements can be met with exception of few minor secondary requirements
.05	Negligible	VLO	May require that program reserves be exercised (schedule slack or budget reserves), but all requirements are met without exception

Example of Expanded/Detailed Impact Rating (I)

Nominal Value	Nominal Description	Nominal Cost Description	Nominal Schedule Description	Nominal Performance Description
.8	Critical	Increase > 15%	Slip >12 months	Would not achieve minimum acceptable requirements
.4	Serious	Increase > 10% < 15%	Slip > 6-12 months	Would not achieve secondary performance requirements
.2	Moderate	Increase > 5%, < 10%	Slip 3-6 months	Most important requirements can be achieved. Would not achieve secondary performance requirements.
.1	Minor	Increase < 5%	Slip 1-3 months	All requirements can be met with exception of few minor secondary requirements
.05	Negligible	Increase Manageable	Slip Manageable	All requirements are met without exception

Time Frame Guidelines

The **Time Frame assessment** is the third step in assessing a risk.

Guidelines for Time Frame Ratings

Rating	Definition
Short (Short-term)	A risk is short-term if it will occur in the next 30 days.
Medium (Medium-term)	A risk is medium-term if it occurs in the next 31 to 60 days.
Long (Long-term)	A risk is long-term if it occurs beyond the next 61 days.

Risk Prioritization:

Step 4: Develop Management Plans:

The general process for deciding risk mitigation is to:

1. ***Decide the strategy.*** This is based largely on the assessed risk score which determines a risk's priority.
2. ***Decide the approach.*** This is based on the individual assessments of probability, impact, and time frame.
3. ***Decide the mitigation actions.*** This will take into account several factors to include resources available, the need date for resolution, and most importantly, what is the acceptable level of risk exposure.

Together, the strategy, approach and actions form the ***mitigation action plan*** for the risk.

Impact Rating

Probability Rating	*Description*		VLO	LO	MED	HI	VHI
		Values	.05	.1	.2	.4	.8
	VHI	.9	<.1	<.1	.18	.36	.72
	HI	.7	<.1	<.1	.14	.28	.56
	MED	.5	<.1	<.1	.10	.20	.40
	LO	.3	<.1	<.1	<.1	.12	.24
	VLO	.1	<.1	<.1	<.1	<.1	<.1

RE = 30-99%	**Critical Program Risk**	**RED**
RE = 1-29%	**Significant Program Risk**	**YELLOW**
RE = < 1%	**Minimum Program Risk**	**GREEN**
RE = 0	**Mitigation Actions Complete**	**BLUE**

Deciding the Mitigation Strategy

Risk Mitigation Strategies

Mitigation Strategy	Strategy Description
AVOID	Change acquisition or deployment path to remove the risk completely.
MITIGATE	Take positive action to reduce probability, impact, or time frame of the risk.
WATCH	Mitigation actions complete, monitoring for effectiveness; or, contingency mitigation actions are available but not implemented pending evaluation of some program element.
ACCEPT	Take no action. Prepare a contingency plan to implement as required.
TRANSFER	Make another organization responsible for mitigating the risk.

Deciding the Mitigation Approach

1. Focus on ***reducing the probability*** of the risk,
2. Focus on ***reducing the impacts*** of the risk,
3. Focus on ***extending the time frame*** of the risk, or a
4. ***Combination of both reducing the probability and reducing the impacts.***

Deciding the Mitigation Actions

Example Risk Mitigation Activities by Risk Group

Risk Group	Example of Appropriate Mitigation Activities
Technical, Producibility	Analysis Modeling Simulation (without human in the loop, HITL) Lab and Field Tests
Operability, Supportability	Function, task, and procedure analysis Evaluation of part-task and laboratory prototypes HITL simulations Evaluation of fielded prototypes Operational demonstrations and evaluations
Programmatic, Management, Funding, Political	Cross-organizational consensus Guidelines, standards and recommended practices Memoranda of agreement Policy and management directives Legislative action Market and cost surveys Alternatives analyses Benefits assessments Cooperative research and development agreements Limited installation programs Streamlining certification and deregulation

Risk Manager's Guide to Developing an Effective Risk Mitigation Action Plan

1. **COLLECT DATA:**
   a. **Understand the risk & the principal risk drivers(s)** – cost/schedule/performance
   b. **Schedule factors involved** – milestones, dependencies, available slip
   c. **Assess constraints** - resource limitations and reserves ($$, time, political concerns)
   d. **Others involved** – people, organizations, support teams, etc.
   e. **Talk to Product Team Manager as required** – keep Product Team Lead (PTL) involved and informed in this process.

2. **ANALYZE ACCEPTABLE MITIGATION STRATEGIES AND APPROACHES:**
   a. **Strategies** – AVOID, TRANSFER, ACCEPT, MITIGATE, WATCH
   b. **Approaches** – Reduce the Probability of Occurrence and/or Reduce the Impacts, or extend the Time Frame
   c. **Considerations** – What level is necessary; how far to "reduce"; what can you "live with"
   d. **Others that need to be involved** – who/what can help facilitate the plan

3. **DEVELOP THE ACTION PLAN:**
   a. **Develop Options** – Consider alternative actions and scenarios
   b. **Evaluate Options** – Based on expected effectiveness, cost of mitigation, schedule constraints, other management reserve limitations
   c. **Decide Start Dates and Completion Dates** – Line it up with affected milestones, allow time for some contingency action. What is/are the critical path Risks?
   d. **Metrics and Measurement** – Decide how and what will be used to measure effectiveness of the action plans. Establish "Trigger Dates" for checking these measurements.
   e. **Develop Contingency Plan(s)** – If the first choice of action plan(s) is non-effective, these contingency plans will be used as next course of action. They may come from the "pool" of original options, initially rejected perhaps as being too complex or requiring too many resources.

4. **DOCUMENT AND MONITOR THE PLAN:**
   a. **Document** - record proposed plans
   b. **Admin Requirements** - Inform the Administrative Risk Coordinator to review the risk database entry.
   c. **Monitor the Plan** – Monitor Trigger Dates. Use the Metrics and Measurements items to check effectiveness. Keep the RM Team informed of status and any concerns.
   d. **RM Team Involvement** - Status of Action Plans will be briefed to the Project Management Team

5. **TOOLS AVAILABLE:**
   a. **Risk Assessment Guidelines pamphlet.** Short section on Risk Mitigation that discusses the basic strategies and example mitigation activities.
   b. **Risk Mitigation Action Plan templates.** Microsoft WORD templates that provide assistance in collecting and documenting pertinent data to support action plan development.
   c. **Schedules.** The Project Management Schedule depicts appropriate milestones for the project.
   d. **Risk Management Team**. The Project RM Team will provide action plan development support as needed.

Successful Risk Mitigation Strategies

Mitigation Strategy	Risk Area	Description of the Strategy
Evolutionary Spiral Development	Software Development	Development process in which major software projects are broken down into smaller packages of functionality that can be built, tested, and integrated into the system with greater effectiveness. Effectively mitigates cost, schedule, and performance risks.
Specialized Metrics and Reporting	Software Development	Used to provide greater insight into software production contractors productivity and earlier detection of potential issues. Effectively mitigates schedule risks.
Tech Transfer Support	Software Development	Active coordination between the developer and production contractor. Supports software development and effectively mitigates schedule and technical performance risks.
Field Evaluation Prototype	Software Development, Requirements Validation, Operational Acceptance	Used to evaluate early software spirals, support requirements definition, and gain early user operational acceptance of a capability. It can be effectively used to support procedures development and assess training requirements as well as gain some insight into operational impact assessment requirements.
Operations and Maintenance User Teams	Requirements Validation, Operational Acceptance	Capability specific Operations and Maintenance User Teams are an effective mitigation strategy to ensure operational acceptance and validate requirements. Separate Ops and Maint. Teams lead the efforts to develop procedures, training, and maintenance processes that support implementation. They interact directly with System Integration Management functions and Facility Implementation Team (FIT').
FIT Teams	Operational Acceptance	Facility Implementation Team (FIT'), comprised of facility stakeholders, helps to effectively mitigate operational acceptance risks and management deployment bandwidth issues at the facility.
Integrated Program Management Schedule	Deployment Bandwidth	An integrated schedule will help identify all known schedule influences that may affect implementation. The schedule effectively mitigates dependency issues as well as other schedule pressure risks. Inputs include Facilities, Dependencies, Airspace reviews, and other intersecting activity.
Human Factors Review Board	Operational Acceptance, Requirements Validation,	Used to effectively identify, assess, and respond to any human factors related risk. Provides specialized expertise for immediate mitigation planning.
Risk Review Board	Risk Mitigation	Used to effectively identify and analyze risk, then provide analysis of proposed mitigation strategies and monitoring of mitigation effectiveness.
Safety Working Group	Operational Acceptance, Risk Mitigation	Used to effectively identify and analyze operational safety hazards, and provide expert guidance on proposed mitigation activities. Effectively supports acceptance of operational capabilities.
Technical "Tiger Team"	Operational Acceptance, Test and Evaluation	Used to assess and analyze risks unique to the test and validation processes during any test activity such as Factory Acceptance or Site Acceptance. Helps mitigate interoperability and non-interference testing requirements as well as better define an acceptable test strategy for planned capabilities.

RISK RECORD

Risk ID:

Data Ver: 0.0 *Date*

Priority:

Risk Title:

Manager: **Phone:** ***E-Mail***

1. RISK STATEMENT:

2. RISK BACKGROUND INFORMATION:

3. RISK PROBABILITY AND IMPACT ASSESSMENT:

Event Probability Analysis	
Schedule Impact Analysis	
Cost Impact Analysis	
Performance Impact Analysis	

General Status/ Comments:

Risk Control Plan Worksheet

RISK CONTROL PLAN WORKSHEET			
Tracking Number	Date	Risk Manager's Name	Phone
Risk Control Strategy:			

RISK PLANNING

Strategy:
- ☐ Avoid
- ☐ Transfer
- ☐ Mitigate
- ☐ Accept
- ☐ Merge to _____

Schedule: Affected Milestones:

Known Constraints:

Mitigation Performance Metrics:

Action 1:

Start Date: _____ **Actionee/POC/Office:** _____ / _____

Action 2:

Start Date: _____ **Actionee/POC/Office:** _____ / _____

Action 3:

Start Date: _____ **Actionee/POC/Office:** _____ / _____

RISK MITIGATION TRACKING & CONTROL

Review Date	Comments:

COORDINATION

Product Team Approval:	RRB Reviewed:	RA Team for Updating:	Risk DBMS Update:
Date	Date	Date	Date

MITRE Facilities and Lab Tour
Tender Management

Thursday June 19, 2003

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Thursday June 19, 2003

Agenda

- PIU Open Discussions
- MITRE Facilities and Lab Tour
- Project Tender Management
- Seminar Exercise—FAMUS Tender Management

Lunch Demonstration: Integrated DSS
Afternoon Demonstration: Airport Visualization

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Lunch Presentation

Integrated DSS

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Tender Management

- Major phases of procurement or tender management
  - Procurement planning
  - Tender planning
  - Invitation for Tender (including Tender Process)
  - Tender evaluation and contract award
  - Contract administration
  - Contract closeout

EBRD Goals: efficiency, economy, equal opportunity, and transparency.

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Tender Management
Procurement Planning

- Procurement planning is key to EBRD approval and successful implementation. Project Delivery Strategy (PDS) outlines key strategy decisions:
  - Background, objectives, statement of need, and required performance
  - Budget and funding arrangements
  - Procurement process (Open tendering, two-stage tendering, selective tendering, single tendering, shopping, local competitive tendering)
- Procurement Plan documents contracting arrangements and risks:
  - Contract type
  - Major risks
  - Potential sources and methods to ensure competition
  - Source selection procedures including evaluation criteria and milestones
  - Logistics and security considerations
  - Contract administration framework

Once the overall strategy is developed and agreed upon, SMATCA must manage the project as its own.

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Tender Management
Procurement Planning--continued

- Contract Type
  - Cost Reimbursable--
    - Contractor is reimbursed for all allowable costs. High cost risk to buyer (cost for unplanned or underestimated effort paid by the buyer).
    - Buyer is purchasing the best efforts of the contractor to deliver goods and services.
  - Fixed Price--
    - Contractor is paid a fixed price for delivering products or services. High cost risk to seller (cost for unplanned or underestimated effort paid by the seller).
    - Buyer is purchasing the delivery of goods and services.

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Tender Management
Procurement Planning--continued

- Incentives--used to motivate contractor. Can be used with Cost Reimbursable and Fixed Price contracts.
  - Incentive Fee--fee adjusted by formula based on relationship between target and actual costs
  - Award Fee--fee based on evaluation of contractor performance (cost, schedule, technical).

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Tender Management

Tender Planning

- Preparing and obtaining internal approval of Tender Documents.
- Obtaining EBRD "no objection" to planning and specific Tender Documents.
- Tender Documents include the following:

  Volume I: The Tender
  Volume II: The Contract
  Volume II: The Requirements

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Tender Management

Tender Planning--continued

Volume I: The Tender

Invitation for Tender

i--Instructions to Tenderers

(Cannot be changed. Includes details on evaluation process)

ii--Tender Data

(Procurement specific information and Tender Evaluation Factors)

iii--Tender Form-1st stage

iv--Tender Form-2nd stage

v -- Tender Security Form

vi--Manufacturer Authorization Form

vii--Letter of Acceptance

viii--Price Schedules

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Tender Management

Tender Planning--continued

Volume II: The Contract

- i--General Conditions of Contract
  - (Can not be changed.)
- ii--Specific Conditions of Contract
  - (Procurement specific information)
- iii--Form of Contract Agreement (with Appendices)
- iv--Performance Security Form
- v--Bank Guarantee Form for Advance Payment
- vi--Form of Completion Certificate
- vii--Form of Operational Acceptance Certificate
- viii--Change Order Procedures
- Annexes

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Tender Management

Tender Planning--continued

Volume III: The Requirements

i--Specifications

ii--Drawings

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Tender Management
Tender Planning--concluded

- Tender Evaluation Criteria should meet the following constraints (per EBRD documentation):
  - The factor could have an impact on contract performance (including the rights and obligations of the Employer and the Contractor in terms of contract time, quality (including technical performance) and risk.
  - The impact on performance resulting from factor variations can be reasonably quantified in a reliable, fair, and objective manner.
- Tender Evaluation Criteria must:
  - Represent the important areas of emphasis to be considered during the evaluation.
  - Support meaningful comparison and discrimination.

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Tender Management
Invitation for Tender

- Invitation for Tender documents may be sent to only pre-qualified tenderers.
- The following potential tender process techniques may be used:
  - Pre-Proposal Conference
  - Questions and Answer Amendment
  - Oral Presentations
  - Site Visits
  - Past Performance Inquiries

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Tender Management

Tender Evaluation and Contract Award

- A Source Selection Plan must be developed documenting the following:
  - Source Selection Organization and Evaluation Process
  - Source selection standards
  - Source selection documentation requirements
  - Administrative logistics and requirements, including restrictions on exchanges with tenderers
  - Training and security information
- The source selection process should be kept confidential.

Source selection must be conducted in accordance with the Source Selection Plan.

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Tender Evaluation and Contract Award--concluded

- Evaluation process outlined by EBRD:
  - Receipt and public opening of tenders
  - Examination of tenders
  - Seeking written clarifications from tenderers
  - Rejection of tenders that are not substantially responsive
  - Evaluation and comparison of substantially responsive tenders
  - Determination of the lowest evaluated tender
  - Post-qualification of the lowest evaluated tender
  - Award recommendation
  - Development of Tender Evaluation Report
  - Notification of award

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Tender Management
Contract Administration

- Process of ensuring that contract performance meets contract requirements.
- Project team performs the following tasks:
  - Monitors and reviews work results (deliverables, scope compliance, standards, costs, schedule).
  - Reports on contract performance to appropriate stakeholders.
  - Processes invoices to facilitate timely payment.
  - Reviews change requests for approval or disapproval.

Extremely important that project team be aware of any legal implications of actions or non-actions taken by both parties.

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Tender Management

Contract Closeout

- Process of determining the work was successfully completed (acceptance), processing the final invoice, and creating the contract file (indexed project records and documents).
- Procurement Audits are conducted to review the process from procurement planning through closeout to identify successes and failures.

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Seminar Exercise
FAMUS Tender Management

- Outline Tender Strategy
- Develop High Level Evaluation Criteria

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Afternoon Demonstration

Airport Visualization

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Communication Management, Cost Management, and Project Control

Friday June 20, 2003

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Friday June 20, 2003
Agenda

- Communication Management
- Cost Management
- Project Control
- Session 1 Wrap Up

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Communication Management

- "Processes required to ensure timely and appropriate generation, collection, dissemination, storage, and disposition of project information" PMBOK 2000
- Processes include the following:
  - –Communication Planning
  - –Information Distribution
  - –Performance Monitoring
- Performance Monitoring and Information Distribution will be discussed in Session 2 in Belgrade.

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Communication Management
Communication Planning

- From Monday's discussion:
  - Communication planning--Determining the information and communication needs of stakeholders (who needs what information, when they need the information, how will the information be delivered, and who will deliver the information).

- Communication Planning Process includes the following:
  - Identify stakeholders.
  - Perform needs assessments.
  - Establish communication goals and objectives.
  - Establish communication activities.
  - Develop activities to measure success of communication activities.

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Communication Management

Communication Planning--continued

After the initial analysis of stakeholder needs, the Project Team develops a Communication Plan to document the following:

Section		Purpose
Section 1:	Introduction	Describes the purpose, scope, related documents, and organization of this document.
Section 2:	Communication Process	Presents the communication process.
Section 3:	Communications Goals and Objectives	Defines specific communication goals and objectives to successfully complete the FAMUS project.
Section 4:	Communications	Describes the communications activities for informing and educating stakeholders.
Section 5:	Performance Measures	Discusses development of performance measures for assessing communications efforts.

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Communication Management
Communication Planning--continued

Example Communication Goals, Objectives, Activities

Goal 1: Build and sustain SMATCA staff support to promote acceptance of modernized systems and equipment.

Objectives:

SMATCA staff has an understanding of the FAMUS objectives and what parts of their business will change and what parts will not.

SMATCA staff has input into and is informed of upcoming changes.

Activities:

Monthly meetings to inform staff on a regular basis regarding program status, activities, and progress.

Staff review of system and interface requirements to allow staff to provide input.

Focus groups to determine staff issues and concerns.

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Communication Management

Communication Planning--concluded

- The Communication Plan should also document methods to measure the success of communication activities. Potential methods include the following:
  - Meetings with individual stakeholders.
  - Focus groups with groups of stakeholders.
  - Survey questionnaires distributed to stakeholders.
- The method to determine success of the communication activities should analyze the following:
  - Is the format (e.g., meeting, focus group, newsletter) effective?
  - Is the frequency appropriate?
  - Is the intended audience appropriate?
  - Is the goal and objectives being satisfied?

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Cost Management

- "Processes required to ensure that the project is completed within the approved budget" PMBOK 2000
- Cost management processes include the following:
  - –Resource planning
  - –Cost estimating
  - –Cost budgeting
  - –Cost control

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Cost Management
Resource Planning

- Determining the types and amounts of resources (e.g., staff, consultants, equipment, supplies) needed throughout the life of the project.
- Resource requirements should be determined at the lowest levels of the WBS and is essential for cost estimating.

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Cost Management
Cost Estimating

- Determining the likely costs for the project.
- Cost estimates need to account for direct and indirect costs.
  - Direct Costs--Labor (direct, contract), materials, equipment, travel, fees, and incidentals.
  - Indirect costs--General and administrative costs, other fixed or variable overhead costs.
- Estimating methods
  - Bottom up--estimating cost of individual work packages (lowest level of WBS) and rolling up costs to the project level.
  - Analogous--Estimating the cost of the total project based on the actual costs of a similar project (sometimes called top down estimating).
  - Parametric--estimating costs using a mathematical model (e.g., cost per line of software code, cost per building square meter).

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Cost Management
Cost Estimating

- Level of accuracy indicates how precise the estimate is felt to be.
- Level of accuracy can be indicated by the following:
  - Cost ranges (e.g., 100,000 to 125,000 Euros)
  - Confidence intervals (95% confident cost is 100,000 Euros +/- 10,000 Euros)
  - Descriptive terms
    - Order of magnitude, SWAG, ballpark (+75%,-25%)
    - Budget, preliminary, design (+25%, -10%)
    - Definitive, engineering, grass (+10%, -5%)

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Cost Management
Cost Estimating

Guidelines for Cost Estimating

- Utilize the WBS.
- Use the most accurate method given the information you have.
- Document assumptions.
- Document the level of accuracy.
- Do not overly inflate estimates.

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Cost Management
Cost Budgeting

- "Allocating the cost estimates to individual work packages to establish a cost baseline (time phased budget) for measuring project performance." PMBOK 2000
- Project schedule (planned start and finish date of all activities) is needed to determine when costs will be incurred.
- Reserve--Money set aside to mitigate cost, schedule, or performance risk or solve problems.
  - Management reserve--set aside to reduce the impact of missed activities.
  - Contingency reserve--set aside to reduce the impact of poor planning of known activities.

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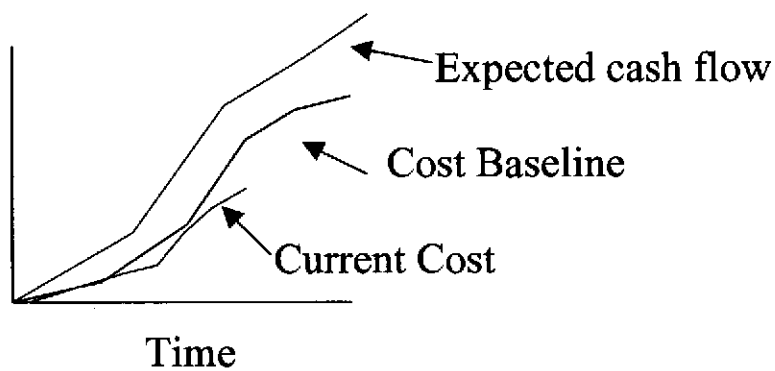
Cost Management
Cost Budgeting

Cost baselines are usually displayed in table form and S-Curve form.

S-Curve



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Project Control

- Monitoring project performance to identify real or potential variances (cost, schedule, or scope) from the project plan.
- Project Control involves the following activities:
  - Overall change control
  - Scope change control
  - Cost control
  - Schedule control
  - Quality control
  - Risk monitoring (Risk control)

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Project Control
Overall Change Control

- Project baseline--Approved project plan (original plus any approved changes) against which performance is measured and variances are identified. Includes cost baseline, schedule baseline, and performance baseline.
- Overall Change Control--
  - Ensure that proposed changes to the project baseline (cost, schedule, and scope) are appropriately reviewed and approved by a Change Control Board (CCB) or Configuration Control Board (CCB) using a pre-defined change control process.
  - Inform stakeholders of approved change.
  - Manage approved changes (update baseline, update other project documents as appropriate).

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Project Control
Scope Change Control

- Scope Change Control--
  - Ensure that proposed changes to the project scope are appropriately reviewed and approved by a CCB using a pre-defined scope change control process.
  - Inform stakeholders of approved change to project scope.
  - Manage approved scope changes (update WBS, project schedules, and other project planning documents).

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Project Control
Cost Control

- Cost Control--
  - Ensure that proposed changes to the project cost baseline are appropriately reviewed and approved by a CCB using a pre-defined cost change control process.
  - Inform stakeholders of approved change to the cost baseline.
  - Manage approved cost baseline changes (revise cost estimates, update project budgets, update other project planning documents).
- In performing cost control, the project team performs the following:
  - Review cost reports and analyze cost variances (using pre-determined cost reporting methodology).
  - Continually assess Estimate at Completion (EAC).

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Project Control
Cost Control--continued

Cost Reporting Methodology

- Planned versus Actual by reporting period.
- Earned Value Management (EVM)--Analyzing planned cost, actual cost, and earned value to measure project progress. Earned value is the value or budget of work completed.

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Project Control

Cost Control--continued

Earned Value Example:

Current date is June 20, Actual Cost=$250

	Planned Value	Start Date	End Date
Task A	$200	June 1	June 19
Task B	$100	June 16	June 19
Task C	$200	June 21	June 30

Under Budget? On Schedule?

Planned Cost = $300

Earned Value = Planned Value * Percent Complete
=$200*100%+$100*25%+$200*0%
=$225

Task A-complete, Task B-25% complete, Task C-not started

Cost variance = Earned Value - Actual cost
=$225 - $250
= -$25 (over budget)

Schedule variance=Earned Value - Planned Cost
=$225-$300
= -$75 (behind schedule)

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Project Control
Cost Control--concluded

Estimate at Completion techniques

(AC=Actual Cost, PV=Planned Value or Budget, EV=Earned Value):

- $EAC = AC + PV_{\text{remaining work}}$
- $EAC = AC + PV - EV$
- $EAC = AC + (PV - EV) / CPI$

  where CPI (Cost Performance Index) = EV/ AC

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Project Control
Schedule Control

- Schedule Control--
  - Ensure that proposed changes to the project schedule are appropriately reviewed and approved by a CCB using a pre-defined change control process.
  - Inform stakeholders of approved schedule change.
  - Manage approved schedule changes (revise project schedules, update other project planning documents).
- In performing schedule control, the project team performs the following:
  - Review progress and status reports and analyze schedule variances.
  - Continually asses potential impact of schedule variances on future tasks start dates and project completion date.
  - Critical path, activity float, and activity free float are important information to consider when assessing potential impact.

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Project Control
Quality Control

- Reviewing project results, systems, and documentation to determine compliance with appropriate standards.
- Taking appropriate action (acceptance, rework) when review determines non-compliance.

Quality Control will be discussed in detail in Belgrade.

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Project Control
Risk Monitoring (Risk Control)

- Risk Monitoring involves the following:
  - Executing risk mitigation strategies.
  - Assessing the status of identified risks.
  - Implementing appropriate plans if risks become issues.
  - Identifying new risks.

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Risk Monitoring (Risk Control)--concluded

- Project team conducts regular risk monitoring meetings. The risk manager of each identified risk discusses the following:
  - Status of the risk mitigation plan. Has probability or potential impact of risk changed? Has a risk event occurred?
  - Status of contingency plan (plan implemented if risk becomes and issue).
  - Proposed corrective action if risk has occurred.
  - Potential new risks.

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Wrap Up

- Questions
- Feedback
- Final planning for Session 2
- Other

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Project and Engineering Management
For the
Serbia and Montenegro Air Traffic Control Authority
(SMATCA)

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Project and Engineering Management
for the
Serbia and Montenegro Air Traffic Control Authority (SMATCA)

Sunday September 7, 2003[1]

- Belgrade ACC, Tower, and Training Center Tours

Monday September 8, 2003

10:00-4:00

- Review and discussion of SMATCA`s draft documents:
  - FAMUS Project WBS
  - FAMUS Project Time Schedule
  - FAMUS Project Risk Management Plan
  - PIU Communication Plan
  - Invitation for Tenders
  - Instructions to Tenderers
  - General Conditions of Contract

Tuesday September 9, 2003

9:00-12:00

- System Engineering and Program Implementation
  - Operational Concepts
  - Strategic Plan
  - Life-cycle system engineering approach
    - Concept development and validation
    - Prototype development and deployment
    - Technical and Implementation Readiness
  - Participation of the airspace users
  - Integration
  - Benefits
  - Program Office Viewpoint
    - Role of System Engineering, Research and Development
    - Acquisition guidelines (example: FAA acquisition process)
  - Contractor Viewpoint
    - Requirements review
    - Critical design review
    - Program reviews
    - Other reviews

- Monitoring Versus Performing System Engineering
  - Roles and responsibilities of contractor (service provider) and FATCA (customer)
  - Discussion of collaboration, negotiation, trust
  - Keeping stable requirements
  - Monitoring the development process through "Problem Reports" (Tracking problem reports by opening, closing, counting)

[1] Starting time to be determined.

- Using Modeling and Simulation—why, how, and when

- Functional Elements of Air Traffic Management
  - Discussion of surveillance processing, flight data processing, airspace design, automation functions, communication, display technologies

- Evaluating Designs
  - How to establish a common reference approach for evaluating designs (evaluation plan for source selection)

1:00-3:00

- Seminar Exercise—System Engineering
  - Define organizational roles, responsibilities, and goals regarding system engineering
  - Identify major system engineering stakeholders and points of contact
  - Outline a basic Functional Requirements Document and identify who will be responsible for specific requirements areas

Wednesday September 10, 2003

9:00-10:00

- Overview of System Safety
  - Summary of ICAO and RTCA guidelines
  - Definition of safety-critical programs, mission-critical programs
  - The role of certification (hardware, software, people)

- Establishing Requirements
  - Development approaches and requirements for different levels of safety
  - Case studies: Definition and Application of "Risk Ratio" and "Probability of Collision" metrics

- Operations and Support
  - How to maintain or ensure system safety
    - Automation functions to detect conflicts, function to alert supervisory personnel if aircraft violate safe standards
    - Approaches to training and maintaining proficiency (e.g., the use of scenario-based simulation).

10:00-12:00

- Defining Reliability and Maintainability (R&M)

- Determining Minimum reliability and maintainability standards for specific systems
  - How to establish agreed-upon R & M requirements
    - What is needed versus what is desired?
    - The trade-off between R & M and cost

- Measuring R&M
  - Approaches and metrics for monitoring R&M

- Ensuring R&M Standards are Met
  - Approaches and requirements for ensuring that R&M levels are sustained

1:00-2:00

- Quality Management
  - Quality Planning
  - Quality Assurance vs. Quality Control
  - Role of Quality Manager
  - References:
    - ICAO Doc 4444 Rules of the Air and Air Traffic Chapter 2
    - Annex 11 Air Traffic Services paragraph 2.26

2:00-4:00

- Seminar Exercise—Reliability and Maintainability
  - Prioritize FAMUS capabilities according to desired reliability; i.e., what capability or function is most important, next important, etc.
  - Create a plan to research other ATM systems' R&M requirements and assign actions to FATCA representatives

<u>Thursday September 11, 2003</u>

9:00-10:30

- The definition, steps, and levels of Configuration Management and how they are applied, including:
  - Identification
  - Control
  - Status Accounting
  - Auditing
  - Process Improvement

- Configuration Items (i.e., what is controlled?)

- Software
- Data
- Documentation

- CM Reporting
  - Change Notices
  - Chronology Report for every release or update

- Lessons learned and examples of problems that occur without CM, and those that can occur with CM if proper oversight is not conducted

- Establishing and Managing the Configuration Control Board
  - CCB size, roles and responsibilities, positions, leadership, continuity
  - The significance of the Configuration Manager

- Proposing, Evaluating, and Approving System Changes
  - The significance of CM forms

- Technical Data Management
  - Creating and maintaining a central repository for information
  - Coordinating with the Configuration Management Function
  - Assigning Responsibilities (contractor and program office)

10:30-12:00

- Defining System Installation, Test, Evaluation, and Acceptance

- Establishing Installation and Test Procedures
  - Where in the System Life-Cycle do the procedures get developed?
  - Configuration Management of test and evaluation activities and data
  - The need for dedicated facilities and on-site support
    - Field facilities
    - Laboratory facilities that can be adapted

- Using Test and Evaluation to Monitor Progress (including collecting and maintaining Problem Reports)

- Defining Test Objectives and Requirements
  - Test Procedures
  - Pass/Fail Criteria
  - Factory Acceptance Testing
  - Final Acceptance Testing

1:00-2:00

- Case Study: Display System Replacement (DSR) Engineering and Test Processes
  - Hardware Factory Testing
  - Installation and Integration Testing
  - Development, Test, and Evaluation Subsystem Testing
  - Development, Test, and Evaluation System Testing
  - Acceptance Testing
  - Formal Operational Testing

2:00-4:00

- Seminar Exercise—Configuration Management
  - Define a Configuration Control Board and appoint a Configuration Manager
  - Address a change proposed by the contractor

Friday September 12, 2003

9:00-10:00

- Transition and Training
  - Observations
  - Roles and Responsibilities
  - Training Methods
  - Case Studies

10:00-11:00

- Maintenance Strategy Options and Alternatives (distributed versus centralized)
  - Descriptions
  - Examples
  - Benefits
- Organizing to Manage Operations and Support
- Allocating Responsibilities to Operating Entities
- Understanding Maintenance Levels and Functions
- Contracting for Operations and Support Functions
- Case Study: FAA Infrastructure Management Concept

11:00-1:00

- Performance Monitoring
  - Program Reviews
  - Monthly Reports
  - Oversight Briefings
  - Technical Performance Monitoring
  - Information Distribution

- Seminar Exercise
  - FAMUS Performance Monitoring and Oversight Product Development

Saturday September 13, 2003

9:00-1:00

- Seminar Exercise—FAMUS Risk Identification, Analysis, and Response Planning

Sunday September 14, 2003

9:00-12:00

- Seminar Exercise—FAMUS Tender Management by EBRD Rules

12:00-100

- Course Wrap-up

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System Engineering and Program Implementation

September 9, 2003

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Overview

- Observations and Definitions
- System Life-Cycle
- Operational Concepts
- Strategic (Master) Plans
- Engineering Approach: From concept to deployment
- Participation of the Users
- Integration
- Benefits
- The Role of Research and Development

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Overview (Concluded)

- Monitoring the Process
  - Roles and Responsibilities: Customer/Contractor/Consultant
  - Requirements
  - Problem Reports
- Modeling and Simulation
- Functional Elements of Air Traffic Management
- Evaluating Designs
- System Engineering Exercise

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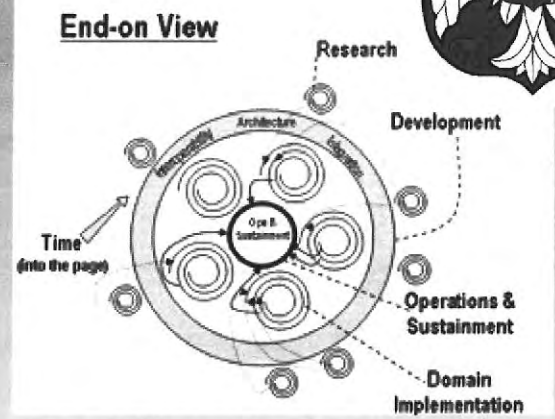
Observations

System acquisitions are inherently risky and offer lots of opportunities for problems to arise

ATM is moving away from all ground based systems toward collaboration with the cockpit via GPS and data link



The FAA is moving from large system acquisitions to smaller acquisitions characterized by prototypes that evolve in a spiral model

Vendors now have more commercial off the shelf (COTS) air traffic management systems available for sale

Acquisition programs tend to underestimate the technology, operational, and programmatic challenges

The user community demands participation in capability implementation and evaluation of system performance

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Some Basic Definitions

- **Mission Need Statement (MNS): A statement of operational need that is not tied to any specific system.**

- **Operational Requirements Document (ORD): Performance requirements and operational parameters for the proposed system.**

- **Concept of Operations (CONOPS): A summary of the new system's impact on operations.**

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System Engineering

- **System engineering is a logical sequence of activities and decisions that:**
  - **Facilitate the transforming of *operational needs* into system *performance parameters* and a preferred system *configuration* and *architecture* to satisfy those operational needs.**
  - **Provide for *management* decision making.**
  - **Provide the process of the technical efforts required for transforming *requirements* into *operational systems.***

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Life-Cycle System Engineering Approach

- Four phases in system development require a system engineering approach:
  - Planning
  - Design
  - Implementation
  - Use and enhancements
- Multiple activities within each phase must be carried out to:
  - Mitigate risks
  - Minimize schedule delay and cost overruns
  - Ensure system quality and smooth operation
- Avoid "big-bang" acquisition approach.
- Requires all parties (users, consultant, and system integrator) to collaborate.

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System Implementation Life-Cycle

Phase 1 Planning	Phase 2 Design	Phase 3 Implementation	Phase 4 Use and Enhancements
• Feasibility Study • Strategy Analysis • Master Planning • Operations Concept • Budget Request • RFP for Consultant	• System Architecture and Basic Design • Facility Criteria • Training Concept • Testing Concept • Maintenance/Logistics Concept • RFP for System Integrator • Support Proposal Evaluation and Negotiation	• Support Project Management • Review Detailed Design • Monitor System Integrator • Support Training • Participate in Testing • Support Generation of Operation Procedures	• Support System Operational Test and Evaluation • Recommend System Enhancements and Future Upgrades
		System Integrator • Detailed Design • Hardware Construction • Software Development • Subcontract Management • Subsystem Factory Testing • Site Installation • Functional, Performance and Reliability Test	• System Integration Test, Acceptance Test • Provide Training • Participate in System Operational Test and Evaluation • System Corrections • System Improvements • Warranty Service
	Consultant • RFP, Proposal Evaluation and Contract Award		
		User • Design Review, Training, Testing	• Operation, Use and Evaluation

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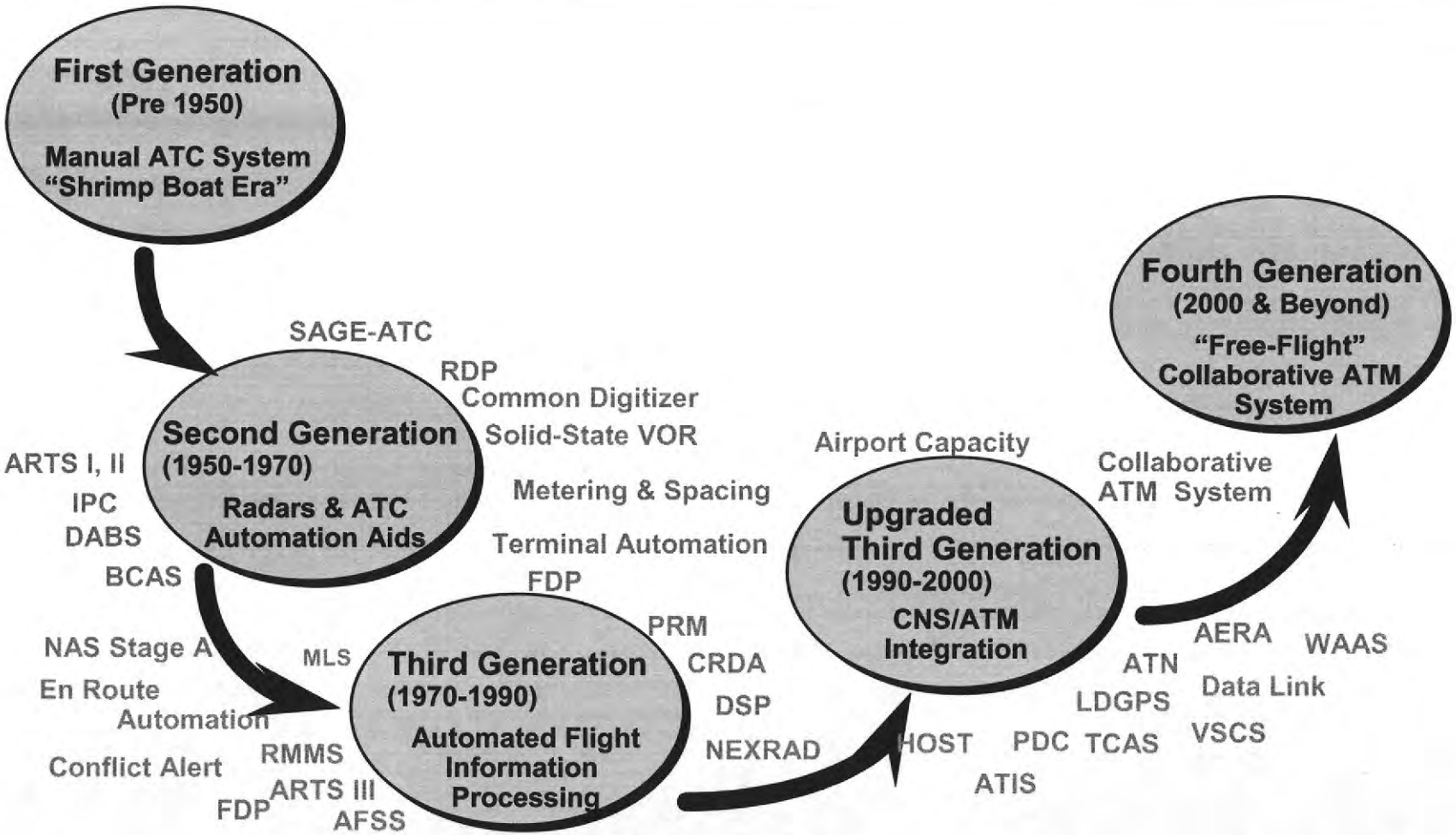
The Evolution of Air Traffic Management Capability in the United States: How We Got Here



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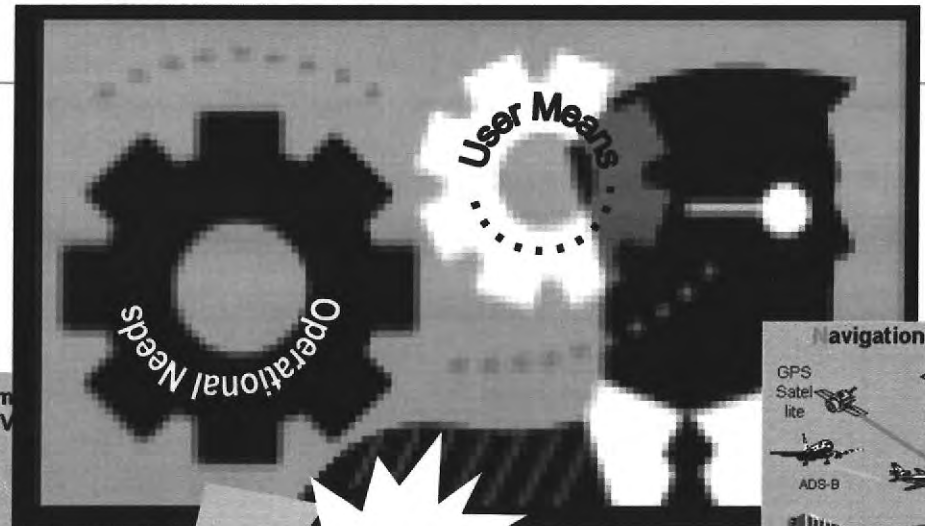
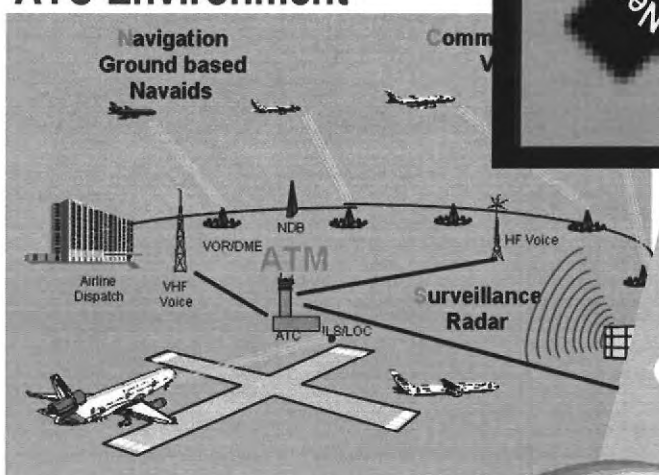
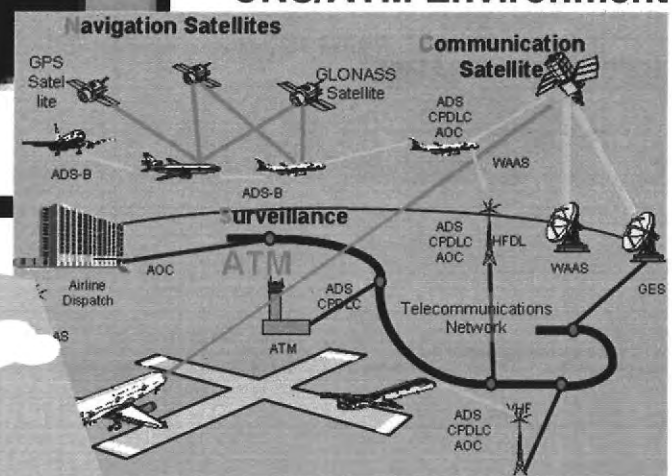
Defining the Needs Leading to a Clear Transition Path



Current
ATC Environment



Future
CNS/ATM Environment



Miracle

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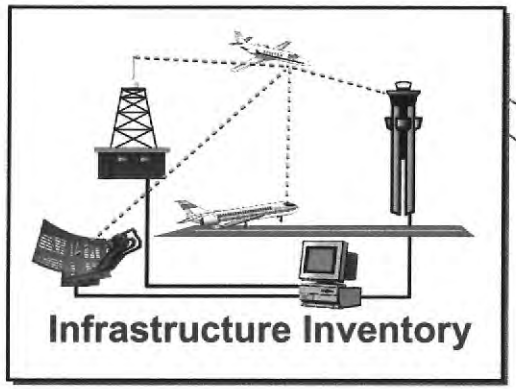
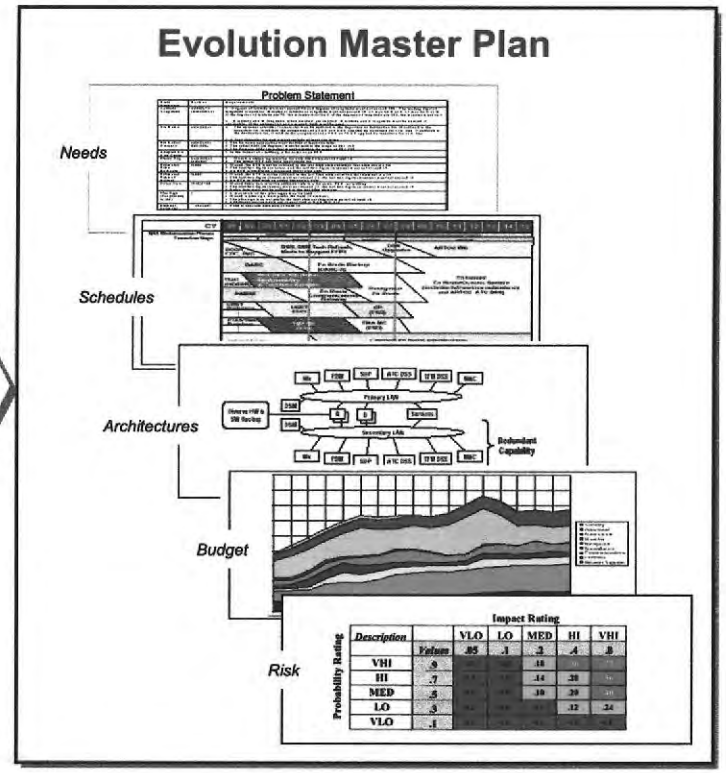
Evolution Planning Process

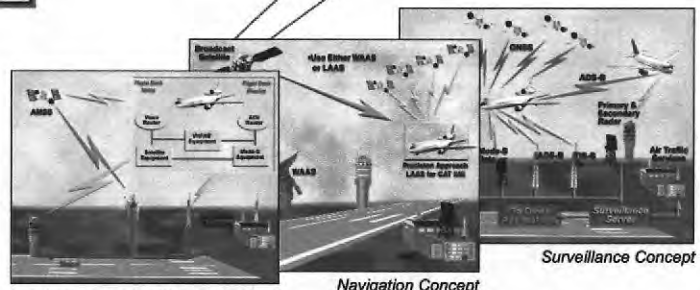


ANS Needs

Evolution Pressure

Needs Analysis





Communication System Concept *Navigation Concept* *Surveillance Concept*

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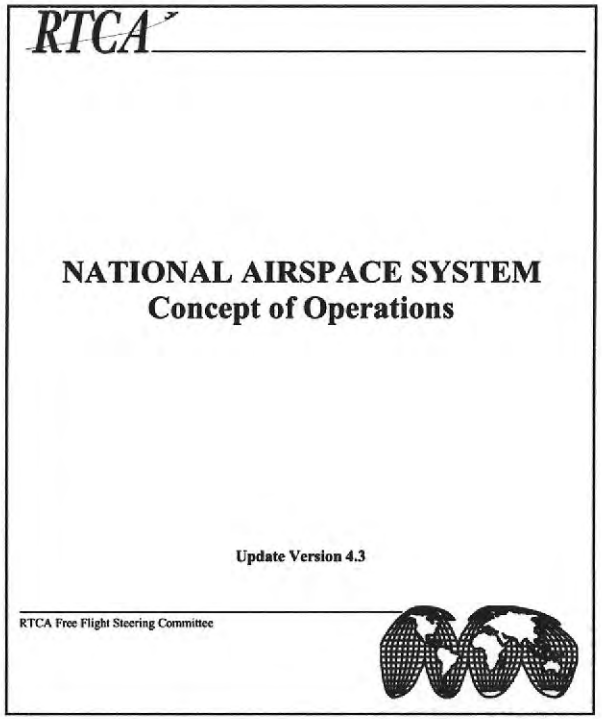
End Results: System Operational Concept and Operational Evolution Plan



Describes desired future operational capabilities

http://www.rtca.org

Describes commitments over next 10 years

http://www1.faa.gov/programs/oep/

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What is an Operational Concept?

- An operational concept is a description of a desired operational environment, primarily in terms of functional capabilities. Methods range from text reports to computer animations.
- The operational concept results in a "blueprint" for developing the infrastructure, automation, procedures, airspace needed for improving the system.

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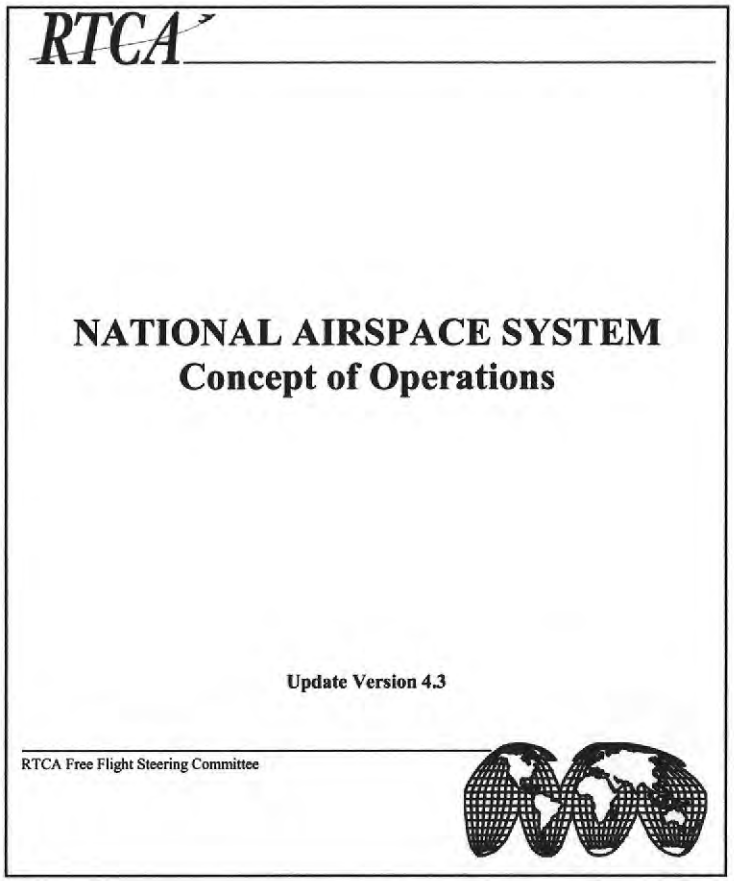
Contents of NAS Operational Concept


RTCA

NATIONAL AIRSPACE SYSTEM
Concept of Operations

Update Version 4.3

RTCA Free Flight Steering Committee

- Traffic Management
- Infrastructure Management
- Flight Planning and Emergency Services
- Surface Operations
- Arrival/Departure Operations
- En Route Operations
- Oceanic Operations

3 Timeframes: Near-, Mid-, Far-Term
2 Perspectives: User, Service Provider

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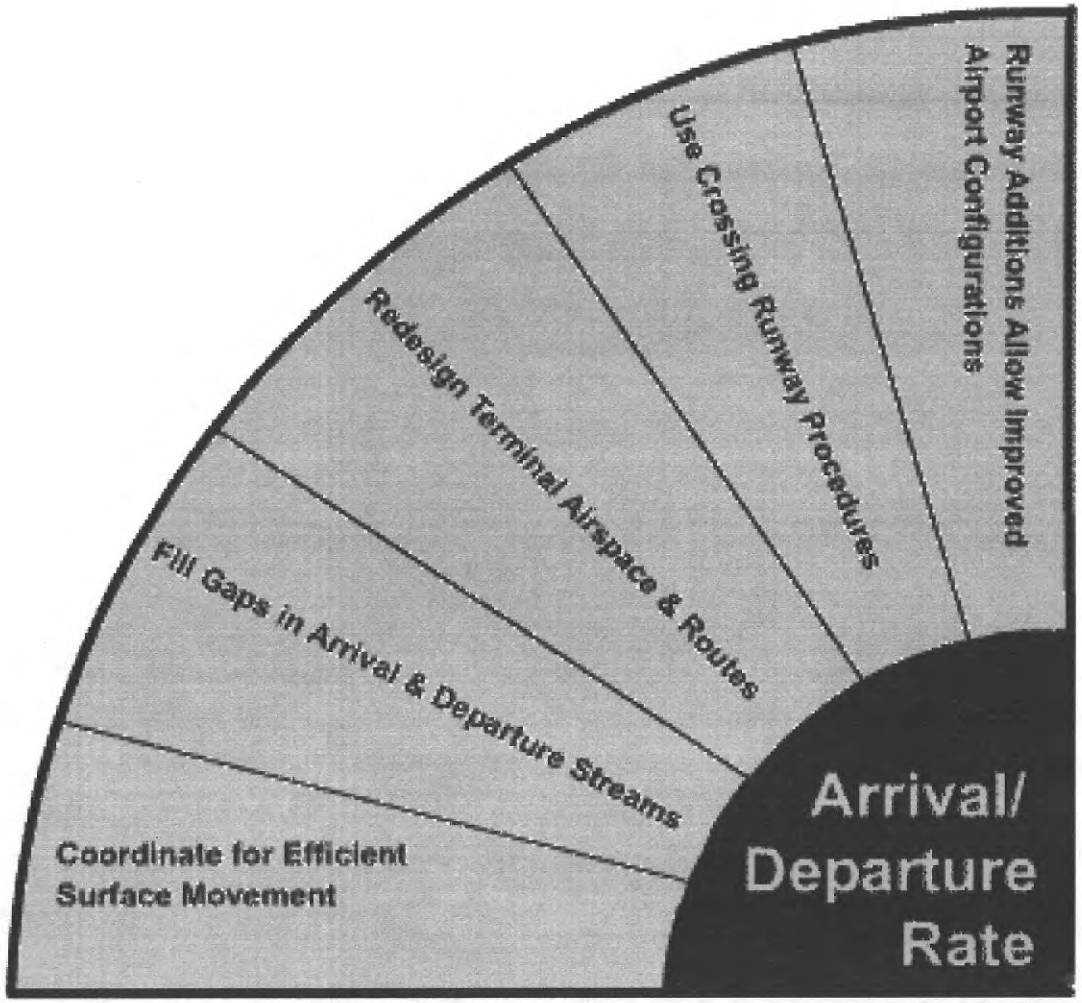
Contents of Operational Evolution Plan



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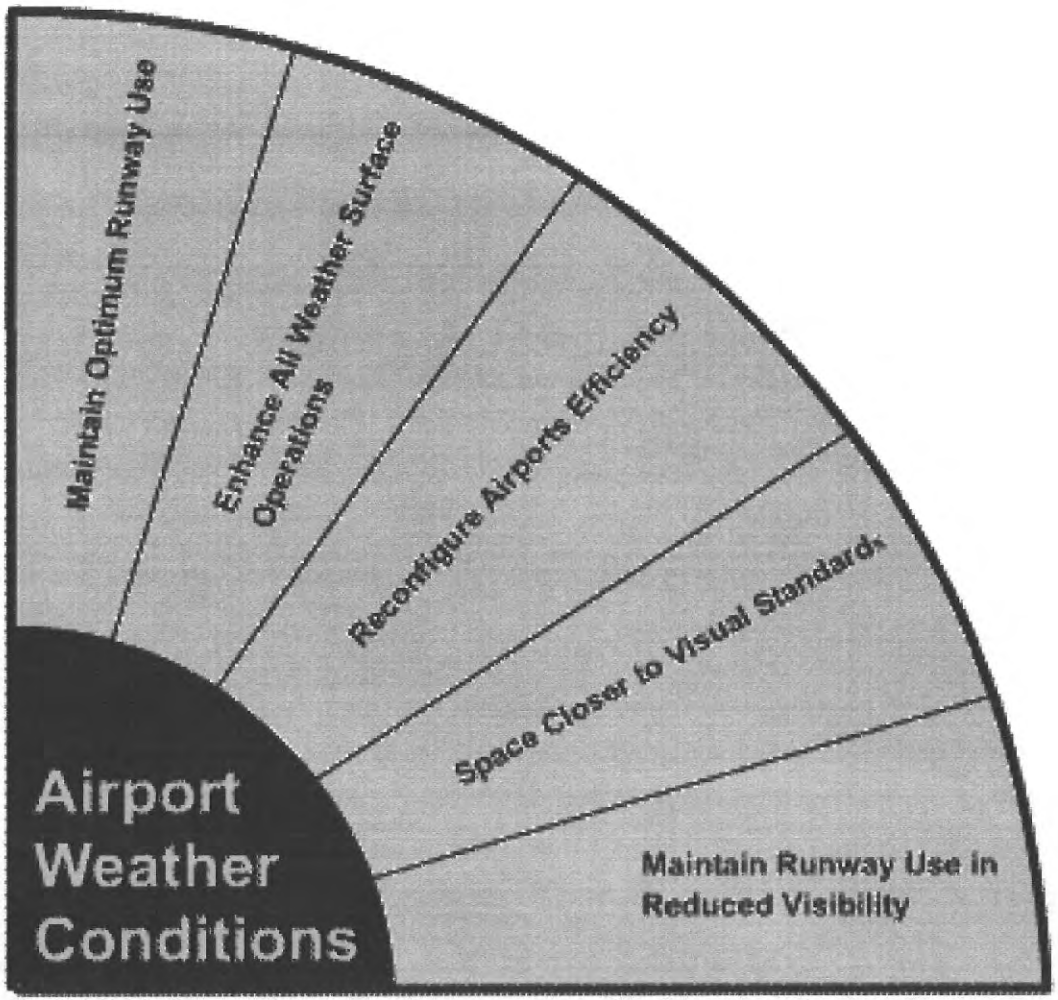
Contents of Operational Evolution Plan (continued)



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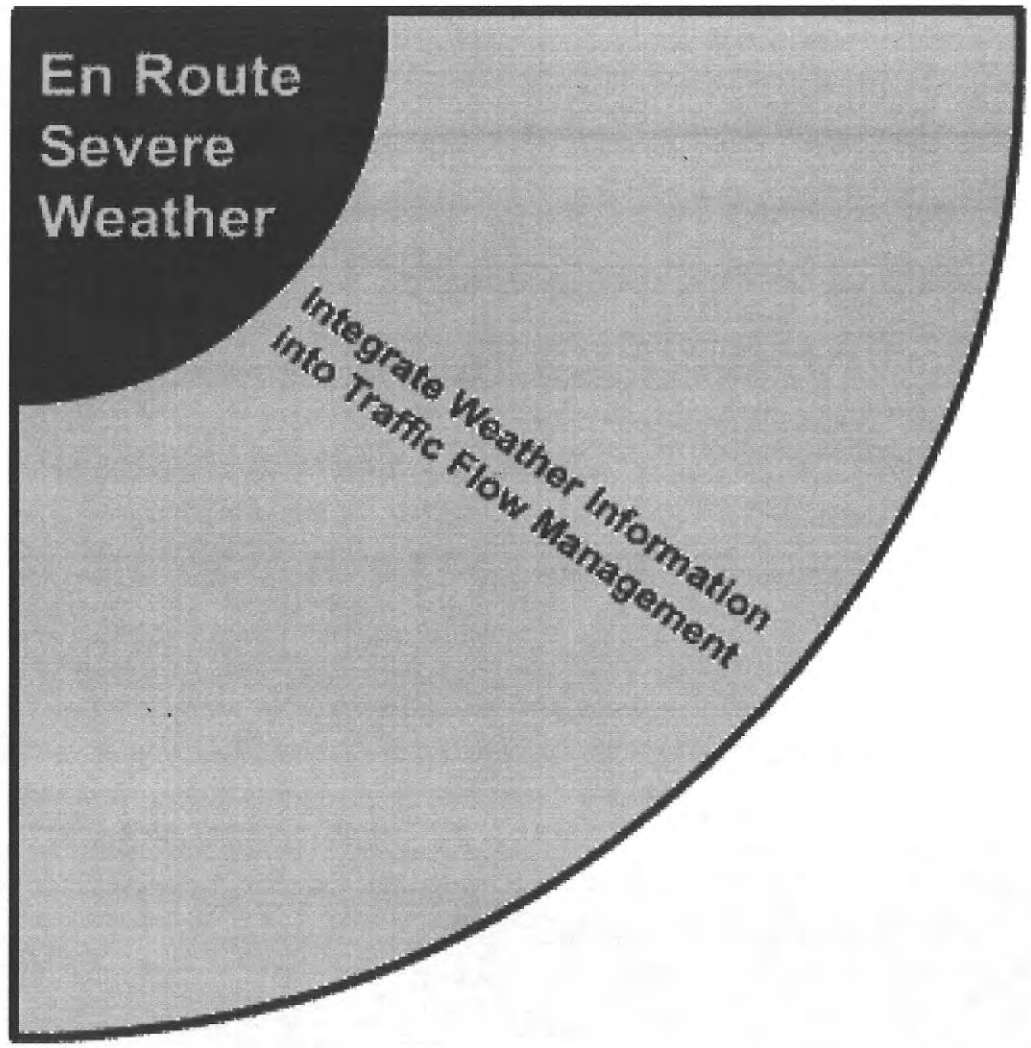
Contents of Operational Evolution Plan (continued)



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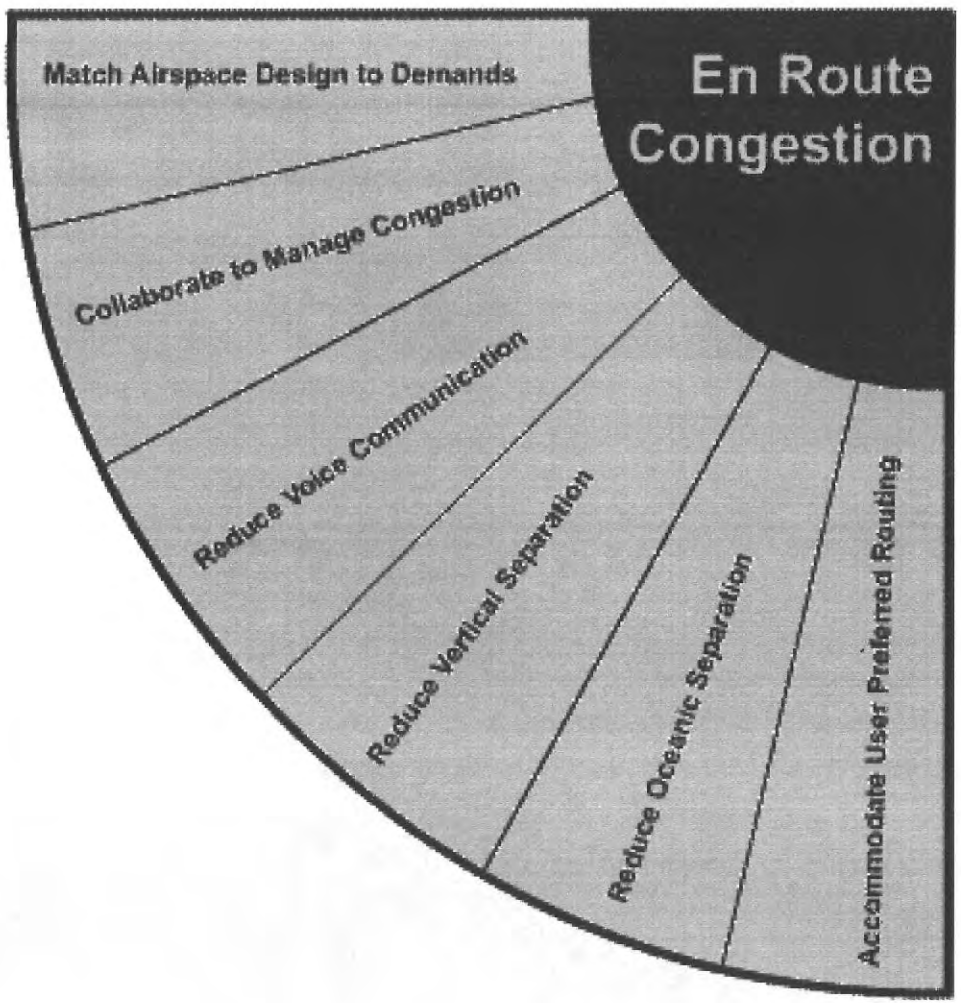
Contents of Operational Evolution Plan (concluded)



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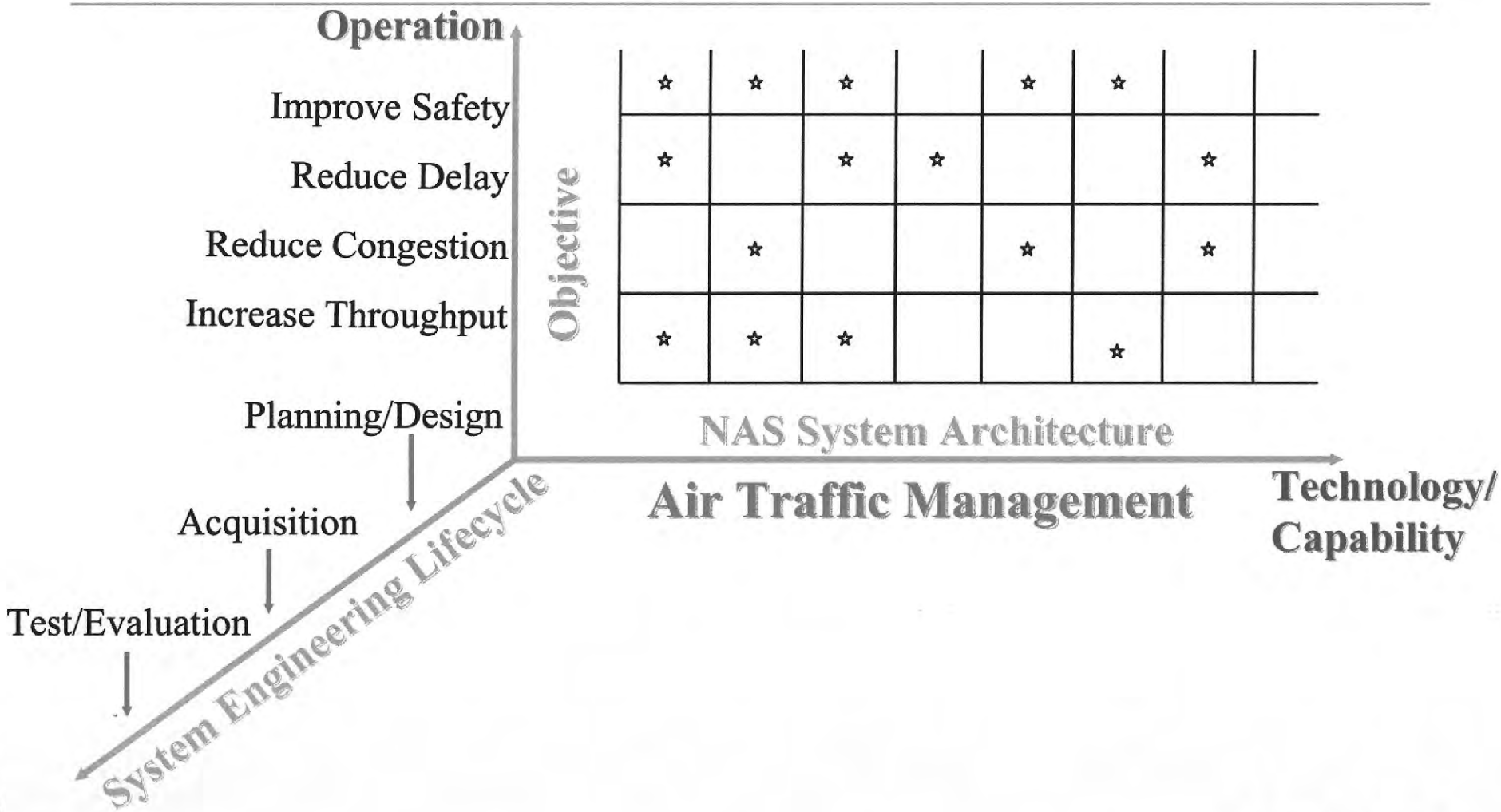
Operation, Technology and System Engineering



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Strategic Planning (Master Plan)

Project Scope	Content of Plan

• Assessment of current FIR ATC operation
• Assessment of national aviation needs
• Understanding worldwide system development status
• Planning the CNS/ATM development scope and schedule
• Assessment of transition strategy
• Analyzing manpower and fiscal requirements
• Developing master implementation plan (phased)
• Developing technology transfer plan
• Conduct of seminars
	• Program goals and constraints
	• Program objectives and tasks
	  • Communications
	  • Navigation
	  • Surveillance
	  • Air Traffic Control
	  • Traffic Flow Management
	  • Airspace Management
	  • Aviation Weather
	• Acquisition and Implementation
	• Program management approach
	• Human resource and training requirements
	• Facility requirements
	• Implementation schedule

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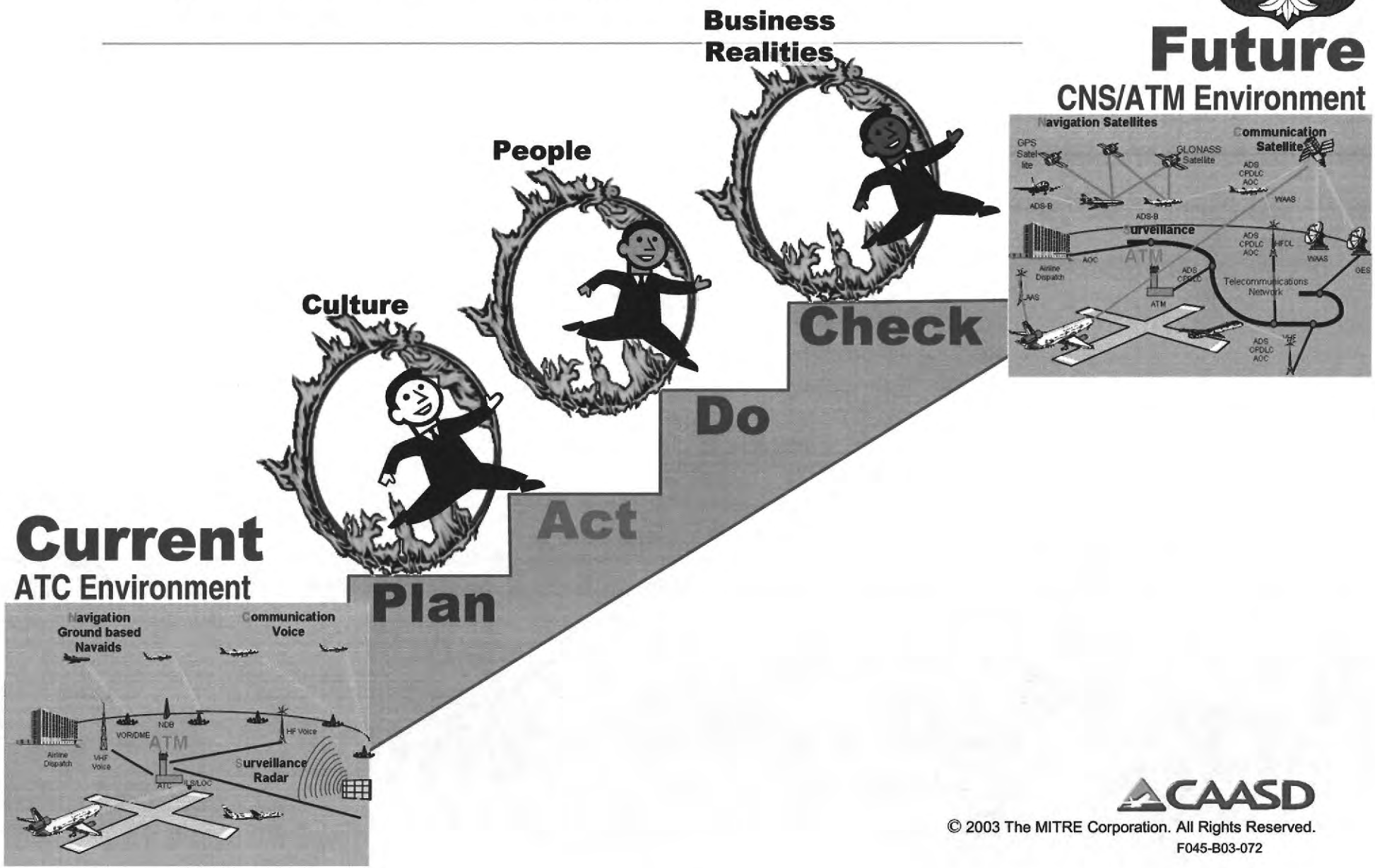
Transition
(in the absence of a miracle)



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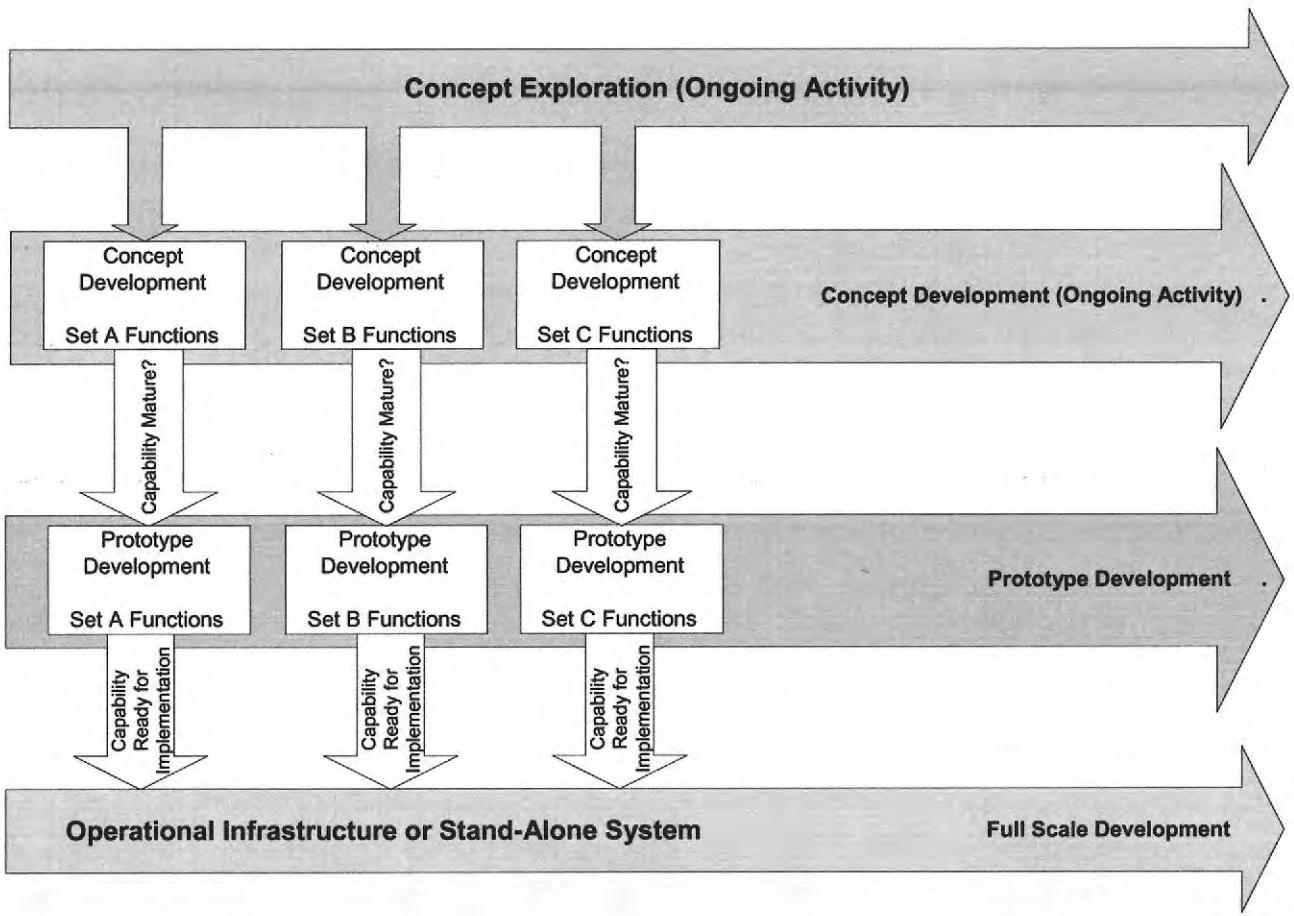
The Four Phases of Research and Development



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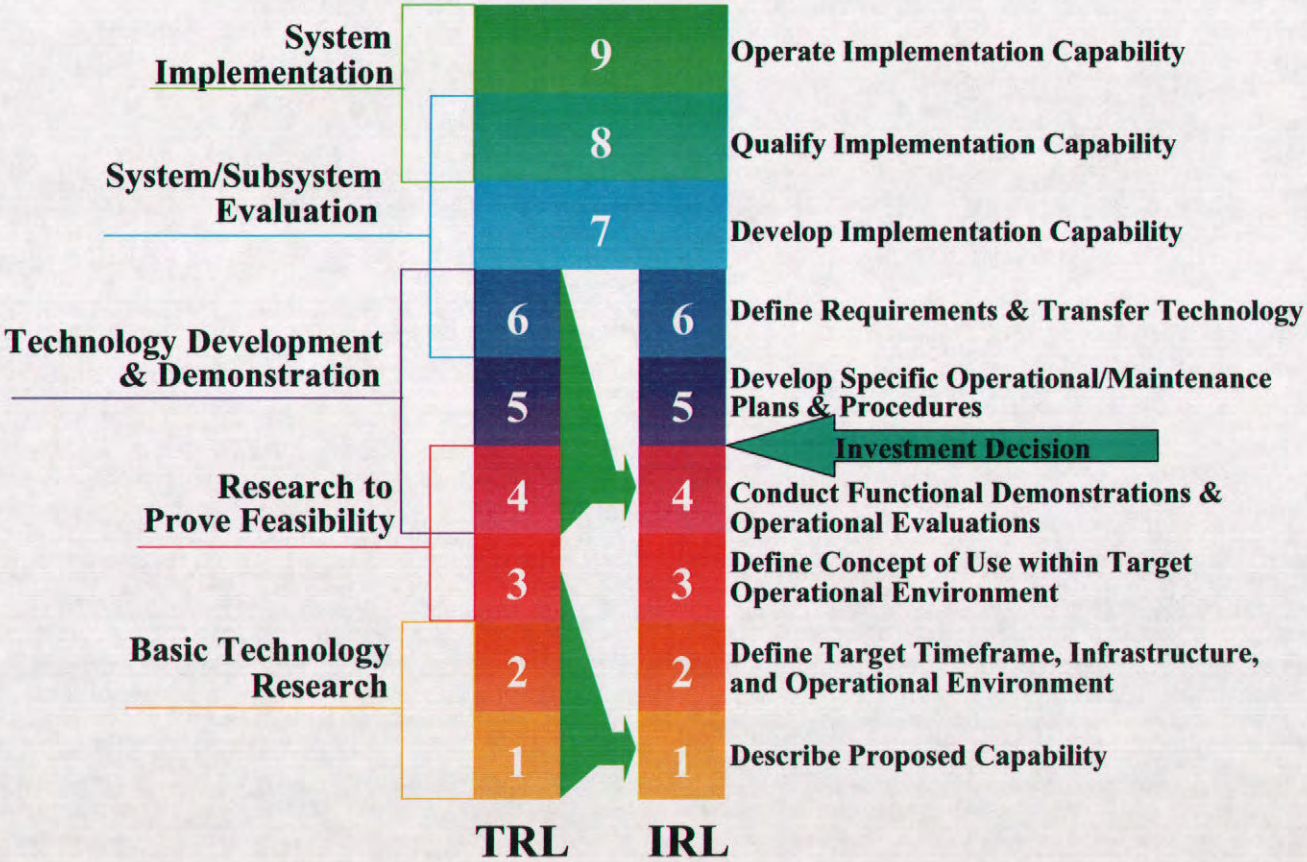
Research and Development Readiness Levels

Readiness Levels

Technology Readiness Level (TRL) and Implementation Readiness Level (IRL)



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Participation of the Users

- One of the best things you can do is get your users (e.g. controllers) involved early in the design process.
- Users should take ownership of new technology and functions rather than have decisions made for them.

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System Integration

- *Functional* integration of components
- *Operational* integration of infrastructure, functional capabilities, personnel and procedures
- *Service* integration with global systems/services

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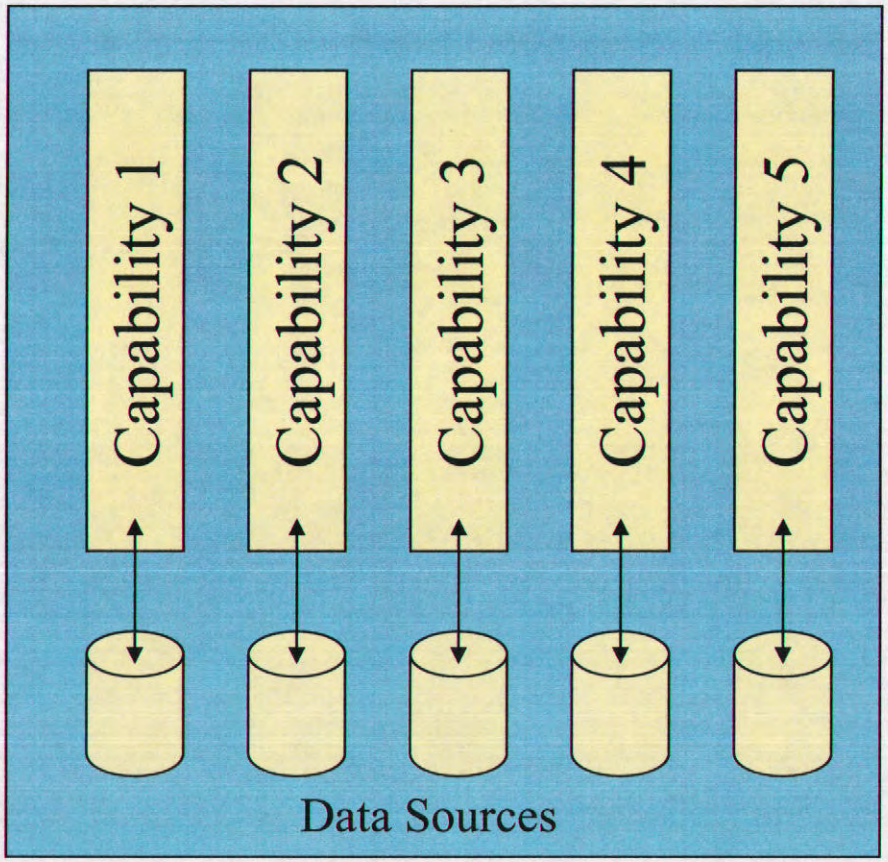
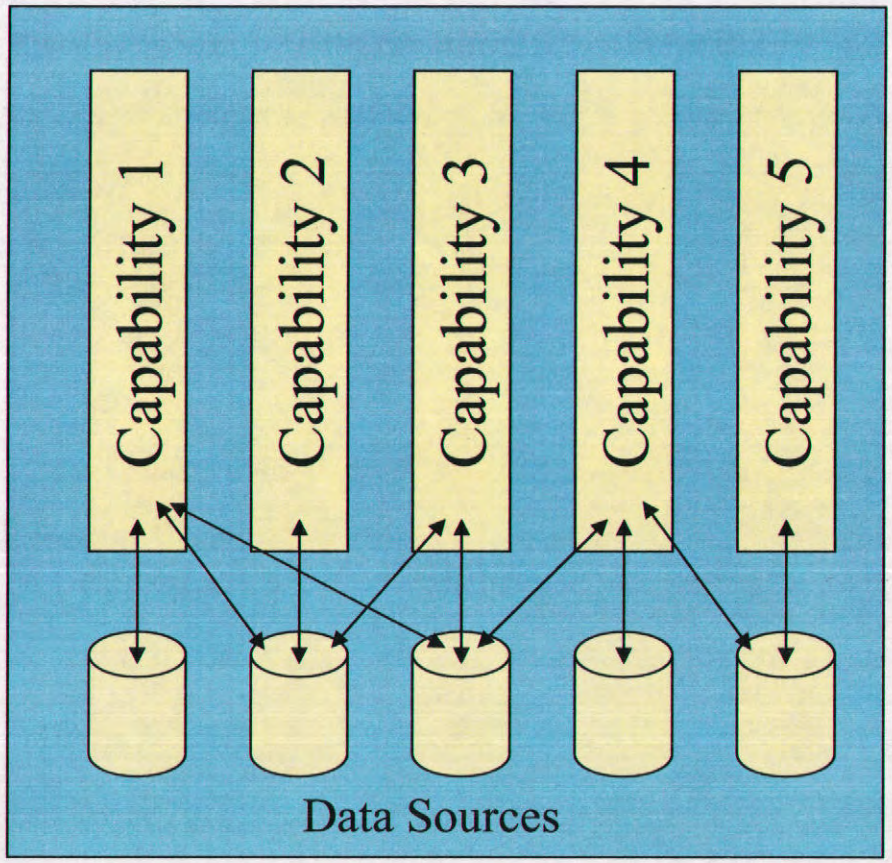
System Integration (Concluded)

- **Avoid "stove-piped" capabilities:**



NO



YES

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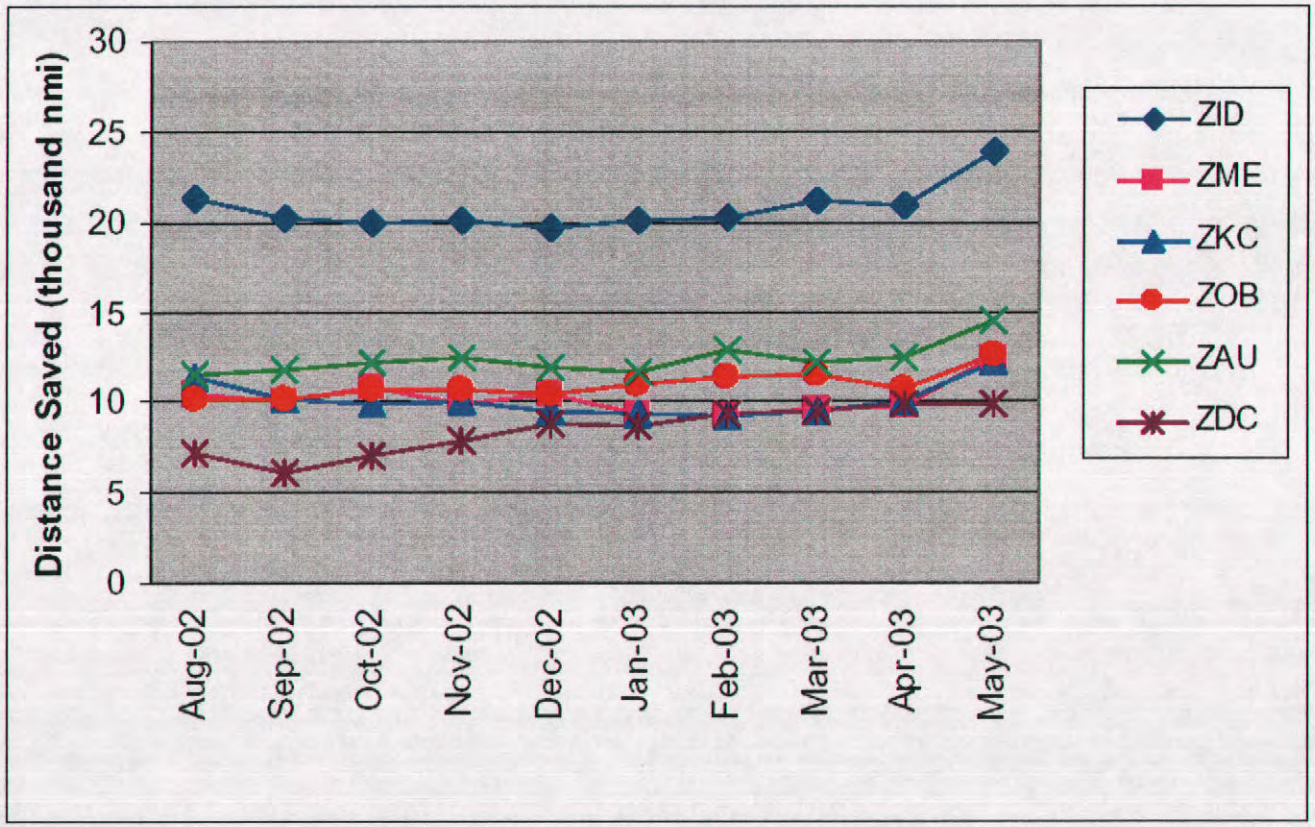
Q: How Do You Measure Benefits?
A: Define and Assess Metrics

User Request Evaluation Tool (URET) Benefits



Average distance saved per day by lateral amendments at URET sites

Source: FAA Free Flight Program Office

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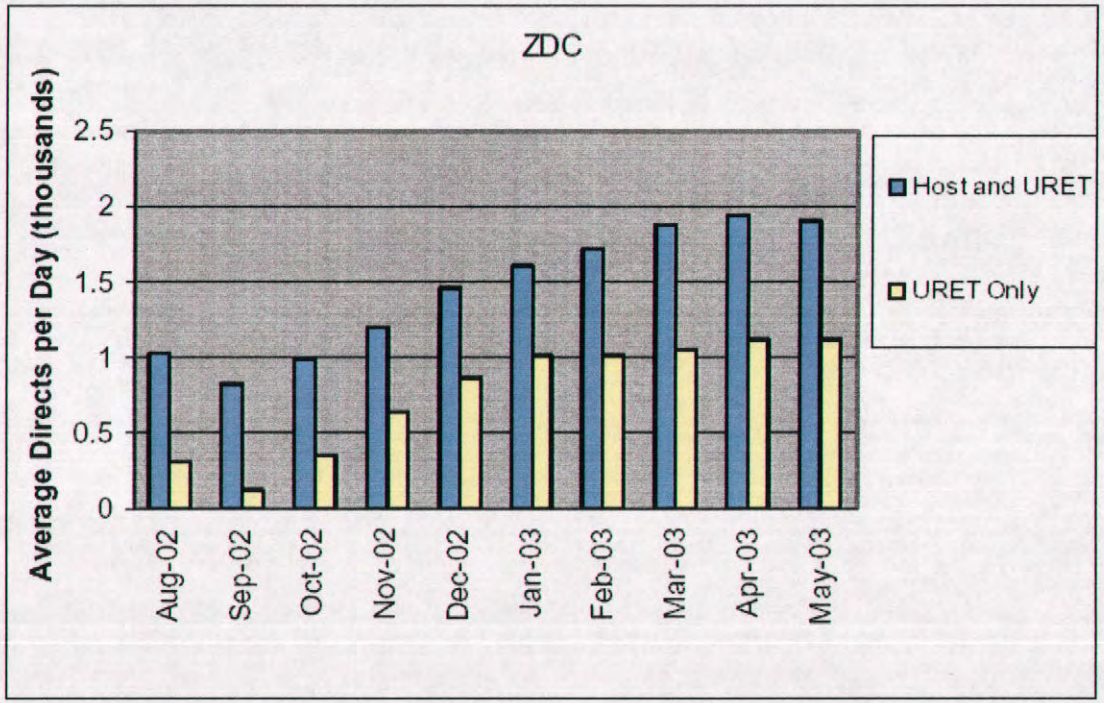
Additional Benefits: User Request Evaluation Tool



URET directs as a subset of total directs for ZDC

Source: FAA Free Flight Program Office

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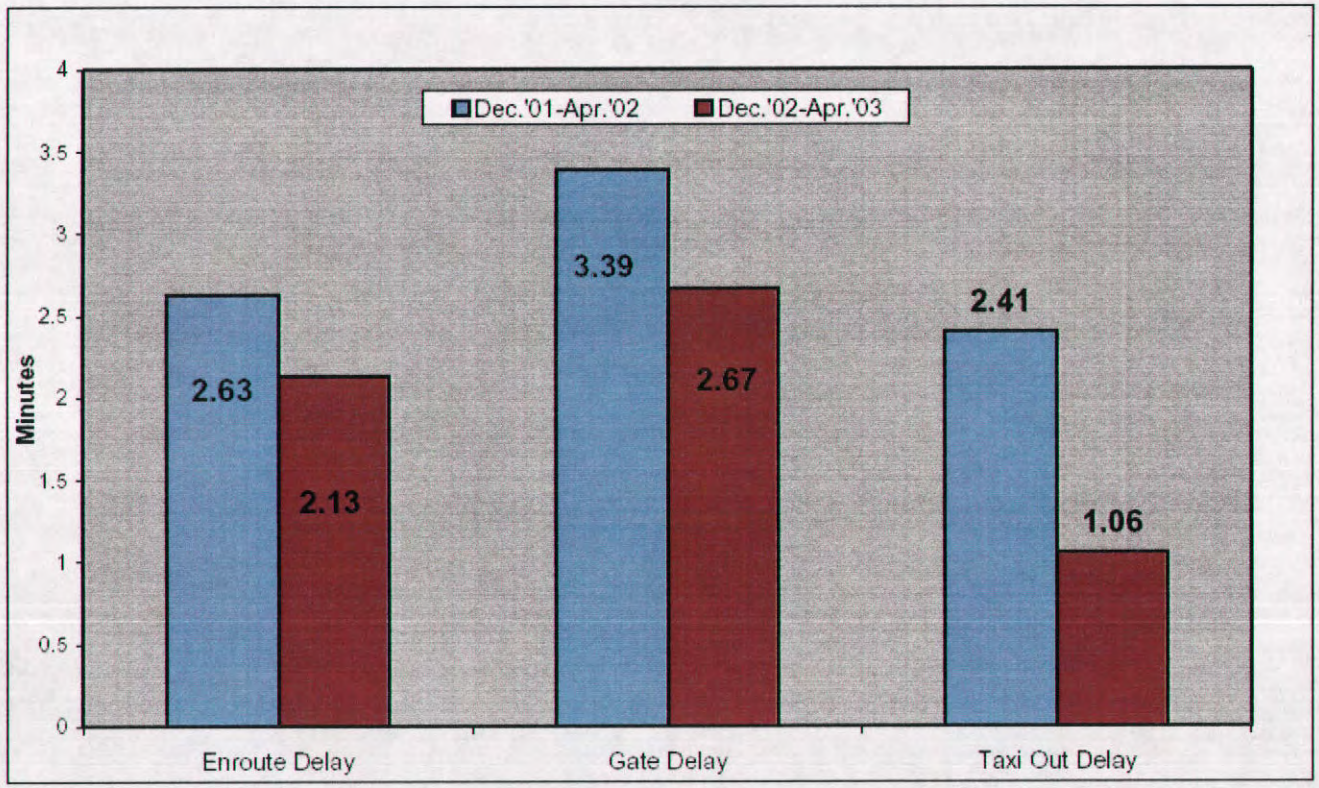
Additional Benefits: Traffic Management Advisor



Delays for ZLA internal departures to LAX

Source: FAA Free Flight Program Office

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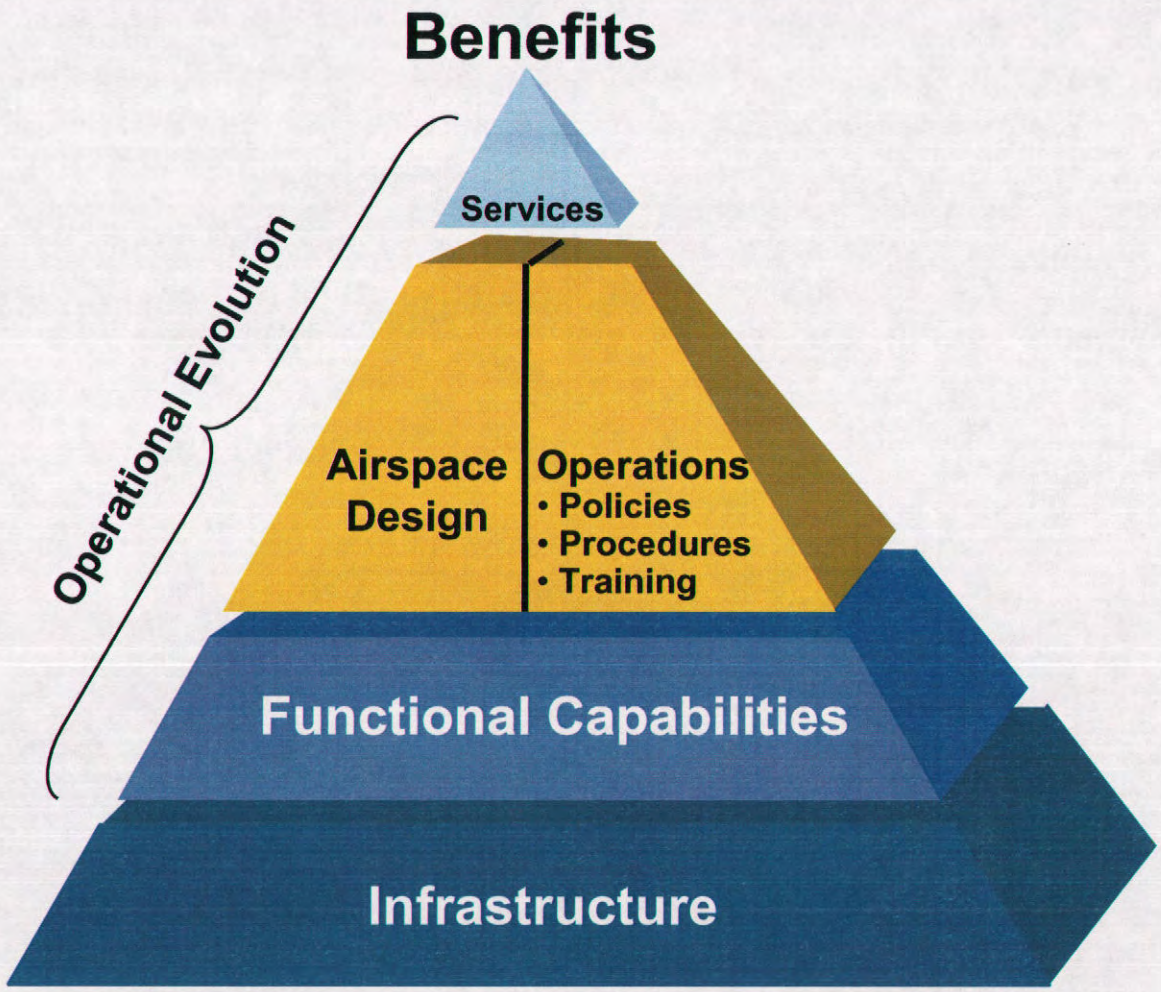
Research, Operations Analysis, and Engineering Integration To Deliver Benefits



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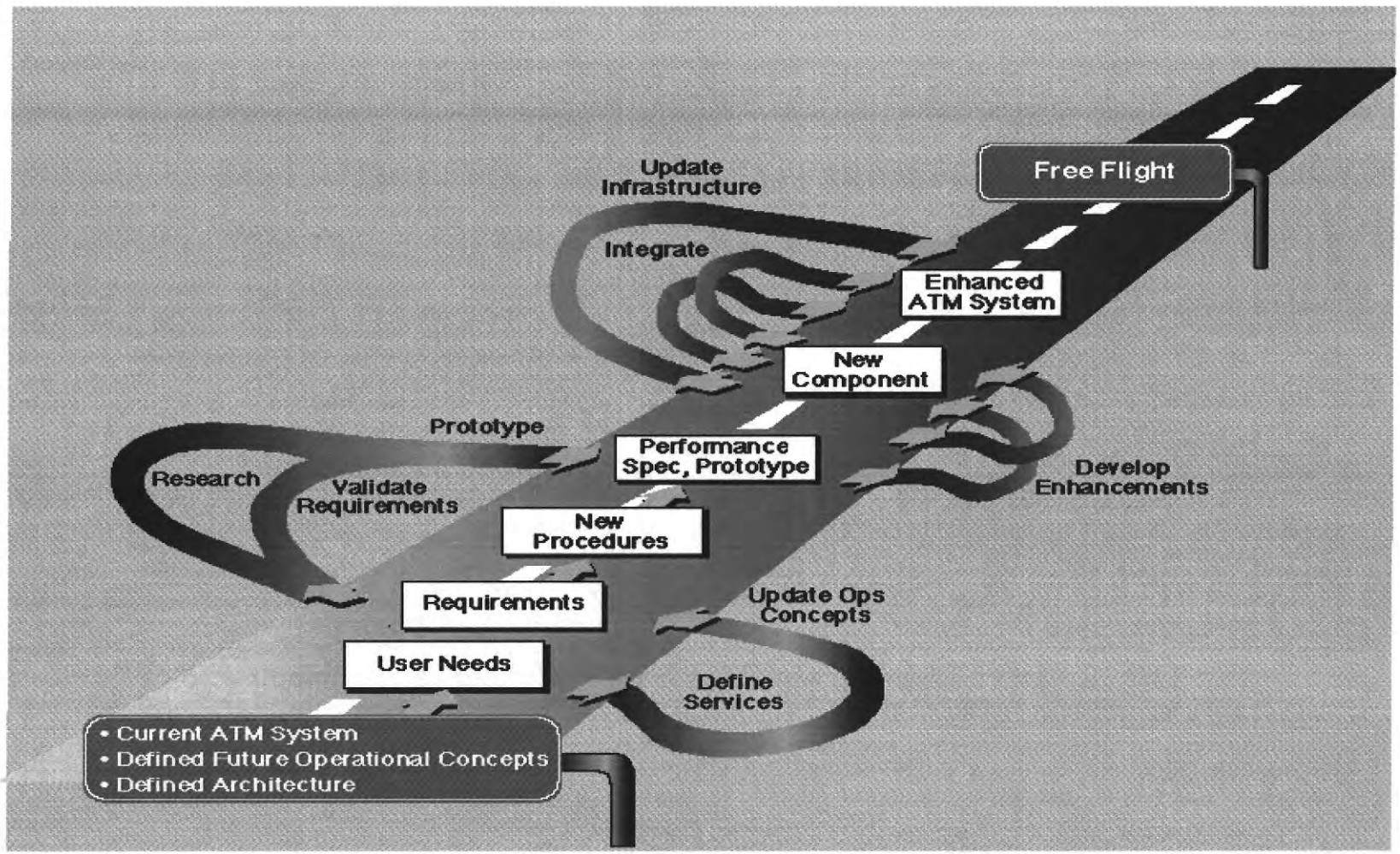
The Role of Research and Development



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Acquisition Guidelines

- **Develop and follow established guidelines for the system acquisition process. It is important to document the necessary steps and to follow them through.**
- **FAA Acquisition Management System:**

  "The Federal Aviation Administration (FAA) Acquisition Management System (AMS) establishes policy and guidance for all aspects of the acquisition lifecycle from the determination of mission needs to the procurement and lifecycle management of products and services that satisfy those needs. It is intended to simplify, integrate, and unify the elements of lifecycle acquisition management into an efficient and effective system that increases the quality, reduces the time, and decreases the cost of delivering needed services to its customers."

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Roles and Responsibilities of the CAA

- Civil Aviation Authority (CAA) must have the authority and ability to plan and execute modernization programs.
- Government budgetary process must be uniform and robust.
- There must be oversight organizations to monitor the progress of major programs.
- Within CAA, there must be a clear division of regulatory and service functions.
- Within CAA, there must be an organization responsible for research, development and acquisition.

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Roles and Responsibilities of the Contractor

- Identify a program manager who is the primary point of contact with the CAA.
- Plan well, mitigate risks.
- Ensure the work proceeds as planned.
- Report noncompliances.
- Develop and implement corrective actions.
- Conduct program reviews at critical stages of project.
  - Requirements Review
  - Design Review

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Roles and Responsibilities of the Consultant

- Be the CAA's partner.
- Apply system acquisition expertise.
- Where appropriate, perform independent verification and validation.
- Understand requirements.
- Serve as a resource for both customer and contractor.

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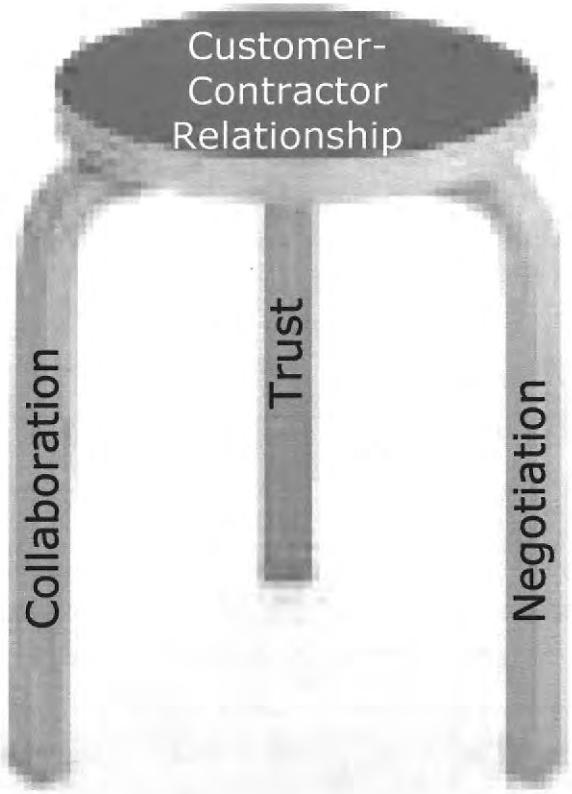
Key Components of the Customer-Contractor Relationship



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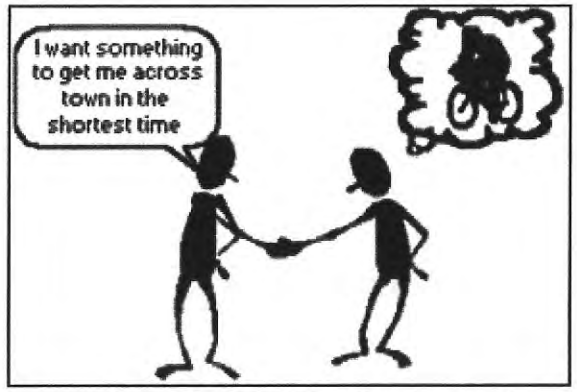
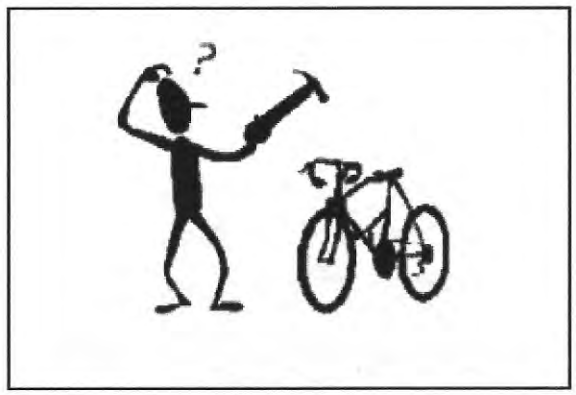
Requirements Must be Clear

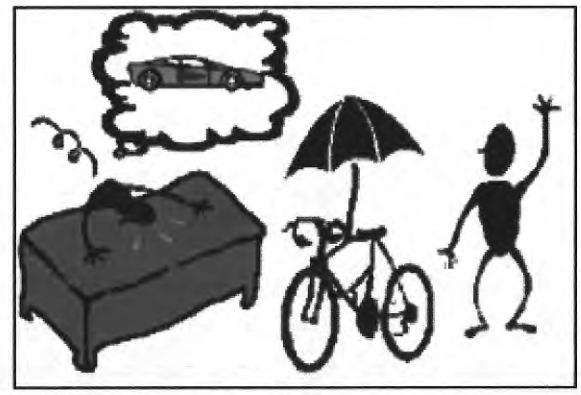


Requirements Statement

Emerging Requirements



Redesign



Six Months Later

Source: http://www.consult-me.co.uk/requirements-analysis.htm

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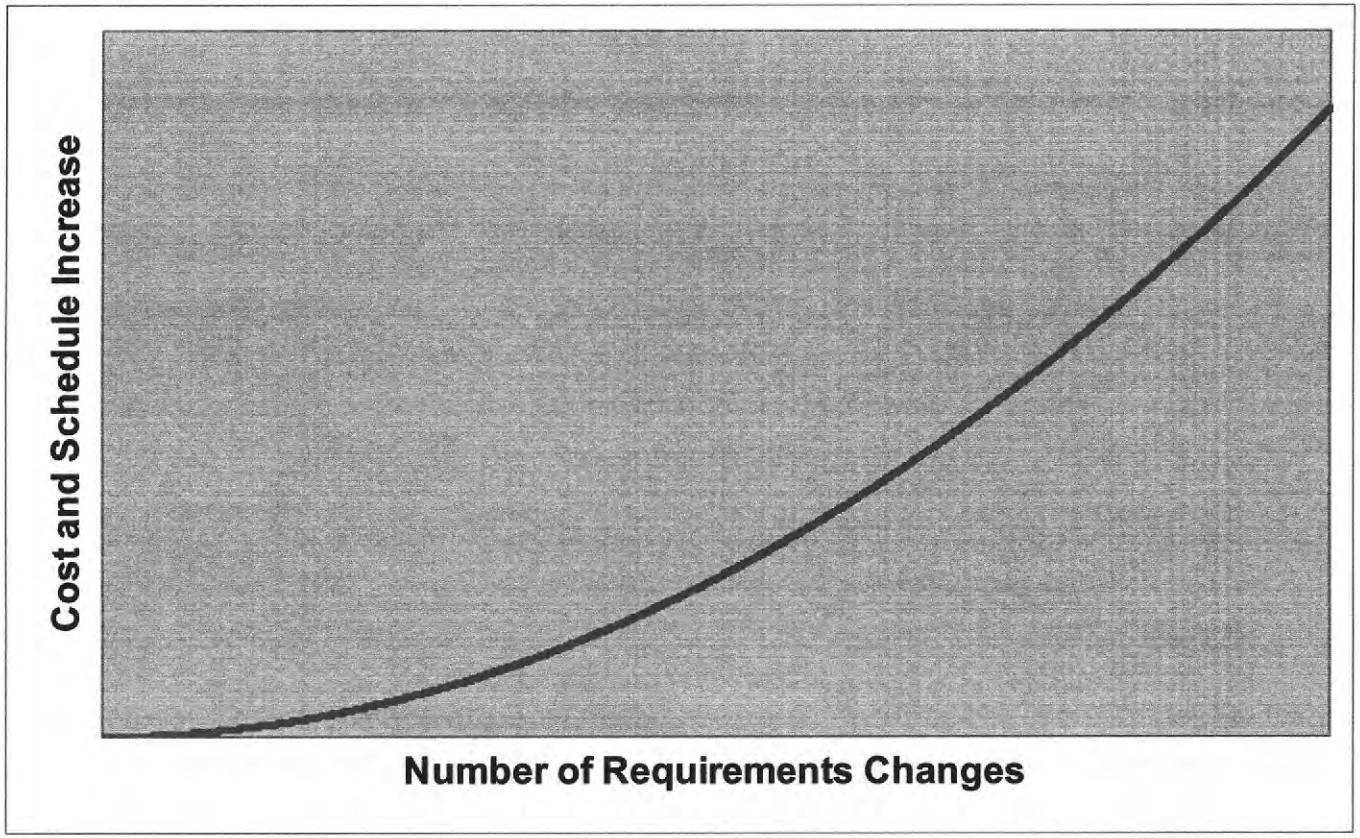
Stable Requirements are a Key!



Note: Notional Data

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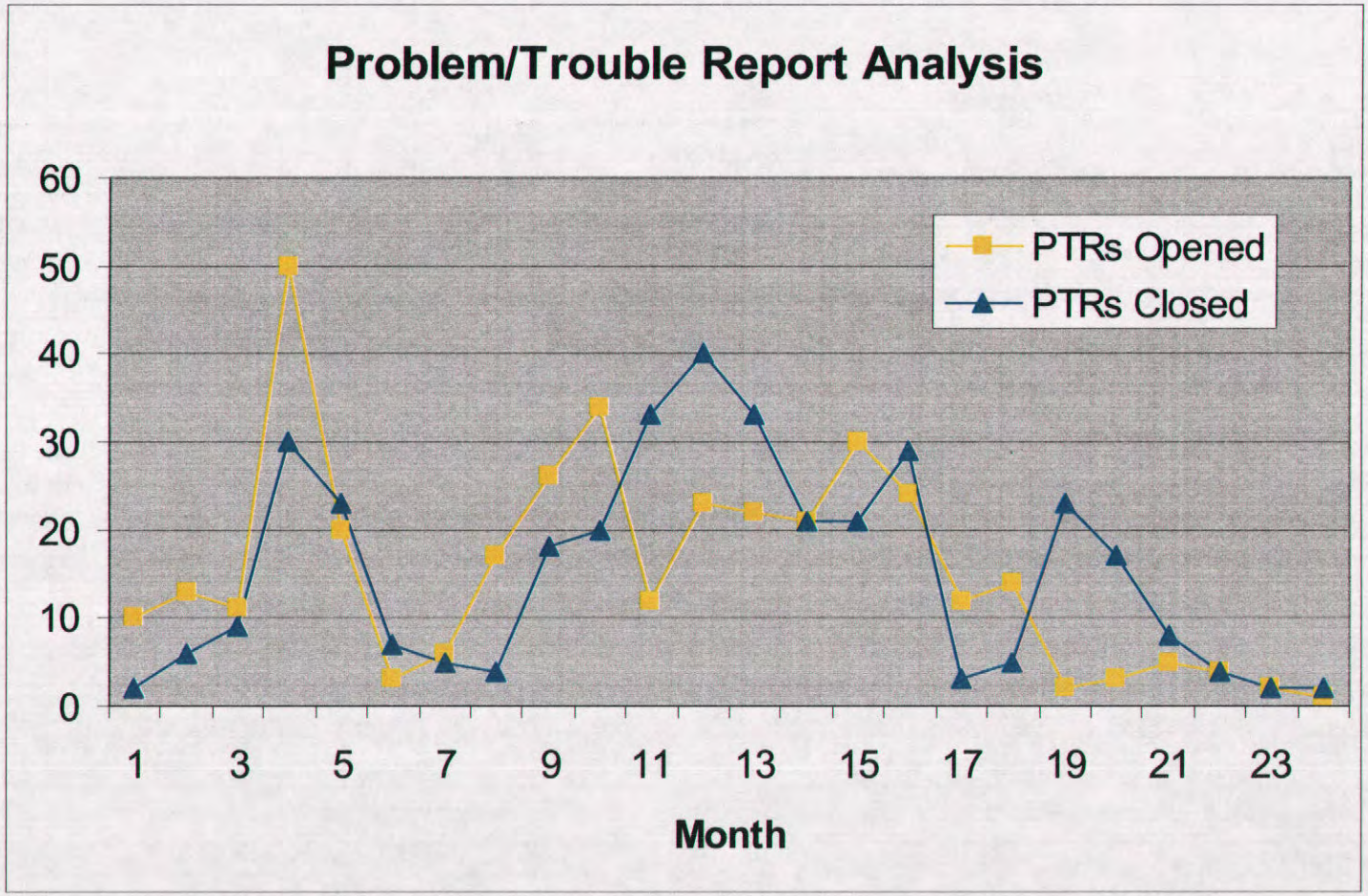
Keeping Track of Problem Reports



Note: Notional Data

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Risk Reduction Matrix

Risk Factors		Major CNS Programs					Free Flight Phase 1					DSS Infrastructure			
		GPS/WAAS	CPDLC build 2+	NEXCOM	Extensive ADS-B A/A and A/G	TIS/FIS	Initial Conflict Probe	CPDLC Build 1 (Now)	Limited CTAS	Full CTAS	CDM/TFM	Interim Host	DSR	En route Infrastructure	STARS
Avionics Costs	Airlines	R	R	R	R	R	G	G	G	G	G	G	G	G	G
	GA	R	R	R	R	R	G	G	G	G	G	G	G	G	G
Certification		R	R	R	R	R	Y	R	Y	Y	Y	Y	Y	Y	Y
Requirements Uncertainty & Complexity		R	Y	R	R	Y	G	G	Y	R	R	G	G	Y	Y
Information Security		R	R	Y	R	G	G	R	Y	Y	Y	G	G	G	Y
Procedures/Ops. Concepts		Y	Y	Y	Y	R	Y	G	Y	R	R	G	G	G	Y
International Standards		Y	R	Y	Y	Y	G	G	G	G	G	G	G	G	G
Technical/ Information Architecture		Y	G	Y	R	G	G	G	Y	Y	Y	G	G	G	G
Adaptation		Y	G	G	G	G	Y	G	Y	R	Y	G	G	G	G
Deployment Rate Limitations	FAA	Y	R	R	Y	R	R	R	R	R	R	R	R	R	Y
	User	Y	Y	R	Y	Y	G	G	G	G	R	G	G	G	G
System Acceptance	FAA	Y	R	Y	R	Y	R	R	Y	R	Y	Y	Y	Y	R
	User	Y	Y	R	Y	Y	G	Y	G	G	G	G	G	G	G

R Serious Concern Y Limited Concern G No concern

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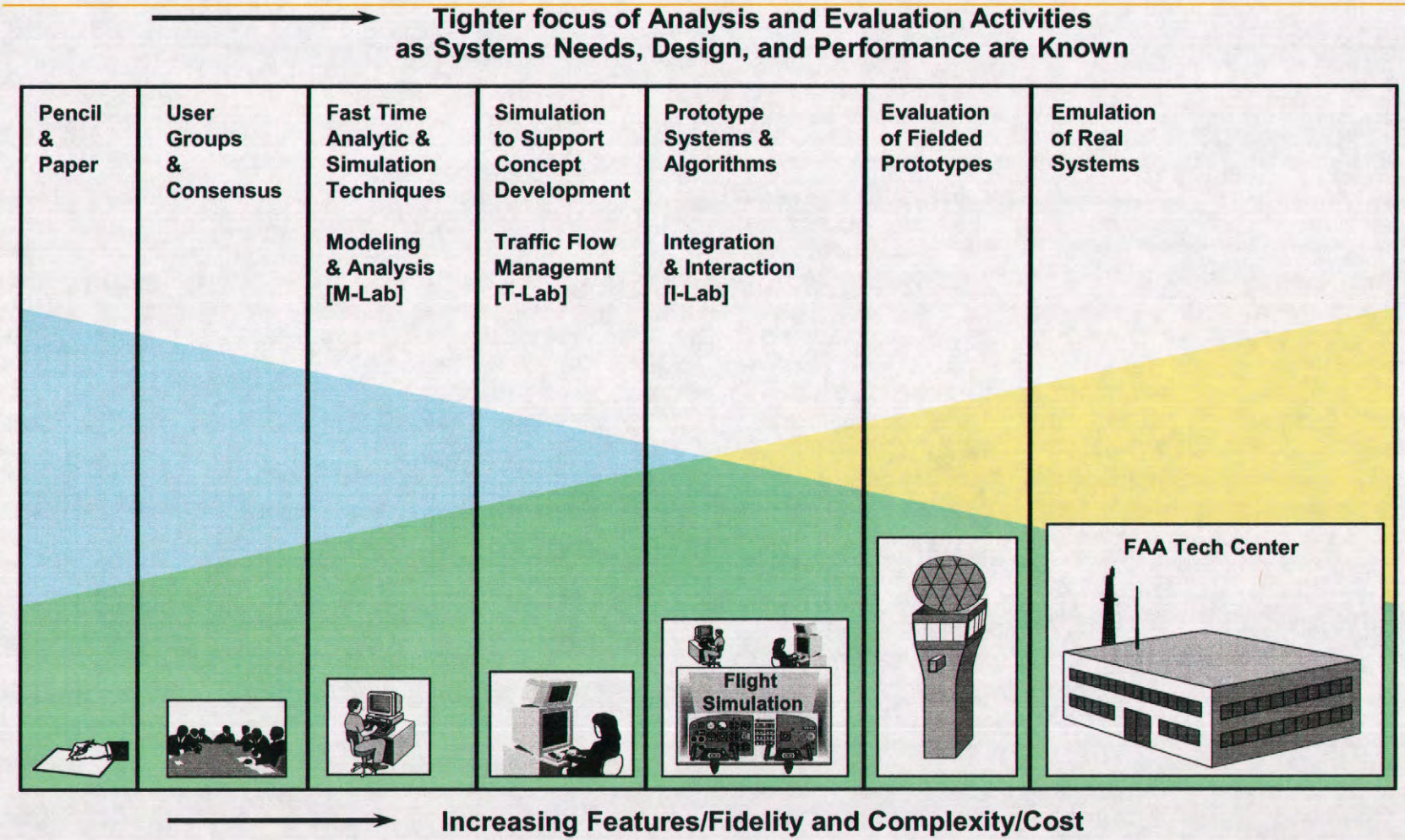
Analysis, Modeling & Simulation Capabilities



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Utility Of Modeling

- Support understanding of operational environment
  - Needs
  - Problems
  - Causes
  - Influencing factors
- Support definition of system architecture
  - Functional components of Air Traffic Management (ATM) (solution development)
  - Experiment with various options without risk
- Support complex decisions with objective analysis of:
  - Efficiency
  - Workload
  - Noise
  - Cost tradeoffs (solution evaluation)
- Support collaboration among decision makers and stakeholders by establishing a common framework for communication

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Classification of Modeling

- **Infrastructure/Operation Modeling**
  - **Airspace**
  - **Airport**
  - **Air Routes**
- **Functional Modeling**
  - **Communication, Navigation, Surveillance**
  - **Air Traffic Management**
  - **Avionics**
- **Performance Modeling**
  - **Throughput**
  - **Delay**
  - **Workload**
  - **Cost, etc.**

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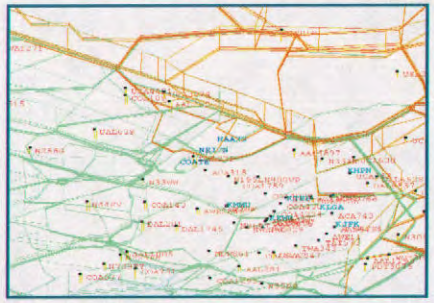
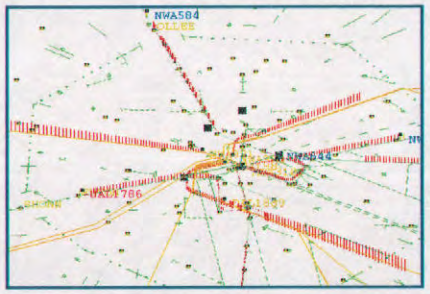
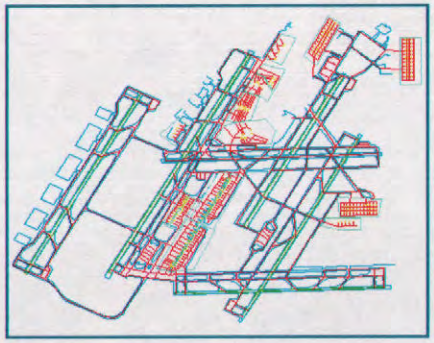
Approaches to Modeling the NAS

Model Building Block	Model Results
 Full regional dynamics	Traffic scenarios +CNS* + DSS** + Avionics airport/airspace configurations (multiple airports & regional airspace) Delay, Throughput, Noise, Workload
 Arrivals & departures; airspace transitions	Traffic scenarios + CNS + DSS + Avionics airport/airspace configurations (one or two airports) Delay, Throughput, Noise, Workload
 Airport operational dynamics	Demand + Capacity Delay

*CNS=Communication, Navigation, Surveillance

**DSS=ATM Decision Support System

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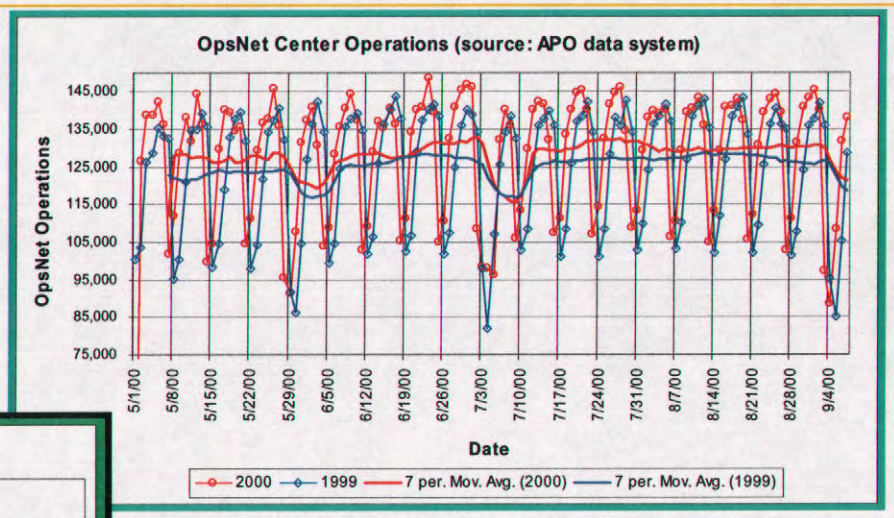
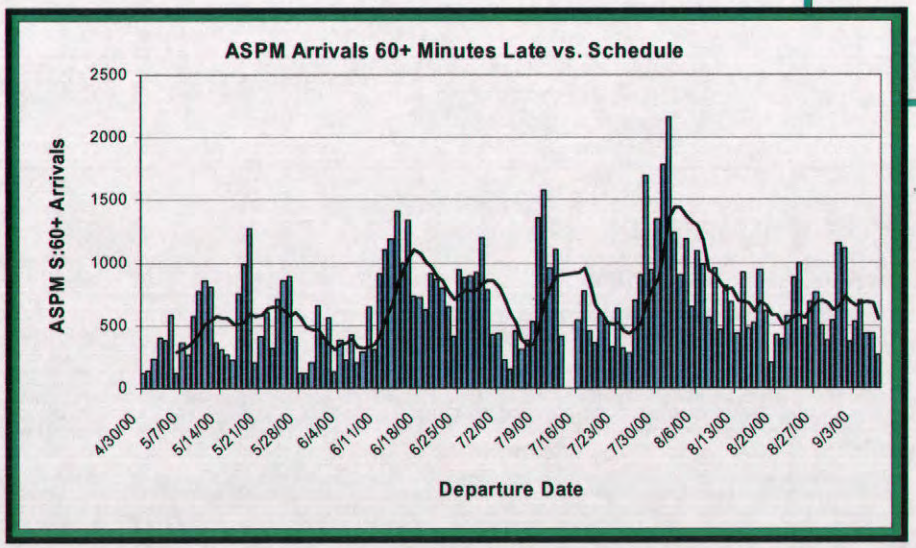
Determine Bottom Line Performance





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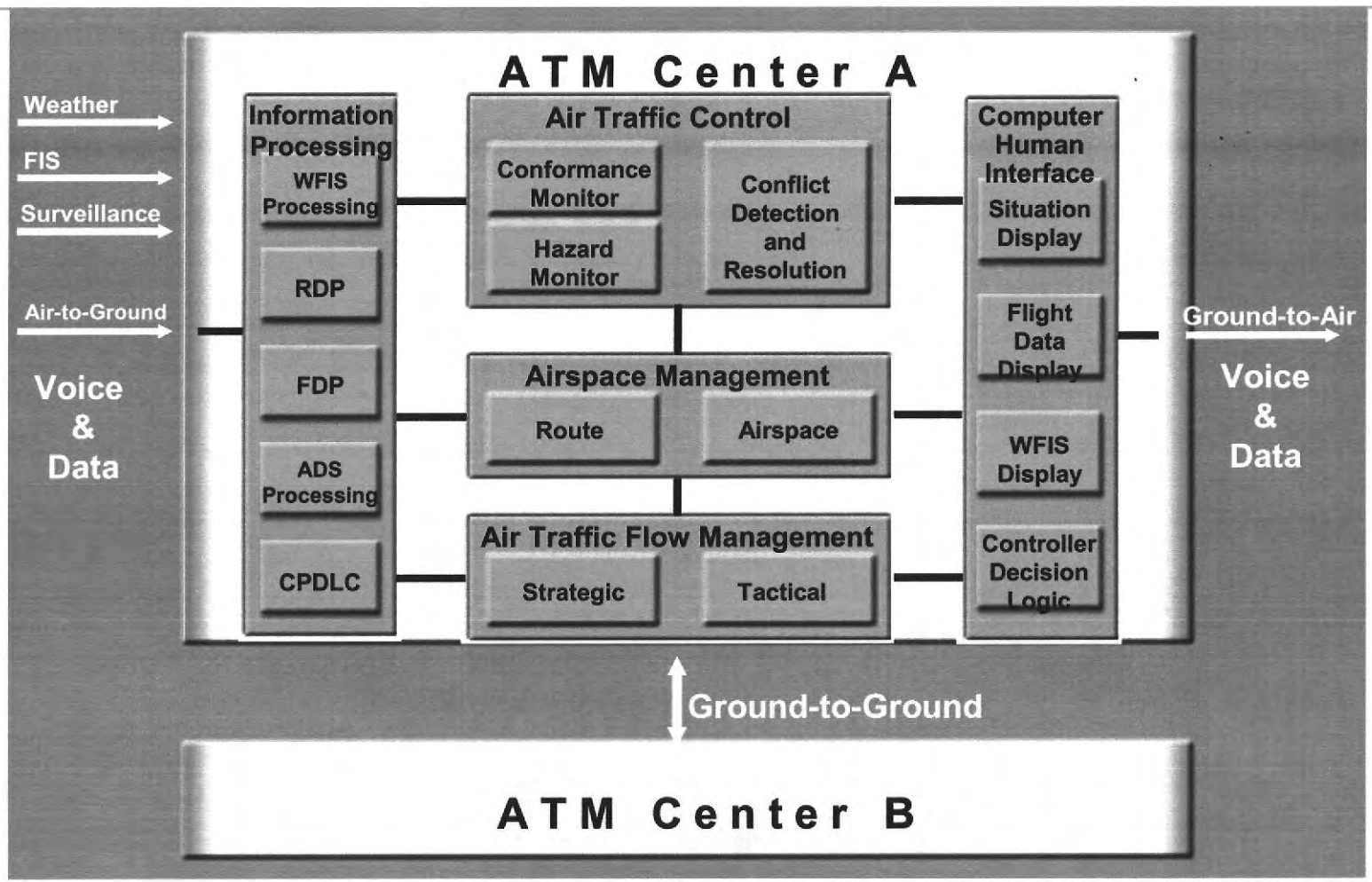
Functional Elements of Ground ATM



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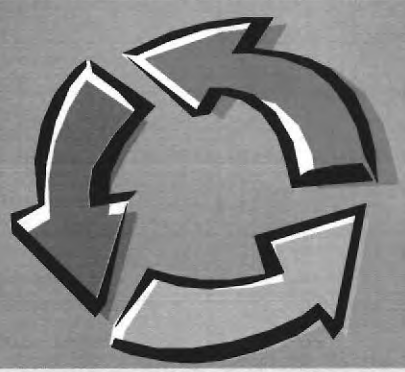
Implementation Approach

- ICAO and international requirements
- ICAO Charter and Annexes
- International bi-lateral and multi-lateral agreements

Integration of airspace, systems, facilities and procedures

User community participation

Regulations and standards



Life cycle system engineering approach

Strategic plan based on need and with full budget commitment

Delivery of benefits/capabilities, not equipment/systems

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Proposal Evaluation Process: Typical Request for Proposal Package

- Statement of work (SOW)
- Instruction for Preparation of Proposal (IFPP)
- System Architecture / Requirements
- System Specifications
- Interface Requirements
- Contract Data Requirements List (CDRL)
- Quality Assurance Concept
- Maintenance and Logistics Concept
- Personnel and Training Concept
- Supplemental Procurement Documentation (SPD)

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Evaluation Process

- **Typical Evaluation Criteria**
  - **Technical**
  - **Cost**
  - **Business/Management Plan**
- **Government must decide how much weight to give each item and develop a scoring process.**

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System Engineering Exercise

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Objectives

- Define Organizational Roles, Responsibilities, and Goals.
- Identify major stakeholders and points of contacts.
- Outline a Basic Functional Requirements Document and identify who will be responsible for specific requirements areas.
- Define an approximate schedule.
- Identify qualitative and quantitative benefits, and how will they will be measured.
- Outline plans and schedules for evaluating proposals.

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ATM System Safety

September 10, 2003

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Overview

- Overview of System Safety
- Standards
  - ICAO Guidelines
  - FAA Safety Initiatives
  - Safety-Critical vs Non-Safety Critical Systems
- Establishing Requirements
  - Data-Driven Approaches
  - Case Studies: Risk Ratio/ Collision Risk Model
- How to Ensure Safety?
  - Automation
  - Training

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System Safety

- Safety is the most important element of any aviation-related program
- Can be applied in a fundamental and business-like process of risk management
  - AT ALL LEVELS
  - Throughout the ENTIRE SCOPE of operations
- Requires:
  - The commitment of your management team
  - An established safety culture
- Result: Everyday safe work practices of aviation professionals

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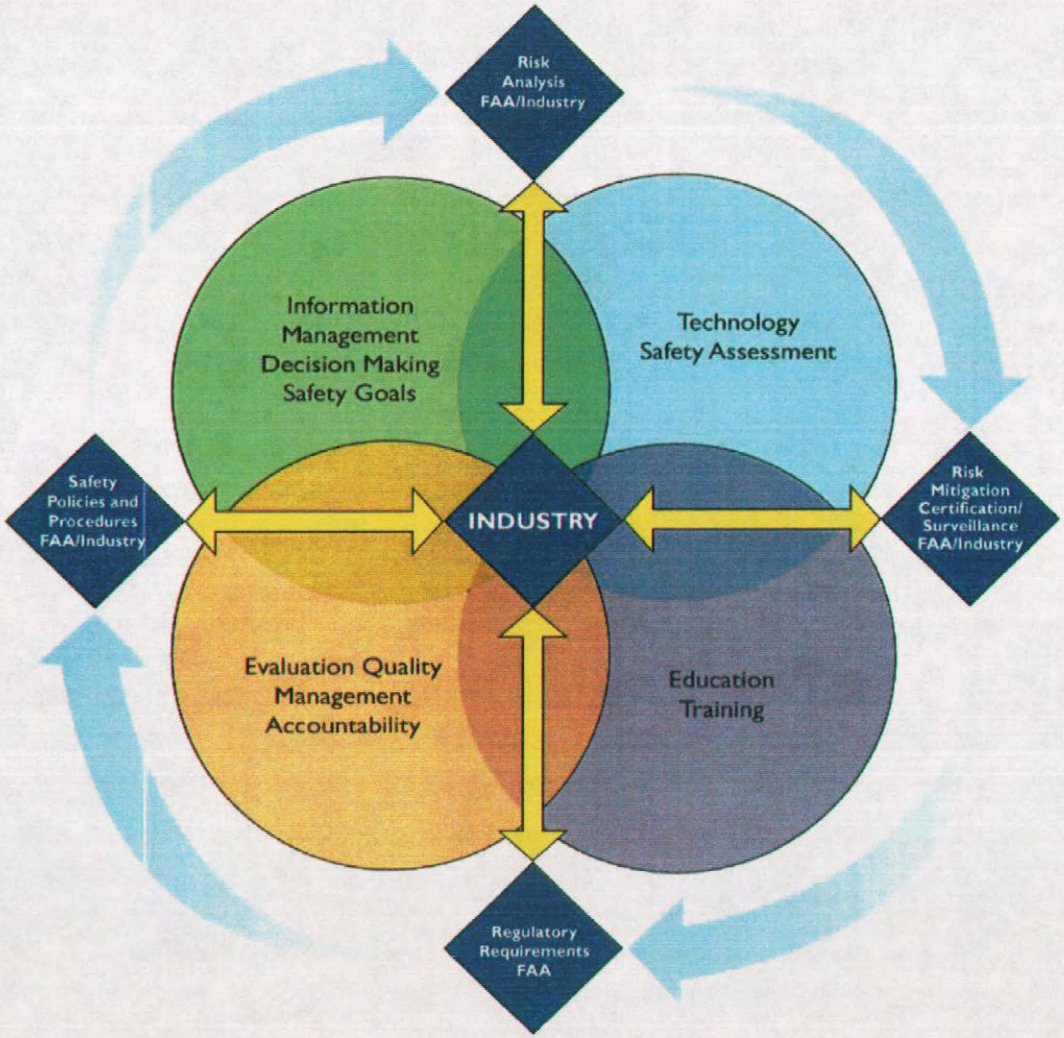
Safety Overview



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The Role of ICAO in Aviation Safety

- **ICAO responsibilities and objectives are set out in the Chicago Convention**
- **Article 44 requires ICAO to:**
  - **Ensure the safe and orderly growth of civil aviation throughout the world**
  - **Meet the needs of the people of the world for safe, regular, efficient and economical air transport**
  - **Promote safety of flight in international aviation**

Source: ICAO Provisions for Air Traffic Services Safety Management

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Promulgation of Requirements

- ICAO promulgates requirements for international aviation as Standards and Recommended Practices (SARPS), which are published in Annexes to the Convention.
- The Annexes are the foundation for all ICAO provisions, including those related to Safety Management.

Source: ICAO Provisions for Air Traffic Services Safety Management

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Origins of ICAO Safety Requirements

- The Global Aviation Safety Plan (GASP) was first proposed by the Air Navigation Commission in April 1997
- GASP was endorsed by the 32nd ICAO Assembly in 1998

Source: ICAO Provisions for Air Traffic Services Safety Management

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GASP Objectives

- **Reduce the number of accidents and fatalities regardless of the volume of air traffic.**
- **Achieve a significant decrease in worldwide accident rates, placing emphasis on regions where these remain high.**

Source: ICAO Provisions for Air Traffic Services Safety Management

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Annex 11 Provisions(1)

- **States shall implement systematic and appropriate Air Traffic Service safety management programs to ensure that safety is maintained in the provision of Air Traffic Service within airspaces and at airports.**

Source: ICAO Provisions for Air Traffic Services Safety Management

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Annex 11 Provisions(2)

- As of 27 November 2003, States will be required to establish acceptable levels of safety and safety objectives applicable to the provision of Air Traffic Services within their areas of responsibility.
- When applicable, safety levels and safety objectives shall be established by regional air navigation agreement.

Source: ICAO Provisions for Air Traffic Services Safety Management

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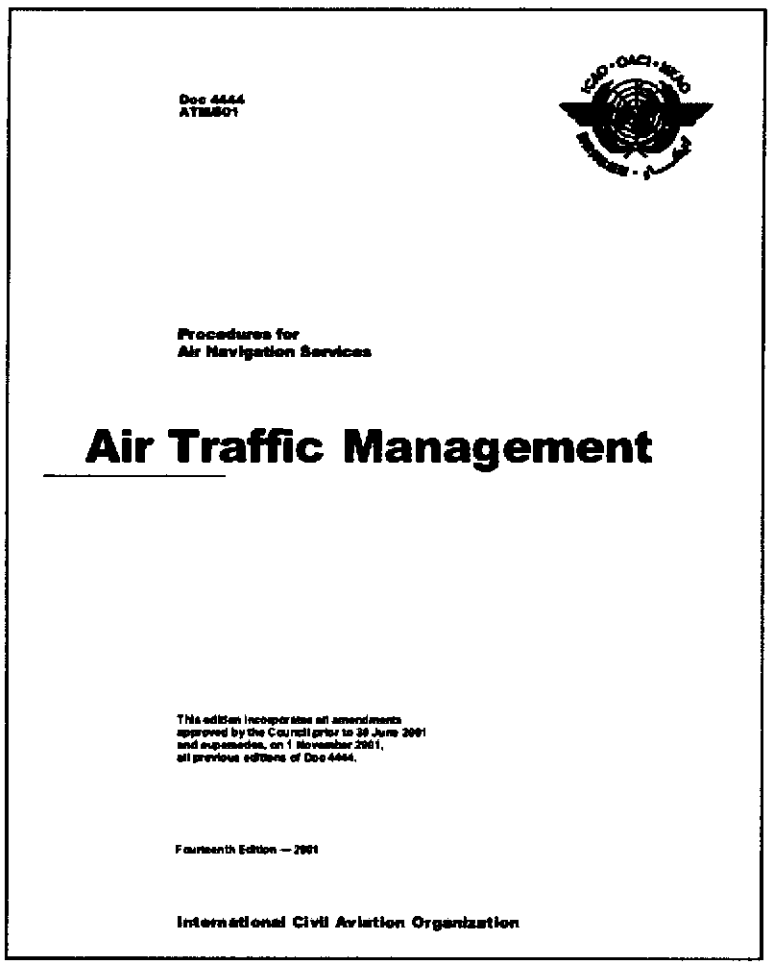
ICAO PANS-ATM
(PANS: Procedures for Air Navigation Services)


Doc 4444
ATM/501

Procedures for
Air Navigation Services

Air Traffic Management

This edition incorporates all amendments approved by the Council prior to 30 June 2001 and supersedes, on 1 November 2001, all previous editions of Doc 4444.

Fourteenth Edition — 2001

International Civil Aviation Organization

Specifies in more detail what composes an Air Traffic Service safety management program

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Air Traffic Services Safety Management

- Ensure that Air Traffic Services, communications, navigation, and surveillance are appropriate and adequate for an acceptable level of safety.
- Requirements in support of Air Traffic Services should be established with harmonization with neighboring airspace in mind.
- Formal and systematic safety management programs are needed.

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PANS-ATM Safety Provisions

- **An Air Traffic Services safety management program should include:**
  - **Monitoring of overall safety levels and detection of any adverse trend**
  - **Safety reviews of ATS units**
  - **Safety assessments of system changes**
  - **A mechanism for identifying the need for safety enhancing measures**

Source: ICAO Provisions for Air Traffic Services Safety Management

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PANS-ATM Safety Provisions (concluded)

- **The PANS-ATM safety management provisions are contained in Chapter 2 which specifies:**
  - **Monitoring of Safety Levels**
  - **Safety Reviews**
  - **Safety Assessments**
  - **Safety Enhancing Measures**

Source: ICAO Provisions for Air Traffic Services Safety Management

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The Manual on Safety Management in ATS

- **The new Manual on Safety Management in ATS will provide more detailed guidance on implementation of the provisions of Annex 11 and the PANS-ATM Doc 4444.**
  - **Document still under development**
  - **It will be presented in the 11th Air Navigation Conference (Montreal, Sep/Oct 2003)**

Source: ICAO Provisions for Air Traffic Services Safety Management

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Topics to be Covered in the Manual

- Management for safety
- Factors affecting system safety
- Determination of the acceptable level of safety
- Safety assessment and risk management techniques
- Ensuring the on-going safety of operational systems

Source: ICAO Provisions for Air Traffic Services Safety Management

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State Regulatory Responsibilities

- **The State will always be responsible for**
  - **The establishment of the regulatory framework which forms the basis of the safety management requirements.**
  - **Oversight of the safety management procedures, and monitoring the achieved levels of safety, of the Air Traffic Service providers and Airport operators.**

Source: ICAO Provisions for Air Traffic Services Safety Management

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The State as a Service Provider

- **Where a State provides ATS services and operates airports, it will, in addition, be responsible for the implementation of safety management programmes at its Air Traffic facilities and airports.**

Source: ICAO Provisions for Air Traffic Services Safety Management

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Independent ATS Providers and AD Operators

- **State regulations and oversight programmes must ensure that independent Air Traffic Service providers and Airport operators implement adequate safety management programs.**

Source: ICAO Provisions for Air Traffic Services Safety Management

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Third Party Service Providers

- **The term "Third Party Service Providers" refers to organizations such as communications providers, which are not answerable to the State aviation authority.**

Source: ICAO Provisions for Air Traffic Services Safety Management

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Safety Assurance of Third Party Services

- ATS providers and Airport operators must consider third party provided services in carrying out safety assessments.
- Safety requirements applying to such services and the responsibilities of each party should be specified in contractual requirements, or formal documents such as letters of agreement.

Source: ICAO Provisions for Air Traffic Services Safety Management

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FAA Safety Initiatives

Taking Safety to the Next Level

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FAA Safety Programs

- **Air Transportation Oversight System**
  - **Focuses on air carriers**
    - **Ensures that air carriers have safety built into their operations**
    - **Identifies and corrects deficiencies BEFORE they cause problems**
    - **Assesses new procedures and technologies**
- **System Safety Approach for General Aviation**
  - **Joint Government/Industry collaboration in the application of**
    - **New technology**
    - **Training**
    - **Education**
    - **Decision-Making**
  - **Increases effectiveness of FAA's surveillance and certification processes for General Aviation.**

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FAA Safety Programs (continued)

- System Approach for Safety Oversight
  - An overarching program to integrate and provide oversight to all Flight Standards Service business processes:
    - Certification
    - Surveillance
    - Investigation
    - Enforcement
  - Automated databases are used to make better informed safety decisions.
  - Helps identify, assess, and mitigate safety-related hazards and risks.

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FAA Safety Programs (concluded)

- **Quality Management**
  - **FAA is pursuing International Organization for Standardization (ISO) registration for its quality management system (ISO 9001:2000 is the current standard).**
  - **Such standards are critical for reflecting international community's commitment to system safety.**

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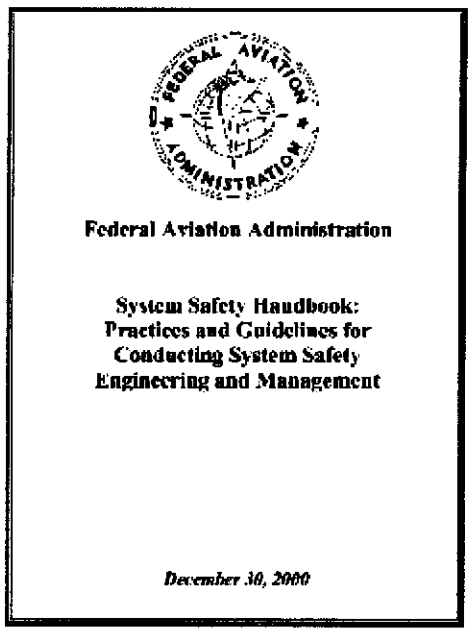
FAA Resource:
FAA System Safety Handbook


Federal Aviation Administration

System Safety Handbook:
Practices and Guidelines for
Conducting System Safety
Engineering and Management

December 30, 2000

The purpose of the handbook is to provide instructions on how to perform system safety engineering and management for FAA personnel involved in system safety activities, including FAA contractor management, engineering, safety specialists, analysts and personnel throughout FAA regions, centers, facilities, and any other entities involved in aviation operations.

http://www.asy.faa.gov/risk/SSHandbook/cover.htm

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Safety and Mission Critical Programs

- **Safety-Critical Services: if lost, would *prevent* the system from exercising safe separation and control over aircraft. (Example: Radar Services).**

- **Mission-Critical Services: if lost, would *reduce* the capability of the system to exercise safe separation and control over aircraft. (Example: Flight Data Processing Services).**

- **Routine Services: if lost, would *not significantly degrade* the capability of the system to exercise safe separation and control over aircraft. (Example: Traffic Management Services).**

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Establishing Requirements

- Difficult to put a number against safety.
- Minimum requirements deal with following established and disciplined processes.
- Quantitative measures are useful in assessing safety improvements.

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Data-Driven Approach to System Safety

- **Goal of Safety Programs: create a high level of safety using data-driven processes to identify safety trends and prevent accidents.**
  - **Examples**
    - **Runway incursions**
    - **ATC operational errors**

    Where, When, Why, How Often?

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Independent System Safety Assessment Free Flight Phase 1

- Review Problem/Trouble Reports (PTRs) identifying those with safety implications. Track these safety related PTRs to closure and elevate the issue to the appropriate program manager if closure is not timely.
- During implementation, identify any safety-related issues and validate.
  - Elevate validated issues to the Program Manager
  - Track issues to closure
- Review any operational error, operational deviation, accident, or incident where ground-based system was a contributing factor.
  - Elevate the issue resolution
  - Track resolutions to closure

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Independent System Safety Assessment Free Flight Phase 1 (continued)

- Submit special emphasis items on URET and TMA safety to the Air Traffic and Airway Facilities Evaluation Staffs.
  - The special emphasis items will be evaluated during Air Route Traffic Control Center (ARTCC) facility evaluations.
  - Review the results of the special emphasis items and elevate any validated issue to the appropriate program manager for resolution.
  - Track the issue to closure.
- Conduct site visits to evaluate high severity safety risks.
  - Brief the Director of the Free Flight Program Office on the findings.
  - Recommended resolution, and track the hazards to closure.
- Brief the Free Flight System Safety Workgroup at each meeting on safety issues identified during the assessment.

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Independent System Safety Assessment Free Flight Phase 1 (concluded)

- **The Independent System Safety Assessment is an on-going process and continues throughout the life cycle of the Free Flight Program.**

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Establishing Acceptable Levels of Risk

- **Metrics for assessing impact of new automation**
  - **Risk Ratio is a ratio of two different probabilities**

$$R = \frac{P_{\text{event with new capability}}}{P_{\text{event without new capability}}}$$

  - **Collision Risk**
    - **Probability of undetected collision due to surveillance or display accuracy**
    - **ICAO-endorsed models are available**

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Case Study: TCAS Risk Ratio

- **TCAS: Traffic Alert and Collision Avoidance System "Risk Ratio" studies**

Version Combo.		Tracker	Risk-Ratio Component (%)						Risk Ratio
			I	II	III	IV	V	VI	
7.00	none	100-ft	5.5	11.2	20.5	13.5	30.4	19.3	0.104
7.00	7.00	100-ft	1.8	4.0	4.6	3.4	57.6	27.7	0.024
7.00	none	25-ft	4.7	12.5	13.9	13.1	32.6	23.4	0.082
7.00	7.00	25-ft	1.2	4.1	1.6	2.9	61.6	28.2	0.024
7.00	6.04A	100-ft	1.7	5.0	4.2	3.3	55.8	29.3	0.021
6.04A	none	100-ft	4.9	11.4	16.5	13.4	32.5	21.3	0.096
6.04A	6.04A	100-ft	3.0	5.8	6.8	4.0	50.5	30.3	0.020
6.02	none	100-ft	2.9	6.9	30.2	23.1	19.1	17.4	0.057
6.02	6.02	100-ft	1.6	3.1	9.4	11.0	38.6	37.0	0.006

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Case Study: Collision Risk Model

- **To assess impact of new surveillance system, CAASD conducted a collision risk assessment. The following table summarizes the results:**

Radar Position - .10 nmi sigma Collision Risk Analysis

Radar Position - .10 nmi Sigma - Actual v. Displayed Upper Bound Probabilities							
	P(Displayed Separation >= x nmi | Actual Separation)						
Actual Separation	x=1	x=2	x=3	x=4	x=5	x=6	x=7
0	6.28E-05	8.15E-26	1.89E-65	5.97E-131	1.43E-210	0	0
1	9.98E-01	1.60E-06	1.24E-29	6.45E-74	9.57E-140	3.08E-222	0
2	1	9.98E-01	1.57E-06	4.89E-30	2.41E-74	6.81E-140	2.38E-227
3	1	1	9.98E-01	1.57E-06	4.89E-30	2.41E-74	4.57E-140
4	1	1	1	9.98E-01	1.57E-06	4.89E-30	2.41E-74
5	1	1	1	1	9.98E-01	1.57E-06	4.89E-30
6	1	1	1	1	1	9.98E-01	1.57E-06

Separation Standard	2	3	4	5	6	7
Upper Bound Collision Risk	1.3E-31	3.7E-100	3E-239	0	0	0

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Ensuring Safety: Processes

- Certification
- Surveillance/Inspection
- Investigation
- Enforcement

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Ensuring Safety: Controller Tools to Aid Safety

- **Predicting Loss of Separation:**
  - Short Term Conflict Alert (40-120 secs)
  - Long-Term Conflict Probe (5 min-20 min)
- **Predicting Flight into Unsafe Conditions:**
  - Low Altitude Warning
  - Hazardous Airspace Warning
- **Detecting Current Problems:**
  - "Immediate Alerts"
  - "Quality Assurance" programs
- **Automation should *enhance* safety**
- **Recurrent training is a key to maintaining safety**

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Reliability and Maintainability

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Overview

- **Defining Reliability and Maintainability (R & M)**
  - **What is Reliability?**
    - **Reliability Prediction**
    - **Reliability Testing**
  - **What is Maintainability?**
    - **Maintainability Prediction**
    - **Maintainability Testing**
- **Determining Minimum R&M Standards**
- **Establishing R&M Requirements**
- **Measuring R&M: The Concept of Availability**
- **R&M Exercise**

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Reliability and Maintainability – the Basics

- **Reliability and Maintainability are *performance specifications.***
  - **Such specifications must be met just like any other specification.**
  - **R & M specifications are not "just some data that the customer wants."**
  - **Although they are often used together, they are separate issues.**
- **Reliability refers to the length of time that the equipment operates before needing repair.**
- **Maintainability refers to how easy it is to repair the equipment.**

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What is Reliability?

- **Reliability: An indication of how long the equipment will perform its function before it needs repair**
  - **Metric: Mean Time Between Failure (MTBF)**
  - **MTBF is THE requirement for reliability**

- **Example: Customer wants 10,000 refrigerators with a MTBF of 20,000 hours (2 ½ years) and a MTTR of 1 hour**

- **Two methods are used for determining if reliability requirements are met:**
  - **Reliability Prediction**
  - **Reliability Testing**

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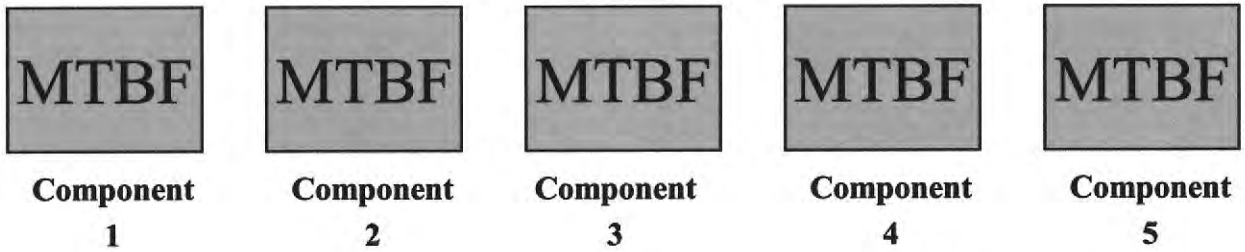
Reliability Prediction

- **Reliability prediction is an engineering discipline.**
  - **Equipment is viewed as a system made of functional components.**
  - **Each component has its own predicted reliability.**



- **Total Reliability is computed based on the MTBF of each component:**

$$MTBF_1 + MTBF_2 + MTBF_3 + MTBF_4 + MTBF_5$$

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From our Example:

- **Requirement: MTBF = 20,000 hours (50 failures in 1,000,000 hours)**

Component	MTBF	Failures/1M hrs
Motor	100,000	10
Compressor	50,000	20
Thermostat	50,000	20
Tubing	500,000	2
Wiring	500,000	2
TOTAL		54*

Example courtesy of O'Neil Associates

* Since prediction exceeds requirement, supplier will need to change one of the components

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Reliability Prediction - Summary

- **Prediction is a low cost method of ensuring reliability requirements are met.**
- **Customer must carefully review calculations and ensure that reliability of each component is traceable to some accepted standard.**

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Reliability Testing

- **Testing is the preferred method of ensuring that reliability requirements are met:**
  - **Seen as more robust than reliability prediction**
  - **Accurate testing would require a large number of units operating for many times the required MTBF (such as 20 units over 10 years!**
    - **Usually not practical**
    - **(Records from previous customers can be used, however)**
  - **Tradeoff: perform statistical tests that have some degree of accepted uncertainty**
  - **Conditions must be stated very early in the Request for Proposal**

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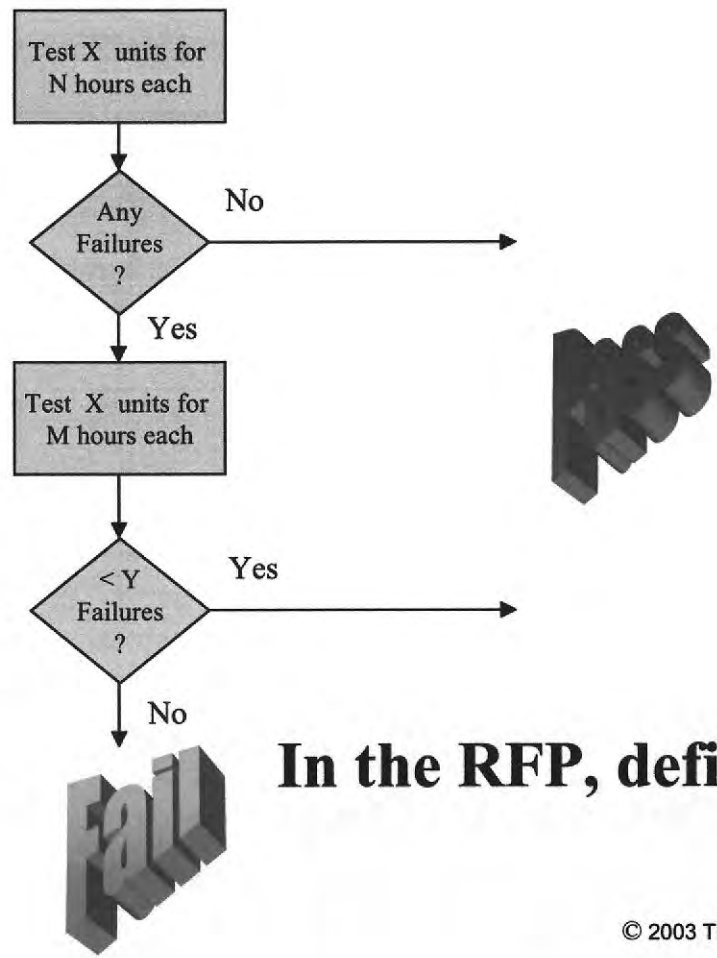
From our Example:

RFP Conditions



In the RFP, define X, Y, M, N

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What Is Maintainability?

- **Maintainability:**
  - **An indication of how easy the equipment will be to repair**
  - **Metric: Mean Time to Repair (MTTR)**

- **Example: Customer wants 10,000 refrigerators with a MTBF of 20,000 hours (2 ½ years) *and* a MTTR of 1 hour**

- **Like Reliability, two methods are used to determine MTTR:**
  - **Maintainability Prediction**
  - **Maintainability Testing**

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Maintainability Prediction

- **Maintainability prediction is an engineering discipline.**
  - **For a complete analysis, all possible repairs should be considered.**
  - **MTTR is computed from:**
    - **Frequency of each repair (available from RELIABILITY computations)**
    - **Time required to make each repair**

Repair Time	Repair Time	Repair Time	Repair Time	Repair Time
Component 1	**Component 2**	**Component 3**	**Component 4**	**Component 5**

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MTTR

Estimating the Hardware MTTR		
Where are hardware spares kept?	**How is site manned?**	**Estimated MTTR**
Onsite	24 hours a day	30 minutes
Onsite	Operator is on call 24 hours a day	2 hours
Onsite	Regular working hours on week days as well as weekends and holidays	14 hours
Onsite	Regular working hours on week days only	3 days
Offsite. Shipped by courier when fault condition is encountered.	Operator paged by system when a fault is detected.	1 week
Offsite. Maintained in an operator controlled warehouse	System is remotely located. Operator needs to be flown in to replace the hardware.	2 week

Source: EventHelix.com

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From our Example:

Requirement: MTTR = 1.0 hours

Repair Task	Repairs/1M hrs	Time to Make 1 Repair	Total Time
Replace Motor	10	0.8	8
Replace Compressor	20	1.5	30
Replace Thermostat	20	0.5	10
Repair Tubing	2	2.0	4
Repair Wiring	2	2.0	4
TOTAL	54		56*

Example courtesy of O'Neil Associates

* MTTR=1.04 Hours (56/54). The MTTR requirement is not met. Again, a redesign may be needed.

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Maintainability Testing

- **Maintainability testing is simpler than a complete maintainability analysis.**
  - **Customer simply gives a MTTR for each component.**
  - **Contractor must prove that EACH repair time (not the average) is within the MTTR.**

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Determining R&M Standards

- Customer should select which method (prediction, testing) is required.
- Customer should request from the contractor a R & M Plan.
- R & M Plan should include:
  - Previous analyses (especially if same equipment was used in other procurements)
  - Test or analysis plans for assessing compliance with requirements
  - Component list
- Ideally, assessment of requirements should be done with a combination of test and analysis.
- Basing requirements compliance on analysis alone could lead to erroneous results.

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Determining R&M Standards (continued)

- Contractual requirements should be traceable to operational requirements and capable of verification (i.e., do you really need each display to have a MTBF of 1 M hours when 100,000 hours will do?)
- Estimated or measured reliability and maintainability characteristics should be used to evaluate the design, but ensure that the estimates are based upon some standard.
- Trade-offs can be made if MTBF and MTTR are too expensive to meet.

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Determining R&M Standards (continued)

- **Avoid single point failures**
  - **If a mission-critical or safety-critical single point of failure cannot be avoided, ensure that the design is robust, or at least redundant.**
  - **Fault tree analysis and failure modes, effects, and criticality analysis are tools that should be used to help identify where failure could compromise the mission or safety of operators and maintainers.**

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Determining R&M Standards (concluded)

- Hardware design should be based on established parts selection practices and guidelines.
- Previous use of components, physical/environmental stresses, and component criticality should be considered in the part selection process.

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Reliability, Maintainability vs Cost

- R&M characteristics are major drivers of Operating and Support Costs. An item that cannot be repaired quickly has an obvious impact on operations and support.
- Increased R&M requires more up-front development costs:
  - However, in the long run, increased R&M results in less operating and support costs
  - There is a delicate tradeoff between the operational need for increased R&M and the need to reduce development costs
- You get what you pay for.

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Availability as a Metric for Measuring R&M

- **Availability of the module is the percentage of time when system is operational.**
  - **Availability of a hardware/software module can be obtained by the following formula:**

$$A = \frac{MTBF}{MTBF + MTTR}$$

  - **Availability is typically specified in "nines" notation.**
    - **3-nines availability corresponds to 99.9% availability.**
    - **5-nines availability corresponds to 99.999% availability.**

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Availability as a Metric for Measuring R&M (concluded)

- **Downtime per year is a more intuitive way of understanding the availability. The table below compares the availability and the corresponding downtime.**

Availability	Downtime
90% (1-nine)	36.5 days/year
99% (2-nines)	3.65 days/year
99.9% (3-nines)	8.76 hours/year
99.99% (4-nines)	52 minutes/year
99.999% (5-nines)	5 minutes/year
99.9999% (6-nines)	31 seconds/year

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Availability of ATM Services

Services/Functions	Availability	Single loss of service
Safety Critical	0.99999	not exceed 6 seconds
Mission Critical	0.999	not exceed 10 minutes
Routine	0.99	not exceed 1.68 hours

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What About Software?

- Software failures can be characterized by keeping track of software defect density in the system. This number can be obtained by keeping track of historical software defects. Defect density will depend on the following factors:
  - Software process used to develop the design and code (use of peer level design/code reviews, unit testing)
  - Complexity of the software
  - Size of the software
  - Experience of the team developing the software
  - Percentage of code reused from a previous stable project
  - Rigor and depth of testing before product is shipped.
  - Defect density is typically measured in number of defects per thousand lines of code (defects/KLOC).

  - The above items should be considered during the source selection process.

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Estimating Software MTTR

Estimating Software MTTR		
Software fault recovery mechanism	**Software reboot mechanism on fault detection**	**Estimate MTTR**
Software failure is detected by watchdog and/or health messages	Processor automatically reboots from a ROM resident image.	30 seconds
Software failure is detected by watchdog and/or health messages	Processor automatically restarts the offending tasks, without needing an operating system reboot	30 seconds
Software failure is detected by watchdog and/or health messages	Processor automatically reboots and the operating system reboots from disk image and restarts applications	3 minutes
Software failure is detected by watchdog and/or health messages	Processor automatically reboots and the operating system and application images have to be download from another machine	10 minutes
Software failure detection is not supported.	Manually operator reboot is required.	30 minutes to 2 weeks (software MTTR is same as hardware MTTR)

Source: EventHelix.com

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Summary

- Reliability and Maintainability are key aspects of any system.
- Testing and Prediction are the primary means of assessing reliability and maintainability.
- It is hard to talk about Reliability and Maintainability without talking about Availability.
- R & M apply not only to hardware, but to software as well.

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Reliability and Maintainability Exercise

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Objectives

- **Prioritize FAMUS capabilities according to desired reliability; i.e., what capability or function is most important, next important, etc.**
- **Create a plan to research other ATM systems' R&M requirements and assign actions to SMATCA representatives.**

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Quality Management

September 10, 2003

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Overview

- Programmatic Quality Management
- Operational Quality Management

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Programmatic Quality Management: Quality Planning

- Process of determining the quality standards specific to the project.
- Development of an organization in which the quality manager plays a key role in:
  - Risk Management
  - Test and Evaluation
  - Configuration Management
- Ensures appropriate trade-offs among cost, schedule, and quality standards.

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Programmatic Quality Management: Quality Assurance Versus Quality Control

- **Quality Assurance--Process of determining the procedures and tactics to be used to provide confidence that the identified quality standards will indeed be satisfied.**
- **Quality Control**
  - **Process of monitoring project results to measure the variance between the project standard and actual results.**
  - **Includes process of determining methods to correct significant variances.**
- **The *output* of Quality Control is often the *input* to Quality Assurance.**
- **Quality Control is about the *Product*; Quality Assurance is about the *Process***

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Programmatic Quality Management: Role of the Quality Manager

- Develop SMATCA Quality Assurance Plan.
- Approve and Oversee Implementation of Contractor Quality Control Plan
- Ensure that:
  - Appropriate standards are selected and incorporated into the contract
  - Standards are implemented.
  - Significant variances are corrected.
- Support Configuration Control Board.
- Support Risk Management Process.
- Support Test and Evaluation.

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Operational Quality Management: Overview

- The success of the quality assurance effort is dependent on the recognition that all ATS providers, independently and collectively, must strive to provide the best service possible.
- Quality will continue to be measured against historical data
  - Number of ATS incidents
  - Delays
  - Employee and customer feedback
- Willingness to function
  - Team
  - Training
  - Actions taken to support zero ATS incidents all factor into quality assurance

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Operational Quality Management: Scope and Purpose

- Specific guidance on reporting, investigating and resolving various types of ATS incidents that impact the quality of ATS
- Designed to work in conjunction with
  - ICAO SARPs
  - State's regulations
- Objectives
  - Prevent ATS incidents
  - Continually improve overall quality of air traffic services

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Operational Quality Management: Structure

- Acceptable and productive program structure may involve:
  - ATS chief designating/selecting experienced ATC expert to be ATS unit quality assurance officer/specialist
  - ATS unit QA specialist assumes duties and responsibilities of QA for ATS unit
  - Larger ATS units could develop ATS QA unit/department
    - Several ATS QA specialists
    - Assistant chief with extensive ATC experience

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Operational Quality Management: Implementation

- States/ATS service providers should implement an ATS quality Assurance program with associated supporting documents. The program should outline the purpose, goals, objectives and responsibilities of the program within the State/ATS service provider.
- Each ATS unit should establish such a program.

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Operational Quality Management: Responsibilities

- ICAO and Regional Offices
  - Provide guidance and assistance to States/ATS service providers in the development of ATS quality assurance programs.
- States/ATS service providers
  - Should implement an ATS quality assurance program with associated supporting documents.
  - Program should outline the purpose, goals, objectives and responsibilities within the State/ATS service provider and each ATS unit should establish a program.
  - ATS QA programs are maintained and evaluated for effectiveness.

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Operational Quality Management: Program Content

- ATS QA programs should establish methods to identify and correct shortcomings and recognize successes in the following areas:
  - ATS incident prevention
  - Teamwork
  - Communications
  - Customer service/feedback

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Operational Quality Management: ATS Incident Prevention

- ATS refresher training
- Aeronautical phraseology improvement
- English language proficiency
- Incentive/recognition
- List of good operating practices
- Recordings monitor evaluation
- Simulation training
- Personal accounts of lessons learned
- Periodic quality assurance briefings in ATS units covering trends, customers input, evaluations, etc.
- Aggressive resolution of problems identified
- Incorporation of past ATS incidents scenarios into training

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Operational Quality Management: Teamwork

Teamwork

- Air traffic service teamwork training
- Teamwork incentive/recognition programs
- Roles of different positions/jobs
- ATS Operational Supervisor training course
- Team meetings/briefings
- Expectations of all employees clearly communicated

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Operational Quality Management: Communications

Communications

- Electronic bulletin board system
- Internet/intranet access to data
- National database containing national and local ATS QA data
- Newsletters
- ATS QA seminars, conferences and workshops
- All staff meetings
- Reports from International organizations, i.e. IFATCA, IATA, IFALPA, PAAST, etc., and other industry safety reports

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Operational Quality Management: Customer Service/Feedback

Customer service/feedback

- Pilot education programs
- Surveys of internal and external customers
- Interaction with other aviation organizations
- Air traffic controller/Operational Supervisor evaluation of shift performance
- All staff meetings
- Familiarization flights
- Contacts with customer organizations (i.e. local flight schools, airlines, aviation organizations, etc.)
- Pilot safety seminars and airport management workgroups

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Operational Quality Management: ATS Evaluation

- ATS evaluation activities include
  - Assessing service provided to users
  - Ensuring operating procedures conform with standards
  - Assessing operational requirements
  - Identifying potential unsafe procedures or operating practices
  - Detecting problem areas or deficiencies
  - Examining effectiveness of intra/inter-unit communications and coordination
  - Examining personnel utilization, position workload and establishments to ensure compatibility
  - Recommending corrective actions

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Operational Quality Management: User Forums

- Pilot/controller user forums
  - Conduct annually
  - Can produce good relations and enhance communications between ATS authorities, pilots and controllers
  - Main objective
    - Bring together people in the ATS system that work together on a daily basis
      - Pilot on the flight deck
      - Controller in the control room/tower
      - Better understanding of each other's responsibilities and duties
  - Can also be used to present and explain information on the local or national ATS system and procedures

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Operational Quality Management: Conclusions

- ATS quality assurance programs would place safety at the forefront while expediting and maintaining an orderly flow of air traffic.

- Quality assurance is a dynamic process used to continually improve an ATS system.

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Configuration Management

September 11, 2003

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Overview

- Definitions
- Configuration Items
- Levels of Configuration Management
- Classical Configuration Management
- The Configuration Control Board
- Proposing, Evaluating, and Approving System Changes
- Case Study: User Request Evaluation Tool
- Configuration Management Exercise

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"Configuration Management is ..."

- **"Configuration Management (CM) is a discipline applying technical and administrative direction and surveillance to identify and document the functional and physical characteristics of a configuration item, control changes to those characteristics, record and report change processing and implementation status, and verify compliance with specified requirements."**
  IEEE-Std-610

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More Simply…….

The purpose of Configuration Management is to establish and maintain the integrity of the <u>products</u> *of the project throughout the project's life cycle.*

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Configuration Items: The Products That Should be Controlled

- **Typical Configuration Items**
  - **Statement of Work**
  - **Schedules**
  - **Requirements**
  - **Trouble Reports**
  - **Meeting Summaries**
  - **Engineering Designs and Reports**
  - **Software and Hardware versions**
  - ***Anything that might change!***

  - **Some of these are controlled by you, the customer. Others are controlled by the contractor…ensure that the contractor has a CM plan too!**

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Configuration Stakeholders: Who Cares?

- Your stakeholders are the people and organizations that have a vested interest in the outcome of your program.
  - Identify them early
  - Ensure that they know that they are stakeholders
  - Ensure that they know what the configuration items are
- Make sure your contractor follows Configuration Management guidelines also.

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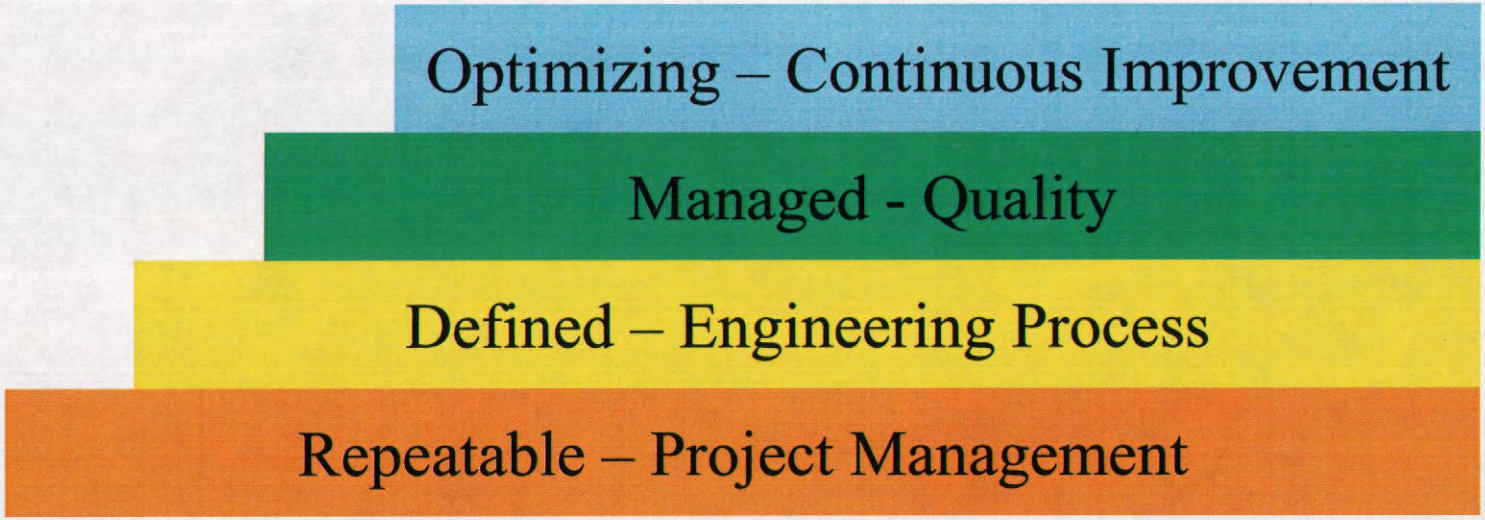
Levels of Configuration Management



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Repeatable - Project Management

Repeatable – Project Management

- **Project Planning**
- **Project Planning & Oversight**
- **Subcontract Management**
- **Quality Assurance**
- **Requirements Management**

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Defined - Engineering Process

Defined – Engineering Process

- **Organization Process Focus**
- **Organization Process Definition**
- **Peer Reviews**
- **Training Program**
- **Intergroup Coordination**
- **Product Engineering**

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Managed - Product & Process Quality

Managed - Quality

- **Quality Management**
- **Quantitative Process Management**

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Optimizing - Continuous Improvement

Optimizing – Continuous Improvement

- **Process Change Management**
- **Technology Change Management**
- **Defect Prevention**

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Classical Configuration Management

- Identification: Configuration Items (CIs)
- Control: Methods for Management and Technical Control
- Status Accounting: Reports regarding ALL Past and Current Configurations
- Auditing: Assure correct functioning of CM process
- Process Improvement: Capability Maturity Model
- Management: Configuration Control Board with Configuration Manager

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FAA Sample Configuration Management Template

CM Plan Section	Section Content
a. Cover Page	Includes the document title, effective date, and document control number.
b. Table of Contents	Lists the title and page number of all titled sections and subsections, followed by the title and page number of all figures, tables, and appendices.
c. Section 1 – Introduction	Includes the following: • The purpose and scope of the plan • A brief description of the system or top-level CI and of the component lower-level CIs • A description of the plan's major features and objectives
d. Section 2 – Reference Documents	Lists the specifications, standards, manuals, and other reference documents by title, document number, issuing authority, revision, and date of issue.
e. Section 3 – Organization	Includes the following: • Relationships and integration of region organization and CM organization • Responsibility and authority for CM of all participating groups, including their role in configuration control boards • Identification of the CM organization • Interfaces between the CM organization and contractors and subcontractors

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FAA Sample Configuration Management Template (continued)

f. Section 4 – Configuration Management Phasing and Milestones	Includes the schedules of the following: • Recursive milestones of life cycle CM for the regional facility • Events and products, with associated CM activities
g. Section 5 – Data Management	Describes the methods for the following: • Data identification • Data version control • Digital data transmittal • Data access control
h. Section 6 – Configuration Identification	Describes the following: • Selection of CIs • Establishment and management of development configuration • Establishment of baselines • Release of products • Assignment and application of configuration identifiers
i. Section 7 – Interface Management	Describes the procedures for identification of interface requirements and establishment of interface agreements
j. Section 8 – Configuration Control	Describes the following: • Functions, responsibility, and authority of configuration control boards • Classification of changes • Change proposal processing (NCPs, ECPs, variances, etc.)

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FAA Sample Configuration Management Template (concluded)

k. Section 9 – Configuration Status Accounting	Describes the following: • Methods for collecting, recording, processing, and maintaining data necessary to provide status accounting information • Description of contents of reports • Methods of access to information in status accounting systems
l. Section 10 – Configuration Audits	Describes plans, procedures, and schedules for audits.
m. Section 11 – Inventory Management	Describes configuration identification considerations associated with the facility configuration and describes inventory procedures.
n. Section 12 – Library Management	Describes methods for the establishment, implementation, control, status accounting and reporting for the acquisition, storage, retrieval and distribution of technical information within the facility's library system.
o. Section 13 – Cable Management	Describes methods for coordination, regulation, and recording of cable configurations. Describes the structure of the database used for cable management.
p. Section 14 – Contractor/Vendor Control	Describes the methods for ensuring contractor/vendor compliance with the configuration management requirements.
q. Appendices	Optional; appendices may include abbreviations and acronyms, definitions, and other generic information.

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CM Reporting

- **Change Notices: Whenever a new version of a Configuration Item is created, all stakeholders must be informed.**

- **Change History: Every change notice must include a "history" of the changes.**
  - **To inform recipients what has changed and**
  - **To "recreate" latest version if necessary**

- **Data Bases: Latest versions of Configuration Items available to stakeholders via web site, for example.**

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CM Auditing

- **A periodic audit is essential to ensure that the CM process is being followed.**
- **Responsibility: Configuration Manager**

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The Configuration Control Board (CCB)

- **The CCB is the decision-making body for your CM process.**
- **They vote on all changes, and classify changes according to:**
  - **A. A correction to an error**
  - **B. A necessary improvement**
  - **C. A new item, such as a new requirement**
- ***The Configuration Manager is the leader of the CCB and is ultimately responsible.***

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Proposing, Evaluating, and Approving System Changes

- The CM Form is THE fundamental element of CM.
- NO CHANGE is created without the request having been documented and approved.
- A different form is needed for each configuration item.
- Process:
  - Request is formally submitted to CCB using a CM form that describes the change and the expected impact
  - CCB reviews requested change, considering other related changes
  - If approved, the change is assigned to a "build." If not approved, reasons are noted and feedback given to originator
  - Objective: Trace any change back to the originating request

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Example Configuration Management Form (from TCAS program)

SRS-CP-_____

TCAS System Requirements Specification Change Proposal Form

Date of Change: Submitted By:

TCAS SRS Version Modified:

SRS Pages Affected (Name of TASK, ROUTINE, FUNCTION, PROCESS, etc. and page number):

Description of Change:

Pseudocode Change Proposal Form Cross Reference:

Reason for Change (with PTR/CRF/DR number if applicable):

Reference Documentation:

Reviewer 1 Approval:

Reviewer 1 Approval:

Attach "Before" and "After" SRS pages

Figure B-1. TCAS System Requirements Specification Change Proposal Form

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Problem Reports
Example from TCAS program

Problem/Trouble Report

Date: _____ No. _____

Function Area:

Check one of the following: Surveillance ☐ CAS ☐ Coordination ☐

Priority:

Check one of the following: Urgent ☐ Necessary ☐ Optional ☐

Description of Problem:

Initiator:

Check one of the following: MITRE ☐ FAATC ☐ ACADS Prog. Office ☐
MIT/LL ☐ Manufacturer ☐

Resolution of Problem:

Disposition:

Check one of the following: On Hold ☐ Testing ☐ Redesigning ☐
Done ☐

Final approval and delivery of pseudocode changes:

Signature _____
Date _____

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Technical Data Management

- The need for managing data is often overlooked.
- Key data should be controlled just like any other configuration item.
- Key data should be copied and stored in a safe place.

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Configuration Management Organization Responsibilities

- Develop and maintain CM policy, standardized processes and procedures.
- Monitor the CM program.
  - Reporting on deficiencies
  - Ensure that corrective actions are taken
- Serving as the focal point for the resolution of CM issues.
- Develop and execute the plan for improvement of CM.
- Manage the acquisition and implementation of CM technology to improve the effectiveness and responsiveness of CM processes.
- Implement a comprehensive CM training program.
- Develop, Integrate, and Implement CM tools.
- Note: Configuration Management does not necessarily have to be performed by SMATCA; a consultant can be hired.

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Case Study: MITRE/CAASD User Request Evaluation Tool

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URET CM Goals

- Support aggressive prototype development and release schedule.
- Develop, Train and Implement a consistent CM process.
- Maintain continuous software integrity and product control during development and deployment.
- Everyone should know the status of all released versions.
- CM all outgoing and incoming URET software and data.
- Provide various CM reports when needed.
- Practice Process Improvement.
  - Maximize Productivity while Minimizing Mistakes
  - Accommodate program growth
  - Improve product and process quality

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General Lessons Learned from URET CM

- Responsibility for CM assigned to dedicated group, called a *Configuration Control Board.*
- CM does the formal Release and Patching of the products.
- Use methods that are formal but as simple as possible.
- Use supported tools (COTS and Open Source).
- Develop special CM tools as required (e.g., forms).
- Tailor CM process to meet evolving & changing program goals.
- Use CM tools and email to manage and document requests, changes, and significant CM actions.

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Biggest Lessons Learned from URET CM

- CM is a service organization; without the cooperation and support of the developers, CM will suffer.
- Always document. A Chronology file of major CM (and sometimes project) events is invaluable for recreating history.
- Process and Procedures will change, so be flexible.
- Shortcuts are tempting, but sticking to the process increases the chances of success.

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How URET CM Was Applied

- CM tools are used to verify and maintain
  - Integrity of the CM libraries and repositories
  - Compliance of developers with CM guidelines and rules
  - The "releaseability" of the system
- Integrity checks are made prior to release by
  - Identifying software and data not in CM
  - Monitoring the history records
- CM personnel are the only ones allowed to modify any erroneous CM library history records.
- CM handles shipping and receiving – Incoming and Outgoing Products are under CM control.
- Use On-site (fireproof safe) and Off-site (service) storage.
- All deliveries are documented; ensure that the recipient receives the information!

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URET Configuration Items

- Software
  - Run-Time, Support, and Off-line
  - Test, Utilities, Adaptation Processing, Scenario Generation, Data Reduction and Analysis, Tools
- Data
  - Adaptation Data
  - Recorded Air Traffic Data
  - Wind Data
  - Console Logs
  - Scenario Data
- Documentation
  - Coding Standards & Templates, Data Collection, Debugger Guidance, Units Standards, CM training & orientation
  - NOTE: Program Office manages requirements, tech transfer, specification, and other similar documentation.

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URET CM Reporting

- Chronology Report entry for every release, patch and delivery.
- CM Notice of Shipment and Change Notice for each software release
- Other Status Reports as needed (e.g., history reports)
- Source Lines of Code (SLOC) count of released software

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URET CM Reporting (concluded)

- Memos have been used for formal record keeping
- Email extensively used
- Other CM actions
  - Database Updates
  - Pre-releases
  - Releases
  - Patching
  - Final report at the completion of a CM action
- All email saved for historical record

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Configuration Management Exercise

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Objectives

- **Define a Configuration Control Board and appoint a Configuration Manager.**
- **Address a Change Proposed by the Contractor.**

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System Installation, Test and Evaluation, and Acceptance

September 11, 2003

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Overview

- Definitions
- Relationship of activities to system life-cycle
- Details of Test and Evaluation Activities
- Dedicated Test and Evaluation Facilities
- Testing Methods, Procedures, and Requirements
  - Types and phases of test and evaluation
  - Use of modeling and simulation
  - Establishing test objectives and requirements
  - Regression Testing
- Monitoring Progress

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Some Basic Definitions (1 of 3)

- Test: Using the system to accumulate a statistically significant quantity of operational data.
- Demonstration: Using the system to show its operational use.
- Retest: Any execution of a previously executed test
  - Usually because the first test failed
  - Used to see if the problem has been fixed
- Regression: Retesting to see if the modification had any other impacts (Did the "fix" break something else?)

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Some Basic Definitions (2 of 3)

- **Passed Test: The test met the established criteria (that is, the system met the testing requirements).**
- **Failed Test: The test did not meet the established criteria (that is, the system did not meet expectations).**
- **Successful Test:**
  - **Identifies errors/shortcomings in the system**
  - **Provides enough data to evaluate the system**
- **Unsuccessful Test:**
  - **Does not identify errors/shortcomings in the system**
  - **Does not provide enough data to evaluate the system**

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Some Basic Definitions (3 of 3)

- **Installation:**
  - **The processes of installing the equipment in a facility**
  - **Includes location, power, interfaces**
  - **May require new physical space**

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Objectives

- Define the role of Test and Evaluation (T&E) in the acquisition process.
- Provide an understanding of the types of T&E activities, the purpose and objectives of each, and who the customer is.
- Describe the processes:
  - Test planning
  - Test conduct
  - Evaluation and Reporting
- Provide practical T&E perspectives.

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System Implementation Life-Cycle

Phase 1 Planning	Phase 2 Design	Phase 3 Implementation	Phase 4 Use and Enhancements
• Feasibility Study • Strategy Analysis • Master Planning • Operations Concept • Budget Request • RFP for Consultant	• System Architecture and Basic Design • Facility Criteria • Training Concept • Testing Concept • Maintenance/Logistics Concept • RFP for System Integrator • Support Proposal Evaluation and Negotiation	• Support Project Management • Review Detailed Design • Monitor System Integrator • Support Training • Participate in Testing • Support Generation of Operation Procedures	• Support System Operational Test and Evaluation • Recommend System Enhancements and Future Upgrades
	Consultant • RFP, Proposal Evaluation and Contract Award	**System Integrator** • Detailed Design • Hardware Construction • Software Development • Subcontract Management • Subsystem Factory Testing • Site Installation • Functional, Performance and Reliability Test	• System Integration Test, Acceptance Test • Provide Training • Participate in System Operational Test and Evaluation • System Corrections • System Improvements • Warranty Service
		User • Design Review, Training, Testing	• Operation, Use and Evaluation

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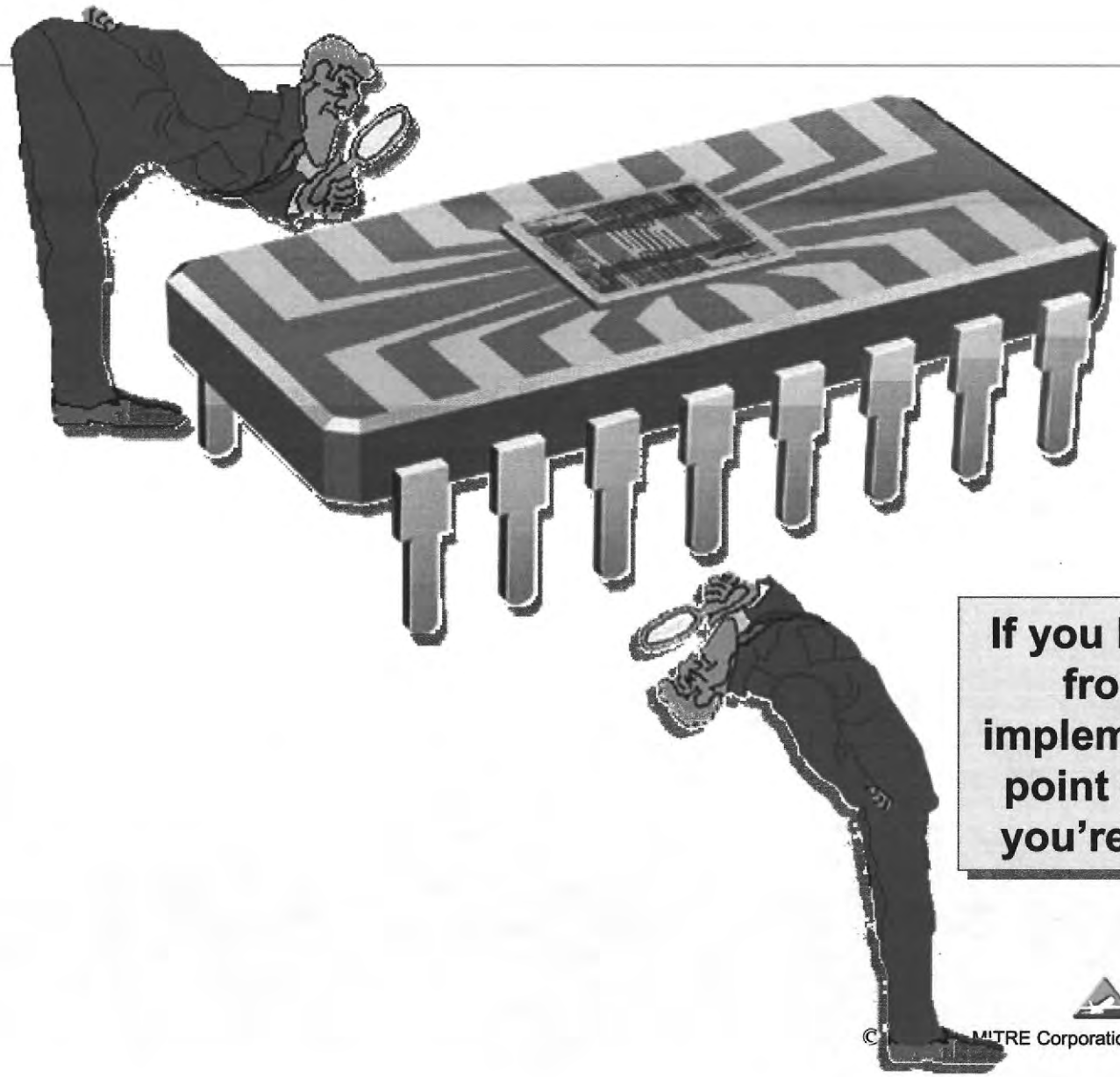
What is Testing? What is Evaluation?

If you look at it from a mission point of view, you're evaluating



If you look at it from an implementation point of view, you're testing

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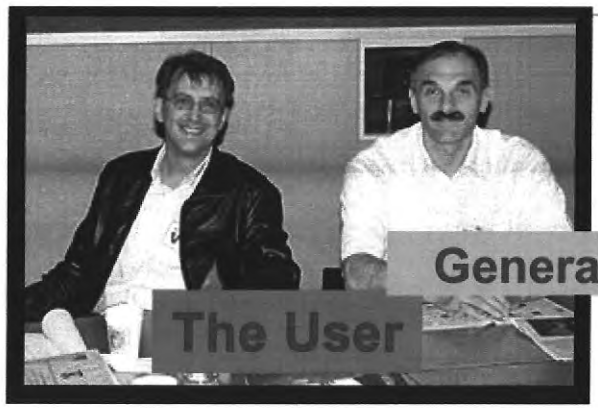
Why Test? Why Evaluate?



The User

Generates

The MNS, ORD, And CONOPS

Based on

The Threat

Leads to

Does (will) the Solution Neutralize the threat?

The Specs

Which define the performance Characteristics of

A Solution

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*Note that "solution" implies all aspects of the "system" (see the next slide)

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How Systems Get Built

Requirements get translated into designs

Prototypes are tested against requirements

Designs get built as prototypes or initial production lots

The real test compares the production units to the operational requirements

Prototypes are put into production

Don't forget the human(s) in the loop

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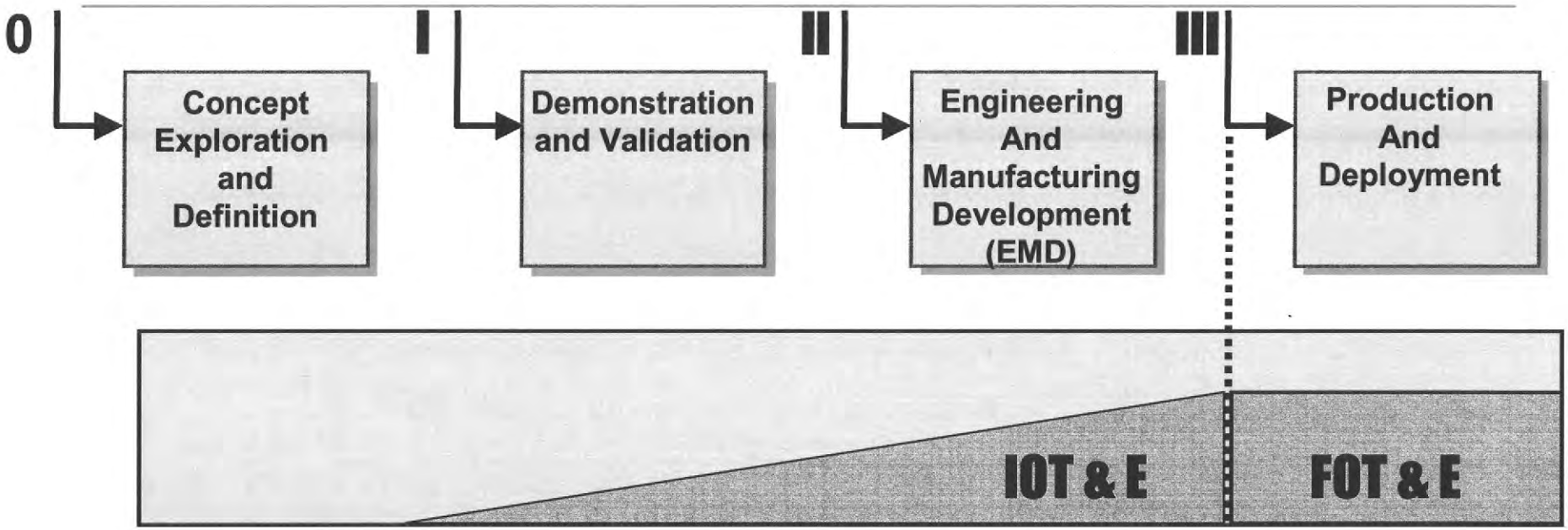
The Old View of Test and Evaluation (T&E)



DT&E	Demonstrate satisfaction of contractual requirements
IOT&E	Identify deficiencies to Program Office
FOT&E	Tell user what to expect
	Assess performance against operational requirements

DT&E: Developmental OT&E
IOT&E: Integration OT&E
FOT&E: Follow-on OT&E

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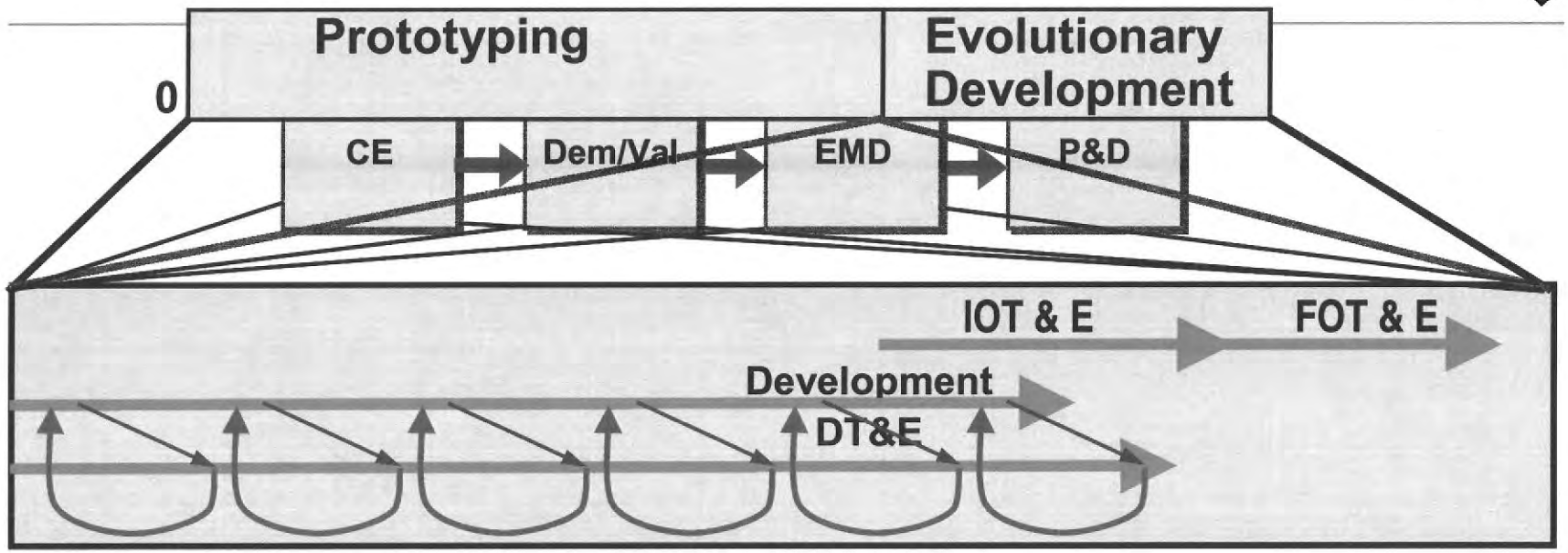
The New View of Test and Evaluation



Acquisitions more likely to involve only a single phase and to involve enhancement of existing systems by integration of new and existing capabilities; build-a-little, test-a-little

DT&E — Demonstrate satisfaction of contractual requirements

IOT&E — Identify deficiencies to SPO

FOT&E — Tell user what to expect

Assess performance against operational requirements

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DT&E: Developmental OT&E
IOT&E: Integration OT&E
FOT&E: Follow-on OT&E

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Evaluating a System

- A System includes
  - Hardware
  - Software
  - Documentation
  - Human Operators
  - Maintenance personnel
  - Interfaces with other systems
- Each of these must be evaluated in light of the others
  - Standalone testing should be done
  - But the real test is in how it is all put together

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Methods of Testing

- **Methods**
  - Inspection: Testing by visual observation
  - Analysis: Testing by calculation
  - Demonstration: Testing by "showing"
  - Test: Testing by operation
- **Appropriateness: Choose the method most appropriate to the parameter or requirement.**
  - Inspection for physical parameters (e.g., color, weight).
  - Analysis for parameters that cannot be evaluated in the real world (e.g., maximum load, dangerous situations).
  - Demonstration for parameters easily observed.
  - Test for parameters not easily observed or with complex operational properties.

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Types and Phases of Test and Evaluation

- **Informal Testing**
  - Testing done without formally approved test procedures and without official witnesses
    - Disciplined
    - Results presented at pre-acceptance reviews
    - Conducted by the contractor
- **Formal Testing**
  - Testing done in accordance with approved test procedures and in front of witnesses
  - Conducted by contractor and customer

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Types and Phases of Test and Evaluation (concluded)

Formal Tests

- Developmental Test and Evaluation (DT&E)
  - Testing done by the acquiring organization (customer)
    - Environmental testing
    - Stress testing
    - Integration testing
    - Interoperability testing
- Operational Test and Evaluation (OT&E)
  - Testing done before full-rate production and deployment
- Follow-on Operational Test and Evaluation (FOT&E)
  - Testing done during on-going production or as a system evolves over its lifetime

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Uses of Modeling and Simulation

- During early planning
  - Understand utility of potential system
  - Demonstrate concept
- During development
  - Deal with human factors
  - Solve design and implementation problems
- During testing and early deployment
  - Validation of test parameters
  - Evaluate operation in complex environments
- When operational
  - Training
  - System evaluation

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Dedicated Facilities for Testing

- Contractor's location is used for all pre-delivery testing.
- Operational facility is used for initial testing.
  - When multiple facilities are involved, a "key site" is identified early in the system life-cycle
  - Contractor is responsible for installation and test activities
- Dedicated customer facility is sometimes used before testing at an operational facility.
  - e.g., FAA Technical Center
  - Customer responsible for test activities
  - Can be adapted to replicate operations of any facility

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Establishing Test Objectives and Requirements

- For each test item, determine the acceptable method of testing.
  - Customer establish criteria, including priority assessment of requirements
  - Contractor establish procedures with customer concurrence
- Two general milestones:
  - Factory Acceptance Testing: applies to tests conducted at contractor facility before delivery to customer operational location
  - Final Acceptance Testing
    - Applies to testing to ensure requirements are met in the operational environment
    - Seeks to ensure operational acceptability

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Regression Testing

- **Regression Test – the re-execution of a previously passed test after modifications have been made to determine whether the modifications have affected the product.**
- **Question: What test cases do you include in your regression suite after a major modification or component upgrade?**

Use a "Traceability Matrix" to find requirements put at risk by the Modification or upgrade.

Retest all at-risk requirements

	Requirement 1	Requirement 2	Requirement 3		Requirement N
Test 1	X	X			
Test 2	X	X			
Test 3	X	X	X		
Test 4			X		
Test Z					X

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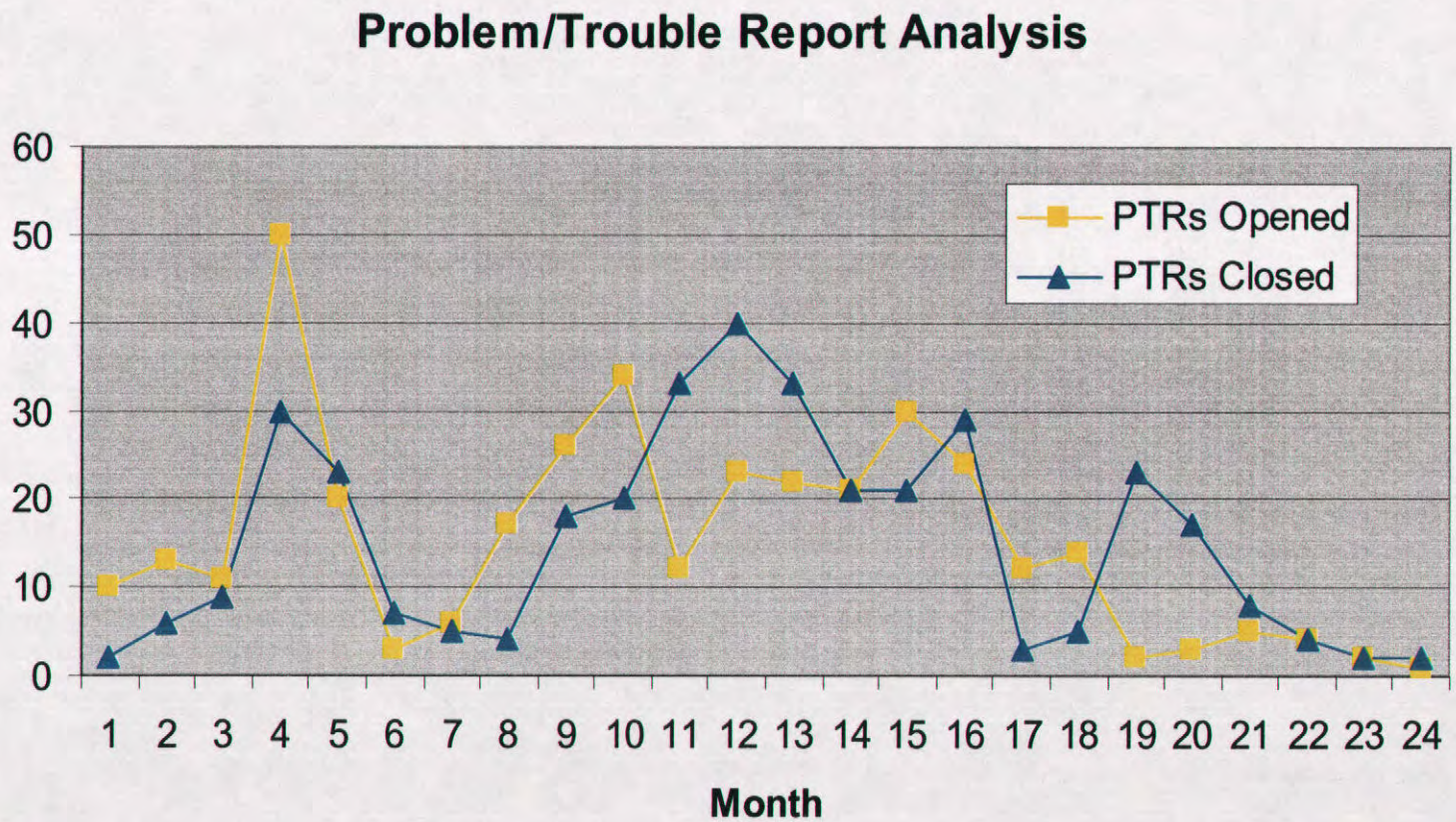
Using Test and Evaluation to Monitor Progress

- **Problem Reports can be the key to tracking progress**



Note: Notional Data

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COTS and NDI – Definitions

- COTS – Commercial, off-the-shelf
  - Has been commercially available for some time
  - At least X units have been produced and sold to Y customers
  - Operation and maintenance documentation exists
  - Training program exists
  - Satisfaction of allocated requirements can be demonstrated
  - No more than Z% of product has changed since qualification
- NDI – Non-Developmental Item
  - Not developed using current contract funds
  - Includes components developed for other customers, but not commercially available

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Testing COTS and NDI

- **The best evidence of proper operation of COTS and NDI is track record.**
  - **Developer/vendor track record**
    - **In business for time ΔT**
    - **Established customer base**
  - **Product history**
    - **Commercially available for time ΔT**
    - **At least X units sold to Y different users**
  - **Version history**
- **Do not let the use of COTS or NDI preclude testing against operational requirements.**

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Interoperability-Definition

- Environmental Compatibility
  - Electromagnetic Interference
  - Power
  - Physical Characteristics
  - Usage of shared resources (e.g. disk space, CPU cycles)
- Functional/Performance Compatibility
  - Can exchange meaningful information
  - Provide timely response to external requests
  - Non-interference testing with existing capabilities
- More to the point:
  - I don't affect other systems, and other systems don't affect me.
  - I can use information that other systems send and other systems can use the information that I send.

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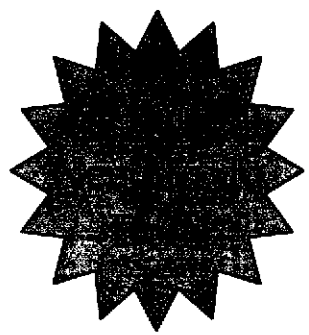
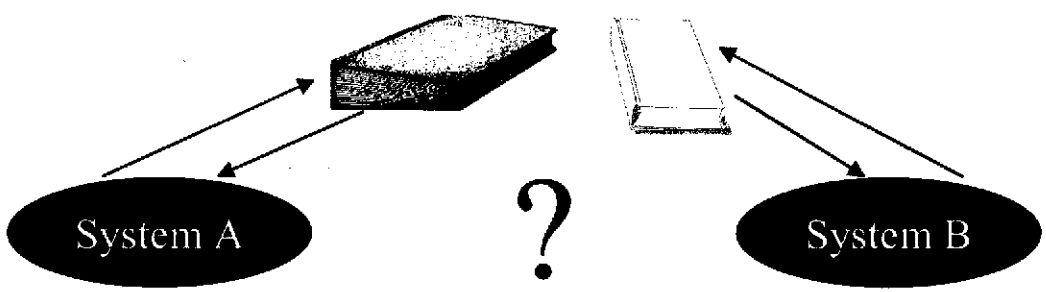
Testing for Interoperability

- **Testing against an operational system**
  - **Demonstrates communication in the real world**
  - **Does not demonstrate compliance with Interface Control Document (ICD)**



- **Testing against an ICD**
  - **Demonstrates compliance with Interface control document**
  - **Does not demonstrates communication in the real world**



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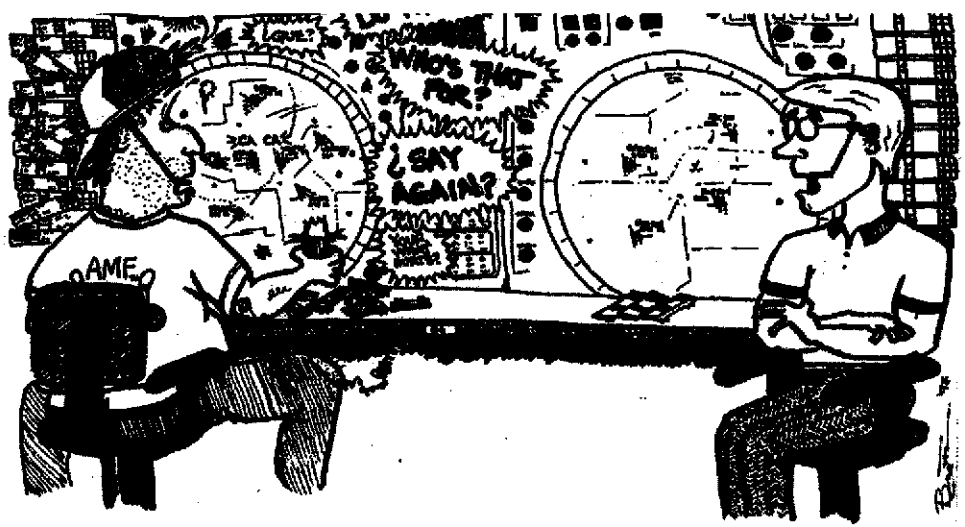
Developing an Approach to Human Factors

- **The human is the key to system success**
- **Human Factors Teams are needed to focus on:**
  - **System impact on operator's performance**
  - **Operator limitations (physical and mental) impact on system performance**
  - **Improving system performance by ensuring manpower, personnel, training, and safety as part of comprehensive system testing**



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Contractor Responsibilities

- Internal (informal) tests
- Formal Tests
  - Formal Qualification Testing
  - Stress Testing
  - Environmental Testing
  - Reliability/Availability/Maintainability Testing
  - System Integration Tests
  - Interoperability Testing

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Customer Responsibilities

- **Ensure you get what you wanted and what you needed:**
  - **Tests by the contractor: Concentrate on verification of performance and functional requirements**
  - **Independent T&E agency tests (usually tests the system before the users): Focus on evaluation of product against current need**
  - **User tests: Emphasize operational use of the system**

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The Testing Script

- **Test and Evaluation Master Plan (TEMP) documents the overall plan for testing the system**
  - **It discusses both Developmental T&E and Operational T&E**
  - **Before you write one, you need to develop your T&E strategy**

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Test Planning

- Test planning requires thinking about
  - What has to be tested
  - How it is going to be tested
  - How much testing is necessary
  - Who will do the testing
  - Where will they test
  - What will they test with
  - When will the testing be done
  - How much will the testing cost
  - How you will know when things are going well
  - What you should do when things go wrong

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What Makes a System Successful?

- **Start with a specification for a system that you can:**
  - **Verify meets the mission requirements**
  - **Build in a cost-effective manner**
  - **Sustain in a cost-effective manner**

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A Word About Verification and Validation (V&V)

- Verification means that you built the system correctly
  - In other words, the requirements are met
  - (which doesn't necessarily mean it will work!)
- Validation means that you built the correct system
  - In other words, the system meets its intended mission
  - (which means of course that the requirements were right and that the system WILL work!)

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The Players and their Responsibilities

- **Program Office (SMATCA)**
  - **Ultimate responsibility for the product and test program**
  - **Provide a Test Manager to keep the strategic focus of the entire test program**
- **Users (Controllers, technicians)**
  - **Provide requirements and Operational Concept**
  - **Participate in system trade-off decisions throughout the program lifecycle**

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The Players and their Responsibilities (continued)

- Responsible Test Organization (SMATCA, Contractor)
  - Manage the day-to-day test effort
  - Provide the test director
- Test Agency (Consultant)
  - Independent company working for SMATCA
  - Provides some independent test activities and assists where needed
- Certification Agencies (V&V Contractor)
  - Ensure that compliance objectives are met
  - Ensure that certification objectives are met

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Acquisitions: Past, Present, Future

- Past–concentrate on entire systems
  - Grand design approach
  - Custom build all pieces
- Present–mix of new equipment, upgrades and enhancements
  - Less grand design, more evolution
  - COTS becoming increasingly important
- Future–mostly upgrades and enhancements
  - Evolutionary design
  - Architectures and COTS dominate design and implementation

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Case Study
Display System Replacement

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Hardware Factory Testing

- Design Verification Tests
- First Article Tests, where as subset of requirements are tested

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Installation and Integration Testing

- **Over 80 DSR consoles were involved in the testing, with simulated input being provided by separate equipment (console simulators).**

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DT&E Subsystem Testing

- These tests verified the functionality and performance of each subsystem to verify specifications.

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Factory Acceptance Testing

- **These tests verified the function and performance of the complete systems.**

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Technical Center Acceptance Testing

- These tests used a single set of test procedures demonstrating the overall capabilities of DSR.
- Acceptance testing is also planned for future system regression tests.

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Formal Operational Testing

- These tests exercised DSR using field personnel in realistic situations and configurations to determine their level of operational acceptability and to identify any operational problems.

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Formal Installation and Integration (I&I) Testing at Seattle ARTCC

- These tests demonstrated that all DSR hardware was correctly installed and that all components have the appropriate communication paths.

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FAA System Testing

- These tests verified that fixes and changes that were applied to the operational software were correctly integrated and that there were no adverse effects on other functions.

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Independent Operational Test and Evaluation-Overview

Operational Evaluation at Field Facilities (Key Site)

- ***Independent of System Acquisition/Developer***
- ***Planned, Conducted, and Reported by Operational Users (DSR Test Team)***
- ***Facilitated and Led by FAA***

Result: **Senior Decision Makers Informed of Operational Risks Directly from Users**

Source: FAA (ATQ-BPR-BR07-01-F)

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Independent Operational Test and Evaluation-Characteristics

- Scope based on defined Operational Requirements.
- IOT&E Strategy defined early…No surprises…Minimal impact to program schedule.
- Structured process (tailorable)…Built on existing T&E activities.
- Contingent upon IOT&E Readiness Declaration (IOTRD) from Developer.
- IOT&E generally 4 weeks in actual operating environment.

Source: FAA (ATQ-BPR-BR07-01-F)

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Independent Operational Test and Evaluation-Benefits

- **Early Issue Identification**
- **Keeps Developer Focused on Operational Need**
- **Unbiased Assessment of System Readiness**
- **Direct Operational Input from Users**
- **Operational Risk Identification for Decision Makers**

- ***IOT&E Facilities Operational Risk Identification by Users…Users are the experts***

Source: FAA (ATQ-BPR-BR07-01-F)

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Transition and Training

September 12, 2003

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Overview

- Transition and Training Observations
- Roles and Responsibilities
- Training Methods
- Transition and Training Case Studies

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Some Observations

- System transition can be compared to changing a flat tire while your car is still driving.
- Requires coordination and backup plans if the transition does not go smoothly.
- Training takes much more time than you might think.
- Training must be done for operational and maintenance personnel.
- Simply knowing "which buttons to push" will not provide the benefit of new equipment.
  - The real benefit comes from using the equipment to achieve some operational benefits (i.e., proficiency).
  - On-the-job training and experience often results in new uses.

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Some Observations (concluded)

- **The transition to the new architecture needs to be carried out in a manner that ensures there is:**
  - **No disruption to air traffic services**
  - **Minimal initial impact on the controller work force**
  - **Retains Computer-Human Interface (CHI), media, and processing results similar to the existing environment at the time of transition.**
- **Adequate transition space is required for concurrent (parallel) operation of existing and replacement systems until the replacements are commissioned.**
- **There are two kinds of training:**
  - **Training on *how to use* the equipment**
  - **Training on becoming *proficient* with the equipment.**

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Who Does the Training?

- Depending on the contract, the vendor may supply the training or the user may supply the training through a third party contractor.
- However, the best training comes from the operators themselves.
  - Cadre training is a key component.
    - A "Cadre" is a core group of people (controllers, technicians) who are trained first, and then use their experience to train others.
    - Training is then added to their job responsibilities.
  - Simulation should be used whenever possible.

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Typical Training Exercises

- **Operational Training**
  - **Shows users how to use the new equipment.**
  - **Computer-based training is useful and more cost-efficient.**
  - **Near-Real Time operational environment is very useful.**
- **Maintenance Training**
  - **Operational and periodic (preventive) maintenance checks.**
  - **Repair of faulty components.**

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Training Methods

Documentation (text)

Audio (recordings)

Audio/Visual (video)

Multimedia (computer-based)

Training Device

Simulator

Hi-Fidelity Simulator

Operational Equipment

Effectiveness

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Near-Real Time Operational Environment

- **DYSIM: Dynamic Simulation**
  - **Ability to run recorded ATM data through the operational equipment**
  - **Provides the closest thing to real-time simulation using actual equipment**

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Transition and Training Examples

- **New Hardware and Software Systems:**
  - **Display System Replacement (DSR)**
  - **Standard Terminal Automation Replacement System (STARS)**
- **New Functionality: Traffic Management Advisor (TMA)**

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Display System Replacement (DSR)

- **DSR replaces the old monochrome monitors at en route ATC facilities**

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Display System Replacement Transition

- Case Study: Cleveland Ohio En Route Center:
  - Monday April 5, 1999: FIRST radio transmission to an aircraft from a DSR sector
  - Thursday April 15, 1999; LAST radio transmission to an aircraft from a DSR sector
- How did they do it?
  - Lots of preparation and planning
    - Ensure equipment arrives on time and is installed correctly
    - Ensure everyone cooperates
    - Be flexible
  - To be conservative, temporary restrictions were put in place to avoid increased traffic in DSR sectors.

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Standard Terminal Automation Replacement System (STARS)

- STARS is a joint FAA and Department of Defense (DoD) program to replace capacity-constrained, older technology systems at FAA and DoD terminal radar approach control facilities and associated towers.
- Controllers will use STARS to provide ATC services to aircraft in terminal areas.
  - Separation and sequencing of air traffic
  - Provision of traffic alerts and weather advisories
  - Radar vectoring for departing and arriving traffic

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STARS Transition

- The STARS team recognized the importance of providing uninterrupted safety and service.
- One of the biggest challenges will be to change over to this new system without inconveniencing the FAA's customers.
- STARS was initially deployed at several key sites –
  - FAA facilities: Philadelphia, Pennsylvania, Syracuse, New York and El Paso, Texas .
  - Several DoD facilities.
  - These deployments enabled the FAA to evaluate STARS performance in an operational environment.

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STARS Transition (concluded)

- The key to the changeover to STARS is a smooth transition at each facility.
  - STARS design allows the new STARS displays to be run in parallel with the existing ARTS computers and hardware.
  - This parallel approach allows the equipment to be quickly installed, with controllers resuming duties on new displays the next day.
  - As controllers and technicians become proficient with the new commands and capabilities of STARS, the facility can begin operation with the new system as the primary.
- The full transition to STARS will occur only when the controllers and technicians are confident the new system provides the necessary safety and efficiency.

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Traffic Management Advisor (TMA)

- **TMA is a strategic planning tool for high altitude controllers and traffic management specialists.**
  - **Provides computer automation to enhance arrival sequence planning in the extended terminal airspace surrounding major airports.**
  - **TMA enables controllers and traffic management specialists to develop complete arrival-scheduling plans ("meter lists").**
  - **Support early runway assignments that maximize the airport's use of its capacity.**
  - **TMA uses "time-based metering" for sequencing arriving aircraft. This is claimed to be more efficient than "miles in trail" method**

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TMA Transition and Training at Los Angeles Center (ZLA)

- Two groups of arrival sectors were selected for initial transition.
  - ZLA designated a *cadre* of controllers from each area as the first to be trained and to field test TBM.
  - Cadre forms an experienced core of controllers to assist training the additional controllers.
  - Other controllers in Areas A and C were then trained. ZLA
  - Areas B and E were trained next and begin using TBM.
- A significant aspect of the TBM transition process was training of the controller cadre using simulations of ZLA airspace.
- Simulations at the FAA's technical center were conducted to introduce the metering concept and demonstrate how it works with TMA.
- Controllers took their simulation experience back to ZLA center and to the TRACON to conduct a seven-week live field test of TBM.
  - Use TMA to manage arrivals to LA
  - Evaluate its effectiveness
  - Identify and address any issues

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Maintenance Strategy Options

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Overview

- Maintenance Strategies
- Organization of Maintenance Operations
- Roles and Responsibilities of Operating Entities
- Maintenance Functions
- Contracting for Operations and Support
- FAA's Maintenance Concept: Infrastructure Management System

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Maintenance Alternatives: Distributed vs Centralized

- "To streamline management of the NAS, centralization of Operations and Maintenance (O&M) functions will continue, driven by customer needs, technological developments, and the goal of greater efficiency. O&M functions will be centralized to reduce costs, standardize the functions, provide organizational flexibility, optimize staffing resources, and simplify coordination."
- "O&M functions will be centralized to the extent possible in order to streamline NAS infrastructure management (NIMS), and accomplish performance based management."
  - NIMS Operational Concept

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What Works for SMATCA?

- **Centralized maintenance offers a low-cost approach to keeping the system running.**
  - **Send the technicians to the job site as needed.**
  - **Maintain a central repository of status information.**
  - **Instead of prioritizing maintenance at the *local* level, prioritize based on *system* needs.**
  - **Fewer technicians are needed if maintenance managed from a centralized perspective.**
- **Distributed maintenance on the other hand, can result in faster response.**
- **What equipment can you afford to have down for a lengthy period of time?**
- **Need to prioritize your maintenance needs.**

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Why Create a Maintenance Strategy?

Problem Areas	Envisioned Solutions
Inconsistent maintenance operations	•Standardized operating procedures •A balance between centralized and distributed operations management
Inefficient use of the work force	•Efficiently allocate field specialists •Centralized expertise •Additional remote system maintenance capabilities and use
Inefficient use of resources	•Integrated resource management
Lack of standard problem reporting system for customers	•Single point of contact for customers •Standardized problem reporting procedures
Lack of accurate integrated view of the infrastructure	•Accurate information system that provides: •Integrated view of the infrastructure •Real-time distribution of infrastructure system and service status
Inadequate cost and performance reporting	•System- and service-oriented cost and performance reporting
Inadequate field specialist training on new technology	•Combination of service provider and industry-provided training on new systems and technology

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Organizing to Manage Maintenance Operations

- ***Monitor and Control*** **- Managing services and systems by monitoring and controlling infrastructure resource performance**
- ***Workforce Management*** **- Optimizing the productivity of people and resources**
- ***Help Desk*** **- Responding to customer needs and requests, 24 hours a day, 7 days a week**
- ***Engineering Analysis*** **- Ensuring continuous improvement in infrastructure management and reducing risk**
- ***Customer Service*** **- Ensuring quality service delivery, system performance and customer satisfaction**

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Roles and Responsibilities of Operating Entities

Monitor and Control

Workforce Management

Help Desk

Engineering Analysis

Customer Service

Source: "Airway Facilities Operations in the NIM Environment," FAA

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Monitor and Control Responsibilities

- ***Monitor and Control*** **is the capability to observe the performance of the system <u>infrastructure*</u> as it delivers *services*, and to manipulate or control infrastructure *systems* to ensure continuous, optimal service delivery.**
- **How to Do It?**
  - **Real-time remote monitoring, including automatic "health" assessments**
  - **Physical inspections**

* Infrastructure refers to the equipment and resources needed to perform ATM operations

Source: "Airway Facilities Operations in the NIM Environment," FAA

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Monitor and Control Responsibilities (continued)

- Some kinds of work can be accomplished from centralized locations, thereby saving the costs associated with trips to remote locations.
- Examples: Software upgrades or System re-boot

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Source: "Airway Facilities Operations in the NIM Environment," FAA

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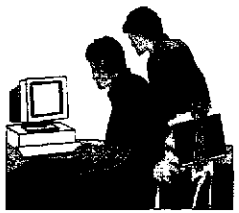
Monitor and Control Responsibilities (concluded)



- **Remote Monitoring will provide immediate or advance knowledge of service problems, along with an understanding of the impact of one system or service on other systems and services.**
  - **This will enable system and service restoration or failure prevention activities to be more efficiently planned and executed.**
  - **Relationship between equipment and services needs to be defined.**

Source: "Airway Facilities Operations in the NIM Environment," FAA

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Workforce Management Responsibilities

- *Workforce Management* refers to the effective application of field resources: the planning, scheduling, dispatching and monitoring of highly qualified staff and resources for operation and maintenance (O&M) activities.
- The concept is simple: Make sure you have the right people and equipment available at the right time and at the right place.

Source: "Airway Facilities Operations in the NIM Environment," FAA

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Help Desk Responsibilities

- The *Help Desk* function is a 24-hour, operations-focused customer service geared to providing one-stop, effective response to maintenance specialists through a single point of contact.
- They are the ones to call if maintenance is needed
- Provides a focused and systematic interaction with customers and users.

Source: "Airway Facilities Operations in the NIM Environment," FAA

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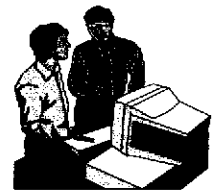
Engineering Analysis Responsibilities



- ***Engineering Analysis*** **is the compilation, correlation, and assessment of infrastructure and service performance to identify, understand, and find ways to minimize risks to service delivery and to verify the quality of service delivery.**
- **Obtain information about system and service performance characteristics, personnel actions, and processes/procedures.**
- **This information will then be used to investigate the circumstances surrounding system and service outages, identify the hazards and sequence of events that could compromise operations, and understand the factors contributing to service delivery shortfalls.**

Source: "Airway Facilities Operations in the NIM Environment," FAA

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Engineering Analysis Responsibilities (continued)

- **Trends in system performance are analyzed to identify tendencies for failures, providing added depth to the understanding and prediction of system and service outages.**
  - **Identify tactical risk to service delivery and system performance, contributing critical information in avoiding or mitigating service degradation.**
  - **Provide valuable lessons learned and the opportunity to apply them in future service and system performance engineering and procedures development, and in contingency planning. This is done for overall strategic planning of infrastructure service delivery.**

Source: "Airway Facilities Operations in the NIM Environment," FAA

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Engineering Analysis Responsibilities (concluded)

- **The Engineering Analysis function will also routinely generate system and service performance summaries to upper management at the local and national levels.**

Source: "Airway Facilities Operations in the NIM Environment," FAA

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Customer Service Responsibilities

- The *Customer Service* function refers to efforts to identify and respond to customer needs, and to track and measure service delivery performance against established service standards.
  - Determine and review customer needs
  - Define required service standards
  - Develop and execute implementation plans to establish and maintain those service standards
  - Obtain and analyze customer feedback

Source: "Airway Facilities Operations in the NIM Environment," FAA

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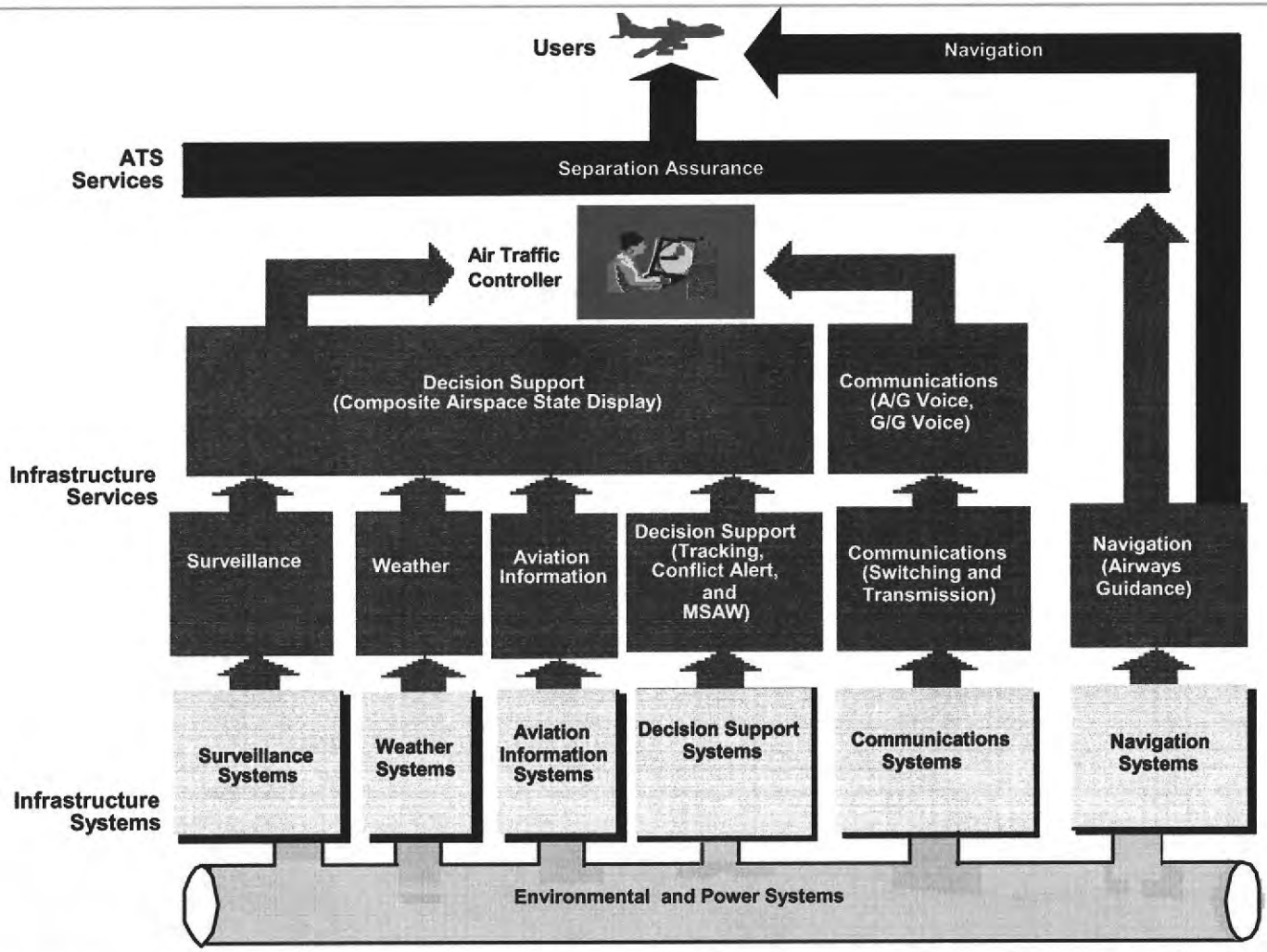
Maintenance Functions: Infrastructure Service Layering



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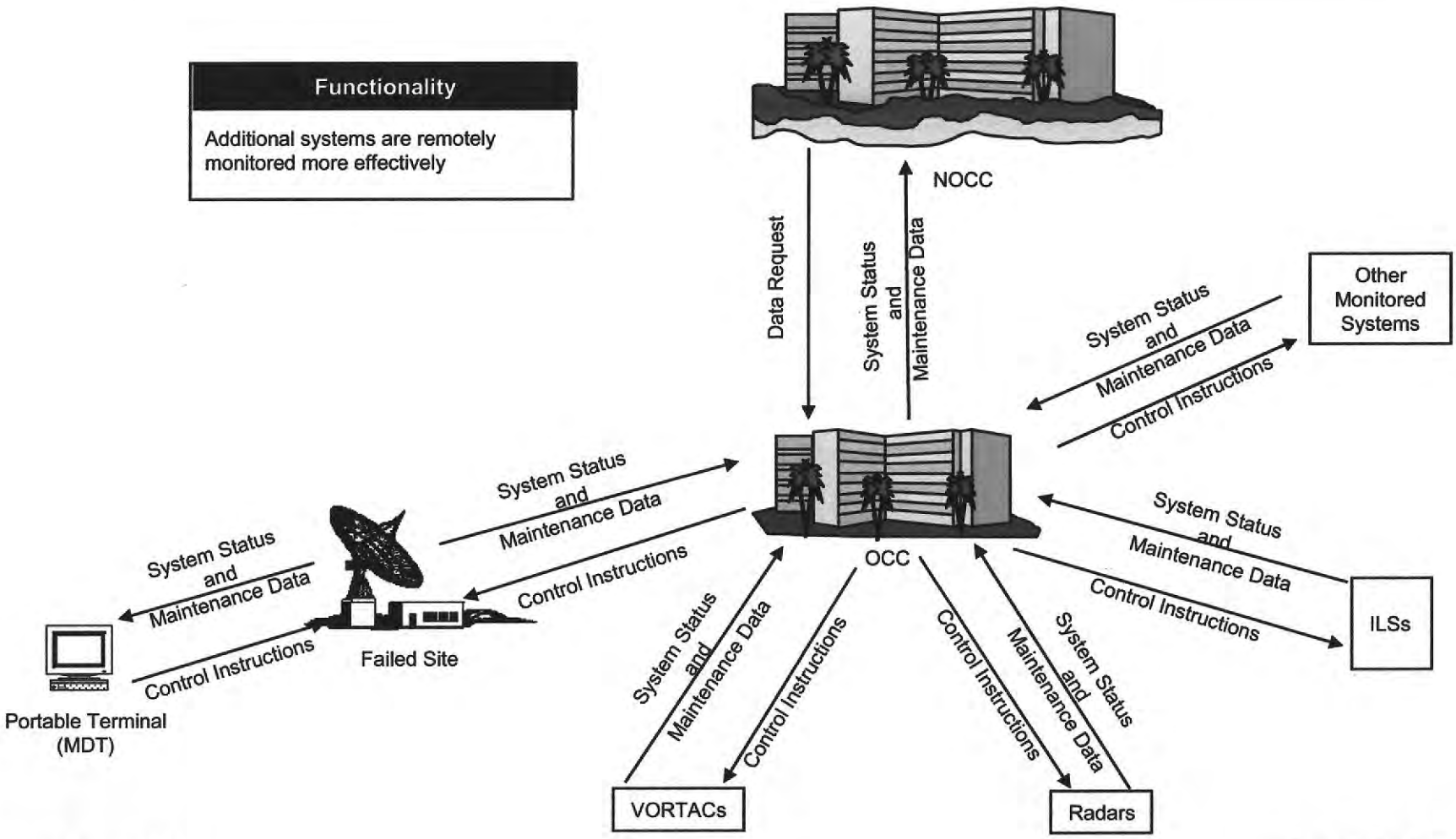
ATM Maintenance Functions

Functionality

Additional systems are remotely monitored more effectively



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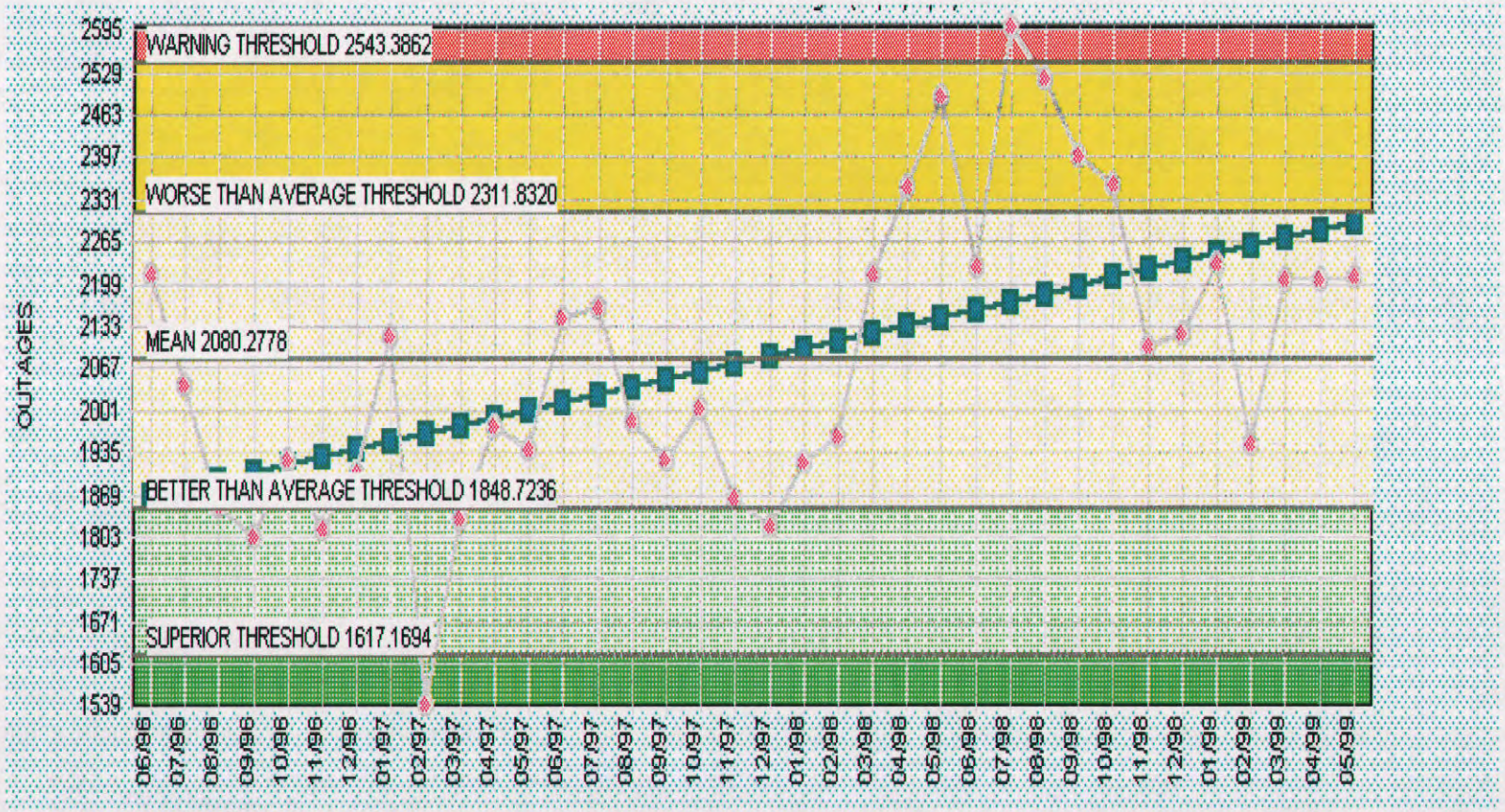
Metrics to Consider
Unscheduled Outages



Source of Data: AF Cost and Performance Management System (CPMS)

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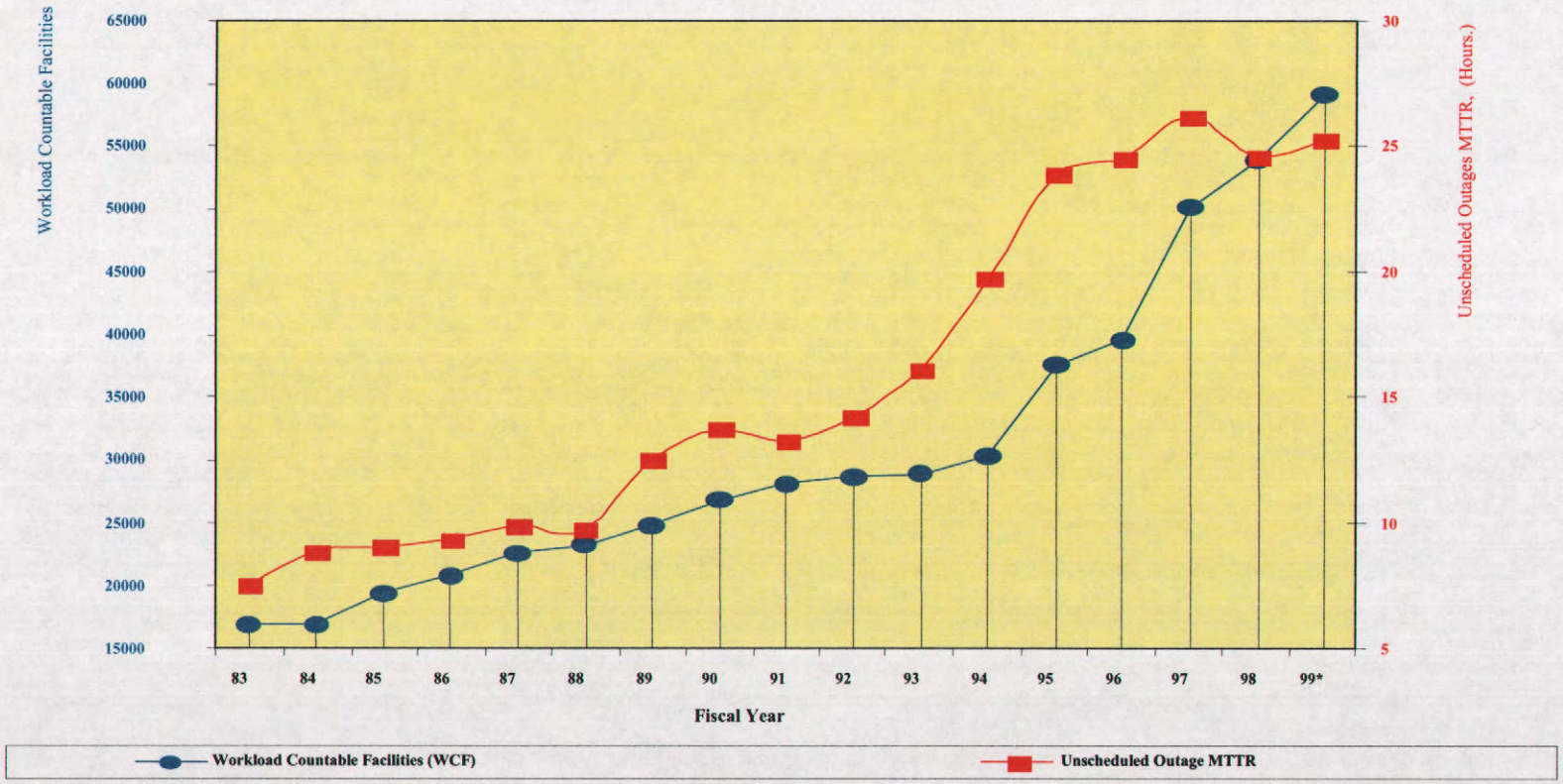
Metrics to Consider
Mean Time to Repair



Source of Data: AF AOP-200
** Data for FY99 is through 4/99 only*

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Metrics to Consider
Trends in Delays and Outages

Source of Data: AF/AOP-200

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Contracting for Operations and Support

- The best maintenance may be available from the contractor who built the equipment.
- Contracting these services is generally cost-effective for the near-term.
- Customer will want to train their own people to do maintenance.
- As with most decisions, a cost/benefit assessment should be made and should consider both cost and expertise.

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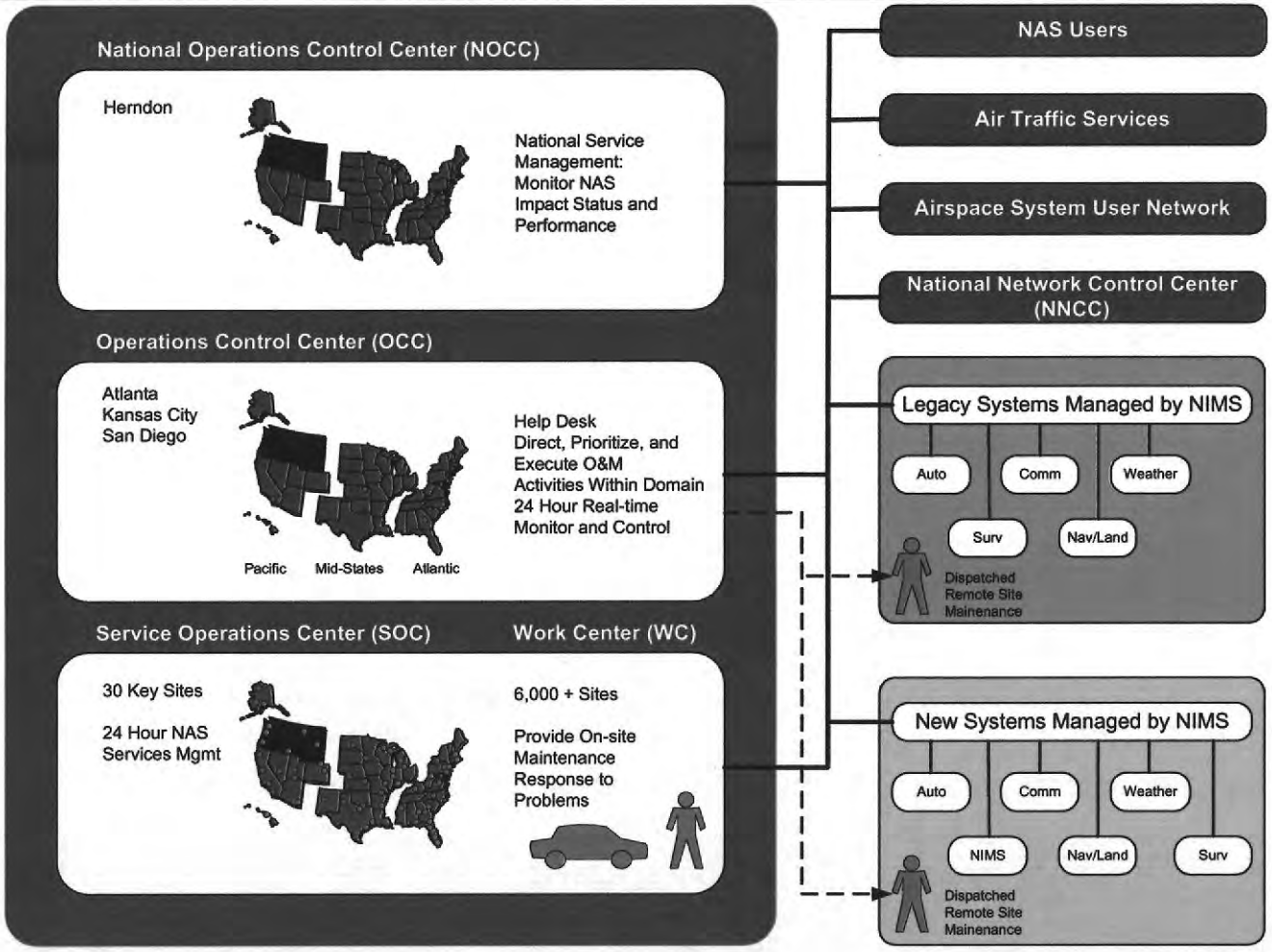
FAA's National Airspace System (NAS) Infrastructure Management (NIM) Structure



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NIM System Service Components

- ***National Operations Control Center*** *(NOCC)* **- National in scope. Covers all services, but only monitors and coordinates.**
- ***Operations Control Center*** *(OCC)* **- Approximately one-third of the country in scope (including Alaska and offshore service areas). Provides coverage for all services, and has significant monitoring and control functions, with the exception of telecommunications.**
- ***National Network Control Center*** *(NNCC)* **- Approximately one-half of the country in scope, with additional international responsibilities. Focused on telecommunications; has significant monitoring and control functions.**
- ***Service Operations Center*** *(SOC)* **- Scope limited to support of selected high impact Air Traffic facilities. Covers all services, and has complete monitoring and control functions.**
- ***Work Centers*** *(WCs)* **- Scope limited to a specific geographic area. Some work centers service large geographic areas while others service only single high impact facilities. Cover all services, and have local control functions. Coordinate with assigned OCC or SOC.**

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National Operations Control Center (NOCC)

- **Manages and oversees the tactical delivery of infrastructure services from a national perspective.**
  - **24 hour a day, 7 day a week monitoring of the NAS infrastructure.**
  - **Tracks maintenance activities in response to major events, monitoring and assessing restoration activities for services that have widespread or highly visible impact on NAS operations.**
  - **Reports significant infrastructure events to FAA Management.**
  - **Identifies and coordinates courses of action to minimize the operational impact of faults or failures that have widespread impact on NAS infrastructure services.**
  - **Coordinates the allocation of O&M resources from a national perspective.**
  - **Plans daily work and future NAS infrastructure services delivery and management strategy.**

The NOCC is collocated with the Air Traffic Control System Control Center (ATCSCC) in Herndon, VA.

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  - **Reports ent.**
  - **Identifi operational impact of faults or failures that have widespread impact on NAS infrastructure services.**
  - **Coordinates the allocation of O&M resources from a national perspective.**
  - **Plans daily work and future NAS infrastructure services delivery and management strategy.**

The NOCC's primary focus is on ***providing a national view*** *of service delivery and system status.*

The NOCC is collocated with the Air Traffic Control System Control Center (ATCSCC) in Herndon, VA.

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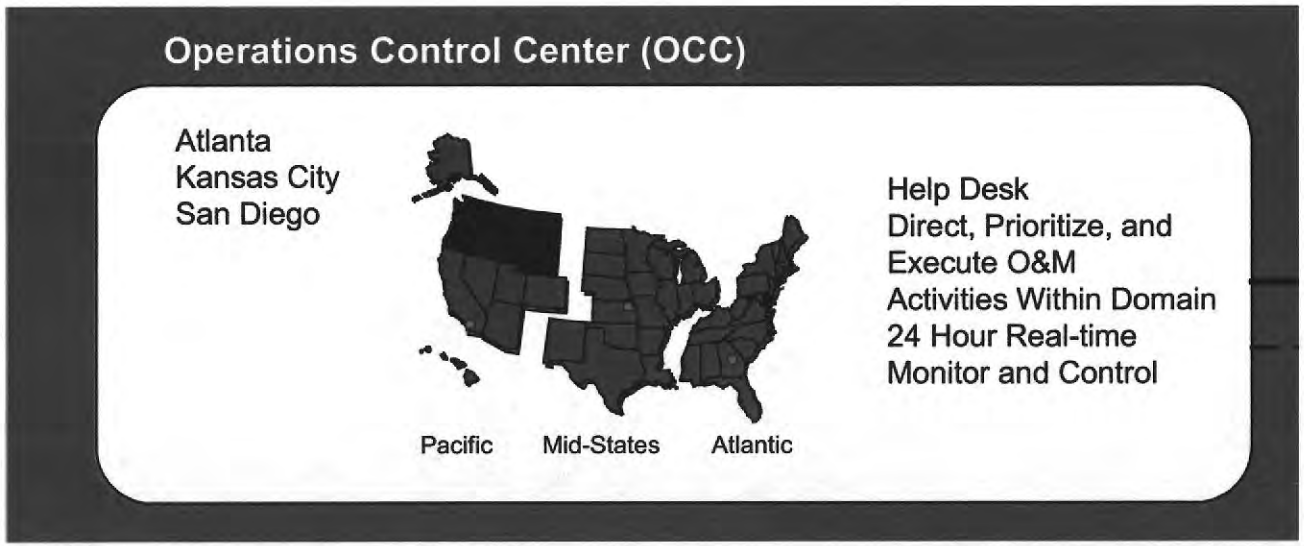
Operations Control Center (OCC)

- **Provides day-to-day tactical management of infrastructure services.**
- **Each OCC domain will encompass approximately one-third of the contiguous United States.**



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Operations Control Center (OCC) (continued)

- The OCC will coordinate and prioritize infrastructure management actions within its domain. It will monitor the NAS infrastructure performance, serve as point of contact for trouble reports, and determine and direct O&M actions required to maintain service delivery.
- The OCC will also remotely control and manage NAS infrastructure services/systems within its domain.
- OCC specialists will work in service/system discipline areas (e.g., surveillance, communications, navigation).

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Operations Control Center (OCC) (concluded)

- **The OCC will coordinate and prioritize infrastructure manage[illegible] monitor the NAS [illegible] oint of contact f[illegible] direct O&M ac[illegible] very.**
- **The OC[illegible] e NAS infrastru[illegible] n.**
- **OCC specialists will work in service/system discipline areas (e.g., surveillance, communications, navigation).**

The OCC focus is on ***tactical service and system O&M management*** *- prioritizing, managing and executing all O&M activities in their domain.*

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National Network Control Center (NNCC)

- Provide national and international data telecommunications management.
- Each NNCC domain covers approximately one-half of the United States and can take over for the other NNCC in case of major interruptions.

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National Network Control Center (NNCC) (continued)

- The NNCC oversees the leased and FAA-owned telecommunications used in NAS operations, and coordinates with the NOCC, OCCs, users, and national/international customers and service providers to ensure telecommunications integrity.
- The NNCCs monitor and dynamically manage telecommunications capacity and redundancies to ensure and maintain service availability.
- The NNCCs are considered operational extensions of the NOCC. Telecommunications service restoration activities will be coordinated and directed through the NOCC and/or OCC.

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National Network Control Center (NNCC) (concluded)

- **The NNCC oversees the leased and FAA-owned telecommunications used in NAS operations, and coordina roviders national/ to ensure**
- **The NNC s to telecomm ensure a**
- **The NNCCs are considered operational extensions of the NOCC. Telecommunications service restoration activities will be coordinated and directed through the NOCC and/or OCC.**

The NNCC focuses on the management and delivery of ***telecommunications*** *to ensure its availability to support NAS infrastructure operations.*

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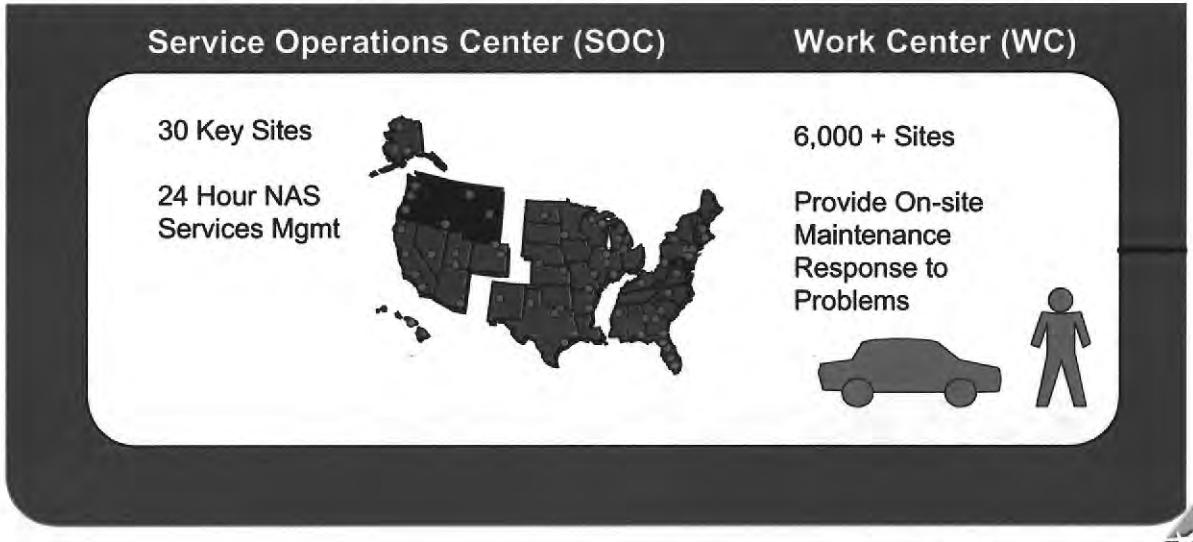
Service Operations Center (SOC)

- **SOCs will be located at and support high impact facilities such as:**
  - **Air Route Traffic Control Centers (ARTCCs)**
  - **Large stand alone Terminal Radar Approach Control facilities**
  - **Designated Air Traffic Control Towers (ATCT) and/or Terminal Radar Approach Control (TRACON) facilities having critical air traffic operations.**



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Service Operations Center (SOC) (concluded)

- **SOCs will be the primary point of contact for infrastructure management services in these critical Air Traffic facilities. They will perform functions similar to an OCC, but will focus on the specific NAS infrastructure services supporting the specific facility.**
- **SOC specialists will monitor the status of services and systems within the SOC area.**
  - **Diagnose and perform or direct the restoration of interrupted services/systems.**
  - **Operationally reconfigure services/systems to minimize interruptions and enhance service predictability.**
  - **Coordinate with the NNCC, OCC, and WCs (as designated), AT customers and other customers on all service activities.**

The SOC focus is on
providing tactical infrastructure O&M management for high NAS impact facilities
serving critical Air Traffic operations.

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Work Center (WC)

- Work Centers are located within an OCC or SOC domain to provide direct, efficient and effective maintenance and restoration activities.
  - Some work centers are located where there is a large concentration of NAS equipment related to high impact facilities such as ARTCCs.
  - Other work centers are located where dispatched specialists can best service geographically dispersed equipment.
- Work centers assure response to tasks, and are responsible for the maintenance and restoration of NAS systems, subsystems and equipment in their domain.
- Each WC will be operationally directed by and coordinates task performance with an assigned OCC or SOC.

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Work Center (WC) (concluded)

- **Work center functions will include equipment maintenance, fault correction, certification, modification, and installation.**
  - **Maintenance and restoration activities will be performed locally on equipment at the work center, or on remote equipment using either remote controls provided by NIMS, or by physical dispatch of assigned specialists.**
  - **Mobile and remote facility communications will be used to coordinate maintenance, restoration and certification activities with an SOC or OCC.**
- **Work centers are locations where AF specialists report for assigned work.**

The Work Center focus is on ***executing on-site O&M activities.***

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Improved Infrastructure Maintenance Management (continued)

- NAS Systems are continually monitored for acceptable performance. Reports of anomalies are transmitted to an operations control center (OCC) .
- During maintenance activity and upon completion, the technician inputs data into a maintenance data terminal (MDT) that forwards it to the OCC for evaluation and storage.
- System status and selected performance parameters are provided to the OCC periodically. These parameters can also be read by the OCC upon request.
- System status reports are sent from all OCCs to a national operational control center (NOCC) for NAS impact evaluation and input to the traffic management operation.
- Selected systems accept configuration change instructions through the RMS function. For example, channel changes when a system has a second channel.

- *NIMS and all operational subsystems that interface with it must be protected against intruders*

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Improved Infrastructure Maintenance Management (concluded)

- **NAS Systems are continually monitored for acceptable performance. Reports of anomalies are transmitted to an operations control center (OCC) .**

*NIMS is the **all-purpose real-time communications tool for AF operations** reporting in the NIM environment.*

*Its information can be used to acquire, compile and analyze real-time tactical data for a **variety of tactical and/or strategic cost and performance applications**.*

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the RMS function. For example, channel changes when a system has a second channel.

- ***NIMS and all operational subsystems that interface with it must be protected against intruders***

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Performance Monitoring

Friday September 12, 2003

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Performance Monitoring

- Collecting performance information to
  - Determine if contractor is satisfying contract requirements and performance goals.
  - Provide stakeholders with insight into project status in terms of cost, schedule, scope, quality, issues, and risks.
- Methods to monitor performance include the following:
  - Monthly Reports
  - Program Reviews
  - Oversight Briefings
  - Technical Performance Monitoring and Reports

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Performance Monitoring
Monthly Reports

- Monthly reports are submitted by contractors to document project status and progress:
  - Status—Document the current state of the project.
  - Progress—Document work accomplished since previous report.
  - Forecast—Predict future status and progress.

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Performance Monitoring
Example Monthly Report

This status report to the Serbia and Montenegro Air Traffic Control Authority (SMATCA) covers the work completed for August 2003.

1.0 Accomplishments During the Reporting Period

1.1 Program Management

{Contractor} performed cost and schedule monitoring to determine any relevant variances from the project baseline. {Contractor} facilitated a risk identification and analysis workshop. {Contractor} facilitated a risk monitoring meeting. {Contractor} prepared monthly report.

1.2 Data Processing Systems

{Contractor} attended System Requirements Review meetings to discuss requirements for each major element of the Data Processing System. All outstanding issues were resolved.

1.3 Communication

{Contractor} attended meetings with FAMUS PIU to discuss detailed requirements for ground–ground voice and data communications between ACC Belgrade and adjacent International ATC Centers. No remaining issues.

1.4 Navigation

{Contractor} attended meetings with FAMUS PIU to discuss the schedule for replacing ILS equipment at Podgorica, Beograd, and Batajnica. Issues were documented and will be discussed in additional scheduled meeting.

1.5 Surveillance

{Contractor} attended a meeting with the FAMUS PIU to discuss detailed technical requirements for future PSRs and MSSRs. No outstanding issues remain.

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Performance Monitoring
Example Monthly Report—continued

2.0 Cost Status

Cost Element Title	August Costs	Cumulative Costs	Cost Expected to Date	Variance
Program Management	1,000	17,000	18,000	1,000
Data Processing System	3,000	69,000	65,000	(4,000)
Communication	1,000	2,000	5,000	3,000
Navigation	2,000	14,000	10,000	(4,000)
Surveillance	9,000	27,000	22,000	(5,000)
Total	16,000	129,000	120,000	(9,000)

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Performance Monitoring
Example Monthly Report—concluded

3.0 Work and Deliverables Planned for the Next Reporting Period

3.1 Program Management

{Contractor} will continue its assessment of cost and schedule variances. {Contractor} will continue its risk identification, analysis, and monitoring meetings. {Contractor} will prepare and present quarterly briefing to SMATCA Director General.

3.2 Data Processing System

{Contractor} will continue working with FAMUS PIU to finalize detailed technical requirements for each major element of the data processing system. Requirements need to be finalized by October 31 in order to meet schedule requirements for system development and testing.

3.3 Communication

{Contractor} will meet with FAMUS PIU to discuss detailed requirements for ground–ground voice and data communication between ACC Belgrade and Serbia and Montenegro airports air traffic control for approach and departure.

3.4 Navigation

{Contractor} will meet with FAMUS PIU to determine schedule for replacing DMEs at Podgorica, Nis, and Tivat.

3.5 Surveillance

{Contractor} will meet with FAMUS PIU to discuss schedule for the deployment of new PSRs and MSSRs.

4.0 Items of Interest to FAMUS PIU

{Contractor} attended Air Navigation and Exhibition Conference.

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Performance Monitoring
Program Reviews

- Program Reviews are 'State of the Project' meetings held with key project members to discuss project status, progress, scope, quality, issues, and risks. Program reviews are typically conducted at major milestones and may use one or more of the following analysis techniques:
  - Variance Analysis—Comparing project results to baseline (cost, schedule, technical).
  - Trend Analysis—Examining project results over period of time to determine if project is proceeding as planned or is continuously needing corrective action.
  - Earned Value Analysis—Assessing project performance by determining planned value, actual value, and earned value of work activities (discussed at high level in Washington in June).
  - Resource Analysis—Assessing the past and future use of resources.

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Performance Monitoring

Program Reviews

- Program Reviews use the results of project analysis (variance, trend, earned value, resource) to determine changes needed during next phase of work.
- Questions answered at program reviews may include the following:
  - What additional funds are required to complete the project or what trade-offs must be considered?
  - What changes to the schedule are needed for future activities due to current schedule variances?
  - What other additional resources are necessary?
  - Will the product meet quality standards?
  - What are the major near term risks moving forward?

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Performance Monitoring
Oversight Briefings

- Oversight Briefings are presentations by the project team (including contractor) to provide oversight committees and other stakeholders (SMATCA Director General, EBRD, EIB, Ministries) with insight into project status, progress, scope, quality, issues, and risks.
- Oversight Briefings are intended to provide oversight committees and other project stakeholders a high-level overview--not day-to-day details.

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Performance Monitoring
Oversight Briefing—Example

Project Summary

*Ahead of schedule, below budget.

*System requirements baselined for initial release.

1

Schedule Status

*All tasks on schedule

*Key milestone met. System requirements review completed as schedule.

2

Cost Status

* Activities 1,2, and 4 below budget.

•Activities 3 and 5 on budget.

3

Funding Status

*Funds received = x, Costs incurred = y

*Current funds exhaust date is DD/MM/YY

4

Technical Issues and Risks

*FDPS will provide…

*Major risks and corresponding strategies include

5

Upcoming Efforts

*FDPS beta testing

*ILS to be installed at X location.

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Performance Monitoring
Technical Performance Monitoring

- Technical Performance Monitoring—Examining technical progress to ensure the product or service satisfies the planned technical requirements.
- Necessary in both system and civil works projects.
- Techniques include the following:
  - Technical Information Exchange Meetings
  - Requirements Management
  - Functional Analysis and Audits
  - Technical Analysis
  - Validation and Verification
  - Documentation Review
- Successful technical performance monitoring depends on qualified, knowledgeable, and skilled staff to interface with corresponding contractor staff.

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Information Distribution

- Information Distribution—Providing required performance information to project stakeholders in a timely manner.
- Various methods for providing information include:
  - Paper distribution
  - Email
  - Web page postings
  - Briefings
  - Library
- Communication Plan documents the project stakeholders, their required performance information, method of communicating information, and frequency of communication.

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Seminar Exercise
FAMUS Performance Monitoring and Oversight Product Development

- Determine Director General performance monitoring and reporting requirements.
- Discuss potential FAMUS performance monitoring and oversight techniques to meet requirements.
- Begin development of performance monitoring products.

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Seminar Exercise
FAMUS Risk Identification, Analysis, and Response Planning

Saturday September 13, 2003

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Seminar Exercise
FAMUS Risk Identification, Analysis, and Response Planning

- Review results of risk identification from Washington in June.
- Analyze documented risks in terms of probability and impact.
- Prioritize risks.
- Determine risk strategies (Accept, Avoid, Transfer, Mitigate, Watch) for highest priority risks.
- Establish risk monitoring process.

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Seminar Exercise
FAMUS Risk Identification, Analysis, and Response Planning

- Review Risks
- Assign Probability Scores
  - High (.9)—Risk event likely to occur.
  - Medium (.5)—Risk event has significant chance of occurring.
  - Low (.1)—Risk event probably will not occur.
- Assign Impact Scores
  - High (.8)—Would cause program failure. Requirements would not be achieved.
  - Med (.2)—Would cause moderate cost and or schedule increases. Important requirements would be achieved.
  - Low (.05)—Small or insignificant cost and or schedule increases. All requirements can be met.

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Seminar Exercise

FAMUS Risk Identification, Analysis, and Response Planning

	Impact	Low	Medium	High
Probability	Values	.05	.2	.8
High	.9	<.1	.18	.72
Medium	.5	<.1	.1	.4
Low	.1	<.1	<.1	<.1

Critical Risk: .4-.99 Red

Significant Risk: .1-.39 Yellow

Minimum Risk: <.1 Green

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Seminar Exercise

FAMUS Risk Identification, Analysis, and Response Planning

Risk Strategy	Description
Avoid	Change acquisition or deployment to remove the risk completely.
Mitigate	Take positive action to reduce probability or impact of the risk.
Watch	Mitigation action complete, monitoring for effectiveness; or contingency mitigation actions are available but not implemented pending evaluation of some program element.
Accept	Take no action. Prepare contingency plan to implement as required.
Transfer	Make another organization responsible for mitigating the risk.

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Seminar Exercise
FAMUS Tender Management by EBRD Rules

Sunday September 14, 2003

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Seminar Exercise
FAMUS Tender Management by EBRD Rules

- Review tender process as defined by EBRD.
- Discuss "Lowest Evaluated Price" and relationship to evaluation criteria.
- Discuss potential evaluation criteria.

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Seminar Exercise

FAMUS Tender Management by EBRD Rules Review

Major phases of procurement or tender management

- Procurement planning
- Tender planning
- Invitation for Tender (including Tender Process)
- Tender evaluation and contract award
- Contract administration
- Contract closeout

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Seminar Exercise

FAMUS Tender Management by EBRD Rules Review

Procurement planning

- Involves the development of a Tender Strategy that documents the following:
  - Background, objectives, statement of need, and required performance
  - Risks
  - Procurement process (Open tendering, two-stage tendering, selective tendering, single tendering, shopping, local competitive tendering)
  - Potential sources and methods to ensure competition
  - Source selection procedures including milestones
  - Contract type, budget, and funding
  - Logistics and security considerations
  - Contract administration framework

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Seminar Exercise

FAMUS Tender Management by EBRD Rules Review

Tender Planning

- Preparing and obtaining approval of the tender documents.
- Tender Documents include the following:

Volume I: The Tender
Volume II: The Contract
Volume II: The Requirements

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FAMUS Tender Management by EBRD Rules Review

Invitation for Tender

- Invitation for Tender documents are sent to pre-qualified tenderers. The following potential tender process techniques may be used:
  - Pre-Proposal Conference
  - Questions and Answer Amendment
  - Oral Presentations
  - Site Visits
  - Past Performance Inquiries

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Seminar Exercise

FAMUS Tender Management by EBRD Rules Review

Tender Evaluation and Contract Award

- Evaluation process outlined by EBRD:
  - Receipt and opening of tenders
  - Examination of tenders
  - Seeking written clarifications from tenderers
  - Rejection of tenders that are not substantially responsive
  - Evaluation and comparison of substantially responsive tenders
  - Determination of the lowest evaluated tender
  - Post-qualification of the lowest evaluated tender
  - Award recommendation
  - Tender Evaluation Report
  - Notification of award

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Seminar Exercise

FAMUS Tender Management by EBRD Rules Review

Contract Administration

- Process of ensuring that contract performance meets contract requirements.
- Project team performs the following tasks:
  - Monitors and reviews work results (deliverables, scope, standards, costs, schedule).
  - Reports on contract performance to appropriate stakeholders.
  - Processes invoices to ensure timely payment.
  - Reviews change requests for approval or disapproval.

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Seminar Exercise

FAMUS Tender Management by EBRD Rules Review

Contract Closeout

- Process of determining is the work was successfully completed (acceptance), processing the final payment, and creating the contract file (indexed project records and documents).
- Procurement Audits are conducted to review the process from procurement planning through closeout to identify successes and failures.

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Seminar Exercise

FAMUS Tender Management by EBRD Rules Review

Contract Closeout

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Seminar Exercise

FAMUS Tender Management by EBRD Rules

Lowest Evaluated Price and Evaluation Criteria

Offeror	Evaluated Price	Evaluated Price Points (max=85)	Merit Points (max=15)	Total Points
A	125.5	66.78	15	81.78
B	115.2	72.75	15	87.78
C	100.6	83.31	12	85.31
D	98.6	85.00	2	87.00

Evaluate Price Points=
(Lowest evaluated price / evaluated price of offeror)*max points

Merit Points:
Past Experience—5 maximum points
Technical Solution—4 maximum points
Key Personnel—4 maximum points
Training Approach—2 maximum points

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Course Wrap-Up

- Questions
- Feedback
- Potential MITRE support

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Project and Engineering Management
For the
Serbia and Montenegro Air Traffic Control Authority
(SMATCA)

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