Transitioning Air Traffic Management Research into Operational Capabilities

A Study by the Transition Working Group

Air Traffic Services Subcommittee

Research, Engineering and Development Advisory Committee

Federal Aviation Administration

20 September 2005

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EXECUTIVE SUMMARY

Overview

This report provides findings and recommendations on the transition of new air traffic management (ATM) concepts from research[1] through development to implementation. They were developed by the Transition Working Group (TWG) of the Air Traffic Services (ATS) Subcommittee and the Federal Aviation Administration (FAA) Research, Engineering and Development Advisory Committee (REDAC).

This is a timely study in light of the renewed demand for additional system capacity and the vision set forth in the Next Generation Air Transportation System (NGATS) report published by the Joint Planning and Development Office (JPDO). The development of increasingly complex concepts and changing human roles foreseen in that document will necessitate smoother transitions if the ATM system is to meet national air transportation needs.

The objective of this twelve-month study was to identify and analyze barriers to transition. To that end, the TWG gathered data from relevant literature and over thirty briefings from industry, government, academia, national research centers, and aviation organizations. Twelve major programs[2] were then analyzed to identify successes and barriers to transition from several perspectives. This information was then used to develop preliminary findings that were reviewed by the REDAC and ATS Subcommittee at a February 2005 workshop.

The TWG subsequently developed a refined set of findings and recommendations, which were presented to the FAA in a March 2005 letter and at the April 2005 REDAC meeting. This report contains that material and additional findings and recommendations developed since then.

It is hoped that the FAA, industry, academia, and the national laboratories will find this report useful as they work together to enable our nation’s air transportation system to meet the ever-increasing demand for safe and efficient movement of people and materiel.

Key Characteristics of Successful Transitions

The study found that successful transitions have two key characteristics: broad approval or a mandate, and strong program leadership. Broad approval exists when there are clear benefits to aviation stakeholders and the public. Strong leadership exists when the program is disciplined, collaborative and integrated, has strong advocates, and is visible to senior FAA management.

[1] In this study, “research” means the initial concept explorations that may or may not provide useful capacity or safety benefits. “Development” begins when FAA decides that a research concept will meet an aviation need. This study focused on the transition beginning at the hand-off from research to development and ending at when a significant number of systems have been deployed successfully.
[2] TCAS, TDWR, CPDLC, URET, TMA, FAST, RNP, LAAS, PRM, ITWS, ADS-B, TFM/CDM (see acronyms list in Appendix E).

Summary Recommendations

The following list summarizes the recommendations of this study:

Executive Oversight

- Create an executive-level oversight committee
    - Assign executives to oversee major programs in transition

Effective Management Practices and Processes

- Adopt industry best practices for managing programs in transition that:
    - Ensure clear needs and a business case
    - Identify major uncertainties and mitigation strategies
    - Establish and monitor key decision points
    - Ensure that deliverables occur as needed for the transition, especially from the research organizations
    - Establish joint plans, commitments, and oversight for programs with other government or private sector organizations
- Develop a program management career path to parallel the existing technical career paths
- To take advantage of lessons learned and new technologies, ensure that at least one cycle of enhancements occurs after the initial deployment in all major programs
- Establish guidelines and processes to ensure the transfer of data and knowledge to system implementers and production contractors

Change Management

- Conduct research on transforming the roles of aviation workforce

Financial Management

- Ensure adequate funding for transition

Selecting and Managing Technology Priorities

- Determine risks of new technologies using the REDAC or an Aviation Science Board modeled after the Department of Defense (DoD) Defense Science Board
- Continue to use field prototypes and field trials to reduce risk
- Move National Airspace System (NAS) systems toward open architectures

Industry

- Provide government furnished information as a resource when appropriate
- Audit recent successful transitions to identify and institutionalize best practices for working collaboratively with industry and research organizations

Consensus

- Strive for consensus, but place aviation needs above parochial interests
- Involve FAA stakeholders in planning and implementation

Environment

- Develop noise measurement standards, including monitoring and analysis methods

Certification and Safety

- Continue the Certification Process Improvement program
  - Expand this process to include the particular issues associated with integrated air-ground systems
- Separate the certification and program management roles
- Expand the use of Designated Engineering Representatives (DERs) to accelerate the deployment of new procedures
- Conduct research to develop best practices for human-in-the-loop assessments
- Develop objective safety criteria and assessment methods

Aircraft Equipage

- Enable early operational advantages when seeking to implement concepts that require equipage of aircraft

Separation Standards

- Review and, where needed, establish new risk assessment methods for evaluating existing and proposed separation standards and procedures

Change Management – An Overarching Factor

As the FAA considers the recommendations in this report, it is recommended that any actions contemplated be taken by applying a formal organizational change management approach. Changes introduced in isolation without considering their impacts across the greater FAA organization and its employees and unions and on the various stakeholders, including airlines, general aviation, research institutes, and industry suppliers, may or may not be effective, and in many cases are likely to meet with resistance.

Disciplined change management processes and tools exist in the private sector to support the planning, initiation, realization, and stabilization of change within an organization. Change management, properly implemented, addresses system wide barriers to the introduction of new processes and technologies, including barriers associated with individual or group resistance to change. Once elements of resistance are identified, specific action plans can be developed to overcome resistance and gain the buy-in of stakeholders.

1. INTRODUCTION

This report provides findings and recommendations on the transition of new air traffic management (ATM) concepts from research[1] through development to implementation. They were developed by the Transition Working Group (TWG) of the Air Traffic Services (ATS) Subcommittee and the Federal Aviation Administration (FAA) Research, Engineering and Development Advisory Committee (REDAC).

This is a timely study in light of the renewed demand for additional system capacity and the vision set forth in the Next Generation Air Transportation System (NGATS) report published by the Joint Planning and Development Office (JPDO). The development of increasingly complex concepts and changing human roles foreseen in that document will require smoother transitions if the ATM system is to meet national air transportation needs.

The objective of this twelve-month study was to identify and analyze barriers to transition. To that end, the TWG gathered data from relevant literature and over thirty briefings from industry, government, academia, national research centers, and aviation organizations. Twelve major programs[2] were then analyzed to identify successes and barriers to transition from several perspectives. This information was then used to develop preliminary findings that were reviewed by the REDAC and ATS Subcommittee at a February 2005 workshop.

The TWG subsequently developed a set of refined findings and recommendations, which were presented to the FAA in a March 2005 letter and at the April 2005 REDAC meeting. This report contains that material and additional findings and recommendations developed since then. The latter is summarized in Appendix B.

It is hoped that the FAA, industry, academia and the national laboratories will find this report useful as they work together to enable our nation's air transportation system to meet the ever-increasing demand for the safe and efficient movement of people and materiel.

2. KEY CHARACTERISTICS OF SUCCESSFUL TRANSITIONS

The study found that successful transitions have two key characteristics: broad approval or a mandate, and strong program leadership. Broad approval exists when there are clear benefits to aviation stakeholders and the public. Strong leadership exists when the program is disciplined, collaborative, and integrated, has strong advocates, and is visible to senior FAA management.

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3. CHANGE MANAGEMENT - AN OVERARCHING FACTOR

As the FAA considers the recommendations contained in this report, it is recommended that any actions contemplated be taken by applying a formal organizational change management approach. Changes introduced in isolation without considering the impacts across the greater FAA organization and its employees and unions and on the various stakeholders, including airlines, general aviation, research institutes, and industry suppliers, may or may not be effective, and in many cases are likely to meet with resistance.

Disciplined change management processes and tools exist in the private sector to support the planning, initiation, realization, and stabilization of change within an organization. Change management, properly implemented, addresses systemwide barriers to the introduction of new processes and technologies, including barriers associated with individual or group resistance to change. Once elements of resistance are identified, specific action plans can be developed to overcome resistance and gain buy-in by stakeholders.

Several examples of the lack of a disciplined change management process became evident in the course of information gathering by the TWG and are referred to throughout the report. In these instances, the stakeholders were not clearly aligned to work toward common objectives, resulting in organizational conflict and less than optimal performance for the transition of research into implementation.

4. FINDINGS AND RECOMMENDATIONS

The findings and recommendations in this report are organized into eight major categories, with the Transition Management category divided into four subsets, as follows:

- Executive Oversight of Transitions
- Transition Management
    - Effective Management Practices and Processes
    - Change Management
    - Financial Management
    - Selecting and Managing Technology Priorities
- Industry
- Consensus
- Environment
- Certification and Safety
- Aircraft Equipage
- Separation Standards

A. Executive Oversight of Transitions

Throughout the document there are references to the establishment of management groups to oversee the transition processes. The involvement of senior FAA leadership is treated as a separate and distinct item, since it has been crucial in past efforts to successfully transition research into operational capabilities.

Finding: Executive-level involvement is vital to successful transitions.
The visible involvement of senior leadership is vital to the success of major innovations, especially in a community as diverse as aviation. This is particularly important when transitioning concepts through the regulatory, certification, and procedural steps, which can pose even more of an obstacle than the technical aspects. Of the 12 major projects reviewed, the 8 successful ones all benefited from the direct involvement of the administrator or a senior executive. Relevant examples are provided in Section A of Appendix A.

Recommendation: Create an executive-level transition oversight committee.
FAA should form an internal, executive-level Transition Oversight Committee to review quarterly or semiannually all major projects in transition. The committee should be chaired by a senior FAA executive (e.g., Deputy Administrator), include representatives from all the major FAA organizations (e.g., Associate Administrators and Vice Presidents), and report to the Administrator.

Recommendation: Assign an executive-level manager to sponsor and have oversight responsibility for each major project in transition.
FAA should assign an executive-level manager with ultimate responsibility for ensuring that a capable leader and staff are in place to manage the day-to-day program and that adequate funding exists for the successful implementation of the program. This manager should act as the ultimate escalation point to resolve program conflicts when necessary.

Recommendation: Continue executive oversight throughout each program's lifecycle.
It is important that executive involvement should not end at Joint Resources Council 2a (JRC-2a), but continue until deployment and operational use is well underway, with measured evidence that the promised capability is being realized.

B. Transition Management

For the purpose of this report, transition encompasses moving research through the concept phase to field implementation and operational use. Transition management is a broad category, including issues related to effective management practices and processes, change management, management of funds, and selecting and managing within established technology priorities. Sections C, D, E, and F, below, address these topics in sequence.

C. Effective Management Practices and Processes

Finding: The transition process appears to be ad hoc.
The introduction of new Air Traffic Service capabilities sometimes appears to be an ad hoc process, with inconsistent commitments, priorities, funding, and evaluation procedures.

***Recommendation*: Use industry best practices to transition research.**
FAA should develop transition processes based on best practices from industry to manage the transition of research from the laboratory to operational use. Specific actions should include the following:

- Establish a clear link between the research product and an aviation community need that has been subjected to a business case analysis
- Identify any major technical risks or other uncertainties and strategies for their mitigation
- Define decision points throughout the development process that provide opportunities to adjust forward plans in the context of changing needs (e.g., terminating projects whose business case does not justify their continuation)
- Define standard deliverables throughout the transition process to facilitate the transfer of technology from laboratory to industry to operations
- Develop a formal transition plan that identifies funding, personnel, commitments, and key managers in each organization for projects involving research organizations outside the FAA (e.g., NASA, Federally Funded Research and Development Centers, academia, etc.).

Finding: Programs suffer from inconsistent management skills and excessive turnover.
Program management skills varied across the programs that were reviewed, and weak management or changes in management personnel consistently contributed to program delay. One cause is that managers are often selected from primarily technical positions but lack management skills. Section C-1 of Appendix A presents an example of frequent turnover.

***Recommendation*: Develop a program management career path.**
The FAA should develop a program management career path for those who wish to manage and not pursue a technical path.

Finding: The contracting process can be too rigid.
The full-scale development and production contracting process can be too rigid, obstructing opportunities for beneficial changes that emerge during the development process. Since the project manager's performance is usually judged by the ability to deliver the technology on schedule and within cost, there is a natural resistance to change, regardless of the expected result. While discipline is needed to avoid requirements drift, this motivation may also drive the project manager to meet only the functional specifications in the original design in the most cost effective way, resulting in a system that misses opportunities or is closed and difficult to change. A relevant example is provided in Section C-2 of Appendix A.

***Recommendation*: Include at least one spiral cycle to enable enhancements after Initial Operating Capability (IOC).**
Every major procurement should be constructed with at least one spiral cycle included in the baseline program. This will permit IOC to be achieved within the original cost and schedule parameters, yet enable at least one cycle of enhancements to incorporate technologies or lessons learned discovered during the development phase. Should it turn out that enhancements are not worthwhile, the reserved funding could be released for other purposes, such as to support unanticipated deployment costs, a technology refresh, or downstream sustainment. *Note that this has been done in the past, in, for example, the Airport Surveillance Radar - Model 9 (ASR-9) program.*

Finding: A standardized process is needed to identify and manage research contractor deliverables.
The User Request Evaluation Tool (URET), Traffic Management Advisor (TMA), Terminal Doppler Weather Radar (TDWR), and Integrated Terminal Weather System (ITWS) programs ultimately experienced successful transitions from research and prototype stages to implementation and deployment. However, they would all have benefited from standard processes specifying the deliverables required of the research organization to facilitate the transition to contractors involved in productizing and deploying the technology. Two examples appear in Section C-3 of Appendix A.

Recommendation: Establish guidelines for how the research organizations transfer their knowledge and data to production contractors.

D. Change Management

Finding: Innovation often requires changes in concepts, skills, and responsibilities.
Automation technologies offer improvements in capacity or flexibility but often require changes in operating concepts, workforce skills, and organizational responsibilities. Although there has been success in implementing URET and Traffic Management Advisor (TMA), others such as Precision Runway Monitor (PRM), Simultaneous Offset Instrument Approach (SOIA), Controller-Pilot Data Link Communications (CPDLC) and Final Approach Spacing Tool (FAST) have yet to be fully implemented.

Recommendation: Conduct research aimed at transforming the roles of the aviation workforce.
FAA needs to establish a research program to understand and guide the transformation of the roles of pilots, dispatchers, and controllers in future ATM systems.

E. Financial Management

The management of costs and schedules associated with NAS modernization has been a major challenge to the FAA. A recent Government Accountability Office (GAO) report[3] discussed this subject in detail, noting that 13 of 16 major acquisitions have experienced significant cost and schedule growth. Most of these problems arose during the transition period, but some, such as Global Positioning System (GPS), were the result of inadequate risk management during the conceptual phase.

Finding: There is a lack of financial forward planning for transition.
Presentations made to the TWG repeatedly underscored the lack of forward financial planning. When a research and development (R&D) project is started, realistic financial planning estimates are generally not included for the transition phase. Similarly, when a research project appears to be headed for acquisition and system wide implementation, funds are not adequately programmed for field testing, essential facility improvements, training, or operational

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[3] FAA Has Made Progress but Continues to Face Challenges in Acquiring Major Air Traffic Control Systems, GAO-05-331, June 2005.

maintenance and support. This has been a frustrating problem for NASA, for example, when they are ready to transfer their research to FAA for full-scale development and deployment but find FAA financially unprepared.

<u>Recommendation</u>: Ensure adequate funding for the transition phase.
When the decision occurs to implement research results, funding must be identified for the transition process, to include production, deployment, training, and one cycle of enhancements. This budget should be reviewed and updated every six months to ensure that program management and senior leadership are kept informed.

F. Selecting and Managing Technology Priorities

<u>Finding</u>: Risks associated with adopting new technologies must be properly understood.
Improper assessment of risks can cause large cost overruns, program delays, failure to realize benefits, and a negative perception of the organizations involved. Understanding the risks when a new and complex technology is proposed can be a daunting challenge. For example, GPS, developed for military purposes, presented major risks associated with integrity and jamming. However, its precision and universal coverage, along with the perception that it would reduce FAA operational costs, led FAA and the community to abandon Microwave Landing System (MLS) and pursue GPS without adequately addressing those risks. After some 15 years and several billions of dollars, precision approaches are still not available, nor have many legacy navigation aids been shut down, as originally promised.

<u>Recommendation</u>: Conduct independent reviews of the risks of new technologies.
When a new and complex technology such as GPS is considered, FAA should conduct independent technical and economic reviews to ensure that all risks have been revealed and realistic mitigation steps and their likely costs identified. This may be done by either a special study by the REDAC augmented with outside experts or by forming an Aviation Science Board (ASB) modeled after the DoD Defense Science Board.

<u>Finding</u>: Prototypes and field trials are very valuable in identifying risks.
Prototypes and field trials have played key roles in the development of automation technologies such as URET and TMA and infrastructure technologies such as Next Generation Weather Radar (NEXRAD), TDWR, ASR-9 WSP, and ITWS. Field trials have also served to identify technologies as not yet ready for nationwide deployment. For example, initial simulation studies and field tests at Dallas Fort Worth (DFW) Airspace of the Final Approach Spacing Tool (FAST) achieved excellent controller and pilot acceptance. However, after the addition of a new runway and the changes in airspace procedures associated with the Metroplex operation, DFW controllers no longer felt comfortable relying on an advisory to increase capacity but still being held responsible for separation assurance.

<u>Recommendation</u>: Continue using prototypes and field trials to mitigate risks.

<u>Finding</u>: Open-systems architectures facilitate desirable change.
The application of open-systems architectures is providing significant benefits in newer systems such as NEXRAD, TDWR, and En Route Automation Modernization (ERAM) now in

development. For example, NEXRAD now accepts, tests, and distributes major functional enhancements every six months. Notably, most recent enhancements involve software modifications, not hardware changes.

***<u>Recommendation</u>*: Migrate NAS systems to an open-systems architecture.**
FAA should audit all major existing NAS systems to determine if and when they can be moved into an open-systems architecture and take action to move in that direction. All new major procurements should be required to have an open-systems architecture.

G. Industry

<u>Finding</u>: Government furnished information can be a useful resource.
During recent major acquisitions, including the ITWS, TMA, and URET programs, the production contractor was provided access to research software that had been reworked to support the handover to industry and cross-referenced against the production specification. The software was provided as government furnished information for optional use by the production contractor. Access to key research staff was also encouraged to explain the technology, testing, and lessons learned during the research. In several instances this significantly reduced the risks and costs of full-scale software development. Similarly, test methods and data were provided to the contractor to facilitate comprehensive testing prior to deployment.

***<u>Recommendation</u>*: Provide government furnished information when prudent.**

<u>Finding</u>: Collaboration between industry and R&D teams is vital to success.
An early and strong collaboration between industry and the research and development teams is vital to success. The URET program with MITRE CAASD and Lockheed Martin, ITWS with MIT Lincoln Laboratory (MIT/LL) and Raytheon, and TMA with NASA and Computer Sciences Corporation (CSC) are examples of how research organizations, FAA program managers, and industry can work together effectively to achieve success. Once the competition phase of an acquisition has been completed, the FAA should be proactive in creating a collaborative working relationship between the program office, production contractor, and research team.

***<u>Recommendation</u>*: Establish best practices for collaboration with industry and research organizations.**
FAA should examine recent programs to identify best practices for engaging industry in the transition process and include these practices in program management doctrine and training.

H. Consensus

The air transportation system has many stakeholders, including various branches of the government, airlines, air cargo, general aviation, public and private sector labor, airports, and suppliers. The traditional means of implementing change has required buy-in from all stakeholders, who need to know the purpose, expected cost, schedule and benefits. They also need assurances that the government infrastructure will be in place on a complementary schedule. This has been a daunting process for many programs, as illustrated in Sections H and K of Appendix A.

Finding: Common good is possible without unanimous endorsement.
The introduction of new ATS capabilities is sometimes hindered by the lack of unanimous endorsement within the aviation community, even though a common good may result. The recent deployment of Domestic Reduced Vertical Separation Minima (DRVSM) shows the benefit of implementing a new capability that lacked a consensus endorsement but nevertheless provided an incentive for improved operations.

Recommendation: Strive for consensus, but do not be held hostage to it.
Where possible, the FAA should strive to create benefit-driven incentives and community consensus. However, when this is not possible, meeting the needs of the nation's air transportation system must transcend parochial interests, possibly by mandating certain equipments and procedures.

Finding: Early involvement of FAA supporting organizations mitigates the risk of delay in OT&E.
Lack of participation in research programs by the FAA Airway Facilities (AF), Air Traffic (AT), and Flight Services (FS) organizations, especially during the early phases, often contributed to significant delays during Operational Test and Evaluation (OT&E).

Recommendation: Involve FAA stakeholders in the planning and implementation of change.

I. Environment

Finding: Environmental factors are increasingly impacting airspace and airport changes.
Environmental considerations are increasingly impacting on airspace and airport operations. Public interest groups are influencing land use, noise, and emissions matters as the aviation community attempts to meet the demand for air transportation. The general aviation (GA) community has a continuing concern where land use is encroaching on GA airports. For example, an environmental group in New Jersey[4] is attempting to influence traffic flow in and around major New York metropolitan airports to reduce noise.

Furthermore, recent noise research indicates the need for better noise monitoring to establish accurate environmental baselines and understand the value of mitigation steps. This need is being resisted by local officials who fear that new measurements might show that current operations violate applicable standards.

Recommendation: Develop noise measurement standards.
Guidelines, measurement specifications, and noise monitoring methods should be developed and provided to FAA offices and airport managers. Existing noise modeling should be improved to better predict short-term day-to-day variations and effects such as local winds.

[4] New Jersey Coalition Against Aircraft Noise.

J. Certification and Safety

Certification and associated safety considerations continue to be major challenges to transitioning new technologies and procedures. Certification has been defined for this study as FAA approval of compliance with Federal safety regulations. This definition excludes systems that do not undergo "certification" in a regulatory sense, such as ground systems, which are "commissioned" through internal FAA directives and functional specifications not in the regulatory structure. This current dichotomy raises concerns as to how FAA will "certify" emerging systems involving integrated air-ground architectures. Some cases are discussed in Section J of Appendix A.

Finding: The certification process continues to be uncertain.
The aviation community continues to be concerned that certification requirements can be initially uncertain, may evolve late in the program, and take too long to meet. There is a related concern that methods do not exist to certify increasingly complex future integrated air-ground systems.

The FAA Certification Process Improvement (CPI) effort addresses aircraft and avionics, but does not appear to be designed for integrated air-ground systems. There is also concern that if avionics requirements are directly applied to ground systems without accounting for the different safety-of-flight considerations, system certification may be unnecessarily difficult.

Recommendation: Continue the CPI efforts.
FAA should continue the CPI program to reduce the uncertainty, time, and costs associated with certification, and methods should be developed to certify new concepts and technologies involving integrated air-ground systems. It is also recommended that there be one office responsible for the certification of integrated air and ground systems.

Finding: There is a conflict when the program advocate is also a regulator.
It was found that a single person or entity cannot function as a program advocate and a regulator without a conflict of interest, especially if the regulator has a role in the certification of a competing technology. For instance, it appears that the Local Area Augmentation System (LAAS) and the Required Navigation Performance (RNP) programs have been confounded with challenging requirements, allegedly because some of the program regulators are advocates for the Wide Area Augmentation System (WAAS).

Recommendation: Separate the certification and program management roles.
FAA should separate the responsibilities of regulators from those of program advocates.

Finding: Certification offices are understaffed.
FAA certification offices are typically understaffed and fully occupied with the maintenance of existing systems, posing a potential major impediment to the timely introduction of new systems.

***Recommendation*: Expand the use of Designated Engineering Representatives (DERs).**
Reduce the workload on certification offices by training and certifying DERs to support certification work, including the development of new procedures.

Finding: There are no standard methods for human-in-the-loop assessments.
It is widely accepted that human-in-the-loop assessments are necessary to ensure effectiveness and address safety issues. These assessments are particularly important to predict system performance in the occurrence of rare events such as blunders. Past programs have developed ad hoc acceptance criteria that, while conservative, are not always based on field data or analysis. It also appears that there is no generally accepted process to assess how a new technology that changes the control of traffic will impact safety, especially if a human remains in the primary control loop.

***Recommendation*: Develop best practices for human-in-the-loop assessments.**
Research is needed to develop experimental and analytical methods for human-in-the-loop performance assessments, with the goal of establishing a set of best practices and tools for the government and private sectors.

Finding: Objective, quantitative safety criteria are needed to guide operational approval.
The FAA, having primary responsibility for system safety, is appropriately cautious about accepting new technologies and procedures. In many cases the safety regulators' resistance to change is well founded. Their diligence has produced a United States air transportation system that is extremely safe.

However, regulators sometimes resist change if it involves new technologies or procedures that do not fit well in existing assessment methods or are just different. GPS is an example, where augmented satellite-based navigation and satellite-based instrument approaches offer improved safety over well-established operational alternatives. But the program to enhance GPS to support civil aviation needs has incurred major cost growth and schedule delays due, in part, to the lack of stable, pragmatic, and quantifiable safety criteria.

The use of data link for communicating ATM messages and the broader use of Automatic Dependent Surveillance - Broadcast (ADS-B) are additional instances where objective-based safety criteria and processes appear to be absent.

We note that the FAA is moving toward a concept of required navigation performance, which should resolve this particular issue for navigation cases if appropriately applied.

***Recommendation*: Develop and promulgate objective safety criteria.**
FAA should develop safety criteria and assessment methods and make them available to government and private sector entities.

K. Aircraft Equipage

<u>Finding</u>: Stakeholders accept technologies when they perceive that benefits can be realized.
Aircraft owners and operators influence change management by the rate at which they equip with new avionics. They will generally invest only if it results in a significant competitive advantage or convincing return on investment. They are also reluctant to invest if the benefit is not realized until full equipage by all affected users.

Performance-Based NAS concepts can serve as incentives if more capable aircraft get better access. The implementation of DRVSM is a good example of a Performance-Based NAS improvement that provided an incentive for aircraft equipage, as amplified in Section K of Appendix A.

<u>Recommendation</u>: Enable early operational advantages to promote equipage.
Early operational advantages should be afforded to expedite aircraft equipage necessary to implement new concepts.

L. Separation Standards

<u>Finding</u>: Separation standards need to be accepted and respected by the aviation community.
As capacity-enhancing concepts emerge that involve reduced aircraft separations, it is important that they be judged according to standards accepted and respected by the aviation community. There is a concern that existing safety and risk assessment methods are based on questionable analyses and legacy risk assumptions of uncertain origin, as further detailed in Section L of Appendix A.

<u>Recommendation</u>: Review separation standards and revise them as appropriate.
FAA should review and, where needed, establish new risk assessment methods to judge existing separation standards and proposed procedures. This process would involve the international community and might best be done through an industry-government forum, supported by a technical team. This initiative should institutionalize data collections to document aircraft operations, especially in "blunder situations."

5. SUMMARY

This study found that successful transitions occur when there is broad approval or a mandate, and strong leadership. It identified the following as specific actions that should lead to more successful transitions:

Executive Oversight

- Create an executive-level oversight committee
    - Assign executives to oversee major programs in transition

Effective Management Practices and Processes

- Adopt industry best practices for managing programs in transition that:
  - Ensure clear needs and a business case
  - Identify major uncertainties and mitigation strategies
  - Establish and monitor key decision points
  - Ensure that deliverables occur as needed for the transition, especially from the research organizations
  - Establish joint plans, commitments, and oversight for programs with other government or private sector organizations
- Develop a program management career path to parallel the existing technical career paths
- To take advantage of lessons learned and new technologies, ensure that at least one cycle of enhancements occurs after the initial deployment in all major programs
- Establish guidelines and processes to ensure the transfer of data and knowledge to system implementers and production contractors

Change Management

- Conduct research on transforming the roles of aviation workforce

Financial Management

- Ensure adequate funding for transition

Selecting and Managing Technology Priorities

- Determine risks of new technologies using the REDAC or an Aviation Science Board modeled after the Department of Defense (DoD) Defense Science Board
- Continue to use prototypes and field trials to reduce risk
- Move National Airspace System (NAS) systems toward open architectures

Industry

- Provide government furnished information as a resource when appropriate
- Audit recent successful transitions to identify and institutionalize best practices for working collaboratively with industry and research organizations

Consensus

- Strive for consensus, but place aviation needs above parochial interests
- Involve FAA stakeholders in planning and implementation

Environment

- Develop noise measurement standards, including better monitoring and analysis methods

Certification and Safety

- Continue the Certification Process Improvement program
  - Expand this process to include the particular issues associated with integrated air-ground systems
- Separate the certification and program management roles

- Expand the use of Designated Engineering Representatives (DERs) to accelerate the deployment of new procedures
- Conduct research to develop best practices for human-in-the-loop assessments
- Develop objective safety criteria and assessment methods

Aircraft Equipage

- Enable early operational advantages when seeking to implement concepts that require equipage of aircraft

Separation Standards

- Review and, where needed, establish new risk assessment methods for evaluating existing and proposed separation standards and procedures

Lastly, it is critically important that industry, airlines and other stakeholders work collaboratively with the FAA to identify how and where the system may be improved. Only then can the nation's air transportation system advance to meet future needs.

Tabular Summary of Findings and Recommendations

- The complete set of findings and recommendations is summarized in the following table, cross- referenced to the eight categories. Since there is unavoidable overlap, 1 indicates the best fit, whereas, 0 indicates relevance.

Note: Transition Management includes: Effective Management Practices and Processes, Change Management, Financial Management, and Selecting and Managing Technology Priorities.

Section		Executive Oversight of Transitions	Transition Management	Industry	Consensus	Environment	Certification	Aircraft Equipage	Separation Standards
A.	**Executive Oversight of Transitions**								
	<u>Finding</u>: Executive-level involvement is vital to successful transitions.	1	O						
	<u>Recommendation</u>: Create an executive-level transition oversight committee.	1	O						
	<u>Recommendation</u>: Assign an executive-level manager to sponsor and have oversight responsibility for each major project in transition.	1	O						

Section		Executive Oversight of Transitions	Transition Management	Industry	Consensus	Environment	Certification	Aircraft Equipage	Separation Standards
	<u>Recommendation</u>: Continue executive oversight throughout each program's lifecycle.	1	O						
B.	**Transition Management**								
C.	**Effective Management Practices and Processes**								
	<u>Finding</u>: The transition process appears to be ad hoc.	O	1						
	<u>Recommendation</u>: Use industry best practices to transition research.	O	1	O					
	<u>Finding</u>: Programs suffer from inconsistent management skills and excessive turnover.	O	1						
	<u>Recommendation</u>: Develop a program management career path.	O	1						
	<u>Finding</u>: The contracting process can be too rigid.	O	1	O					
	<u>Recommendation</u>: Include at least one spiral cycle to enable enhancements after IOC.	O	1						
	<u>Finding</u>: A standardized process is needed to identify and manage research contractor deliverables.	O	1	O					
	<u>Recommendation</u>: Establish guidelines for how the research organizations transfer their knowledge and data to the production contractors.	O	1	O					
D.	**Change Management**								
	<u>Finding</u>: Innovation often requires changes in concepts, skills, and responsibilities.	O	1		O		O		
	<u>Recommendation</u>: Conduct research aimed at transforming the roles of the aviation workforce.	O	1		O		O		
E.	**Financial Management**								
	<u>Finding</u>: There is a lack of financial forward planning for transition.	O	1						
	<u>Recommendation</u>: Ensure adequate funding for the transition phase.	O	1						

Section		Executive Oversight of Transitions	Transition Management	Industry	Consensus	Environment	Certification	Aircraft Equipage	Separation Standards
F.	**Selecting and Managing Technology Priorities**								
	Finding: Risks associated with adopting new technologies must be properly understood.	O	1	O		O			
	Recommendation: Conduct independent reviews of the risks of new technologies.	O	1	O		O			
	Finding: Prototypes and field trials are very valuable in identifying risks.	O	1	O					
	Recommendation: Continue using prototypes and field trials to mitigate risks.	O	1	O					
	Finding: Open-systems architectures facilitate desirable change.	O		1	O		O	O	
	Recommendation: Migrate NAS systems to an open-systems architecture.	O	1	O	O		O	O	
G.	**Industry**								
	Finding: Government furnished information can be a useful resource.		O	1					
	Recommendation: Provide government furnished information when prudent.		O	1					
	Finding: Collaboration between industry and R&D teams is vital to success.		O	1	O				
	Recommendation: Establish best practices for collaboration with industry and research organizations.		O	1	O				
H.	**Consensus**								
	Finding: Common good is possible without unanimous endorsement.			O	1	O		O	
	Recommendation: Strive for consensus, but do not be held hostage to it.	O	O	O	1	O			
	Finding: Early involvement of FAA supporting organizations mitigates the risk of delay in OT&E.		O		1				
	Recommendation: Involve stakeholders in the planning and implementation of change.		O	O	1	O			
I	**Environment**								

Section		Executive Oversight of Transitions	Transition Management	Industry	Consensus	Environment	Certification	Aircraft Equipage	Separation Standards
	<u>Finding</u>: Environmental factors are increasingly impacting airspace and airport changes.		O		O	1			
	<u>Recommendation</u>: Develop noise measurement standards.		O		O	1			
J.	**Certification and Safety**								
	<u>Finding</u>: The certification process continues to be uncertain.		O			O	1		
	<u>Recommendation</u>: Continue the CPI efforts.		O			O	1		
	<u>Finding</u>: There is a conflict when the program advocate is also a regulator.	O	O				1		
	<u>Recommendation</u>: Separate the certification and program management roles.	O	O				1		
	<u>Finding</u>: Certification offices are understaffed.		O				1		
	<u>Recommendation</u>: Expand the use of DERs.		O				1		
	<u>Finding</u>: There are no standard methods for human-in-the-loop assessments.		O				1		
	<u>Recommendation</u>: Develop best practices for human-in-the-loop assessments.		O				1		
	<u>Finding</u>: Objective, quantitative safety criteria are needed to guide operational approval.		O				1		
	<u>Recommendation</u>: Develop and promulgate objective safety criteria.		O				1		
K.	**Aircraft Equipage**								
	<u>Finding</u>: Stakeholders accept technologies when they perceive that benefits can be realized.	O	O	O				1	
	<u>Recommendation</u>: Enable early operational advantages to promote equipage.		O	O				1	
L.	**Separation Standards**								
	<u>Finding</u>: Separation standards need to be accepted and respected by the aviation community.		O	O	O				1

Section		Executive Oversight of Transitions	Transition Management	Industry	Consensus	Environment	Certification	Aircraft Equipage	Separation Standards
	<u>*Recommendation*</u>*: Review separation standards and revise them as appropriate.*		O	O	O				1

6. ACKNOWLEDGEMENTS

The TWG[5] is very grateful for the support provided by FAA staff during this study. In particular, the assistance provided by John Rekstad, Gloria Dunderman, and Ken Leonard were invaluable. We also greatly appreciate the assistance rendered by George Price in the final editing of this report.

We also note that the strong cooperation from all aviation segments demonstrates that these issues are important and must be addressed to enhance the introduction of new concepts into the NAS. (Appendix D is a list of the organizations that briefed the TWG.)

[5] Membership of the TWG is listed in Appendix C.

APPENDIX A

RELEVANT EXAMPLES PERTAINING TO FINDINGS

Section A: Executive Oversight of Transitions

Programs that were successful in the transition of technology from research into implementation were characterized by strong FAA executive involvement and advocacy, with clear direction and priorities. The User-Request Evaluation Tool (URET), Traffic Management Advisor (TMA), and Integrated Terminal Weather System (ITWS) stand out as three examples. Programs lacking such advocacy were often beset by delays or subject to inter-program conflict. Wide Area Augmentation System (WAAS) and Required Navigation Performance (RNP) are examples in the latter category. Traffic Alert and Collision Avoidance System (TCAS) is an example of a very challenging program that succeeded thanks to an excellent FAA management team, strong teamwork with the research community and industry, and the direct involvement of senior FAA leadership, including the Administrator.

Section C-1: Strong, consistent program management is needed to mitigate the risk of program delay.

Program management experience varied across the programs that were reviewed. Weak program management or excessive changes in program management contributed to program delay. An example of excessive changes in program management contributing to program delay occurred in the Multi-Center Traffic Management Advisor (McTMA) program, which had four different program managers, all with different management styles, agendas, and priorities. In general, changeovers cause program instabilities that negatively impact costs and schedules.

Section C-2: The contracting process can be too rigid.

The full-scale development and production contracting process can be too rigid, blocking the opportunity to consider beneficial changes that emerge during the development process. The Integrated Terminal Weather System (ITWS) program provides a recent example of an opportunity initially missed, where funding was originally not provided for subsequent enhancements and it was very difficult to find the resources to add an important capability for one-hour storm forecasts that nearly doubled the ability to reduce air traffic delay during storms.

Section C-3: There is a need to standardize processes for contractor deliverables.

Standard processes and deliverables should be required of the research organization to facilitate the transition to contractors involved in productizing and deploying the technology. For example, Lockheed, Raytheon and Northrop Grumman reported excellent relationships with MITRE and MIT Lincoln Laboratory, respectively, in working to transition URET, TDWR, ITWS, and WSP from the laboratory to the field.

Similarly, CSC reported excellent relationships with NASA in working to transition TMA from the laboratory to the field. However, standard deliverables documenting research and prototype design and test procedures were neither initially identified nor required, and thus were developed ad hoc. If defined at the outset, they would have significantly accelerated knowledge transfer and saved cost and time.

Section H: Consensus

The government has the authority to impose mandates on participants in the NAS. Though it is rarely exercised, an example was the requirement for increased equipage of Mode C transponders, within 30 nm of large airports, following the Cerritos accident.

Major decisions regarding change are within the purview of FAA in its role as the regulator, with primary responsibility for assuring the nation has a responsive and safe air transportation system. But the FAA has a related responsibility to meets its obligations once an initiative has begun and the air transportation industry responds with investments in anticipation of that commitment. When the initiative does not materialize, such as with oceanic Automatic Dependent Surveillance (ADS), a loss of trust emerges and later initiatives are viewed with considerable skepticism, regardless of their merit.

The implementation of Domestic Reduced Vertical Separation Minima (DRVSM) is a noteworthy example of implementing change. Operational requirements were the basis for this change. Government and industry collaborated, even though some elements of the community did not readily concur with the change milestones. After considering the various arguments, FAA decided to proceed with DRVSM in the interests of the common good. A schedule was announced, and training and equipment investments were made by those who wanted the attendant operational benefits. They are now receiving these benefits, and in most cases the benefits exceed the costs of equipage. Those who did not participate are being denied access to some of the airspace until they commit to the change. It is important to note that DRVSM is a partial mandate, limited to a specific segment of the airspace; non-participants are still able to fly, and thus all participants have a clear choice.

Section J: Certification and Safety

Certification was a significant barrier to transitioning both TCAS and LAAS. The TCAS certification process was very lengthy and involved extensive tests. LAAS, which initially was a non-Federal program, needed both the ground station and avionics to be certified. However, the ground element was redefined to be a Federal system since it was believed that "commissioning" LAAS, as is done with Instrument Landing System (ILS), would be easier than moving the system through a certification process.

In both TCAS and LAAS, the certification requirements evolved as the program proceeded, entailing additional time and resources. In the case of LAAS, the requirements, which exceed those of ILS, have not yet been demonstrated.

Certification levels include target levels of safety and other operational parameters. If the safety targets are set too high to be met in practice, the new technology cannot be implemented, even if it offers operational and safety improvements over the existing systems. The RNP program is a recent example. There is also a perception that Category III operations, much studied and safely conducted for several decades, would not be approved if judged against current standards.

Section K: Aircraft Equipage

Aircraft owners and operators influence change management by the rate at which they equip with new avionics, driven by perceived operational benefits. If aircraft operators do not invest the required funds, due to an unconvincing return-on-investment or because they can not access financial markets, owners and operators don't equip and thereby delay or avoid change. Commercial operators will often invest if they can obtain a timely and significant competitive advantage.

The Alaska Airlines investment in RNP equipment to support its Alaska operation is a good example. In a similar manner, some Part 91 operators initially invested in LORAN and even more recently invested in various GPS avionics because of safety or access-related operational benefits.

Mode S was developed in response to a national study[1] indicating the need for more discrete transponder codes, a unique ID tied to the aircraft frame, and an integral data link. Mode S was required to be compatible with Mode A/C transponders to ease transition. However, resistance arose from general aviation over the unique ID, which they feared would enable user fees and enforcement actions, as well as greater cost. There was also resistance by the airlines, who wanted FAA to provide a common data link for both airline operational purposes and air traffic control. Later, the development of alternative data links, perceived to provide better performance at less cost, further impeded Mode S adoption. Mode S was thus not implemented on many aircraft until it became mandated for all TCAS installations[2].

[1] Air Traffic Control Advisory Committee Report, 1969.
[2] Mode S provides the air-air data link for TCAS coordination purposes.

CPDLC is another case where some Part 121 operators perceived operational benefits from the use of data link for ATC communications. Together with suppliers and a service provider, they made major investments in data link avionics based on a "partnership" understanding that government would provide the requisite infrastructure elements for a data link. The government subsequently did not meet its commitments, and the experience seriously eroded private sector trust and will likely adversely impact the introduction of subsequent changes requiring voluntary concurrent private investment.

Section L: Separation Standards

As capacity-enhancing concepts emerge that involve reduced aircraft separations, it is important that they be judged using standards that are accepted and respected by the aviation community. There is a concern that existing safety and risk assessment methods are based on questionable analyses and legacy risk assumptions of uncertain origin.

An example is the existing requirement for 3- and 5-nautical-miles separations, depending on the range to the radar and whether both aircraft are seen by a common radar. These criteria were developed in the 1960s, when separation was monitored using direct video displays of primary radar returns. Separation was believed to be assured if the controller could observe "green in between" two aircraft representations on the display.

Since 1993, the FAA has had the opportunity to redefine these requirements by taking advantage of much higher resolution displays and sensors. The recent amalgamation of TRACONs has motivated studies to expand the area of 3 nm separation. For example, a recent result now being documented suggests that the 3 nm rule can immediately be extended to at least 60 nm (actually 100 nm, but the terminal radars operate to only 60nm). This would, for instance, allow 3 nm separations throughout the Northeast corridor. However, this work merely extends the range of reduced separation, without changing the basic criteria developed some years ago.

If separation reductions are to be implemented, a technically objective standard is needed to judge the merits of reduction proposals, especially in light of recent exploration of automated separation.

A second example concerns the definition of blunders. While these are important and must be addressed carefully to ensure that any proposed system will respond appropriately, the blunders should be defined in terms of plausible, data-driven worst case situations.

APPENDIX B

FINDINGS AND RECOMMENDATIONS AFTER MARCH 2005

On March 31, 2005, the TWG delivered an initial findings and recommendations letter to FAA Administrator, Marion Blakey. The FAA responded to those initial findings. For reference purposes, the following is a list of the titles of the findings and recommendations that were added after the March 31, 2005 letter.

Recommendation: Continue executive oversight throughout program's lifecycle.
Recommendation: Assign senior-level manager to manage daily transition activities.

Finding: Lack of standard management practices and processes for transition.
Recommendation: Develop and standardize a transition process.

Finding: Program management needed to mitigate program delay risk.
Recommendation: Ensure program management competency and continuity.
Recommendation: Institute a career path for acquisition management.

Finding: There are risks associated with adopting immature technologies.
Recommendation: Conduct independent reviews of new technologies.

Finding: Contracting process can be too rigid.
Recommendation: Include spiral cycle to enable enhancements during development.

Finding: Need to develop standards for development methodologies and deliverables.
Recommendation: Establish standard processes and deliverables for transition.

Finding: Technologies often require changes in concepts, skills and responsibilities.
Recommendation: Conduct research for transforming roles of aviation workforce.

Finding: Change management process needed to leverage lessons learned.
Recommendation: Involve an integrated team to manage changes resulting from technology improvements.

Finding: Lack of financial forward planning for transition phase.
Recommendation: Ensure adequate funding for transition phase.

Finding: Difficult to determine financial status of transition.
Recommendation: Develop and institute a transition financial management process.

Finding: An open systems architecture provides benefits.
Recommendation: Migrate NAS to an open system architecture.

Finding: Benefits are realized by providing government furnished information.
Recommendation: Establish collaborative working relationships.

Finding: Advanced research prototypes have falsely elevated stakeholder expectations.
Recommendation: FAA needs to manage stakeholder expectations of research.

Finding: Early involvement of FAA supporting organizations mitigates risk of delay in OT&E.
Recommendation: Involve stakeholders in the planning and implementation of change.

Finding: Workforce factors can influence acceptance of change.
Recommendation: The FAA should not allow workforce contract issues to influence the transition process.

Finding: Environmental factors are impacting airspace and airport changes.
Recommendation: Develop environmental measurement standards.

Finding: Certification process can be lengthy.
Recommendation: Benchmark The FAA and Industry Guide to Product Certification.

Finding: There is a conflict when the program advocate is also a regulator.
Recommendation: Separate certification and program management roles.

Finding: Certification offices are short staffed.
Recommendation: Expand use of Designated Engineering Representatives (DER).

Finding: There is no standard process for assessing safety when technology changes the role of the human.
Recommendation: Conduct human-in-the-loop assessments.

Finding: Objective, quantitative safety criteria is needed for operational approval.
Recommendation: Develop and make available safety criteria information.

APPENDIX C

TRANSITION WORKING GROUP MEMBERSHIP

• Raymond LaFrey (Chair)	Consultant, MIT/LL
• Sarah Dalton	Director, Airspace and Technology, Alaska Airlines
• Dallas Denery	NASA Ames Associate
• Chris Horne	VP ATM Engineering, Technology & Operations - Lockheed Martin
• Andrew Lacher	Research Strategist, MITRE CAASD
• John Rekstad	Designated Federal Official, FAA
• David Watrous	President, RTCA
• Supporting	
– Ken Leonard	FAA ATO-Plans
– Gloria Dunderman	FAA Research Office
– John Hansman	MIT
– George Price	NASA Headquarters
– Harry Swenson	NASA Ames
– Aleksandra Mozdzanowska	MIT

APPENDIX D

ORGANIZATIONS THAT BRIEFED THE TWG

• Mike Landis	NASA	AATT Program
• George Price	NASA	NSTC Transition Paper
• Ken Leonard	ATO-Plans	Transition Activity
• Amr ElSawy, et al	MITRE	URET, Safe Flight 21/Capstone, CPDLC, RNAV/RNP, TFM/CDM/CRCT, Infrastructure, ERAM
• Steve Bussolari, et al	MIT/LL	Surveillance Sensors and SDN Weather Sensors and Systems
• Tom Chryzanowski	Northrop Grumman	Surveillance Sensors
• Bruce Carmichael	NCAR	Weather Research Transitioning
• Dan Gutwein	FAA	AT Ops
• Kevin Chamness	FAA	Oceanic
• Wilson Felder	FAA	ATO-Plans
• John Wiley	FAA	WJHTC
• Gloria Kulesa	FAA	Weather Research
• Robert Rosen	CSC	NASA AATT
• Mel Weinzimer	Raytheon	TDWR, ITWS, SMS
• Rich Niehl	FAA, NASA	PDARS
• Randy Kenagy	AOPA	GA
• Rocky Stone (UAL)	ATA	Airline ATA
• J. P. Clarke	MIT	Environmental Barriers
• Paul Fiduccia	SAMA	Wake Program

• Capts. McVenes and Townsend	ALPA	Pilots
• Bill Leber `	Northwest Airlines	Airline Dispatch
• Sarah Dalton	Alaska Airlines	New Technology
• Raj Agarwal	Rockwell Collins	Avionics Manufacturer
• John Hansman	MIT, NEXTOR	Academia
• Karl Grundmann	NASA	Workforce Issues

APPENDIX E

ACRONYMS

Acronym	Description
AATT	Advanced Air Transportation Technologies
ADS-B	Automatic Dependent Surveillance - Broadcast
AF	Airway Facilities (FAA)
ALPA	Air Line Pilots Association
AOPA	Aircraft Owners and Pilots Association
ARTS	Automated Radar Terminal System
ASB	Aviation Science Board
ASR-9	Airport Surveillance Radar - Model 9
AT	Air Traffic (FAA)
ATA	Air Transport Association
ATC	Air Traffic Control
ATM	Air Traffic Management
ATO COO	Air Traffic Organization Chief Operating Officer
ATS	Air Traffic Services
CAASD	Center for Advanced Aviation System Development
CPDLC	Controller-Pilot Data Link Communications
CPI	Certification Process Improvement
CRCT	Collaborative Routing Coordination Tools
CSC	Computer Sciences Corporation
DER	Designated Engineering Representative
DFW	Dallas Fort Worth (Airspace)
DoD	Department of Defense
DRVSM	Domestic Reduced Vertical Separation Minima
ERAM	En Route Automation Modernization
FAA	Federal Aviation Administration
FAST	Final Approach Spacing Tool
FS	Flight Services (FAA)
GA	General Aviation
GAO	Government Accountability Office
GPS	Global Positioning System
ID	Indentifier
IOC	Initial Operating Capability
ILS	Instrument Landing System
ITWS	Integrated Terminal Weather System
JPDO	Joint Planning and Development Office
JRC	Joint Resources Council (FAA)
LAAS	Local Area Augmentation System
LORAN	Long Range Navigation
McTMA	Multi-Center Traffic Management Advisor
MIT/LL	Massachusetts Institute of Technology Lincoln Laboratory

Acronym	Description
MLS	Microwave Landing System
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NEXRAD	Next Generation Weather Radar
NEXTOR	National Center of Excellence for Aviation Operations Research
NGATS	Next Generation Air Transportation System
nm	nautical mile
NSTC	National Science and Technology Council
OT&E	Operational Test and Evaluation
PDARS	Performance Data Analysis and Reporting System
PRM	Precision Runway Monitor
R&D	Research and Development
REDAC	Research, Engineering and Development Advisory Committee
RNAV	Area Navigation
RNP	Required Navigation Performance
SAMA	Small Aircraft Manufacturers Association
SDN	Surveillance Data Network
SMS	Surface Management System
SOIA	Simultaneous Offset Instrument Approach
STARS	Standard Terminal Automation Replacement System
TCAS	Traffic Alert and Collision Avoidance System
TDWR	Terminal Doppler Weather Radar
TFM/CDM	Traffic Flow Management / Collaborative Decision Making
TMA	Traffic Management Advisor
TRACON	Terminal Radar Approach Control
TWG	Transition Working Group
UAL	United Airlines
URET	User Request Evaluation Tool
WAAS	Wide Area Augmentation System
WJHTC	William J. Hughes Technical Center (FAA)
WSP	Weather Systems Processor