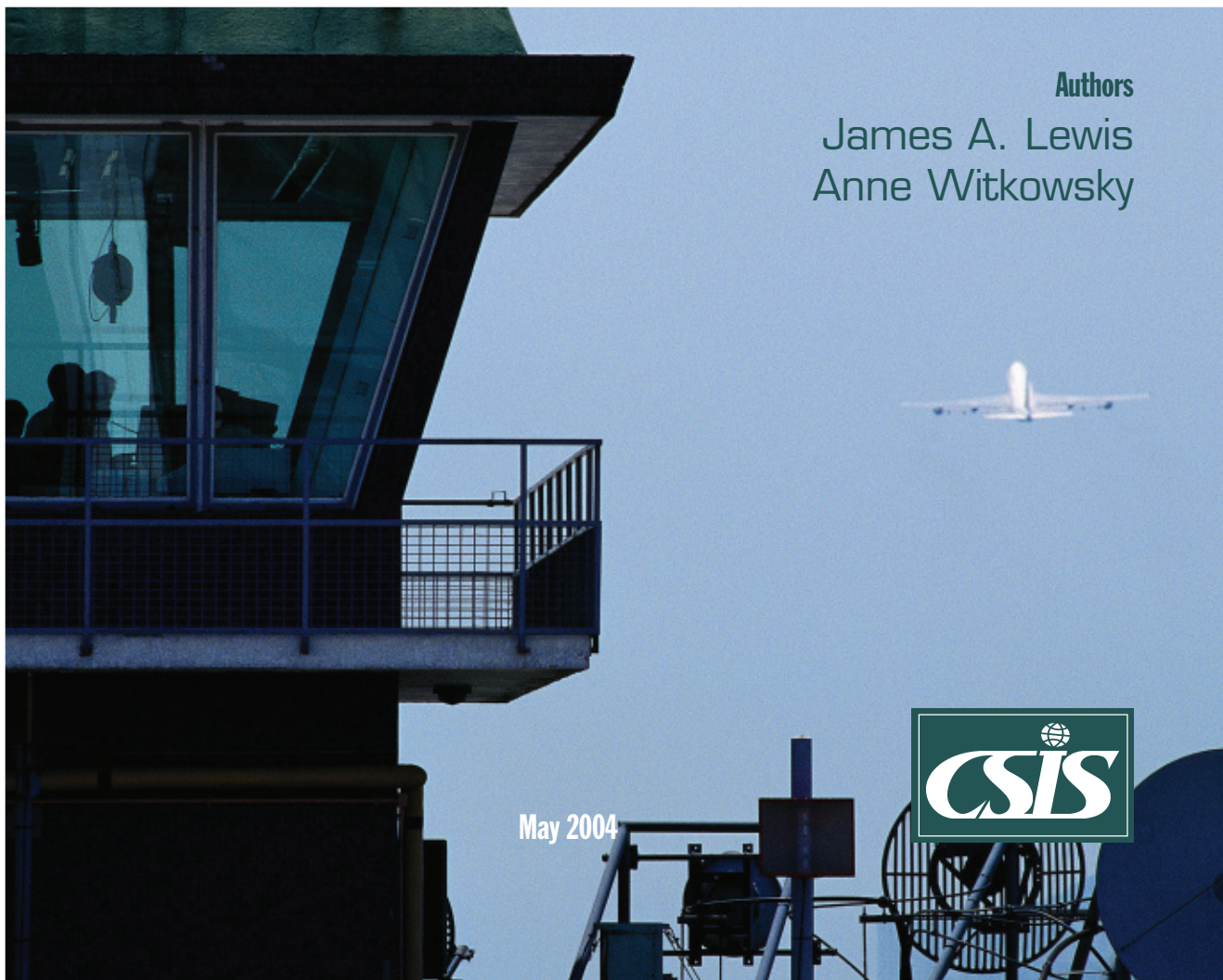


TRANSFORMING AIR TRAFFIC MANAGEMENT BEYOND EVOLUTION

A Report of the CSIS Technology
and Public Policy Program

Authors

James A. Lewis
Anne Witkowsky



May 2004

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Executive Summary

Air traffic management exemplifies the difficulties that public policy can face in a period of sustained technological change. Complex problems go beyond the jurisdiction of a single country and challenge our ability to devise collaborative solutions. At the same time, delay can create serious costs for national economies. The tragic events of September 11, 2001, highlight the critical need for improved aviation security and safety. This is not a technological problem—technologies already exist that could improve tracking and facilitate ground-to-air communication. However, the use of new technologies creates difficult organizational, budgetary, and policy issues. Deploying a new air traffic control system internationally will also raise serious questions regarding sovereignty and governance.

In considering how to move ahead, we might want to start by listing the factors that will shape the environment for modernizing air traffic management (ATM). They include

- **LACK OF A POLITICAL IMPERATIVE.** Air traffic management has not commanded consistent attention and oversight from Congress and the White House. The Federal Aviation Administration (FAA) initiative to develop a new national air transportation plan and recent congressional legislation are encouraging and have provided new impetus and direction, but it remains to be seen if this can be sustained over time.
- **LEGACY OF TECHNOLOGICAL PROBLEMS.** The last decade has seen many false starts in deploying new technologies for ATM. This has consumed resources and created a disinclination to invest.
- **BUDGET CONSTRAINTS.** A new ATM system could yield large savings for the economy, but massive federal investment in a system where the payoff could be delayed for a decade is unlikely given the budget problems the United States now faces. Nor are the airlines in a situation where they could fund large-scale change.
- **ENGINEERING CULTURE.** The FAA and U.S. aerospace community have a huge reservoir of talent and expertise, but there are insufficient links to policy-making or to the political leadership. ATM is a complex subject. This can limit the ATM community's effectiveness in influencing policy and decisionmaking.

These factors work against progress, but two interrelated developments will compel the United States to pay more attention to reconsidering air traffic management. The most important of these is ATM consolidation and modernization in Europe. Europe's airspace is more crowded than the United States' and far less efficiently managed. The existing ATM architecture utilizes ground-based technologies and fundamentally takes a national approach to ATM. This approach is expensive, inefficient, and as several tragic accidents have demonstrated, increases safety risks. As part of the political consolidation underway in Europe, ATM is moving from a national to a continental approach,

which will be guided at the political level by the European Commission. Politics, budgets, inefficiencies, and safety-of-flight issues are driving the Europeans to reorganize their ATM. They want not only to harmonize and standardize technologies and processes across Europe, but over the longer term, they are looking ahead to take advantage of new technologies to build a continent-wide, satellite-enhanced ATM system.

Change in Europe is complemented by change in Asia. New markets in Asia need to upgrade ATM systems. China's ATM system infrastructure is limited in areas where demand for air service is growing rapidly. As China builds an infrastructure to deal with this demand, it will be making important decisions about architecture and systems required to accommodate rapidly growing domestic demand. Lacking a heavy investment in legacy ATM systems, China has an opportunity to "leapfrog" to more advanced communication, navigation, and surveillance technologies.

As Europe and Asia move toward new ATM systems, the United States will find itself compelled to advance its own strategy for change if it wishes to continue its leadership in ATM. The worst outcome would be a drive toward incompatible approaches, using different systems, creating battles over radio spectrum, and losing potential gains in efficiency and safety. However, changes in the three major ATM markets (North America, Europe, and Asia) also offer an opportunity.

Though still in the formative stages, an increasingly similar vision about what a new ATM system would look like has emerged. This vision is a seamless global air traffic system, satellite based, highly automated, using networked data systems to enhance information sharing and to move functions from the ground to the aircraft. The new approach would take advantage of advances in technology to integrate now-separate information systems, provide for greatly increased air traffic situation awareness, allow more aircraft to share the sky, and could increase capacity, security, and safety.

The leading ATM organizations—the FAA, Eurocontrol, and the International Civil Aviation Organization (ICAO)—are coalescing around this vision. The challenge now is in creating the new levels of institutional, political, and industrial cooperation that globalization—and an ATM overhaul—demands. Whether these cooperative efforts are formal or loose partnerships, it is clear that some additional level of planning for management, operations, and avionics is necessary for transition to the future.

Moving from a fragmented, ground-based system that fits sovereign national borders to a "seamless" and "global" system creates a new set of political challenges. The international challenge is the need to motivate people and organizations. It requires a degree of political coordination among nations that will be difficult to achieve. The use of new satellite and information technologies will increase situational awareness for flight, increasing capacity and safety, but it also raises sovereignty issues that did not exist before—a seamless global network will lead to greater transparency for commercial, military, and private operations.

As other countries begin to modernize their management of air traffic, the United States faces difficult choices. There is a risk that the pace of change and the course it takes may not be efficient and may not fully address U.S. interests. The United States has an opportunity to take advantage of new technologies for air traffic management, but it lacks the institutional tools and perhaps the long-term commitment to develop and sustain transformation.

Building a continuing political imperative for ATM modernization will be difficult, but it is the central challenge. The center of gravity for change is in Europe. The Europeans face economic and political pressures for modernization not found in the United States. The best solution for this country, in the current political and budgetary cycle, may be to piggyback on the European imperative for change and make our goal to ensure compatibility in the transatlantic air transportation system. With this in mind, we have five recommendations for accelerating modernization of this national infrastructure.

1. The administration's decision to look beyond the Operational Evolution Plan (OEP) with a new ATM plan is positive. The new plan should not be another study. It must create a broad vision for the future and focus on action. This means identifying relevant existing programs, allocating resources as needed to new research and programs, establishing processes within the FAA and other agencies, and creating a coherent, integrated approach to change.
2. Robust consultation on modernization with foreign ATM authorities at the political and technical level (in Europe and perhaps in Asia) to ensure international coordination must become a primary FAA mission. These processes must facilitate ATM transformation and become a core component of the FAA's work. The joint planning effort will require the development of new formal processes for coordination, for example through new bilateral agreements at the political level, with corresponding coordination at the technical level.
3. We need a presidential decision to endorse ATM transformation as a national priority, identify goals and timelines, and designate a White House entity specifically responsible for coordinating action on ATM among all involved agencies (FAA, NASA, and the Departments of Defense, Transportation, State, and Commerce). The president has put forth a new vision for U.S. space programs; he should do the same for ATM transformation. The FAA, unequalled in its technical expertise, should not be asked to shoulder interagency policy and political tasks for which it was not designed.
4. Despite the larger budgetary difficulties the United States faces, once program requirements are established under the new ATM planning effort, new mechanisms for funding the modernization of air traffic management should be found to allow a substantial increase. The first step is to fund the developmental and planning effort. The congressional committees of jurisdiction, which play a central role in providing continued oversight and encouragement for modernization, should consider whether additional legislation could help achieve this.

5. The FAA is reorganizing itself to emphasize customer service. This is good, but the FAA also needs to reorganize to make transformation of ATM a core organizational mission. This will require a long-term strategy endorsed by senior management at the FAA and Department of Transportation, as well as coordination with foreign ATM authorities. In approaching this problem, the FAA can draw on the experiences of the Department of Defense (DOD) in transformation.

ATM modernization is, ultimately, a political problem. Plans and more discussion cannot take the place of a political decision to move ahead. Only the president and Congress can accelerate a move to a new ATM system and seize the opportunity presented by shared requirements for change in North America, Europe, and Asia. If they make the commitment, action will follow.

Transforming Air Traffic Management

Beyond Evolution

James A. Lewis and Anne Witkowsky

Jeffrey Lewis, research consultant

Introduction

In the summer of 2000, air travel in the United States was marked by long lines, long delays, and frequent cancellations. Public sentiment and the interest of Congress were engaged with how to better manage air traffic. The delays led to calls for a new approach to air traffic management (ATM) that would speed flights on their way and clear crowded airports. Demand for air travel was booming and all predictions pointed to continued growth that would strain the existing system and compound delays unless new architectures and new technologies were brought to bear.

All this changed on September 11, 2001. Though long-term predictions are that air travel will recover and increase beyond the levels of 2000, the immediate public pressure for modernization in the United States is gone. This does not mean, however, that the need for a well-thought-out program for change has diminished. In considering how to move ahead, we might want to start by listing the factors that will shape the environment for modernizing ATM. They include

- **LACK OF A CONSISTENT POLITICAL IMPERATIVE.** Air traffic management has not commanded the consistent attention and oversight from Congress and the White House that would speed progress. Civil aerospace issues have moved to the second tier in Washington, and with air traffic delays down, there is no broad public interest in this subject. The Federal Aviation Administration (FAA) initiative to develop a new national air transportation plan, together with recent congressional legislation, are encouraging and have provided new impetus and direction, but it remains to be seen if this effort will be sustained and its plans implemented.

- LEGACY OF TECHNOLOGICAL PROBLEMS. The last decade has seen a number of false starts in deploying new technologies for ATM. This has not only used up resources but also created a disinclination to invest in new technologies without better planning to provide a greater assurance of success.¹
- BUDGET CONSTRAINTS. Although a new ATM system might, like the federal highway program of the 1950s, yield economic benefits, massive federal investment in a system where the payoff could be delayed for decades is unlikely given the budget problems the United States now faces, nor are the airlines in a situation where they could fund large-scale change.
- ENGINEERING CULTURE. The FAA and U.S. aerospace community have a huge reservoir of talent and expertise, but there are insufficient links to the policy community or to the political leadership. ATM is a complex subject with a profusion of technologies, acronyms, and players. This can sometimes limit the effectiveness of the ATM community in influencing policy and decisionmaking.

These factors militate against sustained progress, but two interrelated developments will compel the United States to place a higher priority on reconsidering air traffic management. Both of these developments are occurring outside of the United States.

The most important of these is the consolidation and modernization of air traffic management in Europe under the European Commission (EC) Single European Sky initiative. Europe's airspace is more crowded than the United States' and far less efficiently managed. Europe's provision of air services is nationally based, with 41 air traffic control centers. By comparison, the United States has 21 centers, handling twice as much air traffic in a geographic area roughly the same size. Until now, pan-European standards for air traffic management services have had no enforcement mechanism, relying instead on voluntary compliance by individual states. The existing European ATM architecture utilizes ground-based technologies and fundamentally takes a national approach to ATM. This national approach was not a problem in the days of slower aircraft and fewer flights, but increased traffic, longer flights, and faster planes result in a large and complex number of handoffs from control center to control center as aircraft traverse two or more countries. The current approach to

1. Numerous Government Accounting Office (GAO) studies provide an overview of some of these dilemmas. See, for example: *Major Management Challenges and Program Risks: Department of Transportation*, GAO-03-108 (Washington, D.C.: GAO, January 2003); *High-Risk Series: Federal Aviation Administration Air Traffic Control Modernization*, GAO-03-119 (Washington, D.C.: GAO, January 2003); *National Airspace System: Reauthorizing FAA Provides Opportunities and Options to Address Challenges* (Statement of Gerald L. Dillingham), GAO-03-473T (Washington, D.C.: GAO, February 12, 2003); *National Airspace System: Current Efforts and Proposed Changes to Improve Performance of FAA's Air Traffic Control System*, GAO-03-542 (Washington, D.C.: GAO, May 2003); *Air Traffic Control: FAA's Modernization Efforts—Past, Present, and Future* (Statement of Gerald L. Dillingham), GAO-04-227T (Washington, D.C.: October 30, 2003).

ATM in Europe is expensive, inefficient, and potentially increases risks to the safety of flight.

As part of the political consolidation underway in Europe, air traffic management is moving from a national to a continental, Europe-wide approach, which will be guided at the political level by the European Commission. Politics, budgets, inefficiencies, and safety-of-flight issues are driving the Europeans to reorganize and overhaul their ATM. They want not only to harmonize and standardize technologies and processes across Europe, but over the longer term, they are looking ahead to take advantage of new technologies, such as the Galileo navigational satellite program, to build a continent-wide, satellite-enhanced ATM system.

Change in Europe is complemented by the beginning of significant change in Asia. New air service markets in Asia—and particularly in China—are growing rapidly and face an urgent need to upgrade ground-based national ATM systems. China's ATM system infrastructure is sparse in many areas that are now developing economically and where demand for air service is growing rapidly. As China builds the new infrastructure to deal with this demand, it will be making important decisions about the architecture and systems required to accommodate rapidly growing domestic demand. Without the heavy investment in legacy ATM systems, in principle China has an opportunity to “leapfrog” to more advanced technologies.

As Europe and Asia plan for new ATM systems, the United States will find itself compelled to advance its own strategy for change if it wishes to continue its leadership in ATM. The worst outcome would be a drive toward incompatible systems, requiring duplicative equipment, creating battles over radio spectrum, and losing potential gains in efficiency and safety. However, changes in the three major ATM markets (North America, Europe, and Asia) also offer an opportunity.

Since 2000, a common vision about what a new ATM system would look like has begun to emerge among the various ATM communities. This vision is a seamless global air traffic system, satellite based, highly automated, using networked data systems to enhance information sharing and to move functions from the ground to the aircraft. The new approach would take advantage of advances in technology to integrate now-separate information systems, provide for greatly increased air traffic situation awareness, allow more aircraft to share the sky, and could increase capacity, security, and safety.

Two major government efforts are underway to help realize ATM transformation at the strategic level. The FAA has begun developing a plan for a “Next Generation Air Transportation System.” The plan, due in December 2004, will address the U.S. air transportation system broadly, of which ATM will most likely be a significant part. It is to look out to the next 20 years with a goal of significantly increasing air traffic capacity and efficiency to meet anticipated demand. Europe has been engaged on these ATM issues for several years already, and as a result, in February 2004, the European Union (EU) passed a package of

proposals on air traffic management that will realize a “Single European Sky.” They are now developing the regulations that flow from the legislation, in order to begin implementation of the Single Sky initiative by the end of 2004. These regulations, while focused on reducing inefficiencies in the European airspace, also include a series of goals for transformation over the next 15 years. The advantages could be enormous if new systems make Europe’s use of airspace more efficient and more secure.

A new ATM architecture based on technologies that expand situational awareness and increase capacity will require a greater degree of political coordination among nations, which will be difficult to achieve and which historically has been absent from the ATM arena. Moving from a fragmented, ground-based system that closely tracks sovereign national borders to a “seamless” and “global” system will create a new set of political and operational challenges. Among them, use of new satellite and information technologies will increase situational awareness for flight, increasing capacity and safety, but it also raises challenges for cross-border coordination and sovereignty that are much greater than today—a seamless global network would result in more widely available integrated information for commercial, military, and private flights.

As other countries begin to modernize and consolidate their management of air traffic, the United States faces some difficult choices in technology, organization, and international cooperation for the twenty-first century. New ATM systems will raise a series of questions for public policy. Are the right mechanisms in place internationally to ensure the development and implementation of compatible systems? What are the issues for countries that have air traffic control managed by military organizations or managed jointly between civilian and military organizational entities? How will an information-rich, highly automated environment affect the respective roles of controllers, pilots, and planners? What security elements should be built into new systems? What is needed to ensure a smooth transition from legacy architectures?

Without sustained strategic planning, there is a risk that the pace of change and the course it takes may not be the most efficient possible and may not fully address U.S. interests. The nation’s air traffic control system manages a complex mixture of air traffic involving thousands of flights by commercial, general, and military aviation. Transforming this system will be a major challenge, but it is a challenge that is unavoidable. The United States has an opportunity to take advantage of new technologies for civilian air traffic management, but it may lack the institutional tools and the basis for a long-term commitment to develop and sustain transformation. This report discusses the current ATM environment, calls for accelerating movement toward a new approach to ATM, and argues for seizing the opportunity presented by shared requirements for change in North America, Europe, and Asia.

Air Traffic Management Today

Countries have regulated the use of their airspace since before World War II. Today, thousands of flights—commercial, military, and private—are made every day, placing enormous demands on air traffic management systems. Air traffic control exemplifies the problems of governance in an era of sustained technological change. It faces complex problems that go beyond the jurisdiction of a single country and challenges our ability to devise collaborative solutions. This is not primarily a technological problem. The problem lies more in finding ways to get governments to adopt new technologies and devise solutions for the problems that the use of new technologies creates for organizations, budgets, financing, and policy.

The benefits of advances in air traffic management have in the past generally been viewed through an economic lens. The events of September 11, 2001, showed, however, that managing commercial air traffic is more than a financial issue. There are serious potential risks for aviation safety and for national security that must be factored in as we develop and implement new air traffic management systems. There are also important sovereignty and governance issues associated with these functions. The combination of public safety, security, and economic consequence makes air traffic management a critical, albeit not widely recognized, national activity.

The core of the current air traffic control system is ground-based radar and voice-radio systems. This core technology has been supplemented by ground-based navigation systems whose signals are used by aircraft for en route navigation and landing guidance. The land-based system of radio signals is being augmented with navigation aids at runways and by satellite navigation, but airspace management is mainly based on communication, navigation, and surveillance systems dating from the 1960s. Because of the limits of ground-based radar, there are large areas of the oceans and the North American, Asian, and African landmasses that are not monitored effectively.

In addition, the information regarding communications, navigation, surveillance, and weather services all function on separate systems. This is inefficient when communicating with the aircraft in flight and allows for limited flexibility. The fragmentation of data and the reliance on voice limits the ability to adjust traffic flow or to respond to in-flight crises. It is a complicated system that is tested by the performance of modern aircraft and is reaching the limits of its capabilities.

Europe and the United States face a number of common challenges in modernizing their air traffic management systems, and they must move in a common direction to gain the full benefit of the necessary changes. Air traffic management would be improved if it could take full advantage of modern communications, navigation, and surveillance systems. This need not (and could not) be done in a single major effort but, with the right planning, could be accomplished with a series of steps that build on each other and lead to a

transformed ATM system. The way forward to a modern, truly global ATM system remains unclear, but commitment, planning, and effort could change this.

The Operational Evolution Plan

Following record delays in August 2000, the FAA transformed what was originally a business planning activity into a 10-year program to “expand capacity, decrease delays, and improve efficiency while maintaining safety and security.”² The Operational Evolution Plan (OEP) is an \$11.5-billion program to modernize the National Airspace System (NAS) with a goal of an additional 700 to 800 flights in the air at a given time during normal operating hours—a 30 percent increase—and to accommodate growth in air traffic through 2012.³ The OEP includes more than 100 separate programs.

The FAA anticipated that enhancements in arrival/departure rates would contribute nearly two-thirds of the improvements promised by the OEP. Although 546 airports in the United States are served by commercial airlines, 31 of these handle 70 percent of the passenger traffic. The OEP has two strategies to increase terminal throughput. First, the OEP supports the opening of new runways and the modification of procedures to allow new operations on existing runways. A major part of the expansion in capacity that the OEP will produce is based on increasing the number of runways at major airports. Fourteen new runways anticipated in the OEP are expected to increase NAS capacity by more than 12 percent—more than any other measure in the OEP. Although this is sound from an engineering perspective, a plan to expand the number of runways makes political assumptions about the willingness of cities and their residents to surrender property for airport expansion that may be unrealistic. NIMBY—“not in my backyard”—is a potent political force that the OEP underestimates.

Second, the OEP attempts to optimize the use of existing runway capacity through improved airspace design, procedures and standards for arrivals and departures, pilot and controller workload, use of terminal separation standards farther from the airport, and information exchange and decision support for surface operations. In cases where the construction of new runways is not feasible, the OEP calls for new procedures to increase airport capacity. The FAA estimates that automated tools to improve sequencing and runway balance could increase arrivals and departures by 10 percent. The FAA would also like to reassign airspace from en route to terminal facilities in order to allow more aircraft to operate with the three-mile separation standard. In the near term, incremental improvements like these will expand air traffic capabilities and the performance of the current system.

2. FAA, *National Airspace System Operational Evolution Plan*, Version 4.0 (Washington, D.C.: FAA, December 2001), at <http://www.faa.gov/programs/oep/Archive/V4/History.htm>.

3. FAA, *National Airspace System Operational Evolution Plan*, Version 3.0 (Washington, D.C.: FAA, June 2001), at http://www.faa.gov/programs/oep/Archive/V4/archive/main/exec_summ.pdf.

The chief problem, however, with OEP is that it alone cannot provide a basis for coherent ATM transformation. It does not fully capture the opportunity for organizational change and increased capacity offered by new technologies and by the ability of networks and information technologies to increase productivity. Taking advantage of these opportunities requires rethinking how a system operates and how to “de-layer” and streamline. Less hierarchical organizations that make better use of information are becoming the norm; air traffic management needs to follow suit. The OEP makes strides in this direction, but we now need to go further.

Incremental Improvement

In addition to the OEP, the FAA is taking a number of other steps to make incremental improvements to ATM. Some of these involve technological changes that offer some possibility for increased capacity and safety. However, other programs show the limitations of an incremental approach. Better technologies, in the absence of a sustainable ATM strategy, are unlikely to provide the improvements that are needed.

The FAA has developed a system for air traffic controllers known as the Standard Terminal Automation Replacement System (STARS). STARS provides better air traffic coverage and larger radar color displays that can show additional data.⁴ The STARS system is currently in use at 16 airports with additional installations planned in the near future. Although STARS is a considerable improvement over existing systems used by controllers, it offers little improvement to data transmission between controller and aircraft or for the monitoring of flights. The FAA has encountered some difficulties in implementing the new system. Estimated development costs have increased 80 percent to \$1.69 billion.

The Wide Area Augmentation System (WAAS) and Automatic Dependent Surveillance Broadcast (ADS-B) are more promising programs for ATM improvements. WAAS is a system of satellites and ground stations that provide global positioning system (GPS) signal corrections to provide better position accuracy—some industry sources say an average of up to five times better. Other governments are pursuing similar satellite-based systems. Japan is developing the Multi-Functional Satellite Augmentation System (MSAS), while Europe has the European Geostationary Navigation Overlay Service (EGNOS).⁵ WAAS and the other augmentation systems make satellite navigational data accurate enough to allow increased operations in poor weather conditions, without degrading safety, and increase en route airspace capacity.

ADS-B complements WAAS and will also safely expand airspace capacity. ADS-B is a system where an aircraft automatically broadcasts its position, altitude,

4. See Raytheon STARS product description, at <http://www.raytheon.com/products/stars/>.

5. A similar system, the Local Area Augmentation System (LAAS), will allow more operations in low visibility at and around airports.

and velocity every second via a digital data link. Other aircraft and air traffic controllers can use this data to determine the sending aircraft's position, altitude, and trajectory. ADS-B uses GPS data to provide pilots and air traffic controllers with precise information on aircraft traffic. It works at low altitudes and is effective in remote areas or where radar coverage is limited or unavailable.

WAAS and ADS-B offer a number of advantages. First, the existing ground-based radar system used to manage flight is old and expensive to operate and maintain. WAAS and ADS-B offer a lower cost and more reliable approach to the service these radars provide. Used together, WAAS and ADS-B would increase capacity and allow airlines and general aviation to use more economically viable routes with greater information available for both safety and security.

User Request Evaluation Tool (URET) is a software system that compares the flight path of an aircraft with all other aircraft in the area to predict potential collisions and automatically notify of conflicts between aircraft. URET allows controllers to determine how to change an aircraft's flight path and select the optimal alternative. This lets controllers and aircraft adjust flight plans and allows aircraft to save both time and fuel. URET adds flexibility and increases efficient use of the airspace without degrading safety. Currently URET has been deployed to six Air Route Traffic Control Centers. The FAA plans to deploy URET to the remaining 14 centers by the end of 2005.

The FAA and Eurocontrol experimented with a digital data link known as Controller Pilot Data Link Communications (CPDLC). This technology would move air traffic control away from the voice communications on which it now relies heavily. Voice communications can create problems for pilots and controllers in congested airspace as messages from multiple aircraft interfere with each other and must be repeated. CPDLC supplements voice communications between controllers and pilots by moving routine exchanges to a digital data channel. The data is displayed on a small screen in the cockpit. CPDLC reduces the volume of repeated messages and the possibility of error. After some initial investment, FAA cancelled CPDLC, but Eurocontrol continues to pursue its own version.

The most important question posed by incremental improvement is how to manage change. One strategy is to take a broad, transformational approach to air traffic management. Alternatively, the United States could continue to fund and implement incremental improvement. This is clearly the easiest path and one preferred by conservative elements of the ATM community. The disadvantage of incremental change is that the sum of the various changes will add up to be less than the total of the parts. The best outcome may be to blend the two approaches—to ensure that these incremental changes are made in the context of a larger strategy of national and international transformation that emphasizes greater use of digital information technology and space-based assets, greater situational awareness for pilots, dispatchers, and controllers, and greater flexibility and autonomy for flight. Absent a larger strategy in a policy framework, incremental technological change will not solve the ATM problem we will face in the future.

Beyond the OEP

Recognition of the advantages of broadly transforming ATM has been growing in the United States. In 2001, the White House Office of Science and Technology Policy called for the development of a “21st Century global air transportation system” that would provide “safe, secure, efficient and affordable transportation of people, goods and information in peacetime and wartime—enabling people and goods to move freely anywhere, anytime, on time.”⁶ Similarly, in its 2002 report, the Commission on the Future of the U.S. Aerospace Industry declared, “The nation needs a clear air transportation policy with an objective to move air traffic capacity substantially ahead of anticipated demands while enhancing public safety and homeland security.”⁷ According to the commission, transforming the air transportation system should be a national priority. It requires “a new, highly automated air traffic system, beyond the Federal Aviation Administration’s Operational Evolution Plan,” as well as the additional airports and runways.

In November 2003, the National Research Council (NRC) issued a call for change and for establishing air transportation as a national priority “with strong, focused leadership.” Its report echoed the Aerospace Commission’s call for a national vision, supported by measurable goals, along with the development of meaningful and useful operational concepts.⁸ The NRC’s focus is well into the future—25 to 50 years from now—yet many of its recommendations are relevant for the near term as well.

In the legislative branch, Congress passed the Century of Aviation Reauthorization Act in December 2003. In it, Congress called for the establishment of a Joint Planning and Development Office (JPDO) within the FAA to develop a new national plan for air transportation that is capable of meeting air traffic demand by 2025. This was an effort to encourage the FAA to strengthen and accelerate planning processes already underway. The act continues the guarantee that all the taxes and revenues paid into the Aviation Trust Fund are fully spent to fund airport improvements and air traffic control modernization.

Early in 2004, Secretary of Transportation Norman Mineta announced the development of the Next Generation Air Transportation System. In doing so, Mineta acknowledged that our global leadership in aviation is being challenged by the Europeans and stated, “If America wants to retain its global air transportation leadership, we need to modernize and transform our air transportation system—

6. John Marburger, “The Future Belongs to the Mobile,” presentation to the Commission on the Future of the U.S. Aerospace Industry, November 27, 2001, at http://www.ostp.gov/html/02_1_17.html.

7. Commission on the Future of the U.S. Aerospace Industry, *Interim Report #2*, March 20, 2002, p. 14, at <http://www.aerospacecommission.gov/intrpt2.pdf> or <http://www.fas.org/asmp/resources/govern/AerospaceInterimRpt2.htm>.

8. Committee on Aeronautics Research and Technology for Vision 2050, National Research Council, *Securing the Future of U.S. Air Transportation: A System in Peril* (Washington, D.C.: National Academies Press, November 2003), at <http://www.nap.edu/books/0309090695/html/>.

starting right now.”⁹ As a government-wide effort, this work will be overseen by an interagency, cabinet-level senior policy committee chaired by the secretary of transportation and coordinated within the FAA—the JPDO. This interagency approach is a significant departure from FAA efforts in the past and correctly takes account of the need to factor in national and homeland security requirements, among others, to air transportation planning. In its initial phase, the FAA will need to work to ensure that this long-term planning approach fits into the larger and more near-term focused “customer-service” orientation that the agency has taken. Long-term planning does not provide immediate benefits to customer service and could easily be underemphasized in the larger effort to improve performance. This is a central risk in the recent FAA reorganization, which is not being adequately addressed and could hobble U.S. modernization efforts.

Mineta noted that “the FAA’s Operational Evolution Plan (OEP)—as essential as it is to keeping up with demand over the course of the next decade—will not be sufficient to accommodate the air transportation market 15 or 20 years from now.”¹⁰ Whereas the goal of the OEP was a 27 percent increase in capacity by 2013, this new initiative looks out to 2025 and aims to increase airspace capacity by a factor of three. The plan is in a formative stage, but judging by public statements, the Next Generation initiative is likely to depend on new technologies to achieve its goals.

The European Environment

Given the political and practical imperatives in Europe to press ahead with an overhaul to the European ATM system, the United States may soon face three alternatives: follow the European lead, develop a U.S. vision and enter into discussions with the Europeans on a common way forward, or find ourselves on diverging paths. With Europe moving ahead with plans for change, the importance of ensuring transatlantic dialogue and coordination is tremendous. However, there are major questions about what new mechanisms will ensure the necessary sustained cooperation. Though a number of Europeans are calling for enhanced consultations—notably the current head of Eurocontrol,¹¹ as well as key industry leaders—Europeans are at the same time intensely focused on putting their internal arrangements in order.

Improving ATM operations has a prominent place on the European political agenda, where it has become an important part of realizing European integration. At the same time, it features prominently in Europe’s efforts to boost its aeronautics research agenda and worldwide competitiveness in the aerospace

9. Norman Mineta, “Securing America’s Place as Global Leader in Aviations’ Second Century,” remarks at the Aero Club of Washington, Washington, D.C., January 27, 2004, at <http://www.dot.gov/affairs/minetasp012704.htm>.

10. Ibid.

11. Victor Aguado, director general of Eurocontrol, remarks made at CSIS, Washington, D.C., June 3, 2003.

industry. These drivers of change have created an environment in which, in principle, developing and implementing an agreed vision for ATM transformation may in fact be possible. Whether that vision utilizes existing technologies, develops new technologies, or a combination of the two, it will in all likelihood seek to take Europe beyond its immediate harmonization and efficiency challenges.

Europe faces unique demands in civil aviation. The most obvious is that more than 30 separate governments control Europe's skies. Eurocontrol must work across 32 member nations¹² to coordinate and harmonize operations that have grown up around the same number of national systems. To maintain voice contact with air traffic control centers along the route of a flight from Brussels to Geneva, for example, a pilot needs to change radio frequencies nine times.¹³

Although Eurocontrol is the principal European institution charged with the development of "a seamless, pan-European air traffic management (ATM) system," it is not Europe's equivalent of the FAA.¹⁴ Its primary function is to develop regulatory consensus among its member nations on technical standards for air traffic management and to coordinate the implementation of such measures. Moreover, Eurocontrol has no authority to enforce compliance. (A new European Aviation Safety Agency is being established, and it will perform the safety regulatory functions in Europe similar to those of the FAA in the United States.)

As in the United States, congestion is a problem at major European airports. In 2003, 40 percent of all flights in Europe were delayed on departure, with 16 percent delayed more than 15 minutes.¹⁵ Even with the recent downturn in air traffic, Europe's air traffic is expected to double by the year 2020.¹⁶ Some estimates suggest that 350,000 aircraft flight hours per year are lost in Europe due to inefficient air traffic management and airport delays. These delays are costly, estimated by the European Commission in 2002 at 4.4 billion annually—roughly equivalent to the value of air navigation services themselves.¹⁷ These inefficiencies also raise serious safety issues: three accidents (including a mid-air collision between a Russian passenger aircraft and a cargo plane) are attributable to ATM failures in Europe.¹⁸ The inefficiencies also hurt European efforts to reduce greenhouse gas emissions.

12. Eurocontrol will soon expand to 40 nations.

13. EC Directorate-General for Energy and Transport, *A Single European Sky: Broadening Horizons for Air Travel* (Brussels: European Commission, April 2002), p. 4, at http://europa.eu.int/comm/transport/air/single_sky/doc/publications/brochure_en.pdf.

14. Eurocontrol, "Our Organization," at <http://www.eurocontrol.int/about/index.html>.

15. Central Office for Delay Analysis, Eurocontrol, "Delays to Air Transport in Europe, Annual Report 2003," p. 7, at http://www.eurocontrol.int/eCoda/codarep/2003/annual_report_2003_full.pdf.

16. Aguado, remarks made at CSIS, Washington, D.C., June 3, 2003.

17. EC Directorate-General for Energy and Transport, *A Single European Sky*, p. 6.

18. Aguado, remarks made at CSIS, Washington, D.C., June 3, 2003.

European efforts to modernize air traffic management began in 1997 when a meeting of European transport ministers called for Eurocontrol to develop a comprehensive air traffic management strategy that would meet the needs of the aviation sector up to 2015. In response, Eurocontrol prepared the *Air Traffic Management Strategy for the Years 2000+*¹⁹ (or *ATM 2000+*). Its stated core objective is: “For all phases of flight, to enable the safe, economic, expeditious and orderly flow of traffic through the provision of ATM services which are adaptable and scaleable to the requirements of all users and areas of European airspace. The services shall meet demand in a cost-effective way, be globally inter-operable, operate to uniform principles, be environmentally sustainable and satisfy national security requirements.”

The strategy views air traffic management “as part of a complex network of individual systems, including those of the aircraft operators and the airports, which all inter-connect and pass data to each other.”²⁰ The strategy establishes a framework for the sharing of real-time information between aircraft, airlines, and airports using modern communications technologies, with the goal of managing flights using better and more informed decisions and making air traffic more flexible in responding to changing conditions.²¹ It calls for replacing traditional air traffic control with “a new ATM concept” that includes “capitalising on newly emerging technologies and fully utilising, where possible, the co-operative capabilities of both air and ground systems.”²²

To implement the *ATM 2000+* plan, Eurocontrol designed the European ATM Programme (EATMP). EATMP is similar to the FAA’s Operational Evolution Plan, although the former greatly exceeds the scope of the latter. The EATMP outlines the development and implementation of the measures set out in the strategy, as follows: a revised Eurocontrol convention to provide an institutional framework for the application of rules and standards; management of projects and programs at the appropriate regional or multi-state level; a streamlined and common European rulemaking process for ATM coordinated by Eurocontrol; a European R&D strategy to develop and implement R&D products; and study of new economic and financial arrangements for ATM. The *ATM 2000+* plan is now in the process of being updated.

Eurocontrol’s plans predict that by 2015, “The airspace in Europe will become a single airspace for air traffic planning and management purposes, and the majority of flights will be able to fly the most fuel-efficient routes.”²³ To achieve

19. Eurocontrol, *Air Traffic Management Strategy for the Years 2000+: Executive Summary* (Brussels: Eurocontrol, July 2003), p. 2, at <http://www.eurocontrol.int/eatmp/library/documents/ATM2000-EN-executive-2003.pdf>.

20. Eurocontrol, “ATM 2000+ Strategy in Brief,” at http://www.eurocontrol.be/dgs/publications/atm2000plus_strategy/atm2000strategy/main.html.

21. *Ibid.*

22. Eurocontrol, *Air Traffic Management Strategy for the Years 2000+: Executive Summary*, p. 5.

23. Eurocontrol, “ATM 2000+ Strategy in Brief.”

this, Eurocontrol will accelerate the integration of ATM information into other related information systems. This will involve improved information exchange between systems, more accurate information about aircraft positions (through the use of navigational satellite data), and improved computer support tools for pilots, dispatchers, and air traffic controllers. The goal is a high-level “system of systems” across European states that will provide integrated air traffic management.

On the political level, the European Commission has been rapidly consolidating its regulatory role in the ATM arena. Europe’s Single Sky initiative seeks to relieve its inefficient use of airspace and traffic congestion, which the EU assesses as a real constraint on Europe’s economic growth and international competitiveness.²⁴ The European Commission has elevated air traffic management to a priority, as a key building block of its common transport policy. The EU describes this as a “radical overhaul” of systems dating to the 1960s, which are patched together country by country and are inefficient.²⁵

The objective of the Single European Sky initiative is to enhance current safety standards and overall efficiency for general air traffic in Europe, to optimize capacity meeting the requirements of all airspace users, and to minimize delays. It establishes a committee of member-state representatives and an industrial consultation body to advise the EC. It is also establishing a joint consultation board with Eurocontrol to seek to ensure coordination between policy and research. It will set forth regulations to standardize services across air traffic service providers, seeking to put an end to the unevenness across entities and states. It will merge national airspace zones into a single European airspace, from which functional blocks will be created. This is to address a number of issues, including altitude restrictions that vary across nations and the inefficiencies created by large blocks of airspace controlled by the military. It will also set forth essential requirements for interoperability across ATM systems within Europe.

Europe has begun to move toward a political, institutional, and industrial cooperation that provides a new context for European research and development on an ATM system. Europe, however, has a far greater number of stakeholders than the United States and thus an even more cumbersome decisionmaking process. Europe may lag behind current U.S. operations and face inefficiencies that will be challenging to overcome, but Europe has also developed a coordinated government-industry process that already is creating a longer-term vision utilizing advanced technologies for ATM.

Private-sector Efforts

Concerned with the pace of change, private-sector groups began to develop and promote their own ATM concepts. In parallel to the Single Sky process, European industrial leaders have been considering strategies to promote a new approach to

24. EC Directorate-General for Energy and Transport, *A Single European Sky*, p. 2.

25. *Ibid.*

ATM and the competitiveness of European aeronautics industries in the global market. Their work has produced two key documents and the creation of industrial committee structures that will now underpin the EC's Single Sky initiative. The first of these documents is *European Aeronautics: A Vision for 2020*²⁶ (or *Vision 2020*), produced in January 2001 by a group of industrial leaders at the behest of the European commissioner for research. Among other things, the document calls for a seamless air traffic management system that can handle up to three times more air traffic.

It also calls for the implementation of sophisticated ground- and satellite-based communication, navigation, and surveillance systems, along with substantial noise reductions and an increase in airport capacity to allow airports to operate around the clock. And it calls for Europe to assume global leadership in the field. Following on *Vision 2020*, the European Advisory Group on Aeronautics, a government and industrial group of leaders, produced the *STAR 21* report²⁷ in July 2002, a rough equivalent to the U.S. Aerospace Commission effort. Within the ATM context, its most significant recommendation was the creation of an industrial master plan to support the Single European Sky initiative. Led by the members of the newly created Air Traffic Alliance (comprising EADS, Airbus, and Thales), the master plan has since been drafted and is being circulated to stakeholders for comment.

Vision 2020 also recommended the establishment of the Advisory Committee for Aeronautics Research in Europe (ACARE), to develop and maintain a strategic research agenda (SRA) for aeronautics in Europe. Launched at the Paris Air Show in 2001, ACARE is industry chaired and comprises about 30 members representing member states, the EC, and key ATM stakeholders. Its primary mission is to produce this strategic research agenda for aeronautics research (encompassing, but not limited to, ATM). In October 2002, the first SRA was produced, focusing on an R&D roadmap to achieve the *Vision 2020* objectives. It called for substantially more output from the European research community and a major increase in investment on the order of 100 billion over 20 year. The SRA will be updated every two years and is a main feeder to the developing European master plan.

In the United States, the JPDO planning process has reached out to industry but has not yet established and institutionalized coordination with the private sector. In the interim, the Boeing Company has actively promoted an initiative to develop a systems approach to an integrated, network-based ATM architecture. The model they have proposed draws on work within the ATM community and builds on Boeing's experience in defense modernization to create a global

26. *European Aeronautics: A Vision for 2020*, report of the Group of Personalities (Brussels: European Commission, January 2001), at http://europa.eu.int/comm/research/growth/aeronautics2020/pdf/aeronautics2020_en.pdf.

27. *STAR 21: Strategic Aerospace Review for the 21st Century* (Brussels: European Commission, July 2002), at http://europa.eu.int/comm/enterprise/aerospace/report_star21_screen.pdf.

framework for ATM. Boeing has actively promoted a vision for a future ATM through its Working Together program, a four-part initiative to develop a systems approach to a new, integrated, net-based, ATM architecture.²⁸ The plan has four elements: It calls for “airspace redesign” to divide airspace into different zones where aircraft would operate; the use of “aircraft trajectories” that will allow ATM systems to better predict where an aircraft will be as it progresses through its flight; sharing trajectory information and other data through a “common information network” that will allow flight plans to be revised to take into account the actions of other aircraft, weather conditions, or other factors; and, new satellites to complement the GPS to provide the communication, navigation, and surveillance services the ATM architecture would need.

An Increasingly Similar Vision

Even in the absence of details, many of the same themes for an ATM vision are now being articulated on both sides of the Atlantic. European and American aerospace industry leaders in particular argue that current improvements on the margins (e.g., revisions to aircraft separation guidelines, increases in runway capacity) will run their course in the next 10 years and cannot sustain air travel increases over time. The near to mid-term continues to consume much of the strategic and tactical thinking in both Europe and the United States, but there is also increasing recognition of the need for a plan that looks out 20 years, when both U.S. and European systems may well be overloaded.

The new vision of ATM, with its emphasis on increased situational awareness through greater information flows, bears some similarity to the network-centric warfare (NCW) concepts and capabilities developed by the U.S. Department of Defense (DOD). Net-centric approaches emphasize that organizations should adjust how they operate to take advantage of information technology (IT) networks for communication and sharing of information. NCW allows military forces to take greater advantage of available information and use this information to coordinate operations in a rapid and flexible manner. This requires robust networking to provide adequate information sharing. This approach to air traffic management faces a number of obstacles. These include the lack of secure, robust connectivity and interoperability among aircraft and controllers, concern over the effects of disruptive innovation on the provision of an essential service, and a shortfall in technology investments. None of these problems is insurmountable, but as DOD’s experience with NCW has shown, it takes a sustained commitment of resources and political leadership to move existing bureaucracies with legacy architectures to a new mode of operation.

Much of the information used today to manage air traffic comes from what the aircraft crew can see from the cockpit, what the controller or other pilots can

28. Boeing Air Traffic Management Working Together Team, *Working Together to Define the Future Global ATM System*, v. 5.0 (Seattle, Wash.: Boeing Company, May 16, 2003), p. 11, at http://www.boeing.com/atm/pdf/wtt_global.pdf.

tell them, and perhaps from a few short-range systems in aircraft. A new approach that uses new satellite-based and information technologies would greatly expand the amount of information, the degree of coverage, and the speed of communication. This would give pilots, dispatchers, and controllers the ability and the information to adjust to new conditions and take advantage of opportunities to avoid delay. Using digital information technologies and space-based assets to communicate information on traffic patterns and weather conditions, and to provide location and navigational data, could allow for continuous coverage and greater transparency and situational awareness.

This would transform air traffic management by providing for integrated communications, navigation, and surveillance operations with information from all sources shared broadly, cutting across the stovepipes that now characterize air traffic planning and control operations. Systems would be highly integrated and depend more on automated networks and satellite data. This ATM overhaul would roughly reflect the kind of network-centric approach being pursued by the U.S. military, where real-time data flows in many directions—from aircraft pilots, to commanders on the ground, to headquarters, to surveillance teams—allowing for a dramatically increased situational awareness and the ability to share decisionmaking with the pilots themselves.

Automated tools using information from other aircraft and navigation and weather satellites would provide the crew with optimal routes for a trip. This IT-intensive system would be more flexible than the National Route Program (NRP) used now. It would increase the number of aircraft that could safely fly to various destinations, reduce costs for airlines, and somewhat counterintuitively, increase control of airspace, as national authorities would have much more information on the location, heading, and altitude of aircraft.

In both the United States and Europe, some believe this shift should be realized through development of interoperable architectures that would be imposed on the existing structure. This concept poses real challenges given the vast number of stakeholders in the ATM system. Skeptics question how one could undertake such an approach—or why it might be necessary. Others see advantages in being able to use an architecture to overhaul a system that is notoriously resistant to change. They also argue that a common, agreed architecture would add a badly needed measure of predictability for suppliers and airlines, which must plan for the long term and on a large scale. Given the high costs of retrofitting the cockpit, a common approach would be advantageous.

On a transatlantic basis, there is a history of cooperation on ATM between the United States and Europe on research and development, sponsored through the FAA and Eurocontrol. The two organizations have in place a formal memorandum of cooperation on R&D and, in July 2002, established periodic high-level strategic meetings on broader ATM issues. These two bodies will play an important role, as Europe moves ahead with strategic change that the United States is only beginning to contemplate. Nevertheless, with new roles being assumed by the EC and with the institutionalization of an industrial advisory role

for the Single European Sky program, there are some new opportunities and needs for cooperation that should be addressed at the political level.

The process of European integration will have a significant impact on air traffic management, both within Europe and across the Atlantic. For example, if a new “open skies” accord can be negotiated between the United States and the EU, it may well open up significant new patterns of flight—for U.S. airlines within Europe and for European airlines within the United States—and increase imperatives for common, or at least, compatible, new ATM approaches. Although the EC is pressing forward on ATM, nation states, for the time being, still dominate air traffic management in Europe. The Single Sky initiative is changing that. In turn, it may form the basis for successful negotiations with the United States, and the rest of the world, on global ATM standards.

International Civil Aviation Organization

There already is a vehicle for international cooperation on ATM issues: the International Civil Aviation Organization (ICAO). In fall 2003, ICAO’s Eleventh Air Navigation Conference endorsed the development of a globally harmonized and seamless air navigation system that will enhance safety, reduce congestion, delays, and flight times, and lessen the effect of aviation on the environment.²⁹ Implementation of the ICAO plan will take the next 25 years. ICAO had previously decided (in 1991) that ATM should move to greater use of satellite-based navigation systems, and the 2003 decision built on this precedent. ICAO’s “Global Air Navigation System of the Future” makes safety the most important element of ATM systems, but it also emphasizes efficiency, cost effectiveness, and protection of the environment. The conference recommended greater harmonization of air navigation systems between regions to increase the capacity of the existing airspace, noting that harmonization (through cooperation and consensus among countries and regions) was vital for providing a transparent and seamless global ATM system.

The history of ICAO suggests that it serves a crucial function in securing international consensus, in developing technical standards, and in overseeing implementation of plans and architectures. In this sense, if the United States or the EU were to begin implementing national or regional plans for a new, space-based, information-intensive approach to ATM, ICAO would be essential in translating this into standards for an international system. ICAO is the crucial link for a new global ATM system, but as it is a technically oriented UN organization with 120 members and 40 observers, the initial work and testing may have to be tried first on a national or regional basis.

29. ICAO News Release, “Global Air Navigation System of the Future to Lead to Greater Safety and Convenience,” October 3, 2003, at: http://www.icao.int/icao/en/nr/2003/pio200316_e.pdf.

Managing Change

Planning and implementing change is a slow process in a community that demands high standards for safety and reliability. Equipment compatibility issues are a major burden for air carriers and for major suppliers. Whether air navigation rules, digital communications, or the new automated dependent surveillance system, differences between the United States and Europe will need to be resolved. There is a considerable amount of work underway, but we are far from an agreed and comprehensive roadmap, nationally or internationally, thus creating some uncertainty about where to invest for the long term.³⁰

One of the major issues for a next-generation ATM is how to transition from the legacy architecture. Technology may not be the main impediment to overhaul of the ATM system, but legacy technologies will play a huge role in the pace with which system improvements or changes can be made. There are major sunk costs in existing avionics packages and a reluctance to plan for new packages without assurance that these will be sufficient for new global standards.

The most immediate of these compatibility issues is that concerning GPS and Galileo. There has been real progress in ensuring compatibility in signals, but much work remains to be done in the details of implementing compatibility. From the standpoint of air traffic management, it is essential that these two systems be compatible in the cockpit and on the ground. Compatibility is crucial for a number of reasons, but the aviation community sees advantages in having satellite communication redundancy. This will be even more true as the system depends increasingly on satellites for communication, navigation, and surveillance.

Additionally, changes in ATM are eroding the traditional boundaries that have separated communication, navigation, and surveillance systems. These can no longer be considered isolated categories of ATM technology, yet the current system of operations treats them separately. Not only does the technology need to be integrated, but controllers, communicators, and surveillance operators will also need to find new ways to integrate their operations.

Increasingly, in the post-9/11 environment security has become an important dimension of ATM. Although other security measures are under more immediate consideration, there is some argument for also looking at a network-centric, information-managed future where a broad community can share information to understand threats and adaptively respond to those threats when they present themselves. However, that too raises questions about what kind of information should be shared across national boundaries and across civilian and military operations. This in turn raises questions about cooperation among the civilian, military, and security officials within nations and across borders, as well as the means by which one integrates the information that must flow across these lines.

30. Aguado, remarks made at CSIS, Washington, D.C., June 3, 2003.

Moving to greater automation and broader sharing of information will create technological, operational, and political questions. There is the technical challenge of shifting to a more highly automated environment. Validation will present a range of difficulties because of the assurance required that the new system work as well or better than the old system. There are also associated operational questions: how much information should be shared across an ATM system of controllers, pilots, and planners; and what are the implications of that information for decisionmaking processes, as well as for sovereignty and security. Pilots will need to be trained to have new skills, as a new ATM system will provide them with more information and a greater degree of autonomy in acting on that information.

Funding Change

Perhaps the hardest question is who will pay for a new ATM architecture when the financial condition of many major airlines is weak. In the United States, the airline crisis has caused the industry to look inward, and it is certainly not in a position to welcome costly new upgrades. Greater transnational ownership of airlines, now under informal discussion among policymakers, could create another driver for greater compatibility. To the extent it improves airline profitability, it could also offer a more welcoming climate for significant additional investment in the elements of a new ATM architecture.

Furthermore, the poor financial health of many airlines, exacerbated by the global downturn in air travel levels, has created a climate in which airlines are less willing and able to pay for ATM-related upgrades. Legacy systems represent tremendous sunk costs and disincentives to change, especially in the face of uncertainty about how long any single new technology will continue to be utilized. The FAA's decision to cancel its Controller Pilot Data Link Communications program³¹ because of airlines' inability to pay their part,³² suggests the challenges that lie ahead for an even more ambitious set of changes. Advocates of an ATM overhaul argue that the temporary downturn in air travel may present funding challenges but also offers opportunities to plan for systemic change before the air traffic system again falls victim to tremendous strain. This is particularly important as new patterns of operation are emerging with the greater use of smaller, regional jets (which fly faster and higher than the turboprop craft they replace, leading to more aircraft in the same parts of the sky for the same number of passengers) and the development of regional point-to-point jet service. Airlines will need to see a clear vision of an ATM system that works across both the Atlantic and the Pacific Oceans before they willingly part with scarce resources.

31. The program, a variant of which is being pursued in Europe, would substitute automated data-linked communications for a number of the exchanges now conducted by voice between pilots and air traffic controllers.

32. *Aviation Week and Space Technology*, June 23, 2003.

Operations and maintenance, not surprisingly, take up the bulk of FAA funding. In 2003, the Office of Management and Budget reported that the FAA spent \$249 million on the procurement and modernization of air traffic control facilities, \$631 million on improving efficiency, and \$637 million on increasing the capacity and reliability of the national airspace. NASA's FY 2005 request asks for \$154 million for projects to increase the capacity and mobility of the national airspace. NASA has said it will shift the focus of its R&D spending to concentrate on the Next Generation ATM system that is being be outlined by the JPDO.

The effect of this spending is less than the sum of its parts. FAA estimates that modernizing air traffic control will cost an additional \$16 billion through 2007.³³ Out of the \$14 billion appropriated to the FAA in 2004, \$2.9 billion will go toward modernizing air traffic control (facilities and equipment),³⁴ a slight decrease from \$2.96 billion in 2003. The FY 2005 request is for even less: \$2.5 billion. From one perspective, the downward trend is discouraging. On the other hand, \$2.5 billion spent on the right programs rather than on disjointed efforts could make progress toward improvement. Though more funding is needed for ATM modernization, this funding will only be effective once there is a multiyear plan with a consistent set of objectives to which political leaders have committed.

Homeland and National Security

Security also has a prominent role in considering future air traffic management. New security requirements are becoming a major new contributor to airline delays.³⁵ Our current security focus is ground based. New ATM architectures that increase awareness of an aircraft's position and trajectory provide an opportunity to enhance security for the post-9/11 era. Future security plans could use aircraft-based systems that automatically report where a plane is and what it is doing to complement radar tracking capability. Situational awareness could be increased not only for pilots, dispatchers, and controllers, but for law enforcement and defense as well.

Security will affect and shape ATM modernization. There are currently a number of homeland defense initiatives, each with the potential to affect modernization of the national airspace system. The most important element of these initiatives is the need to increase situational awareness for air traffic, to be able to rapidly spot and respond to unplanned or unannounced deviations from flight paths, or to detect trajectories that place an aircraft in restricted airspace much earlier than is possible now.

33. GAO, *Air Traffic Control* (Statement of Gerald L. Dillingham).

34. Kenneth Mead, inspector general, U.S. Department of Transportation, "Observations on Bringing Fiscal Discipline and Accountability to FAA's Air Traffic Control Modernization Program," statement before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, U.S. House of Representatives, October 30, 2003, at http://www.oig.dot.gov/show_pdf.php?id=1195.

35. Department of Homeland Security official, Air Traffic Controllers Association Workshop, Washington, D.C., July 2003.

Over the last several decades, the United States has allowed its national air defense system to decline. North American Aerospace Defense Command (NORAD) was focused on strategic, missile, and space threats, not the control of the airspace over the continental United States. One of the surprises of September 11 was the lack of knowledge among U.S. authorities of aircraft positions and trajectories. Radar coverage of the United States is incomplete and depends in many instances on older radars, and the ability to share information on a timely basis still depends to some extent on ad hoc networks and telephone communications. The FAA has moved to share its radar systems with NORAD and has established an emergency communications network to assist military-civilian cooperation and coordination. This is a necessary step and a good short-term solution, but it does not address the fundamental problems.³⁶

ATM modernization, by increasing the amount of knowledge available to all participants on aircraft position, trajectory, and intent, and by creating networks to rapidly and automatically share this information, could be a crucial element of improved homeland security. Other surveillance technologies (pseudo-satellites, ground-based passive sensors, sensor-bearing airships) could also provide the additional information needed for homeland defense. Although the FAA and DOD have enjoyed reasonably cordial relations, the evolving role and requirements of the Department of Homeland Security (DHS) originally created some uncertainty. One DHS official noted, “Our mandate covers the modernization of the national airspace as a security issue, while the FAA looks at it as an economic issue. We both realize, however, that there is only one system.”³⁷

Another set of security concerns relates to military operations. Ironically, while transparency could increase homeland security, it might also degrade national security by exposing military operations to greater scrutiny, if the proper safeguards are not or cannot be built into the system. The global operations of the U.S. military could be compromised by more transparent, situationally aware conditions. Other nations will also not appreciate transparency in their military air operations—for example, China treats military flight information as a “state secret,” with penalties for disclosure. Reviewing the U.S. Air Force (USAF) record in keeping pace with evolutionary civilian ATM modernization, the Air Force Scientific Advisory Board (AFSAB) suggested that, “High priority military programs compete for limited funds. In the past we have resisted or ignored similar challenges until the threat of airspace exclusion or an accident involving loss of life forced an emergency reaction equipping essential aircraft.”³⁸

Moreover, the military will have to develop contingency plans to operate stealthy aircraft in a system designed to create transparency in the skies. “It is

36. Dan Verton, “FAA Moving to Enhance Integration with Norad,” *Computerworld*, August 13, 2002, at <http://www.computerworld.com/securitytopics/security/story/0,10801,73427,00.html>.

37. DHS official, Air Traffic Controllers Association Workshop, July 2003.

38. Air Force Scientific Advisory Board, *Global Air Navigation Systems*, vol. 2 (SAB-TR-97-02) (Washington, D.C.: Department of the Air Force, September 1998).

unlikely that all USAF combat aircraft can comply with all future international regulations,” the AFSAB noted, “It will be necessary to conduct some ‘fighter drag’ operations in which combat aircraft are accompanied by [global air traffic management system]–qualified aircraft. There will be emergency situations where aircraft proceed with ‘due regard.’”

Other military concerns may also arise. The global nature of any such system will require the transfer of technology and expertise from the United States and Europe to the developing world. In some cases, however, the dual-use nature of such technology could raise concerns among those who oppose technology transfer, given the possibility for use in air or even missile defense or in improving general military capabilities.

Conclusion

Air traffic control exemplifies the problems of governance in an age of sustained technological change. Complex problems go beyond the jurisdiction of a single country and challenge our ability to devise collaborative solutions. The tragic events of September 11, 2001, highlight the critical need for improved aviation security and safety. This is not a technological problem—technologies exist that could improve tracking and facilitate ground-to-air communication. However, the use of new technologies creates difficult organizational, budgetary, and policy issues, as well as important challenges for national security. Deploying a new air traffic control system internationally could also raise issues regarding sovereignty.

In Europe, the United States, and internationally through ICAO, there is a common recognition of the need to build a truly global ATM system. The leading ATM organizations are coalescing around a common vision of what a future global ATM system should look like. Technology is not the obstacle to modernization. The technology for data-linked, satellite-based operations is here. The real challenge will be creating the new levels of institutional, political, and industrial cooperation that globalization—and an ATM overhaul—demands. Whether these cooperative efforts are institutionalized or grouped around loosely gathered partnerships, it is clear that some additional level of agreement on planning, which affects the management, operation, and avionics equipage of aircraft, will be necessary for transition to the future.

There are several benefits to an approach that emphasizes international cooperation, not only at the technical level but also at the policy planning level. First, FAA and Eurocontrol may benefit by winning funding if they make common cause. Second, the transatlantic region (the United States and Europe) remains the most modern and most active aerospace industry sector, so common changes there will set the course for the rest of the world. Progress in recent talks on compatibility between Galileo and GPS could serve as a model. There could also be political benefits from finding new grounds for cooperation with Europe as it continues to reconstitute itself into a single entity. ATM modernization is a relatively neutral subject where both sides of the Atlantic have incentives to

cooperate. The key issues are refining that common vision into an implementable plan and finding the political will and resources to execute it.

Building a political imperative for implementing ATM transformation will be difficult, but it is the central challenge. ATM modernization is moving ahead, but at a slower pace and more incrementally than is needed. The center of gravity for change is in Europe. The Europeans face economic and political pressures for modernization not found in the United States. One solution might be for the United States, in the current political and budgetary cycle, to piggyback on the European imperative for change and make our goal to ensure compatibility in the transatlantic air transportation system. With this in mind, we have five recommendations for accelerating modernization of this national infrastructure.

1. The administration's decision to look beyond the OEP with a new ATM plan is a positive step. The new plan should not be another study. It must create a broad vision for the future and focus on action. This means identifying relevant existing activities, allocating resources as needed to new research and new programs, establishing processes within the FAA and other agencies, and creating a coherent, integrated approach to change.
2. Robust consultation on modernization with foreign ATM authorities at the political and technical level (in Europe and perhaps in Asia) to ensure international coordination must become a primary FAA mission. These processes must facilitate ATM transformation and become a core component of the FAA's work. The joint planning effort will require the development of new formal processes for coordination, for example through new bilateral agreements at the political level, with corresponding coordination at the technical level.
3. We need a presidential decision to endorse ATM transformation as a national priority, identify goals and timelines, and designate a White House entity specifically responsible for coordinating action on ATM among all involved agencies (FAA, NASA, and the Departments of Defense, Transportation, State, and Commerce). The president has put forth a new vision for U.S. space programs; he should do the same for ATM transformation. The FAA, unequalled in its technical expertise, should not be asked to shoulder interagency policy and political tasks for which it was not designed.
4. Despite the larger budgetary difficulties the United States faces, once program requirements are established under the new ATM planning effort, new mechanisms for funding the modernization of air traffic management should be found to allow a substantial increase. The first step is to fund the developmental and planning effort. The congressional committees of jurisdiction, which play a central role in providing continued oversight and encouragement for modernization, should consider whether additional legislation could help achieve this and ensure sustained investment.
5. The FAA is reorganizing itself to emphasize customer service. This is good, but the FAA also needs to reorganize to make transformation of ATM a core organizational mission. This will require a long-term strategy endorsed by senior management at the FAA and Department of Transportation, as well as

coordination with foreign ATM authorities. In approaching this problem, FAA can draw on the experiences of DOD in transformation.

In thinking about how to move forward, we can draw on the experience of how other organizations in both the private and public sectors have streamlined their operations with new technologies. One common conclusion is that a commitment to change is the key condition for success. If there is no sustained commitment among leaders, it does not matter if the technology works, if plans are made, or if money is spent. We began this report by noting that the United States has an opportunity to improve ATM but lacks the institutional tools and the consistent political will to take on this complex, long-term set of issues. ATM modernization is, ultimately, a political problem. More planning by a single agency and more discussion cannot take the place of a top-level political decision to move ahead. Only the president and Congress can accelerate a move to a new ATM system and seize the opportunity presented by shared requirements for change in North America, Europe, and Asia. If they make the commitment, action will follow.

About the Authors

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