Faster, Safer, Greener Commercial Aviation

The U.S. air traffic management system is being modernized to take advantage of the advanced positioning, navigation, and timing capabilities offered by satellite systems on a global scale. Similar modernization efforts are also underway in other countries. The benefits of next generation air traffic management systems include reductions in air traffic congestion, more efficient operations, improved safety, and lower environmental impact.

Aviation Today

Though they are often thought of as separate activities, space and aviation have always been closely linked. The National Advisory Committee for Aeronautics (NACA), which helped the aviation industry to grow, eventually became the National Aeronautics and Space Administration (NASA). Space systems and technology play an integral role in commercial aviation – a role that will become even more significant as the skies become more crowded.

Commercial aviation experienced some rough times from 2007 through 2009 due to the impact of the economic meltdown on company finances and consumer demand, combined with the crippling effects of wild variations in fuel prices. The airlines responded with a number of cost-cutting measures, including a reduction in the number of flights they offered. Even with fewer flights taking place, delays are still a common frustration for passengers, with 24 percent of flights from U.S. airports experiencing delays in 2008.[1] There may be fewer planes in the air, but air traffic management remains a challenge that will only become more difficult as economic recovery spurs greater passenger travel and renewed growth in aviation.

Environmental issues are another global concern for the aviation industry as the U.S. government considers regulation of greenhouse gas emissions, and the European Union and others implement new emissions policies. While airlines recognize the economic and environmental benefits of reducing fuel consumption, it would be very costly to make sudden, drastic changes to the aircraft in operation today. New models, such as the Boeing 787, are designed to use 20 percent less fuel than comparable aircraft in service now.[3] However, it will take time before these fuel-efficient aircraft constitute a significant percentage of planes in the air.

Stress detectors

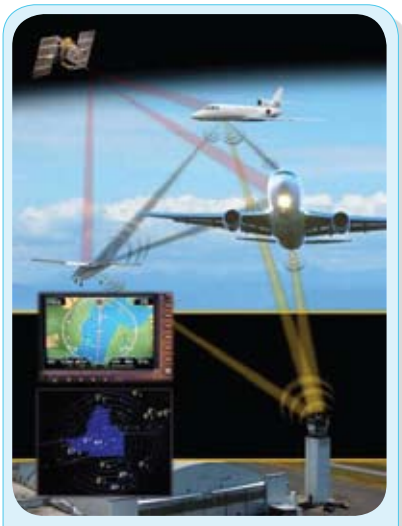
Modern aircraft owe a great deal to the space program for innovations such as the fly-by-wire flight controls pioneered by the Apollo spacecraft. The next generation of aircraft will continue to incorporate space technology, borrowing techniques for monitoring the structural integrity of composite materials that make up as much as half of new airplanes such as the Boeing 787. By embedding fiber optic cables in new composite materials, excessive stresses on the structure can be detected by shining a light down the cable, a technique developed for the Space Shuttle.[2]

The Space Report 2009 features this stress detection technology, along with an abundance of facts and figures about global space activity. Find out more at www.TheSpaceReport.org.

The issues with air traffic flow and airport congestion can be addressed to some extent by building new runways and airports, and environmental issues can be alleviated by improvements to aircraft design. However, space technology can help to address these and other problems much more rapidly. Space technology is essential to the Next Generation (NextGen) Air Transportation System. The Federal Aviation Administration (FAA), NASA, Department of Defense, other government agencies, and partners from industry are developing NextGen together. Other countries and regions have similar air traffic modernization programs under way that will rely on satellite-based navigation rather than terrestrial infrastructure. Regardless of where they are built and operated, these new systems offer the potential for safer, cleaner, and more economical air travel thanks to satellite navigation and communications.

An Overview of the NextGen System

Air traffic control procedures gradually developed during the 20th century in parallel with aviation itself. The present system uses multiple networks of radars (many of which date back to the World War II era), voice communications via radio, and navigation by means of visual cues. This has worked remarkably well, up to a point, as air transportation is considerably safer than other methods of travel. However, the air traffic control system is showing its age, and 21st century technology enables far greater precision and control of larger numbers of aircraft. In the face of heavy air traffic expected in the coming years, a radar-based system that updates aircraft positions once every 12 seconds would only be able to preserve safety at the expense of efficient operations. By contrast, NextGen will provide location and direction updates every second, along with a host of other information.[4]



Aircraft in the future will use the Automatic Dependent Surveillance-Broadcast (ADS-B) system to determine their position, speed, and direction based on signals from navigation satellites. This information will then be shared with nearby aircraft and ground controllers so that air traffic can be managed more efficiently.

Image Courtesy of the FAA

The cornerstone of NextGen is a satellite-based technology called Automatic Dependent Surveillance-Broadcast (ADS-B). The name is somewhat unwieldy, but it accurately describes the critical characteristics of the system. ITT Corporation, the FAA's lead contractor for developing the ADS-B system, explains the name this way:

Automatic: It is always on and requires no operator intervention.

Dependent: It depends on an accurate Global Navigation Satellite System signal or a Flight Management System for positional data.

Surveillance: It provides "radar-like" surveillance services to determine the position of an aircraft.

Broadcast: It continuously broadcasts aircraft position and other data to any properly equipped aircraft and ground station.[5]

Thanks to ADS-B, air traffic controllers will be able to keep track of what is going on in their airspace with unprecedented accuracy and clarity. Cockpit displays and advanced guidance software will enable pilots to share airspace safely with more planes because they will know exactly where each one is and how it is moving. The ultimate goal is to transform each control tower and aircraft into a self-aware node in a network that is capable of tracking all nearby nodes.

Such a system would not be possible without the positioning and timing signals sent down from space by the Global Positioning System (GPS) satellites built and maintained by the United States Air Force. Other satellite navigation options, such as the

Always connected

Satellite TV is already available on some aircraft, but other forms of connectivity are making their way on board. Southwest Airlines has begun testing in-flight Internet service provided by Row 44, a company that uses satellite data links to establish a two-way data feed between air and ground.[6]

European Galileo system, are expected to be available in the future, but GPS is currently the only fully operational system. The accuracy of GPS is further enhanced within the United States by the Wide Area Augmentation System (WAAS), which includes ground stations that calculate errors in the GPS signal due to atmospheric conditions and other factors. WAAS satellites in geostationary orbit then broadcast a signal that tells navigation devices how to correct the errors in their GPS readings. Similar GPS augmentation systems exist in other regions in the world.

The equipment for ADS-B has been installed in several locations for initial testing and review by the FAA, and the results have been extremely promising. The rollout of ADS-B to additional sites has been approved, thanks to the efforts of the equipment manufacturers, air traffic controllers, and the airlines that participated in trial programs by equipping some of their airplanes with the new hardware. As the system expands to serve the entire nation, the benefits will include reduced air traffic congestion, increased safety, lower noise levels near airports, and a reduction of the environmental impact of aviation.

Congested Airways

The skies are increasingly busy and crowded. Even though we are not likely to see flying cars and personal air transportation devices anytime soon, the number of people flying by conventional means is projected to increase significantly as the economy recovers. This is great news for airlines that have been financially challenged, but problems will arise due to limited airport capacity. In Europe, the busiest airport is London's Heathrow, which operates at full capacity eight hours per day. This does not leave much slack in case of disruptions, and it is estimated that as many as 39 European airports could be functioning under similar constraints by 2030.[7] When multiple airports are operating under this kind of pressure, a delay in one location can start a devastating chain of delays throughout the global air transit system.

Coming soon!

The next few years are likely to see the first suborbital flights of the commercial human spaceflight industry. Companies such as Virgin Galactic, XCOR Aerospace, and Blue Origin are planning to take passengers high enough to experience weightlessness and see the Earth spread out below, before returning to land at the same launch site. The spacecraft may also be used in the near term for non-tourist purposes such as science, and for point-to-point travel at a later date. These flights, regardless of their purpose, will have to be integrated into the air traffic management system to ensure the safety of everyone involved.

In addition to conventional passenger and cargo aircraft, it is likely that the skies of the future will witness the proliferation of a wide variety of unmanned aerial vehicles (UAVs). These systems are best known for their military uses, but police departments and other civilian government bodies are exploring their potential. In major cities, several police helicopters are in use at any given time, but UAVs will be able to perform some of the same tasks for a fraction of the cost. For example, the Miami-Dade police department has been experimenting with Honeywell's Micro Air Vehicle for use in hostage situations or other times when it would be helpful to rapidly deploy "eyes in the sky."[8]

A crucial challenge that comes along with deployment of these systems is that they are most likely to be used in or near urban areas, which is where air traffic is the heaviest. At present, many civilian UAVs are more like high-powered hobbyist aircraft whose controllers keep watch from the ground. As technology advances, they may operate more like military vehicles that are piloted via satellite from centralized command centers that rely on satellite navigation for vehicle control. If the growth in UAV use transpires as forecast, then a new class of vehicles will have been introduced into the airspace currently used for commercial aviation.

The NextGen air traffic control system will address rising congestion by providing situational awareness to pilots and ground controllers alike. There are several components to this process. The first step is for all aircraft to broadcast information to ground controllers by 2020, a capability known as ADS-B Out.[9] ADS-B In capability would then provide pilots with information on what is happening in the air around them. From the airlines' point of view, it would be beneficial for new traffic control procedures using ADS-B In to be available at the same time as ADS-B Out, so that they can make immediate use of the NextGen capabilities. Although the deadline is 2020, airlines should be able to use the system before then on airplanes carrying ADS-B equipment at any airport that has the required ground infrastructure and control systems. Major airports are at the top of the list for equipment installation. However, new software applications and flight rules must also be established before the information provided by ADS-B can be used to bring about improvements in air traffic management.

Backseat pilots

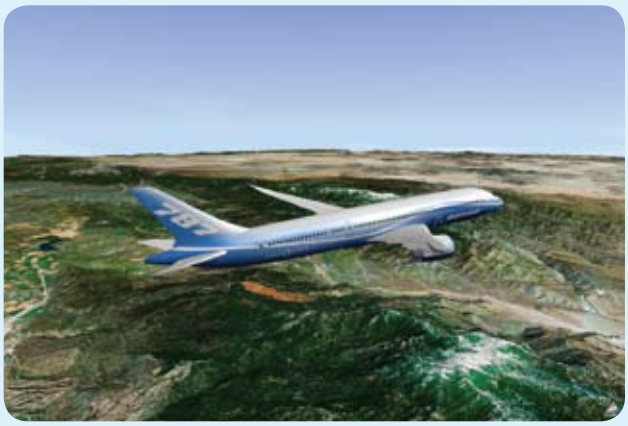
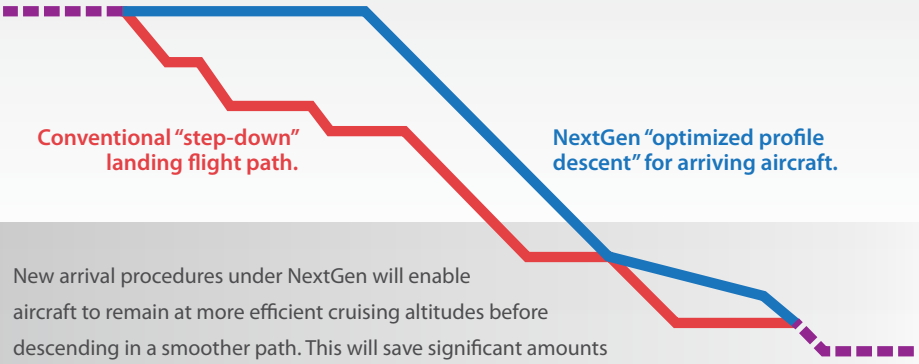


Image Courtesy of AGI

Flight crews and air traffic controllers are not the only ones who can make use of NextGen's capabilities. An in-flight entertainment system from Analytical Graphics, Inc. (AGI) offers passengers an enhanced version of the flight maps that airlines sometimes use to show an airplane's progress. The AGI software allows passengers to view the airplane's flight path as a 3D environment with the capability to highlight points of interest along the flight, such as the International Space Station passing overhead, which can be visible during night flights. For airlines that do not have high-tech screens in the seatbacks of their aircraft, an Internet browser-based version of the software may allow passengers to view the virtual environment via their own laptops or smartphones.[10]

In addition to providing everyone a better picture of how things are moving in the air, ground controllers will take advantage of NextGen's precision to move aircraft in and out of airports in a steady stream, limited by the availability of runways and airport facilities rather than the traffic control system. By assigning incoming aircraft an exact landing time and flight path, it will be possible for the pilots to tailor their descent so that they fly in a relatively straight, smooth path down to the runway instead of the commonly used "step-down" approach that means spending more time at inefficient cruising altitudes. Tests in Sweden have shown that pilots who receive a landing time and flight path when they are an hour away from the destination airport are able to land within seven seconds of the assigned time.[11] This precision promises to clear up much of the congestion near airports by allowing air traffic controllers to bring aircraft to the ground more directly and with fewer communications. It also opens the potential for the FAA to designate narrower aircraft-only corridors for direct approach routes to the airport, freeing up airspace for other uses.

Optimized Profile Descent Example



New arrival procedures under NextGen will enable aircraft to remain at more efficient cruising altitudes before descending in a smoother path. This will save significant amounts of fuel and reduce noise levels during landing. The example shown here is from flight tests in Phoenix, Arizona.

Source: FAA, format modified

Safety

NextGen will introduce many safety benefits, both in the air and on the ground. The benefits of increased situational awareness for airborne crews are obvious, as pilots will be able to see if they are on a collision course with another aircraft. The system will also enable air traffic controllers to safely direct more aircraft in areas where there are no ground-based radar installations, such as central Australia or the Gulf of Mexico. In the past, aircraft in these areas have had to maintain large separations to ensure safety, which placed a limit on the number of aircraft that could fly along the most efficient routes. As part of the effort to extend better air traffic control to underserved areas, ITT has installed ADS-B stations on oil rig platforms in the Gulf of Mexico. This is a mutually beneficial arrangement for the oil companies that rely on helicopter transportation for crew members working aboard the platforms, as well as the broader air transportation community that can use the ADS-B signals for better routing over the Gulf.

Cockpit displays will also make use of ADS-B when planes are on the ground, showing the crew the plane's location on a map of the airport, along with routing instructions from the control tower. This is intended to reduce the number of incidents when two aircraft try to taxi onto the same stretch of pavement at the same time and to prevent an airplane from taking a wrong turn onto an active runway. It is thanks to the diligence and alertness of ground controllers and other pilots that these incidents typically do not result in accidents; however, it would be preferable to prevent such occurrences in the first place. Commercial companies already have systems that can provide some of these services. For example, Honeywell manufactures a SmartRunway system that offers audio and graphical alerts to keep pilots aware of their position on or near the ground. The system is designed to make use of ADS-B, once it is widely available, to improve accuracy and automation.[13]

Did you know?

The pattern of tiny grooves cut in the surface of most runways is designed to prevent aircraft from slipping when the surface is wet. NASA researchers figured out the most effective pattern when they were looking for ways to prevent the Space Shuttle from sliding if it had to land in wet conditions.[12] This technology was inducted into the Space Technology Hall of Fame in 1990. Find out more at www.SpaceTechHallOfFame.org.

Lightning strikes… repeatedly

Airports often have miles of underground cables, including many that belong to outdated systems that are no longer used. However, lightning that strikes these cables can cause power surges that affect critical systems still in use. Technology developed to detect lightning strikes near NASA's launch pads is now being used to precisely determine where there may be "lightning attractors" at airports so that maintenance crews can either remove or relocate the affected systems.

Better information in the cockpit is always a good thing, but NextGen also offers the prospect for better directions from ground control. Instead of directing aircraft by means of voice communications via radio, air traffic controllers in the future will be able to send flight path information directly from their computers to cockpit computers, specifying the details of where the aircraft should be at all times. This will allow ground control computers to select the best paths automatically, and ADS-B will enable controllers to make sure that aircraft are following those paths. Computer-aided calculations will also improve routing of aircraft on the ground, particularly in the busiest airports where hundreds of aircraft are being monitored and directed at any given time.

This new model for traffic control will require the development of software assistants for both the cockpit and the ground. Pilots already have a large number of essential tasks to perform, so they will need a system that interprets the data provided by ADS-B and brings the important details to their attention. Similarly, ground controllers will need software that extrapolates future positions and directions of aircraft to safely and smoothly direct them into the correct landing slot. NASA is conducting much of the research required for implementing this part of NextGen, drawing on experience with complex flight systems and highly automated navigation software.

Weather Information for Aviation[14]

Today	NextGen (new requirements)
Not integrated into aviation decision support systems	Completely integrated into decision support systems
Inconsistent/conflicting on a national scale	Nationally consistent
Relatively long time between data points, so less detail is available	Shorter time between data points, providing a more accurate picture of what is happening
Disseminated in minutes	Disseminated in seconds
Updated according to a schedule	Updated as events occur
Fixed product formats (graphic or text)	Flexible formats

The networked nature of NextGen will extend to areas other than control of an aircraft's trajectory. It will improve the ability of airlines and airports to mitigate the effects of weather, one of the major causes of delays in aviation today. Pilots will receive satellite-collected weather data while they are in flight, and the quality of this data is expected to improve as new satellite systems become available. The National Oceanic and Atmospheric Administration (NOAA) is updating its weather-monitoring hardware, forecasting software, and data-sharing systems to provide weather information that is more detailed and more frequently updated than is currently the case.

To take advantage of the expected weather monitoring and forecasting capabilities, Lockheed Martin, Embry-Riddle Aeronautical University, and other partners are working in Florida to develop methods for merging weather forecasts with aircraft routing procedures.[15] Since thunderstorms are common in Florida, it would be useful if aircraft could be rerouted as early as possible so that they avoid not only the stormy areas but also the areas where storms are expected to be at the time the aircraft would be passing through. According to the FAA, two thirds of all flight delays in 2008 due to the National Aviation System were weather-related, so improvements in this area will have a major impact on the efficiency of the air transportation system.[16]

In the NextGen system, aircraft will automatically share satellite-derived navigation information with air traffic controllers via radio towers like this one in Boca Raton, Florida. These towers will provide coverage in areas that are currently underserved and will replace many of the complex and expensive radar installations that exist today. The equipment can even be installed on existing cell phone towers.

Image Courtesy of ITT Corp.

NextGen weather and flight path information also enhances safety for general aviation, the category that includes all aircraft besides military flights and regularly scheduled commercial airliners. Since many of the aircraft in this category are small, they often do not have the sophisticated cockpit instruments available to larger aircraft. As a result, they rely heavily on the information that is provided to them from outside sources. Some companies, such as L-3 Avionics Systems, use GPS and satellite data links to make essential services available for general aviation. The L-3 SmartDeck instrument provides pilots with terrain maps based on the aircraft's location, airport maps, lightning detection, weather information via satellite, and a host of other functions to improve flight safety.[17] A significant advantage of NextGen is that it will work for all aircraft that carry the equipment to make use of the system, and instrument manufacturers are already incorporating these technologies in anticipation of NextGen's availability.

Even with all of these enhancements to air safety, and in spite of air transportation's remarkable safety record, it is inevitable that there will be accidents. The tragic loss of an Air France jet en route from Brazil to France in June 2009 is a stark reminder of this reality. Although space technology may have been unable to prevent this disaster, it could have assisted with the search and rescue efforts. Most commercial aircraft carry GPS units

Water, water, everywhere

Some UPS aircraft carry water vapor sensors derived from NASA technology originally designed for the Mars Polar Lander mission in 1999. These sensors provide meteorologists with real-time data that would otherwise be unavailable. As for how much water is in the air, one scientist noted that more water vapor passes through the sky over the dry state of Arizona than flows down the Mississippi River during the course of a typical year. By adding sensors for water vapor and other atmospheric factors to aircraft, our understanding of weather and its impact on aviation can be vastly improved.[18]

that provide navigation assistance for the crew, and they also broadcast their location to air traffic control periodically while over the ocean. These location updates happen approximately once an hour, depending on the aircraft speed and the separation that is supposed to be maintained between aircraft in the area. Modern aircraft also have automated communications systems on board that can use satellite data links to stay in touch with the airline's headquarters, relaying information about the aircraft's performance and the integrity of its systems. However, it is up to the individual airlines to decide what information is sent via this data link and location information is not necessarily included. Air France received automated messages from the troubled aircraft, including location data, indicating that some of the flight systems were not performing correctly.[19] Unfortunately, the airplane continued to fly for some distance without transmitting any further messages, and Air France headquarters did not suspect its loss until the pilot failed to make a scheduled radio call at a checkpoint along the flight path, hours after the accident occurred.[20]

It probably would not have been of any use in this case since the jet may have broken apart in midair, but knowing the aircraft's precise location would have been essential for a timely rescue if the flight crew had been able to make a controlled water landing like the US Airways flight that came down in the Hudson River in January 2009. Failing that, searchers would at least have a better chance of gathering the wreckage, including the flight data recorders, so that the cause of the accident could be determined. Considering the impending requirements for commercial aircraft to have ADS-B on board, it would make sense for airlines to increase the frequency of location reports as part of the data transmitted from airplanes to airline headquarters. That way they would be able to respond quickly if an airplane's automated system failed to transmit according to schedule.

Environmental Impact

Air transportation worldwide generates approximately 3 percent of manmade greenhouse gases each year, primarily from the fuel used in aircraft.[21] On a local scale, airplanes also generate noise that can disturb neighborhoods near airports. As governments consider regulations to address these issues, airlines are trying to adapt in advance to the operating conditions they anticipate. NextGen has the potential to play a significant role in these efforts.

Cap-and-trade legislation for greenhouse gas emissions would establish a limit for the amount of greenhouse gases, with the requirement that polluters who exceeded their limits would have to buy permits from those who had not reached their limits. The U.S. Congress is considering cap-and-trade proposals, and the European Union has had such a system in place since 2005.[22] The question of who should pay for the permits is yet to be decided in the United States. In the European Union, the system requires airlines to pay directly based on their emissions. Some members of the airline industry are calling for a global arrangement for aviation due to the large numbers of international flights that might result in multiple charges under various national regulatory systems. Even as these regulations are being crafted, airlines understand the need to reduce the emissions for individual flights if they intend to increase the total number of flights in response to growing markets for air travel.

The NextGen air transportation system is highly responsive to fuel conservation efforts. More aircraft will be able to fly the most direct routes between major destinations because they will be able to reduce the separation between flights without sacrificing

safety. In the future, new weather satellites such as the National Polar-orbiting Operational Environmental Satellite System (NPOESS) will provide a more detailed view of air currents so that aircraft can choose the most efficient altitude and course.[23] At the end of the journey, by flying an optimized descent rather than gradually descending and spending time at less efficient cruising altitudes, aircraft will save significant amounts of fuel. UPS Airlines has been testing this method for its cargo aircraft at the UPS hub in Louisville, Kentucky, as part of the trial for ADS-B. Fuel savings for the last 25 minutes of flight have ranged from 21 percent to 31 percent, depending on the aircraft.[24]

Takeoff and landing are currently the most fuel-intensive parts of any flight, so reducing the fuel consumed during the landing process by nearly one third will translate into major fuel savings for airlines and carbon emissions reductions for the environment. With the advent of NextGen and other fuel-saving measures, fuel consumption during landing could be reduced to levels much closer to those experienced during the majority of the flight. Lower fuel consumption could also be achieved during takeoff by allowing airplanes to ascend directly to higher, more efficient cruising altitudes. This would replace the current practice of flying at lower, less fuel-efficient altitudes before being cleared to ascend. The FAA estimates that new landing patterns, once they are implemented, will save airlines at least 100 million gallons of fuel annually within the United States.[25] When other fuel-saving traffic measures are included, the savings are even greater. On a global scale, the FAA estimates savings of 3.3 billion gallons of fuel by 2025 due to NextGen.[26]

An added benefit of the expected landing practices is the reduction in noise levels. By flying in a smoother, more gradual landing approach, pilots are able to throttle back their engines at a greater distance from the airport, reducing noise by approximately 30 percent.[27] This can mean the difference between an acceptable level of noise and picture frames rattling on the walls of nearby houses due to low-frequency vibrations. The noise issue is one that threatens to severely limit the growth of certain airports located near major population centers.

As airports seek to build additional runways, they often meet opposition from local organizations and may run afoul of national regulatory bodies. Italy's capital city is served by two airports, Ciampino and Fiumicino, with the former being the closest to downtown Rome. Regional authorities have restricted growth at Ciampino, citing noise impact, and the possibility of the airport being shut down is already being discussed. If this happens, airlines that fly into Ciampino would have to negotiate for operating space at Fiumicino or consider the alternative offer of Viterbo airport, approximately 60 miles from the center of Rome. Citing the poor public transportation infrastructure at Viterbo, the affected airlines strongly favor Ciampino remaining open.[28] It is possible that noise reductions arising from airplanes on more efficient flight paths would alleviate the problem, allowing Ciampino airport and dozens of others around the world to continue operations.

NextGen is on the way

Early experiments with NextGen have proven the value of the system, and the FAA's contractors are installing the ground infrastructure at additional sites across the United States. As of December 2008, ADS-B essential services were active in southern Florida, one of the early testing grounds. The FAA has confirmed that the services meet its requirements for performance, safety, and security. The next steps include deployment of tracking services to 19 regions by June 2010, and "critical services" to four more test locations.[29] These critical services are intended to provide air traffic controllers with sufficient information so that the FAA can begin to eliminate antiquated radar installations and the high maintenance costs they carry.

By the end of fiscal year 2010, the FAA expects to have 340 of the 794 ADS-B ground stations installed, with the remainder scheduled for completion by 2013. As a result of progress in this area and other components of the system, the FAA estimates

that NextGen will reduce delays by 35-40 percent in 2018, compared to the expected number of delays for that year if the current air traffic system were used.[30] Much work remains to be done: technical standards and requirements need to be finalized, government and industry must develop the new air traffic control software and procedures, and the remaining infrastructure and onboard equipment will have to be installed. The NextGen program is an ambitious undertaking to modernize air transportation, and it will ultimately bring about improvements in the way we fly, thanks to space technology and the people who use it.

Recommendations for Government

- Accelerate deployment of ground infrastructure and software for NextGen so that the benefits can be experienced sooner. The downturn in commercial aviation has offered a temporary reprieve, but growth is expected once the economy recovers; the new system should be in place before the skies become more crowded.
- Set final technical standards for the equipment that aircraft will have to carry so that airlines can buy equipment with assurance that it will meet the new standards. This would also enable aircraft manufacturers to cost-effectively include the equipment in new planes rather than retrofitting them at a later date.
- Establish NextGen traffic control procedures as early as possible so that airlines can make use of the new equipment and begin to realize a return on their investment. The public will also begin to see a return on the FAA's infrastructure investment when these procedures are implemented.
- Cooperate internationally on environmental legislation that affects the aviation industry.
- Structure cap-and-trade systems so that an airplane traveling from one country to another does not incur multiple costs under multiple systems.
- Use the advanced capabilities offered by space technology to better track distances traveled and time spent in the air. Offer incentives for airlines that are equipped to operate on more efficient flight trajectories.
- Use funds accrued from environmental fees paid by the aviation industry to speed deployment of energy-saving systems such as NextGen and to support other research on environmentally-friendly aviation technology.
- Begin the process of setting standards for UAVs operating in domestic airspace to include basic transponders that would show up on the NextGen displays for both traffic controllers and pilots. This would enable UAVs to operate more safely in airspace close to commercial air routes.

Recommendations for Industry

- Install or update equipment and procedures for satellite-based tracking and communication on all long-haul aircraft as soon as possible so that search and rescue teams know the precise location of an aircraft in distress.
- Prioritize investment in NextGen equipment for aircraft flying into airports that are the most congested or most likely to receive noise complaints.
- Enhance passenger travel experience with satellite-based in-flight entertainment systems. As consumers become accustomed to being constantly connected, they will expect to have entertainment and Internet capabilities even when they are in the air.

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End Notes

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