On June 29, a “super derecho,” a quick-moving wind and thunder storm, slammed 700-miles along the east coast including the Washington metro area, leaving 3.5 million households without power and causing 22 deaths. Unfortunately, most people had no idea it was coming until it was overhead.

Imagine the effect the storm had on the thousands of aircraft in-flight that evening and on airports with thousands of passengers and dozens of scheduled departures and arrivals every hour.

Fortunately, the derecho is a rarity, but weather – rain, wind, storms, and even temperature extremes – disrupts the flow of air travel every day. Weather is a serious, costly and frustrating force in the aviation industry. In fact, the Federal Aviation Administration (FAA) estimates that 70 percent of all aviation delays are caused by weather events, costing the U.S. $27 billion in lost productivity annually and resulting in inconvenience and delays felt by the traveling public.

But two-thirds of these delays are preventable with better planning through access to information. That is why the public and private sector are working together to improve how air traffic controllers and pilots identify and manage weather, minimizing its negative impact on aviation. It is a key initiative of the FAA’s Next Generation (NextGen) air traffic control modernization program, an effort that has already begun to improve the National Airspace System and transform the way we fly. NextGen reduces delays, enhances safety and saves fuel by integrating current and emerging technologies to advance our entire air traffic infrastructure.

NextGen will ensure that we are able to accommodate the growing demands on our nation’s national air space and aviation industry, which sustains millions of jobs and accounts for more than five percent of U.S. gross domestic product.

For example, NextGen is moving aircraft navigation from traditional ground-based radar systems to a global constellation of satellites and upgrading air traffic communications infrastructure to enhance real-time data availability and enable effective collaboration through information sharing. Through these and other initiatives, NextGen will address the growing need for more flights and increased passenger and cargo capacity in America’s congested airspace.

But it is the FAA’s commitments to NextGen, including the Common Support Services – Weather and NextGen Weather Processor programs, which will give air traffic controllers access to more accurate and consistent weather models and increase the quality and quantity of weather information available.

These NextGen initiatives will allow us to better predict, plan and respond — not just react — to weather, and that will provide real benefits for both air travelers and businesses.

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Solving Commercial Aviation’s $27 Billion ‘Weather Problem’
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Today, air traffic managers are required to use human judgment to “interpret” weather conditions and estimate weather’s impact in the U.S. airspace. However, differing technologies, which vary from region to region, limit the controllers’ ability to efficiently manage the flow of air traffic around the day’s weather events, resulting in inconsistencies and delays in information sharing.

NextGen’s weather and automation initiatives will standardize aviation weather products, and consolidate various weather displays to streamline the decision making process while improving strategic planning and tactical operations through decision support tools for maximum benefit.

In relying on these emerging systems, and the training that comes with their use, the FAA’s ability to more effectively plan for weather events with all aviation stakeholders before they occur will mean fewer delays, more efficient routes, less fuel and billions in cost savings each and every year.

NextGen it is not just about time and cost savings. Reductions in fuel use and minutes shaved off thousands of flights through greater efficiencies will reduce CO2 emissions as well, resulting in a healthier planet. The FAA estimates that, in the Washington, D.C. region alone, NextGen will reduce fuel consumption by between 2.5 and 7.5 million gallons each year. That means a reduction of up to 75,000 metric tons of CO2 emissions in our atmosphere annually.

We cannot control the weather. But, through enhanced information sharing, innovative 4-Dimensional weather modeling, improved aviation weather products and our nation’s air traffic managers all operating with a common set of strategic and tactical tools, NextGen can ensure that the next derecho will be much less disruptive to the aviation industry.

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**NextGen Operational Improvements Through Terminal-Centric Airspace Modernization**

The air traffic in the U.S. national airspace system (NAS) is predicted to nearly double by 2025\(^1\). From now through 2025, advanced air traffic capabilities will become operational, supporting what is known as NextGen — the modernization of air traffic technologies and infrastructure to increase efficiency, capacity and safety. This evolution and transformation of the air traffic system is occurring not just domestically, but globally.

As traffic increases, this congestion problem is exacerbated, especially pronounced in the U.S. due to the separation of airspace domains across different automation systems in the tower, terminal and en route. While international air navigation service providers (ANSP) typically have a single system to manage an entire airspace, such as Raytheon’s AutoTrac III in India for the Airport Authority of India (AAI), the U.S. has separate systems, such as the En Route Automation Modernization (ERAM) system, and Raytheon’s Standard Terminal Automation Replacement System (STARS) used to manage the en route and terminal airspace, respectively. Unlike its international equivalents where one system shares all the information and capabilities across different airspace regions, the demarcation of systems in the U.S. creates additional challenges that result in operational inefficiencies between different airspace regions, inefficiencies that are not conducive for efficient operations needed for NextGen.

In order to help the FAA support this predicted growth which results in the need to increase capacity of the NAS, Raytheon is addressing a fundamental problem — congestion in the airspace region after aircraft leave their en route phases of flight, on approach to the airport, through terminal airspace and down to the tower and surface. Congestion of the departure stream must also be addressed in this airspace region. Raytheon calls this airspace region the TCA (terminal-centric airspace).

Today, for example, average delays in the TCA have resulted in three minutes per aircraft on approach\(^2\) at some of the busiest airports around the world. At Atlanta’s Hartfield-Jackson International Airport, the busiest airport in the U.S., this congestion results in, on average, four minutes per aircraft on taxi-in, and about eight minutes per aircraft on taxi-out\(^3\). On average, five minutes of taxi delay results in 80 kg of jet fuel consumed, and three minutes of approach delay (within 100 nm to the airport) results in 120 kg of jet fuel consumed\(^1\).
With roughly 30,000 to 40,000 commercial flights a day in the NAS, the total potential of delays per year caused by these seemingly small minutes of delays at these busy airspace and airports quickly add up to many days’ worth of delays in the NAS, resulting in millions of gallons of excessive fuel burn, which in turn drives up carbon emissions in the hundreds of millions and even billions of kilograms. While delays in the NAS as a whole appear to be currently in check, the projected uptick in capacity will only worsen this congestion problem in the TCA if advancements in capabilities are not applied to current and future automation and decision support tools. Leaving them as separate systems without shared capabilities as well as information will not promote the most efficient ways to improve operations. These new and updated systems must help the airspace user and managers share more timely information and reduce the work load in order to increase operational efficiency, safety and capacity.

Raytheon has a vast global air traffic management footprint, and a profound understanding of both domestic and international automation systems based on a 60 year legacy of industry leadership. Raytheon has a long history of modernizing systems for the NAS, including our STARS automation platform, modernizing management of the terminal airspace and consolidating onto a single platform; and our Digital Airport Surveillance Radar (DASR) where we deployed modern solid state radars in the terminal airspace to replace the aging tube-based radars. Raytheon is working closely with the FAA on development for NextGen, to leverage the technologies and lessons learned from our long-term modernization efforts here in the U.S. and the global deployment of modern automation systems. International automation specifically brings operational expertise of advanced technologies in the area of shared information and capabilities across different airspace regions. This expertise can be applied directly to NextGen to help the FAA design and upgrade systems for efficient operational improvements in the TCA.

**Enabling Capabilities**

On the path to achieving integrated trajectory based operations (TBO*) enabled by NextGen, near-term measures are already being employed, such as optimized descent profiles (globally known as continuous descent approaches) using the navigation performance of the aircraft employing Raytheon’s Wide Area Augmentation System (WAAS) infrastructure capability to fly approaches that save both time and fuel when the aircraft leaves the en route airspace. Also, terminal merging and spacing capabilities and operations are being investigated to enable tighter spacing on approach to save time and fuel. Surface congestion is being addressed through better management of the departure and arrival stream and the optimization of gate push-back times at the airports. Rounding out these efforts is research and development in weather monitoring and prediction to help mitigate the impact of adverse weather, which accounts for over 70 percent of the delays today.

*TBO: flight trajectories optimized for fuel burn, distance and time, against all airspace constraints including weather.
Raytheon’s proven products and technologies provide a strong foundation for the NextGen air traffic control system. For the FAA, the STARS terminal automation platform footprint, which under the Terminal Automation Modernization Replacement (TAMR) contract will likely be in all Terminal Radar Approach Control (TRACON) facilities and towers in the NAS. It can be expanded to integrate capabilities down into the tower and surface, and to expand capabilities up into en route to cover management of the metrolplex and surrounding airspace. Many functions that will further enable operational improvements for NextGen need to occur in the TCA. These include a trajectory modeler that can integrate the arrival and departure flow with that of the airplane trajectory to better meet time requirements at each point in this region. The sharing of flight information among the airports, tower and TRACON will streamline the efficient movement of aircraft from gate push to departure and en route handoff. The reverse flow for the arrival stream using this information will also better coordinate management between the different airspace regions. Many of these capabilities already exist in our AutoTrac III international automation system, which coordinates the airspace management capabilities on one platform, while others are being developed as part of our TCA vision.

Architecture and Infrastructure

The ATM system architecture must be robust, scalable and flexible with the expanding capabilities that will be needed to support NextGen as it evolves toward 2025 and beyond. The system being built today must stand the test of time.

The FAA System Wide Information Management (SWIM) program, along with other telecommunication programs such as Automatic Dependent Surveillance-Broadcast (ADS-B), NAS Voice Switch (NVS) and Data Communications Integrated Services (DCIS), are on course to transform the future of ATM by focusing on architecture and infrastructure to enable interoperability. SWIM will leverage the industry proven system oriented architecture (SOA), shown conceptually in the Figure (right), to build extended interfaces, eliminating the current point-to-point interfaces that limit data sharing and prevent deployment of new capabilities to enhance efficiency and capacity, for both tactical (i.e., terminal) and strategic (i.e., en route) environments.

Current operations rely on the ATM automation providers to create unique decision support tools based on local information to help controllers make safe and efficient decisions. Over the years, new capabilities were introduced building on existing platforms and technologies, but without changing the underlying infrastructure or technologies, resulting in unique, complex platforms, with limited capability for local or remote interoperability. As demand increased over time, and is projected to continue to increase, the pressure for more capacity is driving the need for an architectural and infrastructural change.
Notional high-level SOA-based automation architecture

While some of the systems today may be able to provide adequate assistance to current operations, they were not designed to lend their capabilities or information to other systems that will require them to enable better decision making in the future. As an example, in NextGen, the flight data including the flight plan and trajectory must be readily available to all systems within the NAS; traffic managers, en route controllers and tactical controllers in the terminal and tower environments must all benefit. If not, how can operational improvements in the terminal and on the surface be realized? How can traffic be optimized within the terminal domain where most of the congestions occur? How can the many benefits of trajectory based operations be realized from gate to gate? The key is to build service-oriented interfaces and capabilities that efficiently and securely share information with newly developed systems, and with legacy systems adapted to these interfaces. SWIM enables this evolution.

When information is shared across the NAS, convergence of capabilities may be realized. The focus is no longer on capabilities of specific automation platforms, but rather on integration of services, local or remote, and orchestration of new services providing new capabilities, such as TCA operational improvements. The focus on capabilities and use of SOA also remove platform-specific dependencies on custom infrastructure, operating systems, programming languages and hardware. SOA gives SWIM the ability to truly realize the benefits of integrating useful current day capabilities while integrating future feature sets required for NextGen.

The SOA enabler provides the possibilities of reducing cost by eliminating duplicative functionality across different systems; faster integration of new capabilities; supporting legacy systems through low-cost service adapters; and lowering maintenance costs by permitting specific capabilities to go through upgrade cycles, without involving the entire platform. This infrastructure enables both cost and operational efficiencies necessary to increase efficiency and capacity in our future global airspace.

By establishing the enterprise middleware architecture through SOA, SWIM will pave the way for efficient service architecture for NextGen applications. Raytheon is working with the FAA and Volpe National Transportation Systems Center (part of the U.S. Department of Transportation’s Research and Innovative Technology Administration) on the SWIM Terminal Data Distribution System (STDDS), providing SOA interfaces to legacy tower systems enabling operational improvements for traffic management systems.

While terminal-centric TBOs may still be some time away, Raytheon is partnering with the FAA to establish the automation and advanced capabilities needed to be put in place to enable future operational benefits in the TCA. These includes better flow management in the metroplex airspace, and better merging and spacing capabilities in the terminal that will enable more efficient separation and allow more planes in the arrival and departure stream. These also includes better surface, flight data management and operational real-time schedules in the arrival and departure stream needed in the tower airspace, and better surface and gate management at the airports. To truly realize the operational efficiencies in this traffic stream and to reduce the workloads of controllers, the stove-piped airspace management approach must be eliminated to enable tighter automated coordination between these airspace regions through shared capabilities and information. Consolidating these automated capabilities through TCA will help the FAA, global ANSP, airlines and airports realize operational benefits that translate to fuel savings, emissions reduction, more efficient time and airspace management, and more passenger volume — all part of the NextGen and global ATM modernization mission.

**STARS**

Raytheon’s Standard Terminal Automation Replacement System (STARS) provides a state-of-the-art air traffic control system for managing terminal area airspace for both the FAA and Department of Defense. STARS receives radar data and flight plan information and presents the information to air traffic controllers on high resolution, 20” x 20” color displays allowing the controller to monitor, control, and accept hand-off of air traffic. STARS is capable of tracking up to 1,350 airborne aircraft simultaneously within a terminal area. The system interfaces with multiple radars (up to 16 short- and long-range), 128
controller positions, 20 remote towers, and a 400 by 400 mile area of coverage. The STARS multi-sensor fusion tracker, the only one certified by the FAA for operation in the NAS, is also integrated into En Route Automation Modernization (ERAM) — the automation system used at the FAA’s high altitude en route centers.

**WAAS**

Raytheon’s Wide Area Augmentation System (WAAS) is a safety-critical system that enables the Global Positioning System (GPS) to meet air navigation performance requirements for en route, terminal, non-precision approach and precision approach phases of flight. WAAS’ satellite-based augmentation system provides safe and precise horizontal and vertical approach guidance to all runway ends without any ground equipment at the airport. Raytheon’s system provides reliable, all-altitude navigation signals, even in remote and mountainous areas. This underlying infrastructure is truly the enabler for all GPS-based navigation required for NextGen.

WAAS expands the number of satellite ranging signals to significantly increase GPS navigation system availability. It monitors GPS performance and provides timely warnings to users when unsafe conditions exist to improve integrity. It also substantially increases the accuracy of the GPS and enables precision RNP RNAV operations.

In addition, WAAS provides high integrity navigation signals for non-aviation users such as boaters, precision agriculture, crop dusters, surveyors, vehicle dispatchers and location services, cell phone 911 emergency services, hikers, and other personal recreation uses.

**Raytheon’s AutoTrac III**

Raytheon’s next generation air traffic management system, AutoTrac III (AT3), is now operational at three Indian airports run by Airports Authority of India — Delhi, Mumbai and Chennai — covering three of the four Indian Flight Information Regions. These installations are an important milestone in AAI’s plans for the modernization of India’s airspace in order to accommodate projected levels of growth in the region’s air traffic. AT3 is also on plan for operations in other areas around the world, such as Dubai and Hong Kong, and we are actively working with our customers to ensure success.

The AT3 system is an advanced, cost-effective solution to the challenges facing the ATM community in the 21st Century — traffic growth outpacing revenue growth and the drive to increase capacity and productivity in a cost conscious environment. The AT3 system, with its modern open architecture design and high performance characteristics, is fully adaptable and scalable to any ATM environment, ranging from a simple tower automation application to a fully integrated national multi-center system.

Raytheon’s AT3 system has the features, functions and performance which air navigation service providers require from advanced air traffic management systems. Functions include advanced surveillance data processing, multi-sensor tracking, safety nets, automatic dependent surveillance/controller pilot data link (ADS/CPDLC), flight data processing, clearance processing, monitoring aids (MONA), medium term conflict detection (MTCD), system supported coordination (SYSCO), “stripless” human machine interface (HMI), Electronic Flight Strips (EFS), and much more. The system can support the highest traffic densities experienced in the world’s busiest Area Control Centers.

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2. 03 June 2011 Joint FAA/Eurocontrol Presentation, “Managing Arrival Congestion”, Chen X, Enaud P.
Raytheon’s Weather Solutions to Reduce Delays

Weather accounts for 70 percent of air traffic delays in the U.S. and improving information about weather and weather impact is vital to meeting future demand for air travel; studies have indicated up to two-thirds of weather delays are potentially avoidable. Similar challenges related to weather affect flights across the globe and the financial costs to airlines and other stakeholders can be counted in the billions.

The primary goal of the Next Generation Air Transportation System (NextGen) is to address the needs of the aviation industry for increased capacity, safety and efficiency, including the demand for air traffic services to provide accurate, timely weather information at the temporal and spatial scales required by aviation decision makers.

Raytheon has teamed with AirDat LLC and Metron Aviation to provide a low-risk, cost effective and innovative approach for the Federal Aviation Administration’s NextGen Weather programs. The partnership will help the FAA meet its airspace modernization efforts through better weather information that is assimilated into weather processing systems throughout the National Airspace System (NAS).

The Raytheon team will address two major FAA programs: Common Support Services-Weather (CSS-Wx) and NextGen Weather Processor (NWP). The combined forces of Raytheon, AirDat and Metron Aviation will provide more accurate and consistent weather models, offering common benefits to stakeholders for tactical operations and strategic planning.

“Raytheon’s teaming agreement with AirDat and Metron Aviation positions us to provide the NextGen weather solution set today through innovative and proven technologies that deliver weather benefits to NAS stakeholders and align with the FAA’s NextGen Weather vision,” said Mike Prout, vice president for Raytheon Network Centric Systems’ Security and Transportation Systems. “Collectively, we have proven expertise across the entire CSS-Wx and NWP requirements.”

The Raytheon team’s solutions enable the FAA to accelerate NextGen Weather benefits to system users and achieve many of the far-term objectives envisioned by the FAA through the integration of advanced weather information tailored for aviation users and for use by predictive models, traffic flow management, automation and other FAA decision support tools. The overall objective is to reduce the need for the stakeholders to understand the science of meteorology, and increase the understanding of the impact of weather on operational processes and decisions across the NAS.

Facilitated by more accurate weather information and translation models, the NAS stakeholders are afforded the opportunity to focus on NAS system impacts via the availability of consistent weather data, which positions stakeholders to make more effective, transparent decisions regarding NAS operations. The acceleration of NextGen Weather benefits will help stakeholders improve operational efficiency and, ultimately, save money.

As a world leader in air traffic control systems, Raytheon is focused on developing and delivering air traffic systems and products that significantly improve the efficiencies of the global aviation fleets. Doing so will significantly reduce the amount of fuel used by large aircraft, which also reduces the fleets’ carbon dioxide emissions.

Raytheon has more than 50 years of experience in helping the FAA manage the NAS through systems such as the Standard Terminal Automation Replacement System (STARS), Integrated Terminal Weather System (ITWS), Terminal Doppler Weather Radar (TDWR), Wide Area Augmentation System (WAAS) and many more.
Raytheon has developed the Integrated Terminal Weather System (ITWS) for the Federal Aviation Administration (FAA). It is an air traffic management tool that provides graphic, full-color displays of essential weather information at major U.S. airports.

**Benefits of ITWS**
- Improves the safety, efficiency and capacity of terminal area aviation operations.
- Requires no meteorological interpretation by air traffic personnel, air traffic management systems, pilots and airlines.

ITWS was developed to fill the need of air traffic managers, controllers, and airlines to integrate weather data from a number of sources and provide customers a single, easily used and understood display of support products. The system depicts current and short-term predictions of terminal weather through the integration of data from FAA and National Weather Service sensors and systems, as well as from aircraft in flight. The ITWS program includes development, installation, testing, training, maintenance, and life cycle operational support. The FAA has commissioned 34 operational ITWS to date. Raytheon’s technology is helping to reduce air traffic weather delays and to support collaborative air traffic flow management decision making throughout the National Airspace System.