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NextGen Research Partnerships: Looking Back and Looking Forward

Plenary Talk

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At a recent aviation forum, I began by telling a short story—one that continues to unfold today—a story about aviation and the power of research and innovation. I'd like to begin by sharing that same story with you, about an air traffic jam in the skies over New York City.

In January 1956, an article in Popular Mechanics magazine stated: "Planes were stacked up in every holding pattern around the city, with more roaring in from every direction. They were backed up halfway across the country. Disgruntled passengers in Miami and Chicago grumbled about delays while tense traffic controllers in New York guided all those planes onto cleared runways."

The article looked to research and technology as solutions for safe air travel in the future and a better means of using a limited resource—the crowded space above our heads. Long-range radars would allow controllers to know where the plane is and to follow it from far outside the landing area. Transponders, if installed on commercial planes, were expected to extend the usefulness of radar, easily identifying the plane. And simulations would be used to design new flight procedures. The advent of computers could perhaps quickly and constantly calculate the path that a plane would fly to land safely, at a rate of two aircraft per minute.

Today, research remains critically important to full realization of both NextGen and SESAR. Research and technology must push our air transportation system to the next level, keeping travelers safe, providing more airspace capacity where it is needed, and allowing growth while being mindful of the environment. Forging strong partnerships—among governments, industries, and people—is key to gaining success. To explain, let's begin by taking a walk through recent history and then leap forward to new challenges.

NextGen, like SESAR, was predicated on the challenge of growth. It was a network problem, one where demand was quickly outpacing capacity and the outcome would ultimately bog down the economic system.

In 2003, legislation established the Joint Planning and Development Office (JPDO) within the Federal Aviation Administration (FAA). The JPDO brought together partners from across the US government—the Departments of Transportation, Commerce, Defense, and Homeland Security—together with NASA, the FAA, and the White House Office of Science and Technology Policy—to create the Integrated Plan. The founding charter calls for us to oversee NextGen R&D by:

- Coordinating goals, priorities, and research;
- Facilitating technology transfer; and
- Creating multi-agency roadmaps.

In 2005, bold goals and objectives were laid out in the NextGen Integrated Plan. These goals included:

- Expanding capacity by satisfying future growth up to three times current levels, reducing domestic curb-to-curb transit time by 30 percent, and minimizing weather disruptions to establish a 95 percent on-time rate;
- Ensuring safety;
- Protecting the environment; and
- Ensuring national and homeland defense, and operational diversity.

About the same time, the JPDO established the NextGen Institute (see http://www.ncat.com/ngats/index.html) to insure that industry was fully engaged in the planning. Government and industry experts within working groups envisioned all of the capabilities that might be required to meet the goals for 2025. Hundreds of experts, including myself, gathered together to develop and document the concept. I can tell you that I added everything that I thought I could research for the rest of my career to that vision!

The broad vision moved us from air traffic control to air traffic management. Today, we use radars to separate aircraft. Controllers know the current position, and estimate where an aircraft is going. In the early days, flyers navigated across the country following a series of bonfires. The vision postulated the future based on a concept of trajectory-based operations—separation using 4D trajectories that enable operators to know both current and future positions (intent).

As the experts set the unconstrained vision, we knew that there were many challenges to be sorted out: How much precision? How can we infuse new computing technologies? How much automation?

Key research challenges were identified, and the research houses, including NASA and NOAA, got busy and engaged the help of the best and brightest in academia. Basic algorithms and lab studies were published on human factors, trajectory management, and probabilistic forecasting. Concepts and terminology were being worked with researchers from the FAA and Eurocontrol to harmonize the ideas.

At the JPDO, the concepts were maturing. With the vision outlined, the JPDO developed enterprise architecture to establish connectivity between the many elements of the interagency portfolio.

By 2008, implementation was beginning at the FAA. NextGen was finally becoming real.

In these years, teams from NASA and FAA were bridging the gap from research to implementation using optimal profile descents and 3D Path Arrival Management. Also, the Atlantic Interoperability Initiative to Reduce Emissions (AIRE) brought together partners from the FAA and Europe to demonstrate benefits of oceanic trajectory optimization in fuel savings and emissions reductions. This resulted in synchronization of procedures and technical integration of systems across international airspace. AIRE joint gate-to-gate demonstrations have been expanded and continue as pathfinders even today.

The need for global harmonization is increasing as the initiatives mature. The JPDO's Working Group for Global Harmonization released a comparative assessment of the NextGen and SESAR operational concepts in May 2008. The paper reported that the visions were generally aligned. Differences were noted in some areas, such as weather infrastructure and prediction and modeling, since convective weather is not prevalent in Europe. Expectations were that implementation differences would become apparent once details were added to the concept.

In 2010, the JPDO compared the operational improvements in NextGen and the SESAR Master Plan. We found alignment with the 36 ICAO global plan initiatives. While the mapping was not one-to-one (it was many-to-one), there were no orphans.

That brings us to present time. In the US, transformational programs are well underway at the FAA. Programs like ADS-B, DataComm, and SWIM to name a few. Operators in the Gulf of Mexico are reaping the benefits of new routes made possible by ADS-B. And air carriers such as Southwest, Jet Blue, and UPS are trying out the new technologies.

Looking back at NextGen, our path and partnerships for transformation are clear. Steve Jobs, Apple's CEO, once talked about his career. He commented about how looking back 10 years, the steps along his career path from college drop-out to Apple founder all fit together. But he said, "You can't connect the dots looking forward; you can only connect them looking backwards." To continue to transform air transportation, we must now go forward, facing new challenges and creating robust new partnerships to meet them.

I've got a few thoughts to share as we look at the path forward.

First, innovation fuels growth. Big infrastructure investments often tend to overshadow the research contribution, particularly when budgets get tight. We can't afford to let it deter us from research! But we must make smart choices. For this reason, I've asked the JPDO to take a hard look at the implementation path and the priorities for NextGen in 2025. This will help us prioritize those capabilities where the most mature development and demonstrations are needed. And more importantly, it will let us balance our research investments, keeping an eye on where innovation must be sought for the longer term. I really believe that it is time for the research community to step up and set the foundation for what's next. I think we're a little too comfortable with what we know.

Next, by creating a strong research portfolio, we can maintain some stability for science practitioners during incredibly dynamic times in our world. Events like volcano eruptions, economic downturns, and increasing environmental concerns all influence our original goals. We recently had a discussion at the JPDO about the stability of R&D, given these constant tugs and pulls on competing goals of capacity, safety, security, and environment. We concluded that at the end of the day we're still looking for the most efficient and safe systems possible. Many of the technologies create efficiency whether you're targeting capacity, environment, or security.

Lastly, let's talk about a few things that need to be in the research portfolio.

NextGen is characterized by potential new roles for humans and greater automation. Prior JPDO work showed that current V&V tools and techniques will not be adequate to deal with such a complex socio-technical system. Today's tools make assumptions about the independence of different parts of the system—an assumption that falls apart when you consider the many interdependencies of NextGen components. The tools we have today are also insufficient in dealing with people as an integral part of the system of systems—again a fundamental characteristic of NextGen. Finally, the V&V tools for NextGen must be able to validate the resilience of the system design, something that is beyond today's state-of-the-art.

The JPDO sees V&V as a major risk to long-term transformation. Therefore, our Safety Working Group, a team made up of public and private sector experts, has started planning for a NextGen/Trajectory-Based Operations safety case.

In this seminar, the small set of papers focused on safety methodology rather than safety analyses. Two papers did focus on new methods. I believe the recommendation from the 2009 seminar—to take human factors, organizational aspects, and emergent behavior into account—still holds.

The eight papers on human factors represented a rich and effective use of methods spanning high-fidelity, human-in-the-loop simulations, part task simulations, fast-time modeling, and analytic techniques using existing data sets. I think it is important to point out that human-system integration considerations are addressed in papers, not just in the human factors track but in other tracks such as air/ground integration. This trend is important because it shows that controllers and pilots will continue to have pivotal roles in order to accrue benefits from NextGen and SESAR technologies, and automation. While the mix of equipped aircraft was not given much attention in the human factors track, it was factored into papers in other themes.

The JPDO worked with the FAA and NASA to produce a Human Factors Research Coordination Plan in early 2011. Given the critical role of humans in aviation, the JPDO looks forward to continued progress in human factors.

In the US, weather accounts for nearly 70 percent of all delays. We need to improve the use of weather information in ATM decision-making. The JPDO is committed to working with the ATM users and meteorologists to try to understand accuracy requirements. How much accuracy is needed for aviation applications? Can the forecasts deliver that accuracy?

In this seminar, there were four papers covering “Weather in ATM.” The papers address particular aspects of the four-step process to move from weather information in the “cube” to decision-support tools. Specifically, the four papers covered the middle two steps, weather translation and impact conversion. The research cited in these papers is necessary but it only represents the beginning of the work that must be accomplished.

From the paper sample in this track, the research is mostly point- or sector-specific—it’s not built to take into account factors outside that area. And much basic research will need to be done to develop operational thresholds and constraints in a given weather situation. We then need to convert that “pending impact to the NAS” information into an understanding of how traffic flow management will change, so mitigation action can be taken. This makes me think that we might need a more comprehensive view of the R&D portfolio in areas like weather.

Interoperability is a topic that was not covered in the technical papers. Nonetheless, it is of critical importance as concepts and technologies are developed for NextGen, SESAR, and the world. The JPDO’s Global Harmonization Working Group is developing an interactive roadmap based on the interagency architecture. This will provide a collaborative platform for identifying and informing activities that support effective NextGen interoperability with international stakeholders. This will be accomplished through activity analysis and identification of capabilities that impact global harmonization.

On Tuesday, in my greeting to the seminar participants, I talked about the importance of the recently signed Memorandum of Cooperation between the US and Europe that establishes a binding, basic framework for cooperation in air traffic management research, and outlines our respective tasks and responsibilities. Already, more than 20 specific programs have been identified for action. It provides for the exchange of information, execution of joint analyses, coordination of R&D programs, and projects based on shared effort and exchange of scientific staff. We can now build on the agreement, our years of experience together, and the relationships we've made during this seminar to help lay the foundation for expanding air traffic transformation globally.

To sum it up, partnerships at all levels are the key to making NextGen and SESAR reality. As history has shown us, no one can do it alone. It takes relationships between many people and organizations, and it takes cooperation—scientists working in close partnership with colleagues around the world. That's your part!

I hope you have all learned from this forum, and I wish you safe travels home.