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## **Meeting Summary, September 29, 2011**

### **NextGen Advisory Committee (NAC)**

The September 29, 2011 meeting of the NextGen Advisory Committee (NAC) convened at 9:00 a.m. in the RTCA Headquarters, Colson-NBAA Meeting Room, 1150 18<sup>th</sup> Street, NW, Suite 910, Washington, DC 20036.

The meeting discussions are summarized below. Attendees are identified in Attachment 1, the presentations for the Committee are contained in Attachment 2, the NAC Subcommittee Terms of Reference in Attachment 3, each of the seven recommendations (six documents) approved by the Committee during the meeting are included as attachment 4 and the Chicago Department of Aviation Airport Noise Management System Fact Sheet as Attachment 5.

#### **Welcome and Introductions**

Mr. Dave Barger, President and CEO of JetBlue Airways, and the Chairman of the NextGen Advisory Committee, called the meeting to order and welcomed the NAC members and others in attendance. He stated that the Committee has a “dense agenda” as a result of the hard work of the NACSC led by Co-Chairs Steve Brown and Tom Hendricks, along with the hundreds of other volunteers.

Chairman Barger recognized and welcomed new NAC member:

- John Hickey, Deputy Associate Administrator for Aviation Safety, FAA, who is replacing Peggy Gilligan

All NAC members were asked to introduce themselves. (Attendees are identified in Attachment 1.)

#### **Designated Federal Official Statement**

Designated Federal Official (DFO) Michael Huerta, FAA Deputy Administrator, read the Federal Advisory Committee Act notice governing the open meeting.

## **Approval of May 19, 2011 Meeting Summary and NAC Subcommittee Terms of Reference**

Chairman Barger asked for consideration of the written summary of the May 19, 2011 meeting. The Committee approved the Summary with no revisions or objections.

Chairman Barger asked for consideration of the revised Terms of Reference (TOR) for the NACSC to incorporate the DataComm Roadmap Tasking from the FAA and the establishment of the DataComm Task Group. The Committee subsequently approved the revised TORs (Attachment 3).

### **Chairman's Remarks**

Excerpts from Mr. Barger remarks to the Committee follow:

“I’d like to share some thoughts with you that come to mind as I have reflected on the 54 weeks since I have been working as Chairman of the NAC...

1st, we now have a shared HISTORY:

All of us in aviation share the history of Orville and Wilbur Wright...

We share the history of the first commercial flight operated by Tony Janus in Florida; the advent of radio communications in flight and the birth of RTCA...

We share the history of the modern jet age and what it has meant for the mobility of people and goods around the planet...

More particularly, we jointly shared being invited by the FAA in mid-2010 to join this NextGen Advisory Committee, where the FAA sought an executive-level group to guide NextGen’s implementation...

Next, our group has alignment and a shared desire to see concrete POLICIES move forward at the FAA...

In my individual discussions with most of you, there is consensus that our work must result in FAA policies and actions to take us to the next level – not only acceptance of our recommendations but action...

Next, the NAC has undeniably made PROGRESS, though much work remains...

Each of us believes our mission is to make active, relevant, actionable, data-driven recommendations to the FAA each with a foundation of enhanced safety and increased efficiency towards implementing NextGen...

With our gathering today, we have had four meetings...

Hundreds of industry volunteers, each subject matter experts in their own right, have engaged in the work of the NAC, our Subcommittee, its Work Groups and Task Groups...

In our first full year, we have provided recommendations to the FAA addressing:

1. Near-term priority for regional airspace analysis:
2. User groups and capabilities that should be eligible for equipage incentives:
3. NextGen capabilities that should be considered for implementation and prioritization at the Metroplexes:
4. Business case analysis for NextGen capabilities and performance metrics: and
5. Expanding the use of Special Activity Airspace.

Next, we have a shared view that our work should result in ACTION AND EXECUTION...

The NAC will not only continue to work on its current and future Taskings but we will actively watch to ensure our work is not merely received and filed but rather reviewed, duly considered and acted upon in a manner affecting implementation...

Our Taskings are difficult ones and include difficult transition issues such as Equipage Incentives, Trajectory Operations and a DataComm roadmap...

Next, as I've become immersed in our Taskings, it is apparent that the FAA must PRIORITIZE...

As budget realities come to fruition, things cannot be merely slid to the right...

Decisions must all center around what will actually and meaningfully improve the performance for the industry...

Next, I think of PERFORMANCE METRICS...

The FAA must regain the trust of all stakeholders by holding itself accountable to meaningful, impactful measurements on how decisions impact NextGen's implementation...

Next, as I visit Washington and read the daily stories on budgets, debt and deficits, taxes, fees and cuts, I wonder if our group will need to think of a PLAN-B?..

Should we focus on the what-ifs of funding realities interfering with our consensus-based recommendations?...

Is that our concern or one solely for the FAA?...

I know Michael will share some insight into these possibilities in a moment...

Finally, in closing, a word comes to mind: OPTIMISTIC...

Our work continues despite the headwinds.

54 weeks ago, what drove me to accept the invitation to Chair this advisory committee remains alive and well today . . . and that is knowing I am part of a community of eager, willing and expert aviation partners who each desire and are willing to work for a better and safer future...

I am confident that the Administration and both houses in Congress support our work and our shared mission...

I look forward to visiting members of Congress with each of you to push for continued and strengthened support...

I close by asking you to remain optimistic, remain engaged and to double down on your investment of time both personally and with your organization...

Recently, our colleague Lee Moak reminded me that as we seek safer and more efficient skies, this shouldn't be that hard...

Lee is right – it shouldn't be and I urge each of you to continue your work on recommending the best paths forward for the FAA to follow..."

### **FAA Report – Mr. Huerta**

Excerpts from Mr. Huerta remarks to the Committee follow:

"Thank you, Dave (Barger). And thank you, all of you, for the hard work you have done in preparing for today's meeting. I look forward to a productive discussion today..."

First, I would like to provide an update on some current developments and how they affect our operation at the FAA and NextGen...

As you know, we recognize that we need to change the FAA internally to best serve the future needs of our nation's air transportation system. This means realigning some functions in order to better handle the enormous transformation to NextGen...

Congress approved the reprogramming request we submitted this summer to change our reporting structure and implement other organizational changes. This is a critical step in moving forward with the changes that will lay the foundation for our success as an agency in the next 15 years...



The reprogramming approval allows us to create a NextGen office that will report to me. And it allows us to create an Assistant Administrator for NextGen. I'm very pleased that Vicki Cox is serving in this position. Together, we are setting the strategic direction for NextGen and continuing to raise NextGen's profile within the FAA and within the aviation community. While much of NextGen involves the air traffic control function, it also involves much more than that and needs the involvement and focus of every FAA office going forward...

Our reprogramming request for the Joint Planning and Development Office was not approved. In their response, the appropriations committees said they supported the mission and goals of the JPDO but were not supportive of our proposed approach. Instead, they said the JPDO would be addressed through the appropriations process. We share Congress' support for the JPDO's mission and are especially supportive of the work of Dr. Karlin Toner and her team on NextGen. We will be working with Congress to resolve how best to address the JPDO's organizational structure...

Congress did, however, support our proposal for how we handle large programs. We are creating a Program Management Office within the Air Traffic Organization to better manage our major acquisition programs effectively. That includes NextGen acquisitions. Currently, air traffic acquisitions managers are embedded in different offices. ..

They will now all be in one place. These changes will help us to better coordinate the evolution of our air traffic control system as we embrace NextGen...

We have a new way of doing business and this advanced technology is going to improve our aviation system. But in a certain sense flying is very simple. As they say, it only takes two things to fly -- airspeed and money...

To that end we are continuing to work for a multi-year reauthorization for the FAA. This month, we avoided a repeat furlough of nearly 4,000 FAA employees. We have been reauthorized until the end of January. But this is our 22<sup>nd</sup> short-term reauthorization. The FAA needs longer-term funding to better plan improvements that will help us to maintain our system as the largest and safest aviation system in the world...

We are working on many fronts to secure the funding that we need to deliver the policies, the procedures and infrastructure that will take us into the next century of flight...

President Obama recognizes the importance of maintaining our infrastructure and the economic good that comes from putting people back to work on these projects...

The American Jobs Act proposes a \$50 billion immediate investment in construction jobs to rebuild America's airports, roadways, railways and transit systems. It will put

people to work restoring 150 miles of runways, upgrading 150,000 miles of road and improving 4,000 miles of train tracks...

As part of this infrastructure investment, the Act includes \$1 billion to conduct research and development to advance NextGen...

And it proposes \$2 billion for airport improvements – runways, taxiways, aprons, terminals and noise mitigation – above and beyond monies in the regular AIP program...

You've also heard talk of a National Infrastructure Bank. The American Jobs Act proposes a bank with \$10 billion in upfront funding. The bank would operate independently and issue loans and loan guarantees emphasizing two criteria: how badly a project is needed and how much good it would do for the economy. Airport projects and air traffic control systems would be eligible...

We are encouraged by these proposals...

President Obama has also called for a new air traffic system fee as part of his deficit reduction efforts...

I want to explain a little bit about this...

This new fee establishes a \$100 per-flight surcharge to be used for airport investments and air traffic control costs...

Approximately \$11 billion in revenue would be generated over a ten-year period. Most general aviation aircraft are exempt from paying this user fee – more than 80 percent would not have to pay it...

Establishment of this fee would help address current inequities in the costs of operating the air traffic control system...

While I understand there is opposition to this proposal, these are difficult times and the deficit is a serious problem. We are all being asked to do our part...

In the meantime, Congress is in the midst of the 2012 budget process. The President has asked for more than \$18 billion to run the FAA and he is very supportive of NextGen...

Now what this committee is helping us do today is ensure that we pick the correct course of action to enhance our aviation system. You are helping us navigate the many options and chart a course to produce the best results from our investments...

I want to acknowledge that this committee has done an incredible amount of work to come up with the recommendations today...

I recognize that at this time last year, we gave all of you a large volume of complex tasks and asked for your input in a relatively short period of time...

I want to thank you all—those who worked on the committees, subcommittees and workgroups—for your dedication to this process. I look forward to hearing the recommendations today and having a good dialogue...

Thank you..."

During discussion following Mr. Huerta's remarks, several Committee members expressed concerns with the administration's proposal for a per flight fee. Other observations made included statements from NAC Members that:

"When looking at NextGen, the word "scenario" comes to mind. Rarely is there one path to the destination, and we need to look at different and alternative scenarios."

"The NAC proposals being approved doesn't mean that the work is complete..."

"In approving something, the FAA needs to be nimble and flexible in how it is implemented..."

"The aviation community should be proactive in its spectrum of outcomes if cuts are made in FAA's budget..."

"The United States is not an island, other countries are facing similar issues and dialogue should continue in the international arena..."

"Important to understand the meaning of NAC recommendations to the public, Congress, etc..."

Global harmonization is important.

### **Subcommittee Report: NAC Subcommittee & Work Groups**

Chairman Barger introduced NAC Subcommittee (NACSC) Co-Chairs Steve Brown, National Business Aviation Association and Tom Hendricks, Air Transport Association, who provided an overview of NACSC activities that served as an introduction to the recommendations discussed later in the meeting.

Mr. Hendricks pointed out that the NACSC has helped focus the efforts of the Work Groups and Task Groups to shape the deliverables for consideration by the NAC in response to the Taskings from the FAA. Mr. Brown explained that the NACSC has followed an aggressive work plan to meet the NAC schedules during the last year, but it is important for the upcoming second year of the NAC that more time is allowed to provide deeper analysis and discussion for developing recommendations.

In response to a question about how the NACSC and Work Groups have addressed gaps in skill sets, Mr. Brown explained that Subject Matter Experts are called upon and that the skill sets and mix of participants are regularly reviewed. In reply to a related question, Mr. Hendricks emphasized that individuals that are participating should be able to speak for their organizations.

A member of the NAC commented that Facilities and Equipment investments should be expedited and that the recommendations should help make the case in support of FAA budget requests and investment priorities. Another NAC member expressed the need for identifying the policy and financial implications on what is needed to do more.

A discussion occurred among NAC members about the challenge of needing data for decision making, but the recognition that it is not always readily available. However, it was emphasized that it is essential to base recommendations on available analysis and data. It was also pointed out that transparency is vital for whatever decisions are made in developing recommendations.

Chairman Barger acknowledged the work of the “standing” Work Groups, including the leaders and the specific names shown below:

#### **Airspace and Procedures**

- Bob Lamond, Director, ATS & Infrastructure, National Business Aviation Association
- Bill Murphy, Director, ATC & Airfield Operations, US Airways

#### **Business Case & Performance Metrics**

- Ed Lohr, Director, Fleet Strategy, Delta Air Lines
- Debby Kirkman, NextGen Performance Integration Lead, The MITRE Corporation

#### **Integrated Capabilities**

- Chris Oswald, Vice President, Safety & Technical Operations, Airports Council International
- Sarah Dalton, Director, Airspace & Technology, Alaska Airlines

#### **DataComm Task Group**

Ms. Jenny provided a brief review of the recent tasking from the FAA to develop a roadmap for Tower and domestic En Route DataComm services and associated technologies. The Group is being Co-Chaired by Steve Dickson, Delta Air Lines and Forrest Colliver, The MITRE Corporation, who are leading the Task Group in developing a response to a revised Tasking letter delivered by Mr. Huerta to RTCA at the NAC meeting. The initial tasking was revised in response to concerns about the Task Group’s work related to the on-going DataComm procurement underway by the FAA.

Following the briefing, several Committee members stated their view that harmonization of DataComm roadmaps is important. One Committee member pointed out that The Boeing Company and Airbus are in alignment about their views on DataComm and their position that autoland capability of the Flight Management System should be required. Another member stated that they welcomed the formation of the Task Group to provide consensus recommendations on those points, pointing out that the US and the Europe can't afford different solutions, but could have different priorities. Another Committee member reinforced that providers of avionics can't afford a divided approach.

Chairman Barger concluded the discussion by committing to further discussion on this significant policy issue.

### **Consideration of Reports and Recommendations**

The Committee received a series of briefings on individual documents containing specific recommendations and actions developed by the NAC Equipage Ad Hoc and NACSC for NAC consideration.

After discussion, the Committee approved six recommendations in the following areas, each of which are covered in detail below.

- **What Types of Incentives Should Be Used to Equip for NextGen?**
- **NextGen Equipage: User Business Case Gaps**
- **Measuring NextGen Performance: Recommendations for Operational Metrics and Next Steps**
- **Recommendations for Implementing Trajectory Operations in the Mid-Term (2011-2018)**
- **Findings and Recommendations: Metroplex Prioritization and Integrated Capabilities Scoping & Requirements**
- **Recommendations for Enhancing Operations in Specific Regional Airspace**

#### **What Types of Incentives should be used to Equip for NextGen?**

NAC Member Ed Bolen, chair of the NAC Equipage Ad Hoc Task Group, outlined the recommendation on incentives that could be used for aircraft equipage. He explained the Phase One recommendations that identified three aircraft capabilities (RNP/WAAS for light GA, ADS-B Out, and DataComm) to be deployed in a specific regional area (Boston-New York-Washington DC –Chicago).

The second phase examined the incentives necessary for closing the business case. The BCPMWG conducted much of the analysis used to develop the recommendation.

For economic incentives, the aviation industry prefers direct grants over a loan program, but recognizes that this may not be realistic in the current economic environment. With that understanding, a public-private loan guarantee program is the most feasible financing

instrument for encouraging timely NextGen equipage investments on the part of the operators.

Mr. Bolen stated that the group summarized the benefits of the three capabilities packages as follows:

- Package 1 benefits the individual users in the near term
- Package 2 (ADS-B Out) benefits the FAA, and
- Package 3 (DataComm) benefits the users and the whole National Airspace System

Mr. Bolen emphasized the view of the Ad Hoc that the essential success criterion of any government financial incentives program is that those incentives achieve their intended *operational* outcome. It is imperative that each financial incentive has a clearly defined performance improvement target metric that will dictate when the operator would be required to begin paying back the loan.

The recommendation also recognizes that U.S. government aircraft (i.e., DoD) operators are not typically eligible for public-private partnerships and function under a different business case analysis. These operators also compete with overall federal spending priorities for NextGen investments.

Several Committee members offered comments about the challenge of incorporating any non-equipped aircraft in a mixed-equipage environment, e.g. foreign carriers, certain regional aircraft or GA operators. One member also suggested that ground-based infrastructure could be an important solution to some of these challenges. There was a robust discussion about this issue with one Committee member concluding that this is really an evolutionary approach and incentives help to bring about the full implementation end state.

Committee members expressed enthusiasm over the potential benefits of new technologies, but emphasized the need for the government to deliver capabilities and the alignment of incentives with requirements to make investments. Mr. Huerta commented that it is beneficial and important to recognize the difficulty in making these decisions and the group's challenge to prioritize these choices.

**Committee Action:** The Committee agreed by consensus to approve the recommendation (Attachment 4) for submission to FAA that endorses the use of a public-private loan program with specific measurements/triggers based on availability of NextGen capabilities and request additional work on developing operational incentives.

### **Equipage Ad Hoc Task Group and Business Case & Performance Metrics Work Group Gap Assessment**

Mr. Hendricks discussed that the BCPMWG had provided important analytical support by examining the business case and gaps for the three previously mentioned aircraft equipage packages identified as key foundational infrastructure for NextGen capabilities. He also

explained that financial payback was the primary business case closure criterion used for commercial operators and high-end GA (turbine and jet aircraft) of 2.5 and 5 years, respectively. Maintaining airspace access and mission accomplishment was the primary criteria for the military. Low-end GA (piston aircraft) placed importance on the affordability of aircraft equipage and access as a relevant non-financial consideration. The research also found that the NAS-wide operator business case does not close for any of the targeted capabilities for 100% of aircraft in the relevant user groups, due to one or more of the following:

- The high cost of equipping some aircraft, particularly older aircraft.
- Uncertainty about the magnitude of anticipated benefits accruing to equipped users.
- Uncertainty about future FAA capability implementation plans by specific time and location, compounded by the uncertainty of funding.

The recommendation includes two conditions that warrant government financial and/or operational incentives: (1) achieving a minimum percentage of equipage to be able to deliver operational benefits; and (2) equipping the most expensive aircraft when operational benefits cannot be achieved without 100% equipage.

Mr. Huerta stated that the Ad Hoc and the BCPMWG had done good work and it is important to continue building the compelling case for incentives. He also pointed out the need for specificity such as, "What is the appropriate time frame for acting on incentives?" This was responded to by several NAC members that the FAA will need to provide more specifics in its follow-on request to enable the Committee, its Subcommittee and Work/Task Groups to provide additional detail in the future recommendations. There was general agreement that this is an appropriate way to proceed with the Committee, agreeing that once the specific regions and capabilities are identified, more specific recommendations can be developed on which operators and aircraft should be incentivized.

Recognizing the uniqueness of incentives for DoD aircraft, at the request of a Committee member, the NAC also agreed to refine the wording related to incentives for government aircraft.

**Committee Action:** The Committee agreed by consensus to approve the recommendation (Attachment 4) for submission to FAA with an editorial change requested by the DoD Committee member clarifying the limits of DoD not necessarily being at 100% equipage in a given area. The recommendation identifies the parameters of the business case for economic and operational incentives.

### **Chicago's O'Hare Community Noise Monitoring Program**

Committee member Arlene Mulder, Mayor, Village of Arlington Heights, IL, was recognized by Chairman Barger to provide a brief description of long-term efforts by the City of Chicago and the surrounding communities to implement its Airport Noise Management System. Mayor Mulder stated that the program has been important in reducing the impact if the airport's operations on the community. A Fact Sheet is contained in Attachment 5.

## **Measuring NextGen Performance: Recommendations for Operational Metrics and Next Steps**

Mr. Brown introduced the BCPMWG recommendations for the FAA's planned NextGen Dashboard that will report on the operational improvements towards NextGen goals. He pointed out that based on the diversity of stakeholder perspectives, a suite of metrics is needed; no single metric can capture NextGen impacts. The recommendations also ask the FAA to include reducing fuel burn and flight operating costs, maintain or improve access to airspace and airports for all stakeholders and support mixed capability operations when describing NextGen goals.

A Committee member expressed a concern that too many metrics could be a problem with really defining what is critical. During the discussion, BCPMWG Co-Chair Ed Lohr clarified that fuel burn data is not available on flight-by-flight basis. Another Committee member raised the importance of determining how to measure constraints on a flight and the aviation system response.

During the discussion about metrics, the NAC expressed its desire that the BCPMWG continue its work by refining the metrics recommendation to identify a smaller number of metrics (approximately five) that capture an overall status of NextGen implementation. The intent for the Metrics is to measure improvements in the PERFORMANCE of the air traffic management system as a result of the implementation of NextGen components, not to measure FAA programmatic milestones or deployment of infrastructure.

Finally, one of the Committee members recommended that the BCPMWG obtain information on an upcoming European developed paper, "What is the most cost effective change from first-come, first-served policy?"

It was also agreed that there is more work to do before all of the recommendations can be acted upon by the FAA and that the FAA could respond with additional Taskings to complete this work.

**Committee Action:** The Committee agreed by consensus to approve the recommendation (Attachment 4) for submission to FAA. The BCPMWG is also being requested to identify a smaller number of metrics (approximately five) that capture an overall status of NextGen implementation.

## **Recommendations for Implementing Trajectory Operations (TOPs) in the Mid-Term (2011-2018)**

Mr. Brown explained the background of air traffic operations that have progressed to the point of beginning the use of trajectory-based operations. Addressing this important element of NextGen future operations, the NAC considered recommendations from a Task Group that was established to develop industry comments on FAA's Mid-Term Operational Scenarios related to TOPs mid-term (2011-2018) operational concepts and scenarios. In addition to these comments, the TOPs2 Task Group recommended that once the FAA has addressed



the TOps2 recommendations, that the FAA “baseline” the Operational Scenarios, distribute these to the aviation industry and update them in the future with input from aviation stakeholders. The TOps2 document also prioritized the Operational Improvements (OI’s) contained in the FAA NextGen Implementation Plan needed to implement Trajectory Operations capabilities.

**Committee Action:** The Committee agreed by consensus to approve the recommendation (Attachment 4) for submission to FAA that provides important industry views and comments for the mid-term implementation of TOps. The Task Group will sunset having completed its tasking.

After the approval of the TOps2 recommendation, Chairman Barger recognized the hard work of the TOps2 Task Group and the leadership of Dan Earman of Lockheed Martin and Rick Shay of United Airlines.

### **Findings and Recommendations: Metroplex Prioritization and Integrated Capabilities Scoping and Requirements**

Mr. Hendricks explained how the ICWG developed criteria for selecting Metroplex sites. (A Metroplex is a geographic area covering many airports, serving major metropolitan areas with a diversity of aviation users and aircraft operators.) The criteria include a Tier One level of Operational Need, Benefits and Feasibility. Within each of these, specific Tier Two metrics have been identified. Operational Need includes Delays, Operations, Efficiency, Complexity, Metro Connectivity and Metroplex Factors. Benefits cover Safety, Operational and Community Benefits, and Operational Cost. Feasibility Metrics are Capability Assessment, Metroplex Considerations and Other Considerations.

In discussing the recommendations, Mr. Hendricks stated that the next step for the ICWG is mapping integrated capabilities for individual Metroplexes. Doing so enables a more reliable assessment of the benefits and feasibility of these capabilities, which are site specific. This work will be completed by the next NAC meeting in February 2012.

**Committee Action:** The Committee agreed by consensus to approve the recommendation (Attachment 4) for submission to FAA that provide Metroplex prioritization criteria and operational improvements linked to enhance Metroplex operations.

### **Enhancing Operations in Specific Regional Airspace Enhancing Operations in Specific Regional Airspace of the National Airspace System**

Mr. Hendricks provided a brief history of the aviation community’s role in providing recommendations that assist the FAA in making enhancements to aviation operations in specific areas. He then explained the seven recommendations to address operational enhancements developed by the APWG. These included requesting the FAA to validate the safety and capacity benefits of RNAV Off the Ground as part of the Agency’s implementation process.

Mr. Huerta then led a short discussion about the clearly tactical, local nature of the work of the APWG, which is different from the rest of the recommendations the NAC considers. He acknowledged that this work is extremely valuable for the FAA to do its work well. It was agreed to continue to do this work within the NAC structure.

**Committee Action:** The Committee agreed by consensus to approve the recommendation (Attachment 4) for submission to FAA.

Upon completion of the Committee's consideration of the recommendations, Chairman Barger commended Mr. Brown and Hendricks for a "job well done". Mr. Huerta also expressed his thanks to them as well for driving to conclusions and recommendations.

### **Other Business/Anticipated Issues for NAC Consideration and Action at February 3, 2012 Meeting**

Chairman Barger provided a brief overview of 2012 actions that will be considered by the Committee at its next meeting:

- Performance Metrics
- Metroplex Mapping
- DataComm
- Equipage Incentives (pending FAA response)

There was no new business.

### **Adjourn**

Chairman Barger closed the meeting of the Committee at 3:05 p.m.

### **Next Meeting**

The next meeting of the NAC is February 3, 2012, Daytona Beach, FL at Embry-Riddle Aeronautical University.



## NAC September 29, 2011 Meeting Attendance

<b>NAC Members</b>		
<b>Last Name</b>	<b>First Name</b>	<b>Organization</b>
Baer	Susan	The Port Authority of NY & NJ
<b>Barger</b>	<b>Dave</b>	<b>JetBlue Airways</b>
Bolen	Edward M.	National Business Aviation Association
Carbary	Sherry A.	The Boeing Company
Cox	Vicki	Federal Aviation Administration
Esposito	Carl	Honeywell Aerospace
Fuller	Craig	Aircraft Owners and Pilots Association
Gray	Robert	ABX Air
Grizzle	David	Federal Aviation Administration
Harris II	John D.	Raytheon Technical Services Company LLC
Hickey	John	Federal Aviation Administration
Huerta	Michael	Federal Aviation Administration
Jenny	Margaret	RTCA, Inc.
Ky	Patrick	SESAR Joint Undertaking
McMillan	David	Eurocontrol
Moak	Lee	Air Line Pilots Association
Mulder	Arlene	Village of Arlington Heights
Rankin	James	Air Wisconsin Airlines Corporation
Rinaldi	Paul	National Air Traffic Controllers Association
Sinha	Agam	The MITRE Corporation
Williams	Brett	United States Air Force
Cebula	Andy	RTCA, NAC Secretary
Brown	Steve	NBAA (Co-Chair NACSC)
Hendricks	Tom	ATA (Co-Chair NACSC)



## NAC September 29, 2011 Meeting Attendance

<b>Non-NAC Member Attendees</b>		
<b>Last Name</b>	<b>First Name</b>	<b>Organization</b>
Baldwin	Bryan	JetBlue Airways
Baun	Chris	ALPA
Benich	Chris	Honeywell
Bertapelle	Joe	JetBlue Airways
Brown	Cyndy	RTCA, Inc.
Calet	Alicia	Raytheon
Carey	Bill	AIN
Cassidy	Shawn	ALPA
Challan	Peter	Harris Corporation
Clark	Patty	Port Authority NY & NJ
Crowley	Daniel	Raytheon
De Leon	Ben	Federal Aviation Administration
Diana	Tony	Federal Aviation Administration
Egan	Kevin	GAO
Fearnsides	Jack	MJF Strategies
Garvin	Michael	NextGen Institute
Gilbert	Patricia	NATCA
Glennon	Ray	NOBLIS
Hagy	Keith	ALPA
Hawkins	Ron	ARINC
Heinrich	Rick	Rockwell Collins Inc.
Heinsius	Jon	Intermap
Hennig	Jens	GAMA
Hockenbury	Allen	Deloitte
Keegan	Charles	Raytheon
Kenagy	Randy	Raytheon
Kirkman	Debby	The MITRE Corporation
Kuha	Megan	Beacon Management Corporation
LaMarche	Ronald	The Boeing Company
Lohr	Ed	Delta Air Lines



## NAC September 29, 2011 Meeting Attendance

Lowry	Joan	AP
McKinley	Eric	Accenture
Miner	Cheryl	Federal Aviation Administration
Mohler	Gisele	Federal Aviation Administration
Narvid	Juan	DOD
Oswald	Chris	Airport Council International NA
Planzer	Neil	The Boeing Company
Ramadani	Almira	Federal Aviation Administration
Rocheleau	Chris	Federal Aviation Administration
Romanowski	Mike	Office of The President
Ryals	Lillian	MITRE
Sears	Bill	Beacon Management Corporation
Shellabarger	Nan	Federal Aviation Administration
Spurio	Kip	Federal Aviation Administration
Stothard	Greg	Deloitte
Sypniewski	Jessica	Federal Aviation Administration
Takamora	Paul	Federal Aviation Administration
Tedford	Ann	Federal Aviation Administration
Tomblyn	Neal	LMCO
Tuttle	David	GDIT
Vallin	Travis	Jviation
Wells	Michael	Federal Aviation Administration
White	Beth	Federal Aviation Administration
Williams	Heidi	AOPA
Young	Ray	Saab Sensis
Zogg	Andy	Raytheon

## TERMS OF REFERENCE

### NextGen Advisory Committee Subcommittee (NACSC)

#### Subcommittee Leadership:

Position	Name	Organization	Telephone	Email
<b>Co-Chair</b>	Steve Brown, Sr. Vice President, Operations & Administration	National Business Aviation Association	(202) 783-9350	sbrown@nbaa.org
<b>Co-Chair</b>	Tom Hendricks, Sr. Vice President, Safety, Security & Operations	Air Transport Association	(202) 626-4240	thendricks@airlines.org
<b>Secretary</b>	Cyndy Brown	RTCA	(202) 330-0655	cbrown@rtca.org

#### Background

NextGen offers the United States the unprecedented opportunity to increase the safety, predictability and environmental performance of aviation. By establishing the NextGen Advisory Committee (NAC)<sup>1</sup> in September 2010, the FAA has established an ongoing venue and process to enable stakeholders to advise the FAA on issues related to near- and mid-term implementation by providing a shared vision of NextGen for domestic and international arenas. The NAC Subcommittee will support the NAC as defined in this Terms of Reference.

#### Purpose and Scope

The purpose of establishing a subcommittee of the NAC is to support the NAC in developing consensus-based recommendations to the FAA on issues related to NextGen implementation. A requirement is an understanding of overall NextGen operational capabilities and implementation constraints, with an emphasis on the near- and mid-term (through 2018). The Subcommittee will represent the same stakeholder groups as the NAC (defined below).

Specifically, the Subcommittee supports the NAC by providing a group of experts on operations, finance, FAA plans and programs, and technologies that are critical to the successful implementation of NextGen. In essence, the Subcommittee will provide the staff work for the NAC, applying knowledge and expertise to forge consensus on critical issues and providing input to the NAC for public deliberation and decision to forward to the FAA. In conducting its work, the

<sup>1</sup> See [www.rtca.org](http://www.rtca.org) to view a copy of the Terms of Reference for the NAC

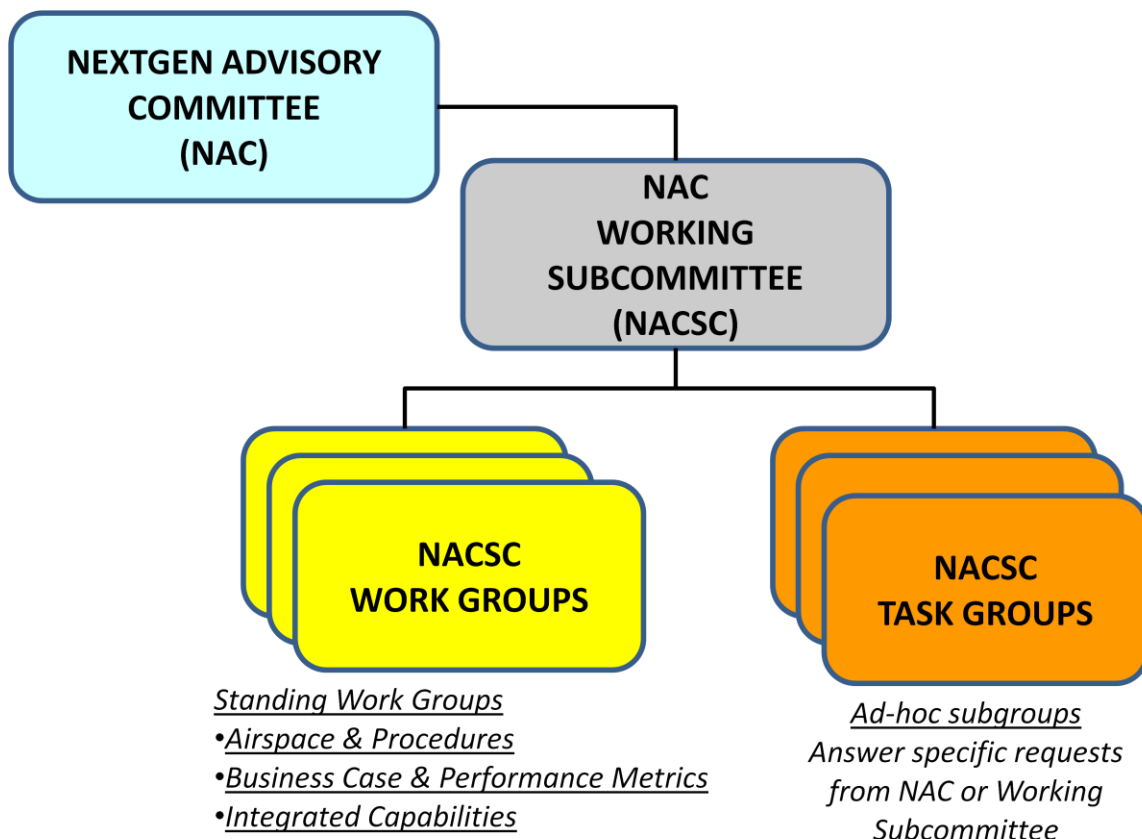
Subcommittee will help the NAC in fostering a common understanding of success with joint performance objectives and development milestones to be reviewed as implementation progresses. The primary focus is on implementation issues, including prioritization criteria at a national level, joint investment priorities, location and timing of capability implementation and recommendations for new or revised policies aimed at facilitating the timely delivery of NextGen benefits.

Finally, the Subcommittee plays an important role for the NAC in providing a venue for the FAA as well as industry partners to report on progress on the implementation of NextGen operational capabilities and associated airspace performance improvements under the umbrella of the Federal Advisory Committee Act.

**Committee Structure**

The NAC Subcommittee will obtain its tasking from the NAC, and will utilize the subordinate Work Groups to develop detailed recommendations. The structure is depicted below.

**NAC and Associated Structure**



- **NextGen Advisory Committee (NAC)**
  - Overall direction of Committee
  - Review and approve recommendations to FAA
  - Field requests from FAA
  - Review and approve creation of Work Groups, as appropriate
  - Meet three times per year in Plenary (open to public)
  - Direct work of Subcommittee
  
- **NAC Subcommittee (NACSC)**
  - Staff to Advisory Committee
  - Develop TORs, review work of WGs and TGs, present findings to NAC
  - Meet bi-monthly or as needed
  - Forward recommendations and other deliverables to NAC for consideration
  
- **NACSC Work Groups and Task Groups**
  - Created to address specific Taskings
  - May be short-term or standing activities
  - Forward recommendations and other deliverables to NACSC

### **Operating Guidelines**

The Subcommittee will tackle issues as directed by the NAC. If in the conduct of their work, the Subcommittee feels it would be beneficial to provide advice to the FAA on other topics, they may request that the NAC task them to develop those recommendations and bring them to the NAC. Subcommittee meetings are not open to the public.

### **Subcommittee Representation**

The NAC Subcommittee membership will represent the following stakeholders:

- Air Traffic Management Automation Providers (automation, infrastructure and system engineering)
- Aircraft Manufacturers (Air Carrier, General Aviation, Military)
- Airports
- Avionics Manufacturers/PBN procedures
- DoD
- Environmental Interest
- FAA
- FFRDC
- Finance
- International
- Labor
- MITRE
- Operators: Air Carriers, General Aviation/Business Aviation
- RTCA
- TSA



## **Subcommittee Membership**

Membership on the NAC Subcommittee is weighted toward those who not only operate in the system, but will have to make critical investment decisions as we move toward NextGen. The NACSC will utilize a combination of one-year and two-year terms for the initial appointments and have two categories – Members and Observers.

**Members:** As with the NAC itself, members of the NACSC must be able to speak for and commit their organizations to the consensus of the committee, and have working knowledge and expertise of the FAA, the NextGen programs, technologies and operations. Members have full voting rights (see exceptions below). Members are expected to be present at all meetings. Their designated Alternate may attend no more than twice a year. Co-chairs will review committee structure annually and take committee participation into account for ongoing membership.

**Observers:** In an effort to maintain an appropriate balance between operators and providers, there is a rotating membership for these two stakeholder groups designed to maximize opportunities for participation. The rotating categories are (1) automation, infrastructure and system engineering providers and (2) avionics manufacturers and developers of Performance-Based Navigation procedures. While restricted from voting, observers have access to deliberations of the Working Subcommittee, may attend meetings and provide comments for consideration and entry into the record of the meeting.

Four ATM and three Avionics/Procedures companies are selected to serve the first term on the Subcommittee as Members. Individuals from organizations not selected for the current term will be given “observer status”, enabling the selected individual from that organization access to deliberations of the NACSC and time permitting, to provide comments for consideration and entry into the record of the meeting. In future years there will be an agreed upon rotation to provide opportunities for Observers to serve as a Member of the Subcommittee.

Observers are expected to be present at all meetings. Their Alternate may attend no more than twice a year. Co-chairs will review committee structure annually and take committee participation into account for ongoing membership.

**Alternates:** One designated Alternate for a Member or Observer can be identified by submitting a single person for approval by the NAC Subcommittee co-chairs, to serve the same term as the member. Like a Member or Observer, an Alternate is selected based on their knowledge, experience, position in their company and ability to speak for and commit their organization to the consensus of the group. A designated Alternate can attend in place of a Subcommittee Member or Observer, but not more than twice a year.

**Non-voting Members:** FAA (Air Traffic Operations, Aviation Safety, Airports, and Policy and Environment), MITRE and RTCA are non-voting members of the Subcommittee. They will take part in the Subcommittee’s deliberations and provide input to final products; however, they do not represent affected user groups in reaching consensus.

All participants on the NACSC, regardless of position, are expected to keep their organization’s representative on the NAC (if applicable) informed of the NACSC work.

## **Work Groups**

Work Groups will be established as outlined below. The Subcommittee and the Work Groups may need to establish Task Groups to accomplish specific, shorter term tasks. WG products—including recommendations, where appropriate—are presented to the NAC Subcommittee for review and deliberation, and if so directed by the NAC, presented to the NAC for consideration at its public meetings. Members of Work Groups and Task Groups will be appointed by the NAC Subcommittee Co-chairs in consultation with the RTCA President and NAC Chairman and DFO. Work Groups and Task Groups meetings are not open to the public.

The NACSC will approve Terms of Reference for each Work Group defining the objective, scope, membership, specific tasks and deliverables with a schedule. Unlike the NAC and the Subcommittee, members of the Work Groups and Task Groups do not represent a particular affected entity and are selected for their expertise in the subject matter rather than their affiliation. Work Groups develop draft recommendations for consideration by the NAC Subcommittee. Annually, Terms of Reference for Work Groups and Task Groups must be reviewed and updated as appropriate. Work Groups and Task Groups, unless specifically noted otherwise in the Terms of Reference, will terminate upon delivery of their recommendations.

## **NACSC Meetings**

The NACSC will, at a minimum, meet every other month, with seven to eight (7- 8) meetings planned for 2011. Because the Subcommittee and its associated Work Groups are not Federal advisory committees, its meetings are not required to be open to the public; nor can the Subcommittee make recommendations directly to the FAA. While not required, some meetings of the NAC Subcommittee might be open to the public to provide an early opportunity to identify potential concerns associated with draft recommendations.

## **NACSC Work Groups**

Three Work Groups are being established under the NAC Subcommittee to support the development of recommendations for the FAA. The following outlines the scope of the Work Groups:

### **Airspace & Procedures**

- Performance-Based Navigation implementation and associated redesign of Airport, Terminal and Metroplex airspace to enhance efficiency of airport traffic flows
- All aspects of implementing new procedures and modifying airspace to deliver operational benefits
- Strategy for reduced separation and/or wake vortex standards to take advantage of Closely-Spaced Parallel Runways
- Parallel work with the FAA/Industry Collaborative Decision Making (CDM) team accomplishing implementation of surface management systems Surface CDM Deployment Team (SDT)

### **Business Case & Performance Metrics**

- Financial aspects of NextGen capabilities
- Analysis
- Performance Metrics
- Cost/Benefit/Risks of capabilities

**Integrated Capabilities**

- Delivering benefits-yielding operational capabilities, including capabilities at each Metroplex, between Metroplex/city pairs and in the en route airspace
- Applications for ADS-B, DataComm, SWIM, other NextGen foundational elements as specified in the FAA’s 2011 NextGen Implementation Plan and Enterprise Architecture
- Integrated CNS/ATM – Surface, Runway, Metroplex, Cruise, Pre-flight applications
- Interface with Metroplex Optimization of Airspace and Procedures work efforts, including how these operational changes integrate with other improvement efforts across all domains (e.g. surface and cruise).

**Specific Tasks and Deliverables**

The NAC Subcommittee will deliver its consensus output to the NAC fifteen (15) days in advance for deliberation in meetings open to the public. It is expected that the NACSC will utilize the Work Groups to develop the products and bring them to the NACSC for consensus. These are further defined in the Work Groups Terms of Reference.

**Airspace and Procedures**

Product	Brief Description	Intended Use	Due Date
Strategic Airspace recommendations	In conjunction with the Integrated Capabilities Work Group, develop strategic recommendations on operational components of the nation’s future airspace and forum to identify operational re-design goals.	Ensure customer feedback to FAA on decisions concerning proposed airspace re-design, management and usage policy.	Ongoing
Develop recommendations to transition to a fully automated SAA/SUA	Develop recommendations for transition to a fully automated Special Activity Airspace (SAA) and Special Use Airspace (SUA).	FAA and DoD will use to build system where real time, operationally useful information is available to operators.	Ongoing
Metroplex Prioritization	Metroplex Prioritization: In conjunction with the Integrated Capabilities Work Group, review prioritization criteria and considerations approved by the NAC evaluating these for application to the Metroplex Optimization efforts.	FAA will use to prioritize implementation of airspace and procedures changes at metroplexes.	June 2011
Metroplex Airspace and Procedures Feedback	Metroplex Airspace and Procedures Feedback: Provide Industry participation to operational Metroplex efforts.	FAA will use in modifying airspace and procedures in the identified metroplexes.	Ongoing

## Business Case & Performance Metrics

Product	Brief Description	Intended Use	Due Date
Key NextGen Performance Indicators	Recommend performance indicators.	FAA will use the performance indicators for measuring NextGen	August 2011
NextGen Measurement Methodology	Recommend a measurement methodology (baseline; empirical vs. analytical data; frequency).	FAA will use the measurements to Evaluate NextGen implementation	August 2011
Commitments from Participants	Secure commitments from participants to provide data currently not available to the FAA.	Industry will support the FAA by providing data for evaluating NextGen implementation	August 2011
Updated Cost/Benefits/Risks Database	Build on Task Force 5 Cost/Benefit/Risks dashboard that served as the basis for selecting operational capabilities.	Industry can determine how operational capabilities have been integrated into the FAA's 2011 NGIP	Ongoing
Equipage Tasking	<p>Using recommendations approved by the NAC in May 2011, for each relevant user group, identify the gaps in the business case (i.e. the delta between cost and associated benefit) for NextGen-required equipage that operational or financial incentives could be used to close.</p> <p>Support the NAC Equipage AdHoc: Using recommendations approved by the NAC in May 2011, for each relevant equipage type and/or user group, as appropriate, identify the incentive(s) most likely to close the business case gap. Also, identify which delivery mechanisms would be the most effective for the recommended incentive(s). Most helpful would be scenarios of various financial options, i.e. loans, grants, other avenues, that are in accord with current political and fiscal climates.</p> <p>In coordination with the ICWG (dividing work responsibilities as appropriate):</p> <ul style="list-style-type: none"> <li>Identify reasonable conditions that would justify investment of taxpayer funds on incentives.</li> </ul>	FAA will receive specific information on capabilities and associated equipment that could receive operational or financial incentives.	Equipage Taskings September 2011

Product	Brief Description	Intended Use	Due Date
	<ul style="list-style-type: none"> <li>Define a realistic timetable for recommended financial and/or operational incentives to drive investment decisions and transition, along with any related considerations.</li> <li>In terms of an incentives program, identify the assurances that could be provided to early adopters of NextGen technology.</li> <li>Recommend criteria for evaluating the success of incentives.</li> </ul>		

### Integrated Capabilities

Product	Brief Description	Intended Use	Due Date
Metroplex Prioritization	Metroplex Prioritization: In conjunction with the Airspace and Procedures Work Group, review criteria and considerations approved by the NAC for site prioritization for the Metroplex Optimization efforts.	FAA will use to prioritize implementation of airspace and procedures changes at Metroplexes.	June 2011
Integrated Capabilities Scoping and Requirements	Integrated Capabilities Scoping and Requirements: Create preliminary portfolio of integrated capability requirements, with time frames for implementation.	FAA can map the capabilities identified in the Task Force 5 Final Report and NGIP Action Plans.	June 2011
Integrated Capabilities Future Planning	Integrated Capabilities Future Planning: Review FAA's specific plans for capability implementation.	FAA will receive specific recommendations for investments and priorities for successful NextGen implementation.	On-going effort with specific timing TBD
Strategic Airspace recommendations	In conjunction with the Airspace and Procedures Work Group, develop strategic recommendations on operational components of the nation's future airspace and forum to identify operational re-design goals.	Ensure customer feedback to FAA on decisions concerning proposed airspace re-design, management and usage policy.	Ongoing

Product	Brief Description	Intended Use	Due Date
Equipage Tasking	Prioritize the NextGen mid-term operations that are dependent on equipage.	FAA will receive specific information on capabilities and associated equipment that could receive operational or financial incentives.	May 2011
	<p>In coordination with the BCPMWG (dividing work responsibilities as appropriate):</p> <ul style="list-style-type: none"> <li>• Identify reasonable conditions that would justify investment of taxpayer funds on incentives.</li> <li>• Define a realistic timetable for recommended financial and/or operational incentives to drive investment decisions and transition, along with any related considerations.</li> <li>• In terms of an incentives program, identify the assurances that could be provided to early adopters of NextGen technology.</li> <li>• Recommend criteria for evaluating the success of incentives.</li> </ul>		September 2011

### NACSC Task Group

To provide continuity and to complete the work of the previous Air Traffic Management Advisory Committee, Trajectory-Based Operations (TOPs) Sub-Work Group, a Task Group (TOPs2) has been established. The Tasking is to develop a Trajectory-based operations Recommendation and Report for consideration at the NAC September 29, 2011 meeting.

By February 3, 2012, develop recommendations for a roadmap for Tower and domestic En Route Data Comm services and associated technologies through 2030. The roadmap should include commitments made to both the FAA and aviation community sides. It should address concerns about U.S. and European alignment of ground systems and avionics, as well as expected avionics service life and potential for obsolescence. The services should be prioritized in case they cannot be implemented concurrently.



## **Welcome to the Meeting of the NextGen Advisory Committee**

September 29, 2011  
RTCA Headquarters  
Washington, DC



## **NextGen Advisory Committee**

September 29, 2011  
RTCA Headquarters  
Washington, DC



## Welcome & Introductions

**NAC Chairman Dave Barger**  
**President & CEO**  
**JetBlue Airways**

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## Meeting Agenda

- Welcome and Introductions
- DFO Statement
- Review & Approval of May 19, 2011 Meeting Summary/NACSC Revised Terms of Reference
- Chairman's Report
- FAA Report
- NAC Subcommittee Report
- Status Report – DataComm Tasking
- Economic & Operational Equipage Incentives – NAC Ad Hoc
- Business Case Gap Assessment – BCPMWG
- Enhancing Operations in Regional Airspace – APWG

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## Meeting Agenda (cont'd)

- Measuring NextGen Performance – BCPMWG
- Mid-Term Trajectory Operations – TOps2
- Metroplex Prioritization & Capabilities – ICWG
- 2012 Tasking – What Comes Next?
- Other Business/Anticipated Issues for NAC  
Consideration and Action at Next Meeting – February 3, 2012
- Adjourn

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### **PUBLIC MEETING ANNOUNCEMENT**

**Read by: Designated Federal Official Michael Huerta  
NextGen Advisory Committee  
September 29, 2011**

In accordance with the Federal Advisory Committee Act, this Advisory Committee meeting is OPEN TO THE PUBLIC.

Notice of the meeting was published in the Federal Register on:

**September 1, 2011**

Members of the public may address the committee with PRIOR APPROVAL of the chairman. This should be arranged in advance.

Only appointed members of the Advisory Committee may vote on any matter brought to a vote by the Chairman.

The public may present written material to the Advisory Committee at any time.

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## **Review and Approval of:**

### **May 19, 2011 Meeting Summary NACSC Revised Terms of Reference**



## **Revised TORs – Add DataComm**

“By February 3, 2012, develop recommendations for a roadmap for Tower and domestic En Route Data Comm services and associated technologies through 2030.

The roadmap should include commitments made to both the FAA and aviation community sides. It should address concerns about U.S. and European alignment of ground systems and avionics, as well as expected avionics service life and potential for obsolescence. The services should be prioritized in case they cannot be implemented concurrently.”



## Chairman's Report

**NAC Chairman Dave Barger**  
**President & CEO**  
**JetBlue Airways**

A dark blue rectangular graphic containing white text. At the top, the words "History" and "Optimistic" are written in a large, white, serif font. On the left side, the word "POLICIES" is written vertically in a large, white, bold, sans-serif font. On the right side, the word "PROGRESS" is written vertically in a large, white, bold, sans-serif font. In the center, the words "Action/Execution" are written in a white, bold, sans-serif font. Below that, the phrase "\$Closing the Business Case\$" is written in a white, sans-serif font, slanted upwards. Underneath, "Plan - B?" is written in a white, bold, sans-serif font, also slanted upwards. At the bottom, "Prioritizing" is written in a white, bold, sans-serif font. The word "Metrics" is written in a white, bold, sans-serif font, slanted downwards, overlapping the bottom of "Plan - B?" and "Prioritizing".



## FAA Report

**Michael Huerta**  
**FAA Deputy Administrator**



## FAA Report Organizational Update

- Foundation for Success
  - + Congressional Approval
  - + Prioritize NextGen
  - + Establish PMO



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## FAA Report Budget Update

- Reauthorization
  - + 22<sup>nd</sup> Extension
- Appropriations
  - + NextGen Implications



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## FAA Report 2012 Outlook

- American Jobs Act
  - + \$50B Infrastructure
    - \$1B NextGen
    - \$2B Airports
  - + National Infrastructure Bank





## **DISCUSSION**

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### **NAC Subcommittee Report**

**Co-Chairs:**

**Steve Brown, NBAA**

**Tom Hendricks, ATA**



## Work of NACSC

Active efforts by three Work Groups:

- Airspace and Procedures
- Business Case and Performance Metrics
- Integrated Capabilities

Task Groups

- DataComm
- Trajectory Operations (TOps2)

Informational briefings – dialogue with FAA

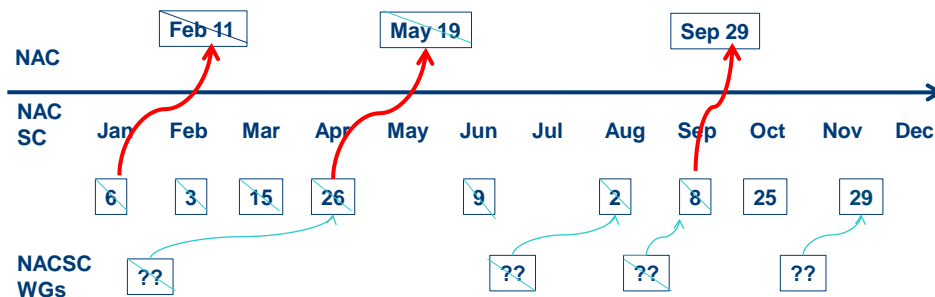
Robust discussion by NACSC of all recommendations

Shaping, focusing and providing crucial policy review

19



## NACSC Meetings 2011

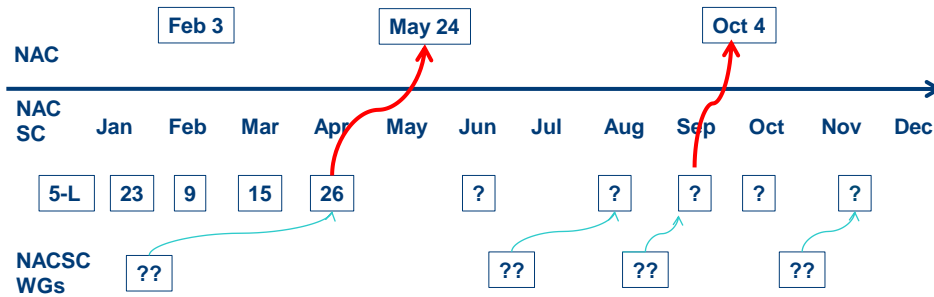


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# NACSC Meetings 2012



# DISCUSSION



## **NextGen DataComm Roadmap Task Group**

***Status Report***  
**Margaret Jenny, RTCA**



### **FAA DataComm Tasking**

- Genesis of Tasking from NAC Discussion – May 2011 Meeting
- Evolutionary Set of Globally Harmonized DataComm Services
- July 2011 letter from the FAA requesting:
  - Develop recommendations for a roadmap for Tower and domestic En Route DataComm Services and associated technologies through 2030.
- Due February 2012



## DataComm Task Group

- Formed September 2011 – Two Meetings
- Co-chaired by
  - Forrest Colliver, The MITRE Corporation
  - Steve Dickson, Delta Air Lines
- Broad participation (approximately 30 members) continuity important – no alternates
- Concerns of DCIS bidders
- Modified Terms of Reference – revised questions
- FAA Revised Tasking letter expected early Oct
- Issues likely to lead to post Feb 2012 activities

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## Approach

- Include all relevant stakeholders
- Operator (buyer) - driven
- US and European perspectives
- Data-driven; analytic; cost/benefit
- Review and consider previous work
- Leverage work of BCPMWG

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## DISCUSSION

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## BREAK



## NAC Equipage Ad Hoc Task Group

Chairman Ed Bolen, NBAA



### Equipage Enablers From Phase One

GPS, RNP .3 for Air Carriers  
WAAS/LPV for GA

ADS-B Out

DataComm  
FANS 1/A+, VDL-2

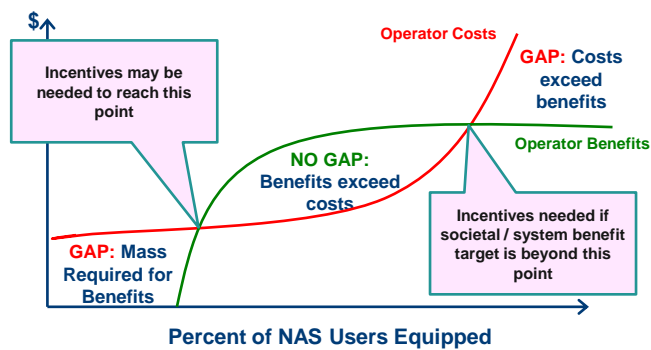
***Fleet-wide Equipage:  
all aircraft to minimum capability level***



## Regional Deployment



## Highlights of Phase 2



*A combination of financial and operational incentives should be made available for aircraft that are the first to equip*



## Findings

- Aviation industry prefers direct grants but ...
- Public-private loan program...
  - is the most feasible financing instrument for encouraging timely NextGen equipage investments on the part of the operators.
- To be successful, the benefits associated with equipage, in the form of measurable improvements to the air traffic management system, must be achieved.

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## Findings (Cont'd)

- The FAA must remove the uncertainty associated with implementing capabilities to close the business case for an operator.
- Success of financial and operational incentives will be measured in terms of a ***specific target improvement in system performance***, not simply reaching an equipage target level or deploying infrastructure.

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## Phase 2 Recommendations

- If grants are not viable, then implement a public-private loan guarantee initiative
- Identify measurable performance targets against which success of incentives can be assessed
  - Select metrics from the BCPMWG
  - Assign targets for each operational capability
- Use targets as triggers for repayment of loans
- FAA to establish clear timelines and priorities to remove uncertainty in delivery of ops capabilities

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## Special Note on Government Aircraft

- US Government Aircraft (DoD, etc) are not typically eligible for public-private partnerships
- Function under a different business case analysis
- Compete with overall federal spending priorities for NextGen investment

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## **NAC Action**

**Consider Phase 2  
Recommendations and Transmit to  
the FAA**

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## **DISCUSSION**

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## **Business Case & Performance Metrics Work Group Update**

***Business Case Gap Assessment***  
**Tom Hendricks, NACSC Co-Chair**

BCPMWG Co-chairs:  
Debby Kirkman, The MITRE Corporation  
Ed Lohr, Delta Air Lines



### **Business Case & Performance Metrics WG: *Business Case Tasking***

- Identify what financial business case gaps exist for priority capabilities involving NextGen equipage
- Assess the impacts of incentives to close those identified business case gaps



## BCPMWG Equipage Gap Analysis

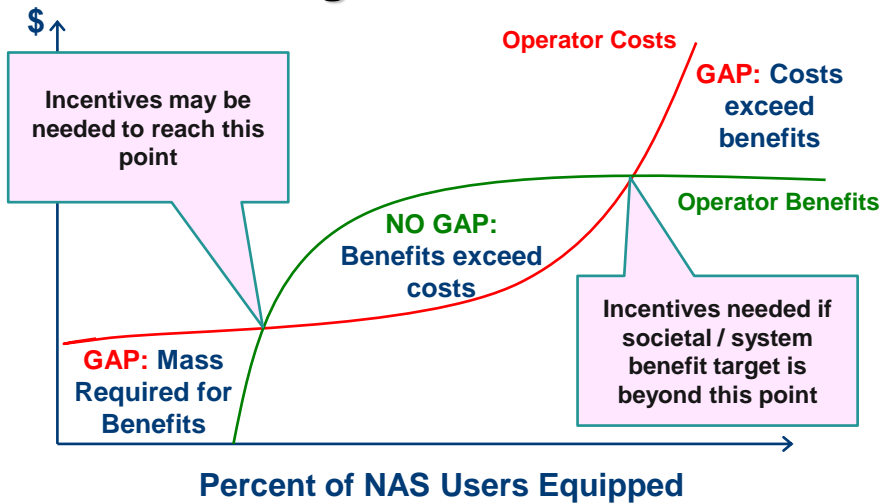
**NAC Ad Hoc recommended three key equipage packages providing a foundational “infrastructure” for NextGen:**

- Performance Based Navigation: RNP 0.3/RF for Part 121; WAAS/LPV for GA
- ADS-B “Out” for Part 121 & GA users
- ATC Data Link (FANS 1/A+ or ATNB1 over VDL-2) for Part 121 users

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## Notional Marginal Cost vs. Benefit



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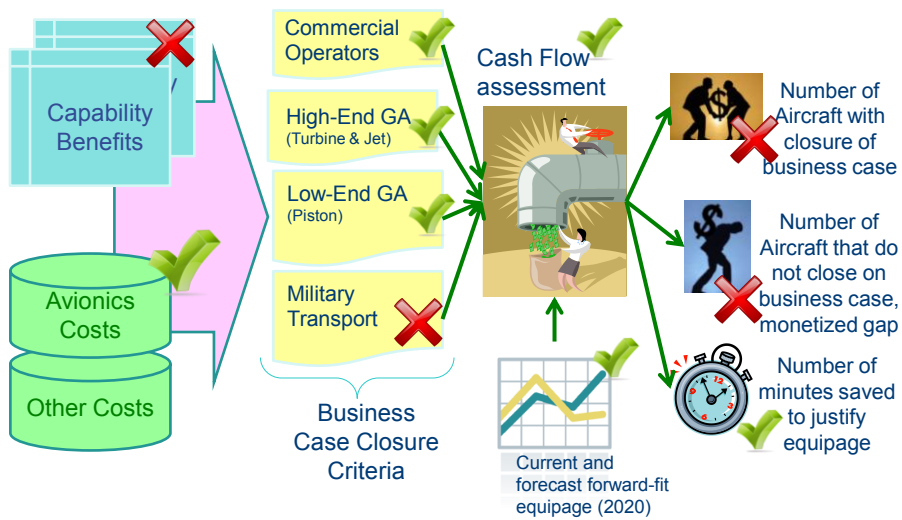
## User Business Case Criteria

Business Case Closure Criteria	Commercial	High-End GA	Low-End GA	Military
Financial Threshold	2.5 Year Payback	5 Year Payback	Affordability	Cost Neutrality
Monetized Benefits	User Direct Operating Costs	Fuel Savings	(not used)	(not used)
Non-Financial Factors	Fleet Mobility	Access and Time Savings	Access and Safety	Mission, Access and Fleet Mobility

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## Proposed Gap Analysis Framework vs. Results



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## Summary of Results

	RNP 0.3 w/ RF legs	WAAS	ADS-B Out	ATC Data Link
<b>US Operators Evaluated</b>	Part 121	IFR-capable GA	Part 121 / Transponder-equipped GA	Part 121 / High-end GA
<b>Analysis Approach</b>	Parametric	Cost only	Part 121 Parametric / GA Cost only	
<b>2020 Equipage Forecast</b>	55%	30%	100% (Mandate)	<ul style="list-style-type: none"> <li>• 8% of Part 121</li> <li>• Y% of High-End GA</li> </ul>
<b>2020 Fleet Cost</b>	\$2.6B	\$2.3B	\$4.2B	<ul style="list-style-type: none"> <li>• FANS1/A+: 64% at \$1.3B</li> <li>• FANS1/A+ or ATNB1: \$1.5B for Part 121</li> </ul>

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## DoD Equipage

**Recommendation 1:** FAA should work with the DoD to assess the extent to which equipping military aircraft with NextGen avionics is required to achieve NAS-wide and other societal benefits

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## RNP 0.3 with RF Legs

**Recommendation 2:** FAA should develop capabilities to allow the large percentage of currently equipped users to routinely perform RNP 0.3 with RF leg procedures

## WAAS / LPV

**Recommendation 3:** FAA should continue to work with the General Aviation community to implement WAAS approaches at eligible runway ends

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## ADS-B Out

**Recommendation 4:** The FAA should incentivize ADS-B Out equipage in advance of 2020 including the development of criteria for low-cost ADS-B In equipment supporting situational awareness

## DataComm

**Recommendation 5 (changed to a finding by the NACSC pending the DataComm Task Group):** The most cost-effective means to achieve a high level of ATC data link equipage is for the FAA to allow operators to choose either FANS 1/A+ or ATN Baseline 1 solution.

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## Joint Investment Considerations

**Recommendation 6:** Recognizing that the user business case does not close “on the average”, FAA and users should jointly analyze marginal costs and benefits to prioritize equipage required to realize system benefits

**Recommendation 7:** FAA should increase user confidence in benefit realization for capabilities requiring joint investment:

- Develop estimates of the direct benefits for equipping users
- Establish a stable implementation plan
- Determine key benefit thresholds

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## Joint Investment Considerations

**Recommendation 8:** FAA should undertake actions to address user business case gaps:

- Understand the business case for bundled equipage options
- Offer incentives for early adopters
- Use joint accountability mechanisms

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## **NAC Action**

**Consider Business Case Gap  
Assessment Recommendations  
and Transmit to the FAA**

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## **DISCUSSION**

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## LUNCH



## **Business Case & Performance Metrics Work Group**

***Measuring NextGen Performance:  
Recommendations for Operational Metrics***  
**Steve Brown, NACSC Co-chair**

BCPMWG Co-chairs:  
Debby Kirkman, The MITRE  
Corporation  
Ed Lohr, Delta Air Lines



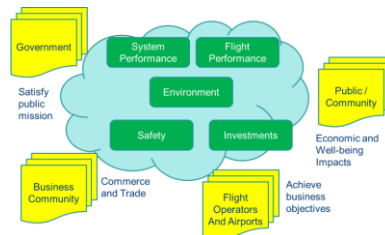
## Business Case & Performance Metrics WG: *Metrics Tasking*

- Recommend operational metrics that are most important to measuring NextGen implementation impacts
- Seek agreements with stakeholders to provide new data sources that illuminate key NextGen metrics

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## Suite of Metrics: No Single Metric Can Capture NextGen Impacts



- Diversity of aviation stakeholder interests
- Changes in the NAS will affect several dimensions of performance
- Performance tradeoffs are understood through multiple metrics (e.g., predictability vs. flexibility)
- ICAO Key Performance Area framework is used to capture these performance dimensions

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## NextGen Goals

**Recommendation 1:** FAA should expand the NextGen goals to explicitly include the following elements:

- Reduce fuel burn and flight operating costs
- Maintain or improve access to airspace and airports for all stakeholders
- Support mixed capability operations

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## NextGen Metrics Dashboard

**Recommendation 2:** The FAA's NextGen Dashboard should:

- 2A – Include KPIs for Capacity, Efficiency, Predictability, Flexibility, Access and Equity, Safety, and Environment
- 2B – Provide the ability to select different views
- 2C – Report data from all core airports, all airports and airspace within Metroplex areas, and highly utilized high-altitude airspace
- 2D – Provide insight on FAA and Flight Operator implementation status

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## NextGen Metrics Dashboard

### **Recommendation 3 – Additional Work on**

**Metrics:** The FAA should continue to work with RTCA to:

- 3A – Develop detailed KPIs for Flexibility
- 3B – Further develop KPIs for Access and Equity, including implementation progress metrics
- 3C – Determine the venue for developing diagnostic-level metrics and data sources for specific NextGen initiatives

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## Measurement of NextGen Impacts

### ▪ **Recommendation 4 – Metrics Collection**

**Resources:** The FAA should ensure that NextGen programs include resources for collecting, analyzing, and reporting post-implementation impacts

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## **NAC Action**

**Consider Measuring NextGen  
Performance Recommendations  
for Operational Metrics and  
Transmit to the FAA**

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## **DISCUSSION**

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## **Trajectory Operations Task Group (TOPs2)**

### ***Recommendations for implementing Trajectory Operations in the Mid-Term***

**Steve Brown, NACSC Co-chair**

TOPs2 Co-Chairs:

Dan Earman, Lockheed Martin

Rick Shay, United Airlines



## **Tasking**

- March 29: Original Scope to develop a “Trajectory Operations 2018: Concept of Use Document”
- April 18: Scope/approach modified to review and comment on FAA’s “Mid-Term Operational OV-6 Scenarios for NAS EA” Documentation



## Progression to Trajectory Operations

- Fixed routes-fixed altitude
- Fixed route-change altitude
- Change routes “flexible route”, i.e. best wind routes
- Allow customization of routes to individual aircraft
- Continuously variable route as well as altitude “Parabolic Trajectory”
- Available for every aircraft

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## Trajectory Operations Dependent On:

- Good air traffic control technologies
- Accurate weather information and forecast
- Ground based conflict probes, etc.
- Must all be certified!

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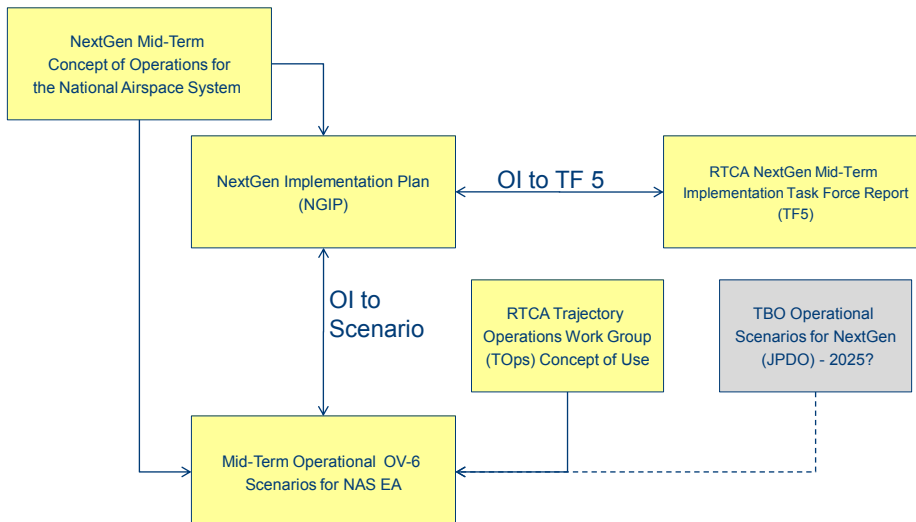


### TOps2 Task Group Members

First Name	Last Name	Company
Frank	Alexander	International Air Transport Association
Clay	Barber	Garmin
Joe	Bertapelle	JetBlue Airways
Joe	Celio	The MITRE Corporation
Andy	Cebula	RTCA
Sarah	Dalton	Alaska Airlines
<b>Dan</b>	<b>Earman</b>	<b>Lockheed Martin</b>
Jeffrey	Geller	DoD Policy Board on Federal Aviation
John	Glassley	Federal Aviation Administration
Bob	Graham	Single European Sky ATM Research (SESAR)
Joshua	Gustin	Federal Aviation Administration
Mark	Hopkins	Delta Air Lines, Inc.
Mike	Jackson	Honeywell International, Inc.
Pascal	Joly	Airbus Americas, Inc.
Joel	Klooster	General Electric
Jarrett	Larrow	Federal Aviation Administration
Michele	Merkle	Federal Aviation Administration
Paul	Mettus	Lockheed Martin Corporation
Dave	Nakamura	The Boeing Company
Mark	O'Neil	National Air Traffic Controllers Association
Jon	Pendleton	Delta Air Lines, Inc
<b>Rick</b>	<b>Shay</b>	<b>United Continental Holdings</b>
Pat	Somersall	Federal Aviation Administration
Ernie	Stellings	National Business Aviation Association
David	Strand	American Airlines
Brian	Townsend	US Airways
Bryan	Will	American Airlines



### Reference Documentation







## **TOps2 Findings: Trajectory Operations in the Mid-Term (2011-2018)**

- FAA incorporate specific industry comments from TOps2 on 22 of the 26 FAA Mid-Term Operational Scenarios related to TOps mid-term operational concepts and scenarios.
- FAA incorporate the TOps prioritization of the 22 Operational Scenarios related to TOps.
- The FAA “baseline” the Operational Scenarios, distribute to the aviation industry and update in the future with input from aviation stakeholders.
- The FAA utilize the prioritization of the Operational Improvements (OI's) contained in the FAA NextGen Implementation Plan needed to implement Trajectory Operations capabilities.
- DataComm is crucial to achieving the maximum benefits from TBO, serving as a basic “building block” for NextGen capability.

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## **NAC Action**

**Consider Recommendations for  
Implementing Trajectory  
Operations in the Mid-Term and  
Transmit to the FAA**

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## DISCUSSION

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## BREAK



## Integrated Capabilities Work Group

### *Metroplex Prioritization & Capabilities* Steve Brown and Tom Hendricks, NACSC Co-chairs

ICWG Co-chairs:

Chris Oswald, ACI-NA

Sarah Dalton, Alaska Airlines



## ICWG Taskings

- Integrated Capabilities Scoping & Requirements (i.e., “what and when”):** Create a preliminary portfolio of integrated capability requirements with timeframes for implementation.
- Metroplex prioritization (i.e., “where & why”):** Assess the relevance and utility of NAC-approved Metroplex prioritization criteria for capabilities within the ICWG’s remit. Map integrated capabilities to Metroplexes.
- Integrated capabilities future planning (i.e., “who & how”):** Review FAA’s plans for integrated capability implementation. Provide recommendations regarding how industry and the FAA can improve/expedite implementation.
- Strategic recommendations:** Together with the Airspace & Procedures WG, provide strategic recommendations to the NAC regarding NextGen operational capabilities.



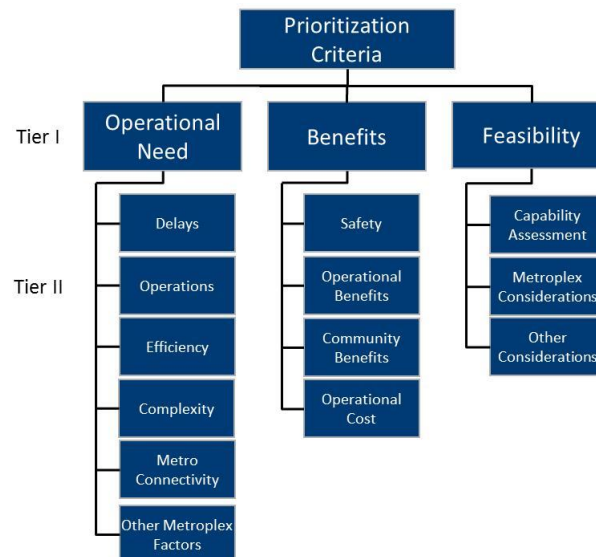
## Key Findings

- Focus Metroplex prioritization efforts defining *what* integrated capabilities should be deployed *where* and *when*
- To assess “what, where, and when”, integrated capabilities must be mapped to individual Metroplexes
- Objective, quantitative data regarding the benefits and feasibility of many integrated capabilities is not available, particularly at the Metroplex level
- ICWG will need to rely primarily on qualitative, expert-judgment driven assessments of benefits and feasibility
- Mapping and qualitative evaluation of integrated capabilities Metroplex-by-Metroplex requires work efforts through at least the end of the calendar year

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## Metroplex Prioritization Hierarchy



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## Metroplex Prioritization Metrics

- Findings
  - Benefits and feasibility metrics require Metroplex-specific evaluations
  - Reliable, quantified data regarding benefits and feasibility are very limited, particularly at the individual capability and metroplex level
  - While quantifiable assessments of these metrics are desirable, they will likely be impractical to obtain, necessitating use of qualitative evaluations (e.g., low/medium/high) by subject matter experts

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## Metroplex Selection

- Started with the 21 metroplexes from OAPM effort (incl. Dallas & DC)
- Added or reconfigured metroplexes based on ICWG member input
  - Separated PHL from NY/NJ/PHL metroplex
  - Metroplexes worthy of consideration due to relationships with/dependencies on other metroplexes (e.g., PDX, STL)
- Include supporting airports within 50-70 n.m. of the metroplex center

**27 metroplexes recommended for further consideration**

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## Recommended Metroplexes for ICWG Effort

Metroplex (Note 1)	Core Airports	Other Airports
Atlanta	ATL	FTY, PDK, RYY
Boston	BOS	BDL, PVD, BED, BVY, MHT, OWD
Charlotte	CLT	RDU, CAE, GSO, GSP, JQF, UZA
Chicago	MDW, ORD	DPA, MKE, UGN, AAR, ENW, GYY, IGQ, LOT, PWK, RFD
Cincinnati		CMH, CVG, SDF, DAY, LEX, LUK
Cleveland		CLE, PIT, BKL, CGF, LEB
Dallas-Ft. Worth	DFW	DAL, ADS, AFW, DTO, FTW, GKY, TKI
DC Metro	BWI, DCA, IAD	DMW, FDK, HEF, JYO, MTN, W66
Denver	DEN	APA, BJC
Detroit	DTW	DET, PTK, YIP
Hawaii	HNL	OGG
Houston	IAH	HOU, MSY, AXH, CXO, DWH, EFD, IWS, LVI, MSY, SGR
Las Vegas Valley	LAS	HND, HND, VGT
Southern California	LAX, SAN	BUR, CNO, LGB, ONT, SNA, VNY, CRQ, HHR, MYS, OXR, POC, PSP, SDM, SEE, SMO, WHP
Memphis	MEM	OLV
Minneapolis-St. Paul	MSP	21D, ANE, FCM, LVN, MIC, SGS, STP
New York	EW, JFK, LGA	FRG, HPN, ISP, MMU, SWF, TEB, ABE, CDW
Northern California	SFO	HWD, LVK, OAK, RNO, SJC, SMF, CCR, PAO, RHV, SQL
Orlando	MCO	JAX, ISM, ORL, SFB
Philadelphia (Note 2)	PHL	ILG, ACY, LOM, PNE
Phoenix	PHX	TUS, CHD, DVT, EFZ, GEU, IWA, SDL
Portland		PDX, HIO
Salt Lake City	SLC	
Seattle	SEA	BFI, PAE, RNT, S50, S43, TIW
South Florida	FLL, MIA	DAB, PBI, RSW, FXE, LNA, OPF, TMB
St. Louis		STL, CPS, SUS
Tampa	TPA	PIE, SRQ
<b>Notes:</b>		
1. Shaded rows indicate metroplexes that were not considered in OAPM metroplex prioritization efforts.		
2. In OAPM prioritization efforts, Philadelphia was included within the New York metroplex.		

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## Integrated Capabilities Definitions

- Refined the definitions of the integrated capabilities that the ICWG recommended in May; particular focus on “new” capabilities not currently included in the FAA’s NSIP
- Conducted a readiness assessment of identified integrated capabilities to assist in evaluating the implementation feasibility of the integrated capabilities in the mid-term future (i.e., by 2018)
- Specific details in Appendix A

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## Mapping Integrated Capabilities to Metroplexes

- Explicitly called for the ICWG's terms of reference
- Also necessary to assess benefits and feasibility of integrated capabilities in a particular metroplex
- Two initial mapping exercises completed: New York and Houston
  - Qualitative assessment of benefits and feasibility, followed by an overall high/medium/low assessment of each capability
  - Metrics previously described used as guidelines for assessments
- Recommend continuing with mapping exercises at additional metroplexes in Fall/Winter 2011
- NACSC Reduced List

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## ICWG Next Steps/Work Plan

Activity	September	October	November	December	January
September NAC report refinement	X				
Integrated capabilities mapping guidelines	X				
Additional mapping exercises					
Interim mapping findings			X		
Final mapping findings				X	
Initial metroplex prioritization of ICs					
February NACSC report preparation					X
NAC report refinement					X

X: Written deliverable

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## **NAC Action**

**Consider Metroplex Prioritization &  
Capabilities Recommendations  
and Transmit to the FAA**

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## **DISCUSSION**

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## **Airspace & Procedures Work Group**

***Enhancing Operations in Specific Regional Airspace***  
**Tom Hendricks, NACSC Co-Chair**

APWG Co-chairs:  
Bob Lamond, NBAA  
Bill Murphy, US Airways



### **Regional Airspace Recommendations**

#### **Recommendation #1: RNAV off the Ground (ROTG)**

FAA should validate the safety and capacity benefits of RNAV-Off The-Ground (ROTG) as part of the implementation process.

#### **Recommendation #2: Houston Ultra High Sectors**

RTCA agrees with the Houston Optimization of Airspace and Procedures (OAPM) Study Team and recommends additional analysis of the potential benefits of Houston Center (ZHU) Ultra-High Sector modifications.

#### **Recommendation #3: Denver RNAV Implementation**

Monitor the timeline of the Denver RNAV Implementation project closely and ensure that the expanded scope of the project does not significantly impact the implementation schedule or the realization of operational benefits.



## Regional Airspace Recommendations

### **Recommendation #4: Chicago Airspace Program (CAP)**

- Finish design and implementation of the current phase of the CAP within the O'Hare Modernization Project (OMP) time constraints.
- Work with the FAA to develop potential airspace and procedures improvements for the Chicago Metroplex to be considered and developed after the CAP is done. Consider use of technology and procedures that have evolved since the original CAP design process began several years ago that could be allowed within the current EIS.
- Continue to encourage full stakeholder participation in the development of CAP with the intent of achieving as many optimized procedures as possible within the constraints of the EIS.

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## Regional Airspace Recommendations

### **Recommendation #5: Powder River Training Complex**

The USAF and RTCA should continue discussions to implement a FACA process to bring USAF and aviation industry together to work towards airspace that is acceptable to the mission and business cases of all airspace users when the AF develops large scale airspace proposals.

### **Recommendation #6: NextGen Air Traffic Management Tools**

The FAA continues to develop Traffic Management Advisor (TMA), Relative Position Indicator (RPI) and other decision support tools to help the ATO increase airspace capacity and efficiency in the NAS. Appropriate metrics should be developed with these tools to measure their effectiveness and to quantify throughput/capacity increases.

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## **Regional Airspace Recommendations**

### **Recommendation #7: South Florida Airspace**

#### **Redesign/Caribbean Routes**

- The FAA should start work with industry and DoD to optimize the airspace serving south Florida air carrier and general aviation airports in coordination with commissioning of the new RWY 09R/27L at FLL in 2014 and optimization of Caribbean Airspace and Routes using PBN.
- The FAA should initiate the south Florida work via the CY12 OAPM process and work should be coordinated with central Florida airspace. Resources are limited and “connecting” these two areas of airspace is critical.

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## **NAC Action**

**Consider Enhancing Operations in  
Specific Regional Airspace  
Recommendations and Transmit to  
the FAA**

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## DISCUSSION

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### **Discussion of 2012 Taskings** ***What comes next?***

**Michael Huerta**  
**FAA Deputy Administrator**



**Other Business/Anticipated Issues for NAC  
Consideration and Action**

**Dave Barger  
President & CEO JetBlue Airways**



**Adjourn**

**Next Meeting  
Friday, February 3, 2012  
Daytona Beach, FL**



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## **Attachment 4**

# **RECOMMENDATIONS APPROVED BY THE NEXTGEN ADVISORY COMMITTEE SEPTEMBER 29, 2011**



**Approved by the NAC September 29, 2011**

## **What Types of Incentives should be used to Equip for NextGen?**

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*A Report of the NextGen Advisory Committee in Response to Tasking from  
The Federal Aviation Administration*

*September 2011*

## Contents

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## Background

In a letter dated January 28, 2011 from FAA Deputy Administrator Michael Huerta to RTCA President Margaret Jenny, the Agency requested that the NextGen Advisory Committee (NAC) provide recommendations on incentives for aircraft investments in NextGen. An ad hoc Task Group was formed by the NAC at its February 11, 2011 meeting to respond to the following request (FAA, FAA Equipage Tasking Letter to the NAC, 2011):

1. **PRIORITIZED OPS CAPABILITIES:** Prioritize the NextGen mid-term operations that are dependent on equipage
2. **USER GROUPS:** Recommend the aircraft types or user groups that should be considered for incentives.

The NAC approved the Equipage Ad Hoc Task Group recommendation (below) at its meeting on May 19, 2011.

### Phase 1 Recommendation: Fleet-Wide, Minimum Capability Incentives; Regional, Metroplex Deployment of Operational Capabilities

The Ad Hoc Task Group recommended an approach that equips near 100% of operator fleets to a minimum capability level with regional deployment of operational capabilities by the FAA consistent with approaches recommended in the RTCA TF5 final report and as adopted by the FAA in its NextGen Implementation Plan (NGIP) (FAA, FAA NextGen Implementation Plan, 2010).

The Ad Hoc Task Group did not make distinction between various types of civilian aircraft operators (e.g. air carriers, general aviation) for eligibility of equipage incentives. The Ad Hoc Task Group also recommended that to meet this policy goal, the U.S. government will have to fund federal public aviation organizations, such as DoD and DHS, to comply with appropriate minimum capabilities.

The three technologies that enable multiple NextGen operational capabilities which would also be considered for equipage incentives are (not in priority order):

- **Package A— (GPS) RNP0.3 with RF legs for air carrier and GPS-WAAS-LPV for general aviation**
- **Package B – ADS-B Out**
- **Package C – ATC Data Link Communications**

### Relationship to Work of NACSC WGs

The Ad Hoc Task Group was tasked with considering who should be incentivized to equip for NextGen and to characterize various aspects of those incentives. While the Ad Hoc Task Group did suggest what capabilities should be considered for incentives, the NACSC Business Case Performance Metrics Work Group (BCPMWG) and NACSC Integrated Capabilities Work Group (ICWG) are tasked with making the

final recommendations on priorities for operational capabilities and for identifying the business case gaps. To ensure that the NAC produced a comprehensive and coordinated set of recommendations for the FAA, the WGs have provided input to the NAC regarding the business case gaps, and the WGs have taken the output phase one of the Ad Hoc Task Group and validated their findings regarding RNP, WAAS, ADS-B Out and DataComm as the key capabilities that should be considered for incentives. The recommendations from this Ad Hoc Task Group, therefore, are limited to addressing the six questions below, with the business case information coming from the fully vetted analysis of the BCPMWG.

## Phase Two of the FAA's Equipage Tasking

Phase Two of the FAA's request requires an analysis of various elements of the incentives that could be used for aircraft equipage for consideration by the NAC.

1. **GAPS:** For each relevant user group, identify the gaps in the business case for NextGen-required equipage that operational or financial incentives could be used to close.
2. **INCENTIVES:** For each relevant equipage type and/or user group, as appropriate, identify the incentive(s) most likely to *close* the business case gap. Also, identify which delivery mechanisms would be most effective for the recommended incentives(s). Most helpful would be scenarios of various financial options, i.e., loans, grants, other avenues, that are in accord with current political and fiscal climates.
3. **JUSTIFICATION:** Identify reasonable conditions that would justify investment of taxpayer funds on incentives.
4. **TIMETABLE:** Define a realistic timetable for recommended financial and/or operational incentives to drive investment decisions and transition, along with any related considerations.
5. **EARLY ADOPTERS:** In terms of an incentive program, identify the assurances that could be provided to early adopters of NextGen technology.
6. **EVALUATION CRITERIA:** Recommend criteria for evaluation of the success of incentives.

## Responding to the FAA Phase Two Request

### Gaps in Business Case

The BCPMWG performed an extensive analysis of costs for General Aviation and Part 121 equipage and performed a parametric analysis to determine what level of benefits would be required to close the business case for the aggregate Part 121 fleet (reference presentation in Appendix A). However, the BCPMWG was not able to perform a direct business case analysis of any of the packages due to the lack of clear timeframes, locations and directly-attributable benefits for equipped aircraft. The primary business case gap in the three packages (other than WAAS) is the lack of confidence in the timeframe for delivery of benefits for equipped users.

Findings of the BCPMWG include:

- Notional minimum levels of equipage necessary to achieve benefits
- Current and 2020 forecast levels of equipage
- Key cost factors
- Cost to achieve 100% equipage

Summarizing the conclusions drawn by BCPMWG regarding closing the business case gap for each identified operational capability:

- **RNP 0.3/RF: FAA should develop capabilities to utilize these procedures routinely with *current* equipage.**
- **WAAS/LPV: Continue to develop WAAS approaches, the availability of these approaches at non-air carrier airports drives user equipage.**
- **ADS-B Out: Incentives needed to increase equipage in advance of the mandated compliance date of 2020.**
- **ATC Data Link Communications: The most cost-effective means to achieve a high level of ATC data link equipage is for the FAA to allow operators to choose either FANS 1/A+ or ATN Baseline one solution.**

Table 1: Summary of Business Case Analysis of Key NextGen Technologies

	RNP 0.3 w/ RF legs	WAAS	ADS-B Out	ATC Data Link
<b>US Operators Evaluated</b>	Part 121	IFR-capable GA	Part 121 / Transponder-equipped GA	Part 121 / High-end GA
<b>Postulated User Benefits / Equipage Threshold</b>	Reduced flight time; 80% threshold postulated for congested locations	Low-visibility access & safety	Reduced flight time; 100% equipage required	Reduced operating time for dept clearance & airborne reroutes; 20% equipage is lowest threshold in models
<b>Analysis Approach</b>	Parametric*	Cost only	Part 121 Parametric / GA Cost only	Part 121 Parametric / GA Cost only
<b>2020 Equipage Forecast (current + forward fit)</b>	55%	30%	100% (Mandate)	<ul style="list-style-type: none"> <li>8% of Part 121</li> <li>High-End GA: unknown</li> </ul>
<b>Cost for 100% equipage</b>	\$2.6B	\$2.3B	\$4.2B	<ul style="list-style-type: none"> <li>FANS1/A+ only: 64% max at \$1.3B</li> <li>FANS1/A+ or ATNB1: \$1.5B</li> </ul>
<b>Minute Savings for 100% Part 121 equipage</b>	60 Minutes	<i>Not applicable</i>	24 Minutes	30 minutes (option of FANS or ATNB1)

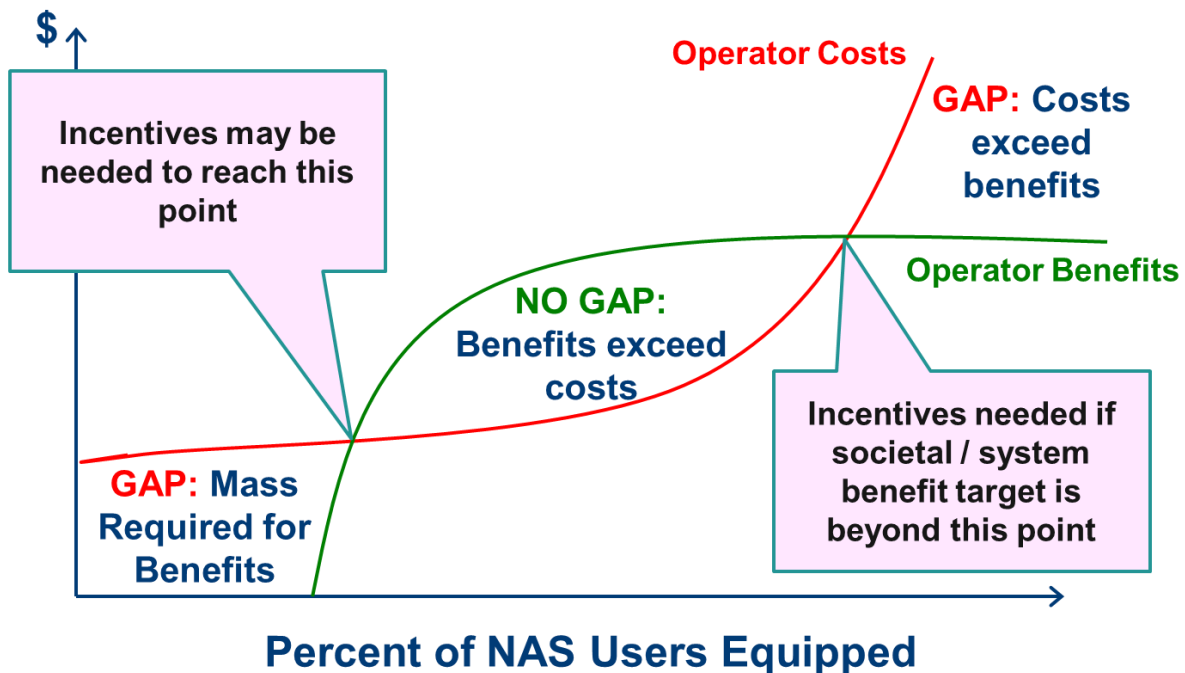
\*The parametric analysis assumes fuel costs of \$3/gallon, 2.5 year payback, and benefits accruing immediately upon equipage

As the Notional Marginal Cost versus Benefit graphic illustrates below, it is necessary for incentives to be provided to overcome business case gaps for early adopters or when overall benefits require equipage that is not justified by the flight operator. The goal is to use incentives to reach the “sweet spot” where there is no gap in the business case and the benefits exceed the costs. There are also instances when the cost for equipage simply exceeds the benefits or even the practicality of equipping certain aircraft. The initial emphasis is on early adopters because the benefits cannot be achieved until these are addressed.

It is also important to note that each capability (i.e. RNP, WAAS, ADS-B, DataComm) would have a unique cost benefit outcome.

Figure 1: Notional Marginal Costs vs. Benefits for NextGen Equipage

## Notional Marginal Cost vs. Benefit



### Types of Incentives

As part of its work on the equipage Tasking, the Ad Hoc Task Group met with individuals engaged in developing and/or analyzing financial incentives to encourage aircraft equipage for NextGen. The goal was to identify incentives most likely to close the business case for NextGen technologies in the cockpit<sup>1</sup>.

<sup>1</sup>Federally funded public aviation organizations, such as DoD, are not able to use financial incentives as discussed in this recommendation. Additionally, any incentives that include USG services or pay to public-private loan guarantees may draw upon the same funds that public aviation organizations will use to fund NextGen.

During July, August, and September 2011, the Ad Hoc Task Group received briefings from the FAA, Nexa Capital, The Boeing Company and The MITRE Corporation. The presentations are contained in Appendix A.

### **Menu of Financial Incentives**

The FAA has developed the following overview of the various types of incentives available including the current status of each incentive and identification of whether additional legislative authority is necessary.

- National Infrastructure Bank (I-Bank) for financing transportation projects (contained in the President's 2012 budget request and the American Jobs Act proposed legislation announced by President Obama on September 8, 2011.)
- Direct loans, highly discounted loans, secured lines of credit, loan guarantees
- Tax credits & deductions
- Public-Private Partnerships (P3s) -- agreements between a public agency and private sector to improve delivery & financing of projects

In addition to the FAA tasking, during the Ad Hoc Task Group meetings, the FAA posed additional questions to help frame the discussion:

- 1) Given the spectrum of options, rank the incentives in order of usefulness
- 2) How should incentives be prioritized? (e.g. regional focus, technology focus, user-group focus, etc.)
- 3) What level of cost-share would be effective at closing the business case?
- 4) Given the current budget situation, which incentives would compete the best against other demands on federal dollars?

An underlying principle for any Public-Private Partnership loan program is that the FAA must be held accountable for the **performance** outcomes promised by NextGen investments. Measuring program implementation is more than meeting program milestones or deploying infrastructure. For operators to invest, they must see a positive business case. To the extent that they do not have confidence they will achieve the benefits, they will not be able to close the business case. "Buying down the risk" will require increasing the confidence that investment will lead to tangible performance improvement in safety, capacity and efficiency.

**Recommendation: Although not realistic in the current economic environment, the aviation industry prefers direct grants over a loan program. With that understanding, a public-private loan program is the most feasible financing instrument for encouraging timely NextGen equipage investments on the part of the operators. However, for those incentives to be successful, the benefits associated with**

**equipment, in the form of measurable improvements to the air traffic management system, must be achieved.**

### **Reasonable conditions that would justify investment of taxpayer funds**

The rationale for employing financial incentives is to fill a gap in the business case for investing in equipment required to advance the performance of the air transportation system. In the case of NextGen, as stated above, there are two conditions that warrant government incentives: (1) achieving a minimum percentage of equipment to be able to deliver operational benefits, and (2) equipping the most expensive aircraft when operational benefits cannot be achieved without 100% equipment.

An essential success criterion of any government financial incentives program is that those incentives achieve their intended outcome. It is imperative that each financial incentive be linked to a clearly defined performance improvement target against a metric by a specific date. The time frames for implementing NextGen capabilities are identified in the FAA's NextGen Implementation Plan. The BCPMWG has identified the deltas between current equipment percentages and the level required to achieve full operational benefits.

**Recommendation: Using the ICWG inputs, the FAA and the aviation industry must validate and agree which specific capabilities warrant an investment of taxpayer funds. For each capability, the FAA should work with the NAC to identify the metrics and the target user and system performance improvements. The metrics used should be those identified by the September 2011 NAC BCPMWG recommendations for measuring NextGen performance. As an initial step, identify, by February 2012, the metrics associated with each capability for Packages A, B and C.**

**In addition, taxpayer funds should only be used for the following conditions (See Figure 1.):**

- **To overcome business case gaps to achieve minimum threshold conditions for benefits to accrue.**
- **To overcome business case gaps to achieve optimal equipment levels that enable substantial system or societal benefits that exceeds the cost of the incentive.**

### **Realistic Timetable for Financial/Operational Incentives**

As addressed in the previous section, the FAA and the aviation industry must validate and agree which specific NextGen capabilities warrant an investment of taxpayer funds based on the timeframes in the NGIP. A minimum level of user equipment is necessary to achieve benefits from the operational availability of a capability. Reasonable time frames for users to reach targeted equipment levels must include allowances for user internal analysis and decision making, implementation planning and engineering, training and alignment of on-aircraft retrofit with scheduled maintenance opportunities. To achieve these benefits in a timely manner, this needs to be done in parallel with the FAA's deployment of capabilities, technology, procedures and training. It is also critical that there is full support and cooperation of all stakeholders in the aviation community.

**Recommendation: The FAA must remove the uncertainty associated with implementing capabilities that close the business case for an operator. For each of the capabilities using financial incentives for**

avionics equipage, FAA and industry should identify the equipage timeline that is needed to achieve minimum equipage thresholds and removing any uncertainty in the capability delivery date. In addition, the FAA and the operators must develop and carry out synchronized action plans to timely achieve the benefits of the deployed capability.

### Assurances to early adopters

To provide assurances that early adopters will not be disadvantaged, the Ad Hoc Task Group makes the following recommendations:

#### Recommendation:

- **A combination of financial and operational incentives should be made available for aircraft that are the first to be equipped but cannot reap benefits until a critical mass of aircraft are equipped.**
- **A combination of financial and operational incentives should be made available for aircraft operators who have already equipped but are still not achieving the intended benefits.**
- **Success of financial and operational incentives must be measured in terms of a specific target improvement in system performance, not simply reaching an equipage target level.**
- **Where it is possible to deliver operational benefits to aircraft who are equipped, operational incentives should take precedence over financial.**

### Applying Operational Incentives

An operational incentive is some sort of preferential treatment enabled by that equipage that results in a tangible benefit to the equipped aircraft. The FAA's proposed framework classifies operational incentives into four classes based on their impacts:

- Class 1: The incentive provides a net benefit to equipped operators with no impact on the unequipped.
- Class 2: The incentive provides a net benefit to an equipped operator that significantly exceeds the negative impacts on the unequipped.
- Class 3: The incentive results in significant benefits to society and to equipped users, with negative impacts to the unequipped.
- Class 4: The incentive results in short-term negative impacts that outweigh the benefits but leads to significant, longer-term societal benefits.

The preliminary results of work by The MITRE Corporation show that the application of operational incentives for specific NextGen capabilities is a promising option for closing all or part of the business case gap, especially early adopters. In the case of providing efficient reroutes for airborne aircraft around severe weather, for example, there is clear potential for those who are equipped with DataComm to receive reroutes that are more efficient and delivered earlier than for non-equipped aircraft, resulting in a substantial reduction in weather-related delays (see Appendix B). This operational preferential treatment, offered to early adopters could provide enough incentive to close the business case to equip.



Operational incentives are a promising tool within the FAA's capability and authority and if validated operationally, can potentially address all or part of user business case gaps for certain NextGen capabilities, especially for early adopters. In addition, operational incentives can provide benefits to equipped DoD aircraft or other public-use aircraft. Initially, Class 1 and 2 operational incentives are likely to be the most effective mechanisms to incentivize equipage for some of the avionics packages under consideration.

**Recommendation: The FAA should work with the NAC to identify specific NextGen operational capabilities for which the FAA can provide operational incentives and evaluate the business case implications for equipped users. Those operational capabilities for which operational incentives show promising business cases should be considered for further development and accelerated implementation.**

### Criteria for evaluating success of incentives

It is the strong feeling of the members of the Ad Hoc Task Group that success of a financial incentive should be measured in terms of the associated improvement in the performance of the air traffic management system or the delivery of the associated measurable operational benefit to those who equip. Simply achieving a level of avionics equipage, without benefits, is not a success if it does not lead to an improvement in the system performance.

For each incentive, metrics and targets performance levels should be identified at the start. This will facilitate identification of the point (i.e., when positive benefits begin to accrue) at which users who accepted financial incentives are obligated to complete any agreements (e.g. payback of loans).

**Recommendation: As each capability involving avionics incentives is implemented, the FAA should work with the NAC to measure the achieved user- and system- performance impacts that are directly associated with the capability and compare achieved performance with targeted performance. Success is equaling or exceeding the identified target performance impacts.**

### Summary of Equipage Incentive Recommendations

- 1. Recommendation:** Although not realistic in the current economic environment, the aviation industry prefers direct grants over a loan program. With that understanding, a public-private loan program is the most feasible financing instrument for encouraging timely NextGen equipage investments on the part of the operators. However, for those incentives to be successful, the benefits associated with equipage, in the form of measurable improvements to the air traffic management system, must be achieved.

**Note:** Federally funded public aviation organizations, such as DoD, are not able to use financial incentives as discussed in this recommendation. Additionally, any incentives that include USG services or pay to public-private loan guarantees may draw upon the same funds that public aviation organizations will use to fund NextGen.

- 2. Recommendation:** Using the ICWG inputs, the FAA and the aviation industry must validate and agree which specific capabilities warrant an investment of taxpayer funds. For each capability, the FAA should work with the NAC to identify the metrics and the target user and system performance improvements. The metrics used should be those identified by the September 2011 NAC BCPMWG recommendations for measuring NextGen performance. As an initial step, identify, by February 2012, the metrics associated with each capability for Packages A, B and C.

In addition, taxpayer funds should only be used for the following conditions (See Figure 1.):

- To overcome business case gaps to achieve minimum threshold conditions for benefits to accrue.
- To overcome business case gaps to achieve optimal equipage levels that enable substantial system or societal benefits that exceeds the cost of the incentive.

- 3. Recommendation:** The FAA must remove the uncertainty associated with implementing capabilities that close the business case for an operator. For each of the capabilities using financial incentives for avionics equipage, FAA and industry should identify the equipage timeline that is needed to achieve minimum equipage thresholds and remove any uncertainty in the capability delivery date. In addition, the FAA and the operators must develop and carry out synchronized action plans to timely achieve the benefits of the deployed capability.

**4. Recommendation:**

- A combination of financial and operational incentives should be made available for aircraft that are the first to be equipped but cannot reap benefits until a critical mass of aircraft are equipped.
- A combination of financial and operational incentives should be made available for aircraft operators who have already equipped but are still not achieving the intended benefits.
- Success of financial and operational incentives must be measured in terms of a specific target improvement in system performance, not simply reaching an equipage target level.
- Where it is possible to deliver operational benefits to aircraft who are equipped, operational incentives should take precedence over financial.

- 5. Recommendation:** The FAA should work with the NAC to identify specific NextGen operational capabilities for which the FAA can provide operational incentives and evaluate the business case implications for equipped users. Those operational capabilities for which operational incentives show promising business cases should be considered for further development and accelerated implementation.

- 6. Recommendation:** As each capability involving avionics incentives is implemented, the FAA should work with the NAC to measure the achieved user- and system- performance impacts that are directly associated with the capability and compare achieved performance with

targeted performance. Success is equaling or exceeding the identified target performance impacts.

## Members of the NextGen Advisory Committee Ad Hoc Task Group (Phase Two)

- Ed Bolen, NBAA (Chair)
- Sue Baer, PANYNJ
- Dave Barger, JetBlue Airways
- Sherry Carbary, Boeing
- Craig Fuller, AOPA
- Bob Gray, ABX Air
- Margaret Jenny, RTCA
- Lee Moak, ALPA
- Julie Oettinger, FAA (Observer)
- Jim Rankin, Air Wisconsin
- Gen. Williams, US Air Force
- Agam Sinha, MITRE

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RTCA, I. (2010). *www.rtca.org*. Retrieved from [http://www.rtca.org/CMS\\_DOC/NAC%20Terms%20of%20Reference.pdf](http://www.rtca.org/CMS_DOC/NAC%20Terms%20of%20Reference.pdf)



# NextGen Equipage Gap Analysis

by the  
Business Case & Performance Metrics WG

*10 August 2011*

Debby Kirkman, MITRE

Ed Lohr, Delta Air Lines

## BCPMWG Equipage Gap Analysis

- ✱ NAC ad-hoc recommended three key packages providing an avionics “infrastructure” for NextGen:
  - Package A: RNP 0.3/RF for Part 121; WAAS/LPV for GA
  - Package B: ADS-B “Out” for Part 121 & GA users
  - Package C: Data Comm (FANS 1/A+ or ATNB1 over VDL-2) for Part 121 users
- ✱ BCPMWG evaluated an aggregate analysis of costs and benefits using inputs on upgrade paths costs and available information on benefits & plans
  - Focused on benefits resulting from **reduced flight time** (minutes saved)
  - Did not address business case for individual operators
  - Did not address potential cost savings from “bundled” equipage
  - Parametric analysis used if benefits data was not available
  - GA analysis focused on avionics cost estimates due to diversity of operations
  - Did not address DOD fleet



## Monetized Costs & Benefits

	Part 121 – Wide & narrow body	Part 121 – RJ	High End GA	Low End GA	DOD*
Avionics costs	X	X	X	X	
Installation	X	X			
Initial Crew training	X	X			
Fuel savings	X	X			
Crew savings	X	X			

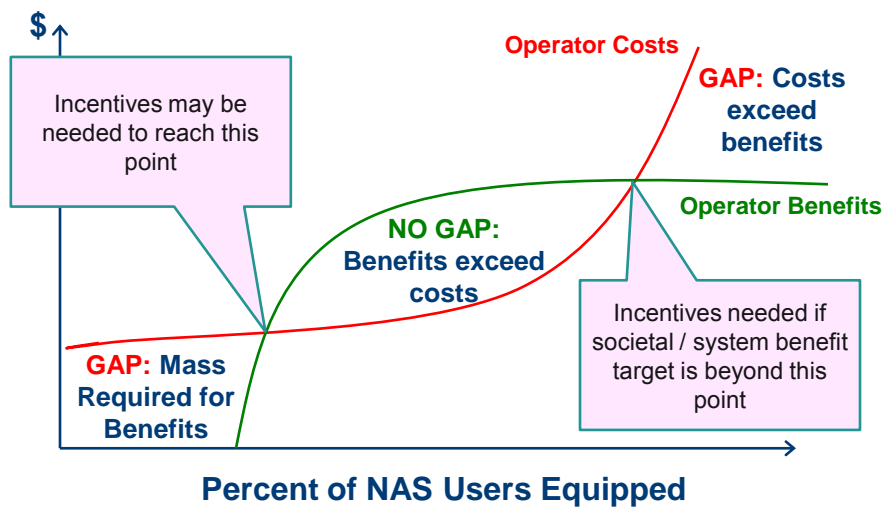
Costs Not evaluated: ANSP ground infrastructure capital and lifecycle costs, Operator dispatch automation system changes, Avionics lifecycle costs, or Recurring crew training costs

Benefits not evaluated: Reduced block times, Improved airframe utilization, Increased scheduling opportunities

DOD transport aircraft typically treated differently from tactical aircraft

THE GOLD STANDARD FOR AVIATION SINCE 1933

## Notional Marginal Cost vs. Benefit



## Proposed Recommendation

- ✦ FAA should work with flight operators to maximize overall value; addressing equipage marginal costs and benefits for NextGen capabilities. To achieve system- and societal benefits and to enable synchronized investments, FAA should, within its legislative authority:
  - Maximize ability for operators to achieve benefits in a mixed equipage environment
  - Develop estimates of the *direct* user benefits from equipage for NextGen avionics
  - Establish stable, long-term implementation plans (locations & dates) and joint accountability mechanisms
  - Offer incentives to overcome business case gaps for early adopters or when overall benefits require equipage that is not justified from an investing flight operator's perspective



## Summary of Results

	RNP0.3/RF leg	WAAS	ADS-B Out	Data Comm
<b>US Operators evaluated</b>	Part 121	IFR-capable GA	Part 121, transponder-equipped GA	Part 121, (high-end GA)
<b>User Benefits</b>	Reduced flight time; 80% threshold postulated for congested locations	Low-visibility access & safety	Reduced flight time; 100% equipage required	Reduced operating time for dept clearance & airborne reroutes; 20% equipage is lowest threshold in models
<b>Methodology</b>	Parametric	Cost only	Part 121 – Parametric; GA – Cost only	Discrete time savings from DCL & Reroute services
<b>Current Equipage</b>	42%	30%	0% (rule-compliant)	0.2% of Part 121
<b>Cost for 100% equipage</b>	\$0.8-2.5B	\$2.3B	\$4B	<ul style="list-style-type: none"> <li>• FANS 1/A+: NA</li> <li>• Choice of FANS or ATNB1: \$1.5B</li> </ul>
<b>Key cost factors</b>	RJ fleet not RF capable	Low-end GA affordability	ADS-B in will drive benefits; Low-end GA affordability	VDL-2 upgrade costs FANS costs vs ATNB1; RJs not autoload capable
<b>Conclusions</b>	FAA should develop capability to utilize routinely with <i>current</i> equipage	Continue to develop WAAS approaches	Incentives needed to increase compliance by 2020	FAA should support both solutions & allow user choice



## Package A: Performance Based Navigation – RNP 0.3/RF

- NAC Ad-hoc focus: Part 121 Operators
- Benefits: Shorter arrival paths, airport deconfliction, add'l arrival & departure paths
- Key equipage threshold estimated at 80% for a high-density location with non-overlay procedures
- Current equipage of Part 121 is 42%
- Parametric analysis results shows that with a 3 min savings/flight, an additional 88-96% of the unequipped aircraft achieve payback within 2.5 years
- Finding A: An 80% equipage level at the busiest airports would require near full equipage of Part 121 aircraft - including RJs - as well as a significant equipage of other airspace users (eg, high-end GA, military)
- Finding B: A major gap in calculating the user business case is the lack of published specific location benefits and implementation dates. This also affects forward-fit forecasts.

Grand Metroplex Analysis Summary	JFK	LGA	EWR	PHL	ORD	MDW	IAD	DCA	BWI	BOS
Operators										
Mainline Air Carriers	67%	44%	61%	36%	35%	70%	32%	39%	72%	51%
Regional Airlines	27%	54%	37%	42%	54%	5%	37%	54%	7%	20%
Business/ GA	6%	2%	2%	22%	10%	24%	30%	5%	21%	25%
Military/Other	<1%	0%	1%	0%	2%	1%	2%	2%	1%	4%
NextGen Operations Applicable										



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## Package A: Performance-Based Navigation – WAAS LPV

- NAC Ad Hoc Target User Group: General Aviation
- Benefits: Improved access, especially in low visibility. WAAS/LPV approaches can be added without expensive ILS infrastructure
- Critical Mass Threshold: None for individual user benefits; societal cost avoidance benefits arise from decommissioning ILSs and VORs
- Methodology: Assumed high-end forward fit with WAAS; low-end retrofit only
- High-end GA fleet: 30% currently equipped of 18,500; forecast equipage is 38% of 28,000 US-registered airframes in 2020
- Low end GA fleet: 30% currently equipped (of 108,000 IFR-capable airframes); 2020 forecast is driven by retro-fit market
- Finding C: For GA, most investment decisions are personal, driven by affordability and availability of LPV procedures, ie, "Is there a WAAS/LPV approach at my home airport?"



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## Package B: ADS-B Out

- NAC Ad Hoc Target User Groups: Commercial, General Aviation
- Benefits: Spacing & routing in non-radar airspace (eg, Gulf of Mexico); merging & spacing; surface mgmt safety and efficiency
  - Voluntary Equipage likely to be driven by ADS-B In applications
  - ADS-B Mandate requires DO-260B compliant equipage in most NAS airspace after 2020;
  - No Rule compliant avionics currently available
  - Critical Mass Threshold: 100% for NAS-wide benefit, Methodology:
- Methodology: For Part 121, focused on parametric analysis; difficult to translate system-wide benefits data to direct user (airframe) benefits from equipage
- Finding D: There is a risk of a large non-compliant population of aircraft if equipage decisions are delayed due to the capacity of retrofit installation facilities
  - Avionics Industry estimates capacity is 10 – 20,000 units/year
  - Users may press for extension of the rule compliance date



## Package C: Data Comm

- NAC Ad Hoc Target User Groups: Part 121 operators
- Alternative capabilities: FANS 1/A+ or ATNB1
  - FANS 1/A+ postulated to support advanced applications, including tailored arrivals & complex clearances
  - European mandate specifies ATNB1 by 2015 with accommodation of FANS
  - FAA is evaluating a potential requirement for FMS autoload
- Methodology focused on Program office planned capabilities: Departure Clearance (DCL) & Airborne reroutes
  - Used program office estimates of DCL benefits & TF5 estimates of reroute time savings
  - No information on implementation of other capabilities
- Equipage Considerations:
  - 121 aircraft currently equipped with FANS 1/A+/VDL2
  - FMS Autoload capability retrofit is not offered for the RJ fleet
  - 34% of the Part 121 fleet is equipped with VDL2
    - Significant cost to upgrade VDL-0 to VDL-2 (ROM \$300K)
  - Per-aircraft costs for FANS 1/A+ implementation are about twice the costs of ATNB1
  - Estimated retrofit /forward fit options for high-end GA are TBD (awaiting input from GA manufacturers)





## Open Discussion -- Key Themes of Final Report

- Closing the business case for each capability
- Identify incentives most likely to CLOSE the business case
- Identify reasonable conditions that would justify incentives
- Assurances to early adopters
- Criteria for evaluating success of incentives



### Next Steps

# Financing Alternatives

## *Ad Hoc NextGen Advisory Committee (NAC) Meeting*

Presented to: NAC Incentives Work Group

By: Julie Oettinger, *Assistant Administrator Policy, International Affairs, and the Environment*

Date: July 20, 2011



Federal Aviation Administration



## Introduction

- **Financial mechanisms can be used to incentivize infrastructure and public service projects. Examples include:**
  - ♦ National Infrastructure Bank\*
  - ♦ Loan Programs
  - ♦ Tax Incentives
  - ♦ Grants
  - ♦ Public-Private Partnerships
- **Financing options are not necessarily mutually exclusive.**
- **Budget scoring & legal authorities should be considered when evaluating options.**

\*Proposed in President's FY12 Budget – pending Congressional approval.



Federal Aviation Administration

## National Infrastructure Bank

- **The President's budget proposes a National Infrastructure Bank (I-Bank) for financing transportation projects.**
  - ♦ I-Bank would leverage limited private resources.
- **Congressional approval is required (and pending).**
- **State infrastructure banks are successful models:**
  - ♦ Ohio (loans for terminal & gates at regional airports, roads, etc.)
  - ♦ California (loans for local roads, utility upgrades etc.)
  - ♦ Vermont (loans for roads, bridges, commuter vans)



## Other Loan Programs

- **Direct loans, highly discounted loans, secured lines of credit, loan guarantees**
  - ♦ Interest rate may be set below market
  - ♦ Payback period may be more attractive
- **FAA does not have broad legal or budgetary authority to issue loans or loan guarantees although has been appropriated funds in the past.**
- **Examples of loan programs include:**
  - ♦ Transportation Infrastructure Finance & Innovation Act (TIFIA)
  - ♦ State of Alaska Capstone Avionics Loan Program
  - ♦ FAA aircraft purchase loan guarantee program (1958-1983)



## Tax Incentives

- **Tax credits & deductions are tools that can incentivize behavior.**
  - ♦ Carry-forward rights and allowing credits to be transferable enhances the value of these instruments.
- **Would require changes to tax laws as well as funding from Congress prior to adopting such a program.**
- **Several Government tax incentive programs are in existence. Examples include:**
  - ♦ Energy tax credits (hybrid gas-electric vehicles, energy-star windows, etc.)
  - ♦ Research & Development tax credits
  - ♦ General aviation aircraft accelerated depreciation



## Grants

- **Grant programs can range from a small subsidy up to full cost of a purchase.**
  - ♦ Typically grants do not fund 100% of a purchase, but require a matching contribution.
- **FAA has broad authority that could be used. However, budget appropriations are also necessary.**
- **Federal grant programs include, for example:**
  - ♦ FAA's Airport Improvement Program (AIP)
    - ♦ Voluntary Airport Low Emissions (VALE)
  - ♦ DOT's TIGER Grant Program
  - ♦ DOE reverse auction for cellulosic biofuel producers



## Public-Private Partnerships (P3s)

- **P3s are agreements between a public agency and private sector to improve delivery & financing of projects.**
  - ♦ Many variations on P3s.
- **Legal authority depends on financial agreement – many FAA P3s are cost-share projects. FAA has legal authority, but also requires funds to be appropriated.**
- **P3 examples:**
  - ♦ FAA/Helicopter Association (satellite surveillance over the Gulf of Mexico);
  - ♦ FAA/JetBlue (ADS-B trials)
  - ♦ The Department of Energy’s “Energy Savings Performance Contracts” (ESPCs)
  - ♦ Private investment with government as partner (e.g. NEXA proposal)



## Concluding Remarks

- **Multiple financial instruments can be used to incentivize behavior**
- **Some instruments can be combined (including operational incentives)**
- **We look forward to your ideas on how to structure NextGen financial incentives**
  - 1) Given the spectrum of options, how would the working group rank the incentives in order of usefulness?
  - 2) How should incentives be prioritized? (e.g. regional focus, technology focus, user-group focus, etc.)
  - 3) What level of cost-share would be effective at closing the business case?
  - 4) Given the very tough budget situation, which of these incentives would compete the best against other demands on federal dollars?




[www.nextgenfund.com](http://www.nextgenfund.com)

# Implementing NextGen: One Business Case at a Time

NAC Equipage Ad Hoc  
July 20, 2011

NextGen Equipage Fund, LLC



NEXA Capital Partners, LLC  
NEXA Capital powers the industry

NextGen Fund For Public Release

## Outline

1. The NextGen Equipage Paradox
2. Closing the Airline Business Case
3. Satisfying All Stakeholders
4. The NextGen Equipage Fund


NextGen Fund For Public Release


## The NextGen Equipage Paradox

### Summary


- The “NextGen Equipage Paradox” exists because despite the potential for significant benefits from NextGen, airlines and other operators are not making the needed aircraft equipage investments.
- There are still uncertainties in NextGen requirements and benefits. This means that in the end, those operators who are last to equip with NextGen avionics will reap the most financial benefit, while those operators who are first will get the lowest returns at a far greater risk.
- Moreover, many domestic airline balance sheets remain weakened making the cost of discretionary, non-aircraft capital expensive, and protecting cash flow remains a top priority. This handicaps their ability to close their business cases for long term, non-aircraft capital investments, such as NextGen equipage.
- The NextGen Equipage Fund solves this “Paradox” through proven regulatory and policy mechanisms, in combination with private sector capital, commercial leasing structures, and service contract commitments.
  - ✓ Private-Sector Capital (Equity and Debt) provided by strategic investors, led by ITT Corporation.
  - ✓ A \$1.5 billion fund, capable of equipping up to 75% of the US commercial air transport fleet.
  - ✓ Equipage includes ADS-B In/Out, Data Comm, etc., as well as installation, licensing and maintenance costs.
  - ✓ Unique accountability is created using “Best-Equipped, Best-Served” contract agreements.
  - ✓ Federal loan guarantees securing non-recourse loans over 15 year period.

**Without aircraft equipage, NextGen will never be realized**

 NextGen Fund For Public Release



## Section 2: Closing the Airline Business Case

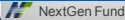
 NextGen Fund For Public Release

## Closing the Airline Business Case

### A Demand-Based Commercial Investment Decision

- Without each airline closing their individual business case, aircraft retrofit equipage will never be realized.
  - ✓ Without a mandate, closing the business case will be required.
  - ✓ Every individual airline business case is different from one another.
  - ✓ Every airline business case will be subject to changing future projections.
- Although every airline business case for NextGen is different, the reasons they remain open is due to some key commercial investment factors.
  - Commercial capital investment decisions will always demand best value.
    - ✓ Discretionary capital investments of this size will require board-level approval.
    - ✓ Hurdle rates are driven higher by both return uncertainties and cash-flow risk.
    - ✓ While a low cost of capital is required for a long-term investment, it alone can not overcome these risks and uncertainties.

**NextGen implementation will only occur when the majority of airlines successfully close their individual business cases for aircraft equipage.**


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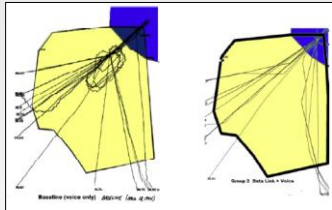
## Closing the Airline Business Case

### Why Unilateral Airline Decisions to Equip For Benefits Is Unlikely

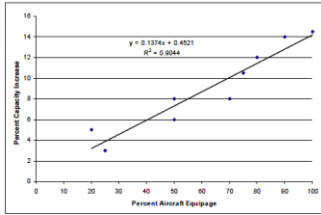
#### DATA COMMUNICATIONS EXAMPLE


- En route airspace congestion causes delays from Air Traffic Controller workload saturation.
- These delays are seen as excessive miles-in-trail spacing, inefficient vectoring, and airborne holding.
- The largest benefit of NextGen is the reduction in operating costs associated with these delays.
- Capacity is limited by controllers ability to handle multiple aircraft in a given en route sector.
- Regression analysis shows a 90% correlation between capacity and equipage level.
- A 75% equipage level will increase sector capacity by 10% to a maximum of 14% with 100% equipage.
- **KEY FINDING: The benefits needed for operators to offset their capital invested begins to accrue at predominant equipage levels of 50% to 60%.**

*NextGen Reduces Delay in Congested Enroute Airspace*



*Airspace Capacity Increases with Equipage*




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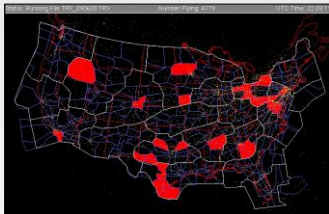
## Closing the Airline Business Case

Even In Mixed Equipage Applications, Predominant Equipage Drives the Benefits

### DATA COMMUNICATIONS EXAMPLE

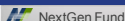
- Congested airspace surround the Northeast and extend to Chicago, Atlanta, and Dallas-Ft. Worth.
- Maximum return-on-investment will be driven by achieving a high percentage of Data Comm equipped aircraft in the shortest time.
- In 2002, MITRE CAASD projected detailed delay savings by individual airline for controller-pilot data link communications [CPDLC].
- Since airlines don't equip their aircraft fleets for specific geographic regions, equipage funding must plan for all aircraft in each airline's fleet type.
- AA example shows only \$8.7 million yearly savings at its hubs if only AA is equipped vs. \$80 million if all airlines are equipped.
- KEY FINDING: The benefits are dramatically lower if an airline unilaterally decides to equip by itself.**


*The Areas of Airspace Congestion*




*Airline Savings Depend on Congestion Exposure*

AAL Dollar Savings	Only AAL & American Equipage Equipped	
	Most Likely Projection	All Airlines Equipped
Airport	AAL yearly savings at Hub	AAL yearly savings at Hub
Boston	\$0	\$1,300,000
Chicago	\$1,400,000	\$14,000,000
Dallas-Ft. Worth	\$5,200,000	\$24,800,000
JFK	\$100,000	\$2,400,000
Los Angeles	\$100,000	\$2,200,000
Miami	\$200,000	\$1,800,000
St. Louis	\$100,000	\$1,600,000
All Other Hubs	\$7,600,000	\$32,200,000
NAS-wide yearly savings	\$8,700,000	\$80,300,000


For Public Release



## Section 3: Satisfying All Stakeholders


For Public Release

## Satisfying All Stakeholders

### The NextGen Fund Resolves Barriers and Risks with Shared Accountability

Airlines / Operators	Government
<p><b>Investment Barriers and Resolutions</b></p> <ul style="list-style-type: none"> <li>✓ High Airline Capital Costs: Reduced cost-of-capital.</li> <li>✓ At-Risk Capital Requirement: Reduced with at-risk private-sector equity.</li> <li>✓ Predominant equipage benefits: Equipage leases structured to achieve predominant equipage levels by region or local facilities.</li> <li>✓ Upgrade protection from future requirements: Equipage leases include installation and software updates.</li> </ul> <p><b>Implementation Risks and Mitigations</b></p> <ul style="list-style-type: none"> <li>✓ Delays in FAA programs: Airline payments are deferred until the new system is installed and being used.</li> <li>✓ Widely Varying Aircraft Configurations: Preserves airline choice, leverage, &amp; related efficiencies in the supply chain.</li> <li>✓ High Installation Costs: Longer installation schedules eliminate special aircraft out-of-service time by using heavy-check maintenance lines.</li> </ul> <p><b>Accountability and Performance Penalties</b></p> <ul style="list-style-type: none"> <li>✓ Variable security deposit to manage variable credit worthiness.</li> <li>✓ Pays high out-of-service costs if unable to meet installation commitments.</li> </ul>	<p><b>Investment Barriers and Resolutions</b></p> <ul style="list-style-type: none"> <li>✓ Constrained FAA Facilities &amp; Equipment Budgets: Stretches FAA equipment dollars with leveraged finance.</li> <li>✓ Constrained FAA Operating Budgets: Reduces escalating costs of operating existing &amp; NextGen ATC systems.</li> <li>✓ Administrative and Legal Costs: Can be reimbursed.</li> <li>✓ Growing Budget Deficit: Leveraged funds are directly invested into U.S. jobs and economic activity, producing immediate federal tax revenue.</li> <li>✓ Growing Trade Deficit: Enhances global competitive leadership of U.S. manufactured NextGen aircraft and ground systems.</li> </ul> <p><b>Implementation Risks and Mitigations</b></p> <ul style="list-style-type: none"> <li>✓ Applicant Default: Structure shields government from individual default.                             <ul style="list-style-type: none"> <li>• Provides substantial private-sector equity/debt at-risk</li> <li>• Requires ongoing operational and technical services</li> </ul> </li> <li>✓ Unfunded Government Mandates: Avoided with effective incentives.</li> </ul> <p><b>Accountability and Performance Penalties</b></p> <ul style="list-style-type: none"> <li>✓ Defer payments continue until NextGen system is deployed and used.</li> </ul>
Supply Chain	Investors
<p><b>Investment Barriers and Resolutions</b></p> <ul style="list-style-type: none"> <li>✓ Market Demand Uncertainty: Predominant equipage requirement levels improve market size certainty with significant near-term demand and revenue.</li> <li>✓ Market Timing Uncertainty: Reduces costs with more predictable heavy-check maintenance installation schedules improve medium and long term demand forecasts and required production volumes.</li> <li>✓ High Cost of Early Development: Faster and more efficient recovery of research and development investments.</li> </ul> <p><b>Implementation Risks and Mitigations</b></p> <ul style="list-style-type: none"> <li>✓ High Inventory Costs: Long installation schedules improve just-in-time production opportunities to keep raw and finished inventories low.</li> <li>✓ New or Changing FAA Requirements: Large installed base of equipment stabilizes introduction of new requirements.</li> </ul> <p><b>Accountability and Performance Penalties</b></p> <ul style="list-style-type: none"> <li>✓ Competitive environment maintains market pressure on supply chain costs.</li> <li>✓ Accelerated demand will ensure availability certified equipment and software.</li> </ul>	<p><b>Investment Barriers and Resolutions</b></p> <ul style="list-style-type: none"> <li>✓ High Capital Costs: Reduces cost of capital with a Federal Loan Guarantee.</li> <li>✓ Long-term Returns: Reduces cash outlays with accelerated depreciation.</li> <li>✓ Limited Cash Returns: Upside returns from market valuation of the Fund as a commercial entity.</li> </ul> <p><b>Implementation Risks and Mitigations</b></p> <ul style="list-style-type: none"> <li>✓ Customer Default Risk: Use successful leasing professionals managing a well-diversified portfolio with proven credit-risk management practices.</li> <li>✓ Maintaining Liquidity: Significant cash reserves created early</li> <li>✓ Startup Investment Risks: Equity &amp; debt committed over longer time.</li> </ul> <p><b>Accountability and Performance Penalties</b></p> <ul style="list-style-type: none"> <li>✓ All of investor's capital is completely at-risk if leasing business entity fails.</li> <li>✓ Government's guaranteed debt is senior to all private sector's at-risk capital.</li> </ul>

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## The NextGen Fund's Multiplier Effect

### Makes Appropriate Use of a Federal Loan Guarantee

**Direct Grant**

Government Investment:  
Direct Grant. Scored by  
Budget Rules

**\$1.0 B**

**Airplanes Equipped  
(Per Federal Dollar)**

**Federal Loan Guarantee**

Supply Chain Efficiencies  
and Buying Power

Private-Sector Capital Plus  
Income/Cash Flow

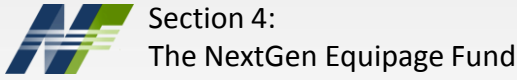
Credit Risk Premium  
Scored by Budget Rules

**\$2.3 B**

**\$1.6 B**

**\$125 MM**

NextGen Fund
For Public Release



Section 4:  
The NextGen Equipage Fund

NextGen Fund For Public Release

### The NextGen Equipage Fund, LLC Capital and Legal Structure

- NextGen Equipage Fund:
  - ✓ Limited Liability Company and share issuer
  - ✓ Operating and borrowing entity
  - ✓ Maintains all financial and contractual relationships
  - ✓ Full liability protection to investors/owners
  - ✓ Established board, and appoints GP
- Limited Partners:
  - ✓ Aggregate equity investment
  - ✓ Oversight through LP board of directors
  - ✓ Share issuance comprising common and preferred shares
- General Partner:
  - ✓ Primarily responsible for operation and administration of the entity
  - ✓ Employs and compensates executive management

**Limited Partner Level**

*Liability Celling*

LP 1   LP 2   ...   LP n


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**General Partner Level:**

*NEXA General Partnership & Management Company, LLC*

NEXA GP

Operating and Borrowing Entity



**NextGen Equipage Fund**

Operators/Airlines

Aircraft Financiers

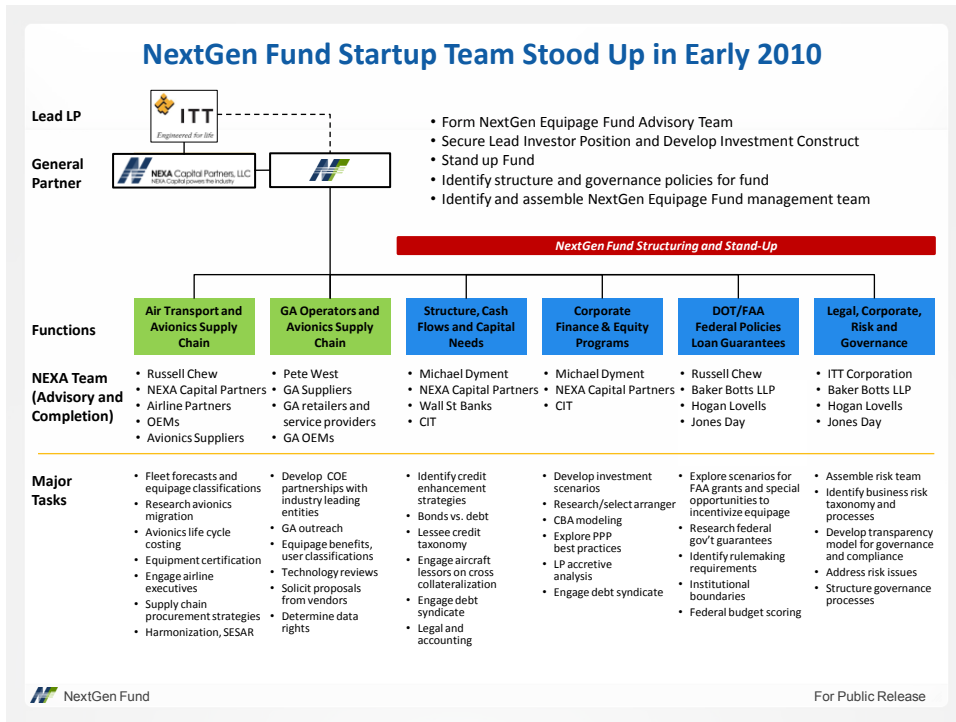
Avionics Suppliers

Term Lenders

Regulators

Financial and Contractual Relationships

NextGen Fund For Public Release




[www.nextgenfund.com](http://www.nextgenfund.com)

# Implementing NextGen: One Business Case at a Time

**NAC Equipage Ad Hoc**  
July 20, 2011

**NextGen Equipage Fund, LLC**

  
NEXA Capital Partners, LLC  
NEXA Capital powers the industry

NextGen Fund For Public Release

# Equipping the Aviation Fleet for NextGen

## Is a Metric Driven Government Loan Guarantee an Option?

Neil Planzer, The Boeing Company

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### Overview – Metric Driven Government Loan Guarantee

- Statistics on the Fleet
- Financing Options
- Conundrum – No Investment Without the Assurance of Benefits (unfulfilled promises)
- Linking NextGen Outcomes to Financing
- Minimizing Government Loan Guarantee Risks
- Alternatives without Metrics
- Needed Tasks

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## Fleet

- Number of aircraft in the domestic system – 18,519 total domestic aircraft (7,177 domestic flag and cargo aircraft, 11,342 commuter air carriers and air taxis)
- Cost to retrofit – FAA estimate for ADS-B Out \$2.5B to \$6.2B (“Out” alters transponders – “In” requires new TCAS equipment with an optional new display)
- Length of time necessary to retrofit (5-7 years) per piece of avionics installed if retrofit done sequentially
- Cost of retrofit may exceed value of the aircraft
- Need for requirement of all avionics for NextGen implementation

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## Financing Options

- Airlines pay for avionics
- Airlines borrow funds to pay for avionics over time
- Government augments, subsidizes loans, or pays in the entirety for the avionics
- Third party purchases avionics and leases to airlines to use/use to buy

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## Conundrum – No Investment Without the Assurance of Benefits

- Past failures – i.e. MLS, CPDLC, RNAV, FANS-1
- Mandated avionics, safety imperative – i.e. TCAS
- Lack of trust without accountability (it's not a financing issue)
- Government must guarantee outcomes and benefits (industry needs to be assured)

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## Defining Outcome Metrics – Notional Examples:

- Are the aviation accident and accident precursor rates improving?
- Are average gate-to-gate travel times for city-pair routes decreasing?
- Is individual runway utilization capacity increasing?
- Are new runways being introduced where added capacity is needed?
- Are the FAA unit costs of operation decreasing?

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## Linking NextGen Outcomes to Financing

- 3<sup>rd</sup> party financing for a specific fleet
- 7-10 year pay back period
- Outcome metrics supplies the revenue stream with 60% to the airline/ 40% to pay back loan
  - Example: reduce flight time between Chicago and New York. (notional savings: 150 flights per day x 15 minute reduction x \$60/per minute = \$135,000 per day)
- Guaranteed by the government
  - If FAA does not realize the metrics in 3 years, the government services the loan
  - If the FAA does not achieve the outcome in the following 3 years, the government pays the loan in full

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## Minimizing Government Loan Guarantee Risks

- Holding FAA accountable for the outcomes promised by NextGen investments
- Government must change the way it is measuring FAA ATO program success
- “Buying down the risk” will include linking performance metrics to FAA individual personnel agreements
- “Buying down the risk” includes forming working groups to focus on the outcomes (NextGen is not just better information – but improved safety, capacity and efficiency)
- “Buying down the risk” include a three year buffer on benefit realization
- It will take 3 years from the time you have defined the metrics to equip enough of the fleet to achieve the benefits (tipping point – percentage of fleet needed to get the NextGen benefits)

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## Alternatives Without Metrics

- When will airlines equip?
- When will FAA produce outcome benefits?
- When will the “tipping point” of equipage occur?
- How long will you operate with a limited fleet mix? (if only a small percent of the fleet equip – there are no benefits)
- A modernized ground based ATC system that isn’t linked to the airframes provides no benefits over today’s system
- When does NextGen investment cease without outcome benefits?
- Without avionics equipage, why are we doing NextGen?
- If the Government doesn’t trust FAA to produce the benefits, why should the industry?
- Another alternative is to mandate equipage.....

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## Needed Tasks

- What are the outcome metrics needed to drive rapid NextGen benefits
- Define the “tipping point”
- What is the equipage timetable to reach the “tipping point”
- Define a regional approach and concept of operations using key city pairs
- What are the separation requirements for NextGen

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# Avionics Equipage Policy Impacts

Deborah Kirkman  
703-983-5964 • dkirkman@mitre.org

MITRE Sponsored Research

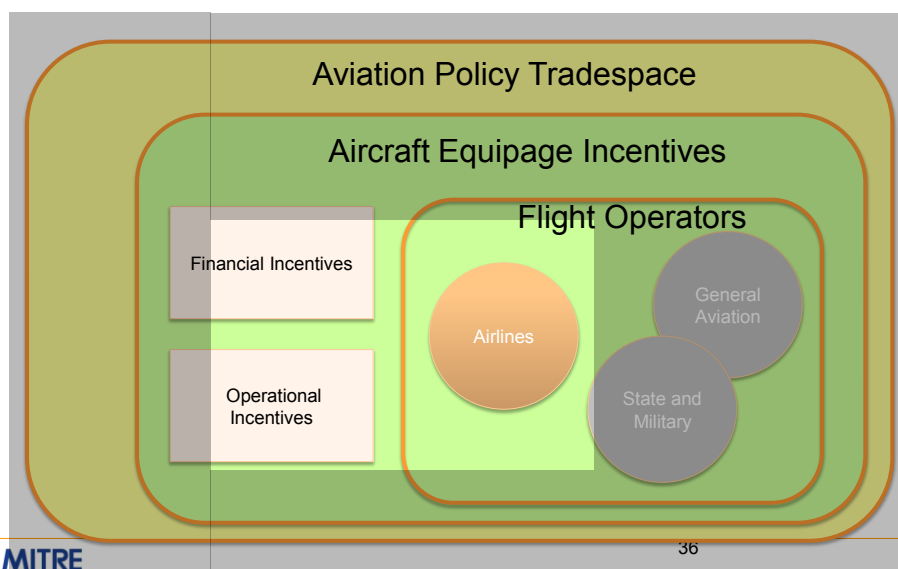


## MITRE Sponsored Research on Aviation Policy Tradespace

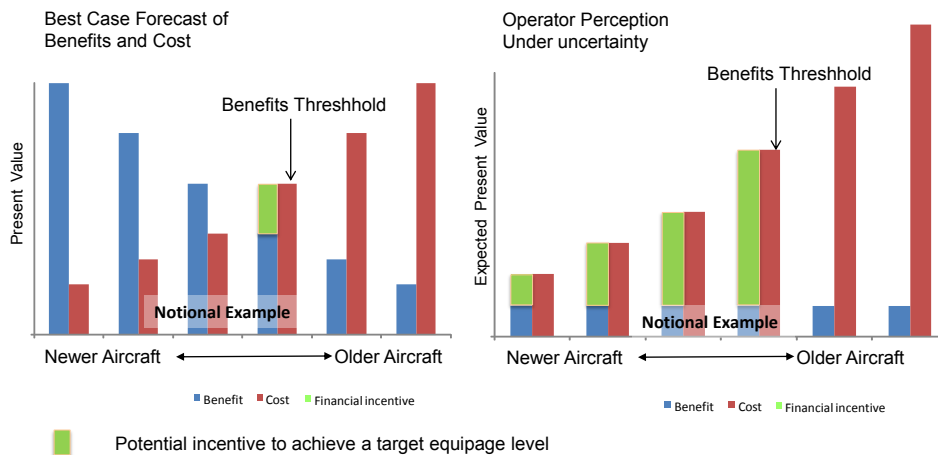


- **Objective:** Further the understanding of aviation policies on stakeholder actions through development of policy impact analysis tools and methodologies
  - Understand both operational and economic impacts
  - Understand multiple stakeholder perspectives
- **FY11 focus:** Evaluate the impacts of financial and operational incentives to accelerate NextGen avionics equipage

## Current Research Focus



## Finding: Uncertainty produces Inefficient Incentives



## Operational Policy Concept Exploration



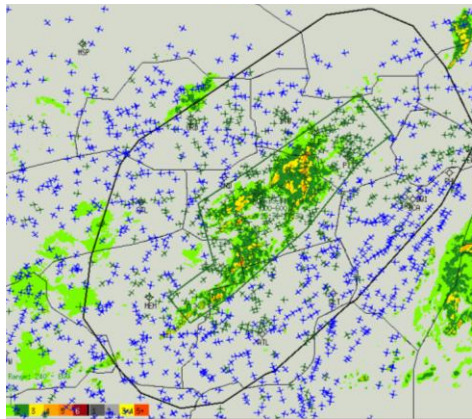
- **Question under evaluation: What is the impact on flights equipped with ATC Data Communications if a policy is in place to give preferential treatment over non-equipped flights?**
  - **Policy move toward Best Equipped Best Served**
  - **Assumed reroute assignment are performed by TFM automation (policy is transparent to controllers) and are transmitted to aircraft**

***Note: Did not evaluate direct benefits of Data Comm to aircraft***

## Proof-of Concept Experiment Scenario



9/27/2007: severe weather reduces sector capacity  
 Baseline Model has 250+ Flights Rerouted or Ground Delayed



- Ground and airborne reroutes around severe weather
- Initial data link equipped aircraft assigned playbook or historical reroutes before unequipped aircraft



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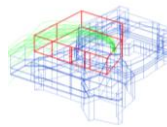
## Experimental Design



### Policy

First Come, First Served  
 Best Equipped, Best Served

X



### Sector Capacity

100%  
 120%

X



### Fleet: % Equipped

0%  
 25%  
 50%  
 75%  
 100%

Baseline: “First Come, First Served”, 100% Sector Capacity



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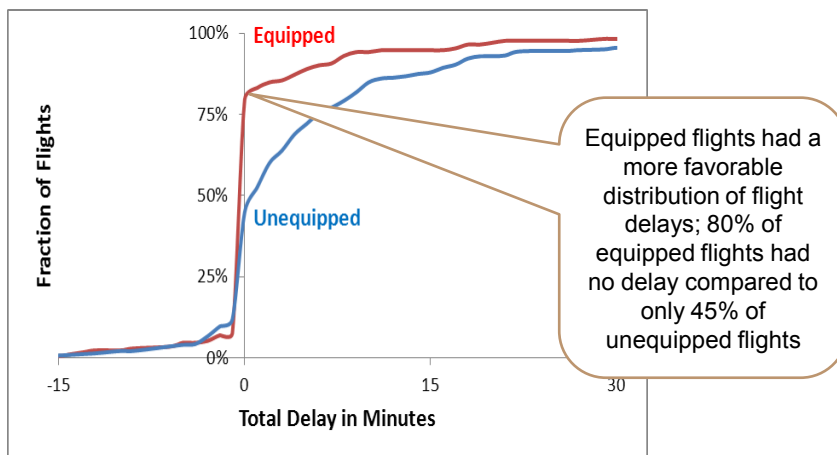
## Preliminary Results: Baseline sector capacity

Sector Capacity	Aircraft Group	% of Fleet Equipped				
		0%	25%	50%	75%	100%
Baseline	Unequipped	4.7	5.4	5.8	7.5	
	Equipped	(N/A)	1.7	2.8	3.4	4.7

			Metric: Delay per Flight (Min)
--	--	--	--------------------------------

Preliminary Results: based on analysis of weather scenario on 9/27/2007

## Preliminary Results – Baseline Sector Capacity (25% equipage scenario)



## Preliminary Results: Incentives May Address Early Adopter Benefit Gaps



Sector Capacity	Aircraft Group	% of Fleet Equipped				
		0%	25%	50%	75%	100%
Baseline	Unequipped	4.7	5.4	5.8	7.5	
	Equipped		1.7	2.8	3.4	4.7
120%	Unequipped	(N/A)	3.2	3.2	3.4	
	Equipped		1.2	2.0	1.9	2.4
		Metric: Delay per Flight (Min)				

All flights benefit when higher equipage levels are achieved.

Preliminary Results: based on analysis of weather scenario on 9/27/2007

## Policy Questions



- Can policy changes resulting in operational incentives be transparent to pilots and controllers?
- What are the potential “unintended consequences” of an operational incentive policy?
- What would it take for the operational community to accept an operational policy that includes preferences for equipage?
- What is the decision process to implement an operational or financial incentive policy? What organizations would be involved?



## BACKUP

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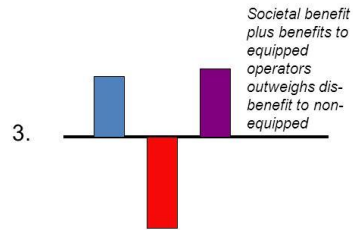
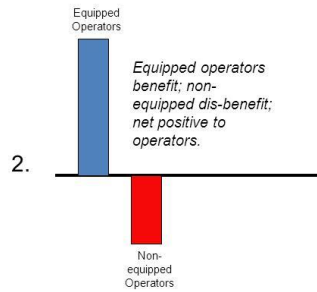
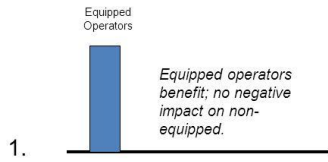
### Operational Incentives for NextGen Eqpige

- **Considerations for favoring equipped aircraft**
  - Direct routings for equipped aircraft and keeping them on preferred routes as much as practical
    - Move less capable aircraft when separation conflicts develop
    - Disadvantage more capable aircraft only in emergencies
  - Priority to equipped aircraft on
    - approach to airports with flow control
    - on environmentally friendly routes or flows





## Operational Incentives: Potential Outcomes of Interest





**Approved by the NAC September 29, 2011**

## **NextGen Equipage: User Business Case Gaps**

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*A Report of the NextGen Advisory Committee in Response to Tasking  
from the Federal Aviation Administration  
September 2011*

## Abstract

At the request of the NextGen Advisory Committee (NAC), the Business Case and Performance Metrics Work Group (BCPMWG) assessed the business case and gaps for three aircraft equipage packages identified as key foundational infrastructure for NextGen capabilities: Performance-Based Navigation (RNP 0.3 with RF for commercial operators; WAAS / LPV for General Aviation), ADS-B Out, and ATC data link communications.

The *aggregate* user business case for each package was assessed using representative criteria for four airspace user groups: Commercial, Military, high-end General Aviation (turbine and jet aircraft), and low-end GA (piston aircraft). It should be noted that there will be cases where individual flight operator business cases may have different results based on specific mission, geography, or other factors.

Financial payback was the primary business case closure criterion used for commercial operators and high-end GA (2.5 and 5 years, respectively), maintaining airspace access and mission accomplishment was the primary criteria for the military, and for low-end GA the affordability of aircraft equipage relative to other personal priorities was most important.

In general, we find that the NAS-wide operator business case does not close for any of the targeted capabilities for 100% of aircraft in the relevant user groups, due to one or more of the following:

- The high cost of equipping some aircraft, particularly older aircraft
- Uncertainty about the magnitude of anticipated benefits accruing to equipped users
- Uncertainty about future FAA capability implementation plans by specific time and location

This report identifies barriers to business case closure and offers recommendations to accelerate equipage with NextGen avionics from the users' business case perspective.

## Business Case Closure Criteria

Business case closure criteria differ by user group and individual user. The BCPMWG did not evaluate the business case for individual airspace users, but did apply representative business case closure criteria to the three NAC Ad Hoc packages: Performance-Based Navigation (RNP 0.3 with RF for commercial operators; WAAS / LPV for General Aviation), ADS-B Out, and ATC data link communications.

While the NAC Ad Hoc focused on accelerating NextGen capabilities in the region bounded by the Washington DC Metroplex, the New York and Boston Metroplexes, and the Chicago Metroplex, the BCPMWG found that the mobility of user aircraft made it difficult to apply the business case to a subset of aircraft, and has instead evaluated gaps considering the entire US fleet. For these four user categories, the BCPMWG surveyed business case analytic methods and typical closure criteria – identifying differences in both financial criteria, benefits included, and non-financial considerations. The user business cases for NextGen equipage differs significantly from FAA methodologies, which typically focus on system level or societal benefits over long spans of time.

The table below summarizes business case closure criteria by user category:

Business Case Closure Criteria	Commercial	High-End GA	Low-End GA	Military
Financial Metric	2.5 year payback	5 year payback	Affordability	Cost Neutrality
Monetized Benefits	User Direct Operating Costs	Fuel Savings	(not used)	(not used)
Non-Financial Considerations	Fleet Mobility	Access and Time Savings	Access and Safety	Mission Accomplishment, Access, and Fleet Mobility

**Cost / Benefit Analysis** The BCPMWG sought business case input data from multiple sources, but found many gaps in detail, consistency, and underlying assumptions. In general, cost data was more robust than benefit data, and benefit data (when available) was generally aggregated at the societal or NAS-wide level of detail. Due to data sensitivities regarding DoD fleet current equipage and potential upgrade paths the BCPMWG were unable to directly assess military transport aircraft retrofit. However, the BCPMWG notes that the large quantity of aircraft, diversity of equipage baselines, and specialized missions are significant obstacles for the DoD to participate materially in NextGen equipage retrofits.

**Recommendation 1:** Recommendation 1: FAA should work with the DoD to understand the operational and financial impacts of DOD partial equipage of military aircraft with NextGen avionics, understanding the diversity of aircraft and missions, the sensitive nature of the data and analysis results, and the consideration that DoD will not be able to equip 100% of their aircraft.

The BCPMWG then determined whether the business case closed for the remaining segments of the U.S. registered fleet based on the user financial criterion, combined with equipage cost estimates compiled by MITRE in collaboration with airframe and avionics manufacturers. For commercial operators, insufficient benefit data was available to directly assess the business case; therefore “closure” for a segment of the fleet was assessed by estimating the amount of flight time savings required to offset the cost of equipping (a “parametric analysis”) as an indicator of reasonableness. This parametric analysis was comprised of determining the number of minutes of flight-time savings (fuel and crew costs) that an operator would need confidence in achieving in order to close its business case. In addition to the 2.5 year payback requirement to close the business case for commercial operators, the parametric analysis assumed fuel cost at \$3 per gallon, benefits achieved immediately after equipage, and every flight deriving benefit. Sensitivity to these assumptions was also analyzed. Annual Part 121 cost savings were calculated on an airframe-by-airframe basis, using typical service patterns for individual airframes as well as typical crew sizes.

The parametric analysis constructed was a “macro”, aggregated view – neither location nor user specific – so the Work Group recognizes that the “micro” business cases may be different (and potentially close) for segments of users based on geography, fleet mix, mission, or other factors. For evaluation of the business case closure for commercial operators, the BCPMWG sought to use only benefits that could be directly attributable to the equipping aircraft user’s operations. Other system or societal benefits, such as overall system capacity (benefitting both equipped and unequipped operators) were not included in

the business case consideration. However, these *are* important considerations from a policy perspective with respect to whether incentives are appropriate.

## Specific Findings: Business Case Gaps by Equipage Type

### RNP 0.3 with RF Legs

**Description** Required Navigation Performance (RNP 0.3) with Radius-to-Fix (RF) Legs allows repeatable curved approaches on a shorter path than traditional arrival and approach procedures using ground-based NavAids. For this capability, an RF capability in accordance with AC 90-105 appendix 5 is assumed.

Potential benefits to equipped users include but are not limited to:

- Improved flight efficiency via shorter arrival paths
- Improved deconfliction of traffic arriving and departing from adjacent airports
- Improved hazard avoidance
- Increased numbers of arrival and departure paths for airports

Forward-fit or retrofit with RNP 0.3 with RF legs is most applicable to commercial operators and high-end GA.

**Benefit Data Gaps** In assessing the business case for RNP 0.3 with RF legs, the BCPMWG encountered material gaps in benefit data, specifically:

- Lack of forecasted potential benefits from RNP procedures by location, usage, equipped aircraft population, and overlay vs. non-overlay
- Lack of long-range capability implementation plans detailing future RNP procedure deployment at specific locations

**Minimum Equipage Threshold** Anecdotal reports suggest that 80% equipage would be required at high-density airports in order for significant benefits to accrue to operators. Airports with a scale of operations to warrant this minimum equipage threshold are primarily but not exclusively used by Part 121 operators, so GA and other non-commercial access is also a consideration. The BCPMWG is not aware of any conclusive evidence of minimum equipage thresholds for medium- or high-density airports.

The table below (from the FAA’s Grand Metroplex analysis of June 2011) illustrates the diversity of users in the large Northeast Metroplexes:

Grand Metroplex Ops Analysis Summary										
Grand Metroplex Analysis Summary	JFK	LGA	EWR	PHL	ORD	MDW	IAD	DCA	BWI	BOS
Operators					Traffic					
Mainline Air Carriers	67%	44%	61%	36%	35%	70%	32%	39%	72%	51%
Regional Airlines	27%	54%	37%	42%	54%	5%	37%	54%	7%	20%
Business/ GA	6%	2%	2%	22%	10%	24%	30%	5%	21%	25%
Military/Other	<1%	0%	1%	0%	2%	1%	2%	2%	1%	4%
NextGen Operations Applicable										

**Current Fleet Equipage and Forward / Retrofit** 41% of the 6,653 active Part 121 commercial aircraft are currently equipped for RNP 0.3 with RF legs, though not all aircrews are trained to use the RNP procedures with RF turns. Based on forward-fit of forecasted new aircraft deliveries and likely retirements, about 55% of the Part 121 fleet could have RNP 0.3 with RF leg equipage by 2020. This capability is commonly delivered on new Airbus, Boeing and Embraer aircraft, but is either optional or not offered on the remaining aircraft in the Part 121 fleet. In addition to Part 121 aircraft, high-end GA aircraft are also likely candidates to take advantage of AC 90-105 advanced RNP terminal procedures (i.e. those with RF legs), especially with respect to achieving time savings through reduced track miles or ground delays. High-end GA equipage is likely to be driven by the availability of RNP 0.3/RF procedures into key reliever airports.

An additional 39% (mostly regional jets) could be retrofitted at an estimated cost of \$150K - \$650K each, via a Display or FMS upgrade, or both. The wide range of estimated upgrade cost is due to lack of both detailed existing configuration data and engineered and / or certified solutions. For the remaining 20% of the current Part 121 fleet (mostly mid-aged and older mainline jets), the cost to retrofit is estimated at \$100K - \$750K each. However, for many aircraft in this category there are no engineered or certified upgrade paths currently available. As shown, the parametric analysis assessing required benefits to close RNP equipage costs (using the more conservative cost estimates) is listed at right, based on the 2020 fleet forecast.

**Percent of Part 121 Fleet  
Business Case Closure versus  
Minutes Saved for RNP 0.3/RF  
(2020 forecast)**

Minutes Saved	% Fleet
0.5	55%
1	55%
2	55%
3	56%
4	74%
5	75%
6	90%
7	96%
8	96%
9	96%
10	96%
20	99%
60	100%

**Finding A:** An 80% equipage level at the busiest airports would require near full equipage of Part 121 aircraft - including RJs - as well as a significant equipage of other airspace users (e.g., high-end GA, military).

**Finding B:** A major gap in calculating the user business case is the lack of published specific location benefits and implementation dates. This also affects the rate at which operators are willing to forward-fit these capabilities for new aircraft.

**Recommendation 2:** Given the high cost of retrofitting the entire Part 121 fleet for RNP 0.3 with RF legs, FAA, in collaboration with the aviation community, should develop capabilities (including needed policies, procedures, and complementary automation) to allow the large percentage of currently equipped users to routinely perform RNP 0.3 with RF leg procedures to realize near-term benefits in a mixed equipage environment and to stimulate forward-fit and retrofit decisions.

**WAAS**

**Description** WAAS improves GPS signal accuracy from 100 meters to approximately 7 meters. This allows GPS to be used as a primary means of navigation from takeoff through Category I precision approach. Potential benefits to equipped users include but are not limited to:

- Improved access during low-visibility weather conditions
- Ability to use LPV procedures in lieu of ILS approaches

Forward-fit or retrofit with WAAS is most applicable to high-end GA (approximately 18,500 in the current US fleet, forecasted to be 28,000 in 2020) and to IFR-capable low-end GA airframes (approximately 108,000 in the current US fleet, and to remain at that level in 2020).

**Benefit Data Gaps** Primary user benefit is improved access, which is difficult to monetize.

**Minimum Equipage Threshold** None for user - WAAS signal is already broadcast via satellite. In addition, equipped users can take advantage of individual LPV procedures as soon they are published. FAA cost savings benefits by FAA can be achieved, however, if sufficient WAAS equipage enables decommissioning of ground-based Nav aids required to support traditional approaches.

**Current Fleet Equipage and Forward / Retrofit Considerations** 30% of the current fleet of 20,000 high-end GA aircraft are currently equipped. 29% of the 2020 forecasted fleet of 28,000 US-registered airframes are expected to be equipped. Retrofit cost for the remaining unequipped aircraft is forecasted to be approximately \$0.8B.

For Low-end GA, 30% of 108,000 IFR-capable airframes are currently equipped. The proportion of aircraft equipped in 2020 will be determined by the retrofit market due to the limited quantity of new low-end GA aircraft expected to enter the fleet. Retrofit cost for the remaining IFR-capable aircraft is approximately \$1.4B.

**Finding C:** For GA most investment decisions are personal, driven by affordability and availability of LPV procedures, i.e., “Is there a WAAS/LPV approach at my home airport?”

**Recommendation 3:** [FAA should continue to work with the General Aviation community to implement WAAS approaches at eligible runway ends.](#)

## ADS-B Out

**Description** With ADS-B Out, controllers and their decision support tools can provide aircraft surveillance based on GPS position information transmitted by the aircraft itself. ADS-B Out is considered an improvement over radar because the surveillance data is updated in close-to-real time, the positional accuracy does not degrade with distance or terrain, and it can be used to provide surveillance in certain non-radar airspace. Potential benefits to equipped users include but are not limited to:

- Improved spacing and routing in non-radar airspace (e.g. the Gulf of Mexico)
- Increased capacity due to improvements in ATC merging and spacing
- Increased surface traffic efficiency for airport operations

The FAA ADS-B Out mandate, which requires equipage by 2020, affects all four user groups evaluated. For GA, the estimated population affected is 190,000 airframes. Aircraft operators that fly internationally, further, may also be affected by proposed mandates such as Europe’s which may require equipage as early as 2015.

*(Note – the ADS-B “In” aviation rulemaking committee (ARC) is currently addressing avionics costs, benefits, and implementation strategies; the committee’s work has not yet been made public and was not available to the BCPMWG for consideration.)*

**Benefit Data Gaps** Many of the benefits of ADS-B Out accrue to the FAA, society, or the entire user community rather than specific users. The FAA's Benefits Basis of Estimate – used for the Surveillance and Broadcast Services (SBS) program’s final investment decision – measures NAS-wide benefits based on large-scale ADS-B Out equipage, but does not provide a measure of benefits that would accrue to individual users. Benefits will also vary by location (e.g. radar vs. non-radar airspace). Available benefit data – such as Gulf of Mexico non-radar efficiency improvements - could not be translated directly to user benefits for equipped airframes in radar airspace – so analysis methodology focused on costs.

It is also expected that much of the voluntary equipage with ADS-B out will be driven by applications associated with ADS-B “in” – to the extent that “in” performance requirement differences, if any, do not materially impact avionics costs.

**Minimum Equipage Threshold** 100% for NAS-wide benefits, including future ADS-B “in” benefits.

**Current Fleet Equipage and Forward / Retrofit Considerations:** Current fleet equipage is essentially zero; however aircraft approvals of rule-compliant avionics for ADS-B Out equipment are expected in 2011. Current GA repair station installation capacity is 10,000 – 20,000 units per year – and absent near-term benefits most users are likely to delay equipage, possibly overwhelming existing retrofit capacity.

Cost to equip the Part 121 fleet is estimated at approximately \$0.9B. If ADS-B Out saved users 3 minutes per flight, the Commercial user business case closes for 93% of the Part 121 fleet - based on typical aircraft utilization rates, \$3 per gallon fuel, and assuming benefits would begin to accrue immediately to an equipped aircraft. The results of the parametric analysis of the benefits required to justify Part 121 equipage are shown to the right:

The quantity of general aviation aircraft subject to the ADS-B Out rule is 190,000. High-end GA equipage is estimated to cost approximately \$2.0B. For low-end GA, equipage is estimated to cost approximately \$1.3B – GA community representatives indicate that the cost sensitivity threshold is about \$1,500 per aircraft. Given an estimated \$8,000 equipage cost per aircraft (including installation), this means that the cost gap is about \$6,500 per aircraft.

**Percent of Part 121 Fleet Business Case Closure versus Minutes Saved for ADS-B Out**

Minutes Saved	% Fleet Equipped
0	0%
0.5	28%
1	66%
2	92%
<b>3</b>	<b>93%</b>
4	93%
5	93%
6	95%
7	95%
8	96%
9	96%
10	99%

**Finding D:** The retrofit capacity of ADS-B out installation facilities will be exceeded close to the 2020 mandate deadline due to postponed equipage decisions, since most operators are unlikely to equip early. An extension to the ADS-B Out compliance date is a risk. The FAA’s policy on Supplemental Type Certificates is also important to increase GA installation.

**Recommendation 4:** The FAA should incentivize ADS-B out equipage via:

- Incentives to users to equip with ADS-B Out earlier than the 2020 mandate to reduce likelihood of extensions to the compliance date.



- Developing airworthiness and operational approval criteria for low-cost ADS-B In equipment supporting situational awareness for GA operators, in order to incentivize voluntary ADS-B Out equipage.
- FAA should also track ADS-B out equipage and installation rates and work with the aviation community if the equipage rates indicate a risk of significant levels of non-compliance.

## ATC Data Link Communications

**Description** ATC Data Link Communications consist of using text messages rather than voice for certain aircraft / controller communications. Potential benefits include but are not limited to:

- Reductions in read-back / hear-back errors
- Reduced time to deliver revised pre-departure clearances
- Reduced time to deliver airborne reroutes
- Reduction in controller workload – and a corresponding increase in sector capacity – due to the automation of routine messages

Preliminary studies indicate that the aggregate benefit to airspace users (i.e., savings in airline direct operating costs or other user direct operating costs) – just from automating en route sector handoffs – would be over \$200 million per year, assuming that about 1/3 of the fleet is equipped.

Two alternative implementation options were assessed: (1) FANS 1/A+ over VDL-2 (involving FMS autoloading of route information), and (2), the cheaper of FANS 1/A+ over VDL-2 or ATN Baseline 1 (likely using a CMU or ATSU-based implementation). Forward-fit or retrofit with data link is most applicable to commercial and high-end GA users. For the analysis, the BCPMWG used a parametric analysis; immediate benefit accrual upon equipage is assumed. See appendix for specific value used.

### Benefit Data Gaps

- The safety value of read-back / hear-back errors avoidance is difficult to monetize
- The increase in sector capacity is assumed to have significant spillovers, and thus – despite its importance – is not viewed as a direct benefit for the purpose of calculating payback by equipped users
- No quantitative benefits information is available on the marginal value of an implementation requiring autoloading functionality.
- FAA benefit analyses have focused on identifying system and societal benefits; little information is available on direct user benefits.

**Minimum Equipage Threshold** Societal benefits have been modeled to accrue beginning with 20% equipage of flights, and increasing as more aircraft equip. Eurocontrol has postulated an optimum equipage level of 70% for societal benefits arising from sector capacity constraints.

**Current Fleet Equipage and Retrofit Considerations** 34% of the current Part 121 fleet is equipped with VDL2; there is no equipage with ATNB1/VDL2 in the US fleet. Two percent (2%) of the fleet is currently equipped with FANS 1/A and VDL2. Estimated retrofit /forward fit options for high-end GA are available for some of the large intercontinental aircraft. The Eurocontrol mandate for ATNB1 requires equipage by 2015 with forward-fit beginning in 2011 (current FANS aircraft exempted), while FAA is evaluating a potential requirement for FMS autoloading.

**Percent of Part 121 Fleet Business Case Closure versus Minutes Saved for FANS 1/A+/VDL2 (2020 forecast)**

Minutes Saved	% Fleet
0	8%
0.5	30%
1	38%
2	47%
3	51%
4	61%
5	62%
6	64%

*Option 1: FANS 1/A+ over VDL2 only*

The equipage level in 2020 is expected to be at least 8% (current equipage plus new deliveries where FANS 1/A+ and VDLM2 is a standard offering). An additional 32% (FANS capable) of the 2020 fleet could be equipped for \$0.2B. A further 24% of the fleet (requiring VDLM2 retrofit) can be equipped for \$1.1B. Cumulative cost for 64% Part 121 equipage (of the forecast 2020 fleet) is \$1.3B. The remaining 36% of the expected 2020 Part 121 fleet (primarily regional jets and narrow body aircraft) have no current upgrade path identified to FANS-1/A+.

High-End GA: Based on a partial survey of high end GA aircraft, 7% of the forecasted 2020 fleet of 10,932 high-end GA aircraft could have FANS capability over VDL2 at a cost of \$118M. The remainder of the surveyed high-end GA fleet has no FANS upgrade path currently identified. The status of the remaining high-end GA fleet expected in 2020 (approximately 18,000 aircraft) is unknown.

*Option 2: Cheaper of FANS 1/A+ or ATNB1 over VDL2*

Current Part 121 equipage with FANS 1/A+ over VDL2: 2%; there is no current equipage with ATNB1/VDL2. By 2020, a total of 8% equipage with FANS 1/A+ is forecast. An additional 48% (VDL2 enabled) can be retrofitted at a cost of \$0.2B. The remaining 44% (VLDO equipped or unequipped) can be retrofitted at an additional cost of \$0.3B. Cumulative cost for 100% Part 121 equipage (of the forecast 2020 fleet) is \$1.5B.

High-End GA: GA aircraft and avionics manufacturers are planning to offer ATNB1 capabilities for some newer production aircraft types in the future to support EU requirements but are not anticipating sales of these upgrades to U.S. operators due to the lack of a viable business case, since there are no current plans to provide data link services via ATNB1.

**Finding E:** The BCPMWG has not found any quantifiable evidence that (1), the capabilities associated with FANS 1/A+ (e.g., autoloading) provide marginal benefits that outweigh the marginal costs in comparison to ATNB1; or (2), that support of ATNB1 precludes the ability to implement future ATC data link communication capabilities (such as ATNB2).

Currently, no operator business case can be made for requiring autoloading capabilities for domestic ATC data link services. Further, requiring FMS autoloading for achieving domestic ATC data link capabilities will preclude many regional aircraft from participating and will incur opportunity costs for operators who could cost-effectively implement ATNB1. [Without a clear business case for limiting ATC data link services to aircraft having an integrated solution, the most cost effective means to achieve an optimum level of ATC data link equipage is through an approach that implements, in the ground system, a capability supporting both integrated and non-integrated \(federated\) avionics solutions \(i.e., auto-load and non-autoloading\). This could expedite the achievement of equipped operator, system and societal benefits.](#)

**Percent of Part 121 Fleet Business Case Closure versus Minutes Saved for FANS 1/A+ or ATNB1/VDL2 (2020 forecast)**

Minutes Saved	% Fleet
0	8%
0.5	60%
1	61%
2	75%
3	85%
4	94%
5	94%
6	96%
10	98%
15	99%
20	99%
25	99%
30	100%

*Note: The assumptions and recommendations regarding specific DataComm-related technologies (FANS, ATN, VDL) will be reviewed and subsequently addressed by the follow-on NAC DataComm Roadmap Task Group developing a report for consideration by the NAC in February 2012.*

## **General Findings: Joint Investment Considerations**

Unlike traditional improvements to improve the operation of the NAS, many of the benefits that arise from NextGen capabilities require joint, synchronized investments among the FAA, flight operators, and other stakeholders. FAA standard practice for investment analysis, per OMB guidelines, uses a long term (20 years) perspective, uses a standard discount rate of 7%, and includes a combination of flight operator, societal, and FAA benefits to assess whether an investment is warranted. This has worked well for assessing internal FAA initiatives that are either local (such as airspace redesign or a new procedure) or national (such as deploying automation).

**Finding F:** Non-federal stakeholders typically have different criteria leading to investment commitments. Without an understanding of different stakeholder criteria and needed mitigations to close business case gaps, it will be difficult to achieve societal benefits that require joint investments.

**Finding G:** There is a potential for cost efficiencies when equipage bundles of capabilities are considered. The business case for bundled capabilities may close when individual cases do not.

**Recommendation 5:** Where significant retrofit and forward-fit actions are needed to achieve system and societal benefits, FAA should work with the community to develop tailored strategies for maximizing benefits in a mixed equipage environment to achieve optimal value overall, considering the marginal costs and benefits associated with increasing equipage (i.e., the business case does not close on the “average”).

**Finding H:** Confidence in the benefits and implementation schedule of FAA infrastructure and associated procedures is a critical precursor for operator investment commitment

- Without greater certainty in capability deployment schedules (including location) and benefit data, flight operators are unlikely to exercise forward-fit equipage options or close retrofit business cases.
- The lag between equipage retrofit and realization of benefits has a major negative impact on business case closure. In general, FAA implementation needs to precede flight operator retrofits.

**Recommendation 6:** To increase user confidence in equipage business cases, FAA should:

- Develop estimates of the direct benefits for users equipping with NextGen avionics in conjunction with the affected operator(s)
- Establish a stable, long-term implementation plan for each capability requiring a critical mass of installed avionics to achieve user- or societal benefits
- Determine key benefit thresholds (by location and time of day); and look for opportunities to reduce those thresholds to facilitate faster realization of benefits

**Recommendation 7:** To close user business case gaps for capabilities with positive (net) system and societal benefits, FAA should:

- Work with the aviation community to better understand the business case for bundled equipage options
- Offer incentives for early adopters where a critical mass is needed and to stimulate user forward-fit and retrofit decisions – and / or -
- Use joint accountability mechanisms available within its legislative authority

## **BCPMWG Membership and Meetings**

**Group Formation and Scheduling** The RTCA Business Case and Performance Metrics Work Group of (BCPMWG) of the NextGen Advisory Committee (NAC) was formed in January 2011 to address performance metrics for NextGen. Its membership includes a broad spectrum of the aviation community, including commercial operators, general aviation, military aviation, airport operators, and the Federal Aviation Administration. Since forming, the BCPMWG has conducted full-day in-person meetings at least once per month (with accommodations for remote participation), and weekly to bi-weekly meetings and telecons of a Task Group.

**BCPMWG Membership** The BCPMWG is chaired by Ed Lohr (DAL) and Deborah Kirkman (MITRE). Additional members include Alex Burnett (UAL), Jim Crites (DFW Airport), Bill Dunlay (Leigh-Fisher), Kyle Gill (NetJets), Raquel Girvin (FAA), Jim Littleton (FAA), Joel Murdock (FedEx), John Novelli (AMR), Almira Ramadani (FAA), Kirk Rummel (Houston Airport), Craig Spence (AOPA), Joe White (ATA), and John Witucki (DOD). In addition BCPMWG has been supported through a number of subject matter experts assisting with equipage business case analyses, including: Chris Benich (Honeywell), Joe Bertapelle (jetBlue), Joe Burns (UAL), Carlos Cirillo (IATA), Forrest Colliver (MITRE), Lisa Connell (Delta), Eric Deichman (SH&E), Ken Elliott (JetCraft), Steve Giles (MITRE), Brian Haynes (XCelar), Cole Hedden (L3-com), Jens Hennig (GAMA), Dan Johnson (XCelar), Pascal Joly (Airbus), Rick Heinrich (Rockwell Collins), Peter Lyons (Aspen), Louis Pack (ICF), Bill Sears (Beacon Management), Stephen Smothers (Cessna), Rico Short (Beacon Management), Michael Wells (FAA), and Jim Wetherly (FAA)

## Introduction

Implementation of NextGen capabilities – and more importantly the realization of NextGen’s benefits - requires complex synchronization of standards and procedures development, training and equipage investments, on both aircraft and on the ground for FAA and airspace users. The equipage investments required for NextGen can be different for different capabilities or overlap with more than one capability. Depending on the capability, the benefits of NextGen can be narrow and localized, regional, or system-wide, yet requiring a critical mass of equipped users before any significant benefits are realized. The complexity of capability definition, investment, and deployment creates a confidence gap that execution of NextGen will occur on time and that benefits will be achieved.

The question of increasing user confidence in making NextGen investments as well as incentives to achieve desired levels of aircraft equipage has been addressed in such documents created by the Future of Aviation Advisory Committee recommendations, FAA’s NextGen Implementation Plan, and the RTCA Task Force 5 recommendations on midterm NextGen capabilities, to name a few.

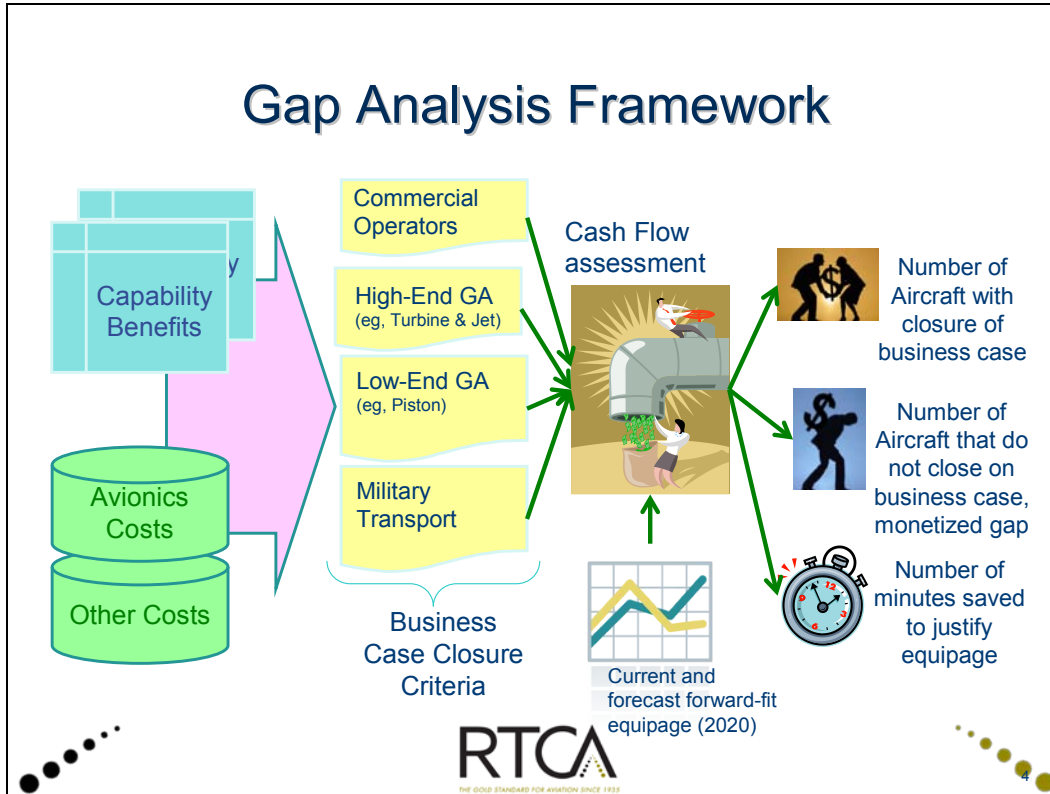
Recognizing that for some NextGen capabilities users are not retrofitting aircraft in significant numbers, the FAA submitted a Tasking Letter to RTCA in January 2011 asking for analysis of the business case gaps that exist for NextGen and whether financial and / or operational incentives were an appropriate and likely stimulus to increase rates of equipage. In support of this tasking, the BCPMWG analyzed the equipage user business case gaps for four packages identified by the NAC: RNP 0.3 with RF legs, WAAS, ADS-B Out, and Data Comm.

The macro user business case perspective for NextGen was previously analyzed in the September 2009 report of the RTCA Mid-Term Implementation Task Force (aka, TF5). The highlights of the business case findings were that smaller investments with quicker paybacks are more likely to close for users than large investments with long paybacks. Another finding of the Business Case Working Group of Task Force 5 was that data on aircraft equipage costs and discrete benefits was often incomplete and inconsistent (ie, based on differing assumptions and data sources).

Since 2009 progress has been made on both equipage costs and benefit gaps – though shortfalls remain. For equipage cost, MITRE Corporation under sponsorship of the FAA, , has conducted an extensive survey of avionics and airframe manufacturers to analyze the cost of equipage and upgrade paths for the U.S. Part 121 fleet (the results on this Analysis are included in Appendix B). For General Aviation (both high- and low-end) equipage cost data from the avionics manufacturers was used. For the military no cost data was identified due to the diversity of fleets and sensitivity of current equipage levels. Equipage installation costs were estimated using inputs from both airlines and manufacturers.

Operational cost data (variable crew cost, fuel burn, and average annual aircraft utilization) were available for the Part 121 fleet via Delta Air Lines data extrapolated for other fleets. Operating cost data and annual aircraft utilization for high-end and low-end GA was not available, so analyses for these two groups focused on the cost of equipage.

Equipage benefit data was specifically sought that could be discretely attributed to equipped users (not societal or system benefits). However, hard data on such benefits was often incomplete, and was more often available only at the aggregate (system or societal) level.



**Business Case Evaluation Framework** Business Case closure criteria differ by user group and individual user. BCPMWG did not evaluate the business case for individual airspace users, but did apply representative business case closure criteria to the four NAC Ad-hoc packages. The four user groups for which equipage business cases were considered were:

- Part 121 Commercial (passenger and cargo airlines) Aviation
- High-end General Aviation (Business jets and turbine aircraft)
- Piston General Aviation
- Department of Defense Aviation

After collecting or estimating cost and benefit data, the business case closure criteria for each user group (detailed below) was applied to the cost and benefit cash flows. If sufficient benefit data existed, the number of aircraft for which the user business case closed and did not close was calculated. Where benefits data was lacking, a parametric analysis was conducted for the Part 121 fleet which determined the number of minutes of flight-time savings (fuel and crew costs) that an operator would need confidence in achieving in order to close its business case.

## User Business Case Criteria for NextGen Equipage

The business case for equipage differs by both user category and individual user. The user business case for NextGen equipage also differs significantly from FAA methodologies, which focus on system level or societal benefits over long spans of time.

In its initial deliberations, the BCPMWG considered the use of traditional net present value analysis techniques. In that context, the commercial aircraft operators identified 17.5% as the appropriate discount rate for NextGen-related aircraft investments. In subsequent discussions, it was determined that the payback period was so aggressive as to obviate the necessity of discounting the benefit cash flows. In other contexts, however, use of industry-appropriate discount rates is crucial to a fully-informed business case.


The user business case criteria for NextGen is primarily defined by (1) what is the primary financial criteria on which the business case competes for prioritization and (2) what weightings of benefits are used:

1. **Financial threshold:** Cash flow analysis is the common methodology for business case assessment for all users. Payback period (ie, the number of years of benefits required to recoup the initial investment) was the primary criterion – preferred to Net Present Value (NPV) and Return on Investment (ROI) though these values were also calculated as complementary data points. For commercial operators the typical payback period threshold was 2.5 years given the historical unpredictability of positive cash flows. For high-end General Aviation the typical payback criteria was 5 years which aligns with asset depreciation accounting, and for the Department of Defense payback period was 15 years (though not used as DoD's primary decision criterion). For piston GA users the most important financial metric is affordability since expenditures can choices between equipage and other household priorities.
2. **Monetized Benefits:** Differences in benefit weightings are also seen between airspace user groups. For commercial operators aircraft direct variable operating costs savings (e.g., fuel and crew cost avoidance) is the primary benefit considered within a NextGen business case; societal or system benefits are generally excluded. For high-end GA, fuel savings is considered the primary monetary benefit. For military and piston GA, direct cost-benefit calculations are typically not done, but rather equipage depends upon non-financial considerations.
3. **Non-Financial Considerations:** In addition to or in place of financial thresholds, some users also consider other factors to determine whether an investment makes sense. For General Aviation maintaining or improving access to airspace and / or airports is important. Mission accomplishment is the primary decision factor the military. For commercial users, the fact that fleets are mobile and are not isolated to specific geographies is material.



The table below summarizes business case closure criteria by user category described above:

User Business Case Criteria Applied				
Business Case Closure Criteria	Commercial	High-End GA	Low-End GA	Military
Financial Threshold	2.5 year payback	5 year payback	Affordability	Cost neutrality
Monetized benefits	User Direct Operating Costs	Fuel Savings	(not used)	(not used)
Non-Financial Considerations	Fleet mobility	Access and Time Savings	Access, and Safety	Mission Accomplishment, Access, and Fleet Mobility



## Why Equipage Business Case Gaps Occur

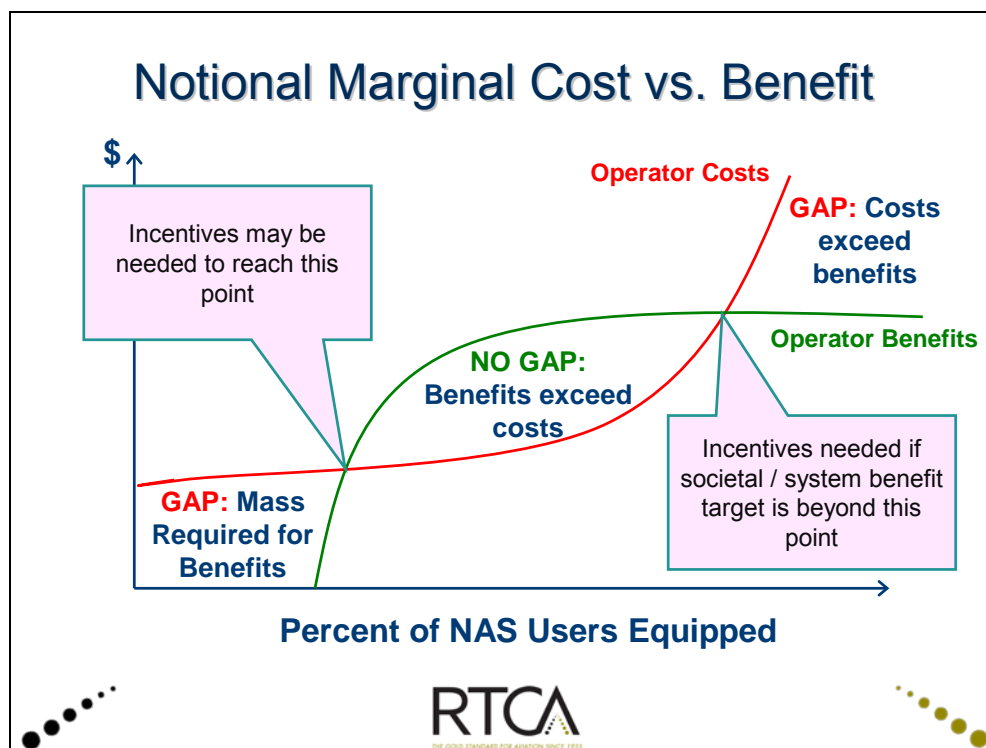
Notionally, the likely user business case gaps for NextGen equipage exist in two places on the equipage spectrum: (a) Where a critical mass of equipped users is required before benefits begin to accrue, and (b) where the marginal cost or feasibility to retrofit an aircraft exceeds the marginal benefits.

**Notional Gap Analysis** Three distinct areas of potential user business cases exist as the percentage of equipped users in the NAS increases from 0% towards 100%:

1. **Critical Mass Required** Some NextGen capabilities require that a threshold number of users at an airport, metroplex, sector, or region be equipped in order for the capability to create benefits. As an example, a RNP 0.3 / RF approach to a runway at a capacity constrained airport can only create the flight minute savings benefit if sufficient equipped inbound aircraft can utilize that runway’s capacity. So, any users that equip in advance of that critical mass will not be able to close their internal business case since equipage investment will significantly precede benefit realization.
2. **Benefits Exceed Costs** Once a critical mass of users is achieved and benefits begin to accrue the user business case has the greatest likelihood of closing independently.



- Marginal Cost of Expensive to Retrofit Aircraft Exceeds Marginal Benefits** NextGen retrofit suitability of retrofit can be an impediment to NextGen equipage. Some older aircraft are not able to feasibly retrofit NextGen equipment under any circumstances. For other aircraft – some relatively new - the Flight Management System and / or display architecture was not designed to enable the calculation or display of curved flight paths, potentially driving marginal user cost above the marginal benefit they can expect to achieve. In many aircraft, components like the Flight Management Computer are not designed with open architecture interfaces to support coupling with other components such as communication management units to enable auto-load of uplinked clearances.



## Scope and Methodology

At the request of the NextGen Advisory Committee (NAC), the Business Case and Performance Metrics Working Group (BCPMWG) assessed the business case and gaps for three aircraft equipage packages identified as key foundational infrastructure for NextGen capabilities: Performance Based Navigation (RNP 0.3 with RF for commercial operators; WAAS / LPV for General Aviation), ADS-B Out, and Data Comm.

For most of the equipage packages, there was insufficient data on benefits that could be realized from the equipage at the aircraft level, so the BCPMWG used a parametric analysis to compute the business case for the Part 121 fleet. This analysis comprised of determining the number of minutes of flight-time savings (fuel and crew costs) that an operator would need confidence in achieving in order to close its business case. In addition to the 2.5 year payback requirement to close the business case for

## Appendix A: Equipage Gap Analysis

commercial operators, the parametric analysis assumed fuel cost at \$3 per gallon, benefits achieved immediately after equipage, and every flight deriving benefit. Sensitivity to these assumptions was also analyzed. Annual Part 121 cost savings were calculated on an airframe-by-airframe basis, using typical service patterns for individual airframes as well as typical crew sizes.

For general aviation, there are wide variations in the usage patterns for individual airframes, so no aggregate business case closure requirement could be computed. Instead, the BCPMWG has estimated costs to equipage high-end and low-end GA with the three packages.

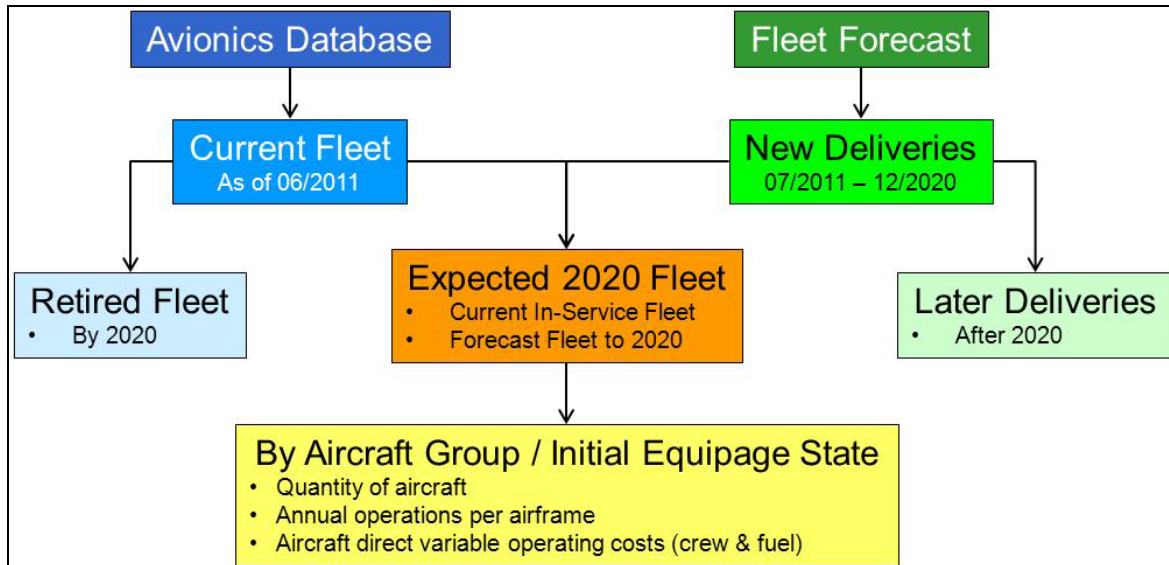
The following sections document the results of applying this analytical framework to the 4 major avionics types addressed by the NAC Ad Hoc group:

- RNP 0.3 with RF Legs
- WAAS
- ADS-B Out
- ATC Data Link Communications

### Fleet Data

In order to establish the operational basis for the business case analysis, it was necessary to establish and characterize the expected Part 121 aircraft fleet for the target time frame. The process for establishing the fleet is described and illustrated below:

- The MITRE Avionics Database [MITRE / Colliver] was used to establish the current active US-registered Part 121 fleet, as of June 2011. This fleet excluded those US-registered Part 121 aircraft that are not actively in service based upon their operational approval status.
- The current active US-registered Part 121 fleet was filtered to identify all aircraft assumed to have been retired from the fleet based upon their entry-into-service date.
  - Passenger aircraft were assumed to have an expected service life of 25 years; and,
  - Freighter aircraft were assumed to have an expected service life of 40 years.
- Those aircraft in the current active US-registered Part 121 fleet that were assumed to have retired by 2020 were set aside for purposes of this analysis.
- The MITRE Fleet Forecast [MITRE / Hollinger] was used to establish the expected delivery of new US-registered Part 121 aircraft. The MITRE Fleet Forecast provides a model- and series-level decomposition of the Part 121 aircraft forecast provided in the FAA Terminal Area Forecast [FAA TAF].
- New deliveries for the period 2011-2020 are extracted from the MITRE Fleet Forecast on an annual basis.
  - Since the MITRE Avionics Database addresses the current fleet as of June 2011, the MITRE Fleet Forecast results for 2011 are halved to reflect 2011 deliveries made in the first half of the year.
  - In addition, aircraft orders for new aircraft types not otherwise captured in the MITRE Fleet Forecast (i.e., the MRJ and C-Series) are added.
- Those aircraft forecasted to be delivered after 2020 were set aside for the purposes of this analysis.
- The result of the foregoing processes the expected US-registered 2020 Part 121 fleet composed of:
  - That portion of the current fleet expected to be in service in 2020; and,
  - New deliveries between 2011 and 2020.



## Benefits Data

In order to conduct the parametric analysis of benefits a common set of aircraft operational parameters were identified for commercial operators that were applied consistently across the three capabilities that were assessed for those operators (i.e., RNP-0.3 with RF Legs, ADS-B Out, and ATC Data Link Communications).

Benefit value derived from minutes saved in flight was based on direct operating costs comprised of pilot and flight attendant salaries and fuel gallons consumed by fleet type from Delta Air Lines (extrapolations were made where specific fleet type data was not available). The following table provides the detailed values used for crew cost in dollars-per-minute, fuel consumption in gallons-per-minute, and annual operations by aircraft type.

The process for characterizing the benefit mechanism is described below:

- Data captured in the expected US-registered 2020 Part 121 fleet is expressed at the level of manufacturer / model / series (e.g., Boeing 737-800); this unit constitutes the aircraft group used as the basis for this analysis. A count for each aircraft in each aircraft group is provided.
- An aircraft operator [Delta / Connell] provided data on the annual operations per aircraft for each aircraft group: Number of take-off / landing cycles per aircraft year for each airframe group.
- An aircraft operator [Delta / Connell] provided data on the direct, variable operating costs for each aircraft group. Aircraft direct variable costs:
  - Crew costs per minute for each airframe group.
  - Fuel gallons used per airborne minute for each airframe group.
  - Fuel gallons user per taxi minute for each airframe group.
- In order to monetize the fuel used, a fuel cost parameter was established:
  - Parameter treated as a range (triangular distribution):
    - \$2 / gallon (minimum)
    - \$3 / gallon (mode)
    - \$5 / gallon (maximum)

Appendix A: Equipage Gap Analysis

AC Type	Op Costs per Min		Average
	Crew*	Fuel Gallons	Annual Ops
A-300	\$7	31.2	740
A-310	\$7	27.0	787
A-318	\$7	14.6	1,556
A-319	\$7	15.1	1,321
A-320	\$7	16.1	1,189
A-321	\$8	17.7	958
A-330	\$16	32.2	459
AIRLFT-C46	\$3	6.2	600
ATR-42	\$3	1.6	1,715
ATR-72	\$3	1.6	1,715
B-717	\$7	12.9	1,917
B-727	\$5	10.7	1,251
B-737	\$7	14.2	1,317
B-747	\$18	59.7	557
B-757	\$7	18.9	1,076
B-767	\$8	27.3	791
B-777	\$21	16.5	558
BE-1900	\$2	1.2	898
CL-600	\$3	7.8	1,893
CV-340	\$2	3.9	600
CV-440	\$2	3.9	600
CV-640	\$2	3.9	600

AC Type	Op Costs per Min		Average
	Crew*	Fuel Gallons	Annual Ops
DC-10	\$17	45.0	597
DC-6	\$3	4.4	600
DC-8	\$12	28.5	729
DC-9	\$6	17.0	1,457
DHC-6	\$2	1.2	992
DHC-8	\$3	1.7	2,197
DO-328	\$2	1.4	1,039
EMB-120	\$4	1.7	2,728
EMB-135	\$3	4.2	1,895
EMB-145	\$3	5.9	1,830
ERJ-170	\$4	8.8	1,699
ERJ-190	\$7	12.7	1,566
FLYTGR-C46	\$3	6.2	600
L-382	\$3	10.3	600
MD-10	\$17	45.0	597
MD-11	\$13	45.0	560
MD-11F	\$13	45.0	511
MD-88	\$7	17.7	1,945
MD-90	\$7	16.9	1,340
SAAB-340	\$2	1.4	2,013
SD-3	\$2	1.3	1,138

\* Pilot and Flight Attendant (if applicable) variable cost

Crew costs were adjusted to exclude flight attendant salaries for aircraft types that represent primarily cargo operators. Average annual operations were calculated for known fleet types based on cumulative cycles over the life of the aircraft. Assumptions and extrapolations were made where this data was not available for the fleet types corresponding to the Part 121 fleet database.

## RNP 0.3 with RF Legs

### Technology and Benefits

Required Navigation Performance (RNP) is a type of performance-based navigation (PBN) that defines the necessary performance for an aircraft to fly a specific path. The value associated with an RNP procedure indicates the lateral performance constraint for that procedure. RNP .3 means the aircraft must stay within a radius of .3 miles for the duration of that procedure. RF (Radius to a Fix) is a curved path at a constant radius about a point, or fix. RNP 0.3 with RF Legs allows precision curved approaches in a shorter space than traditional arrival and approach procedures using ground-based nav aids.

Potential benefits to equipped users include:

- Improved flight efficiency via shorter arrival paths
- Improved deconfliction of traffic arriving and departing from adjacent airports
- Improved hazard avoidance

### Targeted Users

Forward-fit or retrofit with RNP.3 with RF legs is most applicable to commercial operators and high-end GA operating a major Metroplex airports. The commercial operator user category consists of Part 121 passenger and cargo operators. Business case analysis was conducted for the commercial operator user category as a whole and did not get down to the specific individual user or location level of detail. High-end GA was not evaluated for RNP .3 with RF equipage.

### System/Societal Benefits and Equipage Thresholds

Although most of the benefits that have been estimated from using RNP procedures with RF turns accrue directly to the equipped users, conventional wisdom holds that in busy airspace, a minimum threshold of equipage may be required before these procedures can be used efficiently. Although there is little hard evidence on this topic, if such an assertion is true, it would mean that anywhere between 60% - 80% of users in a busy terminal area would have to be equipped before any of them would begin to realize benefits. The BCPMWG neither endorses nor dismisses this assertion, but its implications are discussed below.

### Current Equipage and Cost to Retrofit – Part 121

41% of the 6,653 active Part 121 commercial aircraft are already equipped for RNP 0.3 with RF legs. An additional 39% (mostly regional jets) could be retrofitted at an estimated cost of \$150K - \$650K each, via a Display or FMS upgrade, or both. The wide range of estimated upgrade cost is due to lack of both detailed existing configuration data and engineered and / or certified solutions. However, the lower range costs are considered highly unlikely as representative of the retrofit costs for most aircraft in a given category. For the remaining 20% of the current Part 121 fleet (mostly mid-aged and older mainline jets), the cost to retrofit is estimated at \$100K - \$750K each. However, for many aircraft in this category there are no engineered or certified upgrade paths currently available.

A summary of the number of aircraft in today's fleet in each cost category is depicted below. Note that regionals are called out specifically because they make up a large share of operations at many airports.

RNP 0.3 w/RF for Part 121 AC

# Aircraft	% Aircraft	Description of Aircraft Majority	Cost per Aircraft (\$)	Total Cost (\$M)	Cumulative Total Cost (\$M)
2,734	41%	Newer & mid-aged mainline jets	\$0	\$0	\$0
2,571	39%	Regionals	\$150,000 - \$650,000	\$386 - \$1,671	\$386 - \$1,671
691	10%	Mid-aged mainline jets	\$100,000 - \$600,000	\$69 - \$415	\$455 - \$2,086
369	6%	Mid-aged & older mainline jets	\$250,000 - \$750,000	\$92 - \$277	\$547 - \$2,363
288	4%	Regionals and cargo aircraft	\$750,000	\$216	\$763 - \$2,579

## Business Case Closure Analysis

### Methodology Used

The BCPMWG sought business case input data from multiple sources, but found many gaps in detail, consistency, and underlying assumptions. In general, cost data was more robust than benefit data. In assessing the business case for RNP 0.3 with RF legs, the BCPMWG encountered material gaps in benefit data, specifically:

- Lack of forecasted potential benefits from RNP procedures by location, usage, equipped aircraft population, and overlay vs. non-overlay
- Lack of long-range capability implementation plans detailing future RNP procedure deployment at specific locations

The data gaps were handled by creating a parametric business case that defines the number of flight minutes that would need to be saved in order to close a typical commercial operator's business case.

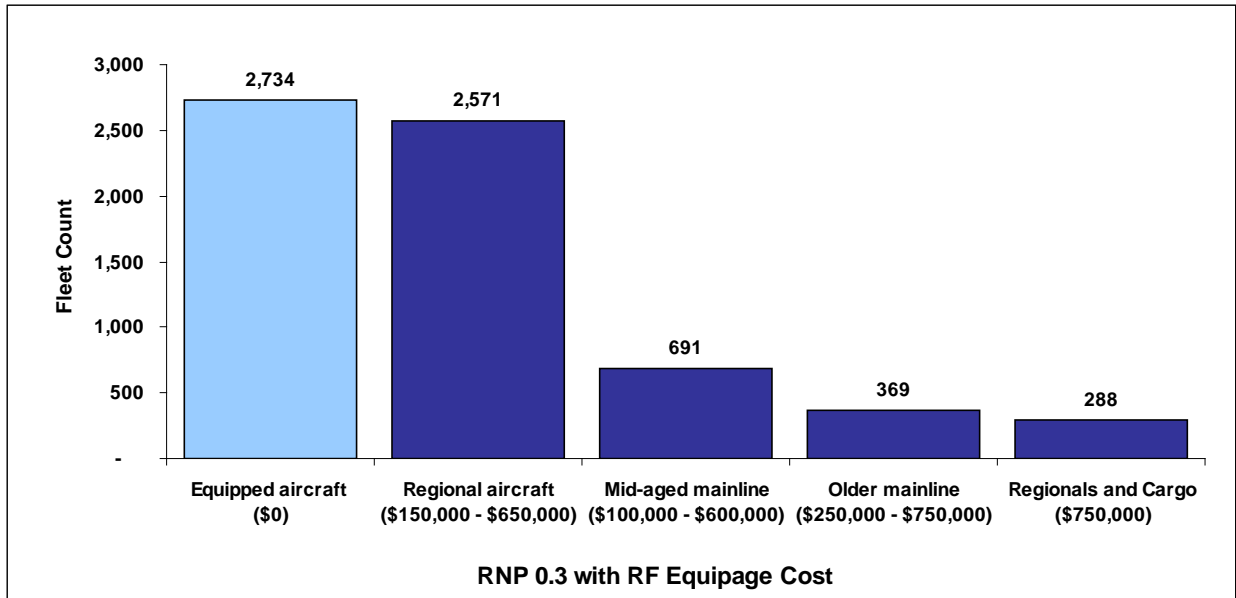
A 2.5 year payback is required to close the business case for commercial operators. Additional assumptions for the parametric analysis include fuel cost at \$3 per gallon, benefits achieved immediately after equipage, and every flight deriving benefit.

### Benefit Data

In order to conduct the parametric analysis of benefits a common set of aircraft operational parameters were identified for commercial operators that were applied consistently across the three capabilities that were assessed for those operators (i.e., RNP-0.3 with RF Legs, ADS-B Out, and ATC Data Link Communications). See the discussion of benefits in the overall methodology section above for further details.

### Cost Data

The data summarized in the chart below were provided by the MITRE Corporation. More detailed data are available in Appendix B.

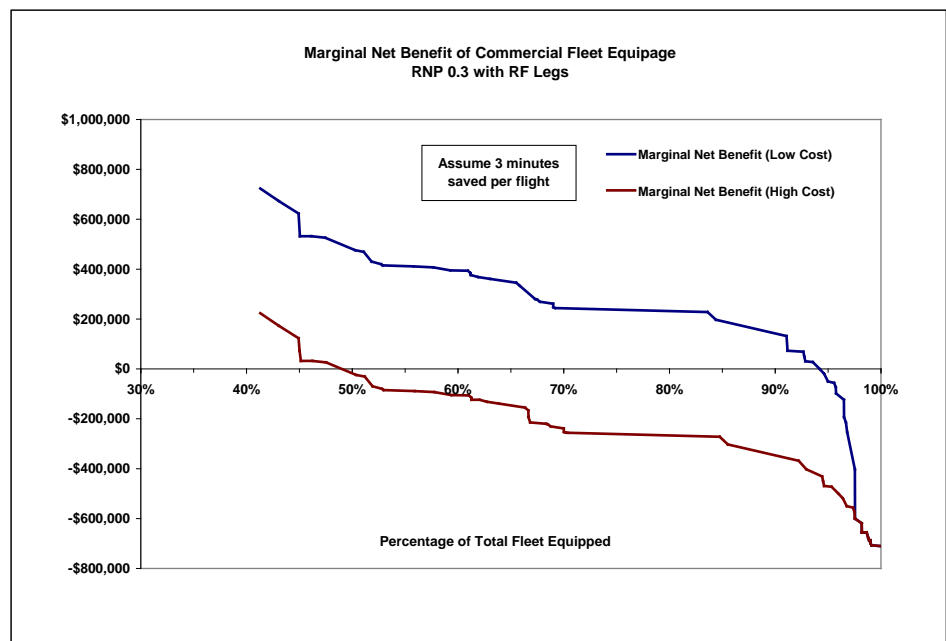


### Analysis and Results

The number of additional aircraft with a positive business case depends upon three factors:

- how costly they are to retrofit,
- how many minutes per flight assumed to be saved by equipping, and
- how much a minute of time is worth in direct operating cost.

In other words, the higher the time savings associated with RNP 0.3 with RF legs, the greater the share of the fleet that might be expected to equip. However, the first to equip may not necessarily be the least expensive; aircraft with a relatively high cost-per-minute to operate or a large number of flights per day will get a higher benefit from equipping.



## Appendix A: Equipage Gap Analysis

The following chart illustrates this. It shows the marginal net benefit for each additional aircraft that equips, using our baseline assumptions of 3 minutes saved per flight, \$3.00 per gallon fuel cost, a 2.5 year payback period, and immediate accrual of benefits. The share of aircraft equipped is ordered from highest to lowest payback; thus, the first aircraft to equip (after the 41% already equipped) are assumed to be those with high net benefit.

As the chart above shows, if an average of 3 minutes per flight could be saved by equipping with RNP 0.3 with RF legs, then somewhere between 48% – 94% of the fleet would have a positive business case. The wide variation in the range reflects uncertainty about the actual cost to equip individual airframes.

The percentage of aircraft with a positive business case is also very sensitive to the expected savings achieved per flight. The table at right shows the amount of time savings that would be required to close the business case for a given share of the forecast 2020 fleet.

### Key Sensitivities

Sensitivity analyses were performed for three of our major assumptions: lag time between equipping and achieving benefits, minutes saved in flight, and fuel price. The results are most sensitive to the lag between equipage and realization of benefits. The next most significant impact driver is minutes saved in flight. Fuel price per gallon was the least sensitive of the three.

The sensitivity tables are shown for both the low and high ends of the cost range estimates. Each table calculates the percentage of the non-equipped commercial fleet for which the business case closes with a 2.5 year payback or less assuming all flights drive benefit, zero benefit lag, three minutes saved in flight, and \$3.00 fuel per gallon, (unless that assumption is the variable).

**% of Fleet With Business Case Closure vs. Minutes Saved**  
(% based on total fleet, 2020 forecast)

**RNP 0.3 with RF Legs**

Minutes Saved per Flight	% of Fleet with Closure
0.5	55%
1	55%
2	55%
<b>3</b>	<b>56%</b>
4	74%
5	75%
6	90%
7	96%
8	96%
9	96%
10	96%
15	98%
20	99%
25	99%
30	99%
35	99%
40	99%
45	99%
50	99%
55	99%
60	100%



<b>SENSITIVITY</b>
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**% of Commercial Fleet Closing the Business Case**

		<b>Benefit Lag (yrs)</b>				
		<b>0.0</b>	<b>0.5</b>	<b>1.0</b>	<b>1.5</b>	<b>2.0</b>
Low Costs		94%	93%	91%	80%	49%
High Costs		48%	43%	41%	41%	41%

		<b>Minutes Saved</b>				
		<b>2.0</b>	<b>2.5</b>	<b>3.0</b>	<b>3.5</b>	<b>4.0</b>
Low Costs		91%	93%	94%	95%	95%
High Costs		41%	43%	48%	53%	67%

		<b>Fuel Price</b>				
		<b>\$2.00</b>	<b>\$2.50</b>	<b>\$3.00</b>	<b>\$3.50</b>	<b>\$4.00</b>
Low Costs		93%	93%	94%	94%	95%
High Costs		41%	43%	48%	52%	64%

## High-End General Aviation Considerations

High-end GA aircraft will be in better position to take advantage of AC 90-105 advanced RNP terminal procedures (i.e. those with RF legs) at equipage levels that can truly influence airspace management if RNP 0.3/RF procedures are available at key reliever airports within a metroplex.

This document does not quantify the potential for immediate high-end GA participation once OEMs can provide the capability. For example, the Collins and Universal FMS boxes both have the capability right now, today, of flying RF Legs. FAA uses the UNS FMS to flight check RNP AR procedures. Rockwell-Collins is working to implement RF legs in the Fusion package and then migrate it down into the ProLine 21, which is the most popular avionics suite in use in the high end GA. In contrast, the vast majority of the RJ fleet with ProLine 4 or PRIMUS 1000 suites, while equipped with FMS that might capable of RF legs, do not possess the display capability for flying RF legs per AC 90-105 without expensive display upgrades. The high-end GA fleet is in position to rapidly implement this capability, with the expectation that retrofit and forward fit for this population is likely to be at a lower cost. This makes the business case for the high-end GA fleet easier to build.

If FAA builds a SID, STAR, or IAP with RF legs that streamlines arrivals/departures into airports such as TEB, HPN, and/or MMU, there is likely to be demand for the capability by high-end GA aircraft owners and a market response by the aircraft OEMs. In general, operators of these aircraft are motivated to equip their aircraft to gain the advantage in time saved through reduced track miles, reduced ground delays, that would occur if procedures are made available.

The biggest drawbacks to RNP AR are equipage (i.e. lack of RNP AR capable FMS), training costs, and maintainability (database validation, third-party fly ability assessments). RNP RF legs eliminate those three issues.

## References

MITRE

Delta Air Lines

Ascend Aircraft & Airline Data

FAA Advisory Circular No: 90-101

## WAAS

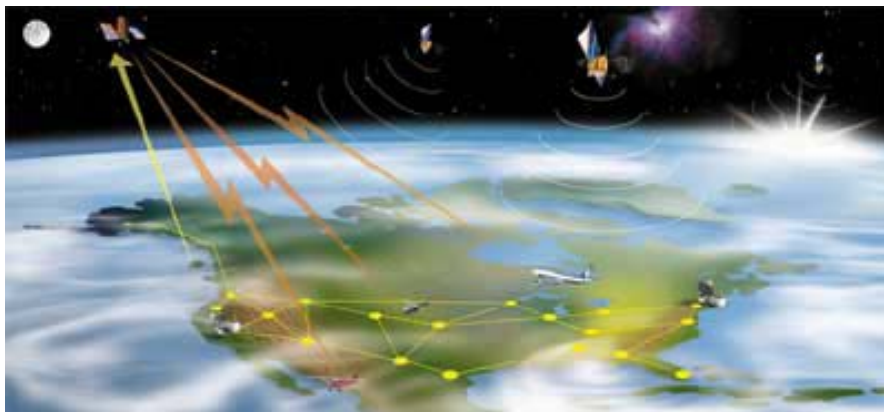
### Technology and Benefits

The Wide Area Augmentation System (WAAS) is a navigation system composed of satellites and ground stations that improve the quality of the Global Positioning System (GPS). Although the WAAS signal is approved for instrument flight, and WAAS avionics are available, additional work is required on LPV procedure development before the full benefits of WAAS are realized by the entire general aviation community.

With WAAS on board the aircraft, pilots are authorized to fly throughout the United States under instrument flight rules (IFR) without reliance on ground-based navigation aids. Capable of supporting all phases of flight including precision instrument approaches, WAAS is a cost-effective navigation system that general aviation pilots can use to improve safety as well as increased access to airports in all weather conditions.

### How WAAS Works

There are 24 GPS receivers throughout the United States, all networked into the WAAS system. The extremely accurate receivers evaluate the quality of the GPS signal and pass that information on to two master stations. They receive the information and determine what differential GPS information is needed to improve the quality of GPS to precision navigation quality. The master stations then transmit the correction data through a ground transmitter up to geostationary satellites that "hover" over the United States. These satellites broadcast the GPS correction signal, which is received by a WAAS-capable satellite navigation receiver.



The WAAS receiver uses the WAAS signal to calculate the improved accuracy and integrity information, ultimately improving its known GPS position. Simultaneously, the receiver uses WAAS to ensure that the pilot will not be receiving false or misleading navigation information.

### The Benefits of WAAS

WAAS provides service for all classes of aircraft in all phases of flight - including en route navigation, airport departures, and airport arrivals. This includes vertically-guided landing approaches in instrument meteorological conditions at all qualified locations throughout the NAS.

The WAAS broadcast message improves GPS signal accuracy from 100 meters to approximately 7 meters. Given its precision approach capability, access to airports by equipped aircraft will increase. The FAA is publishing WAAS LPV (localizer performance with vertical guidance) approaches to general aviation airports. They are frequently providing minimums of less than 300 feet and ¼ mile. The LPV approaches provide unprecedented access to general aviation airports, at a fraction of the cost of traditional instrument landing system (ILS) approaches.

WAAS also supports "pseudo glide slope" capabilities to every runway served by a non-precision GPS approach. The WAAS avionics system generates a virtual glide path that the aircraft's navigation system presents to the pilot. The pilot follows the glide path, reducing workload and eliminating the need to level off at intermediate step-down points along the final approach. There are over 3,000 straight-in GPS and RNAV (GPS) approaches published with straight-in minimums. Glide slope information is provided for each of these approaches.

WAAS promotes smart aviation policy. Because there are no ground navigation systems (e.g., ILS) to purchase or maintain, the cost of installing a WAAS approach is less than 10 percent of an ILS. And while the annual ILS maintenance cost can be as high as \$85,000, the cost to maintain a WAAS approach is less than \$3,000 every two years.

Because WAAS is permitted as a sole-means navigation system, general aviation reliance on very high frequency omnirange (VOR) for instrument flight is reduced. Over the next decade, the use of VOR will continue to decline, and the role of VOR will increasingly become an optional en route navigation backup.

### Targeted Users

The target population for WAAS equipage is primarily the general aviation (GA) community. Like all equipment packages, we divided the aircraft into two segments: High- and Low-end GA. High-end GA represents all turbine operators, while low-end GA comprises the piston fleet. This distinction was made based on the different categories contained within the General Aviation and Air Taxi Survey data, the altitude structure where these two segments normally operate, and the corresponding equipage requirements.

When determining the aggregate number of aircraft for equipage it was assumed that all aircraft in the high end category would be candidates for WAAS equipage, but only a subset of the piston fleet would be eligible. The determining factor in the low end category was those aircraft that are currently equipped with an ILS receiver, thus possibly being capable of flights under instrument conditions.

### Societal Benefits and Equipage Thresholds

Most of the benefits that are estimated from using WAAS LPV procedures accrue directly to the equipped users, although cost savings and cost avoidance to the FAA are anticipated in the future from reduced numbers of navigational aids. However, there is no particular minimum threshold of WAAS equipage which the BCPMWG found as being a desired target in order to achieve overall benefits.

## Current Equipage and Cost to Retrofit

Forward-fit or retrofit with WAAS is most applicable to high-end GA (approximately 18,500 in the current US fleet, forecasted to be 28,000 in 2020) and to IFR-capable low-end GA airframes (approximately 108,000 in the current US fleet, and to remain at that level in 2020).

30% of the current fleet of 18,500 high-end GA aircraft are currently equipped. 39% of the 2020 forecasted fleet of 28,000 US-registered airframes are expected to be equipped. Retrofit cost for the remaining unequipped aircraft is forecasted to be approximately \$0.82B.

For Low-end GA, based on the FAA estimated 30% current equipage rates of the 108,000 IFR-capable airframes, retrofitting the remaining IFR-capable aircraft is approximately \$1.43B. The proportion of aircraft equipped in 2020 will be determined by the retrofit market as current GA forecast data shows relatively zero growth during that timeframe.

## Business Case Closure Analysis

### Methodology Used

Avionics equipage decisions for some General Aviation operators do not depend on cost benefit analysis in the same way they do for commercial operators. Some GA operators may be unwilling to make the investment in upgrades that constitute a significant percentage of the aircraft hull value and cannot be recovered in the resale marketplace. Others may choose to install all the latest avionics capabilities regardless of a quantifiable return on investment.

### Benefit Data

WAAS benefits to individual users include:

1. More direct enroute flight paths.
2. New precision approach services
3. Reduced and simplified equipment on-board the aircraft
4. Increased access to small airports

However, an information gap exists on many of the operational metrics for general aviation, including aircraft hours and fuel burn, delays, % of flights conducted VFR versus IFR, what % of the fleet accounts for the differing level of flight and activity, price inflection points and other key measures that would allow a more detailed business case analysis. The task group continues to working with GA manufactures to obtain more accurate ways to obtain data on cost validation, aircraft usage, and upgradeability.

### Cost Data

Many of our costing assumptions were derived from information contained in the FAA's Application Integrated Work Plan (AIWP). The AIWP ranks and costs equipment requirements needed for many of the NextGen applications dependent upon ADS-B. However, it is useful as a proxy for WAAS upgrade costs, since many of the required components for basic operations are the same. The AIWP "avionics enabler" designation corresponds to a minimum avionics capability necessary to perform a designated application. For our purposes, an avionics enabler of level 4 was used to calculate the cost figures. The table below provides the ranges for computing the different sectors

## Appendix A: Equipage Gap Analysis

Enabler No.	Air Transport Unit Cost		High-End GA Unit Cost		Mid/Low GA Unit Cost	
	Range	Average	Range	Average	Range	Average
1	\$32-175K	\$104k	\$16-53K	\$35k	\$8-11K	\$10K
2	\$134-\$322K	\$233k	\$23-143K	\$83k	\$10-14k	\$12k
3	\$194-392K	\$293k	\$23-143K	\$83k	\$14-23k	\$19K
4	\$194-392K	\$293k	\$23-143K	\$83k	\$14-23k	\$19K
5	\$243-845K	\$544k	\$23-143K	\$83k	\$15-30K	\$22K
6	>\$243->845K <sup>1</sup>	>\$544k <sup>1</sup>	>\$23->143K <sup>1</sup>	>\$83k <sup>1</sup>	>\$15->30K <sup>1</sup>	>\$22K <sup>1</sup>
7	>\$243->845K <sup>1</sup>	>\$544k <sup>1</sup>	>\$23->143K <sup>1</sup>	>\$83k <sup>1</sup>	>\$15->30K <sup>1</sup>	>\$22K <sup>1</sup>
8	>\$243->845K <sup>1</sup>	>\$544k <sup>1</sup>	>\$23->143K <sup>1</sup>	>\$83k <sup>1</sup>	>\$15->30K <sup>1</sup>	>\$22K <sup>1</sup>

<sup>1</sup>There are potentially some unique costs estimated as compared to Enabler 5, but currently unknown

Further analysis with manufacturers may drive the enabler level to 5 or above, thereby increasing average costs for mid / low-end general aviation operators by approximately \$3,000.

### Analysis and Results

As stated above, avionics equipage decisions for General Aviation may not depend on cost benefit analysis in the same way they do for commercial operators. For GA most investment decisions are personal, driven by affordability and availability of LPV procedures; that is, "Is there a WAAS/LPV approach at my home airport?" Therefore, we only present here the cost data to equip the relevant fleet, but we find little insight into the expected total number that will eventually equip.

As of today, 30% of the current fleet of 18,500 high-end GA aircraft is currently equipped. (39% of the 2020 forecasted fleet of 28,000 US-registered airframes are expected to be equipped via forward fit.) Retrofit cost for the remaining unequipped aircraft is forecasted to be approximately \$0.82B.

For Low-end GA, based on the FAA estimated 30% current equipage rates of the 108,000 IFR-capable airframes, retrofitting the remaining IFR-capable aircraft is approximately \$1.43B. The proportion of aircraft equipped in 2020 will be determined by the retrofit market as current GA forecast data shows relatively zero growth during that timeframe.

The table below summarizes this information.

#### WAAS for GA

Description	Current Fleet*	% Not Equipped	# Not Equipped	Retrofit Cost per Aircraft (\$)	Total Retrofit Cost (\$M)	Cumulative Total Cost (\$M)
GA Piston	108,000	70%	75,600	\$19,000	\$1,436	\$1,436
GA Turboprop	8,900	70%	6,230	\$30,000	\$187	\$1,623
GA Jet	11,000	70%	7,700	\$82,000	\$631	\$2,255

\* AC counts are IFR capable fixed-wing aircraft, excluding helicopters.

## References

ID	Reference
NAC	RTCA NAC, <a href="#">Who (Which User Groups) Should be Incentivized to Equip for NextGen</a> , Agenda Item 8, May 2011.
TF5	RTCA Task Force 5, <a href="#">NextGen Mid-Term Implementation Task Force Report</a> , Sept 2009.
	FAA General Aviation and Air Taxi Activity Report, 2008
AWIP	FAA Application Integrated Work Plan, Version 2.0 June, 2010
NGIP	FAA NextGen Implementation Plan, March 2011
	Summary Data on General Aviation Fleets Prepared for NGATS Institute Cost Workshop, Aug 25, 2006
	GAMA Statistical Databook & Industry Outlook, 2010

## ADS-B Out

### Technology and Benefits

Automatic Dependent Surveillance-Broadcast Out (ADS-B Out) is a satellite-based system that broadcasts information (such as horizontal and vertical position and velocity) about an aircraft through an onboard transmitter to ground stations and other equipped aircraft.

With ADS-B Out, controllers can see radar-like displays of aircraft based on GPS position information transmitted by the aircraft itself. ADS-B Out is considered an improvement over radar because the surveillance data is updated in close-to-real time, the positional accuracy does not degrade with distance or terrain, and it can be used to provide surveillance in certain non-radar airspace. Potential benefits to equipped users include:

- Improved spacing and routing in non-radar airspace (e.g. the Gulf of Mexico)
- Increased capacity due to improvements in ATC merging and spacing
- Increased surface traffic efficiency for airport

### Targeted Users

Equipage with ADS-B Out is mandated by 2020 for anyone who wishes to operate an aircraft in US controlled airspace. This business case analysis focused on the commercial operator user category, which consists of Part 121 passenger and cargo operators. Analyses were conducted for the commercial operator user category as a whole and did not get down to the specific individual user or location level of detail. For GA users, data on the cost to equip is presented below.

### Societal Benefits and Equipage Thresholds

ADS-B is a baselined FAA program, and as such it was required to demonstrate a program-level business case with positive returns to society in order to move into full development. According to the ADS-B program business case (2007), ADS-B, along with TIS-B and FIS-B services, is expected to yield over \$18 billion of benefits over the program life cycle. This is over \$100 million per year after full deployment, and increasing to several hundred million per year after full equipage. Unfortunately, the program business case does not break out benefits accruing to equipped users versus unequipped users and other stakeholders. Nevertheless, there is a target level of equipage of 100% in controlled airspace, as expressed by the 2010 ADS-B Out equipage mandate, in order to achieve the program goal of making a complete shift to GPS-based ATC surveillance.

### Current Equipage and Cost to Retrofit

Current fleet equipage is essentially zero, as rule-compliant avionics for ADS-B Out are not expected to be available until late 2012. Cost to equip the Part 121 fleet is expected to range from \$59K to \$312K per aircraft, for a total fleet cost of approximately \$900 million.



## Appendix A: Equipage Gap Analysis

A summary of the number of commercial aircraft by cost category is depicted below.

### ADS-B Out

# Aircraft	% Aircraft	Description of Aircraft Majority	Cost per Aircraft (\$)	Total Cost (\$M)	Cumulative Total Cost (\$M)
2,594	39%	Newer mainline jets & regionals	\$59,000	\$153	\$153
352	5%	Mid-aged mainline jets	\$88,207	\$31	\$184
1,311	20%	Mid-aged mainline jets	\$101,832	\$134	\$318
136	2%	Cargo aircraft	\$108,301	\$15	\$332
607	9%	Mid-aged mainline jets	\$198,918	\$121	\$453
487	7%	Cargo aircraft	\$208,000	\$101	\$554
1,166	18%	Older mainline jets & regionals	\$312,000	\$364	\$918

For GA users, the cost to equip is shown below.

### ADS-B Out for GA

Description	Current Fleet*	% Not Equipped	# Not Equipped	Retrofit Cost per Aircraft (\$)	Total Retrofit Cost (\$M)	Cumulative Total Cost (\$M)
GA Piston	165,250	100%	165,250	\$8,000	\$1,322	\$1,322
GA Turboprop	13,700	100%	13,700	\$35,000	\$480	\$1,802
GA Jet	11,000	100%	11,000	\$140,000	\$1,540	\$3,342

\* AC counts are all fixed-wing GA aircraft, excluding helicopters

## Business Case Closure Analysis

### Methodology Used

Many of the benefits of ADS-B accrue to the FAA, society, or the entire user community rather than specific users. The FAA's Basis of Estimate - used for the Surveillance and Broadcast Services (SBS) program's final investment decision - does not break out the direct benefits that are realized by users equipped with ADS-B Out. Benefits will also vary by location (e.g. radar vs. non-radar airspace) and operator mission profile.

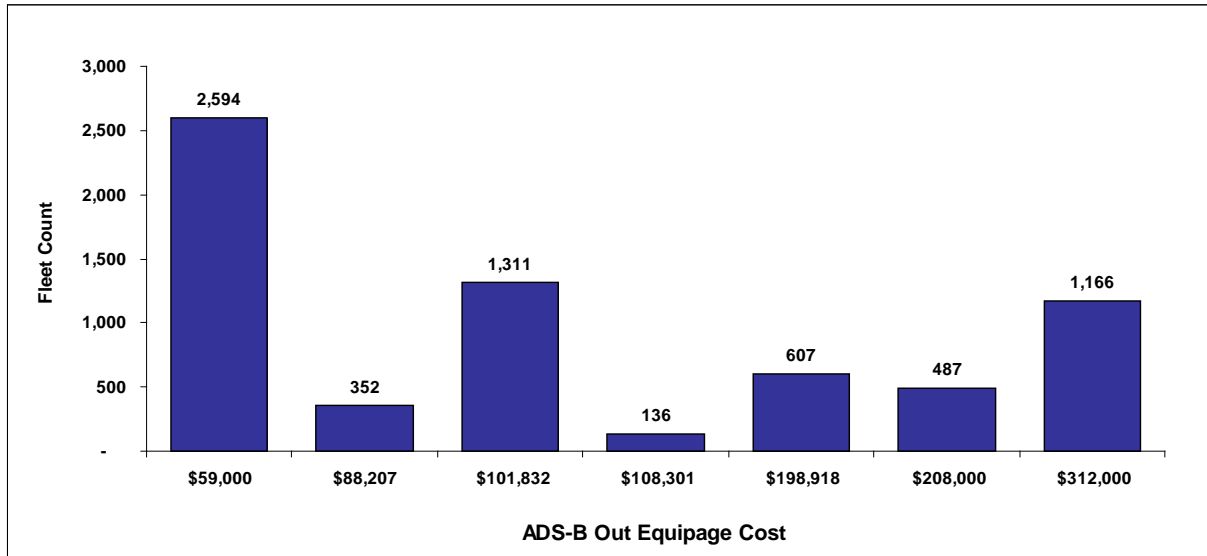
These data gaps were handled by creating a parametric business case that defines the number of flight minutes that would need to be saved in order to close a typical commercial operator's business case. A 2.5 year payback is required to close the business case for commercial operators. Additional assumptions for the parametric analysis include fuel cost at \$3 per gallon, benefits achieved immediately after equipage, and every flight deriving the average benefit.

### Benefit Data

In order to conduct the parametric analysis of benefits a common set of aircraft operational parameters were identified for commercial operators that were applied consistently across the three capabilities that were assessed for those operators (i.e., RNP-0.3 with RF Legs, ADS-B Out, and ATC Data Link Communications). See the discussion of benefits in the overall methodology section above for further details.

### Cost Data

The data summarized in the chart below were provided by the MITRE Corporation. More detailed data are available in Appendix B.



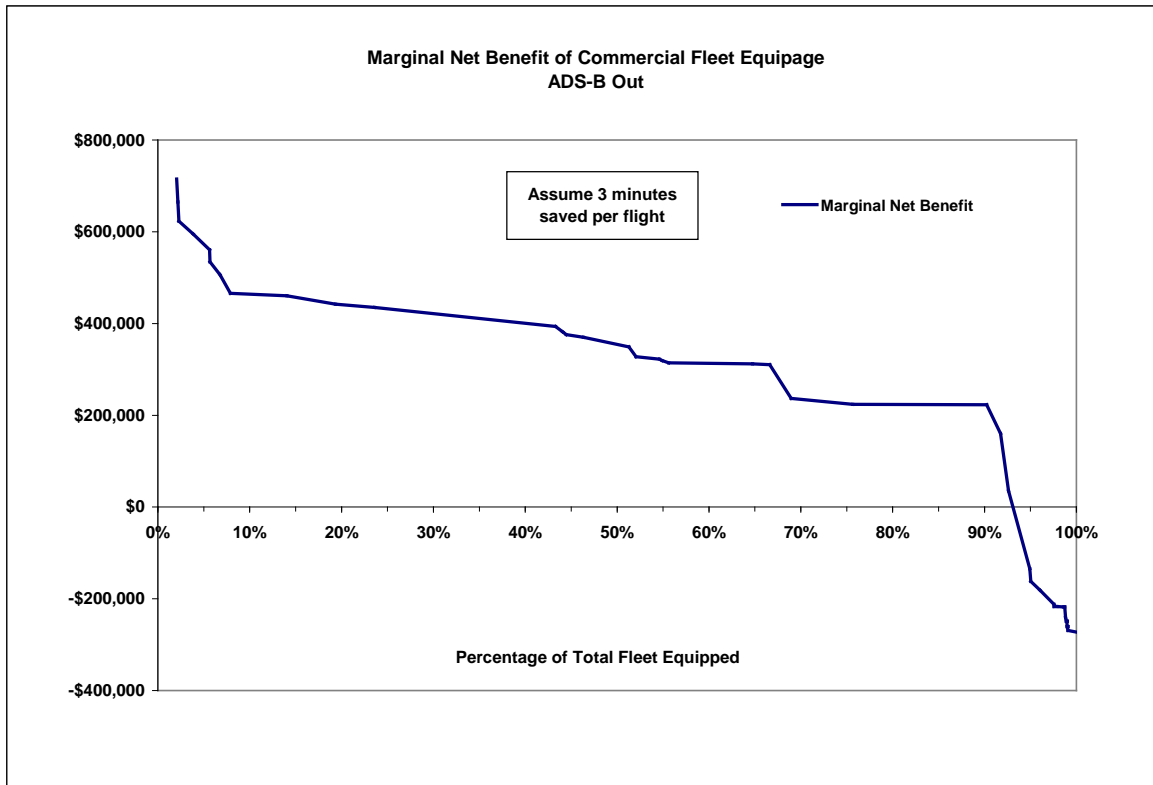
### Analysis and Results

The number of aircraft with a positive business case depends upon three factors:

- how costly they are to retrofit,
- how many minutes per flight could be saved by equipping, and
- how much a minute of time is worth in direct operating cost.

In other words, the higher the time savings potentially associated with ADS-B Out, the greater the share of the fleet that might be expected to equip. However, the first to equip may not necessarily be the least expensive; aircraft with a relatively high cost-per-minute to operate or a large number of flights per day will get a higher benefit from equipping.

The following chart illustrates this. It shows the marginal net benefit for each additional aircraft that equips, using our baseline assumptions of 3 minutes saved per flight, \$3.00 per gallon fuel cost, a 2.5 year payback period, and immediate accrual of benefits. The share of aircraft equipped is ordered from highest to lowest payback; thus, the first aircraft to equip are assumed to be those with high net benefit.



As the chart above shows, if an average of 3 minutes per flight could be saved by equipping with ADS-B Out, then 93% of the fleet would have a positive business case.

The percentage of aircraft with a positive business case is also very sensitive to the expected savings achieved per flight. The table below shows the amount of time savings that would be required to close the business case for a given share of the fleet.

**% of Fleet With Business Case Closure vs Minutes Saved**  
(% based on total fleet)

ADS-B Out	
Minutes Saved	% Fleet Equipped
0	0%
0.5	28%
1	66%
2	92%
<b>3</b>	<b>93%</b>
4	93%
5	93%
6	95%
7	95%
8	96%
9	96%
10	99%

### Key Sensitivities

Sensitivity analyses were performed for three of our major assumptions: lag time between equipping and achieving benefits, minutes saved in flight, and fuel price. The results are most sensitive to the lag between equipage and realization of benefits. The next most significant impact driver is minutes saved in flight. Fuel price per gallon was the least sensitive of the three.

The sensitivity tables are shown below. Each table calculates the percentage of the non-equipped commercial fleet for which the business case closes with a 2.5 year payback or less assuming all flights drive benefit, zero benefit lag, three minutes saved in flight, and \$3.00 fuel per gallon unless that assumption is the variable in the sensitivity table.

SENSITIVITY				
% of Commercial Fleet Closing the Business Case				
Benefit Lag (yrs)				
0.0	0.5	1.0	1.5	2.0
93%	92%	92%	81%	30%
Minutes Saved				
1.0	1.5	2.0	2.5	3.0
66%	85%	92%	92%	93%
Fuel Price				
\$2.00	\$2.50	\$3.00	\$3.50	\$4.00
92%	92%	93%	93%	93%

### References

- MITRE
- Delta Air Lines
- Ascend Aircraft & Airline Data
- Federal Aviation Administration, 14 CFR Part 91
- Federal Aviation Administration, ADS-B Application Integrated Work Plan, Version 2.0 June, 2010

## Initial ATC Data Link Communications

### Technology and Benefits

ATC data link communication services are currently being widely offered and extensively used in US-managed oceanic and remote airspace; this business case analysis report focuses on the avionics required to realize initial data link services for domestic NAS operations. The scope of this business case analysis report is limited to avionics capabilities needed to realize initial domestic data link capabilities, as identified by the RTCA NextGen Advisory Council (NAC) [NAC].

This business case analysis does not reflect possible effects of the FAA Data Communications Program Screening Information Request [SIR] that includes options for avionics incentives.

By reducing and reallocating the workload associated with controller-pilot voice communications, initial domestic data link significantly increases airspace capacity and throughput during nominal and non-nominal conditions [Shingledecker]. It provides a supplemental means to manage aircraft trajectories and aircraft separations from other aircraft, airspace, and weather on a strategic basis. When used in conjunction with flow management tools, operational predictability is improved through a more precise execution of traffic flow strategies. As such, initial data link is a key enabler for more advanced NextGen operational concepts. [TF5]

### Targeted Users

It is assumed that most of the benefits for initial data link will accrue to commercial users and some high-end GA. However, most of the following analysis focuses on commercial (Part 121) users.

The BCPMWG evaluated two equipage scenarios:

- Scenario 1: Initial ATC Data Link Communication services are provided only to aircraft equipped with FANS-1/A+ using VDL Mode-2.
- Scenario 2: Initial ATC Data Link Communication services are provided either to aircraft equipped with FANS-1/A+ using VDL Mode-2; or, to aircraft equipped with ATN Baseline 1 using VDL Mode-2. Assignment of the lower cost solution was made for each aircraft configuration.

FANS-1/A is used extensively for oceanic and remote operations in US-managed airspace and elsewhere in the world; operators are interested in realizing additional benefits from their equipage investments by expanding the scope of their use to domestic operations. Large numbers of aircraft are capable of conducting FANS-1/A-based data link operations. In order to meet the safety and performance requirements stipulated in [DO-290/2] for initial domestic data link, FANS-1/A avionics configurations may need to be updated; it is anticipated that appropriately configured [DO-258A] FANS-1/A+ aircraft could be accommodated through the implementation of a ground-based data link application gateway compliant with [DO-305] accommodation interoperability requirements. FANS-1/A+ is offered on a range of aircraft by [Boeing] and [Airbus].

ATN Baseline 1 is specified in [DO-280B]; the European Union has mandated equipage with the LINK2000+ subset of ATN Baseline 1 [DLS IR]. The CMU-based ATN Baseline 1 architecture [ARINC 758] is targeted at addressing the need to offer a technically and economically viable path for older or less well equipped aircraft and operators to participate in initial domestic data link-based operations. A range of CMU-based ATN Baseline 1 offerings are available [Boeing] [Airbus] or in the regulatory

approval process [EASA]. Due to the lack of ATC data link services in the domestic NAS, there is no current equipage with the CMU-based ATN Baseline 1 capability within the US aircraft fleet. However, significant numbers of aircraft typically used for Part 121 operations have the precursor components (VDR Mode-2 and CMU) in place to enable rapid and low cost introduction of the capability. Similarly, GA aircraft and avionics manufacturers are planning to offer ATN Baseline 1 capabilities for some newer production aircraft types in the future to support EU requirements but are not anticipating sales of these upgrades to U.S. operators due to the lack of a viable business case (based upon the current FAA program office position not to support ATN Baseline 1).

### **Societal Benefits and Equipage Thresholds**

The FAA estimates that substantial benefits will accrue to all operators from initial ATC data link for en route operations. This effect is anticipated due to reductions in controller workload and consequent increases in productivity due to automated aircraft transfers of communication, which increases sector capacity and aircraft throughput. This effect benefits both equipped and unequipped airspace users, though the preponderance of benefits accrue to the equipped aircraft. Although final estimates from the FAA program office are not yet available, preliminary studies indicate that the total benefit to airspace users – just from automating en route sector transfer of communications – would be over \$200 million per year, assuming that about 1/3 of the fleet is equipped. However, in order to achieve these NAS-wide benefits for all users, research also indicates that at least 20% of the fleet must be equipped. If less than 20% of en route flights have initial data link capabilities, models suggest that the capacity benefit will be small or non-existent. Analysis by EUROCONTROL [DLS IR]—corroborated by MITRE modeling results [MITRE / Giles]—indicates that a 70% equipage rate by Part 121 operators would effectively eliminate the en route controller sector workload constraint and realize all expected benefits.

FAA is evaluating a potential requirement for FMS auto-load of complex clearances; however, the marginal benefits arising from such a requirement have not been established.

## Appendix A: Equipage Gap Analysis

The following initial ATC data link communication services were evaluated by an Air Transport Association user group to establish a sense of their relative benefit contributions:

ATA Ranking	Service	FANS-1/A+ supports?	LINK2000+ supports?	Airline Benefit	Airline benefit?	Early implementation?
N/A	Departure Clearance	In Part, combined messages	In Part (3 issues pending)	Faster and more efficient departure clearances reduce operating costs	Yes	Yes (initial FAA capability – 2014)
1	Go Button	Yes	Yes No auto load on A/C	Faster and more efficient reroutes reduce operating costs	Yes	Yes (initial FAA capability – 2018)
2	Routes	Yes	Yes No auto load on A/C	Faster and more efficient reroutes reduce operating costs	Yes	Yes (initial FAA capability – 2018)
3	Tailored Arrivals	Yes	No	Tailored arrivals reduce fuel burn on arrival and reduce operating costs	Yes	Yes (in limited form at select airports)
N/A	Transfer of Communication / Initial Contact	No FANS-1/A+ not able to concatenate Contact / Monitor message with Confirm Assigned Level report	Yes Except for Boeing FANS-2 offering (Based on MITRE survey of avionics vendors)	Significant reduction in controller workload resulting in fewer delays and increased sector capacity - reduced operating costs	Yes	Yes (initial FAA capability – 2018)
4	Direct to fix	Yes	Yes	Direct to issued more frequently to equipped users – fewer miles flown	Yes	Yes (initial FAA capability – 2018)
5	Crossing restrictions	Yes	Yes	Combined with other clearance information reduces controller workload and increases sector capacity – reduced operating costs	Yes	Yes (initial FAA capability – 2018)
6	Advisory messages	Yes	Yes	Capacity benefit	No	Yes (initial FAA capability – 2018)
7	Altitude / speed / heading	Yes	Yes	Combined with other clearance information reduces controller workload and increases sector capacity – reduced operating costs	Yes	Yes (initial FAA capability – 2018)
8	Altimeter settings	Yes	Yes	Needed to reduce voice communications associated with other functions	No	Yes (initial FAA capability – 2018)
9	Beacon codes	Yes	Yes	Needed to reduce voice communications associated with other functions	No	Yes (initial FAA capability – 2018)
10	Stuck Microphone	Yes	Yes	Capacity benefit	No	Yes (initial FAA capability – 2018)

## Expected 2020 Fleet Equipage and Cost to Retrofit

- Expected 2020 commercial (Part 121) fleet projected to include 8,071 aircraft.
- 56.5% of the expected 2020 Part 121 fleet is equipped with VDL Mode-2 [ARINC 750] [TSO-160].
- Eurocontrol mandate for ATN Baseline 1 requires equipage by 2015 with forward fit beginning 2011 (current FANS aircraft exempted) for aircraft operating in European domestic airspace above FL285.

### Option 1: FANS 1/A+ over VDL2 only

#### Expected 2020 Part 121 Commercial Fleet:

- Current Part 121 equipage with FANS 1/A+ over VDL Mode-2 aircraft comprising 1.6% of the expected 2020 Part 121 fleet at no additional cost.
- New aircraft to 2020 with FANS 1/A+ over VDL Mode-2 as a standard offering comprising 6.6% of the expected 2020 Part 121 fleet at no additional cost.
- New aircraft to 2020 with FANS 1/A+ over VDL Mode-2 as an optional offering comprising 18.5% of the expected 2020 Part 121 fleet for \$90M.
- Current FANS 1/A+ capable, VDL Mode-2 aircraft enabled comprising 13.7% of the expected 2020 Part 121 fleet for \$145M.
- Current FANS capable/enabled, VHF Mode-0 (ACARS) equipped aircraft comprising 23.9% of the expected 2020 Part 121 fleet for \$1075M.
- The remaining 35.6% of the expected 2020 Part 121 fleet (primarily regional jets and narrow body aircraft) have no current upgrade path identified to FANS-1/A+. Note that the maximum feasible FANS 1/A+ over VDL Mode-2 equipage is 64.4% of the expected 2020 Part 121 fleet, due to the lack of FANS 1/A+ offerings for some aircraft types.

#### High-End GA:

- Information from GAMA indicates that of 6000 large intercontinental, medium continental, and light regional airframes surveyed, none are enabled with FANS-1/A+.
- 292 high-end GA aircraft can be retrofitted with a FANS-1/A capability using VDL Mode-2. (It is still to be verified whether these aircraft can be retrofitted with FANS 1/A+). The cost to achieve a FANS capability is estimated at \$18.4M for this portion of the fleet.
- In 2020, it is expected that 150 high end GA aircraft will be delivered with dual-stack FANS-1/A+ / ATN Baseline 1 capabilities, with an additional 350 aircraft being delivered with the option for upgrading to FANS-1/A+/ VDL Mode-2 at a cost of \$18M for this portion of the fleet.

### Option 2: Cheaper of FANS 1/A+ or ATN Baseline 1 over VDL2

#### Part 121 Commercial Fleet:

- Current Part 121 equipage with FANS 1/A+ over VDL Mode-2 aircraft comprising 1.6% of the expected 2020 Part 121 fleet at no additional cost.
- New aircraft to 2020 with FANS 1/A+ over VDL Mode-2 as a standard offering comprising 6.6% of the expected 2020 Part 121 fleet at no additional cost.
- New aircraft to 2020 with ATN Baseline 1 over VDL Mode-2 as an optional offering comprising 25.1% of the expected 2020 Part 121 fleet for \$98M.
- Current ATN Baseline 1 capable, VDL Mode-2 aircraft enabled comprising 23.2% of the expected 2020 Part 121 fleet for \$ 70M.
- Current ATN Baseline 1 capable, VHF Mode-0 (ACARS) equipped aircraft comprising 43.5% of the expected 2020 Part 121 fleet for \$1,328M.



### High-End GA:

- Information from GAMA indicates that of 6000 large intercontinental, medium continental, and light regional airframes surveyed, none are enabled with FANS-1/A+.
- 292 high-end GA aircraft can be retrofitted with a FANS-1/A capability using VDL Mode-2. (It is still to be verified whether these aircraft can be retrofitted with FANS 1/A+). The cost to achieve a FANS capability is estimated at \$18.4M for this portion of the fleet.
- In 2020, it is expected that 150 high end GA aircraft will be delivered with dual-stack FANS-1/A+ / ATN Baseline 1 capabilities, with an additional 350 aircraft being delivered with the option for upgrading to FANS-1/A+ / VDL Mode-2 at a cost of \$18M for this portion of the fleet.
- GA aircraft and avionics manufacturers are planning to offer ATN Baseline 1 capabilities for some newer production aircraft types in the future to support EU requirements but are not anticipating sales of these upgrades to U.S. operators due to the lack of a viable business case, since there are no current plans to provide data link services via ATN Baseline 1.

## Business Case Closure Analysis

### Methodology Used

The BCPMWG sought business case input data from multiple sources, but found many gaps in detail, consistency, and underlying assumptions. In general, cost data was more robust than benefit data. In assessing the business case for ATC data link communications, the BCPMWG encountered material gaps in benefit data, specifically:

- Lack of forecasted potential benefits accruing uniquely to equipped operators from specific services identified above.
- Lack of implementation plans detailing timing and capability of future FAA decision support tools capable of providing complex route clearances necessitating auto-load to the FMS.
- Lack of forecasted potential marginal benefits accruing uniquely to equipped operators from the exchange of complex route clearances necessitating auto-load to the FMS beyond those benefits realized through exchange of non-complex route clearances not necessitating auto-load to the FMS.

The data gaps were handled by creating a parametric business case that defines the number of flight minutes that would need to be saved in order to close a typical commercial operator's business case.

A 2.5 year payback is required to close the business case for commercial operators. Additional assumptions for the parametric analysis include fuel cost at \$3 per gallon, benefits achieved immediately after equipage, and every flight deriving benefit.

### Benefit Data

In order to conduct the parametric analysis of benefits a common set of aircraft operational parameters were identified for commercial operators that were applied consistently across the three capabilities that were assessed for those operators (i.e., RNP-0.3 with RF Legs, ADS-B Out, and ATC Data Link Communications). See the discussion of benefits in the overall methodology section above for further details.

### Cost Data

MITRE [MITRE / Colliver] provided the Part 121 fleet database and equipage costs; a summary of those inputs is provided below, see Appendix B for more detail. For purposes of the BCPMWG equipage gap

## Appendix A: Equipage Gap Analysis

analysis, the expected 2020 Part 121 fleet was grouped as illustrated below. These grouping designations will be used for reporting the analysis results.

# Appendix A: Equipage Gap Analysis

## Initial ATC Data Link Communications Aircraft Configuration Transition States, Quantities, and Unit Costs

Expected 2020 US Part 121 Fleet																				Total Expected 121 Fleet				
Initial Aircraft Capability States Mapped to Alternate Data Link Configuration Transition Paths																								
Architecture		Federated										Integrated Modular Architecture												
FMS/ATSU Initial State	FANS-Capable in FMS*			FANS-Enabled in FMS**			FANS HW Upgradeable in FMS***		AB - Not ATSU Equipped		AB - ATSU Needs Replacement			Capable ATSU	Unable / Unlikely to Upgrade to FANS****			Unknown FMS Capability	FANS-Capable in FMS	FANS-Enabled in FMS		FANS HW Upgradeable in FMS	Unable / Unlikely to Upgrade to FANS****	
FANS Upgrade Costs (Boeing/Airbus)	ACARS MU VDL/0	CMU/VDR VDL/2 Enabled	Forward Fit Option	ACARS MU VDL/0	CMU/VDR VDL/2 Enabled	Forward Fit Standard	ACARS MU VDL/0	CMU/VDR VDL/2 Enabled	VDL 0	VDL 2 Enabled	VDL 0	VDL 2 Enabled	VDR Yes VDL Mode ?	VDL 2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	Forward Fit Option	Unknown Data Capability	CMU/VDR VDL/2 Enabled	CMU/VDR VDL/2 Enabled	CMU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/VDR VDL/2 Enabled	
Implementation State	Retrofit	Retrofit	Forward Fit Option	Retrofit	Current Fleet	Forward Fit Standard	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit	Forward Fit Option	Retrofit	Retrofit	Forward Fit Option	Retrofit	Forward Fit Option	Current Fleet	Forward Fit Standard	Retrofit	Forward Fit Option	
<b>FANS Transition Cost Path</b>	1	2	Option	3	Enabled	Standard	4	5	6	7	8	9	10	Option	N/A	N/A	N/A	N/A	Option	Enabled	Standard	4	N/A	
<b>FANS Transition Path Cost</b>	\$ 602,600	\$ 80,600	\$ 60,000	\$ 539,600	\$ -	\$ -	\$ 867,600	\$ 341,600	\$ 377,600	\$ 187,600	\$ 327,600	\$ 137,600	\$ 124,600	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 60,000	\$ -	\$ -	\$ 1,000,000	\$ -	
Increment if installing new ATSU & DCDU									\$ 50,000	\$ 50,000	\$ 100,000	\$ 100,000	\$ 100,000											
Replace existing ATSU (incl DCDU)									\$ 100,000	\$ 100,000	\$ 100,000	\$ 100,000	\$ 100,000											
ATN Baseline 1 SW SB/Option	\$ 43,000	\$ 43,000																						
FMS FANS SW Option (per aircraft)									\$ 4,000	\$ 4,000														
FANS 1/A+ FMS Software Upgrade 2x																								
VDR 631-5 Upgrade																								
CMU 631-5 Upgrade																								
CMU VDL/2 SB																								
Data Recording SW Upgrade		\$ 4,000							\$ 4,000	\$ 4,000	\$ 4,000	\$ 4,000	\$ 4,000											
FMS HW Upgrade (Includes FANS SB) (2x retrofit)			\$ 60,000						\$ 150,000	\$ 150,000	?	?	?	?										
FMS Installation Kit (ATC Button) 2x	\$ 10,000	\$ 10,000							\$ 10,000	\$ 10,000	\$ 10,000	\$ 10,000	\$ 10,000											
Data Recording Kit	\$ 6,800	\$ 6,800							\$ 6,800	\$ 6,800	\$ 6,800	\$ 6,800	\$ 6,800											
INSTALLATION	\$ 16,800	\$ 16,800							\$ 16,800	\$ 16,800	\$ 16,800	\$ 16,800	\$ 16,800											
<b>FMS / Data Recording Subtotal</b>	\$ 76,600	\$ 80,600	\$ 60,000	\$ 13,600	\$ -	\$ -	\$ 341,600	\$ 341,600	\$ 187,600	\$ 187,600	\$ 137,600	\$ 137,600	\$ 124,600	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 60,000	\$ -	\$ -	\$ 1,000,000	\$ -	
CMU	\$ 46,000	\$ 46,000							\$ 46,000	\$ 46,000	\$ 46,000	\$ 46,000	\$ 46,000											
VDR	\$ 49,000	\$ 49,000							\$ 49,000	\$ 49,000	\$ 49,000	\$ 49,000	\$ 49,000											
MCDU (2x)	\$ 168,000	\$ 168,000							\$ 168,000	\$ 168,000	\$ 168,000	\$ 168,000	\$ 168,000											
INSTALLATION	\$ 263,000	\$ 263,000							\$ 263,000	\$ 263,000	\$ 263,000	\$ 263,000	\$ 263,000											
<b>Price Total</b>	\$ 602,600	\$ 80,600	\$ 60,000	\$ 539,600	\$ -	\$ -	\$ 867,600	\$ 341,600	\$ 377,600	\$ 187,600	\$ 327,600	\$ 137,600	\$ 124,600	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 60,000	\$ -	\$ -	\$ 1,000,000	\$ -	
<b>Estimated FANS Market Price</b>	\$ 602,600	\$ 80,600	\$ 60,000	\$ 539,600	\$ -	\$ -	\$ 867,600	\$ 341,600	\$ 377,600	\$ 187,600	\$ 327,600	\$ 137,600	\$ 124,600	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 60,000	\$ -	\$ -	\$ 1,000,000	\$ -	
<b>ATN Transition Cost Path</b>	A	B	Option	B	N/A	N/A	A	B	C	D	E	F	G	Option	A	B	Option	A	N/A	N/A	N/A	N/A	Option	
<b>ATN Transition Path Cost</b>	\$ 366,600	\$ 32,600	\$ 60,000	\$ 32,600	\$ -	\$ -	\$ 366,600	\$ 36,600	\$ 392,600	\$ 202,600	\$ 342,600	\$ 152,600	\$ 159,602	\$ -	\$ 366,600	\$ 32,600	\$ 15,000	\$ 366,600	\$ -	\$ -	\$ -	\$ -	\$ 15,000	
Increment if installing new ATSU & DCDU									\$ 50,000	\$ 50,000	\$ 100,000	\$ 100,000	\$ 100,000											
Replace existing ATSU (incl DCDU)									\$ 100,000	\$ 100,000	\$ 100,000	\$ 100,000	\$ 100,000											
ATN Baseline 1 SW SB/Option	\$ 15,000	\$ 15,000																						
FMS FANS SW Option (per aircraft)																								
FANS 1/A+ FMS Software Upgrade 2x									\$ 4,000															
VDR 631-5 Upgrade																								
CMU 631-5 Upgrade																								
CMU VDL/2 SB																								
Data Recording SW Upgrade	\$ 4,000	\$ 4,000							\$ 4,000	\$ 4,000	\$ 4,000	\$ 4,000	\$ 4,000											
FMS HW Upgrade (Includes FANS SB) (2x retrofit)			\$ 60,000						?	?	?	?	?											
FMS Installation Kit (ATC Button) 2x									\$ 10,000	\$ 10,000	\$ 10,000	\$ 10,000	\$ 10,000											
Data Recording Kit	\$ 6,800	\$ 6,800							\$ 6,800	\$ 6,800	\$ 6,800	\$ 6,800	\$ 6,800											
INSTALLATION	\$ 6,800	\$ 6,800							\$ 6,800	\$ 6,800	\$ 6,800	\$ 6,800	\$ 6,800											
<b>FMS / Data Recording Subtotal</b>	\$ 32,600	\$ 32,600	\$ 60,000	\$ 32,600	\$ -	\$ -	\$ 32,600	\$ 36,600	\$ 202,600	\$ 202,600	\$ 152,600	\$ 152,600	\$ 159,602	\$ -	\$ 32,600	\$ 32,600	\$ 15,000	\$ 32,600	\$ -	\$ -	\$ -	\$ 15,000	\$ -	
CMU	\$ 46,000	\$ 46,000							\$ 46,000	\$ 46,000	\$ 46,000	\$ 46,000	\$ 46,000											
VDR	\$ 49,000	\$ 49,000							\$ 49,000	\$ 49,000	\$ 49,000	\$ 49,000	\$ 49,000											
MCDU (2x)	\$ 72,000	\$ 72,000							\$ 72,000	\$ 72,000	\$ 72,000	\$ 72,000	\$ 72,000											
INSTALLATION	\$ 167,000	\$ 167,000							\$ 167,000	\$ 167,000	\$ 167,000	\$ 167,000	\$ 167,000											
<b>Price Total</b>	\$ 366,600	\$ 32,600	\$ 60,000	\$ 32,600	\$ -	\$ -	\$ 366,600	\$ 36,600	\$ 392,600	\$ 202,600	\$ 342,600	\$ 152,600	\$ 159,602	\$ -	\$ 366,600	\$ 32,600	\$ 15,000	\$ 366,600	\$ -	\$ -	\$ -	\$ 15,000	\$ -	
<b>Estimated ATN Market Price</b>	\$ 366,600	\$ 32,600	\$ 60,000	\$ 32,600	\$ -	\$ -	\$ 366,600	\$ 36,600	\$ 392,600	\$ 202,600	\$ 342,600	\$ 152,600	\$ 159,602	\$ -	\$ 366,600	\$ 32,600	\$ 15,000	\$ 366,600	\$ -	\$ -	\$ -	\$ 15,000	\$ -	
Narrow Body	673.5	830.5	812	365.5	101	143	180.5	198.5	22	0	563	35	44	644	655	763	491	927.5	40	30	389	122.5	40	4011.5
Wide Body				365.5	101	143	77	104											131		30	389	122.5	1463
Regional Jet															649	763	465	324						2241
Turboprop															3		26	326						355
<b>Total</b>	<b>673.5</b>	<b>830.5</b>	<b>812</b>	<b>365.5</b>	<b>101</b>	<b>143</b>	<b>180.5</b>	<b>198.5</b>	<b>22</b>	<b>0</b>	<b>563</b>	<b>35</b>	<b>44</b>	<b>644</b>	<b>655</b>	<b>763</b>	<b>491</b>	<b>927.5</b>	<b>40</b>	<b>30</b>	<b>389</b>	<b>122.5</b>	<b>40</b>	<b>8070.5</b>
<b>% of Expected 121 Fleet</b>	<b>8%</b>	<b>10%</b>	<b>10%</b>	<b>5%</b>	<b>1%</b>	<b>2%</b>	<b>2%</b>	<b>2%</b>	<b>0%</b>	<b>0%</b>	<b>7%</b>	<b>0%</b>	<b>1%</b>	<b>8%</b>	<b>8%</b>	<b>9%</b>	<b>6%</b>	<b>11%</b>	<b>0%</b>	<b>0%</b>	<b>5%</b>	<b>2%</b>	<b>0%</b>	<b>100%</b>

Source: "121\_MOAS\_20110607\_R8.5.xlsx"  
 \*Narrow Body aircraft capable FANS FMS (i.e., Pegasus, GE U10.5+, FMS2, VIA2000), but requires enabling via software and service bulletin upgrades.  
 \*\*Wide Body aircraft with FANS 1/A or 1/A+ enabled FMS (i.e., Pegasus, GE U10.5+, AIMS1/2, PIP, FANS1, VIA2000).  
 \*\*\*Aircraft with available hardware upgrade option for FMS to FANS capability (e.g., GE U5.0, Legacy 200K/700K, H79100).  
 \*\*\*\*Aircraft that are highly unlikely to upgrade to FANS due to cost of FMS replacement (e.g., CMA-900, FMS-4200, EPIC, Universal). Suitable candidates for CMU data link solution.

## Analysis and Results

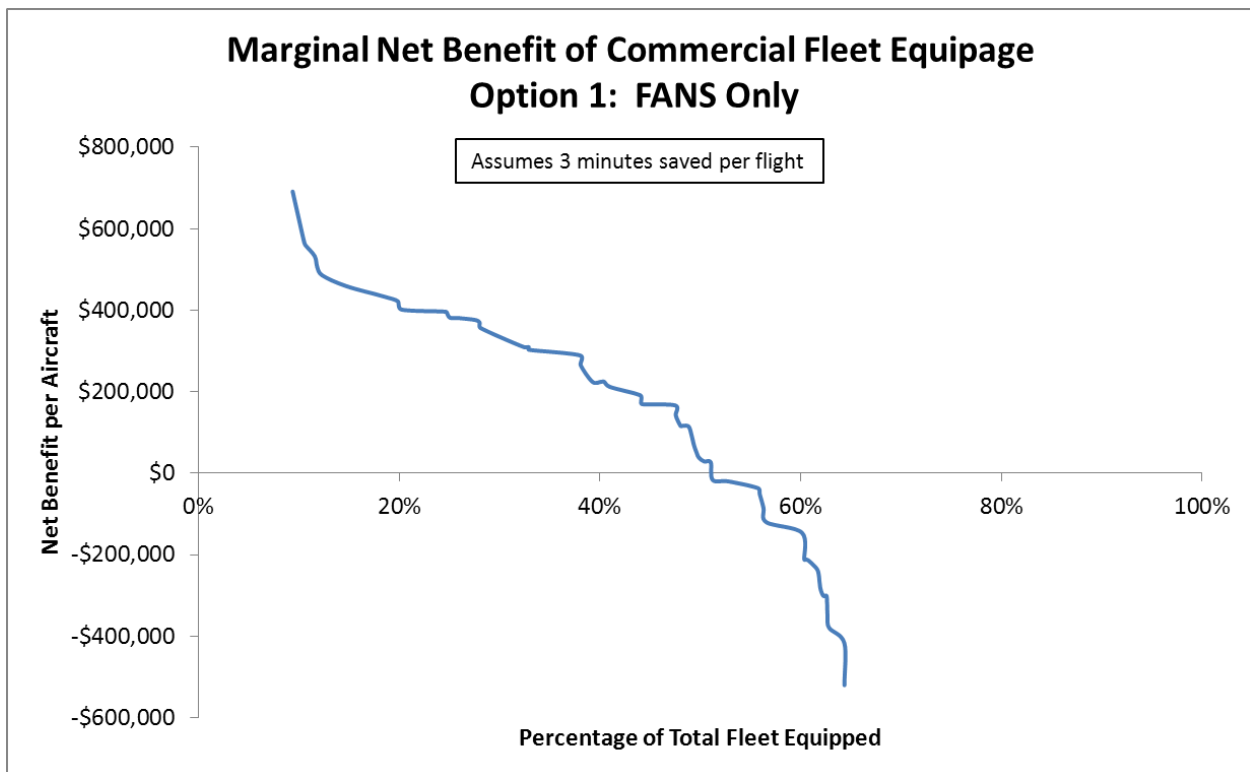
### Option 1: FANS 1/A+ over VDL2 only

The number of additional aircraft with a positive business case depends upon three factors:

- How costly they are to retrofit;
- How many minutes per flight assumed to be saved by equipping; and,
- How much a minute of time is worth in variable direct operating costs?

In other words, the higher the time savings associated with initial ATC data link, the greater the share of the fleet that might be expected to equip. However, the first to equip may not necessarily be the least expensive; aircraft with a relatively high cost-per-minute to operate or a large number of flights per day will get a higher benefit from equipping.

The following chart illustrates this. It shows the marginal net benefit for each additional aircraft that equips, using our baseline assumptions of 3 minutes saved per flight, \$3.00 per gallon fuel cost, a 2.5 year payback period, and immediate accrual of benefits. The share of aircraft equipped is ordered from highest to lowest payback; thus, the first aircraft to equip are assumed to be those with high net benefit.



As the chart above shows, if an average of 3 minutes per flight could be saved by equipping with the FANS-only option for initial ATC data link communications, then 51% of the expected 2020 fleet would have a positive business case.

The percentage of aircraft with a positive business case is also very sensitive to the expected savings achieved per flight. The table below shows the amount of time savings that would be required to close the business case for a given share of the fleet.

<b>% of Fleet With Business Case Closure vs Minutes Saved</b>	
<b>Initial ATC Data Link Communications Option 1: FANS Only</b>	
<b>Minutes Saved</b>	<b>% Fleet</b>
0	8%
0.5	30%
1	38%
2	47%
3	51%
4	61%
5	62%
6	64%

**Key Sensitivities**

Sensitivity analyses were performed for three of our major assumptions: lag time between equipping and achieving benefits, minutes saved in flight, and fuel price. The results are most sensitive to the lag between equipage and realization of benefits. The next most significant impact driver is minutes saved in flight. Fuel price per gallon was the least sensitive of the three.

The sensitivity tables are shown below for both the low and high ends of the cost range estimates. Each table calculates the percentage of the non-equipped commercial fleet for which the business case closes with a 2.5 year payback or less assuming all flights drive benefit, zero benefit lag, three minutes saved in flight, and \$3.00 fuel per gallon, unless that assumption is the variable in the sensitivity table.

<b>SENSITIVITY</b>				
<b>% of Commercial Fleet Closing the Business Case</b>				
<b>Benefit Lag (yrs)</b>				
<b>0.0</b>	<b>0.5</b>	<b>1.0</b>	<b>1.5</b>	<b>2.0</b>
53%	48%	41%	38%	32%
<b>Minutes Saved</b>				
<b>1.0</b>	<b>1.5</b>	<b>2.0</b>	<b>2.5</b>	<b>3.0</b>
38%	38%	47%	49%	53%
<b>Fuel Price</b>				
<b>\$2.00</b>	<b>\$2.50</b>	<b>\$3.00</b>	<b>\$3.50</b>	<b>\$4.00</b>
47%	49%	53%	57%	58%

**Option 2: Cheaper of FANS 1/A+ or ATN Baseline 1 over VDL Mode-2**

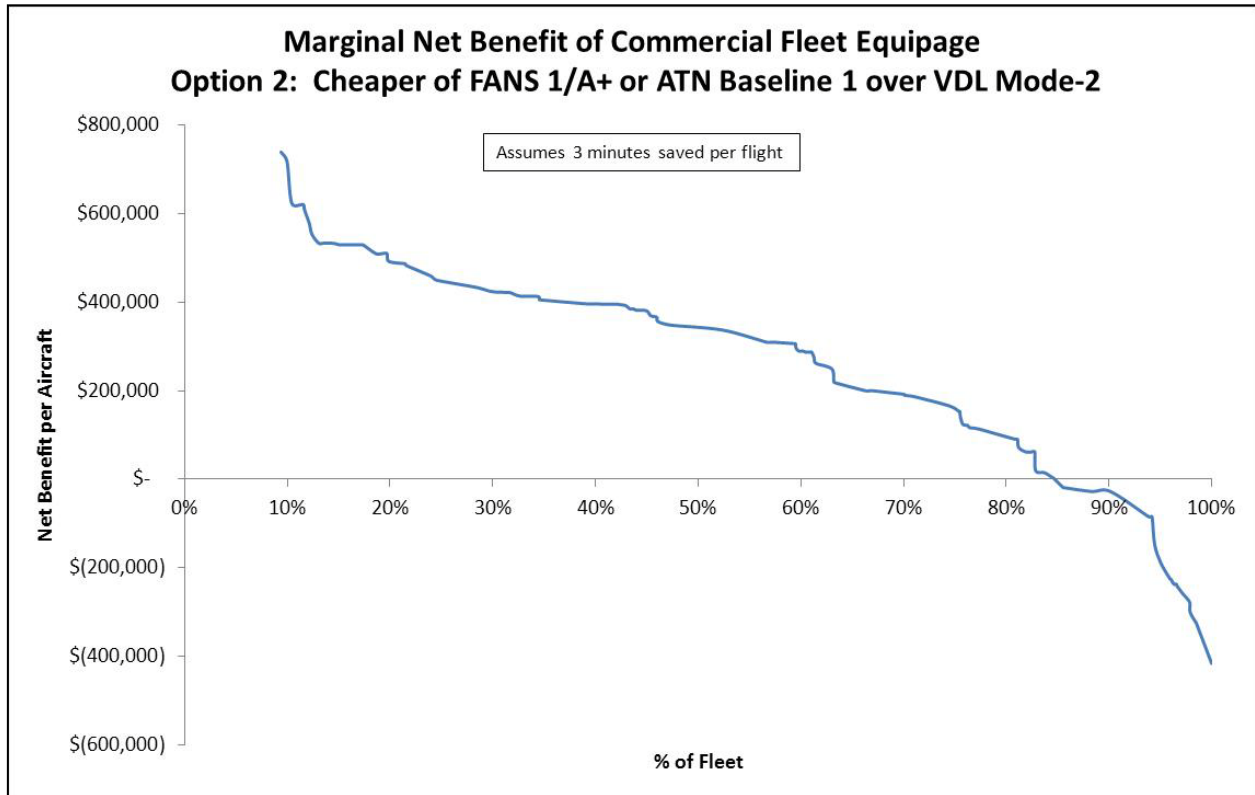
The number of additional aircraft with a positive business case depends upon three factors:

- How costly they are to retrofit;
- How many minutes per flight assumed to be saved by equipping; and,
- How much a minute of time is worth in variable direct operating costs?

In other words, the higher the time savings associated with initial ATC data link, the greater the share of the fleet that might be expected to equip. However, the first to equip may not necessarily be the least expensive; aircraft with a relatively high cost-per-minute to operate or a large number of flights per day will get a higher benefit from equipping.

The following chart illustrates this. It shows the marginal net benefit for each additional aircraft that equips, using our baseline assumptions of 3 minutes saved per flight, \$3.00 per gallon fuel cost, a 2.5

year payback period, and immediate accrual of benefits. The share of aircraft equipped is ordered from highest to lowest payback; thus, the first aircraft to equip are assumed to be those with high net benefit.



As the chart above shows, if an average of 3 minutes per flight could be saved by equipping with the cheaper of FANS 1/A+ or ATN Baseline 1 for initial ATC data link communications, then 84% of the expected 2020 fleet would have a positive business case.

The percentage of aircraft with a positive business case is also very sensitive to the expected savings achieved per flight. The table below shows the amount of time savings that would be required to close the business case for a given share of the fleet.

<b>% of Fleet That Closes vs Minutes Saved</b>	
Initial ATC Data Link Communications Option 2: Cheaper of FANS 1/A+ or ATN Baseline 1 over VDL Mode-2	
<b>Minutes Saved</b>	<b>% Fleet</b>
0	8.2%
0.5	60.0%
1	61.0%
2	74.7%
3	84.6%
4	94.2%
5	94.2%
10	98.2%
15	99.4%
20	99.4%
25	99.4%
30	100.0%

**Key Sensitivities**

Sensitivity analyses were performed for three of our major assumptions: lag time between equipping and achieving benefits, minutes saved in flight, and fuel price. The results are most sensitive to the lag between equipage and realization of benefits. The next most significant impact driver is minutes saved in flight. Fuel price per gallon was the least sensitive of the three.

The sensitivity tables are shown below for both the low and high ends of the cost range estimates. Each table calculates the percentage of the non-equipped commercial fleet for which the business case closes with a 2.5 year payback or less assuming all flights drive benefit, zero benefit lag, three minutes saved in flight, and \$3.00 fuel per gallon, unless that assumption is the variable in the sensitivity table.



<b>SENSITIVITY</b>				
<b>% of Commercial Fleet Closing the Business Case</b>				
<b>Benefit Lag (yrs)</b>				
<b>0.0</b>	<b>0.5</b>	<b>1.0</b>	<b>1.5</b>	<b>2.0</b>
85%	77%	64%	61%	60%
<b>Minutes Saved</b>				
<b>1.0</b>	<b>1.5</b>	<b>2.0</b>	<b>2.5</b>	<b>3.0</b>
61%	62%	75%	81%	85%
<b>Fuel Price</b>				
<b>\$2.00</b>	<b>\$2.50</b>	<b>\$3.00</b>	<b>\$3.50</b>	<b>\$4.00</b>
75%	81%	85%	90%	90%

## References

ID	Reference
NAC	RTCA NAC, <a href="#">Who (Which User Groups) Should be Incentivized to Equip for NextGen</a> , Agenda Item 8, May 2011.
TF5	RTCA Task Force 5, <a href="#">NextGen Mid-Term Implementation Task Force Report</a> , September 2009.
SIR	FAA, <a href="#">Data Communications Integrated Services (DCIS) Acquisition, Section J-2 Avionics Equipage</a> , July 2011.
DLS IR	European Commission, <a href="#">Data Link Services Implementing Rule</a> , January 2009.
Boeing	Boeing, <a href="#">ATN Data Link and Datalink Recording Mandates</a> , Datalink Users Forum, July 2010.
Airbus	Airbus, <a href="#">SESAR: Airbus Readiness and Preparation</a> , AEEC Systems Architecture and Integration Subcommittee, January 2011.
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ARINC 758	Airlines Electronic Engineering Committee (AEEC), <a href="#">758-3 Communications Management Unit (CMU) Mark 2</a> , November 2010.
ARINC 750	AEEC, <a href="#">750-4 VHF Data Radio</a> , August 2004.
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DO-290/2	RTCA, <a href="#">Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard)</a> , June 2007.
DO-280B	RTCA, <a href="#">Interoperability Requirements for ATN Baseline 1 (INTEROP ATN B1)</a> , June, 2007.
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DO-258A	RTCA, <a href="#">Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications</a> , April 2005.
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FAA / TAF	FAA, <a href="#">Terminal Area Forecast, 2010-2030</a> , February 2011.
Shingledecker	Shingledecker, <a href="#">Projecting the Effect of CPDLC on NAS Capacity</a> , September 2005.
MITRE / Giles	MITRE (Giles), <a href="#">Portfolio Analysis Methodology, Data Sets, and Proof of Concept for Segment Bravo</a> , MTR100377, September 2010.
Delta	Delta Airline (Connell), <a href="#">DL_FuelCrewCosts_12MEApr2011.xls</a> , May 2011.

## Introduction

This appendix contains three sections:

1. Variability of Time and Cost for NextGen Aircraft Equipage Installation
2. Part 121 NextGen Aircraft Equipage and Upgrade Path Cost Estimates
3. Part 91 NextGen Aircraft Equipage and Upgrade Path Cost Estimates

## Variability of Time and Cost for NextGen Aircraft Equipage Installation

*Source: Ken Elliott (JetCraft Avionics LLC)*

Aircraft equipage for NextGen technologies requires careful consideration in terms of indirect and hidden impact elements in terms of time and cost. With respect to fleet wide requirements those considerations are even more significant.

After reviewing a number of indirect impact elements it became clear that there are **equipment** elements that affect both time and cost providing up to an approximate 5% variation to currently assumed estimates specifically for equipment acquisition. Also it was concluded that a number of aircraft elements of time and cost impact could be applied to **all aircraft** re installation and operation of equipage providing up to an approximate 10% impact to currently assumed estimates. Finally it was concluded that a number of **aftermarket only** aircraft elements of time and cost impact could be applied to all aircraft re installation and operation of equipage providing up to an approximate 15% time and 20% cost impact to currently assumed estimates.

Category	Area of impact	Estimated Impact up to %
Equipment	Time and Cost	5
All aircraft	Time and Cost	10
Aftermarket aircraft	Time	15
Aftermarket aircraft	Cost	20

Focusing on the primary impact elements for **equipment** the certification path via TSO or PMA can play a major part. Software level requirements are also critical in terms of impact with one unknown being the effect of DO 178C assurance criteria that will be new to the industry. Existing TSO or PMA equipment is a given in terms of impact but new or changes of existing hardware + software upgrades can present many unexpected certification hurdles.

A primary **time** element for **all aircraft** is the fleet cycle time because any single delay may have a ripple and even exponential time impact to a flight operation or airline.

One of the critical **time and cost** impact elements for **all aircraft** are FAA TC / STC issue papers and special conditions. These are unknown today although may be speculated, but their ability to delay projects is significant. Another time and cost element is FAA AVS time spans for STC programs still an issue despite ODAR facilities. Initial flight test programs may be extensive with ergonomic concerns

often arising at that later stage. More time and cost elements that may be applied to all aircraft are, indirect impact of aircraft out of service, continued airworthiness requirements, special subscription + user fees, technical manuals, spares, test equipment and any special tooling or support equipment. Finally initial crew and recurrent training is an unknown and hidden cost.

Specifically applying to **aftermarket aircraft** where it is already apparent that implementation costs would be typically higher than new build, there are many **time and cost** impact elements. Aside from the elements that apply to all aircraft and already listed, decisions need to be made around in-house or out sourcing of MRO activity. Upgrades may be STC, OEM bulletins-mods and in increasingly rarer cases, the lesser impact field-approval process.

High on the list of significant impact is anything related to interior R+R. Adding an antenna for example can mean full removal of one-piece headliners and much more in addition to routing coaxial cables. Damage tolerant areas on many large areas present additional work load analysis along with bird strike, structural integrity, bulkhead penetration, HIRF and anti-icing to name a few.

There are 5 NG implementation operational improvement groups, three of which are being evaluated by the BCPMWG with time and cost elements impacting all in varying degrees. As an example an additional antenna may not be required for PBN solutions but could be required for ADS-B or Datacom. A new build aircraft solution may not be concerned either way regarding the impact of an additional antenna while an aftermarket upgrade would be very concerned about this time and cost element.

To lessen the % impact of time and cost elements covered in this document a couple of primary baseline considerations could be considered.

Firstly no single equipage requirement or incentive program should be in place as a mandate or recommendation until the NAS OI [or set of OI's] is both in place and a certain minimum % of airport, runway or airspace implementations are complete. For example now that WAAS LPV is in 2520 runway ends [June 2011] both the technology requirement and the enabled operations are at a mature stage providing confidence to operators to invest and equip.

Secondly once the airport, runway or airspace is enabled and technology fully defined early adapters should be incentivized first or to a higher degree than later adopters. This will minimize bunching of upgrades centered on the last two years of any mandate or recommendation expiry date. RVSM, TCAS and TAWS presented major time and cost negative impacts due to date bunching causing overcapacity, manpower starvation and other hidden time + cost elements to each program.

In summary while BCPMWG cost [and in some cases time] estimates are provided as recommendations through the NACSC to the NAC, this appendix suggests it may be prudent to provide a conservative cushion of % margin to those recommendations to offset indirect or hidden time and cost elements to NG technology programs. The data provided is by no means exclusive and percentages provided are estimations only.

## Part 121 Equipage Cost Estimates

*Source: Forrest Colliver, Sean McCourt, Sam Miller, Quang Nguyen, Jim Nickum, Don Nicolson, and Todd Stock (The MITRE Corporation)*

MITRE Corporation, at the request of the FAA \_\_\_\_\_Office, collaborated with airlines, avionics and airframe manufacturers to create a database of current Part 121 fleet equipage, upgrade paths available to meet possible future equipage requirements, and detailed cost estimates of implementing those upgrade paths.

Note that the cost estimates did not assume potential economies of scale that (a) larger operators may achieve via volume discounts or (b) bundling of multiple equipage packages into one buy and/or installation event.

The image shows the cover of a report. At the top left is the CAASD logo, which consists of a yellow triangle with a blue mountain-like shape inside. Below the logo is the text 'CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)'. The main title is 'Avionics Equipage Assessment for US Part 121 Fleet' in large blue font. Below that is 'Data Comm & Performance Based Navigation' in a slightly smaller blue font. Underneath is '15 August 2011 Update (Rev B)'. The authors' names are listed at the bottom: 'Forrest Colliver, Sean McCourt, Sam Miller, Quang Nguyen, Jim Nickum, Don Nicolson, Todd Stock'. At the very bottom, there is a small line of text: 'Approved for Public Release: 10-9999. Distribution Unlimited'. In the bottom right corner, there is the MITRE logo and the text '© 2011 The MITRE Corporation. All rights reserved.'



## MITRE's Avionics Equipage Analysis

- **Intent: Support for FAA NextGen decision-making**
  - Provides single source for avionics/fleet data
  - Supports capabilities assessment; cost/benefit analyses
  - Identifies equipage gaps and potential for incentivization
- **Analysis Products:**
  - Fleet Capabilities → NextGen Transitions → Upgrade Costs
- **Value-Added: Intelligent fusion of multiple data sources**
  - Sources: Manufacturers, Aircraft Operators, Airframers
  - Equipage information collected by operational capability
  - Covers active fleet with qualifying data
- **NextGen capabilities under analysis**
  - DataComm, ADS-B, RNAV/RNP

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**Avionics Evolution**  
**Data Communications**

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## Data Communications Assumptions & Analytical Context

- **DataComm Implementation**
  - May be implemented in one of the following architectures:
    - an FMS or ATSU-hosted architecture (FANS 1/A+)
    - a CMU or ATSU-hosted architecture (ATN Baseline 1)
  - Choice will depend on aircraft upgrade potential, ground-based service offering, and/or need for direct-loading of route clearances into the FMS
  - VHF service requirement assumed to be VDL Mode 2
- **Assumed Ground-based Service Offering Options:**
  - FANS 1/A+ only, or,
  - Dual-stacked FANS 1/A+ and ATN Baseline 1

### **NOTE**

*Transition and costing information are works in progress, and are updated as new information is obtained from manufacturers and operators.*

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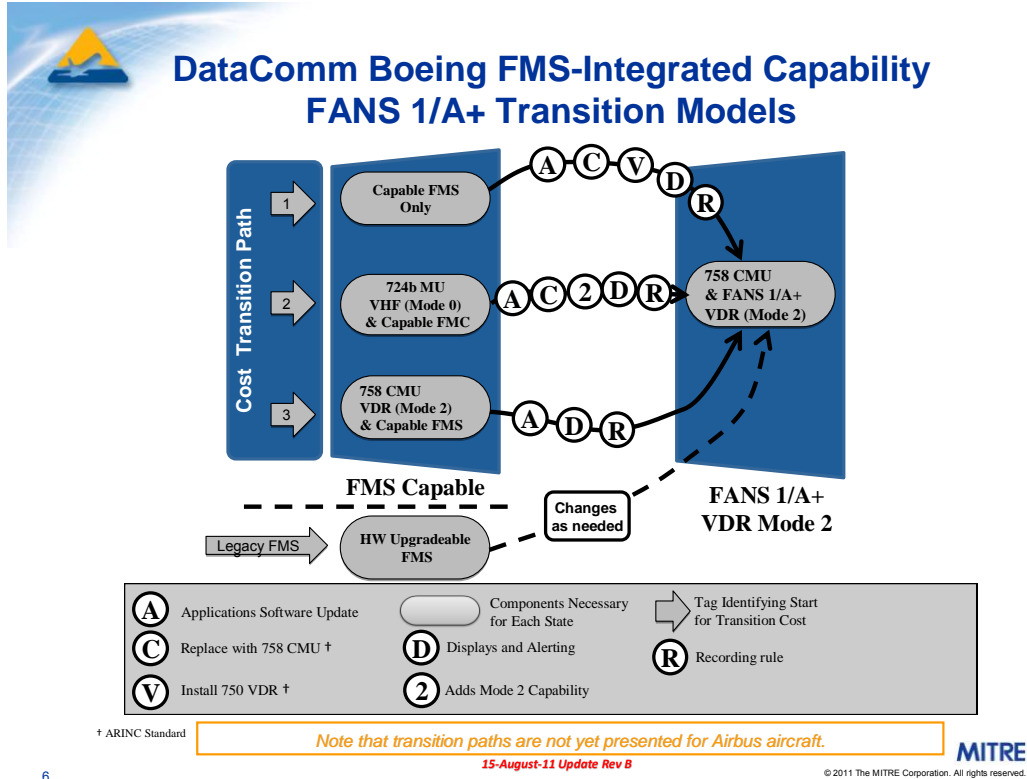
## Data Communications Fleet Capabilities

- **Current Fleet Aircraft Capabilities:**
  - US fleet oceanic-route Airbus/Boeing aircraft have generally been delivered with FANS 1/A+ enabled.
  - US domestic route Airbus/Boeing aircraft have generally been delivered without FANS, and are capable of upgrade to either FANS 1/A+ or ATN Baseline 1, subject to age and equipage.
  - Regionals (<100 seats) & Turboprops are generally only capable of CMU-hosted ATN Baseline 1, due to architectural and offered-solution limitations.
- **New Production Aircraft Capabilities**
  - Airbus/Boeing
    - Depending on aircraft type, FANS 1/A+ or ATN Baseline 1 are stated to be offered either as standard fit or as a paid option
  - Bombardier/Embraer
    - For the Bombardier C-Series, FANS 1/A+ is stated to be offered as a paid option
    - For Bombardier/Embraer regional aircraft, there are no stated FANS offerings for these aircraft, but both manufacturers state Link 2000+ ATN Baseline 1 offerings

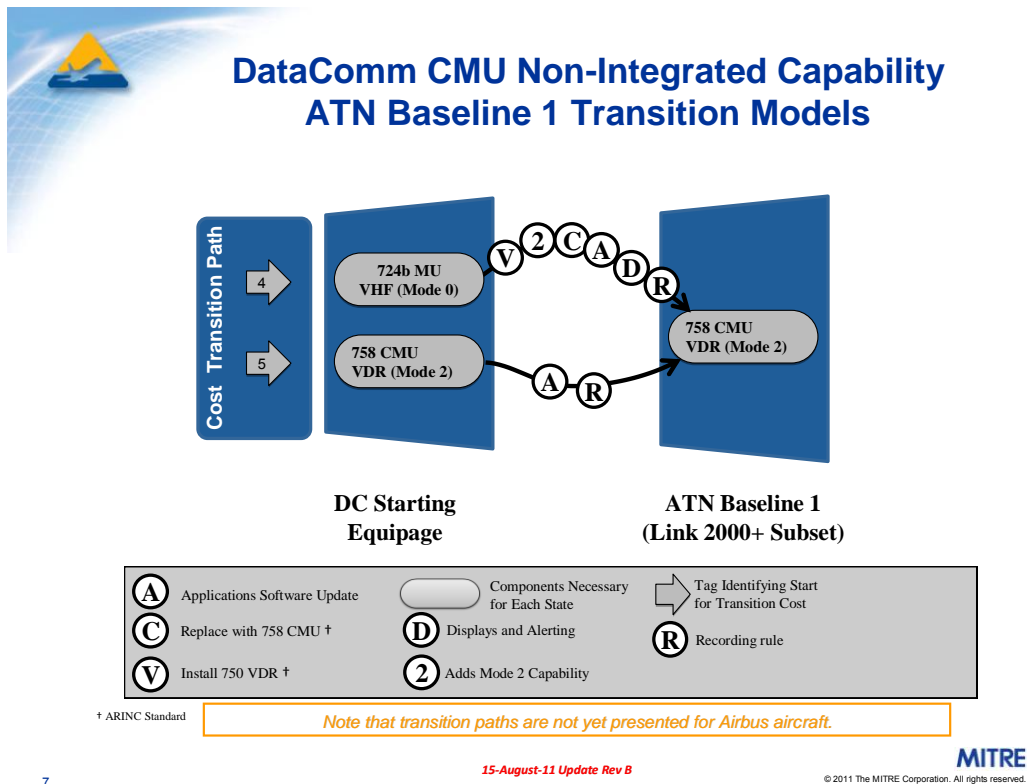
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## DataComm FANS 1/A+ & ATN Baseline 1 Options Aircraft Counts

	FANS Transitions				ATN Transitions				Unknown Aircraft	Total Fleet
	- \$425k	- \$71k	- \$372k	- \$0k	- \$300k	- \$37k				
	FANS-Capable FMS* (\$43K SW + \$5K HW SB)		FANS-Enabled FMS**		FMS HW Upgradeable*** (\$75K HW and SW SB)		Unlikely to Upgrade to FANS**** (Candidate for CMU Data Link Solution)			
Transition Cost Path	1	3	2	N/A	Candidate for CMU-Based Solution		4	5		
FANS Upgrade Costs (Boeing/Airbus)	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled		
Narrow Body	1456	961			550	106	111		197	3381
Wide Body			550	122	133	110		161	1076	
Regional Jet (< 100 seats)							748	763	248	1759
Turboprop							27		410	437
<b>Total</b>	<b>1456</b>	<b>961</b>	<b>550</b>	<b>122</b>	<b>683</b>	<b>216</b>	<b>886</b>	<b>763</b>	<b>1016</b>	<b>6653</b>
% of Active 121 Fleet	22%	14%	8%	2%	10%	3%	13%	11%	15%	100%

	FANS-Capable FMS* (\$43K SW + \$5K HW SB)		FANS-Enabled FMS**		FMS HW Upgradeable*** (\$75K HW and SW SB)		Unlikely to Upgrade to FANS**** (Candidate for CMU Data Link Solution)		Unknown Aircraft	Total Fleet
Transition Cost Path	1	3	2	N/A	Candidate for CMU-Based Solution		4	5		
FANS Upgrade Costs (Boeing/Airbus)	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled		
Narrow Body	350	425							44	819
Wide Body			91	35		6		8	140	
Regional Jet (< 100 seats)							370	490	168	1028
Turboprop							3		56	59
<b>Total</b>	<b>350</b>	<b>425</b>	<b>91</b>	<b>35</b>	<b>0</b>	<b>6</b>	<b>373</b>	<b>490</b>	<b>276</b>	<b>2046</b>
% of Active 121 Fleet	5%	6%	1%	1%	0%	0%	6%	7%	4%	31%

Source: "121\_MOAS\_20110607\_R8.5.xlsx"  
 \*Narrow Body aircraft capable FMS FMS (i.e., Pegasus, GE U10.5+, FMS2, VIA2000), but requires enabling via software and service bulletin upgrades.  
 \*\*Wide Body aircraft with FANS 1/A or 1/A+ enabled FMS (i.e., Pegasus, GE U10.5+, AIMSJ/2, P10, FANS1, VIA2000).  
 \*\*\*Aircraft with available hardware upgrade option for FMS to FANS capability (e.g., GE U5.0, Legacy 200K/700K, HT9100).  
 \*\*\*\*Aircraft that are highly unlikely to upgrade to FANS due to cost of FMS replacement (e.g., CMA-900, FMS-4200, EPIC, Universal). Suitable candidates for CMU data link solution.

Note that costing data is not yet presented for Airbus aircraft.

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## DataComm FANS 1/A+ & ATN Baseline 1 Options Cost Breakdown

Transition Legend	Current Fleet Upgrade Costs							New Production Aircraft	Unlikely to Upgrade to FANS**** (Candidate for CMU Data Link Solution)			Post-Install New Production Aircraft
	FANS-Capable FMS (SW SB + HW SB)		FANS-Enabled FMS		FMS HW Upgradeable (New HW + SW SB)				Candidate for CMU-Based Solution			
Transition Legend	1	3	2	N/A	Candidate for CMU-Based Solution			Candidate for CMU-Based Solution		4	5	
FANS Upgrade Costs (Federated Architectures)	ACARS MU VDL/0	CMU VDL/2 Enabled	ACARS MU VDL/0	CMU VDL/2 Enabled	ACARS MU VDL/0	CMU VDL/2 Enabled	CMU VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	CMU/ATSU/VDR VDL/2 Enabled	CMU/ATSU/VDR VDL/2 Enabled	
A	ATN Baseline 1 SW SB Option											
A	FMS/ATSU FANS SW Option	\$43,000	\$43,000									
A	FANS 1/A+ FMS Software Upgrade					\$2,000	\$2,000					
Z	VDR 631-5 Upgrade											
Z	CMU 631-5 Upgrade											
Z	CMU VDL/2 SB											
R	Data Recording SW Upgrade		\$4,000				\$4,000					
R	FMS HW Upgrade (includes FANS SB)					\$75,000	\$75,000					
A	FMS Installation Kit (ATC Button)	\$5,000	\$5,000			\$5,000	\$5,000					
R	Data Recording Kit	\$6,800	\$6,800	\$6,800		\$6,800	\$6,800					
	INSTALLATION	\$11,800	\$11,800	\$6,800	\$0	\$86,800	\$86,800		\$11,800	\$10,800		
	FMS / Data Recording Subtotal	\$66,600	\$70,600	\$13,600	\$0	\$175,600	\$179,600		\$38,600	\$36,600		\$15,000
C	CMU	\$46,000		\$46,000		\$46,000						
V	VDR	\$49,000		\$49,000		\$49,000						
D	MCDA	\$84,000		\$84,000		\$84,000						
D	INSTALLATION	\$179,000		\$179,000	\$0	\$179,000			\$121,000			
	<b>Estimated Market Price</b>	<b>\$424,600</b>	<b>\$70,600</b>	<b>\$371,600</b>	<b>\$0</b>	<b>\$533,600</b>	<b>\$179,600</b>		<b>\$300,600</b>	<b>\$36,600</b>		<b>\$15,000</b>

SOURCE DATA NOTES: 1. "DC CL to CL Transition costs evaluator v4.3.xlsx", dated 29 June 2011  
 2. FANS SW SB cost based on Boeing Service Bulletin pricing  
 3. FMS HW upgrade costs are representative and may be substantially higher

SOURCE DATA NOTES: "DC CL to CL Transition costs evaluator v4.9.xlsx", dated 9 July 2011

Cost estimates in these tables have been derived from operator, air frame manufacturer and avionics vendor surveys, and are representative market-adjusted ranges of prices typically paid by Part 121 owners and/or operators. Specific costs will of course vary by aircraft type, age and condition.

Note that costing data is not yet presented for Airbus aircraft.

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## DataComm FANS 1/A+ & ATN Baseline 1 Options Aircraft Counts: Current Fleet

Current Fleet

Transition Cost Path	FANS Transitions				ATN Transitions				Unknown Aircraft	Total Fleet
	FANS-Capable FMS* (\$43K SW + \$5K HW \$B)		FANS-Enabled FMS**		FMS HW Upgradeable*** (\$75K HW and SW \$B)		Unlikely to Upgrade to FANS**** (Candidate for CMU Data Link Solution)			
	1 →	3 →	2 →	N/A	Candidate for CMU-Based Solution		4 →	5 →		
FANS Upgrade Costs (Boeing/Airbus)	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled		
A310/300 Wide Body			53		24	94			1	172
A320 Single Aisle	637	35			32				44	748
A330/350 Long Range			48						5	53
A380										0
ATR									68	68
B737	449	767			40				41	1297
B757/767/747	370	71	276	39	83	122			89	1050
B787/747-800										0
B777			135	19					2	156
MDx, B717		88	38	64	472		9		63	734
C-Series										0
CRJ-1000										0
CRJ-700/900							75	267	52	394
CRJ-200							218	188	170	576
DASH-8-400							3		76	79
DASH-8-100/200/300									76	76
ERJ170/190							133	111		244
ERJ135/145							322	197	26	545
EMB120									57	57
M-Jet										0
Legacy					32		126		246	404
<b>Total</b>	<b>1456</b>	<b>961</b>	<b>550</b>	<b>122</b>	<b>683</b>	<b>216</b>	<b>886</b>	<b>763</b>	<b>1016</b>	<b>6653</b>
% of Active 121 Fleet	22%	14%	8%	2%	10%	3%	13%	11%	15%	100%

Source: "121\_MOAS\_20110607\_R8.5.xlsx"  
 \*Narrow Body aircraft capable FANS FMS (i.e., Pegasus, GE U10.5+, FMS2, VIA2000), but requires enabling via software and service bulletin upgrades.  
 \*\*Wide Body aircraft with FANS 1/A or 1/A+ enabled FMS (i.e., Pegasus, GE U10.5+, AIMS1/2, PIP, FANS1, VIA2000).  
 \*\*\*Aircraft with available hardware upgrade option for FMS to FANS capability (e.g., GE US.0, Legacy 200K/700K, HT9100).  
 \*\*\*\*Aircraft that are highly unlikely to upgrade to FANS due to cost of FMS replacement (e.g., CMA-900, FMS-4200, EPIC, Universal). Suitable candidates for CMU data link solution.

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## DataComm FANS 1/A+ & ATN Baseline 1 Options Aircraft Counts: Entry into Service 2003+

Fleet with 2003+ EIS

Transition Cost Path	FANS Transitions				ATN Transitions				Unknown Aircraft	Total Fleet
	FANS-Capable FMS* (\$43K SW + \$5K HW \$B)		FANS-Enabled FMS**		FMS HW Upgradeable*** (\$75K HW and SW \$B)		Unlikely to Upgrade to FANS**** (Candidate for CMU Data Link Solution)			
	1 →	3 →	2 →	N/A	Candidate for CMU-Based Solution		4 →	5 →		
FANS Upgrade Costs (Boeing/Airbus)	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled	ACARS MU VDL/0	CMU/ATSU/VDR VDL/2 Enabled		
A310/300 Wide Body			29			6				35
A320 Single Aisle	197	35							39	271
A330/350 Long Range			39						5	44
A380										0
ATR										0
B737	144	373							5	522
B757/767/747	9	7	9	16					3	44
B787/747-800										0
B777			14	19						33
MDx, B717		10							10	10
C-Series										0
CRJ-1000										0
CRJ-700/900							66	236	52	354
CRJ-200							70	65	106	241
DASH-8-400							3		56	59
DASH-8-100/200/300										0
ERJ170/190							131	111		242
ERJ135/145							103	78	10	191
EMB120										0
M-Jet										0
Legacy										0
<b>Total</b>	<b>350</b>	<b>425</b>	<b>91</b>	<b>35</b>	<b>0</b>	<b>6</b>	<b>373</b>	<b>490</b>	<b>276</b>	<b>2046</b>
% of Active 121 Fleet	5%	6%	1%	1%	0%	0%	6%	7%	4%	31%

Source: "121\_MOAS\_20110607\_R8.5.xlsx"  
 \*Narrow Body aircraft capable FANS FMS (i.e., Pegasus, GE U10.5+, FMS2, VIA2000), but requires enabling via software and service bulletin upgrades.  
 \*\*Wide Body aircraft with FANS 1/A or 1/A+ enabled FMS (i.e., Pegasus, GE U10.5+, AIMS1/2, PIP, FANS1, VIA2000).  
 \*\*\*Aircraft with available hardware upgrade option for FMS to FANS capability (e.g., GE US.0, Legacy 200K/700K, HT9100).  
 \*\*\*\*Aircraft that are highly unlikely to upgrade to FANS due to cost of FMS replacement (e.g., CMA-900, FMS-4200, EPIC, Universal). Suitable candidates for CMU data link solution.

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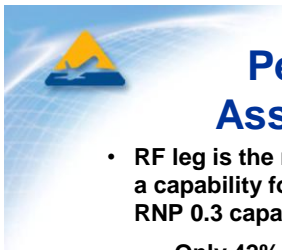
**Avionics Evolution**  
**Performance Based Navigation**

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## **Performance Based Navigation Assumptions & Analytical Context**

- RF leg is the major limitation of the fleet with less than half the fleet having a capability for RF leg where 75% or more of the fleet has RNAV and/or RNP 0.3 capability
  - Only 42% of the Part 121 fleet has an Aircraft Flight Manual (aircraft is capable) statement that the aircraft is RF leg capable, although a part of the remaining fleet has FMS that outputs RF leg.
  - High equipage levels at key metroplexes requires near-full equipage of Part 121 aircraft, including RJs, as well as a significant equipage of high-end GA.
- GPS navigators are least expensive path for unequipped (no FMS) to RNAV1 or RNP 0.3
  - Unequipped is not a large community in Part 121 (186 total)
  - GPS navigators do not have RF leg for terminal or approach, but it is possible in the next few years
- Displays are very costly and upgrades that require addition of displays or changes of existing displays are significant cost drivers for capability

**NOTE:**

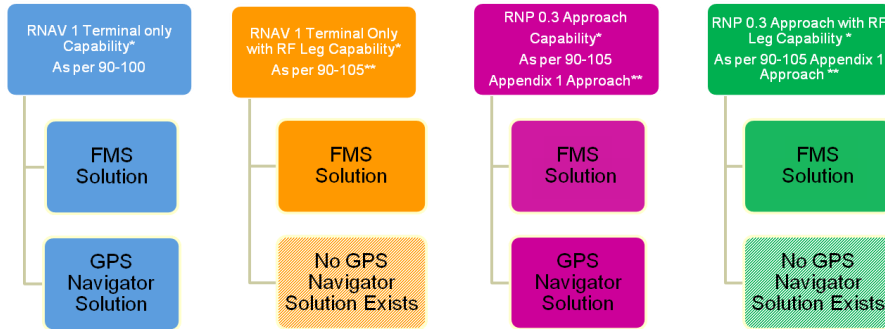
*Transition and costing information are works in progress, and are updated as new information is obtained from manufacturers and operators.*

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## PBN Capability and Transition Overview



Notes:

\*May include systems that have greater capability

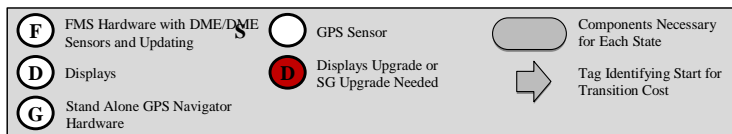
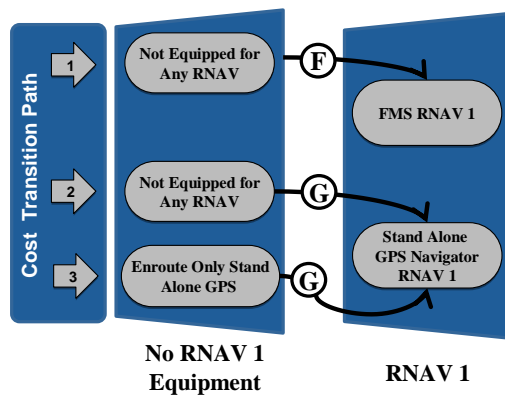
\*\*90-105 allows for RF legs in the terminal, but does not allow for RF legs in the final approach segment

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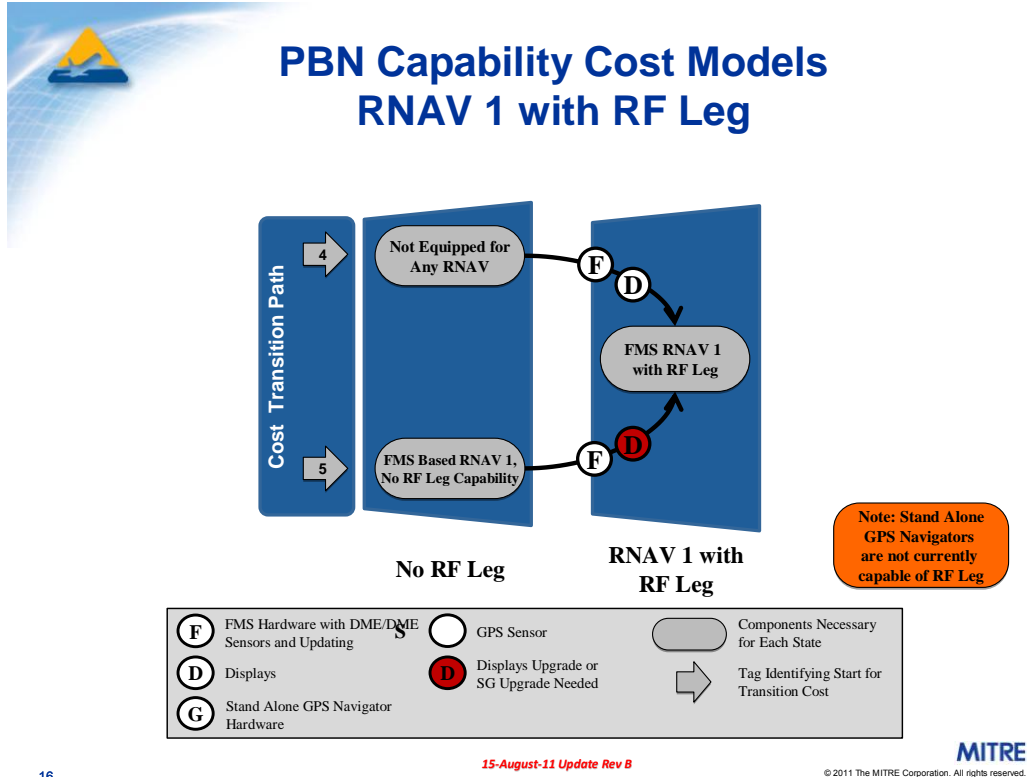
## PBN Capability Cost Models RNAV 1



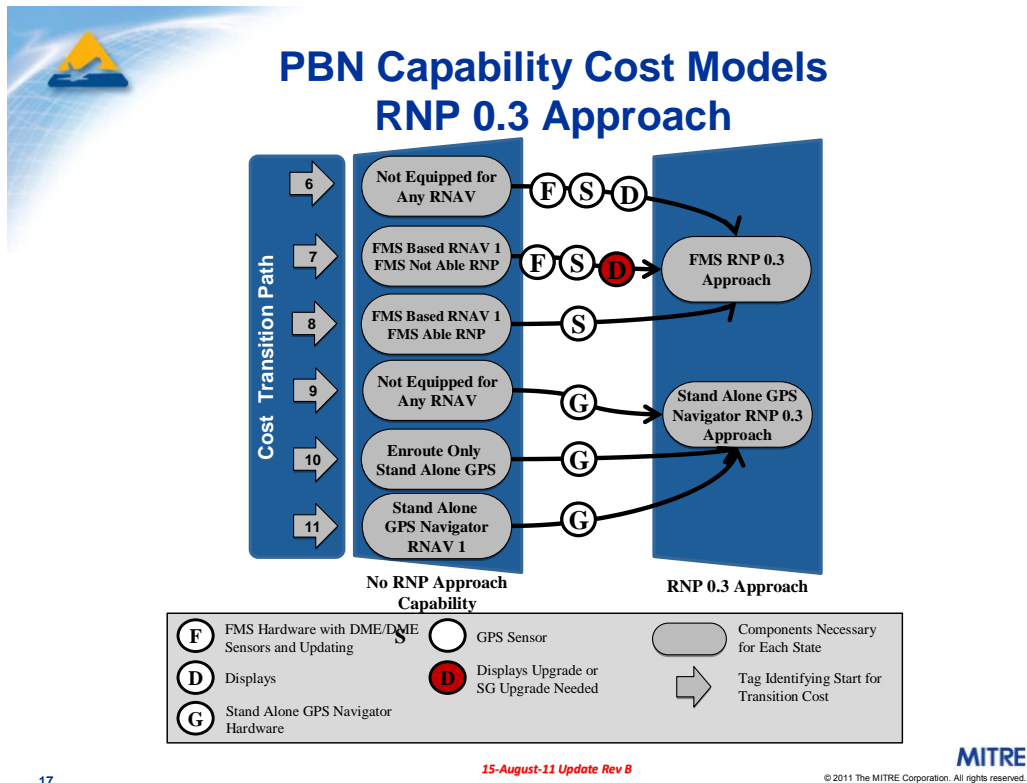
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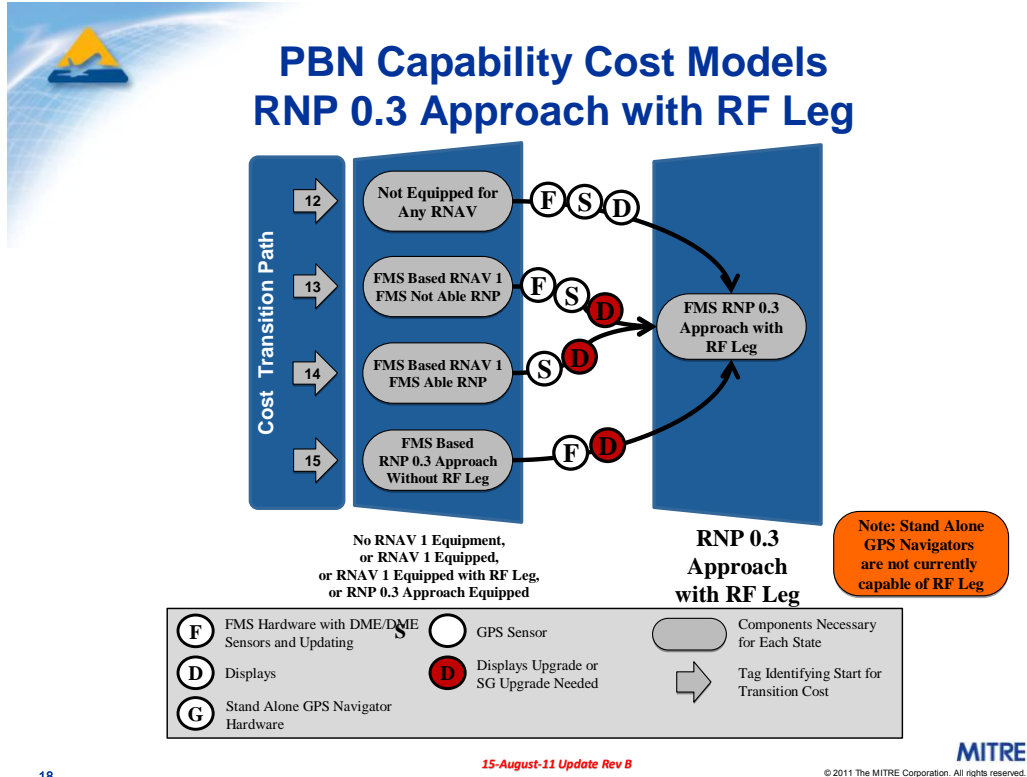
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### Aircraft Breakout (1/2) (by capability and aircraft type)

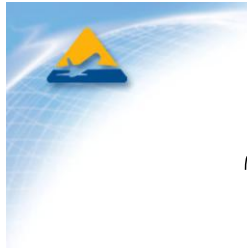
	<i>RNAV 1 FMS Solution</i> \$150K	<i>RNAV 1 GPS Solution</i> \$60K	<i>RNAV 1 GPS Solution</i> \$60K	<i>RNAV 1 with RF Leg FMS Solution</i> \$650K	<i>RNAV 1 with RF Leg FMS Solution</i> From \$150K to \$650K	<i>RNP 0.3 Approach FMS Solution</i> \$750K	<i>RNP 0.3 Approach FMS Solution</i> From \$250K to \$750K	<i>RNP 0.3 Approach FMS Solution</i> \$75K
Transition Cost Path	#1	#2	#3	#4	#5	#6	#7	#8
<b>PBN Capability State Transitions</b>	RNAV 1 capable FMC added to aircraft unequipped for RNAV 1	RNAV 1 capable Stand Alone GPS added to aircraft unequipped for RNAV 1	Enroute capable Stand Alone GPS replaced with RNAV 1 capable GPS	RF Leg capable FMS added to aircraft unequipped for RNAV 1	FMS capable of RNAV 1 but not RF Leg replaced with RF Leg capable FMS	RNP 0.3 Approach capable FMS and Displays added to non-equipped (round dial) aircraft	RNAV 1 capable FMS replaced with RNP 0.3 Approach capable FMS	RNAV 1 and RNP able FMS adds GPS for RNP 0.3 Approach capability
Narrow Body	105	105	11	105	711	105	261	474
Wide Body	2	2	5	2	472	2	98	63
Regional Jet (< 100 seats)					970			12
Turboprop	79	79	71	79	183	79	10	55
<b>Total</b>	<b>186</b>	<b>186</b>	<b>87</b>	<b>186</b>	<b>2336</b>	<b>186</b>	<b>369</b>	<b>604</b>
<b>% of Active 121 Fleet</b>	<b>3%</b>	<b>3%</b>	<b>1%</b>	<b>3%</b>	<b>35%</b>	<b>3%</b>	<b>6%</b>	<b>9%</b>

Source: "121\_MOAS\_20110607\_R8.5.xlsm"

Notes:  
 1. This table represents the percent of the fleet for each transition path that would need an upgrade to have the capability specified (e.g., RNP 0.3)  
 2. Small values in the total percent columns show that the fleet is largely equipped for the capability and few aircraft need to be transitioned

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## Aircraft Breakout (2/2) (by capability and aircraft type)



Transition Cost Path	#9	#10	#11	#12	#13	#14	#15
<b>PBN Capability State Transitions</b>	RNP 0.3 Approach capable GPS added to non-equipped aircraft	RNP 0.3 Approach capable GPS replaces enroute only GPS	RNP 0.3 Approach capable GPS replaces RNAV 1 GPS	RNP 0.3 Approach with RF Leg FMS added to non-equipped (round dial) aircraft	RNP 0.3 Approach with RF Leg FMS replaces RNAV 1 FMS	GPS sensor added to RNP 0.3 Approach and RF Leg capable FMS	RNP 0.3 Approach with RF Leg capable FMS replaces FMS that is capable of approach but does not have RF Leg
Narrow Body	105	11		105	261	474	581
Wide Body	2	5		2	98	63	361
Regional Jet (< 100 seats)						12	1503
Turboprop	79	71		79	10	55	141
<b>Total</b>	<b>186</b>	<b>87</b>	<b>? (&lt; 102)</b>	<b>186</b>	<b>369</b>	<b>604</b>	<b>2586</b>
<b>% of Active 121 Fleet</b>	<b>3%</b>	<b>1%</b>	<b>? (&lt; 2%)</b>	<b>3%</b>	<b>6%</b>	<b>9%</b>	<b>39%</b>

Source: "121\_MOAS\_20110607\_R8.5.xlsm"



## RNAV 1 & RNAV 1 with RF Leg Avionics Cost

Transition Cost Path		Current Fleet Upgrade Costs				
		FMS Solution			Stand Alone GPS Navigator Solution	
		1	4	5	2	3
<b>Transition Legend</b>	<b>RNAV 1 and RNAV 1 with RF leg Upgrade Costs for: WB, NB, RJ, TP</b>	RNAV 1 capable FMC added to aircraft unequipped for RNAV 1	RF Leg capable FMS added to aircraft unequipped for RNAV 1	FMS capable of RNAV 1 but not RF Leg replaced with RF Leg capable FMS	RNAV 1 capable Stand Alone GPS added to aircraft unequipped for RNAV 1	Enroute Capable Stand Alone GPS replaced with RNAV 1 capable GPS
F	FMC Hardware with DME/DME sensors and Updating Stand Alone GPS Navigator Capable of RNAV 1	\$75,000	\$75,000	\$75,000		
G	EFIS Displays needed)		\$250,000		\$30,000	\$30,000
D	Display Upgrade or Replacement Needed but cost unknown			\$?		
	INSTALLATION	\$75,000	\$325,000	\$75,000	\$30,000	\$30,000
	<b>Estimated Market Price</b>	<b>\$150,000</b>	<b>\$650,000</b>	<b>\$150,000</b>	<b>\$60,000</b>	<b>\$60,000</b>

Cost estimates in these tables have been derived from operator, air frame manufacturer and avionics vendor surveys, and are representative market-adjusted ranges of prices typically paid by Part 121 owners and/or operators. Specific costs will of course vary by aircraft type, age and condition.

### RNP 0.3 Approach and RNP 0.3 Approach with RF Leg Avionics Costs

		Current Fleet Upgrade Costs										
		FMS Solution						Stand Alone GPS Navigator Solution				
Transition Cost Path		6	7	8	12	13	14	15	9	10	11	
Transition Legend	RNP 0.3 and RNP 0.3 with RF leg Upgrade Costs for: WB, NB, RJ, TP	RNP approach capable FMS and displays added to non equipped (round dial) aircraft	RNAV 1 capable FMS replaced with RNP 0.3 Approach capable FMS	RNAV 1 and RNP able FMS adds GPS for RNP 0.3 approach capability	RNP 0.3 Approach with RF leg FMS added to non equipped (round dial) aircraft	RNP 0.3 approach with RF leg FMS replaces RNAV 1 FMS	GPS sensor added to RNP 0.3 approach and RF leg capable FMS	RNP 0.3 approach with RF leg capable FMS replaces FMS that is capable of approach but does not have RF leg	RNP 0.3 approach capable GPS added to non equipped aircraft	RNP 0.3 Approach capable GPS replaces enroute only GPS	RNP 0.3 approach capable GPS replaces RNAV 1 GPS	
	F	FMC Hardware with DME/DME sensors and Updating	\$75,000	\$75,000		75,000	\$75,000		\$75,000			
	G	Stand Alone GPS Navigator Capable of RNAV 1								\$30,000	\$30,000	\$30,000
	D	EFIS Displays (needed)	\$250,000			250,000						
	U	Display Upgrade or Replacement Needed but cost unknown		\$ ?			\$ ?	\$ ?	\$ ?			
	S	GPS Sensor	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000				
		INSTALLATION	\$375,000	\$125,000	\$25,000	375,000	\$125,000	\$50,000	\$75,000	\$30,000	\$30,000	\$30,000
		<b>Estimated Market Price</b>	<b>\$750,000</b>	<b>\$250,000</b>	<b>\$75,000</b>	<b>\$750,000</b>	<b>\$250,000</b>	<b>\$100,000</b>	<b>\$150,000</b>	<b>\$60,000</b>	<b>\$60,000</b>	<b>\$60,000</b>

SOURCE DATA NOTES: RNAV 1 DME/DME FMS aircraft do not need efis displays

*Cost estimates in these tables have been derived from operator, air frame manufacturer and avionics vendor surveys, and are representative market-adjusted ranges of prices typically paid by Part 121 owners and/or operators. Specific costs will of course vary by aircraft type, age and condition.*

### NextGen Avionics: The Big Ideas

- **Aircraft avionics evolution is a systems business**
  - Aircraft upgrades are seldom initiated to solve only one problem; operators typically target overall cockpit or avionics upgrade packages
  - Commonality of avionics enablers supports shared business cases between ADS-B, Data Comm, and Performance Based Navigation (PBN)
- **GPS, Display & FMS upgrades will drive NextGen successes**
  - Suitable GPS capability is essential for ADS-B, RNP 0.3 and DataComm
  - Display capability (or the lack of it) impacts ADS-B, DataComm and PBN
  - Newer FMSs and displays will enable cross-domain capabilities
- **Mandates drive vendors to offer forward fit and retrofit solutions**
  - Europe – DataComm ATN Baseline 1 / Link 2000+
  - US/Europe – ADS-B Out
- **Mixed equipage will be the rule, not the exception**
  - The pace of equipage evolution varies by make, model and fleet and is nearly impossible to time synchronize by capability type or by region/metroplex
  - New aircraft production will improve the situation with time, but this improvement will be gradual and will depend on economic growth
  - Air traffic management procedures must be designed to function in airspaces and regions where multiple CNS capabilities will coexist





**Background Information**



**US Part 121 Fleet Snapshot**  
**Current & Forecast Aircraft Quantities**

Production Aircraft	US 121 Fleet 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Airbus Single Aisle*	748	29	19	99	76	111	82	78	50	50	50
B737*	1297	56	68	128	98	111	106	87	57	50	51
A330/350 Long Range*	53	16	23	11	24	19	29	30	28	24	36
B757/767/747*	1050	5	5	10	0	0	0	0	0	0	0
B787/747-800*	0	6	16	11	15	14	21	14	29	14	20
B777*	156	13	14	9	11	10	14	8	7	11	15
C-Series*	0	0	0	0	5	12	12	11	0	0	0
CRJ-700/900*	394	93	25	30	22	13	8	5	1	7	17
DASH-8-400*	79	18	0	0	0	0	0	0	0	0	0
ERJ170/190	244	71	28	39	27	19	16	12	8	8	16
ATR	68	8	0	0	0	0	0	0	0	0	0
M-Jet	0	0	0	0	5	12	12	11	0	0	0

- Excludes legacy aircraft for which no new US deliveries are expected (e.g. ERJ 135/145, A310/300, MDs, B717, etc.)
- Excludes aircraft representing small delivery quantities in the US fleet (e.g. A380, CRJ 1000, etc.)

*This table cannot be used to compute the US Part 121 fleet size as of 2020, since a large number of the current aircraft in the fleet are 15 years of age or older, and will be retired prior to 2020. This retirement effect is particularly significant for the current Boeing and Airbus aircraft population.*

## Part 91 Equipage Cost Estimates

*Source: Chris Benich (Honeywell International), Jens Hennig (General Aviation Manufacturers Association), and Rick Heinrich (Rockwell Collins)*

The U.S. registered high-end General Aviation fleet (defined as turbine powered aircraft capable of flight levels within positive control airspace) is forecasted to consist of 9,273 aircraft by 2020.

Of the 2020 fleet, 1416 aircraft (15% of total) have an upgrade path to FANS1/A+ over VDL2 at a cost of \$154M. These 1416 aircraft fall into 3 upgrade cost bands:

- 786 aircraft could upgrade to FANS-1/A+ over VDL2 at a total cost of \$118M (\$150K per aircraft)
- 315 aircraft could upgrade to FANS-1/A+ over VDL2 at a total cost of \$32M (\$100K per aircraft)
- 327 aircraft could upgrade to FANS-1/A+ over VDL2 at a total cost of \$5M (\$15K per aircraft)

Note regarding ATNB1: High-end general aviation aircraft and avionics manufacturers are planning to offer ATNB1 capabilities for some newer production aircraft types in the future to support EU requirements but are not anticipating sales of these upgrades to U.S. operators due to the lack of a viable business case.

The table below details current high-end General Aviation ATC Data Link Communication equipage baselines and cost (if upgrade path identified) to reach FANS1/A+ over VDL2:

Appendix B BCPMWG Equipage Gap Analysis Cost Inputs

	Platform	US Fleet	No DC - No FANS Option	VDLM0 - No FANS Option	VDLM2 - No FANS Option	VDLM0 - FANS Option	VDLM2 - FANS Option	VDLM0 - FANS Capable	VDLM2 - FANS Capable	FANS & ATNB1 Capable	
	Upgrade Cost (\$000)		N/A	N/A	N/A	\$ 150	\$ 100	\$ 50	\$ 15	N/A	
Large Intercontinental	Airbus A319-CJ	1									
	Boeing 737-BBJ	50									
	G550	141				31	35		75		
	F7X	24					24				
	G450	130				35	45		50		
	G500	6				2	2		2		
	G350	8				2	6				
	Falcon 900DX	8					8				
	F900LX	2					2				
	F2000EX/LX (EPIC)	53				11	42				
	F2000DX/DLX	1					1				
	GEX/XRS	117				117					
	Gulfstream V	140				140					
	F900C	13				13					
	F900EX	70				70					
	G-IVSP/G400	243				243					
	G300	7				7					
	F2000LX	19				19					
	Legacy 600	39	34	5							
	Global 5000	46				46					
	Challenger 604/605	268		241	27						
	Challenger 850	1		1							
	F2000EX (Collins)	16		16							
	F2000	157		157							
	U.S. Reg New Production	650			100	50	150		200	150	
	<b>TOTAL 2020 Fleet</b>	<b>2210</b>	<b>34</b>	<b>420</b>	<b>127</b>	<b>786</b>	<b>315</b>	<b>0</b>	<b>327</b>	<b>150</b>	
<b>Total Cost (\$M)</b>					<b>\$ 118</b>	<b>\$ 32</b>	<b>\$ -</b>	<b>\$ 5</b>			
Medium Continental	Sovereign	185		90	95						
	Hawker 4000/4000TS	53	10	10	33						
	Envoy 3	22	18	4							
	Citation X	237		237							
	Hawker 800XP (HON)	161		161							
	Challenger 300	207	147	20	40						
	F50EX	73		73							
	G200	172	17	155							
	G100	14	9	5							
	G150	67	52	10	5						
	Hawker 800XP (Collins)	160		160							
	Hawker 900XP	101	70		31						
	LJ60	207	104	103							
	U.S. Reg New Production	800	100	200	500						
	<b>TOTAL 2020 Fleet</b>	<b>2,459</b>	<b>527</b>	<b>1,228</b>	<b>704</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	
	Light Regional	Excel/ExcelXLS (Primus)	409	229	180						
		LJ45/45XR	258	232	26						
LJ40		16	10	6							
LJ40XR		67	60	7							
LJ31		19	15	4							
Bravo (550B)		184	166	18							
Encore (560)		136	100	36							
Citation XLS+ (ProLine)		51	31	20							
Hawker 750		21	15		6						
Hawker 400XP/Xpi		157	100	57							
CJ3 /525B		243	234	9							
Encore+		55	30	11	14						
CJ4		49	47	2							
CJ1/CJ1+		173	168	5							
CJ2/CJ2+		234	224	10							
Premier I/A		184	178	6							
Beechjet 400A		259	259								
Citation Mustang 510		179	177	2							
Phenom 300		22	22								
Phenom 100	88	88									
U.S. Reg New Production	1,800	1,620		180							
<b>TOTAL 2020 Fleet</b>	<b>4,604</b>	<b>4,005</b>	<b>399</b>	<b>200</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>		

**Avionics Legend**  
 Epic  
 Fusion  
 Primus classic  
 Proline 4/21



**Approved by the NAC September 29, 2011**

# **Measuring NextGen Performance: Recommendations for Operational Metrics and Next Steps**

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*A Report of the NextGen Advisory Committee in Response to Tasking from  
the Federal Aviation Administration  
September 2011*

## Background

The aviation community needs a commonly understood set of metrics to understand both the implementation status of NextGen programs as well as the operational and financial impacts of NextGen capabilities as they are implemented in order to track the progress of NextGen implementation and to guide future investments. For example, the September 2009 report of the RTCA Mid-Term Implementation Task Force (TF5), recommended that RTCA be utilized as a forum *“to track the progress on implementation milestones, to evaluate and address key risks, and to measure performance improvements in the NAS resulting from implementation of NextGen capabilities”*.

The importance of jointly developed government and industry metrics was also recognized by the GAO, which recommended in its report of July 2010 [GAO-10-629], that *“the Secretary of Transportation direct the FAA Administrator to develop a timeline and action plan to work with industry and federal partner agencies to develop an agreed-upon list of outcome-based performance metrics and goals for NextGen broadly and for specific NextGen portfolios, programs, and capabilities”*.

In October 2010, the FAA requested that RTCA provide recommendations on a collective suite of outcome-based performance metrics to be used to assess and report on the collective progress towards NextGen goals. Since the formation of the Business Case and Performance Metrics Work Group (BCPMWG) in January 2011, the FAA has been working with the aviation community as recommended by GAO. This paper summarizes the recommendations from RTCA to the FAA on the development of metrics to track the operational performance of NextGen capabilities and on the next steps for collaboratively developing additional metrics.

## Scope and Methodology

While NextGen has a broad scope, the BCPMWG focused on defining metrics that will measure the operational impacts of new capabilities included in the FAA’s NextGen Implementation Plan (NGIP). The BCPMWG did not address FAA’s Destination 2025 goals and Key Performance Areas that are not directly related to NextGen capabilities or users’ operations, and has deferred work on metrics regarding implementation progress or those related to the economic impacts of NextGen. The recommendations also do not cover detailed, diagnostic metrics that explore the causes of off-nominal or unexpected behaviors.

**Background Research, Data Gathering, and Collaboration** Initial BCPMPG meetings focused on level-setting the team via briefings from subject matter experts on relevant previous metric research, current and evolving goals for NextGen, and potential evaluation frameworks from other institutions with similar tasking. Sources consulted included the ATA Customer Metrics Working Group, the International Civil Aviation Organization (ICAO) Key Performance Area Framework, Task Force 5, and FAA NGIP and Destination 2025 documents. Another key input to the WG was a set of performance metrics developed by the FAA’s (internal) NextGen Performance Metrics Working Group (NPMWG). The BCPMWG also reviewed European efforts, such as those in the SESAR program, to facilitate its work as well as to initiate dialog on the international harmonization of its recommendations.

The BCPMWG coordinated the proposed metrics with the NAC Subcommittee (NACSC) and the Integrated Capabilities Work Group (ICWG) to ensure that the recommended metrics captured priority concerns of the community. We also collaborated with the ICWG to confirm that these recommended metrics would be able to capture the operational impacts of the priority capabilities recommended for Metroplex implementation. During metric development, the BCPMWG also considered the extent to which metrics represented direct measurements (instead of metrics that could only be modeled), the importance and relevance of each metric to specific user groups, how the metrics align with NextGen goals and key performance areas, and the appropriate level of metric dashboard.

**ICAO Key Performance Area Framework** The recommended operational performance metrics were categorized by using the FAA's NextGen Performance Assessment framework based on the ICAO Key Performance Areas (KPA). This framework provides for:

- Standardized approach for international harmonization
- Comparison of different NextGen capabilities and implementation solutions
- Understanding performance tradeoffs among KPAs
- A means to understand performance from multiple stakeholder perspectives

KPAs are distinct groups of performance aspects that may be of interest in understanding overall Air Traffic Management (ATM) system performance. While distinct, they are not independent and are carefully chosen to support the study of trade-offs in performance that any changes in NAS characteristics or inputs may cause. ICAO's Global Air Traffic Management Operational Concept defines the following 11 KPAs: Access and Equity, Capacity, Cost Effectiveness, Efficiency, Environment, Flexibility, Global Interoperability, Predictability, Participation, Safety, and Security.

A Key Performance Indicator, or KPI, is a metric that facilitates understanding of system performance relevant to a corresponding KPA. *(Note – In this document, the terms “KPI” and “metric” are used interchangeably.)*

## NextGen Goals

The FAA provided to the BCPMWG the following summary of NextGen goals:

- Increase System Safety:
  - With no accidents where NextGen technology or operations are a contributing factor
  - By reducing accident and incident rates by targeting key risk areas, including runway incursions, mid-air collisions, and controlled flight into terrain
- Increase Efficient Performance by:
  - Reducing the means and variances of actual block times between core airports
  - Increasing effective throughput in the NAS, having enough flexibility in the NAS that users can adapt and operate according to their own needs

- Enable Sustainable Growth by:
  - Increasing NAS fuel efficiency by at least 2% per year, reducing net aviation carbon dioxide emissions to 2005 levels by 2020
  - Decreasing aviation noise and emissions health & welfare implications in absolute terms despite growth

Of particular importance to the Flight Operator Community are specific goals that are complementary to the foregoing NextGen goals\*:

- Reduce fuel burn and flight operating costs
- Maintain or improve access to airspace and airports for all stakeholders
- Support mixed capability operations

\*Note: Goals may not be directly measured by a specific KPI. For example, fuel burn and flight operating costs would not be routinely measured but would be calculated from the recommended KPIs.

## Operational Concept for Metrics Use

A major consideration for NextGen metrics is that there is no single metric that can capture all relevant considerations of the aviation community. Instead, a suite of metrics must be evaluated to understand both direct and indirect impacts of any initiative. Further, a given metric may not be able to isolate the impacts of NextGen from other factors affecting performance. For example, delay metrics will be affected by the incidence of severe weather and changes in demand patterns. The accuracy of metrics will also be affected by data availability, timeliness, and robustness. In addition, the measured performance and progress towards goals depicted in a Dashboard is usually reported relative to a commonly understood baseline set of measurements.

**Policy and Performance Tradespace** NextGen metrics are intended to inform policy tradeoff decisions. Each stakeholder (e.g. flight operators, airport operators, government, the business community, and the public) will view the impacts of NextGen from a different perspective and weigh the importance of changes in NAS system performance, flight performance, the environment, safety, or investment requirements differently. Because much of NextGen requires joint investments to achieve many of the envisioned benefits, all stakeholders need a common view of the forecast and measured performance of NextGen initiatives, so that individual stakeholders can determine whether an investment is aligned with their objectives and mission.

NextGen performance metrics are interrelated meaning that a change affecting one performance metric (such as throughput) can impact other metrics. For example, targeted reductions in emissions (affecting environmental performance) may require investments in engine or airframe technologies to be traded off with investments in required avionics for conducting advanced flight procedures that affect flight efficiency or access; investments to improve the capacity of a NAS resource may result in either increased throughput or reduced delays. Another example of this tradespace is related to system performance versus individual flight performance. For NAS resources that have high demand, individual flight operators'

flexibility to fly as desired may be curtailed to achieve improved system throughput and predictability (e.g., through metering or specific route assignments).

**Dashboard Implications** Metrics require a form of communication, and dashboards are the expected way in which NextGen metrics are formatted, summarized, expanded, and categorized to meet the needs of specific audiences and users. While considering the dashboard implications of metrics, the Work Group identified three levels of dashboards that are likely required to meet the information needs of different users:

1. System-Level Dashboard: This Dashboard provides a visualization of aggregate measure of progress towards NextGen goals at the national level – across locations and capabilities and supports the Policy Tradespace.
2. Medium-Level Dashboard: Provides deeper visibility into NextGen performance at the domain (e.g., airspace or airport) or capability level.
3. Diagnostic-Level Dashboard: These dashboards contain metrics that help answer why a system or component behavior observed in other dashboards occurred.

*(Note – Diagnostic level metrics are outside of the scope of the BCPMWG tasking. While this document does not address diagnostic-level metrics, further collaboration between FAA and stakeholders will be needed to define and collect diagnostic-level metrics for specific initiatives and to align these metrics with medium-level and system-level metrics.)*

In addition to the different levels of metrics, stakeholders interacting with a NextGen dashboard will likely need to apply various *filters* to look at metrics from a specific perspective. Filters can include factors such as type of weather (Visual Meteorological Conditions vs. Instrument Meteorological Conditions), specific geographic location, or specific stakeholder class, etc. Filters may be applied to any level dashboard.

## Findings – Operational Performance Metrics

The BCPMWG has developed detailed recommendations for the Capacity, Efficiency, Flexibility, and Predictability Key Performance Areas. Instead of developing independent recommendations for the Safety and Environment KPAs, the BCPMWG recognizes that the FAA has already developed a number of mature metrics for these areas and as a result, believes the FAA should utilize the metrics that have already been developed. For the *Flexibility* and *Access and Equity* KPAs, the BCPMWG has found that there are few mature metrics for these areas and has identified objectives for further development.

The System-Level KPIs recommended include the following:

- NAS-Wide Annual and Peak-Day Throughput
- Efficiency measures and predictability computed from average and standard deviation of aircraft:
  - Operating Time
  - Airborne Time
  - Operating Delay
  - Airborne Delay



- Percent of:
  - Flights not subjected to constraints
  - Flight operator requests granted
  - Airframes capable of using NextGen services
  - NAS where NextGen services are available
  - Non-NextGen capable airframes accommodated

Detailed definitions of these KPIs, as well as the Medium-Level KPIs, are captured in Appendix A. **Finding 1:** The FAA’s NextGen Dashboard will serve a broad range of stakeholders and the public, each of which will be interested in different aspects of NextGen performance. There is a tradeoff, however, between the amount of data collected across the entire NAS and the insights that can be gained from collecting, managing, and processing data at specific locations. Of greatest priority for data collection is to support metrics on all core airports, all airports and airspace within Metroplex areas identified by the Integrated Capabilities Working Group (ICWG), and highly utilized high-altitude airspace. KPIs for Capacity, Efficiency, and Predictability capturing key user concerns are provided in Tables 1 and 2 below.

**Table 1: Capacity KPA**

KPA	System Level KPI NAS-Wide	Medium Level KPIs	
		Airspace	Airport & Metroplex
<b>Capacity</b> <i>Note – These two rows capture actual operations and maximum potential operations</i>	<b>NAS-Wide Throughput (annual and peak day)</b>	<b>Sector Throughput</b>	<b>Airport Throughput</b>
		<b>Sector Occupancy</b>	<b>Metroplex Throughput</b>
	<b>N/A</b>	<b>Maximum Sector Count</b>	<b>Airport Arrival Rates (AAR)</b>

**Table 2: Efficiency and Predictability KPAs**

KPA	System Level KPI NAS-Wide	Medium Level KPIs			
		Taxi	Climb	Cruise	Descent
<b>Efficiency</b>	<b>Operating Time Efficiency</b>	<b>Departure Taxi Time</b>	<b>Aircraft Climb Efficiency</b>	<b>Cruise Efficiency</b>	<b>Aircraft Descent Efficiency</b>
	<b>Airborne Time Efficiency</b>	<b>Arrival Taxi Time</b>	<b>Time Below 10,000 AGL</b> <b>Time Below 18,000 MSL</b>		<b>Time Below 10,000 AGL</b> <b>Time Below 18,000 MSL</b>
	<b>Aircraft Operating Delay</b> <b>Aircraft Airborne Delay</b>	<b>Gate Delay</b> <b>Taxi Out Delay</b> <b>Taxi In Delay</b>			

<b>Predictability</b>	<b>Variability in Aircraft Operating Time</b>	<b>Variability in Aircraft Taxi Time</b>	<b>Variability in Aircraft Climb Efficiency</b>	<b>Variability in Cruise Time</b>	<b>Variability in Aircraft Descent Efficiency</b>
	<b>Variability in Airborne Time</b>				
	<b>Variability of Delay</b>	<b>Variability in Taxi or Gate Delay</b>			

*\*Note: Detailed definitions of the metrics listed above are provided in Appendix A.*

Finding 2: FAA has existing processes for developing and soliciting community input on *Safety* and *Environmental* metrics. For these KPAs, the FAA should continue utilizing the already-mature metrics that have been developed, as well as coordinating with previously established venues for community input as new metrics are developed.

Finding 3: Two of the Key Performance Areas explored by the BCPMWG, *Flexibility* and *Access and Equity*, need additional work to define robust measures. Both of these performance areas are of high interest to all stakeholders; however, it is difficult to identify specific measures that capture the impact of NextGen in these areas in comparison to other KPIs that are and have been measured in the past. The metrics identified under Flexibility and Access and Equity are somewhat aspirational, in that, many have not been measured previously, and data may not be currently available to measure them. Insight into these Key Performance Areas is necessary for a complete assessment of NextGen capabilities.

- **Flexibility Metrics:** Flexibility measures the degree that users are able to respond to changing conditions in the system. It encompasses the level to which users are impeded or unimpeded in achieving their business objectives. (Refer to Table 3.)
- **Access and Equity:** Access measures the ability of users to utilize NAS services based on their performance capabilities and authorization, and equity to receive fair and impartial treatment within the policy and rules established for the system. These performance metrics also need to measure the extent the system can accommodate users of varying levels of capability and airframe characteristics by providing unbiased access according to the agreed upon rules for service. (Refer to Tables 4 & 5.)

**Table 3: Flexibility KPA**

KPA	System Level KPI NAS-Wide	Medium Level KPIs	
		Pre-flight	Airborne
Flexibility	% of flights not subjected to constraints % of flight operator requests granted	% of position swaps over first-come-first-serve approach (CDQM)  % of flight plans accepted as filed <ul style="list-style-type: none"> <li>% of user preferred plans (e.g., business trajectory) granted</li> <li>- future</li> </ul>	% of non-scheduled IFR flights that can depart on-time % of altitude/vertical-change requests accommodated % of route change requests accommodated % of OPDs granted % utilization of SUA

**Table 4: Access & Equity KPA**

KPA	System Level KPI NAS-Wide	Medium Level KPIs
Access & Equity	% of airframes capable of using NextGen services (refer to table 5) % of NAS where NextGen services are available (includes time & geographic component) % of non-NextGen capable airframes accommodated	% of flights utilizing NextGen services

**Table 5: Key Avionics Enablers to Track via the NextGen Dashboard**

Performance-Based Navigation	Automatic Dependent Surveillance	ATC Digital Communications	Flight Safety and Weather	Low-Visibility Operations
RNP 10	ADS-B Out	FANS 1/A	FIS-B	HUD / ILS
RNP 4	CDTI	FANS 1/A+	MDCRS	EFVS
RNAV 1 / 2	Surf-IA	ATN B1	TAMDAR	CVS
RNP/Rf	ITP	FANS 2/ATN B2		
RNP AR	Interval Mgmt			
VNAV	TSAA			
LPV	Parallel			
GLS Cat I	Approach			
GLS Cat II/III				

**Finding 4:** There are limitations in the available data to measure the KPIs identified in this report. For example, while there is a wide range of data available to measure commercial operations, there is less data collected for other operations; e.g., VFR operations or Part 91 instrument operations. As a result, the impacts of NextGen on constituents other than commercial operators cannot be easily measured.

## **Recommendations – Operational Performance Metrics**

### **Recommendation 1 – NextGen Goals:**

FAA should expand the NextGen goals to explicitly include the following elements:

- Reduce fuel burn and flight operating costs
- Maintain or improve access to airspace and airports for all stakeholders
- Support mixed capability operations

### **Recommendation 2 – NextGen Dashboard:**

The FAA's NextGen Dashboard should:

- 2A - Convey measurements of FAA-selected KPIs for Safety and Environment as well as for the listed KPIs for Capacity, Efficiency, Predictability, Flexibility, and Access and Equity (as referenced in Tables 1-4).
- 2B - Provide the ability for stakeholders to select different views at any level of dashboard including the different filters.
- 2C – Collect data from all core airports, all airports and airspace within Metroplex areas, and highly utilized high-altitude airspace.
- 2D - Provide insight on the extent of NextGen implementation by flight operators and on the extent of NextGen implementation by FAA.

### **Recommendation 3 – Additional Work on Metrics:**

The FAA should continue to collaborate with RTCA and the aviation community to:

- 3A - Develop detailed KPIs for Flexibility.
- 3B - Further develop KPIs for Access and Equity to measure the ability to utilize NAS services, capture FAA implementation progress and risk to facilitate joint investment decisions.
- 3C - Determine the venues for developing diagnostic-level metrics and data sources for specific NextGen initiatives.

### **Recommendation 4 – Metrics Collection Resources:**

The FAA should ensure that NextGen programs include resources for collecting, analyzing, and reporting post-implementation impacts.

# *Measuring NextGen Performance:* **Recommendations for Operational Metrics and Next Steps**

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## **1. INTRODUCTION AND BACKGROUND**

### *Group Formation and Scheduling*

The RTCA Business Case and Performance Metrics Working Group of (BCPMWG) of the NextGen Advisory Committee (NAC) was formed in January 2011 to address performance metrics for NextGen. Its membership includes a broad spectrum of the aviation community, including commercial operators, general aviation, military aviation, airport operators, and the Federal Aviation Administration. Since forming, the BCPMWG has conducted full-day in-person meetings at least once per month (with accommodations for remote participation), and weekly- to bi-weekly meetings and telcons of a Task Group.

Since January, the Business Case & Performance Metrics Working Group and Metrics Task Group members have met on 16 occasions for more than 70 hours to research, analyze, debate, and develop our recommended metrics.

**Summary of Terms of Reference** The BCPMWG of the NextGen Advisory Committee (NAC) is tasked to recommend metrics, using the ICAO KPA/KPI framework, for tracking NextGen performance using the following criteria:

- Include associated methodology for generating metrics from available data sources
- Work with aviation stakeholders to identify new data sources to improve NextGen performance tracking
- Provide input on NextGen business case considerations
- Maintain and update the NextGen capabilities Dashboard, with benefits, costs, and risks

### *Purpose*

This work is focused on measuring the impact of NextGen capabilities on operational performance. This includes:

- Financial aspects of NextGen capabilities
- Analysis
- Performance Metrics
- Cost, Benefits, and Risks to operational capability implementation

In addition, the work is focused on evaluations of the business case considerations for NextGen capabilities.

The Work Group will use the internationally-accepted ICAO Key Performance Areas and NextGen goals as a framework for this effort. The Work Group is expected to recommend key performance indicators (metrics) that from industry's perspective will illustrate our collective progress in meeting the goals of NextGen. Availability of data is often a limiting factor for performance measurement; therefore, the Work Group is expected to provide assistance to the FAA in providing required data sources to which the agency does not currently have access. In some cases, such as General Aviation, these data sources will need to be developed.

## Appendix A: Detailed Findings and Recommendations

The Work Group will also build on the wealth of data collected and delivered as a foundation to the Task Force 5 recommendations to ensure that we have a continuing understanding of the costs and benefits of operational capabilities, and will continue to ensure a positive business case for NextGen.

### *Operational Concept for Metrics Use*

Operational metrics being evaluated by the Working Group are meant to determine what operational measures are most important for understanding airborne and system performance impacts post-deployment of new and advanced NextGen capabilities.

## 2. DRIVERS OF NEXTGEN OPERATIONAL PERFORMANCE METRICS

### NextGen Goals

“NextGen is a series of inter-linked programs, systems, and policies that implement advanced technologies and capabilities to dramatically change the way the current aviation system is operated.” [Destination 2025] “The primary goals of NextGen are to enhance the safety and reliability of air transportation, improve efficiency in the National Airspace System (NAS), and enable sustainable aviation growth.” [NGIP, 2011] Without NextGen, the U.S. aviation system will face increasing difficulties to meet our nation’s mobility needs vital to our economic stability, growth, and security.

Some of these goals interact with each other. For example, improving NAS efficiency in part enables sustainable growth by reducing fuel consumption and emissions for each operation. Improving NAS efficiency also leads to other desirable outcomes for the users, such as increased system capacity, reliability, and flexibility.

The FAA’s NextGen Implementation Plan (NGIP) lays out how the agency plans to meet the NextGen goals and desired outcomes by 2018, and describes operational benefits realized today in terms of safety, efficiency, and the environment. Operational capabilities are expected to be in place at every phase of flight. Benefits are expected from integrated flight planning, surface traffic management and enhanced surface traffic operations, streamlined departure and arrival management, and efficient cruise.

Operational performance metrics are needed in order to measure the progress of NextGen implementation towards the desired outcomes and high level goals:

- NextGen will be a better way of doing business. Travel will be more predictable because there will be fewer delays, less time sitting on the ground and holding in the air, with more flexibility to get around weather problems.
- NextGen will reduce aviation’s impact on the environment. Flying will be quieter, cleaner, and more fuel-efficient. We’ll use alternative fuels, new equipment, and operational procedures, lessening our impact on the climate. More precise flight paths help us limit the amount of noise that communities experience.
- NextGen will help us be even more proactive about preventing accidents with advanced safety management to enable us, with other government agencies and aviation partners, to better predict risks and then identify and resolve hazards.
- NextGen boils down to getting the right information to the right person at the right time. It will help controllers and airlines make better decisions. This data will assist airlines in keeping employees and passengers better informed.
- Our nation’s economy depends on aviation. NextGen lays the foundation that will continually improve and accommodate future needs of air travel while strengthening the economy with one seamless global sky.
- NextGen will help communities make better use of their airports. More robust airports can help communities attract new jobs, and help current employers expand their businesses. By doing this the U.S. will strengthen its economy and help communities realize all the benefits that aviation can bring.

- NextGen will allow us to meet our increasing national security needs and ensure that travelers benefit from the highest levels of safety.

### Key Performance Areas (KPA)s

The recommended operational performance metrics were categorized by using the FAA's NextGen Performance Assessment framework based on the ICAO Key Performance Areas (KPA).

Key Performance Areas are distinct groups of performance aspects that may be of interest in understanding overall Air Traffic Management (ATM) system performance. They are distinct but not independent; in fact, they are carefully chosen to support the study of trade-offs in performance that any changes in NAS characteristics or inputs may cause.

The KPAs summarized below are founded on the expectations of the ATM community defined in ICAO's *Global Air Traffic Management Operational Concept*.

**Access and Equity KPA** addresses the requirement of the ATM system to provide all authorized users with access to ATM services in a fair and equitable manner.

**Capacity KPA** addresses the ability of the ATM system to accommodate current and future aviation demand levels.

**Cost Effectiveness KPA** addresses the cost effectiveness of ATM services from the perspective of the ATM service provider; it focuses on the efficiency and productivity of the ATM service provider.

**Efficiency KPA** addresses the operational and economic cost effectiveness of gate-to-gate flight operations from a single flight perspective; it focuses on the extent to which the airspace users are able to execute their preferred trajectories and, thus, achieve their business goals.

**Environment KPA** addresses the requirement to conduct air traffic operations in an environmentally efficient and friendly manner.

**Flexibility KPA** addresses the ability of the system to provide for dynamic flight trajectory adjustments in response to operational restrictions and opportunities as they materialize in real-time; it focuses on available options, operators preferences and whether they are met or not.

**Global Interoperability KPA** addresses the requirement to ensure the technical and operational interoperability of regional ATM systems as they merge into the global ATM system.

**Predictability KPA** addresses the requirement of the ATM system to facilitate airspace users in accomplishing consistent and dependable levels of performance.

**Participation KPA** addresses the need for the continuous involvement of ATM stakeholders in the conduct of operations as well as in the planning and implementation of ATM system enhancements.

**Safety KPA** addresses the prevention and mitigation of air traffic accidents and incidents. Safety remains aviation's highest priority under NextGen; as such, it demands global standardization of ATM safety management processes and practices.



**Security KPA** addresses the prevention and mitigation of intentional and unintentional threats that may negatively impact the ATM system such as terrorism, human errors, natural disasters, etc. This KPA captures all of the details that may be important for assuring that people, aircraft, equipment and information are protected against any security threats, and that security risk management facilitates ATM system stakeholders in executing their mission.

### Key Performance Indicators (KPIs)

A Key Performance Indicator is a metric that facilitates understanding of the air transportation system performance relevant to the corresponding KPA. Ideally, a KPI provides for clear understanding of whether an observed performance outcome is good or not, or whether an observed direction of change in performance outcome is good or not. Sometimes it may not be possible to capture all relevant aspects of performance by observing a single KPI. For instance, changes in airborne delay can be easily misjudged if they are not studied simultaneously with potential changes in demand characteristics and air traffic throughput or capacity. Therefore, KPIs should be not observed in isolation from each other but in groups that provide for a comprehensive case-based performance analysis including all of the relevant and interdependent KPAs.

The System-Level KPIs recommended include the following:

- **NAS-Wide Annual Throughput:** Capturing the total number of IFR operations served NAS-wide annually (scope: between core airports?, or something else)
- **NAS-Wide Peak-Day Throughput:** Capturing the total number of IFR operations served NAS-wide during the peak day (within the same year)
- **Average and Standard Deviation of Aircraft Operating Time Efficiency:** Average and standard deviation of out-to-in times divided by great circle distance
- **Average and Standard Deviation of Aircraft Airborne Time Efficiency:** Average and standard deviation of off-to-on times divided by great circle distance
- **Average and Standard Deviation of Aircraft Operating Delay:** Average and standard deviation of out-to-in actual aircraft times relative to planned aircraft times divided by great circle distance
- **Average and Standard Deviation of Aircraft Airborne Delay:** Average and standard deviation of off-to-on actual aircraft times relative to planned aircraft times divided by great circle distance
- **Percent of flights not subjected to constraints:** The number of flights not subject to any restrictions due to congestion divided by all flights filed
- **Percent of flight operator requests granted:** The number of change requests accepted regarding an active flight (either from the pilot or from the FOC) divided by the total number of change requests

### 3. NEXTGEN DASHBOARDS

The FAA's Air Traffic Organization (ATO) is currently engaged in an effort to develop a FAA-specific dashboard that will assist it in tracking progress towards accomplishing NextGen goals and capabilities. Likewise, RTCA's NextGen Advisory Committee (NAC) desires to develop an aviation industry dashboard derived from the metrics that the Business Case Planning Metrics Working Group (BCPMWG) have defined. The NAC dashboard will be designed by BCPMWG; however, the FAA will build and maintain the dashboard.

This section explains the concept behind a dashboard for RTCA stakeholder use, identifies the various dashboard types, and describes how a dashboard would be used by the NAC.

#### **Objective: Measure Progress toward NextGen Goals**

The objective of the NAC dashboard is to assist the FAA and NAC members in measuring progress towards NextGen goals. The RTCA terms of reference for the Business Case & Performance Metrics Work Group state, "To assess our collective progress toward NextGen goals, FAA and the community need a suite of recommended outcome-based performance metrics." The NAC dashboard is the display for organizing the relevant metrics to focus on measuring the impact of NextGen capabilities on operational performance and allowing the members to quickly and readily interpret these impacts.

#### **Dashboard Types**

Dashboards are the preferred method of monitoring progress toward NextGen goals because they provide a visual and quantitative display of the most important information needed to achieve one or more objectives. There are three levels of dashboards that are of interest in monitoring progress toward NextGen goals:

1. **System-Level Dashboard:** The system level dashboard is an executive level tool to be used for strategic purposes such as deciding whether progress is being made toward achieving NextGen goals. Contemplated for use by the NAC, the system-level dashboard displays information that is not collected in real-time such as weekly, monthly, or quarterly measurements. Trend and forecast information is often displayed across locations and capabilities and is designed to support the Policy Tradespace.
2. **Medium-Level Dashboard:** The medium-level dashboard will display medium level KPIs and will be more analytic in nature, provide deeper visibility into NextGen performance by providing information at the domain (e.g. airspace or airport) or capability level. Individual stakeholders will most likely use the medium level dashboard and will be able to apply filters that will provide insight their interests (e.g. Percent of flights operator requests granted filtered by air carrier airports only). It may be necessary to design separate medium-level dashboards for major stakeholder groups such as General Aviation, Military, Air Carrier, and so forth if their interests are sufficiently divergent.
3. **Diagnostic-Level Dashboard:** Designed to assist in answering the questions of why upper level behaviors are occurring, the diagnostic level dashboard assists in the investigation of causality, the exploration of more complex data and relationships and provides analysts with insight towards areas deserving additional investigation. Although metrics and measurements on the diagnostic dashboard are linked to medium

and high level KPIs, the diagnostic-level dashboard will support additional drill-down capabilities that will help analysts answer why upper level behaviors are occurring,

**Recommendation: System-Level Dashboard**

Given the need for assessing collective progress towards achieving NextGen goals, the sub-committee recommends the creation of a system-level dashboard to support strategic decision-making by the NAC. Since the NAC is comprised of stakeholders from across the aviation community, this strategic dashboard should contain measures that will enable NAC members to monitor the progress towards achieving NextGen goals.

**Limitations of the High Level Dashboard**

This recommendation is only a starting point and a system level dashboard alone is insufficient for measurement, analysis, and diagnosis of NextGen performance metrics for various stakeholder groups. Constituent stakeholders rightly require their own medium level dashboards, tailored to their specific regional or airport-specific interests and needs. Although the scope of these medium level dashboards is outside the current effort, a robust group of stakeholder specific dashboards are essential to providing the aviation community with information about the effectiveness of NextGen performance improvements and should be undertaken as follow-on to the current dashboard effort.

**Measuring Progress towards NextGen Goals**

The system-level dashboard should be organized around the Key Performance Areas (KPAs) and the NextGen goals associated with each. The actual dashboard measurements are the high level Key Performance Indicators (KPIs-1) described and defined in earlier sections for each KPA and Goal area.

The dashboard display of 1<sup>st</sup> level KPIs should provide users appropriate context for the magnitude, trend and targets (if applicable) for that KPI. In addition, the quantitative measure should be displayed, along with a simple indicator such as an up/down icon to alert the user if the measure is out of normal limits. The necessary context should accompany the measure. If recent and long term trends make a difference, the data should be displayed in an easy to absorb fashion. The figure below shows a notional display of gallons of fuel used over the past 5 years, 12 months, and shows the quarterly average and quarterly year over year difference with an icon to indicate increase or decrease.

**Figure 1 - Notional display of fuel burn KPI**



Grouping KPIs into a dashboard display provides the NAC with a portfolio measurement device that will inform broad questions of interest to the NAC. The metrics working group has assigned high level KPIs to each of the KPAs, allowing them to be grouped by goal area. Taken as a set, they inform progress towards accomplishment of NextGen goals.

### **Providing Additional Understanding of NextGen Performance**

The high level dashboard should also allow additional questions related to understanding NextGen performance to be answered by examining metrics across KPAs.

For example, a question NAC members may ask is whether NextGen is improving flight operations? A combination of the high level KPIs should inform the answer:

1. Efficiency - NAS-Wide Operating Time Efficiency, Airborne Time Efficiency
2. Predictability - Variability in Aircraft Operating Time and Airborne Time and Delay
3. Capacity – NAS-Wide Throughput Annually and Peak Day
4. Safety – Accident and safety measures per FAA practice

Looking across the KPAs should give a broad picture of changes in various phases of flight including ground, airborne and surface operations.

Other questions the executive dashboard should be able to answer:

1. How much is NextGen changing access to airports and airspace?
2. Do communities have a better quality of life as a result of NextGen?

## 4. NEXTGEN PERFORMANCE: POLICY TRADE SPACE FOR SOCIETAL INTERESTS

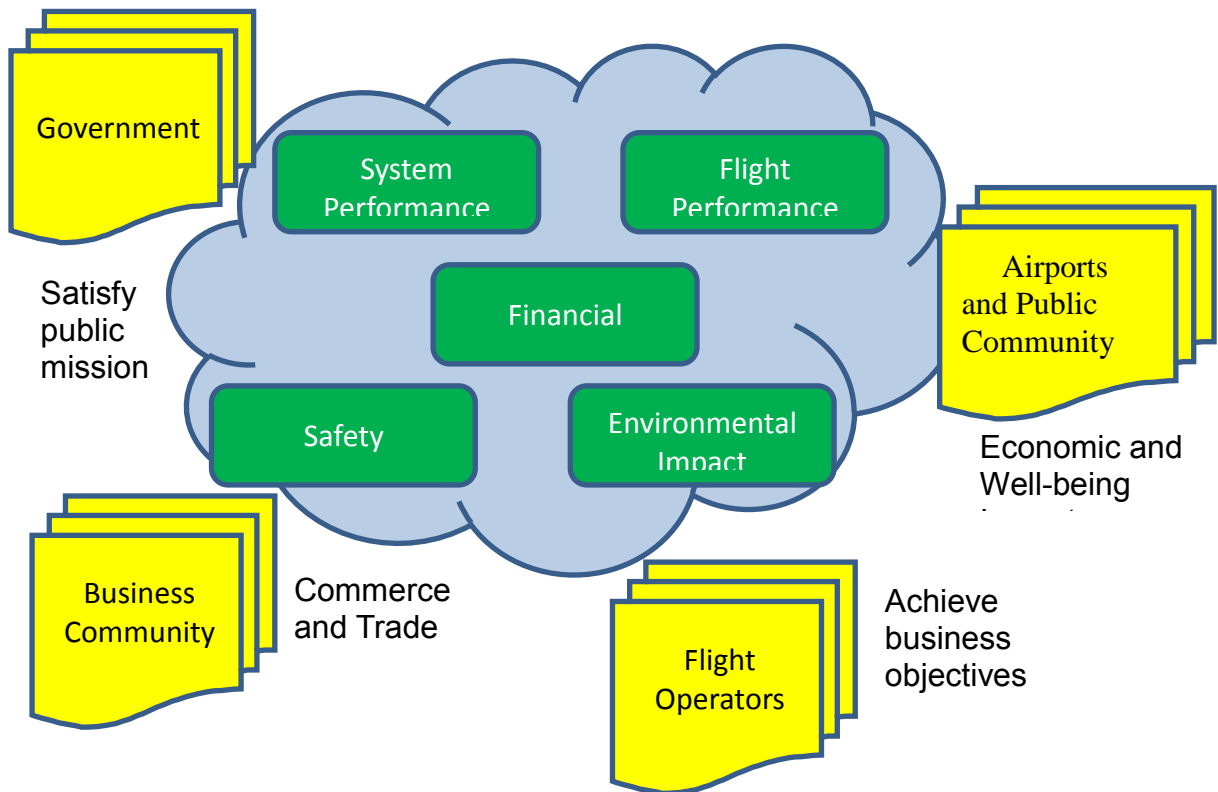
### Policy Tradespace in Evaluating NextGen Performance

NextGen goals will be achieved through enhanced development of processes, procedures, policies and technical capabilities, as well as from decisions stakeholders will make regarding the procurement and fielding of these capabilities.

Achievement of goals will involve stakeholders making individual and collective decisions based upon policy-based tradeoff analyses wherein they will compare the benefits received versus the costs incurred. The Key Performance Area Metrics that have been developed to measure NextGen Operational Performance enable the stakeholders to conduct these analyses. In other words, it will be through comparing and contrasting several of these metrics that holistic decisions will be made.

The following diagram depicts this Policy Tradespace, while the following paragraphs articulate the overarching questions that might guide stakeholder collective engagement in the overarching Policy Tradespace from which NextGen development and fielding decisions will ultimately be made.

Figure 2: Policy Tradespace



### **Flight Operators:**

#### ***Are Investments in NextGen Worth Making?***

Flight Operators will ascertain the flight performance benefits they receive from increased throughput, reduced airborne times and fuel burn, as well as new market access, and contrast these benefits against the costs associated with equipping their aircraft. They will also assess the opportunity costs associated with having potentially less access should they choose not to equip when making their private investment decisions.

### **Airports and Public Community:**

#### ***Does our community have a better quality of life as a result of Next Gen?***

Airports and the Public Communities they serve will collaborate to assess the effect that additional operational capacity and throughput have on enhancing their local economy through increased commerce and trade and contrast these benefits against the affect that additional flight operations have on their local environment and quality of life in terms of air quality and noise levels.

### **Business Community**

#### ***What is the Return On Investment and Financial Benefits of NextGen?***

NextGen lays a foundation that will continually improve and accommodate future needs of air travel while strengthening the economy with one seamless global sky [NGIP, 2011]. The business community will make decisions regarding their participation in the development and funding of NextGen to the extent that improved market access for the distribution of their goods and services provides a sufficient return on their investment.

### **Government**

The FAA is quite cognizant of the tradeoff analyses that stakeholders will conduct, and as such has approached NextGen implementation through extensive collaboration with all aviation community stakeholders, including operators, equipment manufacturers, academia, other federal agencies and the international aviation community [NGIP, 2011].

This engagement will occur at all levels of NextGen deployment so as to answer fundamental questions such as:

- Where Is NextGen improving flight operations across the NAS?
- How much is NextGen changing access to airports and airspace?
- Is NextGen interoperable with corresponding systems throughout the International community?
- Is Public Investment in NextGen worth making?

The FAA has already begun to assess the combination of NextGen System Performance capabilities that will be required to address the challenges of 21 “Metroplexes, the busy metropolitan areas where multiple airports and competing airspace lead to less-than-efficient operations” [NGIP, 2011]. Herein lays the clearest example of the complex policy tradespace analysis that each stakeholder will be making. The holistic gains that will be achieved in each

## Appendix A: Detailed Findings and Recommendations

Metroplex may not come as a result of optimizing the increased throughput of a singular airport within a Metroplex, but rather, be based upon the overall affect that NextGen improvements will have on all airports and airspace throughout the entire Metroplex.

The stakeholders will perform similar tradeoff analyses at all levels, up to and including Domestic and Oceanic Cruise Airspace. Herein, FAA will also collaborate with the Single European Sky Air Traffic Management Research (SESAR) and similar World efforts to ensure global interoperability and enhanced operational performance.

### **Policy Tradespace**

There are a number of significant aspects to the myriad tradeoff analyses that aviation stakeholders will be conducting. Stakeholder communication and collaboration will foster better understanding of the value streams and associated costs as identified by all stakeholders. Stakeholders will use this understanding to develop policies that will guide their engagement with other stakeholders. Finally, it is likely that decisions reached will vary throughout the country based upon the policies formulated by the specific stakeholder community making decisions for their specific region or Metroplex.

Specifically, airport communities in various regions of the country have demonstrated differing policy positions regarding airport and airspace capacity enhancement initiatives since Airline Deregulation which carries on even today. As a result, available capacity enhancements have not been uniformly fielded throughout the NAS.

One example that might serve to illustrate this is to contrast the recent decision of the Chicago Metroplex to make airspace and airfield reconfiguration enhancements at O'Hare Airport to address rising demand for air service, with the New York Metroplex community, facing a similar challenge, which has not elected to field solutions that have thus far been offered to them. It is hoped that new NextGen Technologies will be developed that do satisfy their Policy Tradespace decision criteria.

Therefore, it is envisioned that Policy Tradespace decision criteria will continue to vary by Metroplex region, which will result in potentially dissimilar advancements in NextGen deployment throughout the United States. This is important to recognize so as to ensure reasonable goal setting for NextGen.

## 5. NEXTGEN METRICS HIERARCHY

### 5.1 Common Considerations Across Metrics

In addition to the different levels of metrics, stakeholders interacting with a NextGen dashboard will likely need to apply various *filters* to look at metrics from a specific perspective. Filters can include factors such as type of weather (Visual Meteorological Conditions vs. Instrument Meteorological Conditions), specific geographic location, or specific stakeholder class, etc. Filters may be applied to any level dashboard.

**Table 1: Filters**

Filters for KPIs	
<ul style="list-style-type: none"> <li>• Flight Operator Type                             <ul style="list-style-type: none"> <li>○ Commercial operator (e.g., passenger and cargo operations)</li> <li>○ Business General Aviation</li> <li>○ Military Transport</li> <li>○ Piston and other GA</li> </ul> </li> <li>• Meteorological Conditions                             <ul style="list-style-type: none"> <li>○ VMC/MVMC/IMC</li> <li>○ Wind conditions</li> <li>○ Precipitation / convective activity</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Class of airport (Core, Reliever, or other)</li> <li>• Date (and time) range, peak</li> <li>• Type of airspace</li> <li>• Airport (e.g., runway use) configuration</li> <li>• Individual or sets of airports, metroplexes, or sectors</li> <li>• Selected runways, airports, or metroplexes</li> <li>• Type of Aircraft                             <ul style="list-style-type: none"> <li>○ Proposed: By approach speed category</li> </ul> </li> <li>• Aircraft Equipage Capability</li> </ul>

Type of statistics reported for each KPI:

- Standard Deviation
- Mean
- Median
- 95<sup>th</sup> Percentile

#### Key Data Gaps

- OOOI for GA and other non-scheduled operations
- VFR actual and planned trajectories
- Aircraft gate “ready” times
- Non-approved change requests
- 10,000 and 18,000 MSL crossing times for all operations
- Actual SID, STAR, departure or arrival procedures cleared and flown (e.g., RNAV vs. standard)
- Correlation of flights with airframe equipage
- Aircraft delays absorbed in non-movement areas
- Actual fuel used in different phases of flight

### 5.2 Capacity KPA and Associated KPIs



### Introduction

The term "capacity" has a multitude of different meanings and applications in the aviation industry. Therefore, it is important to clearly define what we mean by *Capacity* as a Key Performance Area (KPA) for purposes of measuring NextGen performance post-implementation.

Weather conditions (ceiling, visibility, and winds) have a significant effect on capacity. Therefore, at least for airports, capacity is typically specified for Visual Meteorological Conditions (VMC), Marginal Visual Meteorological Conditions (MVMC), and Instrument Meteorological Conditions (IMC).

It is also important to specify the NAS element or geographic unit for which capacity is measured. For example, actual throughput can be measured for the NAS as a whole, individual airspace sectors, Metroplexes, or airports. Similarly, maximum throughput capability can be determined for individual airspace sectors, metroplexes, and airports.

Finally, the time interval for which capacity is defined must be specified. The appropriate time interval may depend on the NAS element or geographic unit being considered. The appropriate time intervals for measuring the actual throughput of the NAS as a whole are a year or a peak day; while the appropriate time intervals for measuring the maximum throughput capability of an airspace sector, a Metroplex, or an airport are typically much shorter (e.g., an hour or 15 minutes). In general, both actual throughput and maximum throughput capability are most meaningful for shorter time periods. Capacity is an indicator of saturation or full utilization, which typically may occur only in short time intervals. Actual throughput measured over a longer time intervals is often more an indicator of demand than an indicator of capacity.

### Definition

The capacity KPA is a measure of the ability of the National Airspace System (NAS), an airspace sector, a Metroplex, or an airport to accommodate demand. The BCPMWG recommends that the capacity KPA be defined in terms of both (1) the actual throughput in peak demand periods, and (2) the maximum throughput capability in a specified time interval. The main difference between these two Key Performance Indicators (KPIs) is that actual throughput can be measured by direct observation, while maximum throughput capability is typically calculated using available data and models that reflect the rules and procedures that determine capacity. The connection between the two KPIs is that the actual throughput can be used to estimate and validate the maximum throughput capability and to determine the degree to which the maximum throughput capacity is utilized.

Specific definitions of the Key Performance Indicators (KPIs) recommended for the capacity KPA are summarized below in Table 2, which includes both high-level and medium-level KPIs. High-level (or system-level) KPIs are defined for the NAS as a whole; medium level KPIs are defined for airspace sectors, metroplexes, and airports.

**Table 2: Capacity KPA**

KPA	KPI Definition	System Level KPI	Medium Level KPIs
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		NAS-Wide	Airspace	Airport & Metroplex
Capacity	<b>Throughput</b> Actual total number of aircraft operations accommodated during a specified time interval with emphasis on peak periods	<b>NAS-Wide Throughput</b> Total annual and Peak-day aircraft operations in the NAS	<b>Sector Throughput</b> Total number of aircraft operations passing through the sector in a specified time interval  <b>Sector Occupancy</b> Instantaneous count of aircraft in a sector	<b>Airport Throughput</b> Total number of aircraft operations at the airport  <b>Metroplex Throughput</b> Total number passing through the Metroplex in a specified time interval
	<b>Maximum Throughput Capability</b> The number of arriving aircraft which an airport or airspace can accept from the ARTCC per hour, and the number of aircraft which can depart an airport and the airspace can accept per hour			<b>Maximum Sector Count</b> Capacities of airspace sectors that represent identifiable capacity limits on sector throughput

Except for airspace sectors and metroplexes, the term “aircraft operations” in Table 2 would generally mean the number of "landings & takeoffs" in a specified time interval. For airspace sectors and metroplexes, "aircraft operations" would generally mean the total number of aircraft operations passing through the sector ("ins & outs") in a specified time interval.

**Throughput**

Because throughput can be measured and observed directly, its definition is relatively straightforward. Throughput measures could be aggregated by sets of sectors (e.g., ARTCCs and TRACONS), sets of Metroplexes representing wider regional areas, or sets of airports representing a Metroplex or category of airport. Actual throughput data also could be aggregated by selected city pairs, particularly where NextGen would alleviate capacity constraints at the destination airport or en route to the destination airport. Throughput is readily available in two formats: maximum number of departures, or arrivals, or operations per hour or the percentiles of the arrival, departure or operations counts. It is presently available in ASPM.

### ***Maximum Throughput Capability***

The maximum throughput capability KPI is more complex than actual throughput KPI because it is determined through a combination of analysis of available throughput data and modeling based on the rules and procedures that determine capacity for a given set of conditions. Therefore, further discussion is presented below of the recommended definitions of the maximum throughput capability KPIs for airspace, and airports/metroplexes:

#### **Airspace**

Capacities of airspace sectors represent identifiable limits on sector throughput, even though they are generally specified as maximum sector counts. For example, the FAA currently uses the Monitor Alert Parameter (MAP) as an indicator of sector capacity. MAP values reflect the maximum instantaneous aircraft count that can be safely handled by sector controller, and MAP values are set to reflect a controller's acceptable workload. As such, MAP was not intended to be a measure of capacity in terms of a limit on maximum throughput of the sector, and there was considerable discussion within the BCPMWG about its suitability as a KPI for airspace capacity. Nevertheless, we include it here as the best measure currently available for this purpose.

The FAA is currently sponsoring research to develop new tools and metrics for measuring controller workload and airspace sector capacity. In addition, much like the discussion below for AARs and ADRs, it is anticipated that the FAA would update and modify the sector MAP values as conditions change with NextGen implementation to reflect the operational improvements and changes in procedures. Therefore, the BCPMWG recommends that the MAP be included as a KPI for sector capacity in terms of maximum throughput capability, but that it also be identified as a potential gap that needs filled as new techniques for specifying sector capacity are developed.

#### **Airport and Metroplex**

Airport Arrival Rates (AARs) and Airport Departure Rates (ADRs) are the maximum number of landings and takeoffs that can be handled by an airport under a given set of operating conditions including visibility, runway use, winds, facility and procedure availability, etc. The FAA Pilot/Controller Glossary defines AARs and ADRs as follows:

*AIRPORT ARRIVAL RATE (AAR) – A dynamic input parameter specifying the number of arriving aircraft which an airport or airspace can accept from the ARTCC per hour. The AAR is used to calculate the desired interval between successive arrival aircraft.*

*AIRPORT DEPARTURE RATE (ADR) – A dynamic parameter specifying the number of aircraft which can depart an airport and the airspace can accept per hour.*

AARs and ADRs are calculated using a combination of peer analyses of actual throughput data and modeling. As NextGen operational improvements are introduced, these AARs and ADRs will be recalculated to reflect the improved capabilities. Therefore, AARs and ADRs are suitable high-level metrics for the post-implementation measurement of the impact of NextGen improvements.

## Appendix A: Detailed Findings and Recommendations

There are two types of AAR available:

- Capacity AAR is the number of arrivals per hour or quarter hour that an airport is capable of handling.
- Efficiency AAR is the number of arrivals per hour or quarter hour that an airport is capable of handling when a traffic management initiative (TMI) is in effect.

In the absence of TMIs, airport capacity refers to the sum of capacity AAR and ADR (airport arrival rates). AAR and ADR numbers are provided by the Command Center on a daily basis for a set of 77 airports tracked by ASPM. OPSNET does not have airport capacity but TFMS does and it is used to anticipate delays and collaborative programs. The AAR and ADR numbers are based on time of the day, flight schedules (OAG), available staff to handle traffic, weather conditions (ceiling and visibility) and runway configurations.

### *Data Sources*

**Availability:** Data on actual aircraft operations, AARs and ADRs, are available from ASPM, OPSNET, and ETMS by airport, weather condition, and runway use configuration.

**Requirements:** Ideally, one would observe throughput under saturated conditions to be able to reflect the potential increase in capability provided by NextGen. Observing such saturated conditions would apply mainly to shorter time periods and specific geographic units or NAS element such as sectors, metroplexes, and airports.

### *Gaps*

Because these data are actual number of aircraft operations accommodated, they are as much a measure of demand as they are of capacity. Therefore, judgment must be applied to identify the appropriate time intervals and percentiles to use as measures of throughput in peak periods. Ideally, the data collection system would identify maximum actual rates for specified time periods and locations and also provide statistics on the distribution of those rates so that the analyst could identify the effects of operational improvements provided by NextGen.

A specific gap identified by the BCPMWG is the need for a metric that is intended to measure airspace sector capacity in terms of maximum throughput capability as limited by the maximum sector count to potentially replace the current Monitor Alert Parameter (MAP). ASPM and OPSNET do not have information on sector capacity. Sector capacity is usually computed over 56 days as the maximum traffic count/interval over 56 days when there are no weather, traffic flow restrictions, or outage events in the sector. Sector capacity for a 24 hour day is the difference between maximum capacity and maximum traffic count/interval on that flight day independent of event occurrences. The only source known for sector capacity is TFMS.

## 5.3 Efficiency KPA and Associated KPIs

### Introduction

The *Efficiency* KPA addresses the operational and economic cost effectiveness of gate-to-gate, and “in air” flight operations from a single flight perspective. Therefore, the underlying KPIs address measures of airborne efficiency, such as operating time, delay and cost. The RTCA recommended performance metric detailed in this section measures the expected reductions in aircraft operating time and delays in the NAS from NextGen implementations.

Delay is an important performance indicator of the NAS. Delays are arguably the most visible manifestation, and often cited, measure reported to gauge the performance of the aviation system. That being said, any evaluation of NextGen and future or current performance assessment of the aviation system, needs to recognize the performance trade-offs involved and the potential actions by stakeholder that often effect delay. Delays are stochastic, propagated, and induced. Weather is not controllable. Delays at one airport may represent the cumulative effect of delays in previous flight legs. Finally, ground delay programs allow the airspace system to recover from any event (especially severe weather) that may put an additional burden on already-constrained airport capacity. For example, there is a recognized trade-off between throughput and delay in the system, so in the future it is possible that delays could remain constant while the number of flights increases to accommodate demand as NextGen technologies and initiatives are deployed. Therefore, evaluating delays in the future without considering other factors and measures will provide an incomplete assessment of the performance of a NextGen implementation.

### Definition

Aircraft operating time can be defined in multiple ways by multiple users. For air carriers, the elapsed time from leaving the origin gate until arriving at the destination gate is one measure (known as “block” time); another measure is the time the aircraft is in the air (from wheels “off” the ground to wheels “on” the ground) and the rate of fuel consumption is highest. For general aviation engine start to engine shut-down is a common measure.

The working group recommends capturing both block and off/on time as high-level KPIs, as the difference between the two represents taxi time and is influenced by factors other than track miles and vertical profile. It is proposed that this measure capture a representative sample of the NAS and is expressed in speed (great circle miles between origin and destination divided by block and off/on minutes). The mean, median, and standard deviation should also be calculated.

A wide variety of delays metrics have been used to measure the performance of the NAS. One of the most commonly reported is the number of aircraft delayed more than 15 minutes in the system. In order to measure NextGen performance, the working group recommends a more inclusive delay metric that captures the performance of a flight versus expectations or the operator’s flight plans. The measure **aircraft operating delay** was deemed best suited to capture the amount of time beyond expectations that it takes to complete an operation. It is also proposed that at the highest level this metric be measured by a representative sample of the NAS and the mean, median and standard deviation be calculated.

Appendix A: Detailed Findings and Recommendations

Taxi-out time metric is meant to record the amount of time that elapses from the moment an aircraft is ready to leave its gate until it takes off, and includes all of the delays it may accumulate between the two points such as delays due to surface traffic management, gate management, de-icing, security holds, etc. However, since we do not record the ready-times, we default to the only data we do have available: Gate-out to wheels-off; as a result, delays that are taken at the gate, will not be included in the Taxi-out evaluation.

**Table 3: Efficiency KPA**

KPA	KPI Definition	System Level KPI NAS-Wide	Medium Level KPIs			
			Taxi	Climb	Cruise	Descent
Efficiency	<b>Aircraft Operating Time</b> Aircraft operating time from initial movement through arrival	<b>Operating Time Efficiency</b> “block” time (out – in) divided by great circle distance  <b>Airborne Time Efficiency</b> (off- on time, divided by great circle distance)	<b>Departure Taxi Time</b> (out – off)  <b>Arrival Taxi Time</b> (on-to-in)	<b>Aircraft Climb Efficiency</b>  <b>Time Below 10,000 AGL</b> <i>(future data reporting need)</i>  <b>Time Below 18,000 MSL</b> <i>(future data reporting need)</i>	<b>Cruise Efficiency</b> (measured as time from TOC to TOD)	<b>Aircraft Descent Efficiency</b>  <b>Time Below 10,000 AGL</b> <i>(future data reporting need)</i>  <b>Time Below 18,000 MSL</b> <i>(future data reporting need)</i>
	<b>Aircraft Operating Delay</b> The difference between actual and planned operating times	<b>Aircraft Operating Delay</b> Difference between actual and planned aircraft flight operating times  <b>Aircraft Airborne Delay</b>	<b>Gate Delay</b> (“Out” time minus “ready”) - No data available  <b>Taxi Out Delay</b>  <b>Taxi In Delay</b>			

**Data Sources**

- ARINC's OOOI – Records actual time recorded by the aircraft
- TFMS/ETMS Data – Records filed flight plans
- ASPM

### *Gaps*

Airline Service Quality Performance reports (released by the Bureau of Transportation Statistics on a monthly basis) include 18 major carriers for domestic flights within the 48 contiguous states. TFMS/ETMS has departure (DZ) and arrival (AZ) messages for all IFR flights but no gate-in and gate-out times. ASPM adds an estimation of gate-out and gate-in times for international flights. However, ASPM tracks traffic at only 77 leading U.S. airports. ASPM has ARINC's OOOI times for 21 carriers including Air Canada, FedEx, and UPS that ASQP does not report. The flight plan that serves as a benchmark to evaluate delay is the last one filed before wheels-off.

There is still incomplete information on surface operations, especially parsing taxi time into ramp operations, holding in a designated aircraft movement area, and time waiting in the departure queue. ASDE-X data has the potential to fill in some surface gaps in the future.

### 5.4 Predictability KPA and Associated KPIs

The KPIs for Predictability KPA are based on the calculated standard deviation of the Efficiency KPIs for Aircraft Operating Time and Aircraft Operating Delay.

#### Introduction

The *Predictability* KPA addresses the operational and economic cost effectiveness of reduced variability of airspace operations. Therefore, the KPIs contained herein address reduced variability. The RTCA recommended performance metric detailed in this section measures the variation in actual aircraft Gate-to-Gate and Off-to-On time in the NAS from NextGen implementations.

**Table 4: Predictability KPA**

KPA	System Level KPI NAS-Wide	Medium Level KPIs			
		Taxi	Climb	Cruise	Descent
Predictability	Variability in Aircraft Operating Time	Variability in Aircraft Taxi Time	Variability in Aircraft Climb Efficiency	Variability in Cruise Time	Variability in Aircraft Descent Efficiency
	Variability in Airborne Time				
	Variability of Delay	Variability in Taxi or Gate Delay			

#### Gaps

Airline Service Quality Performance reports (released by the Bureau of Transportation Statistics on a monthly basis) include 18 major carriers for domestic flights within the 48 contiguous states. TFMS/ETMS has departure (DZ) and arrival (AZ) messages for all IFR flights but no gate-in and gate-out times. ASPM adds an estimation of gate-out and gate-in times for international flights. However, ASPM tracks traffic at only 77 leading U.S. airports. ASPM has ARINC's OOOI times for 21 carriers including Air Canada, FedEx, and UPS that ASQP does not report.



## 5.5 Flexibility KPA and Associated KPIs

### Introduction

*Flexibility* should measure the degree that users are obtaining requests to navigate and adjust to changing conditions in the system. It encompasses the level to which users are impeded or unimpeded in achieving their business objectives. In the strategic area, this can apply to obtaining a preferred route to reach its destination and while airborne, requesting tactical preferences when responding to weather, congestion, etc. The following are some of the actions that should be considered when developing flexibility metrics:

- “Closeness” of final flight plan to desired flight plan (pre-flight)
- Ability of NAS to accommodate tactical requests (in-flight)
  - Reroutes, change of altitudes, % of pilot requests accepted
- Amount of restricted airspace available for use (SAA)? % of time and airspace available

Flexibility metrics are also needed to understand NAS system robustness, such as the ability to recover from a disruptive weather event, or the ability to reallocate resources to respond to dynamic system needs. More work is needed to understand and develop measures in this area.

### Definition

The Flexibility KPA measures the aviation system’s ability to satisfy users’ changing operational needs and permit users to adapt their operations to changing conditions. Flexibility is important to users because it gives them latitude to adjust to changing conditions, better meet their individual operational priorities and business objectives, and minimize the costs of disruptions. Individual operational priorities and business objectives are complex; they can be wide-ranging (e.g., minimize operating costs, preserve network or critical connections, arrive on-time), often vary user-by-user and flight-by-flight, and can change rapidly based on operational and other conditions (e.g., bad weather, mechanical problems, crew shortage or other staffing issues). Therefore, it is difficult for the FAA to know user intent and priorities and the FAA cannot effectively prioritize on behalf of users. Instead, users must determine how to best meet their economic and customer service goals and make the best use of their resources through the planning and execution of their operation, and communicate their specific operational requests and preferences to the FAA. The FAA must reduce operational constraints and accommodate user requests and preferences to the extent possible within the safety and capacity constraints of the aviation system.

It is possible to measure flexibility in terms of the number of options available to users, but to be meaningful those measures would require an understanding and ranking of the relative desirability and costs of the options. Conversely, it may be possible to measure lack of flexibility in terms of the number of, and severity of, or cost of, constraints imposed on flights. A simpler solution may be to measure as an indicator of flexibility the percentage of flights that are free of FAA-imposed constraints. The BCPMWG recommends further study of these possibilities.

Appendix A: Detailed Findings and Recommendations

It is possible based on data available today to make some measurements of flexibility in terms of the percentage of user requests granted. These measures of flexibility should ideally be based on full knowledge of user requests and preferences. The information that is currently available to the FAA on user requests and preferences is far from complete. Flight plans and flight plan amendments are some of the best information available, but do not necessarily capture or represent true preferences. The BCPMWG recommends that the FAA use the best information available to produce indicators of flexibility today, and then work together to identify the most important aspects of flexibility to users and determine the appropriate mechanisms for users to provide the associated requests and preferences. Then, additional and more objective measurements of flexibility can be made.

**Table 5: Flexibility KPA**

KPA	KPI Definition	System Level KPI NAS-Wide	Medium Level KPIs	
			Pre-flight	Airborne
Flexibility	The aviation system’s ability to satisfy changing operational needs and permit users to adapt their operations to changing conditions	% of flights not subjected to constraints	% of position swaps over first-come-first-serve approach (CDQM)	% of non-scheduled IFR flights that can depart on-time
		% of flight operator requests granted	% of flight plans accepted as filed  % of user preferred plans (e.g., business trajectory) granted - future	% of altitude/vertical-change requests accommodated  % of route change requests accommodated  % of OPDs granted  % utilization of SUA

**Data Sources**

- None

**Gaps**

- Information is available for requests approved, but not the number requested.
- Would like to be able to track stakeholder requests, not only those by the FAA

## 5.6 Access and Equity KPA and Associated KPIs

### Introduction

*Access* measures the ability of users to enter the NAS and *Equity* is the ability to receive fair and impartial treatment within the policy and rules established for the system. Performance metrics should address the extent the system can accommodate users of varying levels of capability and airframe characteristics by providing unbiased access according to the agreed upon rules for service. These metrics are especially important when addressing the concerns of all users during the transformation of the NAS through NextGen. They should identify how users have been positively, or negatively, impacted in their respective abilities to use the air transportation system. Additionally, these metrics should capture if system improvements are coming at the expense of one segment or airspace user over another or how constraints are applied to all users. These measurements can be further defined as:

#### *Improve Access:*

- Ensure that shared use of airspace and airports by different classes of airspace users will be significantly improved (classes defined by type of user, type of aircraft, type of flight rule);
- **Where shared use is conflicting** with other performance expectations (safety, security, capacity, etc.), ensure that viable airspace/airport alternatives will be provided to satisfy the airspace users' needs, in consultation with all affected stakeholder (refer to Participation KPA).

#### *Improve Equity:*

- For priority management, ensure that more options will be available than just the 'first-come, first-serve' rule;
- Ensure that priority rules will always be applied in a transparent, correct manner.

### Definition

This indicator will measure the utilization of defined airspace and/or location by user in order to gauge access and measure equity. The objective is to provide a depiction of access and equity, but the problem is, what does this actually imply? Is it a breakdown of user availability; how many hours or percentage of time the service is "open" for specified users, or is it a measure of actual use; what was the distribution of counts of actual use by the community, or is it a combination of both?

In summary the metric will require an enumeration of users, a definition of the equipage level, and the location and the type of capability to be evaluated. The metric should capture the percentage of time access is granted by user and by capability.

**Table 6: Access & Equity KPA**

KPA	KPI Definition	System Level KPI NAS-Wide	Medium Level KPIs
Access & Equity	Ability of users to enter the NAS, use services and receive fair treatment	% of airframes capable of using NextGen services % of NAS where NextGen services are available <i>(includes time &amp; geographic component)</i> % of non-NextGen capable airframes accommodated	% of flights utilizing NextGen services

**Data Sources**

- OPSNET, ETMS (TFMS)
- Data sources that capture a broader spectrum of stakeholders are required.

**Gaps**

- Need to improve the ability to track “performance capable” aircraft and not just avionics in the aircraft
- Need to be able to track actual utilization of NextGen services, not just availability.

## Implementation Progress

**Table 7: Aircraft Avionics Equipage Tracking**

Performance-Based Navigation	Automatic Dependent Surveillance	ATC Digital Communications	Flight Safety and Weather	Low-Visibility Operations
RNP 10 RNP 4 RNAV 1 / 2 RNP/RF RNP AR VNAV LPV GLS Cat I GLS Cat II/III	ADS-B Out CDTI Surf-IA ITP Interval Mgmt TSAA Parallel Approach	FANS 1/A FANS 1/A+ ATN B1 FANS 2/ATN B2	FIS-B MDCRS TAMDAR	HUD / ILS EFVS CVS

### *NextGen Capability Implementation*

To support joint investments in implementing NextGen, both government and private stakeholders need a common understanding of the progress, expected implementation path, and risks associated with planned NextGen capabilities, as well as the utilization of capabilities already in place. In particular, stakeholders need to understand the following aspects of NextGen implementation to develop joint, synchronized plans for implementing capabilities, including training, acquisition, policies, and procedural definition:

- For capabilities not yet available or not yet delivering benefits, the NextGen dashboard should provide the implementation schedule for planned operational improvements and increments, including locations and dates, key decision points, and risks associated with the successful delivery of benefits
- For operational improvements or increments that have been implemented, a common understanding is needed of the locations that they are available and the level of utilization. For example, if a NextGen procedure is in place involving RNP routes, how often is the procedure used?

*Note: Currently, the NGIP provides a public view of planned NextGen capabilities. Information shared on the NextGen dashboard should be consistent with the FAA's Integrated Master Schedule for NextGen operational improvements and increments.*

## 5.7 Environment KPA and Associated KPIs

### Key Performance Area (KPA): Environment

The *Environment* KPA addresses NextGen's contribution towards enabling sustainable growth through operational improvements, aircraft and engine technology advances, sustainable fuels, policy initiatives, and advances in science and modeling. The five major environmental areas of interest in aviation are: noise, emissions, climate, energy, and water quality.

The NextGen Advisory Committee's Business Case and Performance Metrics Working Group has identified Environment as a critical KPA for NextGen. However, because of the considerable established and ongoing work by the FAA to measure environmental performance, the BCPMWG has opted not to develop metrics for this KPA and instead supports the use of FAA's NextGen environment metrics, as detailed in this section.

### NextGen Goal Area

The FAA has described its plan for transformation of the NAS in its *Destination 2025* report. The report summarizes the objectives into six overarching goals. The goal that explicitly pertains to environment is *Sustaining our Future*, to develop and operate an aviation system that reduces aviation's environmental and energy impacts to a level that does not constrain growth and is a model for sustainability. The targets it set to meet this goal are:

- The U.S. population exposed to significant aircraft noise around airports has been reduced to less than 300,000 persons.
- Aviation emissions contribute 50% less to significant health impacts and are on a trajectory for carbon neutral growth by 2018 using a 2005 baseline
- One billion gallons of renewable jet fuel is used by aviation by 2018.
- A "drop-in" replacement fuel for leaded aviation gasoline is available by 2018 that is usable by most general aviation aircraft.

### Tradespace:

Sustainability means providing development and economic activity in a manner that does not cause present or future adverse effects. The overarching environmental performance goal for NextGen is environmental protection that allows sustained aviation growth. The primary environmental and energy issues that significantly influence the capacity and flexibility of the national aviation system are aircraft noise, air quality, climate, energy, and water quality. These issues are being addressed under a range of environmental laws and regulation, and by governmental and industry initiatives. Environmental and energy challenges must be successfully managed and mitigated for NextGen to realize its full potential and for the U.S. to meet the aviation transportation needs of the 21<sup>st</sup> century.

### System-Level KPI

**Noise:** Reduce the number of people exposed to significant noise around U.S. airports in absolute terms, notwithstanding aviation growth, and provide additional measures to protect public health and welfare and our national resources.

**Air Quality:** Achieve an absolute reduction of significant air quality health and welfare impacts attributable to aviation, notwithstanding aviation growth.

**Climate:** Limit the impact of aircraft CO<sub>2</sub> emissions on the global climate by achieving carbon neutral growth by 2020 compared to 2005, and net reductions of the climate impact from all aviation emissions over the longer term (by 2050).

**Energy:** Improve National Airspace System (NAS) energy efficiency by at least two percent per year, and develop and deploy alternative jet fuels for commercial aviation.

**Water Quality:** Limit the adverse aviation discharges to U.S. waters and reduce aviation's contribution to significant water quality impacts.

### *Detailed Quantitative Definitions*

**Noise:** Number of people exposed to significant (DNL 65) noise around U.S. airports

Note: The Day-Night Average Sound Level (DNL) is the Energy-Averaged Sound Level (Leq) measured over a period of 24 hours, with a 10 dB penalty applied to nighttime (10 p.m. to 7 a.m.) sound levels to account for increased annoyance by sound during the night hours.

**Air Quality:** Mass of health-related pollutants from aircraft exhaust emissions for U.S. commercial operations

**Climate:** Mass of aircraft CO<sub>2</sub> emissions for U.S. commercial operations

**Energy:** NAS-wide fuel burn efficiency in terms of mass of fuel burned per miles traveled

**Water Quality:** Tentatively planned as the amount of adverse discharges to U.S. waters - under development

### *Aggregation Level*

The FAA aggregates noise exposure for all United States airports having at least 365 jet departures for the year. Air quality, climate, and energy metrics are aggregated across the entire national airspace system. Water quality data would be collected at all U.S. airports.

### *Available Data Sources*

**Noise:** The Model for Assessing Global Exposure to the Noise of Transport Airplanes, MAGENTA, is used to track airport noise exposure. MAGENTA uses updated population data from the 2000 Census projected to the current year to estimate population within a noise contour area. For smaller airports, a procedure is used where noise contour area is calculated from airport operations data using a statistical relationship. The data source for airport traffic is the FAA Enhanced Traffic Management System (ETMS).

**Air Quality:** The Aviation Environmental Design Tool (AEDT), an FAA-developed computer model that estimates aircraft fuel burn and health-based pollutant emissions based on ETMS data.

**Climate:** The Aviation Environmental Design Tool (AEDT), an FAA-developed computer model that estimates aircraft fuel burn and greenhouse gas emissions based on ETMS data.

## Appendix A: Detailed Findings and Recommendations

**Energy:** The Aviation Environmental Design Tool (AEDT), an FAA-developed computer model that estimates aircraft fuel burn using ETMS data.

**Water Quality:** Water quality data is not currently available. However this metric is under development.

### *Gaps*

**Noise:** Currently, the FAA uses MAGENTA model estimates to calculate noise exposure. The model is subject to errors related to its specifications and FAA has made annual improvements to the model to more accurately capture aircraft noise trends. To further improve the accuracy of this metric, the FAA plans to replace MAGENTA with the Aviation Environmental Design Tool (AEDT), which may result in a change to the current estimates of the number of people exposed to significant noise levels.

**Air Quality:** The FAA is in the process of developing a workflow and modeling process necessary to quantify the emissions-related health impacts from commercial aviation. Currently, the mass of health-related pollutants is utilized as a surrogate for emissions-related health impacts.

**Climate and Energy:** Climate and energy measures are modeled. Empirical data is not currently collected.

**Water Quality:** As noted earlier, this data is currently under development.



## 5.8 Safety KPA and Associated KPIs

### NextGen Goal Area

Increase System Safety (1) with no accidents where NextGen technology or operations are a contributing factor, and (2) by reducing accident and incident rates by targeting key risk areas, including runway incursions, mid-air collisions, and controlled flight into terrain.

### System-Level KPI

Overall NAS performance assessment as opposed to NextGen performance assessment, focuses on overall safety impacts observed from one fiscal year to another and throughout NAS. The corresponding Objectives and Performance Targets are summarized in the 2009-2013 Flight Plan, and elaborated in the FAA's Portfolio of Goals for FY11.

The latest version of the Flight Plan summarizes the current reporting requirements, and includes objectives and targets that are based on the following safety metrics:

- Commercial Air Carrier Fatality Rate
  - Definition: Number of fatalities per 100 million persons on board.
  - Scope: This measure includes both scheduled and nonscheduled flights of U.S. passenger and cargo air carriers (14 CFR Part 121) and scheduled passenger flights of regional operators (14 CFR Part 135). It excludes on-demand (i.e., air taxi) service and general aviation. Accidents involving passengers, crew, ground personnel, and the uninvolved public are all included.
- General Aviation Fatal Accident Rate
  - Definition: Number of fatal accidents per 100,000 flight hours
  - Scope: This measure includes on-demand (non-scheduled FAR Part 135) and general aviation flights. General aviation comprises a diverse range of aviation activities, from single-seat homebuilt aircraft, helicopters, and balloons, single and multiple engine land and seaplanes, to highly sophisticated extended range turbojets.
- Alaska Accident Rate
  - Definition: Number of fatal and serious injury accidents in Alaska per 100,000 flight hours
  - Scope: This measure includes scheduled and non-scheduled FAR Part 135 operations, as well as general aviation flights, and is limited to fatal accidents and/or accidents resulting in serious injury. It is not a sub-measure of the General Aviation Fatal Accident Rate, which does not include non-fatal accidents. Flight operations in Alaska are diverse and they must cope with the state's challenging aviation environment and unique air transportation requirements.

## Appendix A: Detailed Findings and Recommendations

- Runway Incursions (Category A & B)
  - Definition: Rate of Category A & B (most serious) runway incursions per million operations
  - Scope: A runway incursion is any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft. They are grouped in three general categories: air traffic, pilot, or vehicle/pedestrian events. Runway incursions are reported and tracked at airports that have an operational air traffic control tower. Operations are defined as total takeoffs and landings. The FAA tracks four categories of runway incursions - A, B, C, and D - but includes only those with the highest risk of collision, Category A and B incursions, in the measure.
    - Category A: Separation decreases to the point that participants take extreme action to narrowly avoid a collision.
    - Category B: Separation decreases, and there is a significant potential for a collision.
    - Category C: Separation decreases, but there is ample time and distance to avoid a collision.
    - Category D: There is little or no chance of collision, but the definition of a runway incursion is met.
- Total Runway Incursions
  - Definition: The total number of runway incursions for each year.
  - Scope: A runway incursion is any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft. They are grouped in three general categories: air traffic, pilot, or vehicle/pedestrian events. Runway incursions are reported and tracked at airports that have an operational air traffic control tower. Operations are defined as total takeoffs and landings. The FAA tracks four categories of runway incursions - A, B, C, D
- Commercial Space Launch Accidents
  - Definition: Number of accidents resulting in fatalities, injuries, or significant property damage
  - Scope: This measure focuses only on commercial space launch or reentry activities licensed or permitted and monitored by the FAA. "Significant" property damage is defined as any damage estimated to exceed \$25,000 to

property not associated with flight. On board crew members and space flight participants are NOT considered “uninvolved” members of the public.

- System Risk Event Rate
  - Definition: All instances of non-compliance with radar separation standards, termed Loss of Standard Separation, or LoSS.  
Technical explanation for LoSS: The non-compliant application of a prescribed radar separation standard, as defined in FAA Order 7110.65 or other national directive, for an operation under ATO services, including a pilot deviation, which results in less than the applicable separation minima between two or more airborne aircraft.  
System Risk Event Rate (SRER): The LoSS data will be compiled into the SRER, which is the rate of the most serious losses for every thousand losses of standard separation within the system.
  - Scope: This metric will measure the separation compliance performance of radar controlled IFR flights. For FY 2009 this constituted approximately 26 million flights.
  
- Safety Management System
  - Definition: Total number of successful completion of key activities that support the integration of the Air Traffic Organization (ATO), Office of Aviation Safety (AVS), and Office of Airports (ARP).
  - Scope: Key activities selected by ATO, AVS, and ARP as follows:  
Within AVS the activity is: 1) Harmonization of AVS SMS: each service and office will draft a plan that will roll up into the FAA Implementation Plan.  
Within ATO the activity is: 2) Develop policies, procedures, and approval processes to enable operation of unmanned aircraft system (UAS).  
Within ARP these activities are: 3) Design and implement SMS standards for Part 139 certificated airports; and 4) Design and implement SMS for the Office of Airports internal SMS.

Please be advised that the FAA is currently finalizing the new strategic plan, Destination 2025; the new safety reporting requirements, including the corresponding goals/objectives and targets, are likely to change as compared to the above summarized ones. The latest version of the document that was available for public comments focused on the commercial air carrier fatalities; serious runway incursions; GA fatalities; fatalities, serious injuries and significant property damage resulting from commercial spaceflight activity; and safety information analysis practiced by the Part 121 air carrier operations.

**Questions to Consider:**

- What is the right scope of safety metrics, especially for the NextGen focused safety metrics?
  - Fatalities or accidents and incidents?
- What type of safety metrics will add value on the highest level vs. medium and low levels? For instance, do runway incursions belong on the highest level?
- Which of the NextGen capabilities may impact safety and how?
  - Can these safety impacts be grouped somehow?
  - What are the right metrics for each of these groups?
- What categories of safety related impact can be/need to be identified and evaluated as distinct?
  - Accidents and incidents
  - Between aircraft
  - Between aircraft and other vehicles or pedestrians
  - Between aircraft and terrain
  - Causal factors: human error, ground automation, on-board aircraft systems, etc.
  - Etc.

## ***Appendix B: BCPMWG Membership and Meetings***

**BCPMWG Membership** The BCPMWG is chaired by Ed Lohr (DAL) and Deborah Kirkman (MITRE). Additional members include Alex Burnett (UAL), Jim Crites (DFW Airport), Bill Dunlay (Leigh-Fisher), Kyle Gill (NetJets), Raquel Girvin (FAA), Jim Littleton (FAA), Joel Murdock (FedEx), John Novelli (AMR), Almira Ramadani (FAA), Kirk Rummel (Houston Airport), Craig Spence (AOPA), Joe White (ATA), and John Witucki (DOD). In addition BCPMWG has been supported through a number of subject matter experts assisting with operational metrics, including: Tom Berry (MITRE), Joe Bertapelle (JetBlue), Tony Diana (FAA), Rob Eagles (IATA), Ken Elliott (JetCraft), Stephanie Fraser (Metron), Pamela Gomez (FAA), Debi Minnick (FedEx), Bill Sears (Beacon Management), Rico Short (Beacon Management), and EJ Spear (MITRE).

**Group Formation and Scheduling** The RTCA Business Case and Performance Metrics Working Group of (BCPMWG) of the NextGen Advisory Committee (NAC) was formed in January 2011 to address performance metrics for NextGen. Its membership includes a broad spectrum of the aviation community, including commercial operators, general aviation, military aviation, airport operators, and the Federal Aviation Administration. Since forming, the BCPMWG has conducted full-day in-person meetings at least once per month (with accommodations for remote participation), and weekly- to bi-weekly meetings and telcons of a Task Group.

Since January, the Business Case & Performance Metrics Working Group and Metrics Task Group members have met on 16 occasions for more than 70 hours to research, analyze, debate, and develop our recommended metrics.

**Summary of Terms of Reference** The BCPMWG of the NextGen Advisory Committee (NAC) is tasked to recommend metrics, using the ICAO KPA/KPI framework, for tracking NextGen performance using the following criteria:

- Include associated methodology for generating metrics from available data sources
- Work with aviation stakeholders to identify new data sources to improve NextGen performance tracking
- Provide input on NextGen business case considerations
- Maintain and update the NextGen capabilities Dashboard, with benefits, costs, and risks

**Appendix C: Acronyms**

<b>Acronym</b>	<b>Definition</b>
<b>AAR</b>	Airport Arrival Rate
<b>ADR</b>	Airport Departure Rate
<b>ADS-B</b>	Automatic Dependent Surveillance - Broadcast
<b>AEDT</b>	Aviation Environmental Design Tool
<b>ARINC</b>	Aeronautical Radio, Inc.
<b>ARP</b>	Office of Airports
<b>ARTCC</b>	Air Route Traffic Control Center
<b>ASDE-X</b>	Airport Surface Detection Equipment, Model X
<b>ASPM</b>	Aviation System Performance Metrics
<b>ASQP</b>	Airline Service Quality Performance System
<b>ATM</b>	Air Traffic Management
<b>ATN</b>	Aeronautical Telecommunication Network
<b>ATO</b>	Air Traffic Organization
<b>AVS</b>	Office of Aviation Safety
<b>BCPMWG</b>	Business Case Performance Metrics Working Group
<b>CDQM</b>	Collaborative Departure Queue Management
<b>CDTI</b>	Cockpit Display of Traffic Information
<b>CFR</b>	Code of Federal Regulations
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>CVS</b>	Combined Vision System
<b>DNL</b>	Day-Night Average Sound Level
<b>EFVS</b>	Enhanced Flight Vision System
<b>ETMS</b>	Enhanced Traffic Management System
<b>FAA</b>	Federal Aviation Administration
<b>FANS</b>	Future Air Navigation System
<b>FAR</b>	Federal Aviation Regulations
<b>FIS-B</b>	Flight Information Services - Broadcast

Appendix A: Detailed Findings and Recommendations

<b>FOC</b>	Flight Operation Center
<b>FY11</b>	Fiscal Year 2011
<b>GA</b>	General Aviation
<b>GAO</b>	Government Accountability Office
<b>GLS</b>	GPS Landing System
<b>ICAO</b>	International Civil Aviation Organization
<b>ICWG</b>	Integrated Capabilities Work Group
<b>IFR</b>	Instrument Flight Rules
<b>IMC</b>	Instrument Meteorological Conditions
<b>ITP</b>	In-Trail Procedure
<b>KPA</b>	Key Performance Area
<b>KPI</b>	Key Performance Indicator
<b>LoSS</b>	Loss of Standard Separation
<b>LPV</b>	Localizer Performance with Vertical Guidance
<b>MAP</b>	Monitor Alert Parameter
<b>MDCRS</b>	Meteorological Data Collection and Reporting System
<b>MSL</b>	Mean Sea Level
<b>MVMC</b>	Marginal Visual Meteorological Conditions
<b>N/A</b>	Not Applicable
<b>NAC</b>	NextGen Advisory Committee
<b>NACSC</b>	NAC Sub Committee
<b>NAS</b>	National Airspace System
<b>NGIP</b>	NextGen Implementation Plan
<b>NPMWG</b>	NextGen Performance Metrics Working Group
<b>OAG</b>	Official Airline Guide
<b>OOOI</b>	Out-Off-On-In
<b>OPD</b>	Optimized Profile Descent
<b>OPSNET</b>	Operations Network
<b>RNAV</b>	Area Navigation
<b>RNP</b>	Required Navigation Performance

Appendix A: Detailed Findings and Recommendations

<b>RNP RF</b>	RNP Fixed Radius Turns
<b>SAA</b>	Special Activity Airspace
<b>SESAR</b>	Single European Sky ATM Research
<b>SID</b>	Standard Instrument Departure
<b>SMS</b>	Safety Management System
<b>SRER</b>	System Risk Event Rate
<b>STAR</b>	Standard Terminal Arrival Route
<b>SUA</b>	Special Use Airspace
<b>Surf IA</b>	Surface Indications and Alerts
<b>TAMDAR</b>	Tropospheric Airborne Meteorological Data Reporting
<b>TF5</b>	RTCA Mid-Term Implementation Task Force
<b>TFMS</b>	Traffic Flow Management System
<b>TMI</b>	Traffic management Initiatives
<b>TOC</b>	Top of Climb
<b>TOD</b>	Top of Descent
<b>TOR</b>	Terms of Reference
<b>TRACON</b>	Terminal Radar Approach Control Facilities
<b>TSAA</b>	Traffic Situation Awareness with Alerts
<b>VMC</b>	Visual Meteorological Conditions
<b>VNAV</b>	Vertical Navigation





**Approved by the NAC September 29, 2011**

# **Recommendations for Implementing Trajectory Operations in the Mid-Term (2011-2018)**

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*A Report of the NextGen Advisory Committee in Response to Tasking  
from the Federal Aviation Administration (FAA)  
September 2011*

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## Executive Summary

The RTCA Trajectory Operations (TOps2) Task Group of the NextGen Advisory Committee Subcommittee (NACSC) was formed in March 2011 and included aircraft operators (flight operations, operational control, and flight planning), flight planning system vendors, OEMs, avionics vendors, MITRE, National Air Traffic Controllers Association (NATCA) and the FAA.

The specific tasking for the Trajectory Operations Task Group is contained in the Terms of Reference for the NextGen Advisory Committee Subcommittee:

**To provide continuity and to complete the work of the previous Air Traffic Management Advisory Committee, establish a Trajectory-Based Operations (TOps) Sub-Work Group, (Task Group or “TOps2”) to develop a Trajectory-based operations recommendation and report for consideration at the NextGen Advisory Committee (NAC) September 29, 2011 meeting.**

The TOps2 Task Group’s task was to focus on the Mid-Term (2018) Trajectory Operations Concept with consideration for potential evolution beyond 2018.

As presented in the March 2010 version of the FAA NextGen Implementation Plan (NGIP), NextGen is a transformation of the NAS using 21st century technologies to support aviation’s expected growth. The FAA has identified the trajectory-based operations (TBO) concept as a cornerstone to this transformation. The concept represents a fundamental shift of Air Traffic Management (ATM) from clearance-based control to trajectory-based control of aircraft. However, beyond an initial functional description of TBO developed by the Joint Program Development Office (JPDO) NextGen Aircraft Working Group (AWG), there are many aspects of trajectory operations which lack definition and specificity regarding functional and performance allocations, aircraft/ground systems changes and evolution, airspace design considerations, and air traffic management integration.

**Note:** This document uses the term Trajectory Operations (TOps) to distinguish it from TBO, which has been used in FAA planning as a solution set and was described initially more broadly in the JPDO NextGen Operational Concept<sup>1</sup>.

TOps is defined as the increasing integration of ANSP systems, aircraft systems and Flight Operation Centers (FOC) around a consistent and coherent view of the trajectory, resulting in an operation environment that supports and enables NextGen objectives. In Trajectory Operations, every aircraft that is operating in or managed by the ANSP is managed through representations of a four-dimensional trajectory (4DT). Every managed aircraft known to the system has a 4DT either provided by the user or derived from a flight plan or type of operation. TOps represent a mid-term implementation strategy to gain capacity and efficiency.

This report provides industry feedback on the FAA's Mid-Term Operational Scenario document ("Mid-Term Operational Scenario OV-6c Scenarios for NAS Enterprise Architecture") specifically focusing on the mid-term operational concepts and scenarios including a prioritization of the Operational Improvements (OI's) contained in the NGIP needed to implement the capabilities.

In establishing the priorities for implementing NGIP OI's, TOps2 followed the Task Force 5 NextGen Mid-Term Implementation Task Force Report recommendation of leveraging present day equipage to provide beneficial use in the near term as more robust capabilities are developed for the future.

## Summary of Key Findings

- 22 of the 26 operational scenarios were selected as being related to Trajectory Operations (TOps). These 22 mid-term operational scenarios reflect the key TOps concepts and capabilities required in the 2018 timeframe.
- All 26 mid-term operational scenarios should be baselined and distributed to the industry. The scenarios should be periodically updated by the FAA as concepts are matured and refined with input from all stakeholders.
- The Task Group has provided a prioritized list of Scenarios (Figure 3 on page 14) and Operational Improvements (Figure 5 on page 16) that support implementation of the scenarios. The potential benefits of TOps are tied directly to the acceleration of the

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<sup>1</sup> Concept of Operations for Next Generation Air Transportation System, Version 2.0, 13 June 2007

DataComm program and development of new standards for navigation with particular emphasis on vertical and time performance.

- DataComm is crucial to achieving the maximum benefits from TBO, serving as a basic “building block” for this important NextGen capability. Specific DataComm services, Departure Clearances and Route Clearances are critical to realization of TBO (14 of the 22 TOPs related operational scenarios assume that the Departure Clearance and/or Route Clearance service is available).

A key finding of the Task Force 5 report was the need for the industry to leverage current equipment as the transition is made to NextGen operations<sup>2</sup>.

- The FAA should leverage existing airline equipage in demonstration projects<sup>3</sup>.
  - Need to close on the Long-Term DataComm business case / Forward Plan
  - Need to finish the DataComm Standards and Advanced Services (SC-214) definitions by scheduled 2013 deadline.
  - **Note:** The assumptions and recommendations regarding specific DataComm-related technologies (FANS, ATN, VDL) will be reviewed and subsequently addressed by the follow-on NAC DataComm Roadmap Task Group developing a report for consideration by the NAC in February 2012.
- TOPs2 recommends that trajectory operations begin with the exchange of clearances and transition to dynamic routing as more robust capabilities are developed.
  - Enhancements to the navigation capabilities of aircraft, RNAV/RNP with Time of Arrival Control (TOAC) in the descent phase, will begin to increase benefits of TBO through the

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<sup>2</sup> The TOPs2 Task Group concurs with this finding. According to an analysis by The MITRE Corporation, of the 6653 aircraft in the Part 121 fleet; 772 aircraft are FANS enabled, 2417 are FANS capable, and 2548 (of which 1538 are regional aircraft) are not likely to equip with FANS for cost reasons, but are candidates for ATN Baseline One capabilities. The evolution to data communication operations needs to take advantage of the high level of operators currently equipped with FANS 1/A or FANS 1/A+. Furthermore, allow Required Communications Performance (RCP) to dictate the viable subnetwork (e.g. VDL Mode 0/A/2).

<sup>3</sup> This recommendation envisions using more than just FANS 1/A+ over VDL mode 2 to relay basic Data Link Communications in continental airspace. The FAA should leverage existing airline equipage during field-testing of new capabilities like the proposed DCL trials to validate concepts and to evaluate the actual performance of legacy equipment.

adaptability of the aircraft trajectory to enable operational predictability and arrival accuracy of aircraft.

- Need navigation standards activity to define requirements in this area by mid 2013 or early 2014.
- Continuing development of ADS-B functionality will provide improvements to trajectory operations through enhanced surveillance functionality (i.e. aircraft-aircraft intrail, spacing requirements, reduced separation requirements, etc.)
- The TOPs2 Task Group supports the efforts of the NAC Equipage Ad Hoc and the Business Case Performance Metrics Work Group analysis of the operational capabilities to close on the DataComm business case.
- There is a continued need to work towards harmonization with SESAR and EUROCAE.

## Scope and Methodology

The Task Group undertook a series of meetings and conference calls focused on level-setting the team via briefings from subject matter experts on the 26 operational scenarios and their associated OIs.

The overall objectives of these meetings were to:

- Review the FAA's NextGen Mid-term Concept of Operations for the NAS and associated scenarios ("Overview of Mid-Term Operational OV-6c Scenarios for NAS Enterprise Architecture") and develop suggested modifications.
- Collect documentation on the benefits of mid-term TOPs.
- Identify issues associated with both ground and aircraft based systems and technologies that enable mid-term TOPs.
- Map NGIP OIs and Capabilities to mid-term operational scenarios.
- Identify industry's prioritization of NextGen capabilities through prioritization of the operational improvements and operational scenarios
- Identify how TBO can occur in the mid-term and what elements are necessary for the future.
- Consider SESAR and Eurocontrol initiatives enabling TBO.

## Guiding Principles and Assumptions

The TOPs2 Task Group used the following principles and assumptions in its analysis of the scenarios:



- The FAA’s NGIP from March 2011 was used as the baseline document to identify the operational capabilities and implementation timelines. (The assumption was that the FAA will be able to implement the capabilities according to the time frames in the NGIP.)
- Ground-based separation will be the norm in 2018.
- Varying levels of aircraft communication, navigation and flight management equipage is anticipated in the mid-term and beyond.
- Basic DataComm Functions (R-PDC, CPDLC, Weather Reroutes, Tailored Arrivals) will be deployed. **Note:** The assumptions and recommendations regarding specific DataComm-related technologies (FANS, ATN, VDL) will be reviewed and subsequently addressed by the follow-on NAC DataComm Roadmap Task Group developing a report for consideration by the NAC in February 2012.
  - “Exchange of trajectory information” will be used throughout this document to indicate a progression of capabilities from those of FANS 1/A+ (uplink of route clearances with constraints and downlink of basic clearance requests and projected profile information) over ACARS then VDL mode 2, to the capabilities of SC-214 over ATN. (Uplink of route clearances that can include time constraints precise to seconds and downlink of predicted trajectories using extended projected profiles and downlink of requested route clearances.)
- Aircraft DataComm equipment between now and 2018 will increase to a level that is sufficient to achieve benefits from TOps.
- More automation will help controllers, Traffic Flow Management (TFM) specialists and FOC specialists in conduct of ATM (e.g. en route conflict probe, en route weather reroutes, Time Based Flow Management (TBFM), Collaborative Air Traffic Management (CATM)). Appendix A provides a prioritized list of the Mid-Term OIs and Capabilities.
- More automation will begin to help pilots more accurately control aircraft to predicted trajectories with RNAV/RNP TOAC capabilities enhanced to operate in the descent phase.
- Roles and responsibilities of pilots, controllers and TFM specialists will not change.
- ADS-B Out will be on a subset of the fleet by 2018 and by FAA mandate on all of the fleet performing trajectory operations by 2020.
- Definition of a mid-term capability is that the capability is operational and yielding operational benefits to some operators.

To form the basis for a common understanding, TBO provides separation, sequencing, merging and spacing of flights based on a combination of their current and future positions. TBO operates gate-to-gate, extending benefits to all phases of flight operations. TBO uses the 4DT to both strategically manage and tactically control surface and airborne operations. Aircraft are handled by their trajectory.

The following are some of the key concepts associated with Trajectory Operations:

- Every flight being managed by the ATM system has a 4D trajectory, either provided by the user or derived from a flight plan. Trajectories can be generated by aircraft (fully or partially) or by ground systems using the flight plan. Trajectory management will occur in all phases of flight.
- All changes to flights are reflected in its trajectory (unless it's a safety critical, tactical change).
- Trajectories will exist from pre-departure to post-flight and can be categorized into the following phases:
  - Pre-negotiation: The user determining the details of their planned flight prior to negotiating with the Air Navigation Service Providers (ANSP).
  - Negotiation: Users negotiate with the ANSP to determine their trajectory – this can occur pre-departure through flight planning systems or during active flight -- either directly between the flight and the ANSP or through the Airline Operations Center (AOC).
  - Agreement: A brief phase when a trajectory is agreed to by the user and the ANSP. If an agreement doesn't occur, the result is the return to the negotiation phase. If an agreement does occur, the phase changes to the execution.
  - Execution: Phase where a flight is maintaining a cleared trajectory as agreed to with the ANSP. Other than safety-critical maneuvers, all changes to trajectories (whether user initiated or ANSP initiated) will be negotiated and agreed upon.
- Clearances in the mid-term can be provided both through voice and data communications. Data communications will be necessary for more complex clearances, which may lead to more highly equipped aircraft getting better service from the ANSP.
- Open trajectories (i.e. vectoring) will be minimized.
- Aircraft will increasingly be equipped for RNAV/RNP and use satellite based navigation.
- While voice communications will exist, basic digital air-ground data exchange capabilities will exist to allow for exchange of weather data, clearances and 4D Trajectory information.
- Net-enabled systems will exist for the FAA and operators to exchange information in a robust manner.
- ANSP Automation will exist to allow increased capacity, efficiency and safety. Routine controller functions are automated and conflict detection and resolution advisories exist for ground systems. Point in space metering will be in use and supported through time-based metering tools.

## Trajectory Operations Scenarios

During the initial meetings of the Work Group, the FAA and MITRE briefed the Work Group on the “Mid-Term Operational Scenario OV-6c Scenarios for NAS Enterprise Architecture” document developed by the FAA and MITRE to describe the FAA NextGen mid-term operations.

This document was based on the NextGen Implementation Plan, the FAA NextGen Midterm Concept of Operations for the NAS, the NAS EA Mid-Term Operational Improvements and existing mid-term operational concepts. Based on the substantial work already performed by the FAA and MITRE, the TOps2 Task Group redirected its focus to reviewing and commenting on the FAA/MITRE Operational Scenarios document.

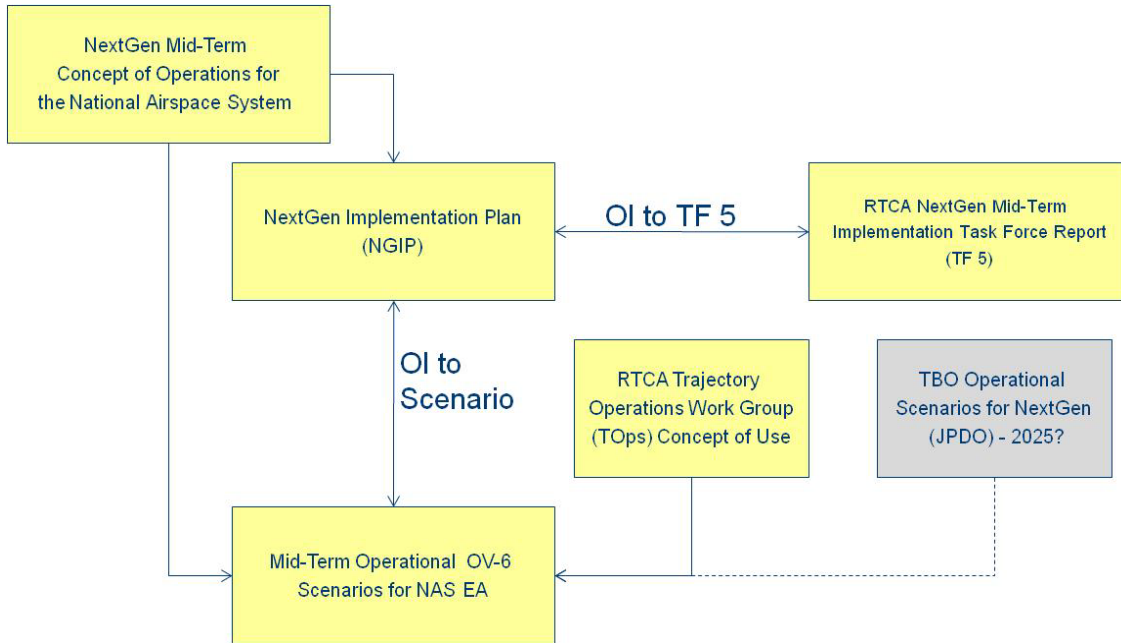
In making its recommendations the TOps2 Task Group considered the 26 Mid-Term Operational OV-6c Scenarios and their underlying Operational Improvements of the NAS Enterprise Architecture that were related to TBO. In reviewing the Mid-Term Operational OV-6c Scenarios it was determined that four of the scenarios did not apply directly to Trajectory Operations and as a result they were removed from consideration for this report (1-Airspace Design, 3- Manage Daily Allocation, 18- Improved Low Visibility Runway Access, 22 – Manage Security Operations).

Each of the Mid-Term Operational OV-6c Scenarios describes how the Operational Improvements could be used in a fully functional NextGen future. The TOps2 Task Group reviewed each of the scenarios from the ANSP, FOC and flight deck perspectives and identified equipment that is in use today, as well as the equipment, common services and operational improvements needed to begin the transition to TBO. In taking this approach, the TOps2 Task Group’s objective was to leverage present day equipage to provide beneficial use in the midterm while enabling a fully functional NextGen future.

The key objectives of the TOps2 Task Group’s review of the FAA/MITRE Scenarios were to address the following questions:

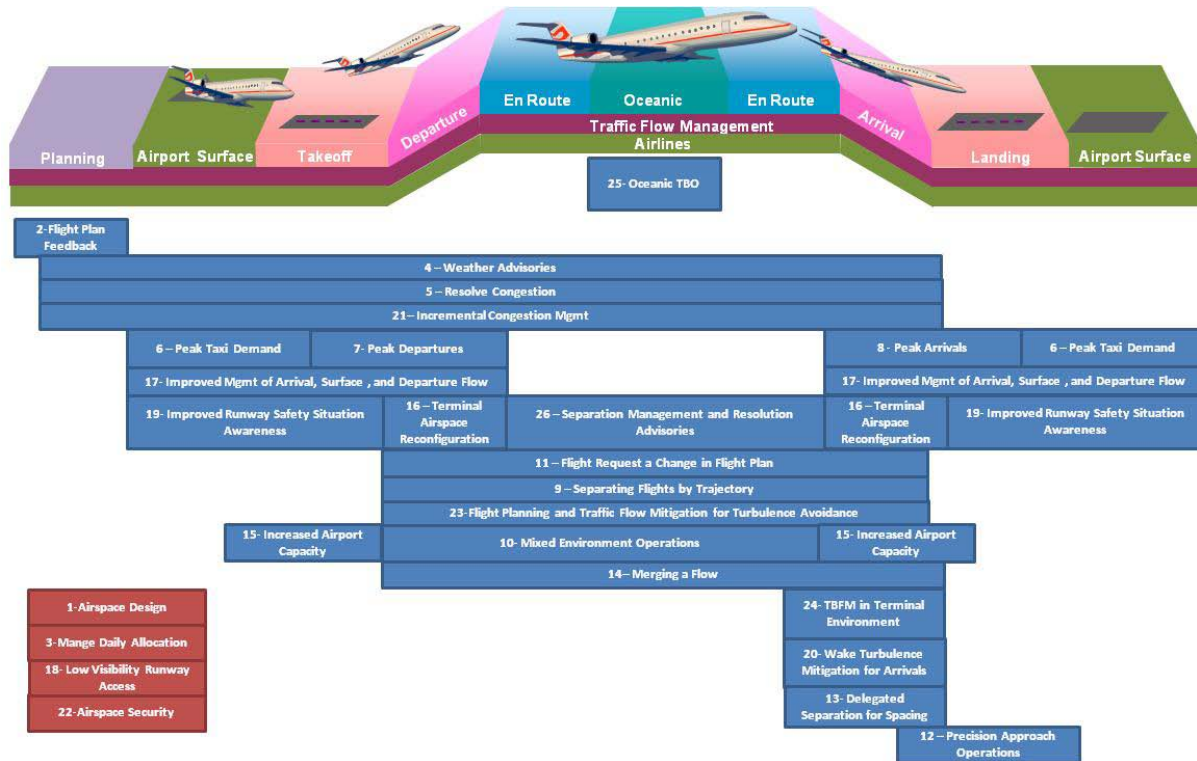
- Are the scenarios comprehensive in the coverage of all of the key aspects of the mid-term operational capabilities related to TOps?
- Do the scenarios reflect the concepts identified in the Task Force 5 recommendation?
- Do the scenarios reflect the concepts identified in the 2010 TOps2 Task Group Scenario document?
- What are the dependencies on the ‘FAAs Enablers’?
- Are there any concerns with the scenarios?
  - Systems, people responsibilities, interactions, policies or procedures.
- What are the essential capabilities that need to be implemented and deployed by 2018 to support initial trajectory-based operations?

**Figure 1: TOps2 Reference Documentation** -- provides a summary of the key reference documentation used by the TOps2 Task Group and their relationships.



**Figure 1: TOps2 Reference Documentation**

**Figure 2: Scenario Mapping to Phase of Flight** provides a summary of the operational scenarios and their associated phases of flight.



**Figure 2: Scenario Mapping to Phase of Flight**

**Figure 3: Prioritization of Scenarios** -- shows the operational scenario prioritization results of the Tops2 Task Group.

Members of the committee each had an opportunity to vote as to the relative priority of the perceived benefits, time to implement, importance to accomplishment of trajectory operations and existing capabilities of the aircraft. Each scenario was ranked in priority order and the scenarios were then bucketed into relative priority bins of high, medium and low. This recommendation along with the subsequent prioritization of operational improvements is intended to give the FAA guidance on which operational capabilities and benefits are most important to industry relative to trajectory operations. The prioritization level of Scenarios with the associated OIs may not directly correlate. The scenario prioritization is intended to organize one or more Operational Improvements into an operational thread. The Operational Improvements were ranked independently since they may cut across multiple scenarios that may have different priorities.

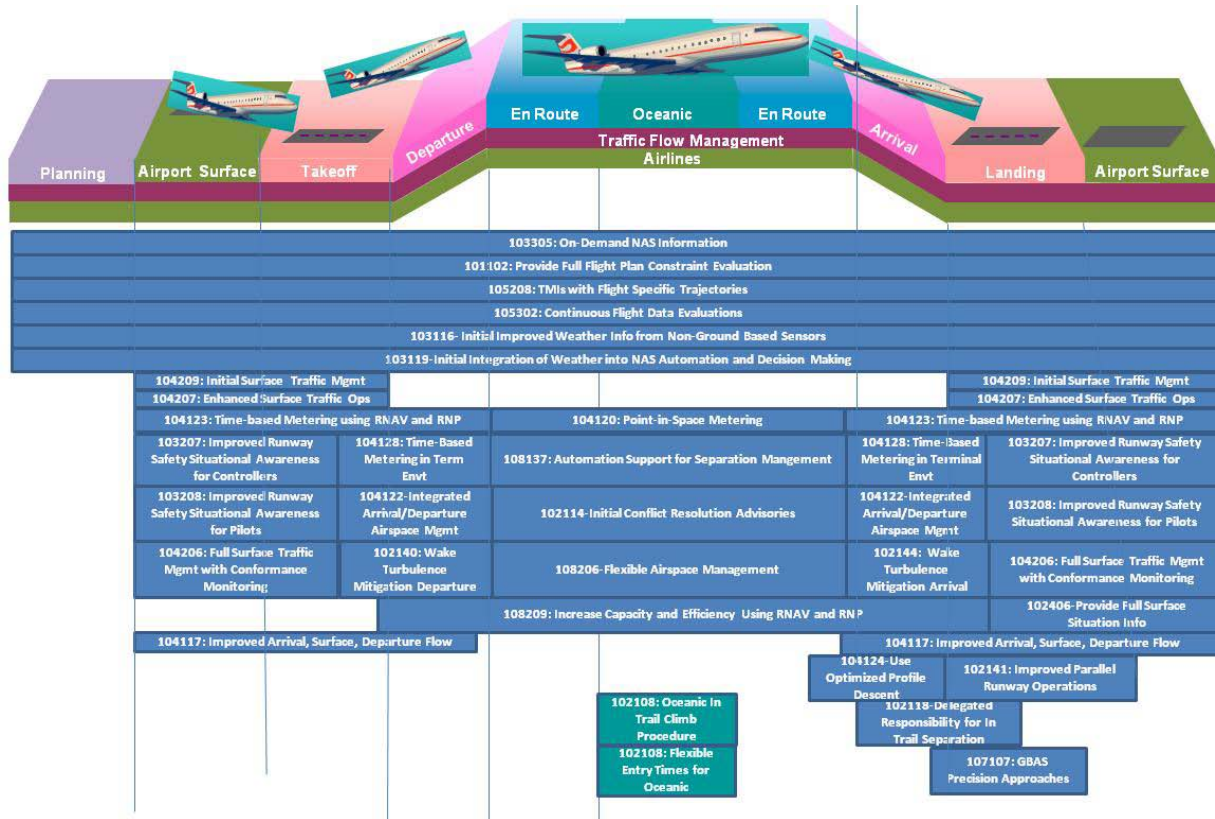
Figure 3: Prioritization of Scenarios

<b>TOps Relative Priority</b>	<b>TOps TG Score</b>	<b>Scenario Number – Scenario Name</b>
<b>High</b>	<b>1.1</b>	8-Peak Arrivals
	<b>1.2</b>	10-Mixed Environment Operations
		7- Peak Departures
	<b>1.4</b>	9-Separating Aircraft using Trajectories
		14-Merging a Flow
	<b>1.5</b>	5-Resolve Congestion
	<b>1.6</b>	2-Flight Plan (Feedback)
<b>1.7</b>	26-Separation Management and Resolution Advisories	
<b>Medium</b>	<b>1.8</b>	16-Terminal Airspace Re- Configuration
	<b>1.9</b>	15-Increased Airport Capacity
		17-Improved Management Arrival, Surface, and Departure Flow
	<b>2</b>	25-Oceanic Trajectory Based Operations (TBO)
		11-Flight Requests a Change in Flight Plan
		19-Improved Runway Safety Situational Awareness
		20-Wake Turbulence Mitigation for Arrivals (WTMA)
	24-Time-Based Flow Management (TBFM) in the Terminal Environment	
	4-Weather Advisories	
<b>Low</b>	<b>2.2</b>	23-Flight Planning and Traffic Flow Mitigation for Turbulence Avoidance
		6-Peak Taxi Demand
	<b>2.3</b>	12-Precision Approach Operations
		21-Incremental Congestion Management
	<b>2.4</b>	13-Delegated Separation Responsibility

### Operational Improvements Priorities for TBO

By starting with capabilities that reside on the ground and on a number of today’s aircraft, the TOps2 Task Group worked to identify priorities for implementing operational improvements between now and 2018.

**Figure 4: Operational Improvement Mapping to Phase of Flight** -- provides a summary of all the Trajectory Based Operational related Operational Improvements and their associated phases of flight.



**Figure 4: Operational Improvement Mapping to Phase of Flight**

**Figure 5: TOps2 Task Group Prioritization of Operational Improvements for Implementing Scenarios** -- shows a summary of the Operational Improvement prioritization results of the TOps2 Task Group. Members of the committee each had an opportunity to vote as to the relative priority of the perceived benefits, time to implement, importance to accomplishment of trajectory operations and existing capabilities of the aircraft. Each Operational Improvement was ranked in priority order and the Operational Improvements were then bucketed into relative priority bins of high, medium and low. Appendix A provides a more detailed list that provides a description for both the Operational Improvement and Operational Capability.

Figure 5: TOPs Task Group Prioritization of Operational Improvements for Implementing Scenarios

TOPs Relative Priority	TOPs-2 Score	NGIP OI #	NGIP Operational Improvement (OI) Name	NGIP OI Capability
H	1.1	105208	TMIs with Flight-specific Trajectories	Delivery of Pre-Departure Reroutes to Controllers
		108209	Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)	Large-scale Redesign of Terminal and Transition Airspace Leveraging PBN
	1.3	105208	TMIs with Flight-specific Trajectories	Basic Rerouting Capability
	1.4	104123	Time-based Metering Using RNAV and RNP route Assignment	Use RNAV Route Data to Calculate Trajectories Used to Conduct TBM Ops
		104124	Use Optimized Profile Descent	OPDs Using RNAV and RNP STARs
		104128	Time-based Metering in Terminal Environment	-
		104207	Enhanced Surface Traffic Operations	Revised Departure Clearance via Data Comm
		108209	Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)	Relative Position Indicator (RPI)
	1.5	104209	Initial Surface Traffic Management	Scheduling and Sequencing
		108209	Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)	Transition to PBN Routing for Cruise Operations
	1.6	101102	Provide Full Flight Plan Constraint Evaluation	Electronic Negotiations
		102108	Oceanic In-Trail Climb Procedure	Automatic Dependent Surveillance-Broadcast (ADS-B) Oceanic ITP and Automation
		102114	Initial Conflict Resolution Advisories	-
		104120	Point-in-Space Metering	Extended Metering
		104122	Integrated Arrival/Departure Airspace Management	-
		104124	Use Optimized Profile Descent	Initial Tailored Arrivals (ITAs)
		105302	Continuous Flight Data Evaluations	Enhanced Congestion Prediction
		108209	Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)	NextGen En Route Distance Measuring Equipment (DME) Infrastructure
M	1.7	104209	Initial Surface Traffic Management	External Data Exchange
			Runway Assignments	
	1.8	102108	Oceanic In-Trail Climb Procedure	Automatic Dependent Surveillance-Contract (ADS-C) Oceanic Climb/Descent
		102137	Automation Support for Separation Management	Automation Support for Non-Surveillance Airspace
		102141	Improved Parallel Runway Operations	Additional 7110.308 Airport
		103119	Initial Integration of Weather Info into NAS Automation and Decision Making	-
		103208	Improved Runway Safety Situational Awareness for Pilots	Moving Map with Own-ship Position
		103305	On-Demand NAS Information	Provide Improved Flight Planning and In-Flight Advisories for Flight Operations Centers (FOCs)/AOCs
	104117	Improved Arrival, Surface, Departure, Flow Operations	Integrated Departure/Arrival Capability (IDAC)	
	1.9	102108	Oceanic In-Trail Climb Procedure	ADS-C Automation for Oceanic CDP
		102137	Automation Support for Separation Management	Aircraft-to-Aircraft Alerts for 3-nm Separation Areas
				Assisted Trial Planning Onto the Radar and Data Consoles
		102406	Provide Full Surface Situation Information	-
104209		Initial Surface Traffic Management	Airport Config Mgt	
	Departure Routing			



		105302	Continuous Flight Data Evaluations	Automated Congestion Resolution
L	2	102137	Automation Support for Separation Management	Wake Vortex Separation Indicator
		102144	Wake Turbulence Mitigation for Arrivals: Closely Spaced Parallel Runways (CSPRs)	-
		104122	Integrated Arrival/Departure Airspace Management	-
		104209	Initial Surface Traffic Management	Taxi Routing
		108209	Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)	FMC Route Offset
		104102	Flexible Entry Times for Oceanic Tracks	-
	2.1	102140	Wake Turbulence Mitigation for Departures (WTMD): Wind-Based Wake Procedures	WTMD
		103208	Improved Runway Safety Situational Awareness for Pilots	CDTI with TIS-B and ADS-B for Surface
	2.2	102118	Delegated Responsibility for In-Trail Separation	-
		103207	Improved Runway Safety Situational Awareness for Controllers	ASDE-X to Additional Airports
		107107	Ground Based Augmentation System (GBAS) Precision Approaches	GBAS Cat II/III
		104206	Full Surface Traffic Management with Conformance Monitoring	-
	2.3	102141	Improved Parallel Runway Operations	Amend Independent and Dependent Runway Standards in Order 7110.65 (Including Blunder Model Analysis)
		103305	On-Demand NAS Information	Provide NAS Status via Digital Notice to Airmen (NOTAMS)
		108209	Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)	Automated Terminal Proximity Alert (ATPA) PBN Route Eligibility Check
	2.4	103116	Initial Improved Weather Info from Non-Ground-based Sensors	-
		107107	Ground Based Augmentation System (GBAS) Precision Approaches	GBAS Cat I Non-Federal Approval
		108206	Flexible Airspace Management	-
	2.5	103305	On-Demand NAS Information	Airport Data Management, Digital Notices to Airmen (NOTAMS)
	2.8	102141	Improved Parallel Runway Operations	Implement SATNAV or ILS for Parallel Runway Ops
				Wake Turbulence Mitigation for Arrivals-Procedures (WTMA-P) for Heavy/757 Aircraft

## **Analysis of Trajectory Operations Scenarios**

This section provides an overview of the 26 Mid-Term Operational OV-6c Scenarios and their underlying Operational Improvements of the NAS Enterprise Architecture that were related to TBO. It includes the comprehensive evaluations undertaken by the TOps2 Task Group. These 26 scenarios cover all the phases of the flight including Planning, Airport Surface, Departure, En route, Arrivals and Landing.

Each reviewed scenario includes the following elements:

- Description
- TOps Relative Priority
- Benefits
- Key Operational Improvements/Enablers
- Common Services Dependencies
- TOps Assumptions
- TOps Concepts
- TOps Key Findings

## Scenario 1: Airspace Design

**Description:** The airspace designer reviews historical and proposed future En Route, transition and airport traffic flows, post-operations analyses, climatological weather patterns, demonstrated NAS user preferences and common airport/special airspace requests. The information gleaned from this integrated analysis is used in the creation of predefined airspace configurations in both the enroute and terminal environments. These configurations are tailored to address anticipated NAS capacity and performance needs and impose structure only as required to optimally manage the NAS under expected weather and congestion conditions.

The TOps2 Task Group reviewed this scenario and determined it did not apply directly to Trajectory Operations and as a result it was removed as a consideration for this report.

## Scenario 2: Flight Plan Feedback (with Weather)

**Description:** The flight planner develops flight trajectories with consideration given to *business* objectives with the benefit of feedback on potential constraints from initial intent to *the* filed flight plan.

**TOps Relative Priority: High**

### Benefits:

- Increase access for the smaller flight operators through inclusion to collaborative planning for congested airspace
- End-to-end congestion and complexity impacts are managed to reduce unintended consequences and ripple effects from primary TMIs.
- Users can resolve many, if not a majority, of the potential congestion situations by stating their options for dealing with projected constraints. Flight planning data is known and shared.

### Key Operational Improvements/Enablers:

- Initial Conflict Resolution Advisories (102114) - **High**
- Continuous Flight Day Evaluation (105302) – **High**
  - With the users collaboratively and continuously assess constraints
  - With the users collaboratively develop mitigation strategies that consider the potential constraints
  - Users and Air Navigation Service Provider (ANSP) dynamically adjust both Predeparture and airborne trajectories in response to anticipated and real-time constraints
- Provide Flight Plan Constraint Evaluation with Feedback (101102) - **High**
  - Constraint information that impacts proposed flight routes is available to users for their pre-departure flight planning
  - Update notifications are provided to filers as anticipated constraints change
  - Users can adjust the flight plan based on available information, submit alternative flight plans or wait for a later time to make adjustments
  - Feedback includes the lists of applicable constraints, conditions driving the constraints, the nature of planned responses and implementation timing
- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) - **Medium**
  - Integrating observation and forecast weather information, to drive automated translation into volumetric characterizations of potential weather constraints
  - This translated information serves as direct input into decision support tools (DSTs) that assess resultant NAS impacts to inform decision making by ANSPs
  - Users will have the option of accessing this constraint information so they can better understand the basis for ANSP decision making
- On-Demand NAS Information (102114) – **High**

### **Common Service Dependencies:**

- Data Comm: Predeparture Clearances, Route Clearances
- Surveillance Common Services: ASDE-X surveillance system and/or ADS-B Out
- Weather Common Services (4-D Weather Data Cube)
- Aeronautical Common Services
- SWIM

### **TOps Assumptions:**

- Mixed Equipment Environment
- User systems for flight planning will operate at multiple levels of sophistication
- Feed back on potential constraints is provided to Flight Planning
  - Days in advance
  - At pre-departure
  - During swap route operations
  - To airborne flight plan changes requests
- The availability of weather Information will increase as 4-D weather cube information becomes available.

### **TOps Comments:**

1. Only FANS 1/A equipped aircraft are capable of participating in this operation today
2. Flight trials for Pre-Departure clearances over FANS 1/A over ACARS are expected to begin in October 2012.
3. Continuous flight plan feedback is provided with specific information on constraints (e.g., weather, congestion, mitigation plans) pertinent to the intended flight. Automated dissemination to flight crew, operations centers, and third-party service providers is supported.
4. SWIM-Users and Air Navigation Service Provider (ANSP) dynamically adjust both real-time departure and airborne trajectories in response to anticipated and real-time constraints

### **TOps Key Findings:**

1. This scenario was identified as a high priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits

### Scenario 3: Manage Daily Allocation (With Weather)

**Description:** Predefined Parameters allow selection and scheduling of airspace (sector) configuration changes to maintain throughput during weather constraints and other capacity/demand disruptions. This includes pre-coordinating configuration changes that would be used to mitigate potential weather events if they arise.

The TOps2 reviewed this scenario and determined it did not apply directly to Trajectory Operations and as a result it was removed as a consideration for this report.

## Scenario 4: Weather Advisories

**Description:** The user develops flight trajectories and objectives utilizing feedback on potential weather constraints and operational impacts. The weather impact information is developed by Weather Advisories and provided to the user by the flight plan feedback capability. Once in-flight, the pilot is automatically advised, by Weather Advisories, of changes in the weather situation that would impact the planned trajectory, or area of flight in the case of General Aviation (GA).

### **TOps Relative Priority: Med**

#### **Benefits:**

- Increase safety due to earlier warning of changes in weather situation
- Information provided that does not require user to interpret and integrate multiple weather sources, leading to improved, consistent decision making
- Users and ANSPs can negotiate strategies for dealing with weather from a common understanding of the weather
- Automated feedback to users on weather situation enables more efficient flight planning, while improving safety
- Increase safety in-flight because pilot is warned of changes in previously communicated weather

#### **Key Operational Improvements/Enablers:**

- Provide Full Flight Plan Evaluation with Constraint Feedback (101102) - **High**
  - The flight planner develops flight trajectories and objectives with the benefit of feedback on potential constraints from initial intent to filed flight plan; Initial Integration of Weather Information into NAS
- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) - **Medium**
  - Integrating current and forecast weather information into decision support tools (DST) that translate these inputs into weather impacts to inform decision making by users and ANSPs
- On-Demand NAS Information (103305) – **Medium & Low**

#### **Common Service Dependencies:**

- Data Comm: Predeparture Clearances, Route Clearances
- Weather Common Services (4D Weather Cube)
- SWIM

#### **TOps Assumptions:**

- Mixed Equipment Environment
- User systems for flight planning will operate at multiple levels of sophistication

- Feed back on potential constraints is provided to Flight Planning
  - Days in advance
  - At pre-departure
  - During swap route operations
  - To airborne flight plan changes requests
- The availability of weather information will increase as 4-D weather cube information becomes available.

**TOps Comments:**

1. Initial Conflict Resolution Advisories (102114) also contributes to this scenario for tactical resolution trajectories.
2. FANS 1/A equipped aircraft are capable of participating in this operation
3. Change in trajectory needs to be coordinated between flight deck, FOC and ATC
4. Full implementation relies on common data sharing (same data) between flight deck, FOC and ATC

**TOps Key Findings:**

1. This scenario was identified as a medium priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. FAA should ensure GA aircraft have access to the 4-D weather cube information other than over FANS 1/A+ and/or ATN data links. (103119)



## Scenario 5: Resolve Congestion

**Description:** A traffic management specialist determines when the conditions warrant taking action to resolve congestion and issues flight specific adjustments to alleviate the congestion.

**TOps Relative Priority: High**

### Benefits:

- Capacity and efficiency are increased with less frequent disruptions to individual flight profiles.
- Complex clearances are delivered efficiently to aircraft; instances of verbal miscommunication and frequency congestion are reduced.
- Aircraft are provided more efficient conflict resolutions. Capacity is increased by allowing aircraft to fly closer to the separation minima, while improving safety through more accurate conflict prediction.

### Key Operational Improvements/Enablers:

- Traffic Management Initiatives with Flight Specific Trajectories (105208) - **High**
  - Individual flight-specific trajectory changes resulting from Traffic Management Initiatives (TMIs) will be disseminated to the appropriate Air Navigation Service Provider (ANSP) automation for tactical approval and execution. This capability will increase the agility of the NAS to adjust and respond to dynamically changing conditions such as bad weather, congestion, and system outages
- Initial Conflict Resolution Advisories (102114) - **Medium**

### Common Service Dependencies:

- Data Comm: Predeparture Clearance, Route Clearance.
- SWIM

### TOps Assumptions:

- This scenario will be conducted in a mixed equipage environment
- User systems for modifying flight planning can operate at multiple levels of sophistication
- Individual flight-specific trajectory changes can be sent to equipped aircraft and FOC

### TOps Comments:

1. This Scenario is essential to the FAA Data Communications “Go Button” function.
2. Present day equipage can be leveraged to provide beneficial use in the near term as more robust capabilities are developed for the future.
3. Alternate routing can be based on “Play Book” routes
4. FANS 1/A+ equipped aircraft are capable of participating in this operation.
5. Change in trajectory needs to be coordinated between flight deck, FOC and ATC

6. Full implementation relies on SWIM, ERAM, CTOP capabilities, CACR
7. Full implementation is dependent on Automation and Decision Making (103119)

**TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.

## Scenario 6: Peak Taxi Demand

**Description:** This thread demonstrates how surface automation capabilities provide for more efficient means of surface operations. Primary focus is on improved taxi routing and conformance monitoring operations.

**TOps Relative Priority: Low**

### Benefits:

- Throughput and capacity at high-density airports are increased. Schedule integrity is maintained and demand is more accurately predicted.
- Efficiency of airport operations is improved along with increased flexibility in staging arrival and departure flows in and out of high-density airports. This results in shorter departure queues and reduced fuel burn and engine emissions. More timely distribution of weather information results in faster turnaround of the airport due to weather impacts and enhanced safety.

### Key Operational Improvements/Enablers:

- Initial Surface Traffic Management (104209) - **High, Medium & Low**
  - Automation of sequencing and staging of surface traffic, primarily Departure traffic, at high density airports to maintain throughput
- Provide Full Surface Situational Information (102406) - **Medium**
  - Automated broadcast of aircraft and vehicle position to ground and aircraft sensors/receivers will provide a common digital display of the airport environment to Air Navigation Service Provider (ANSP), equipped aircraft, and Flight Operations Center
- Enhanced Surface Traffic Operations (104207) - **High**
  - Data communication between aircraft and ANSP will be used to exchange clearances, amendments, requests, NAS status, weather information, and surface movement instructions

### Common Service Dependencies:

- Surveillance Common Services : ASDE-X surveillance system and/or ADS-B Out
- Flight Common Services
- SWIM

### TOps Assumptions:

- The capability of Aircraft to receive taxi route instruction and clearance delivery via data comm. is post Mid-Term.
- This scenario will be conducted in a mixed equipage environment
- Ground Automation performs surface sequencing

### TOps Comments:

1. Ground Automation (DST for surface trajectories) is required to perform sequencing.
2. To be fully implemented, automation will be required to determine off-nominal taxi operations
3. Non-conformance alerting to the flight crew is delayed when alerting automation only resides on the ground.
4. Non-conformance alerting to the controller cannot rely on cockpit automation.
5. Automation to determine off-nominal taxi operations should reside on the flight deck as well as on the ground.
6. SWIM and Data Comm are used to coordinate clearances, amendments, NAS status, and user requests (Data exchange in terms of surface management applications for FOC's.)
7. Inclusion of elements of CDM Surface sub team concept of operations is a critical component of providing insight into collaborative planning and execution.

**TOps Key Findings:**

1. The capability to send Data Comm Taxi clearances is post Mid-Term.
2. This scenario was identified as a Low priority scenario.
3. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
4. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.

## Scenario 7: Peak Departures

**Description:** This thread highlights the use of automated collaborative scheduling capabilities and the use of time based metering and RNAV and RNP routes to improve departure operations.

**TOps Relative Priority: High**

### Benefits:

- Throughput and capacity at high-density airports are increased. Schedule integrity is maintained and demand is more accurately predicted.
- Efficiency of airport operations is improved along with increased flexibility in staging arrival and departure flows in and out of high-density airports. This results in shorter departure queues and reduced fuel burn and engine emissions. More timely distribution of weather information results in faster turnaround of the airport due to weather impacts and enhanced safety.
- Efficiency and airport throughput are increased by rapidly adjusting and retransmitting revised departure clearances in response to changing conditions.

### Key Operational Improvements/Enablers:

- Initial Surface Traffic Management (104209) – **High & Medium**
  - Automation of sequencing and staging of surface traffic at high density airports to maintain throughput
- Enhanced Surface Traffic Operations (104207) - **High**
  - Data communication between aircraft and Air Navigation Service Provider (ANSP) will be used to exchange departure clearances and amendments, requests, NAS status, weather information, and surface movement instructions
- Point in Space Metering (104120) - **High**
  - Provides greater flexibility in assigning metering fixes in support of Trajectory-based operations and RNAV or RNP, e.g., Setting up a Departure Fix as a resource
- Time-Based Metering Using RNAV and RNP Route Assignments (104123) - **High**
  - RNAV or RNP departure routes will facilitate accurate arrival at metering fixes thus improving efficient merging into overhead flow
- Integrated Arrival/Departure Airspace Management (104122) – **High & Low**
  - New airspace configurations and expanded separation standards and procedures provide increased flexibility toward increasing capacity at high volume airports

### Common Service Dependencies:

- Data Comm: Predeparture Clearances
- Surveillance Common Services
- Flight Common Services
- Weather Common Services
- Aeronautical Common Services

- Present day use of FANS 1/A over ACARS and FANS 1/A+ over ACARS transitioning to FANS 1/A+ over VDL Mode 2 and SC-214 over ATN.

#### **TOps Assumptions:**

- This scenario will be conducted in a mixed equipage environment
- RNAV or RNP routes and procedures begin “off the runway” and are closed (no vector legs) through the TRACON
- Individual flight-specific trajectory changes can be sent to aircraft equipped with Data Comm and RNAV/RNP and the FOC. If the trajectory changes are on defined procedures, then they could be sent via voice.

#### **TOps Comments:**

1. Present day equipage can be leveraged to provide beneficial use in the near term as more robust capabilities are developed for the future.
2. Portions of this scenario can be implemented without a fully integrating Point in Space Metering
3. Initial implementation could utilize multiple alternate routes selected from a “Play Book”
4. FANS 1/A equipped aircraft are capable of participating in this operation
5. Change in trajectory needs to be coordinated between flight deck, FOC and ATC
6. Full implementation relies on Time-Based Metering Using RNAV and RNP Route Assignments (104123)
7. Full implementation relies on 4-D weather Cube, TBFM, SWIM, ERAM.
8. Full implementation is dependent on Automation and Decision Making (103119)

#### **TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. Implement the capabilities outlined in this scenario in steps leveraging present day equipage (FANS 1/A and ACARS equipped aircraft); Note: this is being done in the DCIT DCL Flight trials
5. Implement using stored departure “Play Book” routes, transition to Automation and Decision Making as it becomes available.
6. Transition to RNAV routes and procedures as they become available and transition to Required Navigational Performance (RNP) routes and procedures when required

## Scenario 8: Peak Arrivals

**Description:** This scenario describes how peak arrival flows would be managed starting from Top of Descent (ToD) in order to meet a meter fix crossing time (MFT) with greater accuracy while allowing for some flight descent efficiency. This thread incorporates ground-based automation, flight deck capabilities, and data communication to utilize closed-loop maneuvers for enabling descent efficiency and for more accurately meeting the meter fix schedule so that in-trail aircraft spacing beyond the MFT is improved.

### **TOps Relative Priority: High**

#### **Benefits:**

- Arrival/departure operations and terminal/en route transition planning functions improve. Capacity, safety, and efficiency increase.
- Departure capacity increases. A greater number of routes provide more flexibility to respond to severe weather, traffic, and SAA constraints.
- Aircraft are provided more efficient conflict resolutions. Capacity is increased by allowing aircraft to fly closer to the separation minima, while improving safety through more accurate conflict prediction.

#### **Key Operational Improvements/Enablers:**

- Time-Based Metering using RNAV and RNP Route Assignments (104123) : **High**
  - RNAV and RNP routes improve repeatability and predictability of flight tracks which improves meter fix time schedules
  - Provides alternate routes in transition airspace to a meter fix on a separate path if load balancing is needed
  - Potentially makes new runway assignments
- Increase Capacity and Efficiency using RNAV and RNP (108209) : **High & Low**
  - Provides the structure for route assignments
  - Enables more efficient aircraft trajectories
- Initial Conflict Resolution Advisories (102114) : **High**
  - Conflict probe with rank-ordered resolution advisories
    - For aircraft-to-aircraft separation

#### **Common Service Dependencies:**

- Data Comm: Predeparture Clearances, Route Clearances, Initial Tailored Arrivals
- Flight Common Services
- Surveillance Common Services : ADS-B
- Weather Common Services
- Aeronautical Common Services

**Aircraft Enabler:**

- ADS-B Out
- ADS-B In to support FIM-s
- FIM-S
- RNAV/RNP with enhanced TOAC

**TOps Assumptions:**

- This scenario will be conducted in a mixed Data Comm and ADS-B equipage environment
- Aircraft automation for spacing (FIM-S) may be used selectively (Step 6 in Scenario)
- Aircraft will equip with pairwise Interval Management as the business case allows
- Initial deployment of GIM-S automation will have begun
- Flight deck Interval Management Spacing (FIM-S) could be pilot initiated
- FIM-S spacing instructions can be passed over CPDLC as a Free text message
- A DataComm integrated FMS is required for autoloading complex clearances

**TOps Comments:**

1. Requires DSTs and automation to support revised trajectories, more precise meter times, and dynamic runway assignments
2. The alternative path maneuvers could begin with voice clearances and could evolve to a non-integrated Data Comm capability and then to integrated Data Comm capabilities with route clearance messages (FANS 1/A+)
3. Multiple arrival procedures with a late merge also would greatly help, but such airspace re-design is likely outside the mid-term.
4. The controller could select an appropriate arrival from a list of stored arrival “Play Book” routes.
5. If TBFM automation takes into account the specific RNAV/RNP procedure and speeds that will be flown beyond the Metering Fix, the adjustments to the aircraft needed after the metering fix could be minimized (DFW Metroplex project currently evaluating this)
6. Transition to GIM Automation and Decision Making as it becomes available.
7. FIM-S may be conducted in pairwise intervals and can be done in a mixed environment

**TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. This scenario can be partially implemented without a Data Comm Integrated FMS. However, this scenario is dependent on the availability of this capability to realize the full benefits.



5. Flight Interval Management will be operating in a mixed environment in 2018 limited by the availability of aircraft equipped with ADS-B In and ADS-B out.
6. Elements of scenario can be implemented incrementally and should be implemented as soon as possible
  - a. Transition to Time Based Flow Metering as soon as the enhancements become operational
  - b. Implement Data Linked arrival trajectories based on stored arrival "Play Book" routes
  - c. Transition to Dynamically developed Data Linked arrival trajectories (Non-"Play Book" routes) as Initial Conflict Resolution Advisories (102114) become available.
  - d. Implementation of FIM-S can run concurrently with Data Linked arrival trajectories
  - e. GIM-S instructions can be passed via FANS 1/A+ over ACARS transitioning to FANS 1/A+ over VDL Mode 2 and SC-214 over ATN.
  - f. Although a simple path stretch can be given verbally it is recommended that they be given via data link for aircraft equipped to accept a Data Comm route clearance.
  - g. Transition to RNAV routes and procedures as they become available and transition to Required Navigational Performance (RNP) routes and procedures when required
7. Implement the capabilities of this scenario in steps leveraging present day equipage (FANS 1/A+ and ACARS equipped aircraft).
8. Implement using stored arrival "Play Book" routes, transition to Automation and Decision Making as it becomes available.
9. The operational concept using both Ground and Aircraft Internal management needs to be completed.

## Scenario 9: Separating Aircraft using Trajectories

**Description:** This thread illustrates how 4D trajectories are used for separation in en route operations. The use of trajectories supports automated problem detection and resolution with strategic problem notification. Examples are provided for (1) the use of trajectories in resolving an aircraft-to-aircraft problem detected by the automation and notified to the controller and (2) the use of air-ground data communications by the aircraft to request and be cleared on a user- preferred route during changing weather conditions.

**TOps Relative Priority: High**

### Benefits:

- Increased predictability allows for increased throughput; conflicting trajectories are known further in advance, improving safety; automation increases controller effectiveness in supporting user preferences
- Automating routine information exchange increases efficiency, reduces instances of verbal miscommunication, allows for delivery of more complex clearances, and reduces frequency congestion
- Aircraft are provided more efficient conflict resolutions. Capacity is increased by allowing aircraft to fly closer to the separation minima, while improving safety through more accurate conflict prediction.

### Key Operational Improvements/Enablers:

- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) : **Medium**
  - Volumetric characterizations of weather-constrained airspace provided to automation, ANSPs, and users to support en route operations
  - Automation translates weather information into potentially constrained airspace (e.g., where pilots may not want to fly)
  - As operationally relevant weather changes occur, updates are automatically pushed, to increase available response time
- Initial Conflict Resolution Advisories (102114) : **High**
  - ANSP conflict probe is enhanced to provide rank-ordered resolution advisories
  - Conflict detection, trial planning and resolution automation enable ANSP to better accommodate pilot requests for trajectory changes and tailor clearances to the communications medium
  - Automation probes aircraft-to-aircraft problem resolution advisories against weather constrained airspace to avoid unknowingly directing aircraft into hazardous weather
    - The aim is not to separate aircraft from weather, but rather ensure that ranking takes weather (and other constraints) into consideration
- Increase Capacity and Efficiency Using RNAV and RNP (108209) : **High & Low**

- RNAV and RNP enable more efficient aircraft trajectories
- RNAV and RNP permit the flexibility of point-to-point operations and allow for the development of routes, procedures, and approaches that are more efficient and free from constraints and inefficiencies of the ground-based NAVAIDs

**Common Service Dependencies:**

- Data Comm: Route Clearances
- Flight Common Services
- Surveillance Common Services : ADS-B
- Weather Common Services
- Aeronautical Common Services
- SWIM

**TOps Assumptions:**

- Mixed Equipment Environment
- Limited Data Comm (SC-214 over ATN) deployment prior to 2018
- A DataComm integrated FMS is required for autoloading complex clearances
- RNAV/RNP with enhanced TOAC will be more widely available prior to 2018

**TOps Comments:**

1. Uploading directly into the Navigation system (FMS) requires integrated Data Comm. especially for types of resolutions shown if a closed path (non-vector, where turn off, turn back, and rejoin points are defined) is desired.
2. Full operations rely on SWIM, Characterization of weather-constrained airspace (Weather Cube)

**TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. This scenario can be partially implemented without a Data Comm Integrated FMS. However, this scenario is dependent on the availability of this capability to realize the full benefits.
5. Transition to RNAV routes and procedures as they become available and transition to Required Navigational Performance (RNP) routes and procedures when required.

## Scenario 10: Mixed Environment Operations

**Description:** This thread illustrates complex mixed environment situations requiring automation support for controller situation awareness and separation management. Following a position relieve briefing, a set of near simultaneous events occur which the controller must address. 1) A stream of aircraft is overtaking a set of slower aircraft on the same RNAV Route. 2) Handoff of aircraft in delegated separation 3) Automation detects an aircraft drifting away from its RNP-2 route. 4) Automation detects an aircraft with a planned climb. 5) A traffic management initiative is issued to reroute arrival stream to join alternate RNAV STARs as a result of terminal airspace reconfiguration.

**TOps Relative Priority: High**

### **Benefits:**

- Increased predictability allows for increased through put; conflicting trajectories are known further in advance, improving safety; automation increases controller effectiveness in supporting user preferences
- Automating routine information exchange increases efficiency, reduces instances of verbal miscommunication, allows for delivery of more complex clearances, and reduces frequency congestion
- Aircraft are provided more efficient conflict resolutions. Capacity is increased by allowing aircraft to fly closer to the separation minima, while improving safety through more accurate conflict prediction.

### **Key Operational Improvements/Enablers:**

- Automation Support for Separation Management (102137) : **Medium & Low**
  - ANSP automation provides the controller with tools to manage aircraft in a mixed navigation and wake performance environment
  - ANSP automation enhancements provide situational awareness of aircraft with advanced capabilities (e.g., delegated separation maneuvers, equipped vs. non-equipped aircraft, RNAV, RNP and trajectory flight management)
  - Tools assist controller in coordinating with other facilities or positions when aircraft are performing delegated separation maneuvers
- Initial Conflict Resolution Advisories (102114) : **High**
  - ANSP conflict probe is enhanced to provide rank-ordered resolution advisories
  - Conflict detection, trial planning and resolution automation enable ANSP to better accommodate pilot requests for trajectory changes and tailor to communication medium
- Increase Capacity and Efficiency Using RNAV and RNP (108209) : **High & Low**
  - RNAV and RNP enables more efficient aircraft trajectories

- RNAV and RNP permit the flexibility of point-to-point operations and allow for the development of routes, procedures, and approaches that are more efficient and free from constraints and inefficiencies of the ground-based NAVAIDs
- Delegated Responsibility for In-Trail Separation (102118) : **Low**
  - Enhanced surveillance and new procedures enable the ANSP to delegate aircraft-to-aircraft separation
- Traffic Management Initiatives with Flight Specific Trajectories (105208) : **High**
  - Individual flight-specific trajectory changes resulting from Traffic Management Initiatives (TMIs) will be disseminated to the appropriate Air Navigation Service Provider (ANSP) automation for tactical approval and execution

**Common Service Dependencies:**

- Data Comm: Route Clearances
- Surveillance Common Services : ADS-B
- Flight Common Services
- Weather Common Services
- Aeronautical Common Services

**Aircraft Enablers:**

- ADS-B Out
- ADS-B In
- FIM-S
- FIM-DS
- RNAV/RNP with enhanced TOAC

**TOps Assumptions:**

- Mixed Equipment Environment
- A DataComm integrated FMS is required for autoloading complex clearances
- Aircraft automation for Interval Management - Spacing (FIM-S) will be used selectively
- Aircraft automation for Interval Management - Delegated Separation (FIM-DS) will be used selectively
- Aircraft will equip with FIM-S and FIM-DS as the business case allows
- Initial deployment of GIM-S automation will have begun
- FIM-S could be pilot initiated
- The use of FIM-DS will be at controller's discretion
- Initial FIM-S spacing instructions can be passed over CPDLC as a Free text message
- Initial FIM-DS spacing instructions can be passed over CPDLC as a Free text message

**TOps Comments:**

1. Need to consider certification implications of having many different types of equipage combinations and operations that this equipment must be certified for. In addition to aircraft certification issues, there would also be impacts on the ground automation and controllers to have knowledge of what kind of clearance can be sent to which aircraft depending on equipage. How many different “equipage categories” can realistically be differentiated?

**TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. This scenario can be partially implemented without a Data Comm Integrated FMS. However, this scenario is dependent on the availability of this capability to realize the full benefits.
5. Flight Interval Management will be operating in a mixed environment in 2018 limited by the availability of aircraft equipped with ADS-B In and ADS-B out.
6. Transition to RNAV routes and procedures as they become available and transition to Required Navigational Performance (RNP) routes and procedures when required.

## Scenario 11: Flight Requests a Change in Flight Plan

**Description:** A pilot requests a flight change based on weather conditions, which exceed their company operating parameters (e.g., moderate turbulence). Several other flights from the same company and others are on a similar route/altitude. As the sector controller evaluates the pilot's request and provides clearance, the traffic management coordinator (TMC) prepares for the likely cascade of requests by reviewing how to address the intent options of each.

**TOps Relative Priority: Medium**

### Benefits:

- Routing disruptions from Traffic Management Initiatives (TMIs) are reduced. NAS-wide congestion and capacity impacts are diminished.
- Users can resolve many, if not a majority, of the potential congestion situations by stating their options for dealing with projected constraints. Flight planning data is known and shared.
- End-to-end congestion and complexity impacts are managed to reduce unintended consequences and ripple effects from primary TMIs.
- Efficiency of airport operations is improved along with increased flexibility in staging arrival and departure flows in and out of high-density airports. This results in shorter departure queues and reduced fuel burn and engine emissions. More timely distribution of weather information results in faster turnaround of the airport due to weather impacts and enhanced safety.

### Key Operational Improvements/Enablers:

- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) : **Medium**
  - Integrate weather information and its expected impact on individual 4D trajectories into decision-support tools
  - Provide flow managers with a risk-based tool for strategic decision making
- Continuous Flight Day Evaluation (105302) : **High & Medium**
  - With the users collaboratively and continuously assess constraints
  - With the users collaboratively develop mitigation strategies that consider the potential constraints
  - Users and Air Navigation Service Provider (ANSP) dynamically adjust both pre-departure and airborne trajectories in response to anticipated and real-time constraints
- On-Demand NAS Information (103305) : **Medium & Low**
  - NAS and aeronautical information is consistent across applications and locations, and available to authorized subscribers and equipped aircraft
  - Information and updates are obtained in a near real-time and distributed in a user-friendly digital or graphic format.

### Common Service Dependencies:

- Data Comm: Predeparture Clearances, Route Clearances
- Flight Common Services
- Weather Common Services (4D Weather Cube)
- Aeronautical Common Services
- SWIM

**TOps Assumptions:**

- Mixed Equipment Environment
- Users can participate at different levels
- RNAV/RNP with enhanced TOAC will be more widely available prior to 2018

**TOps Comments:**

1. SWIM and 4D Weather Cube are not required for the pilot to request a flight change based on weather conditions, which exceed their company operating parameters (e.g., moderate turbulence) or compromise safe operation. Related OIs include the following: Initial Integration of Weather Information into NAS Automation and Decision Making (103119), Continuous Flight Day Evaluation (105302), On-Demand NAS Information (103305). They all add value to the basic capability of avoiding the weather.
2. Advanced DSTs are required to incorporate NextGen Network weather
3. SWIM, Data Communications (SC-214 via ATN) and 4D Weather Cube are required to fully implement the operational capabilities in this scenario

**TOps Key Findings:**

1. This scenario was identified as a Med priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. Initial Integration of Weather Information into NAS Automation and Decision Making (103119), Continuous Flight Day Evaluation (105302), On-Demand NAS Information (103305) all add to the robustness of conducting closed loop airborne reroutes enabled by Initial Conflict Resolution Advisories (102114) and Automation Support for Separation Management (102137).



## Scenario 12: Precision Approach Operations

**Description:** This scenario presents the use of an RNAV optimized profile descent (OPD) that begins at an aircraft's top of descent and transits through low to medium density terminal airspace before merging seamlessly with a Ground Based Augmentation System (GBAS) Category II, precision instrument approach.

**TOps Relative Priority: Low**

### Benefits:

- Fuel efficiency improves, and noise, emissions, and holding are reduced.
- Service to airports is expanded, and airport capacity is increased in IFR through increased availability of precision approaches and efficiency of runway operations.
- Departure capacity increases. A greater number of routes provide more flexibility to respond to severe weather, traffic, and SAA constraints.

### Key Operational Improvements/Enablers:

- Use Optimized Profile Descent (104124) : **High**
  - OPDs permit aircraft to remain at higher altitudes on arrival to the airport and use lower power settings during descent
  - OPD arrival procedures will decrease noise and be more fuel-efficient
- Increase Capacity and Efficiency Using RNAV and RNP (108209) : **High & Low**
  - Both RNAV and RNP will enable more efficient aircraft trajectories
  - RNAV and RNP combined with airspace changes, increase airspace efficiency and capacity
- Ground Based Augmentation System (GBAS) Precision Approaches (107107) : **Low**
  - GLS supports precision approaches to Category I/II/III minimums
  - GLS can support approach minimums to all runway ends at an airport with fewer restrictions to surface movement, and offers the potential for curved precision approaches

### Common Service Dependencies:

- Data Comm: Route Clearances, Initial Tailored Arrivals
- Flight Common Services
- Surveillance Common Services : ADS-B
- Weather Common Services
- Aeronautical Common Services

### TOps Assumptions:

- Mixed Equipment Environment

- Users can participate at different levels
- RNAV/RNP with enhanced TOAC will be more widely available prior to 2018

**TOps Comments:**

1. Vulnerability of GPS signals is a concern for the implementation of Trajectory Operations.
2. Use of Optimized Profile Descent (104124), Increase Capacity and Efficiency Using RNAV and RNP (108209) and Ground Based Augmentation System (GBAS) Precision Approaches (107107) make Trajectory Operations more robust and can all be elements of trajectory requests or as data link clearances sent to the flight deck.

**TOps Key Findings:**

1. This scenario was identified as a Low priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be mostly implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. This scenario is dependent on ADS-B, ADS-B in Cockpit Display of Traffic Information (CDTI) and spacing automation for the performing aircraft.
5. The development and implementation of Use Optimized Profile Descent (104124), Increase Capacity and Efficiency Using RNAV and RNP (108209) and Ground Based Augmentation System (GBAS) Precision Approaches (107107) can be done in parallel.
6. Leverage the FANS equipage that the airlines have already invested in by developing Tailored Arrivals that can be converted into Optimized Profile Descents (104124).

## Scenario 13: Delegated Separation Responsibility

**Description:** For appropriately equipped aircraft the controller has the option of delegating responsibility for separation between two aircraft. This thread only illustrates delegated spacing in the en route environment.

**TOps Relative Priority: Low**

### Benefits:

- Delegation of separation responsibility to aircraft reduces the controllers' workload
- Improve Fuel efficiency

### Key Operational Improvements/Enablers:

- Delegated Responsibility for In-Trail Separation (102118) : **Low**
  - Enhanced surveillance and new procedures enable the controller to delegate aircraft-to-aircraft separation
  - Improved display avionics and broadcast positional data provide detailed traffic situational awareness to the flight deck
  - When authorized by the controller, pilots will implement delegated separation between appropriately equipped aircraft using established procedures
- Initial Conflict Resolution Advisories (102114) : **High**
  - Conflict detection, trail planning and resolution automation enable ANSP to better accommodate pilot requests for trajectory changes and tailor to communication medium available (ie Voice or Data Comm).

### Common Service Dependencies:

- Data Comm: Predeparture Clearances, Route Clearances, Initial Tailored Arrivals
- Flight Common Services
- Surveillance Common Services : ADS-B
- Weather Common Services
- Aeronautical Common Services

### Aircraft Enabler:

- ADS-B Out
- ADS-B In

### TOps Assumptions:

- Mixed Equipment Environment
  - ADS-B out for the target aircraft

- ADS-B in, Cockpit Display of Traffic Information (CDTI), and spacing automation for the performing aircraft
- Delegation will be at controller's discretion
- Aircraft capabilities and pilot authorizations are stored in the Flight Object
- Information in the Flight Object is available to the controllers for display
- Delegation will be used for certain flight geometries (e.g. in trail)
- Pilot can accept or reject the delegation
  - Flight deck automation must be capable of supporting the pilot in achieving and maintaining spacing
- SC-214 via ATN will support FIM-DS message sets

**TOps Comments:**

1. Advanced DSTs are required to implement Delegated Responsibility for In-Trail Separation (102118)

**TOps Key Findings:**

1. This scenario was identified as a Low priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits
4. Flight Interval Management will be operating in a mixed environment in 2018 limited by the availability of aircraft equipped with ADS-B In and ADS-B out.

## Scenario 14: Merging a Flow

**Description:** This scenario describes the TMC's role to look across multiple sectors (or an Area) to evaluate possible points where flights in one stream can merge into another flow of aircraft. The TMC uses automation support to determine which trajectory modification will allow each aircraft to merge into a gap in the flow, and then sends a problem-checked trial plan for that modification to the Sector Controller for implementation.

**TOps Relative Priority: High**

### **Benefits:**

- Arrival/departure operations and terminal/en route transition planning functions improve. Capacity, safety, and efficiency increase.
- Departure capacity increases. A greater number of routes provide more flexibility to respond to severe weather, traffic, and SAA constraints

### **Key Operational Improvements/Enablers:**

- Point-in-Space Metering (104120) : **High**
  - Decision support tools
    - Allow traffic managers to schedule arrival times for constrained resources
    - Allow controllers to manage aircraft trajectories to meet the scheduled meter times
  - Metering can be associated with a point in space (or arc)
- Time Based Metering Using RNAV and RNP Route Assignments (104123) : **High**
  - Metering automation will manage the flow of aircraft to meter fixes, thus permitting efficient use of runways and airspace
- Automation Support for Separation Management (102137) : **Medium & Low**
  - Controllers have tools that assist them in coordinating with other facilities or positions when aircraft are flying parallel RNAV and RNP routes
- Initial Conflict Resolution Advisories (102114) : **High**
  - Automation recommends trajectories that will fulfill the metering schedule.

### **Common Service Dependencies:**

- Data Comm: Route Clearances
- Flight Common Services
- Weather Common Services
- Aeronautical Common Services

### **TOps Assumptions:**

- Mixed Equipment Environment

- Users can participate at different levels
- RNAV/RNP with enhanced TOAC will be more widely available prior to 2018

**TOps Comments:**

1. TMC Uses “Go Button” to Issue Trajectories that Satisfy Meter Times
2. Building trajectories to meet the sequence requires accurate trajectory predictor in ERAM and/or TBFM to perform what-iffing of potential trajectories - especially if non level maneuvers are involved in meeting the sequence.
3. RNAV/RNP with TOAC on the aircraft and downlink of 4DT from the aircraft can be used to improve the accuracy of predictions at the merge point
4. Point-in-Space Metering (104120) can be achieved by having the Sector Controller advise the flight of either a new path or time to fly

**TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.

## Scenario 15: Increased Airport Capacity

**Description:** This scenario combines new automation support for the controller with advanced avionics and flight deck automation support for the pilot to enable an advanced procedure that allows properly equipped and performance-compatible aircraft to be paired and flown together on a precision path to closely spaced parallel runways at significantly reduced separation standards in reduced visibility conditions.

**TOps Relative Priority: Med**

### Benefits:

- More efficient use of closely spaced parallel runways in IMC conditions decreases delays and operational costs due to weather.

### Key Operational Improvements/Enablers:

- Improved Parallel Runway Operations (102144) : **Low**
  - Develop new IFR standards that allow closer runway spacing
  - Maintain access to CSPRs in limited visibility by integrating new aircraft technologies
- Wake Turbulence Mitigation for Departures (WTMD): Wind-Based Wake Procedures (102140) : **Low**
  - Increase departure throughput during favorable wind conditions
  - New technology, standards, and procedures will reduce impact of wake vortices
- Automation Support for Separation Management (102137) : **Medium & Low**
  - Automation tools will assist the controller in a mixed navigation and wake performance environment
  - ANSP automation enhancements will provide situational awareness of aircraft with advanced capabilities

### Common Service Dependencies:

- Data Comm: New CPDLC messages to be defined by Interval Management Adhoc Industry Group
- Flight Common Services
- Surveillance Common Services : ADS-B
- Weather Common Services
- Aeronautical Common Services

### Aircraft Enabler:

- ADS-B Out
- ADS-B In to support FIM-s

- FIM-S
- RNAV/RNP with enhanced TOAC

**TOps Assumptions:**

- Mixed Equipment Environment
- Delegated separation between paired aircraft is required to mitigate risk
  - Pilot, with automation assistance, is responsible for maintaining paired position
  - Pilot takes avoidance action, when required, based on system alerts and displays

**TOps Comments:**

1. NASA completed an experiment on airborne Interval Management with Spacing to Dependent Parallel Runways in June 2011 using a simulated FANS environment to pass very complex route and spacing instructions.
2. NASA has proposed an Airborne Demonstration by NASA in 2014
3. Controller DSTs are required to support the mixed equipage environment

**TOps Key Findings:**

1. This scenario was identified as a Med priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. Flight Interval Management will be operating in a mixed environment in 2018 limited by the availability of aircraft equipped with ADS-B In and ADS-B out.
5. The capabilities of Wake Turbulence Mitigation for Departures (WTMD): Wind-Based Wake Procedures (102140) Operational Improvement can be implemented in steps and early steps should not be delayed.



## Scenario 16: Terminal Airspace Re-Configuration

**Description:** This scenario presents a Big Airspace (BA) environment, during a busy arrival and departure time, when a dynamic severe weather event occurs within the boundary of the BA facility. New processes and capabilities are highlighted that will help to improve the transition to a new terminal airspace configuration.

**Tops Relative Priority: High**

### Benefits:

- Terminal area throughput increases using reduced separation earlier in the arrival sequence.
- Delays are reduced by more efficient route sequencing, more effective weather avoidance, decreased vectoring close to the airport, and reduced coordination between terminal and en route controllers.
- Departure capacity increases. A greater number of routes provide more flexibility to respond to severe weather, traffic, and SAA constraints.

### Key Operational Improvements/Enablers:

- Integrated Arrival/Departure Airspace Management (104122) : **High & Low**
- Continuous Flight Day Evaluation (105302) : **High & Med**
  - Air Navigation Service Providers (ANSP) and users collaboratively and continuously assess constraints (e.g., hazardous weather) and associated Traffic Management Initiative (TMI) mitigation strategies (see 'Manage Daily Allocation' scenario)
- Increased Capacity and Efficiency Using RNAV and Required Navigation Performance (RNP) (108209) : **High & Low**
  - Terminal and en route procedures will be designed for more efficient spacing and will address complex operations
- Flexible Airspace Management (108206) : **Low**
  - ANSP automation supports reallocation of trajectory information, surveillance, communications and display information to different positions or different facilities
  - Automated tools to support assessment of alternate configurations and remapping of information to appropriate positions
- Traffic Management Initiatives with Flight Specific Trajectories (105208) : **High**
  - Individual flight-specific trajectory changes resulting from Traffic Management Initiatives (TMIs) will be disseminated to the appropriate Air Navigation Service Provider (ANSP) automation for tactical approval and execution
- Time Based Metering in the Terminal Environment (104128) : **High**
  - RNAV and RNP routes improve repeatability and predictability of flight tracks which improves meter fix time schedules
  - Provides alternate routes in transition airspace to a meter fix on a separate path if load balancing is needed

- Potentially makes new runway assignments
- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) : **Medium**
  - Volumetric characterizations of weather-impacted airspace at and around the airport, along with their probabilities, are provided to assist in planning arrival/departure airspace configurations
  - As weather changes occur, updates are pushed to ANSPs, users, and DSTs, to increase available response time
    - Volumetric characterizations of weather constraints are utilized to calculate the impact on active and alternative terminal airspace configurations and RNAV/RNP routings
- Initial Conflict Resolution Advisories (102114) : **High**
  - Automation enables the Air Navigation Service Provider (ANSP) to better accommodate pilot requests of trajectory changes by providing conflict detection and flight planning, and development and rank-ordering of resolutions taking into account aircraft capabilities and pilot and ANSP preferences
- Time-Based Metering Using RNAV and RNP Route Assignments (104123) : **High**
  - The Terminal Radar Approach Control (TRACON) RNAV routes for both Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs) will be used to calculate the terminal component of aircraft trajectories

**Common Service Dependencies:**

- Data Comm: Predeparture Clearances, Route Clearances
- Flight Common Services
- Weather Common Services
- Aeronautical Common Services
- SWIM

**TOps Assumptions:**

- Mixed Equipment Environment
- Users can participate at different levels
- Easier communication and coordination between terminal, transition sectors, and satellite airports because all are managed by a common control service within a single facility
- RNAV/RNP with enhanced TOAC will be more widely available prior to 2018

**TOps Comments:**

1. The scenario states, “Airborne traffic (that entered the airspace before the switch) are individually rerouted, as appropriate”. Rerouting could leverage current aircraft equipage by using FANS 1/A+ over VDL Mode 2 and then evolve to SC-214 via ATN)
2. FMS Data Comm integration is required to support the reroutes described in this scenario

3. SWIM and 4D Weather Cube are not required to implement the basic operational capabilities described in this scenario. The basic capabilities can be evolved by adding Initial Integration of Weather Information into NAS Automation and Decision Making (103119), Continuous Flight Day Evaluation (105302), Increased Capacity and Efficiency Using RNAV and Required Navigation Performance (RNP) (108209), Flexible Airspace Management (108206) and On-Demand NAS Information (103305) which all adds value to the basic scenario.
4. Time based metering may be used as a tool to support the flow and reduce controller workload.
5. Advanced DSTs are required to incorporate NextGen Network weather
6. SWIM, Data Communications and 4D Weather Cube are required to fully implement the operational capabilities in this scenario
7. The phrase "mixed equipage" applies to the variation in aircraft configurations as the operational capabilities evolve from present day to fully implemented NextGen operations.

**TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.

## Scenario 17: Improved Management Arrival, Surface, and Departure Flow

**Description:** The IASDFM scenario describes a set of advanced Arrival/Departure flow management capabilities, integrated with advanced surface operations to improve overall airport and terminal airspace throughput and operational efficiency. The scenario addresses the integration of arrival, surface and departure scheduling, integration of Runway and Airspace re-configuration, and electronic sharing of information and collaboration automation to manage the flow of traffic more efficiently.

**TOps Relative Priority: Med**

### Benefits:

- Airport flow is improved and schedules are more predictable leading to fewer arrival, departure, and surface delays.
- Improved timing and coordination of airport configuration changes leads to more efficient use of the runways and airspace, more informed stakeholder decisions, and more predictable airport transition times.
- Increased operational productivity due to improved collaboration, and reduced execution time

### Key Operational Improvements/Enablers:

- Improved Management of Arrivals/Surface/Departure (A/S/D) Flow Operations (104117) :  
**Medium**
  - Integrate advanced arrival/departure flow management with advanced surface operations
  - Integrate current flight trajectories, as well as real-time airborne and surface event information into ANSP decision support automation to effectively plan and manage A/S/D flow.
  - Aid collaboration between ANSP flow manager with flight operators and with ANSP controllers to effectively manage HD arrival and departure flows
  - Aid departure scheduling and staging and arrival sequencing based on aircraft wake and airborne performance characteristics using advanced automation

### Common Service Dependencies:

- Data Comm: Predeparture Clearances, Route Clearances, Initial Tailored Arrivals
- Flight Common Services
- Surveillance Common Services : ASDE-X surveillance system and/or ADS-B Out
- Weather Common Services (4-D Weather Data Cube)
- Aeronautical Common Services
- SWIM

### TOps Assumptions:

- Mixed Equipment Environment
- Users can participate at different levels

**TOps Comments:**

1. 4-D Weather Cube, SWIM, DSTs combine to create transparency and allow additional time for modeling and planning trajectories and configurations
2. Operators may share some information that will make the larger system more efficient and maintain capacity subject to competitive and antitrust issues
3. Advanced DSTs are required to incorporate NextGen Network weather
4. SWIM, Data Communications (SC-214 via ATN) and 4D Weather Cube are required to fully implement the operational capabilities in this scenario
5. SWIM-Users and Air Navigation Service Provider (ANSP) dynamically adjust both real-time departure and airborne trajectories in response to anticipated and real-time constraints

**TOps Key Findings:**

1. This scenario was identified as a Med priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Pre-Departure Clearances and Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.

## Scenario 18: Improved Low Visibility Runway Access

**Description:** The scenario includes a set of advanced low visibility capabilities to improve runway access. The capabilities are based primarily on the leveraging of advanced avionics to increase access to runways, primarily those with reduced infrastructure, thereby increasing an airport's capacity during adverse weather conditions. This scenario addresses operations under nominal, low visibility conditions, typically below standard ceiling and visibility minima, where suitably equipped aircraft can continue to operate. The described operations do not discriminate between low, medium or high density airports, except for the ability of the controller to monitor surface traffic via surface surveillance, such as ASDE-X, a capability currently being implemented at the top 35 OEP airports only.

The TOps2 reviewed this scenario and determined it did not apply directly to Trajectory Operations and as a result it was removed as a consideration for this report.

## Scenario 19: Improved Runway Safety Situational Awareness

**Description:** The scenario includes a set of advanced flight deck, tower and airport capabilities to improve the situational awareness and safety of surface operations for controllers and pilots. The capabilities include the proliferation of surface surveillance to high density airports where highly accurate positions of surface traffic are displayed on an airfield map and decision support tools are integrated to provide enhanced capabilities such as predefined taxi routing and surface conformance monitoring and alerting. Flight deck improvements include moving map displays with own ship position and imbedded digital NOTAMS, the position of proximal traffic, and an alerting function to warn the pilot of the potential for runway incursions. Airport infrastructure improvements include improved surface markings, signage, and most notably the installation of runway status lights at selected locations where traffic density and surface complexity result in the potential for incursions and surface collisions.

**TOps Relative Priority: Med**

### Benefits:

- Surface flow and situational awareness are improved and taxi times reduced in low visibility operations
- Runway safety is improved through increased pilot awareness of the flight's location on the airport surface and of surface traffic for appropriately equipped aircraft

### Key Operational Improvements/Enablers:

- Improved Runway Safety Situational Awareness for Controllers (103207) : **Low**
  - At large airports, current controller tools provide surface displays and can alert controllers when aircraft taxi into areas where a runway incursion could result. Additional ground based capabilities will be developed to improve runway safety that include expansion of runway surveillance technology (i.e., ASDE-X) to additional airports, deployment of low cost surveillance for medium-sized airports, improved runway markings, and initial controller taxi conformance monitoring capabilities. These ground-based tools will provide a range of capabilities to help improve runway safety for medium to large-sized airports.
- Improve Runway Safety Situational Awareness for Pilots (103208) : **Medium & Low**
  - Runway safety operations are improved by providing pilots with improved awareness of their location on the airport surface as well as runway incursion alerting capabilities. To help minimize pilot disorientation on the airport surface, a surface moving map display with own-ship position will be available. Both ground-based (e.g., RWSL) and cockpit-based runway incursion alerting capabilities will also be available to alert pilots when it's unsafe to enter the runway. Additional enhancements may include cockpit display of surface traffic (e.g., vehicles and aircraft) and the use of a cockpit display that depicts the runway environment and displays traffic from the surface up to approximately 1,500

feet above ground level on final approach and will be used by the flight crew to help determine runway occupancy.

- **Enhanced Surface Traffic Operations (104207) : High**
  - Data communication between aircraft and ANSP is used to exchange clearances, amendments, and requests. At specified airports, data communications is the principle means of communication between ANSP and equipped aircraft. Terminal automation provides the ability to transmit automated terminal information, departure clearances and amendments, and taxi route instructions via data communications, including hold-short instructions. The taxi route instruction data communication function reduces requests for progressive taxi instructions. Benefits arising from this capability, in conjunction with other NAS investments, include enhanced airport throughput, controller efficiency, enhanced safety, as well as reduced fuel-burn and emissions. At the outset, the current system will be expanded to include provision of initial and revised departure clearances directly to the aircraft. Initial and revised taxi route instructions will be added, replacing today's use of voice to accomplish these activities. As a second step, Aeronautical Telecommunication Network (ATN) based capabilities will be added, replacing much of today's system.
- **Full Surface Traffic Management with Conformance Monitoring (104206) : Low**

Note: This is a far-term OI (2018-2024) but the capability of automation to monitor conformance (position and path) of surface operations may begin prior to the end of the mid-term.

- Efficiency and safety of surface traffic management is increased, with corresponding reduction in environmental impacts, through the use of improved surveillance, automation, on-board displays, and data link of taxi instructions. Equipped aircraft and ground vehicles provide surface traffic information in real time to all parties of interest. A comprehensive view of aggregate traffic flows enables ANSP to project demand; predict, plan, and manage surface movements; and balance runway assignments, facilitating more efficient surface movement and arrival and departure flows. Automation monitors conformance (position and path) of surface operations and updates the estimated departure clearance times. Surface optimization automation includes activities such as runway snow removal, aircraft de-icing, and runway configuration.

#### **Common Service Dependencies:**

- Surveillance Common Services : ASDE-X and/or ADS-B

#### **Aircraft Enablers:**

- Moving map displays
- Conformance tracking and alerting



**TOps Assumptions:**

- Mixed Equipment Environment
- Users can participate at different levels

**TOps Comments:**

1. The time lines for preventing a taxiway incursion are very short. Having a system that determines there is a problem, alerts the controller, redirects the controllers attention, enable the controller to interpret the problem, form a solution, communicate it to the correct pilots to prevent the incursion is probably not the quickest way of getting the problem solved. Conformance tracking and alerting are needed on the ground and on the flight deck
2. This operational capability needs a Level of ramp controller inclusion in pre planning options to ensure safety situational awareness.
3. Pilot contacts ground controller to receive clearance. This may be issued either by voice or data com for equipped aircraft
4. Conflict probe and Alerting needs to be on the ground and on the flight deck

**TOps Key Findings:**

1. The operational requirements described in this scenario are important and need to be addressed from a safety perspective.
2. This scenario was identified as a Med priority scenario.
3. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.

## Scenario 20: Wake Turbulence Mitigation for Arrivals (WTMA)

**Description:** The WTMA capability provides for reduced separation under the principal operational concept attempting to remove constraints imposed by Closely Spaced Parallel Runways (CSPR). The focus of this scenario is one specific concept, Wake Turbulence Mitigation for Arrivals – System (WTMA-S) allows for reduced separations under specific wind and weather conditions. The concept of operations describes a dynamic wind prediction system-based change applying automation to monitor for available wind conditions. Such conditions ensure wake free operations on one of the parallel runways, thus increasing airport arrival rates during these time periods. This concept is an incremental development beyond a static procedural change, Wake Turbulence Mitigation for Arrivals – Procedure (WTMA-P) dependent only on airport configuration, runway geometry, analysis of historical winds, and aircraft weight class.

**TOps Relative Priority: Med**

### Benefits:

- More efficient use of closely spaced parallel runways in IMC conditions decreases delays and operational costs due to weather.

### Key Operational Improvements/Enablers:

- Improved Parallel Runway Operations (102141) : **Medium & Low**
  - Develop new IFR standards that allow closer runway spacing
  - Maintain access to CSPRs in limited visibility by integrating new aircraft technologies
- Wake Turbulence Mitigation for Arrivals (WTMA): CSPRs (102144) : **Low**
  - Increase arrival throughput during favorable wind conditions
  - New technology, standards, and procedures will reduce impact of wake separations standards
- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) : **Medium**
  - Advanced warning of weather condition changes are pushed to both ANSPs and users to assist in timely assessment of operational impacts, enabling a smoother transition into/out WTMA
    - Airport ceiling/visibility, arrival corridor wind profiles, and airport surface winds to determine WTMA
    - Volumetric characterization of convection and strong wind shear constraints that might prohibit WTMA
- Initial Improved Weather Information from Non-ground Based Sensors (103116) : **Low**
  - Increased availability to real-time altitude profile winds enable by NextGen aircraft-based weather observations

**Common Service Dependencies:**

- Weather Common Services
- SWIM

**TOps Comments:**

1. Wake Turbulence Mitigation for Arrivals (WTMA): CSPRs (102144) is a system that will benefit all operators at every airport where the capability is installed and its development should not be encumbered.
2. Controller DSTs are required to support the mixed equipage environment

**TOps Assumptions:**

- Mixed Equipment Environment

**TOps Key Findings:**

1. This scenario was identified as a Med priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. The capabilities of Wake Turbulence Mitigation for Departures (WTMD): Wind-Based Wake Procedures (102140) Operational Improvement can be implemented in steps.

## Scenario 21: Incremental Congestion Management

**Description:** This scenario is an expansion of the “Resolve Congestion” scenario, and will address several methods of incrementally resolving congestion. The scenario will focus on tactical response to congestion about 45-90 minutes in advance of a potential congestion event. In contrast to “resolve congestion” which focused on the flight specific adjustment, this scenario will illustrate incremental adjustments to an aggregate flow in response to shifts in probability a constraint will be needed (e.g., weather degrading or clearing).

**TOps Relative Priority: Low**

### Benefits:

- Impacts to en Route capacity constraints are minimized by resolving congestion with tailored incremental responses using operator preferences
- Capacity and efficiency are increased with less frequent disruptions to individual flight profiles.
- End-to-end congestion and complexity impacts are managed to reduce unintended consequences and ripple effects from primary TMIs.
- Air Traffic Managers and users make more informed decisions concerning air traffic operations with fewer and less severe disruptions to air traffic

### Key Operational Improvements/Enablers:

- Provide Full Flight Plan Constraint Evaluation with Feedback (101102) : **High**
  - Constraint information that impacts proposed flight routes is available to users for their pre-departure flight planning
  - Update notifications are provided to filers as anticipated constraints change
  - Users can adjust the flight plan based on available information, submit alternative flight plans or wait for a later time to make adjustments
  - Feedback includes the lists of applicable constraints, conditions driving the constraints, the nature of planned responses and implementation timing
- Continuous Flight Day Evaluation (105302) : **High & Medium**
  - With the users collaboratively and continuously assess constraints
  - With the users collaboratively develop mitigation strategies that consider the potential constraints
  - Users and Air Navigation Service Provider (ANSP) dynamically adjust both pre-departure and airborne trajectories in response to anticipated and real-time constraints
- Traffic Management Initiatives with Flight Specific Trajectories (105208) : **High**
  - Individual flight-specific trajectory changes resulting from Traffic Management Initiatives (TMIs) will be disseminated to the appropriate Air Navigation Service Provider (ANSP) automation for tactical approval and execution. This capability will increase the agility of the NAS to adjust and respond to dynamically changing conditions such as bad weather, congestion, and system outages

- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) :  
**Medium**
  - Integrate weather information and its expected impact on individual 4D trajectories into decision-support tools
  - Provide flow managers with a risk-based tool for strategic decision making

**Common Service Dependencies:**

- Data Comm: Route Clearances
- Flight Common Services
- Weather Common Services
- Aeronautical Common Services
- SWIM

**TOps Assumptions:**

- Mixed Equipment Environment
- Users can participate at different levels

**TOps Comments:**

1. TMU-based automation and DSTs used for creating TMIs-delivered to control positions thru ERAM/SWIM
2. The scenario should also consider the weather condition moving
3. Needs elements of CACR for En Route constraint resolution and trajectory adjustments.
4. Automation (DSTs) generate trajectory amendments to comply with TMIs
5. Full implementation of the described capabilities requires accurate prediction of convective weather over 2 hour time horizon that can be digitally read by ANSP/FOC automation
6. SWIM and 4D Weather Cube Provide Full Flight Plan Constraint Evaluation with Feedback (101102), Continuous Flight Day Evaluation (105302) and Initial Integration of Weather Information into NAS Automation and Decision Making (103119) are not required to initiate the basic capabilities of this scenario
7. Initial Integration of Weather Information into NAS Automation and Decision Making (103119), Continuous Flight Day Evaluation (105302), On-Demand NAS Information (103305) all adds value to the basic capability of avoiding the weather.
8. SWIM, Data Communications (SC-214 via ATN) and 4D Weather Cube are required to fully implement the operational capabilities in this scenario

**TOps Key Findings:**

1. This scenario was identified as a Low priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.

3. This scenario can be partially implemented prior to the availability of Data Comm Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. Initial Integration of Weather Information into NAS Automation and Decision Making (103119), Continuous Flight Day Evaluation (105302), On-Demand NAS Information (103305) all add to the robustness of conducting closed loop airborne reroutes enabled by Traffic Management Initiatives with Flight Specific Trajectories (105208)
5. Implement the capabilities in this scenario in steps leveraging present day equipage evolving from FANS 1/A+ over ACARS transitioning to FANS 1/A+ over VDL Mode 2 and SC-214 via ATN.

## Scenario 22: Manage Security Operations

**Description:** Airspace Security is managed in relation to two planning timeframes, one being real-time (tactical), as operational security events occur, and the other being at some time prior to the operational security event (strategic), as pre-negotiated security measures or plans. Security measures can take several forms including: a Security Restricted Airspace which is a volumetric expression of airspace further defined by user access instructions, Flight Risk Levels that describe the security characteristic of a type of flight, and pre-negotiated flight plans for certain flights of interest to the U.S., such as Special Interest Flights, Diplomatic Flights, or flights carrying U.S. key government officials. The scenario illustrates how security measures are strategically planned, coordinated, and implemented, how they are tactically monitored, and how non-compliance to planned measures is detected and responded to in a coordinated manner that reduces the impact to NAS operations. Specific emphasis is focused on evaluating the impact of security measures on the NAS, correlation analysis of operational security events, and the expeditious alerting and coordination of both FAA and other government decision-makers. Three security events are described: a response to a predicted Security Restricted Airspace non-compliance event, a response to a flight plan change request for a Special Interest Flight that modifies the pre-negotiated security instructions, and a response to a non-cooperative track that poses a threat to U.S. infrastructure.

The TOps2 reviewed this scenario and determined it did not apply directly to Trajectory Operations and as a result it was removed as a consideration for this report.

## Scenario 23: Flight Planning and Traffic Flow Mitigation for Turbulence Avoidance

**Description:** To support daily planning efforts, Traffic Managers and Users are provided with characterizations of airspace volumes potentially constrained by turbulence, including an expected time period of occurrence. Users utilize the information to plan their flights, based on company rules for dealing with turbulence. Traffic Management (TM) utilizes the information to anticipate which flights might be impacted, and to plan for any TMIs that may be necessary, based on potential congestion due to turbulence. Users and TM re-route flights as necessary, as the turbulence situation clarifies. These proactive actions result in minimizing the number of tactical actions needed by sector controllers to help pilots deal with turbulence.

**TOps Relative Priority: Low**

### Benefits:

- More efficient contingency fuel planning by users, Increased flight safety, ATM decision and flow mitigation plans are more effective and better reflect user preferences
- Engages users earlier, allowing individual preferences to be honored for trajectory changes, increased flight efficiencies, Reduces delays due to controller workload

### Key Operational Improvements/Enablers:

- Initial Integration of Weather Information into NAS Automation and Decision Making (103119) : **Medium**
  - Volumetric characterizations of weather-impacted airspace at and around the airport, along with their probabilities, are provided to assist in planning arrival/departure airspace configurations
  - As weather changes occur, updates are pushed to ANSPs, users, and DSTs, to increase available response time
    - Volumetric characterizations of weather constraints are utilized to calculate the impact on active and alternative terminal airspace configurations and RNAV/RNP routings
- Initial Improved Weather Information from Non-ground Based Sensors (103116) : **Low**
  - Sensors on aircraft and satellites provide enhanced real-time weather information, including objective, real-time turbulence data from aircraft
    - Real-time, measured turbulence is described using the parameter called Eddy Dissipation Rate (EDR)
    - Depending on type, speed and weight, each aircraft is affected differently by a given EDR value
    - In general, smaller, lighter aircraft are affected more by a given EDR value than are larger, heavier aircraft



- High resolution characterizations of potential weather constraints, informed by aircraft- and satellite-based sensors, enable operators and TM to assess the likely impact of weather on specific flights, airspace or airports, and develop mitigation strategies
- Continuous Flight Day Evaluation (105302) : **High & Medium**
  - With the users collaboratively and continuously assess constraints
  - With the users collaboratively develop mitigation strategies that consider the potential constraints
  - Users and Air Navigation Service Provider (ANSP) dynamically adjust both Predeparture and airborne trajectories in response to anticipated and real-time constraints
- On-Demand NAS Information (103305) : **Medium & Low**
  - NAS and aeronautical information is consistent across applications and locations, and available to authorize subscribers and equipped aircraft
  - Information and updates are obtained in a near real-time and distributed in a user-friendly digital or graphic format.

#### **Common Service Dependencies:**

- Data Comm: Route Clearances
- Flight Common Services
- Weather Common Services
- Aeronautical Common Services
- SWIM

#### **Aircraft Enablers:**

- Data Communications integrated with the FMS

#### **TOps Assumptions:**

- Mixed Equipment Environment
- Users can participate at different levels

#### **TOps Comments:**

1. Turbulence forecasting is an objective prediction of the severity of turbulence an aircraft may encounter. On an aircraft flight deck, turbulence reporting and crew reaction is much more subjective. A flight crew will often request altitude changes in light turbulence if there is a cabin service taking place or their subjective evaluation is different than the exact definition of the turbulence terms.
2. The EDR analysis should remove flight crew subjectivity i.e. Depending on type, speed and weight, each aircraft is affected differently by a given EDR value. In general, smaller, lighter aircraft are affected more by a given EDR value than are larger, heavier aircraft.
3. The word "clearance" should be replaced with "trajectory" in this scenario

4. Observation and forecast weather information is translated into constraints and then integrated into decision support tools designed to calculate expected impacts on individual 4D trajectories and provide TMs with risk-based strategic and tactical solution sets.
5. En Route Data Comm (integrated with FMS) would provide significant flexibility in modifying flight route to avoid turbulence when aircraft is already en route

**TOps Key Findings:**

1. This scenario was identified as a Low priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. The operational use of Initial Improved Weather Information from Non-ground Based Sensors (103116) is dependent on SWIM and the 4D Weather Cube. Other Operational Improvements that bring more immediate value should take priority.

## Scenario 24: Time-Based Flow Management (TBFM) in the Terminal Environment

**Description:** The scenario illustrates capabilities built primarily upon the concept to expand time-based metering into the terminal environment. The set of advancements in automation and operations enable traffic managers in the terminal and en route facilities to strategically coordinate, plan and implement Time-Based Flow Management (TBFM) operations inside the terminal airspace. Decision support tools (DSTs) will be available for TRACON traffic managers and controllers to maintain the TBFM schedule and to make tactical adjustments as necessary.

**TOps Relative Priority: Med**

### Benefits:

- Capacity and efficiency in terminal airspace increases with more structured arrival and departure flows. Maximum use of capacity by maintaining the required sequences and runway assignments for the planned procedures
- Increase safety and operational efficiency by modeling and analyzing future actions
- Better satisfy operational objectives for all critical resources through more seamless execution of time based arrival and departure operations

### Key Operational Improvements/Enablers:

- Time-Based Metering in the Terminal Environment (104128) : **High**
  - Implementation of new de-confliction points inside terminal airspace resulting in metering inside the terminal
  - Automation develops trajectories and allocates time-based slots within the terminal environment resulting in sequence and runway assignments which are displayed to terminal controllers
  - Modeling capabilities in the TMU enable traffic managers to perform trial planning such as changing runway assignments
  - Continuous monitoring of actual operations versus expected TBFM schedules to provide feedback to the traffic managers
- Time Based Metering Using RNAV and RNP Route Assignments (104123) : **High**
  - Metering automation will manage the flow of aircraft to meter fixes, thus permitting efficient use of runways and airspace
  - Provides alternate routes in transition airspace to a meter fix on a separate path if load balancing is needed
- Integrated Arrival/Departure Airspace Management (104122) : **High**
  - Extended application of terminal procedures and separation standards allows greater flexibility.
- Improved Parallel Runway Operations (102141) : **Medium & Low**
  - Develop new IFR standards that allow closer runway spacing

- Maintain access to CSPRs in limited visibility by integrating new aircraft technologies

**Common Service Dependencies:**

- Data Comm: Route Clearances
- Flight Common Services
- Surveillance Common Services : ADS-B
- Weather Common Services
- Aeronautical Common Services
- SWIM

**TOps Assumptions:**

- Mixed Equipment Environment
- RNAV/RNP with enhanced TOAC will be more widely available prior to 2018

**TOps Comments:**

1. The transition to Trajectory Operations should enable greater flexibility in the NAS and not simply automate the current structure of the NAS.
2. Not explicitly mentioned, but DSTs should also be able to speed up aircraft to fill slots instead of only delaying them as is done today.
3. Issues section identifies the question of what percentage of aircraft need to be RNAV equipped to efficiently utilize RNAV routes. Although the use of later merge points as suggested should increase ability to handle mixed equipage.

**TOps Key Findings:**

1. This scenario was identified as a Med priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. TBFM operations need to accommodate creation of dynamic routing.

## Scenario 25: Oceanic Trajectory Based Operations (TBO)

**Description:** To enable airspace users to flight plan and fly closer to their preferred four- dimensional trajectories (4DT) while in U.S. oceanic airspace, additional data will be shared between ATC and the airlines Flight Operations Center (FOC). The FOC shares and updates their flight intent information with new FAA automation which provides feedback on the likelihood of being able to fly their preferred 4D oceanic trajectory. U.S. oceanic controllers are provided with enhanced decision support tools that will enable oceanic clearances to more closely match the users' preferred (and coordinated) trajectory.

**TOps Relative Priority: Med**

### Benefits:

- Fuel-efficient trajectories are increasingly common with resultant reductions in flight time, fuel consumption and emissions.
- Users can adhere to preferred trajectories with greater frequency, reducing fuel consumption and increasing overall efficiency.
- Users experience fewer disruptions when entering and exiting oceanic tracks. Preferred trajectories are more common, decreasing flight times, fuel burn, and harmful emissions.

### Key Operational Improvements/Enablers:

- Oceanic In-Trail Climb and Descent (102108) : **High & Medium**
  - When authorized by the controller, reduced longitudinal spacing can be used to allow aircraft to transition to more efficient altitudes
- Flexible Entry Times for Oceanic Tracks (104102) : **Low**
  - Optimized oceanic entry times to fly more efficient trajectories

### Common Service Dependencies:

- Data Communications (Evolving from FANS 1/A transitioning to FANS 1/A+ and SC-214)

### Aircraft Enabler:

- ADS-B Out on most aircraft
- RNAV/RNP with enhanced TOAC

### TOps Assumptions:

- Mixed Equipment Environment
- Users can participate only if properly equipped

### TOps Comments:

1. Flight trials began August 2011.

**TOps Key Findings:**

1. This scenario was identified as a Med priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. We recommend that if the trials for in-trail climbs and descents via ADS-B & ADS-C prove successful then the FAA move to full implementation.

## Scenario 26: Separation Management and Resolution Advisories

**Description:** This thread illustrates how 4D trajectories are used for separation management in en route operations. The use of trajectories supports automated strategic problem detection and resolution. The scenario depicts issues around having two aircraft in different sectors (Sectors A and B) that have a predicted conflict in a common downstream sector (C). The scenario contains three different situations, including instances when there is another sector (D) between one of the aircraft and the sector where the conflict is predicted to occur. The scenario demonstrates why the sector that is in control of the aircraft receives the problem notification and resolution alternatives. Automation support for controller-to-controller coordination and handoff acceptance are used if necessary. The different processes for issuing the resulting clearance for either voice or via data communications are included

### **TOps Relative Priority: High**

#### **Benefits:**

- Increased predictability allows for increased throughput; conflicting trajectories are known further in advance, improving safety; automation increases controller effectiveness in supporting user preferences.
- Automating routine information exchange increases efficiency, reduces instances of verbal miscommunication, allows for delivery of more complex clearances and reduces congestion.
- Aircraft are provided more efficient conflict resolutions. Capacity is increased by allowing aircraft to fly closer to the separation minima, while improving safety through more accurate conflict prediction.

#### **Key Operational Improvements/Enablers:**

- Initial Conflict Resolution Advisories (102114) : **High**
  - ANSP conflict probe is enhanced to provide rank-ordered resolution advisories
  - Conflict detection, trial planning and resolution automation enable ANSP to better accommodate pilot requests for trajectory changes and tailor them to the communication medium

#### **Common Service Dependencies:**

- Data Comm: Route Clearances
- Flight Common Services
- Aeronautical Common Services

#### **TOps Assumptions:**

- Mixed Equipment Environment
- Users can participate only if properly equipped
- RNAV/RNP with enhanced TOAC will be more widely available prior to 2018

**TOps Comments:**

1. This capability should be part of the DCIT En Route Flight Trials.
2. VDL-2 Latency is:
  - 1.6 sec average
  - 3.21 sec 90th percentile
  - 5.52 sec 95th percentile
3. Definitions in the ConUse seem to be slightly different than what is described in this scenario.

**TOps Key Findings:**

1. This scenario was identified as a High priority scenario.
2. This scenario can be implemented in stages according to the Operational Improvement Priority recommendations.
3. This scenario can be partially implemented prior to the availability of Data Comm Route Clearance. However, this scenario is dependent on the availability of these capabilities to realize the full benefits.
4. Implement the capabilities in this scenario in steps leveraging present day equipage evolving from FANS 1/A+ over VDL Mode 2 to SC-214 via ATN.



## Appendix A: Operational Improvement Prioritization Details

<b>TOps Relative Priority</b>	<b>TOps Score</b>	<b>NGIP OI #</b>	<b>NGIP OI Name</b>	<b>NGIP OI Description</b>	<b>NGIP Capability</b>	<b>NGIP Capability Description</b>
<b>H</b>	<b>1.1</b>	105208	<b>TMIs with Flight-specific Trajectories</b>	This capability will increase the agility of the NAS to adjust and respond to dynamically changing conditions such as impacting weather, congestion and system outages.	<b>Delivery of Pre-Departure Reroutes to Controllers</b>	This increment will give En Route Automation Modernization (ERAM) additional capabilities to receive amended routes pre-departure and provide updated flight data to the tower.
		108209	<b>Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)</b>	Area Navigation (RNAV) and Required Navigation Performance (RNP) can enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity.	<b>Large-scale Redesign of Terminal and Transition Airspace Levering PBN</b>	The integrated airspace and procedures approach provides a geographic focus to problem solving, with a systems view of PBN initiatives, to the design of airspace
	<b>1.3</b>	105208	<b>TMIs with Flight-specific Trajectories</b>	This capability will increase the agility of the NAS to adjust and respond to dynamically changing conditions such as impacting weather, congestion and system outages.	<b>Basic Rerouting Capability</b>	This capability is the means by which Traffic Flow Management System (TFMS)- generated reroutes are defined and transmitted via System Wide Information Management (SWIM).
	<b>1.4</b>	104123	<b>Time-based Metering Using RNAV and RNP route Assignment</b>	Area Navigation (RNAV), Required Navigation Performance (RNP) and Time-Based Metering (TBM) provide efficient use of runways and airspace in high-density airport environments. Metering automation will manage the flow of aircraft to meter fixes, thus permitting efficient use of runways and airspace.	<b>Use RNAV Route Data to Calculate Trajectories Used to Conduct TBM Ops</b>	The Terminal Radar Approach Control (TRACON) RNAV routes for both Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs) will be used to calculate the terminal component of aircraft trajectories
		104124	<b>Use Optimized Profile Descent</b>	Optimized Profile Descents permit aircraft to remain at higher altitudes on arrival to the airport and use lower power settings during descent.	<b>OPDs Using RNAV and RNP STARs</b>	OPD procedures are being implemented as RNAV STARs (eventually as RNP STARs, where necessary) with vertical profiles that are designed to allow aircraft to descend using reduced or even idle thrust settings from the top of descent to points along the downwind or final approach
		104128	<b>Time-based Metering in Terminal Environment</b>	Aircraft are time-based metered inside the terminal environment, enhancing efficiency through the optimal use of terminal airspace and surface capacity. This extends current metering capabilities into the terminal environment and furthers the pursuit of end-to-end metering and trajectory-based operations.	-	Aircraft are time-based metered inside the terminal environment, enhancing efficiency through the optimal use of terminal airspace and surface capacity. This extends current metering capabilities into the terminal environment and furthers the pursuit of end-to-end metering and trajectory-based operations.
		104207	<b>Enhanced Surface Traffic Operations</b>	Terminal automation provides the ability to transmit automated terminal information, departure hold-short instructions, clearances and amendments, and taxi route instructions via data communications, including	<b>Revised Departure Clearance via Data Comm</b>	A Revised Departure Clearance (DCL) Data Comm capability will allow the FAA to rapidly issue departure clearance revisions, due to weather or other airspace issues, to one or more aircraft equipped with Future Air Navigation System (FANS) waiting to depart.

<b>TOps Relative Priority</b>	<b>TOps Score</b>	<b>NGIP OI #</b>	<b>NGIP OI Name</b>	<b>NGIP OI Description</b>	<b>NGIP Capability</b>	<b>NGIP Capability Description</b>
		108209	<b>Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)</b>	Area Navigation (RNAV) and Required Navigation Performance (RNP) can enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity.	<b>Relative Position Indicator (RPI)</b>	RPI is a tool that can assist both the controller and traffic management in managing the flow of traffic through a terminal area merge point.
	1.5	104209	<b>Initial Surface Traffic Management</b>	Departures are sequenced and staged to maintain throughput. Air Navigation Service Provider (ANSP) automation uses departure-scheduling tools to flow surface traffic at high-density airports.	<b>Scheduling and Sequencing</b>	The capability displays the departure surface sequence and runway queues as a recommendation to the controller to improve throughput. The capability provides Traffic Flow Management (TFM) constraints to tower controllers. The capability provides estimated flight-specific event times necessary to meet the departure surface sequence and schedule. These event times are shared with users
		108209	<b>Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)</b>	Area Navigation (RNAV) and Required Navigation Performance (RNP) can enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity.	<b>Transition to PBN Routing for Cruise Operations</b>	This approach augments the conventional NAVAID-based Jet and Victor airways with RNAVs, including Q-routes and T-routes.
	1.6	101102	<b>Provide Full Flight Plan Constraint Evaluation</b>	Constraint information that impacts the proposed route of flight is incorporated into ANSP automation, and is available to users	<b>Electronic Negotiations</b>	The Electronic Negotiations increment provides flight planners with information about congestion along their intended routes and proposes flight-specific rerouting.
		102108	<b>Oceanic In-Trail Climb Procedure</b>	Air Navigation Service Provider ( ANSP) automation enhancements will take advantage of improved communication, navigation and surveillance coverage in the Oceanic domain. When authorized by the controller, pilots of equipped aircraft use established procedures for climbs and descents.	<b>Automatic Dependent Surveillance-Broadcast (ADS-B) Oceanic ITP and Automation</b>	The ADS-B ITP will enable aircraft equipped with ADS-B and appropriate onboard automation to climb and descend through altitudes where current non-ADS-B separation standards would prevent desired altitude changes.
		102114	<b>Initial Conflict Resolution Advisories</b>	Automation enables the Air Navigation Service Provider (ANSP) to better accommodate pilot requests of trajectory changes by providing conflict detection and flight planning, and development and rank-ordering of resolutions taking into account aircraft capabilities and pilot and ANSP preferences	-	Automation enables the Air Navigation Service Provider (ANSP) to better accommodate trajectory changes by detection and flight planning non-ground-based sensors (e.g. 28 n pilot requests for providing conflict detection, flight planning, and development and rank-ordering of resolutions taking into account aircraft capabilities and pilot and ANSP preferences.
		104120	<b>Point-in-Space Metering</b>	Air Navigation Service Provider (ANSP) uses scheduling tools and trajectory-based operations to assure smooth flow of traffic and increase the efficient use of airspace.	<b>Extended Metering</b>	Will provide flow deconfliction for metered aircraft at the meter reference points (upstream from the meter fixes).

<b>TOps Relative Priority</b>	<b>TOps Score</b>	<b>NGIP OI #</b>	<b>NGIP OI Name</b>	<b>NGIP OI Description</b>	<b>NGIP Capability</b>	<b>NGIP Capability Description</b>
		104122	<b>Integrated Arrival/Departure Airspace Management</b>	New airspace design takes advantage of expanded use of terminal procedures and separation standards. This capability expands the use of terminal separation standards and procedures (e.g., 3 nm, degrees divergence) within the newly defined transition airspace. It extends further into current en route airspace (horizontally and vertically).	-	New airspace design takes advantage of expanded use of terminal procedures and separation standards. This capability expands the use of terminal separation standards and procedures (e.g., 3 nm, degrees divergence) within the newly defined transition airspace. It extends further into current en route airspace (horizontally and vertically).
		104124	<b>Use Optimized Profile Descent</b>	Optimized Profile Descents permit aircraft to remain at higher altitudes on arrival to the airport and use lower power settings during descent.	<b>Initial Tailored Arrivals (ITAs)</b>	ITAs are pre-planned, fixed routings assigned by oceanic air traffic control facilities and sent from the Oceanic Automation System (Ocean21) via data communications to suitably equipped (i.e., FANS 1/A) aircraft as an arrival clearance into coastal airports
		105302	<b>Continuous Flight Data Evaluations</b>	Continuous (real-time) constraints are provided to Air Navigation Service Provider (ANSP) Traffic management decision-support tools and the National Airspace System (NAS) users.	<b>Enhanced Congestion Prediction</b>	The Enhanced Congestion Prediction increment provides improved capabilities to assess the impact of a set of reroutes on the level of demand and other performance metrics for a point of interest
		108209	<b>Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)</b>	Area Navigation (RNAV) and Required Navigation Performance (RNP) can enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity.	<b>NextGen En Route Distance Measuring Equipment (DME) Infrastructure</b>	Additional DME coverage over the continental United States is needed to optimize and expand RNAV routes by closing coverage gaps at and above Flight Level 240.
<b>M</b>	<b>1.7</b>	104209	<b>Initial Surface Traffic Management</b>	Departures are sequenced and staged to maintain throughput. Air Navigation Service Provider (ANSP) automation uses departure-scheduling tools to flow surface traffic at high-density airports.	<b>External Data Exchange</b>	The FAA will establish a data exchange infrastructure as well as integrated decision support tools, standards and processes that rely on agreed-to information exchange among stakeholders
					<b>Runway Assignments</b>	To assist in efficient runway allocation and use, the automation assigns an aircraft to a runway based on the flight's departure fix and enables ANSP personnel to accept or modify the runway assignment.
	<b>1.8</b>	102108	<b>Oceanic In-Trail Climb Procedure</b>	Air Navigation Service Provider (ANSP) automation enhancements will take advantage of improved communication, navigation and surveillance coverage in the Oceanic domain. When authorized by the controller, pilots of equipped aircraft use established procedures for climbs and descents.	<b>Automatic Dependent Surveillance-Contract (ADS-C) Oceanic Climb/Descent</b>	The ADS-C CDP (previously known as ADS-C In-Trail Procedure (ITP)) is a new concept that allows a properly equipped aircraft (e.g., Future Air Navigation System (FANS) 1/A equipage) to climb or descend through the altitude of another properly equipped aircraft with a reduced longitudinal separation distance (compared with the required longitudinal separation minima for same-track, same-altitude aircraft). This procedure allows more aircraft to reach their preferred altitude
		102137	<b>Automation Support for Separation Management</b>	ANSP automation provides the controller with tools to manage aircraft in a mixed navigation and wake performance environment.	<b>Automation Support for Non-Surveillance Airspace</b>	The en route Automation will provide an indication of possible non-surveillance separation violations using a base set of non-surveillance separation rules. This capability will also utilize electronic flight data, eliminating the need for paper flight strips

TOps Relative Priority	TOps Score	NGIP OI #	NGIP OI Name	NGIP OI Description	NGIP Capability	NGIP Capability Description
		102141	<b>Improved Parallel Runway Operations</b>	This improvement will explore concepts to recover lost capacity through reduced separation standards, increased applications of dependent and independent operations, enabled operations in lower visibility conditions and changes in separation responsibility between air traffic control (ATC) and the flight deck	<b>Additional 7110.308 Airport</b>	This increment provides airports with maximum use of closely spaced parallel runways by authorizing participating aircraft to operate at reduced lateral and longitudinal spacing on dependent, instrument approach procedures to runways with centerline spacing less than 2,500 feet. This increment will expand the application of FAA Order 7110.308 beyond the locations and runway ends already approved.
		103119	<b>Initial Integration of Weather Info into NAS Automation and Decision Making</b>	Advances in weather information content and dissemination provide users and/or their decision support with the ability to identify specific weather impacts on operations (e.g., trajectory management and impacts on specific airframes, arrival/departure planning) to ensure continued safe and efficient flight.	-	Advances in weather information content and dissemination provide users and/or their decision support with the ability to identify specific weather impacts on operations...
		103208	<b>Improved Runway Safety Situational Awareness for Pilots</b>	Runway safety operations are improved by providing pilots with improved awareness of their location on the airport surface as well as runway incursion alerting capabilities. Additional enhancements may include the depiction of other traffic within the airport surface environment	<b>Moving Map with Own-ship Position</b>	Cockpit displays, for instance Electronic Flight Bags (EFBs), may incorporate airport moving map displays that provide constantly changing views of an airport's runways, taxiways and structures to help pilots identify the airplane's location on the surface.
		103305	<b>On-Demand NAS Information</b>	NAS and aeronautical information will be available to users on demand. NAS and aeronautical information is consistent across applications and locations, and available to authorized subscribers and equipped aircraft. Proprietary and security-sensitive information is not shared with unauthorized agencies/individuals.	<b>Provide Improved Flight Planning and In-Flight Advisories for Flight Operations Centers (FOCs)/AOCs</b>	This increment ensures that NAS and aeronautical information is consistent, allowing users to subscribe to and receive the most current information from a single source. Information is collected from ground systems and airborne users (via ground support services), aggregated and provided through system-wide information environment, Data Communications, or other means.
		104117	<b>Improved Arrival, Surface, Departure, Flow Operations</b>	This integrates advanced arrival/departure flow management with advanced surface operation functions to improve overall airport capacity and efficiency.	<b>Integrated Departure/Arrival Capability (IDAC)</b>	Increases NAS efficiency and reduces delays by providing decision-making support capabilities for departure flows. IDAC automates the process of monitoring departure demand and identifying departure slots for tower personnel.
	1.9	102108	<b>Oceanic In-Trail Climb Procedure</b>	Air Navigation Service Provider (ANSP) automation enhancements will take advantage of improved communication, navigation and surveillance coverage in the Oceanic domain. When authorized by the controller, pilots of equipped aircraft use established procedures for climbs and descents.	<b>ADS-C Automation for Oceanic CDP</b>	The automation enhancements to Ocean21 include capabilities to allow a controller to select two aircraft and ensure they are eligible for ADS-C CDP, send concurrent on demand position reports to two aircraft, determine if the minimum separation distance between the two aircraft is greater than the ADS-C CDP separation distance (e.g., greater than 15 nautical miles (nm)), display the ADS-C CDP conflict probe results to a controller, and build an uplink clearance message to the ADS-C CDP requesting aircraft and an uplink traffic advisory message to the blocking aircraft
		102137	<b>Automation Support for Separation Management</b>	ANSP automation provides the controller with tools to manage aircraft in a mixed navigation and wake performance environment.	<b>Aircraft-to-Aircraft Alerts for 3-nm Separation Areas</b>	En route conflict alert will be enhanced to support wake vortex separation requirements in 3-nm separation areas and transition airspace. Problem detection and trial planning capabilities will also be enhanced to support aircraft-to-aircraft alerts in 3-nm separation areas and transition airspace, to include alerts based on wake vortex separation requirements

TOps Relative Priority	TOps Score	NGIP OI #	NGIP OI Name	NGIP OI Description	NGIP Capability	NGIP Capability Description
					<b>Assisted Trial Planning Onto the Radar and Data Consoles</b>	Assisted Trial Planning will be integrated on the en route radar and the data consoles. Integrating this capability into the consoles assists radar controllers in determining possible problem-free flight plan changes without having to use the data consoles to create trial plans. A controller will also be able to use this capability to simultaneously examine the problem status of a set of possible clearances.
		102406	<b>Provide Full Surface Situation Information</b>	Surface Situation Information will complement visual observation of the airport surface. Decision support system algorithms will use enhanced target data to support identification and alerting of those aircraft at risk of runway incursion.	-	Surface Situation Information will complement visual observation of the airport surface. Decision support system algorithms will use enhanced target data to support identification and alerting of those aircraft at risk of runway incursion.
		104209	<b>Initial Surface Traffic Management</b>	Departures are sequenced and staged to maintain throughput. Air Navigation Service Provider (ANSP) automation uses departure-scheduling tools to flow surface traffic at high-density airports.	<b>Airport Config Mgt</b>	To improve responsiveness and effective use of airport resources, and rapidly coordinate airport configuration changes across multiple ANSP activities, this capability provides automation assistance for setting up, assessing and changing the airport configuration.
					<b>Departure Routing</b>	For improved departure operations, this capability provides tower controllers with electronic flight data management and an interface to assessments of weather and Traffic Management Initiative (TMI) impacts on departure routes and associated flights.
		105302	<b>Continuous Flight Data Evaluations</b>	Continuous (real-time) constraints are provided to Air Navigation Service Provider (ANSP) Traffic management decision-support tools and the National Airspace System (NAS) users.	<b>Automated Congestion Resolution</b>	The Automated Congestion Resolution increment recommends reroutes for flight specific Traffic Management Initiatives (TMIs). This allows the traffic manager to adjust the target parameters and evaluate the required trajectory adjustments
L	2	102137	<b>Automation Support for Separation Management</b>	ANSP automation provides the controller with tools to manage aircraft in a mixed navigation and wake performance environment.	<b>Wake Vortex Separation Indicator</b>	To support the en route controller in applying wake turbulence separation standards, the radar display will indicate static wake vortex separation requirements for any given pair of aircraft.
		102144	<b>Wake Turbulence Mitigation for Arrivals: Closely Spaced Parallel Runways (CSPRs)</b>	Changes to wake separation minima are implemented based on measured and predicted airport area winds. Supporting procedures, developed at applicable locations based on analysis of wake measurements and safety, allow more closely spaced arrival operations increasing airport/runway capacity in IMC.	-	Changes to wake separation minima are implemented based on measured and predicted airport area winds. Supporting procedures, developed at applicable locations based on analysis of wake measurements and safety, allow more closely spaced arrival operations increasing airport/runway in IMC
		104122	<b>Integrated Arrival/Departure Airspace Management</b>	ANSP automation uses ADS-B in non-radar airspace to provide reduced separation and flight following. Improved surveillance enables ANSP to use radar-like separation standards and services	-	Provides an integrated approach to arrival and departure management throughout the major metropolitan airspace by incorporating terminal and transition airspace and procedures into one service volume. <ul style="list-style-type: none"> <li>• Develop and mature initial automation, surveillance and flight data requirements</li> <li>• Conduct technical transfer of automation, surveillance and flight data requirements</li> <li>• Support airspace design/analysis, transition strategy plans and procedures development for initial selected locations</li> </ul>

TOps Relative Priority	TOps Score	NGIP OI #	NGIP OI Name	NGIP OI Description	NGIP Capability	NGIP Capability Description
		104209	<b>Initial Surface Traffic Management</b>	Departures are sequenced and staged to maintain throughput. Air Navigation Service Provider (ANSP) automation uses departure-scheduling tools to flow surface traffic at high-density airports.	<b>Taxi Routing</b>	For improved taxi route efficiency, this capability provides dynamic information on airport taxiways and runways integrated with controller displays.
		108209	<b>Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)</b>	Area Navigation (RNAV) and Required Navigation Performance (RNP) can enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity.	<b>FMC Route Offset</b>	Automation provides controllers with support to amend an aircraft's flight plan to indicate that it has been placed on, or has been taken off, a Flight Management Computer (FMC) lateral offset
		104102	<b>Flexible Entry Times for Oceanic Tracks</b>	Optimized oceanic entry times to fly more efficient trajectories	-	-
	2.1	102140	<b>Wake Turbulence Mitigation for Departures (WTMD): Wind-Based Wake Procedures</b>	Procedures are developed at applicable locations based on the results of analysis of wake measurements and safety analysis using wake modeling and visualization. During peak demand periods, these procedures allow airports to maintain airport departure throughput during favorable wind conditions.	<b>WTMD</b>	Procedures are developed through analysis of wake measurements and safety analysis using wake modeling and visualization. During peak demand periods, these procedures allow airports to maintain airport departure throughput during favorable wind conditions. A staged implementation of changes in procedures and standards, as well as the implementation of new technology, will safely reduce the impact of wake vortices on operations. This reduction applies to specific types of aircraft and is based on wind blowing an aircraft's wake away from the parallel runway's operating area
		103208	<b>Improved Runway Safety Situational Awareness for Pilots</b>	Runway safety operations are improved by providing pilots with improved awareness of their location on the airport surface as well as runway incursion alerting capabilities. Additional enhancements may include the depiction of other traffic within the airport surface environment	<b>CDTI with TIS-B and ADS-B for Surface</b>	Surface traffic information for moving map displays is available via TIS-B and from aircraft operating with approved ADS-B capability. Using TIS-B and ADS-B, CDTI will provide a graphical depiction of ground and air traffic, which will improve situational awareness for a variety of operations.
	2.2	102118	<b>Delegated Responsibility for In-Trail Separation</b>	Enhanced surveillance and new procedures enable the ANSP to delegate aircraft-to aircraft separation. Improved display avionics and broadcast positional data provide detailed traffic situational awareness to the flight deck. When authorized by controller, pilots will implement delegated separation between equipped aircraft using established procedures.	-	-
		103207	<b>Improved Runway Safety Situational Awareness for Controllers</b>	At large airports, current controller tools provide surface displays and can alert controllers when aircraft taxi into areas where a runway incursion could result. Additional ground based capabilities will be developed to improve runway safety that include expansion of runway surveillance technology (i.e., Airport Surface Detection Equipment-Model X (ASDEX)) to additional	<b>ASDE-X to Additional Airports</b>	This increment enables air traffic control (ATC) to detect potential runway conflicts by providing detailed coverage of movement on runways and taxiways.

TOps Relative Priority	TOps Score	NGIP OI #	NGIP OI Name	NGIP OI Description	NGIP Capability	NGIP Capability Description
				airports.		
		107107	<b>Ground Based Augmentation System (GBAS) Precision Approaches</b>	GBAS support precision approaches to Category I and eventually Category II/III minimums, for properly equipped runways and aircraft GBAS can support approach minimums at airports with fewer restrictions to surface movement, and offers the potential for curved precision approaches. GBAS also can support high-integrity surface movement requirements.	<b>GBAS Cat II/III</b>	ICAO-compliant standards for operational use of GBAS Category II/III systems will be published by 2015.
		104206	<b>Full Surface Traffic Management with Conformance Monitoring</b>	o Efficiency and safety of surface traffic management is increased, with corresponding reduction in environmental impacts, through the use of improved surveillance, automation, on-board displays, and data link of taxi instructions. Equipped aircraft and ground vehicles provide surface traffic information in real time to all parties of interest. A comprehensive view of aggregate traffic flows enables ANSP to project demand; predict, plan, and manage surface movements; and balance runway assignments, facilitating more efficient surface movement and arrival and departure flows. Automation monitors conformance (position and path) of surface operations and updates the estimated departure clearance times. Surface optimization automation includes activities such as runway snow removal, aircraft de-icing, and runway configuration.	-	-
	2.3	102141	<b>Improved Parallel Runway Operations</b>	This improvement will explore concepts to recover lost capacity through reduced separation standards, increased applications of dependent and independent operations, enabled operations in lower visibility conditions and changes in separation responsibility between air traffic control (ATC) and the flight deck	<b>Amend Independent and Dependent Runway Standards in Order 7110.65 (Including Blunder Model Analysis)</b>	This increment amends runway spacing standards to achieve increased access to parallel runways with centerline spacing less than 4,300 feet and implements this change at approved locations.



TOps Relative Priority	TOps Score	NGIP OI #	NGIP OI Name	NGIP OI Description	NGIP Capability	NGIP Capability Description
		103305	<b>On-Demand NAS Information</b>	NAS and aeronautical information will be available to users on demand. NAS and aeronautical information is consistent across applications and locations, and available to authorized subscribers and equipped aircraft. Proprietary and security-sensitive information is not shared with unauthorized agencies/individuals.	<b>Provide NAS Status via Digital Notice to Airmen (NOTAMS)</b>	This increment enables the issuance of Digital NOTAMs for those airspace constraints affecting a flight based on its trajectory. The initial implementation includes internal distribution within ANSP of those notices that would be distributed via the Flight Information Services-Broadcast (FIS-B) service.
		108209	<b>Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP)</b>	Area Navigation (RNAV) and Required Navigation Performance (RNP) can enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity.	<b>Automated Terminal Proximity Alert (ATPA)</b>	ATPA is an air traffic control (ATC) automation tool that provides situational awareness and alerts to controllers on color displays of Common Automated Radar Terminal System (CARTS) and on Standard Terminal Automation Replacement System (STARS) displays
					<b>PBN Route Eligibility Check</b>	En Route Automation will check the eligibility of aircraft to operate on performance restricted routes.
		103116	<b>Initial Improved Weather Info from Non-Ground-based Sensors</b>	Additions to the sensor network from non ground-based sensors ( e.g., satellite and aircraft) provide operators and the ANSP with enhanced weather information to improve flight and clearance planning, trajectory-based operations and flow management.	-	Additions to the sensor network from non ground-based sensors, e.g., satellite and aircraft) provide operators and the ANSP with enhanced weather information to improve flight and clearance planning, trajectory-based operations and flow management.
	2.4	107107	<b>Ground Based Augmentation System (GBAS) Precision Approaches</b>	GBAS support precision approaches to Category I and eventually Category II/III minimums, for properly equipped runways and aircraft GBAS can support approach minimums at airports with fewer restrictions to surface movement, and offers the potential for curved precision approaches. GBAS also can support high-integrity surface movement requirements.	<b>GBAS Cat I Non-Federal Approval</b>	GBAS Category I is being implemented as a non-federal system on a per-airport request basis
		108206	<b>Flexible Airspace Management</b>	ANSP automation supports reallocation of trajectory information, surveillance, communications, and display information to different positions or different facilities	-	ANSP automation supports reallocation of trajectory information, surveillance, communications, and display information to different positions or different facilities • Develop ARMS evaluation model • Conduct demonstration of ARMS prototype
	2.5	103305	<b>On-Demand NAS Information</b>	NAS and aeronautical information will be available to users on demand. NAS and aeronautical information is consistent across applications and locations, and available to authorized subscribers and equipped aircraft. Proprietary and security-sensitive information is not shared with unauthorized agencies/individuals.	<b>Airport Data Management, Digital Notices to Airmen (NOTAMS)</b>	This increment provides nationwide service coverage to deliver Traffic Information Services-Broadcast (TIS-B) for both Universal Access Transceiver (UAT) and 1090 MHz Mode S Extended Squitter (1090 ES)



<b>TOps Relative Priority</b>	<b>TOps Score</b>	<b>NGIP OI #</b>	<b>NGIP OI Name</b>	<b>NGIP OI Description</b>	<b>NGIP Capability</b>	<b>NGIP Capability Description</b>
	<b>2.8</b>	102141	<b>Improved Parallel Runway Operations</b>	This improvement will explore concepts to recover lost capacity through reduced separation standards, increased applications of dependent and independent operations, enabled operations in lower visibility conditions and changes in separation responsibility between air traffic control (ATC) and the flight deck	<b>Implement SATNAV or ILS for Parallel Runway Ops</b>  <b>Wake Turbulence Mitigation for Arrivals-Procedures (WTMA-P) for Heavy/757 Aircraft</b>	This increment will enable policy, standards and procedures to allow use of Satellite Navigation (SATNAV) or Instrument Landing System (ILS) when conducting simultaneous independent and dependent instrument approaches, and implement this new capability at approved locations.  This increment expands the use of procedural dependent staggered approach separation to allow Boeing 757 and heavy aircraft to lead this procedure.

## Appendix B: Task Force 5 Supported Elements

### **Capability:** CATM-TBO Then 4D (OI#8)

**Description:** Implement and use trajectory-based individual flight planning (e.g., a series of waypoints defining a wind-based, RNAV and RNP or NRS- based trajectory, beyond the current airways system and TBFM) for the best routing available within the context of the day's operations. The trajectory (4D including time/TBFM) is able to be designed to optimize routes and throughput from both an ANSP and operator standpoint, and to reduce miles, emissions, and fuel carriage. A major new enabler is that the operator is able to use more advanced and dynamic flight planning tools to develop the most efficient flight plan. If constraints impact a requested route the customer and ANSP will use electronic negotiation to identify and collaborative on mitigation strategies (route or time). Customer will have a more flexible regulatory framework (e.g., the ability to submit the plan electronically and receive electronic feedback from the ANSP standpoint.) Use TBFM/metering, and merging and spacing tools to allow users and the service provider to negotiate trajectories prior to departure, during en route flight, and during arrival transition to maximize flight efficiency and mitigate system constraints. This builds on TFM Common and assumes Common will be in place. Benefits are therefore incremental (over and above) what are achieved with TFM Common

### **Capability:** DC Reroutes (OI#16)

**Description:** Convective weather causes many delays in today's system due to the labor-intensive voice exchanges of complex reroutes. New data communications automation will enable significantly faster and more efficient delivery of reroutes around convective weather. This operational improvement will expedite clearance delivery resulting in reduce delays and miles flow during convective weather. Equipage with FANS or ATN with VDL-2 is required to enable this operation.

### **Capability:** Data Comm Routine Communications (OI#17)

**Description:** Delivery of routine communications via data enables greater sector capacity and throughput. Both FAA and Europe have conducted numerous studies that show significant capacity benefits resulting from data communications basic services. Projected benefits include increased throughput and reduced delays resulting in fewer miles flown and greater on time performance. Equipage with FANS or ATN with VDL-2 is required to enable this operation.

### **Capability:** MMS FDMS (OI#23)

**Description:** Improve Arrival Metering, Merging and Spacing through Flight Deck Merging and Spacing en route to final approach. From Top of Descent to Landing, maximize traffic flow and enhance dependability of on-time arrival. Optimize queues for flight efficiency and improved predictability.

### **Capability:** Reroutes Weather in Cockpit (OI#31)

**Description:** Enable Aircraft-based Preferential Reroutes, away from the operational structure of the "playbook", to reduce miles flown for suitably equipped aircraft (using new uplinked Graphical Weather & Display)

**Capability:** Separation (MVMC/IMC CAS) (OI#26)

**Description:** Reduce Final Approach (and departure) Spacing in MVMC/IMC by delegating spacing (and separation) to the flight deck on final approach and departure (ADS-B in CDTI assisted visual separation), maintain VMC spacing in IMC conditions. For this assessment, scoring interim step includes a portion of approach segment in IMC terminating in VMC. Not scored is an evolution of this capability which terminates in IMC.

**Capability:** SAA (OI#35)

**Description:** Enable more comprehensive utilization of SAA through real time data exchange to allow for optimized flight planning and utilization both strategically and tactically. Current procedures regarding SAA availability are primarily based on a number of sources that mostly involve manual management and status information sharing processes. NAS stakeholders require technology that facilitates data exchange between DOD, ANSP's, and AOC/FOC's that will allow for SAA status schedules to be readily available. Additionally, technologies need to be enabled that offer the ANSP opportunities to monitor, evaluate, collaborate with stakeholders (including SAA users), and mitigate SAA constraints based on real time knowledge of availability along the entire route of flight. Added technologies are required that will allow for schedules to be included in flight plan development.

**Capability:** Revised Departure Clearance (OI#39)

**Description:** Currently departure clearances are delivered digitally today. However, revisions are often needed to the departure clearance and need to be given manually by voice. This can cause significant delays due to the length of the clearance and the time it takes the controller to issue it to the pilot. Delivery of revised Departure Clearances via data communications will greatly reduce the time and effort needed to issue the clearance. Expected benefits are reduced ground delays and improved system flexibility, especially during bad weather when many revised departure clearances are needed. (Equipage with FANS or ATN with VDL-2 is required to enable this operation. It's possible that FANS may be used with ACARS to perform this operation.)

**Capability:** Tailored Arrivals (OI#42)

**Description:** Using FANS, tailor and send arrival procedures to suitably equipped aircraft. Leverage existing FANS capability in the ATOP system at oceanic ATC facilities to conduct these procedures at coastal airports like San Francisco and Miami: (a) TAs at coastal airports where airspace and traffic permit; (b) TAs at internal NAS airports where airspace and traffic permit.

**Capability:** TFM Common (OI#43)

**Description:** Improved FAA Stakeholders collaborative decision making (CDM) involvement from pre-planning, to execution, to post execution concerning TFM/ATM. Improvements facilitated by an improved Common Operational Picture (COP). Empowered by common displays and shared operational data.

**Capability:** TFM Data Comm (OI#44)

**Description:** The combination of data communications with ground automation is expected to yield significant benefits to airspace users. This capability will leverage CDM/TFM collaboration and automation to ensure airspace user preferences are accommodated quickly and efficiently via data communications delivery of routes. Expected benefits include better accommodation of user preferences, increased throughput and reduced delays resulting in fewer miles flown and greater on time performance.

**Capability:** Data Comm Reroutes (OI#16)

**Description:** Convective weather causes many delays in today's system due to the labor intensive voice exchanges of complex reroutes. New data communications automation will enable significantly faster and more efficient delivery of reroutes around convective weather. This operational improvement will expedite clearance delivery resulting in reduce delays and miles flow during convective weather. Equipage with FANS or ATN with VDL-2 is required to enable this operation.

## Appendix C: Acronyms

4DT	Four Dimensional Trajectory
ADS-B	Automatic Dependent Surveillance-Broadcast
AGD	ADS-B Guidance Display
ANP	Actual Navigation Performance
ANSP	Air Navigation Service Provider
AOC	Airline Operations Center
ASDE-X	Airport Surface Detection Equipment – Model X
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
BA	Big Airspace
CACR	Collaborative Airspace Constraint Resolution
CATM	Collaborative Air Traffic Management
CSPR	Closely-Spaced Parallel Runway
ERAM	En Route Automation Modernization
FANS	Future Air Navigation System
FMS	Flight Management System
FOC	Flight Operations Center
GA	General Aviation
GBAS	Ground-Based Augmentation System
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
ICAO	International Civil Aviation Organization
IMC	Instrument Meteorological Conditions

JPDO	Joint Program and Development Office
LAAS	Local Area Augmentation System
NAS	National Airspace System
NextGen	Next Generation Air Transportation System
OI	Operational Improvement
OPD	Optimized Profile Descent
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
RVR	Runway Visual Range
SAA	Special Activity Airspace
SBS	Surveillance and Broadcast Services
STBO	Surface Trajectory-Based Operations
SWIM	System-Wide Information Management
TBO	Trajectory-Based Operations
TMI	Traffic Management Initiative
TOps	Trajectory Operations
VNAV	Vertical Navigation
WTMD	Wake Turbulence Mitigation for Departures

## Appendix D: Definitions

### Definition of Trajectory Operations

An aircraft trajectory is a representation of the planned or actual flown route in four (4) dimensions (latitude, longitude, altitude and time), with discrete points defined along that route. The granularity of the representation of the flight trajectory depends on the intended use of that information, and may not necessarily include all four dimensions. In its most basic form, a trajectory used by some planning activities may require only a departure airport and time and arrival airport and time (excluding any vertical dimension).

### The 4D Trajectory Defined

The flight trajectory is really a 4D trajectory that describes the path of the aircraft through all four dimensions – latitude, longitude, altitude and time. While the actual trajectory is known after it is flown, there is always some uncertainty with respect to the aircraft execution of the intended trajectory. The management of this uncertainty can be improved by maintaining coherent and consistent views of the trajectory in the various systems. This allows all participants to have a coherent representation of the trajectory at any point in time which reflects the latest flight plan, aircraft information, constraints or clearances that are relevant to the use of that trajectory.

The level of detail in a trajectory view will vary depending on the aircraft capability and type of operation. One fairly complete view of the intended trajectory might consist of the desired trajectory parameters which reflect the operator business objectives along with agreed ATM constraints and the actual trajectory (for the portion of the flight that has been completed). Some additional views are described below to clarify the trajectory concept.

### Optimized Profile Descent Applications

Optimized profile descents (OPDs) can be accomplished on RNAV or RNP arrivals, with the aircraft optimizing the descent within the pre-published, or negotiated and agreed, vertical constraints. However, an RNAV or RNP procedure alone does not provide the controller sufficient knowledge of the arrival time of the aircraft at merge points, nor the aircraft's speed profile. Thus, in today's environment controllers are unable to permit OPDs under moderate or heavy traffic conditions due to the uncertainties associated with the aircraft's trajectory (in the vertical and time dimensions).

If the ANSP can expect adherence (within the required performance) to the trajectory, then increased use of Optimized Profile Descents (OPDs) may be achieved within the overall operations

## Appendix E: TOps2 Membership

First Name	Last Name	Company
Frank	Alexander	International Air Transport Association
Clay	Barber	Garmin
Joe	Bertapelle	JetBlue Airways
Andy	Cebula	RTCA, Inc.
Sarah	Dalton	Alaska Airlines
Dan	Earman	Lockheed Martin
Jeffrey	Geller	DoD Policy Board on Federal Aviation
Bob	Graham	Single European Sky ATM Research (SESAR)
Mark	Hopkins	Delta Air Lines, Inc.
Mike	Jackson	Honeywell International, Inc.
Pascal	Joly	Airbus Americas, Inc.
Joel	Klooster	General Electric
Paul	Mettus	Lockheed Martin Corporation
Dave	Nakamura	The Boeing Company
Mark	O'Neil	National Air Traffic Controllers Association
Jon	Pendleton	Delta Air Lines, Inc.
Rick	Shay	United Continental Holdings
David	Strand	American Airlines
Brian	Townsend	US Airways
Bryan	Will	American Airlines

The following is the list of FAA and MITRE representatives supporting the TOps2 Task Group:

First Name	Last Name	Company
Joe	Celio	The MITRE Corporation
John	Glassley	Federal Aviation Administration
Joshua	Gustin	Federal Aviation Administration
Jarrett	Larrow	Federal Aviation Administration
Michele	Merkle	Federal Aviation Administration
Pat	Somersall	Federal Aviation Administration





**Approved by the NAC September 29, 2011**

**Findings and Recommendations:  
Metroplex Prioritization and Integrated  
Capabilities Scoping & Requirements**

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*A Report of the NextGen Advisory Committee in Response to Tasking  
from the Federal Aviation Administration*

*September 2011*

## Executive Summary

The Integrated Capabilities Work Group (ICWG) developed these recommendations in response to the two initial Taskings described in the ICWG's Terms of Reference: (1) Metroplex prioritization and (2) integrated capabilities scoping and requirements. These findings and recommendations build on preliminary findings and recommendations prepared by the ICWG that were forwarded by the NextGen Advisory Committee (NAC) to the Federal Aviation Administration (FAA) in May 2011.

The recommendations include:

- Metrics for evaluating the three categories of prioritization criteria that were recommended by the ICWG in May: operational need, benefits, and feasibility.
- The list of Metroplexes to be considered in ICWG work efforts. This list is a slight modification of the list originally compiled for ongoing FAA Optimization of Airspace and Procedures (OAPM) efforts, which reflect the broader and longer-term focus of ICWG work efforts.
- Refinements to the set of integrated capabilities that comprise the integrated capabilities "toolbox". These recommendations build on the set of integrated capabilities that the ICWG recommended for consideration in April 2011. We supplemented this list with more detailed descriptions of the capabilities –particularly the "new" interim capabilities – that had been identified in our recommendations approved by the NAC in May.

The recommendations also address discussions of several important ICWG findings that have emerged from our work over the past three months. These include:

- The focus of our Metroplex prioritization efforts should be defining *what* integrated capabilities should be deployed *where* and *when* and not on developing a rank-ordered list of Metroplexes similar to the list that was developed for OAPM efforts.
- To complete the aforementioned assessment of "what, where, and when", the integrated capabilities must be mapped to individual Metroplexes. Doing so also enables a more reliable assessment of the benefits and feasibility of these capabilities, which are site-specific.
- Objective, quantitative data regarding the benefits and feasibility of many of the integrated capabilities is not available, particularly Metroplex-by-Metroplex. As a result, the ICWG will need to rely primarily on qualitative, expert-judgment driven assessments of benefits and feasibility.

- The mapping and qualitative evaluation of integrated capabilities Metroplex-by-Metroplex will require the ICWG to continue its efforts through at least the end of the calendar year.

## Introduction

In February 2011, the ICWG was charged with two initial tasks—(1) Metroplex prioritization and (2) integrated capabilities scoping & requirements. As enumerated in the ICWG’s Terms of Reference, issued by RTCA on February 3, 2011, the Metroplex prioritization task was defined as follows:

*Review criteria and considerations approved by the NAC on September 23, 2010, for site prioritization for the Metroplex Optimization efforts. Determine the applicability and extensibility of the objective criteria with regard to the broader Metroplex and integrated capabilities view for implementation and integration of other NextGen capabilities. Provide specific recommendations on suitability of the criteria set and applicable adjustments.*

The integrated capabilities scoping & requirements task was defined as follows:

*Create preliminary portfolio of integrated capability requirements, with time frames for implementation. Use the results of [the Metroplex prioritization task] to identify and prioritize the major Metroplexes. Map capabilities identified in the Task Force 5 Final Report and NGIP Task Force 5 Action Plans to identified Metroplexes.*

In March and April 2011, the ICWG performed initial work on both of these tasks. This initial work—and the findings and recommendations associated with it—were summarized in two White Papers delivered to the NAC on May 19, 2011. In the first of these, the ICWG outlined a proposed Metroplex prioritization scheme consisting of three general categories—operational need, benefits, and feasibility. In the second paper the ICWG recommended an initial list of integrated capabilities as the “portfolio” of integrated capabilities that would be evaluated in subsequent ICWG work. The portfolio was composed primarily of operational improvements (OIs)—or OI segments—taken from the FAA’s NextGen Segment Implementation Plan (NSIP). OIs were selected for inclusion in the portfolio if they (1) were germane to Metroplex operations and (2) if the FAA planned to implement them in the mid-term future (i.e., by 2018). The ICWG also determined that several operational improvements described in the FAA’s 2011 NextGen Implementation Plan (NGIP) that had post-2018 implementation dates should have near- or mid-term segments defined to reflect industry needs.

The findings and recommendations presented in the May White Papers were subsequently adopted by the NAC.

Since May, the ICWG work has progressed on several fronts. We have worked to refine and operationalize the Metroplex prioritization scheme proposed in May, including defining specific evaluation metrics associated with operational need, benefits, and feasibility. In addition, we have refined our portfolio of integrated capabilities that comprise our integrated capabilities “toolbox.” These recommendations build on the set of integrated capabilities approved in May.

Next, we refined the list of Metroplexes that should be considered in ICWG work efforts. This list has been modified somewhat from the list originally compiled for ongoing FAA Optimization of Airspace and Procedures (OAPM) efforts, reflecting the broader and longer-term focus of ICWG work efforts. We also established a process to map integrated capabilities to Metroplexes, which we have tested in two initial cases—New York and Houston. Finally, we sought to refine the process by which the ICWG will prioritize integrated capabilities and Metroplexes once the mapping effort is completed.

As this work has progressed, we have realized two key challenges to our Metroplex prioritization efforts. First, the unique characteristics of each Metroplex (e.g., specific operational needs, capacity constraints, airspace and airport geometry) make it difficult, if not impossible, to reliably estimate the benefits and feasibility of integrated capabilities without detailed consideration of operational issues facing each Metroplex. Second, we have found very limited data available to quantitatively evaluate benefits and feasibility of individual integrated capabilities or groups of integrated capabilities, particularly in the context of individual Metroplexes.

To address these challenges, we have determined that it is necessary to adjust our planned approach both to evaluating the integrated capabilities and prioritizing Metroplexes, which is described in the “Next Steps” section below.

### **Metroplex Prioritization**

With respect to the ICWG’s first task—Metroplex Prioritization--the ICWG has accomplished the following:

- Reassessed our approach to the overall prioritization effort in light of FAA needs.
- Refined the Metroplex prioritization hierarchy that the ICWG presented in our May 19, 2011 *Metroplex Prioritization Criteria—Preliminary Report*.
- Developed metrics for evaluating the prioritization criteria enumerated in the prioritization hierarchy.

The following subsections describe each of these activities and the findings and recommendations that are associated with them.

## **Reassessment of Metroplex Prioritization Approach**

Findings: In our ongoing conversations with the FAA, the ICWG has refined its understanding of “Metroplex prioritization”. As we now understand it, this prioritization effort *is not* identical to the prioritization effort that was conducted last year in preparation for ongoing OAPM efforts. In that case, a rank-ordered list of Metroplexes was produced and subsequently used to determine the order in which OAPM studies would be conducted. In the case of the ICWG’s effort, the FAA has indicated that it is more interested in knowing what integrated capabilities should be deployed where and, if possible, in what time frame.

Recommendations: The ICWG recommends that we focus our efforts going forward on providing recommendations to the NAC regarding what integrated capabilities should be deployed where and—if possible—when rather than on providing the FAA with a rank-ordered list of Metroplex candidates for integrated capabilities deployment.<sup>1</sup> The following evaluation criteria and metrics will be used to accomplish this initiative.

## **Metroplex Prioritization Hierarchy Refinement**

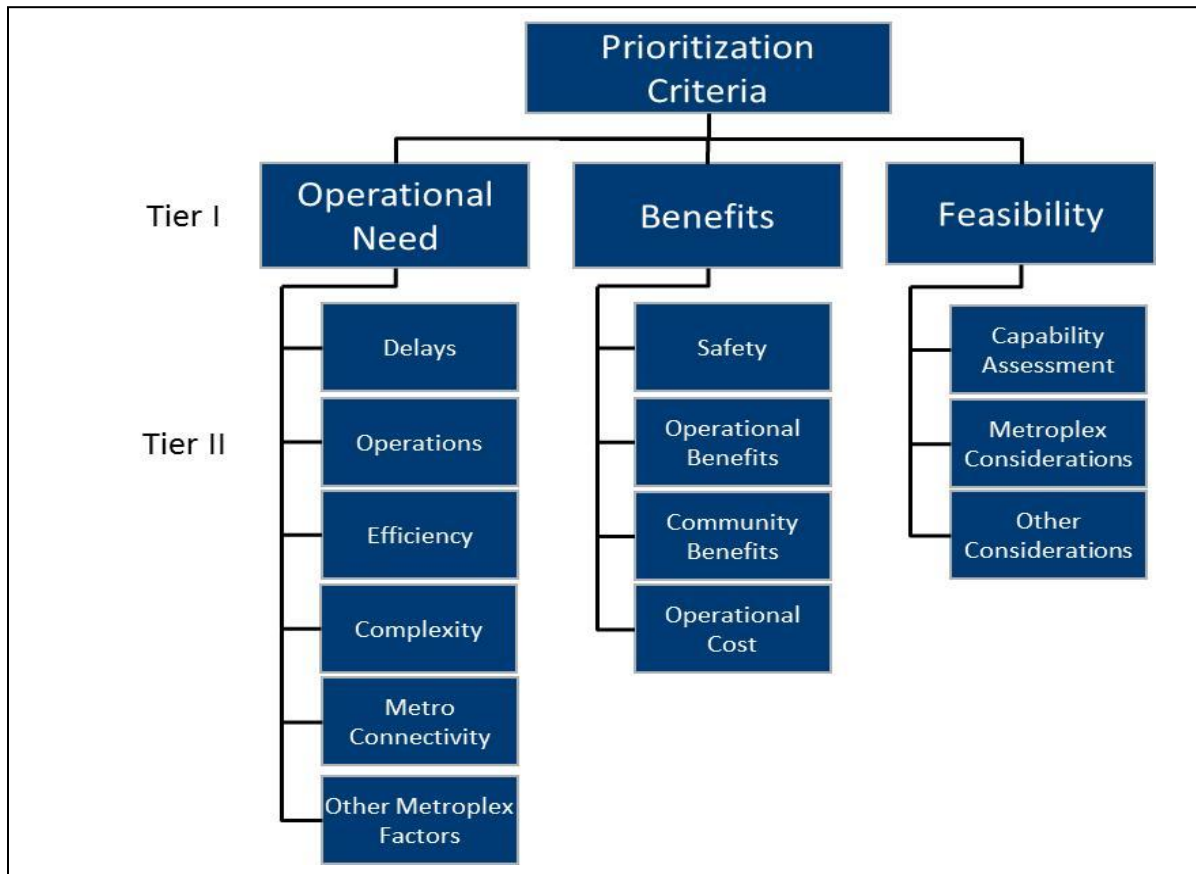
Following the May 19, 2011 NAC meeting, the ICWG refined the Metroplex prioritization hierarchy that appeared in the ICWG’s report, *Metroplex Prioritization Criteria*. These refinements reflect findings and recommendations made by ICWG subgroups that were charged with developing metrics for measuring the three major categories of prioritization criteria established by the ICWG—operational need, benefits, and feasibility.

Recommendations: Figure A shows the final prioritization hierarchy that is recommended by the ICWG.

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<sup>1</sup> Please note that in the course of our work, we may determine rank-order Metroplex priorities for particular capabilities or related sets of capabilities, such as surface management.

**Figure A: Recommended Metroplex Prioritization Hierarchy**



**Recommended Operational Need Metrics**

A subgroup of the ICWG was formed to identify the metrics to be used to quantify the operational need for NextGen integrated capabilities within particular Metroplexes. This effort is an expansion of the work completed in February and March 2011 by the ICWG and the APWG and described in the ICWG’s May 19, 2011 report, *Metroplex Prioritization Criteria*.

The subgroup also used the proposed metrics and indicators that were considered as part of the polling exercise as part of the OAPM metrics development process and as part of the ICWG and APWG exercise from the winter/spring 2011. Each potential metric/indicator was evaluated for understandability, objectivity, calculability and data availability. Where appropriate and applicable, additional metrics/indicators were identified and considered with the same rigor. In the deliberations, the Task Group sought to remove duplication between metrics (example: there were multiple metrics based on taxi-out time) and to remove metrics that were tied to any one specific capability (example: complexity of implementing optimized profile descents).

A total of five operational need subcategories were developed:

- Delays: degree and type of delays that Metroplexes currently experience.
- Operations: number of airport operations in a Metroplex.
- Efficiency: degree of inefficiencies currently within a Metroplex.
- Complexity: degree of airspace or operational complexity within a Metroplex.
- Metroplex Connectivity: degree to which activity in one Metroplex affects other major Metroplexes.

Findings: At the conclusion of this effort, the subgroup presented the following findings:

- The subcategory “Efficiency and Complexity” had many potential metrics and was too broad. The combined category was split into two separate categories.
- Historical metrics indicative of past or current operations were determined to be a better fit as indicators of need than benefit. These metrics—primarily related to socio-economic factors—were shifted from the benefit category of evaluation criteria to the operational need category.

Recommendations: The ICWG recommends using the metrics presented in Table 1 for assessing the level of operational need as part of the Metroplex prioritization efforts.

### **Recommended Benefits Metrics**

A subgroup of the ICWG was formed to identify the metrics to be used to quantify the benefits of integrated capabilities at a given Metroplex. This subgroup started with the benefits categories defined in the ICWG’s May 19, 2011 report, *Metroplex Prioritization Criteria*. The subgroup then reviewed the proposed metrics initially developed by RTCA’s consultants. In addition to these metrics, new metrics/indicators were considered as appropriate. The metrics/indicators were reviewed for understandability and objectivity.

Four benefits categories were discussed and defined as follows:

- Safety: Improvement in aviation safety.
- Operational Benefits: Degree to which capability can increase capacity or reduce travel time.
- Community Benefits: Degree to which capability will impact passengers, communities, and environment.
- Operational Cost: Potential to reduce operating cost or avoid operational investment.

**Table 1: Recommended Operational Need Metrics**

Category	Definition (Note 1)	Metrics
Delays	Degree and type of delays that Metroplexes currently experience	<ul style="list-style-type: none"> <li>• Average scheduled gate arrival delay</li> <li>• Average scheduled airport departure delay</li> <li>• Actual vs. flight plan times (by destination Metroplex)</li> <li>• OPSNET delays as percent of operations</li> </ul>
Operations	Number of airport operations in a Metroplex	<ul style="list-style-type: none"> <li>• Total airport operations</li> <li>• Peak daily operations</li> </ul>
Efficiency	Degree of inefficiencies currently within a Metroplex	<ul style="list-style-type: none"> <li>• Number of level-offs</li> <li>• Percent capacity used</li> <li>• Time below 10,000ft</li> <li>• Change in average taxi in time</li> <li>• Change in average taxi out time</li> </ul>
Complexity	Degree of airspace or operational complexity currently within a Metroplex	<ul style="list-style-type: none"> <li>• Percent of arrival vectoring</li> <li>• Number of additional IFR operations</li> <li>• Number of transition sectors/center</li> <li>• Number of arrival transition sectors</li> <li>• Airport diversity - ratio of core to other airports</li> </ul>
Metroplex Connectivity	Degree to which activity in one Metroplex affects other major Metroplexes	<ul style="list-style-type: none"> <li>• Connectivity index derived from the number of paired Metroplexes</li> <li>• Average change in airborne time</li> </ul>
Other Metroplex Factors	Degree to which Metroplex is impacted by aviation (i.e., importance of aviation to Metroplex)	<ul style="list-style-type: none"> <li>• % Metroplex GDP associated with aviation</li> <li>• % OD passengers per total Metroplex population</li> <li>• % cargo tonnage shipped by aviation in/out of Metroplex</li> </ul>
<b>Notes:</b>		
1. Operational Need metrics are intended to capture the state of the current system prior to implementation of proposed integrated capabilities.		

**Findings:** At the conclusion of this effort, the Task Group presented the following findings:

- Benefits category “Cost Avoidance” was seen as inadequate for the category. The name was adjusted to “Operational Costs.”
- Quantitative and discreet metrics considered under the Community Benefits category were determined to be a better fit as indicators of Operational Need than Benefit. These metrics were shifted from the Benefits area to the Needs area.
- It was acknowledged that quantitative benefits assessments for the majority of these capabilities are not available, and that the evaluations will be subjective assessments. A range of H/M/L will need to be defined; consistent with available data and information.
- Noise assessments will need to reflect potential positive changes.

**Recommendations:** The ICWG recommends using the metrics presented in Table 2 as guidelines for assessing the relative benefits of particular capabilities within Metroplexes.



**Table 2: Recommended Benefits Metrics**

Category	Definition	Metrics (Notes 1 & 2)
Safety	Potential increase aviation safety	<ul style="list-style-type: none"> <li>• Reduction in operational errors</li> <li>• Reduction in runway incursions</li> <li>• Reduction in pilot deviations</li> </ul>
Operational Benefit	Degree to which capability can increase capacity or reduce travel time	<ul style="list-style-type: none"> <li>• Metrics to be defined comparable to the Operational Benefits metrics proposed by the BCPMWG; current hierarchy includes capacity, efficiency, equity/access and flexibility metrics</li> </ul>
Community Benefit	Degree to which capability will impact passengers, communities, and environment	<ul style="list-style-type: none"> <li>• Reduction in passenger travel time</li> <li>• Reduction in noise impact, within 65dnl &amp; within 45dnl</li> <li>• Fuel savings (average per operation in Metroplex)</li> </ul>
Operational Cost	Potential to reduce or avoid operating and/or capital investment costs	<ul style="list-style-type: none"> <li>• Avoided infrastructure investments (e.g. avoided runway investment)</li> <li>• Reduction in operating cost to operator (e.g. fuel efficiency)</li> <li>• Reduction in service provider operating costs (e.g. decommissioning, staffing)</li> </ul>
<p><b>Notes:</b></p> <ol style="list-style-type: none"> <li>1. Estimates of "potential" reductions or impacts may be subjective H/M/L assessments.</li> <li>2. Potential reductions will need to be evaluated relative to baseline values (i.e., without proposed NextGen capabilities).</li> </ol>		

**Recommended Feasibility Metrics**

The feasibility category has the following three subcategories:

- Capability assessment—Overall (i.e., systemic) readiness of an identified integrated capability to achieve projected operational benefits.
- Metroplex considerations—Readiness of a particular Metroplex to implement an identified capability<sup>2</sup>.
- Other considerations—A measure of availability of the resources required to implement the identified capability.

**Recommendations:** The ICWG recommends using the metrics presented in Table 3 as guidelines for assessing the relative feasibility of particular capabilities within Metroplexes. Within the three categories of Feasibility Metrics, the ICWG has identified and reached consensus on individual metrics. The proposed Capability Assessment category has four top-level metrics. The proposed Metroplex Considerations category has five top-level metrics, and the proposed Other Considerations category has two top level metrics.

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<sup>2</sup> “Metroplex considerations” was originally identified to the NAC as “Site Considerations”. However, the ICWG has concluded that Metroplex is a more appropriate name for the category than Site since this category represents the assessed readiness of a Metroplex to implement an identified integrated capability.

**Table 3: Recommended Feasibility Metrics**

Category	Definition	Metrics
Capability Assessment	Overall readiness of an identified capability to achieve operational benefit	<ul style="list-style-type: none"> <li>• Technical readiness (Note 1)</li> <li>• Regulatory readiness (rulemaking process, operational specifications, separation standards)</li> <li>• Procedural process readiness               <ul style="list-style-type: none"> <li>– Flight deck procedures</li> <li>– ATC handbook</li> <li>– FOC procedures</li> <li>– Flight procedures (Note 2)</li> <li>– Other NAS stakeholders (e.g., airport operators)</li> </ul> </li> <li>• Operational readiness               <ul style="list-style-type: none"> <li>– Training</li> <li>– O&amp;M</li> <li>– Measurement &amp; monitoring</li> </ul> </li> </ul>
Metroplex Considerations	Readiness of a particular Metroplex to implement an identified capability	<ul style="list-style-type: none"> <li>• Estimated time to achieve benefits at Metroplex</li> <li>• Potential for extended environmental review</li> <li>• Percentage of operations within the Metroplex for which aircraft are equipped (Note 3)</li> <li>• Ground/automation/surface systems availability</li> <li>• Receptivity of Metroplex (Note 4)               <ul style="list-style-type: none"> <li>– Support of Metroplex airport authority/operator</li> <li>– Support of community</li> <li>– Support of local FAA facilities and ATC SCC</li> </ul> </li> </ul>
Other Considerations	A measure of availability of the resources required to implement the identified capability (Note 5)	<ul style="list-style-type: none"> <li>• FAA resources               <ul style="list-style-type: none"> <li>– Monetary resources</li> <li>– Staff resources</li> </ul> </li> <li>• Industry resources</li> </ul>
<p><b>Notes:</b></p> <ol style="list-style-type: none"> <li>1. Technical readiness includes all airborne and ground subsystems required to support the operational capability.</li> <li>2. Flight procedures are likely to be Metroplex-specific, reflecting the capabilities of the particular Metroplex.</li> <li>3. Need to integrate “percentage of operations for which aircraft are equipped” with training and opspec considerations.</li> <li>4. Airport ownership and political implications—harmony within Metroplex.</li> <li>5. FAA budget was top “impediment” identified at 2011 RTCA Symposium. Second was FAA’s ability to deliver operational benefits. The metrics in this category should be applied “systemically”, considering the complete set of integrated capability/Metroplex priorities that emerge from the ICWG’s Metroplex mapping exercises.</li> </ol>		

Two findings are noted. First, the ICWG agreed that feasibility metrics are best evaluated on a “High”, “Medium” and “Low” basis since many of these measures would be very difficult to accurately quantify and the value of any quantification was thought to be low with regards to the effort. Second, the ICWG found that the “Other Considerations” category is best applied “systemically”, considering the complete set of integrated capability/Metroplex priorities that emerge from the ICWG’s Metroplex mapping exercises and the associated resources—staff and money—needed to implement them.

## Integrated Capabilities Scoping & Requirements

With respect to the ICWG's second task, Integrated Capabilities Scoping & Requirements, the ICWG has accomplished the following:

- Finalized the set of Metroplexes for consideration in Metroplex integrated capabilities mapping and prioritization efforts.
- Refined the definitions of the integrated capabilities that the ICWG recommended for consideration in our work efforts, including the "additional" integrated capabilities that are not part of the FAA's current mid-term NextGen implementation plans.
- Conducted a readiness assessment of identified integrated capabilities to assist in evaluating the implementation feasibility of the integrated capabilities in the mid-term future (i.e., by 2018).
- Began mapping identified capabilities to Metroplexes via two "case study" efforts—one for the New York Metroplex and one for the Houston Metroplex.

The following subsections describe each of these activities and the findings and recommendations that are associated with them.

### Metroplex Selection

The purpose of this effort was to identify the candidate Metroplexes for the prioritization and mapping effort. A Metroplex is defined as a geographic area covering many airports, serving one (or more) major metropolitan area and a diversity of aviation stakeholders.

The effort started with two inputs: the list of Metroplexes being considered under the FAA's Optimization of Airspace and Procedures in the Metroplex (OAPM) project and the FAA's list of Core airports. The FAA's OAPM list consists of 23 Metroplexes, covering the sites recommended under the Metroplex section of RTCA's Task Force 5 report on NextGen. The FAA's 30 Core airports were identified earlier this year and have replaced the 35 airports identified as part of the FAA's Operational Evolution Partnership. The ICWG effort reviewed the 21 OAPM Metroplexes and the 30 Core airports, to determine if additional Metroplexes were required. Following the discussion of the 30 Core airports, the ICWG also considered another 53 airports. These additional airports, once referred to as Secondary Focus airports, were also considered by the FAA in their determination of the 30 Core airports. Of the 83 airports considered, 73 were included in 27 Metroplexes (six more than the 21 OAPM Metroplexes).<sup>3</sup>

In considering the Metroplex Selection initiative during its September 8, 2011 meeting, the NACSC requested that the list be separated into two tiers with the top tier Metroplexes being

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<sup>3</sup>Airports not assigned to a Metroplex: ABQ, ANC, AUS, BNA, BUF, IND, MCI, OMA, SAT, SJU.

the focus of the integrated capability mapping and prioritization efforts that will take place in Fall/Winter 2011. This activity is currently underway and the ICWG will report its findings and recommendations back to the NACSC at its October 25, 2011 meeting.

Findings: The ICWG had the following findings:

- The solution set for the ICWG includes numerous capabilities that go beyond the scope of the OAPM effort. These capabilities may have applications outside of the 23 OAPM Metroplexes.
- The OAPM Metroplexes combined or clustered some Metroplexes, in accordance with operational assumptions made for ongoing airspace and procedures efforts. The capabilities being considered by the ICWG warranted reconsideration of those combinations. Specifically, the New York/Philadelphia and Southern California OAPM Metroplexes were reviewed. The New York/Philadelphia Metroplex was split into two Metroplexes for the ICWG definition. While these two Metroplexes are considered together for airspace and procedures solutions, the ICWG feels that the two Metroplexes have operations that could warrant different prioritization of integrated capabilities.
- Several of the airports not contained in the OAPM Metroplexes have unique operational problems/issues that could be uniquely addressed by some of the capabilities under consideration, even if they are not relevant to an airspace and procedures solution set. These airports were added to existing or included as new Metroplexes. It is expected that their relative value will be assessed as part of the prioritization process. In particular, the ICWG created Metroplexes to cover the two Core airports not included in the OAPM set, Hawaii and Salt Lake City; and added Metroplexes for Portland, St. Louis, Cleveland (includes Pittsburgh and Cleveland) and Cincinnati (includes Louisville and Cincinnati) areas.

Recommendations: For the integrated capabilities mapping and prioritization efforts, the ICWG recommends considering 27 Metroplexes, based on the OAPM Metroplexes with the following adjustments:

- Split New York/Philadelphia into two separate Metroplexes.
- Create Metroplexes to cover the two Core airports not included in the OAPM set – Hawaii and Salt Lake City.
- Add Metroplexes for Portland, St. Louis, Cleveland (includes Pittsburgh and Cleveland) and Cincinnati (includes Louisville and Cincinnati) areas.
- Concentrate the fall/winter 2011 by defining, mapping and applying the prioritization effort on Tier One Metroplexes.

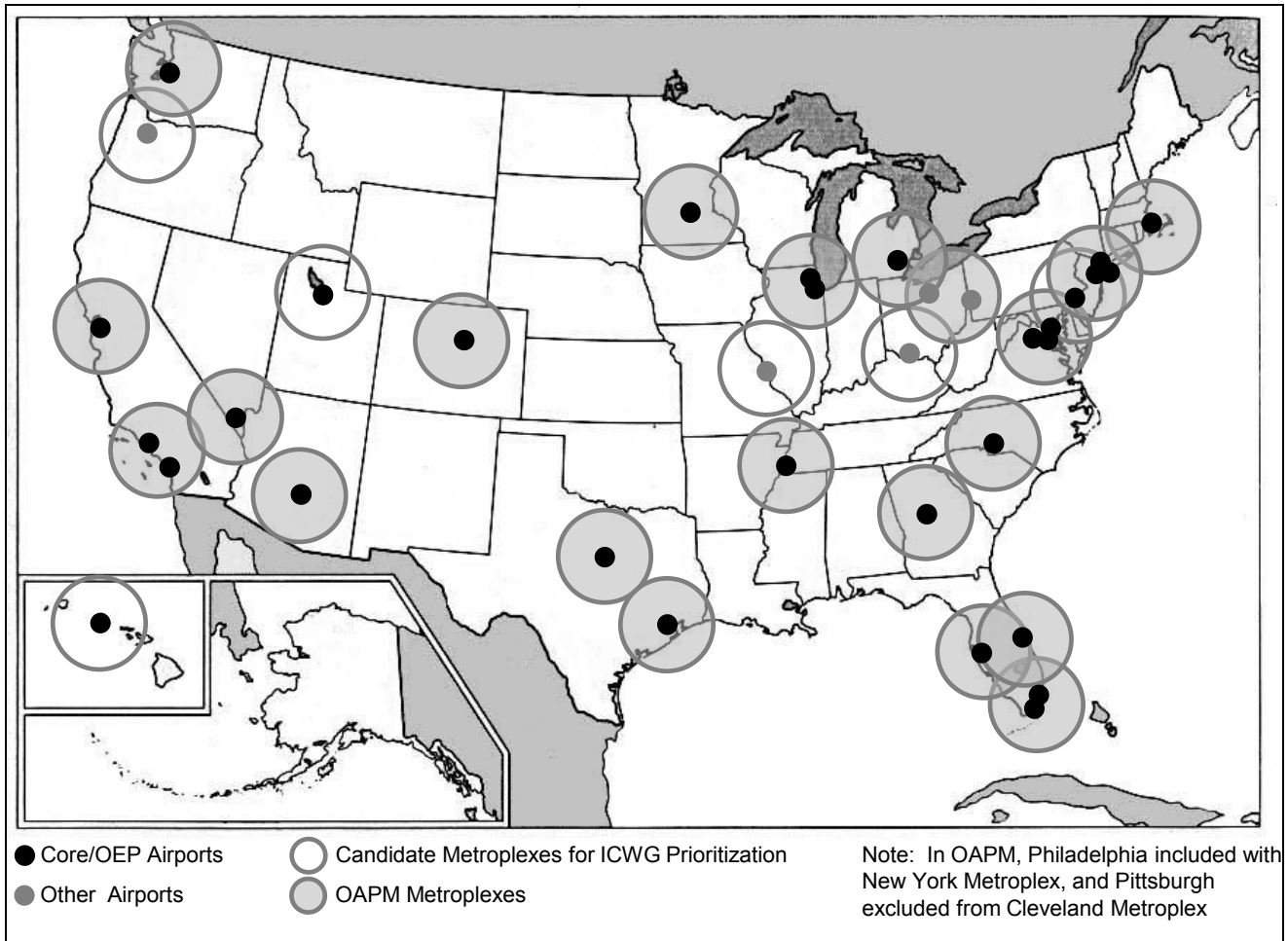
Table 4 lists the 27 Metroplexes with the associated airports, including several reliever airports identified as part of the OAPM Metroplex definitions. Figure B shows the Metroplexes geographically with the comparison to the OAPM Metroplexes.

**Table 4: Recommended Metroplexes for Consideration  
in ICWG Metroplex Prioritization Efforts**

<b>Metroplex (Note 1)</b>	<b>Core Airports</b>	<b>Other Airports</b>
Atlanta	ATL	FTY, PDK, RYY
Boston	BOS	BDL, PVD, BED, BVY, MHT, OWD
Charlotte	CLT	RDU, CAE, GSO, GSP, JQF, UZA
Chicago	MDW, ORD	DPA, MKE, UGN, AAR, ENW, GYY, IGQ, LOT, PWK, RFD
Cincinnati		CMH, CVG, SDF, DAY, LEX, LUK
Cleveland		CLE, PIT, BKL, CGF, LEB
Dallas-Ft. Worth	DFW	DAL, ADS, AFW, DTO, FTW, GKY, TKI
DC Metro	BWI, DCA, IAD	DMW, FDK, HEF, JYO, MTN, W66
Denver	DEN	APA, BJC
Detroit	DTW	DET, PTK, YIP
Hawaii	HNL	OGG
Houston	IAH	HOU, MSY, AXH, CXO, DWH, EFD, IWS, LVJ, MSY, SGR
Las Vegas Valley	LAS	HND, HND, VGT
Memphis	MEM	OLV
Minneapolis-St. Paul	MSP	21D, ANE, FCM, LVN, MIC, SGS, STP
New York	EWR, JFK, LGA	FRG, HPN, ISP, MMU, SWF, TEB, ABE, CDW
Northern California	SFO	HWD, LVK, OAK, RNO, SJC, SMF, CCR, PAO, RHV, SQL
Orlando	MCO	JAX, ISM, ORL, SFB
Philadelphia (Note 2)	PHL	ILG, ACY, LOM, PNE
Phoenix	PHX	TUS, CHD, DVT, EFZ, GEU, IWA, SDL
Portland		PDX, HIO
Salt Lake City	SLC	
Seattle	SEA	BFI, PAE, RNT, S50, S43, TIW
South Florida	FLL, MIA	DAB, PBI, RSW, FXE, LNA, OPF, TMB
Southern California	LAX, SAN	BUR, CNO, LGB, ONT, SNA, VNY, CRQ, HHR, MYS, OXR, POC, PSP, SDM, SEE, SMO, WHP
St. Louis		STL, CPS, SUS
Tampa	TPA	PIE, SRQ
<b>Notes:</b>		
1. Shaded rows indicate Metroplexes that were not considered in OAPM Metroplex prioritization efforts.		
2. In OAPM prioritization efforts, Philadelphia was included within the New York Metroplex.		

As noted above, the ICWG is currently reassessing this list so that only the top tier Metroplexes will be addressed in the integrated capability mapping and prioritization efforts that will take place prior to the end of calendar year 2011.

**Figure B: Recommended Metroplexes for Consideration  
in ICWG Metroplex Prioritization Efforts**



### Integrated Capabilities Definition

In June, the Integrated Capabilities Work Group stood up a Capabilities Definition Subgroup, which met through July and August 2011. The purpose of the subgroup was to:

- Compile the capabilities recommended by the ICWG in its May 2011 report to the NAC into a comprehensive list in a manageable format.
- Finalize definitions of new proposed capabilities.
- Complete remaining analysis and resolve open comments concerning the inclusion or exclusion of specific capabilities.
- Identify, discuss, and address problematic definitions, gaps, and overlaps.
- Categorize the capabilities to the extent practical.

The subgroup also compiled available information regarding the expected implementation timelines for these capabilities.

As background, the list of integrated capabilities that the Subgroup started with was taken largely from the FAA's March 2011 NGIP and associated NSIP. This list was recommended by the ICWG in its May 2011 report to the NAC. For additional details regarding how the list was developed please refer to the May 19, 2011, White Paper, *Metroplex Integrated Capabilities Scoping & Requirements*.

Findings: Appendix A summarizes the results of the subgroup's work. The Appendix lists each of the integrated capabilities currently under consideration by the ICWG, organized in accordance with the FAA's implementation portfolios.

The subgroup also made the following specific changes to the list of integrated capabilities:

- Implementation of satellite navigation (SATNAV) or instrument landing system (ILS) approach procedures for closely-spaced parallel runway operations (ID Number 102141-12) was split into two distinct integrated capabilities to reflect anticipated differences in the timeframes for implementing this capability for ILS-SATNAV and ILS-LPV/GLS approaches. Accordingly we modified 102141-12 (see strikethroughs in description) and added new capability 102141-NEW.
- The subgroup recommended changes to the capability description text for the following capabilities: 101102-11, 102137-13, 102143, 102409, 103208-12, 103305-12, 104209-16, 105208-12.

Recommendations: With respect to integrated capabilities definition, the ICWG has the following recommendations:

- The list of integrated capabilities, definitions, and implementation timeframes shown in Appendix A should be used for Metroplex mapping and prioritization work.<sup>4</sup>
- The FAA should be advised of all "new" capabilities that the ICWG has identified so these can be considered in the next versions of its NSIP. These "new" capabilities are highlighted in orange in the Appendix.

### **Integrated Capabilities Readiness Assessment**

The Integrated Capabilities subgroup of the ICWG also conducted an assessment of the level of difficulty associated with implementing individual integrated capabilities in accordance with the assumed implementation timeline. Implementation difficulty was evaluated for the following five factors:

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<sup>4</sup> The ICWG does expect this to be a "living list" that is continuously revised with information updates, new proposed capabilities, dropped capabilities, improved definitions, etc.

- Aircraft equipage
- Ground equipage
- Standards
- Certification
- Policies & procedures

The readiness of these five factors was assessed by subgroup members using a three-point scale—easy, moderate, or hard. The preliminary results of this assessment appear in the summary tables on Pages A-1 and A-2 of Appendix A. These assessments are still undergoing review by the ICWG and no action is requested from the NACSC or NAC regarding them at this time.

### **Mapping of Integrated Capabilities to Metroplexes**

The ICWG has begun mapping the integrated capabilities enumerated in Appendix A to individual Metroplexes. This mapping activity is explicitly called for in the ICWG’s Terms of Reference. The ICWG has also determined that it is a necessary prerequisite to assessing the benefits and feasibility of particular integrated capabilities due to the unique characteristics and operational needs of each Metroplex.

In August, the ICWG conducted two initial Metroplex mapping exercises—one for New York and one for Houston. In both cases, we conducted the mapping exercise in a workshop setting and sought the participation of subject matter experts that were intimately familiar with the Metroplex in question. In the case of New York, we were able to find expertise within the ICWG; in the case of Houston, we included additional subject matter experts from Continental/United Airlines, Southwest Airlines, and the Houston Airports System.

In both cases, participants in the mapping workshops worked through the list of integrated capabilities shown in Appendix A. Participants evaluated the extent to whether the individual capabilities would (1) provide operational benefits and (2) be feasible to implement in the mid-term future (i.e., by 2018). These evaluations were conducted using a three-point qualitative scale—high, medium, and low—based on the subject matter expertise of workshop participants. The ICWG is currently working to finalize the results of the two initial mapping exercises.

Findings: The ICWG has made the following findings regarding the mapping of integrated capabilities to Metroplexes:

- To complete the assessment of “what, where, and when”, the integrated capabilities must be mapped to individual Metroplexes. Doing so also enables a more reliable



assessment of the benefits and feasibility of these capabilities, which can be highly Metroplex-specific.

- Objective, quantitative data regarding the benefits and feasibility of many of the integrated capabilities is not available, particularly Metroplex-by-Metroplex. As a result, the ICWG will need to rely primarily on qualitative, expert-judgment driven assessments of benefits and feasibility.
- The mapping and qualitative evaluation of integrated capabilities Metroplex-by-Metroplex for the top tier Metroplexes will require the ICWG to continue its efforts through at least the end of the calendar year.

## NEXT STEPS

The ICWG proposes to continue our Metroplex mapping exercises through mid-December 2011. We expect that the rate at which we can complete these exercises will increase as we progress through the Metroplexes. In early November, midway through our mapping exercise, we plan to provide the NACSC with an interim report that discusses the preliminary findings of the mapping exercises, including common sets of integrated capability priorities that emerge from the efforts. We expect to complete the mapping exercise by December. Figure C below provides additional detail regarding our work plan for September 2011 through January 2012.

Activity	September	October	November	December	January
September NAC report refinement	X				
Integrated capabilities mapping guidelines	X				
Additional mapping exercises					
Interim mapping findings			X		
Final mapping findings				X	
Initial metroplex prioritization of ICs					
February NACSC report preparation					X
NAC report refinement					X

X: Written deliverable

**Capabilities by NSIP Categories (plus OIs & New Capabilities) – Ctrl-Click to jump to definition**

“I:” = NSIP Increment, “O:” = EA OI, “N:” = New Capability

Collaborative Air Traffic Management	I: Electronic Negotiations (12-13) <b>S C P</b>		I: Delivery of Pre-Departure Reroutes to Controllers (13) <b>C P</b>		N: Mid-Term CDM Implementation (12-15) <b>S C P</b>		O: Flexible Routing in the Mid-Term (12-15) <b>S</b>		O: Provide Interactive Flight Planning from Anywhere (15-21) <b>S C P</b>				
	DC	FAA, OPS	DC	FAA		FAA, OPS		FAA, OPS	DC, TM	FAA, OPS			
Improved Surface Operation	I: ASDE-X to Additional Airports (10-13)		I: RWSL (10-14) <b>S</b>		I: Revised Departure Clearance via Data Comm (13-15) <b>C P</b>		I: Airport Configuration Management Increment 1 (15) <b>P</b>		I: Taxi Routing Increment 1 (15) <b>C P</b>		I: External Data Exchange (15) <b>S P</b>		
		FAA		FAA, APT	DC	FAA, OPS		FAA		FAA		FAA, OPS	
	I: Moving Map with Own-Ship Position (10-14) <b>C P</b>		I: CDTI/TIS-B for Surface (11-15) <b>C P</b>		I: Runway Assignments Increment 1 (15) <b>C P</b>		I: Scheduling and Sequencing Increment 1 (15) <b>C P</b>		I: Departure Routing Increment 1 (15) <b>C P</b>		O: Provide Full Surface Situation Information (16-19) <b>S C P</b>		
NV		AI	FAA		FAA		FAA		FAA	AI	FAA, OPS, APT		
Time-Based Flow Management	I: Implement TMA’s ACM Capability at Additional Locations (10-14) <b>P</b>		I: Integrated Departure/Arrival Capability (IDAC) (11-14) <b>C P</b>		I: Extended Metering (13-14) <b>P</b>								
		FAA		FAA		FAA							
	I: Implement TMA at Additional Airports (10-14) <b>P</b>		I: Use RNAV Route Data to Calculate Trajectories Used to Conduct TBM Operations (12-13)		N: Mid-Term Trajectory-Based Management, Gate-to-Gate (12-15) <b>S C P</b>		O: Integrated Arrival/Departure Airspace Management (16-19) <b>P</b>						
	FAA		FAA	NV	FAA, OPS	NV	FAA						
Closely Spaced, Parallel, Converging, and Intersecting Runway Operations	I: Use Converging Runway Display Aid (CRDA) (10-13) <b>P</b>		I: Amend Independent and Dependent Runway Standards in Order 7110.65 (10-15) <b>P</b>		I: CSPO Use of PRM-A (10-15)		I: Implement SATNAV or ILS for Parallel Runway Operations (11-15) <b>C P</b>						
		FAA				FAA	NV	FAA					
	I: Additional 7110.308 Airports (WTMA Procedures) (10-15) <b>P</b>		I: Additional 7110.308 Airports (WTMA Procedures) (10-15) <b>P</b>		I: Expand the 7110.308 Procedure to Heavy/757 Aircraft (11-15) <b>P</b>		N: Implement LPV/GLS or ILS for Parallel Runway Operations (11-15) <b>C P</b>						
						NV	FAA						
Improved Approaches and Low-Visibility Operations	Appr	O: Low-Visibility Operations Using Lower RVR Minima (9-11)		I: GBAS Category I Non-Federal System Approval (10-14) <b>C P</b>		I: RNP and RNP AR Approaches (10-15) <b>P</b>		I: LPV Approaches (15) <b>S</b>		I: GBAS Category II/III (14-18) <b>S C P</b>		O: Expanded Radar-like Services to Secondary Airports (18) <b>S C P</b>	
			FAA	NV	APT	NV	FAA	NV	FAA	NV	FAA	AI	FAA, APT
	Other	I: OPDs Using RNAV and RNP STARs (10-11) <b>P</b>		I: Initial Tailored Arrivals (ITAs) (10-12) <b>S</b>		3D PAM [TBD] (16-18)		O: Low Visibility Surface Operations (15-18) <b>S C P</b>		O: Provide Surface Situation to Pilots, Service Providers and Vehicle Operations for Near-Zero-Visibility Surface Operations (15-25) <b>S C P</b>			
	NV	FAA	DC	FAA	TBD	TBD	NV, AI	FAA	NV, AI	FAA, APT			

Appendix A: Capabilities Under Consideration

Performance-Based Navigation	I: Optimization of PBN Procedures (10-12) <b>C</b> <b>R</b>	I: Transition to PBN Routing for Cruise Operations (10-15) <b>G</b>	O: Delegated Responsibility for Horizontal Separation and FIM-S (13) <b>R</b> <b>R</b>	O: Delegated Responsibility for Horizontal Separation (Lateral & Horizontal) (15) <b>R</b> <b>R</b>	O: Reduced Horizontal Separation Standards, En Route-3 Miles (18-25) <b>C</b> <b>P</b>					
	NV	FAA	NV	FAA	AI	FAA	AI	FAA	AO	FAA
	I: Relative Position Indicator (RPI) (12-13) <b>C</b> <b>P</b>		I: Large-Scale Redesign of Terminal and Transition Airspace Leveraging PBN (10-15) <b>C</b>		I: NextGen En Route DME Infrastructure (12-15)		N: Mid-Term Efficient Metroplex Merging and Spacing (15?)			
	FAA	NV	FAA		FAA	TBD	TBD			
On-Demand NAS Information	I: Provide NAS Status via Digital NOTAMs (09-15) <b>S</b> <b>P</b>	I: Broadcast Flight and Status Data to Pilots/AOCs (10-14) <b>S</b> <b>C</b> <b>P</b>	I: Provide Improved Flight Planning and In-Flight Advisories for FOCs/AOCs (11-15) <b>S</b> <b>C</b> <b>P</b>	I: ANSP Real-Time Status for SUAs (13-14) <b>S</b> <b>C</b> <b>P</b>	I: SAA Forecast of Capacity Constraints (14) <b>P</b>					
	AI	FAA	AI	FAA		FAA, OPS		FAA, GOV		FAA
Automation Support for Separation Management	I: Aircraft-to-Aircraft Alerts for 3nm Separation Areas (13-15) <b>P</b>									
		FAA								
Common Services		O: Initial Improved Weather Information from Non-Ground Based Sensors (13-18) <b>S</b> <b>C</b> <b>R</b>	O: Full Improved Weather Information and Dissemination (16-23) <b>S</b> <b>C</b> <b>R</b>							
		DC, WX	FAA, OPS	DC, WX, NV	FAA, OPS					

Green/Yellow/Red represent Level of Difficulty of remaining work (Easy/Moderate/Hard). Notes: does not include funding / level of equipage difficulties; if no requirements, there is no color.

APT = Airport Infrastructure (non-FAA)  
 FAA = FAA Infrastructure or Automation  
 OPS = FOC/AOC Investment  
 GOV = Other Gov't Agency (non-FAA)

Objective: identify major equipage steps for operators

Avionics Requirements ("beyond current"):

- AI = ADS-B In w/ Display (ADS-B Out implicit, GPS-level Nav implicit)
- AO = ADS-B Out (GPS-level Nav implicit)
- NV = Navigation Capability (beyond RNAV)
- DC = Data Comm
- TM = Trajectory Management (mostly EFB/FMS apps)
- WX = Weather Avionics, Sensors, etc.

Standards: Extent of remaining standards work to be done (RTCA, ICAO, etc.)

"S" - None, Low, Med, High (Green, Yellow, Red)

Certification: Extent of remaining certification work to be done – system certification, could be avionics or FAA system (not routine certification of individual pieces of equipment)

"C" - None, Low, Med, High (Green, Yellow, Red)

Objective: identify major ground investments (whether FAA, Operators, other)  
 Ground Requirements ("beyond current"):

Policies & Procedures: Extent of remaining P&P work to be done

"P" - None, Low, Med, High (Green, Yellow, Red)

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Provide Full Flight Plan Constraint Evaluation – Increment: Electronic Negotiations</b>	101102-11	2012-2013	“The Electronic Negotiations increment provides flight planners with information about congestion along their intended routes and proposes flight-specific rerouting. This is a two-way exchange that gives the flight planner the choice of delaying a flight or choosing alternate routes. The initial phase of Electronic Negotiations is limited to the period before a flight plan is filed and is based primarily on ground delays or route options. Controllers will receive these negotiated pre-departure reroute instructions. Through data link, tower controllers can convey revised departure clearances to the users, effectively extending the period of negotiations to the last possible moment before departure. Delivery of the pre-departure amendment to the flight deck is addressed in the Improved Surface Operations Portfolio, in the increment Revised Departure Clearance via Data Comm (104207-11).” [NSIP v3.0, 2.1.1.3.1]	Since Data Comm is in the text, we must interpret it as being part of the capability, but recommend FAA revision that splits ATC-FOC negotiation from DCL.
<b>OI: Provide Interactive Flight Planning from Anywhere</b>	101103	2015-2021	“Flight planning activities are accomplished from the flight deck as readily as any location. Airborne and ground automation provide the capability to exchange flight planning information and negotiate flight trajectory agreement amendments in near real-time. The key change is that the air navigation service provider’s (ANSP) automation allows the user to enter the flight plan incrementally with feedback on conditions for each segment. Rather than testing full trajectories by submitting and waiting for full routes evaluations, the system will test each segment as entered and provide feedback. Through this process the user will work with the system to quickly reach a flight plan agreement. As before any subsequent change, constraint, preference, or intent triggers a full flight plan review with feedback to the filer. The filer can develop preferred trajectories that may include an identified constraint that the automation system maintains in case subsequent changes to conditions will allow its promotion to agreement. Automation thus maintains multiple flight plans for an individual flight.” [NAS EA 7.4]	Though the OI description could be better, some capabilities fitting this description are deemed possible by 2015. Note this includes flight deck, dispatch, AOC/FOC; also strategic to tactical timeframes; many permutations. Different methodology for FAA view of flight plan?
<b>OI: Reduced Horizontal Separation Standards, En Route-3 Miles</b>	102117	2018-2025	“The Air Navigation Service Provider (ANSP) provides reduced and more efficient separation between aircraft where the required performance criteria are met, regardless of location other than operations in oceanic airspace. Advances in Air Navigation Service Provider (ANSP) surveillance (e.g. ADS-B) and automation allow procedures with lower separation minimums to be used in larger areas of the airspace. This reduces the incidence of conflicts and increases the efficiency of the conflict resolution maneuvers.” [NAS EA 7.4]	May want to press for expedited delivery? Calls for ground integration of ADS-B, possibly fused radars.
<b>OI: Delegated Responsibility for Horizontal Separation and FIM-S</b>	102118	2013	“Enhanced surveillance and new procedures enable the ANSP to delegate aircraft-to-aircraft separation. Improved display avionics and broadcast positional data provide detailed traffic situational awareness to the flight deck. When authorized by the controller, pilots will implement delegated separation between equipped aircraft using established procedures. Broadcast surveillance sources and improved avionics capabilities provide ANSP and the flight deck with accurate position and trajectory data. Aircraft that are equipped to receive the broadcasts and have the associated displays, avionics, and crew training are authorized to perform delegated separation when assigned by the controller. ANSP will be provided with a new set of (voice or datalink) procedures directing, for example, the flight crews to establish and to maintain a given time or distance from a designated aircraft, including separations equivalent to, but not less than current wake turbulence separations. This interval may be an absolute value, or a relative designation to remain "no closer than" or "no further than". The flight crews will perform these new tasks along paths, including RNAV paths with turns, using new aircraft functionality.” [NAS EA 7.4]	Examples suggest it is feasible by 2018: <ul style="list-style-type: none"> <li>•UPS example [ACSS avionics, “SafeRoute” product] (Louisville)</li> <li>•USAir Airbus aircraft in Phila. area</li> <li>•JetBlue</li> </ul> Still, lots of issues, especially getting to approved policies & procedures for general use

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Automation Support for Separation Management – Increment: Aircraft-to-Aircraft Alerts for 3nm Separation Areas</b>	102137-13	2013-2015	“En route conflict alert will be enhanced to support wake vortex separation requirements in 3-nm separation areas and transition airspace. Problem detection and trial planning capabilities will also be enhanced to support aircraft-to-aircraft alerts in 3-nm separation areas and transition airspace, to include alerts based on wake vortex separation requirements. Sectors that contain tactical airspace (sectors where 3-nm separation is likely to be used and transition airspace) have traditionally been the areas where problem detection was inhibited. Problem detection will be enhanced to support areas where procedures and surveillance accuracy allow reduced separation in en route airspace. These enhancements will support separation management in more tactical areas of air traffic control, areas where wake vortex separation will need to be applied.” [NSIP v3.0, 2.8.1.1.1]	Assuming these are automation alerts to controllers, not alerts <i>sent</i> “aircraft to aircraft” involving the flight deck.
<b>OI: Expanded Radar-like Services to Secondary Airports</b>	102138	2018	“Expanded capacity is available in Instrument Meteorological Conditions (IMC) at additional secondary airports. Expanded delivery of radar-like coverage with surveillance alternatives such as Automatic Dependent Surveillance-Broadcast (ADS-B) coverage, combined with other radar sources, and with an expansion of communication coverage provides equipped aircraft with radar-like services to secondary airports. Equipped aircraft automatically receive airborne broadcast traffic information. Surface traffic information is also available at select non-towered satellite airports. Enhanced surveillance coverage in areas of mountainous terrain where radar coverage is limited, especially to small airports, enables ANSP to provide radar-like services to equipped aircraft. This capability enhances alerting and emergency services beyond normal radar coverage areas.” [NAS EA 7.4]	Optimistically not seeing any major barriers to some implementation in midterm. Major issues: TIS-B and terminal automation updates. Relying on ADS-B Out in 2018 is problematic.
<b>OI: Improved Parallel Runway Operations – Increment: Additional 7110.308 Airports (WTMA Procedures)</b>	102141-11	2010-2015	“This increment provides airports with maximum use of closely spaced parallel runways by authorizing participating aircraft to operate at reduced lateral and longitudinal spacing on dependent, instrument approach procedures to runways with centerline spacing less than 2500 feet. This increment will expand the application of FAA Order 7110.308 beyond the locations and runway ends already approved, and implement this capability using available ground and airborne equipment, existing displaced runway thresholds, historical wind data, and procedural modifications to instrument approach procedures to maximize the reduced separation benefit.” [NSIP v3.0, 2.4.1.1.1]	
<b>OI: Improved Parallel Runway Operations – Increment: Expand the 7110.308 Procedure to Heavy/757 Aircraft</b>	102141-11a	2011-2015	“This increment expands the use of procedural dependent staggered approach separation to allow Boeing 757 and heavy aircraft to lead this procedure. This will increase the efficiency of runway throughput at approved airports. Initial Operating Capability (IOC) is planned for CY2011. This increment includes amending Order 7110.308 to reflect the change as well as implementing the procedure at approved locations.” [NSIP v3.0, 2.4.1.1.2]	

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Improved Parallel Runway Operations – Increment: Implement SATNAV or ILS for Parallel Runway Operations</b>	102141-12	2011-2015	<p>“This increment will enable policy, standards, and procedures to allow use of SATNAV or ILS when conducting simultaneous independent and dependent instrument approaches, and implement this new capability at approved locations. The current standard for parallel approaches relies on ILS for simultaneous independent and dependent approaches. This increment expands this capability by implementing <del>both</del> unaugmented Global Positioning System (GPS)-based approaches, such as RNAV (GPS), RNAV (RNP), and RNAV (RNP) with Aircrew Authorization Required (AR), <del>as well as augmented GPS-based approaches such as LPV and GLS for these parallel approach applications,</del> providing more options for ATC and users during IMC. These additional options increase the chance of maintaining higher throughput when needed to support the demand. This improvement will increase access to parallel runways during IMC, particularly where various constraints prevent ILS installation, and will allow continued operation using SATNAV as a backup approach option if the ILS is out of service.” [NSIP v3.0, 2.4.1.1.4]</p>	See edit & next new capability... Recommend splitting RNAV/GPS vs. LPV & GLS -- different timescales, RNAV/GPS is almost done.
<b>Improved Parallel Runway Operations – Increment: Implement LPV/GLS or ILS for Parallel Runway Operations</b>	102141-NEW	2011-2015	<p>This increment will enable policy, standards, and procedures to allow use of SATNAV or ILS when conducting simultaneous independent and dependent instrument approaches, and implement this new capability at approved locations. The current standard for parallel approaches relies on ILS for simultaneous independent and dependent approaches. This increment expands this capability by implementing augmented Global Positioning System (GPS)-based approaches, such as LPV and GLS for these parallel approach applications, providing more options for ATC and users during IMC. These additional options increase the chance of maintaining higher throughput when needed to support the demand. This improvement will increase access to parallel runways during IMC, particularly where various constraints prevent ILS installation, and will allow continued operation using SATNAV as a backup approach option if the ILS is out of service.</p>	New capability specifically for LPV/GLS, longer timescale than 102141-12
<b>OI: Improved Parallel Runway Operations – Increment: Amend Independent and Dependent Runway Standards in Order 7110.65</b>	102141-13	2010-2015	<p>“This increment amends runway spacing standards to achieve increased access to parallel runways with centerline spacing less than 4300 feet and implements this change at approved locations. Current runway spacing standards for independent closely spaced parallel approaches are based, in part, on outdated assumptions about aircraft blunder rates that include severity and frequency. Due to the fact that the blunder assumptions were based on information available 20 years ago and some subjective views at the time, current spacing standards may be unnecessarily conservative, limiting capacity and airport growth. This increment includes the collection and analysis of data leading to a revision of these assumptions, followed by a safety analysis to determine possible new, reduced, safe minimum spacing for simultaneous independent approaches in IMC, as outlined in Order 7110.65. Changes to standards will result in increased access in a number of possible ways, including reducing spacing for new runway construction and allowing independent approach operations where currently only dependent, or single-runway, operations are authorized.” [NSIP v3.0, 2.4.1.1.3]</p>	
<b>OI: Improved Parallel Runway Operations – Increment: CSPO Use of PRM-A</b>	102141-14	2010-2015	<p>“PRM-A is a certified surveillance system based on Airport Surface Detection Equipment Model X (ASDE-X) design with additional multilateration sensors and an equivalent one-second update rate that, along with associated display aids, provides controllers with the precise aircraft position information needed to monitor aircraft on simultaneous, independent, instrument approaches to closely spaced parallel runways. This increment includes an analysis of how best to expand its use at additional locations.” [NSIP v3.0, 2.4.1.1.5]</p>	

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>Mid-Term Efficient Metroplex Merging and Spacing</b>	<b>102142-NEW</b>	2015-2018	<p>“Air navigation service provider (ANSP) automation and decision support tools incorporate aircraft wake characteristics and forecast wake transport conditions. Spacing buffers between streams approaching and departing multiple metroplex runways are reduced to allow efficient airborne merging and spacing, increasing greater traffic throughput and reduced ANSP workload in terminal areas. Arrival and departure flows are planned and executed based on a comprehensive view of real time airport operations. Automation provides optimal departure staging and arrival sequencing based on aircraft wake, wake conditions and airborne performance characteristics. Data communications provides required navigation performance routes to the flight deck. This OI includes development of ANSP capability and procedures and requires an Implementation Decision to determine what complex airborne merging and spacing operations will be required for effective use of high-density metroplex airspace, such as crossing streams, merging and diverging streams, etc.” [NAS EA 7.4]</p>	<p>The ICWG is focused on a mid-term variant of OI 102142, specifically an enhancement to the TMA capability, called GIM-S, to pre-condition arrival traffic to support Flight-Deck Interval Management - Spacing operations. GIM-S will initially rely on using en-route speed clearances only, which will require an extension of the TMA time horizon to 90 minutes prior to ideal Top of Descent. GIM-S will also provide advice to the controller regarding what aircraft pairs should perform FIM-S and what the final approach spacing target should be. Would require Aircraft ADS-B Out and In, with CDTI and FIM-S.</p>
<b>OI: Delegated Responsibility for Horizontal Separation (Lateral &amp; Horizontal)</b>	<b>102143</b>	2015	<p>“Enhanced surveillance and new procedures enable the ANSP to delegate some responsibility for maintaining aircraft-to-aircraft separation to flight crews. Improved display avionics and broadcast positional data provide detailed traffic situational awareness to the flight deck. When authorized by the controller, pilots will implement delegated separation between equipped aircraft using established procedures to achieve more consistent and predictable aircraft spacing. This spacing will more accurately apply existing separation standards, in various meteorological conditions, while at the same time reducing controller workload.</p> <p>Broadcast surveillance sources and improved avionics capabilities provide ANSP and the flight deck with accurate position and trajectory data and therefore increased situational awareness. Aircraft that are equipped to receive the broadcasts and have the associated displays, avionics, and crew training will perform delegated separation when authorized by the controller. During specific meteorological conditions and/or air traffic procedures, delegated separation operations include the transfer of separation authority for a specific maneuver to achieve improved NAS capacity and flight efficiency. For example, during Instrument Meteorological Conditions (IMC), the additional situational awareness on the flight deck provided by displays of proximate traffic enable aircraft to accept some separation responsibility without adding a separation buffer to the 3 NM separation standard. During certain marginal conditions in the terminal area, this procedure enables aircraft to continue with the Visual Meteorological Conditions separation instead of decreasing capacity by switching to much lower capacity IFR operations. Under this procedure, aircraft that have established initial visual contact can continue a visual approach while traversing a light cloud layer, using the onboard traffic display briefly to augment situational awareness until visual contact is reestablished.</p> <p>Aircraft performing delegated separation procedures are paired and separate themselves from one another by maintaining a given time or distance from a designated aircraft using cockpit-based tools. The use of this procedure will replace some of the ATC vectoring and speed instructions made necessary by existing surveillance. For aircraft not delegated separation authority, ANSP automation will still support separation.” [NAS EA 7.4]</p>	<p>Specifics mentioned are feasible; some language is too open-ended such that infeasibility is possible; accept with caveat.</p> <p>Lots of issues, especially getting to approved policies &amp; procedures for general use.</p>

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>Flexible Routing in the Mid-Term</b>	<b>102146-NEW</b>	2012-2015	<ul style="list-style-type: none"> <li>• With some minor policy changes/reduction in restrictions, the already “approved” NRP and High-Altitude Route (HAR) “programs” could yield considerable benefit in the near-term timeframe.</li> <li>• Trajectory Options Sets (TOS’), a central element of CTOP, which is a component of the FAA’s Collaborative Airspace Constraint Resolution (CACR) Program, will enable mid-term flexible routing.               <ul style="list-style-type: none"> <li>• Operators will develop route options based on constraint information for the city pair to be flown.</li> <li>• In consideration of that information and based on operator business rules, the primary route trajectory will be submitted to ATC along with a number of alternative route options that the aircraft has the ability to fly based on fuel and other operational considerations.</li> <li>• Application of these route options is limited to pre departure (wheels up) in the mid-term.</li> <li>• The assignment of a route option by ATC may be facilitated by voice communication or ACARS, via a revised PDC (Data Comm is NOT required for such implementation)</li> </ul> </li> </ul>	<p>This new capability is a nearer-term but similar to OI 102146, “Flexible Routing”. However, 102146 is off our list because of its implementation timeframe.</p> <p>Assume some FAA &amp; operators system-level info exchange.</p>
<b>OI: Provide Full Surface Situation Information</b>	<b>102406</b>	2016-2019	<p>“Automated broadcast of aircraft and vehicle position to ground and aircraft sensors/receivers provides a digital display of the airport environment. Aircraft and vehicles are identified and tracked to provide a full comprehensive picture of the surface environment to ANSP, equipped aircraft, and flight operations centers (FOCs).</p> <p>Surface Situation Information will complement visual observation of the airport surface. Decision support system algorithms will use enhanced target data to support identification and alerting of those aircraft at risk of runway incursion.</p> <p>In addition, non-ANSP functions, such as airport (movement and non-movement areas) and security operations will benefit from information exchange and situational awareness of aircraft and equipped vehicle surface position and movement.” [NAS EA 7.4]</p>	<p>TIS-B plus additional flows to AOC/FOC, Airport ops, etc. We’ve assumed ADS-B In but B/W req’ts could lead to data comm.</p>
<b>OI: Provide Surface Situation to Pilots, Service Providers and Vehicle Operations for Near-Zero-Visibility Surface Operations</b>	<b>102409</b>	2015-2025	<p>“Aircraft and surface vehicle positions are displayed to aircraft, vehicle operators, and air navigation service providers (ANSP) to provide situational awareness in restricted visibility conditions, increasing efficiency of surface movement.</p> <p>Surface movement is guided by technology such as moving map displays, enhanced vision sensors, synthetic vision systems, Ground Support Equipment and a Cooperative Surveillance System. Aircraft and surface vehicle position will be sensed and communicated utilizing systems such as Cockpit Display of Traffic Information (CDTI) and Automatic Dependent Surveillance-Broadcast (ADS-B). Efficient management of surface movement requires cooperative surveillance (i.e., ADS-B out) for all aircraft and ground vehicles present.” [NAS EA 7.4]</p>	<p>Assume situational awareness only.</p>



Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<p><b>OI: Initial Improved Weather Information from Non-Ground Based Sensors</b></p>	<p><b>103116</b></p>	<p>2013-2018</p>	<p>“Additions to the sensor network from non-ground based sensors (e.g., satellite and aircraft) provide Operators and the ANSP with enhanced weather information to improve flight and clearance planning, trajectory based operations, and flow management. The enhancements include greater 3-D resolution of weather information/hazards in specifically affected airspace enabling users to better understand the potential impacts of weather on airspace or airports (e.g., regions of turbulence, convection, terminal winds). The result is increased reliability of forecasts for turbulence, convection, and in-flight icing improving the effectiveness and efficiency of all aspects of the operation including turbulence and icing impacts to in-flight aircraft. In addition, terminal area forecasts of fog and ceilings are improved to provide the ability to match strategic flow plans to conditions and optimizing use of the airport.</p> <p>Satellite and aircraft water vapor sensors better define atmospheric moisture by actively collecting and transmitting essential networked-enabled weather observations to ground-based systems for integration with other weather information into the 4-D Weather Data Cube (and later on into the 4-D Weather Single Authoritative Source (4-D Wx SAS)). This enhances the accuracy of in-flight icing and convective forecasts. Turbulence algorithms added to flight management systems provide more objective (accurate) and frequent turbulence reporting which is essential to improved turbulence forecasting and warnings to in-flight aircraft. Planned new satellite-based sensors improve detection and will also assist in the prediction of fog and ceilings that impact airport departures/arrivals. The expansion of aircraft types carrying these sensors improves atmospheric sampling from the atmospheric boundary layer up through maximum flight levels, which improves aviation model forecast output. Once in the 4-D Weather Data Cube, this information is disseminated to ANSPs, users, and their automation systems, providing reliable, timely and consistent weather information that enables them to mitigate the impacts of weather on operations.” [NAS EA 7.4]</p>	

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<p><b>Full Improved Weather Information and Dissemination</b></p>	<p>103121</p>	<p>2016-2023</p>	<p>“This improvement provides the full capability that supports the NextGen concept of operations to assimilate digital weather information into decision-making for all areas of operations. The net-centric access of weather observations, analyses, forecasts (including probability), and climatology via a robust 4D Weather Data Cube and a de-conflicted 4-D Weather Single Authoritative Source (4-D Wx SAS) becomes complete. Requisite weather information is 'pushed' to ANSPs, flight operations, and aircrews if a change in weather may potentially impact operations (based on user-defined weather thresholds of interest). All weather information is provided at the appropriate aviation decision-maker tailored resolution, update frequency, geographic scale, etc. crucial to NextGen operations. Improved accuracy of forecast information and universal access to the 4-D Wx SAS enables integration of weather and its uncertainty into user and ANSP decision support tools, which supports risk management.</p> <p>Today, the NAS is unable to provide a common weather picture for universal use. When aviation decision makers use weather information that is inconsistent in source, derivation and content, collaborative decision making is virtually impossible. Given a common weather picture, aviation operations that can be affected by weather are made more consistent with respect to potential system and individual flight operation impacts. The resolution of these impacts can be formulated more effectively and decision making becomes more seamless over operational times, boundaries, and activities. NextGen's mid-term implementation of the 4-D Wx SAS begins to rectify these inefficiencies. In the far-term, the 4-D Wx SAS matures, meeting all NextGen operational decision-making performance requirements for accuracy, latency, availability, etc. Also, the mechanism involved in determining the SAS, from available weather sources, becomes dynamic, highly automated, and more effectively provides the 'best' source of weather information to stakeholders to support operational decision making. The 4-D Wx SAS also meets the needs of stakeholders for tailored weather information directly applicable to all manner of NextGen era decisions. Stakeholders can pull tailored weather information or it can be proactively updated ("pushed") based on user requests. Safety, efficiency, and capacity are enhanced by providing decision makers and decision support tools with tailored weather information such as: timing of a wind shift to more effectively support airport runway reconfiguration; flight impacting weather along a 4DT; high-resolution terminal area wind forecasts to support arrival/departure operations; or timely hazardous weather information from a lead aircraft that is provided to following aircraft. Combined with universal (net-centric) access, the 4-D Wx SAS provides a common weather picture to all stakeholders and decision support tools (DSTs). This common weather picture facilitates effective collaborative decision making, supports traffic flow management by trajectory, and allows users to duplicate and better understand tactical ANSP recommendations.” [NAS EA 7.4]</p>	
<p><b>OI: Improved Runway Safety Situational Awareness for Controllers – Increment: ASDE-X to Additional Airports</b></p>	<p>103207-12</p>	<p>2010-2013</p>	<p>“This increment enables Air Traffic Control (ATC) to detect potential runway conflicts by providing detailed coverage of movement on runways and taxiways. By collecting data from a variety of sources, ASDE-X is able to track vehicles and aircraft on the airport movement area and obtain identification information from aircraft transponders. The system essentially creates a continuously updated map of the airport movement area that controllers can use to maintain situational awareness. It includes safety logic to assist the controllers in identifying and resolving potential conflicts before the conflicts become hazards.” [NSIP v3.0, 2.2.1.1.1]</p>	<p>existing technology &amp; policies/procedures</p>

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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Improved Runway Safety: Situational Awareness for Pilots – Increment: Moving Map with Own-Ship Position</b>	103208-11	2010-2014	“Cockpit displays, for instance Electronic Flight Bags (EFBs), may incorporate airport moving map displays that provide constantly changing views of an airport’s runways, taxiways, and structures to help pilots identify and anticipate the airplane’s location on the surface. The Global Positioning System (GPS) provides the capability to depict an accurate own-ship position on the airport surface as the aircraft moves. With moving map displays and own-ship positions, pilots will see exactly where their aircraft are on the airfield, thus increasing situational awareness and compliance with the assigned taxi clearances.” [NSIP v3.0, 2.2.1.2.2]	AMM Flight deck procedures and training
<b>OI: Improved Runway Safety: Situational Awareness for Pilots – Increment: CDTI/TIS-B for Surface</b>	103208-12	2011-2015	“Surface traffic information is available via Traffic Information Service Broadcast (TIS-B) for moving map displays. Using TIS-B, Cockpit Display of Traffic Information (CDTI) will provide a graphical depiction of ground and air traffic, which will improve situational awareness for a variety of operations. Surveillance information from ASDE-X will be broadcast in TIS-B format to be received by suitably equipped aircraft.” [NSIP v3.0, 2.2.1.2.3]	Assume this is just SA (anything more would require additional P&P); we expect AOC/FOC feed as well but not as a "requirement"
<b>OI: Improved Runway Safety: Situational Awareness for Pilots – Increment: RWSL</b>	103208-13	2010-2014	“RWSL are lights that provide pilots with indications of occupied runways to help avoid incursions and hazards resulting from those incursions. RWSL comprises an array of red, in-pavement lights deployed at taxiway/runway intersections and runway take-off and hold positions. Airport surface surveillance sensors provide surface vehicle and traffic information to RWSL, which have logic to enable types of lights that indicate to pilots and vehicle operators that a runway or taxiway is currently occupied and unsafe to enter, cross, land on, or depart from. Runway Entrance Lights (REL) are deployed at taxiway/runway crossings and illuminate red when there is high-speed traffic on or approaching the runway to signal that it is unsafe to enter the runway. Take-off Hold Lights (THL) are deployed by the departure hold zone and illuminate red when there is an aircraft in position for departure and the runway is occupied by another aircraft or vehicle.” [NSIP v3.0, 2.2.1.2.1]	airport involved in funding and construction; not conceptually difficult
<b>OI: On-Demand NAS Information – Increment: Broadcast Flight and Status Data to Pilots/AOCs</b>	103305-11	2010-2014	“This increment provides nationwide service coverage to deliver TIS-B for both Universal Access Transceiver (UAT) and 1090 MHz Mode S Extended Squitter (1090 ES). Flight information services from the essential services specification are available for UAT operators (including SAA status).” [NSIP v3.0, 2.7.1.2.1]	
<b>OI: On-Demand NAS Information – Increment: Provide Improved Flight Planning and In-Flight Advisories for FOCs/AOCs</b>	103305-12	2011-2015	“This increment ensures that NAS and aeronautical information is consistent, allowing users to subscribe to and receive the most current information from a single source. Information is collected from both ground systems and airborne users (via ground support services), aggregated, and provided through a system-wide information environment, Data Communications, or other means. Information on current and planned airport configuration is provided by Tower Flight Data Management (TFDM). The collected information follows the Aeronautical Information Exchange Model (AIXM) standard and provides runway status and configuration as in-flight advisories (via SWIM).” [NSIP v3.0, 2.7.1.2.2]	We interpret data comm. as optional. Very aggressive timeframe.
<b>OI: On-Demand NAS Information – Increment: Provide NAS Status via Digital NOTAMs</b>	103305-13	2009-2015	“This increment enables the issuance of Digital NOTAMs for those airspace constraints affecting a flight based on its trajectory. The initial implementation includes internal distribution within the ANSP of those notices that would be distributed via the FIS-B service.” [NSIP v3.0, 2.7.1.2.3]	

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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Current Tactical Management Of Flow in the En Route for Arrivals/Departures – Increment: Implement TMA’s ACM Capability at Additional Locations</b>	104115-11	2010-2014	<p>“To expand the benefits of time-based metering and TBFM’s other advanced flow management capabilities, ACM will be implemented at the following additional locations:</p> <ul style="list-style-type: none"> <li>• LAX — ACM from ZAB and ZLA</li> <li>• SFO — ACM from ZSE, ZOA, ZLA, and ZLC</li> <li>• SAN — ACM from ZLA and ZOA</li> <li>• ATL — ACM from ZDC and ZHU</li> <li>• IAD — ACM from ZNY”</li> </ul> <p>[NSIP v3.0, 2.3.1.4.1]</p>	
<b>OI: Current Tactical Management Of Flow in the En Route for Arrivals/Departures – Increment: Implement TMA at Additional Airports</b>	104115-12	2010-2014	<p>“To expand the benefits of time-based metering and TBFM’s other advanced flow management capabilities, TBFM will be implemented at the following additional locations:</p> <ul style="list-style-type: none"> <li>• Baltimore, Maryland (BWI)</li> <li>• Cleveland, Ohio (CLE)</li> <li>• Washington, D.C., Reagan National (DCA)</li> <li>• San Diego, California (SAN)</li> <li>• Morristown, New Jersey (MMU)</li> <li>• Teterboro, New Jersey (TEB)”</li> </ul> <p>[NSIP v3.0, 2.3.1.4.2]</p>	
<b>OI: Improved Management of Arrival/Surface/Departure Flow Operations – Increment: Integrated Departure/Arrival Capability (IDAC)</b>	104117-11	2011-2014	<p>“IDAC, the first increment of this OI, increases NAS efficiency and reduces delays by providing decision-making support capabilities for departure flows. IDAC automates the process of monitoring departure demand and identifying departure slots. It also deconflicts the departure times between airports with traffic departing to common points in space and provides situational awareness to air traffic control tower personnel so they can select from available departure times and plan their operations to meet these times. The results of these enhancements are more efficient departure flows and less delay.” [NSIP v3.0, 2.3.1.3.1]</p>	Note this is relatively near-term and scope focused on departure management. Part of the TBFM portfolio.
<b>OI: Point-in-Space Metering – Increment: Extended Metering</b>	104120-11	2013-2014	<p>“The first increment of this OI is Extended Metering. By definition, this capability will extend the metering horizon beyond the nominal distance used today. Currently, metering is conducted approximately 150 to 200 nautical miles from the adapted arrival airport, though this distance is extended during ACM operations, which are conducted at several locations in the National Airspace System (NAS) today. ACM will be implemented at additional locations. Building upon the ACM capability, Extended Metering will increase the distance from the airport where metering will be conducted without significant degradation in the accuracy of aircraft-specific slot times to the meter reference points. This capability will provide flow deconfliction for metered aircraft at the meter reference points (in addition to meter fixes). The specific distances and locations where extended metering operations will be implemented will be based on operational need and benefits. This capability will be leveraged in the future to support end-to-end metering, meaning metering through each phase of flight.</p> <p>Additionally, the technical infrastructure that will be developed for this increment will be scalable to support additional metering initiatives planned for subsequent implementation.” [NSIP v3.0, 2.3.1.1.1]</p>	

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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Integrated Arrival/Departure Airspace Management</b>	<b>104122</b>	2016-2019	<p>“New airspace design takes advantage of expanded use of terminal procedures and separation standards. This is particularly applicable in major metropolitan areas supporting multiple high-volume airports. This increases aircraft flow and introduces additional routes and flexibility to reduce delays. ANSP decision support tools are instrumental in scheduling and staging arrivals and departures based on airport demand, aircraft capabilities, gate assignments and improved weather data products.</p> <p>This capability expands the use of terminal separation standards and procedures (e.g., 3 nm, degrees divergence) within the newly defined transition airspace. It extends further into current en route airspace (horizontally and vertically). A redesign of the airspace will permit a greater number of RNAV and RNP procedures within the transition airspace to allow for increased throughput. Extended application of terminal procedures and separation standards allows greater flexibility for traffic to be re-routed during severe weather and other disruptions to normal flows. Certain routes can be bi-directional and are used for either arrival or departure, depending on the traffic situation and the location of the severe weather.” [NAS EA 7.4]</p>	Note relatively further out timeframe, part of PBN portfolio, and wide-ranging.
<b>OI: Time-Based Metering using RNAV and RNP – Increment: Use RNAV Route Data to Calculate Trajectories Used to Conduct TBM Operations</b>	<b>104123-11</b>	2012-2013	<p>“In addition to the en route RNAV routes, which are already used to calculate trajectories, the Terminal Radar Control Center (TRACON) RNAV routes for both Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs) will be used to calculate the terminal component of aircraft trajectories.” [NSIP v3.0, 2.3.1.2.1]</p>	
<b>OI: Time-Based Metering using RNAV and RNP – Increment: Time-Based Metering with Efficient 3D Paths and RNAV/RNP</b>	<b>104123-NEW</b>	2016-2018	<p>[3D-PAM increment – AI get description from Segment Bravo]</p>	<p>The ICWG is focused on a mid-term variant to OI 104123 in which the FAA would enhance the TMA system based in a new capability developed by NASA called the Efficient Descent Advisor (EDA). This capability will compute enroute and descent speed advisories, as well as path stretches when required, to be cleared to the aircraft in a form readily usable in the aircraft Flight Management System. This capability will support the execution of OPD's with idle, or near-idle, descent in moderate to high traffic conditions, and is supported by a very high percentage of today's aircraft fleet. Can be performed using voice communications, as well as FANS-1/A data communications. Would require RNAV and VNAV.</p>

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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Use Optimized Profile Descents – Increment: Initial Tailored Arrivals (ITAs)</b>	104124-11	2010-2012	“ITAs are used in the Segment Alpha timeframe to address an initial version of the tailored arrivals concept. ITAs are pre-planned, fixed routings assigned by Oceanic Air Traffic Control (ATC) facilities and sent from the Oceanic Automation System (Ocean21) via Data Communications to suitably equipped (i.e., FANS 1/A) aircraft as an arrival clearance into coastal airports.” [NSIP v3.0, 2.5.1.1.2]	
<b>OI: Use Optimized Profile Descents – Increment: OPDs Using RNAV and RNP STARs</b>	104124-12	2010-2011	“OPD procedures are being implemented as RNAV STARs (eventually as RNP STARs, where necessary) with vertical profiles that are designed to allow aircraft to descend using reduced or even idle thrust settings from the top of descent to points along the downwind or final approach. They are optimized to the extent possible that will accommodate use by a large population of aircraft and within constraints of the air traffic system. Design is based on the application of altitude windows that can be met by a range of aircraft and performance capabilities.” [NSIP v3.0, 2.5.1.1.1]	
<b>Mid-Term Trajectory-Based Management, Gate-to-Gate</b>	104126-NEW	2012-2015	<p>OI 104126 describes a full end state of trajectory-based operations; however, progress toward this end state can be achieved in the mid-term by deploying several intermediate capabilities, which are currently available:</p> <ul style="list-style-type: none"> <li>• TMA and initial applications of TBFM facilitate crossing times and/or Required Times of Arrival (RTAs) for runway ends and subsequent exit from movement areas (into ramps/gates).</li> <li>• Tactical departure fix reassignment (by voice or ACARS) based on projected delay increase efficiency by reallocating departures across a wider set of departure options based on the Trajectory Options Set (TOS), which is communicated via electronic negotiation capabilities (FOC/AOC-ATM).</li> <li>• En route changes utilizing Collaborative Airspace Constraint Resolution (CACR) provide mitigation options for constraints unknown at time of departure but specify route options. The deployment of CACR, which requires changes to the ground infrastructure (FOCs), is an enabler for TBO in the cockpit.</li> </ul>	This new capability is related to OI 104126, “Trajectory-Based Management Gate-to-Gate”. However, 104126 is off our list because of its implementation timeframe. FANS-1/A for RTAs; could be challenging for FOCs.
<b>OI: Enhanced Surface Traffic Operations – Increment: Revised Departure Clearance via Data Comm</b>	104207-11	2013-2015	“A Revised Departure Clearance (DCL) Data Comm capability will allow the FAA to rapidly issue departure clearance revisions, due to weather or other airspace issues, to one or more aircraft equipped with FANS waiting to depart. This reduces delays, fuel burn, and emissions on the airport surface. The use of Data Comm for this type of capability has both safety and efficiency benefits over the current voice-based method of communications between ATC and the pilot. This initial implementation of DCL is planned for VDL-2 as the link scheme.” [NSIP v3.0, 2.2.1.3.1]	
<b>OI: Initial Surface Traffic Management – Increment: Airport Configuration Management Increment 1</b>	104209-11	2015	“To improve responsiveness and effective use of airport resources, and rapidly coordinate airport configuration changes across multiple ANSP activities, this capability provides automation assistance for setting up, assessing, and changing the airport configuration. It includes airport configuration change modeling for impact assessment. This capability provides a manually requested “what-if” capability to assess the impact of airport configuration change and provides results to ATC/Air Traffic Management (ATM). The capability also supports the dissemination of the selected configuration and scheduled time of the change.” [NSIP v3.0, 2.2.1.4.1]	
<b>OI: Initial Surface Traffic Management – Increment: Runway Assignments Increment 1</b>	104209-12	2015	“To assist in efficient runway allocation and use, the automation assigns an aircraft to a runway via assignment rules based on the flight’s departure fix and enables ANSP personnel to accept or modify the runway. This capability supports alternative departure runways for users, using pre-coordinated departure routes, and allows for real-time runway rule assignment (e.g., if a runway needs to be temporarily closed).” [NSIP v3.0, 2.2.1.4.2]	

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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Initial Surface Traffic Management – Increment: Scheduling and Sequencing Increment 1</b>	104209-13	2015	“For improved departure schedule integrity, this capability generates and displays a predicted departure surface sequence and schedule for each runway showing arrival and departure demand. The capability displays the departure surface sequence and runway queues as a recommendation to the controller to improve throughput. This capability provides TFM constraints to tower controllers, such as Expected Departure Clearance Times (EDCTs). This capability receives and uses flight data from users and ramp towers (e.g., predicted pushback time, departure gate). The capability provides estimated flight-specific event times (e.g., spot times) necessary to meet the predicted departure surface sequence and schedule. These estimated event times are shared with the users.” [NSIP v3.0, 2.2.1.4.3]	
<b>OI: Initial Surface Traffic Management – Increment: Taxi Routing Increment 1</b>	104209-14	2015	“For improved taxi route efficiency, this capability provides dynamic information on airport taxiways and runways integrated with controller displays.” [NSIP v3.0, 2.2.1.4.4]	Real-time controller tools subject to some debate
<b>OI: Initial Surface Traffic Management – Increment: Departure Routing Increment 1</b>	104209-15	2015	“For improved departure operations, this capability provides tower controllers with electronic flight data management and an interface to assessments of weather and Traffic Management Initiative (TMI) impacts on departure routes and associated flights. Automation that conducts these assessments is described in the section on, Collaborative Air Traffic Management.” [NSIP v3.0, 2.2.1.4.5]	
<b>OI: Initial Surface Traffic Management – Increment: External Data Exchange</b>	104209-16	2015	“The FAA will establish a data exchange infrastructure as well as integrated decision support tools, standards, and processes that rely on agreed-to information exchange among stakeholders. A key element of this increment is enabling flight-related information to be provided by users to the FAA for use in improving surface ATC services, for handling special service requests, and for surface Collaborative Decision-Making (CDM). Data is envisioned to be exchanged among surface ATC and other NAS domains to coordinate plans and activities. Data is also exchanged between the FAA and users and other non-government participants, such as fixed-based operators, airport authorities, and ramp operations, to provide common airport situational awareness and facilitate coordination. Data is exchanged between the FAA and other government users such as the Transportation Security Administration, Department of Homeland Security, military (e.g., Air National Guard) for situational awareness and to facilitate coordination. Policies regarding data distribution are a critical enabler for this increment. The FAA will install DDUs at 19 airports, for the purpose of disseminating surface surveillance data to other NAS domains, other government entities, and non-government operators and entities. To achieve operational data exchange, the FAA will use a phased approach. The first phase will achieve an initial data dissemination capability in 2010 that will make surface surveillance data available to other NAS domains, other government entities, users, airports, and other non-government entities. A more robust and longer-term infrastructure will be established during 2011-2013 that will reach the entire CDM community and will support agreed-upon standards and collaborative tools used by the CDM community. As a second phase, External Data Exchange in 2015 will include a more robust set of data intended to assist surface traffic management decision-making, also making it more collaborative. In this second phase, flight-specific data such as departure readiness, predicted taxi start time, and operational data will be shared in accordance with policies, standards, and interoperable processes.” [NSIP v3.0, 2.2.1.4.6]	Recommendation: consider breaking into program-sized initiatives (limited timeframe, users, and capabilities)

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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>Mid-Term CDM Implementation</b>	<b>105207-NEW</b>	2012-2015	<p>OI 105207 describes long-term collaborative capabilities; however, progress can be made in the mid-term by expanding the capabilities that have been developed by applying the existing CDM process, which was created by the CDM Group. A team of industry and FAA representatives facilitate the CDM group, which falls under the Air Transport Association (ATA) umbrella as a “limited technical exchange” group between the association’s members, other invited industry groups and the FAA. It is governed by a CDM Stakeholder Group (CSG) which provides guidance and tasking to multiple subgroups. The CSG is focused on the continual improvement of air traffic management among NAS Stakeholders. The operational improvements are achieved through a collaborative, timely information exchange between the FAA and NAS Stakeholders, and the development of capabilities which make use of the information. Currently, this information exchange includes flight scheduling information and delay status of airports and airspace. The current information exchange capabilities as well as the related policies and procedures are the foundation for future NextGen capabilities which facilitate the sharing of information across all operational domains. Next steps for the CDM group could include developing capabilities associated with the following programs:</p> <ul style="list-style-type: none"> <li>• CACR</li> <li>• SWIM</li> <li>• TBFM</li> <li>• TFM-M</li> <li>• Surface CDM</li> </ul>	This new capability is related to OI 105207, “Full CDM Implementation”. However, 105207 is off our list because of its implementation timeframe.
<b>OI: Traffic Management Initiatives with Flight Specific Trajectories – Increment: Delivery of Pre-Departure Reroutes to Controllers</b>	<b>105208-12</b>	2013	<p>“In the Segment Alpha timeframe, this increment will give En Route Automation Modernization (ERAM) additional capabilities to receive amended routes pre-departure and provide updated flight data to the tower. ERAM will also display the protected route segment data to the en route controllers to make them aware of a constraint it affects. Delivery of the pre-departure amendment to the flight deck is addressed in the Improved Surface Operations Portfolio, in the increment Revised Departure Clearance via Data Comm (104207-11).” [NSIP v3.0, 2.1.1.1.2]</p>	Since Data Comm is in the text, we must interpret it as part of the capability, but recommend clearly separating it out of this increment.
<b>OI: RNAV SIDs, STARSS and Approaches – Increment: LPV Approaches</b>	<b>107103-11</b>	2015	<p>“Airports with LPV approaches that do not have ILS will have significant increases in access, predictability, and efficiency for aircraft that operate in those locations. LPV approaches, which are available to aircraft equipped with GPS/WAAS, are more cost-effective to implement in comparison with the installation of additional ground-based navigation aids (NAVAIDs) and the development of approach procedures for those NAVAIDs. Increasing the number of LPV approaches will provide further incentives for users to equip with GPS/WAAS. This improvement will provide increased utility to the more than 40,000 general aviation aircraft that are already WAAS-capable. It will increase airspace capacity and allow reductions in a costly ground NAVAID infrastructure.</p> <p>In addition to LPV approach implementation, the FAA will deliver LP approaches to runways that do not qualify for LPVs due to obstacles. LP procedures will provide the lower possible minima for runways that cannot support LPV approaches.” [NSIP v3.0, 2.5.1.3.1]</p>	



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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: RNAV SIDs, STARSS and Approaches – Increment: RNP and RNP AR Approaches</b>	<b>107103-12</b>	2010-2015	“RNP and RNP Authorization Required (AR) approaches are performance-based navigation operations that are implemented to meet the needs of the airspace, users, and airports in terms of efficiency, safety, and access. Criteria for procedure design and operations approval guidance for users exist and are being used. A key feature of RNP and RNP AR approaches is the ability to use curved, guided path segments (known as radius-to-fix (RF); currently, an optional capability in aircraft flight management systems). Another important advantage of RNP AR approaches is the potential for decoupling operations associated with adjacent runways or airports.” [NSIP v3.0, 2.5.1.3.2]	RNP adoption is well-established; does this include parallel approaches? Use for decoupling has policy implications.
<b>OI: Ground Based Augmentation System Precision Approaches – Increment: GBAS Category I Non-Federal System Approval</b>	<b>107107-11</b>	2010-2014	“GBAS provides local corrections to GPS to improve accuracy, integrity, and availability of the navigation service. GBAS is designed and being implemented to enable Global Navigation Satellite System (GNSS) Landing System (GLS) precision instrument approaches to Category I, and eventually Category II/III minima, for multiple runways. This includes those not served by Instrument Landing Systems (ILS), perhaps due to siting constraints. GBAS systems design approval for Category I use in the National Airspace System (NAS) was approved in 2009, and it will serve as an incremental step toward the development of a Category III vertically guided approach. GBAS Category I is being implemented as a non-federal system on a per-airport request basis. The GBAS Category I increment involves government-industry partnerships and results in service provision at the first airport in 2010.” [NSIP v3.0, 2.5.1.2.1]	
<b>OI: Ground Based Augmentation System Precision Approaches – Increment: GBAS Category II/III</b>	<b>107107-12</b>	2014-2018	“GBAS is intended to provide precision approach service to Category II/III minima without the need for critical area protection, and offers the potential for curved approaches. Similar to GBAS Category I, GBAS Category II/III provides improved low-visibility access and increases operational efficiency and single and multiple runway capacity through the use of a GNSS and GLS based on GBAS signals. The FAA plans to develop Category II/III standards. Eventually, these standards would enable the use of procedure design criteria and GBAS flexibility to provide much tighter lateral course guidance to Category II/III minima. GBAS provides for multiple approaches to a runway with varying glide path angles or displaced thresholds for multiple applications. The standards for GBAS Category II/III are being developed currently and in harmony with International Civil Aviation Organization (ICAO) standards.” [NSIP v3.0, 2.5.1.2.2]	many unknowns

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Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Low-Visibility Operations Using Lower RVR Minima – Increment: N/A</b>	<b>107119-xx</b>	2009-2011	<p>“Lowering Runway Visual Range (RVR) minima from 2400 feet to 1800 feet (or lower, depending on the airport and requirement) at selected airports using RVR systems, aircraft capabilities, and procedural changes provides greater access to Operational Evolution Partnership (OEP), satellite, and feeder airports during low-visibility conditions. Utilization of these improvements will increase NAS capacity and traffic flow during periods of Instrument Meteorological Conditions (IMC). The increased capacity will be achieved through a greater number of aircraft class being able to complete scheduled flights under marginal weather conditions. Without these improvements, such flights are today either diverted or delayed, both with rippling impact throughout the NAS and a high cost associated with them as well.” [NAS EA Jan. 2010]</p> <p>The FAA and industry have developed new standards for RVR requirements during straight-in landings at certain ILS-capable runways. The availability of lower visibility minima is provided for suitably equipped aircraft (e.g., flight director guidance) and ILS Category I ground equipment not previously allowed for use during conditions below Category I. The new operations require avionics capabilities, crew training, ground equipment, runway infrastructure, and other factors to safely meet the requirements for operations below Category I. Study is needed to determine which runways qualify for the new operations and which runways require infrastructure upgrades to comply with the new standards. The new standards better harmonize some of the operating rules between the FAA and the European Aviation Safety Agency (EASA).” [NSIP v3.0, 2.5.1.7]</p>	Implementation deadlines seem overly aggressive.
<b>OI: Low Visibility Surface Operations</b>	<b>107202</b>	2015-2018	<p>“Aircraft and ground vehicle movement on airports in low visibility conditions is guided by accurate location information and moving map displays. Aircraft and ground vehicles determine their position on an airport from GPS, WAAS, LAAS, via ADS-B and Ground-Based Transceivers (GBT) systems with or without surface based surveillance. Location information of aircraft and vehicles on the airport surface is displayed on moving maps using Cockpit Display of Traffic Information (CDTI) or aided by Enhanced Flight Vision Systems (EFVS), Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS) or other types of advanced vision or virtual vision technology.” [NAS EA 7.4]</p>	Some mentioned possibilities are beyond 2018, but qualifying activity likely. Difficult from cockpit perspective.
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Increment: NextGen En Route DME Infrastructure</b>	<b>108209-11</b>	2012-2015	<p>“Additional DME coverage over the continental United States (CONUS) is needed to optimize and expand RNAV routes by closing coverage gaps at and above Flight Level (FL) 240. Work is being done to improve the determination of Expanded Service Volumes (ESVs) that may help eliminate DME gaps. Where ESVs cannot be established, DME will be installed at selected locations to support RNAV and RNP using DME/DME/Inertial Reference Unit (IRU) as the primary navigation means, and provide backup if GPS is not available.” [NSIP v3.0, 2.6.1.1.2.1]</p>	
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Increment: Optimization of PBN Procedures</b>	<b>108209-12</b>	2010-2012	<p>“Additional teams of stakeholders will be created to address short-term PBN procedures optimization. Efficient development and implementation of PBN procedures will continue to require the collaboration of a broad spectrum of industry, regulatory, aircraft performance, and technical experts. Expert teams focused on the development and implementation of PBN procedures will, at a minimum, do the following:</p> <ul style="list-style-type: none"> <li>• Focus knowledge and experience in the application of standard procedure design criteria.</li> <li>• Provide continuity in the use of tools for the analysis and the development of vertical profiles.</li> <li>• Ensure flexibility of procedures through use of aircraft simulations; ensure viability of procedures through use of Human-in-the-Loop simulations (HITLS) during and after procedure development.</li> <li>• Provide the basis for analysis of procedure benefits and environmental impacts.” [NSIP v3.0, 2.6.1.1.1.1]</li> </ul>	

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Increment: Large-Scale Redesign of Terminal and Transition Airspace Leveraging PBN</b>	108209-13	2010-2015	<p>“The Integrated Airspace and Procedures approach provides a geographic focus to problem-solving, with a systems view of PBN initiatives, to the design of airspace. This approach moves RNAV and RNP procedure design away from individual overlays into multi-airport, arrival/departure, and city-pair networks to support the transition to the Next Generation Air Transportation System (NextGen). The key characteristics of this integrated approach include the following:</p> <ul style="list-style-type: none"> <li>• Use of additional transition access/egress points that are not tied to ground-based NAVAIDs</li> <li>• Concurrent development and implementation of Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs) to ensure an integrated approach to procedural optimization</li> <li>• Decoupled operations between primary and secondary/satellite airports serviced by complex terminal airspace</li> <li>• Development of RNAV routes (e.g., Q-routes, T-routes) through congested airspace to better connect metropolitan areas</li> <li>• Where beneficial, enlarging terminal airspace to expand the use of 3-mile separation and terminal control rules and techniques.” [NSIP v3.0, 2.6.1.1.1.2]</li> </ul>	
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Increment: Transition to PBN Routing for Cruise Operations</b>	108209-14	2010-2015	<p>“This approach augments the conventional NAVAID-based Jet and Victor airways with RNAVs, including Q-routes and T-routes and NRS-based trajectories. However, the usefulness of NRS for the general aviation community must be determined. High-altitude RNAV routes offer an efficient way to traverse en route airspace by removing manufactured choke points that are created by the requirements of ground-based NAVAID-to-NAVAID routing.” [NSIP v3.0, 2.6.1.1.1.3]</p>	Q-routes already being used. Existing concepts.
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Increment: Relative Position Indicator (RPI)</b>	108209-15	2012-2013	<p>“RPI is a tool that can assist both the controller and traffic management in managing the flow of traffic through a terminal area merge point. RPI provides a symbol on the radar situation display that conveys relative position information for converging traffic. It does this by calculating the flight path distance to the merge of the source aircraft and places the indicator at that distance as measured along the merging route, including curved paths. RPI’s effectiveness is enhanced by the predictability and repeatability of flight tracks, like those produced by RNAV, RNP, and advanced leg types, such as RF legs and procedures.” [NSIP v3.0, 2.6.1.1.3.1]</p>	
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Increment: Use Converging Runway Display Aid (CRDA)</b>	108209-16	2010-2013	<p>“CRDA is an automation aid used by air traffic controllers to judge spatial relationships between aircraft that are destined for converging or intersecting runways. CRDA projects position information for an aircraft approaching one runway onto the straight-in final approach course of another aircraft approaching a converging or intersecting runway (known as “ghost” targets), thus allowing a controller to easily visualize and direct a safe and efficient separation distance between the two arriving aircraft. This increment will add CRDA functionality into terminal automation systems and expand its use at more airports, as well as leverage the arrival/departure window tool.” [NSIP v3.0, 2.4.1.2.1]</p>	

Appendix A: Capabilities Under Consideration

Capability Name	ID	Year(s)	Description	Other ICWG Notes
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Increment: FMC Route Offset</b>	<b>108209-17</b>	2013-2014	“Automation provides controllers with support to amend an aircraft’s flight plan to indicate that it has been placed on, or has been taken off, a Flight Management Computer (FMC) lateral offset. With this automation, controllers will have the capability to trial-plan a proposed lateral offset for an RNAV- or RNP-equipped aircraft – this capability being part of the Post En Route Automation Modernization program (ERAM) Release 3 investment decision. This capability is being performed manually today without entering the trajectory into the En Route Automation.” [NSIP v3.0, 2.6.1.1.3.3]	
<b>OI: Increase Capacity and Efficiency Using RNAV and RNP – Deconflict Operations Among Adjacent Airports</b>	<b>108209-NEW</b>	2013-2015	Use RNP/RNAV procedures to deconflict approach and departure procedures from different airports. Establish criteria for vertical separation between approach and departure paths based on VNAV guidance to adjacent airports. Establish criteria for reduced lateral separation between arrival, approach, approach transition, and departure paths in terminal airspace between adjacent airports based on RNAV and/or RNP guidance. This requires addressing both communications and ATC procedures, as well as addressing surveillance performance for monitoring.	The ICWG believes that specific emphasis should be placed on utilizing RNP/RNAV procedures—and if possible associated changes in air traffic separations—to deconflict flight procedures that serve adjacent airports. Would require RNAV/RNP possibly supplemented by GBAS or similar ground augmentation.
<b>OI: Improved Management of Special Activity Airspace – Increment: ANSP Real-Time Status for SUAs</b>	<b>108212-11</b>	2013-2014	“Airspace use is optimized and managed in real time, based on actual flight profiles and real-time operational use parameters. Airspace reservations for military operations, unmanned aircraft system flights, space flight and re-entry, restricted or warning areas, and flight training areas are managed on an as-needed basis. Enhanced automation-to-automation communications and collaboration enables decision-makers to dynamically manage airspace for special use, increasing real-time access and use of available airspace. The enhanced interface provides a consistent source of SUA status digitally to ANSPs to support flight planning and decision-making.” [NSIP v3.0, 2.7.1.1.1.1]	
<b>OI: Improved Management of Special Activity Airspace – Increment: SAA Forecast of Capacity Constraints</b>	<b>108212-12</b>	2014	“This increment translates the SUA activation schedule and knowledge of the airspace configurations into predicted traffic flow constraints. Route impact assessments would therefore account for forecast airspace capacity loss and route blockage, including SUAs.” [NSIP v3.0, 2.7.1.1.2]	



**Approved by the NAC September 29, 2011**

## **Recommendations for Enhancing Operations in Specific Regional Airspace**

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*A Report of the NextGen Advisory Committee in Response to Tasking  
from the Federal Aviation Administration (FAA)*

*September 2011*

## Executive Summary

***FAA Tasking: Provide operator participation to operational Metroplex efforts, including Metroplex Optimization of Airspace and Procedures Study Teams participation and the National Special Activity Airspace Project. Provide review and consensus feedback of airspace and procedures efforts in the identified Metroplexes. Feedback will include input and recommendations on ongoing airspace projects, planned PBN procedures efforts, proposed Metroplex connectivity efforts (including NRS usage/expansion and T&Q-routes), and proposed changes in Special Activity Airspace.***

The Airspace and Procedures Work Group (APWG) has developed the following six recommendations in response to the Tasking for enhancing operations in the National Airspace System.

- Recommendation #1: RNAV off the Ground (ROTG)
- Recommendation #2: Houston Ultra High Sectors
- Recommendation #3: Denver RNAV Implementation
- Recommendation #4: Chicago Airspace Program (CAP)
- Recommendation #5: Powder River Training Complex (PRTC)
- Recommendation #6: NextGen Air Traffic Management Tools
- Recommendation #7: South Florida Airspace Redesign/Caribbean Routes

## Background

The purpose and scope of the APWG is to develop recommendations on operational components of the nation's future airspace and procedure infrastructure. This work is focused on:

- Performance-Based Navigation implementation and associated redesign of airspace in support of airports to enhance efficiency and throughput
- National Special Activity Airspace, National Airspace and Procedures (T&Q-Routes and NRS planning, etc.)

## Recommendations

### **Recommendation #1: RNAV off the Ground (ROTG)**

***The FAA should validate the safety and capacity benefits of ROTG as part of the implementation process.***

#### Discussion:

ROTG is the use of NextGen technology (RNAV) in day-to-day air traffic control to produce consistent and repeatable departure tracks from a runway end and greatly reduce radio communications between controllers and the flight deck.

Industry believes there is potential for cost and environmental savings with ROTG, however, at the various locations in NAS where it has been implemented, there have been mixed results. For instance, a repeatable departure track may be both a benefit and a drawback: the benefit lies in the capacity and efficiency gains the procedure may produce; and the drawback is the fact that in some locations the repeatable flight track has resulted in increased noise complaints.

Another implementation issue that has not been completely resolved is continuing pilot deviations that create conflicts with parallel runway operations or adjacent airports or airspace, leading to loss of separation (operational errors) and lack of controller confidence with the procedures.

A further way in which the results are mixed is in flight path length - and thus the overall effect on efficiency of the operation. Some of the ROTG flight paths are longer than previous vector paths, especially for airplanes who want to go in a direction opposite to the direction they took off. Some additional length is unavoidable in the ROTG design most of the time, since there are contingencies that must be accommodated which are not present all the time. In the "old" way, a vectored airplane would often be cut short if there is no conflict for doing so. The ROTG flight path may involve level-offs that would not be necessary with the old spray-pattern vectoring. To the extent that those level-offs increase in number or length because of ROTG that is also a loss of efficiency.

While supporting further implementation of ROTG, there are factors that must be considered in maturing the tool:

- Do no harm to existing safety or capacity;
- Do not implement ROTG if there are no benefits;
- Recognize that individual airports (and runways) may have different requirements or outcomes.

## **Recommendation #2: Houston Ultra-High Sectors**

***RTCA agrees with the Houston OAPM Study Team and recommends additional analysis of the potential benefits of Houston Center (ZHU) Ultra-High Sector modifications.***

### **Discussion:**

Dallas/Fort Worth Center (ZFW) is planning on full implementation of a new Ultra-High Sector by December 2012. This is a high priority for industry and FAA efforts to implement this new sector have been outstanding.

The Houston OAPM Study Team recommended that any ZHU Ultra-High proposals be aligned and coordinated with the proposed ZFW Ultra-High modifications being pursued by the North Texas OAPM D&I Team, and with any potential modifications in Memphis Center (ZME).

## **Recommendation #3: Denver RNAV Implementation**

***Monitor the timeline of the Denver RNAV Implementation project closely and ensure that the expanded scope of the project does not significantly impact the implementation schedule or the realization of operational benefits.***

### **Discussion:**

The FAA is over two years into a major airspace redesign in Denver that is not part of the current OAPM process. Nonetheless FAA and industry collaboration has been outstanding since the inception of this process and consensus exists that once implemented, the airspace will efficiently serve both industry and ATC missions. The project has served as a pioneering effort for techniques employed on OAPM. However, the project has grown in scope, and slippage of the timeline, delaying efficiency and capacity benefits has become a concern. The project started out with a schedule that began by publishing the STARs 6 at a time in 2011. Once FAA realized there would be a training requirement for the controller workforce (driven by the runway transitions), the publishing schedule had to be completely changed so they could get the runway transitions in place and train the controller work force on them. It was the right thing to do, but it backed the project benefits out significantly. .

Further, there are important, national lessons to be learned from the Denver RNAV effort:

1. Carefully document positive lessons and significant impediments learned from the Denver OAPM experience for application to the other OAPM efforts.
2. Continue to develop metrics that can be consistently used in large scale airspace redesign projects to evaluate benefit gained.
3. The doctrine of "first do no harm" should be applied to every aspect of large airspace projects of this nature.



#### **Recommendation #4: Chicago Airspace Program (CAP)**

- 1. Finish design and implementation of the current phase of the CAP within the OMP time constraints;***
- 2. Work with the FAA to develop potential airspace and procedures improvements for the Chicago Metroplex to be considered and developed after the CAP is done. Consider use of technology and procedures that have evolved since the original CAP design process began several years ago that could be allowed within the current EIS;***
- 3. Continue to encourage full stakeholder participation in the development of CAP with the intent of achieving as many optimized procedures as possible within the constraints of the EIS.***

#### **Discussion:**

CAP is a large-scale legacy airspace redesign project intended to support growth of ORD via the O'Hare Modernization Project (OMP). Like other major legacy projects, CAP is subject to an EIS Record of Decision that constrains development beyond the original design.

#### **Recommendation #5: Powder River Training Complex (PRTC)**

***The USAF and RTCA should continue discussions to implement a FACA process to bring USAF and aviation industry together to work towards airspace that is acceptable to the mission and business cases of all airspace users when the AF develops large scale airspace proposals.***

#### **Discussion:**

The PRTC is one of the largest Special Activity Airspace projects ever undertaken by the US military. After less than optimal efforts at collaboration, there are fresh indications that the sponsors of the PRTC are reaching out to work together with other system stakeholders. This has driven home the need for a repeatable, predictable and inclusionary process for the USAF, and eventually all of DoD, to use in future proposals. While not under the NAC, it is important that a FACA process be established to create an acceptable resolution between the AF and the aviation community that supports the mission and business cases of all airspace users for large scale USAF airspace proposals

#### **Recommendation #6: NextGen Air Traffic Management Tools**

***The FAA continues to develop Traffic Management Advisor (TMA), Relative Position Indicator (RPI), and other decision support tools to help the ATO increase airspace capacity and efficiency in the NAS. Appropriate metrics should be developed with these tools to measure their effectiveness and to quantify throughput/capacity increases.***

#### **Discussion:**

TMA increases situational awareness through its graphical displays and alerts. It generates statistics and reports about the traffic flow at an airport and computes the un-delayed estimated time of arrival (ETA) to the outer meter arc, meter fix, final approach fix and runway threshold for each aircraft. TMA also

assigns each aircraft to a runway to optimize the STAs. Finally, implementation of TMA at a facility has resulted in reductions of no-notice holding (a term used when TRACON controllers, due to volume or other constraints, put aircraft in the Center's airspace in holding without advance notice).

RPI allows a controller to better integrate and merge aircraft on different arrival paths, e.g., a base leg and downwind by projecting a "ghost" target along each arrival path to assist with establishing the desired merge point or final approach spacing.

#### **Recommendation #7: South Florida Airspace Redesign/Caribbean Routes**

***The FAA should start work with industry and DoD to optimize the airspace serving south Florida air carrier and general aviation airports in coordination with commissioning of the new RWY 09R/27L at FLL in 2014 and optimization of Caribbean Airspace and Routes using PBN.***

***The FAA should initiate the South Florida work via the CY12 OPAM process and work should be coordinated with Central Florida airspace. Resources are limited and "connecting" these two areas of airspace is critical.***

#### **Discussion:**

The start of major construction of a new turbo jet capable runway at Ft Lauderdale necessitates a redesign of airspace to service that runway as well as optimizing the airspace serving Miami International and the satellite airports surrounding FLL and MIA.

The projected increase in traffic into the CAR/SAM region calls for optimized routings to/from the Caribbean utilizing PBN to accommodate more efficient routings; for example Q- Routes from ZMA to DR, ZJU and CAR/SAM

SJU Airspace optimization and development using RNAV SID/STARs as well as PBN procedures for SJU PSE BQN will support this effort.

## FACT SHEET

### HISTORY OF THE PERMANENT NOISE MONITORS AT O'HARE

#### Introduction

Installed in 1996, the Airport Noise Management System (ANMS) enables the Chicago Department of Aviation (CDA) to monitor the amount of noise being generated over the communities surrounding O'Hare by the aircraft operating at the Airport. The ANMS collects, analyzes and processes data from a number of sources of information including a network of 32 permanent noise monitors around O'Hare International Airport and correlates the noise data with FAA flight radar data.

#### Purpose of the Permanent Noise Monitors

All noise monitors have been sited in consultation with community representatives and based primarily on the below criteria outlined in the *O'Hare Permanent Noise Monitor Siting Criteria*. The CDA and the O'Hare Noise Compatibility Commission utilize noise data from the permanent monitors to validate the noise contours and identify trends in aircraft noise as they occur.

#### History

- In 1995, the CDA with input from the local communities identified potential noise monitor locations based primarily on the below criteria and also other site constraints. All noise monitor locations were inside the 65 DNL of the 1993 Noise Contour or within 1 nautical mile outside the 65 DNL except for four (4) monitors (10, 21, 36 and 37).
  - Sites 10 and 36 were located along specific arrival flight paths (14R and 22R).
  - Site 21 was located between two departure flight paths (4L and 32L).
  - Site 37 was located north near Chicago Executive Airport (PWK) to assist in quantifying the number of ORD complaints that were a result of PWK flights.
- In 1996 and 1997, twenty-four (24) monitors were installed as a part of the initial ANMS installation.
- In 1998 and 1999, eight (8) additional noise monitors (2, 7, 8, 24, 25, 26, 35 and 36) were installed, bringing the total number of permanent noise monitors to thirty-two (32).
- In 2000, Site 36 was removed at the property owner's request bringing the total number of permanent noise monitors to thirty-one (31).
- In 2005, Site 9 was removed at the property owner's request bringing the total number of permanent noise monitors to thirty (30).
- In 2009, three (3) additional noise monitors were installed specifically to capture aircraft noise from new flight paths associated with the O'Hare Modernization Program bringing the total number of permanent noise monitors to thirty-three (33).
  - Site 29 was located to capture departures from 28R and arrivals on 10L.
  - Site 30 was located to capture departures from 28R turning south.
  - Site 33 was located along the arrival path of 27R.
- In 2011, Site 6 was removed at the property owner's request bringing the total number of permanent noise monitors to thirty (32).



**City of Chicago**  
**Department of Aviation**  
 O'Hare Noise Hotline: 1-800-435-9569  
[www.flychicago.com](http://www.flychicago.com)

**Disclaimer:** Due to strict Federal Aviation Administration guidelines, data collected by permanent noise monitors will not be used to determine eligibility for the Residential and School Sound Insulation Programs.



