Enhanced Surveillance Capabilities in FAA Controlled Oceanic Airspace: Operational Need and Added Benefits

Final Report of the NextGen Advisory Committee in Response to a Tasking from The Federal Aviation Administration

June 2017
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**Background/Introduction**

In July 2016, the Federal Aviation Administration (FAA) requested the NextGen Advisory Committee (NAC)\(^1\) to assist in developing recommendations regarding the operational need and added benefits of Enhanced Surveillance in oceanic airspace.

The FAA mandated Automated Dependent Surveillance-Broadcast (ADS-B) upgrades for all aircraft operating in certain domestic airspace by 2020. The improvements in technology and enhanced surveillance capabilities are now being considered for oceanic airspace. The limitations of the current reporting system require much larger air traffic control separation distances in oceanic airspace. Enhanced surveillance capabilities\(^2\) will contribute to reducing the separation distances and may increase the overall safety, efficiency, fuel-savings, and reduce emissions for aircraft operating in U.S. controlled oceanic airspace.

To that end, the FAA is developing a business case for reduced separation minima in U.S. controlled oceanic airspace. The FAA requires input from operators that ultimately improves understanding and contributes to the development to solutions-sets for improved oceanic operations. The FAA has requested the NAC as an ideal forum to work through complex issue sets and produce consensus derived recommendations.

Accordingly, the FAA tasked the NAC with the following:

- Evaluate the need and benefit of enhanced surveillance capabilities
- Examine the potential benefits to operators of reduced oceanic separation minima using space-based ADS-B or other improvements to surveillance
- Potential funding mechanisms that might be possible and at what cost
- Evaluate the business case for enhanced surveillance in US-controlled airspace

**Executive Summary**

The Enhanced Surveillance Task Group (ESTG) began meeting shortly after the tasking letter was received. The Task Group includes a cross section of entities that operate aircraft in oceanic airspace. The Task Group members are drawing on the expertise from the FAA and providers of services, and automation technology to gather information and develop an understanding of issues, operational concepts, technologies, and potential benefits. The Task Group created a

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\(^1\) July 15, 2016 Letter from Ms. Teri Bristol, Chief Operating Officer, Air Traffic Organization, Federal Aviation Administration to Ms. Margaret Jenny President, RTCA, Inc.

\(^2\) The Advanced Surveillance Enhanced Procedural Separation (ASEPS) Project is investigating the following surveillance alternatives as a means to reduce oceanic separation service below 30 nautical mile (NM) lateral and 30 NM longitudinal separation (30/30):
- Space-Based Automatic Dependent Surveillance – Broadcast (ADS-B) reports
- More frequent Automatic Dependent Surveillance – Contract (ADS-C) reports
Subgroup of operators to have discussions and review analysis that does not include those with a direct financial gain in the outcome.

The output of the ESTG is captured in the following recommendations.

**Summary of Recommendations**

- The FAA should proceed with the introduction of enhanced surveillance capability in Oceanic airspace to support seamless ATC surveillance, enabling efficiency and predictability of aircraft operators and ANSPs at a more precise level than available today.
- Space-based ADS-B technology, when coupled with Future Air Navigation System (FANS, controller-Pilot data link (CPDLC), Automatic Dependent Surveillance – Contract (ADS-C), and required Navigation Performance Level 4 (RNP4) capabilities appears to be closer to providing a reduced separation of 15/15 than ADS-C when coupled with CPDLC and RNP4.
- The FAA should (as an ANSP) bear the financial burden for enhanced surveillance costs as it does domestically. The ESTG does not currently have sufficient information to conduct a valid analysis about the prioritization of this investment in comparison to other investments, and recommend that this would be done at the NAC level.
- Aircraft operators that are equipped with ADS-B, Future Air Navigation System (FANS) Controller Pilot Data Link Communications (CPDLC), Automatic Dependent Surveillance-Contract (ADS-C), and Required Navigation Performance Level 4 (RNP4) capabilities will receive full benefits of enhanced surveillance in FAA controlled oceanic airspace.
- Implementation of enhanced surveillance should be done by regions.
- The WATRS airspace region holds the most potential for increased benefit.
- The ESTG recommends the FAA engages and provides interim reports to the NACSC on the development of the business case analysis.

**FAA Assumptions**

The FAA provided the following assumptions they have made regarding equipage requirements.

- Aircraft will need to be equipped with Future Air Navigation System (FANS) Controller Pilot Data Link Communications (CPDLC), Automatic Dependent Surveillance-Contract (ADS-C), and Required Navigation Performance Level 4 (RNP4) capabilities to be eligible for reduced separation.
- A major benefit to operators from reduced oceanic separation is lower fuel burn associated with operating at higher altitudes more quickly and for
longer periods of time.

- In the FAA’s preferred business model for space-based ADS-B service, operators would contract directly with the service provider or a third party for flight surveillance, like the way ADS-C tracking works today. However, our preliminary estimates indicate that potential benefits vary widely depending on aircraft type and route.

**Task Group Assumptions and Guiding Principles**

The ESTG worked under the following assumptions:

- Reduced separation is the predominant goal of enhanced surveillance.
- A clear statement of requirements (e.g. desired separation standards, etc.) should be established with appropriate performance standards to guide the assessment of implementation alternatives.
- Any changes in Oceanic services should provide safety enhancements, reduced risk to aviation, enhanced capacity and improved operational efficiency that are cost and environmentally beneficial to the aviation community.
- Enhanced surveillance enables and provides global tracking for both normal and distress situations and circumstances.
- Delivery of performance based separation (or ATM) capabilities should maximize the use of current equipage that is compliant with current FAA C/N/S standards with no broad-based fleet upgrades required, although minor upgrades to systems could be considered to make it more robust. This critical issue is addressed comprehensively later in the report.
- Deployment of enhanced surveillance services over the ocean will not affect the current FAA ADS-B Out 2020 mandate, and not add to the mandate.
- Delivery of benefit will require comprehensive training of controllers, pilots and dispatchers, updating automation, and decision support tools.

The ESTG set the following guiding principles to help steer their work:

- The resulting set of recommendations will be transparent and objective, clearly laying out the methodology that the group employed to reach consensus on the specific recommendations.
- The final recommendation must address closing the business case for operators and the FAA.
- The recommendation endorses designing oceanic airspace that provides maximum benefit to aircraft equipped according to the assumptions stated in the task letter.
- The strategy for traffic flow management strategy provides maximum benefit to aircraft eligible to operate on routes and at altitudes that afford reduced separation, and therefore greater efficiency and
capacity. Those aircraft with lesser capabilities would use routes and altitudes commensurate with their capabilities.

- Transitions between air service providers should be considered as part of the integration.
- Enhanced Surveillance services will be introduced by regions or routes based on an assessment of needs, benefits and costs.
- FAA implementation of recommendations might require reducing budget allocation for lower priority initiatives or capabilities.
- Provider/Supplier input is important in the process of information gathering and understanding of issues, operational concepts, technologies and potential benefits, but entities with a direct financial gain are limited to serve as SMEs and not in the development of the final recommendation as well as any meetings/data sharing of specific cost/benefits calculations.

**Methodology**

To complete this initiative, the ESTG took the following steps in creating the recommendation:

**Strong operator participation**

- Operation and Benefits Subgroup formed to allow operators and the FAA to open conversation about cost and benefits, specific ConOps/goals for recommendation
- ESTG has identified industry reps to begin drafting of recommendation: overall statement/principles, equipage and benefits

**Leveraging FAA and Industry SMEs**

In the development of the recommendation, the ESTG received a series of informational briefings from the following entities:

- Aireon/Harris
- FAA – Concept Opns/Benefits Analysis
- Inmarsat
- International Air Transport Association (IATA)
- Iridium
- NAV Canada
- UK NATS
- Various Operators

**FAA Facilities**

The ESTG conducted on-site meetings at Oakland and New York ARTCCs about the benefits from enhanced surveillance. These meetings included SME’s from Dispatch and Controllers that
discussed the analysis and potential findings with ZOA to discuss the Pacific operations and a separate meeting with ZNY to discuss the Atlantic and WATRS airspace.

**Defining the Need for Enhanced Surveillance Services**

The ESTG anticipates the introduction of enhanced surveillance capability would support seamless ATC surveillance, enabling efficiency and predictability of aircraft operators and ANSPs at a more precise level than available today. The following benefits categories that could be accrued from the deployment of enhanced surveillance capabilities in oceanic airspace:

- Reduced Separation Minima - oceanic separation standards
- Optimized operating profiles
  - User Preferred Routings (UPRs)
  - Efficient flight levels and increased opportunity to step climb
  - Variable Mach
- Enhanced Safety
  - Enhanced Aircraft Tracking
  - Enhanced Situational awareness
  - Improved weather avoidance
  - Enhanced safety alerting
  - Improved cross-flight information boundary error detection
  - Improved and earlier detection of off-track errors
  - Enhanced height monitoring in RVSM airspace
- Enhanced Search and Rescue
- Reduction in green-house gas emissions/Fuel savings
- More optimal design of airspace
- Enhanced Air Traffic Flow Management
- Increased surveillance system augmentation and significant decrease of surveillance gaps
- Harmonize surveillance requirements/equipage for increasing interoperability for operators

The use of UPRs, coupled with reduced separation standards, promises the most significant benefit based on the analysis performed on behalf of the operator’s community. This is due in part to the existing practices of aircraft operators that are based on historical experience that has led to flight planning system programming and operational protocols that are used daily.

Optimized operating profiles have a direct and positive impact on fuel burn and green-house gas emissions. Benefits in this regard should be calculated based on time/flight hours of flights

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3 Operational Analysis of Reduced Separation in FAA-controlled Oceanic Airspace (02/13/2017), by Vitaly S. Guzhva, Ph.D., Embry-Riddle Aeronautical University and Kenny Martin, ISA Software, briefing is included as Attachment D.
operating at optimum profiles. Separate benefits analyses provided for the ESTG by the FAA and Embry Riddle calculated a suite of proposed benefits supported by most operators, which includes user preferred routes (in lieu of great circle route), flight level changes, and decreased fuel burn (and fuel loading) into consideration. Variable Mach speed regimes were also studied to determine the overall benefits to operators.

The Case for Enhanced Surveillance

The ESTG and associated Ops and Benefits sub-group received in-depth information regarding potential surveillance sources in the oceanic environment. It is important to assess the equipage requirements associated with each surveillance alternative (ADS-C or space-based ADS-B), and in each case, the percentage of operators who will be capable of participating and deriving benefit. As stipulated in the Guiding Principles, the ESTG is proceeding under the assumption that airspace will be designed in such a way that aircraft equipped with the suite of capabilities described in the FAA Tasking letter would be eligible to receive optimal route, altitude and speed assignments.

The ESTG was informed by FAA that the baseline schedule for upgrading the Advanced Technologies and Oceanic Procedures (ATOP) system includes required ground ATC automation system upgrades to accomplish increased processing necessary to accommodate forecasted oceanic volume in either an ADS-B or ADS-C environment. Within the ESTG Operations and Benefits sub-group there was general agreement that the potential impact to FAA automation platforms supporting end-to-end system infrastructure will have to be assessed to appropriately evaluate system manageability of increased data and ATC’s capability to independently negotiate increased periodic transmission of aircraft information in remote areas of airspace. On this topic, the FAA briefed the sub-group of planned enhancements to ATOP and further, of how automation adaptations have out-paced oceanic traffic demand; the FAA anticipates data link transmission processing will not be an issue provided the appropriate investment in automation are made according to current plans.

Based on the following rationale, the ESTG concluded that the optimal surveillance solution would be space-based ADS-B.

Equipage - Based on the January 1, 2020 ADS-B mandate, operators will be equipped with ADS-B.

Delivery of Enhanced Surveillance - The ESTG received information regarding testing and development of both ADS-B and ADS-C surveillance capabilities (classic ADS-C with higher update rates and new equipage). According to the information provided, it is the opinion of the ESTG that space-based ADS-B technology, when coupled with Future Air Navigation

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4 There was a fundamental disagreement between the industry and the FAA about the nature of ADS-C as surveillance using via HF.
System (FANS, controller-Pilot data link (CPDLC), Automatic Dependent Surveillance – Contract (ADS-C), and required Navigation Performance Level 4 (RNP4) capabilities appears to be closer to providing a reduced separation of 15/15 than ADS-C when coupled with CPDLC and RNP4.

- Any reduced separation standard along with an increase in the percentage of FANS equipped aircraft will reach a tipping point to justify a redesign of oceanic airspace to take full advantage of reduced separation standards.
- Reduced separation, resulting in increased capacity, increased availability of optimal altitudes, and optimal routings, while continuing to support cost index speeds, are the primary benefits from spaced based ADS-B.

One guiding principle cited by the ESTG is the necessity to consider surrounding ANSPs and corresponding Flight Information Regions (FIRs) and factor in any operational constraints that may exist due to lack of interoperability. The U.S. have established ADS-B as a rule for U.S. domestic airspace, and it is apparent that other ANSPs use ADS-B today, and many are considering requiring ADS-B or plan to use it to improve services. Therefore, it is logical for economic, operational and environmental interests to be consistent with the global air navigation plan as the US evolves ATM capabilities. Operators may be able to leverage the ADS-B avionics required for U.S. airspace to gain benefits from ADS-B in other ANSPs airspace as those other ANSPs consider requiring ADS-B domestically or leveraging ADS-B in procedural airspace.

Validation of ADS-B services and related programs should be evaluated on an airspace by airspace basis. The ESTG sub-group was briefed regarding visits to ZOA and ZNY by aircraft operational representatives to collaboratively discuss with ATC management and line controllers the effect and potential benefits of enhanced surveillance in oceanic airspace. The ESTG considered that the differences and dynamics in each oceanic airspace area would need to be closely evaluated on the basis of several characteristics, including but not limited to: traffic flows, aircraft equipage (and mixed equipage) and rate of additional equipage, airway structure, airspace capacity, flight data processing systems, forecasted traffic demand, flexibility of ATC and flight planners and development of “tipping point” type thresholds to detect and anticipate when different or new separation minimums would be most beneficial. In

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5 ICAO Aviation System Block Upgrades (ASBU) references:
ASEP Airborne Separation (ASEP)
Block 0 ASEP-B0/1 Cockpit Display of Traffic Information
Block 0 ASEP-B0/1 ADS-B OUT (aircraft capability)
Block 0 ASEP-B0/2 ADS-B IN equipment/function compliant with DO-317A/ED194 (and subsequent versions) is required to support AIRB and VSA
Block 1 ASEP-B1/1 FIM equipment /spacing functions with advisories
Block 1 ASEP-B1/2 ATC support tools for ASEP-B1 (IM)
Block 1 ASEP-B1/3 Interval Management Procedure published for the operating environment

ASUR Alternative surveillance
Block 1 ASUR-B1/1 (SB ADS-B) Space-Based ADS-B
view of the aforementioned considerations, space based ADS-B might create opportunities in
terms of enhanced ATC operations, weather avoidance, flexible routing, shorter airline (flight)
block schedules, better utilization of airspace (due to military restricted areas), decreased fuel
burn and reduced green-house gas emissions.

It will be necessary to closely monitor the ongoing verification and validation testing of
space-based ADS-B to ensure there are no impediments or delays to delivery of the capability
that will enable reduced separation standards, efficient airspace design and improved service.

Enhanced surveillance, in areas throughout the world where air navigation service providers
employ procedural separation, will increase efficiency and capacity. This translates to greater
route flexibility during congested periods, as well as availability of optimal speed and altitude
assignments. Improvements in measures related to time, distance, fuel and emissions are
projected. In addition, enhanced surveillance will facilitate the goals associated with the ICAO
Global Aeronautical Distress Safety System (GADSS).

Both NextGen and SESAR have committed to an integrated ATM relationship. The ICAO Global
Air Navigation Plan (GANP) assumes a global, cooperative effort among states in their
modernization efforts. This enhanced surveillance effort must consider the direction taken by
many ANSP’s worldwide, including those with airspace contiguous to U.S. FIRs, to ensure global
interoperability and a seamless transition for operators from one service provider to the next.

Costs

The FAA Tasking letter provided the following information and questions related to costs:

- The FAA and industry need to understand whether there will be additional equipage
costs beyond those associated with the January 1, 2020 ADS-B mandate, and whether
there will be recurrent costs or pass-through charges for usage.
- In the FAA’s preferred business model for space-based ADS-B service, operators would
contract directly with the service provider or a third party for flight surveillance, similar
to the way ADS-C tracking works today. However, our preliminary estimates indicate
that potential benefits vary widely depending on aircraft type and route. The FAA needs
to better understand how operators would decide which aircraft, regions, and/or routes
to subscribe to for surveillance services at different price points and for different
charging schemes.

The ETSG offers the following in response to the FAA request for cost based on consideration of
several alternatives for cost related models for the provision of space-based ADS-B surveillance.

1. **Operators would contract directly with the service provider or a third party for flight
surveillance. As the FAA has indicated this model would be similar in principle to that
used for the current provision of ADS-C services since the early 1990s.**
The principle advantage to the FAA is that it receives data at low or minimal cost.

Operators are currently investing in ADS-B Out equipage to meet the January 2020 mandate and will or would need to make additional investments:

- An investment in FANS equipage would be required for receiving full benefits because both communications and surveillance are needed to enable lower separation standards (FANS equipage costs could range from $70-120K/aircraft)
- Associated increased SATCOM costs for equipping aircraft with FANS providing enhanced surveillance
- Flight Planning Software Modifications

NAS users paying a service charge for surveillance does not align with ICAO Document 9082 Policies on Charges for Airports and Air Navigation Services guidelines - Surveillance charges contracted with the ANSP (FAA), instead of individual NAS users, will better satisfy the ICAO 9082 key charging principles of non-discrimination, cost relatedness, transparency, and consultation

Payment for surveillance data by individual operators to a third-party vendor, then to have the data utilized by ANSPs on a flight-by-flight basis, introduces an unwarranted and unneeded level of financial and operational complexity

The associated complexity to individual NAS users having individual contracts with individual ANSP around the world does not lead to low or minimal charges agreements.

2. The FAA (as an ANSP) would bear the financial burden of surveillance costs as it does domestically as the single point of contract for a third-party provider of surveillance in the airspace the FAA controls.

- Dependent on FAA receiving funding to provide the surveillance service
- An ANSP (FAA) is likely to receive a more advantageous price for the surveillance service than each individual operator negotiating a rate
- Supports integration of enhanced surveillance with adjacent FIRs
- Enhanced surveillance services would be determined by equipage beyond ADS-B, not determined by whether an operator pays for surveillance service
- Once modified, the ATOP system would automatically ingest data from any ADS-B transceiver equipped aircraft (not dependent on whether operator had agreement with third party vendor)
- The FAA would follow the current operating charging structure, while remaining as the single point of service delivery in airspace under its authority.
- Integration of ADS-B source adds a level of complexity on the surveillance vendor or service provider in the in the case that not all operators would pay for feed to FAA ATC system - FAA ingestion of data determined by service being “turned on” by an aircraft operator

Summary: The ESTG recommends that the FAA (as an ANSP) should bear the financial burden of surveillance costs as it does domestically.
a. The investment in enhanced surveillance will be subject to a business case analysis for consideration in the development of future FAA budgets. In the event no additional funding is available, the ESTG recognizes that the FAA may need to consider adjustments in other programs. The ESTG does not currently have sufficient information to conduct a valid analysis about the prioritization of this investment in comparison to other investments, and recommend that this would be done at the NAC level. The ESTG recommends the FAA engages and provides interim reports to the NACSC on the development of the business case analysis.

b. ADS-B is a broadcast system implemented by the FAA as a ground based infrastructure for domestic services that will be supplemented with traditional radar capability. The work group discussed ADS-B domestically vs enhanced surveillance, non-domestic, and does not support a change in this philosophy. If space-based ADS-B will enable reduced separation then the FAA should lead the NAS in providing enhanced services just as it has done for all domestic airspace, thereby promoting benefits to NAS users. The industry has long been on record to support the 2020 ADS-B mandate, has reported in different forums (NAC, NACSC, equip 2020) of their commitment to be ready. The work group agreed it is reasonable to capitalize on that investment in other areas of the NAS.

c. The operators are willing to support the FAA with equipage plans that the FAA may need as it develops its business case for enhanced surveillance.

d. Industry desires that any Surveillance data available to the FAA in US controlled FIRs be made available to users, as it is today, through service agreements without fee. Whether that data is from terrestrial radar, ADS-B, space based derived ADS-B, or ADS-C.

   i. If a third party / vendor enhances the surveillance data and wishes to make that available through a decision support tool or display then we expect such a provider would expect to be reimbursed for that - but industry expects FAA (ANSP) data to be available to industry as it is today even if space based ADS-B, or ADS-C expands the geographic coverage beyond where it exists today.

Equipage Related Issues

The crucial technology to allow for Enhanced Surveillance is ADS-B. According to 14 CFR 91.225 and 14 CFR 91.227, after 1 January 2020 aircraft must be equipped with ADS-B to operate in U.S. sovereign Class A, B & C airspace, within the lateral boundaries of a Class B/C airspace area upward to 10,000 feet MSL, within 30 nautical miles of an airport listed in appendix D, section 1, of Part 91 from the surface upward to 10,000 feet MSL, Class E airspace within the 48 contiguous states and the District of Columbia at and above 10,000 feet MSL, excluding the

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The industry has provided a series of briefings to the NextGen Advisory Committee outlining equipage planes for communications, navigation and surveillance. This information was used in the analysis for this report. The equipage plans will also be updated as the FAA develops its investment analysis for enhanced surveillance.
airspace at and below 2,500 feet above the surface, and Class E airspace at and above 3,000 feet MSL over the Gulf of Mexico from the U.S. coastline out to 12 nautical miles. In these areas, aircraft must meet the performance requirements in TSO-C166b (1090 Mhz) or TSO-C154c. In oceanic airspace, i.e. beyond 12 nautical miles, the ADS-B rule is not applicable.

Cooperative surveillance data actively transmitted by aircraft is a commodity which should continue to be available to NAS users as heretofore, free of charge. Should a third party add value to the data and re-form it for commercial purposes, that entity is entitled to a return on its investment as determined by market forces.

While surveillance performance and ADS-B equipage are crucial, communications and navigation requirements must also be considered. Furthermore, ADS-C is required for effective Enhanced Surveillance, because aircraft “intent”7 information is necessary for ATC. It should be noted that separations in oceanic airspace are, and will remain, procedural. Currently, benefits derived for, Enhanced Surveillance for related procedural separation is limited by required communication performance (RCP). To reap the benefits of positive ATC control as employed in the domestic NAS, RCP must be improved by enhancing existing communications technologies and employing new technologies when a positive operational and/or cost-benefit is established. A case in point is the development of a push to talk solution between pilot-controller in place of communication with radio operator/third party.

Currently, substitution of SATCOM in place of one of the two required airborne HF transceivers is under consideration by a number of regulatory authorities, including the FAA. As empirical evidence of positive SATCOM performance increases, both HF transceivers may eventually be replaced by dual SATCOM installations.

The table in Appendix C describes both the presently approved and the proposed separation standards which would apply based on different, common equipage configurations which exists with operators.

Another concern is the mixed equipage scenario. Reduced separation standards may be applied to aircraft equipped with advanced avionics. However, this is complicated when FANS equipped aircraft are surrounded by a preponderance of non-FANS equipped aircraft. For example, an aircraft equipped with FANS/RNP 4 cannot receive the benefit of reduced separation standards if all the aircraft surrounding it are equipped with HF communications and surveillance limited to “significant waypoints”, because this type of equipage is limited to 50 nm lateral separation and 10 minutes longitudinal separation. So, if Enhanced Surveillance is to improve separation procedural standards and operators thus receive that benefit, special considerations must be used to congregate aircraft with advanced equipage and isolate them from aircraft with lesser

7 Intent data is the ADS-C avionics report of future positions (e.g., Estimate Over and Next Position). ATOP checks current position conformance and intent by comparing the future positions and filed route and generates a warning if any future position contained in a position report is out of conformance.
This problem is not insignificant in the WATRS area and the airspace between the US West Coast and Hawaii.

The equipage numbers below are for % of aircraft that are FANS/RNP 4 as of Dec 2016:

- North Pacific (NOPAC) - Anchorage to Far East - 98%
- POLAR and Russian Far East - 96%
- Central East Pacific (CEP) - West Coast to Hawaii - 47%
- Central Pacific (CENPAC) - West Coast to Far East - 98%
- South Pacific (SOPAC) - 95%
- WATRS Atlantic seaboard - 51%
- New York Oceanic East – 98%

Analysis of Specific Oceanic Regions
• Current FANS equipage is at approximately 98 percent and could now be considered for RNP4 classification rather than RNP10.

• 30/30 separation applied between like aircraft when necessary

• ADS-C-CDP used within Anchorage FIR for climb through with minimum of 15nm with RNP4/FANS aircraft

• Volcanic activity in the Anchorage FIR and Russia Kamchatka Peninsula is disruptive to efficiency and makes re-routes complicated

• Current unidirectional routes provide use of all cardinal flight levels at 1000 foot intervals, therefore it may be in our best interest to continue a “structured” system.

• There is an initiative for a re-structuring of the NOPAC being discussed at the Informal Pacific ATC Coordinating Group (IPACG) and Cross Polar Working Group (CPWG) with FAA/JCAB/IATA as the main stakeholders. (Meetings in May (CPWG) and September (IPACG) for further discussions

• Reduced separation, such as 15/15 would be limited westbound unless JCAB joined the ES program. Eastbound from JCAB FIR into Anchorage and Oakland FIRs provides more efficiency

• Weather deviations are very infrequent in this airspace


- Enhanced surveillance holds prospect of compressing the existing airways structure, adding additional airways, and the potential for more opportunities to UPR further west in the Anchorage FIR to the Japan FIR (reduction of current UPR constraints)
- Flight planning systems and airline policies and cultural may need to be “adjusted” to take advantage of these changes

POLAR and Russian Far East

- Current operations supported by ATOP with 10 minutes separation required for transfers into Russia
- Communications above 80N are limited (HF or Iridium) and flight time within the FIR is as low as 6 minutes (89N)
- Traffic volumes into Russia can exceed 70 a day due to seasonal winds.
- Enhance surveillance will provide more efficient routings within the Anchorage “northern” airspace, however communications capabilities will still be an issue depending on latitude and distance traveled within the Anchorage airspace
- Current FIR crossing requirements (constraints) from Edmonton to Anchorage at 141W could be reduced, and in some cases eliminated, pending communications capabilities at certain latitudes
• Russia may continue to be a major constraint due to transfer requirements of 10 minutes longitudinal separation (15nm would be possible if Russia was also using ES)
• Eastbound operations entering the Anchorage FIR would see increased efficiency and potential reduction in constraints, pending communications capability

Central Pacific (CENPAC)

• Current structure is a combination of Flex tracks (PACOTS) and UPRs with 50nm standard separation and 30/30 between like equipped FANS when necessary
• Enhanced surveillance offers the potential to reduce PACOTS track generation constraints by both Oakland Center (westbound) and JCAB (eastbound) in the CENPAC resulting in more efficiencies
• High equipage rates (over 90 percent) in the CENPAC can result in more UPR operations pending JCAB joining the program
- Lower overall FANS equipage rates will reduce potential benefits.
- Six primary fixed routes between CONUS and Hawaii with the four interiors routes being unidirectional (2 westbound and two eastbound) with 1000-foot flight levels on the unidirectional routes.
- Separation can be as low as 30nm with FANS equipped pairs, but as long as 10 minutes for non-equipped.
- UPRs could be considered at “low” traffic periods in both directions.
- Weather deviations are more frequent in the CEP and enhanced surveillance will provide an increase in safety for weather deviations and less reliance on “Captain’s Authority” to deviate without a clearance.
- Enhanced surveillance could result in more closely spaced unidirectional tracks and consideration of non-equipped aircraft being limited to specific tracks or specific flight levels. As more equipped aircraft are introduced into this airspace further enhancements can be implemented to take advantage of operational benefits.
- Unidirectional routes provide greater benefit with reduced separation with 1000-foot flight levels and climbs even for non-equipped aircraft.
• Enhance surveillance would provide for less departure delays, especially from the Hawaiian departure points into the Oakland airspace.

South Pacific (SOPAC)

• Route structure between California, Hawaii and the South Pacific exists but generally due to less traffic UPRs are planned.

• Separation can be as low as 30/30 depending on equipage, which is about 95 percent FANS

• Enhanced surveillance will provide the way to 15/15 separation minima in airspace that is generally less congested and currently utilizes UPRs

• Weather deviations are more frequent in the South Pacific and enhanced surveillance will provide an increase in safety for weather deviations and less reliance on “Captain’s Authority” to deviate without a clearance

Summary of Pacific Airspace

• Enhanced surveillance will enable significant benefits in the FAA Pacific airspace

• Safety is also improved with respect to potential weather deviations and avoidance of forecast moderate to severe turbulence

• A desired outcome is a reduction in passenger and crewmember injuries based on turbulence is possible with the resulting reduced separation minima (15/15) that will enable operators to more efficiently plan routes avoiding forecast SIG weather.

• Space-based ADS-B Based Enhanced Surveillance ADB-B offers a practical solution as the industry moves into the next phase of reduced separation minima. By FAA mandate all aircraft operating in the US are required to upgrade to ADS-B by 2020 so there should be no additional surveillance equipment cost to utilize ADS-B in domestic or oceanic airspace. However, ADS-C and FANS equipage is a requirement for reduced separation.
• Space-based ADS-B also offers an opportunity for Air Navigation Service Providers (ANSPs) to consider airspace redesign as traffic increases in the region. Never has this type of surveillance, almost radar like, been available in oceanic airspace.

West Atlantic Route System (WATRS)

• Aircraft equipage rates in the WATRS is one of the lowest in procedural non-radar FAA regions. Many of these aircraft are thought of as extended domestic operations therefore the aircraft communicate mostly over HF Voice Comm with RNP 10 and 50NM Spacing. Otherwise, aircraft with FANS use SATCOM Digital communications and RNP 4 30/30nm spacing.

• Route structure in WATRS uses opposite direction traffic flows, in a higher density airspace. This is different from the Pacific operation.

• Destinations are dispersed, distance between departure and arrival cities, in the NE as well as along the Leeward and Windward Islands. This leads to greater opportunity for route optimization.

• WATRS airspace in prone to convective weather activity with aircraft deviations on a regular basis, as well as being the area of hurricane development from June-November.
As a result, whole routes are closed by FAA as a mitigation strategy for aircraft deviation due to lack of surveillance.

- There has been increase traffic growth in recent years compounded with continued demand forecasted growth over the next five years.

- Current route structure is designed with fixed airways. Future airspace re-design should take advantage of increased aircraft equipage capability. Current equipage levels are approx. 51%, when this increases to approx. 85% airspace re-design should be implemented to maximize benefits.

- NAS users file on structured routes and controllers keep flights on structured routes.

- Enhanced surveillance in this region would have dual benefits in today’s operation, vertical and lateral adjustments. Each component has benefit to increasing Enhanced Surveillance in today’s operation.

- WATRS airspace will have mixed level of aircraft capability for a while, as such, users will need strategic assurances that the investment made will lead to improved vertical/lateral operations, while less capable aircraft are accommodated on structured routes and altitudes.

- Near term operational improvements of Enhanced Surveillance can occur on the operational edges by augmenting as back up surveillance to unreliable surveillance systems.

- Regional interoperability, harmonization to reduce longitudinal separation is a near term priority for the region.
New York Oceanic East

- 98% Equipped
- 14% of time NAT tracks published New York oceanic airspace
- Remainder airspace UPRs
Appendix A: FAA Tasking Letter
Ms. Margaret Jenny  
President  
RTCA, Inc.  
1150 18th Street, NW  
Washington, DC 20036  

Dear Ms. Jenny:

The aviation community has expressed increasing interest in space-based Automatic Dependent Surveillance – Broadcast (ADS-B) in the oceanic environment. The FAA understands some airlines are in the process of equipping their fleets with ADS-B, and other countries continue to plan for a quick implementation. Based on the discussion at the June 2016 NextGen Advisory Committee (NAC), the FAA requests the NAC's assistance to develop a consensus recommendation regarding the operational need and the added benefits of enhanced surveillance in oceanic airspace.

By 2020, the FAA has mandated ADS-B equipment for all aircraft operating in certain airspace. Air traffic control separation distances in oceanic airspace are much larger than domestic airspace, in part due to the limitations of current position reporting methods. With improvements in technology and enhanced surveillance capabilities, there may be an opportunity for increased benefit. Enhanced surveillance capability could result in increased safety, efficiency, fuel savings, and reduced emissions for the many aircraft crossing U.S.-controlled oceanic airspace.

The FAA is developing a business case for reduced separation minima in U.S.-controlled oceanic airspace. Several alternative approaches have been proposed to allow reduced separation. The FAA requires input from operators to better understand current constraints to oceanic operations and the potential for reduced separation minima to relieve these constraints and thereby reduce operating costs and/or improve air transportation service provision.

Budget constraints and existing priorities require an evaluation of the value of enhanced surveillance capabilities. As a deliberative body with broad industry representation, the NAC provides an ideal forum to weigh the reasons and rationale for pursuing enhanced surveillance in the context of existing priorities and potential tradeoffs.

The FAA hereby tasks the NAC to:

**Evaluate the need and benefit of enhanced surveillance capabilities:** The FAA requests that a new work group be formed to address the reasons and rationale for pursuing an enhanced surveillance capability in the context of established priorities and in light of the tradeoffs that may be required. The work group should be able to produce
recommendations relative to the viability, practicality and benefit to pursuing a path forward for the FAA and operators. The FAA requests the working group examine the potential benefits to operators of reduced oceanic separation minima using space-based ADS-B or other improvements to surveillance; what funding mechanisms might be used and at what cost, and what funding models might be possible if enhanced surveillance is deemed of sufficient value to pursue.

**Evaluate the Business Case:** The FAA will share assumptions on equipment requirements, including communications requirements, as part of the business case. The FAA requires insight from operators in the following specific areas:

- The FAA assumes that aircraft will need to be equipped with Future Air Navigation System (FANS) Controller Pilot Data Link Communications (CPDLC) and Automatic Dependent Surveillance-Communications (ADS-C) and Required Navigation Performance Level 4 (RNP 4) capabilities to be eligible for reduced separation. The FAA needs help in estimating the future fleet capability with FANS and RNP 4 in each of the airspace volumes being considered. The FAA also needs to better understand why many aircraft that appear to be RNP 4-capable today are not indicating that capability on their flight plans.

- The major benefit to operators in the FAA’s current business case for reduced oceanic separation is lower fuel burn associated with operating at higher altitudes more quickly and for longer periods. FAA analysts must make many operational assumptions regarding dispatcher, pilot, and controller actions (e.g., how often and when will pilots request climbs in oceanic airspace?). The FAA needs to validate these assumptions with operators.

- There may be many potential benefits of reduced oceanic separation in addition to flight at higher, more fuel-efficient altitudes. For example, more direct routes may be possible because of reduced lateral separations. The FAA needs to better understand where operators would most benefit from such route changes.

- The FAA needs to better understand how expected fuel savings might lead to reduced fuel loading.

- The FAA and Industry need to understand whether there will be additional equipage costs beyond those associated with the January 1, 2020 ADS-B mandate, and whether there will be recurrent costs or pass-through charges for usage.

- In the FAA’s preferred business model for space-based ADS-B service, operators would contract directly with the service provider or a third party for flight surveillance, similar to the manner in which ADS-C tracking works today. However, our preliminary estimates indicate that potential benefits vary widely depending on aircraft type and route. The FAA needs to better understand how operators would decide which aircraft, regions, and/or routes to subscribe to for surveillance services at different price points and for different charging schemes.
• Input from industry is needed to help capture the benefits of services possible, above and beyond current operations. These benefits will complement the FAA benefits case which intends to include benefits from reduced separation, improved situational awareness, improved traffic flow management capabilities, and global tracking. The benefits should consider US airspace as well as the benefits and costs for enhanced surveillance across airspace boundaries in an integrated way.

The FAA requests an interim recommendation report at the October 2016 NAC meeting, followed by a final report no later than the June 2017 NAC meeting. The FAA will make subject matter expertise available to the NAC upon request. If you need more information or have questions about this tasking, please contact me at 202-267-1240.

Sincerely,

[Signature]

Teri L. Bristol
Chief Operating Officer
Air Traffic Organization

cc: Jim Eck, Assistant Administrator, NextGen
    John Hickey, Deputy Associate Administrator, Aviation Safety
    Jennifer Solomon, Assistant Administrator for Policy, International Affairs
    and Environment
    Eduardo Angeles, Associate Administrator for Airports
### Appendix B: Task Group Members

The following organizations and entities supported the work of the Task Group.

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<th>Organization/Entity</th>
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### Oceanic Airspace Surveillance Performance Assumptions

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</table>

**Purple** – Approved by ICAO but not implemented in FAA-controlled oceanic airspace

**Blue** – Current standards implemented in U.S. oceanic airspace

**Red** – Proposed standards in ASEPS concept.

* There are no RSP or RCP requirements for this standard; listed RSP/RCP are recommendations only.
Appendix D: Operational Analysis of Reduced Separation in FAA-controlled Oceanic Airspace - Embry-Riddle Aeronautical University and ISA Software
Space-Based ADS-B in US

Operational Analysis of Reduced Separation in FAA-controlled Oceanic Airspace
02/13/2017

Vitaly S. Guzhva, Ph.D.
Embry-Riddle Aeronautical University

Kenny Martin
ISA Software
Outline

Executive Summary

ESTG City Pairs Discussion

All Airlines Atlantic Oceanic Region Results

All Airlines Pacific Region Results
Executive Summary

Real time position reports of all ADS-B equipped aircraft in North Atlantic, Pacific, Arctic and other remote areas will allow to reduce separations and increase traffic throughput enabling airlines to use more efficient routes and fly at more efficient altitudes and speeds.

FAA is considering the implementation of Enhanced Oceanic Surveillance and has tasked RTCA to study possible CONOPS and identify benefits through the Enhanced Separation Task Group (ESTG).

This presentation is intended to show the range of benefits that are triggered by alternative CONOPS in oceanic airspace, in line with the CONOPS of neighboring ANSPs.

Benefits are estimated for all flights that enter US Oceanic airspace and represent savings for the entire flight (not only for the US Oceanic portion). However, about 67% of all benefits are realized in US airspace.
Fast time modeling was done using a proven RAMS Plus simulation, 2020 FAA NextGen schedules for 16 Representative Days, and removing operational constraints in line with CONOPS of neighboring airspaces.

Main modeling assumptions:

- Increased equipage by Data Link Mandate
- Neighboring ANSPs having Reduced Oceanic Separation
- Wind optimized User Preferred Routing (UPR) in US oceanic airspace that removes constraints and reduces time and distance flown
- Aircraft cruising at or above FL320 initially assigned altitude of FL300 or FL310 depending on direction of flight. Step climbs attempted in all Oceanic Airspace once per 90 min (wide body aircraft) or per 150 min (narrow body aircraft). If denied, following up requests are made every 5 minutes.

RAMS Plus simulation shows space-based ADS-B enables significant benefits by

- Allowing Reduced Oceanic Separation for FANS and non-FANS (such as HF equipped) aircraft
- Reduced distance/time by wind optimized UPRs in oceanic airspace
Modeling Overview

Baseline Equipage

- Atlantic 2020: 75% FANS (30/30), 25% HF (10 min)
- Pacific 2020: 76% FANS (30/30), 24% HF (10 min)

Test Cases Equipage

- Added FANS to aircraft penetrating Canada/Portugal border to account for Data Link Mandate (increases Atlantic 2020 FANS to 86% overall)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Benefits Case</th>
<th>Benefits Pool</th>
<th>FANS</th>
<th>HF</th>
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<td><strong>Baseline</strong></td>
<td>Wind effects, fuel by alt/weight/Mach</td>
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<td><strong>Alternative 1</strong></td>
<td>Reduced Oceanic Separation (ROS) for FANS/ADS-B Aircraft</td>
<td>ROS for FANS/ADS-B Aircraft</td>
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<td><strong>Alternative 2</strong></td>
<td>ROS for FANS/ADS-B and HF/ADS-B Aircraft</td>
<td>ROS (25/60) for HF/ADS-B Aircraft</td>
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<td>25/60</td>
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<td><strong>Alternative 3</strong></td>
<td>Wind-optimized UPR</td>
<td>UPR for FANS/ADS-B and HF/ADS-B</td>
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<td>25/60</td>
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</table>
Total Annual Monetized Benefits in 2020
(FY16 $ Millions; ADOC and Fuel Only, Fuel price is $2.88 per gallon by FAA guidance)

Annual Benefits for all Airlines in North Atlantic and Pacific Oceanic Airspace

- $39.3 (15/15 FANS/ADS-B; 10 min HF)
- $69.5 (15/15 FANS/ADS-B; 25/60 HF/ADS-B)
- $440.5 (15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR)

Annual Benefits for all Airlines in US Oceanic Airspace

- $26.5 (15/15 FANS/ADS-B; 10 min HF)
- $46.8 (15/15 FANS/ADS-B; 25/60 HF/ADS-B)
- $296.9 (15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR)

Approximately 67% of all oceanic benefits realized in US airspace
Non-Monetized Benefits

Reduced Emissions

Annual Reduction of Carbon Dioxide (Metric Tons) in 2020

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Enhanced Global Flight Tracking

Enhanced Search and Rescue

Improved Tactical Flow Management
Economic Inputs

All values in FY16$ based on the August 2016 Economic Information for Investment Analysis document, produced by the FAA Investment Planning and Analysis

Fuel savings are valued at $2.88 per gallon

Non-fuel ADOC depends on aircraft type

For illustration, Passenger Value of Time for FY20 is $49.54 per hour

The number of seats depends on aircraft type

The assumed load factor is 82.9%
Scheduled Flights  Baseline Runs  UPR Runs

Both with Conflict Resolutions
$ = FY16$;  
243 operations in 16 NextGen representative days (annualized to 5,543 operations per year); 
Fuel is $2.88 per gallon

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<th>Per Flight</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
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$ = FY16$;
251 operations in 16 NextGen representative days (annualized to 5,726 operations per year);
Fuel is $2.88 per gallon

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<th>Per Flight</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>3.39</td>
<td>0.03</td>
<td>35.20</td>
<td>$0.97</td>
<td>$33.06</td>
<td>$34.04</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>3.38</td>
<td>0.48</td>
<td>63.30</td>
<td>$14.45</td>
<td>$59.45</td>
<td>$73.90</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>3.37</td>
<td>0.68</td>
<td>78.89</td>
<td>$20.40</td>
<td>$74.09</td>
<td>$94.49</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Per Year</th>
<th>Total Flight Time (hours)</th>
<th>Airborne Time Savings (hours)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>19,385</td>
<td>187</td>
<td>201,564</td>
<td>5,574</td>
<td>189,309</td>
<td>$194,884</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>19,342</td>
<td>2,776</td>
<td>362,447</td>
<td>82,732</td>
<td>340,410</td>
<td>$423,142</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>19,323</td>
<td>3,919</td>
<td>451,703</td>
<td>116,790</td>
<td>424,240</td>
<td>$541,030</td>
</tr>
</tbody>
</table>
KPHL-TJSJ

Scheduled Flights  Baseline Runs  UPR Runs

Both with Conflict Resolutions
$ = FY16$;  
49 operations in 16 NextGen representative days (annualized to 1,118 operations per year); 
Fuel is $2.88 per gallon

<table>
<thead>
<tr>
<th>Per Flight</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>3.32</td>
<td>0.67</td>
<td>59.11</td>
<td>$20.01</td>
<td>$55.52</td>
<td>$75.53</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>3.32</td>
<td>0.74</td>
<td>81.66</td>
<td>$22.20</td>
<td>$76.70</td>
<td>$98.90</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>3.28</td>
<td>2.96</td>
<td>167.64</td>
<td>$88.30</td>
<td>$157.45</td>
<td>$245.75</td>
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</table>

<table>
<thead>
<tr>
<th>Per Year</th>
<th>Total Flight Time (hours)</th>
<th>Airborne Time Savings (hours)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>3,712</td>
<td>751</td>
<td>66,076</td>
<td>$22,365</td>
<td>$62,059</td>
<td>$84,424</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>3,711</td>
<td>833</td>
<td>91,284</td>
<td>$24,813</td>
<td>$85,734</td>
<td>$110,547</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>3,670</td>
<td>3,312</td>
<td>187,393</td>
<td>$98,707</td>
<td>$176,000</td>
<td>$274,707</td>
</tr>
</tbody>
</table>
$ = FY16$;
60 operations in 16 NextGen representative days (annualized to 1,369 operations per year);
Fuel is $2.88 per gallon

<table>
<thead>
<tr>
<th>Per Flight</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>3.36</td>
<td>(0.23)</td>
<td>(0.78)</td>
<td>($7.00)</td>
<td>($0.74)</td>
<td>($7.74)</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>3.35</td>
<td>0.29</td>
<td>51.48</td>
<td>$8.64</td>
<td>$48.35</td>
<td>$56.99</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>3.34</td>
<td>1.02</td>
<td>55.68</td>
<td>$30.45</td>
<td>$52.30</td>
<td>$82.74</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Per Year</th>
<th>Total Flight Time (hours)</th>
<th>Airborne Time Savings (hours)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>4,599</td>
<td>(322)</td>
<td>(1,074)</td>
<td>(9,585)</td>
<td>($1,009)</td>
<td>($10,594)</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>4,587</td>
<td>397</td>
<td>70,456</td>
<td>11,829</td>
<td>$66,173</td>
<td>$78,001</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>4,571</td>
<td>1,398</td>
<td>76,214</td>
<td>41,672</td>
<td>$71,580</td>
<td>$113,252</td>
</tr>
</tbody>
</table>
KLAX-PHNL (top) PHNL-KLAX (bottom)

Scheduled Flights  Baseline Runs (Both with Conflict Resolutions)  UPR Runs
$ = FY16$;
342 operations in 16 NextGen representative days (annualized to 7,802 operations per year);
Fuel is $2.88$ per gallon

<table>
<thead>
<tr>
<th>Per Flight</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>5.25</td>
<td>0.10</td>
<td>83</td>
<td>$6.77</td>
<td>$78.28</td>
<td>$85.05</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>5.25</td>
<td>0.43</td>
<td>180</td>
<td>$22.59</td>
<td>$169.08</td>
<td>$191.68</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>5.20</td>
<td>3.20</td>
<td>436</td>
<td>$147.95</td>
<td>$409.21</td>
<td>$557.16</td>
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</table>

<table>
<thead>
<tr>
<th>Per Year</th>
<th>Total Flight Time (hours)</th>
<th>Airborne Time Savings (hours)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>40,979</td>
<td>803</td>
<td>650,302</td>
<td>$52,812</td>
<td>$610,764</td>
<td>$663,576</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>40,936</td>
<td>3,365</td>
<td>1,404,561</td>
<td>$176,283</td>
<td>$1,319,164</td>
<td>$1,495,447</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>40,575</td>
<td>24,998</td>
<td>3,399,275</td>
<td>$1,154,311</td>
<td>$3,192,599</td>
<td>$4,346,910</td>
</tr>
</tbody>
</table>
$ = FY16$;
434 operations in 16 NextGen representative days (annualized to 9,901 operations per year);
Fuel is $2.88 per gallon

<table>
<thead>
<tr>
<th>Per Flight</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>4.92</td>
<td>0.19</td>
<td>68</td>
<td>$4.79</td>
<td>$64.12</td>
<td>$68.91</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>4.92</td>
<td>0.28</td>
<td>108</td>
<td>$7.31</td>
<td>$101.78</td>
<td>$109.09</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>4.83</td>
<td>5.49</td>
<td>521</td>
<td>$248.48</td>
<td>$488.90</td>
<td>$737.38</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Per Year</th>
<th>Total Flight Time (hours)</th>
<th>Airborne Time Savings (hours)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>48,699</td>
<td>1,864</td>
<td>675,962</td>
<td>$47,436</td>
<td>$634,863</td>
<td>$682,299</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>48,684</td>
<td>2,742</td>
<td>1,072,879</td>
<td>$72,389</td>
<td>$1,007,648</td>
<td>$1,080,036</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>47,823</td>
<td>54,380</td>
<td>5,153,795</td>
<td>$2,460,063</td>
<td>$4,840,445</td>
<td>$7,300,508</td>
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</tbody>
</table>
Atlantic Oceanic Results
Atlantic Oceanic Region

<table>
<thead>
<tr>
<th>Per Flight</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
<th>PVT Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>6.16</td>
<td>0.09</td>
<td>58</td>
<td>$4</td>
<td>$54</td>
<td>$59</td>
<td>$11</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>6.16</td>
<td>0.26</td>
<td>90</td>
<td>$11</td>
<td>$85</td>
<td>$95</td>
<td>$31</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>6.13</td>
<td>1.94</td>
<td>241</td>
<td>$99</td>
<td>$226</td>
<td>$326</td>
<td>$293</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Per Year</th>
<th>Flights per Year</th>
<th>Airborne Time Savings (hours)</th>
<th>Fuel Savings (M kg)</th>
<th>Non-Fuel ADOC Savings (M $)</th>
<th>Fuel Savings (M $)</th>
<th>ADOC + Fuel Savings (M $)</th>
<th>PVT Savings (M $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>248,246</td>
<td>358</td>
<td>14.4</td>
<td>$1.03</td>
<td>$13.5</td>
<td>$14.5</td>
<td>$2.72</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>248,246</td>
<td>1,085</td>
<td>22.3</td>
<td>$2.63</td>
<td>$21.0</td>
<td>$23.6</td>
<td>$7.61</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>248,246</td>
<td>8,045</td>
<td>59.8</td>
<td>$24.53</td>
<td>$56.2</td>
<td>$80.8</td>
<td>$72.82</td>
</tr>
</tbody>
</table>

$ = FY16$;
10,882 operations in 16 NextGen representative days in Atlantic Oceanic region (680.1 operations per day);
Fuel is $2.88 per gallon
Atlantic Oceanic Region

2020 Per Flight Fuel+ADOC Benefits ($)

- 15/15 FANS/ADS-B; 10 min HF: $59
- 15/15 FANS/ADS-B; 25/60 HF/ADS-B: $95
- 15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR: $326

2020 Annual Fuel+ADOC Benefits ($)

- 15/15 FANS/ADS-B; 10 min HF: $14,537,827
- 15/15 FANS/ADS-B; 25/60 HF/ADS-B: $23,616,254
- 15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR: $80,828,911
New York Oceanic Airspace Step Climbs in 16 Representative NextGen Days

### Step Climbs in WATRS

<table>
<thead>
<tr>
<th></th>
<th>Base</th>
<th>15/15 FANS/ADS-B; 10 min HF</th>
<th>15/15 FANS/ADS-B; 25/60 HF/ADS-B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4,052</strong></td>
<td><strong>4,454</strong></td>
<td><strong>4,761</strong></td>
<td></td>
</tr>
<tr>
<td><strong>9.9%</strong></td>
<td><strong>17.5%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Step Climbs in KZWY

<table>
<thead>
<tr>
<th></th>
<th>Base</th>
<th>15/15 FANS/ADS-B; 10 min HF</th>
<th>15/15 FANS/ADS-B; 25/60 HF/ADS-B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8,331</strong></td>
<td><strong>8,755</strong></td>
<td><strong>9,194</strong></td>
<td></td>
</tr>
<tr>
<td><strong>5.1%</strong></td>
<td><strong>10.4%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pacific Airspace

US airlines tracks are in green
### Pacific Region

#### Per Flight

<table>
<thead>
<tr>
<th>Flight Configuration</th>
<th>Average Flight Time (hours)</th>
<th>Airborne Time Savings (min)</th>
<th>Fuel Savings (kg)</th>
<th>Non-Fuel ADOC Savings ($)</th>
<th>Fuel Savings ($)</th>
<th>ADOC + Fuel Savings ($)</th>
<th>PVT Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>8.23</td>
<td>0.15</td>
<td>68</td>
<td>$5</td>
<td>$64</td>
<td>$69</td>
<td>$17</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>8.23</td>
<td>0.34</td>
<td>117</td>
<td>$17</td>
<td>$110</td>
<td>$127</td>
<td>$40</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>8.18</td>
<td>3.18</td>
<td>920</td>
<td>$134</td>
<td>$864</td>
<td>$999</td>
<td>$348</td>
</tr>
</tbody>
</table>

#### Per Year

<table>
<thead>
<tr>
<th>Flight Configuration</th>
<th>Flights per Year</th>
<th>Airborne Time Savings (hours)</th>
<th>Fuel Savings (M kg)</th>
<th>Non-Fuel ADOC Savings (M $)</th>
<th>Fuel Savings (M $)</th>
<th>ADOC + Fuel Savings (M $)</th>
<th>PVT Savings (M $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/15 FANS/ADS-B; 10 min HF</td>
<td>360,574</td>
<td>927</td>
<td>24.5</td>
<td>$1.80</td>
<td>$23.0</td>
<td>$24.8</td>
<td>$6.28</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B</td>
<td>360,574</td>
<td>2,063</td>
<td>42.4</td>
<td>$6.10</td>
<td>$39.8</td>
<td>$45.9</td>
<td>$14.41</td>
</tr>
<tr>
<td>15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR</td>
<td>360,574</td>
<td>19,109</td>
<td>331.8</td>
<td>$48.43</td>
<td>$311.6</td>
<td>$360.1</td>
<td>$125.55</td>
</tr>
</tbody>
</table>

$ = FY16$;
15,806 operations in 16 NextGen representative days in Pacific region (988 operations per day);
Fuel is $2.88 per gallon
2020 Per Flight Fuel+ADOC Benefits ($)

- $69: 15/15 FANS/ADS-B; 10 min HF
- $127: 15/15 FANS/ADS-B; 25/60 HF/ADS-B
- $999: 15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR

2020 Annual Fuel+ADOC Benefits ($)

- $24,767,020: 15/15 FANS/ADS-B; 10 min HF
- $45,878,606: 15/15 FANS/ADS-B; 25/60 HF/ADS-B
- $360,055,718: 15/15 FANS/ADS-B; 25/60 HF/ADS-B; UPR
Pacific Airspace Step Climbs in 16 Representative NextGen Days

### Step Climbs in KZAK Eastcentral

<table>
<thead>
<tr>
<th>Base</th>
<th>15/15 FANS/ADS-B; 10 min HF</th>
<th>15/15 FANS/ADS-B; 25/60 HF/ADS-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,555</td>
<td>6,070</td>
<td>6,577</td>
</tr>
<tr>
<td>9.3%</td>
<td>18.4%</td>
<td></td>
</tr>
</tbody>
</table>

### Step Climbs in KZAK

<table>
<thead>
<tr>
<th>Base</th>
<th>15/15 FANS/ADS-B; 10 min HF</th>
<th>15/15 FANS/ADS-B; 25/60 HF/ADS-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>11,752</td>
<td>12,369</td>
<td>12,925</td>
</tr>
<tr>
<td>5.3%</td>
<td>10.0%</td>
<td></td>
</tr>
</tbody>
</table>
Questions?

Thank you very much!
Backup Slides
Modeling Overview

**Region:**
- Atlantic and Pacific regions
- US domestic surveilled airspace including Miami Oceanic (Caribbean) and San Juan (TJZS) uses 5 nm en route separation
- The region uses equipage dependent separation:
  - 10 minutes (80 nm) if an aircraft in a pair has HF communications
  - 50/50 for pairs of RNP10 ADS-C CPDLC aircraft
  - 30/30 for pairs of RNP4 ADS-C CPDLC aircraft
  - 15/15 for pairs of FANS/ADS-B equipped aircraft

**Methodology**
- Determine days for simulation (Used NextGen 16 representative days from 2015)
- 2015 schedules grown to model 2020 traffic levels
  - Atlantic 2020 Total Operations: 10,882
  - Pacific 2020 Total Operations: 15,806
- Gathered data on likely ADS-C RNP-4 CPDLC and FANS equipage for 2020
- Built model in RAMS Plus
- Document time and fuel burn results (Fuel burn, ADOC, and PVT values)
Additional Modeling Assumptions

Foreign neighbors are assumed to participate in ROS in all test cases.

Aircraft cruising at or above FL320 initially assigned altitude of FL300 or FL310 depending on direction of flight. Step climbs attempted in all Oceanic Airspace once per 90 min (wide body aircraft) or per 150 min (narrow body aircraft). If denied, following up requests are made every 5 minutes.

Sectors feeding oceanic sectors use sector exit separations equal to oceanic scenario separations, or reduced separation if both aircraft have required equipage.

Canada and Portugal airspace assume 15/15 separation due to Data Link mandate.
A validated ATM fast-time simulation model applied worldwide to Model, Measure, and Quantify ATM system performance, procedures, and concepts.

Incorporates Enroute, Terminal Area, and Ground operations
Models European SESAR and FAA NextGen Operational Improvements
Commercially Available Product Since 1997

FAA, EUROCONTROL, NASA Langley, Lockheed, GE Aviation, GE GRC
ANSP: Spain AENA/INECO; Italy ENAV/SICTA; Portugal NAV Portugal; Sweden LFV; Bulgaria ATSA; Romania ROMATSA; Senegal ASECNA; Japan ENRI; Thailand AERO THAI; China ATMB; Brasil DECEA/ITA; Colombia AEROCIVIL
Universities: London Imperial College; George Mason; Madrid UPM; University of York; Turkey Anadola; Barcelona UPC
Non-Monetized Benefits – Safety

- Enhanced Situational Awareness
- Enhanced global flight tracking
- Enhanced Search and Rescue
- Reduction in Pilot and ATC workload
- Improved cross-flight information boundary error detection
- Improved and earlier detection of off-track errors
- Enhanced safety alerting
- Improved weather avoidance
- Enhanced Height Monitoring in RVSM airspace
- Increased surveillance system augmentation and elimination of surveillance gaps
- Enhanced safety for offshore helicopter operations
- Enhanced incident and accident investigations

Source: Flight Safety Foundation
Wind Modeling

Wind days match FAA NextGen forecast days
- FAA forecast flight schedules are wind-friendly

NCEP/NCAR reanalysis wind data
- Per day, daily averages
  - Sensitivity analysis with stronger winds shows higher benefits
- 2.5 degree grid
- Upper altitude winds
  - 235 300 340 386 443
  - Wind data is interpolated between altitudes

Higher fidelity flight times & fuel calculations
Route Optimization (UPR)
Route optimization was modeled assuming a wind-optimized route from the last filed navaid prior to entering oceanic airspace to the first filed navaid after exiting oceanic airspace.
Appendix E: Information References Related to ADS-B

Satellite-based air navigation has already been proven as a fiscally prudent, globally-accepted strategy to increase safety and efficiency.

The following is excerpted from the FAA NextGen website for domestic airspace:


“ADS-B is transforming all segments of aviation. Real-time precision, shared situational awareness, advanced applications for pilots and controllers alike – these are the hallmarks of ADS-B NextGen surveillance.”

“Real-time ADS-B is used now for air traffic control. General aviation is safer with ADS-B traffic, weather, and flight-information services. Safety and efficiency improve with advanced ADS-B applications.”

“ADS-B improves safety and efficiency in the air and on runways, reduces costs, and lessens harmful effects on the environment.”

FAA Aerospace Forecast; Fiscal Years 2016-2036, states: “Starting in 2017 the international market (comprised of mainline and regional carriers) should again start outpacing the domestic market in terms of enplanements, revenue passenger miles (RPMs) and available seat miles (ASMs) at an average annual rate (FY 2017-2036) of 3.6%, 3.5%, and 3.5% respectively.” The document states the strongest areas for growth for passenger carriers is the Caribbean and Atlantic, while cargo carrier activity will steadily increase in those areas, as well as significant growth throughout the Pacific.