

JPDO Paper

FAA's "Surveillance/Positioning Backup Strategy Alternatives Analysis"

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The U.S. Government will integrate cooperative and non-cooperative surveillance capabilities to meet national objectives for air transportation safety, security, and capacity. Automatic Dependent Surveillance-Broadcast (ADS-B) will be the means of cooperative surveillance in the future, using the Global Positioning System (or systems with equivalent performance) as the positioning source.

The "Surveillance/Positioning Backup Strategy Alternatives Analysis" Report supported the near-term decision-making needed for the Surveillance Broadcast Services (SBS) program.

The JPDO position is that additional exploration and analysis are needed to realize Next Generation Air Transportation System (NextGen) capabilities and support sound U.S. Government investment decisions; the "Surveillance/Positioning Backup Strategy Alternatives Analysis" should be revisited as soon as possible, with a specific target date determined by the FAA after consultation with key stakeholders. This paper describes the different assumptions and analysis needed to realize a surveillance/positioning backup strategy for the NextGen environment.

FAA's "Surveillance/Positioning Backup Strategy Alternatives Analysis"

Automatic Dependent Surveillance – Broadcast (ADS-B) will be the means of cooperative surveillance in the future, using the Global Positioning System (GPS) (or systems with equivalent performance) as the positioning source. As with any service, there are inherent vulnerabilities that require mitigation methods. The FAA formed a technical team in May 2006 to perform a backup strategy alternatives analysis. This team included DoD representatives and other stakeholders via an aviation community ADS-B Steering Group, organized in June 2006 under the RTCA Air Traffic Management Advisory Committee (ATMAC). An investment decision in February 2007 for the FAA Surveillance Broadcast Services (SBS) program required the results from this backup strategy alternatives analysis.

The "Surveillance/Positioning Backup Strategy Alternatives Analysis" Report (referred to herein as the Report) was developed assuming a fully functioning ADS-B capability as described in "Final Program Requirements for Surveillance and Broadcast Services."¹ Several key assumptions were made to determine a mitigation strategy:

- a. Occurrence of a nominal GPS L1 outage of 40-60 nautical mile (NM) radius and 3-4 days duration, anywhere in the National Airspace System (NAS).
- b. An ADS-B rule compliance date of 2020.
- c. Current FAA procedures will be used for radar separation.
- d. "Primary radar" will be used "to mitigate single-aircraft avionics failures" in most terminal airspace.
- e. The backup strategy must support Air Traffic Control (ATC) surveillance services in terminal and en route airspace.
- f. Capacity must be maintained to at least the same level that would be experienced from the loss of service from a single radar facility in today's system.
- g. Safety of operations must be maintained.
- h. The strategy must be made operational on or before the ADS-B rule compliance date.

These assumptions were validated by the RTCA ADS-B Steering Group.

The Report recommended that the FAA retain approximately one-half of the Secondary Radar network as the backup strategy for ADS-B. The Report further recommended that the ADS-B backup strategy be reassessed to reflect further ADS-B operational experience and emerging requirements prior to the FAA's commitment to radar investments beyond 2020. The Report supported the near-term decision-making needed for the FAA SBS program.

The Joint Planning and Development Office (JPDO) position is that additional exploration and analysis is needed to realize NextGen capabilities. The NextGen Concept of Operations (ConOps) v2.0 describes an environment that will be significantly different from current radar separation

¹ Version 1.0, FAA-ATO-E, May 9, 2006, was used in the analysis; the current release is Version 2.1, August 6, 2007.

procedures. Analysis of the capabilities needed for NextGen separation management requires revising the assumptions and alternatives addressed in the Report. For example:

- (1) Assumptions about allowable aircraft positioning uncertainty will be different in a NextGen context, where new paradigms for separation assurance are necessary to safely accommodate increased traffic demand. For example, Trajectory-Based Operations such as “flow corridors” concept hypothesized in the NextGen ConOps v2.0 would require Required Navigation Performance (RNP) values somewhat less than 2.0 to provide operational benefit. Similarly, the JPDO believes that “Super-Density Arrival/Departure Terminal Operations” will require RNP < 1.0.² The JPDO-sponsored NGATS Institute SatNav Backup Study and JPDO involvement in the National Position, Navigation and Timing (PNT) Architecture both indicate that positioning/navigation accuracy and robustness requirements will require a “complementary” PNT system (or systems) based on phenomenology that is dissimilar to Global Navigation Satellite System (GNSS) – candidates include eLORAN and advanced Inertial Reference Units. Such complementary PNT system(s) would mitigate many of the GNSS vulnerability scenarios that led to the assumed requirements for ADS-B backup. Also, by the NextGen timeframe, a variety of PNT capabilities will be fully available that are not in use today, including GPS L5, and other nations’ space-based PNT services, such as Galileo. These new capabilities should improve the robustness of aircraft positioning and will mitigate many of the vulnerabilities of space-based PNT.
- (2) Current radar separation procedures use single sensor reported position and correlation with primary radar, with typical update rates of 4.5 seconds or greater, up to 12 seconds for some radars; aircraft velocity is estimated from a history of reported positions. With the introduction of ADS-B positioning information for Air Traffic Management use at 1-2 second update rates, and the availability of high-quality, real-time aircraft velocity information from modern PNT systems via ADS-B, new approaches to separation management are possible. R&D results indicate that current separation procedures will change as Trajectory-Based Operations and delegated separation procedures are introduced. Since separation management in NextGen will be different, a viable surveillance/positioning backup strategy must address the risks associated with the loss of any and all positioning and velocity information services to include GPS L1, as well as risks associated with transitioning surveillance information update rates in the event of service outages. The JPDO, therefore, recommends that procedures used for separation management should be rethought from first principles.
- (3) Although the analysis considered the mission needs of DoD as they were known at the time of the study, it did not consider the emerging future mission needs and plans of DoD or other Federal agencies with an interest in surveillance information on flying objects in U.S. airspace. In particular, the analysis did not consider the en route primary radars currently operated by FAA and funded by DoD/DHS. The DoD and DHS currently receive “feeds” from FAA radar sites, and these departments have recently indicated concern about the FAA backup strategy

² These statements are made based on expert judgment; the JPDO has not yet conducted a formal analysis to determine target limits for aircraft positioning uncertainty during these and other operations hypothesized in the NextGen ConOps. (This should occur during FY08-09.)

described in the report and the potential impact of such a strategy on DoD/DHS mission needs and operations. As a result, based on ongoing discussions with DoD/DHS about future needs and plans, the JPDO believes that DoD/DHS may put in place one or more non-cooperative air domain surveillance systems during the 2015-2025 period. If this should occur, governmental synergies might lead to several possibilities:

- a. FAA could use DoD/DHS non-cooperative air domain surveillance information as a backup strategy for a variety of ADS-B outages.
- b. DoD/DHS may not be interested in continuing to use/fund FAA-operated primary long-range (en route) radars.
- c. Alternative means of detection emerge. For example, electromagnetic sensors used by DOC/NOAA to detect weather phenomena might be leveraged to detect objects flying in U.S. airspace.

Any of these possibilities would be cause to revisit a variety of assumptions in the Report, and/or would allow the development of heretofore unconsidered backup alternatives.

- (4) Future analysis should more fully consider “airborne applications” of ADS-B information (applications of the “ADS-B In” capability), including airborne applications that are not currently within the SBS program baseline. The analysis considered a limited set of “advisory” airborne applications, and there was no requirement for any backup alternative to preserve the functionality of these applications. From a NextGen perspective, the ADS-B In capability and the potential operational benefits of the hypothesized applications are a primary driver for the development and fielding of ADS-B infrastructure. An early JPDO analysis of NextGen capabilities showed that ADS-B In could provide as much as 30 percent of the capacity growth required to achieve 3x 2004 traffic levels. From this perspective, a backup alternatives analysis for the 2015-2025 timeframe should consider how ADS-B In applications could be provided under different alternatives and the costs/benefits of these alternatives. The ongoing work of the SBS program office and the ADS-B Aviation Rulemaking Committee to better define ADS-B In applications and their benefits should provide useful information for such an analysis.
- (5) Any future analysis should consider the merits of blending sensors in lieu of picking strict “either /or” approaches. The analysis assumed terminal airspace primary radars will be retained for single aircraft failures, so it should also explicitly consider using such primary radar information in the Backup Strategy Alternatives. Use of a sensor system to obtain “flight ID” and altitude information that can be easily correlated with primary radar information may yield a lower cost strategy that meets performance requirements. The JPDO has been told that an FAA/MITRE/Volpe team performed an initial analysis of the above in early 2006, but this analysis was not publicly disseminated and therefore has not been reviewed by the affected stakeholders (nor by the JPDO). The JPDO recommends that this analysis should be revisited in a NextGen context as part of any future ADS-B backup alternatives study.
- (6) The assumption that “at least the same level of capacity must be maintained during a loss of GPS that would be experienced during a comparative loss of radar services today” is not expected to apply in the context of projected NextGen 2025 traffic levels. Today, “loss of radar services” in “high-density terminal airspace” leads to airport throughput rates that are somewhat

less than current nominal rates during non-visual operations. Assuming that 2025 traffic levels are two times today's levels, then supporting less than current airport throughput rates would imply a potential capacity reduction of more than 50 percent in 2025 during the regional service loss assumed in the Report. The economic consequences of operating a high-density terminal airspace like Atlanta, Chicago, or New York at 50 percent (or less) of its nominal capacity for 3-4 days would be substantial; these consequences should be assessed in any cost/benefit analysis of alternatives.

- (7) The analysis implicitly assumes that procedural separation will be used "to mitigate single-aircraft avionics failures" in en route airspace, as is practiced in today's system with 5 NM separation between aircraft. NextGen envisions reduced en route aircraft-to-aircraft separations, to 3 NM or much less in "flow corridors." The FAA is already discussing the potential for 3 NM en route separation for aircraft equipped with ADS-B; whether such aircraft-to-aircraft separation in en route airspace will require "primary radar" as the mitigation for "single-aircraft avionics failures" is unclear and must be addressed in any future ADS-B backup alternatives study.

Summary

The JPDO agrees that the FAA ADS-B Backup Strategy is appropriate to support current traffic levels, current ATC operations, the current FAA SBS program baseline, and was adequate to begin the rulemaking process. However, the JPDO position is that additional exploration and analysis is needed to realize NextGen capabilities and support sound U.S. Government investment decisions.

Actions/Recommendations

To begin to address (3) above and to fulfill its obligations in response to the National Security Presidential Directive-47/Homeland Security Presidential Directive-16 (NSPD-47/HSPD-16) "National Strategy for Aviation Security," the JPDO has formed an Integrated Surveillance Study Team, consisting of members from appropriate JPDO Working Groups, and partner departments and agencies. The team will produce a written report, to be completed in 2008, that should dovetail with the HSPD-16 Implementation Action Items and serve as an alignment roadmap and guide for aviation transportation system surveillance policy and system integration. The Integrated Surveillance Study Team has authored a recommendation that has been adopted by the JPDO Integration Council as a JPDO position (see "Defining an Interagency Mechanism to Achieve NextGen Integrated Surveillance," JPDO Paper No.: 08-006).

The JPDO should sponsor an analysis to determine a target limit for aircraft positioning uncertainty required to enable operations hypothesized in the NextGen ConOps, with particular emphasis on super density operations and flow corridors. An initial analysis should occur during FY08-09 to provide inputs to assumptions for any revised Surveillance/Positioning Backup Strategy Alternatives Analysis.

Given the connectivity between satellite-based navigation and ADS-B-based surveillance, the FAA should perform an FAA-wide (to include both ATO and AVS) systems engineering study of failure modes and risk mitigations for ADS-B, radar systems, and PNT services, to identify requirements for future SBS program segments, other FAA programs, and for services obtained from other

Federal agencies or the private sector. The results of this work should be coordinated with the DoD, DHS, JPDO, PNT National Coordination Office, and other affected agencies, and should be institutionalized in the NAS Enterprise Architecture.

The FAA should revisit the Surveillance/Positioning Backup Strategy Alternatives Analysis through an interagency forum including DOT/FAA, DHS, DoD, and DOC/NOAA,³ to consider information developed since the original Report was completed,⁴ to account for Federal government decisions made since the original study was performed,⁵ and to consider the implications of the NextGen environment described in this paper. The revised Surveillance/Positioning Backup Strategy Alternatives Analysis should be completed as soon as possible, with a specific target date determined by FAA after consultation with key stakeholders.

Finally, FAA should charter and lead a small interagency team to initiate an examination of separation management procedures in the NextGen timeframe. Such an examination should proceed from first principles and should not be constrained to any current procedures. To the JPDO's knowledge, such an effort has not been conducted in about 40-50 years; therefore, we expect that this would be a multi-year effort that should be initiated as soon as possible. In addition to the FAA, the JPDO believes that DoD and NASA should be involved, as well as appropriate experts from academia, appropriate Federally-Funded Research and Development Centers, and the aviation industry. Given that the outcome of any such effort would need to go to the International Civil Aviation Organization, a formal strategy should be implemented for engaging the Europeans and other appropriate nations in this work as it evolves.

³ and other Federal agencies as appropriate

⁴ NGATS Institute SatNav Backup Study, results from the JPDO Integrated Surveillance Study Team, etc.

⁵ DHS/DOT decision to retain/invest in eLORAN infrastructure as a National PNT backup source, decisions from the HSPD-16 Implementation Action Items under the ADSII plan, etc.

The “Surveillance/Positioning Backup Strategy Alternatives Analysis” Report

Document Revision History

VERSION	DATE	DESCRIPTION
Internal version v0.04	July 26, 2007	First draft circulated within JPDO for comment
Internal version v0.05	August 6, 2007	Revision per comments received
Internal version v0.06	August 14, 2007	Revision per comments received
Draft v0.1	August 17, 2007	Transmitted to Vinny Capezzuto, Steve Bradford, and Jim Baird for comment
Draft v0.2	November 27, 2007	Revision per comments received; retransmitted to Capezzuto, Bradford and Baird for "final review"
Draft v0.3	December 3, 2007	Transmitted to leaders of the ANS, Aircraft, NCO, and WX WGs, ANS WG CNS Study Team members, and JPDO Integrated Surveillance Study Team members
Draft v0.4	February 6, 2008	Revision per comments received; submitted to JPDO internal review process
Draft v0.41	April 21, 2008	Revised per comment/request from Bob Pearce
Draft v0.42	May 16, 2008	Revised per comments from DoD and transmitted for IC review
Draft v0.43	May 21, 2008	Revised per comments from DoD/ATA and transmitted for IC review
Draft v0.44	May 22, 2008	Editorial revision per comments from FAA
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