Joint Planning and Development Office

Integrated Surveillance for the Next Generation Air Transportation System

Final Report of the Integrated Surveillance Study Team

October 31, 2008

Reviewed and Approved by the Departments and Agencies for the Next Generation Air Transportation System

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November 21, 2008

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EXECUTIVE SUMMARY

Effective operation of the national air transportation system – for civil aviation, national defense, and homeland security – rests on accurate airspace situational awareness. While progress has been made by the U. S. Government in fielding surveillance capabilities to support this situational awareness, gaps remain that cause operational risks and stand as obstacles to achieving the vision for the Next Generation Air Transportation System (NextGen). Creation of a formal interagency governance mechanism for Integrated Aviation Transportation System Surveillance[1] (also referred to as Integrated Surveillance) would provide a synergy of effort in policy development, requirements generation, technology maturation, and acquisition and operation of surveillance systems, leading to improved overall capabilities and overall cost savings.

This report outlines current key deficiencies in integrated surveillance as well as national surveillance needs projected forward to 2025 for U.S. sovereign airspace, air approaches to the United States, and U.S. airport movement areas. These areas are considered critical to providing appropriate aviation security while maximizing the U.S. Government's ability to provide safe and uninterrupted airborne operations of manned and unmanned aircraft engaged in commerce, defense/security of the homeland, and other flight operations. This report was compiled by the Integrated Surveillance Study Team (ISST), consisting of members from the Joint Planning and Development Office (JPDO), Federal Aviation Administration (FAA), Department of Defense (DoD), and the Department of Homeland Security (DHS).

Multiple departments and agencies have a need for Aviation Transportation System[2] surveillance information and have existing resources and planned programs to meet their mission needs: the FAA for administering the National Airspace System (NAS) and air security, DHS for airborne and airport security, DoD for air defense, and the Department of Commerce (DOC) for hazardous weather information reporting and forecasting. The overlapping roles, responsibilities, authorities, and capabilities of the surveillance mission partners[3] has led to cross-dependencies among the agencies in terms of surveillance system ownership and use of the information produced by these systems, as well as an operational need for timely surveillance information sharing across agencies. However, there is no current institutional mechanism for reconciling these overlaps and coordinating policy, requirements, funding, plans or operations of the nation's aviation transportation system surveillance assets.

The surveillance mission partners are investing considerable resources, time, and energy in developing surveillance, navigation, communications, and information technology to enable surveillance operations within their own core domains. The Department of Transportation (DOT)/FAA is concentrating on fielding Automatic Dependent Surveillance–Broadcast (ADS-

[1] Integrated Aviation Transportation System Surveillance is the integration of information from cooperative and non-cooperative surveillance systems to create a user-defined operational picture (from common information) of real or near-real-time situation for safety, security, and efficiency, within the scope of the Aviation Transportation System as defined below.
[2] Aviation Transportation System is U.S. airspace, all manned and unmanned aircraft operating in that airspace, all U.S. aviation operators, airports, airfields, air navigation services, and related infrastructure, and all aviation-related industry. See NSPD-47 / HSPD-16.
[3] DoD, DHS, DOT/FAA, and DOC.

B), which can provide NextGen cooperative surveillance capability; DHS and DoD are interested in maintaining and potentially improving upon their current air surveillance picture through service life extension programs and research and development programs. The absence of a formal governance mechanism among these different agency activities will result in a continuation of the status quo where duplication, gaps, and inefficiency impede or prevent the achievement of the Integrated Surveillance capabilities envisioned in the NextGen Concept of Operations (ConOps).

ISST found during its investigation that each represented surveillance mission partner had begun analytic efforts which have led or will lead to the identification of their respective future surveillance and data integration requirements. However, these efforts are fragmented, inconsistently scoped, and not synchronized across stakeholders. Questions of how to best address the overlapping surveillance and data integration responsibilities, capabilities, and authorities of the surveillance mission partners have yet to be answered. While ADS-B may enable enhanced interagency safety and security capabilities, it is not capable of providing reliable information on the intent of unlawful operators, including criminals and terrorists operating airborne platforms in the NAS. As a result, additional sensors, processes, and procedures coordinated amongst DHS, DoD, Office of the Director of National Intelligence (ODNI), FAA, and other appropriate U.S. Government organizations and allied governments will be necessary for information sharing to establish the intent and detection of unknown, suspected, or actual airborne threats to the United States.

In mid-2007, the JPDO established the ISST as an interagency group. Periodically, the ISST met with the ISST Review Panel to help ensure alignment between JPDO and the involved agencies. The Review Panel members included representatives from DHS, DOC, DOT/FAA, DoD, ODNI and MITRE; JPDO Interagency Architecture & Engineering and Strategic Interagency Initiatives Divisions, and the following JPDO Working Groups: Air Navigation Services, Net-Centric Operations, Security, and Weather. The ISST task was to:

- Identify high-level aviation transportation system surveillance information and capability needs as envisioned in the NextGen ConOps;
- Identify existing agency aviation transportation system surveillance capabilities and architecture, and future surveillance system plans and needs;
- Identify potential changes in how aviation transportation system surveillance capabilities might be combined to more effectively and efficiently achieve NextGen; and
- Identify what, if any, changes might be necessary in government planning.

ISST members spent considerable energy coordinating with interagency activities on Action Items (AIs) resulting from the National Security Presidential Directive-47/Homeland Security Presidential Directive-16 (NSPD-47/HSPD-16) "Aviation Security Policy." All the AIs are derived from NSPD-47/HSPD-16 activities that developed the "National Strategy for Aviation Security" (NSAS) and seven supporting plans. Of particular interest to JPDO and the ISST were AIs 102 and 103. AI 102 is to *"develop a coordinated air surveillance implementation plan, which recommends solutions to address any gaps in aviation security requirements,"* and AI 103 is to *"develop a plan to integrate the air surveillance data made available from all Federal* *departments and agencies and private sector entities, into an integrated air surveillance picture, definable by the end-user*." The ISST created an early "interim report" of the findings and recommendations contained herein as an input to the AI 102 and 103 teams. The AI 103 and current draft AI 102 findings and recommendations are essentially consistent with the findings and recommendations herein; however, the AI 102 report has yet to complete the interagency approval cycle via NSAS governance mechanisms.

The findings and recommendations of this report focus first on resolving governance, closely followed by technical work necessary to develop a roadmap for reaching an Integrated Surveillance capability. The findings and recommendations are summarized below; the reader is advised to see Section 10 of this report for the full and complete findings and recommendations.

Key findings include:

- There are known organizational barriers to achieving NextGen surveillance objectives that must be addressed before any technical approaches can be successfully evaluated, selected, and implemented.
- There is no institutional mechanism to oversee and coordinate surveillance capabilities across all agencies, nor is there a mechanism in place to synchronize and arbitrate agency efforts to establish an Integrated Surveillance capability.
- There are gaps between NextGen needs and planned surveillance capabilities due to sensor coverage and detection characteristics; data correlation and fusion; network architecture and connectivity; interagency surveillance information sharing and collaboration; and ability to address the spectrum of multi-agency information needs. There is no consensus among the agencies that participated in this study regarding the degree to which these gaps cause near-term operational risks.
- No concept of operations exists that covers the scope of integrated surveillance. Surveillance is currently characterized by each individual agency focusing only on their operational mission needs. Limited capabilities exist for the timely sharing of surveillance information across all stakeholders, which also affects the coordination of responses to detected events.
- There are opportunities to leverage future technologies and other capabilities across agencies to achieve synergy in Integrated Surveillance.

The ISST's first recommendation is critical and key to enabling the remaining recommendations:

1) **Determine and establish a formal, institutionalized interagency mechanism for responsibility, management, and ownership for elements of integrated surveillance (to include funding).** Future Integrated Surveillance data/information requirements must be analyzed holistically, ensuring that the responsibilities of DOT/FAA, DHS, DoD, ODNI, DOC/National Oceanic and Atmospheric Administration, and other appropriate government organizations are understood, reconciled where conflicting, leveraged as necessary, and appropriately addressed. Integrated Surveillance requirements for 2025 must accommodate both the projected increase in the volume of aircraft operations, as well as risk-based assessments of threats to the United States for that timeframe.

Weather surveillance[1] capabilities and requirements should be simultaneously evaluated for potential synergies. Policy development, management and resource commitments must also be defined. The ISST recognizes the importance of integrating interagency surveillance with intelligence information and acknowledges the coordination role of ODNI's Global Maritime and Air Intelligence Integration office in this area. There are many potential mechanisms that might be used to oversee integrated surveillance for the Aviation Transportation System, air defense, and homeland security. Given the complexity of the task and the different priorities of the agencies, the ISST believes that any successful governance structure must be collaboratively developed by the Executive Branch in coordination with the Legislative Branch, to maximize alignment of responsibility, authority, and funding.

The following recommendations should be implemented by the formal interagency mechanism described in the first recommendation:

2) **Develop a concept of operations for NextGen Integrated Surveillance.**
3) **Develop an interagency Integrated Surveillance architecture to support operational, system, technical, and investment decisions**.
4) **Develop and implement an Aviation Surveillance Information Network strategy.**
5) **Develop and execute an interagency Integrated Surveillance implementation plan.**
6) **Use demonstrations and experiments to mature and field early versions of Integrated Surveillance capabilities.**

In addition, the agencies involved should begin to analyze and adjust their internal policy, capabilities development, technology efforts, and acquisition processes by working with other surveillance mission partners wherever possible. Efforts to optimize internal agency efforts and focus interagency participation on future Integrated Surveillance needs will accelerate the transition and evolution of any surveillance governance mechanism.

Enacting the recommendations of this report will enhance the U.S. Government's collaboration in aviation transportation system surveillance and further define, develop, and field the Integrated Surveillance capabilities necessary to support future NextGen and security/defense operations.

[1] Weather surveillance is the means, through human and automated sensors, to measure in-situ characteristics of the atmosphere. It can be done remotely by space-, air-, and land-based systems, including on-board sensors, radar, and satellite technologies.

1.0 TEAM TASK STATEMENT AND REPORT PURPOSE

The Integrated Surveillance Study Team (ISST) was comprised of individuals from the DHS, DoD, and DOT/FAA, at the instigation of the Joint Planning and Development Office (JPDO), [1] to develop a written report documenting consolidated Next Generation Air Transportation System (NextGen) top-level needs for Integrated Aviation Transportation System Surveillance. JPDO study teams are short-term by design and address a specific topic or task by implementing focused activities. The ISST periodically informed and received guidance from the ISST Review Panel, which was comprised of JPDO Working Group (WG) co-chairs and mid-level managers from the DHS, DoD, ODNI, and DOT/FAA (see Appendix D). As described in the Terms of Reference, the surveillance mission partners and others interested in developing surveillance as an integrated capability by year 2025 and beyond, agreed that the ISST was to:

1) Identify high-level Aviation Transportation System surveillance information and capability needs as envisioned in the NextGen Concept of Operations (ConOps);
2) Identify existing agency Aviation Transportation System surveillance capabilities and architecture, and future surveillance system plans and needs;
3) Identify potential changes in how Aviation Transportation System surveillance capabilities might be combined to more effectively and efficiently achieve NextGen; and
4) Identify what, if any, changes might be necessary in government planning.

Activities of the ISST have been coordinated with development activities of the Air Domain Surveillance and Intelligence Integration (ADSII) plan of National Strategy for Aviation Security (NSAS), directed by National Security Presidential Directive-47/Homeland Security Presidential Directive-16 (NSPD-47/HSPD-16) “Aviation Security Policy.”

In its totality, NextGen surveillance needs include the capabilities necessary to detect, identify, and track objects (including ground objects in the airport environment) and atmospheric phenomena (weather) for the purposes of aviation safety, air security, and air defense. This document includes surveillance information which is used to provide Air Domain awareness that will enhance the U.S. Government’s ability to detect, deter, and respond to a range of aviation threats to the homeland such as large commercial aircraft, smaller jet and propeller-driven aircraft, and manned/unmanned aircraft systems.

The report is a step towards identifying and articulating NextGen surveillance capabilities, addressing primary identification of an operating vehicle and objects in and around airport/airfields in the vicinity of operating vehicles. As a product of the ISST and ISST Review Panel, the report provides inputs to JPDO corporate products, and may lead to additional follow-on reports.

This report provides information to build upon the implementation planning directed by NSAS ADSII plan Action Items, particularly AIs 102 and 103.

[1] Created by Public Law 108-176, Sec 709.

Action Item 102 is

> *develop a coordinated air surveillance implementation plan, which recommends solutions to address any gaps in aviation security requirements. At a minimum, this plan should address: (1) Maintenance and improvement of current air surveillance capabilities; (2) Options for enhancement of current air surveillance capabilities for low altitude coverage in areas of national interest; (3) Interagency responsibilities to detect, monitor, track, and identify all aircraft, both cooperative and non-cooperative, in or approaching U.S. airspace; (4) Recommended solutions, including those associated with cost sharing, to address identified surveillance gaps; (5) Development of next generation surveillance and detection capabilities; (6) Transition to future surveillance capabilities; (7) Identify appropriate agencies to implement the plan within a specified timeline*.

Action Item 103 is

> *develop a plan to integrate the air surveillance data made available from all Federal departments and agencies and private sector entities, into an integrated air surveillance picture, definable by the end-user*.

2.0 BACKGROUND AND DEFINITIONS

2.1 Background

The impacts of the September 11, 2001, terrorist attack on the U.S. commercial aviation system have been estimated to be as much as 420 billon (USD) and a two-year recovery period.[1] However, these loss estimates only capture the economic consequences that follow an attack and exclude costs associated with loss of life and replacement of aircraft.

The U.S. Government continues to work toward a scalable, flexible aviation security system that's responsive to varying threat levels and effectively addresses current and future threats, thereby reducing vulnerabilities within the Aviation Transportation System. Significant enhancements to detect threat objects increase the security posture of the entire Air Domain.

A major interagency comprehensive review of National Airspace System (NAS) surveillance systems was documented in the North American Air Surveillance Plan (NAASP), dated 23 Oct 2002. Although not formally approved at the Cabinet level, the NAASP was developed and signed by representatives from the Department of Homeland Security (DHS), Department of Defense (DoD), and Department of Transportation (DOT). The plan identified interagency requirements for surveillance, provided initial funding profiles of existing surveillance systems, and served as an initial reference document for the ISST.

The DOT/FAA expanded communications and surveillance services to appropriate agencies via the NAS Defense Program (NDP) strategy. The NDP has a comprehensive perspective of communications and surveillance.

[1] Economic Impacts of a Terrorist Attack on the U.S. Commercial Aviation System, Study, Risk Analysis, published by the Society for Risk Analysis.

Given the United States' economic reliance on aviation and the expected growth of aviation operations, in 2003 the JPDO was created by Public Law 108-176, to enhance the NAS in 2025 and beyond. The JPDO is chartered to lead a collaborative effort among DoD, DHS, DOC, DOT, NASA, the White House Office of Science and Technology Policy, industry, and academia. The Next Generation Air Transportation System Integrated Plan,[1] developed by the JPDO Government partners, includes goals to improve the safety and security of the NAS.

In June 2006, President Bush issued National Security Presidential Directive-47/Homeland Security Presidential Directive-16 (NSPD-47/HSPD-16) "Aviation Security Policy," establishing U.S. policy, guidelines, and implementation actions to continue the enhancement of U.S. homeland security by protecting the United States and U.S. interests from threats in the Air Domain. NSPD-47/HSPD-16 directed development of the National Strategy for Aviation Security (NSAS), which established the overarching framework for a comprehensive and integrated national approach to security within the Aviation Transportation System. The supporting plans are:

- Aviation Transportation System Security (ATSS) plan;
- Aviation Operational Threat Response (AOTR) plan;
- Aviation Transportation System Recovery (ATSR) plan;
- Air Domain Surveillance and Intelligence Integration plan;
- International Aviation Threat Reduction (IATR) plan [*classified*];
- Domestic Outreach (DO) plan; and
- International Outreach (IO) plan.

The ADSII plan, dated March 26, 2007, contains surveillance-related roles and responsibilities pertinent to this report. The plan also describes the requirements, priorities, and implementation of the initial coordination of national air surveillance resources and the means to share this information with appropriate stakeholders.

To document consolidated Integrated Surveillance needs for the 2025 time horizon, in mid-2007 the ISST was established by the JPDO. The ISST report serves as a key input to future revisions of JPDO planning documents, such as the NextGen ConOps, Enterprise Architecture (EA), and Integrated Work Plan (IWP). Ultimately these products should facilitate coordinated, leveraged research and development (R&D), and future system investments and operations for appropriate communities depicted in the NextGen Enterprise Architecture.

The Interim Report of the ISST was the basis for the following JPDO recommendation to the cabinet-level JPDO Senior Policy Committee (SPC):[2] *"Establish an integrated surveillance implementation entity housed in DoD with the authority, funding, and responsibility for multi-*

[1] Next Generation Air Transportation System Integrated Plan, December 12, 2004, available at http://www.jpdo.gov/library/NGATS_v1_1204r.pdf.
[2] Public Law 108-176, Sec 710.

agency system engineering and program management." At the SPC meeting held on May 6, 2008, the DoD SPC member agreed to lead the surveillance mission partners in formulating a response to this recommendation.

2.2 Definitions

The following definitions are used in this report.

- **Air Domain**: The global airspace, including domestic, international, and foreign airspace, as well as all manned and unmanned aircraft operating, and people and cargo present in that airspace, and all aviation-related infrastructures.[1]
- **Air Domain Awareness**: The effective understanding of threats associated with the Air Domain that could impact the security, safety, or economy of the United States.[2]
- **Air Domain-Related Databases**: Repositories of information that describe aspects of the air domain (e.g., list of airports, restricted airspace, and the technical performance of different airframe types).[3]
- **Aviation Transportation System**: U.S. airspace, all manned and unmanned aircraft operating in that airspace, all U.S. aviation operators, airports, airfields, air navigation services, and related infrastructure, and all aviation-related industry.[1]
- **Cooperative Dependent Surveillance**: Characterized by avionics on board an airborne object that can determine its position through the Global Positioning System (GPS) or through some other navigation system. Periodically, the avionics broadcast this position. This broadcast can be received by ground systems or other airborne objects. It is dependent because the avionics rely on other systems (such as GPS) for positional awareness.[4]
- **Cooperative Independent Surveillance**: Characterized by the need to have cooperative avionics on board an airborne object, and associated ground systems. An example is the Air Traffic Control Radar Beacon System (ATCRBS). A ground (or airborne) system sends an interrogation and the airborne avionics send a reply message. The position of the object is determined by examining the time it takes to receive an interrogation response (yielding distance) and the angle from the ground system. It is independent because the air object's position can be derived regardless of whether the airborne object has awareness of its own position.[4]
- **Flight Data**: Attributes that are associated with each known and planned flight within the Air Domain. This may include dozens of data points including aircraft type, aircraft identification, flight plan, and others.[3]
- **Integrated Surveillance:** The integration of information from cooperative and non-cooperative surveillance systems to create a user-defined operational picture (from common information) of real or near-real time situation for safety, security, and

[1] NSPD-47/HSPD-16.
[2] NSAS Air Domain Surveillance and Intelligence Integration Plan, March 26, 2007.
[3] NSAS Action Items 95 and 98.
[4] NSAS Action Item 102.

efficiency within the scope of the Aviation Transportation System as defined above (also referred to as Integrated Aviation Transportation System Surveillance).

- **Intelligence Community**: The Office of the Director of National Intelligence; the Central Intelligence Agency; the National Security Agency; the Defense Intelligence Agency; the National Geospatial-Intelligence Agency; the National Reconnaissance Office; other offices within the Department of Defense involved in the collection of specialized national intelligence through reconnaissance; the intelligence elements of the Army, the Navy, the Air Force, the Marine Corps, the Federal Bureau of Investigation, and the Department of Energy; the Bureau of Intelligence and Research of the Department of State; the Office of Intelligence and Analysis of the Department of Treasury; the Office of Intelligence of the Coast Guard in the Department of Homeland Security; the intelligence elements of the Drug Enforcement Administration; and such other elements of any other department or agency as may be designated by the President, or designated jointly by the Director of National Intelligence and the head of the department or agency concerned, as an element of the Intelligence Community.[1]
- **JPDO Government Partners:** DoD, DHS, DOT/FAA, DOC, NASA, OSTP.
- **NextGen**: Next Generation Air Transportation System (see Public Law 108-176, "The Vision 100 - Century of Aviation Reauthorization Act.")
- **Non-Cooperative Active Surveillance**: Use of a transmitter to send a radio-frequency (RF) field that reflects off the airborne object and is detected by a receiver collocated with the transmitter or located elsewhere. The distance to the object is determined by the time it takes for the RF to make the round trip, and the angle is determined by the position of the antenna. This type of surveillance works even if the airborne object has no cooperative systems on board.[2]
- **Non-Cooperative Passive Surveillance**: Does not use a dedicated transmitter and can employ a number of techniques to detect and/or identify an object of interest. For example, the use of infrared sensors is among the most common for detection alone. For detection *and* identification, acoustic sensors can be employed, in conjunction with access to an on-board signature database.[2]
- **Surveillanc**e: The ability to obtain or derive the position, vector and, if available, the identity and flight path intent, of an object within the Air Domain, or about to enter the Air Domain (also referred to as air surveillance).[3]
- **Surveillance Community:** The surveillance mission partners, industry, and academia.
- **Surveillance Mission Partners:** DoD, DHS, DOT/FAA, DOC (also referred to as mission partners).
- **Weather Surveillance**: The means, through human and automated sensors, to measure in-situ characteristics of the atmosphere. It can be done remotely by space-, air-, and land-based systems, including on-board sensors, radar, and satellite technologies.

[1] NSAS Air Domain Surveillance and Intelligence Integration Plan, March 26, 2007, p. 6.
[2] NSAS Action Item 102.
[3] NSAS Action Items 95 and 98.

3.0 ASSUMPTIONS AND CONSIDERATIONS

The ISST's effort to find the common space for NextGen Surveillance in the year 2025 and beyond is framed by multiple considerations and assumptions.

3.1 Assumptions

- Funding recommendations are not addressed in this report.
- Weather surveillance requirements must be addressed in order to fully enable the NextGen ConOps.
- Surveillance mission partners will share information in accordance with U.S. law, Presidential directives, other national plans and policies, and applicable international obligations or agreements.[1]
- Frequency spectrum necessary for surveillance operations will be available to meet current and future requirements.[2] However, future work should take into consideration recent, multiple studies and tests indicating issues with some nation's Radio Navigation Satellite Service (RNSS) systems and U.S. L-band radar systems. Additionally, frequency spectrum saturation may have a possible impact on ADS-B.

3.2 Considerations

This final report leverages interagency activities, such as NSAS Action Items, particularly Action Items (AIs) 42, 95, 96, 98, 102, and 103.

- Proliferation of wind turbine "farms" and other man-made structures must be considered in the context of potential impacts on radar surveillance coverage.[2]
- Weather surveillance requirements are addressed herein at the high level but should be dealt with in another or follow-on study. Currently, some progress is being made in investigating service improvements in the weather surveillance function by the MPAR (Multi-function Phased Array Radar) Working Group.
- The NSAS and associated action plans focus generally on a "five-year plan," while JPDO's focus is on alignment of any aviation-related "five-year plan" with NextGen capabilities for the 2015-2025 time frame and beyond.
- NextGen surveillance services are provided by Integrated Surveillance whether it becomes a system, or system of systems. This is true even though current compartmentalizing of capabilities is focused more on cooperative and/or non-cooperative (or "uncooperative") descriptors.
- DoD surveillance requirements are derived from Joint Requirements Oversight Committee (JROC)-approved Homeland Air and Cruise Missile Defense of North America Joint Capabilities Document (HACMD/NA JCD); and interagency-developed documents/products (e.g., NAASP).

[1] NSAS Air Domain Surveillance and Intelligence Integration Plan, March 26, 2007, p. 4.
[2] NSAS Action Item 96.

4.0 DESIRED END STATE

Surveillance services must be able to detect, monitor, track, and identify all airborne objects (including ground objects in the airport environment) and atmospheric phenomenon (weather) for the purposes of aviation safety, air security, and air defense. NextGen envisions a transformed surveillance capability for the NAS and its approaches to enhance safety and security while accommodating increased demand with Operational Improvements (OIs) in air traffic management.

The NextGen ConOps Version 2.0[1] states that NextGen Surveillance Information Services, including improved surveillance accuracy, latency, integrity, and availability, enable:

- Reduced separation standards;
- Comprehensive tracking of aircraft and vehicles operating on the airport surface and within air navigation service provider (ANSP)-responsible and sovereign airspace, and approaching the homeland to improve safety, security, and operational effectiveness;
- Increased Collaborative Air Traffic Management (C-ATM) services within underused airspace and to underused airports;
- Improved Four-Dimensional Trajectory (4-DT) information (e.g., flight plan intent) that allows for flight path conformance monitoring;
- Flexible assignment of multiple NextGen surveillance sources to any operational position at any time to support distributed decision making; and
- Adaptive flexible spacing and sequencing of aircraft on the ground and in the air.

In addition to the above-mentioned attributes, the ISST concluded that NextGen Surveillance Information Services should enable precise and timely information on potentially hazardous weather phenomena. Such information should include both data to help improve short-term forecasts of dynamic weather phenomena, as well as precise and timely detection of potentially hazardous weather as it is occurs.

As an intermediate step toward NextGen, NSAS AI 96 describes a desire for fully integrated, low, medium, and high altitude surveillance coverage with seamless network integration leveraging the full range of U.S. Government sensor systems, capabilities, and analytic support tools to detect, monitor, and track airborne objects within the NAS. AI 96's description fits well in aligning interagency activities toward NextGen.

The end state of surveillance integration should be a NextGen surveillance capability that can persistently detect/track operating vehicles 24/7/365 in all weather conditions, on airport surfaces and from near the ground to near space. Surveillance capabilities should provide basic detection above a baseline altitude for border applications and sparsely populated interior areas, while providing higher performance capabilities for critical infrastructure and other high priority geographical areas. Integrated Surveillance services should improve the ability and allowable

[1] Concept of Operations for the Next Generation Air Transportation System, Version 2.0, June 13, 2007, available at http://www.jpdo.gov/library/NextGen_v2.0.pdf

time for operational decisions. Moving government organizations and stakeholders toward surveillance integration requires a "system of systems" approach. Foundational to the pursuit of a surveillance integration capability that will meet the needs of NextGen is an integrated architecture. At a minimum, the components of the architecture and system(s) should strive for interoperability, accuracy, timeliness, integrity, availability, and robustness.

5.0 NEXTGEN HIGH-LEVEL NEEDS

To enable the "persistent and effective" monitoring called for by ADSII,[1] the Nation must collect, integrate, fuse, analyze, and disseminate cooperative and non-cooperative surveillance information. The first type, cooperative surveillance, requires equipping vehicles with functioning avionics that assist surveillance sensors to detect and identify the object. This type of surveillance is considered the routine and preferred method of airborne object detection because of the additional information it provides. The second type, non-cooperative surveillance, does not require that operating vehicles have functional avionics. Non-cooperative surveillance is required for defense, security, and law enforcement missions. The second type is also required for ATC in high-density terminal areas and must complement other ATC needs when the required cooperative surveillance capability is lost. Today, air surveillance is a relatively disparate collection of systems and capabilities, owned and operated by individual government departments and agencies. The vision of NextGen is to move beyond these distinctions by 2025, and manage Integrated Surveillance as an enterprise (system-of-systems) that provides a capability that is more than the sum of its parts.[2]

5.1 Information Sharing

To achieve the surveillance capability described in the ADSII plan, an enhanced surveillance data sharing framework is needed across the Federal enterprise that is consistent with the protection of civil liberties and privacy. This will require: networking of the surveillance sensor and track information (e.g., Surveillance Data Network [SDN]); deploying new surveillance systems; fusing data from current and future surveillance sensors; optimizing sensor quality and integrity monitoring to support surveillance requirements;[2] and implementing interoperable information assurance/information security programs by the Chief Information Officers (CIOs) of the participating departments and agencies. In the NextGen time frame, it is expected that surveillance information exchange will occur principally through a net-centric architecture, depicted as the singular Enterprise-wide Service on the NextGen Enterprise Architecture OV-1. In the development of NextGen net-centric capabilities, mission partners must remain cognizant of the information sharing that will occur in the Program Management-Information Sharing Environment (PM-ISE), as governed by the Information Sharing Council (ISC). The PM-ISE organization, through the department/agency CIOs, is framing government-wide information/data standards, procedures, net-enabled accessible space, and multi-level security (Cross Domain Security), primarily on counter-terrorist and counter-proliferation focus areas. The PM-ISE efforts should be tracked and continually assessed for their potential, associated

[1] NSAS Air Domain Surveillance and Intelligence Integration Plan, March 26, 2007, p. 2.
[2] NSAS Action Item 96.

impact and benefit to surveillance integration and information sharing among the surveillance mission partners.

5.2 Air Defense and Security

DoD requirements for homeland air defense missions were identified during DoD's HACMD/NA analytic effort. To the maximum extent feasible, these data points concerning surveillance should be merged with this study to complete a description of NextGen surveillance requirements. DHS accepted the results of the HACMD-NA efforts as sufficient to also cover their air security surveillance requirements.

DoD's HACMD-NA analytic efforts identified the following air surveillance requirements for air defense in the 2015 time frame against a set of postulated threats:

- Real time, persistent, survivable, all-weather monitoring and fusion of track information against air threats available throughout command and control elements
  - Fusion into the User Defined Operational Picture (UDOP)
  - Auto track correlation
  - Small radar cross-section
  - Slow speed targets
    - Discern, detect, and monitor an air vehicle with context, to determine dissemination
    - Receive, analyze air event information (intelligence, surveillance) to determine if further information is needed
  - Auto track correlation[1] for access and input into UDOP
  - Net-centric environment connectivity
- Investigation of Visual Identification (VID)
  - Flight Plan Correlation (Electronic, prior arrangements, operating agreement, previous classification, free areas, special areas of operation and track origin)
  - Classification: Determine air track intent based on identifying information coordinated with all known amplifying information (flight path, flight plan, deviation, possible targets, objectives, pilot), manifest information and supporting intelligence information
- Identification of Air Track Elements**:** Type, tail number, flight plan, registration, nation of origin, etc.
- Dissemination of Track Identification: Rapidly provide to all levels of command
- Analyzation: Receive, analyze, and fuse valid track identification information into the UDOP
- Classification of Track Risk
  - Flight path intent
  - Air track amplifying information

[1] Department of Defense Dictionary of Military and Associated Terms (Joint Publication 1-02).

- o Determine track classification

In addition to those data elements above, back-up DoD Air Surveillance Requirements (ADS-B and other sensors) includes Rapid ID of Anomaly.

5.3 Air Traffic Management

NAS surveillance is important today and is required for supporting the ANSP mission of NextGen. The surveillance service provides air traffic state data for automata, pilots, and air traffic managers, enabling shared situational awareness from which to conduct safe and expeditious air and surface operations. Capabilities that require surveillance are described in the table below.

Table 5-1 Capabilities that Require Surveillance

NAS Service	Capabilities that Require Surveillance
Air Traffic Control – Advisory	• NAS Status Advisory • Traffic Advisory
Air Traffic Control – Separation Assurance	• Aircraft to Airspace • Aircraft to Aircraft Separation • Aircraft to Terrain and Obstacles Separation • Surface Separation
Emergency and Alerting	• Alerting Support • Emergency Assistance
Traffic Management – Synchronization	• Airborne • Surface

The FAA air traffic surveillance requirements extending out to year 2025 are contained in the document NAS-SR-1000 (accessible at: http://www.nas-architecture.faa.gov/nas/home.cfm). Several alternative views, such as a service view (located at http://www.nas-architecture.faa.gov/nas/downloads/all_sr1000_report.pdf), are also available. Specific requirements to support JPDO's IWP OIs have yet to be established.

Capabilities identified in Table 5-1 are grouped into categories to allocate current and NextGen OIs. Each OI is associated with surveillance performance requirements. As a next step, the detailed requirements identified in NAS-SR-1000 for DOT must be integrated with the NextGen OIs-associated requirements for DOT, DHS, and DoD.

The NAS has evolved surveillance for Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) flight following that depends on cooperative avionics to support surveillance source data collection systems (i.e., secondary surveillance radar and automatic dependent surveillance). NextGen envisions cooperative surveillance as fundamental to the ANSP mission amid anticipated future demand. When compared to non-cooperative surveillance, cooperative surveillance better maintains situational awareness attributes (surveillance data elements) of coordination identity (aircraft flight number and radio call sign) and altitude, enabling air traffic managers to work at higher levels of productivity for increased air traffic capacity. When only using non-cooperative surveillance, additional activities are necessary to maintain identity and altitude. With projected increases in air traffic volume and an increasingly diversified fleet mix, cooperative surveillance becomes even more important. Closer alignment will also be required between cooperative and non-cooperative surveillance systems and the fusion of that surveillance information will be required to meet security and safety needs.

5.4 Required Surveillance Performance

Surveillance performance affects the behavior of automata, and the quality and utility of pilot, air traffic manager, or safety- and security-provider User Defined Operational Picture (UDOP). Variations in surveillance performance affect the ability to carry out specific operational capabilities. The following surveillance performance attributes characterize surveillance data elements and are required to meet specified values to enable NextGen services for security and traffic management operations:

- Integrity
- Accuracy
- Update Period
- Latency
- Coverage Availability

Generally, the requirements of surveillance performance vary based on a number of factors. NextGen OIs include varying requirements for surveillance coverage and performance. Coverage requirements are driven by specified airspace volumes and surface regions at airports. Performance requirements are driven by the surveillance services needed to support operations that increase air traffic capacity while maintaining safety and security.

5.5 Surveillance Data Elements

Surveillance data is dynamic; that is, subject to change continuously over time. Surveillance data elements are aggregated for use in automata and situational awareness displays and for combining data from multiple sources.

These data are associated with an applicable time (not overtly displayed for ATC) at which they are generated or are valid. Accurate time of applicability is essential for improved data integration and the OIs envisioned for NextGen. The method used with today’s surveillance radars, where the applicable time is assigned by the receiving data processing system (not at the source), adversely affects potential accuracy performance for surveillance data fusion processing. This method may be used in comparison to improve time of applicability for NextGen surveillance.

For NextGen, Integrated Surveillance data is comprised of basic elements used in today’s NAS that include vehicle state and other data required for UDOP and automata. Basic surveillance data elements are not universally available from cooperative and non-cooperative sources, but in many cases are synthesized by automata and sometimes entered manually. The following are basic surveillance data elements for NextGen:

- Surveillance Identity
- Horizontal Position (two-dimensional)
- Barometric Altitude
- Ground Track Angle
- Ground Speed
- Altitude Rate
- Time (applicability)

Many additional surveillance data elements for use by automata functions in development are enabled by cooperative dependent surveillance, that is, ADS-B. Examples of some of these elements are:

- Emitter Category
- Aircraft Identity
- ICAO Address
- Integrity and Accuracy (Navigation Integrity Category, Navigation Accuracy Category, Surveillance Integrity Level)
- Flight path intent

Surveillance identity, a basic surveillance data element enabled by cooperative surveillance (currently and in the foreseeable future), associates a flight plan with independent position source surveillance data. Flight plans include a surveillance identity assigned by the ANSP: the ATCRBS's Mode A transponder code. Aircraft identity (flight identity or tail number) from the flight plan is then used for the UDOP to uniquely identify aircraft that are receiving ANSP IFR or VFR flight following service. Aircraft identity is used as a radio call sign in the NAS to address ATC clearance communications between pilots and air traffic controllers, and to coordinate all ground-based service providers (i.e., controllers, flow managers, airspace security providers). Note that ADS-B provides aircraft identity directly, but only for aircraft receiving ANSP services.

Ground track angle for an air or ground vehicle is typically synthesized in today's surveillance system along with ground speed by using tracking software. With ADS-B, ground track angle and speed are available directly from surveillance. Altitude rate is similarly obtained.

ADS-B packages surveillance reports with information pertaining to integrity and accuracy. Current surveillance integrity and accuracy is monitored by procedures documented in FAA orders 7110.65, *Air Traffic Control*, and 7210.3, *Facility Operation and Administration*. Procedures and monitoring for ADS-B integrity are still in development.

Flight plan intent provided by ADS-B may provide benefits for conflict detection and collision avoidance algorithms, as well as trajectory conformance monitoring and flow management. Short-term and long-term flight plan intent are identified in ADS-B standards documents. Short-term flight plan intent data elements, identified and included in ADS-B Minimum Operational Performance Standards (MOPS), are target (intended) heading, track angle, and altitude. Long-term flight plan intent is documented for future design and development considerations with an engineering judgment level of certainty. Multiple data elements are reserved for trajectory change points, providing data on path and speed changes.

The NAS surveillance service is additionally required to provide these functions:

- Automated Tracking and Multi-Source Fusion
- Achieved Surveillance Performance Monitoring and Reporting
- Surveillance Data Distribution
- Data Archival and Retrieval

5.5.1 Weather Aspects

Weather surveillance data plays a significant role in NextGen. It is a key component of the 4-D Weather Cube that in turn provides the single authoritative source of current and forecast weather to support air traffic management. This data also provides some of the fundamental inputs to decision support tools that will enable trajectory management of aircraft during all phases of flight as well as assists in enabling separation management of aircraft from hazardous weather phenomena.

NextGen weather surveillance requirements will continue to comprise detection, identification, and the ability to track anomalous or hazardous weather phenomena such as thunderstorms, wind shears, icing, etc. However, to support trajectory-based operations, weather surveillance information will need to be more robust than what is available from today's surveillance systems. In NextGen, there is an end-state requirement to make weather surveillance information available in real or near-real time. To realize the NextGen vision, weather surveillance will need:

- Higher accuracy, frequency, resolution, and lower error rate for tactical aviation weather information and to enhance forecast capability;
- Greater detailed lower tropospheric (near surface) observations of the atmosphere to eliminate coverage gaps;
- All-weather surveillance, including measurements in and through clouds;
- Convective weather information that is characterized in sufficient detail and accuracy to enable traffic management initiatives and trajectory based operations;
- Accurate, timely information regarding small-scale phenomena such as wind shear, downburst, turbulence (inclusive of wake vortices), and icing to ensure aircraft safety; and
- Capability to detect, identify, and track hazardous weather phenomena such as thunderstorms, wind shears, icing, volcanic activity and ash plumes, mid- and upper level winds, etc.

NextGen weather surveillance will comprise a broad range of integrated ground, airborne, and satellite observation sources and platforms. An integrated system is crucial to the success of NextGen and key to weather information services.

5.6 Surveillance Integrity and Trusted Information

Surveillance information integrity will have increased importance in NextGen due to the anticipated increase in number of operating vehicles, and OIs that, in turn, require surveillance with high integrity and improved performance attributes. ADS-B will include measures of integrity as a part of the surveillance data it delivers. ADS-B surveillance data integrity directly corresponds with integrity of the navigation system from which it receives its input. Surveillance data integrity monitoring and reporting for NextGen will require both currently used and newly developed means. Consequently, the FAA must investigate additional techniques for independent monitoring of ADS-B in order to detect faults, spoofing, and degradation of information that would in anyway reduce users trust in the information. To fully implement integration across the surveillance community, a cross-domain information-sharing solution is a requirement. Trusted data within a trusted system is necessary for a successful NextGen that does not compromise safety or security.

5.7 Positioning, Navigation, and Timing (PNT)

The provisioning of precise PNT services is critically necessary for integrated surveillance, particularly to support applications of ADS-B. NextGen also relies on PNT for time-referenced trajectory-based operations. The accuracy, availability and integrity requirements of PNT become ever more crucial as the volume of activity in the NAS is increased and the corresponding accuracy and integrity performance of cooperative dependent surveillance increases.

GPS Block III satellites are scheduled for deployment beginning in the 2014 time frame. Prior to 2020, the full GPS constellation should provide a dual frequency capability to civil aviation users, enabling more precise location determination. By the NextGen time frame, use of dual-civil-frequency GPS with other GNSS constellations should provide increased integrity capability.

NextGen reliance on government-provided PNT services requires close interaction with the National Space-based PNT Executive Committee to ensure envisioned PNT requirements are satisfied.

5.8 Integrating Intelligence Information

To complement the surveillance picture, intelligence information needs to be integrated with the information capabilities of the aviation, defense, security, and law enforcement communities for shared awareness across the government. The Intelligence Community's capability to collect, analyze, and disseminate information can provide context and intent on potential threat vectors that when integrated with surveillance and other information sources contribute to maximizing domain awareness.

The Intelligence Community provides Geo-spatial Intelligence, Signal Intelligence, Measurement and Signatures Intelligence, and Human Intelligence reporting and analysis that support aviation security operations. The Intelligence Community's collection and analysis capabilities are for the most part not dedicated solely to the Air Domain, nor directed against U.S. airspace, but can be tasked to provide tailored support through established procedures. The Intelligence Community can distribute products via Top Secret, Secret, and Unclassified networks, as well as other means.

The intelligence, surveillance, defense, security, and law enforcement communities each rely on a variety of automated systems that provide or support Air Domain awareness. While many organizations are developing plans for net-enabled operations, many stove-pipe systems are still in use and rely on different symbology, object attributes, and both functional/technical standards and protocols. Integration of the disparate intelligence and information capabilities is needed to optimize situational awareness and ensure decision-makers and security response elements have the necessary information to take appropriate action.[1]

5.9 Coverage Volumes for Integrated Surveillance

Integrated surveillance coverage requirements and associated factors vary for DOT, DoD, and DHS missions. Surveillance coverage availability is based upon whether sensor or radio coverage exists (basic coverage), and when it does exist by the redundancy of such coverage. System availability also includes communications, data processing, and display system availability. Basic coverage and coverage redundancy requirements for both DOT and DoD are driven by requirements to provide and sustain IFR traffic capacity, that is, to have surveillance available even during subsystem outages. Coverage requirements for DoD and DHS are related to priorities that include, for example, protection of critical assets. The satisfaction of surveillance requirements must consider the practical need to field systems that balance risk with the provision of service costs. Risks associated with coverage loss include the consequences associated with the loss of transportation capacity as well as increased security risk.

Availability requirements integrated across mission areas will determine the total requirement for NextGen surveillance. In developing the integrated requirement it is desirable to coordinate across mission areas and to plan the use of existing and projected cooperative and non-cooperative surveillance capabilities for the benefit of all mission areas. That is, if surveillance assets are deployed primarily for one mission, they should also be fully used to benefit other missions. In addition to planning and sharing of surveillance sources, developing a capability to integrate and share surveillance track data across mission areas will assist in achieving higher overall availability of continuous tracking of airborne objects. Surveillance integration at the track level will facilitate coordination and response to air security events.

Cooperative surveillance coverage is required to manage IFR traffic in the NAS. Traffic capacity demand, which varies by airspace volume, will influence desired availability and redundancy for that volume. Airspace having relatively low capacity demand may be covered with relatively low expected availability when incremental cost does not provide adequate

[1] NSAS Action Items 95 and 98.

benefits. For security surveillance, cooperative and non-cooperative surveillance coverage availability is required, with availability weighed against a different set of benefits and risks. Required security coverage availability depends on factors including operating vehicle's location relative to geography, key infrastructure within range of the operating vehicle, the size, speed, timing of a particular operating vehicle, and the clutter and separation factors that may impede surveillance. The Joint Network Enabled Operations (NEO) Spiral 1 demonstration depicted the four-dimensional aspect of aviation volume(s) of interest and the necessity for surveillance services coupled with net-enabled data access (see Appendix C). The "volume" to fill with surveillance capability—all to provide maximum available time of decision options—underscores the need for a shared, collaborative determination of integrated surveillance.

The extent of surveillance capability may be influenced by geography and infrastructure. It makes a difference as to whether an operating vehicle is near the National Capital Region and the associated Air Defense Identification Zone (ADIZ) around it, U.S. Borders and Air Approaches**,** or over the broad expanses of ocean. The NSAS directs that surveillance coverage be sufficient to allow for effective detection, tracking, identification and interdiction of potential threats and the defeat, if necessary, of actual threats at a safe distance from prioritized defended areas. Tier I and II Critical Infrastructure/Key Resources (CI/KR) have been established pursuant to the National Infrastructure Protection Plan. The critical coverage areas include major metropolitan areas, national security special events, flight restriction zones, and CI/KR facilities.[1]

Intrinsic parameters contributing to capability gap are the predicted growth in aviation operations, future retirement of surveillance radars, and the vulnerability of the surveillance systems that are reliant on GPS-based position information. The current suite of civil systems that rely on GPS are vulnerable to cyber attack, spoofing, satellite jamming, anti-satellite attack, and electro-magnetic pulse (EMP) effect from high-altitude nuclear detonation. As a result, measures to mitigate these vulnerabilities will need to be considered, including life extension programs that retain essential elements of current non-cooperative surveillance capabilities, or the development and replacement of systems that may be vulnerable to some of these attacks. The U.S. Government must address this gap soon to effectively and efficiently transform current surveillance capabilities into the needed NextGen surveillance services.

Surveillance coverage requirements for NextGen ATM, that is, coverage availability at a desired level of performance, vary throughout the NAS, depending on demand for services. As air traffic demand increases, investments are made for air surveillance technology that enable OIs needed to maximize airspace utilization by allowing traffic management procedures that sustain safety and allow increased density. For example, NextGen high-density operational capabilities, similar to today's simultaneous independent approaches to closely spaced parallel runways, will be met with procedures and surveillance that, compared to general terminal area surveillance requirements, need automated surveillance reporting with a shorter data update period, improved integrity, and higher accuracy.

Disparate sizes and speeds of operating vehicles adjust the scale of criticality. Aircraft threats can be disaggregated into four categories of threats: large passenger aircraft; large all-cargo aircraft; small aircraft and helicopters; and non-traditional aircraft, such as Unmanned Aerial

[1] NSAS Action Item 96.

Vehicles (UAVs) (see NSAS pages 9-10 for further details). Characteristics such as proximity of the aircraft flight path to critical infrastructure, national security assets, population centers, or high visibility events adjust the criticality. And the size of the operating vehicle usually increases other parameters important to surveillance criticality such as speed and endurance. Add the complexity of the growing number of operating vehicles expected by NextGen predictive models, and the capability to accurately identify operating vehicles for separation and security purposes, then surveillance becomes increasingly more critical and important to safety and security of the NAS.

6.0 EXISTING SURVEILLANCE CAPABILITIES AND GAPS

Existing capabilities are many and varied; none are complete or fully integrated. Promising technology R&D and technology proofs of concepts, such as capability technology demonstrations, appear to be progressing so as to deliver uncoordinated improvements in the needed time frame. The wide array of current and future possibilities necessitates the critical need for integrated surveillance and associated ownership and leadership.

6.0.1 Current Capabilities

The U.S. Government operates over 500 surface-based radars (primary and secondary Long Range Radars [LRR] and Air Defense Radars) for North American surveillance coverage from a range of 5,000 to 60,000 feet mean sea level (MSL). Surface-based radar sites normally include collocated ATC beacon integrator and primary surveillance radar, but there are a number of locations that lack primary radar. In many metropolitan areas additional coverage exists from the surface to 40,000 feet through the use of the Short Range Radars (SRRs). Airborne and tethered Aerostat Radar Systems (TARS) augment surveillance for DHS and DoD. They provide additional low-level surveillance along the southwestern U.S. border, and DoD over-the-horizon radars provide modest capability in the air approaches over the Caribbean for air security and defense. In some geographical areas, cooperative surveillance systems are now in use within areas of the aviation sector. These systems include ADS-B, airport surveillance detection equipment – multilateration – which provides aircraft position and identification information.[1]

DHS integrates surveillance data at the AMOC, and other locations, and links DoD, DHS, and FAA at the Freedom Center.[2] Furthermore, DoD integrates surveillance data at North American Aerospace Defense Command (NORAD) air defense sectors. Techniques for surveillance data integration vary by facility and include multi-source fusion as well as source selection using a mosaic approach.

A capture of existing capabilities without regard for limitations as described in AI 96:

- Aviation (DOT/FAA; short range radars, long range radars)
- Defense (DoD; early warning, specific DoD radar types, mobile air defense and ATC systems)

[1] NSAS Action Item 96.
[2] The Freedom Center is the new name for the Transportation Security Operations Center under DHS but in which the FAA and DoD participate.

- Intelligence (OCONUS [outside of the Continental United States] Surveillance and other as appropriate)
- Bi-Lateral Surveillance Data Sharing (with international partners which may include NORAD, Canada, North Atlantic Treaty Organization [NATO], Mexico, EUROCONTROL, etc.)
- Tethered Aerostat Radar System providing low-level radar coverage that is only available from a fixed airborne sensor; data is fed directly into the DHS/Customs and Border Protection (CBP) Air and Marine Operations Center (AMOC) and shared with appropriate government organizations

For a recent compilation of current coverage, one should refer to the NSAS Action Items, especially the classified portions of AI 96, 103, and the draft version of AI 102.

6.0.2 Current Coverage Gaps

Current critical coverage is primarily provided by all FAA short range and long primary radar (primarily ARSR [interior and Joint Surveillance System]) plus DoD ATC radars and other assets**.** NSAS Action Item 96 looked at a range of infrastructure, including some outside currently using risk-based air security/defense structures. As a result, the AI 96 report found that not all requirements for critical coverage areas are addressed by existing systems. Due to assumptions made about the emergence of postulated threats, the report conveys a sense of urgency in closing the identified gaps in low-altitude surveillance coverage with low Radar Cross Section (RCS) detection capabilities to detect, deter, and defend against multiple threats. However, this sense of urgency is not shared by all agencies that participated in the ISST. DoD takes the position that the AI 96 report does not adequately account for the roles of R&D and agile acquisition mechanisms in responding to future asymmetric threats.

Gaps exist at low altitude in various parts of the country due to limited site placement in certain regions and where sites exist, the impact of radar line of sight characteristics (terrain masking). For further specificity of critical coverage, refer to draft NSAS Action Item 102, Section 5.0 Air Surveillance Capability Gaps. For example, there are large portions of the country that do not have radar air surveillance coverage at 5,000 feet and below. As mentioned in the discussion about TARS, there are holes of coverage that exist in the Gulf of Mexico and large portions of the Caribbean. Additionally, there are limited capabilities to conduct wide area surveillance off the coasts, particularly at low altitudes due to line of sight, site placement, and far reaches of the airspace approaches caused primarily by range limitations of existing radar systems.[1]

The ISST concluded that radar coverage areas and shortfalls are basically understood by the surveillance mission partners. The ISST did not address vulnerabilities based on a myriad of likely threats. A comprehensive assessment may be required to fully understand the current gap against likely threats to further define radar surveillance capability shortfalls. Technology development and low observable unmanned aerial systems continue adding to growing radar system vulnerability.

[1] NSAS Action Item 96.

Some significant observations regarding awareness over the United States and in the approaches to the homeland are:

- Current surveillance/collection and integration systems are insufficient, within the context of the HACMD-NA assumptions and not accounting for risk, to detect, track, and identify all postulated future threats
  - Low cross-section cruise missiles at 5,000 feet and below
  - General Aviation aircraft and Unmanned Aerial System (UAS)
- Future ATC surveillance will rely on “cooperative” systems on aircraft
  - FAA plans to retain secondary surveillance radars throughout the NAS, as well as primary surveillance radars in busy terminal areas, for “backup” purposes
  - Other primary radars now operated by FAA are expected to be retained as needed to meet DoD/DHS needs

6.0.3 Current Limited Radar Integration

There are over 200 SRRs (DoD and FAA) that are not part of a robust network for shared access regarding the NAS. These non-integrated short range radar systems provide surveillance capabilities that could satisfy some interagency low-level coverage requirements if fully integrated into operational capabilities. Although these systems provide essential data to owning agencies today, they would maximize surveillance coverage for the Nation if they were readily available to all. Additional surveillance assessments are required on the radar sensors that are not included in the current NDP feed.[1]

The DHS Air and Marine Operations Center (AMOC) and Air and Marine Operations Surveillance System currently processes 24,000 tracks from 450 radars every 12 seconds, but

- There are significant surveillance gaps, especially at low altitude along the southern and northern borders to support air security and defense; and
- Users have very little access to re-task sensors if necessary (the majority are currently rotating dish radars).

6.1 Integrated Surveillance Systems

Depending on geographical point or altitude of consideration, at lower altitudes there are airspaces lacking Integrated Surveillance that are deemed a necessary part of NextGen capabilities. Also, the existing weather surveillance capability for aviation has served well but is not sufficient to fully support NextGen. Capabilities can be categorized in many ways, such as active and passive, current and future, or by function. Underway in the DoD is the Office of the Assistant Secretary of Defense for Homeland Defense and Americas’ Security Affairs (OASD [HD&ASA]) Civil Support Capabilities Based Assessment (CBA). Different mixes of capabilities result in minimizing risks. As an example a potential mix might be network-enhanced primary surveillance radars (cooperative/non-cooperative targets, weather) with integrated wireless Gapfiller Arrays (non-cooperative targets/weather), supplemented with ADS-B (cooperative targets) and MSSR / Mode S (cooperative back-up).

[1] NSAS Action Item 96.

6.2 Surveillance System Development

In addition to the capabilities development process previously described and generated by the HACMD-NA effort, DoD has a deliberate process to develop new technologies and determine their efficacy for acquisition consideration. DHS has chosen to model its science and technology effort after DoD's. DHS has indicated that it will likely rely on some DoD analysis and engineering capabilities to make future DHS Integrated Surveillance decisions.

Two current proposed DoD technology demonstrations are relevant to domestic air surveillance: the GAP Filler C2 JCTD, examining data fusion and decision-making tools to enhance accurate and timely decision making for NORAD; and the Next Generation Over the Horizon Radar (OTHR) JCTD, examining upgrades to legacy OTHR and new OTHR technologies to determine whether it is feasible to use OTHR as a persistent detection sensor for air and maritime contacts of interest well offshore from the homeland. Additionally, DHS, DoD, and DOT/FAA, who are three of the four surveillance mission partners, fund and participate in the NEO demonstration Spiral regarding net-centric data sharing capabilities in the aviation sector. These demonstrations, if appropriately funded and aligned, could be leveraged for considerable improvement of surveillance capabilities.

Among DOC, DOT/FAA, and DHS, there is consideration for the development of weather surveillance capabilities under the concept of multi-function radars. A recent study by the National Academy of Sciences assessed the feasibility of Phased Array Radar Technology as a replacement for existing National Oceanic and Atmospheric Administration (NOAA) and FAA radars. This study found in part that "*phased array technology offers significant technical advantages for a next generation of weather and aircraft surveillance radars. A national implementation of approximately 350 MPAR radars could replace existing NWS and FAA radars and offer many performance advantages. Some technical, operational, and cost issues remain to be resolved*."[1] DOC is also considering the use of UASs for weather detection and investigating improved technology for wake vortex detection/measurement.

7.0 SURVEILLANCE ARCHITECTURE

The JPDO is using an architecture-based approach to plan and coordinate the realization of NextGen. This approach provides stakeholders with the necessary management, business, and technical information to understand and implement the NextGen vision, goals, concepts, and operational changes.

The key planning documents are the NextGen Concept of Operations, Enterprise Architecture, and Integrated Work Plan. The NextGen EA, based on the ConOps, provides the JPDO leadership, government partners, and stakeholders with the requisite information necessary for investment decisions to assure timely achievement of NextGen vision and goals. The EA models

[1] National Academy of Sciences, National Research Council, Evaluation of the Multifunction Phased Array Radar Planning Process, 2008, page 1. http://www.nap.edu/catalog/12438.html.

NextGen for the year 2025; the IWP articulates the evolution of NextGen capabilities from the present to 2025.

The NextGen EA provides a standard and consistent framework to describe the 2025 air transportation system. It contains information that reflects alignment with the U.S. Office of Management and Budget's Federal Enterprise Architecture and facilitates alignment among the JPDO government partners. The NextGen EA covers the breath of NextGen at a level sufficient for broad public and private stakeholder planning.

The NextGen EA focuses on the operational aspects of the enterprise, depicting the relationships among people, operating centers, activities, and information, while providing linkages to partner and stakeholder EAs for system-specific details needed for implementation. The document includes architectural information and products for the NextGen mission area, agency and private sector mission/business areas, and mission areas that cross agency bounds. The NextGen EA is primarily expressed using the DoD Architecture Framework (DoDAF), with particular emphasis on operational views.

Portions of the NextGen EA that require specialized focus and greater depth are being cooperatively developed with JPDO WGs and study teams, and linked to the top-level EA. The surveillance architecture, or surveillance segment of the NextGen EA, is such a focused product.

The surveillance architecture was developed by the JPDO Interagency Architecture and Engineering Division (IAED), with the input of subject matter experts (SMEs) from the ISST. The surveillance architecture captures information that has been provided by ISST members and is documented at a level established by IAED.

7.1 Purpose of the Surveillance Architecture

The purpose of the surveillance architecture effort is to capture the operations, systems, and technologies associated with NextGen surveillance needs. The surveillance architecture is intended to support the analysis, design, planning, and realization of the NextGen surveillance capability as an integrated part of NextGen. Specifically, the purpose of the surveillance architecture is to:

- Provide the basis for rigorous analysis leading to decisions on surveillance research and implementation programs;
- Support an understanding of the needed capabilities of the net-centric infrastructure upon which NextGen surveillance will be based;
- Enhance collaboration in the surveillance area across JPDO government partners and with the private sector;
- Permit accurate development of the surveillance portions of the NextGen IWP and NextGen budgetary documents; and
- Provide support for NextGen surveillance operational and business planning.

7.2 Scope of the Surveillance Architecture

The surveillance architecture (consistent with the scope of this report) addresses national surveillance needs projected to 2025 for sovereign airspace of the U.S., air approaches to the U.S., and airport movement areas in the U.S., while maximizing the U.S. Government's ability to provide safe and uninterrupted airborne operations. These operations are those of manned and unmanned aircraft engaging in commerce, defense/security of the homeland, etc. The surveillance architecture addresses the collaborative operational environment that exists within the Air Domain, but only over and surrounding the United States.

Consistent with the scope of the NextGen EA, the depth of the surveillance architecture is kept at a high level to emphasize the mission and business operational aspects of NextGen, leaving details, such as individual facility locations, exact sensor technologies, specific track correlation algorithms, to the implementing mission partners' enterprise and solution architectures.

7.3 Development Methodology for the Surveillance Architecture

The IAED collaborated with the ISST to develop an understanding of the operational activities and the systems needed in 2025 to meet the surveillance needs of NextGen. Based on this understanding, the IAED developed architectural drawings and descriptions (products) and then presented these products to ISST for review and comment. This effort resulted in ISST and IAED designating which operational activities would be performed by people/organizations and automated functions performed by sensors/systems. This was documented using the DoDAF as the appropriate operational or system architecture view.

7.4 Description of the Surveillance Architecture

The surveillance architecture products depict and contribute to an understanding of surveillance data collection in the air transportation system of 2025. To meet NextGen needs, the surveillance architecture was developed using the DoDAF in order to create a common understanding and to later assist with aspects of planning, programming, cost estimation, execution process, capability development and integration, and with acquisition process as necessary.

ISST assisted IAED with the development of the following DoDAF products:

- **The NextGen EA Surveillance High Level Operational Concept Graphic** (OV-1, Figure 7-1) provides an executive level pictorial representation of the salient features of the air transportation system in 2025. It is intended to represent the mission/portfolio covered by the architecture and to facilitate comprehension and discussion of the major components and their inter-relationships. The accompanying text is also vital to understanding the messages conveyed by Figure 7-1, which depicts the major shared sources of surveillance information, net-centric infrastructure, and users of surveillance-related common situational awareness. All surveillance sources, including fixed and mobile air, surface, and weather radar systems, and ADS-B radio receivers, are shared and made available for operational display and data processing using net-centric data distribution. Surveillance source data are correlated, combined, and enhanced by shared and mission-specific trackers and other data reduction processes, and then augmented with mission-specific data (e.g., air vehicle flight plans, clearances, weather watch areas, analysis results and interpretation). Surveillance source, track, and geographic data are used by the public and by government command and control (C2) facilities providing ATM, security, defense, and other services. Shared situational awareness (SSA) among government partners is enabled by both access to shared air vehicle track data and SSA data management services, and by capability for C2 systems to publish and subscribe to specific track and geographic air domain information. Net-centric data distribution capability and service oriented surveillance data exchange protocols developed by the surveillance community-of-interest are fundamental enabling technologies for NextGen surveillance services.

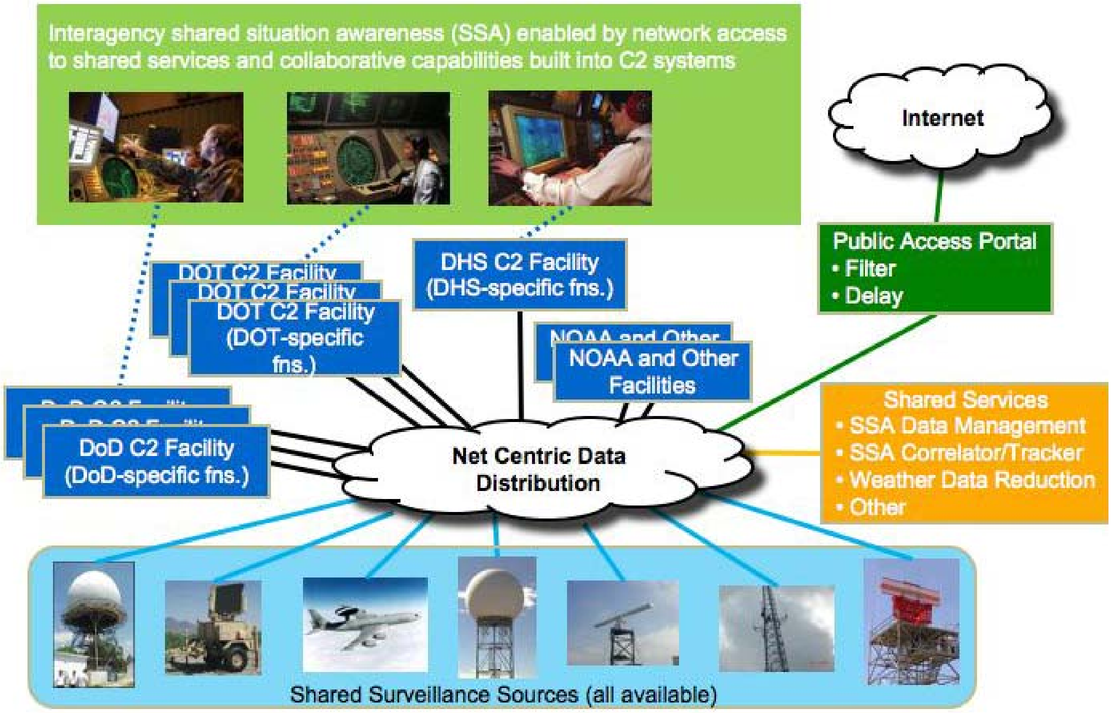

Figure 7-1 Surveillance Operational Concept OV-1

- **The NextGen EA Surveillance Operational Connectivity Description** (OV-2) identifies the organizations and idealized places where people perform activities and provides a high-level description of information that is produced at one node and needed at another. This view organizes the information flows in the enterprise at the highest level so that they can be described in more detail in subsequent views.
- **The NextGen Surveillance Operational Activity Flow Diagram** (OV-5) describes the surveillance activities performed by people in the NextGen Enterprise, the information required by the activities and the information they produce, and shows how those activities are aided by systems, and controlled by regulations and standards. The NextGen Surveillance Operational Activity Flow is presented in three successive levels of detail starting with a context diagram and proceeding to specific activities that govern, configure, operate, and maintain the resources required to collect the surveillance information.

- **The NextGen Surveillance Systems Interface Diagram** (SV-1) provides an overview of the generic types of sensors and systems that will automatically, collect, process, correlate, store and display or use surveillance information. It shows the generic "places" (system nodes) where equipment will be deployed, and the interfaces, or information pathways, needed to convey information among the nodes.
- **The NextGen Surveillance Functional Data Flow Diagram** (SV-4) describes the functions and data exchanges necessary to detect, identify, characterize, and track objects in the NextGen Air Domain using the technologies and types of systems envisioned to meet the vision of NextGen. It describes functions representative of primary radar, secondary radar, Aircraft Dependent Surveillance (ADS-B) and other surveillance technologies, functions necessary to collect, analyze and store the surveillance data, functions that fuse data from various sources, and those that present the data to humans or decision support tools. The Surveillance Functional Data Flow also shows the nature of the data that is received and produced by each function.

Individuals interested in reviewing all of the architecture products in depth are invited to view the architectural products with a JPDO Web-application, called the Joint Planning Environment (JPE), which may be found at http://jpe.jpdo.gov/ee/. Individuals may also request detailed descriptions from the JPDO IAED in the form of reports generated by the System Architect tool, used to store, develop, and provide NextGen EA architecture data.

7.5 Observations

The following paragraphs summarize the most important observations associated with the surveillance architecture effort. These observations support the Findings in section 10.1 and also support the thinking that led to the Recommendations in section 10.2.

- User operational concepts and needs should be the principal drivers for operation and management of the surveillance capabilities and infrastructure necessary to convert sensor data (position and velocity information of objects in NextGen airspace) into useful information for decision making. The operational activity model, Integrated Surveillance Organizational Options (Appendix B), does not adequately depict which operational decisions will benefit from enhanced surveillance picture and information. JPDO should encourage interdisciplinary discussions between SMEs in surveillance, ATM, ground operations, flight operators, and other disciplines to focus surveillance information improvements in areas most likely to be beneficial for users.
- The system interface description identifies three platforms (space-based, airborne, and surface-based), which include sensors and systems that control, distribute, process, correlate, and display surveillance information to achieve NextGen. Data should be shared across all three platforms through controls and data centers that allow each user to create a tailored view to support its mission.
- The surveillance service providers will need to exchange surveillance information with a large number of organizations performing activities and services that are key to the execution of NextGen. Surveillance mission partners currently operate surveillance systems that may not be fully interoperable and favor differing surveillance technologies based on individual

mission objectives. For these reasons, a key consideration for information sharing in NextGen is the development of a common surveillance data framework and the implementation of a middleware that can effectively and efficiently translate data protocols across the various systems.

- An analysis of the NextGen EA Surveillance System Function Flow Diagrams indicates that cooperative dependent surveillance technology (e.g., ADS-B) is necessary to achieve the capacity and safety objectives of NextGen for passenger and freight transportation. Primary radar technology is necessary to support the military, homeland defense, and law enforcement missions. This technology can also complement the use of cooperative surveillance systems, providing key surveillance information in the event of failure of one or more cooperative surveillance systems. However, use of non-cooperative active technology in lieu of cooperative dependent technology is not foreseen to support the 2025 NextGen capacity goals. Therefore, NextGen must include at least primary radar surveillance technology and cooperative dependent surveillance with the ability to fuse the data from these technologies into a common surveillance database.
- This surveillance architecture effort was focused on the top-level purpose, as presented in Section 7.1. This architecture does not support decision making in many specific surveillance areas: aircraft-to-aircraft and aircraft-to-ground vehicle surveillance; the interaction of the civil, defense, and homeland security missions; and the interface and interaction of the surveillance activity/function with other related activities/functions such as PNT and navigation. These additional areas were beyond the scope and resources of this surveillance architecture effort.

7.6 Surveillance Architecture Detailed Recommendations

The ISST developed multiple recommendations based on the observations in Section 7.5 and Findings listed in Section 10.1. The below provides detailed recommendations that expand on the third recommendation in Section 10.2.

Expand the depth of the NextGen surveillance architecture to further depict the operational mission area. Future surveillance architecture efforts should answer explicit questions, inform particular decisions, or support specific analyses. As previously noted, the alternative is to develop a broader Integrated Surveillance architecture that would include the scope of NextGen and also address broader needs. The most important recommendations applicable to follow-on surveillance architecture efforts include:

- The follow-on surveillance architecture should expand depiction of the operational mission area. In this regard, the architecture should include views and information to support determination of the mix of sensor types; to select methods for correlating/fusing surveillance information (e.g., plots or tracks); to determine the methods of sharing surveillance information; to assess failure mitigation strategies; and to address varying timeliness, security, and accuracy requirements. The architecture should show the interaction of operations centers, including the development and management of surveillance databases. Other areas that the follow-on architecture should depict, consistent with the ConOps, are aircraft-to-aircraft and aircraft-to-ground vehicle surveillance; the interaction of the civil, defense, and homeland security missions; and the interface and interaction of the surveillance activity/function with other related activities/functions such as PNT and navigation.

- An important area for decision-making and analysis is capability consolidation. The current surveillance architecture projects a large-scale consolidation of the current surveillance capabilities into a single surveillance service. An important aspect of consolidation is the economy gained by fully sharing surveillance assets, enabling better use of current underutilized redundancy and providing the opportunity for more optimally positioned radars for redundancy and coverage. While NextGen may include some consolidation of surveillance services, more likely there will continue to exist a large amount of separate and distinct surveillance capabilities for DoD, DHS, FAA, and other government partners. The follow-on surveillance architecture should depict a range of futures to support a decision on the amount of consolidation that will be needed.
- The current surveillance architecture appears adequate in the support areas, such as role of surveillance equipment developers, aircraft manufacturers, and avionics manufacturers and, therefore, needs less elaboration here. Similarly, the activities of evaluating and planning the infrastructure appear adequate to meet the architecture's purpose.
- Since the surveillance architecture is a 2025 depiction of the domain, the surveillance architecture needs should inform longer-term R&D investments that are needed to make decisions about the operations and system elements for nearly the next 20 years. The follow-on surveillance architecture should include a view of the surveillance technology roadmap. The architecture should also highlight where policy issues need to be addressed.
- To enable the development of the transition and sequencing plan represented by the NextGen IWP, a clear understanding is needed of the current surveillance architecture and the changes required to achieve the NextGen surveillance architecture. Therefore, at least at the top level, the follow-on surveillance architecture effort should describe or provide references to the current surveillance architecture. Related to this, the follow-on surveillance architecture should indicate that a transition is expected from the current "stovepipe" surveillance situation, where each operations center manages and maintains its own surveillance capability, to the system of 2025 where there are shared surveillance resources among centers. Furthermore, the current system uses awkward protocols that inhibit command center interoperability. The follow-on surveillance architecture should support the development of a solution to the current problematic interconnectivity that has evolved in the ad hoc development of today's system.
- Increase the level of detail in the surveillance architecture to emphasize the differences in technologies and mission objectives among the many departments and agencies that collect and use surveillance information.
- Develop detail of the NextGen Information Management Services (Information Transport, Information Storage and Retrieval, and Net-Centric Information Services) to support coordination of NEO issues among the many surveillance sources and users.

8.0 OPTIONS TO BETTER ACHIEVE NEXTGEN SURVEILLANCE

The ISST agreed that there are known organizational barriers to achieving NextGen Surveillance that must be addressed before any technical approaches can be successfully evaluated, selected, and implemented. This determination defined the organization and the emphasis of this section. Each option addresses the manner in which the surveillance mission partners would work to accomplish planning, acquisition, operations, and maintenance. The options vary in the nature of the collaboration of the mission partners in accomplishing each of these elements. Sections 8.1-8.4 discuss options for organizing and managing surveillance mission partner activities. Section 8.5 describes some technical issues and approaches that the ISST has discussed.

8.1 Independent

The Independent arrangement is the historic and current method for coordinating surveillance activities among the mission partners. Under this arrangement the mission partners independently attempt to reach the capability needed for 2025 and beyond. Each mission partner acts on its own timeline and with its own internal milestones. There is some level of awareness and coordination of independent R&D, bi-lateral agreements on sensor coverage, data integration and dissemination, and cost sharing. The surveillance mission partners develop and implement their own architecture, infrastructure, and command and control or situational awareness with point-to-point data transfer between mission partners. Mission partners would continue to independently vie for the Executive Branch of the Government’s programmatic approval of their capabilities and funding.

8.2 Consortium

The Consortium arrangement relies on a governance body made up of the mission partners to determine overall policy and program direction. This consortium would require agreement among the mission partners regarding information-sharing standards and architecture, promoting surveillance infrastructure development that is founded on system publish-and-subscribe principles toward a net-centric, service-oriented architecture. Each mission partner would remain responsible for planning, implementation, and operations of their own mission-oriented aviation surveillance systems. The consortium would capitalize on broader mission partner awareness and collective R&D to be the harbinger of future national capabilities to optimize surveillance. The Executive Branch of the Government would rely on the consortium to articulate integrated surveillance programmatic direction for decision making.

8.3 Executive

The Executive option assigns a single entity as the lead agent accountable for achieving national surveillance requirements. The Executive entity would for the overall benefit of the Nation collect and manage requirements from all mission partners, and supervise R&D, policy and programmatic details to achieve integrated surveillance. Mission partners would articulate their surveillance capability needs and the Executive entity would define and implement systems to optimize overall national surveillance outcomes, managing scope within approved budget and adjudicating conflicting needs as required. The Executive entity would be the definitive source for all aspects such as architecture, infrastructure, deployment, etc. The Executive Branch of the Government would deal directly with the surveillance Executive entity on all integrated surveillance-related matters.

8.4 Analysis of Surveillance Mission Partner Arrangement Options

The ISST's analysis of these three options is paraphrased below. Each option was evaluated from three different surveillance functional perspectives: Collection, Integration, and Dissemination.

Independent: This option fosters a "stovepipe" environment where information is shared only by request and is not able to be tailored based on a requirement, such as a UDOP. System interfaces are developed for specific applications and without systematic coordination across user needs. Information sharing capabilities allow limited ability to recognize and respond to common tracks of interest and provide no automatic or simultaneous notification of an anomalous event to mission partners, leading to operations that are heavily reliant on extensive verbal communications processes to verify possible security events. Finally, the Independent option presents multiple barriers to optimizing advancements in technology across the mission partner's future aviation surveillance programs.

Consortium: Establishment of an institutional framework for agreeing on and maintaining a common architecture that allows publish-and-subscribe information sharing would offer several advantages over the Independent option. Owners can both share information they collect more easily and still control access/release of the information. This option offers opportunities for improving aviation surveillance coverage and performance improvements in interagency responses to security events, while also reducing overall Federal costs across the mission partners. Another attractive feature for individual mission partners is that this option preserves their prerogative to build and operate aviation surveillance systems whose capabilities are driven largely by their own mission requirements. This option could present transition challenges in modifying multiple department/agency systems to conform to the common information-sharing architecture. A disadvantage of this option is that it requires some level of shared urgency and cooperation between agencies to be effectively implemented in a reasonable time frame – without a clear, top-down driving force for consolidation and change, this option may not survive the "transition" to the desired future state.

Executive: Focusing the collection, integration, and dissemination functions under a single entity allows the opportunity to optimize requirements and allows a single entity responsibility and accountability for all integration issues. Mission partner participation is an essential pre-condition to ensure all requirements are addressed. The primary disadvantages of this option are the lack of any precedent for implementing such an option within the U.S. Government. In ISST discussions of this option, ISST members were in general agreement that this option would not be acceptable to their agencies' senior management at present. The only scenario the Executive option was viewed as a serious option was in the event of a crisis where this option is viewed as the best way to respond effectively to that crisis.

As a result of the analysis above, the ISST members agreed that the Independent option is the least preferred. Either the Consortium or Executive option, or a hybrid variation thereof, is preferred to achieve NextGen objectives for integrated Aviation Transportation System surveillance.

8.5 Potential Technical Issues and Approaches for NextGen

The ISST is cognizant of various approaches that could be taken to implement NextGen Surveillance. The ISST looked at different approaches of "combining/optimizing" capabilities to facilitate the best mix of surveillance assets.

Capability suites for NextGen Integrated Surveillance should capitalize on the Service Life Extension Program (SLEP) of radars underway, the ADS-B system implementation underway, and integrating distributed sensors to create the desired surveillance information. The options presented generally acknowledge the preference for any solution to complement and align the current major surveillance programs of each of the mission partners to maximize use of government resources.

8.5.1 Service Life Extension

SLEP of mid-1950's radars is planned out to 2017 and with longer-term plans to about 2025. Decisions for follow-on replacement of current generation radars are needed by 2011 to maximize efficiency and effectiveness of the SLEP and to set conditions for incorporation or adoption of any future sensor technology.

8.5.2 Wind Farm Considerations

A major issue for the current and future surveillance capabilities of the mission partners is the impact of massive wind farms approved by the Department of Energy. The negative impacts of wind turbines to NextGen Surveillance within radar line of site of L-band and similar characteristic radar systems include the following issues: false target generation; shadowing/screening effect; and loss of target detection/sensitivity above the wind turbines, which is the most serious impact. However, the radar surveillance community cannot unequivocally ascertain the extent of these impacts without additional testing/analysis and density modeling tools to discern the options required in mitigating these impacts.

8.5.3 Critical Infrastructure/Key Resources

Introducing ADS-B systems to improve ATM should be matched with non-cooperative surveillance sensor coverage improvements to appropriately align capabilities—both to ensure security/defense needs are met and also to provide the right level and location of surveillance capability to support air traffic service. Any plan to improve non-cooperative surveillance sensors should be based on a regional CI/KR assessment; that is, operations in the regional areas that are densely populated with CI/KR assets may require first priority in improving sensor capabilities. Eventually, the entire system of sensors and aircraft equipage would be improved toward a completely robust surveillance system across the NAS and its approaches. An alternative concept to phased implementation might be to deploy a combination of several robust coverage systems in "higher value/threat" regions, with a less robust array of sensors in "lower value/threat" regions and appropriate information integration and dissemination.[1]

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[1] See presentation by Dr. Chandra Chandraskar, Colorado State University at the OFCM-sponsored National Symposium "Leveraging Technology for a Next-Generation National Radar System," 10-12 October 2007.

8.5.4 Technologies Generating Interest

Multilateration is used in many fielded surveillance systems and being further considered in future system plans of the surveillance mission partners. Technologies generating interest as they mature are bi- or multi-static radar, passive radar, and space-based radar. Multi-function radar technologies are also attractive if mission requirements can be met in a cost-effective manner. During the June 19-21, 2007 Surveillance Summit, reference was made to one study (classified) that proposed a mixture of capabilities for mission optimization, such as High Altitude Airships (HAA), Tethered Aerostats or UAS Global Hawk, in combination with other surveillance information sources, as a way to provide the desired end state.

8.5.5 R&D and Integration

Introducing promising technology based on sound R&D presents an opportunity to satisfy and optimize all appropriate surveillance mission partner needs. There are potential solutions for sensors to be multi-functional and allow several methods for surveillance information distribution from linked sensors. Compounding the difficulty is the wide variance in mission partner requirements and the varying surveillance attributes and associated elements that must be obtainable to meet NextGen needs. The ISST believes that demonstrations are or will be needed for net-centric accessibility of operational surveillance data, integration of “gap-filler” technologies and systems, and persistent surveillance of the NAS (including approaches to the NAS). The paramount challenge is arriving in the timeliest, most efficient and effective manner at an Integrated Surveillance architecture and capability for the Nation while meeting NextGen and other future national needs.

8.5.6 NEO Spiral 1 Demonstration

Using a working prototype, NEO Spiral 1 demonstrated an architecture that facilitates surveillance data sharing. One goal of NEO Spiral 1 was to develop an initial suite of net-enabled capabilities, with a main focus on civil-military collaboration, strategic flow management, security (air operations and information security), and contingency operations. Surveillance-related operations, systems, and technologies were an integral part of the NEO Spiral 1 capabilities and scenarios.

Spiral 1 demonstrated that existing systems can be adapted to achieve interoperable capabilities. The modern service bus-based architecture, including a surveillance bus with the necessary performance characteristics, enabled secure information sharing and collaboration to satisfy the requirements established by the JPDO for implementing NextGen. See Appendix C for specific lessons learned from the NEO Spiral 1 Demonstration.

9.0 POLICY, GOVERNANCE, AND CULTURAL ISSUES

This report concentrates on Integrated Aviation Transportation System Surveillance, but recognizes the need to meet larger national safety and security needs through surveillance capabilities, intelligence information integration, and integration with surface surveillance of maritime and land sectors. Multi-domain Intelligence Community information integration will be coordinated through the ODNI Global Maritime and Air Intelligence Integration (GMAII) office.

This section will address some of the major policy, governance, and cultural issues that were identified during the ISST's work. The section concludes with multiple case studies representing ISST efforts to examine related or similar activities in the U.S. Government, both current and historical, to identify lessons in the issue areas of this section.

9.1 Policy

The primary policy issue is to determine the responsibility, management, and ownership for elements of integrated surveillance (to include funding). This issue was fairly well developed in the NAASP and has been discussed in multiple Interagency Joint Surveillance conferences in 2007 and 2008, as well as other forums such as the OFCM hosted conference "NextGen Technology for Surveillance" of October 2007.

Another recurring relevant theme is the need for a policy on sharing of surveillance and other applicable information (to include interagency standards). The ISST is aware of the ongoing initiatives of the PM-ISE under ODNI. By Presidential direction, the PM-ISE initiatives are centered on counter-terrorism, homeland security, and law enforcement information and as of August 2007, Weapons of Mass Destruction. The PM-ISE office has Presidential-appointed executives representing their department on the PM-ISE governing board—Information Sharing Council (ISC). The PM-ISE office initiatives, although centered on the counter-terrorist and counter-proliferation focus areas, will continue to influence overall information-sharing standards.

Access to privacy or classified information is another policy issue. Any resolution must ensure that each department/agency receives the required level of information to perform its mission. A policy review should be conducted of existing Intelligence Community authorities regarding intelligence collection that contribute to surveillance operations. Following that review, those appropriate authorities identified to enhance intelligence support of surveillance should be developed and implemented to better support Air Domain awareness requirements.

9.2 Governance and Resources

Governance of Integrated Surveillance in NextGen may be a subset of a governance mechanism with oversight of a larger area than just the aviation sector.

It should be understood that establishing a governance mechanism to provide Integrated Surveillance capabilities is not expected initially to replace current roles and responsibilities. For instance, the FAA has the sole authority to establish regulations, standards, and requirements for weather information necessary for ATM, pilots, and dispatchers. However, a collaborative governance arrangement would strengthen cooperation across the mission partners. As another example, NOAA, FAA, and DoD continue to share responsibility for providing weather surveillance.

Any governance structure would need to address the approach for national sensor integration and the necessary data/information integration to enhance domain awareness and optimize the necessary overlaps/redundancies between systems. Certain elements would be needed in determining the best structure to achieve national air surveillance and data integration. Under the options described in Section 8 of this report, an Independent approach requires expanding interagency agreements, while a Consortium requires direction to standardize an open architecture format, and the Executive approach requires designation of a lead entity and guidance on responsibility of the various surveillance mission partners.

9.3 Cultural

The difficult and complex necessity of Integrated Surveillance envisioned in NextGen must be founded on strengthened relationships between the mission partners. The ISST believes that the requisite trust must be built between the mission partner organizations and in the interpersonal relationships among their employees.

The mission partners must overcome their cultural bias to maintain the status quo. The status quo should be unacceptable and replaced with the commitment to find ways to improve safety and security in a cost-effective manner. Correspondingly, with the drive toward improving safety and security is the shared acknowledgement that each surveillance mission partner is also a security and safety partner. Nearly every security event that takes place has a corresponding safety linkage.

9.4 Case Studies

The below paragraphs describe some of the case studies that were discussed by ISST and used to develop recommendations. These analyses reflect the personal knowledge and perspectives of the various ISST members; they should not be construed as representing official United States Government (USG) Lessons Learned or government positions.

9.4.1 North American Air Surveillance Council (NAASC)

The NAASC was used after September 11, 2001 as a mechanism for coordination of near-term interagency air surveillance activities. Using a medical analogy, one could describe the ensuing activities from 9/11 to present in stages such as “triage,” followed by “alternative medicine,” and then gradual slippage back into the “pre-trauma lifestyle.”

“Triage” would apply to all the immediate, rapid actions that occurred shortly after 9/11 to improve surveillance and collaboration. This collaborative environment was enhanced due to the shared experience among the various interagency participants that was created by the emergency.

During the "alternative medicine" period:

- DoD and DOT/FAA achieved greater sharing of information through the Domestic Events Network (DEN), and Operation Noble Eagle-classified conferencing;
- DoD and DHS established the LRR Joint Program Office;
- DoD, DHS, and DOT/FAA convened the NAASC and delivered the accompanying NAASP to propose an integrated long-range surveillance solution;
- DOT introduced a NAS Defense Program (NDP), as previously described in this report (Section 2);
- DoD, DHS, and DOT/FAA agreed to a national plan called Emergency Security Control of Air Traffic (ESCAT) that defines the responsibilities and actions of agencies and personnel within the Departments of Defense, Transportation and Homeland Security under emergency conditions.

However, the NAASC has been disbanded/abandoned, the NAASP has no driving force and is no longer being implemented, and there has been no additional progress towards integrated surveillance among the mission partners. This leads to the ISST conclusion that the USG has slipped back into its "pre-trauma lifestyle."

Why did the NAASC stop functioning? Although it is not altogether clear why this happened, it is clear that the NAASC suffered when the various department and agency leaders, who "shared the 9/11 experience" and constituted the council, moved on to other positions. Another factor seems to be that the principal product generated by the NAASC, the NAASP, was never endorsed by senior Administration officials nor attracted support of any Congressional representatives. The NAASP may have been a casualty of political timing or the changing job assignments of the NAASC principal members, or both. With no explicit direction from the President or legislation requiring the NAASC's continuation, the committee was a "nice-to-do" collaboration mechanism (versus required) from a leadership perspective.

9.4.2 National Space-based PNT Executive Committee

The cornerstone of U.S. Positioning, Navigation and Timing (PNT) service capability is GPS. Recognizing this, the President in 2004 created (via a National Security Policy Directive) the National Executive Committee for Space-based Positioning, Navigation, and Timing (PNT ExComm) to coordinate Federal entities on matters concerning the GPS and related systems. The PNT ExComm is co-chaired by the Deputy Secretaries of Defense and Transportation.

The ISST Director and JPDO technical support staff evaluated the PNT ExComm (via observation of its activities over the past 2-3 years) as a possible model for identifying policy, governance/resources, cultural issues, and associated recommendations from the ISST.

The PNT ExComm was created solely by Executive Branch action, with no apparent coordination or consultation with the Legislative Branch. Although OMB is an observer on the PNT ExComm, the level of OMB engagement/involvement does not appear significant. The PNT ExComm was designed to govern USG activities as they typically operate, which is the Independent model described in Section 8.1. The PNT ExComm structure has proven useful for achieving cross-agency communication and coordination. When consensus can be achieved among the various USG agencies with PNT "equities," the PNT ExComm has provided a framework for such achieving such agreements in an expeditious manner. The current tendency in PNT ExComm activities is to respond to various requests from the bureaucracy for senior-level ratification of each agency's relatively independent plans and activities. Integration is typically thought of as assembling the various agency plans/budgets and checking for obvious conflicts or divergent plans.

Neither the Presidential Policy directive that established PNT ExComm, nor the ExComm itself, has produced a compelling vision for future USG PNT capabilities or services. Another characteristic of the PNT ExComm structure is that there is no senior official of the Executive Branch with clear responsibility for USG PNT capabilities. Since the Congress was not involved in the creation of PNT ExComm, and all activities of such are buried in various agency budgets, there is no Congressional focus, oversight, or integrated funding of USG PNT capabilities – the various PNT capabilities are developed and funded by each agency, competing with other priorities within each agency, and reviewed by multiple OMB examiners and Congressional committees. Without any real mechanism to unify and catalyze the involved agencies into concerted action, it is not surprising that the tendency for each agency to "do what we were already doing" is largely prevalent.

9.4.3 NextGen Integrated Aviation Weather Governance Case Study

The ISST examined an organizational partnership that has similar interagency relationships and parallels the path that the surveillance mission partners are taking. Historically, the aviation weather community established a relationship between DoD, DOC, and DOT that has continued to develop. The aviation weather community is further developing its partnership to address planning, acquisition, operations, and maintenance of NextGen Weather.

In early 2007, the JPDO Weather WG chartered its Weather Policy sub-team to analyze policy issues raised by NextGen Weather requirements. During its deliberations, the Weather Policy Team considered the same organizational relationships considered by the ISST that are described in Section 8.1-8.4 above. The Weather Policy Team reached the fundamental conclusion that it is critical to the success of NextGen Weather *"that Federal agencies create a standing framework with appropriate authority to coordinate and make decisions on policy matters,"* both initially and throughout the life of NextGen.

The conclusion was presented to the JPDO Board in October 2007. The Board concurred with the recommendation and postulated that it should be responsible for these types of decisions, pending endorsement by the Senior Policy Committee (SPC). A subsequent brief to the SPC in January 2008 confirmed their position. The SPC directed that further study be conducted to resolve governance issues related to domain authority.

Subsequently, the JPDO Weather WG Co-Chair recommended the formation of the NextGen Executive Weather Panel (NEWP). The concept was briefed to and endorsed by the SPC in April 2008. Members of the current ad hoc group are SES-level and are engaged daily on interagency weather issues. The NEWP authority and responsibilities are still being worked out. Their charter will likely include recommending resolution of NextGen weather policy issues to the JPDO Board for decision. Rather than an advisory board, the NEWP may be formally recognized as a governing body for NextGen Weather plan synchronization and implementation, but issues need to be worked out among government entities.

The notional NextGen Integrated Aviation Weather organizational structure is illustrated in Figure 9-1 below. Issues are resolved by the JPDO Board and recommended to the SPC. It is important to note that the roles and responsibilities of the government partners remain unchanged.

Figure 9-1 Notional NextGen Integrated Aviation Weather Organizational Structure

The ISST believes the work done to establish an organizational relationship to handle issues and synchronize implementation of NextGen Weather may offer insights to developing an organizational structure for the surveillance mission partners.

9.4.4 Joint Planning and Development Office

The JPDO was established in the FAA by Public Law 108-176 (Vision 100 – Century of Aviation Reauthorization Act), section 709.[1] The JPDO's responsibilities include: creating and carrying out an integrated plan for a Next Generation Air Transportation System (NextGen) that meets air transportation safety, security, mobility, efficiency, and capacity needs; overseeing research and development on that system; creating a transition plan for the implementation of that system; and reviewing activities relating to noise, emissions, fuel consumption, and safety conducted by Federal agencies.

[1] See http://www.jpdo.gov/vision_100_law.asp.

The JPDO has no authority over any of the government partners whose activities it is supposed to coordinate/oversee. The JPDO is funded to operate the office and conduct relatively small studies, but is not funded at a level that would allow it to influence the activities of the various government partners (by providing "seed money" or funding some efforts outright). The NextGen departments/agencies obtain the entirety of their funding through an OMB/Congressional process that the JPDO has had minimal ability to influence.

The JPDO's successes have come from its ability to establish a "coalition of the willing" within the government. When these coalitions can be created, the JPDO has had reasonable success in fulfilling its responsibilities, though these successes have not come quickly. However, the JPDO's experience is that some of the large and complex barriers to achieving NextGen are unlikely to be overcome by the "coalition" approach, since it is often the lack of agreement across or within government partners that constitute a key element of a given barrier.

9.5 Conclusions about Policy, Governance, and Cultural Issues

Moving from today's national surveillance capabilities to Integrated Surveillance envisioned in NextGen will be both a complex technical endeavor and a complex organizational challenge involving many government entities. From an ISST perspective, a review of recent, complex activities across multiple departments and agencies offers multiple lessons. First, when responsibility, authority, and funding are not aligned, effective action and ultimate success are extremely challenging, even unlikely. This lesson is also obvious from the reading of many management texts, but it is a mistake that is repeatedly made within government, so it is stated here. Second, unilateral action by either the Executive or Legislative branch may yield short-term results, but rarely sustainable effectiveness and success. This is largely due to the reality that no single branch of government can assign responsibilities, authorize actions, and appropriate funding without the cooperation and consent of the other branch.

10.0 FINDINGS AND RECOMMENDATIONS

The purpose of this study was to examine the issues surrounding Integrated Surveillance that will affect the realization of the NextGen vision and to make recommendations that will optimize national capabilities and resources in its implementation.

The focus of this study was on a subset of the Air Domain that includes the NAS and its approaches. It considered all surveillance factors affecting the NAS, such as ground vehicles, weather phenomena, etc. However, the study focused on the surveillance of operating vehicles, reserving for follow-on study the additive effects of other factors. These were considered by the ISST as important but peripheral to the central surveillance problem. The ISST felt that once the central surveillance issues were addressed the study recommendations could be applied to the peripheral issues.

The study:

A. Identified high-level aviation transportation system surveillance information and capability needs as envisioned in the NextGen ConOps, including data attributes (e.g., PNT, integrity and information content) that are needed to support NextGen.
B. Identified existing agency aviation transportation system surveillance capabilities and architecture, and future surveillance system plans and needs.
C. Identified potential changes in how aviation transportation system surveillance capabilities could be combined to more effectively and efficiently achieve NextGen.
D. Identified changes that should be made in government planning.

The ISST determined that its charter to *"identify existing agency aviation transportation system surveillance capabilities, systems and architecture, and future surveillance system plans and requirements"* would best be achieved after the ADSII AI teams completed their reports and recommendations. The report draws upon DoD's HACMD/NA and OSD functional capability assessment, the "Network Enabled Operations (NEO) Spiral 1 Final Report" of May 2008, and other references (see Bibliography).

10.1 Findings

<u>Organizational</u>

- There are known organizational barriers to achieving NextGen Aviation Transportation System Surveillance objectives that must be addressed before any technical approaches can be successfully evaluated, selected, and implemented.
- There is no institutional mechanism to oversee and coordinate surveillance capabilities across all departments and agencies, nor is there a focused mechanism in place to synchronize and arbitrate department and agency efforts to establish an Integrated Surveillance capability.
- Of the "organizational" options evaluated by the ISST, the Independent option (see Section 8.1) is the least preferred approach for achieving NextGen Surveillance objectives. Either the Consortium or Executive option (see Sections 8.2 and 8.3, respectively), or a hybrid variation thereof, is preferred to achieve NextGen objectives for Integrated Aviation Transportation System Surveillance.
- Surveillance solutions, while satisfying individual agency requirements, are currently achieved in an independent, intra-agency fashion.
- There are opportunities to leverage future technologies such as DoD's JCTDs, weather sensors from DOC/NOAA, and other capabilities across departments and agencies, to achieve synergy in Integrated Surveillance that supports NextGen.
- Activities aimed at improving surveillance in airport environments should be integrated with activities aimed at improving surveillance in airspace environments.
- Products developed based on NSAS-ADSII WG Action Item responses to date reflect a propensity to align with NextGen needs.

Operational, Systemic, and Technical

- There are gaps between NextGen needs and Integrated Surveillance capabilities due to sensor coverage and detection characteristics; data correlation and fusion; network architecture and connectivity; interagency surveillance information sharing and collaboration; and ability to address the spectrum of multi-agency information needs. There is no consensus among the agencies that participated in this study regarding the degree to which these gaps cause near-term operational risks.
- No concept of operations exists that covers the scope of Integrated Surveillance. Surveillance is currently characterized by each individual agency focusing only on their operational mission needs. Limited capabilities exist for the timely sharing of surveillance information across all stakeholders, which also affects the coordination of responses to detected events.
- Each department/agency represented in the study team has begun analytical efforts that have led, or will lead, to identification of their respective future surveillance requirements.
- FAA is developing systems that will decrease reliance on radars; opting instead for systems that rely on aircraft equipage as the main source of positioning information for ATM purposes.
  - Cooperative dependent surveillance technology (e.g., ADS-B) is being implemented to achieve the capacity and safety objectives of NextGen for transportation of passengers and freight. The “reliance” of ADS-B on precise positioning information, typically determined via GPS, creates a new dependence between positioning/navigation and surveillance functions that must be understood by all surveillance mission partners.
  - These FAA systems do/will not meet some DHS/DoD mission needs to discover/monitor all areas of U.S. sovereign airspace which vehicles use and approach.
- DoD/DHS must act as soon as possible to insure that aviation surveillance capabilities are provided to meet their mission needs and provide avenues toward implementing improvement to maintain capability well into the future.
- Due to the completeness of the DoD’s systems engineering activities in aviation surveillance, DHS has chosen to utilize DoD’s capabilities determination and validation analysis.
- There are overall NextGen weather surveillance requirements to detect, identify, and track anomalous or hazardous weather phenomena such as thunderstorms, wind shears, icing, etc.

10.2 Recommendations

The ISST recommendations generally address the findings previously described. The first recommendation is critical and key to implementing the remaining recommendations.

1) **Determine and establish a formal, institutionalized interagency mechanism for the responsibility, management, and ownership for elements of integrated surveillance (to include funding).** Future Integrated Surveillance data/information requirements must be analyzed holistically, ensuring that the responsibilities of DOT/FAA, DHS, DoD, ODNI, DOC/NOAA, and other appropriate government organizations are addressed. National

aviation surveillance requirements for 2025 must accommodate both the projected increase in the volume of aircraft operations, as well as national assessments of threats to the United States for that time frame. Weather surveillance capabilities and requirements should be simultaneously evaluated for potential synergies. Management and subordinate arrangements commensurate with funding mechanisms must also be defined.

The ISST recognizes the importance of integrating interagency surveillance with intelligence information, and acknowledges the coordination role of ODNI's Global Maritime and Air Intelligence Integration office in this area.

There are many potential mechanisms that might be used to oversee Integrated Surveillance for NextGen. Given the complexity of the task and the different priorities of the surveillance mission partners, the ISST believes that any successful governance structure must be collaboratively developed by the White House and the Congress, to ensure alignment of responsibility, authority, and funding

The following recommendations should be implemented by the formal interagency mechanism established in recommendation one:

2) **Develop a concept of operations for NextGen Integrated Surveillance.** The NextGen ConOps should be expanded to provide additional surveillance detail necessary to drive the surveillance architecture. A separate surveillance appendix to the ConOps should be considered, analogous in focus to the existing security appendix. Alternatively, the JPDO could participate in developing a broader national integrated surveillance ConOps that would include the scope of NextGen and also address broader national needs such as the inclusion of intelligence and maritime integration. Developing such a ConOps to cover integrated surveillance was also recommended at the Surveillance Summit held 5-6 June 2008.

3) **Develop an interagency Integrated Surveillance architecture to support operational, systemic, technical, and investment decisions.** Expand the depth of the NextGen surveillance architecture to further depict the interagency operational mission area. Early on in the establishment of the interagency mechanism to address surveillance services, a multi-agency system engineering architecture design must be developed. At the 19-20 June 2007 DoD-DHS Surveillance Summit and at the 5-6 June 2008 Interagency Air/Maritime Surveillance Summit, the consensus of the participants was that an architecture is necessary early on in development. The ISST has come to a similar conclusion. See Section 7.6 for more details regarding this recommendation.

    a. **Conduct a national study to evaluate technical/architectural options to overcome safety and security shortfalls in critical coverage areas of U.S. sovereign airspace and approaches to this airspace.** A follow-on study, coordinated amongst DHS, DoD, ODNI, DOT/FAA, DOC, and other U.S. Government organizations and allied governments, is necessary to build on current efforts to determine adequacy and requirements for surveillance coverage and additionally determine the risks and resources required to overcome current deficiencies. The expected result from this study is that additional sensors, processes, and procedures will be necessary to establish the intent and detection of unknown, suspected, or actual airborne threats to the United States. The study must be informed by the National Infrastructure Protection Plan and have provisions to evaluate future system capabilities to move toward a 24/7, persistent, all weather, all vehicle detection capability. This study must also address potential frequency spectrum issues associated with aviation transportation system surveillance and supporting or related PNT systems.

4) **Develop and implement an Aviation Surveillance Information Network strategy**. To effectively use distributed aviation surveillance capabilities that are under the control of different ownership domains, a strategy should be developed and implemented for a surveillance information network. As indicated in the surveillance architecture, this would support net-centric operations that would provide a means to expose, discover, access, and use Integrated Surveillance information to support the missions of the mission partners. The surveillance information network would have cyber-security and management capabilities appropriate to the department and agency missions. All trusted organizations with access to this information would see a UDOP based from the shared surveillance information. Enable sharing of surveillance information through information-sharing standards.

5) **Develop and execute an interagency Integrated Surveillance implementation plan**. The implementation plan should be collaboratively developed by the JPDO government partners and contain the roadmap for realizing the Integrated Surveillance capability. The implementation plan should describe the research, development, and implementation activities across the government partners, and address costs, benefits, risks, and priorities. This document should be an input to the detailed planning activities within the government.

6) **Use demonstrations and experiments to mature and field early versions of Integrated Surveillance capabilities**. To mature NextGen operational concepts, potential systems, and promising technologies, numerous demonstrations and experiments are planned. These demonstrations and experiments, often with live operations, present the opportunity to not only mature Integrated Surveillance capabilities discussed in this report, but also to field early version for operational benefit. The NEO Spiral 1 demonstration showed the promise of net-centric surveillance operations. Follow-on NEO Spirals or other surveillance demonstrations should incorporate the findings and recommendations of this report and follow-on integrated surveillance studies (including the surveillance architecture) in the planning and execution of such demonstrations.

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Integrated Surveillance for the Next Generation Air Transportation System

Document Revision History

VERSION	DATE	DESCRIPTION
Version .20	August 26, 2008	Transmitted to the Partnership Development Division
Version .37	September 3, 2008	Transmitted to ISST Review Panel
Version .45	October 22, 2008	Edited by Partnership Development Division per ISST Review Panel meeting discussion, action items, and Comment Resolution Matrix
Version .50	October 24, 2008	Transmitted to the ISST Lead for review
Version .52	October 26, 2008	Transmitted to the ISST Review Panel
Version .55	October 31, 2008	Edited by Partnership Development Division per feedback received; transmitted to ISST Lead for final review
Version 1.0	November 3, 2008	Transmitted to JPDO Board for approval
Version 1.0	November 21, 2008	Published on the JPDO Web site

Appendix A. Acronyms

4-DT	Four-Dimensional Trajectory
AAFAS	Automated Airborne Flight Alert System
ADAPT	Automatic Detection and Processing Terminal
ADIZ	Air Defense Identification Zone
ADRA	Air Domain Risk Assessment
ADS-B	Automatic Dependent Surveillance- Broadcast
ADSII	Air Domain Surveillance and Intelligence Integration
AFFSA	Air Force Flight Standards Agency
AI	Action Item
AIM	Aeronautical Information Manual
AMDAR	Aircraft Meteorological Data Relay
AMOC	Air and Marine Operations Center
AMOSS	Air and Marine Operations Surveillance System
ANSP	Air Navigation Service Provider
AOTR	Aviation Operation Threat Response
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ASDE-X	Airport Surveillance Detection Equipment-X
ASOS	Automated Surface Observing Systems
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATSR	Aviation Transportation System Recovery
ATSS	Aviation Transportation Security System
AVOI	Airspace Volumes of Interest
AWIPS	Advanced Weather Information Processing System
AWOS	Automated Weather Observing System
C2	Command and Control
CARTS	Common Automated Radar Terminal System
CASA	Civil Aviation Safety Authority
CASP	Common Air Surveillance Picture
C-ATM	Collaborative Air Traffic Management
CBA	Capabilities Based Assessment
CBP	Customs and Border Protection
CI/KR	Critical Infrastructure/ Key Resource
CIO	Chief Information Officer
CIWS	Corridor Integrated Weather System
ConOps	Concept of Operations
CWS	Collaboration Workstation
DCGS	Distributed Common Ground System
DEC	Domestic Event Conference
DEN	Domestic Event Network
DHS	Department of Homeland Security
DIB	Distributed Common Ground System (DCGS) Integration Backbone

DISA	Defense Information Systems Agency
DMSP	Defense Meteorological Satellite Program
DO	Domestic Outreach
DOC	Department of Commerce
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
DOT	Department of Transportation
DRSN	Defense Red Switch Network
DTC	Domestic Threat Conference
EA	Enterprise Architecture
EARTS	En Route Automated Radar Terminal System
EAS	Enhanced Airspace Security
EMP	Electro-magnetic Pulse
ERAU	Embry-Riddle Aeronautical University
ESCAT	Emergency Security Air Traffic Control
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
GMAII	Global Maritime and Air Intelligence Integration
GOES	Geostationary Operational Environment Satellite
GPS	Global Positioning System
HAA	High Altitude Airships
HACMD/NA	Homeland Air and Cruise Missile Defense of North America
IAED	Interagency Architecture and Engineering Division
IATR	International Aviation Threat Reduction
IBM	International Business Machines
IC	Integration Council
IFR	Instrument Flight Rules
IO	International Outreach
ISC	Information Sharing Council
ISST	Integrated Surveillance Study Team
IWP	Integrated Work Plan
JCD	Joint Capabilities Document
JCTD	Joint Capability Technology Demonstration
JET	Joint Environment Toolkit
JIAMDO	Joint Integrated Air and Missile Defense Organization
JPALS	Joint Precision Approach and Landing System
JPDO	Joint Planning and Development Office
JPO	Joint Program Office
JROC	Joint Requirements Oversight Committee
LAAS	Local Area Augmentation System
LRR	Long Range Radar
LRR SLEP	Long Range Radar Service Life Extension Program
METARS	Meteorological Aviation Routine Weather Reports
MOPS	Minimum Operational Performance Standards
MPAR	Multi-Function Phased Array Radar
NAASC	North American Air Surveillance Council

NAASP	North American Air Surveillance Plan
NAC	Navigation Accuracy Category
NAS	National Airspace System
NATO	North Atlantic Treaty Organization
NCES	Net-Centric Enterprise Services
NDP	NAS Defense Program
NEC	Noble Eagle Conference
NEO	Network Enabled Operations
NEWP	NextGen Executive Weather Panel
NextGen	Next Generation Air Transportation System
NIC	Navigation Integrity Category
NLDN	National Lightning Detection Network
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NOTAM	Notice to Airmen
NSAS	National Strategy for Aviation Security
NSPD-47/HSPD-16	National Security Presidential Directive-47/Homeland Security Directive-16
OASD (HD&ASA)	Office of the Assistant Secretary of Defense for Homeland Defense and Americas' Security Affairs
OCONUS	outside of the Continental United States
ODNI	Office of the Director of National Intelligence
OFCM	Office of the Federal Coordinator for Meteorological Service and Supporting Research
OI	Operational Improvement
ONIR	Overhead Non-Imaging Infrared
OSD	Office of the Secretary of Defense
OTHR	Over the Horizon Radar
PBFA	Policy Board on Federal Aviation
PCC	The Border and Transportation Security Policy Coordination Committee
PM-ISE	Program Management – Information Sharing Environment
PNT	Position, Navigation, and Timing
POES	Polar Operational Environmental Satellite
R&D	Research and Development
RAM	Radar Absorbent Material
RAPCON	Radar Approach Control
RCS	Radar Cross Section
REACT	Rogue Evaluation and Coordination Tool
RF	Radio Frequency
RNSS	Radio Navigation Satellite Service
ROTHR	Re-locatable Over-the-Horizon Radar
SBIRS	Space Based Infrared System
SDN	Surveillance Data Network
SIAP	Single Integrated Air Picture
SIL	Surveillance Integrity Level
SLEP	Service Life Extension Program

SME	Subject Matter Expert
SMR-I	Surface Movement Radar- Improved
SOA	Service Oriented Architecture
SOSUS	Sound Surveillance Systems
SPC	Senior Policy Committee
SRR	Short Range Radar
SSA	Shared Situational Awareness
STARS	Standard Terminal Automation Replacement System
SUA	Special Use Airspace
SWIM	System-Wide Information Management
TARS	Tethered Aerostat Radar Systems
TDWR	Terminal Doppler Weather Radar
TOR	Terms of Reference
TRACON	Terminal Radar Approach Control
TSA	Transportation Security Administration
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UDOP	User Defined Operational Picture
UEWR	Upgraded Early Warning Radar
USAF	United States Air Force
USD	United States Dollar
USG	United States Government
VFR	Visual Flight Rules
VID	Visual Identification
WAAS	Wide Area Augmentation System
WG	Working Group
WSR	Weather Surveillance Radar
Wx	Weather

Appendix B. Integrated Surveillance Organizational Options

Approach Name	Independent	Consortium	Executive
Description	Shared integration by agreement; Status quo; Current “stove pipe” environment	Universal common architecture; Publish - Subscribe system with user defined operating picture	Single entity is a responsible and accountable advocate for all user requirements.
Collection	**Independent**	**Consortium**	**Executive**
Ownership and Control	Ownership/Control: Agency decides what assets to own/where to place	Allows owners control on access/release authority	Creates a single entity responsible for NextGen surveillance collection
Collection requirements	Each agency collects info to satisfy own requirements. System capabilities specific to agency mission	Each agency collects info to satisfy own requirements (increased collaboration)	Entity receives requirements from constituents Entity assumes collection responsibilities of existing surveillance infrastructure(s) Allows opportunity to streamline/couple requirements
Cross-agency systems and data sharing	Requires pre-agreed upon permissions/access approval Agreements for sharing assets/info	Allows a publish/subscribe format	Places responsibility on a single entity to program and work all collection issues
	Limited sharing of information	Provides a common system architecture increasing shared data	Makes data available to constituents
Collection-to-Integration Architecture	Need to develop specific interface	Universally defined format to which all constituents must comply which facilitates sharing of information	Single entity is a responsible to establish architecture/format for collection
Integrity		Moderate/general ability to capitalize on system coverage, limited ability to know if system integrity has been compromised	Improved ability to capitalize on multiple system coverage, e.g., know if system integrity has been compromised
Coverage	Optimized for each independent use; Underutilized redundancy	Opportunities to consolidate, relocate, to improve performance at lower cost	Optimized while meeting client coverage requirements
Integration	**Independent**	**Consortium**	**Executive**
Requirement Development	Independent integration within agencies	Allows mission partners to develop their own capabilities Mission partners bring resources	Single entity will determine where integration takes place Places responsibility on a single entity to program and work all integration issues

		No requirement to continually set agreements for info sharing	Requires expertise from mission partners Limits expertise from sponsor agencies
	User determines how data/info is handled during integration	User determines how data/info is handled during integration; may be made available	Single entity determines how data/info is handled
Architecture	Integration system located at each operations center	Integration system located at each operations center	Single entity will determine where integration service located
Dissemination	**Independent**	**Consortium**	**Executive**
Architecture	One way push based on bi-lateral agreements	Allows users to define what information they can access from published info	Makes info available to all constituents based on their defined requirements
	Limited integration leads to collocation requirements for info sharing	Automation enhances dissemination	Automation enhances dissemination
Security/Emergency event notification	There is no easy way to recognize and respond to a common track of interest	Easy way to recognize and respond to a common track of interest	Easy way to recognize and respond to a common track of interest
	No automatic or simultaneous notification of possible problems to all parties	All users get notified of potential problems at the same time	All users get notified of potential problems at the same time
	Incidents require extensive verbal communication to verify objects of interest		
General Characteristics			
		Policy needs to clearly identify responsibilities among mission partners	Policy needs to clearly identify responsibilities of lead and other mission partners
		Moderate/general ability to capitalize on system coverage, limited ability to know if system integrity has been compromised	Improved ability to capitalize on multiple system coverage, e.g., know if system integrity has been compromised
		Requires a security system authorization agreement among mission partners to protect against system vulnerabilities	Requires a security system authorization agreement between mission partners to protect against system vulnerabilities
		Requires a high level policy decision to drive a common architecture	

Appendix C. Lessons From NEO Spiral 1 Demonstration

NEO Spiral 1 demonstrated an architecture that facilitates surveillance data sharing by developing and demonstrating a working prototype. The NEO Spiral 1 demonstration built upon the proof of concept accomplishments of the initial Joint NEO Spiral 0 effort. A goal of NEO Spiral 1 was the development of an initial suite of net-enabled capabilities, with a main focus on civil-military collaboration, strategic flow management, security (air operations and information security), and contingency operations. Another goal was the development and implementation of an extensible architecture that would also be applicable to the future NextGen efforts. Surveillance-related operations, systems, and technologies were an integral part of the NEO Spiral 1 capabilities and scenarios.

With government personnel using working systems and with current technology, NEO Spiral 1 demonstrated that existing systems can be adapted to achieve interoperable capabilities. Further, multi-agency collaboration was facilitated as users used the new capabilities to synthesize novel interoperability solutions to problems. Numerous NEO tools would benefit interagency real-time collaboration.

NEO Spiral 1 demonstrated a multi-agency architecture that reflected the interaction of diverse government organizations in a NextGen environment. The modern service bus based architecture, including a surveillance bus with the necessary performance characteristics, enabled secure information sharing and collaboration to satisfy requirements established by the JPDO for implementing NextGen, as depicted in Figure 1.[1]

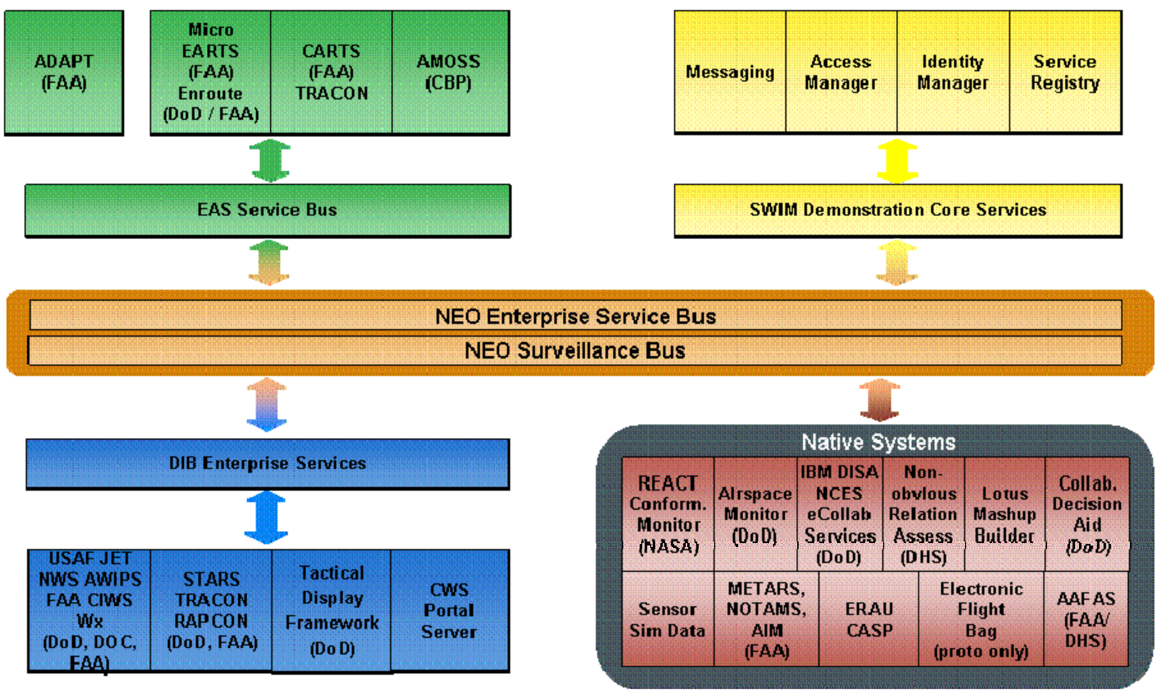

Figure 1 NEO Spiral 1 System Architecture

[1] Network Enabled Operations (NEO) Spiral 1 Final Report.

The NEO Spiral 1 architecture is comprised of:

- NEO Service Bus
- Identity Federation
- Certificate Authority
- Information Producers and Consumers
- Technical Components, Products and Services

A lesson for NextGen surveillance resides in the key principle that guided the NEO technical approach; interagency operations were enabled by the NEO Spiral 1 standards-based system architecture. Several technical development areas relevant to integrate surveillance that were represented in the NEO Spiral 1 architecture and included in the demonstration are:[1]

- **Security:** This is one of the most difficult and most important areas for technical development in supporting the NextGen initiative. Role-based access control and federated identity management were demonstrated. Role-based access control and related total information assurance should continue to be developed and extended in future Joint NEO Spirals.
- **Airspace Volumes of Interest (AVOI) and Selective AVOI and other key data types:** This area is a significant extension and application for this useful data type from Spiral 0. Additional applications and refinement of these data types in such areas as special use airspace (SUA), including dynamic SUAs, "digital NOTAMS," and emergency Temporary Flight Restrictions, would be promising for future development, testing, and application.
- **Integrated surveillance data network:** Additional development and operational experimentation of this critical area was accomplished, including real or near- real time data distribution and network/system performance analysis. This remains a key area for further technical development and experimentation, e.g., extending data reference models, exploring data quality issues, and rationalizing interagency standards and requirements (such as complete surveillance data fusion).
- **Collaboration tools:** NEO Spiral 1 exploited developing collaboration tools, both within and across agencies and other stakeholders (e.g., airlines), as a key enabler to derive value and enhance operations in the NAS and converged aviation operations in the future. The further development and operational testing of collaboration prototypes should be an integral part of future spiral development.

[1] Network Enabled Operations (NEO) Spiral 1 Final Report.

- **Exploiting "mashups"[1] and other key emerging areas/technologies:** Initial mashups implementations for rapidly – and flexibly – combining data sources and services for the aviation domain were developed for NEO Spiral 1. But each of these areas requires further development, testing, and implementation. For example, mashups present new security policy issues for the enterprise before they are fully deployed.

[1] A lightweight web application that combines data from more than one source into an integrated environment. Each data source is considered a feed and used to provide data to widgets that are reusable and sharable components that can be wired together to solve business cases. The term "mashup" is used to emphasize how these programmable components, or widgets, can be mashed together to create rich and complex web applications.

NEO Spiral 1 program implemented a mashup application: NEO Airport Search. Using this technology, airports database, runways database, NOTAMs data by FAA NAIMES Web Service (at https://www.aidaptest.naimes.faa.gov), weather data by CIWS Web Service, and Yahoo map data were used to create data feeds. Widgets were designed and implemented to consume these feeds. Wired together, the widgets address a generic aviation business case. It was demonstrated that hurricane and other emergency planning operations for staging, evacuations, and recovery efforts were enhanced by this capability.

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