National Airspace System Capital Investment Plan

FY2016–2020

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Federal Aviation Administration

Federal Aviation Administration National Airspace System Capital Investment Plan for Fiscal Years 2016 – 2020

1 Introduction

1.1 The Capital Investment Plan

The Federal Aviation Administration (FAA) Capital Investment Plan (CIP) describes the planned investments in the National Airspace System (NAS) for the next five years. The Consolidated and Further Continuing Appropriation Act, 2015 (Public Law 113-235) requires submittal of a five year CIP. The language in the 2015 Act states "[U]pon initial submission to the Congress of the fiscal year 2016 President's budget, the Secretary of Transportation shall transmit to the Congress a comprehensive capital investment plan for the Federal Aviation Administration which includes funding for each budget line item for fiscal years 2016 through 2020 with total funding for each year of the plan constrained to the funding targets for those years as estimated and approved by the Office of Management and Budget."

An overview of the CIP was included in the FY 2016 President's Budget submission to Congress. This is the complete CIP which complements that abbreviated version and satisfies the provision in 49 U.S. Code (USC) 44501 that requires FAA to prepare and publish a national airways system plan. Prior to the submission of the FY 2017-2021 CIP, the FAA will be reviewing the requirements of 49 USC 44501 as well as the content and format of the current CIP to identify ways to clarify the document and address any duplication with other documents published by the agency.

The CIP must include the facilities and equipment the Administrator considers necessary to safely meet the forecasted needs of civil aeronautics and the Department of Defense. The plan should contain estimates of the cost and schedules for implementing required facilities and services. In the process of developing the CIP the FAA reviews information from the NextGen Implementation Plan, NAS Enterprise Architecture, acquisition management system and National Aviation Research Plan.

Section 1 of the CIP Introduction discusses FAA's Strategic Priorities and important factors affecting the planning for the future. Section 2 "Key Considerations in Capital Planning" presents the balance that must be addressed to sustain current system performance while transitioning to the Next Generation Air Transportation System (NextGen). Section 3, "NextGen Portfolios and Implementations", describes NextGen Portfolios and the planned Operational Improvements (OIs) that support the portfolio objectives. Section 4, "Enterprise Architecture Infrastructure Roadmaps", contains the Infrastructure Roadmaps, which outline the planned modernization of the NAS and describe the programs and systems included in the NAS architecture.

Appendix A links capital investment programs to FAA strategic priorities and performance metrics. Appendix B provides capital investment program descriptions, describes how programs contribute to performance metrics and provides program milestones and implementation schedules. Appendix C contains budget line items (BLI) included in the FY 2016 President's budget request and estimated outyear funding amounts from FY 2017 through FY 2020 for current and future BLIs. Appendix D provides cost and schedule status on major capital investment programs. Major programs are those classified as Acquisition Category (ACAT) 1, 2 or 3 which typically are programs with total Facilities and Equipment (F&E) costs greater than $100M or have significant impact, complexity, risk, sensitivity, safety or security issues. For more information on ACAT see: http://fast.faa.gov/AcquisitionCategories.cfm?p_title=Special Topics

Appendix E provides acronym and abbreviation definitions.

1.2 Strategic Priorities and the CIP

The FAA Administrator has established a strategic framework to define where the agency will focus its efforts. This framework includes high-level Strategic Priorities, as well as Priority Initiatives and related Performance Metrics that will measure how well FAA achieves the priorities. The four Strategic Priorities are:

- **Make aviation safer and smarter –** There is an imperative to be smarter about how FAA ensures aviation safety because the aviation industry is growing more complex. At the same time, FAA has more safety data than we have ever had before. This provides an opportunity to be more proactive about safety and constantly raise the bar.

- **Deliver benefits through technology and infrastructure –** The NextGen initiative gives FAA the opportunity to redefine the National Airspace System for the future and prove that benefits can be delivered to the users of the system. FAA also needs to safely integrate new types of user technologies into the airspace, as well as rebalance existing services and modernize our infrastructure, which will enable us to reduce our costs and become more efficient in the long run.

- **Enhance global leadership –** Aviation is a global industry. FAA has to continue to be a world leader in aviation and set the safety standard for others to measure against. FAA needs to be at the table to shape international standards to improve aviation safety and efficiency around the world.

- **Empower and innovate with the FAA's people –** The FAA's employees are the ultimate driver behind its success, and FAA needs the best and brightest talent with the appropriate leadership and technical skills to transform the FAA and the aviation system as a whole.

The Strategic Priorities guide the FAA in upgrading NAS systems and operating procedures to meet the demands of current operations and future growth. Performance Metrics are a tool the agency uses to track progress towards accomplishment of the Strategic Priorities. The agency depends on capital investments to meet the Performance Metrics.

The capital investment program summary in Appendix B identifies the primary Strategic Priority and Performance Metric that the program supports. Many FAA programs will contribute to more than one Strategic Priority or Performance Metric; however, the program alignment in the CIP (appendices A and B) is for the program's most significant contribution. In the summary tables in appendix A, several programs normally appear under each performance metric because many programs are interdependent; a single program by itself may not be successful in meeting a performance metric without other supporting programs. Also, in the complex system used for air traffic control (ATC), system and procedure improvements must address several different operating conditions to reach the overall performance metric, and often it takes multiple programs to address each of the variables, which individually contribute to overall system improvements.

Each program in Appendix B has a section titled, "Relationship of Program to FAA Performance Metric", which gives more specific information about how the program contributes to meeting a Performance Metric.

1.3 Important Factors Affecting Planning for the Future

1.3.1 Economic Considerations

Aviation plays a significant role in promoting economic growth and accounts for over five percent of the U.S. Gross Domestic Product. As NextGen modernizes the existing ATC system by introducing new technologies and advanced decision support tools to make air travel more efficient, safer and environmentally friendly, it supports growth in our economy. A study by the Air Traffic Organization (ATO) Performance Analysis Service Unit, "The Economic Impact of Civil Aviation on the U.S. Economy," published in June 2014, estimated that aviation accounted for over $1.5 trillion in economic activity in 2012, which is 5.4 percent of the total U.S. economic activity. The spending on aviation-related activities supported an estimated 11.8 million jobs. In support of commercial activities, air carriers transported over 61.2 billion revenue ton-miles of air cargo. A reliable worldwide aviation network is essential for today's economy. Domestic and international commerce rely on the access and passenger and freight capacity it provides to cities around the world to sustain economic growth.

1.3.2 Air Travel Demand

Historically, the demand for air travel is heavily influenced by changes in the economy. Figure 1-1 shows that the growth rate in revenue passenger miles (RPM) over the last 30 years has exceeded the growth rate of Gross Domestic Product (GDP).

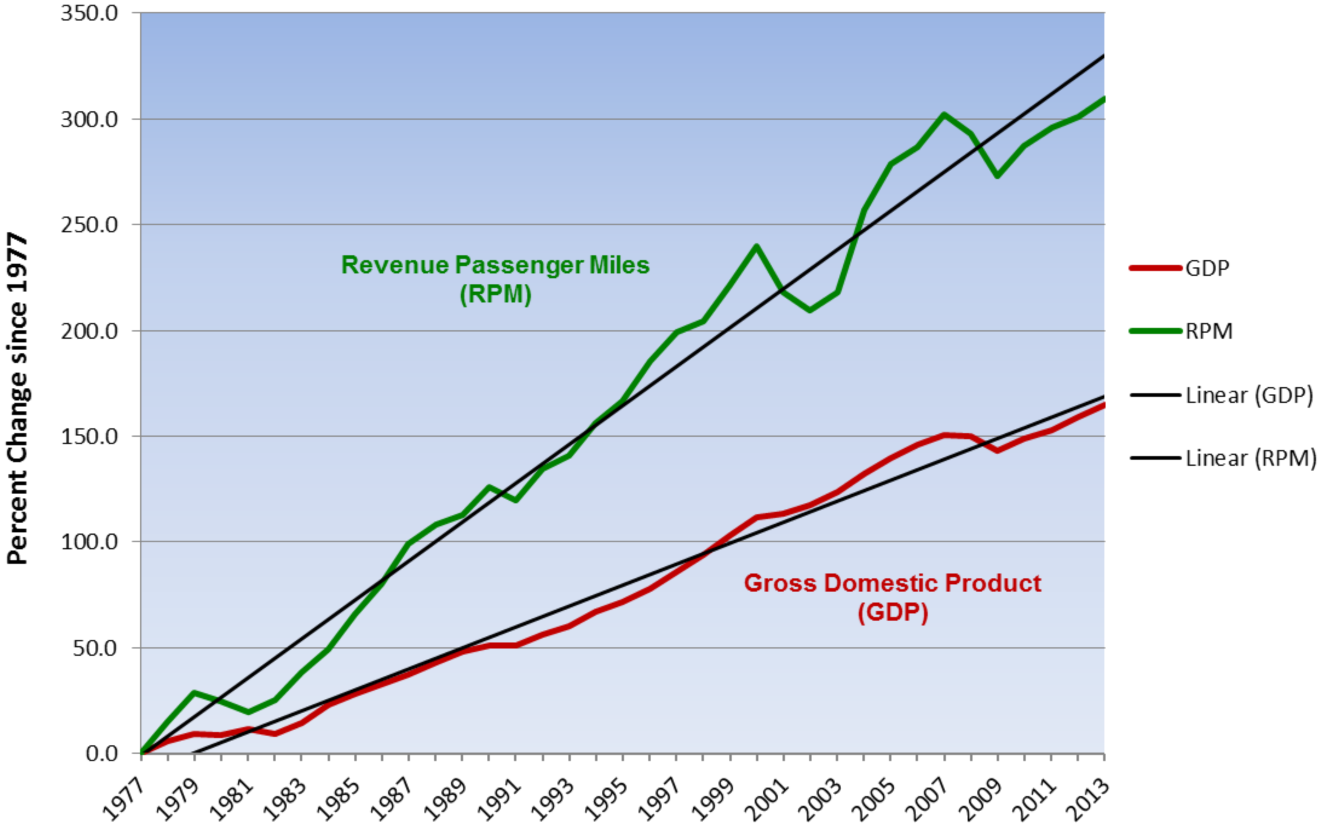

Figure 1-1 Air Travel Demand Growth Compared to Growth in GDP[1]

The U.S. inflation-adjusted (real) economic output long-term growth trend supports the continuing increases in air travel. Recent economic data show growth in GDP is rebounding and the trend lines in figure 1-1 show that continuing growth in the economy is very likely to generate growth in demand for air travel. Currently growth in air travel is being absorbed by larger aircraft and increased load factors, but there are limits to how long that can continue. Increased travel demand at core airports will ultimately result in increased aircraft operations and require that advanced NextGen capabilities be available to handle growth and minimize potential delays.

[1] Sources: U.S. Department of Commerce, Bureau of Economic Analysis and U.S. Department of Transportation, Bureau of Transportation Statistics

1.3.3 Airport Expansion Projects

Ongoing efforts to increase airport capacity with runway infrastructure improvements also affect the need for capital investment, especially at large hub airports, where flights are concentrated. Fort Lauderdale/Hollywood International Airport recently completed a runway extension to support air carrier operations. At Chicago O'Hare International Airport, a new runway opened in 2014 and another is scheduled to open in 2015. Further runway improvements are proposed at the airport for the north airfield. Philadelphia International Airport is extending a primary runway, as part of a long-term major airport reconfiguration program. John F. Kennedy International Airport has a runway reconstruction, widening, and extension project underway. Increasing capacity at large, congested airports is critical to overall NAS performance because delays at the large hub airports often propagate to other airports throughout the system. The 30 large hub airports handle about 72 percent of airline enplanements. The combined total of 63 large and medium hubs supports about 88% of all U.S. passenger enplanements. Clearly delays at large and medium hubs affect a significant number of passengers waiting to depart, as well as passengers waiting to board aircraft at the delayed flight's destination.

When airport authorities (in coordination with FAA) build new runways or otherwise expand capacity, these changes often require additional supporting navigation and surveillance equipment. New procedures may also be needed to make new capacity fully usable. New or relocated runways often require that airspace around the airports be reconfigured to accommodate new approach and departure patterns. Reconfiguration requires installing new navigational aids and precision landing systems to guide pilots in the approach patterns for the runways. When new or relocated precision approach guidance systems are installed, approach lights and visibility sensors must be positioned along the runway so that these systems can be used down to the lowest visibility approved for that airport. Some airports need new surveillance systems to cover expanded departure and approach patterns. Capital investment may also be needed to expand or relocate air traffic control facilities. In cases where significant increases in demand result from the airport improvements, additional controller positions may eventually be needed.

2 Key Considerations in Capital Planning

Capital investments normally involve extensive planning and development time. They often take several years to implement because the systems being purchased are technologically complex and require development of both new software and hardware. New systems also require extensive testing to ensure that they meet the reliability standards before they can be used for air traffic control. To be prepared for future increases in air traffic, capital investments to improve the capacity, as well as efficiency, predictability, and flexibility of the NAS must be made many years in advance of the anticipated growth.

Capital investing must also be balanced between adding new capabilities and ensuring the existing systems operate reliably until they can be replaced. FAA must sustain the performance of the current air traffic control system until a more capable system to handle future growth is in place.

2.1 Sustaining Current System Performance while Transitioning to NextGen

The air traffic control system requires very high reliability and availability. Aircraft on the ground and airborne in controlled airspace must maintain separation from other aircraft, and that depends on reliable operation of communication, navigation and surveillance systems. Each system in the NAS has a high level of redundancy to support system reliability and to minimize service disruptions. Much of this equipment must be replaced regularly to avoid the problems of obsolescence and to reduce the potential for system failures due to aging components that cause deterioration in system performance.

The air traffic control infrastructure is a complex system made up of several thousand components. There are 21 Air Route Traffic Control Centers (ARTCC) that house automation equipment used by air traffic controllers to control en route air traffic. There are over 500 Air Traffic Control Towers (ATCT) and 168 Terminal Radar Control (TRACON) facilities that control air traffic approaching, landing at and departing airports. The flow of air traffic is dependent on several hundred surveillance and weather radars; navigation systems for en route and airport approach guidance, and thousands of communication radios that allow pilots and air traffic controllers to be in continuous contact during an aircraft's flight.

NextGen will incrementally replace and improve much of this equipment to introduce new efficiencies in handling air traffic control, but some existing systems such as communication, navigation and surveillance equipment will stay in operation in the future to supplement or back up NextGen capabilities. Many of the buildings housing existing ATC equipment will also remain in service to house the new replacement NextGen systems. To sustain the high level of reliability and availability required for the safety and efficiency of flight, a continued level of investment in this valuable infrastructure is necessary.

The air traffic control infrastructure has an estimated $4.4B backlog of requirements for sustaining its facilities. Goals, objectives, strategies, processes, and priorities are being established to meet this challenge. Eight systemic issues have been identified that need to be addressed across the ATO: Mold remediation, Fire Life Safety, Fall Protection, Arc Flash, Power Cable, Engine Generators, Fuel Storage Tanks, and ARTCC Chiller replacement.

As requested in the FY 2016 Budget, the ATC Facilities Strategic Sustainment Plan was developed to support the following programs for emphasis in sustaining the NAS:

- ARTCC Building Improvements/Plant Improvements, BLI 2A04;
- Air Traffic Control En Route Radar Facilities Improvements, BLI 2A07;
- Terminal Air Traffic Control Facilities – Replace, BLI 2B06;
- ATCT/TRACON Facilities – Improve, BLI 2B07;
- NAS Facilities Occupational Safety and Health Administration (OSHA) and Environmental Standards Compliance, BLI 2B09;
- Fuel Storage Tank Replacement and Monitoring, BLI 2E01;
- Unstaffed Infrastructure Sustainment, BLI 2E02;
- Facilities Decommissioning, BLI 2E06;
- Electrical Power Systems - Sustain/Support, BLI 2E07;
- FAA Employee Housing and Life Safety Shelter System Service, 2E08;
- Energy Management and Compliance (EMC), BLI 2E09;
- Hazardous Materials Management, BLI 3A01;
- Facility Security Risk Management, BLI 3A05; and
- Mobile Assets Management Program, BLI 3A12.

In addition to air traffic control infrastructure, the FAA has other facilities that support the NAS. The Mike Monroney Aeronautical Center includes facility space used for Air Operations, Engineering, Training (Radar/Navigational Aids (Navaids)), NAS Logistics, Airmen/Aircraft registration, Civil Aeromedical research, Safety, and Business Services. The William J. Hughes Technical Center supports research, test and evaluation of safety systems and new equipment. The infrastructure at these locations requires building system and telecommunications replacement.

Key investments in air traffic control systems that support current and future operation of the NAS are:

- **Terminal Automation –** Older terminal systems must be upgraded to accept Automatic Dependent Surveillance-Broadcast (ADS-B) position reporting and also modernized to a common automation platform to support NextGen and reduce maintenance costs;
- **En route Automation –** The new En Route Automation Modernization (ERAM) platform is operational at all sites. This new platform will require continuing enhancements to support implementation of many NextGen operational enhancements;
- **Navigation/Landing –** The Wide Area Augmentation System (WAAS) program will continue to augment the Global Positioning System (GPS) to support the implementation of improved procedures that are dependent on satellite navigation capabilities. Instrument Landing System (ILS) and other Navigation aids (Navaid) systems will be installed as necessary to replace older unreliable and unsupportable systems; and
- **Surveillance/Weather –** Modernization of en route and terminal primary and secondary surveillance radars will be implemented to upgrade or replace aging unsupportable systems. Weather sensing and processing equipment will also be modernized.

More details on all of the systems and infrastructure are provided in Appendix B.

2.2 Planning for the Future through NextGen Investments

NextGen is an umbrella term for the ongoing, wide-ranging transformation of the NAS to ensure that future safety, capacity and environmental needs are met. NextGen will fundamentally change the way air traffic is managed by combining new technologies for surveillance, navigation, and communications with automation system enhancements, workforce training, procedural changes, and airfield development, while facilitating the introduction and integration of new types of vehicles and operations, such as commercial space operations and unmanned aircraft systems.

NextGen advances will enable precise monitoring of aircraft on the ground and in flight, allow direct routes for travel between cities, improve decision support to manage traffic flows strategically on busy routes, and take advantage of precise navigation aids for fuller use of existing airspace and runway capacity. Having already implemented many of the milestones needed for this transformation, we are reaping the benefits of NextGen today.

The NextGen Implementation Plan provides more information concerning the vision, benefits and implementation details. http://www.faa.gov/nextgen/library/

Development of NextGen OIs can include concept development, modeling the changes in ATC performance, safety analyses, demonstrations of new capabilities, international coordination, standards development, and other pre-implementation activities. When a new concept is adopted, the improvement is implemented by procedure changes, system enhancements, air space changes, training, and upgrades to aircraft avionics as necessary. Development of OIs involves participation by all FAA organizations in cooperation with NAS users. Capital investment programs support the activities leading up to the initial investment management decisions for implementation. A solution, when fully developed, is baselined for acquisition and implementation. More information can be found on OIs in section 3.

Some of the larger NextGen programs that provide the foundation for the introduction of new NextGen OIs are:

- **En Route Automation Modernization (ERAM) – System Enhancements and Technology Refresh** – This program will be upgrading the ERAM software to support NextGen OIs and provides replacement hardware for the ERAM system (BLI 2A01);
- **System Wide Information Management (SWIM)** – SWIM provides the standards, hardware and software to enable information management and data sharing required to support NextGen. This includes Common Support Services – Weather (CSS-Wx) which provides access for NAS users to a unified aviation weather picture (BLI 2A11);
- **ADS-B NAS Wide Implementation (ADS-B)** – ADS-B provides more accurate and timely surveillance data needed to allow direct routing and conflict free routes (BLI 2A12);
- **NextGen Weather Processor (NWP) –** This program will establish a common weather processing platform which will provide improved weather products and support more efficient operations (BLI 2A17);

- **Data Communications in support of NextGen –** Data Comm provides data link communications between controller and pilot to facilitate information transfer, reduce workload and minimize potential errors in communication flight plan adjustments (BLI 2A19);
- **National Airspace System Voice System (NVS) –** NVS will provide a nationwide network of digital voice switches for terminal and en route air traffic facilities. These new systems will provide voice switch configuration flexibility required to support facility backup (BLI 2B13); and
- **Aeronautical Information Management (AIM) Program –** AIM provides digital aeronautical information to NAS users (BLI 4A09).

3 NextGen Portfolios and Implementations

This section contains descriptions of the fundamental changes FAA wants to accomplish with NextGen investments. Before planning the future systems architecture of the air traffic control system, goals must be established regarding the types of performance improvements that will be achieved. Those goals are defined by Operational Improvements listed in the NextGen portfolios described below and represent specific enhancements to present levels of performance that will be possible with NextGen investments.

As NextGen has progressed, pre-implementation work has transitioned into the implementation phase. The NextGen concept development and pre-implementation work is now focused on the next useful segments of capabilities developed in base programs. The efforts described in this section include the engineering and acquisition work to add functionality to base systems and the complementary and necessary effort in standards, guidance and operational descriptions/procedures.

To address RTCA Task Force 5 and NAS working group recommendations, the structure of NextGen planning documents has shifted to focus on implementation portfolios in the NAS Segment Implementation Plan (NSIP) and the NextGen Implementation Plan (NGIP).

The OIs included in this section are targeted for implementation within the 2016-2020 timeframe. Each portfolio section and its corresponding OI descriptions are followed by a list of the portfolio programs that support the OIs. For information concerning the implementing systems, refer to the NAS Enterprise Architecture Infrastructure Roadmap descriptions in Section 4. To obtain more information on NextGen accomplishments visit the following site: http://www.faa.gov/nextgen/snapshots/

Each OI has a 6 digit number assigned and these numbers are included as a reference in the text below. The first 3 digits identify the FAA Service, for example, Air Traffic Management (ATC) Separation Assurance/ Separation Management. The second 3 digits are a unique ID. Additional information can be found on the NAS Enterprise Architecture Web site at: https://nasea.faa.gov

3.1 Separation Management Portfolio

This portfolio provides controllers and pilots with tools and procedures for performing separation management in all of the airspace and airports within the NAS. The aircraft separation assurance service is the cornerstone of ATC operations, and the investments tied to this portfolio provide the tools, procedures, standards and guidance to better manage aircraft in a mixed environment with varying navigation equipment and wake performance capabilities. Enhancements to separation management are articulated in the following Operational Improvements:

Flight Management with Trajectory

Develops and maintains all information about a flight and makes that information available to all decision support tools to improve strategic flight planning and tactical flight management. Users may also supply trajectory option sets that represent their route preferences in the event of a constraint, such as weather. Trajectory flight data will continue to be updated for changes and made available to subscribers so that tactical and strategic plans are developed with the most up to date 4D flight trajectory. (OI: 101202)

Oceanic In-trail Climb and Descent

Air navigation service provider (ANSP) automation enhancements take advantage of improved communication, navigation and surveillance coverage in oceanic airspace to allow climbs and descents with lower separation between the two aircraft. When authorized by the controller, pilots of equipped aircraft can reach more optimal flight altitudes earlier. (OI: 102108)

Initial Conflict Resolution Advisories

The ANSP automation supports the controller in predicting and resolving conflicts. Automation is enhanced not only to recognize conflicts but also to provide rank-ordered resolution advisories to the ANSP. (OI: 104104)

Automation Support for Separation Management

ANSP automation provides the controller with tools to manage aircraft separation in a mixed navigation and wake performance environment. Advances in Performance Based Navigation and additional wake separation categories leads to the use of more sophisticated separation rules between aircraft and the need for advisory support to the controller. (OI: 102137)

Wake Re-Categorization

The current set of pairwise wake separation requirements have been updated and expanded based on analysis of wake generation, wake decay and encounter effects for the current fleet of aircraft. These new separation standards are programmed into the automation systems to allow the controllers to use more accurate aircraft separation standards to increase both flight efficiency and runway capacity utilization. (OI: 102154)

Interactive Planning Using 4D Trajectory Information in the Oceanic Environment

Interactive planning between the airspace user and FAA automation both before and after departure enhances the ability of the flight to fly closer to the user's preferred 4D trajectory. Given the long duration of oceanic flights, there are often changes to wind and weather conditions while the flight progresses which change the flight's progress along the route. The exchange of the route information from the aircraft provides the FAA with more up to date location information. Automation improvements allow the user to more easily request trajectory changes to better fit the new conditions. (OI: 104102)

Integrated Arrival/Departure Airspace Management

This capability expands the use of terminal separation standards and procedures into current en route airspace (horizontally and vertically). A redesign of the airspace where a flight transitions from en route to terminal control will permit a greater number of Area Navigation (RNAV) and Required Navigation Performance (RNP) procedures to allow for increased throughput. (OI: 104122)

Reduced Horizontal Separation Standards, En Route - 3 Miles

By taking advantage of advances in surveillance and surveillance data processing, the ANSP provides reduced separation (down to 3 miles) in greater portions of en route airspace. These reductions will allow procedures with lower separation minima and enable controllers to use more flight efficient clearances to manage conflict resolution. (OI: 102117)

Automated Support for Conflict Resolution

Automated assistance is provided to probe pilot 4D trajectory change requests considering flow requirements and constraints, and identifies potential conflicts. Resolution alternatives provided to the ANSP are improved by including flow constraints in order to safely resolve conflicts while supporting both tactical and strategic objectives. (OI: 104127)

Improved Management of Special Activity Airspace (SAA)

Special Activity Airspace availability is optimized and managed in real-time, based on actual flight profiles and real-time operational use parameters. Assignments, schedules, coordination, and changes to status of SAA are made readily available for operators and ANSPs using automation systems. (OI: 108212)

Current En Route Separation

Current En Route Separation services will be provided to Unmanned Aircraft Systems (UAS) through the seamless integration of communications between pilots-in-command of UAS and air traffic controllers. (OI: 102112)

Capital Investments That Support Separation Management

Pre-implementation activities which provide developmental engineering, standards, implementation guidance and investment support include these programs which are described in Appendix B, BLI 1A05.

- ADS-B In Applications – Flight Interval Management, G01S.02-01
- Modern Procedures, G01A.01-01
- Alternative Positioning Navigation and Timing, G06N.01-06
- Wake Turbulence Re-Categorization, G06M.02-02
- Oceanic Tactical Trajectory Management, G01A.02-02
- Unmanned Aircraft Systems (UAS) Concept Validation & Requirements Development, G01A.01-09
- Reduced Oceanic Separation, G02S.04-01
- Separation Automation System Engineering, G01A.01-06
- Separation Management Concepts & Analysis, G01M.02-04
- NextGen Oceanic Capabilities, G01A.01-07
- Conflict Advisories, G01A.02-03

3.2 Improved Surface/ Terminal Flight Data Manager (TFDM) Portfolio

The NextGen Improved Surface/TFDM portfolio addresses airport surface/tower shortfalls associated with the lack of timely and accurate operational data exchange and the inability to efficiently manage traffic flows into, on, and departing from airports when airspace restrictions exist. The portfolio focuses on improved airport surveillance information, automation to support airport configuration management and runway assignments, and enhanced cockpit displays to provide increased situational awareness for controllers and pilots.

Provide Full Surface Situation Information

Automated broadcast of aircraft and vehicle position to ground and aircraft sensors/receivers provides a digital display of the airport surface. Aircraft and vehicles are identified and tracked to provide a comprehensive picture of the surface environment to ANSPs, equipped aircraft, and flight operations centers. (OI: 102406)

Initial Surface Traffic Management

Departures are sequenced and staged to maintain throughput. ANSP uses automation to integrate surface movement operations with departure sequencing to ensure aircraft meet departure schedule times while optimizing the physical queue in the movement area. (OI: 104209)

Enhanced Separation Services to Small Community Airports

Improved surveillance and communication capabilities at or near smaller community airports allow for increased capacity in previous non-radar environments providing improvements over non-radar separation guidelines. (OI: 102138)

Enhanced Departure Flow Operations

Efficient departure operations are achieved through the improved ability to quickly revise departure clearances in the event that changing weather, winds or system constraints requires amendments to the pre-departure clearance. Traffic managers create route amendments and send the updated flight data to air traffic controllers for delivery to affected flights. Revised departure clearances are issued electronically to equipped aircraft. (OI: 104208)

Capital Investments That Support Improved Surface/TFDM

Pre-implementation activities which provide developmental engineering, standards, implementation guidance and investment support include these programs which are described in Appendix B, BLI 1A06.

- Terminal Flight Data Manager (TFDM) – Segment 1, G06A.03-01
- Surface Tactical Flow, G02A.01-01
- Surface Conformance Monitoring, G02A.01-02

3.3 On-Demand NAS Portfolio

This portfolio ensures that NAS and other aeronautical information is consistently provided across all NAS applications and locations using common net enabled access to aeronautical and flight information utilizing global standards – Aeronautical Information Exchange Model (AIXM) and Flight Information Exchange Model (FIXM).

Improved Management of Special Activity Airspace

Special Activity Airspace availability is optimized and managed in real-time, based on actual flight profiles and real-time operational use parameters. Assignments, schedules, coordination, and changes to status of SAA are made readily available for operators and ANSPs using automation systems. (OI: 108212)

On-Demand NAS Information

NAS and aeronautical information will be available to users on demand. This information is consistent across applications and locations that are available to authorized subscribers and equipped aircraft. Proprietary and security-sensitive information is not shared with unauthorized agencies or individuals. (OI: 103305)

Enhanced Traffic Advisory Services

Aircraft equipped with Automatic Dependent Surveillance-Broadcast (ADS-B) and UAS equipped with sense and avoid avionics broadcast their position, and other aircraft and UAS operators that are properly equipped receive these broadcasts and display traffic data to flight crews and UAS operators. Ground-based systems can also rebroadcast this information to aircraft that are not equipped with ADS-B In. (OI 103209)

Tailored Delivery of On-Demand NAS Information

The delivery of selected NAS and aeronautical information data elements will be available to users and tailored based on the information that pertains to their flight trajectory. (OI 103306)

NAS Wide Sector Demand Prediction and Resource Planning

NAS wide capacity resource drivers, such as airspace and runway access, route availability, and controller workload, modeled in parallel with systemic and dynamic changes to user demand are integrated into one decision support tool. (OI 105104)

Capital Investments That Support On-Demand NAS

Pre-implementation activities and future programs which provide developmental engineering, standards, implementation guidance and investment support include these programs which are described in Appendix B, BLI 1A07.

- Flight Object, G05A.02-03
- Common Status and Structure Data, G05A.02-01
- Flight Object Exchange Services (FOXS), G05A.02-08
- Dynamic Airspace, G05A.04-01
- Advanced Methods, G05A.02-02
- Collaborative Information Management (CIM), G05M.02-01
- Airspace Resource Management System (ARMS), G05A.02-09

3.4 Environment Portfolio

This portfolio focuses on investigations, demonstrations and development of methods to integrate environmental impact mitigation and energy efficiency into the NextGen infrastructure. Integrating impact mitigation and energy efficiency with NextGen improvements to support aviation growth will ensure that FAA goals for environmental issues are met. The establishment and implementation of the NextGen Environmental Management System Framework develops the strategy for integrating environment considerations into decision making for system improvements. It also provides a foundation for facilitating effective and efficient environmental reviews to assess compliance with the National Environmental Policy Act.

Integrated Environmental Modeling - Phase I

Develop an integrated aviation environmental analysis tool suite that is based on the best available scientific knowledge and use this capability to evaluate both the environmental impacts of aviation as well as the performance of potential mitigation. (OI: 701102)

Environmental Policies, Standards and Measures - Phase I

Develop and implement appropriate policies, programs, and mechanisms to mitigate the environmental impacts of aviation. Enable the use of the NextGen Environmental Management System (EMS) framework to address, plan and mitigate environmental issues, through development of an initial EMS framework, pilot analysis, and outreach programs. (OI: 704102)

Integrated Environmental Modeling - Phase II

Enhance the integrated aviation environmental analysis tool suite to reflect new scientific information and use this capability to evaluate both the environmental impacts of aviation as well as the performance of potential mitigation options. (OI: 701103)

Environmental Policies, Standards and Measures - Phase II

Continue to develop and implement appropriate policies, programs, and mechanisms to mitigate the environmental impacts of aviation. The NextGen Environmental Management System (EMS) framework will be used to address, plan and mitigate environmental issues. (OI: 704103)

Capital Investments That Support Environment

The Environment Portfolio is a combination of research related to fuels, engines and airframes and investigating the impact of implementing NextGen changes on the NAS and air traffic management. Pre-implementation activities in F&E which provide developmental engineering, standards, implementation guidance include this program which is described in Appendix B, BLI 1A08.

- Environmental Management System and Noise/Emission Reduction, G06M.02-01

3.5 Improved Multiple Runway Operations Portfolio

The Improved Multiple Runway Operations portfolio enables the FAA to more efficiently use runway capacity through the use of improved technology, updated standards, safety analysis, and air traffic tools and operating procedures to enable more arrival and departure operations.

Wake Turbulence Mitigation for Departures (WTMD): Wind-Based Wake Procedures

Procedures are developed at applicable locations based on the results of analysis of wake measurements and safety analysis to reduce the time delay necessary for an aircraft waiting to depart to insure it will not be adversely affected by wake turbulence from an aircraft departing before it. During peak-demand periods, these procedures allow airports to maintain airport departure throughput during favorable wind conditions. (OI: 102140)

Improved Parallel Runway Operations

This improvement will explore concepts to recover lost capacity through reduced separation standards, increased applications of advanced dependent and independent procedures, and enabling operations in lower-visibility conditions. (OI: 102141)

Improved Parallel Runway Operations with Airborne Applications

Improved flight deck capabilities allow for increased arrival capacity for parallel runway operations in Instrument Meteorological Conditions. Reduced separation for dependent approaches of closely spaced parallel runways will be enhanced through the use of aircraft avionics that assist pilots in maintaining the required interval from other aircraft. Ground automation identifies opportunities to the controller who can provide a clearance to the flight crew for specific lateral and longitudinal separation distance from other aircraft. (OI: 102157)

Wake Turbulence Mitigation for Arrivals: CSPRs

Initially, dependent separation between aircraft on parallel approach courses to Closely Spaced Parallel Runways (CSPRs) will be procedurally reduced in Instrument Meteorological Conditions (IMC) in all crosswind conditions to something less than today's wake separation behind heavy or B757 aircraft based on a safety analysis of the airport geometry, local meteorology and other factors at each airport. Further separation reduction will be permitted down to radar minima for dependent approaches (1.5 nm stagger) using wind sensing and prediction systems to determine when crosswinds are sufficiently stable and strong enough that wake turbulence drift and decay will ensure safe separation reduction. (OI: 102144)

Ground Based Augmentation System (GBAS) Precision Approaches

Global Positioning System (GPS)/GBAS support precision approaches to Cat I and eventually Cat II/III minima for properly equipped runways and aircraft. GBAS can support approaches at airports which require fewer restrictions to surface movement and offers the potential for curved precision approaches. GBAS may also support high-integrity surface movement requirements. (OI: 107107)

Capital Investments That Support Improved Multiple Runway Operations

Pre-implementation activities which provide developmental engineering, standards, implementation guidance and investment support include these programs which are described in Appendix B, BLI 1A09.

- Wake Turbulence Mitigation for Arrivals (WTMA), G06A.01-02
- Closely Spaced Parallel Runway Operations, G06N.01-02
- Ground Based Augmentation System (GBAS), G06N.01-01
- Enhanced Service Small Communities (ESSC), G03M.04-02

3.6 NAS Infrastructure Portfolio

Success in the functional portfolios is often dependent upon changes made to existing systems or the implementation of new systems. This portfolio provides cross-cutting research, early system engineering activities, development, and analysis of capabilities that have substantial cross-portfolio dependencies.

Current Oceanic Separation

The use of ATOP will be expanded into domestic-to-oceanic transition sectors to provide the controllers with integrated rules for setting up transitioning traffic to/from oceanic airspace. Enhancements include modifications needed to handle tactical 5 nautical mile separations. (OI: 102105)

Automated Support for Initial Trajectory Negotiation

En Route sector capacity and throughput are increased through the ability to send route changes and instructions to the cockpit over data communications. Trajectory management is enhanced by automated assistance to negotiate pilot trajectory change requests with properly equipped aircraft operators. (OI: 102158)

On-Demand NAS Information

An integrated set of weather information will be available to users on demand. This information is consistent across applications and locations that are available to authorized subscribers and equipped aircraft. (OI: 103305)

Initial Integration of Weather Information into NAS Automation and Decision Making

Advances in weather information content and dissemination provide users and/or their decision support tools with the ability to identify specific weather impacts on operations (e.g., trajectory management and impacts on specific airframes, arrival/departure planning) to ensure continued safe and efficient flight. (OI: 103119)

Full Improved Weather Information and Dissemination

Weather information will be translated into constraint information to be fully integrated into decision-support technologies. Advanced impact assessment tools improve ANSP and user tactical and strategic planning by providing consolidated weather processing of observational and forecast capabilities to produce consistent weather information for ATM decision-making. (OI: 103121)

Full Integration of Weather Information into NAS Automation and Decision Making

Consistent and improved weather data integrated into decision support tools will enable more effective and timely decision making by both ANSPs and flight operators for meeting capacity, efficiency, and safety objectives. (OI: 103123)

Capital Investments That Support NAS Infrastructure

Pre-implementation activities which provide developmental engineering, standards, implementation guidance and operational descriptions/procedures include these programs which are described in Appendix B, BLI 1A10.

- Weather Observation Improvements, G04W.02-01
- Weather Forecast Improvements, G04W.03-01
- NextGen Navigation Engineering, G06N.01-03
- New ATM Requirements, G01M.02-02
- Surface/Tower/Terminal Systems Engineering, G06A.02-01

3.7 NextGen Support Portfolio at WJHTC

This portfolio will continue to explore new technologies at the NextGen laboratories and support operational assessment for system performance.

Capital Investments That Support NextGen Support Portfolio at WJHTC

The NextGen Support Portfolio provides the laboratories and test beds needed for the development of systems to support operational improvements. The portfolio also provides for the assessment of operational benefits from the NextGen implementation. The program is described in Appendix B, BLI 1A11.

- NextGen Laboratories, G03M.02-01

3.8 Performance-Based Navigation & Metroplex Portfolio

The Performance Based Navigation (PBN) portfolio leverages satellite navigation technology and improved aircraft navigation performance to improve access and flexibility for point-to-point navigation using RNAV and RNP. It also supports the more flexible approaches and departures that save fuel and allow more efficient use of runway capacity. It improves operational efficiency for airports located in metroplexes.

Area Navigation (RNAV) Standard Instrument Departure (SID), Standard Terminal Arrival Routes (STAR), and Approaches

This improvement will develop RNAV routes, SIDs and STARs to allow more efficient flights, saving fuel and time. RNAV will be available throughout the NAS using satellite-based avionics equipment and systems. (OI: 107103)

Increase Capacity and Efficiency Using RNAV and Required Navigation Performance (RNP)

This improvement will allow use of RNAV and RNP to enable more efficient aircraft trajectories. Combined with airspace changes, RNAV and RNP increase airspace efficiency and capacity. Further efficiencies will be gained through the development and implementation of advanced RNP criteria. RNAV and RNP will permit the flexibility of point-to-point operations and allow for the development of routes, procedures, and approaches. (OI: 108209)

Capital Investments That Support Performance Based Navigation & Metroplex

The Performance Based Navigation & Metroplex Portfolio is implemented through these programs described in Appendix B, BLI 1A12.

- NextGen Performance Based Navigation (PBN) – Metroplex Area Navigation (RNAV)/Required Navigation Performance (RNP), G05N.01-01
- Concept Development for Integrated NAS Design and Procedure Planning, G05A.02-04

3.9 Collaborative Air Traffic Management Portfolio

The Collaborative Air Traffic Management portfolio addresses shortfalls in modeling strategic traffic management initiatives, using decision support tools, supporting collaboration between traffic managers and airspace users and establishing capabilities to manage traffic flow strategically. It helps NAS operators and FAA traffic managers, using advanced automation to manage daily airspace and airport capacity issues such as congestion, special activity airspace and weather. Updated automation will deliver routine information digitally.

Provide Full Flight Plan Constraint Evaluation with Feedback

Constraint information that impacts the proposed route of flight is incorporated into ANSP automation, and is available to users. A user can adjust the flight plan based on available information. (OI: 101102)

Provide Interactive Flight Planning from Anywhere

Flight planning activities are accomplished from the flight deck as readily as at any other location. Airborne and ground automation provide the capability to exchange flight planning information and negotiate flight trajectory agreement amendments in near real-time. (OI: 101103)

Interactive Planning Using 4D Trajectory Information in the Oceanic Environment

Interactive planning between the oceanic airspace user and FAA automation both before and after departure enhances the ability of the flight to fly closer to the user’s preferred 4D trajectory. Users can receive feedback on intended Oceanic trajectory and adjust plans if desired. (OI: 104102)

Enhanced Departure Flow Operations

Efficient departure operations are achieved through the improved ability to quickly revise departure clearances in the event that changing weather, winds or system constraints requires amendments to the pre-departure clearance. Traffic managers create route amendments and send the updated flight data to air traffic controllers for delivery to affected flights. (OI: 104208)

Full Collaborative Decision Making

Timely, effective, and informed decision-making based on shared situational awareness is achieved through advanced communication and information sharing systems. (OI: 105207)

Traffic Management Initiatives with Flight Specific Trajectories

This capability will increase the agility of the NAS in adjusting and responding to dynamically changing conditions such as severe weather, congestion and system outages through the automated generation and dissemination of route changes. (OI: 105208)

Continuous Flight Day Evaluation

Continuous (real-time) constraints are provided to ANSP traffic management decision-support tools and the NAS users which improves system constraint predictions and assessments of proposed mitigation strategies. The FAA, in collaboration with users, develops mitigation strategies that consider the potential constraints. (OI: 105302)

Capital Investments That Support Collaborative Air Traffic Management

Activities which provide developmental engineering, standards, implementation guidance and investment support include these programs which are described in Appendix B, BLI 2A14.

- Collaborative Air Traffic Management Technologies (CATMT) – Work Package 3, G05A.05-02
- Collaborative Air Traffic Management (CATM) – Work Package 4, G05A.05-03
- Strategic Flow Management Application, G05A.01-01
- Strategic Flow Management Engineering Enhancement, G05A.01-02

3.10 Time-Based Flow Management (TBFM) Portfolio

The Time-Based Flow Management portfolio enhances system efficiency by:

- Implementing Time-Based Metering (TBM) capability and its trajectory modeler at additional locations;
- Enhancing departure capabilities; and
- Merging a larger proportion of approaching air traffic into the terminal environment to enhance efficiency of PBN procedures and better balance demand with capacity.

Improved Management of Arrival/Surface/Departure Flow Operations

This improvement integrates advanced arrival/departure flow management with advanced surface operation techniques to improve overall airport capacity and efficiency. (OI: 104117)

Point-in-Space Metering

The ANSP uses scheduling tools and trajectory-based operations to assure smooth flow of traffic and increase the efficient use of airspace. Point-in-space metering can be associated with a departure fix, arrival fix, or any other point-in-space, such as airspace boundaries or other flow converging points. Decision support tools will allow traffic managers to develop scheduled arrival times for constrained resources and allow controllers to manage aircraft trajectories to meet the scheduled meter times. (OI: 104120)

Time Based Metering Using RNAV and RNP Route Assignments

RNAV, RNP and time-based metering provide efficient use of runways and airspace in high-density airport environments. Metering automation will manage the flow of aircraft to meter fixes that are the point for aircraft to enter the pattern for runway approaches, thus permitting efficient use of runways and airspace. (OI: 104123)

Time-Based Metering in the Terminal Environment

This OI extends current metering capabilities into the terminal environment and furthers the pursuit of end-to-end metering and trajectory-based operations. It also supports capabilities designed to expand the use of terminal separation standards in transition airspace, and solidifies the foundation for future advanced airborne-based applications that will depend upon ground-based automation to maintain the complete sequence of aircraft into and out of high density terminal locations. (OI: 104128)

Interval Management-Spacing (IM-S)

This OI enables controllers to identify, initiate, and monitor the spacing between aircraft, when they direct flight crews to establish and maintain a given time or distance from a designated aircraft. Controllers will be assisted with ground automation and a new set of voice or datalink procedures. (OI: 102118)

Capital Investments That Support Time Based Flow Management

Activities which provide developmental engineering, standards, implementation guidance and investment support include these programs which are described in Appendix B, BLI 2A15.

- Time Based Flow Management Work Package 3, G02A.01-06
- Time Based Flow Management Technology Refresh, G02A.01-07
- Time Based Flow Management Work Package 4, G02A.01-08

3.11 System Safety Management Portfolio

This portfolio contains activities that ensure that changes introduced with NextGen deliver benefits and either enhance or, at a minimum, do not degrade safety. These changes include the development and implementation of policies, processes and analytical tools that the FAA and industry will use for more efficient operations.

Safety Information Sharing and Emergent Trend Detection

Information analysis and sharing directly supports safety promotion and safety assurance initiatives. It supports analytical efforts such as the comparison of baseline information and trends. It also indirectly supports safety risk management through issue identification, information and tools for analysis of hazards. (OI: 601103)

Enhanced Safety Information Analysis and Sharing

Aviation Safety Information Analysis and Sharing (ASIAS) will improve system-wide risk identification, integrated risk analysis and modeling and implementation of emergent risk management. (OI: 601102)

Integrated Safety Analysis and Modeling

This OI mitigates safety risk associated with the design, evolution and implementation of NextGen by providing enhanced integrated safety methods. It will provide advanced capabilities for integrated, predictive safety baseline risk assessment; advanced capabilities for integrated risk analysis; improved validation and verification processes supporting certification; simulation protocols that provide enhanced evaluation frameworks for safe operational procedures; and enhanced training requirements analysis for safe system operation. (OI: 601202)

Capital Investments That Support System Safety Management

The System Safety Management Portfolio is implemented through these programs which are described in Appendix B, BLI 3A10.

- Aviation Safety Information Analysis and Sharing (ASIAS), G07A.02-01
- Systems Safety Management Transformation (SSMT), G07M.02-01

4 Enterprise Architecture Infrastructure Roadmaps

The detailed infrastructure roadmaps appearing in the following subsections are an integral part of the NAS Enterprise Architecture and show the existing systems in the NAS, and the planned capital programs for legacy and NextGen systems. The roadmaps show planned modernization beyond the 5-year horizon covered in the CIP, because planning to meet future needs of the NAS extends beyond that timeframe. Upgrading the sophisticated systems used for air traffic control requires significant engineering development efforts to ensure the continued safety and efficiency of the NAS while inserting advanced technology into working systems. The roadmaps present an executive view of the programs and systems that make up the NAS and do not include every aspect of the detailed planning behind them. Timelines are included to show the length of time existing systems or their replacements will remain in service. They help FAA program managers anticipate future engineering and financial challenges and integrate the modernization efforts by showing how updates to other systems will impact their program.

Many improvements shown in the roadmaps will also require aviation users to add equipment to their aircraft and adopt new procedures, so the roadmaps serve to inform them what they should expect regarding changes to their equipment and crew training. These roadmaps are updated annually to reflect results of studies, demonstration projects, and economic analysis related to programs; however, the roadmaps are, and should be, reasonably stable from year-to-year. For more detailed information on the roadmaps, view the Enterprise Architecture and Infrastructure Roadmaps at: https://nasea.faa.gov

The infrastructure roadmaps in this section organize the architecture based on functional areas. The systems on the left side in each of the diagrams are currently in service. Funding to maintain and operate the in-service systems is provided by the Operations account. Capital investments to upgrade or replace systems are shown by the program boxes within the roadmap timeline; the box reflects the timeframe for funding the programs. Legacy programs are portrayed as gray bars and NextGen programs are shown as orange bars. To associate programs in the FAA Enterprise Architecture with the funding provided in Appendix C, BLI number references are included at the end of each of the descriptions contained within this section.

Figure 4-1 shows and defines the symbols used in the infrastructure roadmaps. The solid red lines indicate the time the systems, or their replacements will remain in operation and the dashed lines indicate that a system is scheduled to be replaced or taken out of service; final date of operation is indicated with an X. The boxes with names identify programs, functions or systems, which are either described in the text or, when they are not described, their acronyms are spelled out in Appendix E.

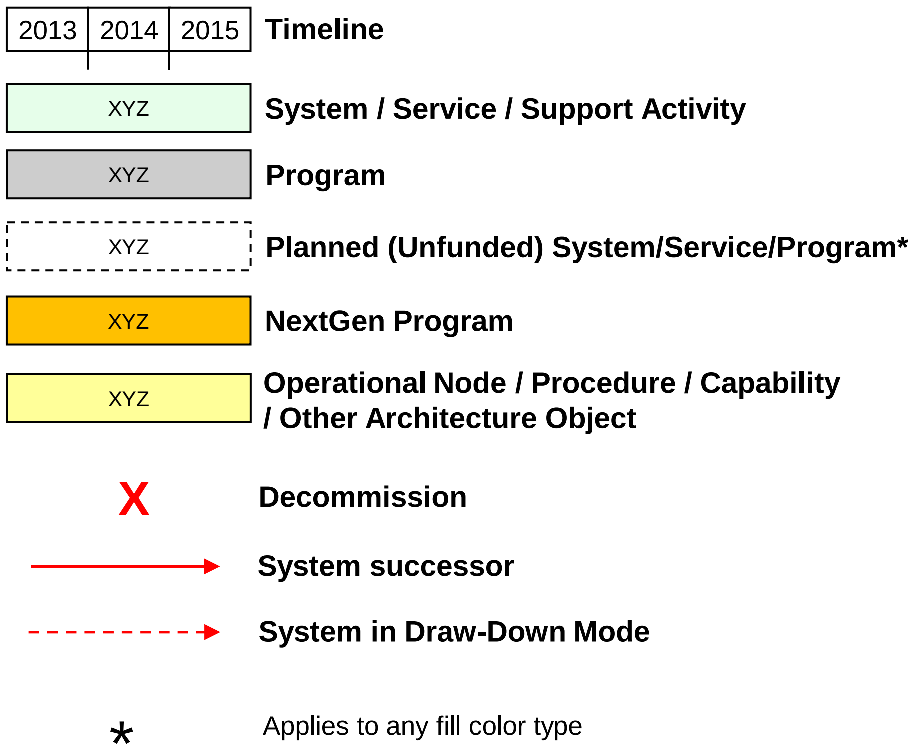

Figure 4-1 Infrastructure Roadmap Legend

4.1 Automation Roadmaps

Automation is a core element of the air traffic control system. Controllers require a real-time display of aircraft location as well as information about the operating characteristics of aircraft they are tracking—such as speed and altitude—to keep the approximately 60,000 daily flights safely separated. Automation gives controllers continuously updated displays of aircraft position, identification, speed, and altitude as well as whether the aircraft is level, climbing, or descending. Automation systems can also continue to show an aircraft's track when there is a temporary loss of surveillance information. It does this by calculating an aircraft's ground speed and then uses that data to project an aircraft's future position.

The Traffic Flow Management (TFM) System at the Air Traffic Control System Command Center (ATCSCC) and the Traffic Management Units (TMUs) at en route centers and TRACONs enable traffic managers to work together in strategic planning and management of air traffic. These systems use inputs from aircraft tracking systems, weather observations and airline operation centers to balance the flow of air traffic with airport capacity. TFM hosts software decision support tools that show projected arrivals and runway capacity and develop traffic management initiatives to meter air traffic to reduce delays and make maximum use of system capacity.

Automation systems will host the software improvements that support many of the NextGen OIs. NextGen programs develop the enhancements which are then installed on existing or upgraded automation systems. Program descriptions in Appendix B provide details on those enhancements.

Automation implementation, including the plans to sustain, upgrade, replace or decommission current systems displayed from 2014 through 2028 in the following NAS EA roadmaps:

1. Roadmap 1 (figure 4-2) - Air Traffic Management and Air Traffic Control
2. Roadmap 2 (figure 4-3) - Air Traffic Support and Oceanic Air Traffic Control
3. Roadmap 2 (figure 4-4) - Flight Services, Aeronautical and Information Support

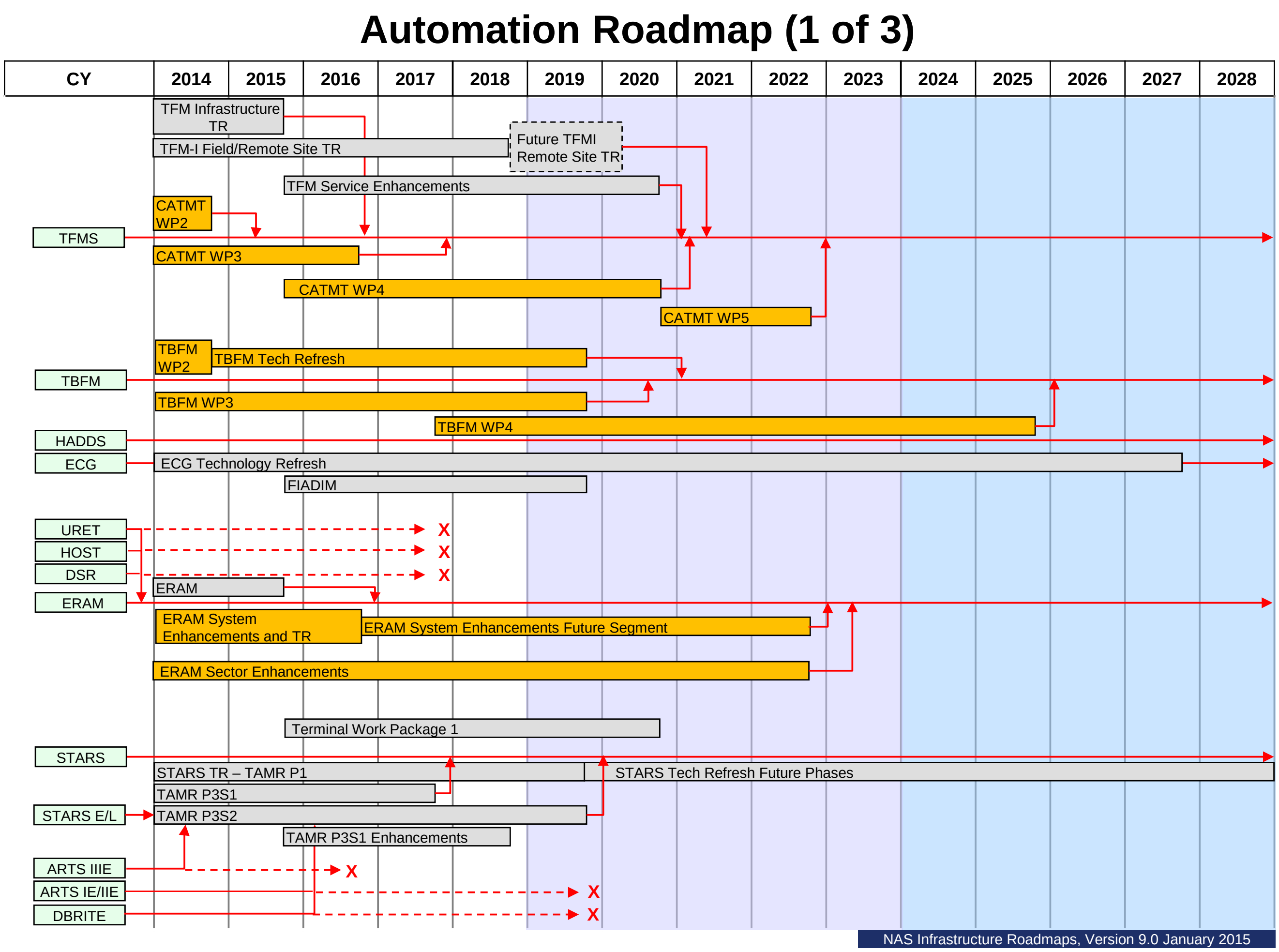

Figure 4-2 Air Traffic Management and Air Traffic Control Roadmap

The first system on the left side of the roadmap is the Traffic Flow Management System (TFMS) installed at air traffic control facilities including the Air Traffic Control System Command Center (ATCSCC), en route centers, and major terminal control facilities. The FAA will continue to implement the TFM Infrastructure and Remote Site Technology Refresh program to upgrade the hardware for existing TFMS components. The TFM Service Enhancements program will upgrade decision support tools to give traffic managers more precise forecasts that will allow them to implement more efficient Traffic Management Initiatives (TMIs). TFMS infrastructure and software enhancements are funded through BLIs 2A05.

The Collaborative Air Traffic Management Technologies (CATMT) work packages are enhancements to the TFMS and expand collaboration to individual pilots and improve information exchange between the FAA and airline dispatch offices. Collaboration improves the efficiency of operations by allowing operators to help determine the most efficient way to allocate NAS capacity. CATMT work packages are funded by 2A14.

The Time Based Flow Management (TBFM) system determines specific times of arrival for points in an aircraft's route. This results in a systemic and efficient flow of aircraft to the terminal airspace, starting hundreds of miles away. Aircraft using this technique can arrive properly sequenced and spaced to maximize capacity at the nation's busiest airports. TBFM Work Package 3 will implement additional NextGen concepts, such as optimized descent during time-based metering (Path Stretch); terminal sequencing and spacing to provide efficient sequencing and runway assignment; expansion of the Integrated Departure/Arrival Capability (IDAC) to additional locations; and making TBFM more flexible to accommodate reroute operations during adverse weather conditions during FY2015-FY2020. The TBFM technology refresh program will replace the system hardware to avoid obsolescence, system performance degradation and impact on other programs. TBFM is funded by 2A15.

The next six blocks on the left side are components of the en route control system. The Host ATM Data Distribution System (HADDS) supplies data to the TFMS discussed above and will remain in operation throughout the roadmap timeframe. The En Route Communication Gateway (ECG), which formats data for the en route automation system, remains a separate program and will continue to receive a technology refresh. The Flight and Interfacility Data Interface Management (FIADIM) program modernizes the flight data exchange between en route, oceanic and terminal automation systems. In conjunction with the Surveillance Interface Modernization (SIM), FIADIM can eliminate the need for the ECG. These programs use internet protocols to replace the serial interfaces used by ECG. ECG is funded by BLI 2A02. FIADIM is funded by BLI 2B20.

The En Route Automation Modernization (ERAM) program incorporates three of the en route system component pieces: User request Evaluation Tool (URET); Host Computer; and Display System Replacement (DSR). ERAM is now fully operational, and it supports the agency's transition to NextGen.

Improvements to ERAM will include ERAM System Enhancements and Technology Refresh and ERAM Sector Enhancements. The System Enhancements segment will include:

- Test and Training System improvements;
- Flight data processing enhancements, enabled by the increased adoption of ICAO flight plan standards;
- Controller usability enhancements;
- Tracking and correlation processing enhancements; and
- Improvement of overall system management, analysis and monitor and control functions.

ERAM Technology Refresh consists of upgrades and modernization of existing system components. ERAM system enhancements and technology refresh are funded through BLI 2A01. ERAM System Enhancements Future Segment will continue the enhancement and technology refresh activities starting in FY 2017.

ERAM Sector Enhancements provides software and hardware enhancements for the En Route sector controller team. It facilitates increased efficiency and effectiveness between the tactical and strategic controllers and establishes a common processing platform, with similar tool sets, that may be tailored for either controller. ERAM Sector Enhancements is funded through BLI 2A01.

Terminal Work Package 1 funds system engineering to develop concepts which address issues relating to system performance in the terminal domain. Proposed technical changes to automation and updated air traffic procedures will be delivered to the appropriate program offices for further development and implementation. It is funded by BLI 2B05B.

The next five systems provide ATC automation for terminal airspace:

- Standard Terminal Automation Replacement System (STARS);
- STARS Enhanced Local Integrated Tower Equipment / Local Integrated Tower Equipment (STARS E/L);
- Automated Radar Terminal System model IIIE (ARTS IIIE);
- ARTS 1E/IIE; and
- Digital Bright Radar Indicator Tower Equipment (DBRITE).

DBRITE is a tower display that allows tower cab controllers to determine the location of approaching traffic before it becomes visible to them. STARS and ARTS systems allow Terminal Radar Control (TRACON) controllers to track aircraft as they transition from en route control to terminal airspace, normally within 60 miles of the destination airport.

There are several phases to the STARS Terminal Automation Modernization and Replacement (TAMR) program for upgrading and modernizing these systems:

- The first phase replaced 47 existing ARTS with STARS. These STARS systems were installed at medium activity level airports;
- The STARS Technology Refresh (TAMR Phase 1) is modernizing the 47 sites installed under the STARS program as well as sites installed under TAMR Phase 2;
- TAMR Phase 2 involved the installation of STARS at five TRACONs and the modernization of four operational ARTS at large TRACONs. Phase 2 is completed and not shown on the roadmap;
- STARS TAMR Phase 3 Segment 1 (P3S1) is replacing 11 ARTS IIIE systems, which are the most sophisticated terminal automation systems located at high activity TRACONs;
- STARS TAMR Phase 3 Segment 2 (P3S2) will replace 91 ARTS IIE systems at medium and small airports with STARS Enhanced Local Integrated Tower Equipment (ELITE) and 6 ARTS IE systems at the smallest airports with STARS Local Integrated Tower Equipment (LITE). The upgraded STARS systems will be able to process position information from the ADS-B system along with information from terminal radars; and

- STARS Technology Refresh Future Phases will continue to address the technology refresh updates needed to modernize the STARS at all sites.

STARS is funded through BLIs 2B03 and 2B04.

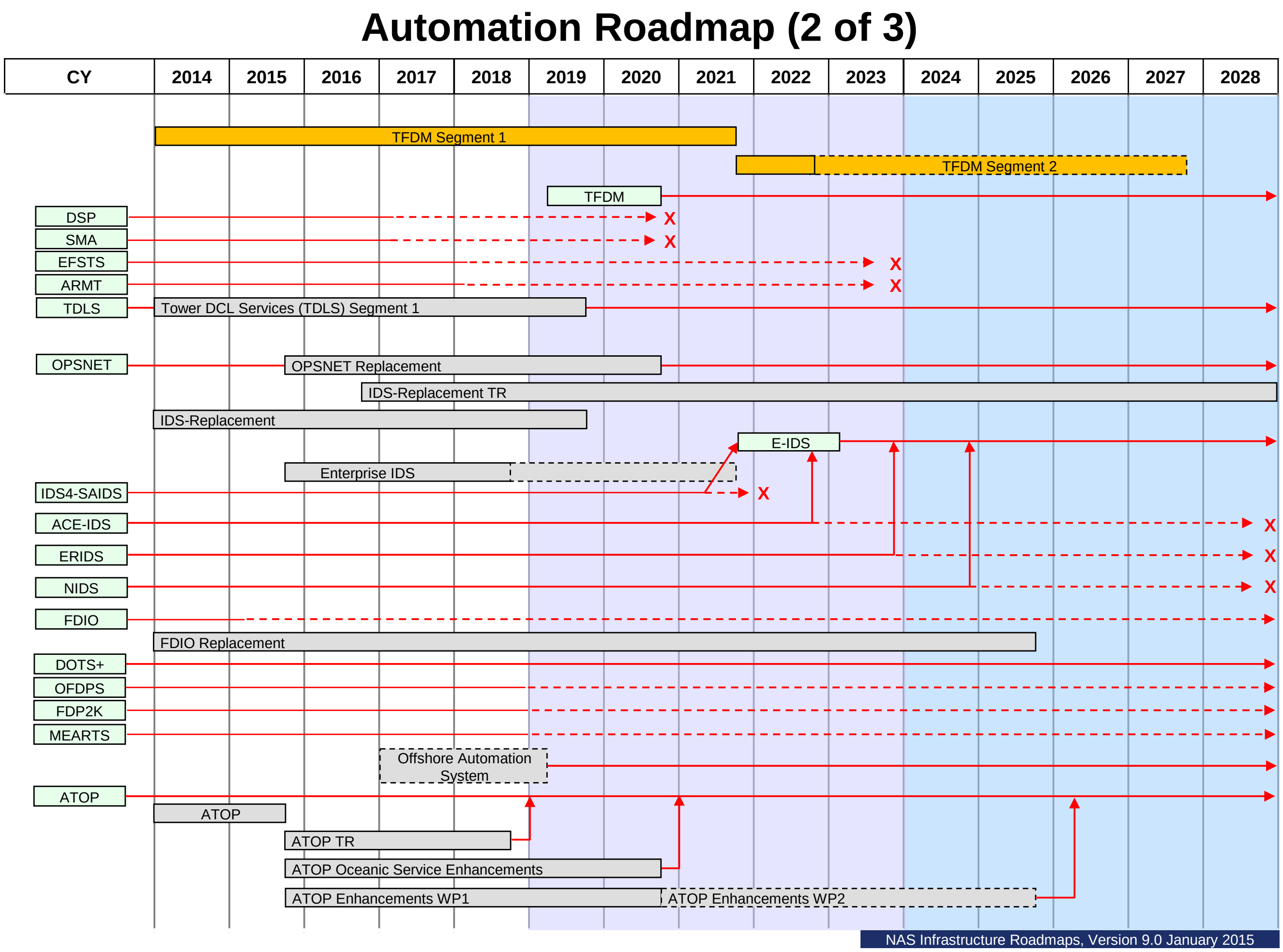

Figure 4-3 Air Traffic Support and Oceanic Air Traffic Control Roadmap

The Terminal Flight Data Manager (TFDM) – Segment 1 program supports a phased implementation of a new terminal local area network (LAN) based infrastructure to reduce redundant displays and integrate flight data functions. TFDM will provide System Wide Information Management (SWIM) enabled flight data exchanges with other NAS subsystems. TFDM initially will integrate data from existing systems, and it will be enhanced in TFDM Segment 2. TFDM is funded through BLI 1A06A.

The Departure Spacing Program (DSP) is used by tower controllers to optimize taxi and takeoff clearances in order to efficiently use available runway and airspace capacity.

The Surface Movement Advisor (SMA) provides the status of aircraft moving from the gates to the runways; and it improves taxiing efficiency. The Electronic Flight Strip Transfer System (EFSTS) is a system to transfer flight information to towers and TRACONs electronically rather than by paper. The Airport Resource Management Tool (ARMT) provides an assessment of available airport capacity.

The Tower Data Link Services (TDLS) provides datalink route clearances to pilots preparing to depart an airport. Data Communications Segment 1 Phase 1will be providing upgrades to the TDLS system.

The Operations Network (OPSNET) Replacement program will upgrade the existing system that collects data on flight operations and the number and reason for delays. It will automate data collection and expand the categories of delay reasons. OPSNET Replacement is funded through BLI 1A01I.

The Integrated Display Systems model 4 (IDS-4), the System Atlanta Information Display System (SAIDS) and NAS IDS (NIDS) provide weather and other information to tower controllers. These systems will be modernized by the IDS Replacement program. IDS Replacement Technology Refresh will provide system sustainment and upgrades starting in FY 2017. The Enterprise IDS (E-IDS) program, if approved, will take over the upgrade/replacement of systems included in the IDS replacement program. IDS is funded through BLI 2B14.

The Automated Surface Observing System (ASOS) Controller Equipment-Information Display System (ACE-IDS) displays weather information collected by ASOS to tower controllers. These services will begin a transition to the proposed E-IDS in 2022.

The En Route Information Display System (ERIDS) will be transitioned to the proposed E-IDS system in 2023. ERIDS is an information display system that provides access to aeronautical data including weather, airspace charts, ATC procedures, Notice to Airmen (NOTAMS), and pilot reports (PIREPS).

Flight Data Input/Output (FDIO) provides pre-filed flight plan and other data to operational facilities shortly before the aircraft is scheduled to begin its flight. It will be replaced incrementally throughout the roadmap timeframe. FDIO is funded through BLI 2B05.

The next group of five systems on the left side support oceanic ATC. The Dynamic Ocean Tracking System plus (DOTS+) system uses weather information to determine the most fuel-efficient routes based on wind velocity and direction. It will continue in operation through the timeframe of the roadmap. The other oceanic automation systems process data regarding the position of aircraft on oceanic and offshore flights to aid controllers in separating flights in FAA controlled oceanic airspace. The FAA plans to decide in 2017 whether to continue operating the Offshore Flight Data Processing System (OFDPS), Flight Data Processing 2000 (FDP2K), and the Microprocessor En route Automated Radar Tracking System (MEARTS) or transition their functions to a new Offshore Automation System.

Three centers (New York, Oakland and Anchorage) house the oceanic control system, Advanced Technologies and Oceanic Procedures (ATOP). Upgraded versions of ATOP will remain in operation throughout the roadmap timeframe. ATOP Technology Refresh, ATOP Oceanic Service Enhancements and ATOP Enhancements Work Packages 1 and 2 will sustain and upgrade the system. The enhanced ATOP systems will allow controllers to apply NextGen concepts such as assigning optimal routes and allowing reduced separation between aircraft to oceanic air traffic control. Enhancements include:

- Improved Accommodation of Flight Operator Trajectory Preferences;
- Increased System Efficiency in Support of Separation Management; and
- Increased Situational Awareness.

The three ATOP programs are funded through BLI 2A09.

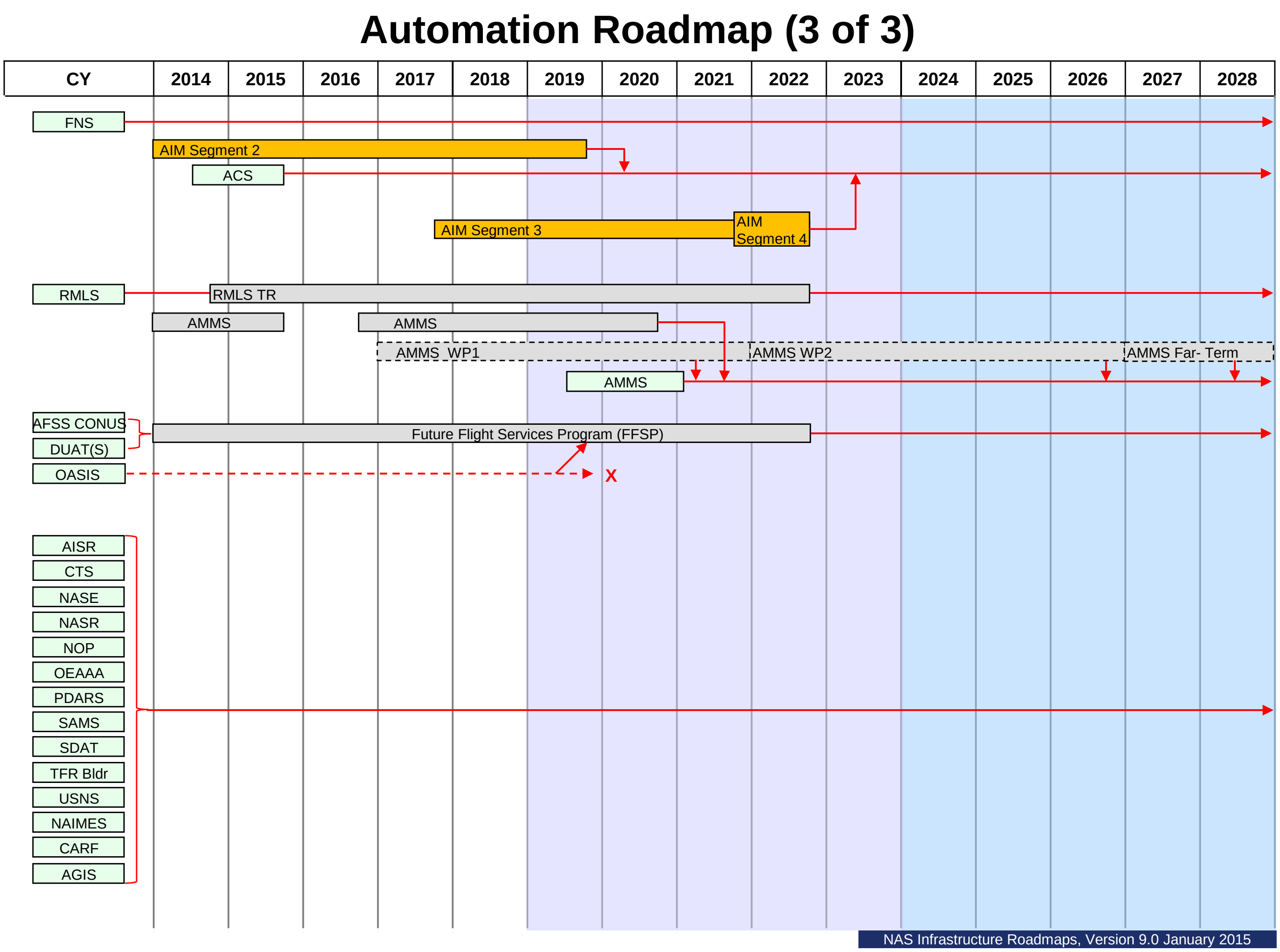

Figure 4-4 Flight Services, Aeronautical and Information Support Roadmap

Figure 4-4 shows the Federal NOTAM System (FNS) will remain in operation throughout the roadmap timeframe. It is a centralized system that collects and distributes Notices to Airmen

(NOTAMs) so pilots are aware of Navaid outages, closed runways, and other factors affecting their planned flight.

The Aeronautical Information Management (AIM) Segments 2, 3 and 4 consolidate and automate the storage and dissemination of aeronautical data used by pilots and aviation planners. They will upgrade the Aeronautical Common Services (ACS) which publishes information about airports, navigational aids and other aeronautical data. AIM is funded through BLI 4A09.

The Remote Maintenance Logging System (RMLS) serves two functions. It allows the maintenance staff to monitor equipment performance electronically from a central location, and it provides software for management of workforce hours and maintenance actions. The existing system is undergoing a technology refresh and will be supplemented by the Automated Maintenance Management System (AMMS). RMLS technology refresh and AMMS are funded through BLI 2B15.

The Automated Flight Service Station Continental United States (AFSS CONUS), Direct User Access Terminal System (DUATS) and Operational And Supportability Implementation System (OASIS) are automation systems that provide aeronautical and weather data to support flight services. Flight services include flight planning and pilot weather briefings, which are primarily used by general aviation pilots. Flight services in the lower 48 States and Puerto Rico are provided by contractor flight service personnel using the AFSS CONUS. The DUATS is a web-based service that allows pilots to access weather and aeronautical data for self-briefings and to file flight plans. The OASIS automation system is used at the Flight Service Stations in Alaska by FAA flight service specialists to provide flight services to general aviation pilots.

The Future Flight Service Program (FFSP) is examining the need for continued availability of flight service information currently provided by DUATS, AFSS and OASIS. The acquisition strategy is being developed. FFSP is funded through BLI 2C02.

Figure 4-4 shows fourteen systems that continue in operation, with technology refreshes, through the roadmap timeframe. A brief description of each system's capability and impact of providing service for airports, airspace, and navigation facilities is provided below:

- Aeronautical Information System Replacement (AISR) – distributes information on weather, flight plans, NOTAMS, Pilot Reports and other NAS status items to FAA facilities, Department of Defense, and pilots;
- Coded Time Source (CTS) – provides the official source of time that synchronizes the information flows in the air traffic control equipment;
- NAS Adaptation Services Environment (NASE) – contains detailed information about the airspace, geography, equipment, and procedures required to make each ATC system work properly;
- National Airspace System Resources (NASR) – contains information pertaining to Instrument Approach Procedures (IAPs), Departure Procedures (DPs), Standard Terminal Arrival Routes (STARs), and Military Training Routes (MTRs);
- National Offload Program (NOP) – allows FAA to download radar information from en route automation systems for analysis and review;

- Obstruction Evaluation/Airport Airspace Analysis (OEAAA) – contains data about obstructions around airports that present a hazard for aircraft taking off and landing;
- Performance Data Analysis and Reporting System (PDARS) – is a fully integrated performance measurement tool designed to help the FAA improve the NAS by tracking the daily operations of the ATC system and its environmental impact. PDARS is funded through BLI 1A01B;
- Special Airspace Management System (SAMS) – informs controllers when airspace ordinarily reserved for military use is available for civilian use;
- Sector Design and Analysis Tool (SDAT) – this is a visualization and analysis tool used to evaluate the impact on controller workload when sector and route changes are being considered during major airspace redesign efforts;
- Temporary Flight Restriction Builder (TFR Bldr) – an automated system for establishing temporary flight restrictions that prohibit aircraft from flying over areas where special events such as the Super Bowl are being held;
- United States NOTAM (Notice to Airmen) System (USNS) – an automated system used to process, store and distribute NOTAM information;
- NAS Aeronautical Information Management Enterprise System (NAIMES) – consists of a suite of NAS safety/mission critical systems and services that directly support the collection, validation, management, and dissemination of aeronautical information in the NAS;
- Central Altitude Reservation Function (CARF) – a system used by military and civilian pilots to reserve altitudes for their planned flights; and
- Airport Geographic Information System (AGIS) – stores data on airport configuration and physical location and size of all elements of the airport. It is used to develop airport modernization plans, and it is necessary for developing new approach and departure procedures.

4.2 Communications Roadmaps

Communication between pilots and controllers is an essential element of air traffic control. Currently the primary method for communication is voice radio. To ensure controllers can stay in contact with pilots remotely located radio sites are used to provide coverage. The controller has electronic links to activate radios at remote sites and ground telecommunication lines from these sites carry the verbal exchange to and from air traffic control facilities. If ground links are not available, satellite communication links can be used, and in the future, data link may be used for most routine communications. Backup systems are essential to ensure the continued ability to maintain communications when the primary systems fail.

NextGen improvements will require improved voice switching and A/G data communications as shown on the diagrams. Details on those investments can be found in the program descriptions in Appendix B.

Communication system implementation is broken down into five different NAS EA roadmaps:

1. Roadmap 1 (figure 4-5) - Telecom and Other Communications
2. Roadmap 2 (figure 4-6) - Voice Switches and Recorders
3. Roadmap 3 (figure 4-7) - Air-to-Ground Voice and Oceanic Communications
4. Roadmap 4 (figure 4-8) - Air-to-Ground Data Communications
5. Roadmap 5 (figure 4-9) - Messaging Infrastructure

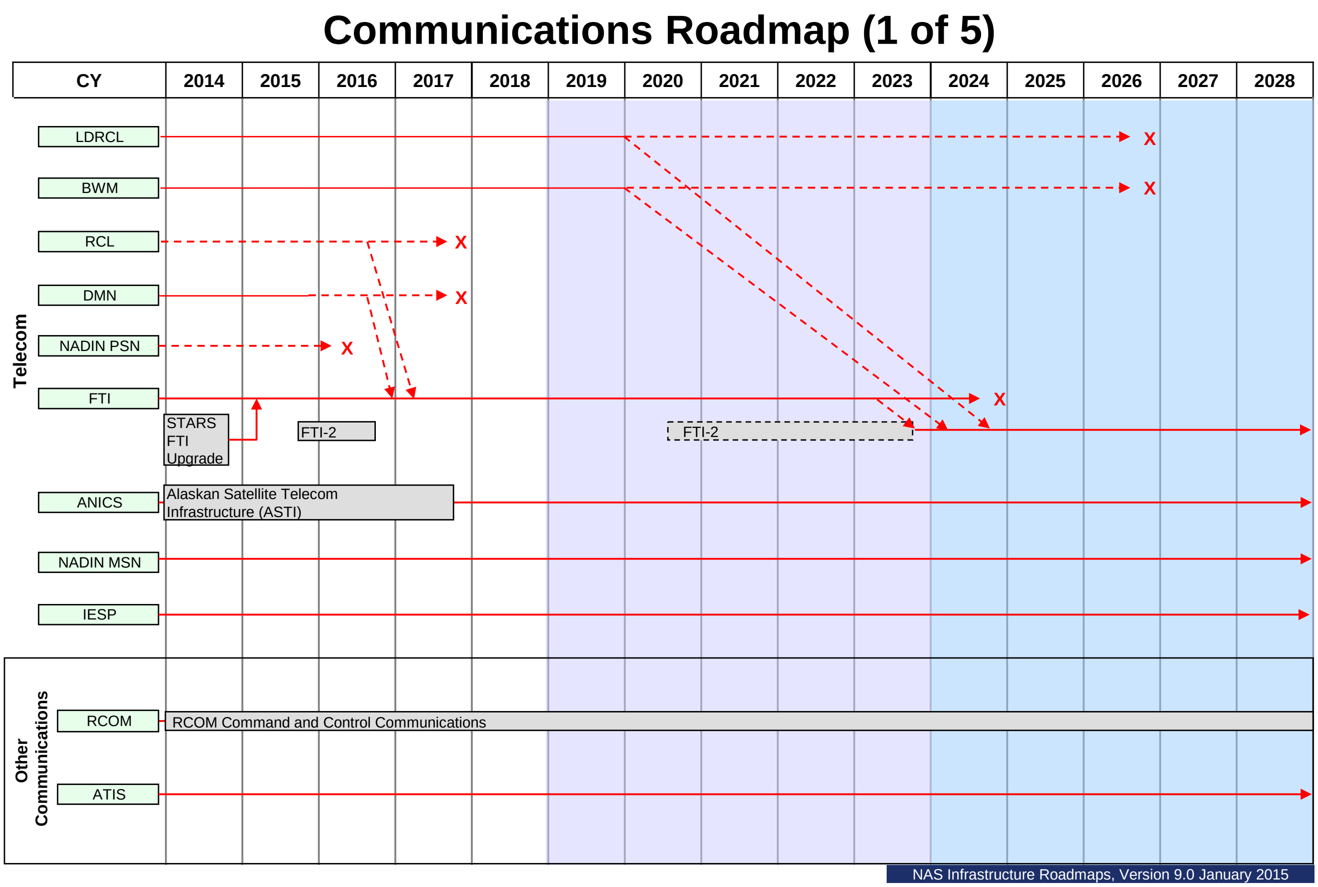

Figure 4-5 Telecom and Other Communications Roadmap

The Low Density Radio Communication Link (LDRCL) and the Radio Communication Link (RCL) are microwave systems that were created to transmit radar data from remote radar sites to FAA air traffic control facilities. These systems were linked in a national network to transmit operational and administrative information to and from air traffic control facilities. Many RCL communication links have already transitioned their functions to the FAA Telecommunications Infrastructure (FTI). The LDRCL will remain in service for areas with limited commercial services, but their functions will be transitioned to the new FTI contract. The Band Width Manager (BWM) improves efficiency of information flow on the microwave network. It will not be needed when microwave links are no longer used. The Data Multiplexing Network (DMN) and National Airspace Data Interchange Network – Package Switching Network (NADIN PSN) transmit flight plans and other important aeronautical information to air traffic facilities. The FAA is transitioning functions of DMN and NADIN PSN to the FTI network. NADIN Message

Switching Network (MSN) will be improved by the NMR (NADIN MSN Rehost) to comply with international standards for transmitting flight plans and remain available for that purpose.

The FTI contract provides communications services between FAA facilities. In 2016, work will begin on preparing for a transition to a new FTI contract under the FTI-2 program. The STARS FTI Upgrade has established a diverse and redundant core Internet Protocol infrastructure across the FTI telecommunications backbone that significantly reduces the impact of any unforeseen events on service. FTI-2 is funded under BLI 2E11.

The Alaska National Airspace System Interfacility Communications System (ANICS) consists of ground stations that send and receive data from communications satellites to connect the operational facilities in Alaska. The Alaska Satellite Telecommunications Infrastructure (ASTI) program modernizes the ANICS infrastructure. Because there are far fewer ground telecommunications connections in Alaska, a satellite system is used to ensure that important air traffic information is reliably transmitted between small and large facilities. ASTI is funded through BLI 2E05.

The Integrated Enterprise Service Platform (IESP) is a shared computing infrastructure that provides a common set of server and network hardware for the hosting of multiple NAS services. It leverages virtualization technology to maximize the return on investment for hardware procurements, and provides value added configuration management and high availability services. IESP uses an enterprise level Simple Network Management Protocol (SNMP) system which is capable of providing monitoring services for external NAS systems.

Recovery Communications (RCOM) is an emergency network to be used for command and control of the ATC system when other communications systems fail. RCOM is funded through BLI 3A04.

The Automated Terminal Information System (ATIS) broadcasts weather and other pertinent information to pilots as they approach an airport. ATIS functions will be maintained during the entire timeframe of the roadmap.

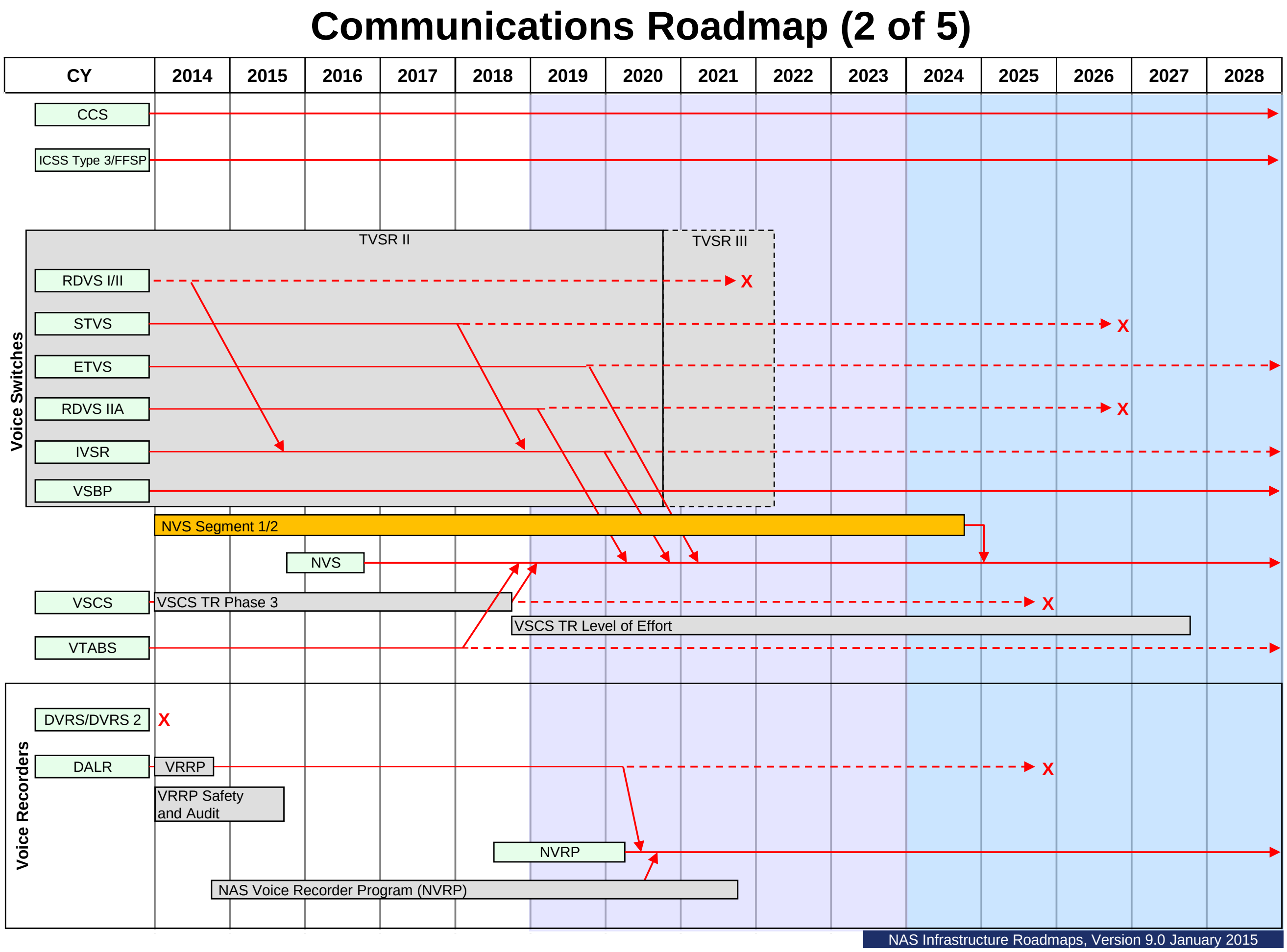

Figure 4-6 Voice Switches and Recorders Roadmap

Figure 4-6 shows the Conference Control Switch (CCS) installed at the Air Traffic Control System Command Center (ATCSCC) facility. It allows the FAA specialists to stay in contact with air traffic control facilities and external users of the NAS. They can coordinate with centers, TRACONs, and users to decide how best to implement traffic management initiatives and when to use severe weather avoidance programs.

The Integrated Communication Switching System Type 3 (ICSS Type 3/FFSP) is installed at flight service stations. Decisions made for the Future Flight Services Program (FFSP) will determine the future status of this switch.

Voice switches used in terminal and flight service facilities enable air traffic controllers to select lines to communicate with pilots as well as other air traffic control facilities. The Terminal Voice Switch Replacement (TVSR) II program, funded through BLI 2B08, is an umbrella program to replace terminal voice switches at the rate of about 5 per year, refurbish approximately 2 voice switches per year and install voice switches in newly constructed air traffic control towers. The switches are:

- Rapid Deployment Voice Switch (RDVS) I, II and IIA;
- Small Tower Voice Switch (STVS);
- Enhanced Terminal Voice Switch (ETVS);
- Interim Voice Switch Replacement (IVSR); and
- The Voice Switch By Pass (VSBP) is a backup voice switch that terminal controllers can use to stay in communication with pilots if there is a failure in the primary voice switch.

In 2021 the TVSR III program will be established to refurbish and replace terminal voice switches that are not replaced under the NAS Voice System (NVS) program.

The FAA has awarded the contract for a two segment procurement of the NVS. The first segment is the NAS Qualification phase which consists of the development and testing of production-ready systems capable of being deployed in the NAS operational environment, including three key site systems. The second segment is the Deployment phase which consists of NVS deployments at operational facilities beyond key sites. The NVS deployment schedule will be finalized to support the Final Investment Decision. The NVS program will also include remote radio control equipment. NVS will provide flexible networking for voice switch-to-voice switch connectivity as well as for voice switch to Air-to-Ground (A/G) radio connectivity. This architecture will facilitate meeting NextGen requirements for ATC workload sharing, unmanned aircraft system (UAS) operations, virtual tower operations, and business continuity. NVS will replace ARTCC, ATCT and TRACON voice switches and is funded through BLI 2B13.

The Voice Switching and Communications System (VSCS) is the voice switch currently used in ARTCCs. The FAA is upgrading VSCS with a technology refresh to replace components that have a high failure rate until the NVS program can replace the switches. Technology Refresh may continue past 2020 depending on the rate at which NVS switches replace VSCS. The VSCS Training and Backup Switch (VTABS) can maintain critical A/G and ground-to-ground communications if the main communications system becomes inoperable as a result of a power outage, a catastrophic system failure, or during system maintenance or upgrade activities. VSCS is funded through BLI 2A08.

The Digital Audio Legal Recorder (DALR) is the voice recorder that is replacing Digital Voice Recorder Systems (DVRS). These voice recorders provide a legally accepted recording capability for conversations between air traffic controllers, pilots, and ground-based air traffic facilities in all ATC domains and are used in the investigation of accidents and incidents and routine evaluation of ATC operations. DALR is also installed in newly constructed air traffic control towers. The NAS Voice Recorder Program (NVRP) is evaluating alternatives for the next generation of recorders. NVRP is funded through BLI 2B18.

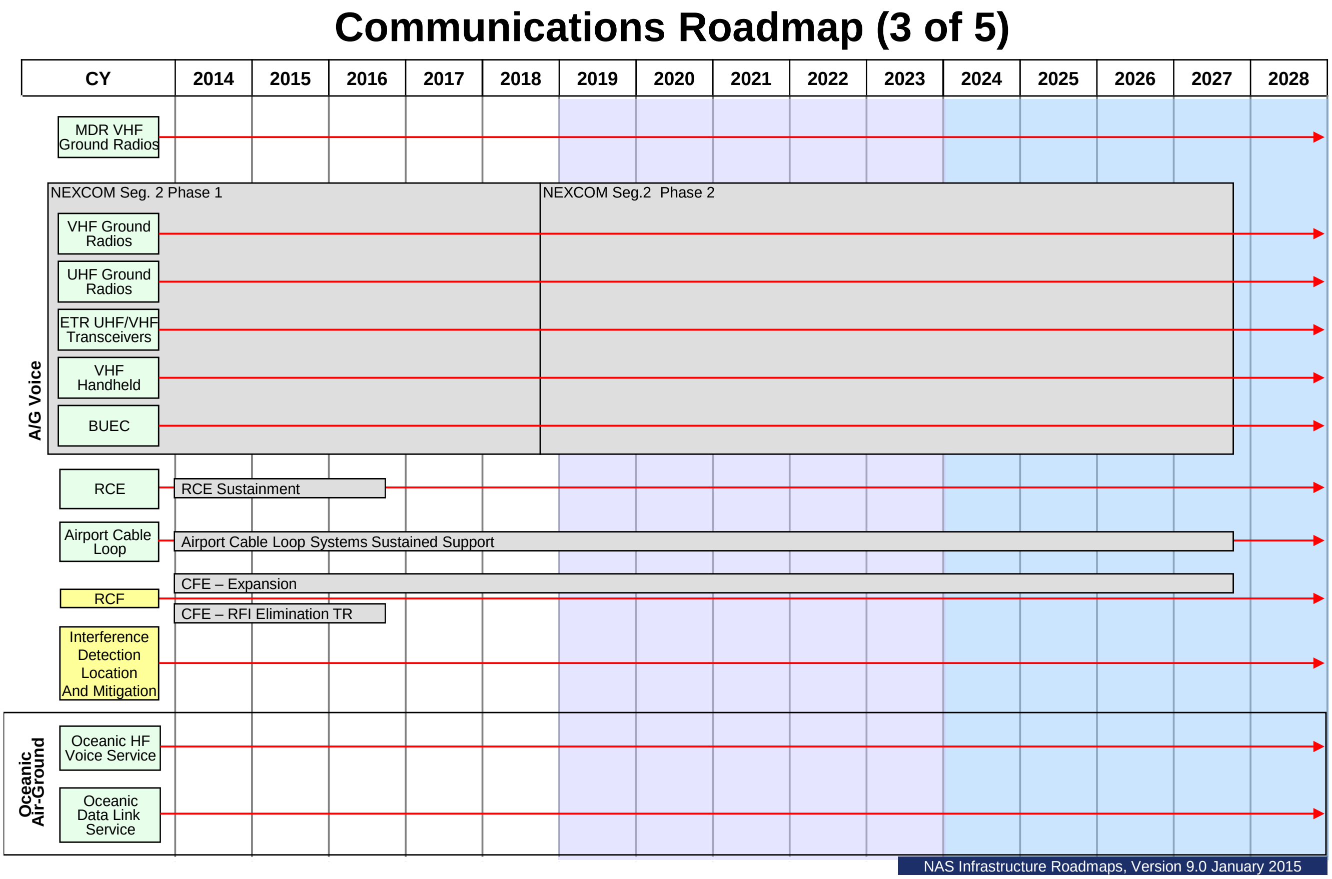

Figure 4-7 Air-to-Ground Voice and Oceanic Communications Roadmap

Figure 4-7 shows the Next Generation Air/Ground Communications (NEXCOM) program is upgrading Very High Frequency (VHF) radios used to communicate with civil aviation and Ultra High Frequency (UHF) radios used by FAA to communicate with military aircraft. The Multimode Digital Radios (MDR) VHF Ground Radios used for high and ultrahigh en route sectors have been replaced and will continue in operation during the timeline of the roadmap. NEXCOM Segment 2 will use a combined contract for both VHF and UHF radios to replace the radios that terminal facilities use. It will also replace emergency backup radios (emergency transmitter replacement (ETR)) that provide service when primary radios are not working. The Back Up Emergency Communication (BUEC) consists of radios installed at remote sites that back-up the primary radios that controllers use. NEXCOM is funded through BLI 2A10.

The Radio Control Equipment (RCE) – Sustainment program modernizes the electronic equipment that allows controllers to control the radios they use at remote sites. RCE is funded through BLI 2A06.

The Airport Cable Loop program replaces the communications cables that control and report the condition of equipment necessary for airport operations such as the Airport Surveillance Radar. FAA is replacing copper wires with fiber optics and adding dual path operations so that a break in the cable does not stop the flow of information. The Airport Cable Loop program is funded through BLI 2E04.

The Communications Facility Expansion (CFE) program enhances operational efficiency and effectiveness by establishing, replacing and upgrading radio equipment at Remote Communication Facilities (RCF) that provide connections to air traffic facilities. The CFE Radio Frequency Interference (RFI) Elimination program installs equipment to eliminate RFI that would affect pilot to controller communication. The programs are funded through BLI 2A06.

The Interference Detection, Location and Mitigation (IDLM) program investigates occurrences of non-FAA transmitters interfering with FAA radios and navigation systems, locates the source, and ensures that they no longer interfere with FAA controlled frequencies. The FAA has specially equipped vehicles that detect and locate the sources of interference.

The last two items on the roadmap are communications systems used for oceanic air traffic control. The first one is the high frequency (HF) radio. HF radio allows the FAA to stay in touch with aircraft that are out of range of VHF radios. Oceanic Satellite Data Link Services is used by equipped aircraft and relies on communications satellites to transfer messages to and from aircraft flying over the oceans.

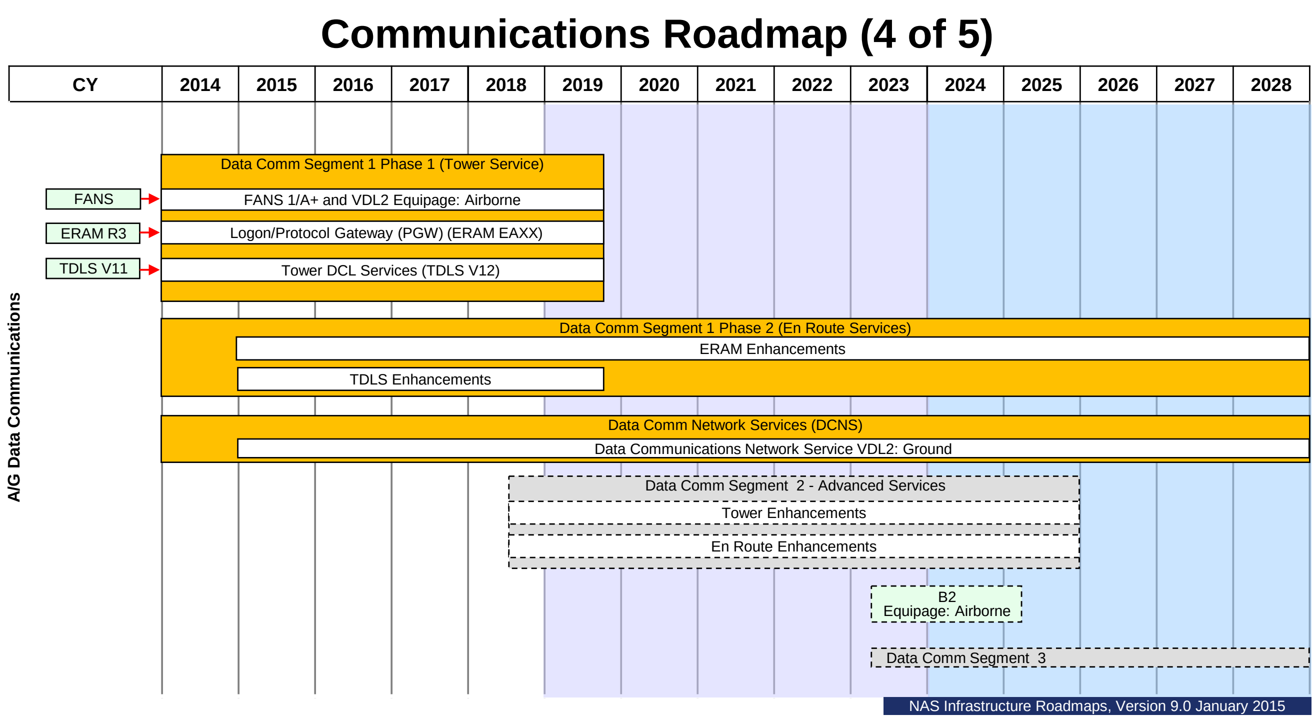

Figure 4-8 Air-to-Ground Data Communications Roadmap

The fourth communications roadmap (figure 4-8) shows the planned addition of data communications services for routine communications between controllers and pilots. Improvements to the NAS will be delivered by Data Comm in two segments.

Data Comm Segment 1 Phase 1 (S1P1) will deliver the initial set of data communications services integrated with automation support tools by deploying an upgraded Terminal Data Link System (TDLS) to deliver the Departure Clearance (DCL) in the Tower domain. Future Air Navigation System (FANS) defines the capabilities used for automated position reporting and satellite data link communications during oceanic operations. Aircraft that are FANS equipped will be able to receive data link messages from ATC facilities. The Logon/Protocol Gateway (PGW) upgrade began development in 2012 to assure security of transmissions to pilots.

Segment 1 Phase 2 (S1P2) will deliver services to the En Route domain in two stages, initial services and full services. Initial services will include transfer of communication/ initial check-in, airborne reroutes, altimeter settings and altitudes, limited controller initiated reroutes, limited direct-to-fix messages, and limited crossing restrictions. Full services will extend the service offerings in En Route domain to include more complex services including tailored arrivals, holding instructions, advisory messages, speeds and headings, beacon codes, stuck microphone, full controller initiated reroutes, full direct-to-fix messages, and full crossing restrictions.

Data Comm Network Services (DCNS) will establish the ground infrastructure necessary to support communication between aircraft and FAA facilities. Data Comm programs are funded through BLI 2A19.

Data Comm Segments 2 and 3 will further enhance services related to the terminal and en route capabilities developed in Segment 1. More advanced services will transmit revised route clearances from en route and terminal ATC automation system to the aircraft's Flight Management System.

B2 Equipage Airborne is the Aeronautical Telecommunications Network Baseline 2 which specifies the aircraft equipage to enable enhanced data communications in en route services leading to full trajectory based operations.

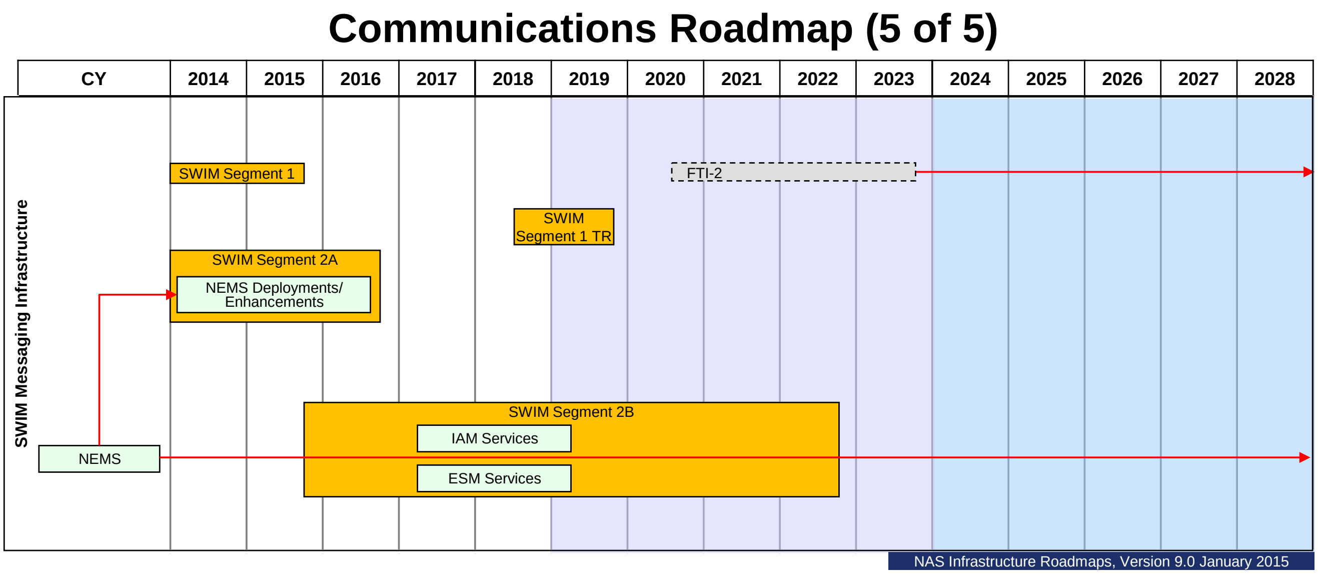

Figure 4-9 Messaging Infrastructure Roadmap

The fifth communications roadmap (figure 4-9) shows the System Wide Information Network (SWIM) components. SWIM is an information system that provides ready connection to many data sources so pilots and traffic managers can take advantage of updated information for more efficient operations.

SWIM segment 1 deployed services to all the ARTCCs, 39 TRACONs and the Command Center. The capabilities include:

- Special Use Airspace automated exchange;
- Integrated Terminal Weather System and Corridor Integrated Weather System data publication;
- Pilot report data publication;
- Reroute data exchange; and
- Terminal traffic, flight data and weather information.

SWIM segment 2A involves the use of the National Enterprise Messaging System (NEMS) to carry the data flows between users and providers. SWIM segment 2B will develop user connection with Identity and Access Management (IAM) and Enterprise Service Monitoring (ESM) services. SWIM programs are funded by BLI 2A11.

4.3 Surveillance Roadmaps

To provide separation services to aircraft, air traffic controllers must have an accurate display of all aircraft under their control. Controller displays use a variety of inputs, including radar and transponder information, to show the location of aircraft. Surveillance data is provided by the following technologies:

- Primary radar – the radar beam is bounced off the aircraft and reflected back to the radar receiver;
- Secondary radar – a reply is generated by the aircraft transponder and sent back to the radar in response to a secondary radar signal. The transponder reply contains the aircraft call sign, altitude, speed and can be processed to determine its position;
- Multilateration – multiple ground sensors receive aircraft electronic signals and triangulate this information to determine aircraft position; and
- ADS-B – the aircraft determines its location using a GPS receiver or other navigation equipment and broadcasts that information to an ADS-B ground station. The ground station relays the position information to automation systems which process the data and send it to controller displays.

En route and terminal facilities normally use Secondary radars (either the Air Traffic Control Beacon Interrogators (ATCBI) or the Mode Select (Mode S)) for traffic separation. Using ATCBI or Mode S enhances the controller's ability to separate traffic because speed and altitude information supplement the position display for each aircraft.

NextGen operational improvements will rely on advanced surveillance capabilities provided by ADS-B and Wide Area Multilateration which will provide more accurate information to controllers and better situational awareness for pilots. See Appendix B for more details on program activities.

Surveillance systems are shown in three different roadmaps:

1. Roadmap 1 (figure 4-10) - En Route Surveillance
2. Roadmap 2 (figure 4-11) - Terminal Surveillance
3. Roadmap 3 (figure 4-12) - Surface, Approach and Cross Domain Surveillance

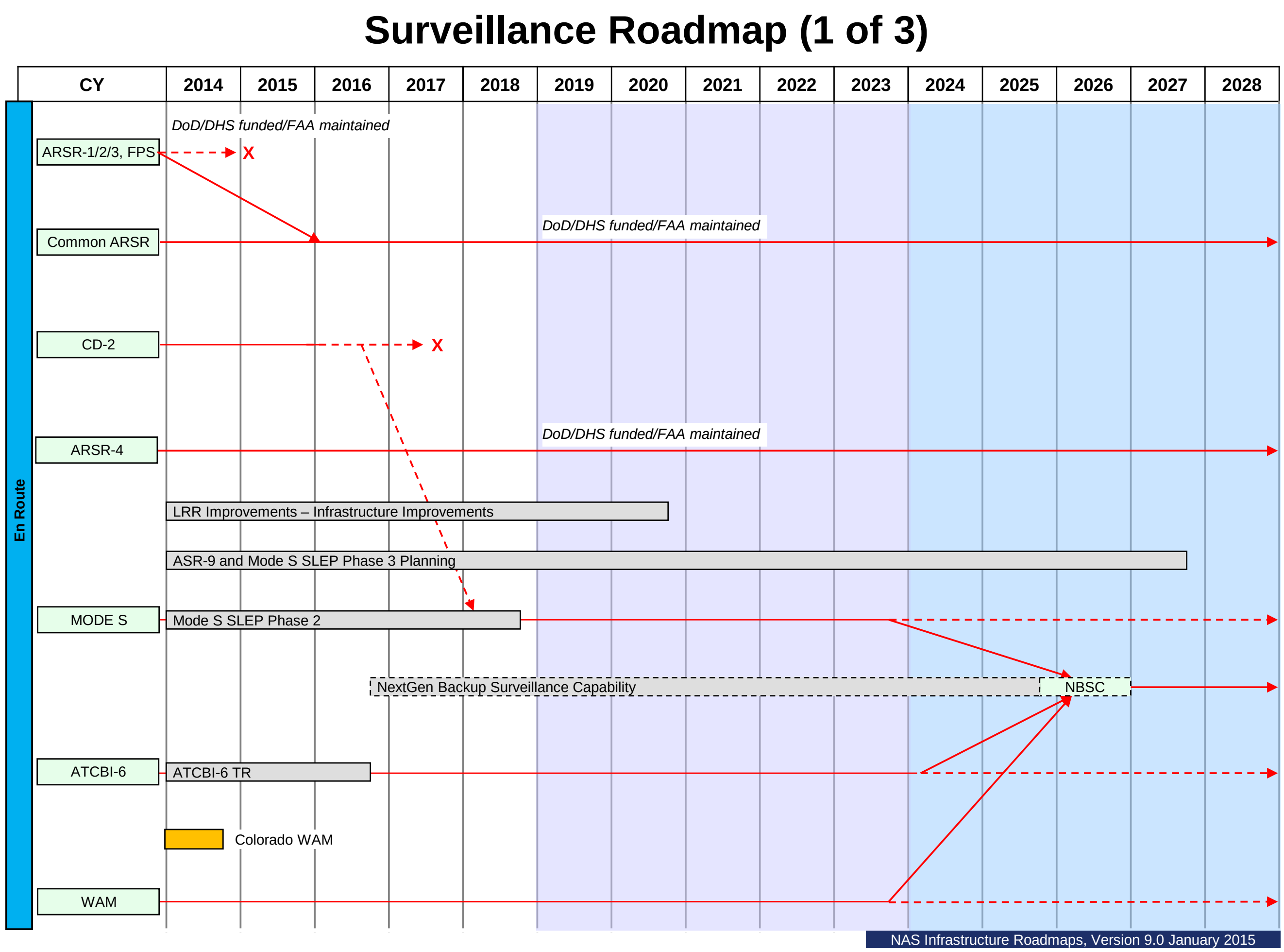

Figure 4-10 En Route Surveillance Roadmap

En route facilities use the Air Route Surveillance Radar (ARSR) model 1, 2, 3 and 4 and the Fixed Position Surveillance (FPS) system as primary radars. The ARSR and FPS radars do not require a cooperative transmission from an aircraft to detect and track its location. The ARSR and FPS have a range exceeding 200 miles. They are "skin-paint" radars (do not require cooperation from the detected aircraft) and transmit high frequency pulses and process the reflected energy to determine aircraft range based on the total time for the signal to reach and return from the target. The direction from the radar is based on the antenna position when the pulse is sent.

Existing early model ASRS 1, 2, 3 and FPS are being converted to the Common ARSR (CARSR) configuration. The existing Common Digitizers (CD-2), which convert analog radar information to a digital format, will not be needed after programs to convert radar information to internet protocols are completed. The Department of Defense will fund system upgrades of the ARSR through 2025 due to national security concerns. ARSR infrastructure upgrades (buildings, power, towers, roads) that support and protect secondary radars used by FAA are funded by the LRR Improvements program through BLI 2A07.

The Mode S SLEP Phase 2 program will implement modifications to the Mode S system to sustain secondary surveillance service through 2028. Mode S SLEP Phase 2 is funded through 2B16A. As part of a continuing effort to maintain the performance of the Mode S systems the ASR-9 and Mode S SLEP Phase 3 Planning program will address additional Mode S obsolescence issues. The SLEP Phase 3 Planning program is funded through BLI 2B16B.

The ATCBI-6 Technology Refresh Program will replace and upgrade obsolete ATCBI-6 original equipment manufacturer peculiar and Commercial Off-The-Shelf (COTS) hardware and software to ensure the continued reliable and cost effective operation of the radar system through its designated lifecycle. ATCBI Model 6 technology refresh is funded through BLI 2A16.

The Next Generation Backup Surveillance Capability (NBSC) is a planned activity to identify and implement a backup surveillance capability for ADS-B which will allow for potential decommissioning of secondary radar systems. An initial investment decision is planned for 2017.

The Colorado Wide Area Multilateration (WAM) system uses electronic transmissions from an aircraft and multilateration technology to detect aircraft position in areas where the radar signal may be unavailable or blocked by mountainous terrain. There are 4 locations in Colorado that are operating the WAM system.

Surveillance Roadmap (2 of 3)

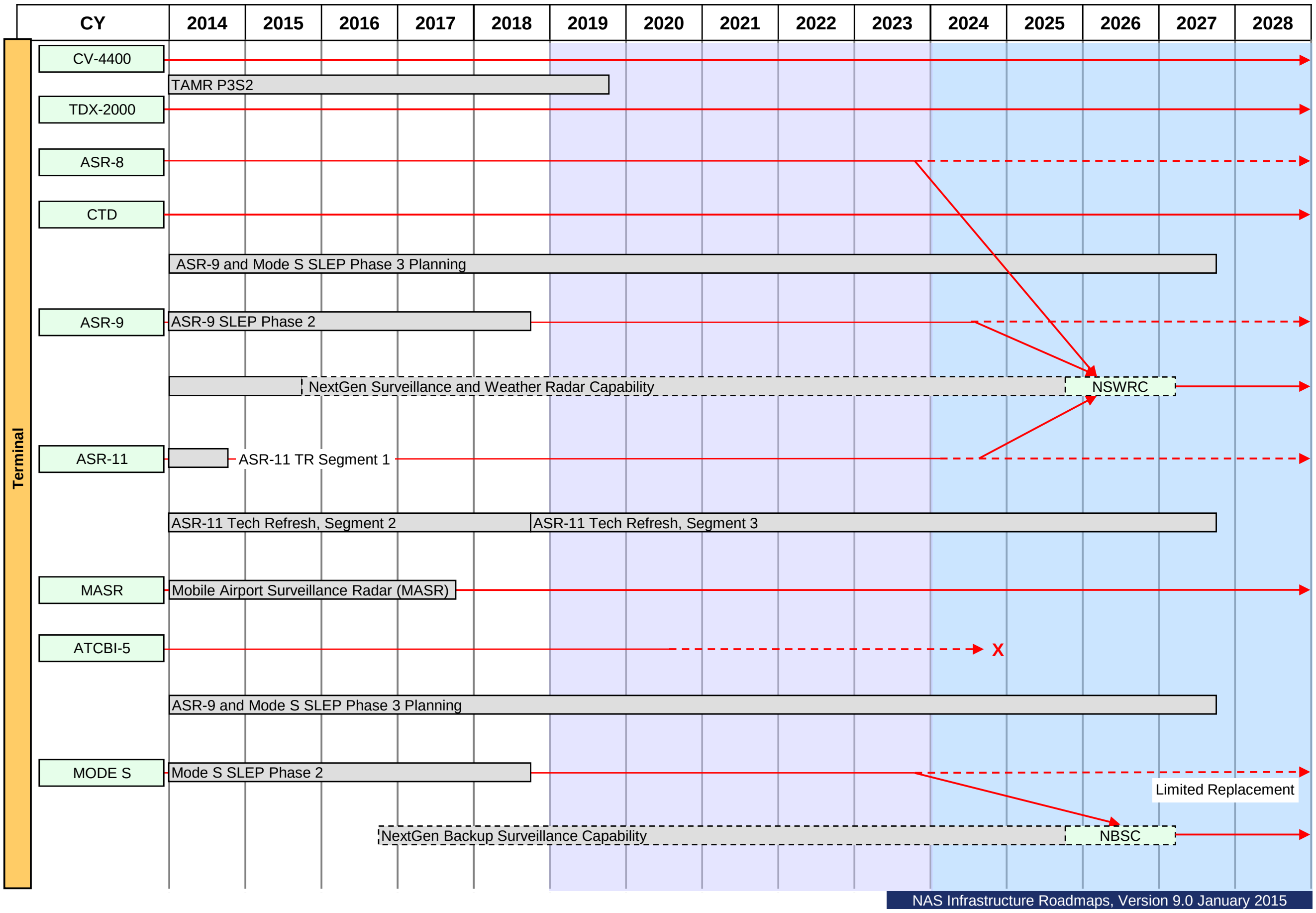

Figure 4-11 Terminal Surveillance Roadmap

The CV-4400 at the top of Figure 4-11 is a legacy system that allows use of terminal radar information in en route automation systems, e.g., using terminal radar to fill gaps in en route radar coverage at selected en route centers. The TDX-2000 is also a legacy system that digitizes the output of analog radars (for example, ASR-8) for use by more modern digital automation systems, such as STARS.

There are three models of terminal radars currently in use. The Airport Surveillance Radar Model 11 (ASR-11) is the newest and has replaced several of the radars that were not replaced by an earlier ASR-9 program. The ASR-9, which serves larger airports, will have a Service Life Extension Programs (SLEP) to update and modernize its components. ASR-9 SLEP and ASR-11 technology refresh programs are funded through BLI 2B10 and 2B11 respectively.

As part of a continuing effort to maintain the performance of the ASR-9 and Mode S systems the ASR-9 and Mode S SLEP Phase 3 Planning program will address additional obsolescence issues. The SLEP Phase 3 Planning program is funded through BLI 2B16B.

The existing ASR-8 is a primary radar system that requires a Common Terminal Digitizer (CTD) be installed to convert analog outputs to digital inputs needed by STARS. As more of the remaining ARTS automation systems are replaced by STARS additional CTDs will need to be installed.

A initial investment decision is planned for 2017 to determine whether to replace existing primary radar (ASR 8, 9, & 11) systems with the NextGen Surveillance and Weather Radar Capability (NSWRC).

The Mobile Airport Surveillance Radar (MASR) is a terminal surveillance radar that can be moved from site to site to support radar relocations, temporary planned outages of an existing radar for installation of upgrades, and emergency operations when existing systems are damaged. MASR is funded through BLI 2B11.

The Next Generation Backup Surveillance Capability (NBSC) is a planned activity to identify and implement a backup surveillance capability for ADS-B which will allow for potential partial decommissioning of secondary radar systems. An initial investment decision is planned for 2017.

Surveillance Roadmap (3 of 3)

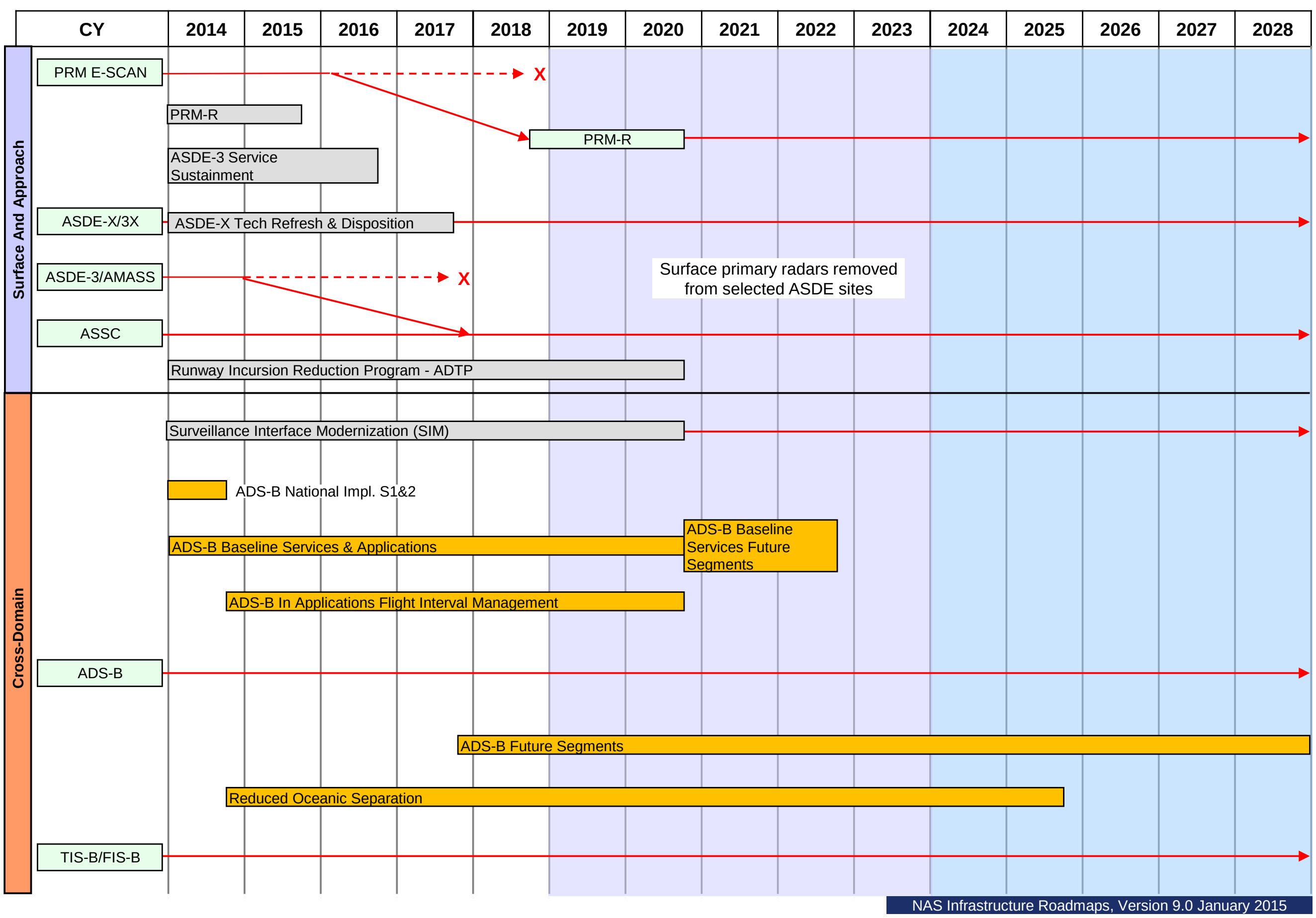

Figure 4-12 Surface, Approach and Cross Domain Surveillance Roadmap

The Precision Runway Monitor (PRM) (figure 4-12) is used to monitor the safety of side-by-side simultaneous approaches to closely spaced parallel runways during IFR conditions. It is a secondary rapid update radar that provides the precision that controllers need to ensure that two aircraft maintain safe clearance between them while approaching closely spaced runways. The electronic scan (E-SCAN) version achieves the rapid update by moving the beam electronically rather than relying on turning the antenna. The FAA Flight Standards organization has determined that required runway separation requirements can be reduced which eliminated the need for PRM at Atlanta (ATL). The PRM at San Francisco (SFO) will be sustained utilizing ATL PRM system assets and will not be replaced.

The FAA uses several systems for tracking aircraft on or near the airport surface. The Airport Surface Detection Equipment Model 3 (ASDE-3) is a primary radar system that provides a display of aircraft and ground vehicles in the airport operating areas (runways and taxiways). The ASDE-X merges primary and secondary radar, multilateration and ADS-B information to improve detection of aircraft and vehicles on or near taxiways and runways. This helps controllers manage aircraft on the ground and warn them of potential runway collisions. ASDE-X has converted 18 of the 35 ASDE-3 sites to ASDE-X which incorporate the existing ASDE-3 radar. Seven ASDE 3 sites have been replaced by ASDE-X. A third system which uses only multilateration is the Airport Surface Surveillance Capability (ASSC), and it will replace nine of the ASDE-3 radars. The ASSC will use multilateration and ADS-B aircraft information to display aircraft location for the airport tower controllers. Controllers use these systems to prevent runway incursions on the airport surface.

ASDE-3 and ASDE-X will have a technology refresh to update some of their components. The technology refresh programs are funded through BLI 2B01. The ASSC program is funded through BLI 2A12.

The Runway Incursion Reduction Program (RIRP) is evaluating other technologies that could be used to track aircraft surface and approach movements. RIRP is funded through BLI 1A01A.

The FAA will begin fielding Surveillance Interface Modernization (SIM) equipment after the Final Investment Decision is approved to replace legacy serial point to point interfaces and implement flexible Internet Protocol (IP) addressable interfaces between FAA radars and automation systems. The SIM IP transmission formats will simplify circuit management, support data security policies, provide higher reporting precision and target information which will reduce life cycle costs, enable efficient distribution of radar data in the NAS and support future FAA operational improvements. SIM is funded through BLI 2B17.

ADS-B implementation supports the NextGen operational improvements that use GPS aircraft position information as the basis for surveillance data provided to controllers. Nationwide implementation of ADS-B enables a more frequent transmission of location and other flight information from the aircraft to air traffic control facilities. ADS-B has a faster update rate (1 second versus 5 seconds for a radar), and unlike radar technology, the accuracy remains constant regardless of the distance from the aircraft to the receiving site. The Traffic Information Service

(TIS-B) broadcasts information on the location of nearby aircraft, and the Flight Information Service (FIS-B) broadcasts weather and airspace information to aircraft that are equipped with the capability to receive it. The Baseline Services and Applications program provides the ADS-B services as provided in the program baseline. Additional applications using ADS-B information will also be developed by the Flight Interval Management program and funded in the ADS-B Future Segments program. Implementation of ADS-B, TIS-B and FIS-B are funded through BLI 2A12. The ADS-B Flight Interval Management program is funded through BLI 1A05A.

The Reduced Oceanic Separation program will address methods to enhance surveillance and communication capabilities to increase the use of 30/30nm separation and potentially reduce separation to 15/15nm in Oceanic Flight Information Regions (FIRs). These improvements to air navigation services would reduce separation minima to allow optimum routing and the capability to create new air routes for increased airspace capacity.

The three Reduced Oceanic Separation alternatives being evaluated:

- promote continued voluntary equipage of Future Air Navigation System (FANS-1/A);
- acquire a space-based Automatic Dependent Surveillance Broadcast (ADS-B Out) service; and
- develop and approve the use of the ADS-B In Pairwise Trajectory Management (PTM) application.

4.4 Navigation Roadmaps

Navigation aids (also called Navaids) can be electronic or visual. En route and terminal electronic aids have traditionally been ground-based radio transmitters that emit signals that pilots, whose aircraft are equipped with related avionics, can use to determine the direction and/or distance from the Navaid. The ground-based system commonly used for en route navigation is the Very High Frequency Omnidirectional Range with Distance Measuring Equipment (VOR with DME). There are more than 1,000 VORs spread across the United States. They define the Victor and Jet airways, which are published routes based on straight lines from VOR to VOR. Aircraft equipped with GPS navigation systems are now able to navigate departure to destination routes without the ground based aids. Visual Navaids are ground based lighting systems that show pilots the path they need to follow during approach and landing.

Navaids have an important role in guiding pilots to a safe landing in low visibility conditions. They support two types of approaches — precision and non-precision. Instrument Landing Systems (ILS) are used for precision approaches and allow pilots to descend to lower minimum altitudes than are possible with non-precision approaches. The minimum altitude also called the decision height is the lowest an aircraft can descend before committing to land, and the pilot must be able to see the runway at that altitude before descending further. Non-precision approaches use Navaids other than ILS and usually only provide lateral guidance, not vertical guidance. The decision height for these approaches is significantly higher than for a precision approach. In addition to the electronic aids used for approach guidance, there are several visual systems that help a pilot see the runway when the aircraft reaches decision height.

Many NextGen OIs rely on improved position information provided by the GPS satellite navigation system. See descriptions in Appendix B which provide more information on program activities.

Navigational aid programs are portrayed in two different roadmaps:

1. Roadmap 1 (figure 4-13) - Precision Approach/Surface Navigation and Safety and Enhancements
2. Roadmap 2 (figure 4-14) - Infrastructure and En Route/ Terminal/Non-Precision Approach

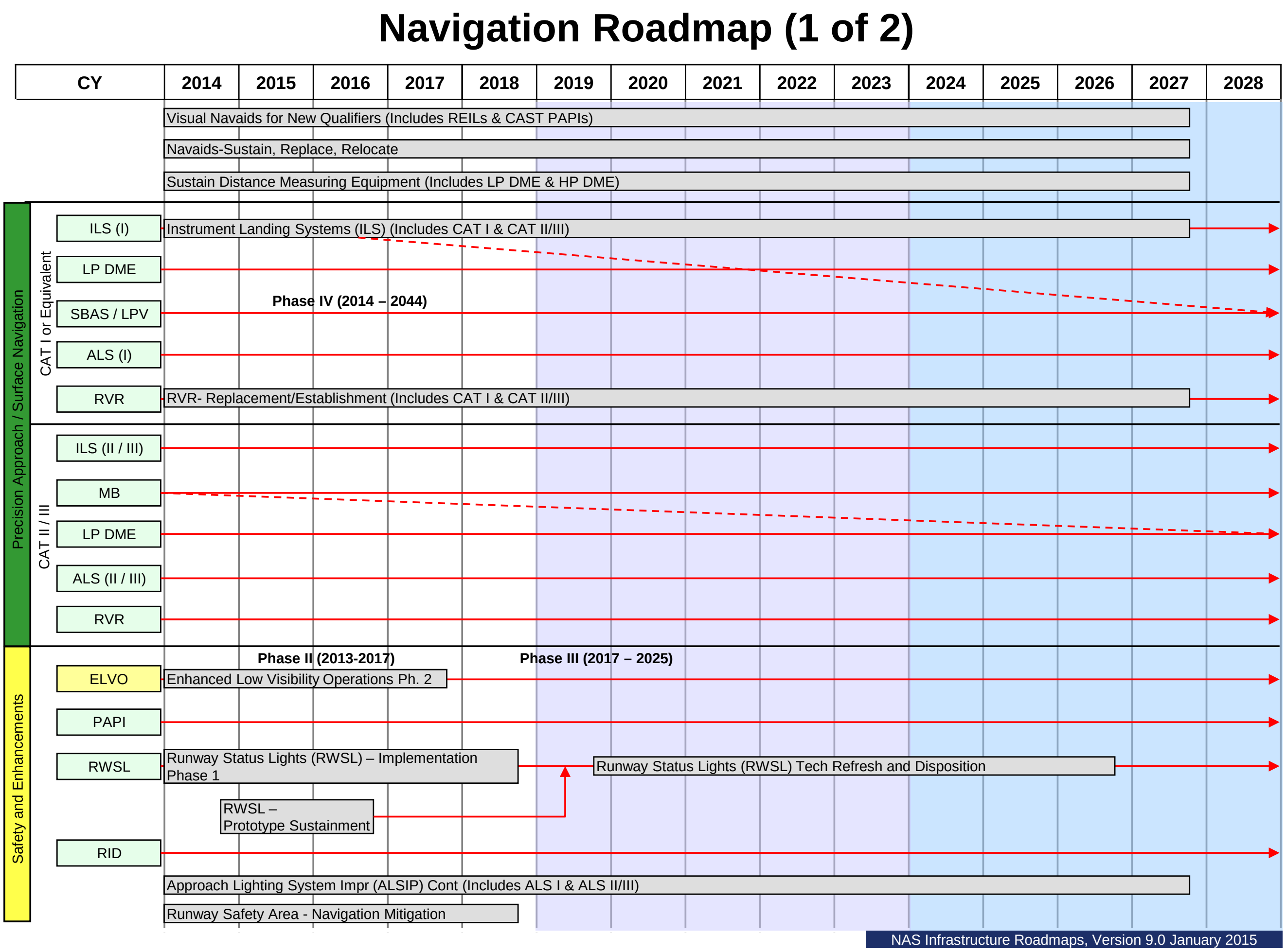

Figure 4-13 Precision Approach, Surface Navigation and Safety & Enhancements Roadmap

At the top of the roadmap, figure 4-13, are 3 programs that support the continued operation of existing systems. Visual Navaids assist pilots in staying on the proper glide path to a runway. The Visual Navaids for New Qualifiers and the Navaids-Sustain, Replace, Relocate programs update, replace and augment the existing inventory of navigational aids. The Sustain Distance Measuring Equipment (DME) program both renovates and increases the number of low power

(LP) and high power (HP) DMEs. Visual Navaids, navigation aids and DMEs are funded through BLIs 2D06, 2D07 and 2D09.

The current most widely used precision landing aids are ILS that guide pilots to runway ends using a pair of radio beams—one for lateral guidance and the other for vertical guidance—to define the approach glidepath, so that pilots can follow it to the runway using cockpit instrumentation. The ILS program also funds the purchase of Approach Lighting Systems with Sequenced Flashing lights (ALSF) and Medium-intensity Approach Light Systems with Runway alignment indicator lights (MALSR). These approach lighting systems must be installed at the end of a runway for an aircraft to descend to the designated minimums for Category I, II, or III ILS landings. Category I is the most commonly available precision approach. It guides the pilot to the runway end, but it typically requires that the pilot be able to see the runway when the aircraft is no less than 200 feet above the field elevation, and the horizontal visibility is one-half mile or more. The Category II and III approaches allow aircraft to descend to lower minimums (i.e., less vertical and horizontal visibility is required). Category II and III ILS have higher redundancy and reliability levels that reduce the risk of equipment failures. There are more than 1,200 ILSs installed in the United States. The ILS program provides for the replacement of aging ILS systems and new installations when new runways are commissioned. ILSs are funded through BLI 2D02.

The LP DME is being installed to replace marker beacons and support advanced procedures requiring performance based navigation equipage. Specially trained pilots can use these procedures to minimize the length of approach. LP DMEs installations are funded through BLI 2D06.

The Space Based Augmentation System (SBAS) is implemented by the Wide Area Augmentation System (WAAS) that uses a network of 38 ground monitors to calculate corrections to the GPS signals and broadcast those corrections from geostationary (GEO) satellites. WAAS-equipped aircraft can use the information to fly a precision approach to a runway in low-visibility conditions. There are more than 4,100 WAAS Localizer Performance with Vertical Guidance (LPV) and Localizer Performance (LP) based precision approaches in place as of January 2015. As SBAS comes into broader use, the FAA can consider decommissioning ILS, and plans to make an initial decision in 2016 on the drawdown of Category I ILS. WAAS is funded through BLI 2D03.

In both Category I and II/III sections of the roadmap, the Approach Light System (ALS) and the Runway Visual Range (RVR) systems are shown. The ALS helps the pilot see the end of the runway and transition from instrument to visual flight for landing before reaching runway minimums. The RVR informs the tower of the measured visibility so that controllers can inform the pilot whether the runway visibility is above or below minimums. In the Category II section the existing MB (Marker Beacon) installations are being evaluated to determine how many can be replaced by LP DMEs. The FAA is also testing use of light-emitting diodes (LED) to replace the incandescent lamps currently in use in ALS to reduce both maintenance and operating costs. The approach lights and visibility sensors will need to be sustained and remain in operation for precision approach guidance regardless of any decision on decommissioning ILSs. ALSs, RVRs and other approaching lighting systems are funded through BLI 2D04 and 2D05.

The Safety and Enhancements section of the roadmap shows several systems designed to assist pilots to operate safely in low visibility conditions. They are:

- Enhanced Low Visibility Operations (ELVO) – allows pilots to land with more limited visibility conditions than standard procedures. Additional RVRs to support this capability are funded through BLI 2D04;
- Precision Approach Path Indicator (PAPI) – allows pilots to determine visually that they are on the proper glideslope for landing. They are funded through BLI 2D10;
- Runway Status Lights (RWSL) – are designed to give pilots a stop signal if it is dangerous to enter or cross a runway, funded through BLI 2B12;
- Runway Incursion Device (RID) – is a system in the tower that alerts controllers when a runway is occupied;
- Airport Lighting System Improvement Program (ALSIP) – a response to the National Transportation Safety Board recommendation to replace steel airport light supports with frangible structures to minimize damage to aircraft that descend below the glidepath, funded through BLI 2D05; and
- Runway Safety Area (RSA) – a program to replace structures in the safety area surrounding a runway with low-impact supports to minimize damage to aircraft that veer off the runway, funded through BLI 2D12.

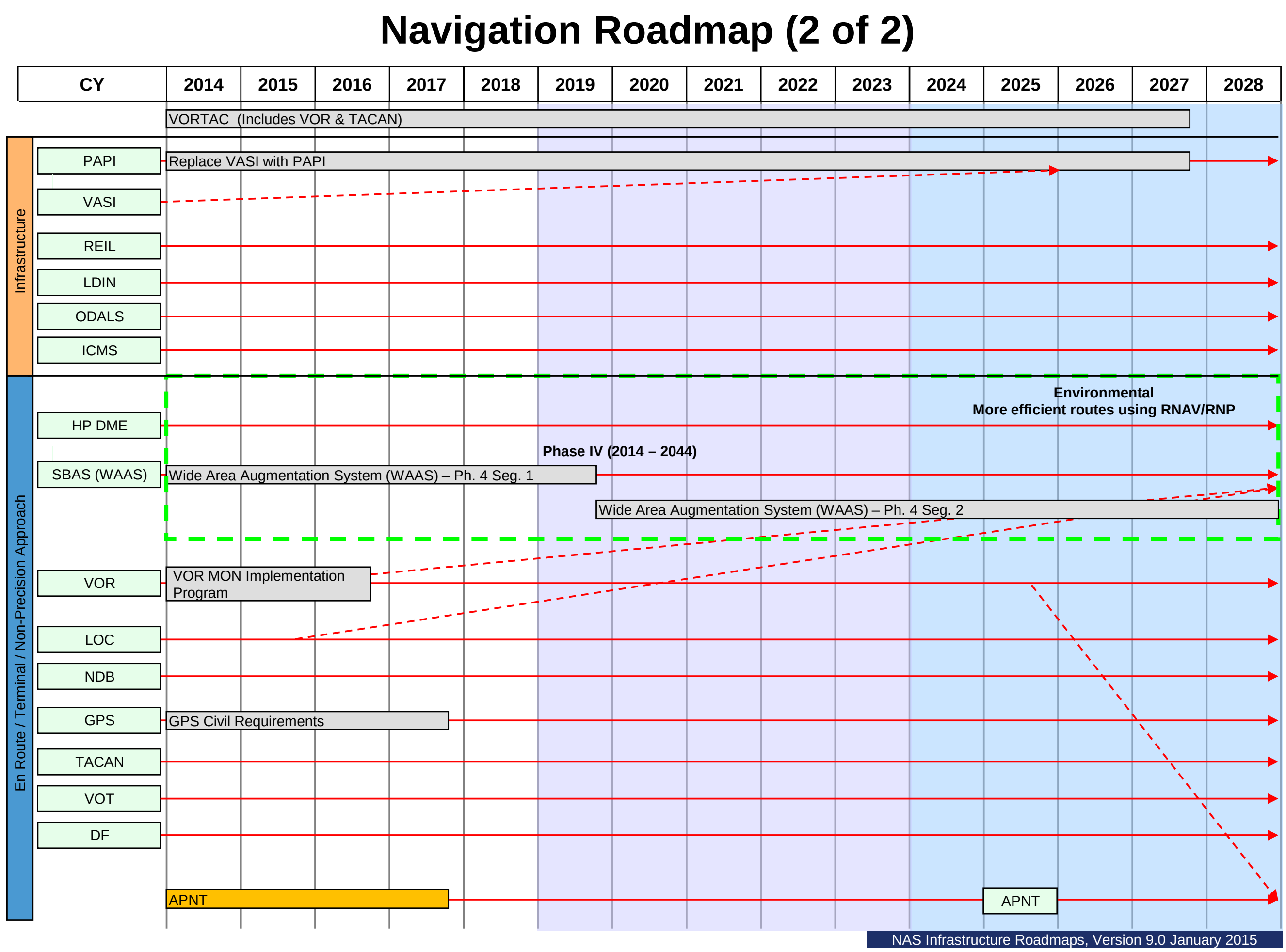

Figure 4-14 Infrastructure and En Route, Terminal and Non-Precision Approach Roadmap

The VORTAC program at the top of the roadmap (Figure 4-14) shows that combined Very High Frequency Omnidirectional Range (VOR) and Tactical Navigation System (TACAN) sites will be supported indefinitely based on the need to retain them. TACAN is the military equivalent of combined VOR and DME systems. VORTAC is a site with a VOR and TACAN co-located, and the VOR uses the TACAN for DME information. The VORTAC program is funded through BLI 2D01A.

There are also two visual systems which are used to confirm that the aircraft is on the proper glide path for a safe landing. Vertical Approach Slope Indicator (VASI) systems are being replaced by Precision Approach Path Indicator (PAPI) systems to meet international standards. The replacement program will be continued until the PAPI replaces all of the current VASI systems, at a time well into the future. The Replace VASI with PAPI program is funded through 2D10.

The Runway End Identification Lights (REIL) help pilots to visually align with the runway for both precision and non-precision approaches. The REIL will continue operating throughout the roadmap timeframe. The LDIN (Lead In Light System) and the ODALS (Omnidirectional Airport Lighting System) are installed at the end of runways to help pilots determine the active runway for landing. The Interlock Control and Monitoring System (ICMS) lets controllers rapidly activate and deactivate the navigational aids at an airport.

HP DME supports navigation for both en route and terminal operations. HP DME installations are funded through BLI 2D06. Analysis is being performed by the NextGen Navigation Engineering program to determine the DME expansion needed to support RNAV and NAS-wide Performance Based Navigation (PBN).   NextGen Navigation Engineering is funded through BLI 1A10D.

The Space Based Augmentation System (SBAS) also called the Wide Area Augmentation System (WAAS) uses a network of 38 ground monitors to calculate corrections to the GPS signals and broadcast those corrections from GEO satellites. The FAA has more than 5,900 Lateral Navigation (LNAV) GPS-WAAS non-precision approach procedures in place. WAAS is funded through BLI 2D03.

As GPS replaces the VOR as a navigation aid, FAA will decrease the number of VORs to a Minimum Operational Network (MON). The MON will serve as a backup for GPS and will be available for those aircraft that have not equipped with GPS navigation systems. The VOR MON program is funded through BLI 2D01B.

The Localizer (LOC) is an ILS component that provides horizontal guidance to a runway end. When used as a stand-alone system without a Glideslope component, the LOC supports non-precision approach operations; SBAS (WAAS) will begin to replace that functionality at airports where only localizers are installed.

The FAA will continue operating Non-Directional Beacons (NDB), because NDBs are still used at some remote areas, where it is not economically justified to install modern navigational equipment.

The Department of Defense operates GPS. There are typically 24 to 30 active satellites in orbit, and a navigation receiver can determine an aircraft's position by interpreting the data transmitted by the satellites in view of the aircraft's antenna. Two GPS upgrades are expected in future years. The next generation of satellites will have a second frequency (L5) for civilian safety-of-life use. An aircraft receiver that receives both the existing L1 signal and the new L5 signal can internally calculate corrections that enhance the accuracy of the position calculation and eliminate the errors caused by ionospheric distortion. The GPS III family of satellites will be upgraded with an additional civil signal (L1C) and increased transmitting power. The GPS Civil Requirements BLI 2D11 will fund the ground monitoring stations to measure the accuracy and reliability of the new civil frequencies.

The VOT (VOR Test Range) is used to check and calibrate VOR receivers in aircraft. The Direction Finder (DF) was used to help locate lost pilots, but it is being decommissioned because better technology is now available.

The Alternate Positioning Navigation and Timing System (APNT) is a program to determine the appropriate back up navigation system in case GPS service is disrupted. It is a NextGen initiative to ensure continuity of service if GPS is disrupted. If it is successful as a backup, the VORs not identified as necessary for the MON may be decommissioned. The APNT program is funded through BLI 1A05.

4.5 Weather Roadmaps

Timely and accurate weather observations and forecasts are essential to aviation safety and for making the best use of aviation capacity. Weather information will be even more important when NextGen direct or user chosen trajectory routing becomes routine. Pilots need to know the direction and speed of winds aloft so that they can take advantage of tailwinds and minimize the effect of headwinds. They also need to know if there will be obstructions to visibility that restrict landings at their destination airport, and whether the runway is wet or dry and how that will affect braking action. Traffic flow managers and pilots use weather observations and forecasts to determine when they need to plan alternative routes to avoid severe weather. Pilots must avoid thunderstorms with hail and heavy rain, turbulence, and icing to avoid damage to the aircraft and the potential for injuring passengers. The FAA has a lead role in collecting and distributing aviation weather data – particularly hazardous weather. The FAA distributes weather hazard information from its own systems and uses both the FAA and National Weather Service (NWS) computer forecast models based on data available from FAA and NWS sensors to develop forecasts for use by air traffic control facilities, pilots, airline operations centers, and other aviation-related facilities.

NextGen operational improvements will rely on improved access to weather information provided by Common Support Services – Weather (CSS - Wx) and better weather processing and forecasting provided by NextGen Weather Processor (NWP).

Weather sensors include weather radars and surface observation systems that measure atmospheric parameters, such as surface temperature, prevailing wind speed and direction, relative humidity, and cloud bases and tops, as well as wind shear and microbursts. These weather sensors provide real-time information to air traffic facilities and to centralized weather-forecasting models.

Weather processing/dissemination/ display systems organize and process the sensor’s observed data. Data from multiple sensors feed forecast models whose output can be disseminated and integrated in national and local processing and display systems that interpret broad weather trends affecting aviation operations. This information can then be sent to air traffic controllers, traffic flow managers, dispatchers, and pilots.

Weather system implementation is broken down into two different roadmaps:

1. Roadmap 1 (figure 4-15) - Weather Sensors
2. Roadmap 2 (figure 4-16) - Weather Dissemination, Processing, and Display

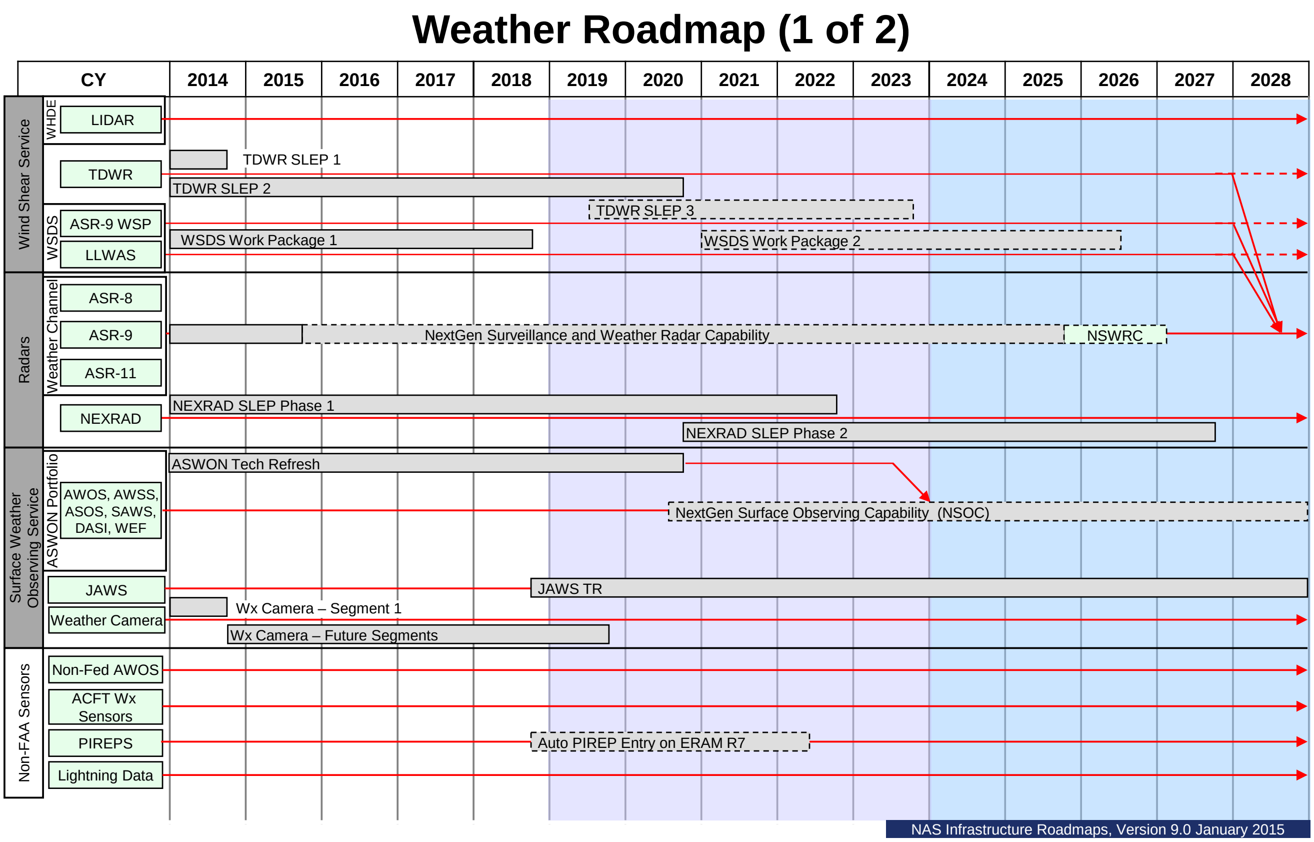

Figure 4-15 Weather Sensors Roadmap

Figure 4-15 shows the Wind Shear Services (WSS) portfolio which includes:

- Light Detection and Ranging (LIDAR) system;
- Terminal Doppler Weather Radar (TDWR);
- Airport Surveillance Radar-9 (ASR-9) Wind Shear Processor (WSP); and
- Low Level Wind Shear Alerting System (LLWAS).

The LIDAR system uses lasers to detect dry microbursts and gust fronts that radar systems may not detect. Evaluation of LIDAR is underway at airports located in dry high plains or mountain environments, where wind shear is not always accompanied by sufficient precipitation for the TDWR to detect it with 90 percent reliability.

TDWR, ASR-9 radars, wind sensors and lasers are used to detect wind shear conditions near the runways and approach areas of airports. TDWR is installed at 46 airports and detects wind shear and microbursts, so controllers can warn pilots of these hazards as they approach the runways and begin landing procedures. TDWR is the most sophisticated wind shear detection system. Using Doppler technology, the radars can detect the rapid changes in wind speed and direction that indicate existence of wind shear hazards for an aircraft approaching or departing a runway. Airports with significant wind shear risk that have a lower volume of air traffic are served by the ASR-9 WSP, a lower cost alternative to TDWR. The ASR-9 WSP processes weather from the two dimensional Doppler search radar signals, which are its standard format to detect wind shear which approximates the output of the TDWR.

LLWAS consists of wind sensors located at 6 to 29 points around the runway thresholds to measure surface wind direction and velocity. The LLWAS computer systems compare the wind velocity and direction detected by these sensors at different locations to determine whether wind shear events are occurring at or near the runways. The sensors measure surface winds and do not detect wind shear above the surface in the approach or departure paths. LLWAS serves airports that may also have a TDWR or ASR-9 because the system supplements the weather radars with point-specific wind measurements to verify the presence and location of wind shear.

The Wind Shear Detection Services (WSDS) Work Package 1 program will provide for modernization of the ASR-9 WSP and LLWAS. The Wind Shear Detection Portfolio is funded through BLI 2A13. The TDWR service life extension program is funded through BLI 2B02.

The ASR-8/9/11 Weather Channel and the Next Generation Weather Radar (NEXRAD) detect precipitation, wind, and thunderstorms that affect aircraft in flight. Replacing the weather information that the ASR-8/9 radars generate will be necessary if these radars are decommissioned. The FAA is evaluating the potential to combine these functions into a NextGen Surveillance and Weather Radar Capability (NSWRC) if the business case shows that solution to be viable.

Development of NEXRAD occurred under a joint program run by the Department of Commerce’s National Weather Service, Department of Defense, and FAA. NEXRAD systems are Doppler weather radars that detect and produce over 100 different long-range and high-altitude weather observations and products, including areas of precipitation, winds, thunderstorms, turbulence, and icing. The NEXRAD radars are essential for forecasting future weather. A cooperative program with the partner agencies will upgrade the NEXRAD radars with a Service Life Extension Program (SLEP) to modernize and renovate the existing system of radars. The NEXRAD SLEP Phase 1 program is funded through 2A03.

The Automated Surface Weather Observation Network (ASWON) Portfolio includes several surface sensors (AWOS/ASOS/AWSS/SAWS/DASI/WEF) that measure weather parameters on the surface and report conditions to air traffic facilities and pilots. The data collected is important to pilots and dispatchers as they prepare and file flight plans, and it is vital for weather forecasting. The Automated Surface Observing Systems (ASOS) and other variants (such as the Automated Weather Observing System (AWOS); the Automated Weather Sensor Systems (AWSS); and the Stand Alone Weather Sensing (SAWS) system) have up to 14 sensors that measure weather data, including temperature, barometric pressure, humidity, type and amount of precipitation, and cloud bases and amount of sky cover. The Digital Altimeter Setting Indicator (DASI) shows tower controllers the current barometric pressure, so they can inform pilots of the proper aircraft altimeter setting so it will display the correct ground elevation of the runway at touchdown. The Wind Equipment F-400 Series (WEF) determine and display the wind direction and velocity on the runways. These systems feed data directly to air traffic control facilities and support automated broadcast of weather information to pilots. They also provide regular updates for the forecast models that predict future weather conditions including adverse weather. These systems will remain in operation until a decision is made to implement the NextGen Surface Observing Capability. The ASWON Technology Refresh program will provide upgrades and replacements needed to address obsolescence, supportability, and maintainability issues. The ASWON Portfolio is funded through BLI 2C01.

The Juneau Airport Weather System (JAWS) is unique to Juneau, Alaska. It uses mountain-peak wind sensors located around Juneau to provide wind hazard information to the Flight Service Station and Alaska Airlines to improve the safety of aircraft arriving at and departing the airport. The Technology Refresh program will provide upgrades and replacements needed to address obsolescence, supportability and maintainability issues. The JAWS program is funded through BLI 2A13.

The Weather Camera program installed cameras along flight routes in Alaska and at airports, so pilots have a visual picture of the weather they might encounter as they file their flight plans for a specific route. Flights can be cancelled if the cameras show poor weather along the planned route or at the destination. The Weather Camera program will replace cameras as they fail or reach end of life. The program is funded through 2C04.

The non-FAA sensors shown at the bottom of the roadmap are sources of weather information that improve FAA’s overall knowledge of weather conditions. Some states and smaller airports operate AWOS for weather observations. Inputs from these systems provide supplemental data to FAA sensors. Aircraft weather sensors can provide humidity, wind speed and atmospheric pressure readings that are helpful in forecasting weather conditions. Pilot Reports (PIREPS) provide real time reports on the weather along major flight routes. A planned activity would enhance ERAM to allow automatic entry of pilot reports. Lightning Data systems provide air traffic facilities important information about the location and intensity of thunderstorms.

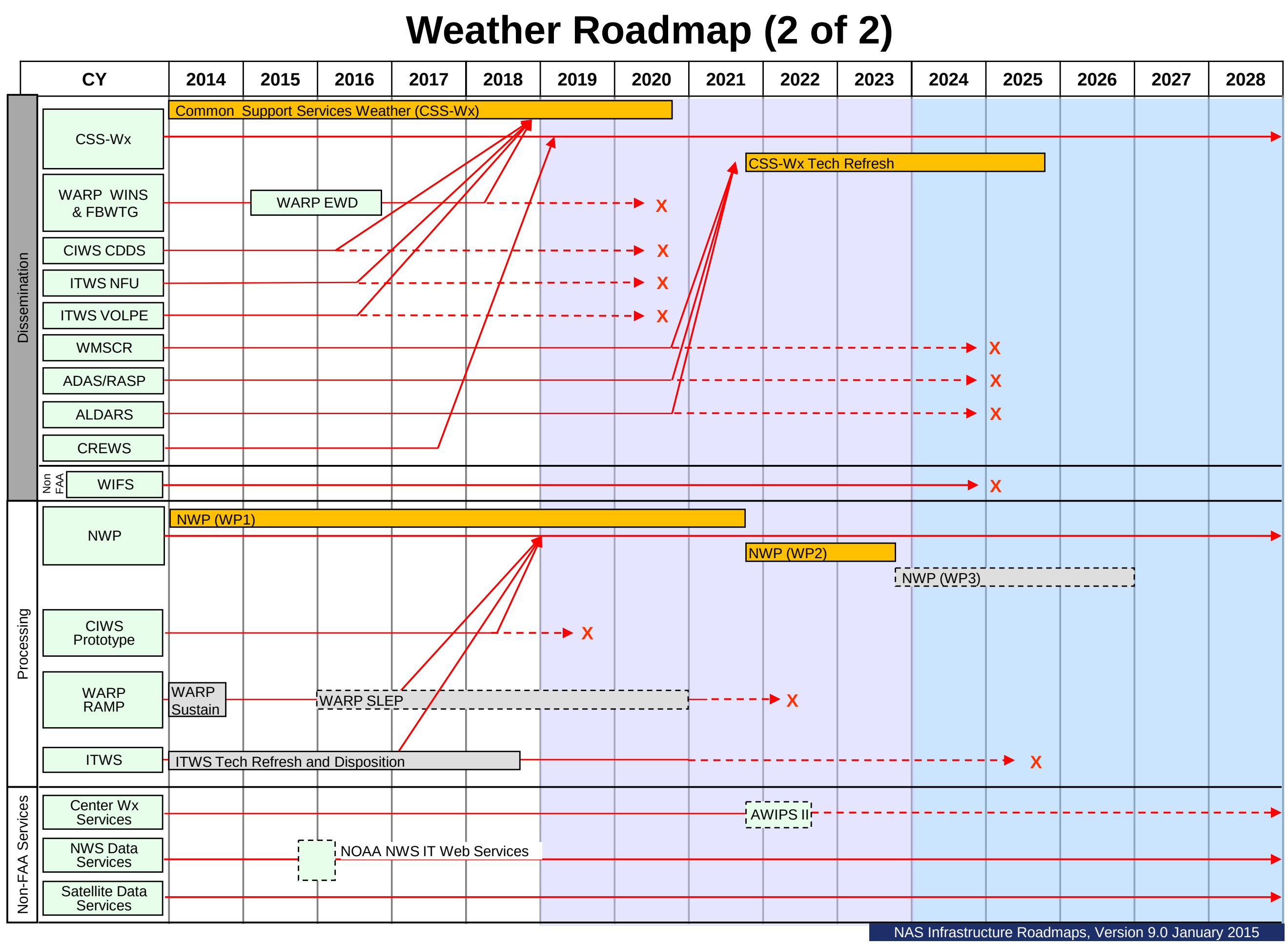

Figure 4-16 Weather Dissemination, Processing and Display Roadmap

Figure 4-16 shows the Common Support Services – Weather (CSS - Wx) which will be the source for weather information and it will provide access to all users throughout the NAS. Supported by the SWIM program, this capability is planned to be operational in 2019. The CCS-Wx program is funded through BLI 2A11B.

The Weather and Radar Processor Weather Information Network Server (WARP WINS) processes and stores data from multiple NEXRAD radars for use by en route control facilities. The information is used by the Center Weather Service Unit to develop forecasts. WARP also provides NEXRAD precipitation intensity data to controllers' displays. The WARP FAA Bulk Weather Communications Gateway (FBWTG) provides NWS data to the center weather service units to aid in their forecast of weather conditions in the center's airspace. The roadmap shows that WARP will be upgraded with an Enhanced WINS distribution (WARP EWD) before the WARP functions are incorporated in CSS – Wx.

The Corridor Integrated Weather System (CIWS) gathers weather information along the busiest air traffic corridors to help air traffic specialists select the most efficient routes when they must divert traffic to avoid severe weather conditions. The CIWS Data Distribution System (CDDS) program enabled the existing CIWS system to distribute data to external NAS users so traffic management participants have the same information for daily route planning.

The Integrated Terminal Weather System (ITWS) consolidates weather information from automated sensors and surrounding radars (TDWR and NEXRAD) to provide real-time weather information for terminal control facilities. The system also projects movement of thunderstorms and gust fronts up to 20 minutes into the future. ITWS has been installed at 23 airports. Tower and Terminal Radar Approach Control (TRACON) controllers use the information to make more precise estimates of when runways should be closed and subsequently reopened. They also use the information to plan for a switch in terminal arrival patterns to avoid inefficient maneuvering to accommodate runway changes. The ITWS will have two enhancements. The National Weather Service Filter Unit (ITWS NFU) will send data collected by FAA to the National Weather Service to use for weather forecasting. The ITWS Volpe will establish an internet connection to the ITWS weather data for external users. After 2018, ITWS NFU and ITWS Volpe data collection functions will be incorporated into the CSS-Wx.

The ITWS systems installed at towers and TRACONs will receive a technical refresh and may be merged with NextGen Weather Processor (NWP). ITWS is funded through BLI 2B19.

The FAA-operated Weather Message Switching Center Replacement (WMSCR) is a network with distribution nodes in Salt Lake City and Atlanta that collects and distributes nationwide weather information. The FAA will integrate WMSCR functionality into the CSS-Wx for weather information distribution.

The Automated Weather Observation System (AWOS) Data Acquisition System/Regional ADAS Service Processor (ADAS/RASP) is a communications link that transmits AWOS/ASOS/AWSS data to air traffic facilities. ADAS also correlates cloud-to-ground lightning strike information to AWOS/ASOS/AWSS data to better determine the location of nearby thunderstorm activity.

The Automated Lightning Detection and Reporting System (ALDARS) will become part of the CSS-Wx in 2021 and its information will be consolidated with other weather inputs.

The Center/TRACON automation system (CTAS) Remote Weather System (CREWS) collects data to help en route and terminal facility controllers coordinate the flows of air traffic into busy terminal facilities. Decisions on its future will be made in 2017.

The World Area Forecast System (WAFS) Internet File Service (WIFS) is a commercial service that provides weather information to support global flight operations.

The NextGen Weather Processor (NWP) will process the weather information collected on CSS-Wx and take over the processing functions of the existing Weather and Radar Processing (WARP), CIWS and ITWS systems. The NWP program will enhance the display of weather information by using new algorithms to portray icing conditions, turbulence, and other hazards. Further upgrades of weather-predicting algorithms will also be added to include Wind Shear/Microburst and Wake Vortex Detection and prediction advisories. The WARP Radar and

Mosaic Processor (RAMP) processes weather data and will remain in service until their functions can be incorporated in NextGen systems. The NWP program is funded through BLI 2A17.

The non-FAA services provide data from the NWS ground and satellite sensors to FAA for use by the NWS meteorologist who interpret and forecast weather at the FAA en route centers.

Center Weather, NWS Data and Satellite Data Services comprise a distributed "virtual" database that will receive weather data directly from sensors, NWS, National Oceanic and Atmospheric Administration (NOAA) and other sources and, either automatically or by request, send data to FAA facilities and users so that observations and forecasts can be more widely and consistently distributed via network-enabled communications. Decision support tools will use this weather information to assist users in understanding weather constraints and taking actions to reduce risk for aviation operations. Integration of these services into the NAS is funded through the CSS-Wx program as part of the SWIM BLI 2A11.

4.6 Facilities

The Air Traffic Organization maintains and operates thousands of staffed and unstaffed operational facilities that must regularly be upgraded and modernized. The largest facilities are the 21 en route centers, that house hundreds of employees and the equipment they use to control aircraft flying in the en route airspace. The other operational facilities with significant staffing are the more than 500 towers and 167 TRACON facilities that control arrival and departure traffic to and from airports.

There are more than 16,000 unstaffed facilities—many in very remote locations—sheltering communications, navigation, surveillance equipment and weather sensors. Much of this equipment is housed in buildings that need renovation. Many have deteriorating steel towers and foundations. Some newer unstaffed buildings and structures frequently need renovation because they are in remote and/or hazardous locations near the ocean or on mountaintops. Replacing roofing, electric power generators, heating/cooling, and structural and security components of these structures is essential to successful operation of the NAS. Modernization of unstaffed facilities is funded through BLI 2E02.

The William J. Hughes Technical Center (WJHTC) in Atlantic City, NJ, and the Mike Monroney Aeronautical Center (MMAC) in Oklahoma City, OK, each have many buildings. Each year, these complexes receive funds to both upgrade and replace infrastructure, and to improve and modernize buildings to support training, logistics, research, and management functions. The MMAC operates under a lease from the Oklahoma City Airport Trust, and funds are requested to pay the annual lease costs. The MMAC also receives funding for building renovation and updated infrastructure. The WJHTC supports research programs to determine the feasibility of NextGen concepts, and it also supports the testing of new equipment that will be installed in the NAS. The FAA has requested funding for 2016 and beyond to upgrade buildings and supporting infrastructure, such as roads. Annual funding is provided to reconfigure the research laboratories to accommodate acceptance testing for new equipment and to test modifications to existing equipment. The WJHTC is funded through BLI 1A02, 1A03 and 1A04. The MMAC is funded through BLI 3B01 and 4A04.

The Terminal Air Traffic Control Facilities – Replace program includes funding for replacement of existing air traffic control towers (ATCT) and TRACON facilities. Projects are funded in five segments and are scheduled based on FAA priorities. A project typically spans a period of 5-10 years from inception to completion depending on the size of the project. Each segment of a project is fully funded in the year requested, but it may take more than one year to complete that segment. Funding is allocated to the segments based on FAA priorities while maintaining the overall 5 year funding estimates for the program. The program also includes the project to replace the New York TRACON on Long Island. The existing N90 facility is old, does not meet operational requirements and needs to be replaced. FAA is currently acquiring real estate and conducting site preparation for the new facility. This program is funded through BLI 2B06.

The Terminal Air Traffic Control Facilities – Modernize program renovates or replaces specific exterior or interior components of existing towers, such as elevators, heating ventilation and cooling equipment, roofs, or other infrastructure that the FAA must upgrade to keep towers functioning. ATCT/TRACON modernization program is funded through BLI 2B07.

The FAA upgrades and improves Air Route Traffic Control Center (ARTCC) facilities by replacing heating and cooling systems, upgrading electrical power distribution systems, and providing other facility needs to meet mission requirements. ARTCC modernization program is funded through BLI 2A04.

5 Conclusion

The capital investment plan contains an annual summary of the ongoing planning to modernize and expand the air traffic control and supporting systems over the next five years. It balances planned improvements between modernizing and upgrading legacy facilities and equipment and investing in the future capabilities of NextGen. That balance is necessary to ensure reliable and safe operation of the NAS while the NextGen operational improvements are implemented. Investment in legacy equipment, facilities and information technology systems cannot be suspended, because these systems must continue to provide services during and, in many cases, after the transition. Computer systems and other technology that FAA currently uses for air traffic control continue to face obsolescence issues. As legacy systems age, reliability becomes an issue and they face the additional problem of not being repairable because manufacturers no longer produce replacement parts.

The capital investment plan draws on several layers of planning integral to building the system of the future. System engineers develop a concept of operations and projected operational improvements to air traffic control consistent with the FAA's Strategic Priorities. As part of that process, functional requirements are developed to design a system architecture that supports operational improvements and NextGen concepts. The next step is determining how fast modernization can proceed by evaluating the financial resources available to build the systems shown in the NAS Enterprise Architecture. The complex equipment necessary to support operational improvements takes time to develop, build, install, and test to ensure it will operate error free. In addition, allowing adequate time to train controllers in the use of the new equipment and procedures is critical to successful implementation.

FAA has completed a significant level of development work that supports progress in implementing NextGen operational improvements. These improved methods of operation have reached the point where aviation users can take advantage of them. FAA has collaborated with industry through the NextGen Advisory Committee to develop a plan to implement high-priority NextGen capabilities that are projected to produce significant near-term benefits. These programs are:

- Increased use of wake categorization and other improvements for dual and independent parallel runway operations at 28 locations nationwide;
- Improving air traffic flow in major metropolitan areas by deploying Performance Based Navigation procedures that allow shorter and more direct flight routes. Work is continuing at Northern California, Charlotte and Atlanta metroplexes, with more to follow when these are complete;
- Improving information sharing and taxi procedures for surface operations at airports. Automation improvements and collaboration with air carriers will reduce delays aircraft experience in reaching active runways and increase the hourly rate of takeoffs and landings by reducing inefficiencies in moving from the gate to the active runway; and
- Replacing some voice communications with data communications will be accelerated to reduce the time needed to relay non-critical air traffic information and reduce the potential for errors in sending and read back of flight plan clearances.

These four initiatives have been identified because industry sees them as having significant benefits and they have been tested at trial sites. The CIP shows the level of resources needed to pursue these commitments, which support the transition to more efficient and safer airspace operations.

6 Appendices

The CIP contains five appendices.

Appendix A

- Lists FAA strategic priorities and metrics.
- Associates CIP programs with performance metrics.

Appendix B

- Provides CIP program descriptions and the alignment of programs to strategic priorities.
- Describes the programs contribution to meeting the performance metric.
- Lists performance output goals for FY 2016–2020.
- Shows system implementation schedules.

Appendix C

- Provides funding amounts from FY 2016 through FY 2020 by BLI. Funding amounts are in Millions of Dollars.

Appendix D

- Response to GAO Report 08-42 - Identifies major programs with cost and schedule changes from the original baseline and explains the causes of those changes.

Appendix E

- Defines acronyms and abbreviations.

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