National Aeronautics and Space Administration

Airspace Systems Program

NextGen Systems Analysis, Integration and Evaluation Project

Project Plan

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Airspace Systems Program

NextGen Systems Analysis, Integration and Evaluation (SAIE) Project Plan

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1 PROJECT PLAN OVERVIEW

1.1 Introduction

1.1.1 Purpose

This document describes the plan for the management and execution of the Next Generation Air Transportation System (NextGen) Systems Analysis, Integration, and Evaluation (SAIE) Project within the Airspace Systems Program (ASP). A Program Plan approved by the Associate Administrator of the Aeronautics Research Mission Directorate (ARMD) covers ASP and its two Projects. The SAIE Project Plan is in response to the ASP Plan, and follows the planning guidance established by ASP and the NASA Research and Technology Development Management Requirements 7120.8. The Project Plan discusses the SAIE Project within the context of NASA's role in Air Traffic Management (ATM) in support of the Joint Planning and Development Office (JPDO), the Federal Aviation Administration (FAA), and the aviation system industry and it's users. The Plan addresses the technical approach of the Project, and the programmatic approach to its management and execution. It defines the responsibilities and activities associated with the planning, tracking, review, and reporting of the Project. The Project Plan is maintained as a configuration-controlled document that is updated at least once per year. The focus of this document is the five-year projection of SAIE project activities and milestones.

1.1.2 Scope

The SAIE Project is primarily responsible for facilitating the Research and Development (R&D) maturation of integrated concepts through evaluation in relevant environments, enabling transition to stakeholders. Opportunities to collaborate with the FAA and industry to further the development of NextGen technologies towards implementation will be sought on a continuing basis. Working with the FAA through various efforts, such as Research Transition Teams (RTTs), or field tests, are examples of collaborative opportunities.

1.1.3 Background

The role of the Airspace Systems Program in defining and achieving the NextGen vision is established with guidance from the NASA Strategic Plan, the 2010 National Aeronautics R&D Plan and Aeronautics Research Mission Directorate principles. The R&D Plan "lays out high-priority national aeronautics R&D challenges, goals and supporting objectives to guide the conduct of U.S. aeronautics R&D activities through 2020." The technical content within ASP directly supports the needs identified in this National Plan, and provides a strategy to enable the stable and long-term fundamental research necessary to achieve the advances and breakthroughs.

In order to achieve revolutionary improvements, ASP has taken a leadership role in NASA's partnership with other agencies supporting the Joint Development and Planning Office (JPDO). The JPDO has outlined the vision of the Next Generation Air Transportation System (NextGen) by developing a Concept of Operations (ConOps), an Integrated Work Plan (IWP) and an Enterprise Architecture (EA) to achieve the NextGen vision. ASP research is focused on achieving the vision of NextGen including: accommodating projected growth in air traffic while preserving and enhancing safety;

providing all airspace system users more flexibility and efficiency in the use of airports, airspace and aircraft; meeting our civil aviation, national defense, and homeland security needs as a national priority; and maintaining pace with a continually evolving scientific and technical environment.

In FY2010, the Program restructured its two projects to improve the focus on concept and technology transitions from foundational research to systems applications:

- The fundamental Research Focus Areas (RFAs) from the original Airspace and Airportal Projects were consolidated into the NextGen Concept and Technology Development (CTD) Project. The Project develops and explores fundamental concepts, algorithms, and technologies to increase throughput of the National Airspace System (NAS) and achieve high efficiency in the use of resources such as airports, en route and terminal airspace.
- The crosscutting RFAs from the Airspace and Airportal Projects were consolidated into the NextGen SAIE Project. The SAIE project is primarily responsible for facilitating the research and development maturation of integrated ASP concepts through evaluation in relevant environments. The project also conducts collective impact and safety assessments, and cost-benefit analyses, of ASP research products to drive ASP research investment decisions.

1.2 Objectives

1.2.1 Project Goal and Technical Objectives

The key objectives of the NASA Airspace Systems Program are to:

- Perform research to enable new aircraft system capabilities and air traffic technology to increase the capacity and mobility of the nation's air transportation system
- Perform research to maximize operational throughput, predictability, efficiency, flexibility, and access into the airspace system while maintaining safety and environmental protection
- Explore and develop concepts and integrated solutions to define and assess the allocation of centralized and decentralized automation concepts and technologies necessary for NextGen

The Program has identified a set of Technical Challenges that collectively support these key objectives (Appendix E). In support of these Program objectives, the NextGen-SAIE Project addresses several of the Technical Challenges within its portfolio. The specific Technical Challenges supported are identified within the descriptions of each of the project's three major focus areas.

The primary goal of the SAIE project is the R&D maturation and transition of integrated ASP concepts through evaluation in relevant simulation and operational environments. The primary technical objectives of the SAIE project to support this goal are:

- Integration, evaluation, and transition of more mature and promising concepts and technologies in an environment that faithfully emulates real-world complexities to facilitate integration, and to take ASP concepts and technologies to higher Technology Readiness Level (TRL) for transition to stakeholders.

- Interoperability research and analysis of ASP technologies across ATM functions is performed in the areas of trajectory prediction and human/system integration.
- Analysis of the Program's concepts and technologies to identify the system-level benefits or impacts. System-level analyses are conducted to increase understanding of the characteristics and constraints of the airspace system and it's domains, and to identify potential gaps in the research portfolio that could lead to new concepts and ideas for research investment.

1.2.2 Alignment

The SAIE Project is aligned to meet national and agency goals and objectives as described in the Airspace Systems Program Plan. Specifically, SAIE will contribute to research in the area of maturing NextGen concepts and technologies from the CTD research portfolio towards higher TRL, and providing system level analysis to support program portfolio management. Achieving these Program goals will provide transition paths for the program's concept and technology research directly addressing the JPDO Operational Improvements (OI's) or R&D needs, as well as addressing stakeholder needs of advancing technologies to higher readiness levels. The following quote substantiates this need:

> *"More resources would be helpful in areas of system level testbeds and taking technology to higher readiness levels for the advances in the Airspace Systems and Aviation Safety programs in support of NextGen."*
> Testimony of Dr. Raymond S. Colladay, before the Subcommittee on Space and Aeronautics of the House Committee on Science and Technology June 18, 2009

The Project is committed to continuing its interaction with the JPDO to ensure alignment with the JPDO NextGen Concept of Operations [1]CONOPS), to understand the rationale behind the formulation of the key JPDO documents, and to inform JPDO deliberations with subject matter expertise and SAIE results. Additional activities such as participation on FAA/NASA RTTs are also supported. The JPDO CONOPS, Integrated Work Plan (IWP), and the R&D Plan will form the high-level project documentation with respect to concepts of operation and research questions. Particular emphasis will be placed on coordination of project research with JPDO metrics and demand forecasts. The Project is participating in JPDO activities to add detail to the current set of JPDO research needs and to validate the mapping of research needs to SAIE activities. The Project is also working with the ARMD Strategy, Architecture, and Analysis team to map SAIE research and analysis activities to an ARMD Architecture Roadmap.

1.3 Technical Approach

The NextGen SAIE Project is responsible for the R&D maturation of integrated concepts through evaluation in relevant environments, providing integrated solutions, characterizing airspace system problem spaces, defining innovative approaches, and assessing potential system impacts and design ramifications of the program's portfolio.

1.3.1 Research Focus Areas (RFAs)

The SAIE Project has defined three RFAs, within which system-level tests and analyses of concepts and technologies are conducted to facilitate transition of research products to the field. These activities involve the outputs from multiple CTD RFAs, other emerging technologies from the NAS, or other existing NAS systems and infrastructure. An overview of each of the RFAs is provided below.

Integration, Evaluation and Transition (IET)

The IET RFA evaluates more mature ASP concepts & technologies in relevant environments to facilitate integration, and to take ASP concepts and technologies to higher Technology Readiness Level (TRL). The purpose of IET is to assess these concepts and technologies in the context of real-world operations, including interactions with other systems present in such an environment. Of particular interest in this RFA is the integration of concepts with each other, and with existing and emerging NAS technologies, and collaboration with NextGen-implementing organizations to facilitate transition of NASA-developed concepts and technologies. This RFA supports the ASP Technical Challenge "Relevant Environment Integration and Evaluation."

Tests within IET are conducted in high-fidelity environments ranging from NASA simulation facilities to live field operations, depending on the requirements of a particular test, and the availability of simulation capabilities and/or field installation candidates to meet those requirements. NASA has a suite of high-fidelity simulation facilities capable of relevant-environment-type testing within the Tower, Terminal Radar Approach Control (TRACON), Air Route Traffic Control Center (ARTCC, or "Center"), and flight-deck environments, or combinations of those environments (distributed simulations). Field operations will be conducted as necessary, with the cooperation of the FAA and/or airlines, at specific Center, TRACON, or Tower locations, or on-board flight-test or commercial flight aircraft.

In addition to full-scale, high-fidelity evaluations of more mature concepts and technologies, IET supports in-situ studies or experiments involving less mature concepts and technologies. The in-situ experiments are typically quick-look shadow evaluations that "piggy-back" on test infrastructure developed for other purposes. The presence of subject matter experts at the test site allows them to informally evaluate the concept, and their evaluations can be placed in the context of the entire operational situation (e.g., particular weather or flow conditions). The data collection infrastructure supports such in-situ experiments as well.

IET-developed infrastructure and capabilities also provide data and analyses applicable to very early stages of concept and technology development.

Interoperability Research (IR)

The Interoperability Research RFA provides research analysis results that are key to the interoperability of ASP technologies and concepts that crosscut specific ATM concepts. These results complement the solutions to interoperability issues that evolve naturally from the research in other RFAs. Outcomes include analysis and design guidelines and tools, integrated solutions, and key technical capabilities common to multiple ASP concepts and technologies. IR focuses on common trajectory prediction/interoperability (TP/I) and Function Allocation (FA) including human/system integration (HSI). Other focus topics may be added as required based on the needs of the project and program. IR supports two ASP Technical Challenges – "Human/Machine, Air/Ground Function Allocation" and " Trajectory Prediction and Interoperability."

The Function Allocation research thread focuses on crosscutting human/system integration activities involving multiple concepts within the ASP research portfolio, or the integration of ASP concepts into the existing ATM architecture. Allocation of roles and responsibilities in the NextGen environment between humans and automation, and between flight deck and ground-based systems, is investigated within this research thread.

The TP/I research thread develops basic trajectory prediction technology and capabilities that are key to, and commonly needed for, enabling Program research thrusts. The principle areas of TP/I research include fundamental trajectory modeling and prediction, TP requirements and validation, and trajectory synchronization to enable the interoperability across automation systems, necessary for Trajectory-Based Operations (TBO).

The current state-of-practice for 4D TBO is limited to specialized areas in air traffic control. Different systems use different approaches to trajectory prediction and analysis. For example, a Flight Management System (FMS) must meet the most stringent quality and reliability requirements because it must provide precise, continuous, real-time flight guidance for lateral and vertical navigation to the pilot or autopilot system. Some FMS use complex energy management algorithms and very detailed aircraft performance modeling, while others use simpler kinematic models of flight dynamics. Current En Route Automation Modernization (ERAM) and conflict probe automation use a higher fidelity kinematic approach while the Traffic Management Advisor (TMA) uses a hybrid of both. Each approach is valid for its specific application. However, interoperability across automation systems and seamless trajectory-based control through all flight regimes will be required for NextGen.

Trajectory synchronization, necessary to ensure the interoperability of disparate automation systems (air and ground), is key to the generation of 4D trajectory predictions in support of seamless TBO. Several considerations must be addressed: the development and use of TP algorithms that are interoperable with airborne FMS algorithms; the generation of suitable surrogates for aircraft that are not equipped with FMS capabilities; ensuring stable interaction and interoperability between multiple legacy systems that utilize their own TP capabilities; and common TP capabilities that may serve multiple automation applications. Trajectory Prediction/Interoperability research will provide the interoperable and common TP algorithms and components necessary to support cutting-edge NextGen research concepts.

System and Portfolio Analysis (SPA)

The System and Portfolio Analysis research focus area is responsible for system-level analysis of the Program's concepts and technologies to identify the system benefits or impacts, to provide input to the prioritization of the programmatic resources, and to provide guidance to researchers and developers. The SPA RFA supports two of the Program's Technical Challenges – "Portfolio Analysis of Integrated system-Level Concepts and Technologies" and "Application of New Solutions to Air Traffic Management Challenges."

To facilitate this, SPA is defining a common set of scenarios and metrics for use by the ASP. Use of common metrics will focus ASP research toward achieving system-level performance goals and objectives and enable the discipline-level RFAs to evaluate the impact of concepts at the system level. These common scenarios and metrics are also shared with JPDO's Interagency Portfolio and System Analysis (IPSA) Division and ARMD's Strategy, Architecture, and Analysis (SAA) team to further facilitate comparability of analysis results.

Individual concept elements need to be integrated before combined benefits can be assessed; this is achieved through integration design studies. SPA is responsible for identifying those concepts that are likely to interact and thus may be candidates for a design study. The design studies then determine how to optimally integrate the selected concept elements.

The NAS is a complex system of systems. In order to properly assess the NAS, a series of NAS-wide assessments will make use of outputs from the individual design studies, and airport and metroplex studies, to determine the incremental benefits achieved as ASP research progresses. This enables measurement of the progress of ASP concepts toward meeting the JPDO goals for NextGen.

In SPA, additional system level studies are done to increase understanding of the characteristics and constraints of various systems that make up the complex NAS, including airspace domains, and to identify and define innovative approaches for portfolio consideration. These types of system studies may work at various TRLs to explore different domain spaces.

To enable the infusion of ideas and approaches that are critical to R&D, problem spaces must be continuously explored. The SPA RFA will conduct coordinated in-house and contracted studies to characterize different problem spaces, to identify constraints, to calculate constraint sensitivities, to identify optimization opportunities, and to start the process of identifying potential solution approaches before handing off to CTD for actual development. These system studies also increase the definition of innovative concepts that either address constraints identified in the system studies or that take advantage of new understanding of the problem space to optimize efficiencies. This work primarily benefits the Program through the analysis of these innovative concepts to identify potential impacts and R&D approaches for consideration as additions to the portfolio.

1.3.2 Milestones

The complete list of milestones defined by the Project is provided in Appendix B. By the end of the current 5-year plan, research results will provide information for design guidance for further research and development. Over the duration of the Project, validated algorithms and prototype technologies that support the JPDO vision and capacity goals will be transitioned to the FAA and to industry for implementation. Details of the near-term technical work planned for FY11 are addressed in the Project's Milestone Records Appendix A.

1.3.3 Externally Tracked Milestones

The SAIE Project is tracking the following milestones as Key Milestones, as supporting an Annual Performance Goal (APG), or as a High Priority Performance Goal (HPPG). Key milestones are tracked externally to the Project, but are not APG or HPPG milestones. See Appendix P for a formal definition of the HPPG.

Specific Milestones:

SPA:

SAIE.SPA.2.04 – "DAC-TFM Design Study" (Key)

SAIE.SPA.3.03 – "NAS-wide Benefits Assessment of Combined Concepts" (Key)

IR:

SAIE.IR.3.05 – "Reusable Trajectory Algorithms for Multiple Airspace Regions" (Key)

IET:

SAIE.IET.2.05 (formerly AS.2.4.08) – MSP Requirements for the mid-term NAS (supports APG 11AT06)

SAIE.IET.3.04 (formerly AS.3.5.09) "3D-PAM/EDA Evaluations" supports the project's HPPG.

FY11 Performance Goals:

APG 11AT06:

"Specify operational requirements for performing Multi-Sector Planning (MSP) functions in the mid-term, including technical and conceptual requirements, with consideration of how requirements might change as the NAS evolves towards NextGen."

HPPG:

"Increase efficiency and throughput of aircraft operations during arrival phase of flight."

2 PROJECT IMPLEMENTATION

2.1 Resources

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2.1.1 FTE & WYE

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2.1.2 Procurement

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2.2 Management

2.2.1 Organizational Structure

Beginning in FY11, a new project governance model was instituted, as presented in Appendix I. The SAIE Project management structure consists of a Project Manager (PM), Deputy Project Manager (DPM), Deputy Project Manager for (DPMF) Langley, DPMF Ames, and Project Scientist (PS).

The PM is responsible and accountable to the ASP PD for the technical objectives and content of the Project, and for the planning and execution of the Project.

The DPM is responsible and accountable to the PM for developing the Project Plan, and for overseeing the execution of the project, with primary responsibility for project fiscal performance.

The DPMFs are responsible and accountable to the PM for technical content and Milestone Record contract execution within each research focus area, along with monitoring budgetary performance, at their respective Centers.

The PS is responsible and accountable to the PM for the technical content, integrity, innovativeness, and long-term vision of the Project, and ensures that the highest technical standards are exhibited by the Project.

The management team is supported by a group of research and programmatic professionals at each Center.

Each of the three RFAs are guided by Technical Leads (TL), who work closely with the DPMFs, and are accountable for the execution of the relevant Milestone Record contracts, across the Centers, for their respective RFAs.

The flow-down of the research from the Project to the Centers is also shown in Appendix I.

2.2.2 *Project Reporting and Reviews*

Reporting and reviews for the Project include scheduled telecons, and internal and external technical peer reviews. Specific examples of Project reporting and reviewing requirements are presented below:

Reporting:

- Weekly project telecons that include the PM, DPM, DPMFs, PS, TLs, and other Project support staff as required. Project-related near-term and strategic planning, issues, and actions are discussed during these telecons.
- Weekly ASP telecons with Program Office staff that include participation of the PM, DPM, DPMFs, and PS. In addition, Center POCs and supporting Research Managers are invited to participate. Program-level strategic issues and near-term actions are discussed during these telecons.
- Bi-monthly ASP Business Telecons with the ASP Program Integration Manager (PIM) that include participation of the DPMs, DPMFs, and Resource Analysts from SAIE and CTD. Program-level business issues and reporting are covered during these telecons.
- Bi-weekly SAIE Business Team Telecons that include participation of the SAIE DPM, DPMFs, and Resource Analysts. Project and Program-level business issues and reporting are covered during these telecons.
- Quarterly reports, submitted to the Program office by the DPM, with input from the DPMFs, answer key State-of-the-Agency (SOA) questions that monitor the programmatic status of the project.
- Weekly Project status reports are provided to Ames Center management. These reports are distributed to the Program Office and to Center POCs. The weekly report is presented by the PM, DPM, or DPMF in an Ames Center stand-up every 5-6 weeks.
- The PM, DPM, and PS from the SAIE and CTD Projects meet periodically to discuss common issues and inter-Project coordination and collaboration. Technical planning and coordination between Project TLs will be conducted as required.

Reviews:

- ARMD year-end Program reviews are conducted. As part of the ASP review, the SAIE Project is presented by the PM to the ARMD Associate Administrator (AA) directly.
- Technical peer reviews (internal and/or external) are held annually. The schedule for, and the content of, these reviews are determined by ASP and ARMD.
- Both Centers conduct quarterly Center Management Council (CMC) reviews of the SAIE and CTD Projects, at which the PM, DPM, or DPMF present the programmatic status of the Project. The PD and Center POCs are invited to participate in all CMC reviews, and copies of slides are distributed to them as well.
- Semi-annual reviews.

- Technical Integration Meetings are held every 12-18 months. Researchers from both SAIE and CTD present their research findings to a broad audience, including the FAA and JPDO, and stakeholders from industry and among users of the airspace system. Significant technical interaction occurs at these TIMs, with special sessions specifically designed to interact with the stakeholder community to obtain their feedback and input to NASA-developed concepts and technologies.

2.3 Controls and Change Process

The processes for documenting milestone completion and for change control in ASP and its Projects are hierarchical. The ASP Program Plan is the agreement and top-level document that describes the program, and is the controlling document for program content and management. The Program Plan is submitted by the PD to the ARMD AA for approval. The SAIE Project Plan is the agreement between the PM, DPM, CD/POCs, and the PD for ASP. (The Project Plan documents technical plans, milestones, deliverables, schedules, resource management approach, etc., to ensure successful delivery of technical products to ASP. Milestone completion constitutes the delivery of technical products from the DPMF and TL to the PM and, in the case of key milestones, the PD.)

2.3.1 NextGen-SAIE Project Milestone Change

The process for documenting concurrence and approval of milestone changes is as follows:

1. The Milestone Change Request (MCR) will document the DPMF's request to the PM for approval to change any one or more of the following elements of a milestone:
    - Title or description
    - Start or end date
    - Slip of more than one quarter within the fiscal year or any slip from one fiscal year to the next.
    - Dependencies
    - Deliverables
    - Metric
    - Exit Criteria
    - Other [as determined by the TL/DPMF]
2. Reason for change
3. Description of change
4. Impact of change

The TL and the DPMF will develop the MCR jointly. It will be coordinated with the PS, and submitted to the PM for approval. If the milestone is a Key Milestone, supports an Annual Performance Goal (APG), or supports a High Priority Performance Goal (HPPG), the PM will obtain the PD's approval for the Change. Once the form is signed off, it will go to the DPM, who will assign a Milestone Change Control Number. A copy of the MCR will then be provided to the Scheduler for any adjustment to the schedule.

2.3.2 NextGen-SAIE Project Milestone Completion

The process for documenting concurrence and approval of milestone completion is:

1. The Milestone Completion Memo (MCM) will document the completion of any milestone. It will be submitted by the DPMF to the PM and will state briefly describe the following:
   - Exit Criteria, and how it was met
   - Metric met. If not fully met, what part of the metric was met and what is the anticipated impact of not fully meeting?
2. Applicable reports or supporting documentation will be attached to the memo. (e.g., Technical report, simulation report, briefing charts)
3. Any additional information the TL might want to provide should be attached to the memo.

The DPMF and the TL will develop the MCM jointly. It will be coordinated with the PS, and submitted to the PM for approval.

If the milestone is a Key Milestone, or supports an APG or HPPG, the PM will obtain the PD's concurrence in the acceptance of the completion of the milestone. In addition, a two page PowerPoint explanation of the results will also be required.

Once the MCM is signed off, it will go to the DPM for archive. A copy of the memo will then be provided to the Scheduler for any adjustment to the schedule.

2.4 Work Breakdown Structure

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2.5 Risk Management

SAIE utilizes the NASA Continuous Risk Management process as its approach to risk management. As part of the Project's approach to managing risk, the Project has developed a Continuous Risk Management Plan, Version 1.1, dated November 2008. The Project will consider its approach to managing risk to be successful if DPMFs and the Risk Manager accomplish the identification and resolution of risk issues prior to impact on research tasks or Project outcomes. As an enhancement to this process, the project also tracks technical risk by milestone. Research findings sometimes indicate original milestone schedules or deliverables are inconsistent with desired outcomes. Milestones at risk of delay, or not delivering on original metrics are tracked in a similar manner as the project or program management risks. While tracking technical risks, the Risk Manager will conduct monthly risk meetings to track progress, and to provide assistance with risk mitigation to enhance the likelihood of successful outcomes.

2.6 Acquisition Strategy

The Project's acquisition strategy for addressing the air traffic management R&D needs of NextGen as defined by the JPDO is compliant with ARMD policy and includes:

- Maintaining NASA's core capabilities in ATM research to the extent practical within resource guidelines.

- Conducting full and open NASA Research Announcement (NRA) solicitations as the means to solicit innovative proposals in key research areas that complement NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. Each year the SAIE Project has a minimum NRA target funding level (see Section 2.1.2). NRAs will be used to perform research activities for which in-house expertise may not be available. These awards will also help strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions. Appendix K identifies the NRA subtopics that have been awarded to date. Project support such as technical writing for operational concepts, code development, and use of non-NASA facilities are not eligible for support through the NRA process.
- Use of Space Act Agreements (SAA) to collaborate with industry, and to establish partnerships with other government agencies (FAA, DoD, DoT, etc.)
- Use of existing performance-based in-house contracts to support research activities at Ames and Langley is expected throughout the life of the Project. New requirements, or unforeseen events and circumstances will require Project adjustments that may involve acquisitions not planned at this point. In all cases, full and open competition will be observed.
- Utilization of the Small Business Innovative Research (SBIR) Program. The SBIR program solicitation is created by Project leadership and focuses on higher risk, innovative ideas to fund typically low TRL research that is aligned with the Project but is not on the critical path. Funding is provided by the SBIR office.

2.7 Partnerships and Agreements

2.7.1 NextGen CTD—SAIE Project Interface

The successful transition of concepts and technologies to stakeholders depends on the SAIE and CTD Projects working in a coordinated manner. To facilitate this transition, the two projects have identified roles based on TRL, likely transition paths that concepts or technologies may find themselves on, Research Transition Teams to conduct transition activities, the actual coordination strategy that CTD and SAIE projects utilize, and a plan to evaluate pop-up ideas or unexpected research opportunities.

TRL responsibilities between projects follow closely with the projects' primary roles (see Appendix F). The CTD project is the lead project for lower TRL (TRL 1-3) activities. At TRL 4, the projects work together as research responsibility shifts from CTD to SAIE. SAIE leads activities at TRL 5-6. Those TRL 5-6 concepts and technologies that have work tasks at the TRL 1-3 are handled by CTD and TRL 4 work will be handled by the appropriate project based on the work documented in the milestone and milestone records.

At TRL 7, there are additional partners in prototype demonstration and again the projects work together with the designated stakeholders for best success. Activities beyond TRL 7 include implementation into operational environments, and neither project will have lead responsibilities for these activities. At this level of readiness, stakeholders take responsibility for implementation, and NASA projects serve as consulting subject matter experts depending on agreements between stakeholder and the program/projects.

Research transition paths to stakeholders vary depending on the type of product and/or interest of the stakeholder. Activities include integrated concepts/technologies that require complex, high fidelity simulations, interoperability/interactions considerations, and involvement of multiple RFA items/concepts/technologies. Other areas involving both projects include testbed demos and field tests at appropriate sites. Demos in testbeds have been discussed with the FAA as a stakeholder and the NASA NTX testbed will facilitate appropriate demos either independently or in the future in conjunction with the FAA testbed under development. Field tests will identify appropriate environments to use and may include FAA field sites such as Air Route Traffic Control Centers (ARTCC, or “Centers”), Terminal Radar Approach Control (TRACON) facilities, and Air Traffic Control Towers (ATCT, or “Tower”).

In the second transition path, SAIE transitions a product to an external stakeholder directly. Tools or technologies being developed by SAIE and made available to stakeholders transition directly to the stakeholder. Analysis being conducted may also be conducted with or leveraged directly by stakeholders based on coordination or agreement. A key stakeholder for these types of products is the JPDO’s IPSA division.

In the third transition path, CTD transitions a product to external stakeholder directly. This is usually a low TRL product that may have been defined by; a stakeholder’s eagerness to transition at an early TRL, a stakeholder’s need for early decision making, or a stand-alone item, in which the stakeholder performs the integration into an existing system, and not requiring any NASA integration activities.

The various transition modes available demand that CTD-SAIE have a coordination strategy to keep foundational research unencumbered and still ensure that the research has a maturation and transition path to stakeholders. In order to accomplish this, CTD and SAIE will work together to accelerate high impact products based on stakeholder interests. Products include technologies, concepts, algorithms, prototypes, or knowledge such as functional allocation. CTD is focused on individual concept and technology development with a deeper focus. SAIE is focused on system-level, integration, and technology transition considerations with a broader focus. In each case, specific understanding between CTD and SAIE needs to be developed. Each technology or concept is likely to have differing needs and different involvements. Activities requiring joint efforts are defined jointly by both projects PM/DPM/PS. During the course of normal project development CTD and SAIE will negotiate how the collaboration will be handled year to year based on the unique requirements of the current concepts and technologies development phase they are in. This collaboration will be documented in the milestones and the associated milestone records for the upcoming year.

Research Transition Teams (RTTs), jointly established with the FAA, have been implemented to help identify research and development needed for NextGen implementation and to ensure that the research is conducted and effectively transitioned to the implementing agency. The SAIE and CTD projects are currently supporting the following RTTs, jointly with the FAA:

- Efficient Flow into Congested Airspace (EFICA) is the responsibility of the SAIE project and focuses on a few key technologies in the dense arrival/departure area such as merging and spacing including work with FAA's ATO-P and SBS office, Efficient Descent Advisor, including field test at FAA's Denver Center.
- Flow-based Trajectory Management (FBTM) is the responsibility of the SAIE project and focuses on identifying the feasibility and benefits of the Multi-sector Planner concept. This is a concept study with human in the loop simulations for demonstration to FAA.
- Integrated Arrival/Departure Surface (IADS) is the responsibility of the SAIE project and includes research from the CTD project. It includes the Precision Departure Release Capability that will conduct testbed studies at NASA's NTX facility. Also, the airport surface optimization is scheduled to conduct similar studies at NTX in the near future.
- Dynamic Airspace Configuration (DAC) RTT remains the responsibility of the CTD being long-term focused research.

RTTs are supported by both CTD and SAIE milestones,

The Projects are continually engaged in efforts to identify new research opportunities both internal and external to the Program. These opportunities are anticipated to present themselves from time to time, and the following process has been defined to properly evaluate these opportunities, and to potentially integrate them into the Program portfolio of activities:

- CTD/SAIE PM/PS/DPM and involved researcher(s) meet to discuss idea. The Project team prepares the proposal to the Program with three options: pursue, don't pursue, or more information/base work/analysis is needed before decision. "Seedling" and other possible sources of funding are explored.
- Host center management and partner center POCs and/or designees will be involved throughout the process.
- Program will make the final decision based on committee/board input.

2.7.2 Partnerships

The SAIE Project will seek partnerships with industry, universities, JPDO, and other government agencies in research related to SAIE goals and objectives. Early involvement of these entities, combined with frequent input, will be necessary throughout the development and validation of the NextGen concepts and research. The development of system-level capabilities and integrated systems is a high TRL effort that is appropriate for collaboration with industry partners and other government agencies. SAIE will consider the following when assessing potential collaborations:

- Collaborations are established only when there is significant benefit to NASA and its constituencies (aerospace community, aerospace industry, academia, and ultimately the U.S. tax-payer).

- Once the collaboration is established, the results can be appropriately disseminated and validated through a peer-review process.

Additional guidelines to be considered:

- Is the collaboration suitable for NASA to pursue?
- Does the collaboration help advance and disseminate knowledge and technology?
- Have we ensured that restrictions for data distribution do not prevent the advancement of knowledge in the specific discipline?

2.8 RTTs

Research Transition Teams (RTTs), jointly established with the FAA, have been implemented to help identify research and development needed for NextGen implementation and to ensure that the research is conducted and effectively transitioned to the implementing agency. For more details refer back to Section 2.7.1.

2.9 Foreign Collaboration

The Airspace Systems Program and its legacy projects actively established participation with foreign organizations to conduct joint ATM research. The NextGen SAIE Project is committed to maintaining these efforts, where appropriate, and to identifying new areas of opportunity for foreign collaboration. Existing and new foreign collaborations will be aligned with the three Project RFAs as appropriate.

To facilitate foreign research collaboration, the NextGen SAIE Project will follow guidelines for capturing and documenting foreign collaborative research efforts established by the NextGen-Airportal Project. The guidance is in full compliance with the U.S. Department of State's International Traffic in Arms Regulations (ITAR) and the U.S. Department of Commerce's Export Administration Regulations (EAR). Titled, "NextGen-Airportal Project Guidance on Foreign Collaboration", the guidance document is tailored to NextGen ATM research and will serve as a template for current and future collaborative research. Rather than inhibit or discourage foreign research collaboration, the guidance is intended to facilitate and encourage collaboration where it can be demonstrated that the collaboration will add value to Project, Program, and ARMD mission, goals, and/or objectives.

The TL in each RFA is empowered with, and responsible for, identifying new opportunities for foreign collaboration and, along with the DPMF(s), for managing existing and new foreign research collaboration. The TL and DPMF(s) will coordinate with both Project and Line management. A formal review and approval process has been developed for use in evaluating foreign collaboration proposals for consistency with Project, Program, and ARMD mission, goals, and/or objectives. Questions that must be adequately addressed by the TL and the DPMF(s) include, but are not limited to, the following:

- Is there a formal charter for the proposed research that delineates tasks, responsibilities, and time period?

- What vehicle will be utilized for the formal agreement (e.g., Action Plan, Letter of Authorization, Memorandum of Authorization)?
- What are the respective responsibilities between NASA and the relevant foreign organization(s)?
- Which organization(s) are responsible for assigning and managing research tasks?
- What amount of effort is required to fulfill the duties (e.g., preparation, travel, meetings)?
- Will the conduct of the foreign research impact the completion of any NextGen CTD Project milestones?
- Is the research directly related to any Project milestones? If so, which milestone(s) are related?
- Does the research provide an advantage to foreign companies at the expense of the U.S. taxpayers? If the answer is no, why not?
- How will the performing organization(s) accommodate new requests for additional or follow-up research?
- Who will approve additional or follow-up research?

The TL shall address these questions in a letter of interest and submit it to the PM for formal approval of the proposed foreign collaboration. The TL should allow 30 days for Project Office and Program review and approval or rejection. Once an agreement is in place, the TL will be responsible for managing foreign collaboration research.

2.10 Knowledge Dissemination

The SAIE Project will disseminate research results to the greatest extent practicable in as timely a manner as possible. The quality of the technical work performed in the Project will be assessed against milestone metrics through informal and formal SAIE management reviews, and peer internal and external reviews. Technical publications, peer-reviewed journal articles, and invited papers and presentations will quantify the level of technical dissemination of SAIE research. This strategy aligns with the ARMD objective of advancing knowledge in the fundamental disciplines of aeronautics, and is in keeping with the Space Act of 1958 that requires NASA to "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

Future programs and projects benefit from the knowledge and understanding gained during the formulation, implementation, and execution of past and current programs and projects. Lessons learned will be documented and shared with other ARMD projects. Documented lessons learned, when appropriate, will be shared with Center and Headquarters' Systems Management Office or Chief Engineer's Office.

3 TASK PLANNING (MILESTONE RECORDS)

Milestone Records document the detailed requirements, work, resources, labs, major facilities, and task deliverables, to conduct SAIE research in the upcoming fiscal year. The TLs and DPMFs, working with Research Managers (RM) and facility managers, develop task plans for their respective RFAs within the Milestone Records. Milestone Records are contracts between the DPMFs, RMs, and the PM. Updated task planning for the upcoming fiscal year takes place during the 3^{rd} and 4th quarters of the current fiscal year. The FY11 Milestone Records are included in Appendix A (or possibly as a separate attachment to this Plan).

Coordination between the SAIE and CTD Projects in year-to-year planning is critical to the success of the two projects, and forms a cornerstone of their planning and research efforts.

Appendix A. Milestone Records

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Appendix B. Milestone Tables

Milestone Numbering Convention

SAIE	.IET (Integration, Evaluation and Test) .IR (Interoperability Research) .SPA (System and Portfolio Analysis)	.4 (System level) .3 (Multi-disciplinary) .2 (Disciplinary) .1 (Foundational)	Sequence number	J (MS Joint with CTD

IET Milestones and Metrics

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Sched Comp Q	Deps	Feeds
SAIE.IET.3.01	Integrated Arrival/Departure/Surface Scheduling - Single Airport (PDRC and SESO elements)	The Precision Departure Release Capability (PDRC) research activity is the primary contributor to this milestone. PDRC will integrate a representative surface traffic management system (NASA SMS) with an arrival/departure management system (research version of FAA TMA/EDC) to answer the question: “Can we reduce missed departure slots by using precise, trajectory-based OFF time predictions when computing departure schedules.” This milestone also draws on SESO surface optimization research. Promising SESO surface trajectory prediction and surface movement scheduling algorithms will be incorporated in PDRC. PDRC features shadow and operational evaluations by SMEs.	SME assessment of precision, accuracy and usability of PDRC schedules in an operationally relevant environment. Reduction in missed departure slots relative to current-day procedures. Operational TMA/EDC departure scheduling performance. SMS/SDSS OFF time prediction performance.	PDRC field evaluation results documented in research paper. Research Transition Product (RTP) delivered to FAA via IADS RTT.	12	1	.	SAIE.IET.3.05
SAIE.IET.3.02 (AS.3.6.05J)	Interval Management to Single or Dependent Parallel Runways	Supports CTD Milestones AS.3.6.09 and AS.3.6.10. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the delivery of the Research Transition Product "Interval Management with Delegated Separation and Self-Separation" for the EFICA RTT.	See CTD Milestone AS.3.6.10 for Metrics.	See CTD Milestone AS.3.6.10 for Exit Criteria.	12	4	.	EFICA RTT

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.IET.3.04 (AS.3.5.09J)	3D PAM/EDA Evaluations	EDA technology and the 3D-PAM concept are evaluated in terms of performance level and acceptability. Results will be transferred to the FAA to support the specification of functional and performance requirements. This work is associated with the Efficient Flow Into Congested Airspace Research Transition Team and shall include fast time, real-time, and human-in-the-loop simulations.	Performance measures for efficiency, safety & capacity; human workload & situation awareness measures; subjective data	Technical reports document the findings of the evaluations.	11	4	AS.3.5.17 IET.3.03J	EFICA RTT
SAIE.IET.3.05	"Integrated Arrival/Departure/Surface Scheduling - Gate-to-Gate (PDRC and SESO elements)"	This extends SAIE.IET.3.01 from a single airport to a full gate-to-gate scenario. A second PDRC research system will be implemented at an FAA NextGen Testbed and linked to the NTX PDRC system. Gate-to-gate PDRC will enable more intelligent departure scheduling by accounting for surface and arrival situations at that destination airport in addition to the surface situation at the departure airport. Departure scheduling into the overhead stream will be dynamically adjusted in response to the actual situation at the destination airport rather than relying on static flow constraints.	Reduction in missed departure slots relative to current-day procedures. Operational TMA/EDC departure scheduling performance. SMS/SDSS OFF time prediction performance.	Successful integration of NASA NTX Testbed with an FAA NextGen Testbed and field evaluation of PDRC in full gate-to-gate scenario. Evaluation results documented in published paper.	14	1	SAIE.IET.3.01	IADS RTT
SAIE.IET.3.06	"Evaluation of Integrated Surface and Arrival/Departure Operations	Evaluation of terminal traffic flow management through integrated simulation of operations incorporating runway configuration management for multiple proximate airports with multiple	Airport throughput and/or total delays with a fixed demand during steady	Research Transition Product (RTP) delivered to FAA via IADS	13	4	AP.2.C.04 AP.2.C.10	IADS RTT

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
	Tools in Representative Environment (SORM)"	runways, arrival/departure balancing across the active runways, and optimized surface operations capabilities. Traffic flow management tools will be evaluated in the context of other tools and systems being used by traffic flow managers and flight crews.	state wx cond. and during wind shifts req runway config. changes. Benefit is validated by comparing throughput to that produced by subject matter experts (SME) in the same scenarios and by comparison to the estimated theoretical max throughput values (considering no uncertainties or unused slots). The target for the initial alg. is perf at least equal to an experienced SME.	RTT.				

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.IET.2.05 (AS.2.4.08, AS.2.7.13)	MSP Requirements for the Midterm NAS	Specify operational requirements for an MSP position in the mid-term, including technical requirements (e.g.: display, decision support, information, communication/coordination) and conceptual requirements (roles and responsibilities in relationship to other humans and automation within the system.) Include discussion of how requirements might change as the NAS (and the human's/MSP's role within the NAS) evolves towards NextGen.	Vetted (with NextGen Project Leaders) mid-term MSP op. requirements (technical and conceptual), along with recommendations for how requirements might change with introduction of future capabilities/ops.	Published study results in a relevant conference, journal, or NASA publication.	11	4	SAIE.IET.2.04	FBTM RTT

IR Milestones and Metrics

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Sched Comp Q	Deps	Feeds
SAIE.IR.4.01 (AS.4.1.01)	Real-time Data Exchange for Interoperability	Conduct an experiment of real-time critical data exchange between disparate trajectory predictors. Identify timing issues and viability of exchanging data. Exchanged data may include additional trajectory constraints and aircraft behaviors to meet those constraints.	Improved trajectory Prediction accuracy relative to data shared and behavior models and increased consistency between trajectory predictions.	Demo of real-time data exchange between airborne and ground based systems using common language for data exchange. Deliverables include software in support of the demo and raw data.	12	4	SAIE.IR.3.03 SAIE.IR.3.07	Out-year milestones
SAIE.IR.3.02	Managing Trajectory Uncertainty to Meet Performance Requirements	Methods for managing/reducing trajectory uncertainty to meet specified performance requirements shall be developed. The prioritization of errors to be addressed based on critical performance requirements shall be examined.	Trajectory prediction accuracy	Conference/ white paper detailing example of reduction of uncertainty error to meet a performance requirement	13	4	SAIE.IR.2.03 SAIE.IR.2.04	Out-year milestones

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.IR.3.04 (AS.3.1.03)	Comprehensive Assessment of Intent Errors.	Collection and analysis of a statistically significant set of airborne and ground-based intent information to determine the make up, frequency, and source of TP intent errors that NextGen must resolve to achieve targeted levels of system performance.	Trajectory prediction errors, as a function of measured (or inferred) intent errors for relevant conditions that are key to NextGen automation applications.	Conference/ journal publication documenting categorizations of relevant intent errors in terms of the relative impact (on TP accuracy), source and frequency of occurrence.	13	3	.	Out-year milestones
SAIE.IR.3.05 (AS.3.1.04)(Critical)	Reusable Trajectory Algorithms for Multiple Airspace Regions	Validation of common trajectory modeling methods for representing NGATS-relevant (e.g., FAA) approach/departure procedures through terminal airspace accounting for specific runway, altitude and speed scheduling. Determine level of consistency between trajectory modeling methods between en-route, terminal and surface tools to enable interoperability.	Trajectory prediction accuracy, reliability	Terminal Area Sensitivity Studies (Paper)	11	4	AS.2.1.03 AS.2.1.05 AS.2.1.06 SAIE.IR.2.02	SAIE.IR.3.09

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.IR.3.07 (AS.3.1.06)	Implement Data Exchange Language	Implement a common language for data exchange in multiple trajectory predictors. Compare complex trajectories sharing critical data. Examine effects of exchanged data on trajectory accuracy.	Trajectory Prediction accuracy relative to data shared and behavior models	Experiment with disparate trajectory predictors exercising common data exchange language to analyze accuracy improvements. Deliverables include software in support of the demonstration and raw data.	11	1	SAIE.IR.3.03	SAIE.IR.3.08 SAIE.IR.3.09 SAIE.IR.4.01
SAIE.IR.3.08 (AS.3.1.07)	Common Trajectory Modeling	Develop a standard library of functions based on behavioral/mathematical models which can be interchanged between disparate trajectory predictors	Trajectory prediction accuracy in 4 dimensions	Library of trajectory prediction functions capable of being used by multiple systems	12	4	SAIE.IR.3.07	Out-year milestones
SAIE.IR.3.09 (AS.3.1.08)	Advance TP Performance Modeling	Improve trajectory prediction performance through enhancement or exchange of aircraft performance data. Examine different performance model libraries for integration with NextGen tools.	Trajectory accuracy, predictability	Check-in of new aircraft performance models	13	4	SAIE.IR.3.05 SAIE.IR.3.06 SAIE.IR.3.07	Out-year milestones

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.IR.3.10	Develop Initial Human/ Machine and Air/Ground Functional Allocation Strategies	The functional allocation strategies will be based on literature review and lessons learned from NASA and other agencies research activities related to NextGen. Strategies will be driven by requirements of the NAS Enterprise Architecture and the concepts and technologies being developed in the Airspace Systems Program.	Proposed system performance metrics for evaluating function allocation strategies in simulations. Findings and recommendations for future simulations, DST development, and potential NextGen implementation.	Initial report documenting findings and recommenda tions for function allocation strategies for combined domains (flight-deck and ground-based).	12	2	SAIE.IR.2.01	SAIE.IR.3.11
SAIE.IR.3.11	Multi-Domain Function Allocation Concepts for Flight-Deck and Ground-Based Systems	Leveraging the results of previous HITL simulations for function allocation, work with CTD researchers to develop new or modified FA strategies for subsequent HITL simulations, including experiment planning, conduct of the simulation(s), and data analysis.	Controller and pilot workload measures for function allocation strategies. Findings and recommendation s for HITL simulations, requirements for NextGen implementation.	Final published report documenting findings and recommenda tions for function allocation strategies for the combined domains (flight-deck and ground-based).	13	2	SAIE.IR.3.10	Out-year milestones

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.IR.3.12 (SAIE.SPA.3.05) (AP.3.A.05)	Workload-sensitive rapid emulation of human operators for fast-time simulations	Refine the rapid emulation method so that distributions in the table are dynamically affected by the changing workloads experienced by operators.	Human response delay and probability as a function of changing workload demands	Report to include dynamic table of response delay distributions and human decision probabilities.	13	3	SAIE.SPA.2.03 SAIE.IR.2.05	Out-year Milestones
SAIE.IR.2.04 (AS.2.1.10)	Determination of Performance Requirements for NextGen Trajectory Predictors	Develop methods to determine, for a target concept/system, the TP accuracy needed to be to achieve the minimum acceptable system/concept performance as well as identify sources of errors. These methods determine the level of TP performance requirements as a function of the minimum acceptable level of concept/system performance. They study the sensitivity of the TP to the models, functions and assumptions made by the driving concept.	Sensitivity of key concept performance indicators as a function of the performance of the underlying trajectory prediction, sensitivity of the performance of a TP as a function of the models, algorithms, and assumptions.	Delivery of simulation platform for development of TP requirements for NextGen concept/DST.	11	4	AS.1.1.01 AS.1.1.02	SAIE.IR.3.02
SAIE.IR.2.05 (SAIE.SPA.2.01) (AP.2.A.04)	Rapid Emulation of Human Operators for Fast-Time Simulations	Improve the fidelity of fast/real time simulations by representing operators with choice probability and response delay distributions developed through HITL and cognitive modeling of the part task data. Allows segregation of human operator issues from automation development issues in ASP simulations.	Delay distributions and human decision probabilities for operator interventions in planned simulations.	Report to include a static table populated with delay distributions and human decision probabilities.	11	4	SAIE.IR.2.01 AP.3.A.01	SAIE.IR.3.12

SPA Milestones and Metrics

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.SPA.4.01 (AP.4.A.02 AP.3.A.06)	Portfolio Analysis I	Conduct the overarching portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with data. NAS internal annual report. Presentation at ASP TIM.	11	2	SAIE.SPA.2.04 SAIE.SPA.3.01	SAIE.SPA.2.06 SAIE.SPA.4.02
SAIE.SPA.4.02 (AP.4.A.02J)	Portfolio Analysis II	Conduct the overarching portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with data. NAS internal annual report. Presentation at ASP TIM.	12	2	SAIE.SPA.2.04 SAIE.SPA.2.05 SAIE.SPA.2.06 SAIE.SPA.4.01	SAIE.SPA.2.08
SAIE.SPA.4.03 (AS.4.7.02)	System-Level Benefits Assessment of Combined Concepts II	Performance assessment of integrated NextGen concepts and technologies. Emphasis on capacity performance, robustness to Wx and non-normal events, and top-level safety performance indicators (baseline and three NextGen options). This assessment will include explicit modeling of at least one metroplex with major concepts and technologies of DAC, TFM,	System-level capacity, robustness, and system level performance indicators.	Published paper on assessment results, integrated concept option descriptions	14	3	SAIE.SPA.2.06 SAIE.SPA.2.08 SAIE.SPA.3.03 SAIE.SPA.4.02	Out-year milestones

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
		Terminal Area, SA and Surface.						
SAIE.SPA.4.04 (AP.4.A.02)	Portfolio Analysis III	Annual update of the portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis, and will include the latest research results and information available for the ASP concepts and technologies being developed.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with updated data. NAS internal annual report. Presentation at ASP TIM.	13	2	SAIE.SPA.2.06 SAIE.SPA.2.08 SAIE.SPA.4.02	SAIE.SPA.4.05
SAIE.SPA.4.05 (AP.4.A.02)	Portfolio Analysis IV	Annual update of the portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis, and will include the latest research results and information available for the ASP concepts and technologies being developed.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with updated data. NAS internal annual report. Presentation at ASP TIM.	14	2	SAIE.SPA.2.08 SAIE.SPA.4.04	Out year milestones

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.SPA.3.01 (AS.3.7.07)	Common Scenarios I	Develop common scenarios, metrics and assumptions for system-wide, and regional assessments and design studies. They will be shared with RFA researchers and used in their experiments as appropriate, to provide consistency and comparability with other concepts seeking similar system performance benefits.	The set of scenarios includes a baseline set for the selected weather days (chosen from 2006 by previous cluster analysis), future scenarios in 0.5X increments of demand up to at least 2X including demand in years 2018 and 2025. Concept specific scenarios and alternative future scenarios will be include as needed by CTD and for use in systemwide benefit assess.	Set of common scenarios published on NX for access by NASA researchers.	11	2	AS.3.7.06	SAIE.SPA.3.04 SAIE.SPA.3.03 SAIE.SPA.4.01 SAIE.SPA.2.06
SAIE.SPA.3.02 (AP.3.A.04)	Formulation and Initial Analysis of Metroplex Operational Concepts and Approaches	Definition, analysis and refinement of metroplex operational concepts at TRL 0 and TRL 1. The concepts explored address the metroplex constraints identified in previous work under AP.2.A.07, or use the metroplex-unique characteristics identified in previous work to optimize efficiencies.	Description of metroplex concepts to include the analytical results of potential benefits of the concepts and the R&D req'ts for advancing the concept.	Published report documenting the analysis methods, assumptions and results including descriptions of metroplex concepts.	11	4	SAIE.SPA.2.02	SAIE.SPA.3.06

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.SPA.3.03 (AS.3.7.10)	NAS-Wide Benefits Assessment of Combined Concepts 1	First-order benefit assessment of integrated NextGen concepts and technologies through simulations. Will make use of scenarios developed by SPA Common Scenarios milestone or its equivalent. There are up to four concepts to be explored: Datalink, Precision Departure Release Capability (PDRC), Efficient ground operation, and Required Navigation Performance (RNP). Datalink concept includes benefits comparison between flying with and without datalink capability around weather. PDRC concept involves efficient use of departure slots in the overhead stream. Efficient ground operation concept involves delivering aircraft efficiently to meet the PDRC requirements. RNP concept involves efficient delivery of aircraft to arrival meter fixes based on distances as opposed to rates. In PDRC, surface, and RNP, as an approximation, departure schedules along with airport departure rate and airport arrival rate are used for the benefits assessment. For example, certain level of system delays would result if the surface concept can deliver aircraft within plus or minus N minutes. Simulations of multiple values for N will be explored to provide a range of benefit levels.	System-level capacity and robustness	Published paper on assessment results, integrated concept option descriptions	12	2	SAIE.SPA.1.01 SAIE.SPA.2.04 SAIE.SPA.2.05 SAIE.SPA.3.01	SAIE.SPA.4.03 SAIE.SPA.2.08 SAIE.SPA.4.04

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.SPA.3.04 (AS.3.7.08)	Common Scenarios II	Refined/Updated common sets of metrics, assumptions and demand sets.	Completeness of common definitions set, with verified applicability/traceability to JPDO Goals/Objs, and Metrics. Broad and appropriate use by NexGen Airspace Program RFAs in their experiments, allowing apples-to-apples comparison with alternative concept approaches.	Published paper that documents the common metrics, demand sets and assumptions.	12	1	SAIE.SPA.1.01 SAIE.SPA.3.01	SAIE.SPA.3.07 SAIE.SPA.4.03 SAIE.SPA.4.04 SAIE.SPA.2.08
SAIE.SPA.2.03 (AS.2.7.01)	Develop Method for Modeling Human Workload in Fast-time Simulations, Validate Models against Workload Measurements	Human workload is a critical limitation on current NAS operations. Under NextGen, automation will play a greater role, but humans will still play important roles in NAS operations. To effectively study the benefits/limitations of new NextGen concepts, human workload needs to be represented in the fast-time simulations used to model the NAS. Initially, workload for humans in current day operations must be modeled and those models validated against available real world data. This provides baseline workload models	Method reduces the uncertainty bounds by 50% for typical Air Midas analyses.	Publication of research results in relevant conference or journal.	11	1	Initial Work	SAIE.IR.3.12 (SAIE.SPA.3.05 (AP.3.A.05)

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
		for comparison with models representing future transitional states as the NAS migrates toward the NGATS concept of operations. As the role of humans in NextGen concepts becomes better defined, workload models for those roles will be updated.						
SAIE.SPA.2.04 (AS.2.7.03)	DAC-TFM Design Study I	Investigate interactions across DAC and TFM operational concepts via performance trade-studies in a common simulation environment (i.e. ACES or similar platform). Collaboratively identify relevant DAC and TFM concepts and research questions related to their interoperability (e.g.: Understand how a DAC resectorization concept interoperates with a TFM concept.)	Capacity, delay and efficiency from simulation of DAC-TFM interacting in a simulation environment.	Write a report on assessment results, integrated concept descriptions that documents DAC TFM interactions.	11	2	Initial Work	SAIE.SPA.3.03 SAIE.SPA.4.02
SAIE.SPA.2.05	System Constraints, Demand/ Capacity Analysis	Analysis of the NAS from a demand/ capacity perspective to broaden characterization of the domain and increase understanding of the physical and operational constraints (including sensitivities)	Identification of constraints and over-demanded resources.	Published report documenting the analysis methods, assumptions and results	11	2	SAIE.SPA.1.01	SAIE.SPA.2.07 SAIE.SPA.3.03 SAIE.SPA.4.02
SAIE.SPA.2.06	TFM/SA Design Study	Investigate interactions across SA and TFM operational concepts via performance trade-studies in a common simulation environment (i.e. ACES or similar platform). Collaboratively identify relevant SA and TFM concepts and research questions related to their interoperability. (e.g.: Rerouting in the presence of Wx and Traffic complexity.) This design study will	Vetted (SPA, relevant CTD RFAs) design study results (capacity, delay and efficiency at a minimum) from simulation of integrated CTD concepts interacting in a	Published paper on assessment results, integrated concept descriptions that documents integrated concept	12	2	SAIE.SPA.3.01 SAIE.SPA.4.01	SAIE.SPA.4.03 SAIE.SPA.4.04

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
		investigate both ground-based and flight deck based SA concepts.	common simulation environment.	interactions.				
SAIE.SPA.2.07	System Constraints, Demand/ Capacity Analysis II	Analysis of the NAS from a demand/ capacity perspective to broaden characterization of the domain and increase understanding of the physical and operational constraints (including sensitivities)	Identification of constraints and over-demanded resources.	Published report documenting the analysis methods, assumptions and results	12	2	SAIE.SPA.2.05	Out-year Milestones
SAIE.SPA.2.08	Design Study III	Investigate interactions across at least two CTD operational concepts via performance trade-studies in a common simulation environment (i.e. ACES or similar platform). RFA concepts (e.g,, SA, SDO, TFM) for integration studies are determined through the portfolio	Vetted (SPA, relevant CTD RFAs) design study results (capacity, delay and efficiency at a minimum) from simulation of integrated CTD concepts interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents integrated concept interactions.	13	2	SAIE.SPA.3.03 SAIE.SPA.4.02	SAIE.SPA.4.03 SAIE.SPA.4.05

Milestone ID	Title	Description	Planned Metric	Exit Criteria	Sched Comp FY	Q	Deps	Feeds
SAIE.SPA.1.01 (AS.1.7.02)	Research Game Theoretic Concerns Related to NextGen System Operation	Gaming of the future NextGen ATC/ATM system, by the various user groups of the NAS will be explored. Changes due to NextGen deployment should provide fair and equitable access among the various NAS user groups. This research will explore the various ways the future NextGen ATC/ATM system alternatives could be gamed for individual advantage, to the detriment of overall system performance. This may reveal where constraints on gaming behavior could be required.	Project Review of Gaming Scenarios considered, and concurrence that primary gaming issues have been considered/ addressed.	Publication of research results in relevant conference or journal.	11	1	Initial Work	SAIE.SPA.3.04 SAIE.SPA.3.03 SAIE.SPA.2.05

Appendix C. Acronyms and Abbreviations

3D-PAM/EDA	Three-Dimensional Path Arrival Management
4D	Four Dimensional
AA	Associate Administrator
ACFS	Advanced Concepts Flight Simulator
ADS-B	Automatic Dependent Surveillance-Broadcast (ADS-B)
AOL	Airspace Operations Laboratory
APG	Annual Performance Goal
ARC	Ames Research Center
ARINC	Aeronautical Radio, Incorporated
ARMD	Aeronautics Research Mission Directorate
ASP	Airspace Systems Program
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
ATM	Air Traffic Management
ATO-P	Air Traffic Organization - Planning
ATOL	Air Traffic Operations Laboratory
CAP	Collaborative Arrival Planning
CMC	Center Management Council
CMF	Cockpit Motion Facility
CONOPS	Concept of Operations
CS	Civil Service
CTD	Concepts and Technology Development
CVSRF	Crew Vehicle Systems Research Facility
D2	Direct-To
DAC	Dynamic Airspace Configuration
DoD	Department of Defense
DoT	Department of Transportation
DPM	Deputy Project Manager
DPMF	Deputy Project Manager For (Center)
DST	Decision Support Tools
EAR	Export Administration Regulations
EDA	Efficient Descent Advisor
EDC	Enroute Departure Capability
EFICA	Efficient Flows Into Congested Airspace
ERAM	En Route Automation Modernization
FA	Function Allocation
FAA	Federal Aviation Administration
FAST	Final Approach Spacing Tool
FBTM	Flow-Based Trajectory Management
FMC	Flight Management Computer
FMS	Flight Management System
FTE	Full Time Equivalent
FY	Fiscal Year
HIS	Human/System Integration
HITL	Human-in-the-Loop
HLA	High Level Architecture
HPPG	High-Priority Performance Goals
IADS	Integrated Arrival/Departure/Surface
IET	Integration, Evaluation and Transition
IPSA	Interagency Portfolio and systems Analysis Division
IR	Interoperability Research
ITAR	International Traffic in Arms Regulations
IWP	Integrated Work Plan
JPDO	Joint Planning and Development Office
LaRC	Langley Research Center
MCM	Milestone Completion Memo
MCR	Milestone Change Request
MSP	Multi-Sector Planner
NAS	National Airspace System
NextGen	Next Generation Air Transportation Systems
NRA	NASA Research Announcement
NTX	North Texas Facility
OI	Operational Improvements

OMB	Office of Management and Budget
PD	Program Director
PDRC	Precision Departure Release Capability
PIM	Program Integration Manager
PM	Project Manager
POC	Point of Contact
PS	Project Scientist
R&D	Research and Development
RFA	Research Focus Area
RM	Risk Manager
RTP	Research Transition Product
RTT	Research Transition Team
SAA	Space Act Agreement
SAIE	Systems Analysis, Integration and Evaluation
SBIR	Small Business Innovative Research
SDSS	Surface Decision Support System
SESO	Safe and Efficient Surface Operations
SPA	System and Portfolio Analysis
TBO	Trajectory-Based Operations
TIM	Technical Interchange Meeting
TL	Technical Lead
TMA	Traffic Management Advisor
TP/I	Trajectory Prediction/Interoperability
TRACON	Terminal Radar Approach Control
TRL	Technology Readiness Level
WBS	Work Breakdown Structure
Wx	Weather
WYE	Work Year Equivalent

Appendix D. Waivers

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Appendix E. Airspace Systems Technical Challenges

Responsible Project	Title	Description
CTD	Efficient Arrival Operations	With limited decision support, air traffic controllers rely on sub-optimal arrival routes and inefficient level-offs to keep aircraft safely separated. Develop new concepts, procedures and algorithms to maximize arrival rates to single airports and metroplexes, while also reducing fuel burn, emissions, and noise. Improved arrival area operations rely on effectively integrating multiple concepts, including high precision scheduling, flight deck merging and spacing, and terminal area (near-airport) conflict detection and resolution.
CTD	Efficient Arrival/Departure/Surface Operations	Controllers lack decision support systems to strategically plan optimal airport resource use across arrivals, departures, and surface operations. Coordinated scheduling of departing and arriving flights with surface operations improves efficiency and throughput at and near the airport.
CTD	Separation Based on Wake Prediction	Static wake vortex separation standards may lead to lost capacity in some cases. Improve airport capacity through use of dynamic wake vortex standards. Advanced sensors, models, and decision support systems allow controllers to apply appropriate wake separation standards based on aircraft characteristics and atmospheric conditions.
CTD	Optimize NAS Performance and Environmental Protection	Sub-optimal strategic flow management decisions, particularly in the presence of hazardous weather can lead to extensive delays. Develop modeling, simulation and optimization techniques to minimize total system delay (or other performance functions), subject to airspace and airport capacity constraints, while accommodating three times traffic in the presence of uncertainty.
CTD	Minimize Impact of Weather	Traffic flow managers have only limited decision support for planning efficient flows in the presence of weather. Develop strategies, algorithms, and decision support tools that allow traffic flow managers to minimize disruptions caused by hazardous weather. Algorithms incorporate probabilistic weather information, contributing to more accurate and efficient decisions on in-flight weather deviation and ground-delay programs.
CTD	Increase Efficiency through User Collaboration	Air traffic service providers face significant challenges in developing traffic flow strategies that provide system-wide efficiency and user equity. Develop and validate concepts and technologies that meet the needs of diverse stakeholders, under high traffic and severe weather conditions. Advanced models also offer greater flexibility to flight operators and service providers when allocating flights and traffic flows to constrained resources.
CTD	Address Demand/Capacity Imbalance	With limited exceptions, today's airspace sectors are static and cannot support higher capacity. Develop concepts, algorithms, and technologies that allow en route capacity to be allocated as needed to meet demand. Capabilities promote more flexible airspace design and include techniques such as airspace boundary changes and dynamic flow corridors.
CTD	Optimized Surface Operations	Imprecise surface movement across multiple independent

Responsible Project	Title	Description
		entities and lack of common situation awareness lead to sub-optimal operations. Enable more efficient surface operations that reduce delays and fuel emissions. Concepts and advanced algorithms provide coordinated, optimized trajectory-based paths supported by high precision taxiing and conformance monitoring.
CTD	Improve Safety of Surface Operations	Reducing runway incursions continues to be a high-profile safety need. Provide ground-based and airborne alerting capabilities that mitigate runway incursions and low altitude conflicts, even under high traffic density operations.
CTD	Trajectory-Based Operations Enabled by Conflict Detection and Resolution	Controller workload is generally the limiting factor to increasing en route capacity and allowing wind-optimal trajectories. Explore greater levels of automation support to help mitigate controller workload. Develop separation assurance algorithms for airborne and ground-based systems that detect and resolve traffic conflicts while meeting assigned trajectory constraints, under high traffic density and with uncertainty.
CTD	Safety Assessment for Conflict Detection and Resolution Automation	Safety assessments and certification processes generally rely on comparison between candidate and previously certified systems. Many separation assurance systems under consideration for NextGen bear little resemblance to legacy systems. Working with Aviation Safety Program, develop and evaluate new methods that allow credible safety evaluations of highly complex, automation-intensive systems. Methods contribute to formal validation and verification of separation assurance operational concepts, algorithms, and software code.
CTD/SAIE	Human/Machine, Air/Ground Functional Allocation	En route airspace capacity is limited by today's ground-based, human-centered separation assurance system. Under NextGen, a greater reliance on automation and/or aircraft capabilities may improve efficiency, while maintaining safety. Support informed NextGen decisions on air/ground and human/automation functional allocation for separation assurance. Comparative studies evaluate different operational concepts and technologies in a variety of trajectory-based operations environments.
SAIE	Relevant Environment Integration and Evaluation	Many NASA technologies could provide benefits to the National Airspace System, yet it's been difficult to transition them to stakeholders. Improve the potential to transition NASA technologies into the National Airspace System through high-fidelity simulations and flight evaluations. Performance assessments concentrate on technology integration with flight and ground hardware systems, proper functioning in operational environments, and interactions with real-world data sources.
SAIE	Trajectory Prediction and Interoperability	Tactical heading and altitude changes are frequently used in today's air transportation system. These control strategies lead to large position uncertainties and inefficient operations. Advance NextGen enabling capabilities related to trajectory prediction and interoperability. Improve the accuracy and capabilities of ground-based and airborne trajectory predictors. Develop methods to reliably assess the ability of

Responsible Project	Title	Description
		different trajectory predictors to meet the needs of NextGen applications. Contribute to common protocols for exchanging trajectory information between ground-based and airborne systems.
SAIE	Portfolio Analysis of Integrated System-Level Concepts and Technologies	Program research should focus on areas of high potential for improving system-wide capacity and efficiency. Conduct benefits assessments of single and integrated concepts to support program portfolio investment. Refine concepts to ensure effective interdependent operations across multiple air traffic domains and time horizons. Collaborate with JPDO on system-level studies and development of common metrics and scenarios.
SAIE	Application of New Solutions to Air Traffic Management Challenges	Program research should be infused with innovative approaches for improving system-wide capacity and efficiency. Identify system level demand/capacity imbalances and approximate upper ceiling of potential capacity improvements. Studies explore trends in future aviation demand and compare with operational and physical constraints that limit capacity growth. Exploratory studies consider new approaches toward addressing aviation demand, while respecting system constraints.

Appendix F. Technology Readiness Level (TRL)

TRL Responsibilities between Projects

TRL (NASA SE Manual)	*Activity*	*Lead Project*
1. Basic principles observed and reported	Bottoms-up, inductive logic, researcher generating an idea -Top-down domain studies to generate better understanding of domain characteristics and constraints; identify potential solution path	CTD
2. Technology concept and/or application formulated	Formulate individual concepts/ideas; algorithms formulated to address a specific operational need Potential solution paths further analyzed; benefit assessments to identify possible impacts and to identify technological challenges (R&D needs)	CTD
3. Analytical and experimental critical function and/or characteristic proof of concept	Conduct initial analysis to show the merits of the concept/ideas/algorithms Conduct thorough benefit assessments; evaluate potential benefits of combined concepts	CTD
4. Component and/or integrated components validation in laboratory environment	Conduct validation of initial integrated (as needed) concept prototype in a laboratory environment Develop initial technology prototype; validation in laboratory environment.	CTD and SAIE
5. Component and/or integrated components validation in relevant environment	Develop relevant environment, scenarios, and integrate multiple components Continue to mature a concept and technology based on simulation results	SAIE
6. System/subsystem model or prototype demonstration in a relevant environment	Integrate technology prototype in high-fidelity relevant environment; conduct testing and evaluation; update benefit, safety, and human factors assessments. Provide the concept/ technology prototype, description and algorithms for necessary demonstration	SAIE
7. System prototype demonstration in an operational environment	Support transition of technology to FAA; prototype modification to address site-specific operations; integration with other facility tools that operate in same environment Provide concept/algorithm modifications and descriptions as necessary to support technology transition	SAIE and CTD
8. Actual system completed and demonstrated in operational environment	No Project responsibility	No Project responsibility
9. Actual system operationally proven through use in operational environment	No Project responsibility	No Project responsibility

Appendix G. Resources

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Appendix H. Facilities and Laboratories

The SAIE Project will utilize NASA simulation facilities and laboratories in FY11 in support of research objectives. Requirements for use beyond FY11 will be determined during the preceding year of Project execution and adjusted as needed to reflect new knowledge and changes in available resources.

Crew Vehicle Systems Research Facility (CVSRF): The CVSRF, part of NASA SimLabs at ARC, houses several high-fidelity simulators capable of full-mission simulation. Specifically, the facility includes two six-degree-of-freedom flight deck simulators (including an FAA-certified "Level D" B747-400 flight deck simulator, and a fully-configurable Advanced Concepts Flight Simulator, or ACFS) and the Air Traffic Control Laboratory (ATC Lab). These simulators are able to interact with each other, as well as other SimLabs simulators, in distributed simulations that enable pilots and controllers to jointly participate in high-fidelity gate-to-gate simulations. CVSRF will continue its on-going support for Efficient Descent Advisor (EDA) requirements development simulations in FY11, supporting milestone SAIE.IET.3.04.

Airspace Operations Laboratory (AOL): The AOL at NASA ARC evaluates ATM concepts and explores human-system interaction issues in a high-fidelity human-in-the-loop simulation environment designed to allow rapid prototyping of NextGen concepts. This environment allows simulations of aircraft, ATM systems and communication infrastructure for both current day operations and a variety of future, highly automated concepts. Controller workstations are realistic emulations of today's en route, Terminal Radar Approach Control (TRACON) and oceanic systems. They also include a full suite of advanced decision support tools and automated functions for conflict detection and resolution, trajectory planning, scheduling and sequencing, and managing advanced levels of airborne equipage. The AOL facility will not be utilized by SAIE during FY11, but AOL staff members will support the documentation of operational requirements for multi-sector planning functions in support of milestone SAIE.IET.2.05 and the FY11 SAIE APG (see Sec. 1.3.3 for description).

NASA/FAA North Texas Research Station (NTX): The NTX is a collaborative effort between NASA and several Federal Aviation Administration (FAA) organizations and supports NextGen research through field evaluations, shadow testing, simulation evaluations and data collection and analysis. NTX has conducted ATM automation tool field evaluations including: Traffic Management Advisor (TMA), Final Approach Spacing Tool (FAST), Conflict Prediction and Trial Planning (CPTP), Collaborative Arrival Planning (CAP) and Direct-To (D2). In addition, the NTX team (NASA civil servants and contractors) has developed expertise in: airspace and surface operations analyses; ATC, air carrier and airport procedures; integrating research prototype systems into operational environments; and the collection and analysis of quantitative and qualitative air transportation system data sets. The NTX supports IADS RTT milestone SAIE.IET.3.01 in FY11.

Air Traffic Operations Laboratory (ATOL): The ATOL at NASA LaRC is a multi-fidelity, part task, air traffic simulation environment designed to explore inter-aircraft,

aircraft/airspace, and air/ground interactions. The ATOL is capable of hosting both batch and human-in-the-loop (HITL) studies to investigate advanced flight deck technologies and air traffic management (ATM) concept-level operations research (flight procedures, human decision making, situational awareness, transfer of authority and responsibility) to meet the needs of NextGen. The ATOL is comprised of over 500 computing platforms, each simulating an individual aircraft. Each aircraft simulation includes six-degree-of-freedom aircraft models in real-time code, Flight Management System (FMS) and Computer (FMC) emulation, generic Boeing glass cockpit flight displays, autoflight and auto throttle systems emulation, Automatic Dependent Surveillance-Broadcast (ADS-B) model, ARINC 429 avionics bus emulation, and Class III Electronic Flight Bag emulation. Hundreds more aircraft with lower fidelity aero-performance models may be combined with the high fidelity aircraft simulations in order to perform high-density airspace studies. Twelve single-pilot stations are used to support studies and simulations involving active airline pilots as participants. The ATOL also hosts five Air Traffic Control (ATC) stations with voice and data link communications to enable HITL studies involving both pilot test subjects and confederate air traffic controllers. The ATOL may be connected, through High Level Architecture (HLA) gateways to other facilities, e.g. full mission, high-fidelity flight decks or air traffic control facilities around the country to leverage their capabilities. The ATOL supports milestone SAIE.IET.3.02 during FY11 and FY12.

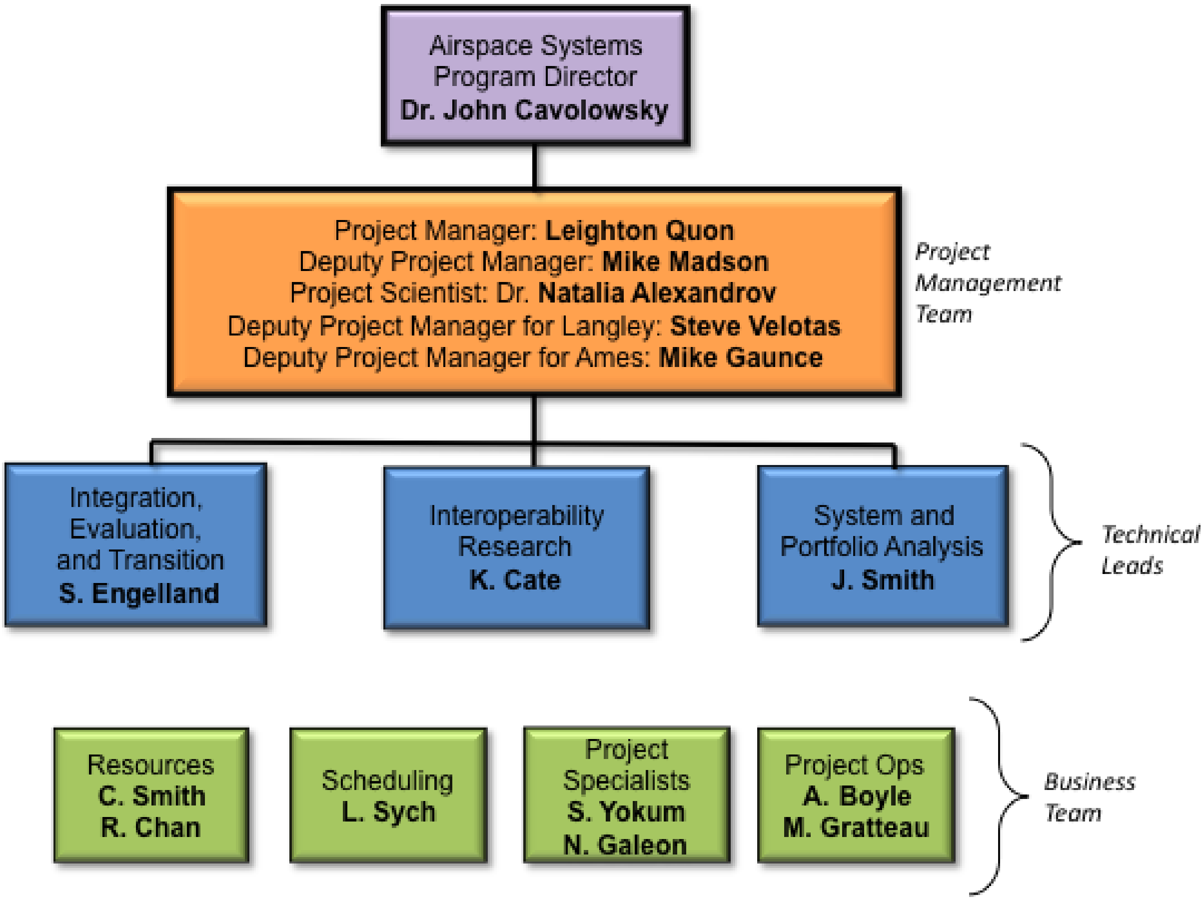
Cockpit Motion Facility (CMF): The CMF at LaRC is a multifaceted motion and fixed-base flight simulation research laboratory designed to support advanced flight deck design research and vehicle operations research for NextGen in which motion cues are critical to the realism of the experiments being conducted. The CMF is made up of fixed-base simulator sites and one motion-base simulator site. The simulators are the Research Flight Deck Simulator (all-glass reconfigurable commercial transport cockpit with programmable sidestick control inceptors), the Integration Flight Deck Simulator (conventional commercial transport cockpit with programmable wheel/column control inceptors – considered equivalent to FAA certified Level D simulator), and the Generic Flight Deck Simulator (all-glass reconfigurable futuristic cockpit with interchangeable programmable control inceptors). Each of these simulators is designed to operate as a fixed-base simulator or as a motion-base simulator when the simulator is put onto the state-of-the-art high-performance, 76-inch six-degree-of-freedom synergistic motion system. The simulators can be tied to the ATOL (see above) as well as simulation facilities at other NASA Centers, DoD facilities, FAA facilities, commercial facilities, and university facilities to conduct large-scale multivehicle simulations. Along with the ATOL, the CMF supports milestone SAIE.IET.3.02 in FY11 and FY12.

Airspace Concepts Evaluation System (ACES): The ACES simulation environment is a NASA computer simulation of the air transportation system; this is a multi-fidelity, non-real-time modeling and simulation system with full gate-to-gate representation of all the major components of the NAS. NASA, FAA, JPDO, and industry have used ACES to perform various ATM studies by simulating today's traffic volume and conditions, as well as future traffic volumes and conditions. In

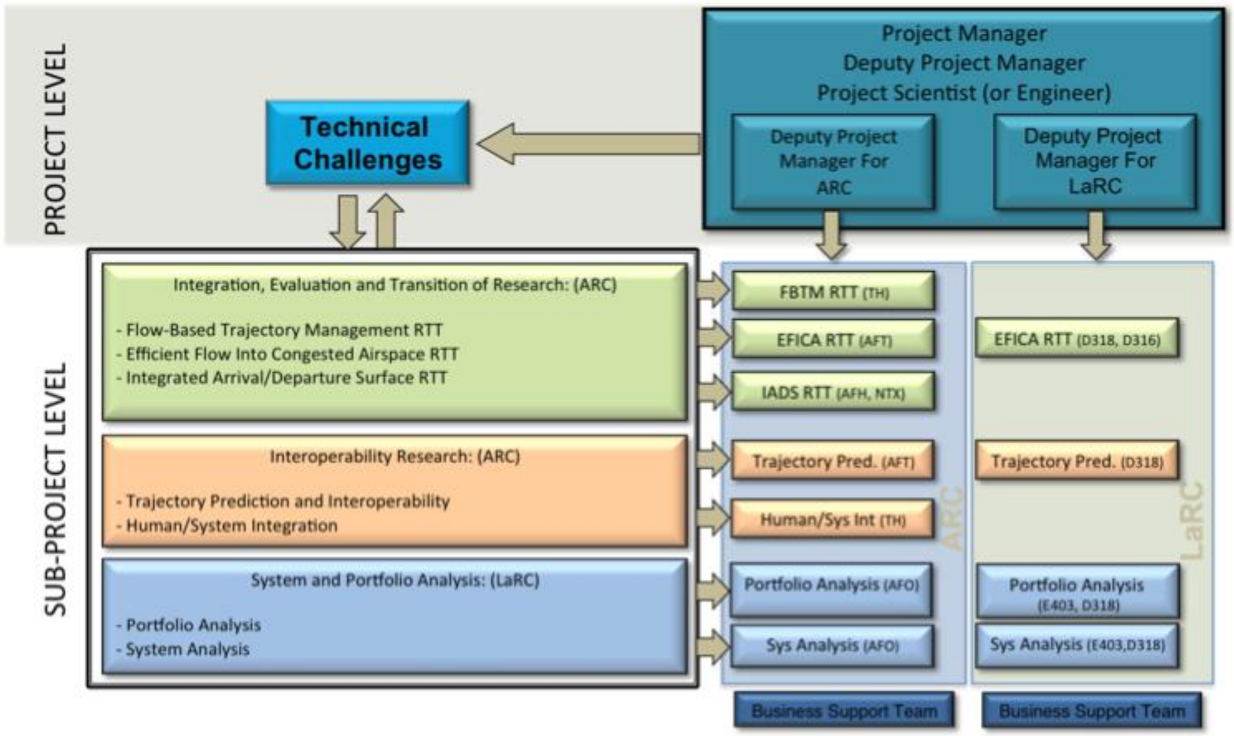
FY11, ACES supports milestones SAIE.SPA.4.01, SAIE.SPA.4.02, SAIE.SPA.3.03, SAIE.SPA.2.04, and SAIE.SPA.2.06.

Appendix I. Project Management Structure

Organization Chart



Flow-Down of Research from the Project to the Centers



Appendix J. Work Breakdown Structure

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Appendix K. SAIE NRA Awards

Title Of Proposal [Organization]	RFA	Award Date	Period Of Performance
Computational Models Of Human Workload: Definition, Refinement, Integration, And Validation In Fast Time National Airspace Simulations [San Jose State U. Foundation]	SPA	9/28/06	10/1/06-12/31/10 (NCE from 9/30/10)
Analysis Of NGATS Sensitivity To Gaming [George Mason University]	SPA	11/1/06	10/1/06-1/31/11 (NCE from 12/31/10)
Development Of Algorithms And Techniques For Trajectory Prediction Accuracy And Uncertainty Estimation [L-3 Services, Inc.]	IR	11/27/06	11/27/06-1/29/10 (NCE from 11/27/09) - Complete
Trajectory Flexibility Preservation And Constraint Minimization For Distributed ATM With Self-Limiting Traffic Complexity [L-3 Services, Inc.]	IR	11/29/06	11/29/06-12/30/10 (No Cost Extensions from 11/29/09) -
A Unified Approach to the Documentation, Analysis, and Cross-Comparison of Trajectory Predictors (Univ of Minnesota)	IR	7/19/07	8/1/07-7/31/09--Complete
Analysis and Comparison of Capabilities and Requirements for Aircraft Trajectory Prediction Technologies (L-3 Services)	IR	7/25/07	7/25/07-4/3/09 (NCE from 3/31/09)--Complete
Characterization Of And Concept For Metroplex Operations (Joint With NextGen-Airportal And -Airspace Projects) [Georgia Tech Res. Corp.]	SPA	08/08/07	7/11/07-7/10/10 (NCE from 7/10/09) - Complete
Investigating The Nature Of And Methods For Managing Metroplex Operations [Mosaic ATM]	SPA	8/14/07	8/14/07-12/31/09 (No Cost Extension from 9/30/09) - Complete
Metroplex Operations (Joint With NextGen Airportal And -Airspace Projects) [George Mason University]	SPA	08/24/07	8/24/07-7/31/10 (No Cost Extension from 9/30/09) - Complete
Integrated Analysis Of Airportal Capacity And Environmental Constraints [Logistics Management Institute]	SPA	12/14/07	01/07/08-01/06/10 - Complete
Identification, Characterization, And Prioritization Of Human Performance Issues And Research In The Transition To Next Generation Air Transportation System (NextGen) [San Jose State U. Foundation]	SPA	1/15/08	1/21/08-12/31/09 (No Cost Extension from 6/30/09) - Complete
Multi-Scale Tools For Airspace Modeling And Design [University Of Virginia]	SPA	2/11/08	03/01/08-05/31/10 (No Cost Ext. from 8/31/09)--Complete
Linking Airspace Modeling and Simulation Tools of Variable Fidelity and System Scope (Sensis)	SPA	3/11/08	3/11/08-3/10/09--Complete

Title Of Proposal [Organization]	RFA	Award Date	Period Of Performance
Open-Source based Software Systems for Linking Disparate software Components (Optimal Synthesis)	SPA	6/6/08	6/9/08-8/26/09 (Supp. Agrmt from 6/8/09)--Complete
A Predictive Tool For Proactive Airportal Operations [SA Technologies, Inc.]	SPA	09/29/08	9/30/08-9/29/11 (Base + 2 option years)
Airportal Functional Allocation Reasoning (AFAR) [Aptima Inc.]	SPA	09/30/08	9/30/08-9/20/11 (Base + 2 option years)
3X-Transparent Research Environment For Aviation Modeling (3X-TREAM) [Aptima Inc.]	SPA	5/20/09	5/20/09-5/19/12 (Base + 2 option years)
Investigation, Modeling, and Analysis of Integrated Metroplex Arrival and Departure Coordination Concepts (Georgia Tech. Res. Corp)	SPA	6/8/10	6/8/10-6/7/11
Metroplex Optimization Model Expansion and Analysis (GMU)	SPA	6/9/10	6/9/10-6/8/11
System Analysis of Dynamic Big Airspace Design for Metroplex Operations (Mosaic ATM)	SPA	6/21/10	6/21/10-6/20/11
A Concept for Flexible Operations and Optimized Traffic into Metroplex Regions (Purdue University)	SPA	6/25/10	6/25/10-6/24/11
Multi-Scope, Multi-Domain, Multi-Metric Systems Analysis and Integration of NextGen Technologies (M3SAINT) (LMI)	SPA	7/21/10	7/22/10-7/21/12
Predictive Modeling and Analysis in Support of Deeper Assessment of System Safety and Risks for NextGen Airspace Concepts (Metron Aviation)	SPA	7/28/10	7/28/10-7/27/13
Complexity Science and Technology Tools for NextGen Airspace Research and Applications (NIA)	SPA	7/30/10	8/1/10-7/31/11
NextGen-Airportal Project Technologies: Systems Analysis, Integration, and Evaluation (Sensis)	SPA	7/30/10	7/30/10-7/29/12
Methodologies to Evaluate Trade-Offs Between Environmental Impacts and Air Transportation System Performance (MIT)	SPA	8/2/10	9/1/10-8/31/13
Systematically Achieving Accurate, Reliable and Consistent Trajectory Prediction (Univ of Minn)	IR	8/12/10	9/1/10-8/30/11
System-Level Environmental Analysis of Concepts and Technologies (SEACAT) (Metron)	SPA	9/21/10	10/1/10-9/30/13 (Base + 2 option yrs)
Integrate, Quantify, Evaluate NextGen Airport Concepts--A systematic experimental design for an airside simulation modeling and benefit-cost analysis approach to integrating and evaluating NextGen concepts for optimizing airfield capability and mitigating airspace, runway, taxiway, gate, and environmental capacity constraints (LeighFisher, Inc—formerly Jacobs Consultancy)	SPA	9/30/10	10/1/10-9/30/12 (Base + 1 option year)
Common Trajectory Prediction Modeling Through Trajectory Predictor Abstraction (Engility Corp)	IR	11/10/10	11/10/10-11/9/11

Appendix L. Formal Agreements

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Appendix M. Milestone Change Table

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Appendix N. Change Log

Revision	Description of Change	Responsible Author	Effective Date
1.0	Baseline Document	N. O'Connor	May, 2010
2.0	FY11 Revision	L. Quon	December 2010

Appendix O. Review Comments and Discussion

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Appendix P. NASA Priority Performance Goal in Aeronautics Research

Increase efficiency and throughput of aircraft operations during arrival phase of flight.

1. Problem being addressed

Current air traffic control operations require an air traffic controller to manually generate and provide clearances (that include path and speeds) to aircraft to arrive at a “meter fix” at a scheduled time during the arrival phase of flight. A meter fix is an established point on a route used to time-regulate traffic entry into an airport’s terminal area. This manual process often results in inefficient trajectories and descent profiles for aircraft, particularly during higher traffic density operations, restricting the throughput, or number of aircraft that can be processed for arrival operations, and increasing negative environmental impacts from the inefficient trajectories, including ”stair step” approaches (level off, descend, level off, descend, etc.) or holding.

The En Route Descent Advisor (EDA) is a tool that proposes to the air traffic controller the speed and path changes which will allow an efficient arrival profile. EDA monitors many aircraft simultaneously, maximizing throughput by ensuring that each aircraft meets its scheduled time at the meter fix while avoiding flight path conflicts. The EDA’s innovation is its transformation of operations from existing procedures to ones that reduce flight time, fuel consumption, noise and emissions, thus resulting in more environmentally friendly enroute and terminal operations. Benefits from the use of off-line EDA-developed trajectories, tested in 2007 at San Francisco with a procedure called Tailored Arrivals in an oceanic environment, are already being realized by our international and domestic airline partners (Qantas, JAL, United, New Zealand Airlines) at San Francisco and Los Angeles airports. The San Francisco Trials indicated efficient trajectories could reduce fuel consumption by as much as 3,000 pounds for large aircraft, with a corresponding reduction of carbon dioxide of up to 10,000 pounds per flight.

Initial procedures and EDA capabilities for domestic operations will be different than the oceanic operations due to differences in flight instrumentation, traffic densities, and procedures. Field testing and subsequent deployment of EDA for en route domestic airspace will allow efficient operations, particularly during heavy traffic periods, and the economic and environmental benefits described above.

2. Relationship to broader agency objectives

The EDA technology supports environmentally responsible operations by creating efficient trajectories while maintaining higher throughput during the arrival phase of flight. It saves fuel and thereby reduces emissions.

NASA’s Aeronautics Research Mission Directorate conducts and supports research that enables revolutionary advances in civilian and military aeronautical systems, for both aircraft and the airspace in which they fly. As such, it addresses the Agency sub-goal

3.E: Advance knowledge in the fundamental disciplines of aeronautics, and develop technologies for safer aircraft and higher capacity airspace systems; and Outcome 3.E.2: By 2016, develop and demonstrate future concepts, capabilities and technologies that will enable major increases in air traffic management effectiveness, flexibility, and efficiency, while maintaining safety, to meet capacity and mobility requirements of the Next Generation Air Transportation System (NextGen).

3. *Contributing programs within the agency*

The Aeronautics Research Mission Directorate's Airspace System Program is the sole NASA sponsor of this technology.

4. *Contributing programs outside the agency*

EDA has been transitioned to the Federal Aviation Administration's 3D Path and Arrival Management project and forms the core technology for the project. It also supports the Joint Planning and Development Office's (JPDO) Next Generation Air Transportation System vision for increasing throughput of the National Airspace System and reducing environmental impact. The JPDO is a federal planning office designed to create and carry out an integrated plan for NextGen, spearhead planning, and coordinate research, demonstrations and development in conjunction with relevant programs of partner departments and agencies, and with the private sector. The JPDO is comprised of representatives from DOT, DOD, FAA, DHS, DOC, NASA, and OSTP. U.S. industry is engaged in JPDO activities through its involvement in the NextGen Institute.

5. *Key barriers and challenges*

The main technical challenge is the development of conflict free trajectory-based solutions that will meet the aircraft arrival scheduled time as well as maintain high throughput. This challenge requires the computation of accurate trajectory predictions under real-world conditions, and effective and robust decision-making algorithms. The other barrier is acceptance of this technology by users. In order to ensure that the technology is acceptable and beneficial to the users, a number of human-in-the-loop simulations and two field tests are planned.

6. *Implementation strategy overview*

In September 2009, NASA will work with FAA, United Airlines, and Continental Airlines to begin the first field test of the En Route Descent Advisor capability. During this first field test, United, Continental, and FAA Tech-Center aircraft will receive pre-scripted speed and path clearances representative of those computed by EDA. The goal of this first field test is to collect data for post-flight evaluation of EDA trajectory-prediction errors. Based on these data, models will be developed to better represent expected EDA trajectory errors in human-in-the-loop simulations, thereby providing a better representation of real-world performance.

The second field test is planned in March 2011. In this field test an EDA prototype will be deployed for real-time decision-making. The speed and path adjustment advisories will be presented on air traffic controllers' displays.

The primary mechanism for deployment is the NASA-FAA Research Transition Team (RTT). The RTT members develop the concept, operational procedures, and scenarios, and assess technology readiness. The FAA and NASA jointly identified EDA as one of the main technologies for potential deployment.

7. *Quarterly measures and milestones*

FY09

1. Denver Field Trial (first): Validation of EDA trajectory predictions and 3D Path and Arrival Management (4Q FY09)

FY10

1. Denver field trial lessons learned documented and used as input into experiment plan and model development (1QFY10)
2. Experiment plan and model development for human-in-the-loop simulation (1QFY10)
3. Human-in-loop simulation to evaluate EDA's core algorithmic performance (2QFY10)
4. Report on human-in-the-loop simulation and model results (4Q FY10

FY11

1. Simulation plan development for air traffic control human-in-the-loop simulation (2QFY11)
2. EDA evaluation by human-in-the-loop simulation with actual controllers (4QFY11)

FY12

1. NASA delivery of EDA Technology Transition Documentation to the FAA, September 2012

The ultimate achievement of any NASA air traffic management concept or technology is its use by the FAA in implementing operational improvements in the National Airspace System (NAS). Since NASA has no operational responsibility for the NAS, NASA's role and value is in providing information and capability to the FAA for informing critical decision-making as they plan investments. For NASA research deliverables, the ultimate achievement is to be captured in FAA implementation roadmaps enabling key deployment decisions, whether the deliverables are data, analysis, algorithms, or decision support tools for use by pilots or controllers. These deliverables are accompanied by a technology transition document, which identifies the maturity of the technology product and delivery requirements as defined jointly by NASA researchers and FAA operational personnel. The transition documents often involve careful analysis and negotiation to ensure maximum value and benefit is transitioned.