National Aeronautics and Space Administration

Technology Development Project Plan

(In accordance with NPR 7120.8)

Phase 2

Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) (UAS-NAS)

Integrated Aviation Systems Program (IASP)

Aeronautics Research Mission Directorate (ARMD)

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This Project Plan is based upon plans for Phase 2 of the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) (UAS-NAS) Project. It is organized into two primary sections, the main body and set of appendices. Changes to the main body will result in a new revision and signature process. Information in the appendices will be updated when deemed necessary by the Project Manager and does not require signature.

1 Objectives

1.1 Introduction

For some time, unmanned aircraft systems (UAS) have operated on a limited basis in the National Airspace System (NAS). These UAS operations, generally approved under a Federal Aviation Administration (FAA) Certificate of Waiver or Authorization (COA), mainly supported public operations, such as military and border security operations. The National Aeronautics and Space Administration (NASA) has used the COA process for UAS aeronautic, meteorological, and environmental research operations requiring flight in the NAS. As UAS and UAS-related technologies and operations mature, the list of potential uses for UAS are rapidly expanding to encompass a broad range of civil activities, including aerial photography, surveying land and crops, communications and broadcast, monitoring forest fires, monitoring environmental conditions, and protecting critical infrastructure. The UAS market is dynamic and the commercial sector is poised for significant growth. There are many forecasts projecting the significant positive impact UAS operations will have on the worldwide economy.

Congress directed that federal agencies accelerate the integration of UAS into the NAS. The FAA Modernization and Reform Act of 2012 contained provisions to promote and facilitate the use of civil UAS. In 2014 the Department of Transportation Office of the Inspector General issued a critical audit report of the FAA's progress in implementing the congressionally mandated requirements in the FAA Modernization and Reform Act of 2012. Also in 2014, the National Research Council's Committee on Autonomy Research for Civil Aviation, Aeronautics and Space Engineering Board reported concern about the technological readiness of the NAS for safe UAS integration.

The FAA created the Unmanned Aircraft Systems Integration Office (UASIO) to address integration of UAS safely and efficiently into the NAS. The FAA is collaborating with many stakeholders, which includes manufacturers, industry, trade associations, technical standards organizations, academic institutions, research and development centers, and governmental agencies – including NASA. The integration of UAS in the NAS is being accomplished similar to integration of any comparable new technology, which includes ensuring the introduction and integration of the new technology does not decrease NAS safety or reduce NAS capacity. While progress towards integration continues, many technology challenges and research opportunities exist. The research areas include aspects of the UAS command and control data link, spectrum, detect and avoid (synonymous with sense and avoid), and human factors. Minimum aviation system performance standards (MASPS) and minimum operational performance standards (MOPS) for UAS-NAS operations do not currently exist. The MASPS and MOPS contribute to certifying UAS operations in the NAS.

The FAA UASIO requested the RTCA develop MOPS for Detect and Avoid (DAA) and Command and Control (C2) Data Link equipment. In response, the RTCA established Special Committee 228 (SC-228), Minimum Performance Standards for UAS, in 2013. In establishing SC-228, RTCA concluded SC-203, Minimum Performance Standards for Unmanned Aircraft Systems. The SC-228 terms of reference (ToR) described two phases for MOPS development. An initial phase, Phase 1, of standards development will focus on civil UAS equipped to operate into Class A airspace under instrument flight rules (IFR) and using L-Band terrestrial and C-Band terrestrial data links. More specifically, the Phase 1 MOPS operational environment was defined in the ToR as the transitioning of a UAS to and from Class A, or special use airspace, traversing Class D and E, and perhaps Class G airspace. A second phase of MOPS development was to specify DAA equipment to support extended UAS operations in Class D, E, and perhaps G, airspace and to provide standards for the use of SatCom in multiple bands as a C2 Data Link to support UAS. Phase 1 deliverables were defined as: White Papers describing the functions, use, and options for DAA and C2 Data Link equipment in support of MOPS to be delivered in December 2013; Preliminary DAA and C2 MOPS and recommendations for a verification and validation test program to be delivered by July 2015; and final Phase 1 DAA and C2 MOPS based on the result of the verification and validation activities to be delivered in July 2016.

To address UAS-NAS integration Technical Challenges, NASA initiated the UAS integration in the NAS (UAS-NAS) Project within the Integrated Aviation Systems Program (formerly the Integrated Systems Research Program) of the Aeronautics Research Mission Directorate in 2010. The UAS-NAS Project plan was to contribute research findings to reduce technical barriers related to the safety and operational challenges associated with enabling routine UAS access to the NAS in technology areas aligned with current NASA expertise and capabilities. The Project was planned for two phases. The first phase included development and integration of system-level key concepts, technologies, and/or procedures based on UAS stakeholder/community needs collected during UAS-NAS Project formulation. Phase 1 also included refinement of those needs as part of defining the specifics of the Phase 2 research portfolio. Phase 1 research activities were continued in Phase 2 and modified as necessary based on the Phase 2 research portfolio. Phase 2 of the Project also includes demonstration of the integrated technologies in operationally-relevant environments.

The technology areas selected for Phase 2 included sense and avoid, communications, human systems integration, and Integrated Tests and Evaluation (LVC-DE development). This selection was accomplished through a fairly rigorous research selection process, described later in this plan, that not only considered existing NASA expertise and capabilities, but also FAA, SC-228, and UAS community research needs. By using a rigorous research selection process, the contribution of the Project's Phase 2 research activities to the development of SC-228 Phase 1 Final DAA and C2 Data Link MOPS, as well as providing foundational research associated with full integration of UAS into the NAS, was maximized.

1.2 History

The NASA has had a significant history of involvement in both operating UAS and in leading and supporting UAS community efforts to enable routine UAS access and operations in the NAS. In conjunction with the Unmanned Aerial Vehicle (UAV) National Industry Team (UNITE) in 2004, NASA participated in a project named Access 5 that desired unrestricted access to the NAS within five years for UAVs operating in the medium to high altitude NAS. Access 5 was a collaborative effort between government and industry, designed to develop the technologies and procedures necessary to enable routine UAS access to the NAS. Through the collaborative efforts of Access 5, the FAA created the FAA's Unmanned Aircraft Program Office (UAPO). Additionally, Access 5 contributed to the establishment of RTCA Special Committee 203 (SC-203). SC-203 was formed to help ensure the safe, efficient, and compatible operation of UAS with other vehicles operating within the NAS. Access 5 concluded in 2006.

The FAA continues to address the public use challenges of NAS access on an "exception" basis. The FAA has improved the COA process and expanded approvals for many public agencies including Department of Defense, Department of Homeland Security, and NASA. This progress was focused on creating exceptions to the Federal Aviation Regulations, and not enduring solutions, which might be relevant in the Next Generation Air Transportation System (NextGen) timeframe.

In 2010 the NASA Aeronautics Research Mission Directorate initiated formulation activities for a UAS integration in the NAS project. A meeting of experts was conducted in August 2010 and a Technical Interchange Meeting was conducted between NASA, the Air Force Research Laboratory, and the Joint Planning and Development Office in October of 2010. These meetings, and other less formal NASA-UAS community discussions, contributed to formulating the two phase UAS-NAS Project. A two-phased project approach (Phase 1 and 2) included development of system-level integration of key concepts, technologies and/or procedures, and demonstrations of integrated capabilities in operationally relevant environments.

Phase 1 completed in September 2013. The Phase 1 objectives were:

- Conduct a gap analysis between current state-of-the-art and NextGen Concept of Operations (ConOps).
- Accomplish an initial UAS-NAS integration national plan development meeting.
- Validate the key technical areas identified by this project.
- Initial modeling, simulation, and flight-testing.
- Complete Subproject Phase 1 deliverables (spectrum requirements, comparative analysis of certification methodologies, et cetera) and continue Phase 2 preparation (infrastructure, tools, et cetera).

In 2013 as part of Phase 1, the UAS-NAS Project developed and validated the Phase 2 research portfolio with completion of a rigorous research selection process. The results from the selection process and the details of the Phase 2 research portfolio were captured in a series of briefings to the ARMD leadership team: *UAS Integration in the NAS Project Phase 1/Phase 2 Transition Key Decision Point (KDP) Briefing* in September 2013, *UAS Integration in the NAS Project KDP Follow-On Briefing* in February 2014, and *UAS Integration in the NAS Project Baseline Review* in May 2014.

Phase 2 initiated in FY14 once approval was received from the ARMD Associate Administrator. Phase 2 is planned to continue through FY16. Specific details of the Phase 2 portfolio are described later in this Project Plan, as are the management processes employed by the UAS-NAS Project to successfully execute Phase 2 of the project.

1.3 Goal, Research Themes, and Technical Challenges

The UAS-NAS Project focuses on routine NAS Access for Civil / Commercial UAS. The Project Goal is:

> *Provide research findings to reduce technical barriers associated with integrating Unmanned Aircraft Systems into the National Airspace System utilizing integrated system level tests in a relevant environment.*

Two Project Research Themes (RT) support this goal:

> *Research Theme 1: UAS Integration - Airspace integration procedures and performance standards to enable UAS integration in the air transportation system.*

> *Research Theme 2: Test Infrastructure - Test infrastructure to enable development and validation of airspace integration procedures and performance standards.*

The two Research Themes are supported by four Technical Challenges:

> *RT 1: Technical Challenge Sense and Avoid - Provide research findings to develop and validate UAS minimum operational performance standards (MOPS) for sense and avoid (SAA) performance and interoperability.*
>
> *RT 1: Technical Challenge Command and Control - Provide research findings to develop and validate UAS minimum operational performance standards (MOPS) for terrestrial command and control (C2) communication.*
>
> *RT 1: Technical Challenge Human Systems Integration - Provide research findings to develop and validate human systems integration (HSI) ground control station (GCS) guidelines enabling implementation of the SAA and C2 performance standards.*
>
> *RT 2: Technical Challenge Integrated Test and Evaluation - Develop a relevant test environment for use in generating research findings to develop and validate HSI Guidelines, SAA, and C2 MOPS with test scenarios supporting integration of UAS into the NAS.*

These Technical Challenges are further decomposed into specific research activity objectives and deliverables as described in the Project Requirements Document.

The UAS-NAS Project is operating in an ever-changing environment guided in part by needs of the FAA, the RTCA SC-228, and the broader UAS community. Consequently, the UAS-NAS Project has developed management processes to remain agile to adapt to the customer/community needs. While the base of what the UAS-NAS Project is planning to deliver is not expected to change dramatically, specifics of the research activity content and final products may change to better meet these needs.

1.4 Project Success

The UAS-NAS Project manages by Technical Challenge. The Project's research activities, which, make up the technical baseline, represent the research needed to complete project Technical Challenges. The UAS-NAS Project measures success of the project by completing the Technical Baseline content per the approved baseline schedule within budget. Completing the Technical Baseline content per schedule and budget maximizes the positive impact of the technology transfer of project research findings to the stakeholders, given the established relationships between the UAS-NAS Project personnel and key stakeholders, coupled with a strategy to be responsive to changing stakeholder needs.

Given the project success description in the preceding paragraph, the UAS-NAS Project does not have objective, quantifiable, and measurable performance goals as referenced by NASA Procedural Requirement (NPR) 7120.8, NASA Research and Technology Program nor Measures of Effectiveness, Measures of Performance, or Technical Performance Parameters as described in NASA/SP-2007-6105 Rev1, NASA Systems Engineering Handbook. The research activities accomplished by the UAS-NAS Project contribute to defining the performance levels and thresholds for future unmanned aircraft system certification and regulation. These evolving UAS requirements are considered by the Project in developing technologies (self-separation algorithms, Control and Non Payload Communication system radio prototype, ground control station display, including models and simulation capabilities) for use in informing the Phase 1 DAA and C2 MOPS. They are not suitable for measuring the progress or success of the Project as project success or progress is measured by contributions towards definition of Phase 1 DAA and C2 MOPS.

The UAS-NAS Project manages performance toward completing the Technical Challenges with Progress Indicators. Each Technical Challenge has its own Progress Indicator. The Progress Indicators represent all Technical Challenge activities that the Project performs, including activity start, the end of activity execution, technology transfer, status and health, and maturity of the data and information required to overcome the Technical Challenge. Each research activity is weighted according to the activity type. Activities that involve higher levels of integration are weighted more than activities that are less integrated in nature. Within a Technical Challenge, the weighted results are normalized on a ten point scale. Thus, at the completion of all baselined research activities, each Progress Indicator will have reached a value of ten indicating that all the research findings from activities have been applied towards the Technical Challenge. In addition to capturing the data collection for individual research activities the Progress Indicator is a representation of technology transfer of research results to stakeholders. With these two characteristics--data collection initiation through completion and results technology transfer completion, the Progress Indicator provides insight into contributing research findings to develop and validate UAS Phase 1 DAA and C2 MOPS as baselined in the UAS-NAS Project's Phase 2 Research Technical Baseline. Progress Indicators are described in more detail in Section 3 of this Project Plan.

In addition to Technical Challenge Progress Indicators, each Phase 2 Portfolio research activity was categorized as either minimum success or full success (refer to Section 2 for individual identification of minimum and full success for each Technical Challenge). This categorization was based on an assessment of the research activities contribution to stakeholder needs with minimum success representing a research activity that was necessary for project success, and full success representing those research activities that were desired for project success. Contributions to SC-228 were deemed more critical to UAS-NAS Project success than contributing to broad UAS community research needs. Research activities are described by their community/stakeholder need, objective, benefit to community, approach, key collaborators, success criteria, deliverables, and plans for use. This identification of minimum or full success for each schedule package was captured in the Project Requirements Document (Doc#: UAS-PRO-1.1-005).

1.5 Relevance to Agency Vision and Mission

The UAS-NAS Project was formulated to take advantage of existing NASA researcher expertise and existing NASA research capabilities to accomplish UAS-related research for achieving routine UAS access and operations within the NAS. The UAS-NAS Project's baselined Phase 2 portfolio is relevant to the NASA, ARMD, and IASP Vision, Mission, and Goals:

- The UAS-NAS Project research is in the area of aeronautics (NASA Mission);
- The commercial applications envisioned for UAS operating routinely in the NAS will improve the quality of life on earth (NASA Strategic Goal);
- The UAS-NAS Project research findings will contribute directly to maintaining NAS safety and efficiency (NASA Objective 2.1);
- Automation is expected be part of a UAS Detect and Avoid capability and will be underlying UAS Ground Control Station Displays (Aeronautics Strategic Thrust 6); and

- The UAS-NAS Project research includes system level integrated tests of developing technologies in relevant environments (IASP Goal).

The UAS-NAS Phase 2 Portfolio aligns with guiding statements from other NASA planning documents as represented by:

> *NASA Vision: We reach for new heights and reveal the unknown for the benefit of humankind.*
>
> *NASA Mission: Drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth.*
>
> *NASA Strategic Goal 2: Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.*
>
> *NASA Objective 2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research.*
>
> *Aeronautics Strategic Thrust 6: Assured Autonomy for Aviation Transformation.*
>
> *Aeronautics Outcome (2015 – 2025): Initial Autonomy Applications with Integration of UAS into the NAS.*
>
> *Integrated Aviation Systems Program (IASP) Goal: Pursue innovative solutions to high priority aeronautical needs and accelerate implementation by the aviation community through integrated system level research on promising concepts and technologies, demonstrated in a relevant environment.*

2 Technical Approach

The technical approach for the UAS-NAS Project is discussed in this section. First, the content decision process is described in order to provide background for the rigor used in selecting Phase 2 content. Then related technical development activities assessment is discussed – important for avoiding duplication and to leverage previous work. Finally technical work accomplished in Phase 1 is discussed, and the Technical Challenges for Phase 2, as well as other less formal challenges are described in detail.

2.1 Gap Analysis (Content Decision Process)

An analysis was accomplished during Phase 1 of the UAS-NAS Project to refine the project research areas from those developed during Project Formulation (see Figure 1 for a depiction of the process). This analysis considered the community needs, NASA capabilities, as well as the UAS-NAS Project's budget, schedule, and time frame for impact. The analysis was included in the UAS-NAS Project Phase 1 to Phase 2 Transition Key Decision Point (KDP) Briefing on September 10, 2013.

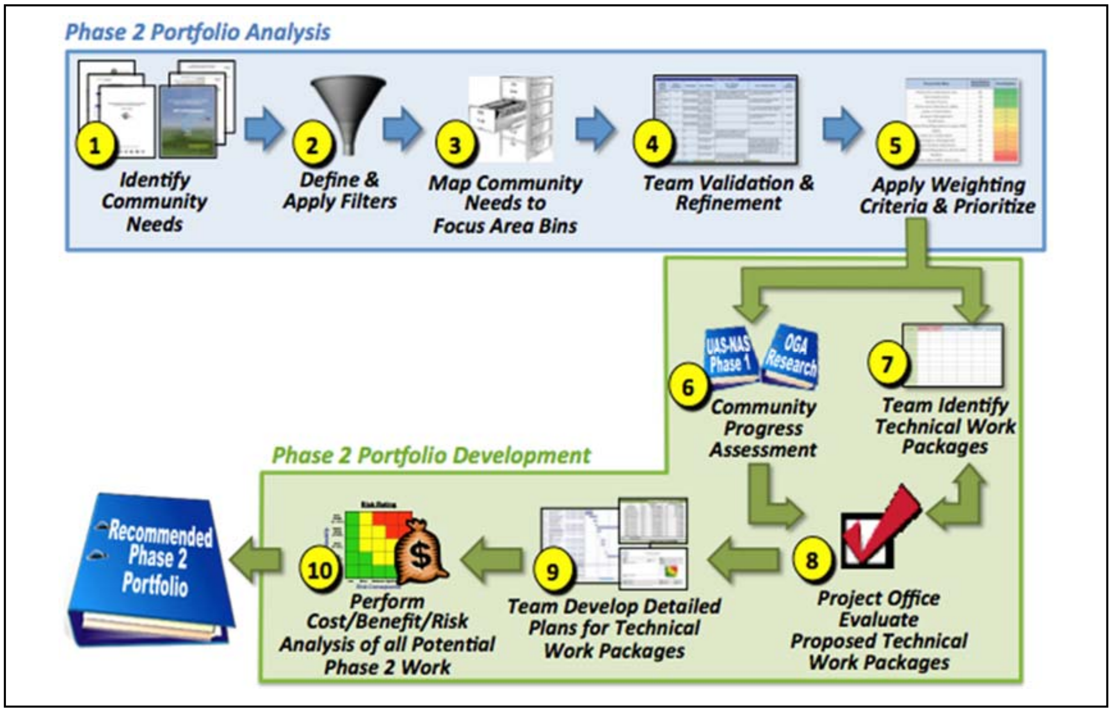


Figure 1. Content decision process.

The following are steps performed as part of the analysis:

Step 1: Identify Community Needs – The community needs were collected from strategic guidance documents and other documents that identified challenges preventing civil/commercial UAS from routinely operating within the NAS. Fourteen documents are cited with 281 community needs identified.

Step 2: Define and Apply Filters – Filters were selected (NASA & ARMD Mission, ARMD skills/capabilities, Project time-frame) to assess which community needs were relevant to NASA, ARMD, and the Project.

Step 3: Map Community Needs to Focus Area Bins – Community needs that made it through the filters were binned into fifteen focus area bins.

Step 4: Team Validation and Refinement – A top down (project office) and bottoms up (Project Engineers (PE) and Deputy Project Managers for (DPMf)) approach was executed in order to achieve consensus on sources and bins.

Step 5: Apply Weighting Criteria and Prioritize – A weighting criteria (community needs, appropriate organization, ability to complete, complexity and testing, public outreach/acceptance) was applied and then prioritization was used to identify lower priority community needs that the Project didn't pursue for Phase 2. Lowest priority items were weather, airport surface operations, and non-CNPC security. The four highest rated focus area bins were Sense and Avoid (SAA) Performance Standards, Command and Control (C2) Performance Standards, Human Systems Integration, and Integrated Test and Evaluation. These are also considered the primary focus areas and ultimately became the Project Technical Challenges.

Step 6: Community Progress Assessment – Evaluated the progress made towards addressing the community needs identified in step 1 by NASA and other government/industry/academic organizations to identify the remaining gaps.

Step 7: Team Identify Technical Work Packages (TWP) – The Project Manager (PM), PEs, DPMfs, and technical leads provided assessments of which community needs the Project should contribute towards in Phase 2. This led to the development of individual TWP.

Step 8: Project Office Evaluate Proposed TWP – The project office reviewed the proposed TWP supplied by the team and evaluated them according to many factors including: consistency with existing Phase 1 plans, lessons learned, and Phase 2 Drivers. Results of the evaluation were out-briefed to the team and feedback was provided to TWP originators to refine the TWP that would be considered for Phase 2.

Step 9: Team Develop Detailed Plans for TWP – PM, PEs, DPMfs, and technical leads developed detailed proposals for each TWP that would be considered for Phase 2. Twenty-eight TWPs were developed.

Step 10: Perform Cost, Benefit, and Risk Analysis for all Potential Phase 2 Work – The project office evaluated and prioritized each TWP in the areas of cost, benefit, and risk to generate an initial portfolio which was then briefed out to the team. That portfolio was evaluated using the following factors: support of Phase 2 Drivers, NASA Advisory Council Aeronautics Committee UAS Subcommittee feedback, and results of Center Independent Cost Assessments. The final recommended portfolio was briefed to the team for feedback.

The Phase 2 Portfolio consists of detailed plans that address the primary gaps without duplicating efforts within those identified areas. The gap analysis summarized above is fully documented in the Portfolio Analysis Overview (Doc#: UAS-PRES-1.1-006).

This work was coordinated with NASA's other government partner agencies to ensure efforts are complementary and non-duplicative. Efforts will be made throughout this Project to leverage work being conducted by our partner agencies and industry to collaborate wherever possible.

2.1.1 Assessment of Related Technology Development Activities

An assessment of related technology development activities in other NASA programs, other Government agencies, and the commercial sector have been conducted to avoid unnecessary duplication of effort. The assessment below is based on direct interaction with other activities, documentation by other activities, and independent assessments by national groups. Beyond avoiding unnecessary duplication, this analysis also aids in identifying opportunities for the UAS-NAS Project to leverage or partner with other activities.

NASA ARMD/Airspace Operations and Safety Program (AOSP) – The Airspace Operations and Safety Program directly addresses the fundamental air traffic management research needs for NextGen by developing revolutionary concepts, capabilities and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS. Capabilities being developed include algorithms enabling separation assurance of aircraft and examination of roles and responsibilities between air traffic controllers, pilots, and airline operations. The UAS-NAS Project will work closely with AOSP to leverage those capabilities that can help enable UAS access to the NAS. The UAS-NAS Project will build off of the AOSP work by examining unique issues related to unmanned aircraft, such as their unique missions and the speeds at which they fly. The UAS-NAS Project will coordinate with all three AOSP Projects (Airspace Technology

Demonstrations (ATD), Shadow Mode Assessment Using Realistic Technologies for the NAS (SMART-NAS), and Safe Autonomous Systems Operations (SASO)). Specifically, the UAS-NAS Project will coordinate with the SASO UAS Traffic Management (UTM) Subproject and the SMART-NAS enhancements to the live, virtual, and constructive – distributed environment (LVC-DE) in development by the UAS-NAS Project.

NASA ARMD/IASP/Flight Demonstrations and Capabilities (FDC) Project –The IASP FDC Project conducts complex and integrated small-scale flight research demonstrations in support of the ARMD Programs. In addition, FDC operates, sustains, and enhances those specific flight research and test capabilities necessary to address and achieve the ARMD Strategic Plan, ARMD Program/Project activities, other NASA mission directorate activities, and national strategic needs.

NASA Science Mission Directorate (SMD) – The SMD engages the Nation's science community, sponsors scientific research, and develops and deploys satellites and probes in collaboration with NASA's partners around the world to answer fundamental questions requiring the view from and into space. SMD has flown a multitude of UAS missions in the NAS, and has a vast amount of experience in defining the current and future mission characteristics required to obtain essential science data within the international community. SMD augments the Ikhana UAS reimbursable project at AFRC that the UAS-NAS Project uses for flight-test activities.

FAA – The FAA has created a UAS Integration Office to oversee UAS related issues and research within the FAA. The FAA has made significant progress in addressing the public use challenges of NAS access on an "exception" basis, including improving the COA process, and has expanded approvals for many public agencies including Department of Defense (DoD), Department of Homeland Security (DHS), and NASA. Initially, progress had been focused on creating exemptions to the Federal Aviation Regulations (FAR), and not universal solutions, which will be relevant in the NextGen timeframe. Recently, the FAA publically released an Integration Roadmap to guide integration efforts in the coming years. NASA has established a close relationship with the FAA in support of this Project to ensure efforts are coordinated and not duplicated. The FAA is a primary stakeholder for UAS-NAS activities and recipient of the project's technology transfer. The identification and selection of six FAA UAS test sites also provides the Project with an opportunity for potential collaboration.

DoD – DoD has invested in a variety of solutions for the collision avoidance challenge. Their investments include the use of ground based radar systems to eliminate the need for ground observers, and airborne solutions for specific platforms like Global Hawk and the MQ-9 Reaper. NASA's sense and avoid research will complement these efforts.

Industry – Industry is primarily focused on building, selling, and operating UAS to various public entities (primarily the DoD). Industry is also working through RTCA SC-228 and other standards organizations to enable civil access. The UAS-NAS Project is a key contributor to the SC-228 process for developing Minimum Operational Performance Standards. The UAS-NAS Project will continue to engage with Industry through collaborative forums and specific Cooperative Agreements.

International – There are several international forums involved in UAS research and UAS integration. The UAS-NAS Project and IASP have personnel that monitor the activities in these forums to stay abreast of their activities, to ensure no duplication of research and to look for potential collaboration opportunities. The UAS-NAS Project work is being leveraged by other in forums where the Project has more involvement, such as the International Telecommunications

Union Radio Communications Sector (ITU-R) World Radio Conference (WRC) and the International Civil Aviation Organization (ICAO) Remotely Piloted Aircraft System (RPAS) Panel.

2.2 Management by Research Themes and Technical Challenges

The UAS-NAS Project organizes the technical work under research themes and Technical Challenges. The UAS-NAS Project will measure performance against this defined set of Technical Challenges. For Phase 2, the two research themes (RT) and underlying TC are the following:

- *RT1 - UAS Integration: Airspace integration procedures and performance standards to enable UAS integration in the air transportation system.*
    - *TC-SAA Performance Standards: Provide research findings to develop and validate UAS minimum operational performance standards (MOPS) for sense and avoid (SAA) performance and interoperability.*
    - *TC-C2 Performance Standards: Provide research findings to develop and validate UAS minimum operational performance standards (MOPS) for terrestrial command and control (C2) communication.*
    - *TC-Human Systems Integration: Provide research findings to develop and validate human systems integration (HSI) ground control station (GCS) guidelines enabling implementation of the SAA and C2 performance standards.*
- *RT2 - Test Infrastructure: Test infrastructure to enable development and validation of airspace integration procedures and performance standards.*
    - *TC-Integrated Test and Evaluation (ITE): Develop a relevant test environment for use in generating research findings to develop and validate HSI Guidelines, SAA and C2 MOPS with test scenarios supporting integration of UAS into the NAS.*

2.2.1 Non-Technical Challenge Work

The UAS-NAS Project will also focus on two additional areas of technical work that are critical to the integration of UAS into the NAS, but the content is not required for minimum success of the project.

- Certification and Safety: Conduct a case study to develop safety substantiation data for a type certificate (restricted category) for a UAS platform performing a commercial precision agriculture operation.
- Small UAS (sUAS): Develop specific data relevant to partner Agencies while conducting representative sUAS missions utilizing increasing levels of autonomy and sUAS technologies.

2.3 Project Phase 1 Summary (FY11 - FY13)

The UAS Integration in the NAS Project was designed as a two-phase project, in which Phase 1 laid a foundation for the more integrated work that would be conducted in Phase 2. Figure 2 illustrates the duration of the Project, its two phases, and key aspects of those phases. In Phase 1, the efforts were focused on initial modeling, simulation, and flight testing efforts within a single research area. This also included completing an analysis to refine the UAS-NAS Project's research areas from those developed during Project Formulation by considering the Project's Phase 2 budget, schedule, and time frame for impact. This analysis leveraged UAS community needs that became more clearly defined through the release of documents like the FAA ConOps and the transition to fixed schedule product-oriented groups like RTCA SC-228 that support the UAS community in developing a national strategy for UAS-NAS integration.

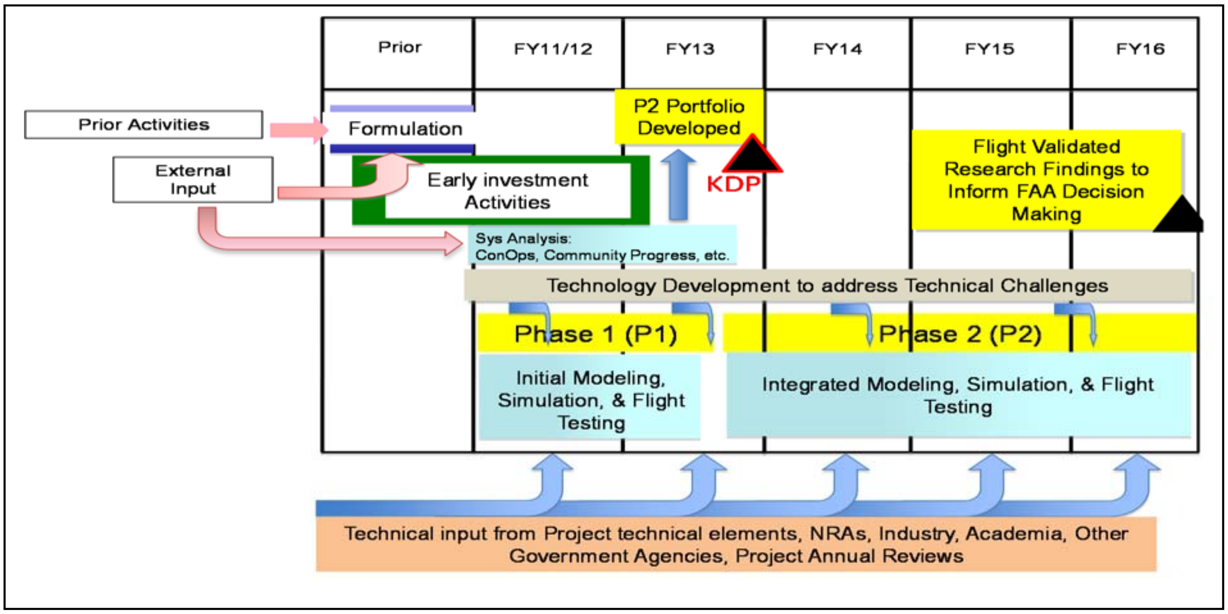


Figure 2. Project Phase 1 and Phase 2.

The UAS-NAS Project was organized by subprojects, which were closely aligned with the Phase 2 Technical Challenges.

- TC-SAA Performance Standards was aligned with the Separation Assurance/Sense and Avoid (SSI) Subproject;
- TC-C2 Performance Standards aligned with the Communications Subproject;
- TC-HSI aligned with the HSI Subproject;
- TC-ITE aligned with the Integrated Test & Evaluation Subproject;
- Non-TC work aligned with both the Certification Subproject and small UAS tasks.

This alignment accounts for the ease of leveraging Phase 1 buildup, initial technology development, and other accomplishments to address Phase 2 Technical Challenges and ease of transition to the more integrated modeling and testing activities in Phase 2.

There were many UAS-NAS Project accomplishments during Phase 1. These included updating existing, or creating new, NASA capabilities and infrastructure to accommodate the unique aspects of unmanned aircraft operations and performance for use in project research. As examples, the Ames Research Center (ARC) Airspace Concept Evaluation System (ACES) simulation was updated with unmanned aircraft performance models and mission flight profiles; at Glenn Research Center (GRC) a prototype control and non-payload communication system (CNPC) was developed with an industry partner; at ARC and Langley Research Center (LaRC) human-in-the-loop simulation capabilities were developed to allow either air traffic controller or UAS pilot-in-command research; and development was initiated and initial characterization completed of a live, virtual, and constructive test environment. Several research activities were completed and reported on in Phase 1 including Concept of Integration for SAA equipped vehicles paper; Well Clear study; UAS-specific capacity constraints report; Line-of-sight spectrum study;

CNPC Threat, Vulnerability, Security, and Mitigation reports; CNPC Gen-1 prototype radio flight-test report; Traffic display part-task simulation reports; and Virtual Type Certification Case Study.

Appendix C presents a more complete list of the Project's Phase 1 accomplishments. These Phase 1 accomplishments developed or contributed to the development of NASA UAS capable infrastructure, provided risk reduction for Phase 2 UAS research, and provided early UAS research findings to the FAA and RTCA.

2.4 Project Phase 2 (FY14 – FY16)

The duration of Phase 2 of the UAS-NAS Project is three years. The UAS-NAS Project will demonstrate solutions to address specific Technical Challenges, which will address operational or safety issues related to UAS access to the NAS. Solutions will advance the state-of-the-art for UAS access. The timeframe for impact of the UAS-NAS Project continues to be 2015 to 2025. The near term impacts are outputs from the research being transferred to Industry. The long term impacts are the development of the Phase 1 MOPS.

In Phase 2, the UAS-NAS Project will provide research findings to RTCA SC-228 to develop and validate UAS Phase 1 MOPS for SAA performance and interoperability and for terrestrial command and control. They will also provide research findings to develop and validate HSI GCS guidelines enabling implementation of the SAA and C2 performance standards. The Project will also conduct a series of integrated tests in this phase evaluating the integrated technologies as a system-of-systems in a test environment representing the NAS. To facilitate the transition of the research findings to the stakeholders, UAS-NAS continues to emphasize partnerships and collaborations.

The UAS-NAS Project will organize tasks within Technical Challenges using Technical Work Packages (TWP) which are further broken down into Schedule Packages (SP). Progress within Technical Challenges and individual Schedule Packages are managed with progress indicators and milestones.

In Phase 2, efforts within the TC work shift towards maturing research capabilities and integrating and testing them at a systems-of-systems level through various fast-time and human-in-the-loop (HITL) simulations and flight-tests.

In the following subsections, the work being performed in each of the Technical Challenge areas and Non-Technical Challenge areas will be described with an introduction, objectives, benefits to community, approach, key collaborators, success criteria, and deliverables. The table at the end of each subsection identifies the individual TWP required to meet Minimum or Full Success for the Project. Note: The Project will be viewed as successful if all Minimum Success TWPs are satisfactorily completed.

2.4.1 SAA Performance Standards Technical Challenge

Existing Code of Federal Regulations (CFR), Special Federal Aviation Regulations (SFAR), procedures, and available technologies do not allow routine UAS access to the NAS. Access to the NAS is hampered by challenges such as the lack of an on-board pilot to see and avoid other aircraft. The SSI Subproject is developing and evaluating concepts for integrating UAS with the air traffic system that accounts for characteristics typical of these new aircraft. These characteristics not only include lack of an onboard pilot but also lower performance (e.g., speed) than traditional aircraft, novel missions with extensive loitering, longer communication latencies, and different allocations of separation responsibility between humans and automation. Although some of these characteristics are not unique to UAS, the number of aircraft that possess them is expected to increase because UAS will be able to fulfill so many new roles.

The SSI Subproject will determine the required performance of candidate self-separation (SS) algorithms, SAA surveillance system requirements, and performance characteristics of and interactions between SAA sub-functions. They will also support the definition of sensor and algorithm-agnostic maneuverability requirements and evaluation of the impact of sensor uncertainties and vehicle performance limitations on the execution of SAA maneuvers.

2.4.1.1 Objectives

- Recommend a set of minimum performance standards for sense and avoid systems and their sub-functions to meet a community-defined overall target performance level.
- To substantiate the development of Phase 1 DAA MOPS, document assessment and recommendations of the:
    - Impact of UAS performance and encounter geometry on DAA requirements.
    - Impact of degraded surveillance data resulting from sensor uncertainties/performance at the SAA algorithm and concept/procedures level.

2.4.1.2 Benefits to the Community

The UAS community will benefit from project research findings that are expected to directly contribute valuable information to SC-228 Phase 1 MOPS development. Also, the community will benefit from the involvement of experienced project personnel, with experience gained from previous UAS integration projects and benefiting from the research and technology developments in the Phase 2 Project Portfolio, through their hands-on involvement with the development of the Phase 1 MOPS. In some cases, UAS-NAS Project personnel plan to be the lead for specific sections within the Phase 1 MOPS.

Specific benefits associated with the SSI Subproject relate to development of a Sense and Avoid concept. Included in the SAA concept development is integration with technologies from the C2 and HSI Subprojects. Testing of integrated systems-of-systems in a relevant environment will provide valuable research findings to SC-228 for Phase 1 MOPS development, and to the FAA for SAA policy and guidance finalization. Specific community benefits include:

- Development of a definition for “Well Clear.” One of the biggest barriers for UAS integration in the NAS is the quantification of manned “see and avoid” or “Well Clear.”
- Development of SAA system performance requirements and SAA interoperability standards.
- Estimating the level of safety of UAS operations.

2.4.1.3 Approach

The subproject plans to:

- Create new modeling and simulation capabilities in the Airspace Concept Evaluation System (ACES) and perform a series of fast-time simulations with the ACES.

- Participate in HITL simulations to obtain human performance metrics resulting from UAS pilot response to SS maneuvers recommended by SAA system.
- Participate in flight-tests to validate sensor models and requirements, trajectory prediction performance, and SS avoidance maneuver effectiveness.
- Conduct batch simulations to evaluate specific maneuver algorithms.
- Conduct HITL evaluation of SAA algorithms and pilot guidance procedures.

2.4.1.4 Key Collaborators

- FAA UAS Integration Office, General Atomics, Massachusetts Institute of Technology (MIT)/Lincoln Labs (LL), Air Force Research Lab (AFRL), Intelligent Automation Inc., RTCA SC-228, and Honeywell.

2.4.1.5 Success Criteria

The subproject will be considered successful if:

- Data are collected through analysis, modeling, simulation, and flight-test that support the recommendations for Well Clear definition, NAS-interoperability requirements, Airspace safety threshold, and interoperability between CA and SS.
- Recommendations are delivered to stakeholders.

2.4.1.6 Deliverables

The following is a list of deliverables:

- UAS performance models & scenarios.
- Fast-time SAA test-bed (ACES).
- Evaluations of definitions of Well Clear and incorporate recommendations.
- Description of the concept of operations for SAA.
- Data, results, and technical reports from analysis, studies, batch simulations, HITL simulations, and flight-tests.
- SAA requirements and recommendations for DAA Phase 1 MOPS.

2.4.1.7 Technical Work Packages

The following table contains the TWP under the SAA Performance Standards Technical Challenge. For each TWP the primary stakeholders are identified. The table also indicates whether successful completion of the TWP contributes to Project Minimum Success or Full Success criteria. A notation of both minimum and full success indicates that at least one of the schedule packages (SP) within that TWP is minimum success and one SP is full success.

TC#	Research ID	TWP Name	Stakeholders	Success Criteria
TC-SAA	S.1	SAA Sub-function Tradeoffs and Requirements	SC-228	Min/Full
	S.2	Interoperability and Impact of SAA-Equipped UAS on the NAS	SC-228	Min
	S.3	Well Clear Definition and SAA Concept of Operations	SC-228, SARP	Min/Full
	S.4	SAA Performance & MOPS Development	SC-228	Min
	S.5	Airspace Integration & SAA Interoperability	SC-228	Min
	S.6	CA-SS Coordination & Interoperability	SC-228, SARP	Min
	S.7	Sensor Modelling & SAA Uncertainty Impact Evaluation	SC-228	Min

Table 1. TC-SAA TWPs.

See Appendix A for Level 1 and Level 2 milestones by Technical Challenge.

2.4.2 C2 Performance Standards Technical Challenge

Civil UAS access to the NAS, from a communication system perspective, has been hampered by lack of allocated frequency spectrum for civil UAS CNPC, and by lack of minimum system performance standards for civil UAS communication systems, which are both required before the FAA can develop UAS communication policies and guidance. This uncertain future in the civil UAS CNPC system architecture has led to the lack of commercially available radio systems. The UAS-NAS Project will address these barriers by supporting national efforts to obtain approved CNPC frequency spectrum, and by partnering with industry to develop a prototype civil UAS CNPC system. The UAS-NAS Project will not be developing new fundamental communication system technologies. The Communications Subproject, with its industry and regulatory partners, will apply existing state-of-the-art communication system technologies (e.g., existing amplifiers, modulation techniques, data protocols, antennas, et cetera) to explore UAS CNPC system architectures that allow safe and acceptable operations of civil UAS in the NAS.

The Communications Subproject will develop and flight-test a prototype terrestrial CNPC system to develop and validate performance requirements. They will also conduct analysis and propose CNPC security recommendations for civil UAS operations and perform UAS Spectrum analysis and testing. Additionally, they will develop an NAS-wide simulation environment to perform analysis of a UAS CNPC system.

2.4.2.1 Objectives

- Develop and validate a candidate UAS CNPC system prototype which complies with proposed international/national regulations, standards, and practices.
- Perform analysis and propose CNPC security recommendations for civil UAS operations.
- Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS.
- Perform analysis to support recommendations for integration of CNPC and ATC communications to ensure safe and efficient operation of UAS in the NAS.

2.4.2.2 Benefits to the Community

The UAS community will benefit from project research findings that are expected to directly contribute valuable information to SC-228 Phase 1 MOPS development. Also, the community will benefit from the involvement of experienced project personnel, with experience gained from previous UAS integration projects and benefiting from the research and technology developments in the Phase 2 Project Portfolio, through their hands-on involvement with the development of the Phase 1 MOPS. In some cases UAS-NAS Project personnel plan to be the lead for specific sections within the Phase 1 MOPS.

Specific benefits associated with the Communications Subproject relate to development of a civil UAS prototype communication system. Included in the prototype communication system development is integration with technologies from the SSI and HSI Subprojects. Testing of integrated systems-of-systems in a relevant environment will provide valuable research findings to SC-228 for Phase 1 MOPS development and to the FAA for communication system policy and guidance finalization. Specific community benefits include:

- The secure, robust, and scalable communication system prototype CNPC system being developed by NASA is the only system in existence that operates within the L-Band and C-Band civil frequency spectrum.
- Flight testing and simulation results will be used to prevent the UAS allocated radio frequency bands from being reallocated to non-UAS applications and to support the channelization of the current spectrum allocation.

2.4.2.3 Approach

The subproject plans to:

- Develop and validate candidate UAS CNPC system prototype using RTCA SC-203 Working Group (WG)-2 proposed performance requirements in a relevant integrated test environment and mixed traffic environment.
- Provide information on UAS CNPC development on an on-going basis to maintain/finalize the technical parameters of the UAS line of sight (LOS) CNPC allocation and support ensuring standards developments.
- Develop control communication system link models for predicting performance and validate during flight-test.

- Verify the performance of a secure terrestrial CNPC System, while interfaced to SAA and HSI components and validate during flight-test.

2.4.2.4 Key Collaborators

- Collaborators: FAA, RTCA SC-228, and University of South Carolina (USC).
- Partners: Rockwell Collins

2.4.2.5 Success Criteria

The subproject will be considered successful if:

- Results from prototype radio, security mechanism development, large scale simulations, and testing are sufficient to validate proposed SC-203 performance standards, mitigate risks and vulnerabilities, and recommend necessary modifications prior to final SC-228 Phase 1 MOPS.

2.4.2.6 Deliverables

The following is a list of deliverables:

- Results from CNPC System prototype performance in relevant environment and mixed traffic environment.
- Analysis, test results, and recommendations of CNPC security architecture performance.
- Propagation environment channel models for terrestrial CNPC spectrum bands.
- NAS-wide UAS LOS CNPC system simulation results of interim (low-medium fidelity) and CNPC link (high fidelity) communications models.
- Air Traffic Control (ATC) and CNPC communications performance impact on delays/capacity of the NAS report and models.

2.4.2.7 Technical Work Packages

The following table contains the TWP under the C2 Performance Standards Technical Challenge. For each TWP the primary stakeholders are identified. The table also indicates whether successful completion of the TWP contributes to Project Minimum Success or Full Success.

TC#	Research ID	TWP Name	Stakeholders	Success Criteria
TC-C2	C.1	Datalink	SC-228	Min
	C.2	Security	SC-228, FAA	Min
	C.3	Spectrum	SC-228, ITU-R	Min
	C.4	Simulation	SC-228	Min

Table 2. TC-C2 TWPs.

See Appendix A for Level 1 and Level 2 milestones by Technical Challenge.

2.4.3 Human Systems Integration Technical Challenge

A century of aviation evolution has resulted in accepted standards and best practices in the design of human-machine interfaces: the displays and controls that serve to optimize safe and efficient flight operations and situational awareness. The current proliferation of nonstandard, aircraft-specific flight crew interfaces in UAS, coupled with the inherent limitations of operating UAS without in-situ sensory input and feedback (aural, visual, and vestibular cues), has increased the risk of mishaps associated with the design of the "cockpit." The examples of current non- or substandard design features range from inefficient to those that are difficult to manipulate or interpret, as well as burdensome and unsafe. The HSI Subproject will collect data to develop the database for and work with standards organizations, to include SC-228 and others, on recommended guidelines for ground control station (GCS). In addition to design documents, a prototype system will be developed to illustrate integrated concepts through integrated tests with SAA and C2 technologies also under development within the Project.

Human factors affect almost every aspect of UAS operations. Allocation of roles and responsibilities between the pilot and air traffic control (ATC) will be a key element of the UAS-NAS Project's research and considered a human factors issue. The human systems integration aspects of SAA and C2 Data Link management will also be part of the HSI effort. Related, but distinct, objectives supporting the human factors area of this Project will focus on the unique attributes of UAS and the GCS and pilot interface. Consideration will be given to the roles and responsibilities of air traffic controllers, pilots, and automation, including how various functions are allocated among them.

The HSI Subproject will develop human factors guidelines including displays, controls, and procedures for UAS operation in the NAS. The overall GCS guidelines will be comprehensive, but will have a specific focus on guidelines for Phase 1 DAA and C2 MOPS to support SC-228 Phase 1 MOPS development. The Subproject will also develop an instantiation of a prototype GCS for use in subproject and integrated testing events.

2.4.3.1 Objectives

- Develop a prototype GCS that will instantiate the GCS guidelines and serve as the GCS for integrated simulations and tests.

- Develop guidelines for GCS design and UAS operations in the NAS.
- Apply GCS guidelines towards Phase 1 DAA and C2 MOPS.

2.4.3.2 Benefits to the Community

The UAS community will benefit from Project research findings that are expected to directly contribute valuable information to SC-228 Phase 1 MOPS development. Also, the community will benefit from the involvement of experienced UAS-NAS Project personnel, with experience gained from previous UAS integration projects and benefiting from the research and technology developments in the Phase 2 Project Portfolio, through their hands-on involvement with the development of the Phase 1 MOPS. In some cases UAS-NAS Project personnel plan to be the lead for specific sections within the Phase 1 MOPS.

Specific benefits associated with the HSI Subproject relate to development of a civil GCS prototype and its integration with technologies from the SSI and C2 Subprojects. Testing of integrated systems-of-systems in a relevant environment will provide valuable research findings to SC-228 for Phase 1 MOPS development and to the FAA for HSI policy and guidance finalization. Specific community benefits include:

- Instantiation of Research Ground Control Station provides validation for recommendations in meeting GCS guidelines.
- Example of compliance to GCS guidelines.
- Assessment of impact of UAS specific scenarios.
- GCS guidelines for industry and DoD to develop, and FAA to certify GCS.

2.4.3.3 Approach

The subproject plans to:

- Conduct simulations, flight-tests, and community-based review to address higher priority issues as assessed by the UAS-NAS Project, FAA, Joint Planning and Development Office (JPDO), and community workshops.
- Perform Part Task Simulations to focus on Contingency Management, SAA Displays, and Measured Response; results will feed into the prototype GCS.
- Perform Full Mission Simulations to address pilot’s ability to respond quickly when operating in various levels of automation; results will feed into the prototype GCS.
- Perform information requirements analyses based on: Federal Aviation Regulations, phase of flight, and pilot functions.
    - Work with community based organizations to identify key elements and develop recommendations for guidelines.

2.4.3.4 Key Collaborators

- Collaborators: AFRL, FAA, RTCA SC-228, California State University (CSU) Long Beach (LB), and CSU Northridge (CSUN).

2.4.3.5 Success Criteria

The subproject will be considered successful if the following items are accomplished:

- Operate a GCS that conforms to developed GCS guidelines in a relevant environment demonstrating a robust system that provides self-separation, contingency management, tolerable pilot workload, high pilot situation awareness, and no adverse effects on Air Traffic Management (ATM).
- Complete and publish GCS guidelines.

2.4.3.6 Deliverables

The following is a list of deliverables:

- Research Ground Control Station.
- Multiple technical reports on findings from specific experiments.
- Human Factors (HF) Guidelines for SAA, C2, and GCS.

2.4.3.7 Technical Work Packages

The following table contains the TWP under the HSI Technical Challenge. For each TWP the primary stakeholders are identified. The table also indicates whether successful completion of the TWP contributes to Project Minimum Success or Full Success.

TC#	Research ID	TWP Name	Stakeholders	Success Criteria
TC-HSI	H.1	RGCS	SC-228, SARP	Min
	H.2	Guidelines	SC-228, FAA	Min

Table 3. TC-HSI TWPs.

See Appendix A for Level 1 and Level 2 milestones by Technical Challenge.

2.4.4 Integrated Test and Evaluation Technical Challenge

During early project formulation, it was clear that developing UAS SAA, C2, and HSI technologies would require integration of the technologies for systems-of-systems testing in a relevant airspace environment. In contrast to the SSI, Communications, and HSI Subprojects, the Integrated Test and Evaluation (IT&E) Subproject will not develop a specific technology for use in reducing technical barriers associated with UAS-NAS integration. The IT&E Subproject will integrate the developed SAA, C2, and HSI technologies and build a test and evaluation infrastructure for integrated testing in a Live, Virtual, Constructive (LVC) Distributed Environment (DE), to enable integrated testing to occur in a relevant environment. The LVC-DE will provide the capability to emulate the ATC environment, simulate constructive background traffic, and incorporate: virtual unmanned aircraft (UA) simulations, live UA, and live surrogate UA test vehicles. The IT&E

Subproject will develop, test, and explore objectives of the SSI, Communications, and HSI Subprojects technology for the development of: concepts, technologies, and capabilities, in evaluating the overall operation of UAS in the NAS in a relevant environment. The LVC-DE will support currently envisioned UAS-NAS IT&E efforts as well as provide the flexibility to support future activity and expand the LVC-DE to include nodes at other Centers, agencies, or industry facilities. The IT&E Subproject will lead the SSI, Communications, and HSI Subprojects in test planning for the integrated test events.

2.4.4.1 Objectives

- Develop a Live, Virtual, Constructive (LVC) Distributed Test Environment to integrate and test subproject technologies in a relevant environment.
- Document the design, objectives, metrics, data collection, and assets for integrated test events.
- Conduct the planning and execution of integrated test events: integrated human-in-the-loop (IHITL) simulation, SAA Initial Flight Test (FT), Flight Test Series 3 (FT3), and Flight Test Series 4 (FT4).

2.4.4.2 Benefits to the Community

The UAS community will benefit from UAS-NAS Project research findings that are expected to directly contribute valuable information to SC-228 Phase 1 MOPS development. Also, the community will benefit from the involvement of experienced UAS-NAS Project personnel and from the research and technology developments in the Phase 2 Project Portfolio.

Specific benefits associated with the IT&E Subproject relate to development and use of a live, virtual, and constructive test environment. Relevant data from integrated testing of developed technologies (SAA concept, prototype C2 communication system, prototype GCS) provides valuable research findings to SC-228 for Phase 1 MOPS development and to the FAA for HSI policy and guidance finalization. Specific community benefits include:

- Access to simulation and flight assets for distributed simulations.
- Risk reduction of flight-test risk with validation and integration of flights into the Test and Evaluation system. Validation of SAA and HSI concepts and GCS display technologies. Validation of Communication data bandwidth estimates and testing of Communication candidate technology under live flight conditions.
- Demonstration of SAA and HSI concepts and C2 equipment in a live environment. Collection of data to validate Phase 1 MOPS.
- Support FAA collision avoidance development.

2.4.4.3 Approach

The subproject plans to:

- Conduct systematic reviews of integrated test events and associated test planning to ensure readiness and functional, physical, and operational performance requirements meet the UAS-NAS Project objectives.

- Develop test infrastructure.
- Define and test airspace and scenario files with researchers.
- Execute and report on integrated test events.

2.4.4.4 Key Collaborators

- Collaborators: UAS-NAS Subprojects and FAA Tech Center.
- Partners: General Atomics and Honeywell.

2.4.4.5 Success Criteria

The subproject will be considered successful if the following items are accomplished:

- Define, develop, and characterize the performance of the LVC test environment instance instantiated for the IHITL, FT3, and FT4, which includes Capstone.
- Record, archive, and distribute the research data collected during the IHITL simulation, SAA Initial Flight Test (FT), FT3, and FT4.
- Perform: IHITL simulation, SAA Initial FT, FT3, and FT4, which includes Capstone.

2.4.4.6 Deliverables

The following is a list of deliverables:

- Integrated design documents including: System Requirements, Interface Control Documents, Software Design Documents, Subsystem Verification & Validation Plans, Test Plans, and system characterization for each integrated event.
- Airspace and scenario definitions, flight plans and initial conditions for each integrated event.
- Final Test Reports for each integrated test.

2.4.4.7 Technical Work Packages

The following table contains the TWP under the IT&E Technical Challenge. For each TWP the primary stakeholders are identified. The table also indicates whether successful completion of the TWP contributes to Project Minimum Success or Full Success. A notation of both minimum and full success indicates that at least one of the schedule packages (SP) within that TWP is minimum success and one SP is full success.

TC#	Research ID	TWP Name	Stakeholders	Success Criteria
TC-ITE	T.1	LVC Distributed Test Environment	SC-228	Min/Full
	T.2	Integrated Human- in-the-Loop (IHITL)	SC-228	Min/Full
	T.3	SAA Initial Flight Test Series	SC-228	Min
	T.4	Flight Test Series 3 (FT3)	SC-228	Min
	T.5	Flight Test Series 4 (FT4)	SC-228	Min/Full

Table 4. TC-ITE TWPs.

See Appendix A for Level 1 and Level 2 milestones by Technical Challenge.

2.4.5 Non-Technical Challenge Work

Non-Technical Challenge work contains far-reaching activities that may have higher technical risk. The Non-Technical Challenge work will be managed slightly differently from the Technical Challenge work. The UAS-NAS Project will use off-ramps and on-ramps in conjunction with the UAS-NAS Project's descope strategy. Off-ramps are defined as milestones/events or reports that would allow the UAS-NAS Project to make a technical content decision after the milestone/event concludes or report is delivered. Those milestones/events or reports are break points where a product of value to the UAS Community is produced. An on-ramp is defined as a decision point to move forward with Non-Technical Challenge work dependent upon funds being available for the following Fiscal Year.

2.4.5.1 Certification and Safety

Title 14 Code of Federal Regulation (14CFR) specifies certification requirements specific to aircraft, to airborne and ground-based systems and equipment, to operations within different airspace classes, and to pilots and other personnel involved in operating or managing any aircraft. As per the FAA's roadmap for UAS integration in the NAS, regulatory standards need to be developed to enable current technology for unmanned aircraft to comply with 14CFR, including regulations for aircraft airworthiness. Most civil aircraft, including their constituent systems and equipment, require compliance with airworthiness standards as one of the conditions necessary to operate in the NAS. According to 14CFR, an aircraft must conform to its type design and be in a condition for safe operation to be considered airworthy. Different types of aircraft have different airworthiness standards covering aspects including flight, structures, design and construction, engines, and avionics. Except for some special cases, such as small UAS (sUAS) with limited weight and operational range, UAS will require design and airworthiness certification to fly civil operations in the NAS. Although the FAA has not established certification standards or other regulatory requirements necessary for that, the FAA has identified a specific requirement (as per their concept level requirements document) to collaborate with industry to develop or adapt airworthiness requirements specific to UAS on which to base type certification.

The extremely diverse range of UAS types and operations makes it very challenging to apply existing regulations and standards to UAS in a way that properly addresses safety. In particular, the weight and configuration based classification scheme used for Part 23, 25, 27, and 29 aircraft complicates the direct application of existing airworthiness requirements to UAS. Research planned in Certification and Safety is directed toward determining the extent to which existing airworthiness standards apply to UAS. The Phase 1 effort evaluated the current airworthiness classification system and determined that the 14CFR aircraft classes and categories may not be appropriate as is for many UAS designs. Phase 2 follows that work by conducting a case study to develop the type certification basis for a specific unmanned aircraft. The case study will include development of a detailed concept of operations for a UAS conducting a precision agriculture application, definition of functional and performance requirements for a UAS that can perform that application, selection of a UAS that could meet those requirements, and development of a type certification basis for the selected UAS. The type certification basis will then be used in two ways: first to evaluate alternate means of documenting safety substantiation data for a UAS, and second to evaluate the applicability of the type certification basis to other UAS and for other special purpose applications.

2.4.5.1.1 Objectives

- Conduct case study and analysis to develop safety substantiation data for a type certificate (restricted category) for a UAS platform performing a commercial precision agriculture operation.
- Evaluate an alternative approach for developing safety substantiation data for a UAS.

2.4.5.1.2 Benefits to the Community

The UAS community will benefit from UAS-NAS Project research findings and from the involvement of experienced UAS-NAS Project personnel and from the research and technology developments in the Phase 2 Project Portfolio. Specific community benefits include:

- Helps enable commercial operations within Continental United States (CONUS) for UAS with no prior military approvals.
- Helps enable an emerging industry.
- Helps define the standards/procedures/processes for UAS airworthiness certification necessary for routine operations.
- Provides example of airworthiness certification expectations and acceptable design and performance criteria.

2.4.5.1.3 Approach

The subproject plans to:

- Determine airworthiness requirements for a UAS doing a precision agriculture application.
- Define the concepts of operations for an unmanned precision agriculture application.
- Develop type design requirements and operational limitations for that UAS.
- Analyze safety data to discern generalized applicability to other UAS.
- Capture safety substantiation data using two different approaches to study suitability.

2.4.5.1.4 Key Collaborators & Formal Partners

- University of North Dakota, Dragonfly Pictures

2.4.5.1.5 Success Criteria

The subproject will be considered successful if the following is accomplished:

- Deliver recommendations for UAS design and performance criteria that would satisfy airworthiness requirements for a UAS platform, doing precision agriculture in a defined context.
- Recommend an approach to safety substantiation for UAS.

2.4.5.1.6 Deliverables

- Initial Report on UAS design and performance criteria.
- Safety Substantiation report.
- Final report on applicability of other UAS and other operations.

2.4.5.2 Small UAS Activity

Although the FAA has developed rules for sUAS operations, there is still research to be done to enhance the use of sUAS in the NAS. Research associated with small UAS (sUAS) includes the development of ConOps, processes, procedures, air vehicles, and sensors to conduct operations and research for the purpose of developing research findings that will contribute towards the integration of sUAS into the NAS in a safe and effective manner. The sUAS team will conduct research activities as on-ramps during Phase 2. The first such activity is described herein.

The United States Fish and Wildlife Service (USFWS) Great Dismal Swamp (GDS) is charged with protecting and preserving the wildlife resources found in the GDS. This includes surveillance of the wildlife refuge in search of nascent fires, support to firefighting personnel engaged in fighting fires, and other activities as appropriate. The UAS-NAS Project expects to collaborate with the USFWS using their mission as a test case for project-developed sUAS technologies.

2.4.5.2.1 Objectives

- Conduct experiments to develop the appropriate data and information related to NAS integration using mission scenarios relevant to the USFWS GDS.
- Characterize optimal use case of sUAS for fire detection mission and demonstrate benefits of increasing automation on a specific mission.

2.4.5.2.2 Benefits to the Community

The UAS community will benefit from UAS-NAS Project research findings and from the involvement of experienced UAS-NAS Project personnel and from the research and technology developments in the Phase 2 Project Portfolio. Specific community benefits include:

- Develop sensor data requirements for sUAS fire detection.
- Evaluation of autonomy-related technologies and procedures allowing new types of UAS missions and applications.

2.4.5.2.3 Approach

The team plans to:

- Design an aircraft specifically for a USFWS GDS fire detection mission.
- Choose key technologies to incorporate into the aircraft that will maximize the efficiency of the mission.
- Build and fly the aircraft to characterize key sUAS and mission parameters.
- Perform technology assessments to increase efficiency of a mission.
- Develop concept of operations, processes, and procedures for safe operation of sUAS in similar scenarios.
- Issue a Request for Information (RFI) to solicit information on sUAS autonomy technology applications and benefits.

2.4.5.2.4 Key Collaborators and Formal Partners

- US Fish and Wildlife Service Great Dismal Swamp.

2.4.5.2.5 Success Criteria

The team will be considered successful if they:

- Develop sensor data requirements for USFWS specific to sUAS GDS fire detection mission.

2.4.5.2.6 Deliverables

- Sensor Requirements Report.
- Autonomy Technology Assessment Report.

2.4.5.3 Non-Technical Work Packages

The following table contains the TWP for the Non-Technical Challenge. For each TWP the primary stakeholders are identified. The table also indicates whether successful completion of the TWP contributes to Project Minimum Success or Full Success.

ID	Research ID	TWP Name	Stakeholders	Success Criteria
Non-TC	N.1	Certification	FAA	Full
	N.2	sUAS Support to Initial Rulemaking	ASTM, ARMD	Full

Table 5. Non-TC TWPs.

See Appendix A for Level 2 milestones by Non-Technical Challenge.

3 Performance

ARMD, IASP, and the UAS-NAS Project measure project performance in multiple ways: completion of Annual Performance Indicators (API) / Annual Performance Goals (APG); completion of Technical Challenges (TC); and completion of project Milestones. Each is described below.

3.1 Annual Performance Indicators/Annual Performance Goals

NASA is a performance-based organization committed to managing towards specific, measurable goals derived from a defined mission, using performance data to continually improve operations. NASA uses APIs/APGs to manage performance. The UAS-NAS Project API/APG is included in NASA's Annual Performance Report and Annual Performance Plan which are companions to NASA's Congressional Justification. Each API/APG is comprised of an indicator or goal statement and green, yellow, and red criteria for measuring accomplishment of the indicator/goal. The UAS-NAS Project's FY12, FY13, FY14 APGs, and the Project's FY15 and FY16 APIs are presented in Appendix D.

3.2 Technical Challenge Progress

Measuring Project performance against Project TCs is a project management methodology within ARMD for technology focused projects. ARMD emphasizes outcomes, which are regarded as the measures of the project that document progress with the stakeholder community over time, and outputs, which are regarded as results from activities that tend to focus on the individual research activity at the time of completion. Both outcomes and outputs contribute to UAS-NAS Project success and satisfying stakeholder needs. Project TC Progress Indicators (PI) were developed to measure the UAS-NAS Project's outputs and outcomes and overall progress towards the completion of Technical Challenges. In this way, they assist the Project and Program in the monitoring and control of the TCs.

For most NASA technology development projects, use of the NASA Technology Readiness Level (TRL) scale, a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technologies, is used as a basis for their TC PIs. The UAS-NAS Project goal is not directly to mature a technology, however. Rather the project goal is to "Provide research findings to reduce technical barriers associated with integrating UAS into the NAS utilizing integrated system level tests in a relevant environment." While technologies will be developed and used for UAS-NAS Project research, the UAS-NAS Project's success is based on contributing to RTCA SC-228 Phase 1 MOPS (outcome) by providing research findings from research activities (output), so applying the NASA TRL scale as a TC PI is not an appropriate measure of UAS-NAS Project success.

The Progress Indicator developed by the UAS-NAS Project measures project contributions and outcomes of SC-228 and other stakeholders as well as measuring key elements of individual project research activities. Figure 3 is an illustrative example of the project-developed TC PIs. The actual UAS-NAS Project's PIs for each TC are included in Appendix B. Referring to Figure 3, the TC PI chart has an upper and lower section. The upper section presents information on technology transfer to stakeholders and the outcomes that those technology transfers will help create. The lower section of the PI chart documents the project research activities and a representative measure of the maturity of the project's research as measured by individual research activities (outputs).

Referencing the lower section of the TC PI chart in Figure 3:

- Key project outputs were identified as L1/L2 milestones (reference section 6 of this Project Plan for additional discussion of milestones). L1/L2 milestones used on the PI generally represent initiation of individual research activities or individual LVC-DE infrastructure development activities.
- The contribution of a selected L1/L2 milestone to TC maturity was estimated by weighting the L1/L2 milestones based on their individual contribution towards achieving the overall TC (High = 2, Moderate = 1, Low = 0). Major integrated test events receive a weighting of high, testing activities including multiple subproject technologies receive a weighting of moderate, and foundational activities receive a weighting of low.
- The TC maturity was then normalized to a ten point maturity scale -- the more milestones included in the TC the smaller amount of progress per milestone of the same weight.
- A TC maturity value of ten corresponds to the completion of all Technology Transfer activities necessary to inform the development of the RTCA SC-228 Phase 1 deliverables, i.e., DAA and C2 whitepapers, preliminary MOPS, and final MOPS, which are shown on the RTCA line in the upper portion of Figure 3 (and are described below).

Referencing the upper section of the TC PI chart in Figure 3:

- The research findings generated from the activities identified in the lower portion of the TC PI chart have gray lines to the upper section of the chart that represent the Technology Transfer to UAS-NAS Project stakeholders. Each technology transfer milestone (also a L2 milestone) is completed when the research findings are provided to UAS-NAS Project stakeholders (briefing, paper, report). In some cases individual research findings are transferred to several key UAS-NAS Project stakeholders as indicated by the label above the milestone. The default, and therefore not labelled, is technology transfer to SC-228; the project primary stakeholder and recipient of research findings.
- The completed Technology Transfer items inform the development of the RTCA SC-228 Phase 1 MOPS deliverables, i.e., DAA and C2 whitepapers, preliminary MOPS, and final MOPS, which are shown on the RTCA line in the upper plot. The SC-228 Phase 1 MOPS deliverables in turn have the potential to influence the UAS-NAS Project's activities as shown by the downward directed arrow from the upper portion of the chart to the lower portion of the chart.

The TC PI chart is used by the UAS-NAS Project to track technical progress towards achieving the TC. Referencing the legend on the right in Figure 3:

- Status of milestones in-work is represented by green, yellow, or red coloring of the milestone symbol.
- Upon completion of a milestone identified on the TC PI chart, the milestone is filled in with the color black.
- Once the milestone representing maturity is completed (black) and the data analysis begins the corresponding milestone on the Technology Transfer line begins showing status (green, yellow, red).
- When the Technology Transfer (briefing, paper, report) has been provided to the stakeholder, the associated milestone in the Technology Transfer portion of the upper section of the TC PI chart is filled in with the color black indicating its completion.

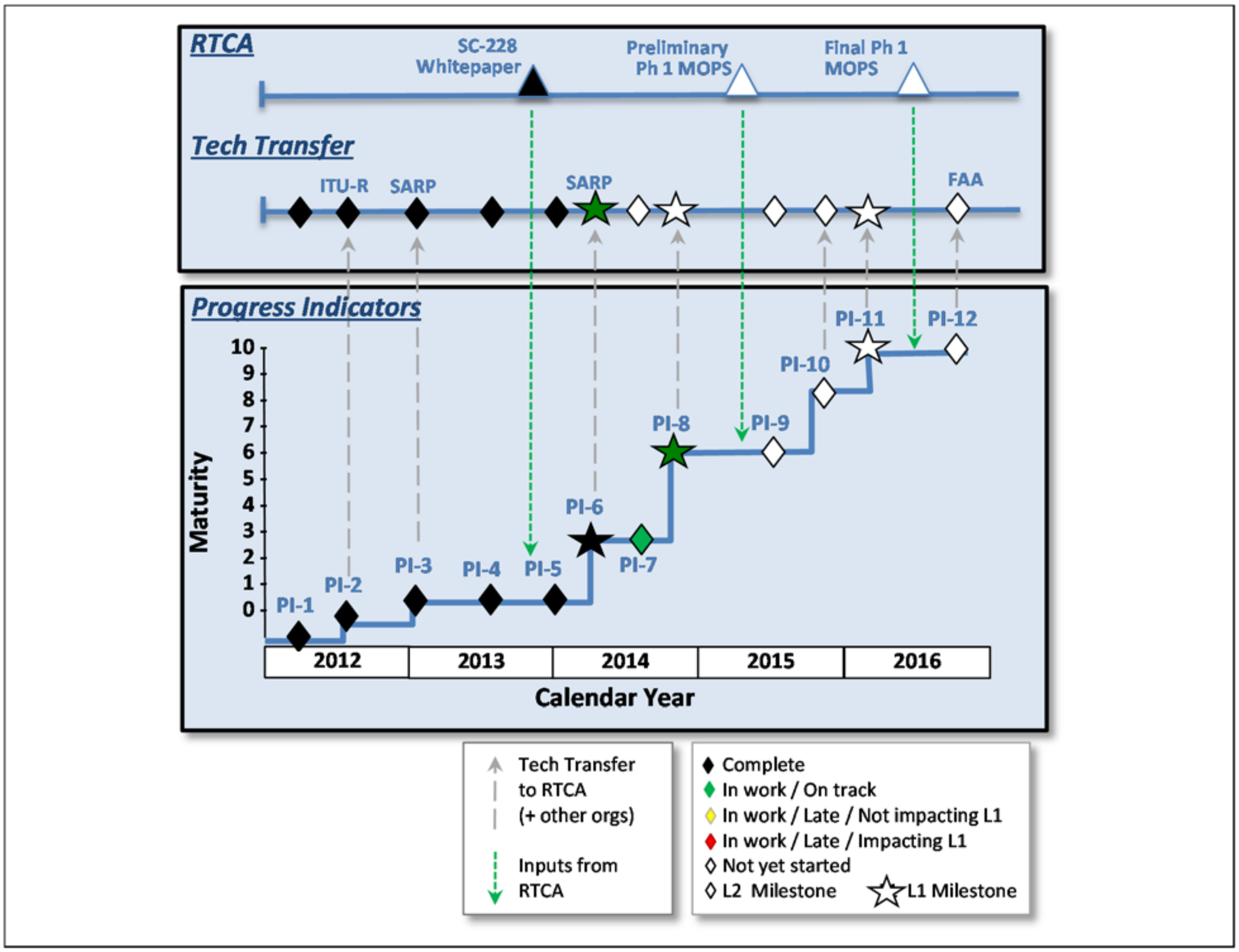


Figure 3. Example progress indicator.

3.3 Milestones

Milestones are used by IASP and the UAS-NAS Project to measure the completion of UAS-NAS Project scheduled activities. Project milestones include delivery of significant technical results (e.g., briefing, conference papers, and reports), initiation or conclusion of research activities, or transfer of significant information or equipment between subprojects. Milestones are also depicted on the progress indicators as shown in figure 3. Milestones are discussed and presented in Section 6 of this Project Plan. A full list project milestones by TC are provided in Appendix A.

4 Management Approach

4.1 Project Authority

The UAS-NAS Project Manager (PM) is accountable to the IASP Director and the Host Center Director. The IAS Program Director (PD) oversees program portfolio formulation, implementation, execution, evaluation, and integration of results with other ARMD/NASA programs. The PD bears the responsibility for developing and maintaining the overall program strategy and authority in support of ARMD Strategic Implementation Plan (SIP); maintaining the relevance of the Program and Project to stakeholder needs; establishing top-level program goals/objectives, Level 1 Milestones/Deliverables, APIs, and TCs collaboratively with Centers and projects; establishing program structure and assigning projects to Centers; conducting regular ongoing communication with projects and Centers to monitor progress of projects and resolve issues/disputes; and tracking strategic progress toward Outcomes.

As the Host Center for the UAS Integration in the NAS Project, Armstrong Flight Research Center (AFRC) provides the project management team and support staff, which will be responsible for the overall technical and managerial support of the UAS-NAS Project. Ames Research Center (ARC), Glenn Research Center (GRC), and Langley Research Center (LaRC) participate as partner Centers. The Centers are responsible for staffing the subprojects at their Centers. Both AFRC and the partner centers will provide the UAS-NAS Project with needed facilities, resources and technical authority support at their Center. Each of the NASA Aeronautics Center Directors assigns an Aeronautics Research Director (ARD) to represent their Center with ARMD, participate in ARMD leadership team to develop strategic directions, and oversee the execution of the ARMD project activities at their Centers. Additional ARD responsibilities include: collaborating and integrating across Centers; ensuring that projects deliver on commitments to programs; and mitigating risks for projects.

4.1.1 Project Organization

The Project Organization is presented in Figure 4, which shows the different roles within the UAS-NAS Project.

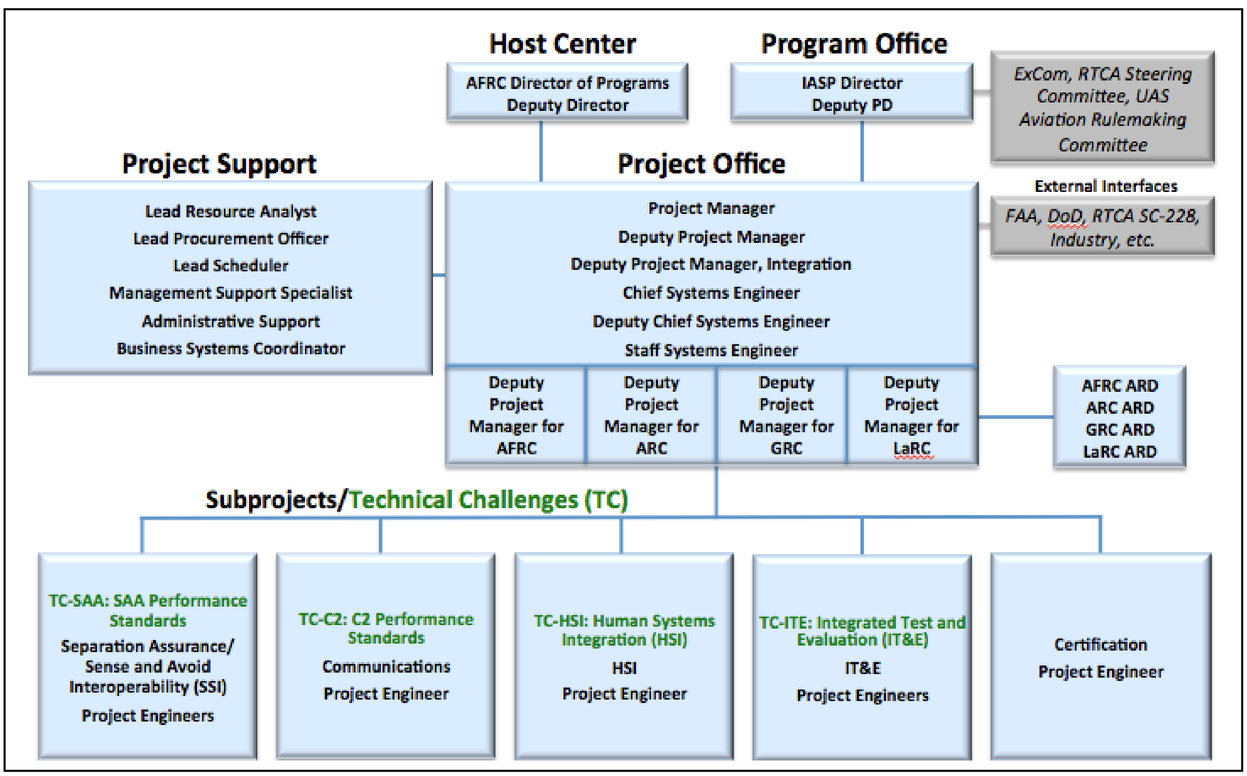


Figure 4. Project management organizational structure.

The project office team at AFRC is comprised of a Project Manager (PM), a Deputy Project Manager (DPM), Deputy Project Manager, Integration (DPMI), Chief Systems Engineer (CSE), Deputy Chief Systems Engineer, and a Staff Systems Engineer.

The Project Manager bears the ultimate responsibility and authority to ensure that the project is executed on schedule, within budget, and meets project objectives. To ensure success in this responsibility, the Project Manager, Deputy Project Manager, and Deputy Project Manager, Integration work together to execute the project management responsibilities for the UAS-NAS Project. Project management responsibilities include: planning, execution, and reporting for the Project to the Host Center ARD and IASP Director; based on program goals, objectives and resources; overall strategic management of the Project to identify, propose, and formulate Technical Challenges and subprojects for approval by the Program; reporting progress toward integrated Technical Challenges; overall management of subprojects, Non-Technical Challenge efforts, and integration of project planning and control (PP&C) functions; and leading interactions with partners and stakeholders within the scope of the UAS-NAS Project.

Of the project management responsibilities listed above, the Deputy Project Manager has the following specific duties: serve as the primary backup for the Project Manager should the need arise, develop the Project Plan with the team, and manage the resource, risk, and NASA Research Announcement (NRA) management PP&C functions.

Of the project management activities listed above, the Deputy Project Manager, Integration has the following specific duties: serve as backup to the Deputy Project Manager and Project Manager should the need arise, manage the project schedule PP&C function including the development of progress indicators, management of the UAS-NAS Project's Non-Technical Challenge efforts and lead interactions with project stakeholders and industry partners.

The Chief Systems Engineer is responsible for the UAS-NAS Project technical focus and has primary responsibility for the technical performance of the UAS-NAS Project. To ensure success in this responsibility, the Chief Systems Engineer, Deputy Chief Systems Engineer, and Staff Systems Engineer work together to execute the technical management responsibilities for the UAS-NAS Project. Technical management responsibilities include: management of the Project Engineers/Technical Leads; coordinate the appropriate technical solution for customers and stakeholders; maintain continuous communications with the PM and appropriate UAS stakeholders to ensure timely access to technical information, impending decisions, and analysis or verification results by the Project Engineers/Technical Leads; serve as the Project Technical Authority; manage the technology transfer process; coordinate with DPMI to ensure delivery of products per agreements; and develop and maintain a Systems Engineering Management Plan (SEMP).

4.1.2 Project Management Support Team

The project management support functions will include a Lead Resource Analyst, Lead Scheduler, Management Support Specialist, Administrative Support, and Business Systems Coordinator. These positions are full-time positions and include inter-Center as well as inter-Agency responsibilities.

The Lead Resource Analyst is responsible for coordinating with the IASP resource analyst and the partner Center resource analyst assigned to the Project, who are responsible for developing project phasing plans and tracking project budget information for their respective Centers. The Lead Resource Analyst has the following additional duties: holds regular resource management meetings with the resource analysts at the partner Centers to coordinate budgets and resources;

provides budgetary metrics for the Project Management Review Board (MRB); develops overall project phasing plans; tracks budget information for the entire project; and analyzes and interprets operating results and long-range budgetary requirements to ensure conformance with legal and regulatory policies.

The Lead Scheduler is responsible for the UAS-NAS Project schedules and providing data to the project leadership. The Lead Scheduler has the following additional duties: provide schedule updates including current task status and modifications for additional tasks; maintain Progress Indicators; generate schedule tracking metrics for the MRB; and generate a two-month look ahead for milestones/deliverables for the weekly project telecon.

The Management Support Specialist is responsible for management support functions. These include: Project's Risk Management administration and process; travel management coordination with lead Resource Analyst; and Project Outreach coordination, support, planning, and execution including close coordination with the Host Center Strategic Communications and Education offices.

The Business Systems Coordinator is responsible for business support functions, which primarily include serving as the UAS-NAS Project's Export Control Representative, Change Management Administrator, Records Manager, and Knowledge Now Administrator.

The Administrative Support Specialist provides support to the Project through a myriad of administrative duties including meeting scheduling/setup, recording minutes, action tracking, and maintaining the UAS-NAS Project look-ahead and other calendars.

4.1.3 Internal Project Team

The internal project team is composed of the Deputy Project Managers for (DPMf) each Center and Project Engineers (PE) (for TC subprojects). The interface and reporting structure for the PEs and DPMfs to the Project Office and ARDs is shown in Figure 4.

For each Center, there is a Deputy Project Manager for (DPMf) who is responsible for task/work plans and ensuring project level milestones are delivered on time and within budget. The DPMf also has a resource analyst to support them and coordinate with the Project Lead Resource Analyst. The DPMf will maintain awareness of their PE/TL's technical activities. In Phase 2 of the Project, the roles and responsibilities of the DPMfs were expanded from those in Phase 1. As such, the DPMfs gained more subproject management responsibilities, which also served to off-load the Project Engineers and allow them to focus more on the technical management of the subproject activities. DPMf responsibilities include: managing the Subproject/Technical Challenge area at their Center as an extension of the Project Office; developing subproject implementation plans; coordinating deliverables at their Center within the constraints of their Center document review/release process and ensure a copy resides in the Project Records Management database; serve as a liaison between Project and Center as illustrated in Figure 4; serve as the Small Business Innovative Research (SBIR) point of contact for the UAS-NAS Project related SBIRs at their respective centers; and managing the subproject risks, schedule, budget, and conflicts at their Center.

The UAS-NAS Project has identified five subprojects to address technical challenge and other work within the project. The five subprojects are: Separation Assurance/Sense and Avoid Interoperability (SSI) subproject working TC-SAA Performance Standards; Communications subproject working TC-C2 Performance Standards; Human Systems Integration (HSI) subproject working TC-HSI; Integrated Test and Evaluation (IT&E) subproject working TC-ITE; and Certification subproject working a Non-Technical Challenge activity.

The Project Engineers (PE) are the leads or co-leads of their respective subprojects. The PEs take guidance and direction from the Chief Systems Engineer and DPMfs and are responsible for: the technical content of their subprojects, subproject deliverables, and maintaining schedule. Other PE responsibilities include: providing regular status of their work through the UAS-NAS Project weekly telecon; execution of their technical activities including data analysis and reporting; and working with their respective DPMf to develop risks and mitigations and to ensure compliance with schedule and budget.

Technical Leads (TL) are the leads for non-subproject work and bear the same responsibilities as the PEs listed above with respect to their technical work packages and schedule packages.

4.1.4 Technical Authority

The technical authority process is established in NASA Procedural Document (NPD) 7120.5/7120.8. The technical authority process is another means by which NASA maintains the technical integrity of its research and technology (R&T) programs and projects including technology development projects. The technical authority process provides for the selection of individuals at different levels of responsibility, who maintain independent authority to ensure that proper technical standards are utilized in the performance of any R&T program or project tasks at the Center. The term technical authority (TA) is used to refer to such an individual. The Armstrong Research Engineering Director, who bears the technical authority responsibility for the Host Center, appointed the Project CSE to serve as the TA for the UAS-NAS Project. Any TA decisions or actions needing to be elevated above the Project TA will be brought to the attention of the Host Center TA, i.e. the AFRC Research Engineering Director.

4.2 Control Plan

In addition to the development of a new technical portfolio, the UAS-NAS Project has established a corresponding budget and schedule for that portfolio, identified stakeholders relying on the deliverables and research findings from the portfolio's technology development activities, developed new management and control processes to govern the execution of the technical portfolio. All of these efforts have put additional rigor into the UAS-NAS Phase 2 Project management to ensure successful execution, i.e., meeting project objectives and completing the project on schedule and within budget.

The management of the Project is accomplished following traditional project management practices, including tracking planned accomplishments, milestones, and deliverables and their associated costs. Project success is measured by the degree to which all stated deliverables for each task are completed within the planned UAS-NAS Project schedule and budget.

The following sections outline the mechanisms in place to manage and control the UAS-NAS Project.

4.2.1 Decisional Forums

The UAS-NAS Project plan is the controlling document for project content and management. The Project Plan is submitted by the PM for approval by the Host Center Director and the IASP Director with concurrence from the partner Center Directors. The Program utilizes decisional forums, i.e., Change Management Board, Risk Management Board, and Schedule Management Working Group, to assist in the management of the Project (see Figure 5). The project leadership participates in the Program-level forums and presents results from the project decisional forums for review and approval by the appropriate IASP board. Results from project decisional forums that would be elevated to the Program for approval include changes to project plan and Technical Challenges; L1/L2 milestones; and top risks.

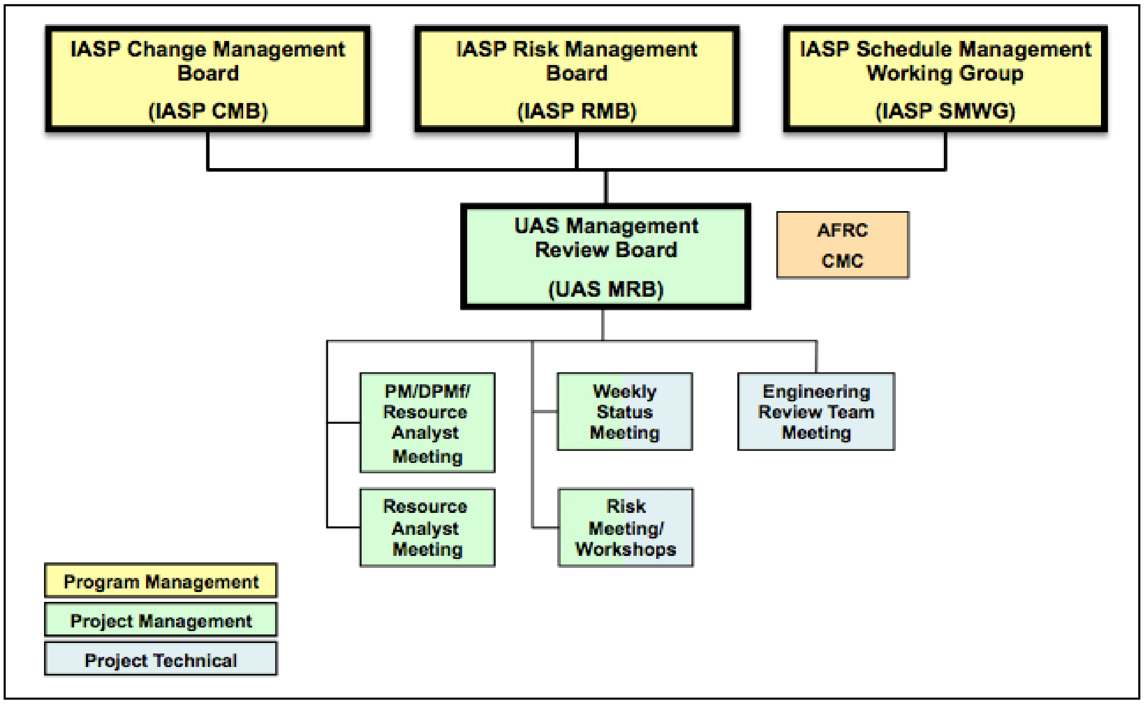


Figure 5. Program/Project decisional forums.

4.2.1.1 Center Management Council

The Host Center Director (or designee) shall oversee the UAS-NAS Project through the Center Management Council (CMC), which monitors and evaluates all project work executed at the Center. The UAS-NAS Project will brief the Host Center's Center Management Council (CMC) bi-monthly on the progress of the project during the previous two months, specifically in the areas of technical accomplishments, status against schedule, spending, performance against metrics, and a summary of project risk assessments. DPMfs brief the Partner Center Management Councils per each Center's schedule. The DPMfs provide the Partner CMC feedback back to the project. In this way the respective Centers gain insight into the project status, risks, issues, and concerns and provide feedback and/or assign actions back to the project.

4.2.1.2 Management Review Board

The UAS-NAS Project will hold a Management Review Board (MRB) to maintain oversight of the project as identified in Figure 5. The MRB is held monthly to review risk, integrated master schedule (IMS) status, milestones, cost/technical performance, and change/data management. The UAS-NAS Project Manager maintains all authority over the MRB. The Project Manager has the authority to formally delegate decision authority to the Deputy Project Manager or other appropriate personnel. All board members are required to attend the MRB. Board members can designate an alternate representative, but delegates will be expected to authoritatively speak and make recommendations to the chair on behalf of the board member. The MRB is chaired by the Project Manager and consists of the following members: Project Manager, Chief Systems Engineer, Project Engineers, Deputy Project Managers for Host and Partner Centers, Lead Resource Analyst, Risk Manager, Risk Administrator, and Business Systems Coordinator.

4.2.1.3 Change Management Process

The UAS-NAS Project will maintain change management of the project baseline though a Change Management Process, which is documented in the UAS-NAS Project Change Management Plan (Doc#: UAS-PRO-1.1-003). The Change Management Process is conducted during the MRB meetings. The project elements under change management are defined as follows:

- L1 and L2 Milestones
- Technical Challenges
- Project Goal and Objectives
- Technical Baseline
- Project Requirements
- Project Budget and Resource Allocations
- Management Plans.

4.2.1.4 Resource Management Process

The UAS-NAS Project Plan establishes the scope of the project (e.g., project goal, project objectives, subproject objectives, project total budget). Manpower and Center estimates are constitute the project resource allocation baseline. This baseline contains the following:

- TWP budget estimates by TWP objective and fiscal year (FY);
- TWP manpower estimates by TWP objective and FY;
- NASA Center budget and manpower estimates by FY;
- Project reserves by FY.

Reserves are held at the Project office and distributed to the subprojects as needed. The basis of estimate for reserves is based on subproject risks, the test activities being performed in a fiscal year, and the level of risk associated with those activities. Reserves are freed up once a risk is reduced to an acceptable level or at the conclusion of a reserve-allocated test activity. The Project on-ramp strategy is used for the identification and selection of activities for which freed-up reserves could be applied.

The UAS-NAS Project utilizes several products and tools to execute resource management. Products include: resource roll-up plan by Center and a comparison against the N2, phasing plans, full time equivalent (FTE) reports, and planned travel at all Centers. These products are used in conjunction with standard tools, e.g., Project Management Tool (PMT), Business Warehouse (BW), and Systems Application Products (SAP) to generate phasing plans and monitor status. Figure 6 shows the different products and tools used by the UAS-NAS Project and benefits derived from those tools. For example, Project phasing plans are developed using PMT, which displays the resource plans versus actuals and the resulting variance percentage by Center and subproject. This data is used for quarterly metrics and is presented at CMCs and the Project MRB.

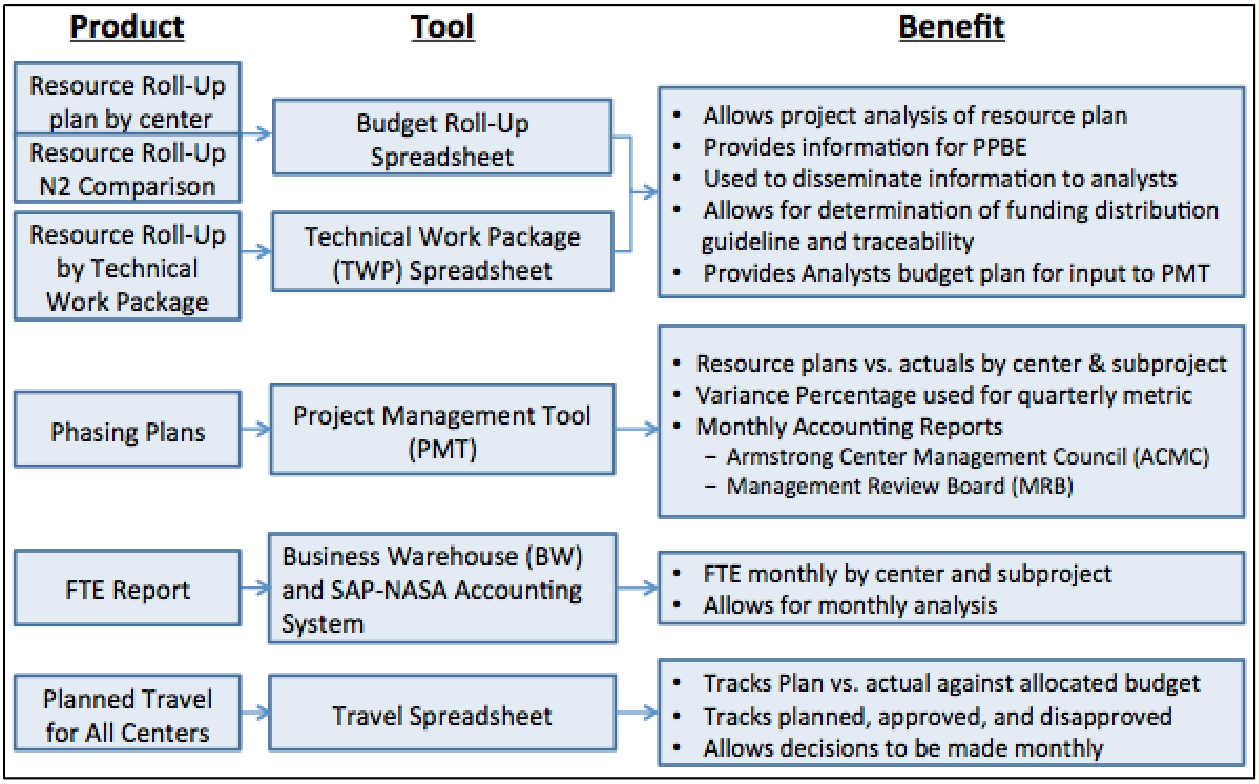


Figure 6. Resource management process.

The Lead Resource Analyst and the Center Analysts use the information generated from the tools identified in Figure 6 to monitor the UAS-NAS Project's budgetary progress. The information is also used to inform: the Centers on a monthly basis, IASP through quarterly reports, and ARMD on an annual basis.

4.2.1.5 Engineering Review Team

Engineering Review Team (ERT) meetings are held as required and serve as the forum where technical decisions that impact multiple subprojects are made. Figure 7 shows how technical topics/issues are identified and resolved through the decision-making flow. Technical topics or issues can be identified by the subproject PEs, IT&E planning review processes and test plan working groups, other project activities, or stakeholder activities. Once identified, these issues should first be addressed for resolution and documented at the lowest levels. Those issues requiring further resolution will be elevated to the Project Chief Systems Engineer (CSE). The CSE will determine whether a technical topic/issue requires an Engineering Review Team (ERT) meeting. The CSE communicates decisions not requiring an ERT to the project team during the UAS weekly telecon and to the Host Center Research Engineering Director, as the governing technical authority, as appropriate.

If an ERT is required, the CSE defines the objective of the ERT and schedules the meeting. The ERT is chaired by the CSE and has the PEs as members. All members or an appropriate designee must be in attendance for the ERT. Designees must have the authority and knowledge to speak on behalf of the PE and properly inform the ERT. During the ERT, team members consider impacts, pro/cons, alternatives, and technical approaches. Through these, a technical decision path is developed. At the conclusion of the ERT, all members provide their recommendation and the CSE makes the final decision. If the technical issue affects the UAS-NAS Project Baseline, it will be brought to the MRB for final approval per the change management and MRB processes previously defined.

Technical decision making process is documented in detail in the Systems Engineering Management Plan (SEMP) (Doc#: UAS-PRO-1.1-007).

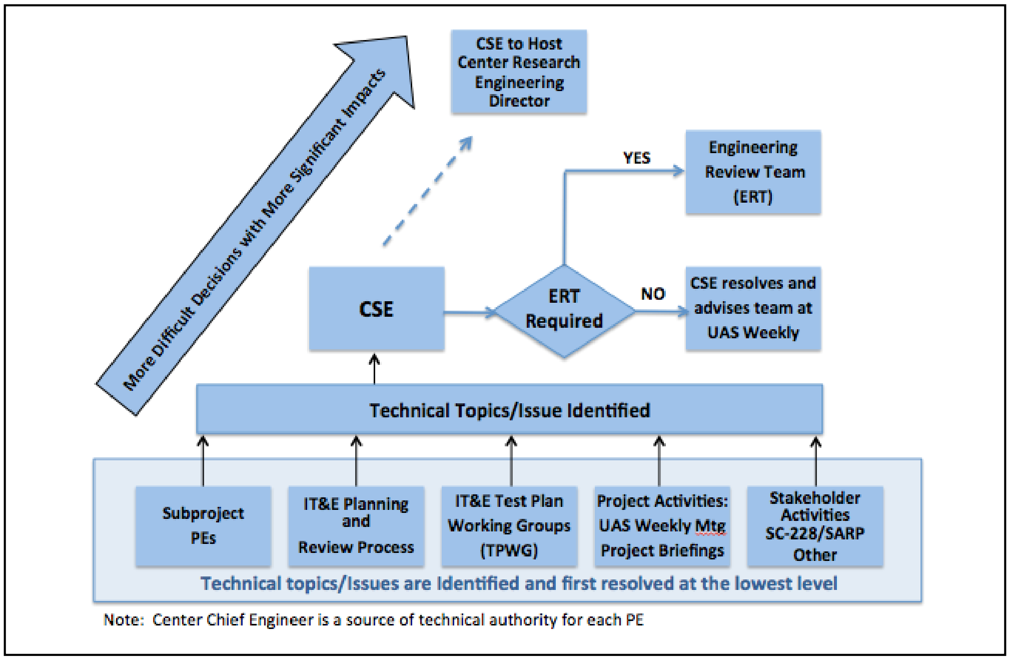


Figure 7. Technical decision making flow.

4.2.1.6 Other Governing Processes

The UAS-NAS Project Schedule Management Process and Risk Management Processes are described in Sections 6 and 9, respectively.

4.2.2 Technical Portfolio Management

The Phase 2 Portfolio, which is comprised of Technical Work Packages (TWP) that define the technical content within each Technical Challenge, was developed through the Phase 2 Content Decision Process (CDP) described in Section 2.1. Within each TWP, there are test activities and tasks supporting them. A specific activity, e.g., human in the loop simulation, and its supporting tasks, are grouped as Schedule Packages (SP) within a TWP. The objectives, approach, and deliverables associated with each SP represent the project technical baseline. The technical portfolio is managed through the technical baseline and project requirements, which are documented in the Project Requirements Document (PRD) (Doc#: UAS-PRO-1.1-005). TWPs and SPs are the mechanism the UAS-NAS Project uses to organize the technical portfolio. SP identification numbers will be used within the UAS-NAS Project integrated master schedule, progress indicators, and reporting structure conveyed to IASP.

The technical work within the subprojects will take place across multiple Centers. The CSE and technical leadership team track the technical progress and ensure requirements are met. The PEs for each subproject provide status for the activities within their SPs during the UAS-NAS Project weekly telecon. These status reports give the project leadership the necessary insight into technical progress, as well as information about existing or potential issues/concerns. The sharing of information during the weekly telecon also allows for the project and PEs to gain insight into the integrated technical inputs the UAS-NAS Project provides to SC-228. In addition to the weekly telecon, the ERT, MRB, and risk management meetings/processes also assist in the management of the technical portfolio. For example, ERT technical decisions and MRB approvals can assist in keeping the technical portfolio relevant to stakeholder needs, allowing changes to the technical baseline, allowing adjustments to schedule, and allowing shifts in resources to ensure successful execution. The risk management meetings provide insight into existing or potential issues/concerns pertaining to the technical portfolio and its acceptance by stakeholders.

The subproject implementation plans (Doc#: UAS-SSI-4.1-001, UAS-HSI-4.2-001, UAS-COMM-4.3-001, UAS-CERT-4.4-001) provide information on governing subproject processes in addition to what is provided in this project plan. These include Center institutional processes and procedures, such as research review processes, that are also used in the management of the technical portfolio.

4.2.3 Systems Engineering Management Plan

The UAS-NAS Systems Engineering Management Plan (SEMP) describes the application of systems engineering within the UAS-NAS Project to meet the project's goal and to provide research findings to the UAS Community. The SEMP defines the technical approach the UAS-NAS Project is using for planning and executing engineering (research) activities. As such, significant tailoring of NPR 7123.1B was accomplished in describing the disciplined engineering approach used by the UAS-NAS Project that is "quantifiable, recursive, iterative, and repeatable for the development, operation, maintenance, and disposal of systems integrated into a whole throughout the life cycle of the Project" (reference NPR 7123.1B) for developing research findings. To create research findings, the UAS-NAS Project is creating hardware and software for use in simulations and tests. The SEMP document (Doc#: UAS-PRO-1.1-007) and, as appropriate, the subproject implementation plans describe the project processes used for technical oversight and insight.

4.2.4 Mishap Response Plan

In the event of a mishap that occurs during Host center and Partner Center's specific testing, subprojects will follow and execute the mishap plans at their respective centers which are documented in the subproject implementation plans and aligned with NPR 8621.1, Center Mishap Preparedness Contingency Plan (MPCP) and respective center procedures

For mishap notification, the Project will adhere to guidance in IASP Mishap Response Plan. For notification of a mishap, the mishap will be reported by the appropriate DPMf, to the UAS-NAS Project Manager. The Project Manager will then notify the IASP Director and Host Center ARD. In the case that they cannot be reached, their respective Deputies will be notified. Notifications above the IASP Director and AFRC ARD will be accomplished by those individuals per IASP Mishap Response Plan and AFRC Mishap Response (DCP-S-001), as needed. It is the Host Center ARD's responsibility to notify the Center Director. Following the notification to the IASP Director and Host Center ARD, the PM will notify the other DPMfs. The mishap notification list

[Doc #: UAS-PRO-1.1-011], which includes names and contact information is maintained as a project office document.

Leaving a voice mail does not constitute compliance for mishap notification. If unable to talk live with the required team member, notifier should proceed to the next step.

Notifications of a mishap or close call should include, at a minimum, the following information:

1. Notifier's name, title, & location
2. Nature of call (e.g., mishap/ close call notification, injury/damage to report, etc)
3. Project name (UAS-NAS), vehicle type, aircraft tail number or facility name, owner, or other identifying description or special circumstance (as appropriate)
4. Description of the mishap or close call and any impacts to personnel and hardware

4.2.5 Subproject Implementation Plans

As the subprojects conduct the UAS-NAS Project technical activities, i.e., schedule packages, to accomplish the technical work packages, and ultimately the project Technical Challenges, these plans define the authority, scope of involvement, governing processes, and role of the Centers with respect to the appropriate subprojects.

The subproject implementation plan contains the following about the subproject: baseline, i.e., technical, schedule, and resource; authority and governance structure; stakeholders; and governing processes and documents including unique subproject or Center specific processes. Examples of these processes include: Safety and Mission Assurance Process including Mishap Plan, Document Review and Release Process including Export Control Processes, and Test/Simulation Data Archiving and Storage Location Processes.

The subproject implementation plan document numbers are as follows: UAS-SSI-4.1-001, UAS-HSI-4.2-001, UAS-COMM-4.3-001, UAS-CERT-4.4-001.

4.2.6 Governing Documentation

The Project Plan is the top-level document that describes the UAS-NAS Project. It forms an agreement between the PM, Center Director, and the Program Director (PD) for IASP. The UAS-NAS Project and Subproject Implementation plans in conjunction with the TWP/SP packages document the technical plan, milestones, deliverables, schedules, resource management approach, et cetera, to ensure successful delivery of technical products to stakeholders. The UAS-NAS Project governing processes are documented within their respective management plans. The project document tree, shown in Figure 8, shows the documents/processes that govern the project.

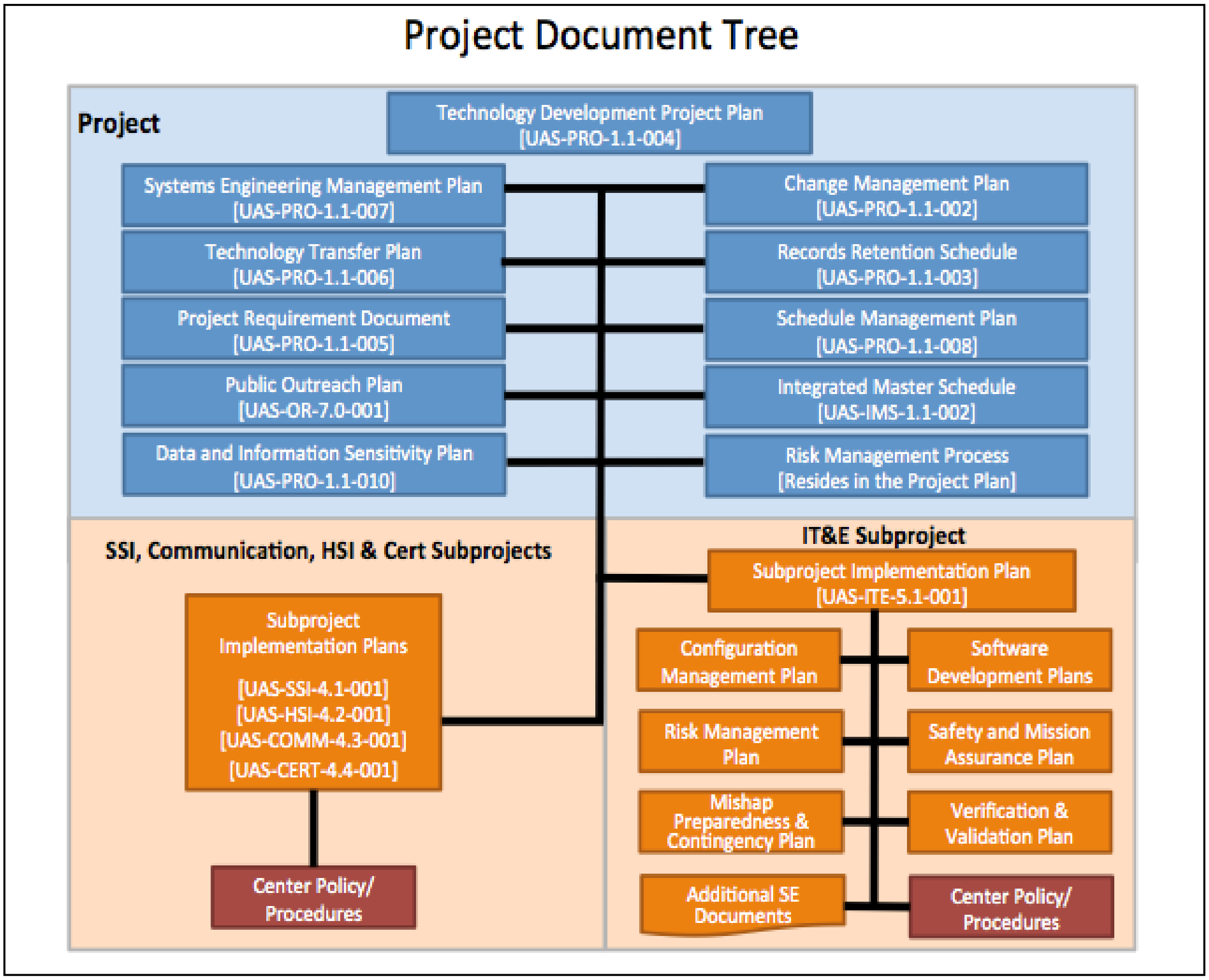


Figure 8. Project document tree.

4.3 Project Interfaces

Related activities that are currently in work at other government agencies, industry, and academia have been assessed; key areas are documented in Section 2.1. Project interfaces represent the collaborative activities that the UAS-NAS Project is conducting with other government agencies, industry, and academia. The UAS-NAS Project works closely with these groups in an effort to ensure that the project research findings will help to contribute to the multi-agency, multi-national efforts to enable routine UAS access to national and global airspace.

4.3.1 Inter-Government Interfaces

ARMD has several other programs that are interested in the outcomes of the UAS-NAS Project. The interest is in various capacities such as documented research findings, future project efforts, technology enhancements, NASA capability enhancements, and many others. The project will regularly interface with these programs sharing technical, managerial, and industry knowledge.

The UAS-NAS Project's major inter-Government interface is with the FAA. In March 2012, the FAA created a UAS Integration Office, headed by a single executive, which brings together specialists from the aviation safety and air traffic organizations. The office serves as the FAA's one-stop portal for all matters related to civil and public use of UAS in National Airspace System. The FAA UAS Integration Office has led the FAA's efforts in planning for UAS integration and has heavily leveraged the FAA Research & Development Integration Division. The FAA has also leveraged DoD and industry in development of strategic planning documents, such as the Integration Roadmap. The UAS-NAS Project has worked with FAA management throughout development of the FAA UAS Integration Roadmap, which was developed based on the Aviation Rule-making Committee (ARC) Implementation Plan development in which NASA participated. Since the onset of the UAS-NAS Project, there has been a close relationship with the FAA. NASA's participation in planning activities for the FAA benefits both agencies, and the UAS-NAS Project's portfolio is closely aligned with the FAA plans. The Phase 2 technical portfolio including objectives, approach, products, and success criteria have been presented to the FAA for their awareness and is currently being leveraged to support RTCA SC-228 Phase 1 MOPS. The UAS-NAS Project has utilized a Memorandum of Agreement (MOA), established in 2011, with the FAA to partner on several strategic efforts. These efforts, which span multiple organizations within the FAA that work closely with the UAS Integration Office are captured in the "Interagency Agreement between NASA and the FAA concerning Unmanned Aircraft Systems Research and Technology Development" (Doc #: AFRC-531). The UAS-NAS Project and both the UAS Integration Office and the FAA Research & Development Integration Division, have had a monthly meeting structure in place since early in Phase 1 of the UAS-NAS Project. Outside of that meeting, interactions are open and frequent. The UAS-NAS Project may also establish collaborations with the FAA UAS Test Sites that were established in FY14.

The UAS-NAS Project coordinates with the DoD through Committees, working groups, and other contacts to ensure the UAS-NAS Project utilizes the vast experience and knowledge base available within the DoD. The UAS-NAS Project is collaborating with the DoD in several key areas, primarily with AFRL and the Office of Secretary of Defense SAA Science and Research Panel (SARP). The UAS-NAS Project is working with AFRL on sense and avoid efforts, particularly related to the Joint Optimal Collision Avoidance (JOCA) research, and on human factors efforts related to UAS access. The UAS-NAS Project will be able to leverage DoD testing to improve their results and provide some additional results that will be applicable to civil operations. The UAS-NAS Project is also utilizing the AFRL developed Vigilant Spirit Control Station (VSCS) as a ground control station in the HITL and Integrated Tests. The UAS-NAS Project's work with the Office of the Secretary of Defense (OSD) SAA SARP consists of supporting their efforts to identify and close SAA research gaps, such as the definition for "Well Clear." Similarly, the Project has also supported SARP efforts in the human factors area as they seek to define the human factors research gaps. The UAS-NAS Project and the SARP work closely together through regularly occurring meetings, workshops, and deep dives. Although there is no specific defined interaction strategy, the SARP officially meets quarterly with weekly interactions being common.

During Phase 2, the UAS-NAS Project will also work with the US Marine Corps in the area of human factors and small UAS and examine other potential collaboration opportunities. The UAS-NAS Project is working with other DoD entities through a request from the Executive Committee (ExCom), on validation of flight-test data for Class D airspace. The UAS-NAS Project is also working with the DoD Policy Board for Federal Aviation and the Office of the Secretary of Defense's UAS Task Force to expand our collaborations further.

In addition to the FAA and DoD entities, in Phase 2 the UAS-NAS Project will also work with Department of the Interior UAS Fish and Wildlife Service Great Dismal Swamp in the area of small

UAS (sUAS). The primary aspect of this relationship is to investigate the possibility of sUAS providing fire detection surveillance of the swamp.

4.3.2 Industry Interfaces

RTCA SC-228 is the primary stakeholder and interface to the majority of the project's research portfolio. The SC-228 Terms of Reference (ToR) defines objectives with respect to developing MOPS for Detect and Avoid (DAA), and Command and Control (C2) data link equipment. Both DAA and C2 have independent working groups defining MOPS for the respective technology area. Each working group is split into a Phase 1 and Phase 2 MOPS effort. The UAS-NAS Project's primary research is focused on developing Phase 1 MOPS for DAA and C2. UAS-NAS Project Engineers (PE) have established working relationships with their counter parts within the respective working groups and they are in continuous dialog during the working group planning, project simulation and testing execution, and subsequent project analysis and reporting of results. UAS-NAS PEs also participate in standing weekly working group meetings. These meetings consist of the technical leads from many stakeholder organizations from other government agencies (OGA), industry, Federally Funded Research and Development Centers (FFRDC), international entities, and many other organizations. Although there is only one bi-weekly telecon for the entire working group, each working group is split into multiple sub-groups that meet weekly. The SC-228 Steering Committee reports to the standard RTCA Program Management Committee (PMC). NASA has leadership representation throughout this process.

In addition to support of RTCA, the UAS-NAS Project's involvement with industry has primarily been through NRAs or contracts; the UAS-NAS Project does have a specific cost sharing arrangement with Rockwell Collins on the development of a candidate UAS communications radio (40 percent NASA and 60 percent Rockwell Collins). This cost sharing activity reduces the government's burden while providing critical industry insight. The communications subproject works closely with Rockwell Collins on the development of the CNPC prototype radios utilized in and matured through UAS-NAS testing activities. The Project is also working closely with General Atomics to further the Project's SAA research and the FAA's Airborne Collision Avoidance System (ACAS) Xu development. An NRA with Honeywell to conduct validation of sensor models and tracking/fusion algorithms using data from representative flight-tests was also extended for FY15.

4.3.2.1 Academic Interfaces

In Phase 2, the Project has involvement with several academic institutions. As defined in section 2.4.5.1, the Certification team is working with the University of North Dakota (UND) under a Space Act Agreement to provide a concept of operations and aircraft design data in support of the case study that the certification subproject will be conducting. In the first year of Phase 2, FY14, the Project also had NRAs with New Mexico State University for sUAS research and with the University of Michigan for Certification research. The University of Michigan NRA was extended through the end of the Project, FY16, to examine the effectiveness of geofencing to mitigate the risks associated with a sUAS departing its approved operating region. Additionally, the Project has grants with California State University (CSU)-Long Beach and CSU-Northridge to conduct human factors research.

4.3.2.2 International Interfaces

The International Telecommunications Union Radiocommunication Sector (ITU-R) is one of the three sectors of the International Telecommunications Union (ITU) and is globally responsible for radio communication. Its role is to manage the international radio-frequency spectrum, to develop radio regulations and standards for radiocommunication systems, to carry out studies, and to approve recommendations on radiocommunication matters. It leverages the World Radio Conference (WRC) to establish recommendations intended to assure the necessary performance and quality in operating radiocommunication systems. It also seeks ways and means to conserve spectrum and ensure flexibility for future expansion and new technological developments. The UAS-NAS Communications Project Engineer's involvement in ITU Working Party 5B WP5B/WRC-12 began during the American Recovery and Reinvestment Act pre-phase of the UAS Integration in the NAS Project as part of the required research during the compilation of the State of the Art/Practice Assessment in FY12. The NASA participation in scheduled WP5B telecons continued and subsequently led to more of an active role through RTCA SC-203 WG2 and RTCA SC-228 C2 WG. Communications team members regularly attend WP5B telecons and meetings to coordinate studies to determine how the UAS CNPC spectrum needs could be addressed. Subsequently, the Communication Subproject has lead multiple studies to consider spectrum requirements and possible regulatory actions, including allocations, in order to support safe operation of UAS. Activities include developing studies for consideration by the WRC-WG5B, presenting the studies, representing UAS communication interests during WRC meetings, and working with the international community. The UAS-NAS Project is also involved in several ICAO activities including the Flight In Non-Segregated Airspace (FINAS) work, the UAS Study Group, the Civil Air Navigation Services Organization (CANSO), Remotely Piloted Aircraft Systems Panel, and Working Group 73.

4.4 Documents and Records Management

The UAS Integration in the NAS Project will comply with "NASA Records Management" (NASA Policy Directive 1440.6) and "NASA Records Retention Schedules" (NASA Procedural Requirement {NPR} 1441.1) Chapter 8: Program Management Records. The "UAS Integration in the NAS Project Records Retention Schedule" (Doc#: UAS-PRO-1.1-003) has been created in accordance with NASA records retention schedule (NPR 1441.1) to manage records specific to the UAS-NAS Project. The primary means of records retention in this project will be through the development and maintenance of an electronic library on the NASA Knowledge Network Docushare system. Access to the folders will be limited to NASA personnel and NASA contractors directly supporting the UAS-NAS Project. The library will store all interim and final financial, programmatic, and technical reports generated by the UAS-NAS Project. Contract documents will be maintained by NASA contracting officers and contracting officer technical representatives.

5 Resource Requirements

5.1 Budget

The IASP provides funding for the UAS-NAS Project on an annual basis per NASA accounting guidelines and procedures. This funding is contingent on the availability of funds, as appropriated by the United States Congress. The Budget is approximately $30M per fiscal year and is shown in Table 6.

President's Approved Budgets as of March 2014 ($'s in K)						
Center	**FY11**	**FY12**	**FY13**	**FY14**	**FY15**	**FY16**
AFRC	$2,319	$12,478	$10,412	$9,740	$11,906	$15,675
ARC	$2,747	$6,307	$7,012	$7,662	$7,655	$7,509
GRC	$2,509	$5,896	$6,436	$5,819	$6,283	$4,299
LaRC	$2,133	$4,901	$5,730	$6,428	$4,162	$4,481
HQ	$75	$439	$945	$868	$671	$696
Totals	**$9,783**	**$30,021**	**$30,535**	**$30,517**	**$30,677**	**$32,964**

Table 6. Budget.

5.2 Acquisition Plans

The UAS-NAS Project will utilize workforce at all four NASA Aeronautics Research Centers (Ames, Armstrong, Glenn, and Langley).

Due to the immature and emerging state of UAS technology, especially as it relates to routine operations in the airspace, it will be important to maintain an agile acquisition strategy. The need to remain agile is all the more important given the required collaboration with external organizations and the expectation that they will provide guidance and recommendations on the key technologies. Therefore, it will be important that the acquisition strategy not lock the Project into long term commitments, or commitments that will result in termination or change fees if new technology is required. Although the potential for changes may exist, the Project has taken definitive steps towards mitigating this potential in Phase 2 through the development of the Phase 2 Portfolio, which tied all the project technical work to the UAS community needs, and by embedding the PEs within key groups such as SC-228 and the OSD SAA SARP that are shaping the direction of UAS integration into the NAS.

The acquisition strategy ultimately requires the utilization of multiple acquisition methods as dictated by the acquisition in question. The following options for acquisition will be considered:

- Traditional procurement options will be utilized primarily.
- Existing support service contracts at each of the Aeronautics Centers will likely represent a considerable percentage of the procurement actions.

- New competitive contracts will be awarded primarily through request for proposals for equipment and supply purchases.
- Funds transfers to/from other Government agencies (OGA) and other NASA Mission Directorates will take place through partnerships. The agreement with the FAA for controller support is an example with OGA and the agreement with the Ikhana project is an example of agreements with another NASA Directorate.
- Grants and cooperative agreements are not expected to represent a significant percentage of the funds for Phase 2 but will be utilized as appropriate. For example, there is a grant with California State University Long Beach for an HSI task and a cooperative agreement with University of Michigan through a NASA Research Announcement (NRA).
- Funding of Phase III Small Business Innovative Research (SBIR) may occur if the research is relevant to the UAS-NAS Project goals. The Phase III SBIR with Intelligent Automation, Inc. is one example. This SBIR further expands on UAS mission scenarios.
- The use of Cooperative Research and Development Agreements (CRADA) may be utilized if appropriate. The CRADA with Rockwell Collins during Phase 1 was completed.
- Existing agreements with the FAA and DoD will be used to ensure collaboration and avoid duplication of effort.
- Agreements with standards organizations, industry, and academia may be established.
- Collaboration with numerous international entities anticipated, but no formal international agreements or contracts are anticipated.

5.3 Facilities and Laboratories

Table 7 identifies the list of primary facilities, laboratories, and assets that will be used to implement the UAS Integration in the NAS Project. Specific facility and laboratory usage details is defined more thoroughly in the detailed subproject implementation plans.

Facility/Lab/Asset	Agency/ Center	SSI	Comm	HSI	IT&E	Cert	sUAS
Air Traffic Control Lab	ARC	x			x		
Air Traffic Operations Lab	LaRC	x			x	x	
Airspace Operations Lab	ARC	x			x		
Small UAS Aircraft and Operations Labs	LaRC	x		x			x
Vigilant Spirit Ground Station	US Air Force	x	x	x	x		
Research Development and Human Factors Lab	FAA Tech Center			x			
Manned Aircraft	ARC, AFRC, GRC, LaRC		x		x		
UAS Assets	AFRC, LaRC	x		x	x	x	x
NextGen Integration and Evaluation Capability	FAA Tech Center	x			x	x	
Multi-UAV Simulation	ARC			x	x		
Universal GCS	AFRC			x	x		
Flight Deck Display Research Lab	ARC			x	x		
Manned Surrogate UAS	GRC	x		x			
Wireless Comm Lab	GRC		x				
Aircraft Communication Simulation Lab	GRC		x				
Sim Development and Analysis Branch Simulators	LaRC	x				x	
UAS and NextGen Lab	FAA Tech Center					x	
ATC Workstations	ARC, FAA Tech Center				x		
R2515 Restricted Airspace	AFRC				x		
747 Cab at ARC	ARC	x			x		

Table 7. Facility and Resource Utilization.

The UAS-NAS Project will comply with “Implementing the National Environmental Policy Act and Executive Order 12114” (NPR 8580.1). Specifically, all ground-test and flight-test areas that use propellants or fluids will develop practices and procedures to avoid the unintentional release of any fluids. Intended release of fluids, through venting or other required practices during testing, will be governed by the host Center’s environmental management policy. Ground- and flight-test operations will be governed by the host Center’s practices and procedures. Compliance with the resident Center’s environmental management policies is the responsibility of the individual test point of contact and flight assets and will be documented and maintained per that Center’s procedures. External contractors will comply with all environment regulations per the FAR as outlined in their contract.

6 Schedule

Schedule Management is an essential management strategy with focused objectives and processes. The Schedule Management process provides regular updates on technical activities to the UAS-NAS Project, IASP, and the Host Center. It also serves as a means to track Progress Indicators (see Section 3) and project milestones.

Project milestones are used as the primary means of schedule management. IASP provides guidance on the definition of L1 milestones, which are managed by the IASP CMB. L1 Milestones primarily include, but are not limited to, the end of execution periods for integrated events and comprehensive inputs to stakeholders (i.e. SC-228). All Annual Performance Goals (APG) and Annual Performance Indicators (API) are also L1 Milestones. L2 milestones directly support and are directly tied to the accomplishment of the IASP Technical Challenges, and are governed by the UAS-NAS Project's change management process executed in the MRB. L2 Milestones primarily include, but are not limited to, the beginning of execution and technology transfer reporting for all major activities (i.e., Schedule Packages) happening within subprojects. All other milestones and tasks are controlled by subprojects.

Schedule Management consists of several major components:

- UAS-NAS Project Integrated Master Schedule;
- Milestones;
- UAS-NAS Weekly Status Telecon;
- IASP Weekly Telecon and UAS-NAS Detailed Status;
- Progress Indicators;
- IASP Quarterly Reports.

Information flows throughout these components by a regular update cycle of IASP and Project meetings. The schedule management process is fully documented in the Project Schedule Management Plan (SMP) (Doc#: UAS-PRO-1.1-008-001).

Figures 9 and Appendix E1 through E4 15 are the TC schedules and L1/L2 milestones as of 5/16/2014 (unless otherwise noted).

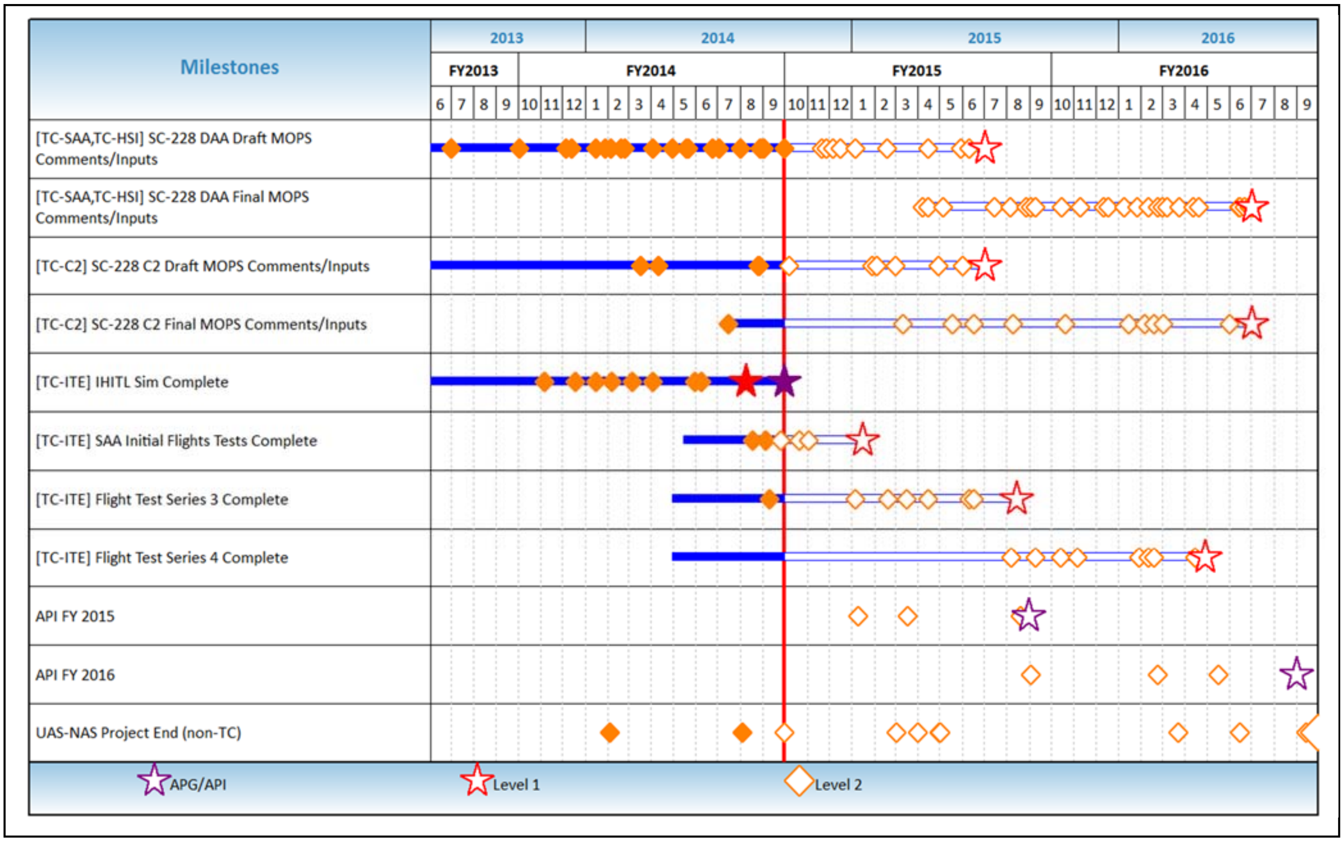


Figure 9. L1/L2 Milestones (as of monthly report 9/30/14).

A full list of L1 and L2 Milestones are identified in Appendix A of this document.

7 Work Breakdown Structure (WBS)

The WBS identifies the management and technical areas that track with the major milestones. The WBS for the UAS-NAS Project is outlined below.

- 1.0 Project Management
  - 1.1 Project Management
  - 1.2 Management Support
  - 1.3 Project Control
  - 1.4 Project External Interfaces
    - 1.4.1 Other Work [e.g. sUAS, United States Marine Corp (USMC), Autonomy]
- 2.0 Project Analysis
  - 2.1 Phase 1 Analysis
- 3.0 Advanced Concepts
- 4.0 Technology Development
  - 4.1 Separation Assurance/Sense and Avoid Interoperability (SSI)
    - 4.1.1 SSI Subproject Control
    - 4.1.2 SSI Technical Work
    - 4.1.3 Performance

4.1.4 Interoperability
4.2 Human Systems Integration
4.2.1 HSI Subproject Control
4.2.2 NAS Compliant GCS
4.2.3 Human Factors Guidelines for Operations in the NAS
4.3 Communications
4.3.1 Communications Subproject Control
4.3.2 Spectrum Requirements and Allocation
4.3.3 Communications Service Level Demonstration
4.3.4 Communications Security
4.3.5 Integration of CNPC and ATC Communications – Data Development
4.4 Certification
4.4.1 Certification Subproject Control
4.4.2 Conduct case study and analysis
4.4.3 Evaluate an alternative approach to developing safety substantiation data for a UAS
5.0 Validation and Test
5.1 Integrated Test and Evaluation
5.1.1 Integrated Test and Evaluation subproject control
5.1.2 Test Support
5.1.3 Integrated Flight Test Series 1
5.1.4 Integrated Simulation 1
5.1.5 Integrated Flight Test Series 2
5.1.5.1 Integrated Flight Test Series 2 – SAA Initial FT
5.1.6 Integrated Flight Series Test 3
5.1.7 Integrated Flight Series Test 4
6.0 Safety and Mission Assurance
7.0 Education and Public Outreach
8.0 Technology Transfer

8 Strategy for Technology Transfer to Stakeholders

This UAS-NAS Project will demonstrate solutions to address operational, safety, technology, and security issues related to UAS access to the NAS. As part of the Phase 2 Portfolio development, the UAS-NAS Project ensured the Phase 2 technical content would be relevant and meet community needs. The technology development activities and subsequent research findings will be provided to key stakeholders to contribute towards enabling more effective and efficient UAS access to the NAS.

Technology transfer is the primary means of achieving desired outcomes and outputs of the Project. The UAS-NAS Project has identified stakeholders, transferrable products, and the methods of product transfer in the Technology Transfer Plan.

The primary project stakeholders are FAA, RTCA SC-228, Office of Secretary of Defense (OSD) Sense and Avoid (SAA) Science and Research Panel (SARP), and the ITU Radiocommunication Sector. Of the four primary stakeholders, the majority of the project's research is focused on ensuring the success of the RTCA SC-228 MOPS. These MOPS will be the means for the FAA to ensure Technical Standards Orders (TSO) can be created. Other safety, certification, air traffic, and research arms of the FAA are also benefited by the findings of the UAS-NAS Project's research. Table 8 presents a list of the project stakeholders and information on key attributes relative to UAS integration. The UAS-NAS Project and its stakeholders all have significant roles in the execution of UAS integration.

Stakeholder	Key Stakeholder Outputs	Community Influence
FAA	Standards and Regulations for UAS Regulation	Responsible for rules and regulations for safe, timely, and efficient UAS Integration. UAS is a broad effort spanning many organizations within the FAA. The Project's primary points of contact in the FAA are the UAS Integration Office and the Research & Development Integration Division.
RTCA SC-228	SAA and C2 minimum operational performance standards (MOPS)	Industry forum providing consensus standards to the FAA to assist with integration of unmanned aircraft.
Office of Secretary of Defense (OSD) Sense and Avoid (SAA) Science and Research Panel (SARP)	Government consensus on SAA issues and SAA Research gaps	Ability to identify, influence, and provide recommendations on key research gaps with respect to SAA.
International Telecommunication Union, Radio communication sector (ITU-R)	Carry out studies and approve recommendations on radiocommunication matters associated with flying UAS	Provides global management of the radio-frequency spectrum for the UAS Community.

Table 8. Stakeholder list.

The technology transfer between the Project and key stakeholders is fully documented in the Project Technology Transfer Plan (TTP) (Doc#: UAS-PRO-1.1-006). The TTP documents how the UAS-NAS Project will generate research findings and communicate them to the stakeholder community. The process of technology transfer begins with the Project identifying the content to deliver. This content and its development is documented through core project processes and documents, which include the IMS, Systems Engineering Management Plan, and Project Requirements Document. These processes and documents are used to create and manage project research activities (or Schedule Packages), which generate the UAS-NAS Project's research findings. The research findings from each activity become the foundational technology transfer elements. Each activity is closely coordinated with the stakeholder community from the onset. The feedback loop with stakeholders is constant throughout the planning, execution, and analysis phases and is officially communicated to the stakeholder community through technology transfer briefings and final reports. Informal technology transfer to the UAS community is done through participation in conferences (papers and panels) and other committees. Additionally, publicly available material is posted on the NASA ARMD website and controlled data, e.g. ITAR data, is provided via secure email/server/website. The close coordination that the UAS-NAS Project has with the UAS community throughout the process allows for project research findings to be both relevant to community needs and provided in a timely manner to support the UAS-NAS Project outcome.

9 Risk Management

The UAS-NAS Project utilizes the NASA Risk Informed Decision Making (RIDM) and Continuous Risk Management (CRM) processes as the approach to risk management in accordance with NPR 8000.4 as required by IASP. As part of the approach to managing risk, the Project uses the CRM process as illustrated in Figure 10 for the UAS-NAS Project and each subproject. This approach allows for the identification, resolution or mitigation of risk issues prior to impact on activity outcomes.

Figure 10. Continuous risk management process.

The UAS-NAS Project falls under the IASP Risk Management Board (RMB). Project risks will be managed at the project-level with program insight. Risks requiring resources beyond those available to the UAS-NAS Project will be tracked or elevated to the Program. Since IASP projects have fixed budgets and schedules, managing risks to cost and schedule is key to Program success. The scope of the IASP Risk Management Plan includes all risks associated with the IASP, related to areas such as Program/Project relevance, achievement of Program goals & objectives, attainment of Project success, development of technologies, research, financial resources, and other strategic issues.

The UAS-NAS Project's application of the CRM process is presented in Figure 11. The project office, subprojects, and all technical areas identify risks. All risks are entered into the risk tracking spreadsheet. Risk mitigation activities are identified and tracked for each risk until the risk is mitigated to an acceptable level. A risk owner is selected based on the subject matter of the risk. If the risk resides in one technical area, the Project Engineer/Technical Lead will be the risk owner. If the risk cuts across the technical areas, it will be owned by either the CSE or the PM.

Concerns identify potential risks and no approval process is needed to enter a concern into the risk tracking spreadsheet. Concerns are reviewed monthly to assess if the concern has increased, decreased, or remained the same. Concerns are dispositioned as follows: concerns that have increased become candidate risks; those that have decreased are determined to be inactive concerns and are no longer tracked; and those that are the same remain on the risk tracking spreadsheet for later evaluation. Monthly, the Project holds risk workshops or a risk meeting to analyze risks based upon likelihood and consequence (LxC). Risk workshops are held for each technical area and the project office. The risk owner is responsible for providing a detailed status on all active risks, discuss any proposed candidate risks, and discuss risks proposed for closure with closing rationale. Risk review meetings are held on alternating months to address the status of top risks, discuss any proposed candidate risks, and discuss any risks proposed for closure with closing rationale. A top risk is any risk that the Project deems of appropriate concern, has an initial LxC score in 'red' area of risk matrix, is a risk with near term impacts associated with a L1 milestone (i.e., FT3 for FY15), or has been identified as of interest to IASP.

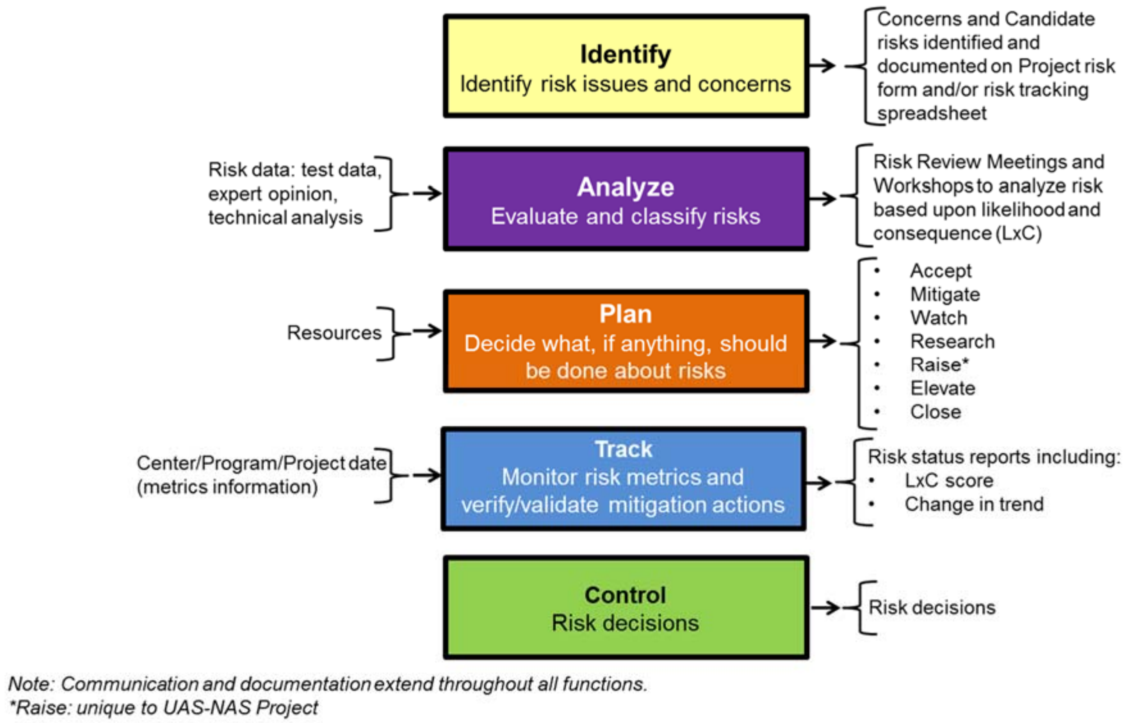
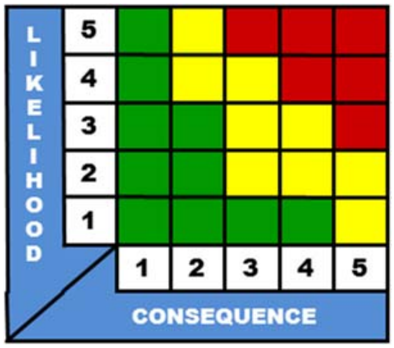


Figure 11. UAS-NAS Project application of CRM process.

Once a candidate risk is identified, it is categorized with one of the following risk actions:

- Accept – Document the assumptions and conditions (risk acceptability criterion) on which the acceptance is based.
- Mitigate – Develop and document a risk mitigation plan including the appropriate parameters that will be tracked to determine the effectiveness of mitigation.
- Watch – Document tracking requirements including decision points, dates, milestones, necessary achievements, or goals.
- Research – Document and track efforts to obtain additional information.
- Raise – Document as a top risk due to UAS-NAS Project concerns, LxC score in 'red' area of risk matrix, and/ or risks with near term impacts associated with L1 milestone risks (i.e., IHITL for FY14).
- Elevate – Transfers the management of a risk to the Program level.
- Close – Document closure rationale and obtain closure approval from the Project Manager.

Risks are placed on a matrix based on risk likelihood and consequence. Risks mitigated into the green area of the matrix may be considered closed once all mitigation activities are complete and they are brought before the MRB with adequate closing rationale. Risks mitigated into the yellow and red areas may be accepted by the Project Manager if closure is requested; accepting yellow or red risks is not a desired outcome. The risk matrix will be included in the UAS-NAS Project reporting at reviews. Figure 12 shows the UAS-NAS Project risk score card and definitions used for scoring likelihood and consequence. The score card is tailored from the IASP scorecard.



LIKELIHOOD		
5	Very High	Qualitative: Nearly certain to occur. Controls have little or no effect.
4	High	Qualitative: Highly likely to occur. Controls have significant uncertainties.
3	Moderate	Qualitative: May occur. Controls exist with some uncertainties.
2	Low	Qualitative: Not likely to occur. Controls have minor limitations /uncertainties.
1	Very Low	Qualitative: Very unlikely to occur. Strong Controls in Place

CONSEQUENCE	1	2	3	4	5
Technical	Negligible Impact to Objective, Technical Challenge, Technology Maturation	Minor Impact to Objective, Technical Challenge, Technology Maturation	Some Impact to Objective, Technical Challenge, Technology Maturation	Moderate Impact to Objective, Technical Challenge, Technology Maturation	Major Impact/Cannot Complete Objective, Technical Challenge, Technology Maturation
Cost	≤ 1% Total Project Yearly Budget (≤ $300K)	1% - 5% Total Project Yearly Budget ($300K - $1.5M)	5% - 10% Total Project Yearly Budget ($1.5M - $3M)	10% - 15% Total Project Yearly Budget ($3M – $4.5M)	>15% Total Project Yearly Budget (> $4.5M)
Schedule *	Level 2 Milestone(s): < 1 month impact	Level 2 Milestone(s): ≥ 1 month impact	Level 1 Milestone(s): ≤1 month impact Level 2 Milestone(s): ≤ 2 month impact	Level 1 Milestone(s): > 1 month impact Level 2 Milestone(s): > 2 month impact	Level 1 Milestone(s): > 2 month impact Level 2 Milestone(s): ≥ 3 month impact

Figure 12. Risk Score Card and the definitions for scoring the likelihood and consequence.

Risks are communicated and documented through a risk tracking spreadsheet and briefing charts that will be presented monthly at the UAS-NAS Management Review Board. The briefing charts include the following: tracking metrics; closing rationale for risks proposed for closure; proposed candidate risks in risk format; and a chart for each active showing risk ID, risk title, trend, current risk level, and target expected risk level. The risk matrix and status of Top Risks are also presented at the IASP UAS Risk Management Board, and bi-monthly at the Armstrong Center Management Council meetings.

9.1 Project Risk Strategy

Within the UAS-NAS Project Risk Management process is a set of process-driven activities aimed at achieving UAS-NAS Project success (e.g., creating the agreed-to project content within allocated and approved budget and schedule) by timely, proactive selection of risk-informed decision alternatives (mitigation plans) and subsequent management of any implementation risks associated with any selected alternative. The timely, proactive integration of RIDM and CRM processes to cost, schedule, and technical content aspects of project execution allow the project to address possible adverse changes as early as possible with intent to mitigate projected impact to the lowest level (least adverse impact on cost, schedule, or agreed-to content).

The UAS-NAS Project's strategy for mitigating risks utilizes an incremental approach in responsibility/authority. The incremental approach starts within the responsibility/authority of the Technical Challenge and Non-Technical Challenge areas, builds to the project office, and builds to responsibility/authority in the IASP, as appropriate.

Specifically, UAS-NAS Project technical content execution responsibility is assigned to the Project Engineers/Technical Leads. Consequently, risk mitigation plans (or decision alternatives) will initially consider only resources within the TC or Non-TC area. Should the PE/TL have inadequate resources for their risk mitigation plan, then they should work with their DPMf to identify approaches to address the mitigation plan. Should the PE/TL or DPMf be unable to resource the proposed mitigation plan from within the subproject or within their Center, then project office management reserves, other subproject resources, or other Center resources will be considered. Consideration of project reserves, other subproject resources, or other Center resources will be based on the priority of the subproject's activity relative to other project and subproject baselined activities. Non-Technical Challenge work is a first component of the de-scope strategy in that work would be reduced (using the off-ramp) as needed to preserve Technical Challenge work.

Should the project office's reserve resources, other subproject resources, or other Center resources be incapable of or inappropriate for mitigating the identified risk, it will be identified to the IASP Office. The UAS-NAS Project will formulate a package that identifies the proposed de-scope of technical content and submit a request for any available funds from the Program to maintain the baselined technical content. If IASP resources are unavailable or IASP approved relief from cost and schedule commitments have not been obtained then the programs/projects only remaining strategy will be to de-scope project activities per the project's proposal to fit within remaining technical content into the fixed, agreed-to-budget and schedule. This project de-scoping will involve consideration of the relative priority and execution status of all remaining project activities.

10 Project Evaluation and Completion

10.1 Program and Center Reviews of the Project

10.1.1 Annual or 12-Month Reviews

IASP will conduct annual reviews of the UAS-NAS Project to assess the Project's quality and performance. The Program Director (PD) will be supported by two panels of government technical management experts for the review process to provide independent perspective and input for consideration in the assessment of the Project. First is the Independent Review Panel (IRP) of non-NASA government or independent NASA experts, and the second is the Performance Review Panel (PRP) of specific NASA ARMD personnel. The review will follow the terms of reference (ToR) developed by the Program. The project annual review content may be leveraged to support the Program annual review conducted by ARMD. The project annual review may include:

- An overview of the overall goals, objectives, and technical content of the Project. The Project will be expected to show how they are managing by Technical Challenges and articulate the progress towards achieving their Technical Challenges.
- Provide key highlights and accomplishments for the project's Technical Challenges.

- Project management performance data including discussion and assessment of the performance during the last year and lay the foundation for effective execution of the Project looking into the next fiscal year. Project performance may be assessed by reviewing technical content, schedule, risk management, resource utilization, and partnerships and collaboration.
- A look ahead at the next fiscal year that includes key activities and milestones by Technical Challenge and potential issues or watch items that may impact project execution in the coming year.

The IASP Office will schedule and coordinate the annual review. At the conclusion of the annual review, the ARMD review team may prepare a written report summarizing the status, findings, and recommendations of the review.

10.2 Center Management Council

The UAS-NAS Project will brief the Host Center's Center Management Council (CMC) bi-monthly on the progress of the Project during the previous two months, specifically in the areas of technical accomplishments, status against schedule, spending, performance against metrics, and a summary of project risk assessments.

The PM is accountable to the Host Center Director and IASP Director who have overall technical and programmatic responsibility for the UAS-NAS Project including strategic and tactical direction. The PM is responsible for the execution of the Project Plan and provides oversight to the day-to-day operation of the UAS-NAS Project. The Host and Partner Centers shall oversee the UAS-NAS Project through their respective Center Management Councils (CMC), which monitor and evaluate all project work executed at the respective Center. The Project Manager presents to the Host Center CMC, and the DPMfs present to the Partner Center CMCs. The CMC evaluation focuses on whether Center engineering, Safety and Mission Assurance (SMA), health and medical, and management best practices (e.g., program and project management, resource management, procurement, institutional best practices) are being followed by the Project and whether Center resources support project requirements. The CMC also assesses UAS-NAS Project execution risk and evaluates the status and progress of activities to identify and report trends and provide guidance to the UAS-NAS Project. The Host Center CMC provides its findings and recommendations directly to the Project Manager, while the Partner Center CMCs provide feedback and/or actions to the Project through the DPMfs.

10.3 Other Interactions

Quarterly, the UAS-NAS Project will prepare and submit a progress report to the IASP Office and appropriate Host Center management. The quarterly report will also identify upcoming activities and other pertinent information. The UAS-NAS Project participates in weekly teleconferences between the project leadership team, the IASP office, and the Center ARDs.

10.4 Project Key Decision Point-2

A KDP-2 was held to establish the UAS-NAS Project’s Phase 2 Portfolio and the control processes by which it would be managed. During the review the UAS-NAS Project requested Authority to Proceed with the execution of Phase 2. The review was based on the ToR. The review content included evidence that:

- TWP needs, objectives, success criteria, requirements, and deliverables support UAS-NAS Project goals and are feasible, executable, and balanced with resource and schedule.
- Requirements are clearly tied to objectives.
- Implementers, customers, and key stakeholders support the plan
- Needs, objectives, deliverables, and requirements are ready to be baselined and placed under change management.
- TWP cost and schedule are adequate estimates that reflect the scope, objectives and requirements. TWP cost estimates have been independently assessed.
- Recommended Phase 2 Portfolio has sufficient reserves/margins, addressing both known and unknown risks.
- Key risks and associated mitigations have been identified and are realistic/appropriate.
- Detailed execution plans are feasible; processes are in place to manage the baselines and risk.
- The team is adequately staffed with the correct skill mix and understands the importance of the success and cost/schedule adherence.
- The proposed UAS-NAS Phase 2 Plan is executable within budget and schedule.

Note: The KDP-2 was divided into two reviews (KDP and Baseline Review) in order to accomplish the above content.

10.5 Project Completion

The project closeout approach will be defined and presented to the Program in the last quarter of FY16.

11 Security Plan

The UAS integration in the NAS Project will follow "Security of Information Technology" (NPR 2810.1) to manage all information technology in a cost-effective manner to ensure an appropriate level of integrity, confidentiality, and availability of information. The project will follow Agency and Center policies, procedures, and requirements to protect NASA information and information technology systems, in a manner that is commensurate with the sensitivity, value, and criticality of the information.

12 Technology Transfer Control Plan (TTCP) or Export Control

This section refers to the handling of data and information via an export control process and should not be confused with the Project Technology Transfer approach and plan mentioned in Section 8. The following TTCP has been developed for the UAS Integration in the NAS Project. An Export Control Representative (ECR) will be identified to represent the UAS-NAS Project. The ECR will coordinate with the Host Center Export Administrator (CEA) on all matters related to export control. The Project DPMfs will coordinate export control related duties and issues with the respective CEA at their center. There will be designated focal points at each of the four Centers for export control related duties and issues. The ECR will work with the designated focal points assigned at each Center to coordinate and work through any issues. Furthermore, it is intended for project technology and research to be published without restrictions where at all possible. The Project has a Data and Information Sensitivity Plan (Doc#: UAS-PRO-1.1-010) that addresses the non-publically releasable content and provides guidance on how sensitive data and information will be handled.

The subprojects identified data covered by the International Traffic in Arms Regulation (ITAR) in the Data and Information Sensitivity Plan. The ITAR data will be controlled through each Center's export control process and will be reviewed by the ECR. For occurrences where the integration of subproject technologies may create ITAR data the Project's Host Center (Armstrong) export control process will be used, including review by the ECR.

This plan will be reviewed and updated as required if any of the subsections addressed below change in any significant or meaningful manner.

All major export related deliverables will be captured and tracked along with other significant UAS-NAS Project deliverables.

Implementing contractor(s)/partners: Please refer to Table 9 for implementing contractors/partners.

Name of agreement(s): This list, Table 9, includes current agreements. Additional details regarding data rights are captured in the Data and Information Sensitivity Plan.

Phase II Agreements	
Company/Agency	**Type of Agreement**
General Atomics	Space Act Agreement
U.S. Fish and Wildlife Service	Interagency Agreement
Dragonfly Pictures	Space Act Agreement
University of North Dakota	Space Act Agreement
FAA	Interagency Agreement
FAA	MOA - Software Use Agreement
AFRL	Task Order
Rockwell Collins	Cooperative Agreement
United States Marine Corps (USMC)	Space Act Agreement

Table 9. Phase II Agreements.

All agreements, contracts, and grants will have the appropriate language in regards to export control classifications and restrictions to ensure partners and contractors provide the proper safeguards for controlled technology. Copies of any export licenses obtained by partners or contractors will be provided to the CEA if NASA is involved in the export.

Foreign Person Participants in Project: In Phase 2, the project is working with General Atomics – Aeronautical Systems Inc. (GA-ASI), which currently has a Technical Assistance Agreement (TAA) with an employee from the Netherlands. The Foreign National (FN) is the primary developer of the GA-ASI Conflict Prediction and Display System (CPDS), which is one of the systems being tested/evaluated during UAS-NAS Project testing activities. General Atomics requested that this individual participate in the Project's testing efforts. In order to share information and data with the FN, the Project applied for a license through the United States State Department: Directorate of Defense Trade Controls (DDTC). The license was issued on March 3, 2015. The FN is affiliated with the company listed below:

Information Systems Delft
Leidekker 1, 2353 XA
Leiderdorp, Netherlands

Export-Controlled Items (i.e., technologies, software, or hardware) involved in the UAS-NAS Project: In order to meet technical objectives, the UAS-NAS Project will be utilizing the Ikhana aircraft, which is protected under the MQ-1 Predator/MQ-9 Reaper Security Classification/Declassification Guide and will require data to be protected accordingly. The Project will be working with other sensitive and controlled information, software and hardware that will also require protection and specific handling. Sensitive and controlled items are documented in detail in the Data and Information Sensitivity Plan, which will be used by the Project to ensure data and information within the Project is properly protected.

Export-Controlled Items which NASA is required to provide to above-listed Foreign Nationals per Governing Agreement or Contract: The information below is covered in the license request. Vigilant Spirit Control Station has been covered in the request; however, it has been determined the FN will not need access above what is currently covered for a FN.

- Data, information and (GA-ASI owned) laptop computer access related to the MQ-9 sense and avoid display, specifically the CPDS and VSCS.
  - Real-time and/or recorded MQ-9 aircraft state data needed to drive the display(s) (e.g., true airspeed, ground speed, altitude, lat./long. position).
- Access to the Ikhana GCS and/or UAS-NAS RGCS during live Ikhana UAS missions.
  - Ikhana MQ-9 head-up and cockpit displays inside the Ikhana GCS.
  - Opportunity to observe MQ-9 flight operations from inside the Ikhana GCS or UAS-NAS RGCS during active MQ-9 flight operations.

Means of Export or Transfer: The primary means of transfer is covered under the export control license.

13 Education and Outreach

13.1 Education

The NASA Office of Education's vision is to advance high quality Science, Technology, Engineering, and Mathematics (STEM) education through a diverse program portfolio to inspire, engage and educate the learning community. The UAS-NAS Project's unique content will align with the Agency's education strategic plan to achieve three high level goals:

(1) Improve STEM instruction;

(2) Increase and sustain youth and public engagement in STEM; and

(3) Better serve groups historically under-represented in STEM fields.

The UAS-NAS Project will work with AFRC's education office to explore educational opportunities at each of the four aeronautics centers to define mutually beneficial collaborations that integrate project-related content into education programs. Education activities may include:

- Student directed activities
- Educator professional development
- Internships, fellowships and scholarships
- Research collaborations with academia.

The UAS-NAS Project will collaborate with AFRC's Office of Education and Office of Strategic Communications to ensure appropriate dissemination of information, consistent with NASA policy and any governing agreements.

13.2 Outreach

The UAS-NAS Project recognizes the importance of working together with other stakeholders within the UAS community to overcome the technical, operational, and public perception barriers. To assist with engaging stakeholders in the areas of public perception and awareness, the UAS-NAS Project developed an Outreach Plan (Doc#: UAS-OR-7.0-001) that defines: (1) what the Project is doing; (2) with whom the Project is engaging; (3) the key messages the Project wants to convey; (4) the intended outcomes; and (5) the steps necessary to achieve UAS-NAS Project goals and objectives. This engagement will: facilitate the building of strong relationships with our partner agencies; provide timely and accurate information to key stakeholders; maintain a clear and consistent message; and increase awareness and visibility of who we are, what we do, and how it benefits the nation as a whole.

The UAS-NAS Project strives to focus its outreach efforts on building a concise understanding of the UAS-NAS Project's goals and research themes, creating visibility into what work is being done, promoting why NASA is essential to play a key role, and developing strong partnerships with others working to help solve related challenges. The communication through this outreach process will help the UAS-NAS Project increase the level of awareness, trust and understanding for our stakeholders, including the Public.

14 Revision History

Revision	Date	Page	Description
Re-Baseline for Phase 2	17 August 2015	All	Release of document for Project Review. Pending concurrences and approvals from Centers.
Re-Baseline for Phase 2; incorporation of comments	24 September 2015	Sig. Page and 2.3 and 2.4	The signature page was corrected to reflect ARDs as signatories instead of Center Directors To clear up potential confusion about Project Phases vs. RTCA SC-228 Phases, titles of sections 2.3 and 2.4 were updated to say "Project Phase 1 Summary" and "Project Phase 2" summary.
Re-Baseline for Phase 2; release of document	06 October 2015	Sig. Page	Document has been fully signed.
Revision 2.1	03 March 2016	Appendix A and Appendix D	Updates to API Language for FY16 and L1 Milestone Dates. Milestone Dates were approved at IASP CMB on 2/24/16 via CR #31. The update to the API language was presented to IASP during the 2/24/16 CMB via an Informational Change (IC)
Revision 2.2	05 July 2016	Appendix A	Updated L2 Milestones to reflect current milestones and current dates

Appendix A – L1/L2 Milestones (as of 6/28/2016)

The following tables present the L1 and L2 milestones: Table 10: L1 milestone list; Table 11: TC-SAA L2 milestone list; Table 12: TC-C2 L2 milestones; Table 13: TC-HSI L2 milestones; Table 14: TC-ITE L2 milestones; Table 15: Non-TC L2 milestones; and Table 16: Project Office L2 milestones.

MS Level	Task Name	Commitment Date
L1	[SP T.2.50] IHITL Sim complete	8/8/2014
L1	[API FY14] Integrated Human in the loop simulation assessment	9/30/2014
L1	[SP T.3.40] SAA Initial Flights Tests Complete	1/15/2015
L1	Preliminary MOPS SC-228 C2 Consolidated NASA Comments Submitted	7/10/2015
L1	Preliminary MOPS SC-228 DAA Consolidated NASA Comments Submitted	8/17/2015
L1	[SP T.4.50] Flight Test Series 3 Complete	9/04/2015
L1	[SP P.1.10] FY15 API	8/31/2015
L1	[SP T.5.60] Flight Test Series 4 Complete	6/30/2016
L1	Final SC-228 DAA Consolidated NASA Comments Submitted	7/15/2016
L1	Final SC-228 C2 Consolidated NASA Comments Submitted	9/16/2016
L1	[SP P.1.10] FY16 API	8/31/2016
L1	Comprehensive Relevant Environment Evaluation	9/14/2016

Table 10. L1 milestone list.

MS Level	Task Name	Commitment Date
L2	[SP S.5.10] UAS CAS1 HITL Start Execution	1/28/2014
L2	[SP S.1.10] Surveillance Requirements (Low Fidelity) Start Execution	2/5/2014
L2	[SP S.3.10] Well Clear Metric and Definition Study Start Execution	4/3/2014
L2	[SP S.2.30] Self-Separation Risk Ratio Study Start Execution	4/30/2014
L2	[SP S.5.10] UAS CAS1 HITL Preliminary Results for Stakeholders Available (Tech Transfer)	5/19/2014

MS Level	Task Name	Commitment Date
L2	[SP S.4.10] UAS - SAA Trade-off Assessments Final Results Report	6/23/2014
L2	[SP S.2.10] SAA Traffic Display Evaluation HIT Human in the Loop Simulations - Ames Results write up	7/2/2014
L2	[SP S.5.30] Comm Gen2 Flight Test SSI Data Report	8/1/2014
L2	[SP S.1.10] Surveillance Requirements (Low Fidelity) Brief results	8/29/2014
L2	[SP S.3.10] Well Clear Metric and Definition Study Brief results to SARP and RTCA	8/29/2014
L2	[SP S.2.30] Self-Separation Risk Ratio Study - Brief results to SARP and RTCA	11/26/2014
L2	[SP S.2.20] IHITL Participation & Data Collection SSI ARC IHITL brief results to RTCA	12/5/2014
L2	[SP S.5.20] Langley Support & Participation in IHITL Preliminary Results for Stakeholders Available (Tech Transfer)	1/5/2015
L2	[SP S.3.30] Phase 1 - Start of Data Collection Execution	3/2/2015
L2	[SP S.2.70] Effect of SAA Maneuvers with Procedures Start Execution	4/8/2015
L2	[SP S.1.20] Surveillance Requirements (Medium Fidelity) Start Execution	4/15/2015
L2	[SP S.5.60] Alerting Times + CA-SS Integration Combined HITL Execution	5/5/2015
L2	[SP S.3.30] Phase 1 - Brief results to RTCA SC-228 (used to inform DAA Prelim MOPS - alerting requirements)	5/20/2015
L2	[SP S.2.30] IFR vs. VFR Encounter Rates & Characteristics Brief preliminary results to SC-228 Safety subgroup	5/21/2015
L2	[SP S.2.30] UAS vs. VFR Encounter Rates & Characteristics Brief preliminary results to SC-228 Safety subgroup	5/21/2015
L2	[SP S.2.60] SAA Traffic Display Evaluation HITL2 HITL Ames Human in the Loop Simulation 2 brief results to RTCA	6/10/2015
L2	[SP S.3.30] Phase 2 - Start of Data Collection Execution	7/13/2015
L2	[SP S.1.20] Surveillance Requirements (Medium Fidelity) Brief results	9/3/2015

MS Level	Task Name	Commitment Date
L2	[SP S.3.30] Phase 2 - Document results in final report/briefing (PRD item)	9/30/2015
L2	[SP S.2.40] FT3 Participation & Data Collection SSI ARC FT3 brief results to RTCA	1/8/2016
L2	[SP S.2.70] ACES Simulation Report (PRD item)	1/19/2016
L2	[SP S.5.60] Alerting Times + CA-SS Integration Combined HITL Brief results	3/4/2016
L2	[SP S.4.30] Start of Simulation for Sensor Uncertainty Mitigation for Guidance and Alerting	3/22/2016
L2	[SP S.1.30] Interoperability of SS and CA Functions Start Execution	4/12/2016
L2	[SP S.1.40] Sub-function Tradeoffs w/ UAS Performance Start Execution	4/18/2016
L2	[SP S.6.10] GA-FAA (SAA Initial Flight Tests) Flight Test Participation w/ IT&E Project Report	5/13/2016
L2	[SP S.4.30] Preliminary results to Stakeholders (SC228)	5/26/2016
L2	[SP S.2.90] Part Task Simulation 6: Start Execution	6/6/2016
L2	[SP S.1.30] Interoperability of SS and CA Functions Brief results	7/1/2016
L2	[SP S.2.50] FT4 Participation & Data Collection SSI ARC FT4 brief results to RTCA	7/14/2016
L2	[SP S.2.90] SSI-ARC PT6 Briefing to RTCA	7/15/2016
L2	[SP S.1.40] Sub-function Tradeoffs w/ UAS Performance Brief results	7/15/2016
L2	[SP S.8.20] Start of Simulation for End to End V&V	7/18/2016
L2	[SP S.8.10] Start of Simulation for DAIDALUS V&V	7/21/2016

Table 11. TC-SAA L2 milestone list.

MS Level	Task Name	Commitment Date
L2	[SP C.2.10] Develop and Test Security Prototype Start Execution	3/17/2014
L2	[SP C.1.10] Gen2 Radio in Relevant Environment Flight Test Start Execution	4/11/2014
L2	[SP C.4.20] ACES Sim Operations w/ Flight Test Models w/Gen2 Start Execution	7/16/2014

MS Level	Task Name	Commitment Date
L2	[SP C.1.10] Gen2 Radio in Relevant Environment Flight Test Briefing to RTCA	8/26/2014
L2	[SP C.2.10] Deliver Security Test Results to SC-228 C2 Draft MOPS	8/26/2014
L2	[SP C.2.20] Performance Validation of Security Mitigations Start Execution	10/7/2014
L2	[SP C.1.20] Perform Gen-4 Flight Test Start	1/28/2015
L2	[SP C.2.20] Performance Validation of Security Mitigations - Relevant Flight Environment Security Mitigations Report	2/4/2015
L2	[SP C.4.30] Recommendations for Integration of CNPC and ATC Comm Draft Start Execution	3/2/2015
L2	[SP C.1.20] Deliver Draft Gen-4 Flight Test Results to SC-228 C2	4/29/2015
L2	[SP C.1.30] C2 MOPS Validation Flight Test Execution Start	2/19/2016
L2	[SP C.1.30] Start Perform Lab Testing of Selected Verification Procedures	5/2/2016
L2	[SP C.4.10] Flight Test Radio Model Development and Regional Sims Start Execution	5/18/2015
L2	[SP C.1.30] Perform FT3 Start	6/17/2015
L2	[SP C.1.30] Deliver C2 MOPS Verification Procedures Results to SC-228 C2	7/1/2016
L2	[SP C.1.30] Deliver C2 MOPS Validation Flight Test Results to SC-228 C2	7/1/2016
L2	[SP C.1.30] Deliver Draft FT3 Flight Test Results to SC-228 C2	10/20/2015
L2	[SP C.4.20] Report - Large-scale Sims with Gen3 Radio Model	1/14/2016
L2	[SP C.4.40] Report - ATC and CNPC Comm Performance Impact on NAS Delay/Capacity	2/5/2016
L2	[SP C.1.30] Verify Prototype Performance - Mixed Traffic Environment Flight Test 2 Execution Start	2/19/2016
L2	[SP C.4.50] SatCom Phase 1 Simulations Start Execution	2/23/2016
L2	[SP C.4.30] Recommendations for Integration of CNPC and ATC Comm Final Start Execution	3/2/2016
L2	[SP C.3.10] Spectrum Compatibility Analysis Final Report on WRC-15	5/16/2016

MS Level	Task Name	Commitment Date
L2	[SP C.4.30] Deliver Draft Report from LS Sims to SC-228 for C2 Final MOPS	6/1/2016
L2	[SP C.1.30] Deliver Draft FT4 Flight Test Results to SC-228 C2	7/1/2016
L2	[SP C.4.10] Flight Test Radio Model Development and Regional Sims Report - Inputs to Standards	7/1/2016
L2	[SP C.4.30] Report - Recommendations for Integration of CNPC and ATC Comm	9/19/2016
L2	[SP C.3.10] UAS CNPC Spectrum Final Report and Recommendations	9/23/2016
L2	[SP C.3.20] C-Band Planning & Standards Final Report	9/30/2016
L2	[SP C.4.50] Report - SatCom for UAS Sim Report	9/30/2016

Table 12. TC-C2 L2 milestones.

MS Level	Task Name	Commitment Date
L2	[SP H.1.30] Full-Mission Simulation 1: Levels of Automation Start Execution	7/1/2013
L2	[SP H.1.20] Measured Response Simulation C Start Execution	10/2/2013
L2	[SP H.2.10] GCS HF Draft Guidelines (Whitepaper) complete	12/13/2013
L2	[SP H.1.20] Measured Response Simulation C Results	2/19/2014
L2	[SP H.1.40] Part-task Simulation 4: SAA Pilot Guidance Start Execution	2/24/2014
L2	[SP H.1.30] HSI FM1 Briefing to RTCA	5/22/2014
L2	[SP H.1.40] HSI PT4 Briefing to RTCA	8/28/2014
L2	[SP H.1.40] Part-task Simulation 4B: SAA Pilot Guidance Start Execution	9/2/2014
L2	[SP H.1.10] HSI IHITL Briefing to RTCA	11/20/2014
L2	[SP H.1.70] Part-task Simulation 5: SAA Pilot Guidance Follow-on Start Execution	2/18/2015
L2	[SP H.1.70] HSI PT5 Briefing to RTCA	5/29/2015
L2	[SP H.1.90] Visual Requirements for Landing Analysis Report	6/1/2015
L2	[SP H.2.30] GCS HF Final Guidelines Start Execution	4/20/2016
L2	[SP H.1.80] Part Task Simulation 6: Full-Mission 2 Start Execution	6/6/2016
L2	[SP H.1.80] HSI PT6 Briefing to RTCA	7/15/2016
L2	[SP H.2.20] GCS HF Draft Guidelines	7/15/2015
L2	[SP H.2.30] GCS HF Final Guidelines	7/29/2016

Table 13. TC-HSI L2 milestones.

MS Level	Task Name	Commitment Date
L2	[SP T.2.30] IHITL Distributed Test Environment / IHITL SRR (IRT)	11/6/2013
L2	[SP T.2.30] IHITL Distributed Test Environment SWRR (delta LVC)	12/18/2013
L2	[SP T.2.20] IHITL Simulation Test Plan	1/15/2014
L2	[SP T.2.10] IHITL Scenarios and Airspace Development Baselined	2/6/2014
L2	[SP T.2.30] IHITL Test Environment Flight Design Review (FDR) Complete	3/5/2014

MS Level	Task Name	Commitment Date
L2	[SP T.2.40] IHITL Interface Control Document (ICD) and Configuration Freeze (all code/algorithms finished) (checklist)	4/3/2014
L2	[SP T.2.30] IHITL Test Readiness Review (TRR)	5/30/2014
L2	[SP T.2.50] IHITL Sim Start	6/9/2014
L2	[SP T.3.10] SAA Initial Flight Tests Delta CDR Complete	8/18/2014
L2	[SP T.3.10] SAA Initial Flight Tests FRR Complete	9/5/2014
L2	[SP T.4.30] FT3/FT4 SRR Complete	9/9/2014
L2	[SP T.3.30] Testing of Ikhana GCS and LVC-DE Complete	9/25/2014
L2	[SP T.3.10] SAA Initial Flight Tests Tech Brief /AFSRB	10/21/2014
L2	[SP T.3.40] SAA Initial Flight Tests Ikhana ready for Flights	11/3/2014
L2	[SP T.4.20] FT3 Test Plan	1/5/2015
L2	[SP T.1.10] SSI Algorithms Integrated into LVC	1/9/2015
L2	[SP T.2.60] IHITL Relevant Environment Evaluation Report	2/17/2015
L2	[SP T.4.30] FT3 FDR Complete	3/9/2015
L2	[SP T.3.40] Integrated SAA Initial Flight Tests Report	3/18/2015
L2	[SP T.4.40] FT3 Stand-up & Integration - Configuration Freeze	4/2/2015
L2	[SP T.4.10] FT3 airspace tested in LVC & FT3 scenarios Baselined	4/15/2015
L2	[SP T.4.30] FT3 Tech Brief	6/10/2015
L2	[SP T.4.50] Initiate Flight Test Series 3	6/17/2015
L2	[SP T.5.20] FT4 Test Requirements to Stakeholders	8/14/2015
L2	[SP T.4.50] Integrated Flight Test 3 Flight Test Report	10/15/2015
L2	[SP T.1.10] Deliver traffic scenario files	12/18/2015
L2	[SP T.5.40] FT4 Requirements Freeze	1/28/2016
L2	[SP T.4.60] FT3 Relevant Environment Evaluation Report	4/15/2016
L2	[SP T.5.40] FT4 Design TIM	2/3/2016
L2	[SP T.5.50] Software Baseline	2/16/2016
L2	[SP T.5.50] Finalize Flight Test Plan	2/19/2016

MS Level	Task Name	Commitment Date
L2	[SP T.5.50] Begin Validation Testing	2/22/2016
L2	[SP T.5.50] Conduct LVC/Ikhana CST	3/11/2016
L2	[SP T.5.50] Completed Integrated LVC/Ikhana Ground Test	3/18/2016
L2	[SP T.5.50] Complete IT&E Flight Test Cards	3/30/2016
L2	[SP T.5.40] FT4 Tech Brief	3/31/2016
L2	[SP T.5.50] FT4 Integrated System Checkout Flights Complete	4/8/2016
L2	[SP T.5.40] Conduct Project Engineer Test Data Review	4/19/2016
L2	[SP T.5.60] Initiate Flight Test Series 4	4/25/2016
L2	[SP T.5.70] Stakeholder Feedback Report	7/29/2016
L2	[SP T.5.60] Integrated Flight Test 4 Flight Test Report	8/5/2016
L2	[SP T.5.70] FT4 Relevant Environment Evaluation Report	8/31/2016
L2	[SP T.1.20] Submit LVC Leave behind document.	9/14/2016

Table 14. TC-ITE L2 milestones.

MS Level	Task Name	Commitment Date
L2	[SP N.1.20] Final Report on extensions to the TCB Complete	12/19/2014
L2	[SP N.2.10] sUAS Testing Execution Start	12/19/2014
L2	[SP N.2.10] RFI Assessment Report Complete	11/18/2014
L2	[SP N.1.20] Select additional extensions of TCB Complete	3/31/2015
L2	[SP N.1.10] GSN Safety Case Package Complete	4/30/2015
L2	[SP N.2.20] Start of ADS-B FT	1/22/2016
L2	[SP N.1.10] Type Certification basis finalized Complete	5/25/2016

L2	[SP N.2.10] Final Integrated Data Analysis <Report>	10/31/2016

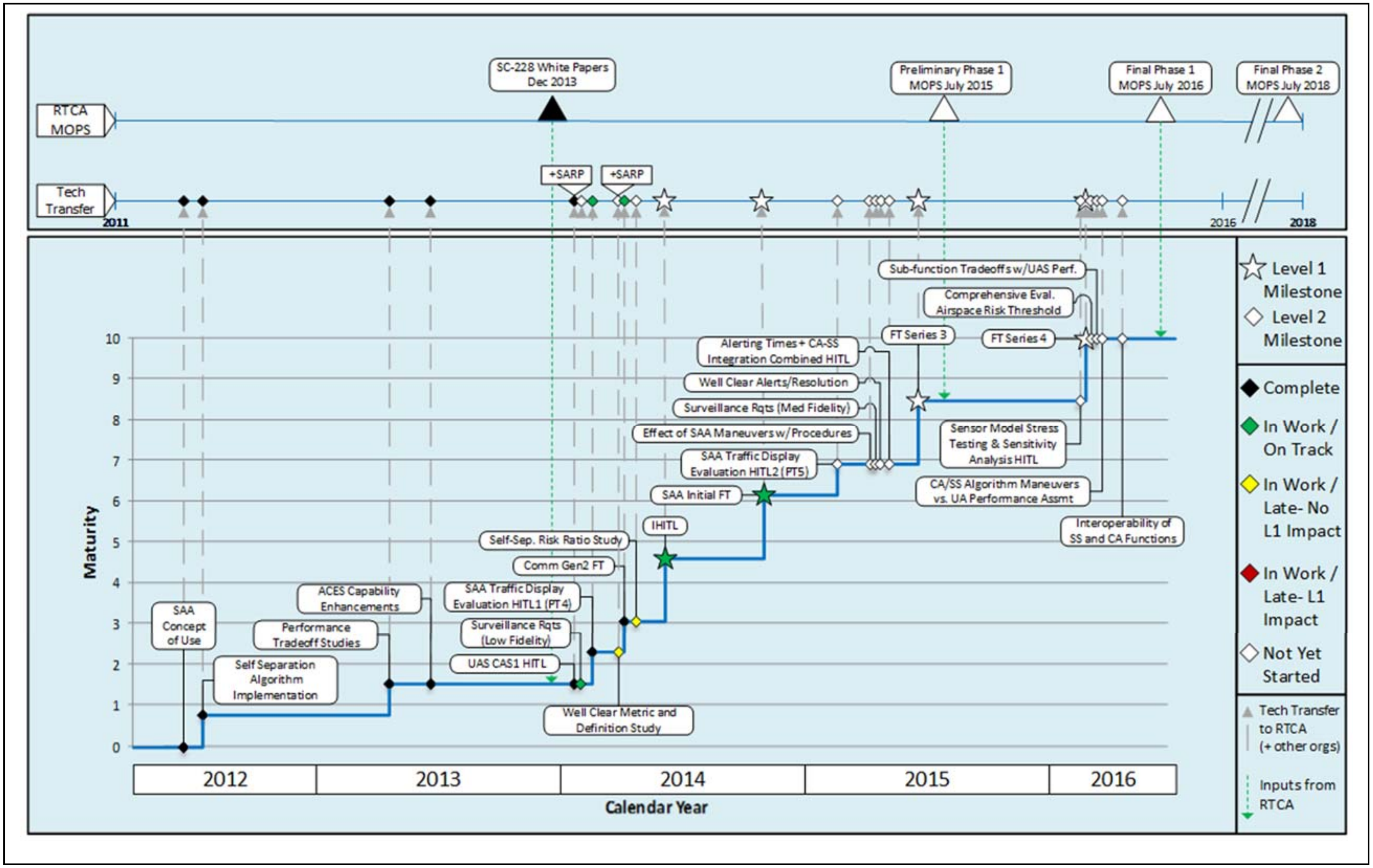
Table 15. Non-TC L2 milestones.

MS Level	Task Name	Commitment Date
L2	SC-228 DAA Whitepaper Consolidated NASA Comments Submitted	12/5/2013
L2	Define Certification Study	2/3/2014
L2	Draft of Comprehensive Research Report	7/15/2016
L2	Comprehensive Research Report	9/30/2016

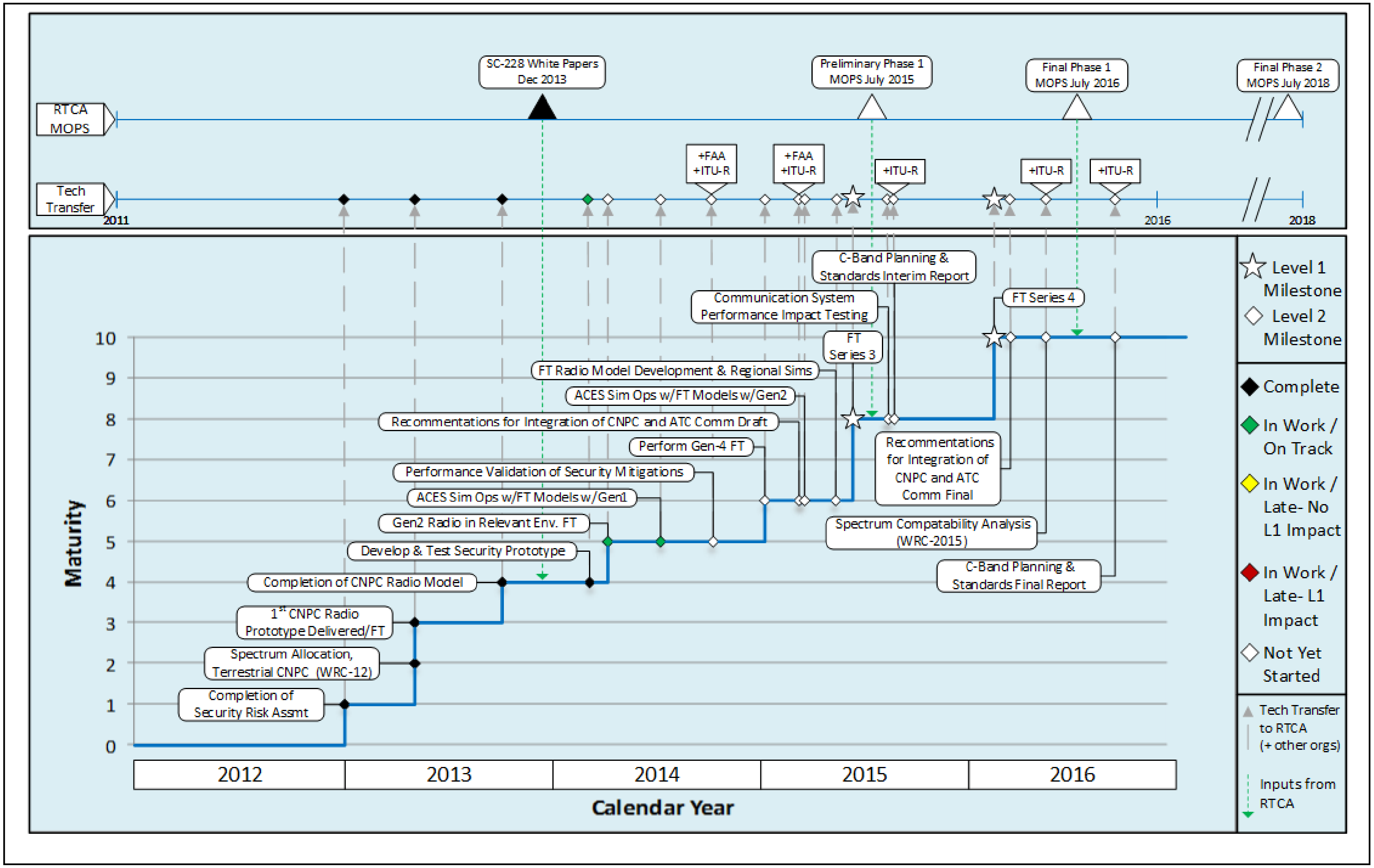
Table 16. Project Office L2 milestones.

Appendix B: Progress Indicators

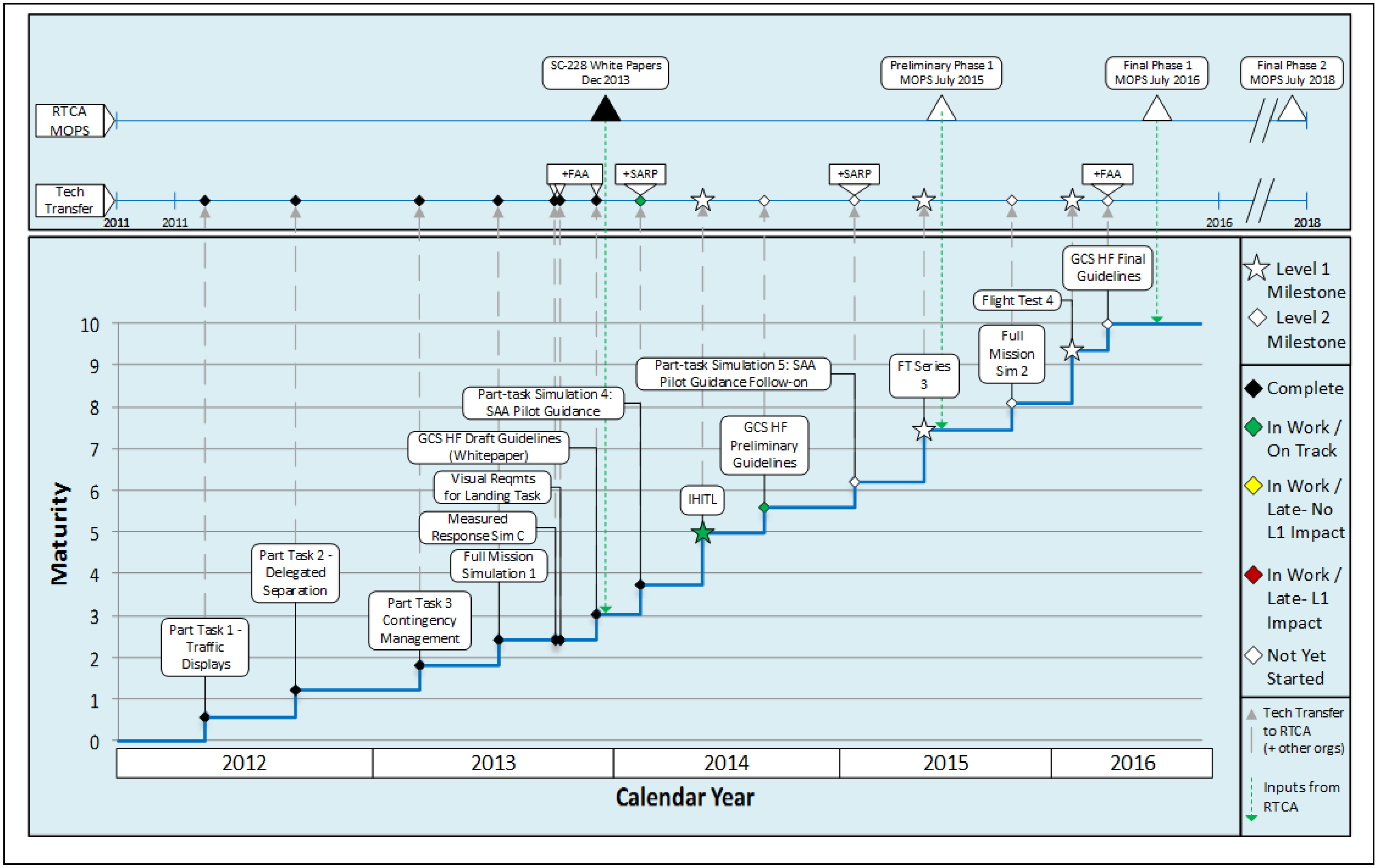
Appendix B1: TC-SAA Progress Indicators (as of Baseline Review 5/16/2014)



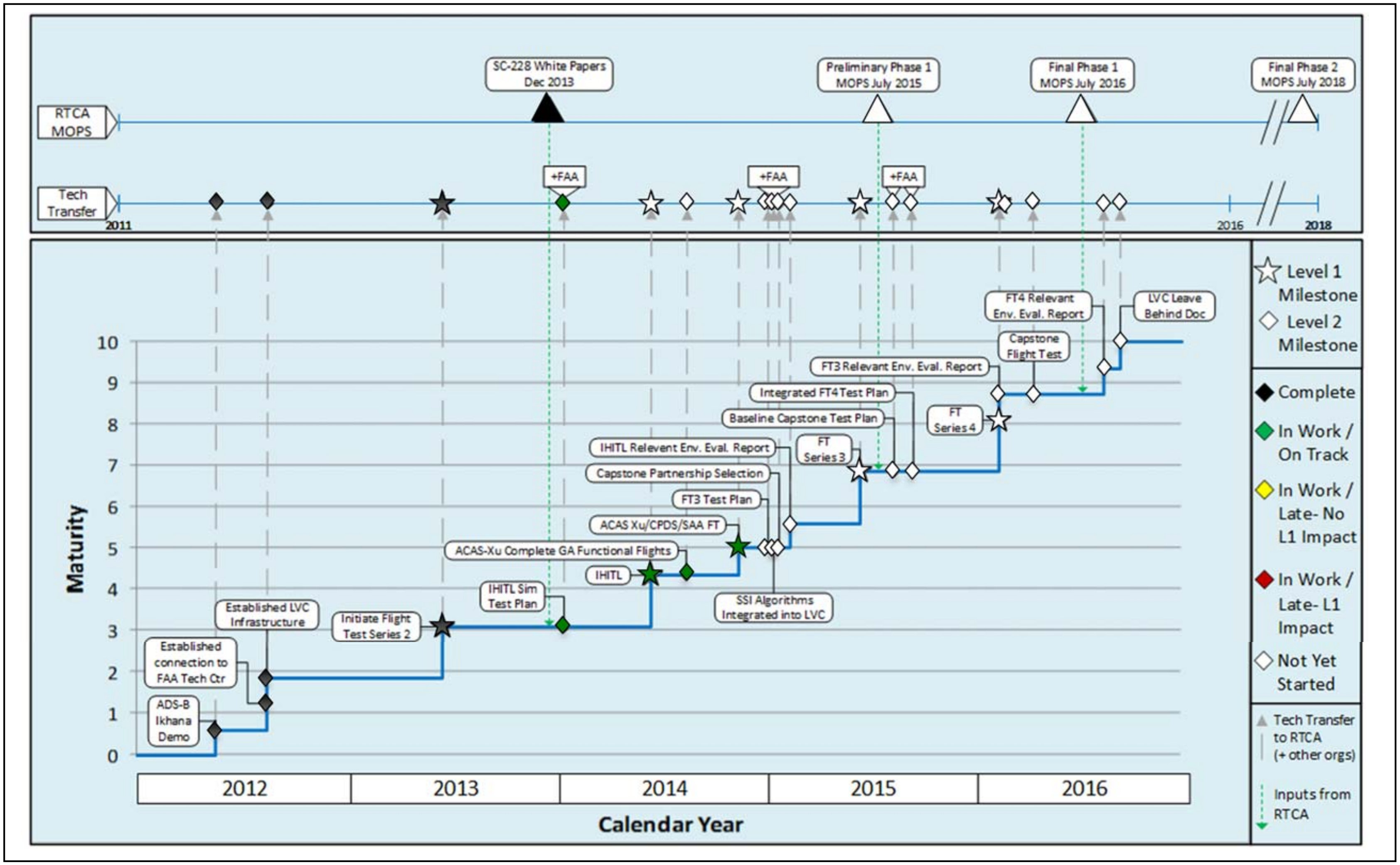
Appendix B2: TC-C2 Progress Indicators (as of Baseline Review 5/16/2014)



Appendix B3: TC-HSI Progress Indicators (as of Baseline Review 5/16/2014)



Appendix B4: TC-ITE Progress Indicators (as of Baseline Review 5/16/2014)



Appendix C: Phase 1 Accomplishments

Appendix C1: SSI Subproject Phase 1 Accomplishments

In Phase 1, the SSI Subproject began developing and evaluating concepts for integrating UAS with the air traffic system that account for characteristics typical of these new aircraft. The table below contains a detailed list of SSI subproject Phase 1 accomplishments, the stakeholder recipient of these, and benefit to the UAS community.

Accomplishments	Stakeholder	Community Benefit
UAS Concept of Integration for SAA Equipped Vehicles	Project, UAS Tech Community, FAA, SC-228	Concept used as the basis of SAA evaluation experiments to generate operational experience and quantitative data needed to support the development of SAA equipage standards
Seventeen UAS aerodynamic and operational performance models developed	SC-203, SC-228, FAA, UAS Tech Community	These models will enable simulation of realistic UAS trajectories and flight profiles.
Algorithm and UAS Use Concept Modifications	Project	Project benefit only
Airspace Concept Evaluation System (ACES) UAS simulation capability enhancements	Project	Allows evaluation of UAS impact on the Air Traffic Control (ATC) system and requirements for SAA systems.
Airspace integration and impact journal paper	UAS Tech Community, FAA, SC-228	Study shows impact slow-flying UAS will have on existing manned traffic.
Deliver initial algorithm & ICD to IT&E	Project	Project benefit only
Completion and publication of formal SAA model [Traffic Alert and Collision Avoidance System (TCAS) II Algorithm]	SC-228, FAA, Science and Research Panel (SARP), UAS Tech Community	A mathematical model of the TCAS-II Resolution Advisory (RA) logic implemented as an algorithm for RA detection as part of the Stratway^{+} capability.
NASA Self-Separation algorithm and pilot guidance display implemented	SC-228, FAA, SARP, UAS Tech Community	Prototype pilot guidance to support pilot self-separation functions based on the Stratway+ algorithm and the notion of prevention bands displayed on the UAS ground control station.
Well clear study published at AIAA Aviation 2013 conference	UAS Tech Community, FAA, SC-228	Informs the definition of well clear and provided initial data used as the basis for a community accepted definition of this airborne separation standard.

Accomplishments	Stakeholder	Community Benefit
UAS-specific capacity constraints report	UAS Tech Community, FAA, SC-228	Define requirements for UAS operations in Class A airspace and evaluate a possible mitigation to their impact on existing aircraft.
Six sets of missions modeled and 13 more will be created over the next 18 months	Project	Uses socio-economic modeling to project future UAS operations so their impact on the NAS and SAA system requirements can be determined.
Multi-Aircraft Control System (MACS) Demonstration of Simulation Capability	SC-228, FAA, SARP, UAS Tech Community	Project benefit only
Sensor models and fusion/tracking algorithms for SAA systems developed	Project	Models for the major sensor systems currently expected to provide surveillance data on intruder aircraft for SAA systems (ADS-B, TCAS transponders, electro-optical, and radar).
SAA algorithm integration and modification with ACES and LVC-DE Gateway [Joint Optimal Collision Avoidance (JOCA), ACAS-Ua, Autoresolver]	Project	This capability allows evaluation of requirements for SAA systems using the most mature algorithms currently being flight-tested.
SAA algorithm-display integration initial capability demonstrated in joint HSI-SSI simulation July 2013	Project	Capability allows SSI to select an algorithm for evaluation independently of HSI's selection of a traffic display, and for IT&E to route the information being passed between these systems between any laboratory, NASA or collaborator facility.
Report on functional decomposition of separation responsibilities for SAA concept of use	UAS Tech Community, FAA, SC-228	A novel, structured way to develop an SAA concept of use based on the decomposition of functional responsibilities in maintaining safe separation. This will inform development of pilot and controller procedures for separating aircraft.

Appendix C2: Communications Subproject Phase 1 Accomplishments

In Phase 1, the Communications Subproject began interacting with the SSI, HSI, and IT&E subprojects, in order to deliver needed communication system parameters, while receiving input on refined requirements of the communication system. They formed a CRADA with Rockwell Collins for the developmental CNPC radios. The table below contains a detailed list of Communications subproject Phase 1 accomplishments, the stakeholder recipient of these, and benefit to the UAS community.

Accomplishments	Stakeholder	Community Benefit
Spectrum: Deliver line of sight (LOS) Spectrum Studies to Working Party (WP) 5B	SC-203,International Telecommunications Union – Radio Communication Sector (ITU-R)	Provide technical data for standards development; Control and Non Payload Communication (CNPC) system simulation; enhance CNPC radio design
Spectrum: Deliver beyond – line-of-sight (BLOS) Spectrum Studies to WP5B	SC-203, ITU-R	Provide technical data for standards development; CNPC system simulation; enhance CNPC radio design
Datalink: Industry Partner Contract Awarded	Project	Project benefit only
Spectrum: World Radiocommunication Conference 2012	SC-203, ITU-R	Paper presentation
Security: Threat Report	FAA, SC-203	Provide technical data for standards development; CNPC system simulation; enhance CNPC radio design
Security: Vulnerability Report	FAA, SC-203	Develop and evaluate systems to mitigate vulnerabilities
Datalink: Finalize simulation and In-situ measurements test plan	SC-203, ITU-R	Provide technical data for standards development; CNPC system simulation; enhance CNPC radio design
Datalink: Gen 1 Radios delivered to Glenn Research Center (GRC)	Project	CNPC radio performance evaluation for improved design and standards development
Datalink: Deliver results flight from simulation and In-situ measurements tests to appropriate standards bodies	SC-203, American Society for Testing and Materials (ASTM) F38, International Civil Aviation Organization (ICAO)	Provide technical data for standards development; CNPC system simulation; enhance CNPC radio design
Datalink: Report on flight-testing of Gen 1 communication system prototype	SC-203, ASTM F38, ICAO	CNPC radio performance evaluation for improved design and standards development
Security: Risk Assessment report	FAA, SC-203	Develop and evaluate systems to mitigate risk
Security: Risk Mitigation report	FAA, SC-203, ASTM F38, ICAO	Develop and evaluate systems to mitigate risk
ICAO ACP WG-F #26: Working Paper 7: "Assessment of Technologies for UAS Line-	ICAO	Data for ICAO

Accomplishments	Stakeholder	Community Benefit
of-Sight Control and Non-Payload Communications"		
ICAO ACP WG-F #26: Information Paper 8: "L-Band and C-Band Air-Ground Channel Measurement Campaign"	ICAO	Data for ICAO
ICAO ACP WG-F #27: Working Paper 20: "Results of the UAS Line-of-Sight CNPC Technology Assessment"	ICAO	Data for ICAO
ICAO ACP WG-F #27: Working Paper 21: "Results of for UAS Line-of-Sight Control and Non-Payload Communications Waveform Trade Study"	ICAO	Data for ICAO
ICAO ACP WG-F #25: Working Paper 13: "Development of CNPC Systems for UAS"	ICAO	Data for ICAO
ICAO ACP WG-F #28: Information Paper 3: "Update on L-Band and C-Band Air-Ground Channel Measurement Campaign"	ICAO	Data for ICAO
M&S: Report on C2 models ground and flight-testing	SC-203, ASTM F38	Simulation of CNPC radio and NAS-wide CNPC system performance
M&S Report on NAS wide communications performance with candidate communication technologies simulations for selected regions	SC-203, FAA	Simulation of CNPC radio and NAS-wide CNPC system performance
M&S: Flight Test Radio Simulation Plan	SC-203, FAA	Simulation of CNPC radio and NAS-wide CNPC system performance
M&S: 1st Model (Gen 1) Defined	SC-203, FAA	Simulation of CNPC radio and NAS-wide CNPC system performance
M&S: Complete 1st Model (Gen 1) Prototype	SC-203, FAA	Simulation of CNPC radio and NAS-wide CNPC system performance
M&S: Gen 1 Model Performance Report	SC-203, FAA	Simulation of CNPC radio and NAS-wide CNPC system performance
M&S: Satellite Communication (SatCom) System/Architecture Study	SC-203, FAA	Simulation of CNPC radio and NAS-wide CNPC system performance

Appendix C3: HSI Subproject Phase 1 Accomplishments

In Phase 1, the HSI Subproject began performing Part Task Simulations and a Full Mission Simulation in order to begin the validation of their concepts. The table below contains a detailed list of HSI subproject Phase 1 accomplishments, the stakeholder recipient of these, and benefit to the UAS community.

Accomplishments	Stakeholder	Community Benefit
GCS: Hold invited workshop with leading Human Factors (HF) researchers, HSI team, and SMEs	UAS Tech Community, DoD, DHS, FAA	Defined community issues, vetted program goals and methods
GCS: Measured Response Simulation A Results	FAA	Defined UAS pilot response distribution
GCS: Document part-task simulation 1 (Class "XX") results for nominal UAS operations	UAS Tech Community, DoD, DHS, FAA	Benefits to both Pilots and Controllers when a traffic display is present in the GCS evidence by significantly higher pilot situational awareness on several dimensions and significantly lower workload for pilots when communicating with ATC.
GCS: Develop matrix of aircraft class "x" and airspace "z" requirements/capabilities for NAS compliant ground station	UAS Tech Community, DoD, DHS, FAA	Basis for development of requirements
GCS: Develop a catalog of current GCS technologies	UAS Tech Community, DoD, DHS, FAA	Defined community issues, vetted program goals and methods
GCS: Document part-task simulation 2 (Class "XX") results for delegated separation	UAS Tech Community, DoD, DHS, FAA	Assessed ability of UAS pilots to perform self-separation
GCS: Measured Response Simulation B Results	FAA	Defined UAS pilot response distribution
GCS: Document part-task simulation 3 (Class "XX") results for contingency operations	DoD, DHS, FAA	Tested standard contingency management procedures with ATC
Guidelines: Assess current efforts of HF guidelines for operations in the NAS	SC-203, FAA, DoD, DHS	Basis for development of requirements

Appendix C4: Integrated Test & Evaluation Phase 1 Accomplishments

In Phase 1, the IT&E Subproject built up the core integrated test and evaluation infrastructure, a Live Virtual Constructive (LVC) Distributed Environment (DE), to enable the Phase 2 integrated testing to occur in a relevant environment. The table below contains a detailed list of IT&E subproject Phase 1 accomplishments, the stakeholder recipient of these, and benefit to the UAS community.

Accomplishments	Stakeholder	Community Benefit
Simulation and Demonstration Facilities Functionalities/Purpose/ Inadequacies Document	Project	An initial assessment of simulation and demonstration facilities required for Project
Test Planning and Coordination (develop scenarios, data analysis plan, flight-test plan)	Project	Initial test planning and coordination of testing requirements based upon subproject needs
ADS-B In and Out Flight testing. Initial integration of Live UAS data to LVC	Project, FAA	Collected ADS-B "as installed" performance flight data that served to inform the LVC architecture design.
Deliver IT&E Phase 2 Test Program Plan	Project	An initial assessment of the Phase 2 test plans
Human-in-the-Loop (HITL) & Flight Test Strategies Developed [Agency Performance Goal (APG) FY12]	IASP, Project	A comprehensive projection of the test objectives and preliminary requirements for the Project
Finalize Test Plan (Flight Test 2)	Project	Define testing requirements for Flight Test (FT) 2
Complete initial evaluation of the Prototype LVC simulation environment using a live UAS	Project	Project use of an LVC distributed environment to test technology
Integrated Human-in-the-Loop (IHITL) Simulation Test Plan	Project	Define testing requirements for IHITL
Established connection to FAA Tech Center	Project, FAA	Coordination between the UAS-NAS Project and the FAA through sims and flight-test
Established LVC Infrastructure	UAS Tech Community, DoD, FAA, Project	Project use of an LVC distributed environment to test technology
UAS Surrogate System Requirements Review	Project	UAS surrogate that can be used to validate technology
Live Virtual Constructive-Distributed Environment (LVC-DE) System Requirements Review	Project	Document system requirements for the LVC-DE

Accomplishments	Stakeholder	Community Benefit
LVC-DE Critical Design Review	Project	Finalize the design for the LVC-DE
Completed LVC Characterization Test	UAS Tech Community, DoD, FAA, Project	Characterization of the LVC
LVC Characterization Test Report	UAS Tech Community, DoD, FAA, Project	Project use of LVC capabilities to implement relevant environment

Appendix C5: Certification Subproject Phase 1 Accomplishments

In Phase 1, Certification subproject provided recommendations to improve safety data collection. The table below contains a detailed list of Certification subproject Phase 1 accomplishments, the stakeholder recipient of these, and benefit to the UAS community.

Accomplishments	Stakeholder	Community Benefit
Request for Information (RFI) for "Virtual" Type Certification	FAA UAPO	"Virtual Type Certification" case study initiated. RFI solicitation was issued on 02-09-12 and closed 03-26-12. Canceled due to two companies initiating Type Certification requests.
Provide recommendations for hazard and risk-related data collection, storage and analysis	FAA UAPO & FAA UAS	Provide recommendations for hazard and risk-related data collection, storage and analysis Research Program
Complete report on comparative analysis of classification and certification approaches	FAA UAPO & FAA UAS Research Program	Supports use of the existing aircraft classification framework for UAS certification, but with tailoring for possible new unmanned aircraft categories
UAS Safety Data – Collection & Analysis	UAS Tech Community	Provides recommendations to improve safety data collection to facilitate analysis of UAS hazards; for example, extending the Aviation Safety Reporting System (ASRS) to better capture relevant data from UAS incidents

Appendix C6: Small UAS Task Phase 1 Accomplishments

In Phase 1, the small UAS task performed flight activity to stimulate the small UAS rule. The table below contains a detailed list of small UAS team Phase 1 accomplishments, the stakeholder recipient of these, and benefit to the UAS community.

Accomplishments	Stakeholder	Community Benefit
Conducted a number of night sUAS Operations	FAA	This activity benefited the FAA through an NASA Research Announcement (NRA) with New Mexico State University (NMSU) on night sUAS operations
Guidelines: sUAS Information Requirements Report	FAA, ASTM F38	This activity provided a report on sUAS information requirements
Developed wide-angle tower-view sUAS simulation with manual input GCS capabilities	UAS Tech Community	Wide-angle tower-view for small UAS

Appendix D: Annual Performance Indicators/Annual Performance Goals

The UAS-NAS Project FY12 - FY16 Annual Performance Goals and Annual Performance Indicators, and their respective success criteria are shown below:

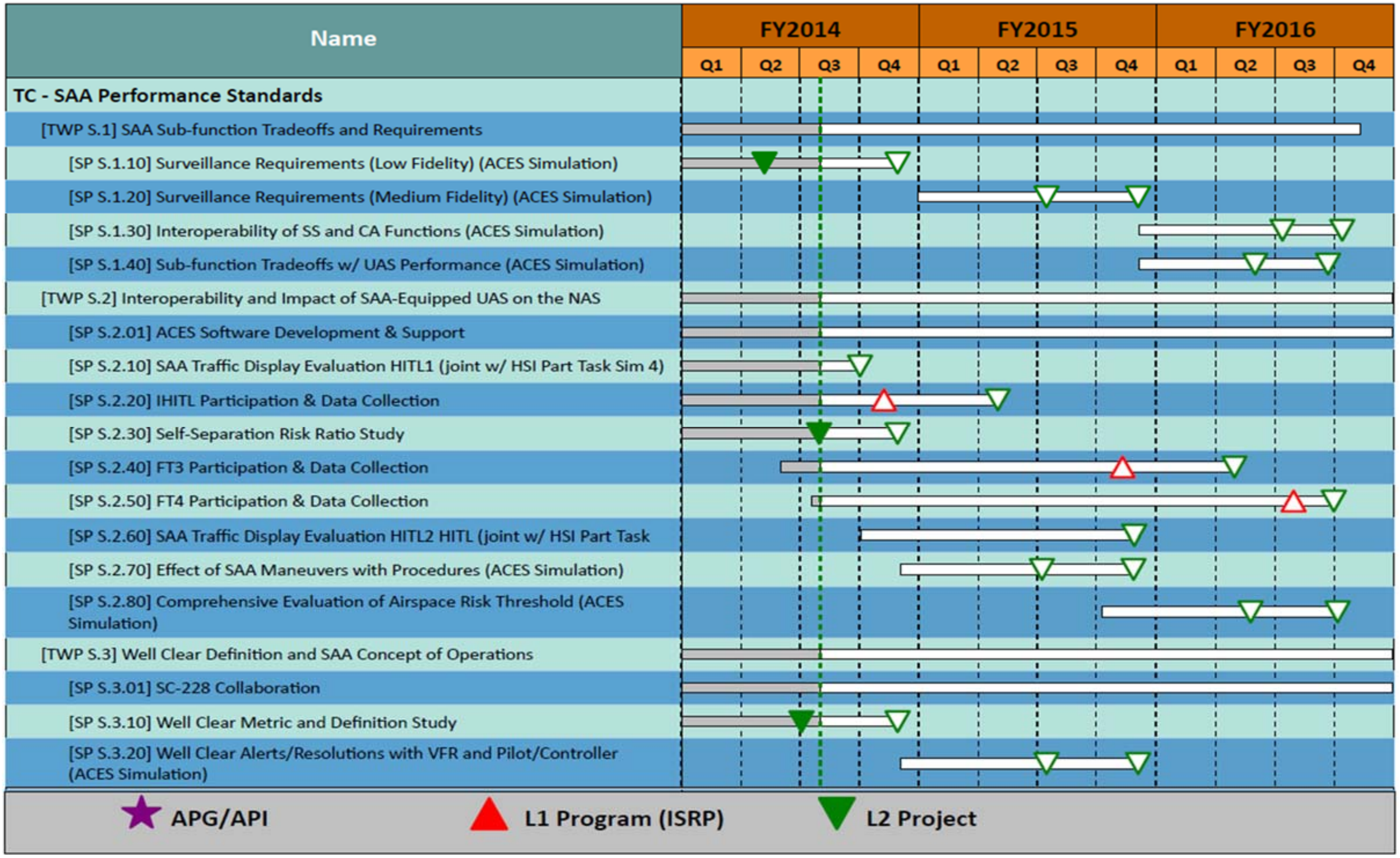
- **FY12 APG: Develop integrated Human Systems Integration, Communications, and Separation Assurance/Sense and Avoid Interoperability subproject test concept and Phase 2 test objectives necessary to achieve human-in-the-loop simulation and flight-test series milestones supporting the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project.**
  - Success criteria
    - Green – Complete and document the plan for the integrated Human Systems Integration, Communications, and Separation Assurance subproject test concept and Phase 2 test objectives necessary to achieve human-in-the-loop simulation and flight-test series milestones supporting the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project.
    - Yellow – Complete and document the plan for the integrated Human Systems Integration, Communications, and Separation Assurance subproject test concept, but unable to document Phase 2 test objectives for Human Systems Integration, Communications, and Separation Assurance subprojects necessary to achieve human-in-the-loop simulation and flight-test series milestones supporting the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project.
    - Red – Unable to complete and document an integrated test concept and Phase 2 test objectives for Human Systems Integration, Communications, and Separation Assurance subprojects necessary to achieve human-in-the-loop simulation and flight-test series milestones supporting the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project.

- **FY13 APG: Complete flight evaluations to assess the capabilities of the Live, Virtual, Constructive (LVC) distributed simulation environment.**
  - Success criteria
    - Green – Complete flight evaluations involving live and virtual aircraft operations in a simulated NAS. Analyze the test results and characterize the LVC system performance.
    - Yellow – Complete evaluations involving virtual aircraft operations in a simulated NAS. Analyze the test results and characterize the LVC system performance.
    - Red – Unable to complete evaluations involving virtual aircraft operations in a simulated NAS, or unable to analyze test results and characterize the LVC system performance.
- **FY14 APG: Conduct a human-in-the-loop (HITL) simulation where UAS aircraft are mixed with manned aircraft and subjected to a range of test conditions.**
  - Success criteria:

    - Green – Complete and report on a Human-In-The-Loop simulation where UAS aircraft are mixed with manned aircraft and subjected to a range of test conditions (i.e., separation alerts, communication latencies).
    - Yellow – Complete a fully-integrated system infrastructure check in preparation for a Human-In-The-Loop simulation where UAS aircraft are mixed with manned aircraft and subjected to a range of test conditions (i.e., separation alerts, communication latencies).
    - Red – Complete a software check of individual, non-integrated systems in preparation for a Human-In-The-Loop simulation where UAS aircraft are mixed with manned aircraft and subjected to a range of test conditions. (i.e., separation alerts, communication latencies).
- **FY15 Annual Performance Indicator (API): Deliver data, analysis, and recommendations based on integrated simulations and flight-tests to the RTCA Special Committee on minimum operational performance standards (MOPS) for Unmanned Aircraft Systems to support preliminary MOPS development.**
  - Success criteria
    - Green – Provide data, analysis and recommendations based on fully completed integrated simulation and flight-test (Part Task Simulation 5, CNPC flight-test series, and DAA flight-test series) to SC-228 Working Groups to support preliminary MOPS development.
    - Yellow – Provide data, analysis, and recommendations based on two completed elements of the integrated simulation and flight-test (Part Task Simulation 5, CNPC flight-test series, and DAA flight-test series) to SC-228 Working Groups to support preliminary MOPS development.
    - Red – Unable to provide data, analysis and recommendations based on at least two completed elements of the integrated simulation and flight-test (Part Task Simulation 5, CNPC flight-test series, and DAA flight-test series) to SC-228 Working Groups to support preliminary MOPS development.
- **FY16 API: Deliver data, analysis, and recommendations based on integrated simulation and flight test series with simulated traffic or live vehicles to the RTCA Special Committee on Minimum Operational Performance Standards (MOPS) for Unmanned Aircraft Systems to support development of the final MOPS.**
  - Success Criteria
    - Green – Provide data, analysis and recommendations based on four fully completed integrated simulation and flight tests (Part Task Simulation 6; CNPC flight test series; and flight test series 3 and 4) to SC-228 Working Groups to support development of final MOPS.
    - Yellow – Provide data, analysis and recommendations based on at least two fully completed integrated simulation or flight tests (Part Task Simulation 6; CNPC flight test series; and flight test series 3 and 4) to SC-228 Working Groups to support development of final MOPS.
    - Red – Unable to provide data, analysis and recommendations based on completing integrated simulation and flight tests (Part Task Simulation 6; CNPC flight test series; and flight test series 3 and 4) to SC-228 Working Groups to support development of final MOPS.

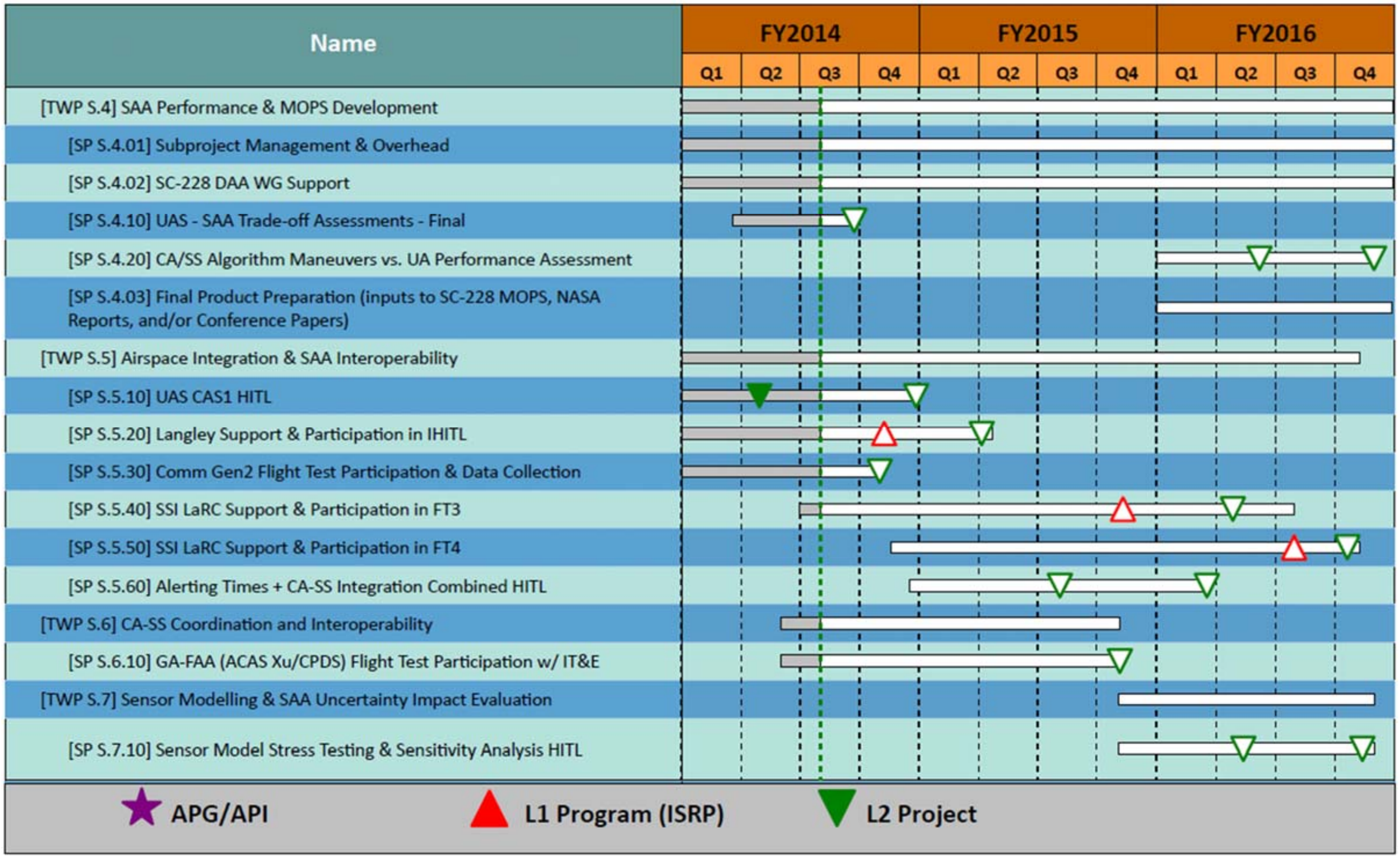
Appendix E: Schedules

Appendix E1: TC-SAA Schedule (as of Baseline Review 5/16/2014)

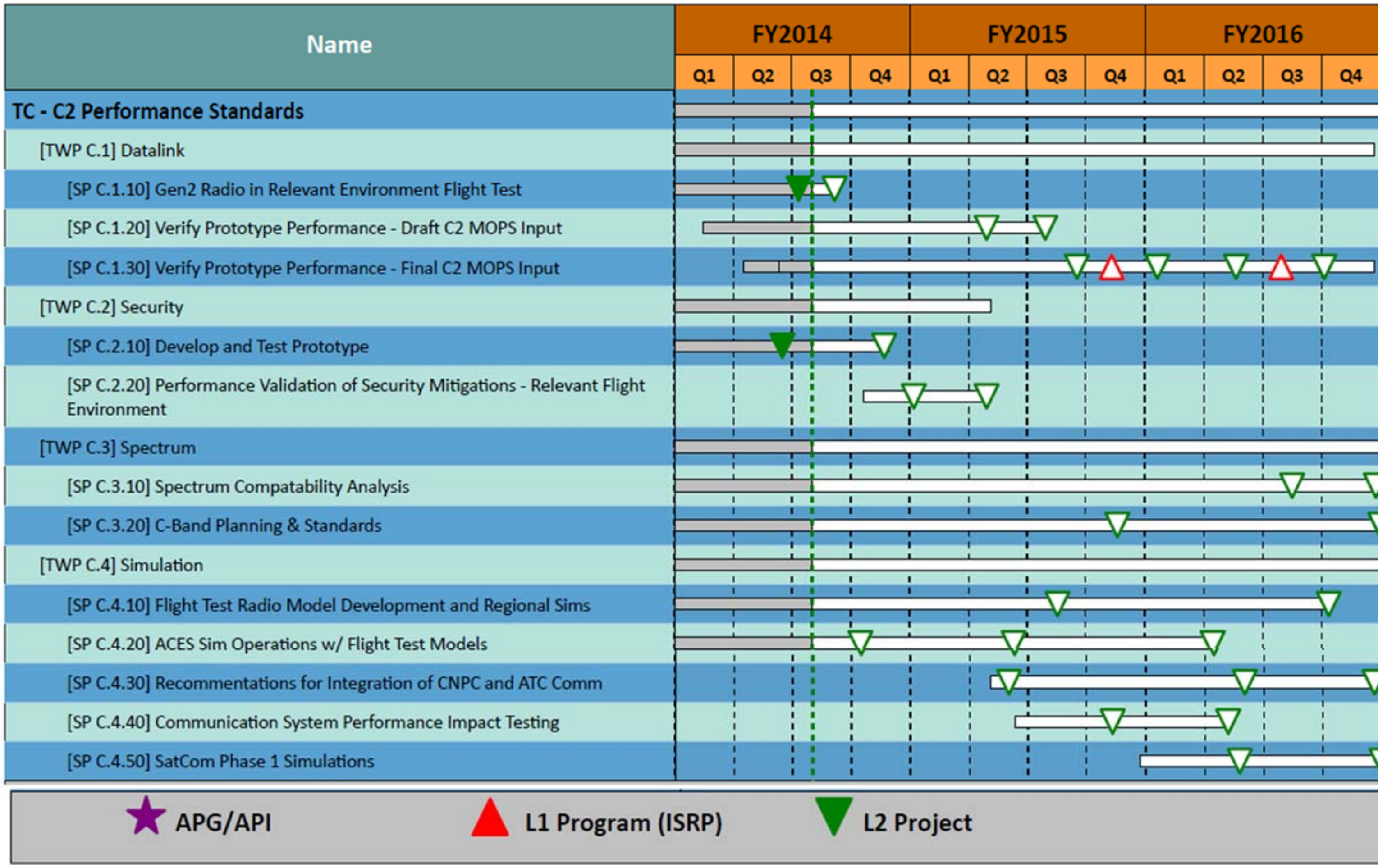


The Integrated Systems Research Program (ISRP) is the former name of IASP prior to the ARMD reorganization in 2015

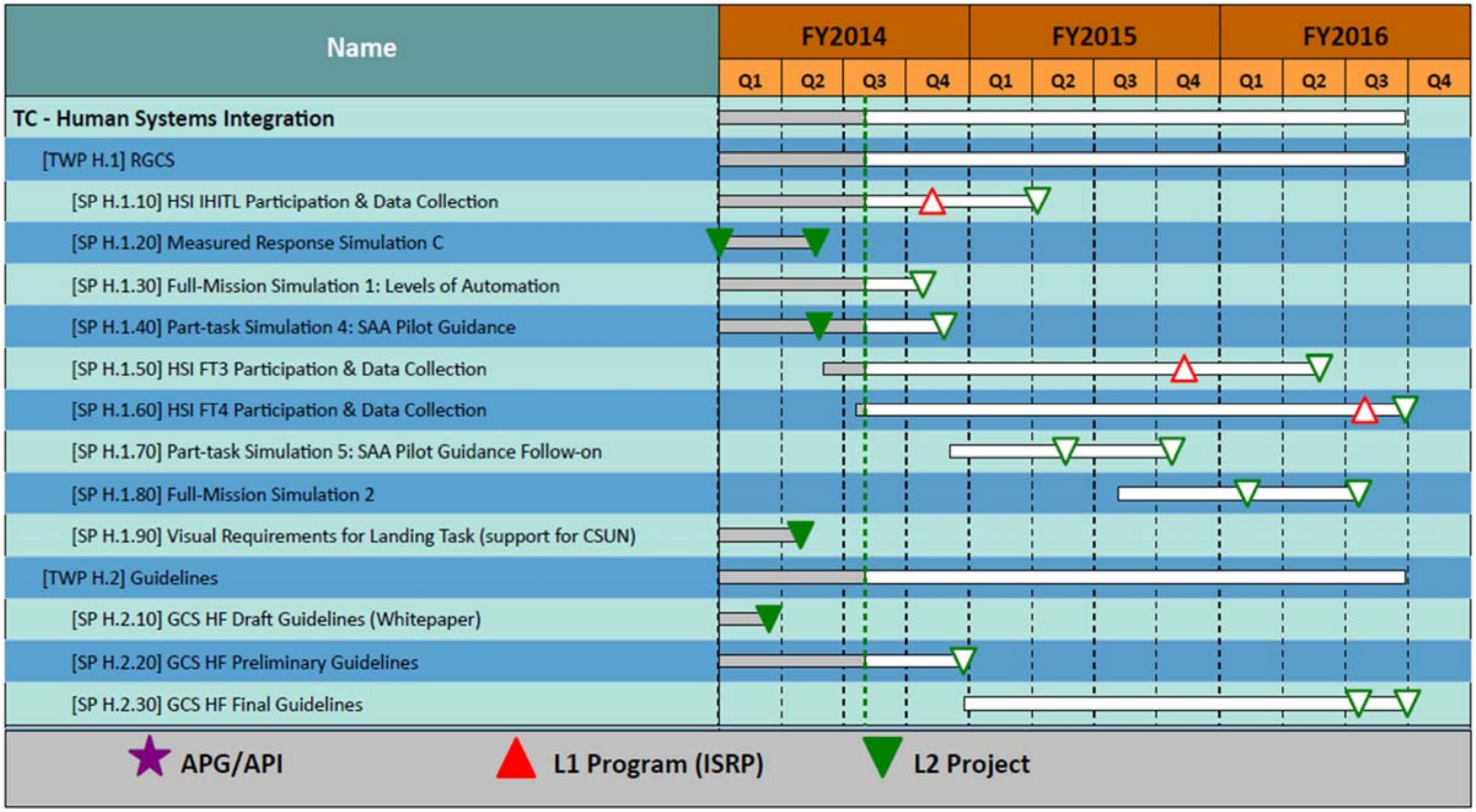
Appendix E1: TC-SAA Schedule Continued (as of Baseline Review 5/16/2014)



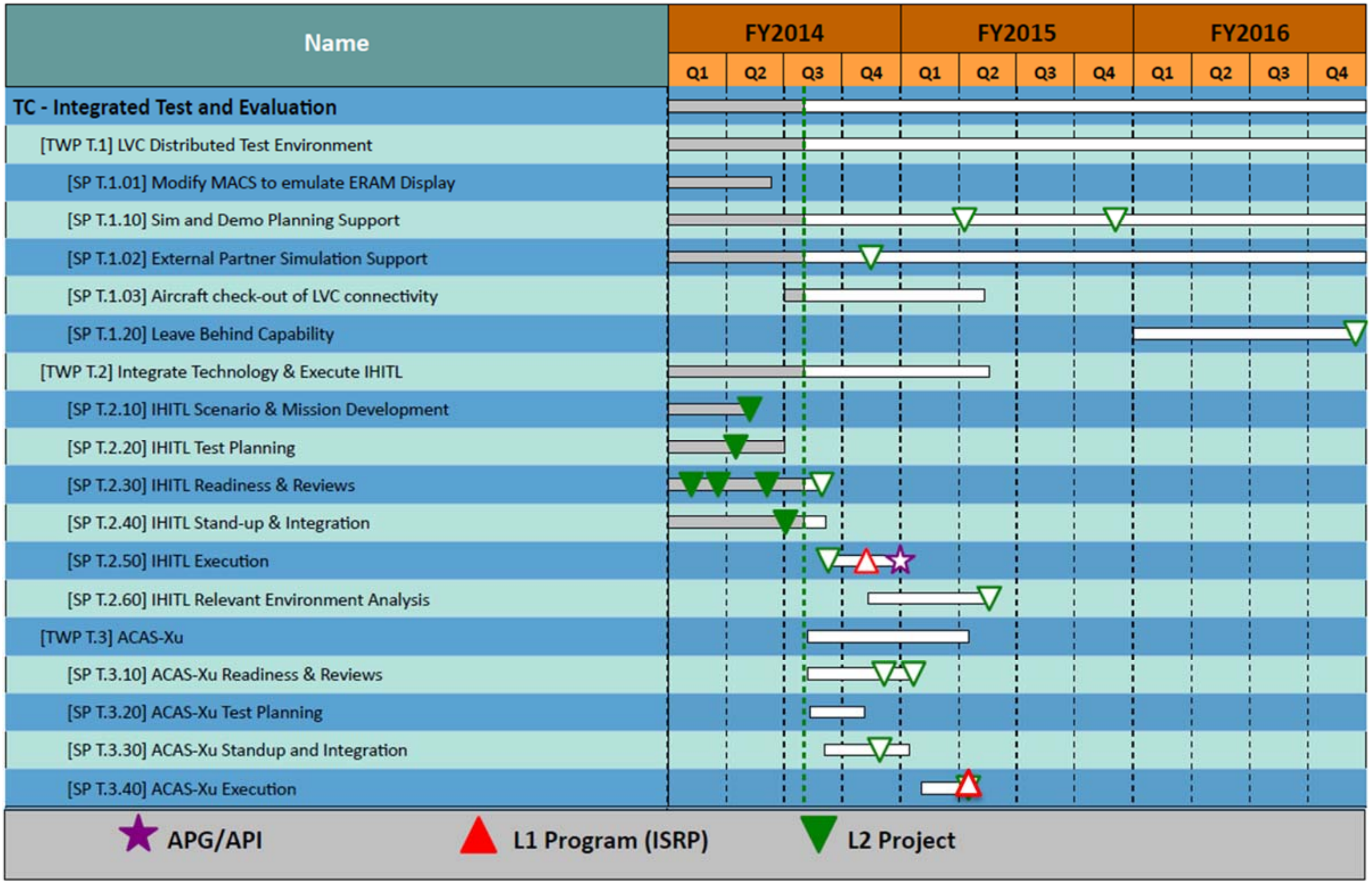
Appendix E2: TC-C2 Schedule Continued (as of Baseline Review 5/16/2014)



Appendix E3: TC-HSI Schedule Continued (as of Baseline Review 5/16/2014)



Appendix E4: TC-ITE Schedule Continued (as of Baseline Review 5/16/2014)



Appendix F: References

Title	Dated
American Recovery and Reinvestment Act (ARRA)	2009
AFRC Systems Engineering Requirements Doc DPR-7123.1-001	Latest version
AFRC Project Chief Engineer's Handbook DHB-R-007	Latest version
AFRC Objectives and Requirements Handbook DHB-R-002	Latest version
AFRC Project Managers' Manual DCP-P-025	Latest version
General Accounting Office (GAO) report# 08-511: Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System	May 2008
FAA Modernization and Reform Act of 2012	February 2012
IASP Plan	May 2012
IASP Change Management Plan	Latest version
IASP Risk Management Plan	Latest version
Interagency Agreement Between NASA and the FAA Concerning Unmanned Aircraft Systems Research and Technology Development	July 2012
MQ-1 Predator/MQ-9 Reaper Security Classification/Declassification Guide	August 2009
NASA Records Management NASA Procedural Document (NPD) 1440.6	Latest version
NASA Records Retention Schedules NPR 1441.1	Latest version
NASA Research and Technology Program and Project Management Requirements NPR 7120.8	Latest version
NASA Research and Technology Program and Project Management Requirements NPR 7123.8	Latest version
NASA Risk Management Procedural Requirements NPR 8000.4	Latest version
NASA Security of Information Technology NPR 2810.1	Latest version
NASA Space Flight Program and PM Requirements NPR 7120.5	Latest version
NASA/SP-2007-6105 NASA Systems Engineering Handbook	Latest version
NASA SE Processes and Requirements NPR 7123.1	Latest version
National Aeronautics Research and Development Plan	February 2010

Title	**Dated**
National Environmental Policy Act and Executive Order 12114 NPR 8580.1	Latest version
NRC Decadal Survey of Civil Aeronautics	2006
NRC Meeting of Experts	August 5, 2010
Terms of Reference RTCA Special Committee 228 Minimum Performance Standards for Unmanned Aircraft Systems RTCA Paper No. 109-13/PMC-1089	May 20, 2013
UAS-NAS Project Formulation Review	October 21, 2010
UAS-NAS Project Plan (Phase 1)	29 July 2013

Appendix F: Acronyms

ACAS	Airborne Collision Avoidance System
ACES	Airspace Concept Evaluation System
ACMC	Armstrong Center Management Council
ACP	Aeronautical Communications Panel
ADS-B	Automatic Dependent Surveillance – Broadcast
AFRC	Armstrong Flight Research Center
AFRL	Air Force Research Lab
AFSRB	Airworthiness and Flight Safety Review Board
APG	Annual Performance Goal
API	Annual Performance Indicator
ARC	Ames Research Center
ARD	Aeronautics Research Director
ARMD	Aeronautics Research Mission Directorate
ARRA	American Recovery and Reinvestment Act
AOSP	Airspace Operations and Safety Program
ASRS	Aviation Safety Reporting System
ASTM	American Society for Testing and Materials
AT&L	Acquisition, Technology and Logistics
ATC	Air Traffic Control
ATD	Airspace Technology Demonstration
ATM	Air Traffic Management
ATP	Aeronautics Test Program
AvSP	Aviation Safety Program
BLOS	Beyond-Line-of-Sight
BW	business warehouse
C2	Command and Control
CA	Collision Avoidance
CANSO	Civil Air Navigation Services Organization
CDP	Content Decision Process
CEA	Center Export Administrator
Cert	certification
CFR	Code of Federal Regulations
CMB	Change Management Board
CMC	Center Management Council
CNPC	control and non-payload communication
COA	Certificate of Authorization or Waiver

Comm	communication
ConOps	Concept of Operations
CONUS	Continental United States
CRM	continuous risk management
CSE	Chief Systems Engineer
CSU	California State University
CSULB	California State University Long Beach
CSUN	California State University Northridge
DAA	Detect and Avoid
DATR	Dryden Aeronautical Test Range
DDTC	Directorate of Defense Trade Controls
DHS	Department of Homeland Security
DoD	Department of Defense
DPM	Deputy Project Manager
DPMf	Deputy Project Manager for
DPMI	Deputy Project Manager - Integration
EC	Experimental Certificate
ECR	Export Control Representative
ERT	Engineering Review Team
ExCom	Executive Committee
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FDC	Flight Demonstrations and Capabilities
FDR	Flight Design Review
FFRDC	Federally Funded Research and Development Center
FINAS	Flight in Non-Segregated Airspace
FN	Foreign National
FT	flight-test
FTE	full time equivalent
FY	fiscal year
GA-ASI	General Atomics – Aeronautical Systems Inc.
GAO	General Accounting Office
GCS	ground control station
GDS	Great Dismal Swamp
GRC	Glenn Research Center
GSN	Goal Structuring Notation
HF	human factors
HITL	human-in-the-loop

HSI	human systems integration
IASP	Integrated Aviation Systems Program
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
ID	identification
IFR	instrument flight rules
IHITL	integrated human-in-the-loop
IMS	integrated master schedule
IRT	Independent Review Team
ISM	Instrument/Scientific/Medical
ISRP	Integrated Systems Research Program
ITAR	International Traffic in Arms Regulation
IT&E	Integrated Test and Evaluation
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union Radio Communication Sector
JOCA	Jointly Optimal Collision Avoidance
JPDO	Joint Planning and Development Office
K	Kilo (1,000)
KDP	Key Decision Point
LaRC	Langley Research Center
LOS	line of sight
LVC-DE	Live Virtual Constructive – Distributed Environment
M	Million (1,000,000)
MACS	Multi-Aircraft Control System
MASPS	minimum aviation system performance standards
MIT/LL	Massachusetts Institute of Technology/Lincoln Labs
MOA	Memorandum of Agreement
MOPS	minimum operational performance standards
MRB	Management Review Board
M&S	modeling and simulation
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NextGen	Next Generation Air Transportation System
NMSU	New Mexico State University
NPD	NASA Procedural Document
NPR	NASA Procedural Requirement
NRA	NASA Research Announcement
OGA	other government agencies

OSD	Office of the Secretary of Defense
PBFA	Policy Board of Federal Aviation
PD	Program Director
PE	Project Engineer
PGCS	Prototype GCS
PI	progress indicator
PM	Project Manager
PMC	Project Management Committee
PMT	Project Management Tool
PO	Project Office
PRD	Project Requirements Document
Q	quarter of a year
R&T	research and technology
RFI	Request for Information
RIDM	Risk Informed Decision Making
RMB	Risk Management Board
RPAS	Remotely Piloted Aircraft System
RT	Research Themes
SA	Separation Assurance
SAA	Sense and Avoid
SARP	Science and Research Panel
SASO	Safe Autonomous Systems Operations
SatCom	Satellite Communication
SBIR	Small Business Innovative Research
SC	special committee
SEMP	System Engineering Management Plan
SFAR	Special Federal Aviation Regulation
SMA	Safety and Mission Assurance
SMART-NAS	Shadow Mode Assessment Using Realistic Technologies for the NAS
SMD	Science Mission Directorate
SMP	Schedule Management Plan
SP	schedule package
SS	self-separation
SSI	Separation Assurance/Sense and Avoid Interoperability
STEM	Science, Technology, Engineering, and Mathematics
sUAS	small UAS
SWG	Schedule Working Group
SWRR	Software Requirements Review

TA	technical authority
TAA	Technical Assistance Agreement
TC	Technical Challenge
TCAS	Traffic Alert and Collision Avoidance System
TL	Technical Lead
ToR	terms of reference
TPWG	Test Planning Working Group
TRR	Test Readiness Review
TSO	Technical Standards Orders
TTCP	Technology Transfer Control Plan
TTP	Technology Transfer Plan
TWP	Technical Work Package
UA	unmanned aircraft
UAPO	Unmanned Aircraft Program Office
UAS	unmanned aircraft systems
UASIO	Unmanned Aircraft Systems Integration Office
UND	University of North Dakota
USC	University of South Carolina
USFWS	United States Fish and Wildlife Service
USMC	United States Marine Corps
V&V	Verification & Validation
VFR	visual flight rules
VSCS	Vigilant Spirit Control Station
WBS	Work Breakdown Structure
WG	Working Group
WP	Working Party
WRC	World Radio Conference
WRC-12	World Radio Conference 2012
WRC-15	World Radio Conference 2015