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)

25 September 2017

By signing this document, you are certifying that the content herein is acceptable as direction for managing this program (or project) and that you will ensure its implementation by those over whom you have authority.

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Foreword

This Project Plan is based on 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 the 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 (PM), without a signature requirement.

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 is rapidly expanding to encompass a broad range of civil activities including aerial photography, land and crop surveying, communications and broadcast, forest fire monitoring, environmental condition monitoring, and critical infrastructure protection. 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 might have on the worldwide economy.

The United States 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 progress made by the FAA in implementing the congressionally-mandated requirements of the FAA Modernization and Reform Act of 2012. Also in 2014, the National Research Council 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 Office of Unmanned Aircraft Systems (AUS)[1] to address the integration of UAS safely and efficiently into the NAS. The FAA is collaborating with many stakeholders, including manufacturers, industry, trade associations, technical standards organizations, academic institutions, research and development centers, and Government agencies, including NASA. The integration of UAS in the NAS is being accomplished in ways similar to integration of any comparable new technology, including ensuring that the introduction and integration of the new technology neither decreases safety nor reduces capacity in the NAS. While progress toward integration continues, many technology challenges and research opportunities exist. Areas of research include aspects of the UAS command and control (C2) data link, spectrum, detect and avoid (DAA) (synonymous with sense and avoid, or SAA), and human factors. The minimum aviation system performance standards (MASPS) and minimum operational performance standards (MOPS) contribute to certifying UAS operations in the NAS.

The FAA Unmanned Aircraft Systems Integration Office (UASIO) requested that RTCA develop MOPS for DAA and C2 data link equipment. In response, RTCA[2] established Special Committee 228 (SC-228), Minimum Performance Standards for UAS, in 2013. In establishing SC-228, the RTCA concluded SC-203, Minimum Performance Standards for Unmanned Aircraft Systems. The SC-228 terms of reference (ToR) described two phases for MOPS development.

SC-228 Phase 1 MOPS development focused on civil UAS equipped to operate in Class A airspace under instrument flight rules (IFR) and using L-band terrestrial and C-band terrestrial

[1] The AUS was formerly known as the Unmanned Aircraft Systems Integration Office (UASIO).
[2] RTCA was incorporated on November 14, 1991.The name of the corporation is RTCA, Inc.

data links. More specifically, the SC-228 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, and traversing Classes D and E, and perhaps Class G airspace. SC-228 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 (V&V) test program (delivered in July of 2015); final SC-228 Phase 1 C2 MOPS based on the result of the V&V activities (published in September of 2016) and the SC-228 Phase 1 DAA MOPS (published in March 2017).

A follow-on phase, SC-228 Phase 2 MOPS development, is 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 satellite communications (SatCom) in multiple bands as a C2 data link to support UAS. Phase 2 deliverables will be defined in White Papers.

To address UAS-NAS integration technical challenges, NASA initiated the UAS integration in the NAS (UAS-NAS) Project within the Integrated Aviation Systems Program[3] (IASP) of the Aeronautics Research Mission Directorate (ARMD) in 2010. The UAS-NAS Project approach 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 consists of two phases, with Phase 1 having a Part 1 from FY11 - FY13 [hereafter referred to as Phase 1 – Part 1] and a Part 2 from FY14 - FY16 [hereafter referred to as Phase 1 – Part 2]. Phase 2 of the Project is hereafter referred to as Phase 2.

Phase 1 - Part 1 included development and integration of system-level key concepts, technologies, and procedures based on UAS stakeholder and community needs collected during UAS-NAS Project formulation. This phase also included refinement of those needs as part of defining the specifics of the Phase 1 - Part 2 research portfolio. Phase 1 - Part 1 research activities were continued in Phase 1 - Part 2 and modified as necessary based on the research portfolio. Phase 1 - Part 2 of the Project included demonstration of the integrated technologies in operationally-relevant environments. The technology areas selected for Phase 1 - Part 2 included SAA, command and control (C2), human systems integration (HSI), and integrated test and evaluation (IT&E) for live, virtual, constructive - distributed environment (LVC-DE) development. This selection was accomplished by way of a fairly rigorous content decision process (CDP), described below, 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 Phase 1 - Part 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.

Phase 2 of the Project was formulated simultaneously with the final year of execution for Phase 1 - Part 2 during the Planning, Programming, Budgeting and Execution (PPBE) fiscal year (FY) 2018 process. The technology areas selected for Phase 2 include DAA, C2, and systems integration and operationalization (SIO). This selection was accomplished using the same basic CDP from Phase 1 - Part 2 noted above.

1.2 History

[3] IASP was formerly known as the Integrated Systems Research Program (ISRP).

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, the 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. The Access 5 Project 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 the Access 5 Project, the FAA created the Unmanned Aircraft Program Office (UAPO). Additionally, the Access 5 Project contributed to the establishment of RTCA SC-203. The SC-203 was formed to help ensure the safe, efficient, and compatible operation of UAS with other vehicles operating within the NAS. The Access 5 Project 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 the Department of Defense (DoD), the Department of Homeland Security (DHS), and NASA. These process improvements were focused on creating exceptions to the Federal Aviation Regulations (FAR), and not on creating enduring solutions that might be relevant in the Next Generation Air Transportation System (NextGen) time frame.

In 2010, the NASA Aeronautics Research Mission Directorate (ARMD) 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 United States 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 UAS-NAS 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, utilizing simulation and flight tests, to support the development and validation of DAA and C2 technologies necessary for integrating Unmanned Aircraft Systems into the National Airspace System.*

The following information is referenced from the ARMD Web site, https://www.nasa.gov/aeroresearch/strategy :

The project goal supports two of the ARMD Strategic Thrusts (see section 1.5 for a detailed explanation of thrusts). Figure 1 below references ARMD Strategic Thrust 1 and 6. Each thrust

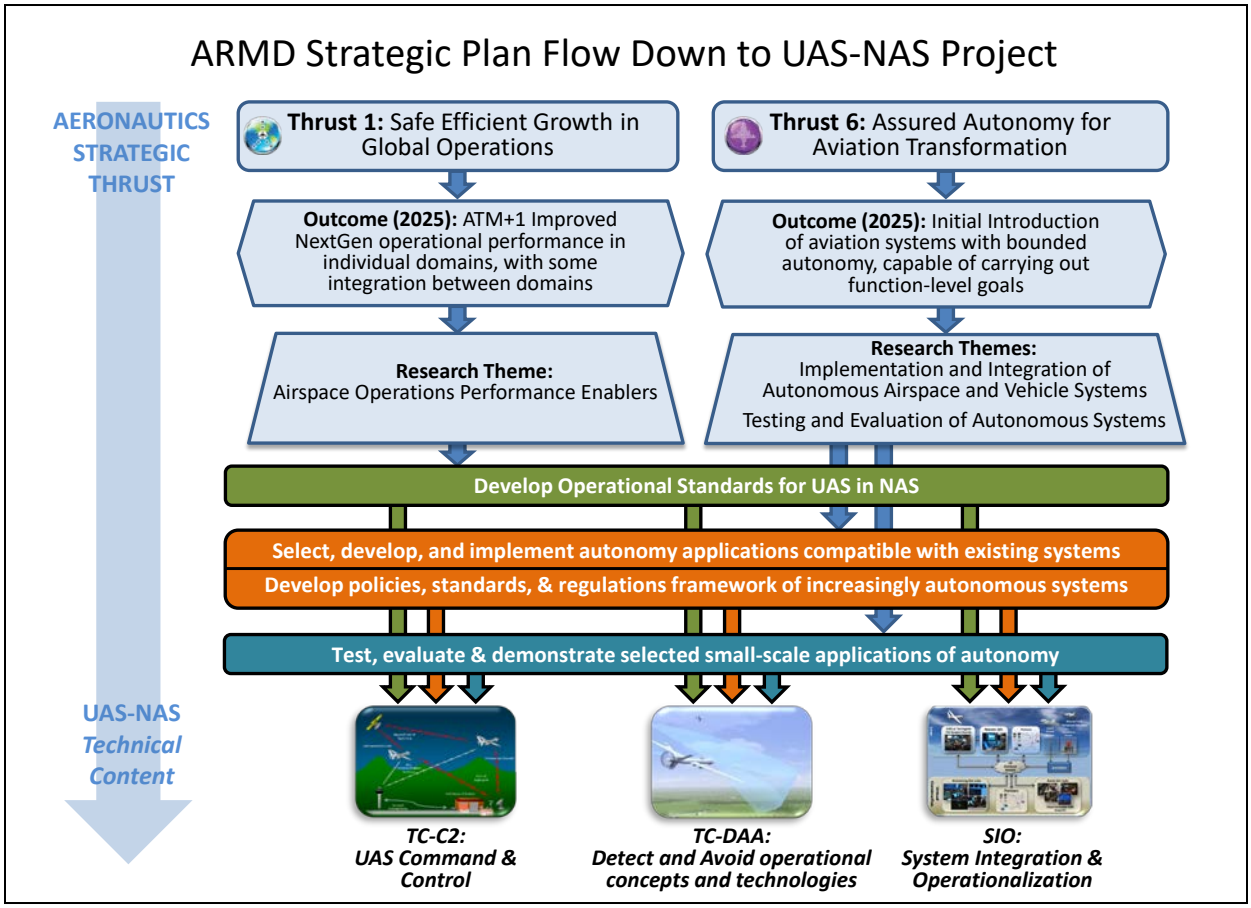


Figure 1: ARMD Strategic Plan Flow Down to UAS-NAS Project

is decomposed into Research Themes and Aeronautics Technical Challenges that maps to the project's technical work. Three of the ARMD Research Themes (RTs) support Thrusts 1 and 6 and the Project goal:

ARMD RT (Thrust 1): Airspace Operations Performance Enablers
ARMD TC: Develop Operational Standards for UAS in NAS

ARMD RT (Thrust 6): Implementation and Integration of Autonomous Airspace and Vehicle Systems
ARMD TC: Select, develop, and implement applications of autonomy that are compatible with existing systems
ARMD TC: Develop framework for co-development of policies, standards, and regulations with development and deployment of increasingly autonomous systems

ARMD RT (Thrust 6): Testing and Evaluation of Autonomous Systems
ARMD TC: Test, evaluate & demonstrate selected small-scale applications of autonomy

The ARMD RTs and ARMD Technical Challenges (TCs) are supported by two UAS-NAS Project TCs and a large scale demonstration activity that were developed by the Project and described below:

> *Technical Challenge Detect and Avoid Operational Concepts and Technologies - Develop Detect and Avoid (DAA) operational concepts and technologies in support of standards to enable a broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to detect and avoid manned and unmanned air traffic.*
>
> *Technical Challenge UAS Command and Control -. Develop Satellite (Satcom) and Terrestrial based Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage allocated protected spectrum.*
>
> *Demonstration Activity: Systems Integration and Operationalization (SIO) -- Demonstrate robust UAS operations in the NAS by leveraging integrated DAA, C2, and state of the art vehicle technologies with a pathway towards certification to inform FAA UAS integration policies and operational procedures.*

These Project TCs and demonstration activity are further decomposed into specific research activity Technical Work Packages (TWPs) and Schedule Packages (SPs) as described in the Schedule Management Plan (SMP)(Doc#: UAS-PRO-1.1-008).

The UAS-NAS Project is operating in an ever-changing environment guided in part by the needs of the FAA, by RTCA SC-228, and by the broader UAS community. Consequently, the UAS-NAS Project has developed management processes to remain agile to adapt to the needs of the customer and the community. The foundation of what the UAS-NAS Project is planning to deliver is not expected to change dramatically, but the 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 TC. The Project research activities, which comprise the Technical Baseline (TB), represent the research planned for the Project to be successful. The UAS-NAS Project measures success of the Project by completing the TB content per the approved baseline schedule within budget. Completing the TB content per schedule and budget maximizes the positive impact of the technology transfer of Project research findings to 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.

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 (DAA guidance, well clear definitions, C2 terrestrial radio prototypes, ground control station display and alerting methods, and modeling and simulation capabilities) for use in

informing the Phase 2 DAA MOPS and C2 MASPS and MOPS. Successful completion of these SC-228 MASPS and MOPS reduces the DAA and C2 barriers to UAS-NAS integration.

The UAS-NAS Project manages performance toward completing the TCs with Progress Indicators (PIs). Each TC has its own PI, which represents TC activities that the Project performs. PIs include the following content for each activity: activity start, the end of activity execution, technology transfer, status and health, and maturity of the data and information required to complete the TC. The PI captures the data collection for individual research activities and 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 PI provides insight into contributing research findings to develop and validate UAS Phase 2 DAA MOPS and C2 MASPS and MOPS as baselined in the UAS-NAS Project Phase 2 TB (Doc#: UAS-PRO-1.1-013). At the completion of all baselined research activities all activity research findings will have been applied toward the TC. Progress Indicators are described in more detail in section 3 of this Project Plan.

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 baselined Phase 2 portfolio is relevant to the NASA, ARMD, and IASP Vision, Mission, and Goals.

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.

- The UAS-NAS Project research is in the area of aeronautics.

NASA Strategic Goal 2: Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.

- The commercial applications envisioned for UAS operating routinely in the NAS will improve the quality of life on Earth.

NASA Objective 2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research.

- The UAS-NAS Project research findings will contribute directly to maintaining NAS safety and efficiency.

Aeronautics Strategic Thrust 1: Safe, Efficient Growth in Global Operations
Aeronautics Outcome (2015 – 2025): Improved NextGen Operational Performance in Individual Domains, with some Integration Between Domains (ATM+1)
Aeronautics Research Theme: Airspace Operations Performance Enablers

- Development and testing of sensors and automation will be part of a UAS-NAS Detect and Avoid Subproject and will drive UAS Ground Control Station displays.
- Development and testing of terrestrial radios will be part of a UAS-NAS C2 Subproject.
- The UAS-NAS Project research includes system-level tests of developing technologies in relevant environments.

Aeronautics Strategic Thrust 6: Assured Autonomy for Aviation Transformation
Aeronautics Outcome (2015 – 2025): Introduction of aviation systems with bounded autonomy, capable of carrying out function-level goals
Aeronautics Research Theme: Implementation and Integration of Autonomous Airspace and Vehicle Systems

- Development and testing of sensors and automation will be part of a UAS-NAS Detect and Avoid Subproject and will drive UAS Ground Control Station displays.
- Development and testing of terrestrial radios will be part of a UAS-NAS C2 Subproject.
- The UAS-NAS Project research includes system-level tests of developing technologies in relevant environments.

Aeronautics Strategic Thrust 6: Assured Autonomy for Aviation Transformation
Aeronautics Outcome (2015 – 2025): Introduction of aviation systems with bounded autonomy, capable of carrying out function-level goals
Aeronautics Research Theme: Testing and Evaluation of Autonomous Systems

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

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.

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

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. Next, related technical development activities assessment is discussed - important for avoiding duplication and to leverage previous work. Finally, the technical work accomplished in Phase 1 (2011-2016) is discussed, and the TCs for Phase 2, as well as other less formal challenges, are described.

2.1 Gap Analysis (Content Decision Process)

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

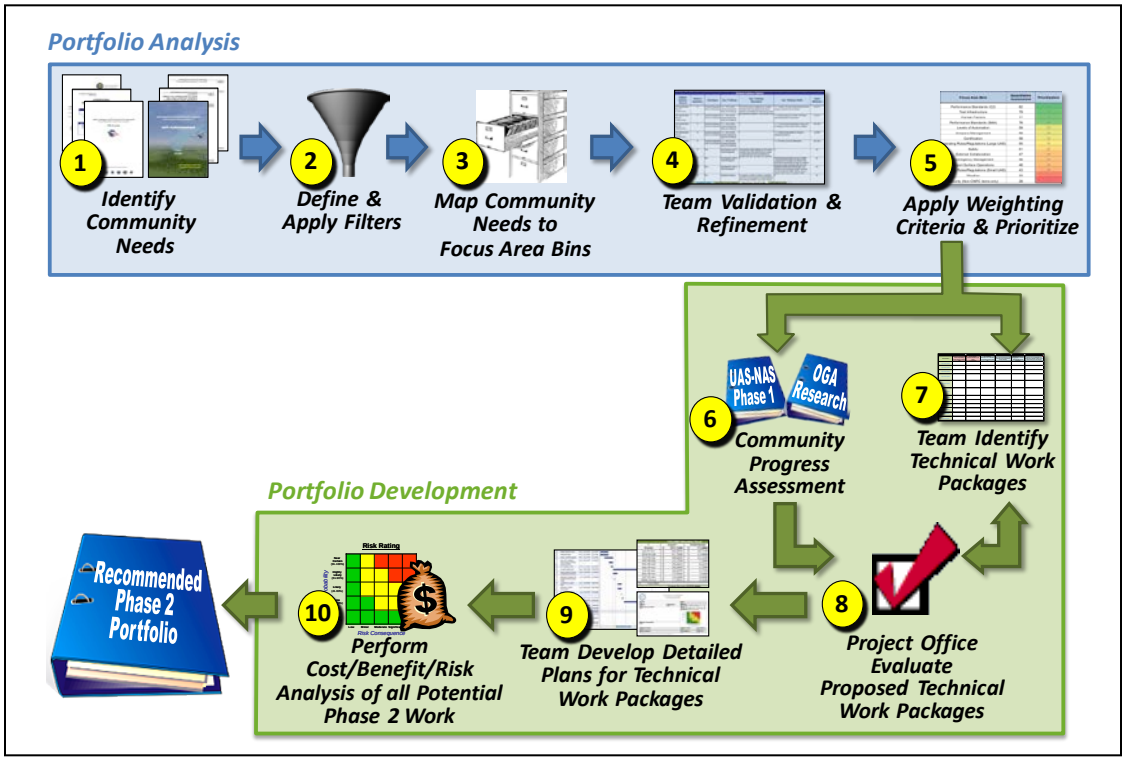


Figure 2. Content decision process.

The following steps were 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 or 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 and ARMD Mission, ARMD skills and 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 15 focus area bins.

Step 4: Team Validation and Refinement - A top-down (Project Office) and bottom-up (Project Engineers [PE] and Deputy Project Managers for [DPMf]) approach was used 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 and acceptance) was applied, followed by prioritization to identify lower-priority community needs that the Project did not pursue for Phase 1 - Part 2. Lowest-priority items were weather, airport surface operations, and non- control and non-payload communication system (non-CNPC) security. The four highest-rated focus area bins were SAA Performance Standards, C2 Performance Standards, Human Systems Integration (HSI), and Integrated Test and Evaluation (IT&E). These focus areas are also considered to be the primary focus areas, and ultimately became the Project TCs.

Step 6: Community Progress Assessment - Evaluated the progress made toward addressing the community needs identified in step 1 by NASA and other Government agencies (OGA), industry, and academic organizations to identify the remaining gaps.

Step 7: Team Identify TWPs - The Project programmatic and technical leadership team provided assessments of which community needs the Project should contribute toward in Phase 1 - Part 2. This assessment led to the development of individual TWPs.

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

Step 9: Team Develop Detailed Plans for TWP - The Project programmatic and technical leadership team developed detailed proposals for each TWP that would be considered for Phase 1 - Part 2. Twenty-eight TWPs were developed.

Step 10: Perform Cost, Benefit, and Risk Analysis for all Potential Phase 1 - Part 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 to the team. That portfolio was evaluated using the following factors: support of Phase 1 - Part 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 1 - Part 2 Portfolio consists of detailed plans that address the primary gaps without duplicating efforts within the 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 OGA to ensure efforts were complementary and non-duplicative. Efforts will be made throughout this Project to leverage work being conducted by our partner agencies and industry in order to collaborate wherever possible.

The Project leveraged the process that was used for Phase 1 - Part 2. Steps 1-5 were relevant to Phase 2 and were not repeated. Step 6 was completed by using the request for information acquisition process along with the completed Phase 1 (FY11 - FY16) work. Steps 7-9 were performed as defined above. A subset of Step 10 was performed: Project leadership conducted

an evaluation of technical content that could be accomplished within the ARMD resource allocation (cost/schedule) of greatest benefit to the UAS community.

2.2 Assessment of Related Technology Development Activities

An assessment of related technology development activities in other NASA programs, OGA, and the commercial sector has been conducted to avoid 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 duplication of effort, 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 (ATM) 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 (SA) 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 the AOSP Projects.

NASA ARMD UAV Projects – The NASA ARMD has developed a UAS Cohesive Strategy. The UAS-NAS Project will coordinate with all Projects working on UAS Integration research activities per the cohesive strategy.

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, the FDC Project operates, sustains, and enhances those specific flight research and test capabilities necessary to address and achieve the ARMD Strategic Plan, ARMD Program or Project activities, other NASA Mission Directorate activities, and national strategic needs. Specifically, the UAS-NAS Project utilized the Armstrong Flight Research Center (AFRC) support aircraft, Dryden Aeronautical Test Range (DATR) assets, and simulation capabilities.

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 partners around the world to answer fundamental questions requiring the view from and into space. The 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. The SMD augments the Ikhana UAS reimbursable project at AFRC that the UAS-NAS Project uses for flight-test activities.

FAA - The FAA has created the Office of Unmanned Aircraft Systems 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 the Department of Defense (DoD), the 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; universal solutions will be relevant in the NextGen time frame. Recently, the FAA released a publicly available Integration Roadmap to guide integration efforts in the coming years. The NASA has established a close relationship with the FAA in support of this Project to ensure efforts are coordinated and not duplicated. The project is formally coordinating with the FAA through a UAS Integration Research Transition Team (RTT) which provides documented Research Transition Products between the two agencies. The FAA is a primary stakeholder in UAS-NAS activities and a recipient of the Project technology transfer. The identification and selection of FAA UAS test sites also provides the Project with an opportunity for potential collaboration.

DoD – The 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. The NASA SAA research will complement these efforts.

Industry - Industry is primarily focused on building, selling, and operating UAS. Routine access facilitates their company goals. 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 MOPS. 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 there is no duplication of research, and to look for potential opportunities for collaboration. The UAS-NAS Project work has or will leverage others in forums where the Project has more involvement, such as the International Telecommunications Union Radio Communications Sector (ITU-R) World Radio Conference (WRC), European Organisation for Civil Aviation Equipment (EUROCAE), and the International Civil Aviation Organization (ICAO) Remotely Piloted Aircraft System (RPAS) Panel.

2.3 Project Phase 1 (Part 1 and 2)

The UAS Integration in the NAS Project was originally intended to be a five-and-one-half year project, in which the work in FY11 - FY13 laid a foundation for the more integrated work to be conducted in FY14 - FY16. The successes in these years led to ARMD approval for an additional phase of work, Phase 2. Figure 3 illustrates the duration of Phase 1 of the Project. In Phase 1 - Part 1, the efforts were focused on initial modeling, simulation, and flight-testing within a single research area. These efforts also included completing an analysis to refine the UAS-NAS Project research areas from those developed during Project Formulation by considering the Project Phase 1 - Part 2 budget, schedule, and time frame for impact. This analysis leveraged UAS community needs that became more clearly defined through the release of documents such as the FAA Concept of Operations (ConOps) and the transition to fixed-schedule product-oriented

groups, such as RTCA SC-228, that support the UAS community in developing a national strategy for UAS-NAS integration.

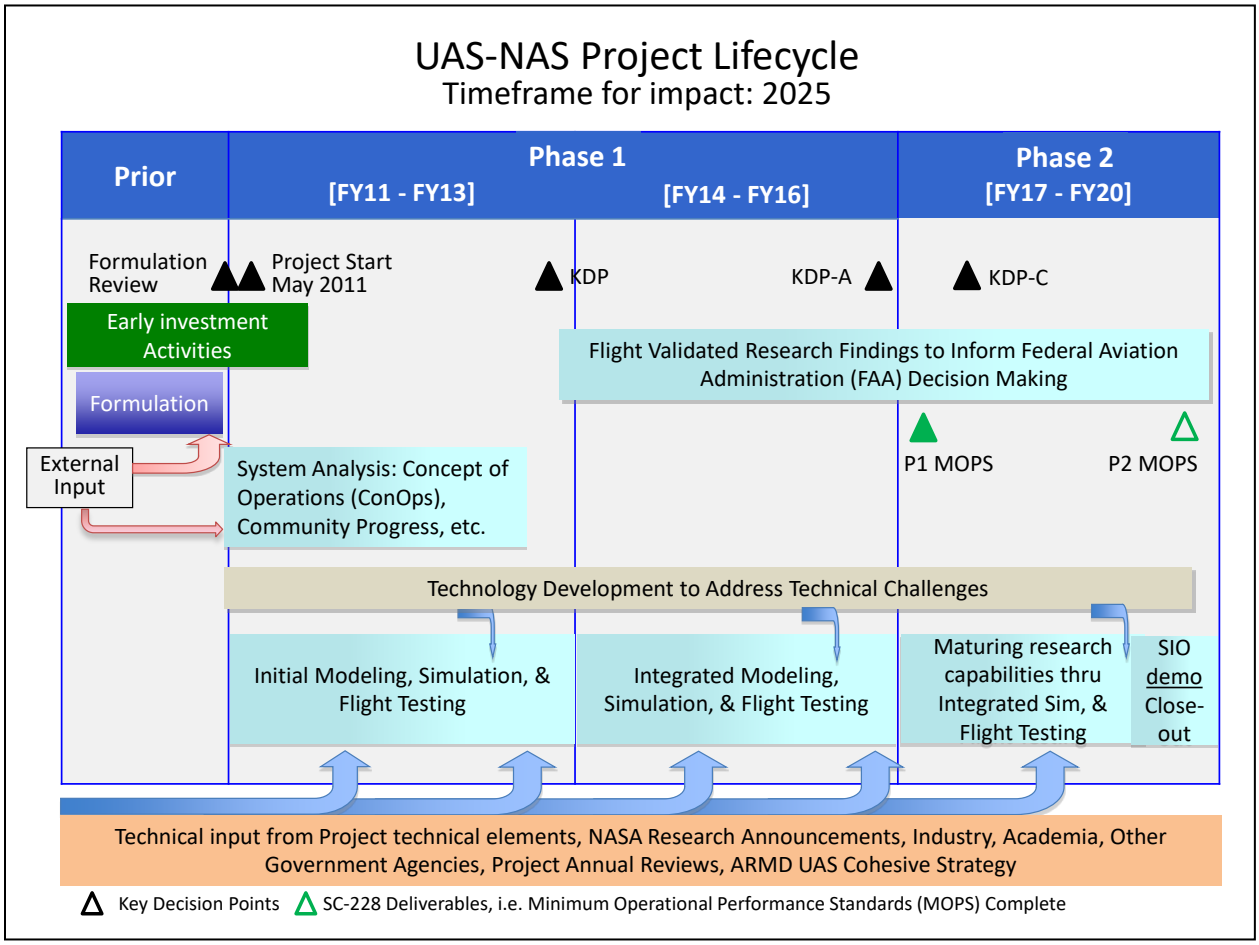


Figure 3. Project Phase 1 - Part 1, Phase 1 - Part 2 and Phase 2.

In Phase 1 - Part 2, the UAS-NAS Project was organized by Subprojects, which were closely aligned with the Technical Challenges (TCs).

- TC-SAA Performance Standards were aligned with the SA / SAA (Separation Assurance / Sense and Avoid Interoperability, or SSI) Subproject;
- TC-C2 Performance Standards were aligned with the Communications Subproject;
- TC-HSI aligned with the HSI Subproject;
- TC-ITE aligned with the Integrated Test and Evaluation Subproject;
- Emerging-TC (formerly known as Non-TC) work aligned with both the Certification Subproject and small UAS (sUAS) tasks.

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

2.3.1 Project Phase 1 - Part 1 Summary

There were many UAS-NAS Project accomplishments during Phase 1 - Part 1. These accomplishments 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 the Glenn Research Center (GRC) a prototype control and non-payload communication system (CNPC) was developed with an industry partner; at ARC and the Langley Research Center (LaRC) human-in-the-loop (HITL) 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.

2.3.2 Project Phase 1 - Part 2 Summary

There were many UAS-NAS Project accomplishments during Phase 1 - Part 2. These accomplishments 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 ARC ACES simulation was updated with unmanned aircraft non-cooperative sensor performance models; at the GRC a prototype CNPC was updated by an industry partner; at ARC and the LaRC HITL simulation capabilities were updated with DAA guidance and alerting methodology to allow either air traffic controller or UAS pilot-in-command research; and development of a live, virtual, and constructive test environment continued as equipment capabilities advanced in parallel with DAA and radar sensor technology advancements.

2.3.3 Project Phase 1 (Part 1 and 2) Deliverables

The Project produced a UAS-NAS Comprehensive Report (UAS-PRO-1.1-014) that described all of the research accomplished by the Project from FY11 - FY16. Included in the report is description of the research activity and its contribution to the development of MOPS.

2.4 Project Phase 2

In Phase 2, the UAS-NAS Project will accomplish research activities to address specific TCs that will address UAS access to the NAS. Solutions will advance the state of the art for UAS access. The time frame 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 SC-228 Phase 2 MOPS and MASPS by the FAA in regulating UAS in the NAS.

In Phase 2, the UAS-NAS Project will provide research findings to RTCA SC-228 to develop and validate SC-228 Phase 2 MOPS for DAA performance and interoperability and for terrestrial C2. 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, the UAS-NAS Project continues to emphasize partnerships and collaborations.

The UAS-NAS Project will organize tasks within TCs using TWPs, which are further broken down into SPs. Progress within TCs and individual SPs are managed with progress indicators and milestones.

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

In the following subsections, the work being performed in each of the TC areas will be described with an introduction, objectives, and benefits to community, approach, key collaborators, and deliverables. The table at the end of each subsection identifies the individual TWP required to support the appropriate TC or large scale demonstration activity. The following sections define the entire TC, some portion of which will not be fully completed by the UAS-NAS Project. Those portions, identified by blue italics, will need to be completed by others in the UAS Community for the entire TC to be completed.

2.5 DAA Operational Concepts and Technologies 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 DAA 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 include lack of an onboard pilot as well as lower performance (e.g., speed) than traditional aircraft, novel missions with extensive loitering, and longer communication latencies. 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 DAA effort will participate with the UAS community through concepts and technology development of DAA technologies applicable to a broad range of aircraft with low cost, size, weight, and power (Low-SWaP) capability. The DAA system will detect other aircraft in the vicinity, predict whether the aircraft trajectories will be in conflict with each other, alert the UAS pilot in command, and determine the appropriate guidance to display to the UAS pilot in command. Pilot and controller responses to the system will be assessed in order to ensure interoperability with mixed traffic environments that include manned aircraft in the NAS. The effort will be in collaboration with OGA and industry partners to perform robust safety and collision risk assessments, guidance development, and display development, to support the broad needs of DAA for the UAS community.

2.5.1 Barrier

- Beyond the scope of SC-228 Phase 1 MOPS (airborne DAA for vehicles capable of transitioning to/from class A airspace), certifiable DAA technologies do not exist for a broad set of UAS that will operate via IFR flight in the NAS
    - i.e., SC-228 Phase 2 MOPS DAA standards must apply to a smaller vehicle class, and provide DAA capabilities in terminal airspace.
- System Performance requirements do not exist that are broadly applicable to all of industry, and will allow the FAA to create associated policy.

2.5.2 Objectives (Blue Italics are not fully covered by UAS-NAS P2 resources allocation)

- Develop and validate UAS DAA requirements for Low-SWaP airborne DAA systems to support standardization through the evaluation of commercial and engineering prototype DAA systems that enable a broader set of UAS operations.
- Implement state-of-the-art DAA technologies into an unmanned aircraft system and test in operationally-relevant scenarios.
- *Develop and validate UAS DAA requirements for Ground Based DAA systems to support standardization through the evaluation of commercially available radars integrated with airborne DAA architectures*
- *Develop and validate human machine interface requirements to support human automation teaming and higher levels of autonomy for UAS DAA systems*

2.5.3 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 2 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 SC-228 Phase 2 MOPS. In some cases, UAS-NAS Project personnel plan to be the lead for specific sections within the SC-228 Phase 2 MOPS.

Specific benefits associated with the DAA Subproject relate to development of a DAA concept. Integration with technologies from human factors is included in DAA concept development. Flight-testing of DAA technologies will provide valuable research findings to SC-228 for the SC-228 Phase 2 MOPS development, and to the FAA for DAA policy and guidance finalization. Specific community benefits include:

- Well clear definition and ATM interoperability,
- Safe and efficient terminal area operations for UAS, and
- Low SWaP DAA system definition, testing and validation.

2.5.4 Approach

The DAA Subproject plans to:

- Develop Concept of Operations in coordination with RTCA and FAA,
- Solicit and establish industry partnerships to develop DAA technologies,
- Perform modeling and simulation to characterize the trade space of the DAA for critical areas such as well clear, collision avoidance interoperability, human machine interfaces, and others,

- Conduct Flight Test and V&V of DAA technologies for performance standard requirements, and DAA system technology builds,
- Jointly develop performance standards with RTCA and FAA throughout the life cycle of concept and technology development, and
- Validate and propose modification of national and international standards for DAA.

The IT&E Subproject plans to:

- Develop simulation and flight-test environments that emulate current and future NAS operations, equip UAS with integrated DAA and C2 technologies, and enable safe and efficient collection of research data to support validation of the SC-228 Phase 2 MOPS.
- Develop the LVC-DE and integration of DAA technologies for simulation and flight-test support.
- Provide support for the planning and conduct of the DAA HITL simulations conducted at ARC, including documentation of the test objectives and requirements, tracing to the system level requirements, and development of the V&V test matrix and conduct of the V&V testing.
- Create a relevant environment to test DAA technologies.
- Integrate the individual technology development simulations and flight-test series objectives into executable tests and provide for a complex test environment to aide in developing DAA concepts, technologies, and capabilities.
- Execute flight tests to allow the immersion of the systems under test into the required relevant flight environment, and explore system interactions in the presence of real data uncertainty and atmospheric conditions.

2.5.5 Key Stakeholders

- Collaborators: RTCA SC-228, The FAA Office of Unmanned Aircraft Systems (AUS), Air Force Research Lab (AFRL), and Massachusetts Institute of Technology (MIT) / Lincoln Labs (LL)
- Partners: General Atomics, and Honeywell

2.5.6 Deliverables

The following is a list of deliverables:

- RTCA Standards Inputs:
  - DAA SC-228 Phase 2 MOPS,
  - Sensor SC-228 Phase 2 MOPS, and
  - Airborne Collision Avoidance System (ACAS) Xu MOPS.
- Technical papers and presentations to technical and regulatory organizations,

- Candidate DAA guidance, displays, and alerting, and
- Integrated design documents for each integrated event.

2.5.7 Technical Work Packages

Table 1 contains the TWPs under the DAA TC. For each TWP the primary stakeholders are identified.

Table 1. TC-DAA Technical Work Packages.

TC#	Research ID	TWP Name	Stakeholders
TC-DAA	D.1	Alternative Surveillance Requirements	SC-228
	D.2	Well Clear / Alerting Requirements	SC-228
	D.3	ACAS Xu Interoperability	SC-228, SC-147
	D.4	External Coordination	SC-228
	D.5	Integrated Events	SC-228
	T.6	Integration of Technologies into LVC-DE	SC-228
	T.7	Simulation Planning and Testing	SC-228
	T.8	Integrated Flight Test	SC-228

Appendix A contains five tables presenting the Level 1 and Level 2 milestones grouped by TC.

2.6 UAS Command and Control 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, both of which are 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 supplying radio frequency propagation data, 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 C2 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 C2 will lead the UAS community through concept and technology development of terrestrial C2 systems that are consistent with international and national regulations, standards, and practices. The C2 will develop and analyze robust data links in designated spectrum and propose security recommendations for civil UAS control communications. All of the identified activities will be accomplished by collaborating with OGA and industry partners to address the technical barriers.

Some initial SatCom Ka- and Ku-Band research was conducted in the C2 subproject in FY17 prior to the KDP-C decision to discontinue UAS-NAS Project SatCom Ka- and Ku-Band system development and test and evaluation research. Ka-Band tasks were accomplished through a NASA/Industry cost share Cooperative Agreement. A survey of existing commercial Ka-Band SatCom systems was completed for possible adoption or adaption for UAS C2 services. A low SWaP investigation of known antenna technologies and research activities was completed to determine the current limits for SatCom equipage for the UAS midsize class. There were no Level 1 or Level 2 Milestones completed in FY17 in the Ka-band SatCom research area. Ku-Band Spectrum Interference Evaluation System Development, Ku-Band Propagation Flights and Interference Analysis, and C-band SatCom Design Study remain in the project baseline. These latter activities have milestones in FY17.

2.6.1 Barrier

- Outside of Phase 1 Terrestrial MOPS, certifiable C2 concepts and technologies do not exist that apply to allocated WRC spectrum that will operate in the NAS.
- System Performance requirements do not exist that are broadly applicable to all of industry and will allow the FAA to create associated policy.

2.6.2 Objectives (Blue Italics are not fully covered by UAS-NAS P2 resources allocation)

- *Develop and validate UAS C2 requirements and radio spectrum allocation decisions to support C2 standardization through the evaluation of commercial and engineering prototype SatCom radio systems.*
- Provide Ku-Band propagation data to support radio spectrum allocation decisions.
- Provide system design studies (payload and earth station) and system design requirements of C-band Satcom systems for C2 standardization.

2.6.3 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 2 MASPS and MOPS development. Also, the community will benefit from the involvement of experienced Project personnel, from the standpoints of experience gained from previous UAS integration projects and benefits gained from the research and technology developments in the Phase 1 - Part 2 Project Portfolio, through hands-on involvement with the development of the SC-228 Phase 1 MOPS. As was demonstrated

in Phase 1, UAS-NAS Project personnel expect to lead the development of specific sections within the Phase 2 MASPS and MOPS.

Specific benefits associated with the C2 Subproject relate to development of a terrestrial civil UAS prototype communication system. Specific community benefits include:

- Validation of proposed SC-228 C2 MOPS or recommendation of necessary modifications to these standards based on test results.
- Results from testing will support the development of a UAS Concept of Operations.
- Validation of proposed SC-228 CNPC performance standards or recommendation of necessary modifications to these standards based on test results.
- Determination of the feasibility of an operational terrestrial CNPC system for the mid-size UAS community in lower flight altitudes - higher-density environments than those considered for the SC-228 Terrestrial C2 Phase 1 MOPS.
- Technical data will be used for performance and design parameters in the development of a terrestrial CNPC system.
- Technical data will support standards, V&V methods for SC-228 terrestrial CNPC MOPS.

2.6.4 Approach

The Subproject plans to:

- Develop Concept of Use to be leveraged for initial requirements for C2 partnerships, and coordination with RTCA and FAA, Implement industry partnership to develop radio technologies in terrestrial frequency bands that are applicable to broad operating environments,
- Conduct Flight Test and V&V of radio technologies for performance standard requirements, and radio technology builds,
- Perform essential implementation studies across Satcom and Terrestrial frequencies,
- Jointly develop performance standards with RTCA and FAA throughout lifecycle of concept and technology development
- Validate and propose modification of National Standards for CNPC

2.6.5 Key Stakeholders

- Collaborators: RTCA SC-228, and the University of South Carolina.
- Partners: Rockwell Collins, Honeywell.

2.6.6 Deliverables

The following is a list of deliverables:

- RTCA Standards Inputs
    - CNPC Link MASPS,

  - C-band Terrestrial MOPS update.

- Technical papers and presentations to technical and regulatory organizations.

2.6.7 Technical Work Packages

Table 2 contains the TWPs under the C2 Performance Standards TC. For each TWP the primary stakeholders are identified.

Table 2. TC-C2 Technical Work Packages.

TC#	Research ID	TWP Name	Stakeholders
TC-C2	C.5	Satellite-based UAS Command and Control	SC-228
	C.6	Terrestrial-based UAS Command and Control	SC-228

Appendix A contains five tables presenting the Level 1 and Level 2 milestones grouped by TC.

2.7 Systems Integration and Operationalization

Systems Integration and Operationalization (SIO) addresses two primary areas required for the integration of UAS into the NAS. Developing robust performance standards that ensure a pathway to vehicle certification requires consideration of aircraft level functional and operational requirements. Integration of UAS into the NAS is a broad multi-faceted problem that requires operationalization of technologies into the NAS through partnership with industry and the FAA to inform timely policy creation.

SIO is a large scale demonstration activity. To define the activities associated with SIO, the project uses the same template to define the DAA and C2 TCs.

2.7.1 Barrier

- State of the art UAS vehicle technologies and airspace integration concepts have not been integrated and tested in their actual operating environments
- Initiatives for the FAA to create a complete set of appropriate policies have not been fully planned or executed

2.7.2 Objectives

- Demonstrate robust UAS operations in the NAS by leveraging integrated DAA, C2, and state of the art vehicle technologies with a pathway towards certification to inform FAA UAS integration policies and operational procedures

2.7.3 Benefits to the Community

- NASA's leadership in vehicle technology development through performance of high profile integrated tests push industries state of the art UAS development, while ensuring aircraft level function and operational performance criteria are included in standards activities.
- Increasing confidence in the maturity of integrated C2, DAA, and other vehicle technologies and SIO demonstration will provide FAA the opportunity to stress/modify the approval process, leading to a playbook for industry to gain access for IFR/VFR – Like missions for extended operations within Classes D, E, and G Airspace.

2.7.4 Approach

The plans for SIO are:

- Develop integrated Phase 2 DAA and C2 ConOps and associated C2-DAA interface requirements for candidate demonstrations
- Leverage Test Sites to perform foundational vehicle technology demonstrations
- Solicit industry inputs to determine a robust partnership strategy that leverages NASA leadership to push state of the art UAS vehicle technologies
- Solicit industry partners that will lead the UAS community in integration of certifiable DAA and C2 technologies, and development of UAS technologies
- Perform necessary technology integration and demonstration testing
- Perform final demonstration

2.7.5 Key Stakeholders

- Collaborators:
  - UAS-NAS Subprojects
  - RTCA SC-228
  - FAA and the FAA Tech Center
  - ICAO, EUROCAE
  - AFRL, US Army
  - Service Providers
- Partners: TBD pending competitive process
  - Industry Aircraft OEMs
  - Industry Sensor Manufacturers
  - Industry Communications Provider
  - FAA UAS Test Sites

2.7.6 Deliverables

SIO is currently not defined as a TC, the deliverables will be defined as content is matured.

2.7.7 Technical Work Packages

SIO is currently not defined as a TC, the TWPs will be defined as content is matured.

3 Performance

The ARMD, the IASP, and the UAS-NAS Project measure Project performance in multiple ways: completion of Annual Performance Indicators / Annual Performance Goals (APIs/APGs); completion of TCs; and completion of Project Milestones. Each measure is described below.

3.1 Annual Performance Indicators / Annual Performance Goals

The NASA is a performance-based organization committed to managing toward specific, measurable goals derived from a defined mission, using performance data to continually improve operations. The NASA uses APIs and APGs to manage performance. The UAS-NAS Project APIs and APGs are included in the NASA Annual Performance Report and Annual Performance Plan, which are companions to the NASA Congressional Justification. Each API or APG is comprised of an indicator or goal statement with green, yellow, or red criteria used to measure accomplishment of the indicator or goal. The UAS-NAS Project FY12, FY13, and FY14 APGs, and the Project FY15 and FY16 APIs are presented in Appendix C. The Phase 2 APIs for FY18 and FY19 are also presented in Appendix D. The API for FY20 is TBD.

3.2 Technical Challenge Progress

Measuring Project performance against Project TCs is a project management methodology within ARMD for technology-focused projects. The 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 the success of the UAS-NAS Project and toward satisfying stakeholder needs. Project TC PIs were developed to measure the UAS-NAS Project outputs and outcomes and overall progress toward the completion of TCs. In this way, they assist the Project and the Program in the monitoring and control of the TCs.

For most NASA technology development projects, use of the NASA Technology Readiness Level (TRL) scale, which is a systematic metric and a 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 the TC PIs. The UAS-NAS Project goal is not directly to mature a technology; however, the Project goal is to "*Provide research findings, utilizing simulation and flight tests, to support the development and validation of DAA and C2 technologies necessary for integrating Unmanned Aircraft Systems into the National Airspace System.*" While technologies will be developed and used for UAS-NAS Project research, the success of the UAS-NAS Project is based on contributing to the RTCA SC-228 Phase 2 MOPS (outcome) by providing research findings from research activities (output), thus, applying the NASA TRL scale as a TC PI is not an appropriate measure of UAS-NAS Project success.

The PIs developed by the UAS-NAS Project measure Project contributions and outcomes of SC-228 and other stakeholders as well as key elements of individual Project research activities.

Figure 4 is an illustrative example of the Project-developed TC PI. The actual UAS-NAS Project PIs for each TC are presented as Appendix B. The TC PI chart in Figure 4 is presented using an upper section and a lower section. The upper section presents information about technology transfer to stakeholders and the outcomes that those technology transfers will help create. The lower section documents the Project research activities and a representative measure of the maturity of the Project research as measured by individual research activities (outputs).

In the upper section of the Figure 4. Example Progress Indicator:

- The research findings generated from the activities identified in the lower portion of the TC PI chart are directed by gray dashed lines to the upper section of the chart that represents the Technology Transfer to UAS-NAS Project stakeholders. Each technology transfer milestone is completed when the research findings are provided to the UAS-NAS Project stakeholders (in the form of briefings, papers, or reports). 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 technology transfer, which is therefore not labelled, is 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 2 MOPS deliverables, i.e., DAA and C2 white papers and Final MOPS, which are shown on the Community Outcomes line in the upper section of the figure. The SC-228 Phase 2 MOPS deliverables in turn have the potential to influence the UAS-NAS Project activities, as shown by the green dashed lines pointing from the upper section of the figure to the lower section of the figure.

In the lower section of the Figure 4. Example Progress Indicator:

- Key Project outputs were identified as L1/L2 milestones (see section 6 of this Project Plan for additional discussion regarding milestones). The L1/L2 milestones used on the PI generally represent initiation of individual research.
- The contribution of a selected L1/L2 milestone to TC maturity was estimated by weighting the L1/L2 milestones based on their individual contribution toward achieving the overall TC (high = 2, moderate = 1, low = 0). Major test events or L1 Milestones receive a weighting of “high,” HITL simulations, completion of in-house systems developments, and demonstrations receive a weighting of “moderate,” and foundational activities receive a weighting of “low.”
- The TC maturity was then normalized to a 10-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 10 corresponds to the completion of all Technology Transfer activities necessary to inform the development of the RTCA SC-228 Phase 2 deliverables, i.e., DAA and C2 white papers, and final MOPS, which are shown on the Community Outcomes line in the upper portion of Figure 4(and are described above)

The TC PI chart is used by the UAS-NAS Project to track technical progress toward achieving the TC. Referring to the right-hand side of the Figure 4 legend:

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

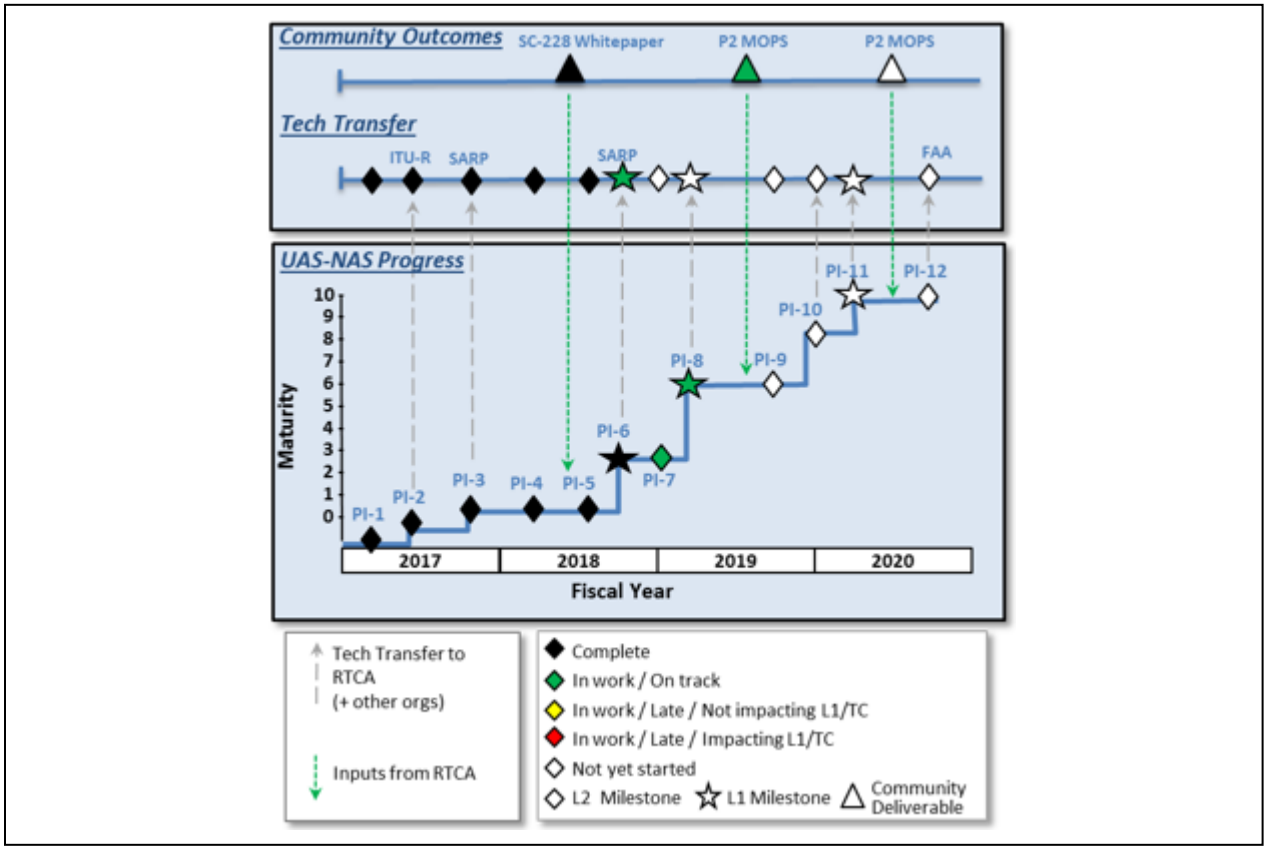


Figure 4. Example Progress Indicator

3.3 Milestones

Milestones are used by the IASP and the UAS-NAS Project to measure the completion of UAS-NAS Project scheduled activities. Project milestones include delivery of significant technical results (briefings, conference papers, or reports), initiation or conclusion of research activities, or transfer of significant information or equipment between Subprojects. Milestones are also depicted on the PIs, as shown in Figure 4. Milestones are discussed and presented in section 6 of this Project Plan. Appendix A contains five tables presenting the Level 1 and Level 2 milestones.

4 Management Approach

4.1 Project Authority

The UAS-NAS 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 the ARMD Strategic Implementation Plan (SIP); maintaining the relevance of the Program and Project to stakeholder needs; establishing top-level program goals and objectives, Level 1 Milestones/Deliverables, APIs, and TCs collaboratively with the Centers and the 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, AFRC provides the Project management team and support staff, who will be responsible for the overall management of the UAS-NAS Project. The ARC, the GRC, and the LaRC participate as partner Centers. Each Center is responsible for staffing their Subproject. 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 5, which shows the different roles within the UAS-NAS Project.

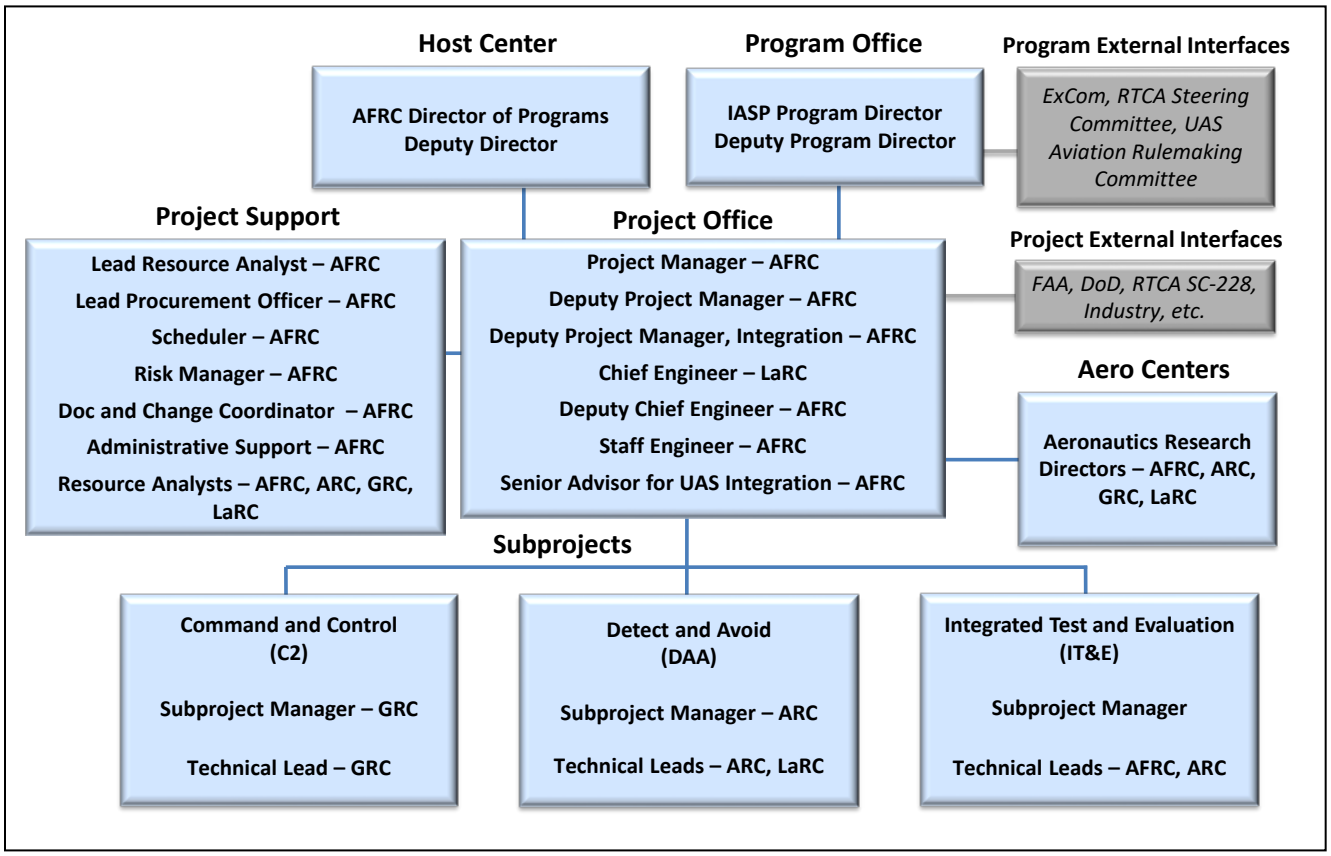


Figure 5. Project management organizational structure.

The Project Office team is comprised of a PM; a Deputy Project Manager (DPM); a Deputy Project Manager, Integration (DPMI); a Chief Engineer (CE); a Deputy CE; a Senior Advisor for UAS Integration; and a Staff Systems Engineer.

The PM 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 PM, DPM, and DPMI 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 TCs and Subprojects for approval by the Program; reporting progress toward integrated TCs; overall management of Subprojects; 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.

The CE 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 CE, Deputy CE, and Staff Systems Engineer work together to execute the technical management responsibilities for the UAS-NAS Project. Technical management responsibilities include: 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 Subproject Managers / Technical Leads (TL); serve as the Project Technical Authority; manage the technology transfer process; 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, Risk Manager, Administrative Support Specialist, and Document and Change Management 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 Scheduler is responsible for the UAS-NAS Project schedules and providing data to the Project leadership. The 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 teleconference.

The Risk Manager is responsible for risk management and other support functions. These functions include: Project Risk Management administration and process; and Project Outreach coordination, support, planning, and execution including close coordination with the Host Center Strategic Communications and Education offices.

The Document and Change Management Coordinator is responsible for business support functions, which primarily include serving as the UAS-NAS Project Export Control Representative, Change Management Administrator, Records Manager, and document server Administrator.

The Administrative Support Specialist provides support to the Project through a myriad of administrative duties including meeting scheduling and setup, recording minutes, tracking action, 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 Subproject Managers (SPMs) and TLs (for each Subproject). The interface and reporting structure for the SPMs and TLs to the Project Office and ARDs is shown in Figure 5.

For each Subproject there is an SPM who is responsible for task/work plans and ensuring project level milestones are delivered on time and within budget. The SPM also has a resource analyst to support them and coordinate with the Project Lead Resource Analyst. The SPM will maintain awareness of their TLs technical activities. SPM responsibilities include: managing the Subproject/TC area as an extension of the Project Office; developing Subproject implementation plans; coordinating deliverables for the Subproject within the constraints of the NASA Centers 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 5; 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 three Subprojects to address UAS-NAS Project work. The three Subprojects are: the Detect and Avoid (DAA) Subproject working TC-DAA Performance Standards; the Command and Control Subproject working TC-C2 Performance Standards; and the IT&E Subproject working TC-DAA. SIO activities will be supported by all subprojects and will be led by a TBD team later.

The TLs are the leads or co-leads of their respective Subproject technical areas. The TLs take guidance and direction from the SPM and are responsible for: the technical content of their Subprojects, Subproject deliverables, and maintaining schedule. Other TL responsibilities include: providing regular status of their work through the UAS-NAS Project weekly status meeting; execution of their technical activities including data analysis and reporting; and working with their respective SPM to develop risks and mitigations and to ensure compliance with schedule and budget.

4.1.4 Technical Authority

The technical authority process is established in NPR 7120.5, “NASA Space Flight Program and Project Management Requirements w/ Changes 1-15,” and 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 CE 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,

reviewed and updated management and control processes to govern the execution of the technical portfolio. All of these efforts have maintained management rigor in 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 to the Host Center Director and the IASP Director with concurrence from the partner Center Directors. The Program utilizes decisional forums, i.e., the Change Management Board, the Risk Management Board, and the Schedule Management Working Group, to assist in the management of the Program (see Figure 6). 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 TCs, L1 milestones, and top risks.

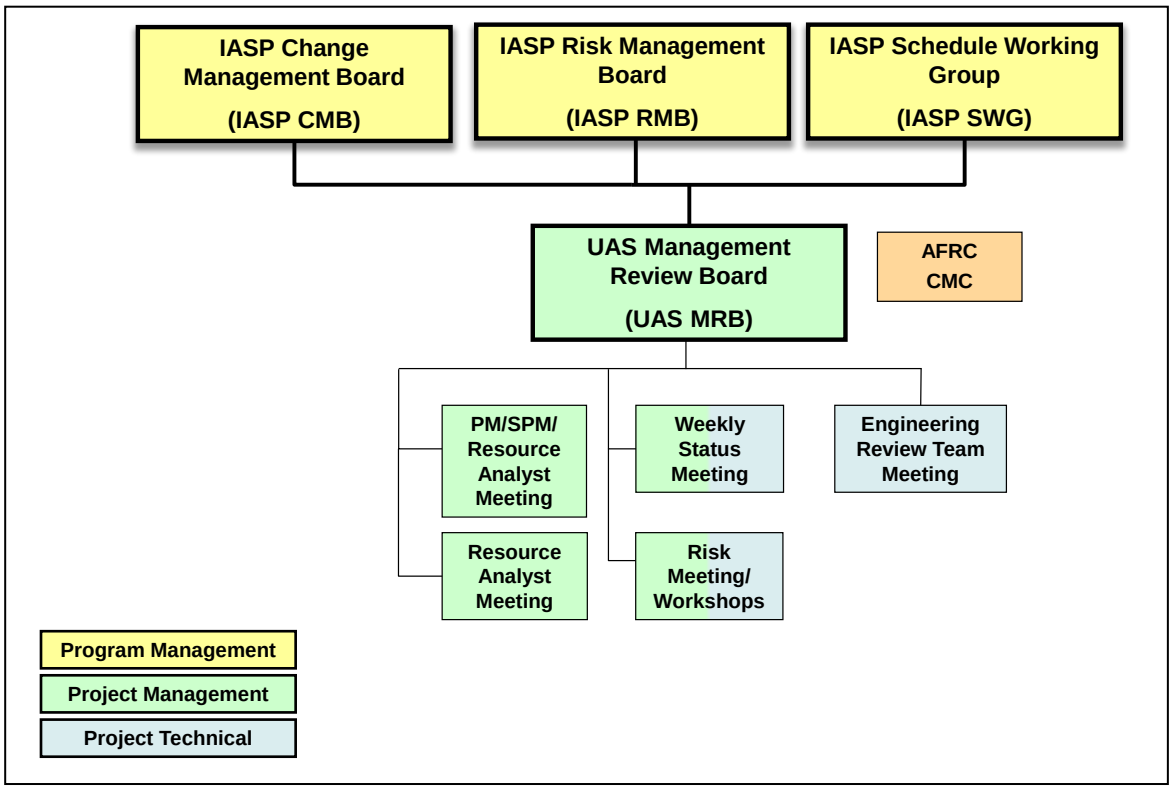


Figure 6. Program/Project decisional forums.

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 CMC bi-monthly on the Project progress in 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. Consistent with Center processes, the SPMs/TLs brief Center-specific project status either at partner Center CMCs or to CMC members, as appropriate. 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 an MRB to maintain oversight of the project as identified in the figure above. The MRB is held monthly to review risk, integrated master schedule (IMS) status, milestones, cost/technical performance, change management, and data management. The UAS-NAS PM maintains all authority over the MRB. The PM 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 PM and consists of the following board members: the Chief Engineer, Subproject Managers, Lead Resource Analyst, and Risk Manager.

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-1.1-002). The Change Management Process is conducted during the MRB meetings. The project elements under change management are defined as follows:

- L1 and L2 Milestones,
- TCs,
- Project Goal and Objectives,
- Technical Baseline,
- Project Budget and Resource Allocations, and
- 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 constitute the project resource allocation baseline. This baseline contains the following:

- TWP budget estimates by TWP objective and FY,
- TWP manpower estimates by TWP objective and FY,
- NASA Center budget and manpower estimates by FY,
- Project reserves by FY.

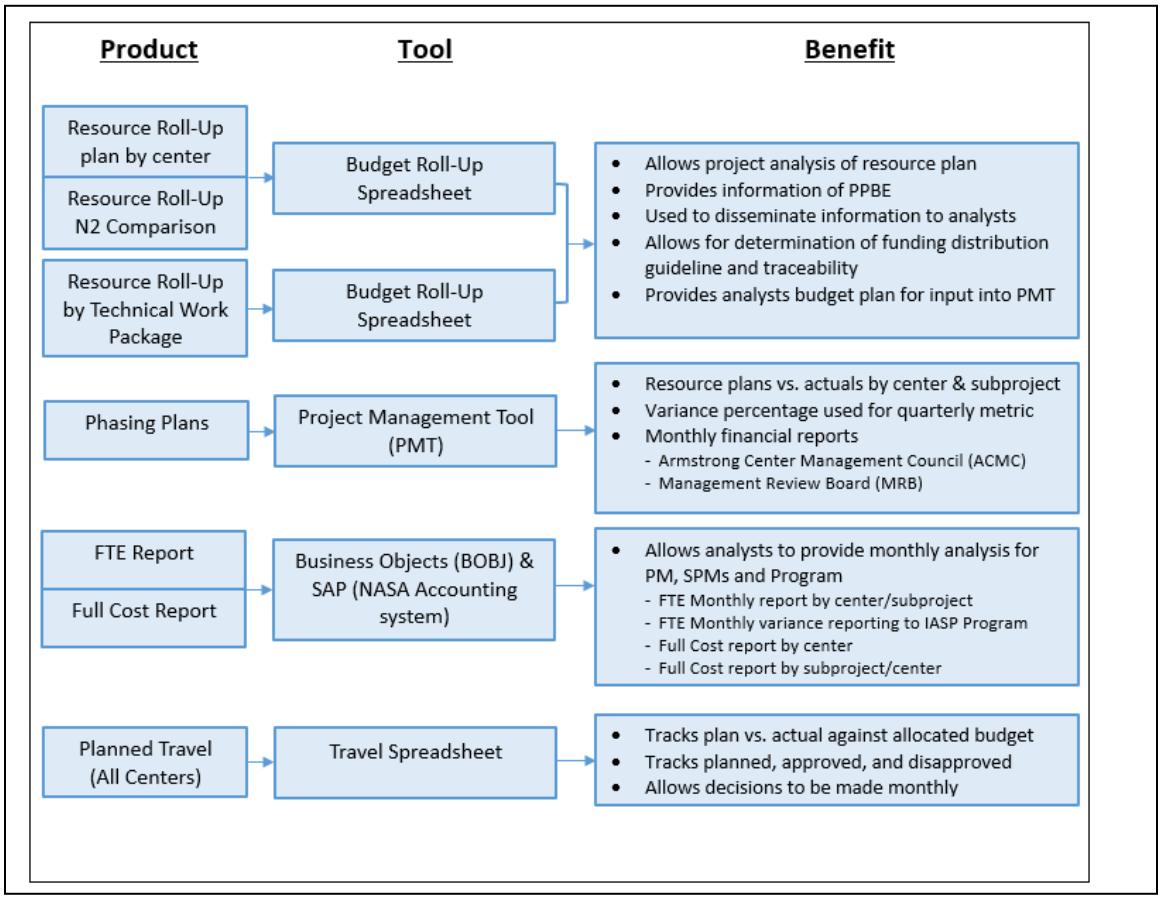


Figure 7. Resource management process.

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 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 2nd upgrade to the original NBS (N2), phasing plans, full-time equivalent (FTE) reports, full-cost status reports, and planned travel at all Centers. These products are used in conjunction with standard tools, e.g., Project Management Tool (PMT), Business Objects (BOBJ), and Systems Application Products (SAP) to generate phasing plans, monitor status, and provide financial analysis and variances. Figure 7 shows the different products and tools used by the UAS-NAS Project and the 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. These data are used for quarterly metrics and presented to CMCs and the Project MRB. In addition an FTE variance explanation is provides to the IASP program monthly.

The Lead Resource Analyst and the Center Resource Analysts use the information generated from the tools identified in Figure 7 to monitor the UAS-NAS Project budgetary progress. The information is also used to inform: the Centers on a monthly basis, the IASP through quarterly reports, and the 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 8 shows how technical topics or issues are identified and resolved through the decision-making flow. Technical topics or issues can be identified by the SPMs/TLs or by the Project CE. 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 CE. The CE will determine whether a technical topic or issue requires an ERT meeting. The CE communicates decisions not requiring an ERT meeting to the project team during the UAS weekly teleconference and to the Host Center Research Engineering Director, as the governing technical authority, as appropriate.

If an ERT meeting is required, the CE defines the objective and schedules the meeting. The ERT is chaired by the CE and has the SPM and relevant TLs as members. All members or an appropriate designee must be in attendance for the ERT meeting. Designees must have the authority and knowledge to speak on behalf of the SPM and properly inform the ERT. During the review, ERT members consider impacts, pros and cons, alternatives, and technical approaches. Through these discussions a technical decision path is developed. At the conclusion of the ERT meeting, all members provide their recommendation and the CE makes the final decision. If the TL issue is not resolved, an alternative path exists through the Center Chief Engineer as a source of technical authority. If a Center Chief Engineer becomes involved, then the Host Center Chief Engineer will be the final decision authority. 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.

The technical decision-making process is documented in detail in the SEMP (Doc#: UAS-PRO-1.1-007).

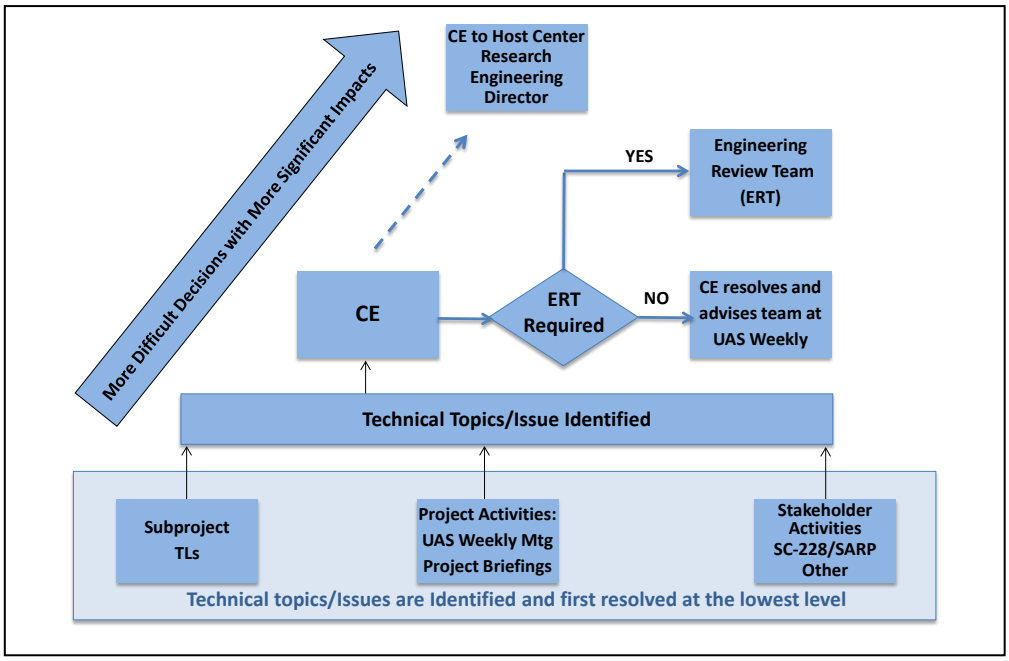


Figure 8. Technical decision-making flow.

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 TWPs that define the technical content performed by the Subprojects toward the completion of each TC. Within each TWP, there are test activities and tasks supporting them. A specific activity, e.g., HITL simulation, and its supporting tasks, are grouped as SPs 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 objectives, which are documented in the Project Technical Baseline Document (TB) (Doc#: UAS-PRO-1.1-013). The UAS-NAS Project uses the TWPs and SPs as the mechanism to organize the technical portfolio. The 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 CE and the technical leadership team track the technical progress and ensure requirements are met. The SPMs for each Subproject provide status for the activities within their SPs during the UAS-NAS Project weekly teleconference. These status reports give the Project leadership the necessary insight into technical progress, as well as information about existing or potential issues or concerns. The sharing of information during the weekly teleconference also allows for the Project and SPMs to gain insight into the integrated technical inputs the UAS-NAS Project provides to

SC-228. In addition to the weekly status meeting the ERT, MRB, and risk management meetings and 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 or concerns pertaining to the technical portfolio and its acceptance by stakeholders.

4.2.3 Systems Engineering Management Plan (SEMP)

The UAS-NAS SEMP describes the application of systems engineering within the UAS-NAS Project to meet the Project goal to provide research findings to the UAS Community. The SEMP defines the technical approach that the UAS-NAS Project is using for planning and executing technical (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" (see NPR 7123.1B) for developing research findings. To create research findings, the UAS-NAS Project is creating hardware and software for use in simulation and flight test. The SEMP document (Doc#: UAS-PRO-1.1-007) and the Subproject implementation plans describe the Project's system engineering.

4.2.4 Mishap Response Plan

In the event of a mishap that occurs during Host Center or Partner Center's specific testing, Subprojects will follow and execute the mishap plans at their respective Centers. These plans 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 the guidance given in the IASP Mishap Response Plan, which is located in the IASP Research and Technology Program Plan. For notification of a mishap, the mishap will be reported by the appropriate SPM to the UAS-NAS PM. The PM will then notify the IASP Director and Host Center ARD. If any party cannot be reached, the coincident alternate designee will be notified. Notifications above the IASP Director and Host Center ARD will be accomplished per IASP Mishap Response Plan and AFRC Center Mishap Preparedness & Contingency Plan (AFPL-8621.1-001), as needed. It is the responsibility of the Host Center ARD to notify the Center Director. Following the notification to the IASP Director and Host Center ARD, the PM will notify the ARD for the Center at which the mishap occurred. The mishap notification list (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 speak with the required team member, the notifier should continue to call until the required team member or alternate designee has been reached.

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

1. The notifier's name, title, and location;
2. The nature of the call (e.g., mishap / close call notification, injury or damage to report, et cetera);

3. The name of the Project (UAS-NAS), the vehicle type, the aircraft tail number or facility name, the name of the owner, or other identifying description or special circumstance (as appropriate);
4. A 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., SPs, to accomplish the technical work packages, and ultimately the project TCs, 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 information 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 Center-specific processes include: the Safety and Mission Assurance Process, including the Mishap Plan; the 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 UAS-DAA-4.7-001, UAS-C2-4.8-001, and UAS-ITE-5.2-001.

4.2.6 Governing Documentation

The Project Plan is the top-level document that describes the UAS-NAS Project. The Project Plan forms an agreement between the PM, the Center Director, and the PD for the 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 9, shows the documents and processes that govern the Project.

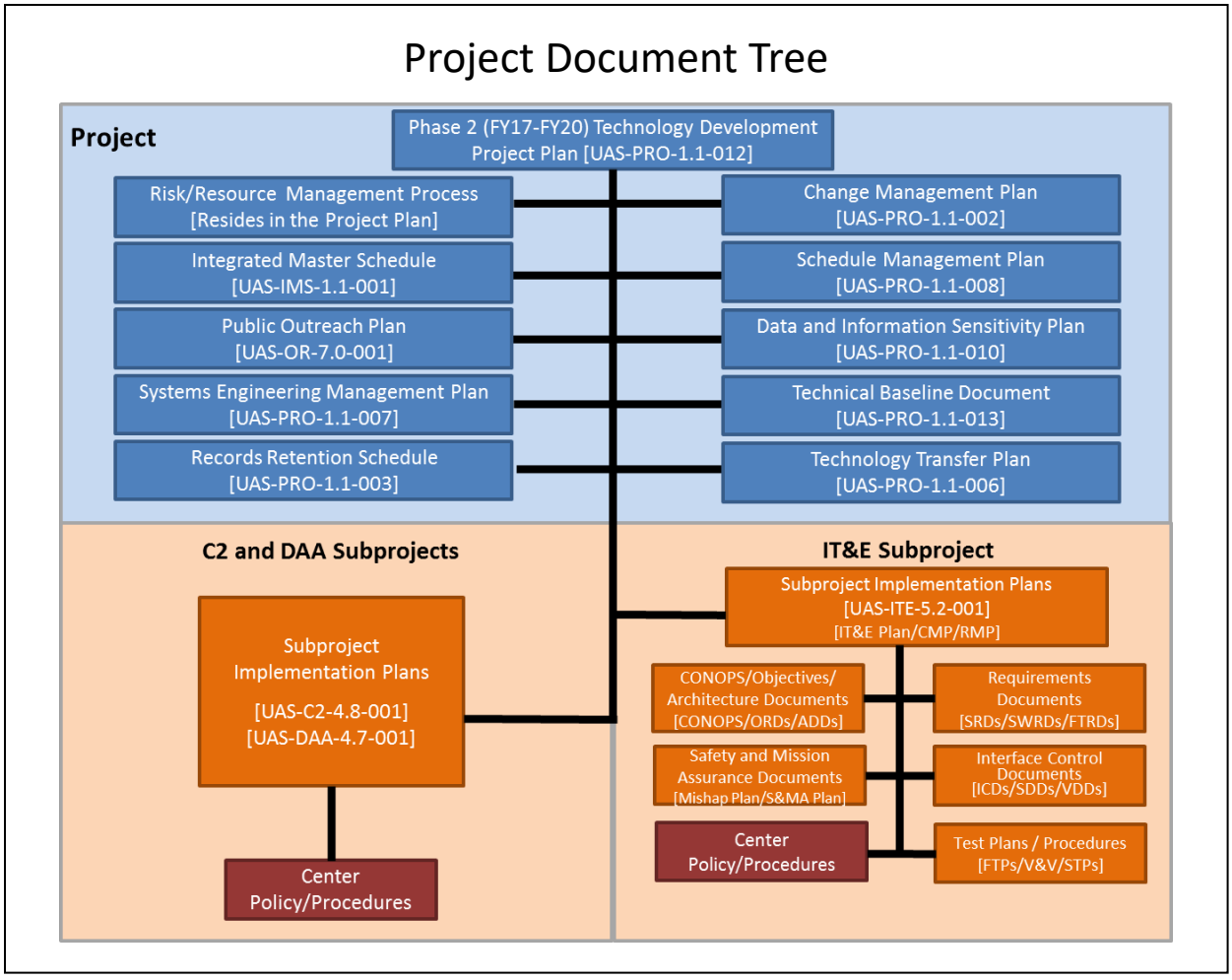


Figure 9. Project document tree.

4.3 Project Interfaces

Related activities that are currently in work at OGA, industry, and academia have been assessed; key areas are documented in section 2.1.1. Project interfaces represent the collaborative activities that the UAS-NAS Project is conducting with OGA, industry, and academia. The UAS-NAS Project works closely with these groups in an effort to ensure that the research findings of the Project 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

The 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 primary inter-Government interface for the UAS-NAS Project is the FAA. In March 2012, the FAA created the UASIO, headed by a single executive, which brought 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 the NAS. In 2016, the FAA implemented organizational changes that resulted in a new name for the UASIO. Now known as the Office of Unmanned Aircraft Systems Integration, it continues to lead the FAA's efforts in planning for UAS integration and has heavily leveraged the FAA Research & Development Integration Division. The FAA has also leveraged the 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 Implementation Plan development in which NASA participated. Since the onset of the UAS-NAS Project, the Project has established a close relationship with the FAA. The participation of NASA in planning activities for the FAA benefits both agencies, and the UAS-NAS Project portfolio is closely aligned with the plans of the FAA. The Phase 1 - Part 2 technical portfolio objectives, approach, and products have been presented to the FAA for their awareness and were 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 Office of Unmanned Aircraft Systems Integration are captured in the "Interagency Agreement between NASA and the FAA concerning UAS Research and Technology Development" (Doc #: AFRC-531). The UAS-NAS Project and both the FAA Office of UAS Systems Integration and Research & Development Integration Division, had a monthly meeting structure in place early in Phase 1 - Part 1 of the UAS-NAS Project. In FY15 and FY16, the Project established collaborations with the six FAA UAS Test Sites that were established in FY14. In Phase 2, NASA and the FAA are establishing a Research Transition Team (RTT) for UAS Integration. The UAS Integration RTT will focus on transitioning UAS-NAS products through the lifecycle of the project, as well as provide a forum for discussing the research gaps that still exist, in order to achieve full UAS integration globally.

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 UAS Executive Committee (ExCom) UAS SARP. The UAS-NAS Project is working with AFRL on SAA efforts, 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 work with the UAS ExCom UAS SARP consists of supporting their efforts to identify and close DAA research gaps, such as the definition of "well clear." Similarly, the Project has also supported SARP efforts in the human factors area as they sought to define gaps in human factors research. The UAS-NAS Project and the SARP work closely together through regularly occurring meetings, workshops, and deep dives.

During Phase 1 - Part 2, the UAS-NAS Project worked with the United States Marine Corps in the area of human factors and sUAS and examined other potential collaboration opportunities. The UAS-NAS Project is working with other DoD entities through a request from the ExCom, on validation of flight-test data for Class D airspace. The UAS-NAS Project worked with the DoD Policy Board for Federal Aviation and the Office of the Secretary of Defense's UAS Task Force to expand collaborations further. As was done in Phase 1, the Project will continue to utilize pilots from the United States Air Force Test Pilot School, Beale Air Force Base, and the United States

Air National Guard to fly UAS in Project research flights and as subjects in the Project HITL Simulations in Phase 2.

In addition to the FAA and DoD entities, in Phase 1 - Part 2 the UAS-NAS Project also worked with Department of the Interior UAS Fish and Wildlife Service Great Dismal Swamp in the area of 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

The RTCA SC-228 is the primary stakeholder of and interface with the majority of the Project research portfolio. The SC-228 ToR define objectives with respect to developing MOPS for DAA, and 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 SC-228 Phase 2 MOPS effort. The UAS-NAS Project primary research during Phase 1 - Part 2 was supporting the development of SC-228 Phase 1 MOPS for DAA and C2. UAS-NAS technical teams established working relationships with their counter parts within the respective working groups and were in continuous dialog during the working group planning, project simulation and testing execution, and subsequent project analysis and reporting of results. UAS-NAS technical teams also participated in standing weekly working group meetings. These meetings consisted of the TLs from many stakeholder organizations from OGA, industry, Federally Funded Research and Development Centers (FFRDCs), international entities, and many other organizations. Although there is only one bi-weekly teleconference 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. The UAS-NAS technical teams will support the development of the SC-228 Phase 2 MOPS similar to the support provided to SC-228 Phase 1 MOPS.

In addition to support of RTCA, the UAS-NAS Project involvement with industry has primarily been through NRAs or contracts; the UAS-NAS Project did 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 reduced the Government's burden while providing critical industry insight. The Communications Subproject worked 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 DAA research and the FAA ACAS Xu development. A NASA Research Announcement (NRA) with Honeywell to conduct validation of sensor models and tracking or fusion algorithms using data from representative flight tests was also utilized.

Phase 2 will continue to use cooperative agreements with Industry to develop C2 and DAA prototype flight hardware in order to draft the SC-228 Phase 2 MOPS.

4.3.2.1 Academic Interfaces

In Phase 1 - Part 2, the Project worked with several academic institutions. As defined in section 2.4.5.1, the Certification team worked with the University of North Dakota 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 1(FY14 - FY16), 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 Phase 1 - Part 2, 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.

In Phase 2, the project will continue to use grants with Universities. One example is a planned grant with The Ohio State University in the area of automation.

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 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 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 teleconferences continued and subsequently led to more of an active role through RTCA SC-203 WG2 and RTCA SC-228 C2 Working Group (WG) in Phase 1 - Part 2. Communications team members regularly attended WP5B teleconferences and meetings to coordinate studies to determine how the UAS CNPC spectrum needs could be addressed. Subsequently, the C2 Subproject has led 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 other International activities associated with the ICAO and the North Atlantic Treaty Organization (NATO) including the Flight In Non-segregated Airspace (FINAS) work, the UAS Study Group, Remotely Piloted Aircraft Systems Panel – specifically the Human Performance Working Group, Working Group 73, and EUROCAE WG-105.

4.4 Documents and Records Management

The UAS Integration in the NAS Project will comply with NASA Policy Directive (NPD) 1440.6, "NASA Records Management," 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 the NASA records retention schedule (see 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 NASA supported docushare server 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 upon the availability of funds as appropriated by the United States Congress. The planned budget by FY is shown in Table 3.

Table 3. The UAS-NAS Project budget.

2018 President's Budget ($s x K)				
Center	**FY17**	**FY18**	**FY19**	**FY20**
Totals	$33,700	$39,200	$37,900	$21,600

5.2 Acquisition Plans

The UAS-NAS Project will utilize workforce at all four NASA Aeronautics Research Centers (ARC, AFRC, GRC, and LaRC).

Due to the emerging state of UAS technology, especially as it relates to routine operations in the national 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. The acquisition strategy, therefore, must 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 toward mitigating this potential in Phase 2 through the development of the Phase 1 (FY17 - FY20) Portfolio, which tied all of the project technical work to the UAS community needs, and by embedding the SPMs within key groups, such as SC-228, 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 and from 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.

- Cooperative agreements are expected to represent a significant percentage of the funds for Phase 2. For example, a cooperative agreement for C2 SatCom work was established with Honeywell (to be discontinued starting in FY18). Also, the DAA subproject plans to establish a cooperative agreement for an alternative surveillance sensor system.
- Grants are not expected to represent a significant percentage of the funds for Phase 2 but will be utilized as appropriate. For example, there will be a grant with The Ohio State University for a DAA task.
- Funding of Phase III 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 expanded on UAS mission scenarios.
- 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 4 identifies the list of primary facilities, laboratories, and assets that will be used to implement the UAS-NAS Project. Specific facility and laboratory usage details are defined more thoroughly in the detailed Subproject implementation plans.

Table 4. Facility and resource utilization.

		Categorized by Subproject		
Facility/Lab/Asset	**Agency/ Center**	**DAA**	**IT&E**	**C2**
Air Traffic Control Lab	ARC	x	x	
Air Traffic Operations Lab	LaRC	x	x	
Aircraft Communication Simulation Lab	GRC			x
Airspace Operations Lab	ARC	x	x	
FAA UAS Test Sites	FAA	X	x	
Flight Deck Display Research Lab	ARC		x	
Manned Aircraft	AFRC, GRC		x	x
Manned Surrogate UAS	GRC	x		
NextGen Integration and Evaluation Capability	FAA Tech Center	x	x	
R2515 Restricted Airspace	AFRC		x	
Research GCS	AFRC		x	
Sim Development and Analysis Branch Simulators	LaRC	x		
UAS Assets	AFRC, ARC	x	x	
Vigilant Spirit Ground Station	US Air Force	x	x	x
Wireless Comm Lab	GRC			x

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 environmental management policy of the Host Center. Ground- and flight-test operations will be governed by the practices and procedures of the Host Center. Compliance with the environmental management policies of the resident Center is the responsibility of the individual test point of contact and flight assets and will be documented and maintained per the procedures of that Center. 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 of major research activities (simulations and flight tests) of significant complexity and comprehensive inputs to stakeholders (i.e. SC-228). L1 Milestones and L2 milestones directly support and are directly tied to the accomplishment of the 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 meeting;
- IASP Weekly Teleconference and UAS-NAS Monthly Detailed Status;
- Progress Indicators; and
- 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).

Figure 10 and Appendixes B1 and B2 present the Project Level and TC schedules and L1/L2 milestones as of 8/24/2017.

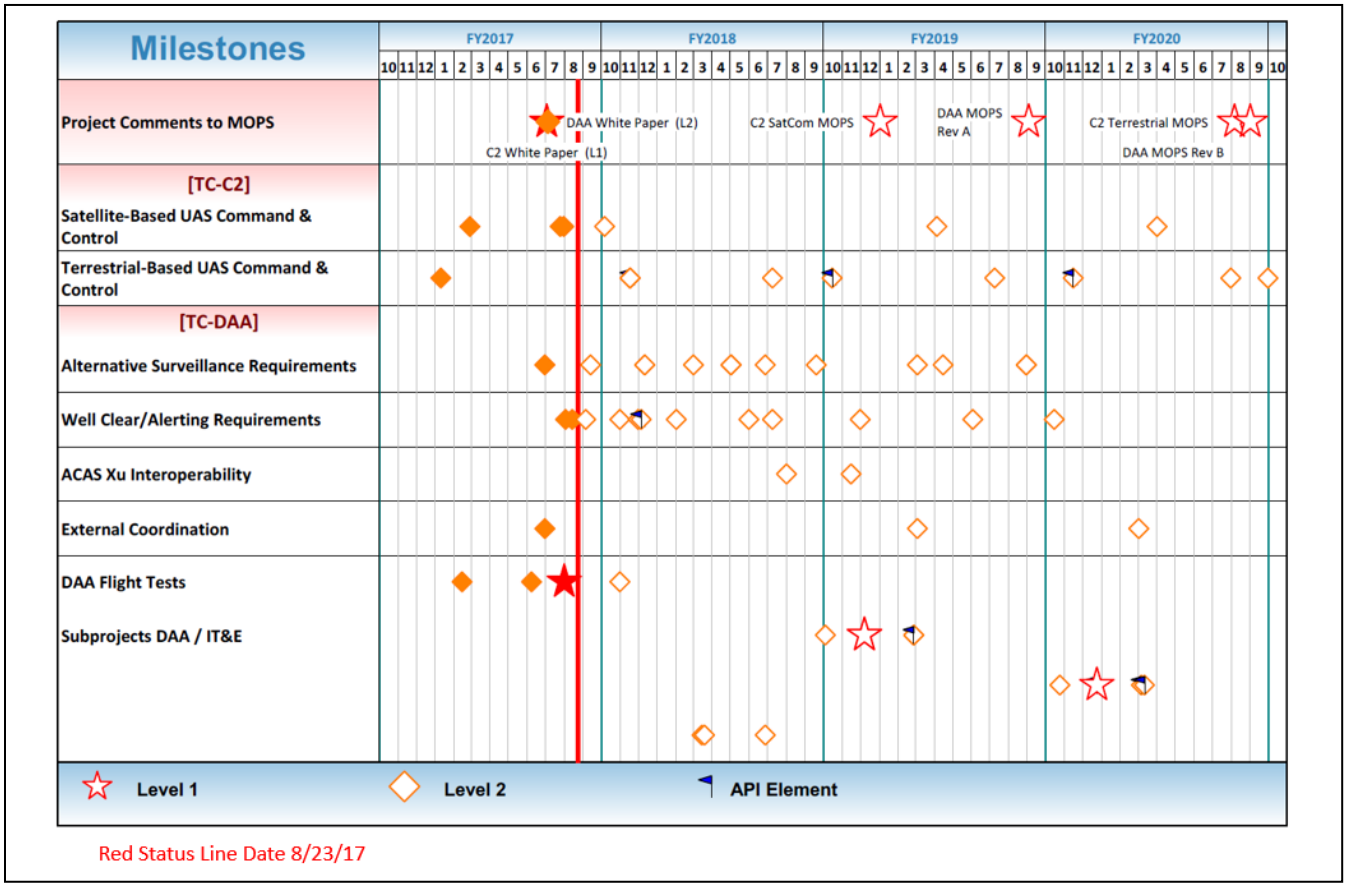


Figure 10. L1/L2 milestones (as of MRB 8/24/17).

Appendix A contains five tables presenting the Level 1 and Level 2 milestones grouped by Project Level, TC, and Subproject.

7 Work Breakdown Structure (WBS)

The Work Breakdown Structure (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 Corps (USMC), Autonomy]
- 4.0 Technology Development
  - 4.7 TC-Detect and Avoid
    - 4.7.1 DAA-Element Control
    - 4.7.2 DAA-Alt Surveillance
    - 4.7.3 DAA-Well Clear
    - 4.7.4 DAA-ACAS XU
    - 4.7.5 DAA-External Collaborations
    - 4.7.6 DAA-Integrated Events
  - 4.8 TC-C2-Command and Control
    - 4.8.1 C2 Element Control
    - 4.8.2 C2-Ka-/Ku-band SatCom
    - 4.8.3 C2-Terrestrial Extension
    - 4.8.4 C2-C-band SatCom
- 5.0 Validation and Test
  - 5.2 Integrated Test and Evaluation
    - 5.2.1 Integrated Test and Evaluation Subproject control
      - 5.2.1.1 AFRC Ownship
    - 5.2.2 Flight Test
    - 5.2.3 Integration of Tech into LVC-DE
    - 5.2.4 Simulation Planning and Testing
    - 5.2.5 Infrastructure Sustainment
- 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 1 - Part 2 Portfolio development, the UAS-NAS Project ensured the Phase 1 - Part 2 technical content would be relevant and meet community needs. The technology development activities and subsequent research findings were provided to key stakeholders to contribute toward enabling more effective and efficient UAS access to the NAS. The Project will use the same process in Phase 2. Additionally, NASA and the FAA have established a UAS Integration RTT. The UAS-NAS Project will be the primary NASA participant in this effort, which will also be used as a mechanism for technology transfer of Project research findings to the FAA.

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, RTCA SC-147, UAS ExCom UAS SARP, ICAO, and the ITU Radiocommunication Sector. Of the six 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 or Advisory Circulars can be created. Other safety, certification, air traffic, and research arms of the FAA also benefit by the findings of the UAS-NAS Project’s research. Table 5 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.

Table 5. Stakeholder list.

Stakeholder	Key Stakeholder Outputs	Community Influence
EUROCAE WG-105	C2 MASPS and MOPS to inform ICAO SARPS, validation of RTCA SC-228 MOPS from European perspective	European forum with US government and industry participation to inform global standards
FAA	Standards and regulations for UAS regulation	The rules and regulations for safe, timely, and efficient UAS Integration. UAS is a broad effort spanning many organizations within the FAA. The Project primary points of contact in the FAA are the Office of UAS Integration, the Research & Development Integration Division, and the Air Traffic Operations Line of Business.
ICAO	Human factors associated with RPAS	Consultants to the RPAS panel and lead of the Human Performance working group.
RTCA SC-228	DAA and C2 MOPS	Industry Forum providing consensus standards to the FAA to ensure successful integration of unmanned aircraft.
RTCA SC-147	Traffic Alert and Collision Avoidance System Performance Standards	Industry Forum providing consensus standards to the FAA to ensure successful integration of unmanned aircraft.
SIO Stakeholders	UAS and UAS Integrator	Develop an RFP with substantial industry investments to conduct the SIO demonstration Work with industry to develop C2 and DAA technologies in concert with essential vehicle technologies Conduct joint SIO demonstration
UAS ExCom UAS SARP	Government consensus on DAA issues, and DAA research gaps	The SARP has the ability to identify, influence, and provide recommendations on key research gaps with respect to DAA.

The technology transfer between the Project and key stakeholders is fully documented in the Project 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 Technical Baseline Document. These processes and documents are used to create and manage project research activities (or SPs), 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., International Traffic in Arms Regulations (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 11, or the UAS-NAS Project and each Subproject. This approach allows the identification, resolution or mitigation of risk issues prior to impact on activity outcomes.

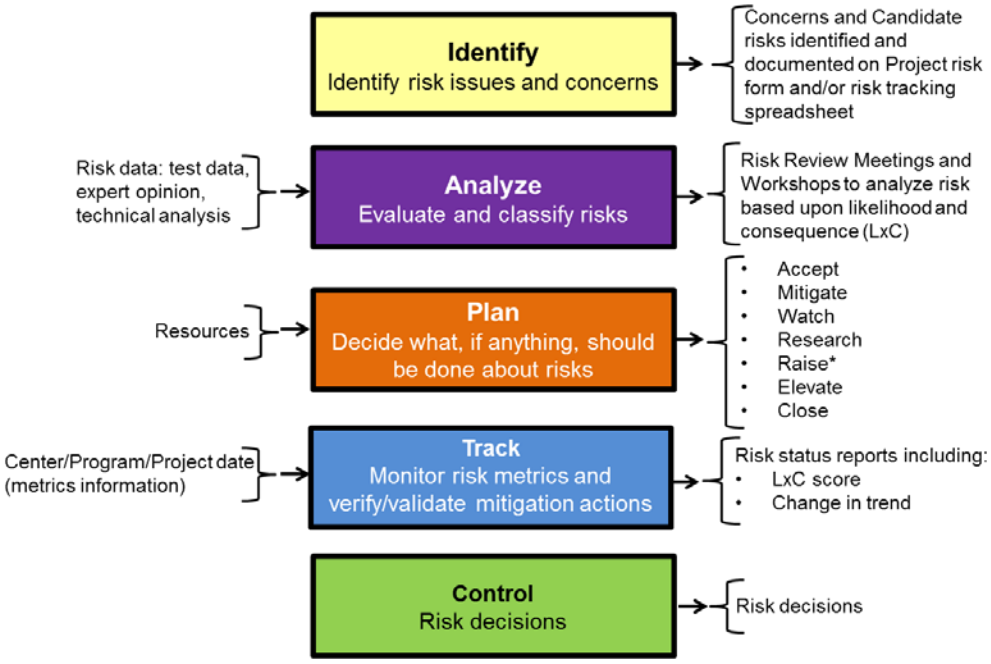
Figure 11. Continuous risk management process.

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 or Project relevance, achievement of Program goals and objectives, attainment of Project success, development of technologies, research, financial resources, and other strategic issues.

The application of the CRM process to the UAS-NAS Project is presented in Figure 12, The Project Office and Subprojects 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 Subproject Manger (SPM) / TL will be the risk owner. If the risk cuts across technical areas, the risk will be owned by either the CE or the PM.

Concerns identify potential risks; 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; concerns that have decreased are determined to be inactive and are no longer tracked; and concerns that remain the same are retained on the risk-tracking spreadsheet for later evaluation. Monthly, the Project holds risk workshops and/or a risk meeting to analyze risks based on 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, discussing any proposed candidate risks, and discussing risks proposed for closure with closing rationale. Risk review meetings are held on alternating months or monthly depending on need, 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 a “red” area of the risk matrix, is a risk with near-term impacts associated with a L1 milestone (i.e., flight test [FT] 3 for FY15), or has been identified as of interest to the IASP. Risks with an LxC score of 5 x 5 “red” will be briefed to the AFRC Center Director. Risk review meetings are not limited to reviewing top risks - they can be used to review all active risks.



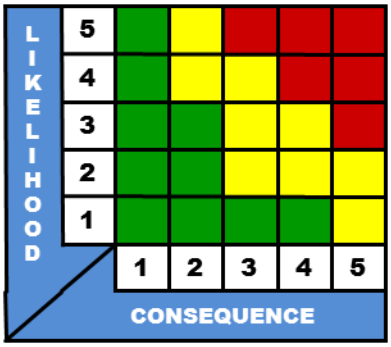
Note: Communication and documentation extend throughout all functions.
**Raise: unique to UAS-NAS Project*

Figure 12. UAS-NAS Project application of the continuous risk management 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.
    - Mitigation is considered complete when mitigation was executed. Mitigation is considered closed when the mitigation was partially executed but was no longer needed to mitigate risk.
- 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., integrated human-in-the-loop [IHITL] for FY14).
- Elevate - Transfer the management of a risk to the Program level.
- Close - Document closure rationale and obtain closure approval from the PM.

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 PM 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 13shows the UAS-NAS Project risk scorecard and definitions used for scoring likelihood and consequence. The scorecard 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 13. Risk scorecard 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 MRB. The briefing charts include: 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 the intent of mitigating the projected impact to the lowest level (resulting in the least adverse impact on cost, schedule, or agreed-to content).

The UAS-NAS Project strategy for mitigating risks utilizes an incremental approach in responsibility and authority. The incremental approach begins within the responsibility and authority of the TC and Emerging TC areas, builds to the Project Office, and builds further to responsibility and authority in the IASP, as may be appropriate.

Specifically, UAS-NAS Project technical content execution responsibility is assigned to the SPMs and TLs. Consequently, risk mitigation plans (or decision alternatives) will initially consider only resources within the TC area. Should the SPM be unable to resource the proposed mitigation plan from within the Subproject or within the supporting Centers, 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 activity relative to other Project and Subproject baselined activities.

Should the Project Office 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. 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 has not been obtained, then the only remaining strategy for the Program or Project will be to de-scope project activities per the Project proposal, in order to fit remaining technical content into the fixed, agreed-to-budget and schedule. 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

The IASP will conduct annual reviews of the UAS-NAS Project to assess the quality and performance of the Project. The 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. The first is the Independent Review Panel (IRP) of non-NASA Government or independent NASA experts; the second is the Performance Review Panel (PRP) of specific NASA ARMD personnel. The review will follow the ToR developed by the Program. The project annual review content may be leveraged to support the Program annual review conducted by the 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.
- 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 laying 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 TC 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 IRP and PRP provide feedback to the Project and the Program that includes an overall assessment of the Project and identification of strengths, concerns, observations, and recommendations. The IASP determines if and when the recommendations need to be addressed.

10.2 Center Management Council

The UAS-NAS Project will brief the Host Center 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 the 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 CMCs, which monitor and evaluate all project work executed at the respective Center. The PM presents to the Host Center CMC. The SPMs/TLs brief Center-specific Project status either at Partner Center CMCs or to CMC members, as requested by the ARDs. The CMC evaluation focuses on whether Center engineering, Safety and Mission Assurance (S&MA), health and medical, and management best practices (e.g., program and project management, resource management, procurement, and 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 PM, while the Partner Center CMCs provide feedback and/or actions to the Project through the SPMs, Project Center personnel, or to the PM directly, as needed.

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 A and Key Decision Point C

Phase 2 of the Project has two KDP reviews: KDP-A and KDP-C.

The purpose of the KDP-A review is to conduct an internal assessment to address the following:

- How does the Project fit into the overall approach to enabling realization of Thrust outcome(s)?
- How do the Project TCs support the strategic thrust roadmap(s)?
  - That is, whether the TC statements describe the challenge, barrier, or gap that needs to be resolved (TC statements are not statements describing what the Project intends to accomplish).
- How does the work addressing these TCs build on completed or ongoing research?
- Why NASA is uniquely positioned to lead or contribute?
- Considering the current state of the art and practice, and the results from the UAS-NAS project, does addressing these TCs further advance technology or knowledge in this area?
- Who are the potential partners and stakeholders?
  - What is the partnership strategy and associated plan?
- What is the tentative schedule between now and KDP-C? When would implementation begin?

The purpose of the Phase 2 KDP-C is to conduct an internal assessment of the relevance, technical plans, resource allocation plans, management plans, and partnership plans for the Project. The Project will be approved to move from formulation to implementation if the Project Management Team can effectively convey that the:

- Technical plans are relevant to the agency's mission and vision as well as, the ARMD Strategic Implementation Plan, and customer/stakeholder needs;
- Technical plans are feasible and executable;
- Planned resources and schedule are adequate to meet the stated goals and objectives of the Project with the acceptable level of risk; and
- Management process updates and partnership approaches are sound for the proposed UAS-NAS Project.

10.5 Project Completion

The project closeout approach will be defined and presented to the Program in the last quarter of FY19.

11 Security Plan

The UAS-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 described in section 8. The following Technology Transfer Control Plan (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 SPMs 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-publicly-releasable content and provides guidance on how sensitive data and information will be handled.

The Subprojects have identified those data covered by 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. If the integration of Subproject technologies creates ITAR data, the export control process of the Project Host Center (AFRC) 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: Lists the implementing contractors and partners.

Name of agreement(s): Lists current Phase 2 agreements. Additional details regarding data rights are captured in the Data and Information Sensitivity Plan.

Table 6. Phase 2 agreements.

Phase II Agreements	
Company/Agency	**Type of Agreement**
AFRL	DAA Task Order
AFRL	DAA Space Act Agreement
FAA	Interagency Agreement
FAA	MOA - Software Use Agreement
General Atomics	IT&E Space Act Agreement
Honeywell	IT&E and DAA Contract
Honeywell	C2 Cooperative Agreement
Rockwell Collins	C2 Cooperative Agreement
Honeywell	DAA Cooperative Agreement

All agreements, contracts, and grants will contain appropriate language with regard 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 1 - Part 2 and 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, in Phase 2. 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 and evaluated during UAS-NAS Project testing activities. GA-ASI has requested that the FN participate in the Project 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 identified 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 are 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 an FN.

- Data, information and (GA-ASI owned) laptop computer access related to the MQ-9 detect 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, latitudinal and longitudinal position).
- Access to the Ikhana ground control station (GCS) and/or UAS-NAS Research Ground Control Station (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 visions of the NASA Office of Education 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 unique content of the UAS-NAS Project will align with the Agency 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 the AFRC Office of Education 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; and

- Research collaboration with academia.

The UAS-NAS Project will collaborate with the AFRC 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 with other stakeholders within the UAS community to overcome the technical, operational, and public perception barriers and to assist with engaging stakeholders in the areas of public perception and awareness. The UAS-NAS Project developed an Outreach Plan (Doc#: UAS-OR-7.1-001) 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 what we do benefits the Nation.

The UAS-NAS Project strives to focus its outreach efforts on building a concise understanding of the UAS-NAS Project goals and research themes, creating visibility into what work is being done, promoting why NASA participation is essential, 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

Table 7. Revision History

Revision	Date	Page	Description
012-001	4/27/2017	All	CR156 All content updated for Phase 2 Prior to KDP-C and also Post KDP-C actions
	9/20/2017	All	Post-Phase 2 Baseline Update

Appendix A – L1/L2 Milestones (as of 8/24/17)

The following tables present the L1 and L2 milestones: Table A1 presents the L1 milestone list; Table A2 the Project Office L2 milestone list; Table A3 the TC-DAA L2 milestone list; Table A4 the TC-C2 L2 milestone list; and Table A5 the IT&E Subproject L2 milestone list.

Table 8 A1. L1 milestone list.

MS Level	Task Name	Commitment Date
	Project Level	
L1	[SP P.7.01] Submit Consolidated Input for DAA MOPS Rev A to RTCA	Tue 9/3/19
L1	[SP P.7.01] Submit Consolidated Input for DAA MOPS Rev B to RTCA	Tue 9/1/20
L1	[SP P.7.01] CE Upload NASA Project Consolidated RAC Comments for C2 White Paper to RTCA Website	Mon 7/3/17
L1	[SP P.7.01] Submit Consolidated Input for C2 SatCom Data Link MOPS to RTCA	Wed 1/2/19
L1	[SP P.7.01] Submit Consolidated Input for C2 Terrestrial Data Link MOPS to RTCA	Thu 8/6/20
	TC: Detect and Avoid (DAA)	
L1	[SP D.5.10] [SP T.8.10] End of Data Collection for ACAS Xu FT 2	Tue 8/1/17
L1	[SP D.5.20] [SP T.8.30] End of Data Collection for FT 5	Fri 1/18/19
L1	[SP D.5.30] [SP T.8.40] End of Data Collection for FT 6	Thu 1/9/20

Table 9 A2. Project Office L2 milestone list.

MS Level	Task Name	Commitment Date
	Project Office	
L2	[SP P.7.01] Submit Consolidated Input for DAA White Paper to RTCA	Wed 7/5/17
L2	[SP P.7.01] NASA Project Personnel Provide CE Comments on C2 White Paper	Wed 6/28/17

Table 10 A3. TC-DAA DAA Subproject L2 milestone list.

MS Level	Task Name	Commitment Date
	Detect and Avoid (DAA) Subproject	
L2	[SP D.1.20] Alternative Surveillance Award Date	Wed 9/13/17
L2	[SP D.1.30] Alternative Surveillance CONOPS Complete	Fri 6/30/17
L2	[SP D.1.40] Start of Data Collection for Foundational Low SWaP Fast-Time Simulation	Thu 6/29/17
L2	[SP D.1.40] Final Results Dissemination for Foundational Low SWaP Fast-Time Simulation to SC-228	Mon 12/11/17
L2	[SP D.1.60] Start of Data Collection for Unmitigated Fast-time Simulation for Low SWaP Sensors Using Surveillance Uncertainty with Updated DAA Well Clear Definition	Wed 5/2/18
L2	[SP D.1.60] Results Dissemination for Unmitigated Fast-time Simulation for Low SWaP Sensors Using Surveillance Uncertainty with Updated DAA Well Clear Definition to SC-228	Fri 9/19/18
L2	[SP D.1.70] Start of Data Collection for Alternative Surveillance HITL Sim 1	Thu 3/1/18
L2	[SP D.1.70] Results Dissemination for Alternative Surveillance HITL Sim 1	Wed 6/27/18
L2	[SP D.1.80] Start of Data Collection for Unmitigated/Mitigated Fast-time Simulation for Low SWaP Sensors Using Surveillance Uncertainty with Updated DAA Well Clear Definition	Mon 3/4/19
L2	[SP D.1.80] Results Dissemination for Unmitigated/Mitigated Fast-time Simulation for Low SWaP Sensors Using Surveillance Uncertainty with Updated DAA Well Clear Definition to SC-228	Fri 8/30/19
L2	[SP D.1.90] Start of Data Collection for Alternative Surveillance HITL 2	Mon 4/15/19
L2	[SP D.1.90] Results Dissemination for Alternative Surveillance HITL Sim 2	Fri 8/30/19
L2	[SP D.2.30] Start of Data Collection for Foundational Terminal Ops HITL	Tue 9/5/17
L2	[SP D.2.30] Results Dissemination for Foundational Terminal Ops HITL	Tue 12/5/17
L2	[SP D.2.40] Start of Data Collection for Foundational Terminal Ops Fast-time Simulation 1	Mon 8/14/17
L2	[SP D.2.40] Results Dissemination for Foundational Terminal Ops Fast-time Simulation 1	Thu 11/30/17
L2	[SP D.2.50] Start of Data Collection for Fast-time Simulation 2	Thu 8/3/17

L2	[SP D.2.50] Results Dissemination for Fast-time Simulation 2	Tue 10/31/17
L2	[SP D.2.60] Start of Data Collection for Fast-time Simulation 3	Thu 2/1/18
L2	[SP D.2.60] Results Dissemination for Fast-time Simulation 3	Thu 5/31/18
L2	[SP D.2.70] Start of Data Collection for Well Clear / Alerting Requirements HITL Sim 2	Mon 7/9/18
L2	[SP D.2.70] Results Dissemination for Well Clear / Alerting Requirements HITL Sim 2	Fri 11/30/18
L2	[SP D.2.80] Start of Data Collection for Well Clear / Alerting Requirements HITL Sim 3	Mon 6/3/19
L2	[SP D.2.80] Results Dissemination for Well Clear / Alerting Requirements HITL Sim 3	Tue 10/15/19
L2	[SP D.3.50] Start of Data Collection for ACAS Xu HITL Sim 1	Wed 8/1/18
L2	[SP D.3.50] Results Dissemination for ACAS Xu HITL Sim 1	Thu 11/15/18
L2	[SP D.4.10] Finalize Input to DAA White Paper for PO Consolidation	Fri 6/30/17
L2	[SP D.4.20] Finalize Input to DAA MOPS Rev A for PO Consolidation	Mon 3/4/19
L2	[SP D.4.20] Finalize Input to DAA MOPS Rev B for PO Consolidation	Mon 3/2/20
L2	[SP D.5.20] Results Dissemination/Briefing to SC-228 for FT 5	Thu 4/4/19
L2	[SP D.5.30] Results Dissemination for FT 6	Wed 3/25/20

Table 11 A4. TC-DAA IT&E Subproject L2 milestone list.

MS Level	Task Name	Commitment Date
	Integrated Test and Evaluation (IT&E) Subproject	
L2	[SP T.8.10] IT&E Finalize ACAS Xu FT 2 and GA Annex 2 Agreements Finish	Tue 2/14/17
L2	[SP T.8.10] Conduct Mission Tech Brief for ACAS Xu FT 2	Thu 6/8/17
L2	[SP T.8.10] ACAS Xu FT 2 Flight-test Report and Export Release Documentation Provided to Project Office and/or Stakeholder(s)	Tue 10/31/17
L2	[SP T.8.20] No-chase COA Tech Brief	Thu 3/15/18
L2	[SP T.8.20] Begin Flights for No-chase COA	Mon 3/19/18
L2	[SP T.8.20] NCC Flight-test Report and Export Release Documentation Provided to Project Office and/or Stakeholder(s)	Wed 6/27/18
L2	[SP T.8.30] FT 5 Encounter Flights Tech Brief	Thu 10/18/18
L2	[SP T.8.30] FT 5 Flight-test Report and Export Release Documentation Provided to PO and/or Stakeholder(s)	Fri 4/5/19
L2	[SP T.8.40] Conduct FT 6 Encounter Flights Tech Brief	Thu 10/24/19
L2	[SP T.8.40] FT 6 Flight-test Report and Export Release Documentation Provided to Project Office and/or Stakeholder(s)	Fri 3/20/20

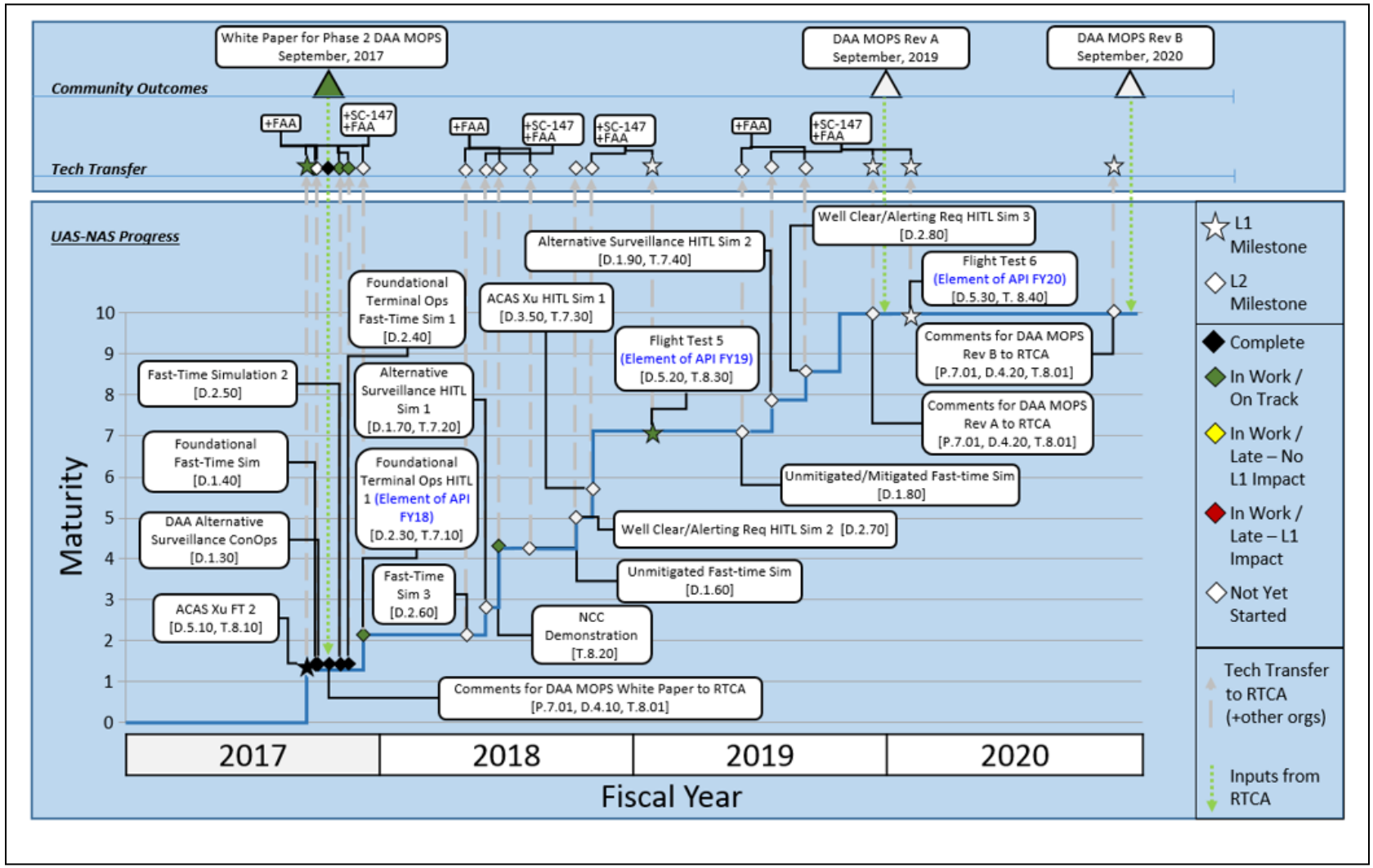
Table 12 A5. TC-C2 L2 milestone list.

MS Level	Task Name	Commitment Date
	Command and Control (C2) Subproject	
L2	[SP C.5.05] Award Cooperative Agreement for C2 SatCom	Mon 2/27/17
L2	[SP C.5.10] Ku Interference Evaluation System Development Complete	Tue 7/25/17
L2	[SP C.5.11] Start Flight-test Phase Ku Interference	Mon 7/31/17
L2	[SP C.5.11] Deliver Ku Interference Final Report Delivered to SC-228 C2 WG	Fri 10/6/17
L2	[SP C.5.41] Start of C-band SatCom Verification & Validation Plan	Fri 4/5/19
L2	[SP C.5.41] C-band SatCom Final Report Complete	Wed 4/1/20

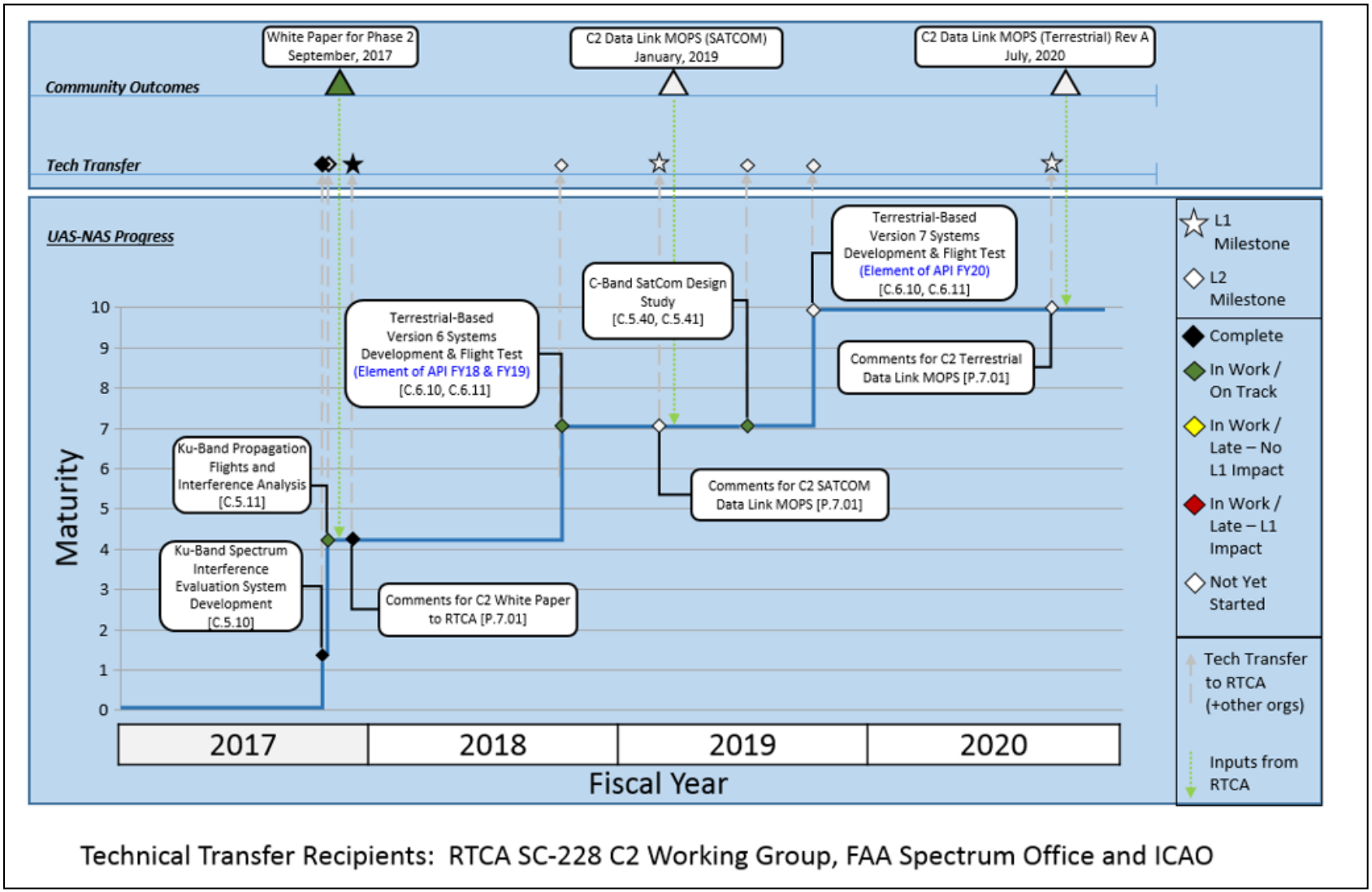
L2	[SP C.6.10] Award Cooperative Agreement for C2 Terrestrial Extensions	Tue 1/10/17
L2	[SP C.6.10] C2 Initial Test Asset Complete	Fri 11/17/17
L2	[SP C.6.10] Low SWaP C2 Radio Cooperative Agreement Modification Complete	Fri 11/17/17
L2	[SP C.6.11] Terrestrial-based Version 6 Flight-testing Begin	Mon 7/9/18
L2	[SP C.6.11] Version 6 Terrestrial-Based UAS Command & Control Flight Test Report Complete	Tue 10/15/18
L2	[SP C.6.11] Terrestrial-based Version 7 Flight Test Begins	Mon 7/9/19
L2	[SP C.6.11] Version 7.0 Terrestrial-based UAS Command & Control Flight Test Report Complete	Fri 11/15/19
L2	[SP C.6.11] Terrestrial-based UAS Command & Control Final Report Complete	Wed 9/30/20
L2	[SP C.6.11] Deliver Comments for C2 Data Link MOPS (Terrestrial) Rev A to CE for Consolidation	Fri 7/31/20
L2	[SP C.6.20] ODM Trade Study Complete	Fri 3/29/19

Appendix B: Progress Indicators

Appendix B1: TC-DAA: Progress Indicator (as of MRB 8/24/2017)



4.5 Appendix B2: TC-C2: Progress Indicator (as of MRB 8/24/2017)



Appendix C: Annual Performance Indicators / Annual Performance Goals

The UAS-NAS Project FY12 - FY16 Annual Performance Goals (APGs) and Annual Performance Indicators (APIs), and their respective success criteria, are shown below. The APIs for Phase 2 will be defined at PPBE19.

- **FY12 APG: Develop integrated Human Systems Integration, Communications, and Separation Assurance/Sense and Avoid Interoperability Subproject test concept and Phase 1 - Part 1 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 1 - Part 1 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 1 - Part 1 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 1 - Part 1 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, and Constructive (LVC-DE) 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-DE system performance.
    - Yellow – Complete evaluations involving virtual aircraft operations in a simulated NAS. Analyze the test results and characterize the LVC-DE 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-DE system performance.
- **FY14 APG: Conduct a human-in-the-loop (HITL) simulation in which 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 in which 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 in which 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 in which UAS aircraft are mixed with manned aircraft and subjected to a range of test conditions. (i.e., separation alerts, communication latencies).
- **FY15 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, control and non-payload communication [CNPC] flight-test series, and Detect and Avoid [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 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.
- **FY17 API**: No Project API per discussion with IASP.
- **FY18 API**: **Complete the data collection, analysis, and reporting for the Detect and Avoid (DAA) well clear / alerting requirements, foundational terminal operations,**

human-in-the-loop (HITL) simulation; and complete the initial test asset for the Command and Control (C2) version six (V6) terrestrial communication system test

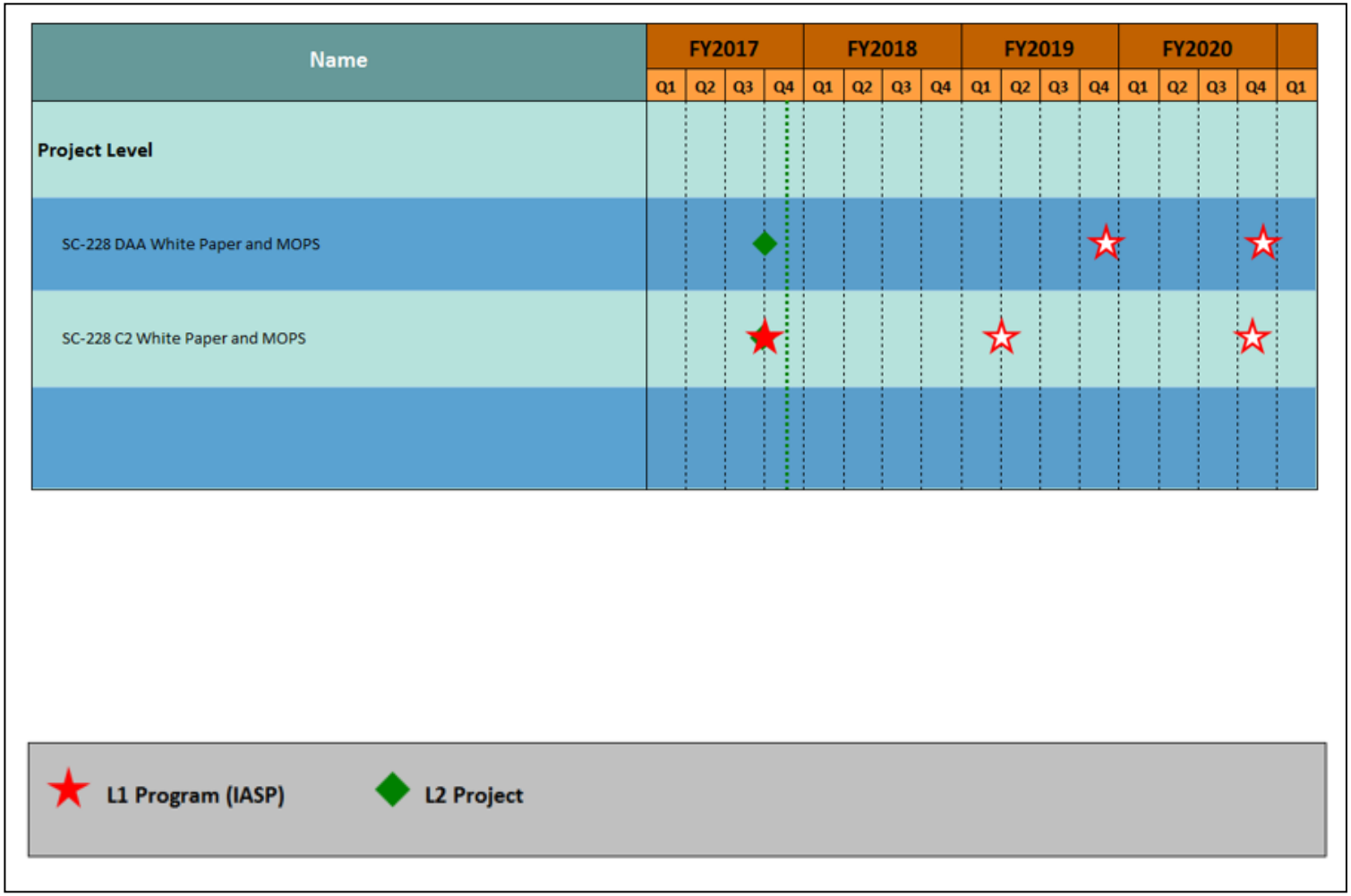
- Success Criteria
  - Green – Complete the data collection, analysis, and reporting for DAA well clear / alerting requirements, foundational terminal operations, HITL simulation and complete the initial test asset for C2 v6 terrestrial communication system test
  - Yellow – Complete the data collection, analysis, and reporting for DAA well clear / alerting requirements, foundational terminal operations, HITL simulation or complete the initial test asset for C2 v6 terrestrial communication system test
  - Red – Do not complete either the data collection, analysis, and reporting for DAA well clear / alerting requirements, foundational terminal operations, HITL simulation or the initial test asset for C2 v6 terrestrial communication system test

- **FY19 API**: **Complete the data collection, analysis, and reporting for Detect and Avoid (DAA) *[and Integrated Test and Evaluation (IT&E)]*[4] flight test five (FT5) and for Command and Control (C2) version six (v6) terrestrial communication system flight test**
  - Success Criteria
    - Green – Complete the data collection, analysis, and reporting for both DAA **[and IT&E]** FT5 and C2 v6 terrestrial communication system flight test
    - Yellow – Complete the data collection, analysis, and reporting for either DAA **[and IT&E]** FT5 or C2 v6 terrestrial communication system flight test
    - Red – Do not complete the data collection, analysis, and reporting for either DAA **[and IT&E]** FT5 or C2 v6 terrestrial communication system flight test

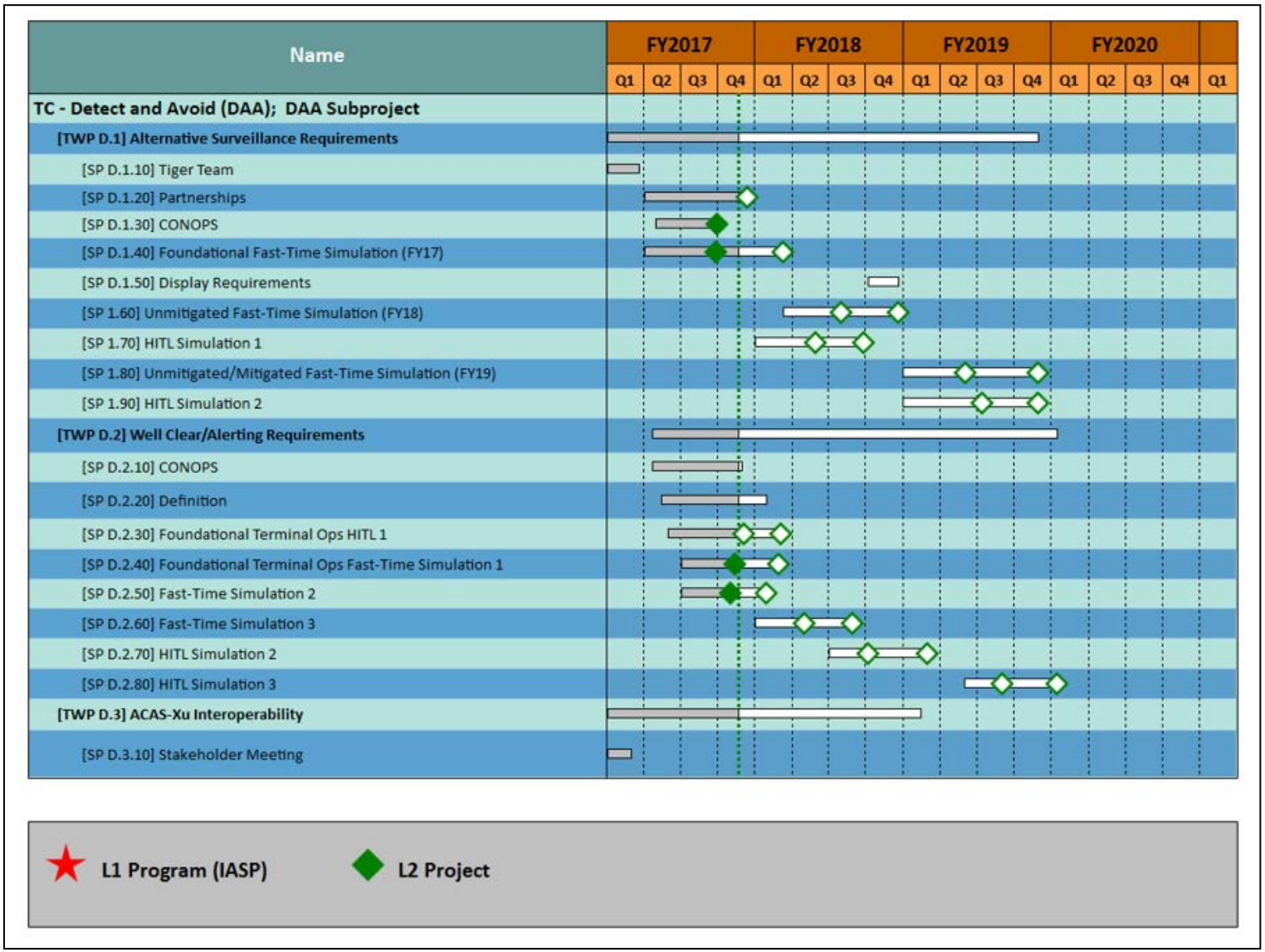
[4] Blue Italics in brackets are to be added when APIs are updated for PPBE19

Appendix D: Schedules

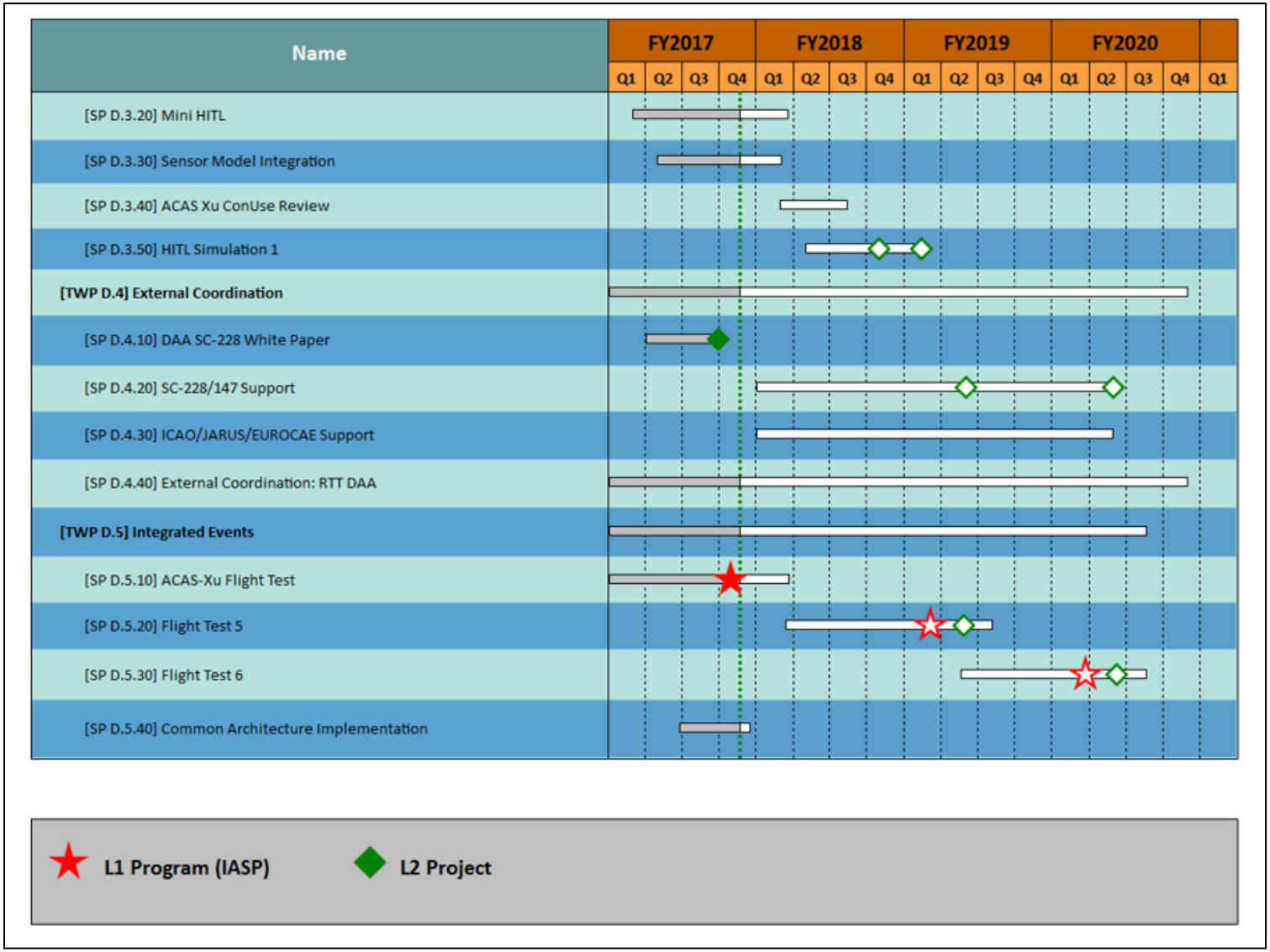
Appendix D1: Project Office: Schedule page 1 of 1 (as of MRB 8/24/2017)



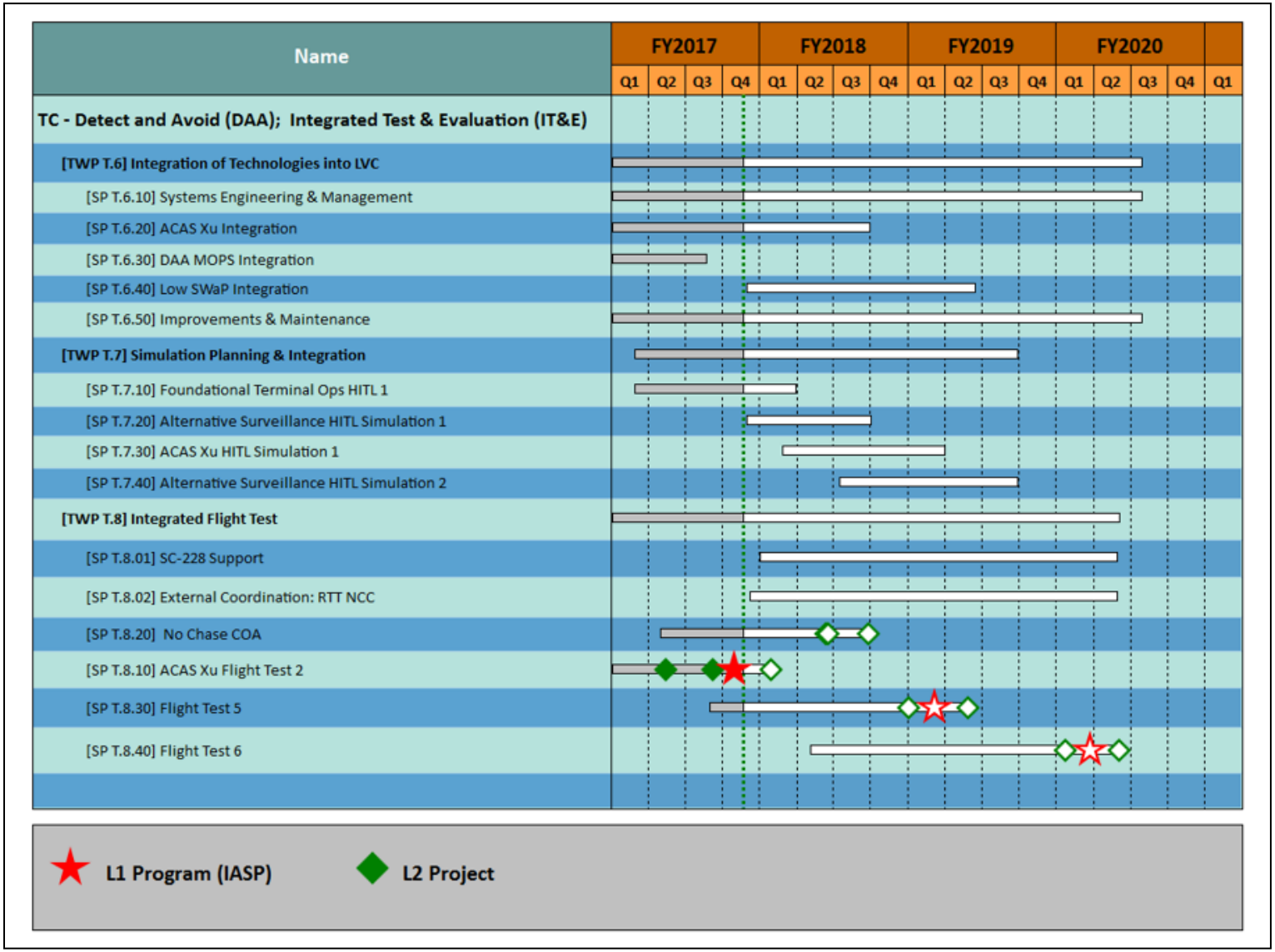
Appendix D2: TC-DAA and DAA Subproject: Schedule page 1 of 2 (as of MRB 8/24/2017)



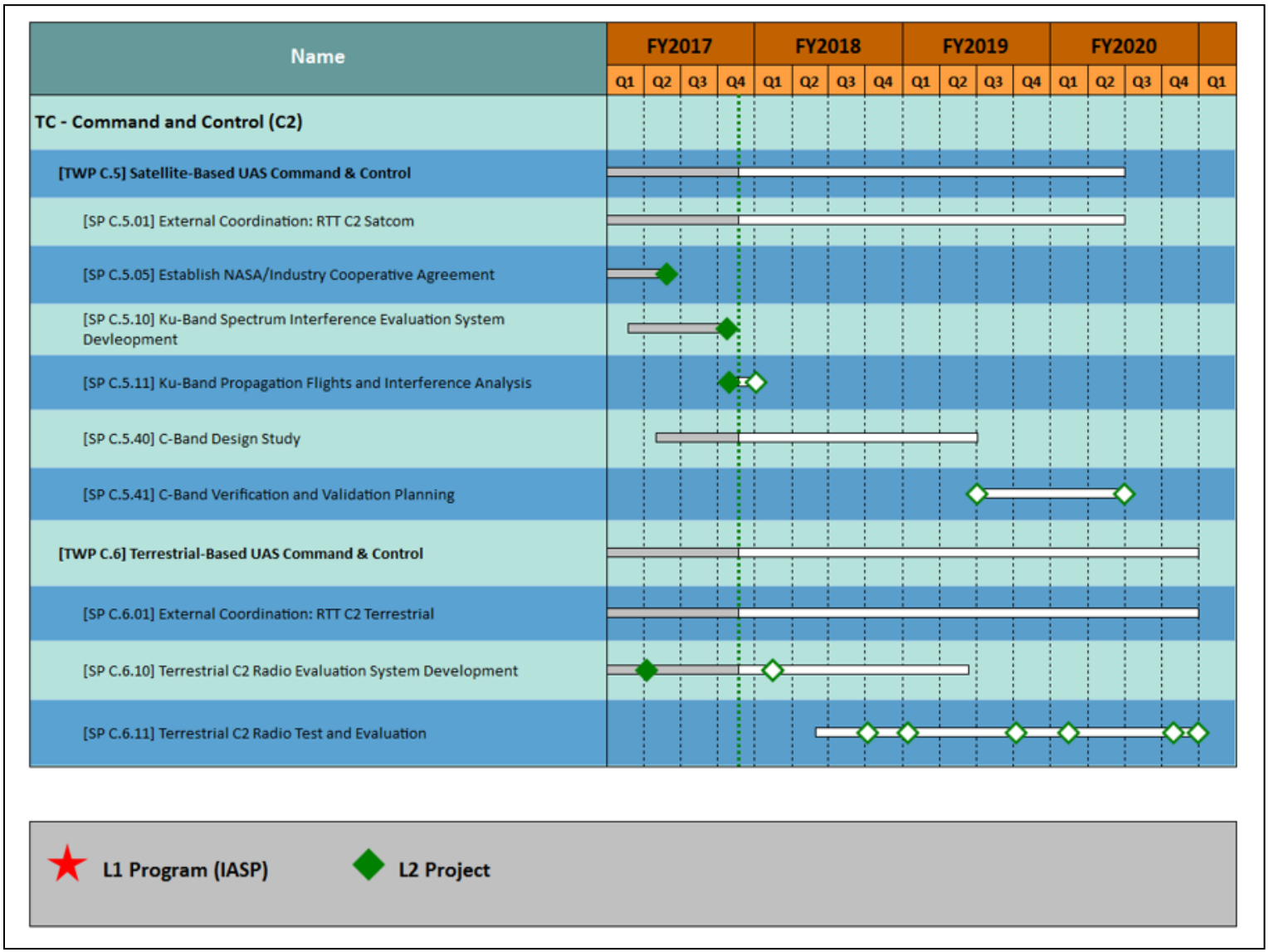
Appendix D2: TC-DAA and DAA Subproject: Schedule page 2 of 2 (as of MRB 8/24/2017)



Appendix D3: TC-DAA and IT&E Subproject: Schedule page 1 of 1 (as of MRB 8/24/2017)



Appendix D4: TC-C2: Schedule page 1 of 1 (as of MRB 8/24/2017)



Appendix D5: SIO (Schedule to be defined after SIO Industry Day)

SIO is currently not defined as a TC, the TWPs will be defined as content is matured.

Appendix E: 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 Aeronautics Strategic Implementation Plan	Latest version
NASA Aeronautics Website: https://www.nasa.gov/aeroresearch/strategy.	N/A
NASA Records Management NASA 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 Systems Engineering Handbook NASA/SP-2007-6105	Latest version

Title	Dated
NASA SE Processes and Requirements NPR 7123.1	Latest version
National Aeronautics Research and Development Plan	February 2010
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
UAS-NAS Project Plan ~~(Phase 2)~~ now Phase 1 - Part 2	28 September 2015

Appendix F: Acronyms

ACAS	Airborne Collision Avoidance System
ACAS Xu	Airborne Collision Avoidance System for Unmanned Aircraft
ACES	Airspace Concept Evaluation System
ACMC	Armstrong Center Management Council
ADD	Architecture Design Document
AFRC	Armstrong Flight Research Center
AFRL	Air Force Research Lab
AOSP	Airspace Operations and Safety Program
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
ATM	Air Traffic Management
AUS	FAA UAS Integration Office
BOBJ	Business Objectives
C	C2 numbering system for TWPs/SPs
C2	Command and Control
CANSO	Civil Air Navigation Services Organization
CDP	Content Decision Process
CE	Chief Engineer
CEA	Center Export Administrator
CFR	Code of Federal Regulations
CMB	Change Management Board
CMC	Center Management Council
CMP	Change Management Plan
CNPC	control and non-payload communication
CNS	Communication, Navigation and Surveillance
COA	Certificate of Waiver or Authorization
Comm	communications
ConOps	Concept of Operations
CPDS	Conflict Prediction and Display System
CRM	continuous risk management
CSU	California State University
D	DAA numbering system for TWPs/SPs

DAA	Detect and Avoid
DATR	Dryden Aeronautical Test Range
DDTC	Director of Defense Trade Controls
DHS	Department of Homeland Security
DoD	Department of Defense
DPM	Deputy Project Manager
DPMf	Deputy Project Manager for
ECR	Export Control Representative
ERT	Engineering Review Team
ETC	Emerging Technical Challenge
EUROCAE	European Organisation for Civil Aviation Equipment
ExCom	Executive Committee
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FDC	Flight Demonstrations and Capabilities
FFRDC	Federally Funded Research and Development Center
FN	foreign national
FRAC	Final Review and Comment
FT	flight test
FTE	full-time equivalent
FTP	Flight Test Plan
FTRD	Flight Test Requirements Document
FY	Fiscal Year
GA	General Aviation or General Atomics
GA-ASI	General Atomics Aeronautical Systems, Inc.
GCS	ground control station
GRC	Glenn Research Center
HITL	human-in-the-loop
HQ	Headquarters
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
IRP	Independent Review Panel

ITAR	International Traffic in Arms Regulations
IT&E	Integrated Test and Evaluation
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union Radio Communication Sector
K	kilo (1,000)
KDP	Key Decision Point
L	Level
LaRC	Langley Research Center
LVC-DE	Live Virtual Constructive – Distributed Environment
LVIS	Live Virtual Integrated System
LxC	likelihood and consequence
MASPS	minimum aviation system performance standards
MIT/LL	Massachusetts Institute of Technology Lincoln Labs
MOA	Memorandum of Agreement
MOPS	minimum operational performance standards
MPCP	Mishap Preparedness Contingency Plan
MRB	Management Review Board
N2	2nd upgrade to the original NBS
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NCC	no-chase COA
NextGen	Next Generation Air Transportation System
NPD	NASA Procedural Development
NPR	NASA Procedural Requirement
NRA	NASA Research Announcement
OGA	other Government agencies
ops	operations
OR	outreach
ORD	Objectives and Requirements Document
P	Project Numbering System for TWPs/SPs
P2	Phase 2
PD	Program Director
PE	Project Engineer
PI	Progress indicator
PM	Project Manager
PMC	Program/Project Management Committee
PMT	Project Management Tool
PO	Project Office

PP&C	Project Planning and Control
PPBE	Planning, Programming, Budgeting and Execution
PRO	Project
req	requirements
rev	revision
RGCS	Research Ground Control Station
RIDM	risk-informed decision-making
RMB	Risk Management Board
RMP	Risk Management Plan
RPAS	Remotely Piloted Aircraft System
RT	Research Theme
RTCA	Radio Technical Commission for Aeronautics
RTT	Research Transition Team
SA	Separation Assurance
SAA	Sense and Avoid
SAP	Systems Application Products
SARP	Science and Research Panel
SatCom	satellite communications
SBIR	Small Business Innovative Research
SC	Special Committee
SDD	Software Design Document
SEMP	Systems Engineering Management Plan
SFAR	Special Federal Aviation Regulations
sim	simulation
SIO	Systems Integration and Operationalization
S&MA	Safety and Mission Assurance
SMD	Science Mission Directorate
SMP	Schedule Management Plan
SP	Schedule Package
SPM	Subproject Manager
SRD	Systems Requirement Document
SSI	Separation Assurance/Sense and Avoid Interoperability
STEM	Science, Technology, Engineering, and Mathematics
STP	Software Test Plan
sUAS	small UAS
SWaP	size, weight, and power
SWG	Schedule Working Group
SWRD	Software Requirements Design

T	IT&E numbering system for TWPs/SPs
TA	Technical Authority
TAA	Technology Assistance Agreement
TB	Technical Baseline
TBD	To Be Determined
TC	Technical Challenge
TL	Technical Lead
ToR	Terms of Reference
TRL	Technology Readiness Level
TTCP	Technology Transfer Control Plan
TTP	Technology Transfer Plan
TWP	Technical Work Package
UAPO	Unmanned Aircraft Program Office
UAS	Unmanned Aircraft Systems
UASIO	Unmanned Aircraft Systems Integration Office
UAV	Unmanned Aerial Vehicle
UNITE	Unmanned National Industry Team
USMC	United States Marine Corps
V&V	Verification & Validation
VDD	Version Description Document
VSCS	Vigilant Spirit Control Station
WBS	Work Breakdown Structure
WG	Working Group
WRC	World Radio Conference
WRC-12	World Radio Conference 2012