National Aeronautics and Space Administration

UAS Integration in the NAS Project Baseline Review

Laurie Grindle

Project Manager, UAS Integration in the NAS Project

May 16, 2014

Baseline Review Decision Request

- KDP Elements
  1. KDP review focused on:
     - ✓ How the Project is addressing the UAS Community needs for NAS Access
     - ✓ The Phase 2 technical content and associated resource estimates, schedule, and risks
  2. Baseline review focuses on:
     - Phase 2 execution plans including project controls for the execution
     - Readiness to baseline the Phase 2 Portfolio and associated needs, objectives, deliverables, requirements, resource estimates, schedules, and risks
     - Technical Challenge cost and schedule are adequate estimates that reflect the scope, objectives and requirements.
     - Phase 2 portfolio has sufficient reserves, addressing both known and unknown risks
     - Center evaluations of ability to execute Phase 2 Portfolio
- Decision the Project is seeking today
  - Approval to proceed with baseline plan

Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge (will step through details for TC-ITE)
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

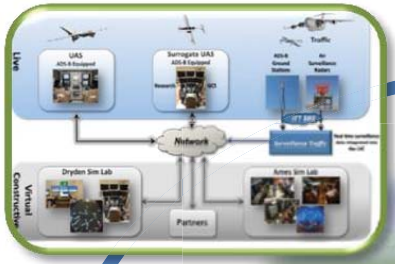
Project Goal, Research Themes, & Technical Challenges

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

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

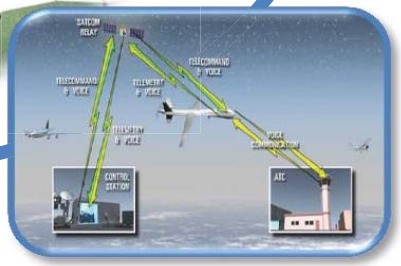
Research Theme 2: Test Infrastructure - Test infrastructure to enable development and validation of airspace integration procedures and performance standards

TC-ITE: Integrated Test & Evaluation



TC-SAA: SAA Performance Standards

TC-HSI: Human Systems Integration



TC-C2: C2 Performance Standards

KDP/KDP Follow-on Results & Action Summary

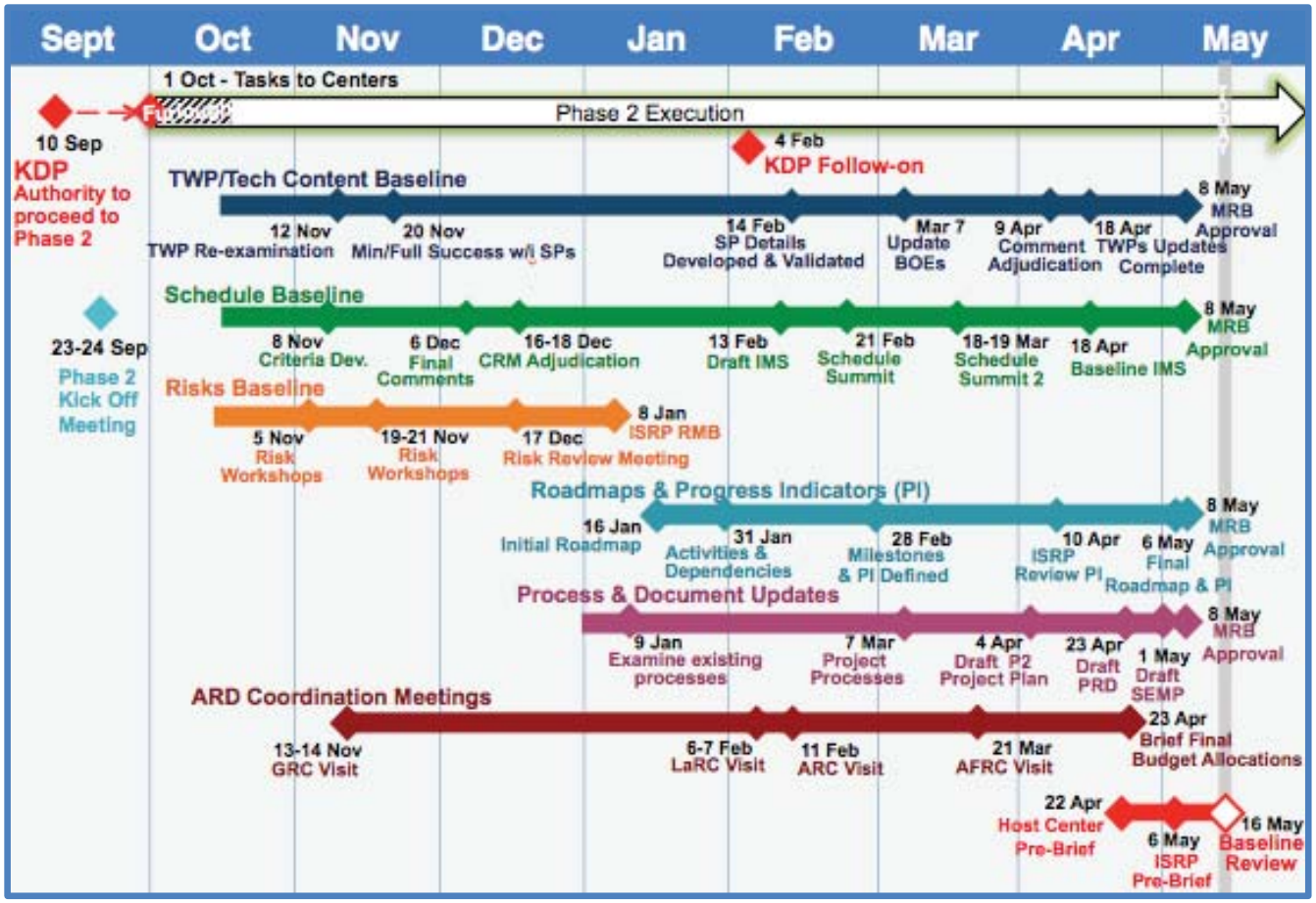
- KDP Outcome
  - Approved to proceed with the execution of TC1 (TC-SAA), TC2 (TC-C2), TC3 (TC-HSI), and TC6 (TC-ITE)
- KDP Actions to be statused at Baseline Review
  - LVC-DE Enhancements Secondary Action
- KDP Follow-on Outcome
  - Approved to proceed with execution of more robust TC6 (TC-ITE)
  - Approved to proceed with the path forward toward identifying future LVC-DE enhancements
- KDP Follow-on Actions to be Addressed at Baseline Review
  - Focus on aligning the work in TC1 (TC-SAA), TC2 (TC-C2), TC3 (TC-HSI), and TC6 (TC-ITE) to meet stakeholder need dates and baseline “full success” in these areas
  - Remove the work that was in TC4 and TC5 from the technical challenge structure for greater flexibility
    - The Non-Technical Challenge work should be far-reaching and address future challenges

Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge (will step through details for TC-ITE)
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

Baseline Review Preparation

- Developed Phase 2 Baseline through the examination and development of the following:
  - TWP/Technical Content
  - Schedule
    - Roadmap & Progress Indicators
  - Risks
  - Budget
  - Monitoring & Control Processes
  - Governing Project Documents
- Additional activities
  - ARD Coordination Meetings
  - Pre-Briefs to Host Center and ISRP



Technical Baseline Development

Technical Challenges (TC)

- Defined by subproject focus area to develop research findings

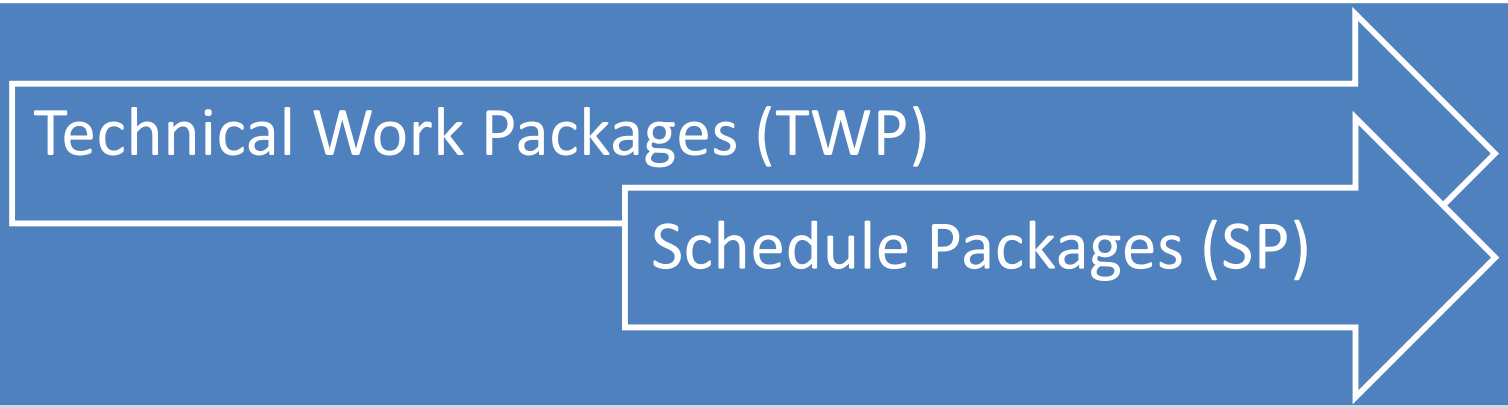
Technical Work Packages (TWP)

- Defined at KDP
- Defined by systematic groupings of SPs
- Provided technical detail and ability to manage SP activities and tasks
- TWP Objectives are documented in the Project Requirements Document (PRD)

Schedule Packages (SP)

- New for Baseline Review
- Defined the Phase 2 technical content and significantly enhances technical detail
- Defined by discrete activities and tasks necessary to accomplish a TWP
- Basis of Estimate (BOE) defined at SP level
- SP Objective, Approach, and Deliverable defined the Phase 2 technical baseline and are documented in Project Requirements Document (PRD)

TWP/SP Content



- Community Need Addressed by the SP	- Objectives
- State of the Art Prior to the Project	- Approach
- Contributions by Phase 1 and/or other SPs	- Deliverables and Plans for Use
- Benefit to the Community	- Dependencies to other SPs or TWPs
- Key Collaborators/Formal Partners	- Schedule
- Success Criteria	- Cost/Resources

TC Requirements Summary and Example

Requirements Summary	Total
TC-SAA: Sense and Avoid Performance Standards Requirements and Technical Baseline	29
TC-C2: Command and Control Performance Standards Requirements and Technical Baseline	16
TC-HSI: Human Systems Integration Requirements and Technical Baseline	13
TC-ITE: Integrated Test & Evaluation Requirements and Technical Baseline	13

Example from Project Requirements Document (PRD)					
Requirement		Verification Method	Technical Baseline		
Number	Description		Objective	Approach	Deliverable
TC SAA: Sense and Avoid Performance Standards Requirements and Technical Baseline					
S.1.30.1	The SSI Subproject shall report on the Interoperability of Self-separation and Collision Avoidance Functions Airspace Concept Evaluation System (ACES) Simulation (reference Integrated Master Schedule UID 4767; SP S.1.30).	I	Analyze the interoperability of self-separation (SS) and collision avoidance (CA) algorithms and the level of integration required for self-separation and collision avoidance algorithms.	Builds on research findings from Sub-Function Tradeoffs with Unmanned Aircraft System Performance ACES Simulation. Create new ACES architecture to interact within different community defined concept of operations. Conduct NAS–wide fast-time simulations to analyze the trade-off in performance of different self-separation and collision avoidance interaction concepts.	Report documenting guidelines for SS and CA algorithms interoperability including SS and CA interoperability requirement recommendations for SC-228 DAA Working Group MOPS (reference Integrated Master Schedule UID 4767; SP S.1.30). Briefings to RTCA SC-228 DAA Working Group if requested(reference Integrated Master Schedule UID 6319; SP S.1.30).

Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
  - Technical
  - Schedule
  - Risk
  - Budget
- Baseline Content per Technical Challenge (will step through details for TC-ITE)
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

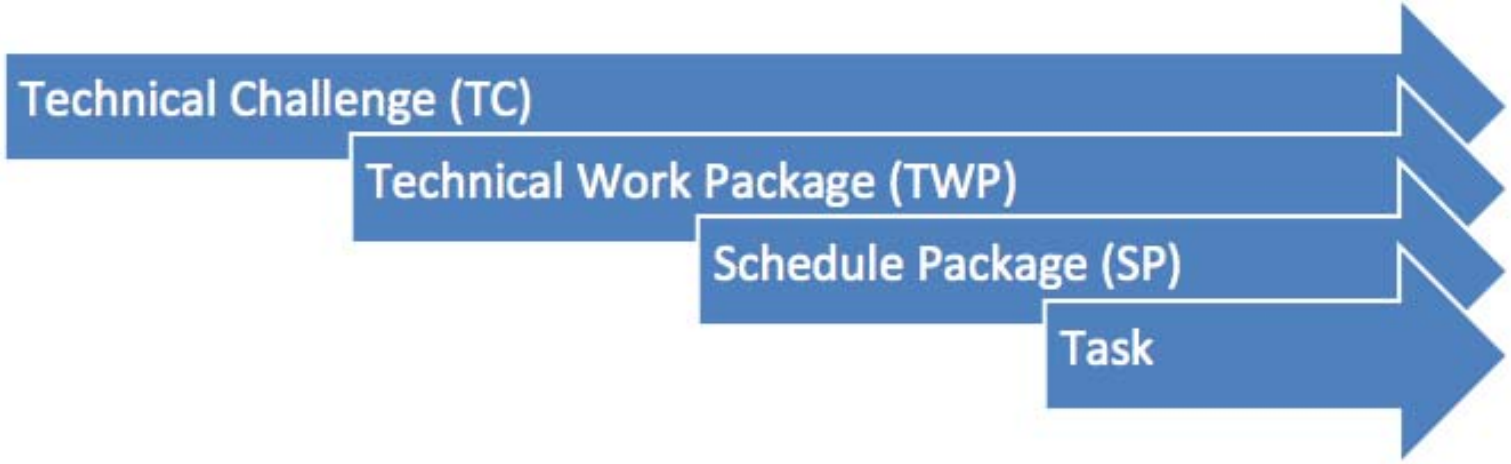
Integrated Master Schedule Review

- Team 1 Focus: Center execution internal to a subproject
  - Responsible Leads: DPMfs
  - Focus Areas:
    - Verify Project and Center processes are represented and appropriate time is allocated
    - Verify fidelity and realism of schedule dates and milestones
    - Verify that all activities end with a product
    - Verify all internal and external dependencies are captured accurately
    - Identify potential schedule risks

- Team 2 Focus: Project execution across the subprojects
  - Responsible Leads: Project Office
  - Focus Areas:
    - Verify all dependencies across TWPs and identify missing dependencies
    - Verify all dependencies with external organizations (e.g. RTCA, FAA, SARP, ITU-R, etc)
    - Confirm all external risk mitigation efforts that require resources are captured
    - Began development of a project roadmap; updated Progress Indicators, and milestones

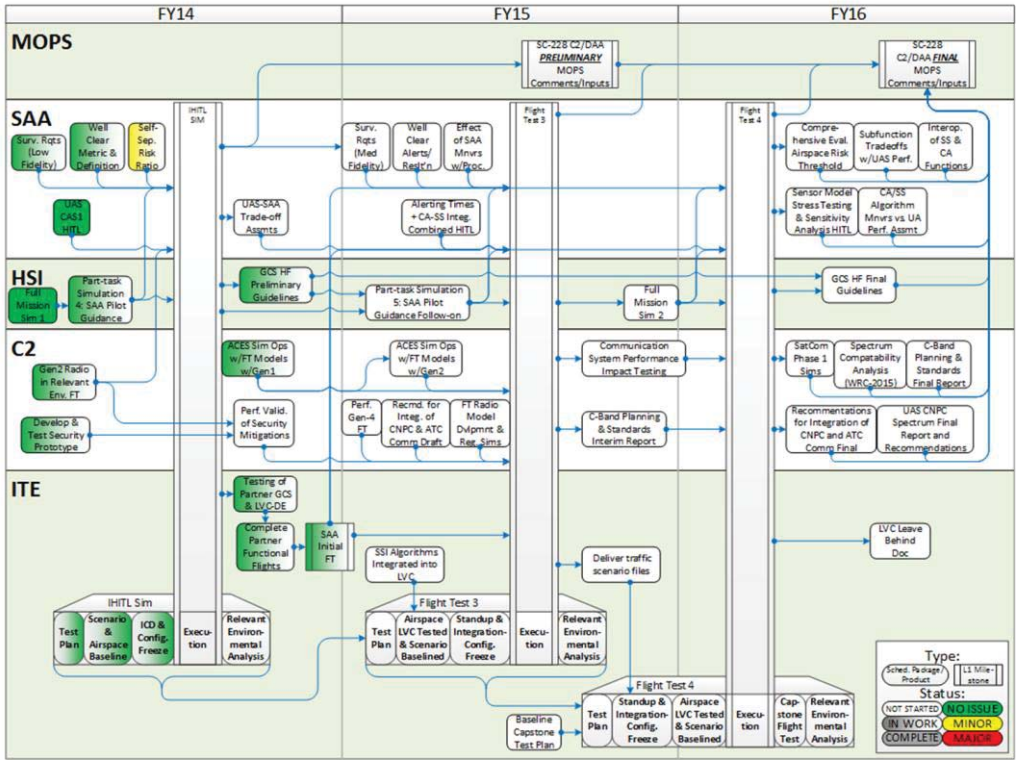
Baseline IMS Development

- Comments from both teams rolled into a project Comment Resolution Matrix (CRM) and resolved
- CRM generated several strategic changes to the schedule including:
  - Deliverables across subprojects
  - Technology transfer
  - Export control processes
  - Synchronized and executable schedule
- Two Schedule Summit meetings held to ensure an achievable schedule
- The Project IMS is currently a network of activities in a common format used to ensure the project meets it's commitments



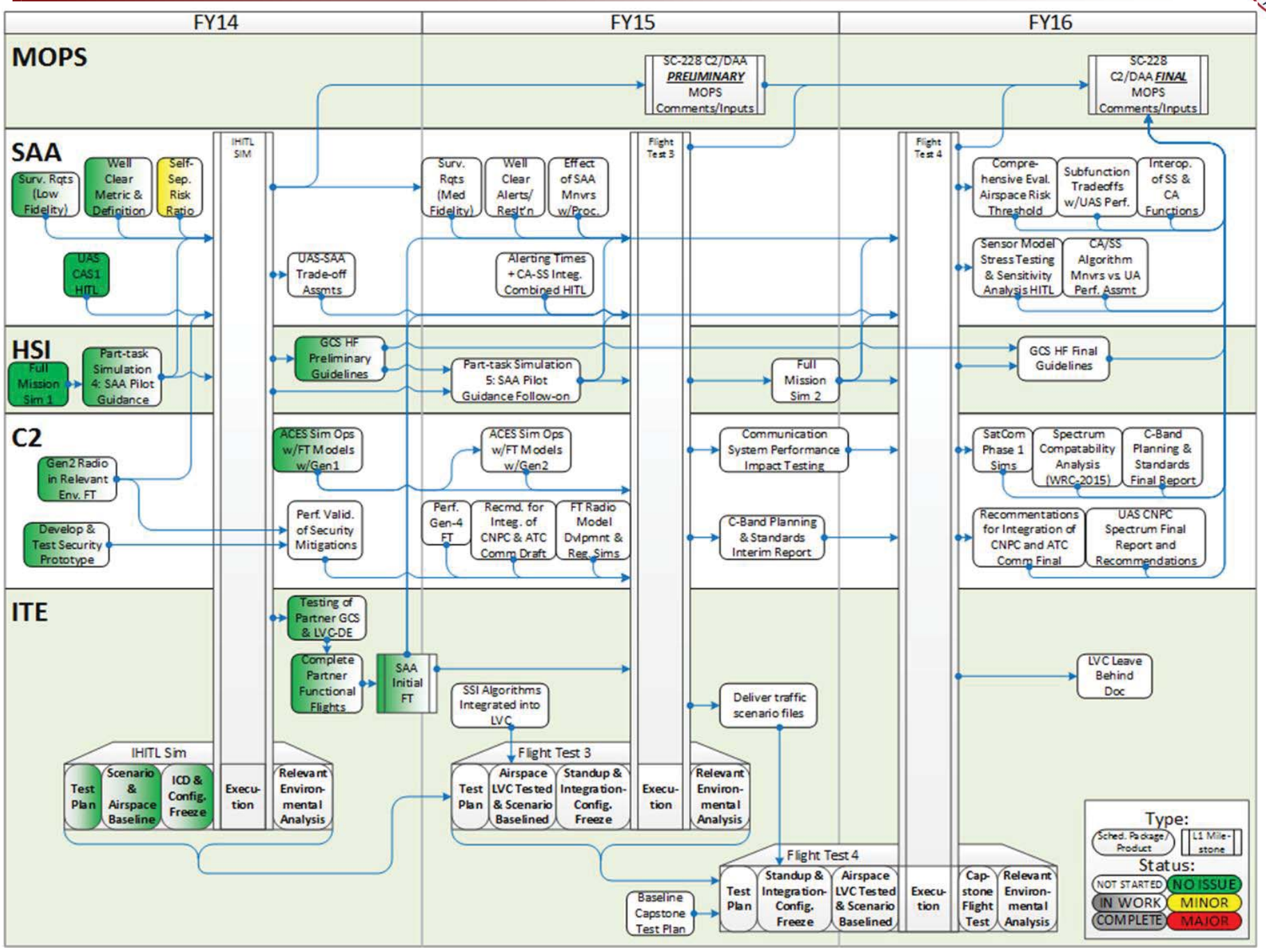
Schedule Roadmap

- Schedule roadmap uses and attributes
  - Provided a template for the definition of milestones
  - Documents dependencies across the schedule packages
  - One page snap shot that displays the status of technical challenge activities (e.g. green, yellow, red)



Roadmap is a tool that aids in the management the Project

Schedule Roadmap (cont.)



Milestone Definition

- Level 1 Milestones primarily include, but are not limited to:
  - End of execution periods for Integrated Events and comprehensive inputs to Stakeholders
  - All Annual Performance Goals (APGs) and Annual Performance Indicators (APIs)

- Level 2 Milestones primarily include, but are not limited to:
  - Start of execution for Schedule Packages
  - Tech Transfer reporting for Schedule

- Other key components in the IMS are defined as “Deliverable” and “Receivable” and tracked as milestones
  - Deliverable milestones document items for which multiple subprojects or centers have a dependency
  - Receivable milestones are opposite of a deliverable milestone in that they document the need for the deliverable

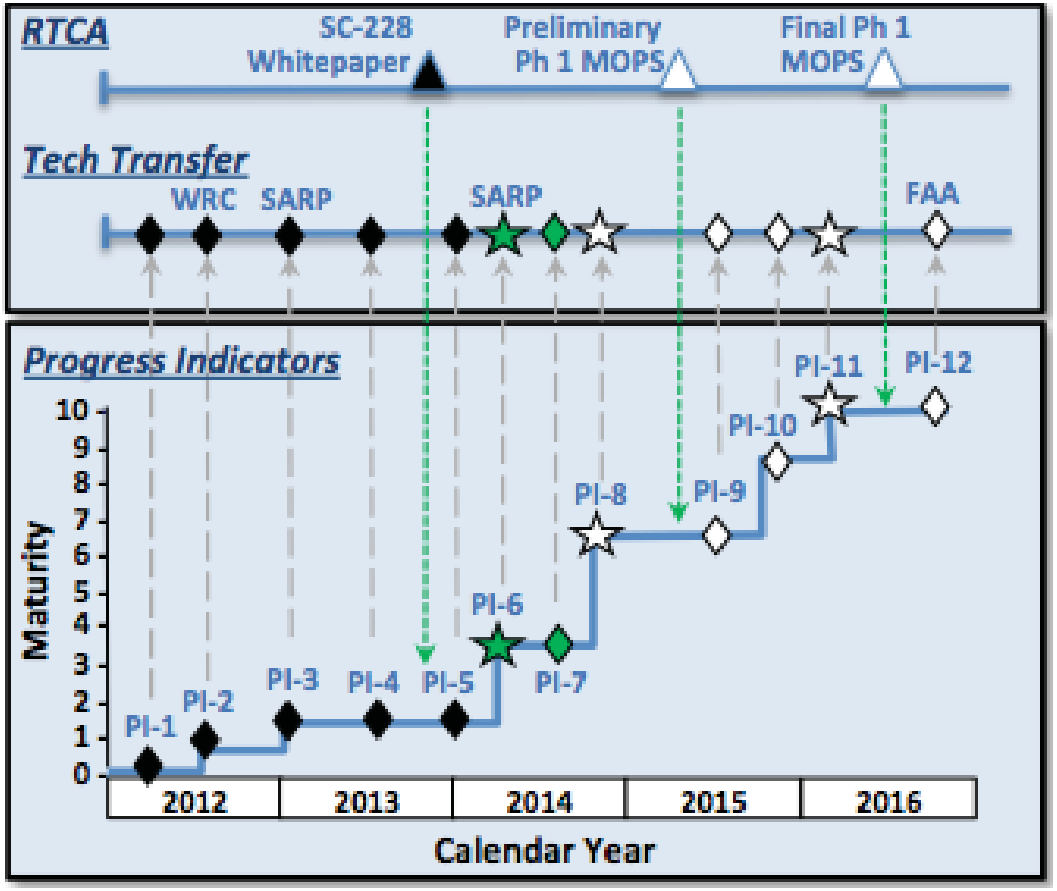
Progress Indicators

- Execution of Schedule Package activities are the L2 milestones for Progress Indicators.

- Individual contribution towards achieving the overall technical challenge
  - High = 2, i.e. Integrated Tests
  - Moderate = 1, i.e. multiple subproject technologies assessed
  - Low = 0, i.e. foundational activities

- Normalized and placed on a 10 point maturity scale
  - The more steps in the TC, the smaller amount of progress per step

- Progress tracked using a red, yellow, green scheme

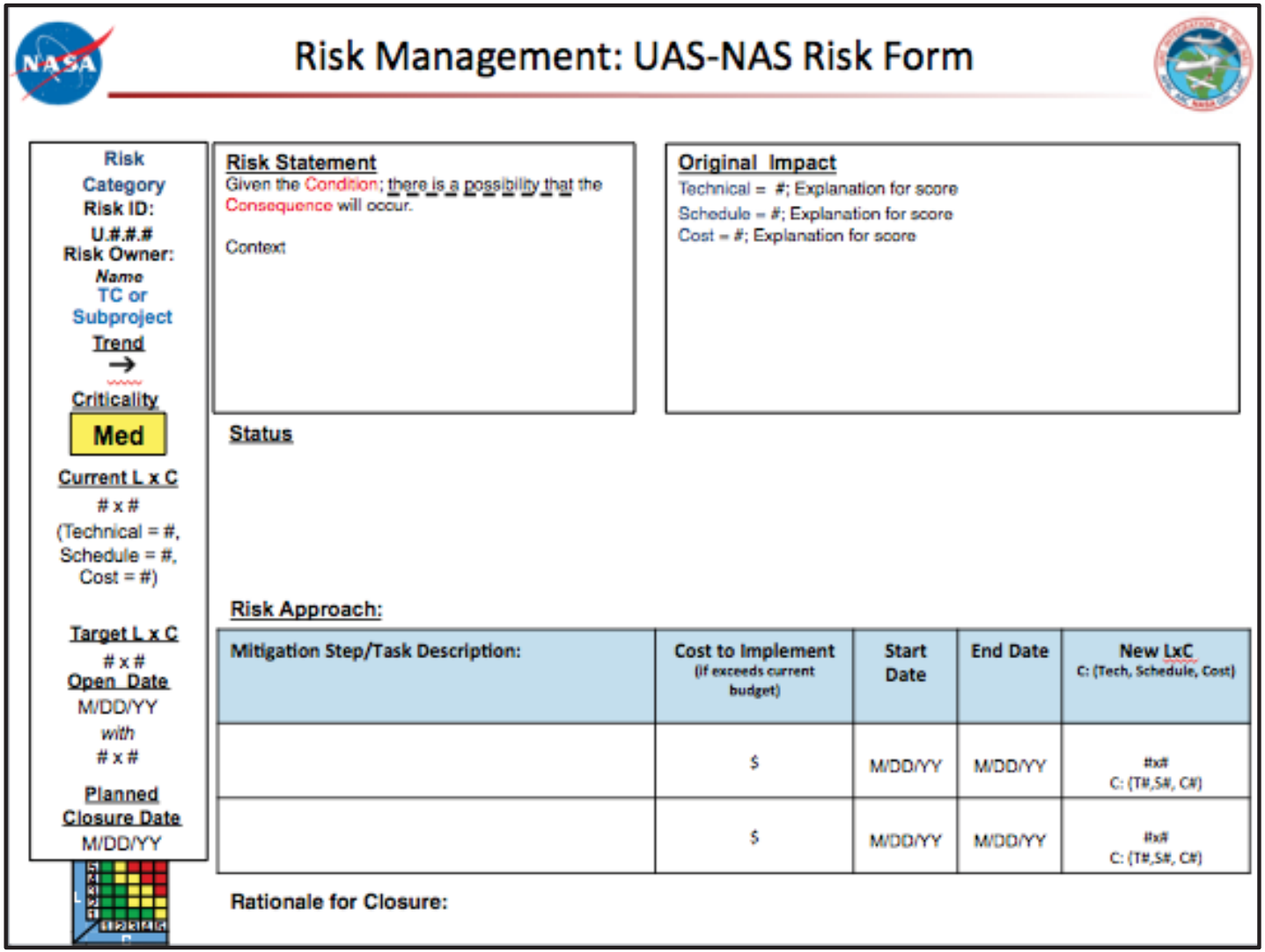


Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
  - Technical
  - Schedule
  - Risk
  - Budget
- Baseline Content per Technical Challenge (will step through details for TC-ITE)
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

Re-examination of risks

- Goal: To have a well defined set of risks that is consistent with the Phase 2 content, with descriptive titles and risk statements, detailed mitigations, and well defined impacts
- Held risk workshops to reformat and re-examine current risks and identify potential candidate risks
- Updates include:
  - Risk Statement and Context defined in a common format
  - Detailed explanation of the original impact and resultant consequence score
  - Defined cost to implement mitigation
  - Updated LxC after each associated mitigation complete
- Risk score card updated/tailored from ISRP risk scorecard



Risk Management: UAS-NAS Risk Form

Risk Category
Risk ID: U.#.#.#
Risk Owner: *Name*
TC or Subproject
Trend →
Criticality: **Med**
Current L x C: # x # (Technical = #, Schedule = #, Cost = #)
Target L x C: # x #
Open Date: M/DD/YY *with* # x #
Planned Closure Date: M/DD/YY

Risk Statement
Given the Condition; there is a possibility that the Consequence will occur.

Context

Original Impact
Technical = #; Explanation for score
Schedule = #; Explanation for score
Cost = #; Explanation for score

Status

Risk Approach:

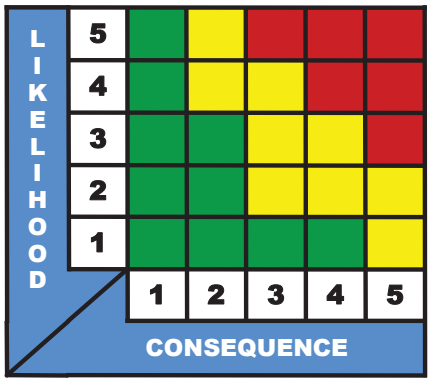
Mitigation Step/Task Description:	Cost to Implement (if exceeds current budget)	Start Date	End Date	New LxC C: (Tech, Schedule, Cost)
	$	M/DD/YY	M/DD/YY	#x# C: (T#,S#, C#)
	$	M/DD/YY	M/DD/YY	#x# C: (T#,S#, C#)

Rationale for Closure:

UAS-NAS Risk 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

UAS-NAS Risk Summary Card



Criticality

High

Med

Low

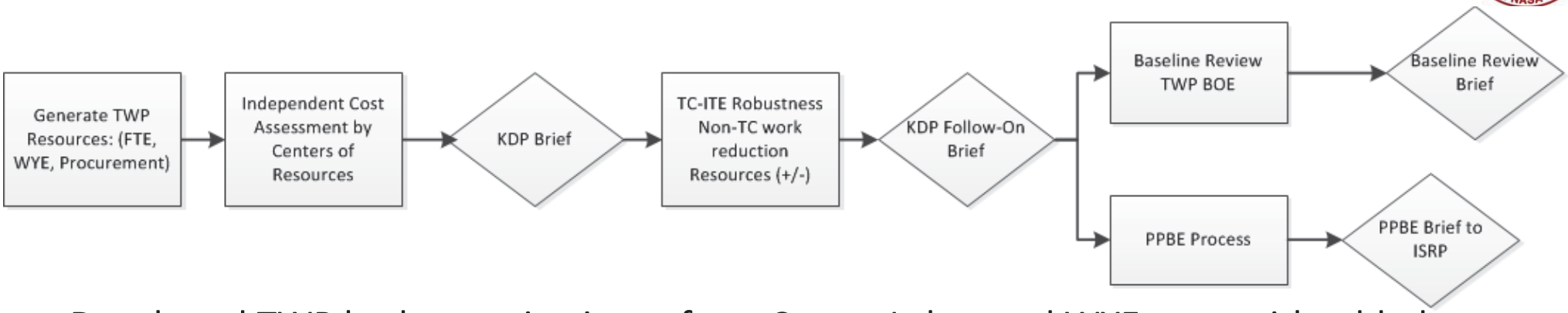
CONSEQUENCE	1	2	3	4	5
Technical	Negligible Impact to Objective, Technical Challenge, Technology Maturation	Minor Impact to Objective, Technical Challenge, Technology Maturation	Some Impact to Objective, Technical Challenge, Technology Maturation	Moderate Impact to Objective, Technical Challenge, Technology Maturation	Major Impact/Cannot Complete to Objective, Technical Challenge, Technology Maturation
Cost	≤ 1% Total Project Yearly Budget	1% - 5% Total Project Yearly Budget	5% - 10% Total Project Yearly Budget	10% - 15% Total Project Yearly Budget	>15% Total Project Yearly Budget
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

* Note: L1 = ISRP L2 = Project

Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
  - Technical
  - Schedule
  - Risk
  - Budget
- Baseline Content per Technical Challenge (will step through details for TC-ITE)
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

Baseline TWP Resource Estimate Development



- Developed TWP budgets using input from Center Labor and WYE rates with added inflation, external contractor estimates, industry estimates, and collaboration agreement in-kind contributions
  - TWP spreadsheet was developed to track and summarize costs by Center/TC
- Each TWP underwent an Independent Cost Assessment (ICA) review by the Centers Jul - Aug 2013
  - Applied information and lessons learned from ICA to TWP resource updates in preparation for Baseline Review
- TWPs modified to address KDP Actions
  - Increased resources for TC-ITE to increase robustness
  - Decreased resources for Certification and sUAS
- Additional Updates
  - NRA projected budget was zeroed out in FY14 and FY15 for activities in FY15 and FY16, respectively
  - Allocated reserves towards risk mitigations for TC-C2 and TC-ITE

Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge (will step through details for TC-ITE)
  - TC-ITE
  - Technical Challenges & Progress Indicators
    - TC-SAA
    - TC-C2
    - TC-HSI
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

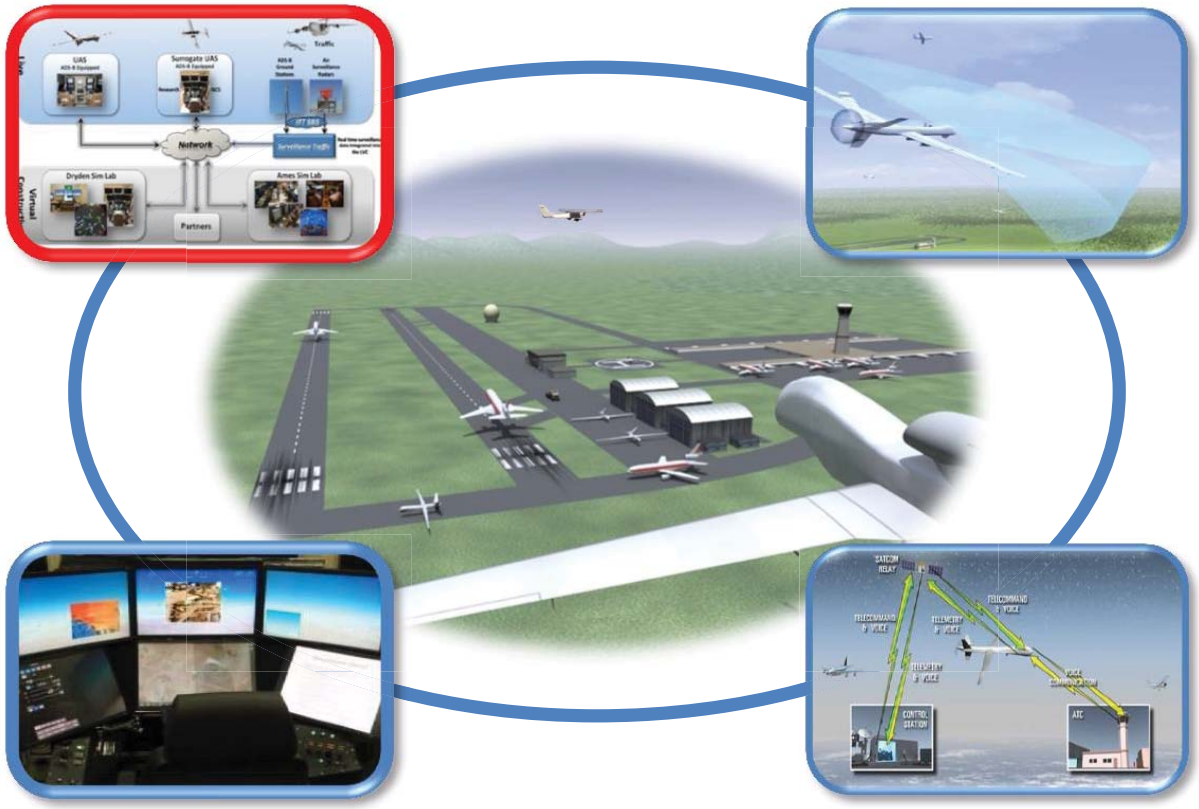
TC-ITE: Integrated Test and Evaluation

RT2 – Test Infrastructure

- Test infrastructure to enable development and validation of airspace integration procedures and performance standards.

TC-ITE - Develop a relevant test environment for use in generating research findings to develop and validate HSI Guidelines, SAA and C2 MOPS with test scenarios supporting integration of UAS into the NAS.

TC-ITE: Integrated Test & Evaluation

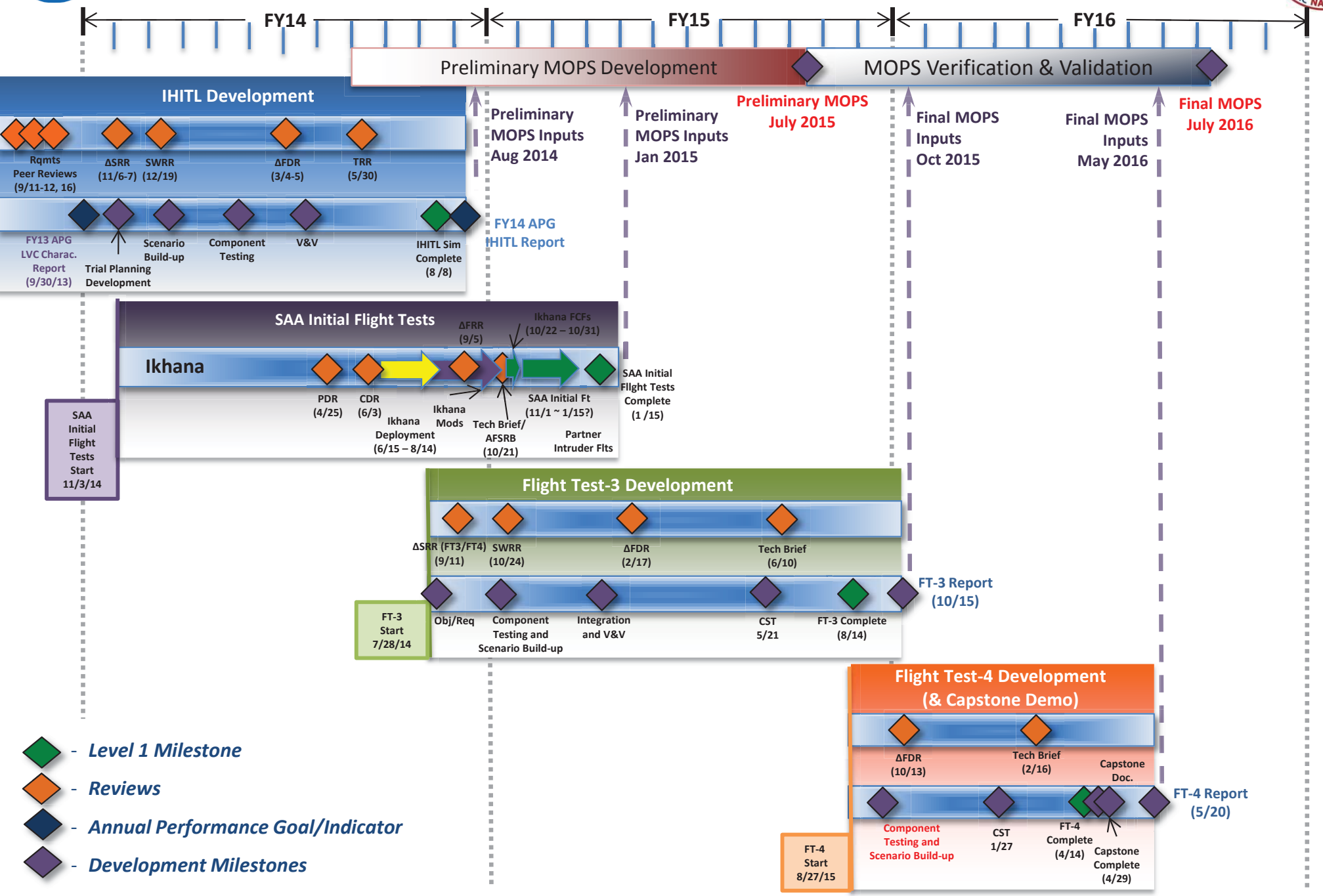


TC-SAA: SAA Performance Standards

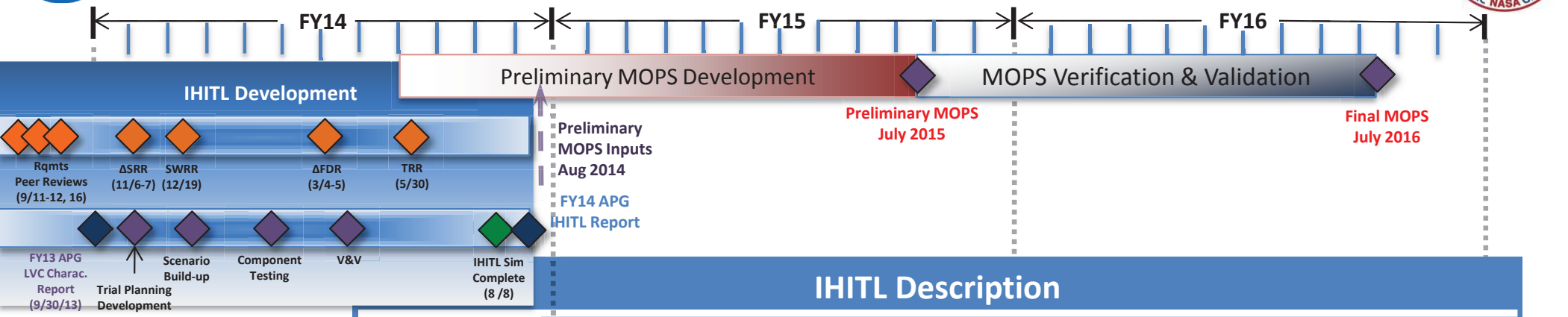
TC-HSI: Human Systems Integration

TC-C2: C2 Performance Standards

IT&E Integrated Test Flow



IT&E Integrated Test Flow
IHITL



- *Level 1 Milestone*
- *Reviews*
- *Annual Performance Goal*
- *Development Milestones*

ZFW (Dallas-Ft Worth)

ZOA (Oakland Center)

IHITL Description

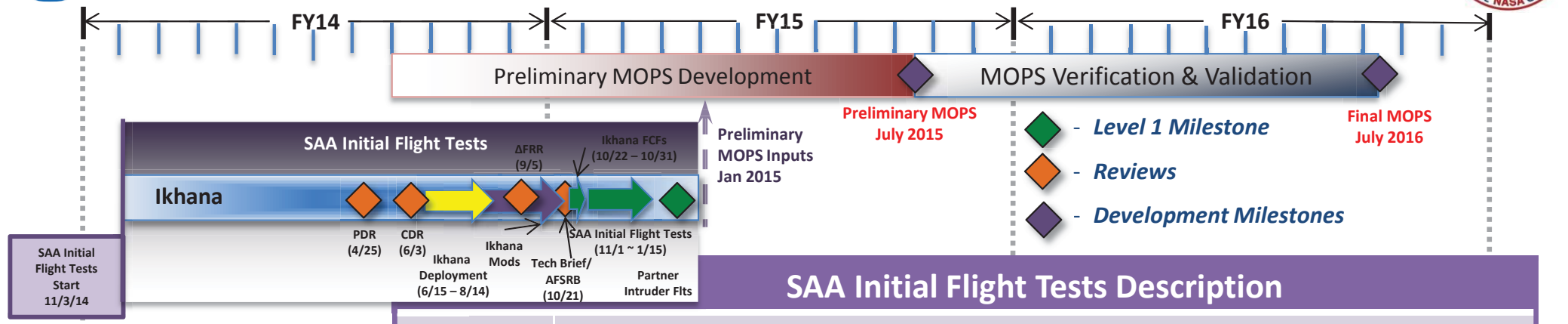
Purpose	• Evaluates and measures the acceptability of algorithms and pilot guidance displays with ATC operations with increased simulation fidelity by adding CNPC time delay, a proof of concept GCS, and VFR cooperative and non-cooperative traffic

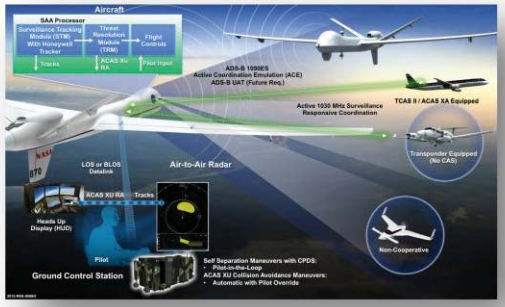
Approach	• 2 LVC configurations to be tested (Config1 & Config2)
	  • Config1: Ames/Armstrong connectivity (ATC and Pilot test set-ups)
	  • Config2: LaRC/Ames connectivity (SAA-CA interoperability)
	• Scenarios - Class E airspace operations near major TRACONs

Test Duration	Jun – Jul 2014
	  • Config1 Test Set-up 1: ATC – 3 weeks (15 Controllers)
	  • Config1 Test Set-up 2: UAS pilots – 2 weeks (10 pilots)
	  • Config2 Test Set-up: ATC – 3 weeks (6 Controllers)

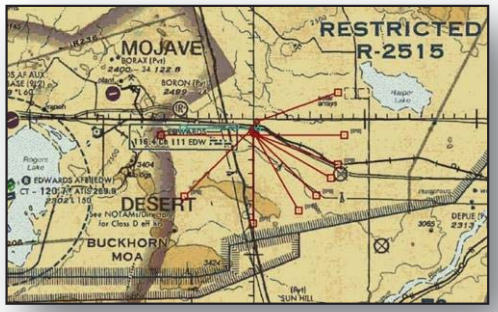
Tech Transfer	• Validated SAA, C2, HSI performance requirements and guidelines • Community insight into LVC Infrastructure capabilities
Project Benefit	• Validates Project models • Risk reduction for SAA Initial Flight Test Series and Flight Test Series 3 • Foundational infrastructure integrated test supports SAA Initial Flight Tests, FT3, & FT4

IT&E Integrated Test Flow
SAA Initial Flight Tests





SAA Initial Flight Tests

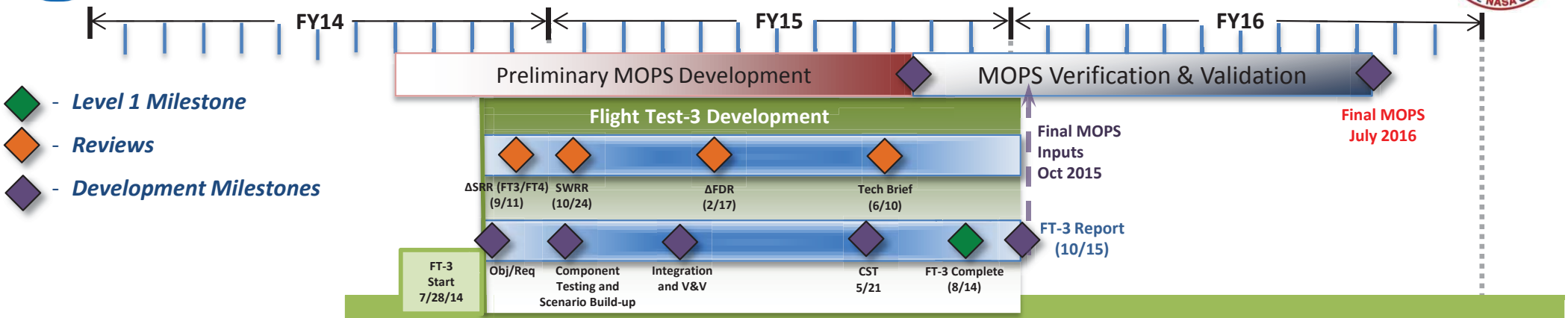


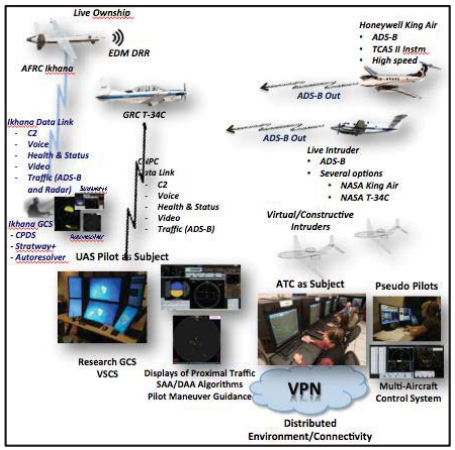
EAFB Restricted Airspace R-2515

SAA Initial Flight Tests Description

Purpose	• Evaluate SAA Algorithm performance with actual sensor data • Demonstrate SAA CONOPS in real-world scenarios • Demonstrate LVC distributed test environment
Approach	• Ikhana UAS modified with Proof of Concept DAA system (Prototype Air-to-Air Radar, SAA Processor, TCAS, ADS-B, Sensor Fusion) • Multiple encounter geometries (CA and SS)
Test Duration	Nov 2014 – Jan 2015 (13 flights/2 backups) • Nov 2014: Collision Avoidance Flight Tests (UAS vs. Manned) • Nov – Dec 2014: Self Separation (UAS vs. Manned) • Dec 2014 – Jan 2015: Collision Avoidance Flight Tests (UAS vs. UAS)
Tech Transfer	• DAA CONOPs and Algorithm flight demonstration • Data for validation of sensor models, well clear definition, and SS/CA interoperability
Project Benefit	• Conduct flight test risk reduction activities for FT3 and FT4 • Project's 1st live flight test for SAA algorithms and pilot guidance displays for real sensor data/uncertainties, real environmental factors • Distributed test environment with partner

IT&E Integrated Test Flow
Flight Test Series 3



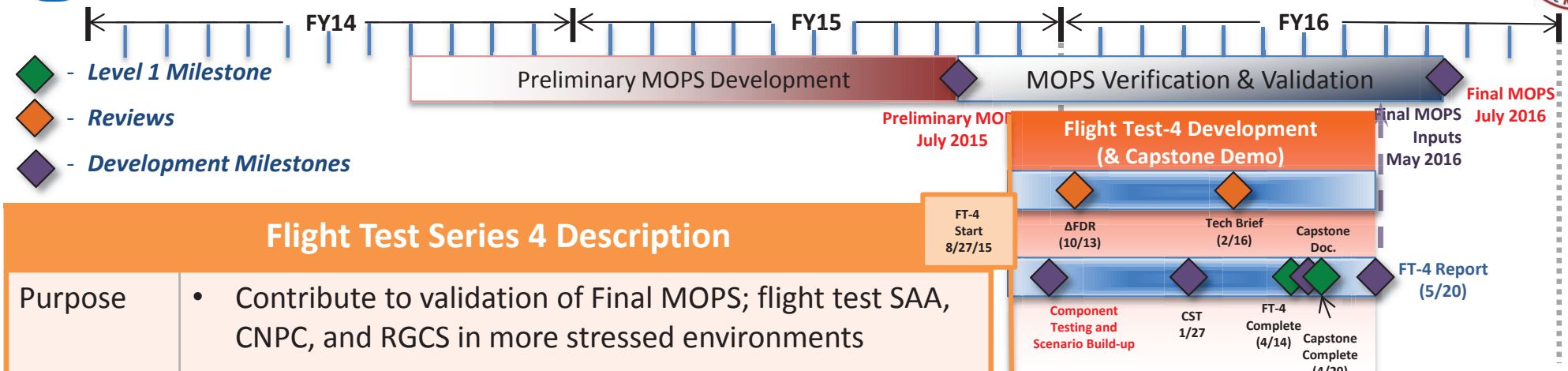


Flight Test Series 3 Infrastructure

Flight Test Series 3 Description

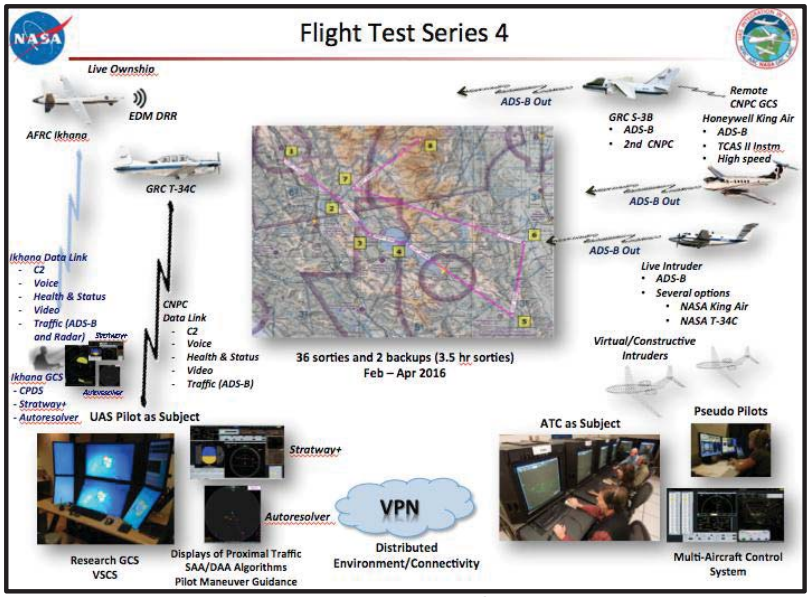
Purpose	• Flight test prototype SAA & C2 systems utilizing RGCS; conduct integrated flight test series to verify Preliminary DAA & C2 MOPS and validate sensor models • Demonstrate system integration of surrogate UAS with CNPC, RGCS, and SS Algorithms
Approach	• Increase complexity from IHITL through live aircraft incorporation and increased definition from MOPS • Focus scenarios on testing of SAA (sensitivity, pilot workload, and maneuver negotiation), C2 (CNPC Mixed Traffic Flight Tests including Integrated SAA), and human factors (RGCS utilized to evaluate pilot information requirements)
Test Duration	Jun – Aug 2015 • 36 flights/2 backups (3.5 hr flights)
Tech Transfer	• First fully integrated flight test including both prototype systems for both DAA and C2 MOPS • Initiates verifications of the preliminary MOPS
Project Benefit	• Baseline FT4 System Architectures implemented • Baseline flight test scenarios developed and validated

IT&E Integrated Test Flow
Flight Test Series 4



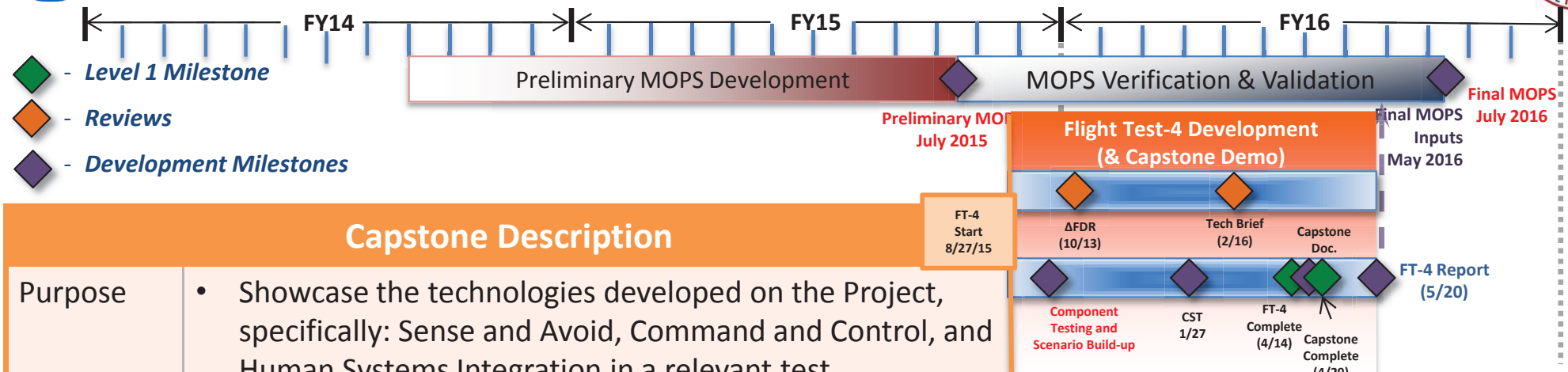
Flight Test Series 4 Description

Purpose	• Contribute to validation of Final MOPS; flight test SAA, CNPC, and RGCS in more stressed environments • Demonstrates systems integration and evaluation of the state of UAS concepts and supporting technologies • Demonstrate final LVC-DE configuration
Approach	Increased complexity from FT3 • Challenging encounter geometries • UAS pilot and ATC negotiation in complex/busy airspace • Two aircraft with CNPC to assess link performance within the same spectrum • Demonstrate CA/SS Interoperability, well clear compliance
Test Duration	Feb - Apr 2016 • 34 flights/2 backups (3.5 hr flights)
Tech Transfer	• DAA and C2 system refinements flight tested • Contributing to validation of final MOPS
Project Benefit	• Baseline technologies for Capstone demonstration



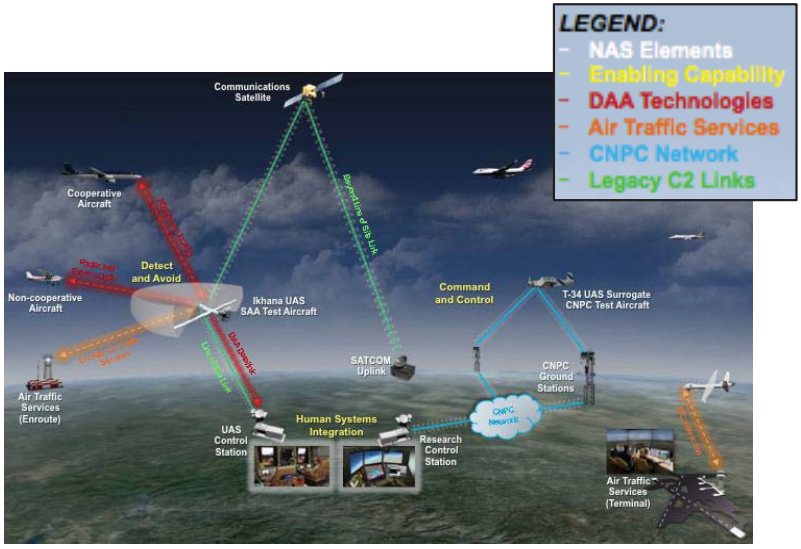
Flight Test Series 4 Infrastructure

IT&E Integrated Test Flow Capstone



Capstone Description

Purpose	• Showcase the technologies developed on the Project, specifically: Sense and Avoid, Command and Control, and Human Systems Integration in a relevant test environment • Increase public confidence in UAS
Approach	• Demonstrate the RTCA SC-228 Phase 1 MOPS, i.e. conduct UAS operations to/from Class A, through Class E, Class D, and possibly Class G • Demonstration flights will be conducted from a Class D airport (e.g. Victorville, CA) and operated in the NAS in partnership with the FAA
Test Duration	Apr 2016 • 2 flights (3 hr flights)
Tech Transfer	• These are flight demonstrations and are not intended for data gathering
Project Benefit	• Provides opportunities for partnering with the FAA test sites, other NASA Mission Directorates (SMD), industry, and academia

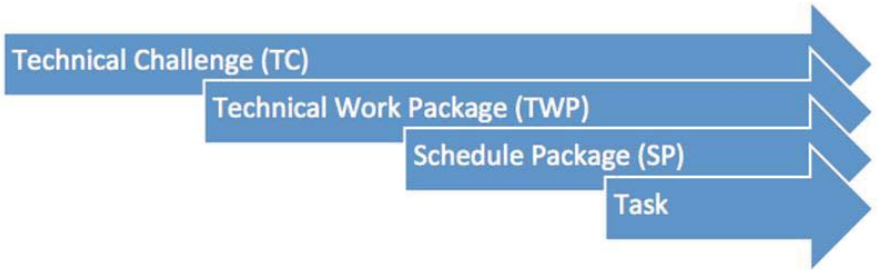


Project Operational View 1 (OV-1)

TC-ITE: High Level Summary (1 of 3)

ID	Schedule Package Title	Approach	Deliverable	MS
T.1.20	Submit LVC Leave behind document	Analysis	Report	L2
T.2.10	IHITL Scenarios and Airspace Development Baselined	TPWG/TIM	Document	L2
T.2.20	IHITL Simulation Test Plan	TPWG/TIM	Document	L2
T.2.30	IHITL Distributed Test Environment Reviews (SRR, SWRR, FDR, TRR)	Review	Briefing (PO)	L2
T.2.40	IHITL ICD and Configuration Freeze (all code/algorithms finished - checklist)	Integration	Document	L2
T.2.50	IHITL Simulation Start	HITL	LVC	L2
T.2.50	IHITL Simulation Complete	HITL	Report	L1
T.2.50	Integrated Human in the Loop Simulation Assessment	HITL	Report (HQ, PO, F)	L1
T.2.60	IHITL Relevant Environment Evaluation Report	HITL	Report (PO, F)	L2

- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones



Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

TC-ITE: High Level Summary (2 of 3)

ID	Schedule Package Title	Approach	Deliverable	MS
T.3.10	SAA Initial Flight Test Reviews (FRR, Tech Brief/AFSRB)	Review	Briefing (AFRC, PO)	L2
T.3.30	Complete Partner Functional Flights	Flight Test	Report (PO)	L2
T.3.40	SAA Initial Flights Tests Complete	Flight Test	Report (PO,SC,F)	L1
T.4.10	FT3 Airspace Tested in LVC & FT3 Scenarios Baselined	Integration	Document (PO)	L2
T.4.20	FT3 Test Plan	TPWG/TIM	Document (PO,F)	L2
T.4.30	FT3 Reviews (SRR, FDR, Tech Brief)	Review	Briefing (PO)	L2
T.4.40	FT3 Stand-up & Integration - Configuration Freeze	Integration	Document (PO)	L2
T.4.50	Flight Test Series 3 Complete	Flight Test	Report (HQ,PO)	L1
T.4.50	Integrated Flight Test Series 3 Flight Test Report	Flight Test	Report (PO, F)	L2
T.4.60	FT3 Relevant Environment Evaluation Report	Flight Test	Report (PO,F)	L2

- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones

Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

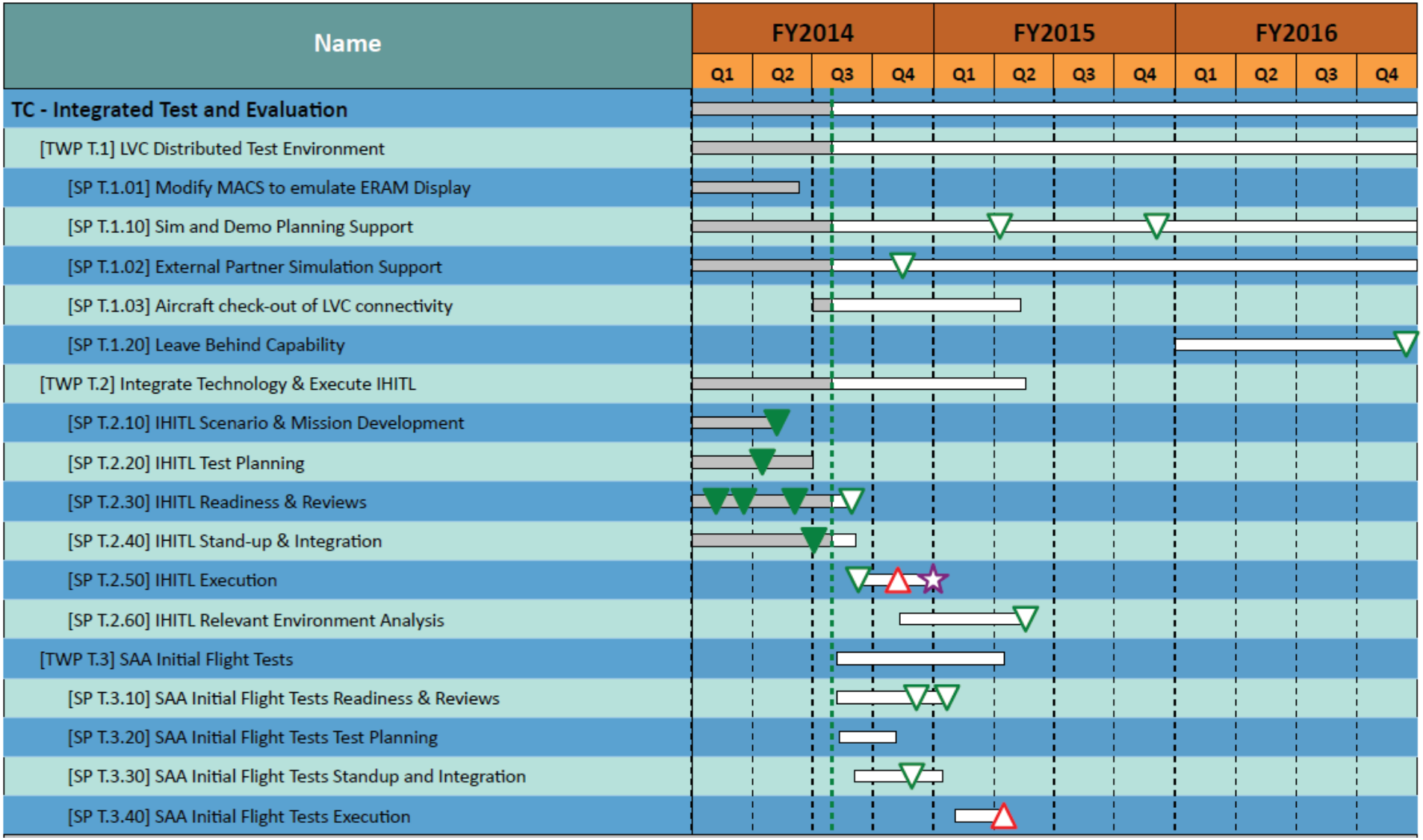
TC-ITE: High Level Summary (3 of 3)

ID	Schedule Package Title	Approach	Deliverable	MS
T.5.10	Select Capstone Partnerships Complete	TPWG/TIM	Document	L2
T.5.10	Baseline Capstone Test Plan Complete	TPWG/TIM	Document	L2
T.5.20	FT4 Test Plan	TPWG/TIM	Document (PO,F)	L2
T.5.30	FT4 Airspace Tested in LVC & FT4 Scenarios Baselined	TPWG/TIM	Document (PO)	L2
T.5.40	FT4 Reviews (FDR, Tech Brief)	Review	Briefing (PO)	L2
T.5.50	FT4 Stand-up & Integration - Configuration Freeze	Integration	Document(PO)	L2
T.5.50	Flight Test Series 4 Complete	Flight Test	Report (HQ, PO)	L1
T.5.50	Integrated Flight Test 4 Flight Test Report	Flight Test	Report (PO, F)	L2
T.5.60	Integrated FT4 Relevant Environment Evaluation Report	Flight Test	Report (PO, F)	L2

- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones

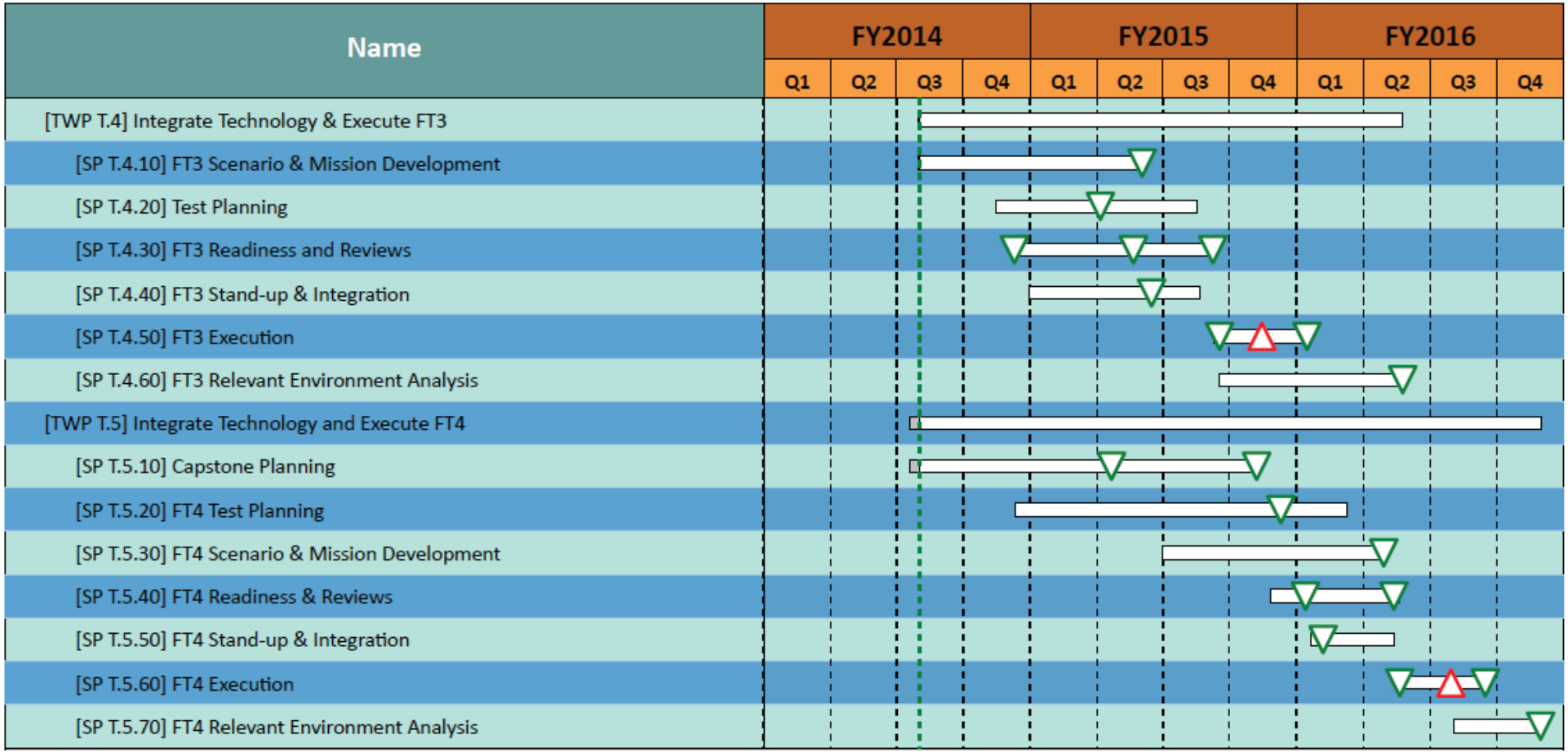
Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

TC-ITE: Schedule



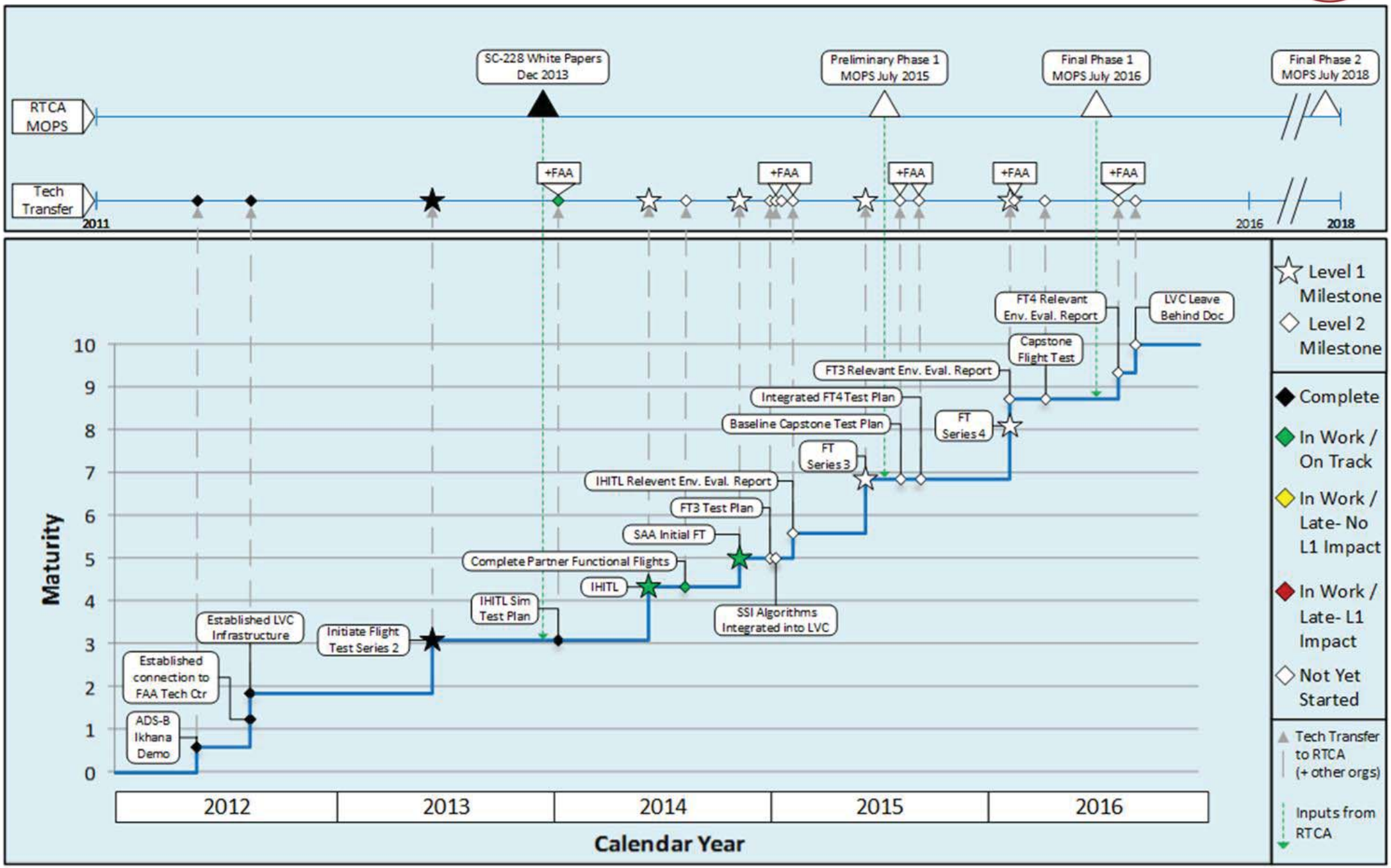
APG/API L1 Program (ISRP) L2 Project

TC-ITE: Schedule (cont.)



APG/API L1 Program (ISRP) L2 Project

TC-ITE: Progress Indicator



TC-ITE: Risk Matrix and Summary

Risk Matrix						
LIKELIHOOD	5					
	4			5.1.19		
	3			5.1.10 5.1.11 5.1.16	5.1.20	
	2			5.1.7 5.1.8		
	1					
		1	2	3	4	5
		CONSEQUENCE				

Risk ID	Trend	LxC	Approach	Risk Title
5.1.20	NEW	3x4	M	Unsigned Agreement could delay flight test and result in the cancellation of SAA Initial Flight Tests
5.1.19	⇨	4x3	M	Eyetracker System Not Installed in RGCS for IHITL
5.1.10	⇨	3x3	M	Required Assets for Flight Test 3 (FT3) not available during test period
5.1.11	⇨	3x3	M	Required Assets for Flight Test 4 (FT4) not available during test period
5.1.16	⇨	3x3	M	Completion of ITE Technical Objectives that Rely upon Formal Partnerships
5.1.7	⇨	2x3	M	Distributed Test Environment requirements for Integrated Flight Test 3 (FT3) not defined

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

TC-ITE: Risk Matrix and Summary Cont.

Risk Matrix						
LIKELIHOOD	5					
	4			5.1.19		
	3			5.1.10 5.1.11 5.1.16	5.1.20	
	2			5.1.7 5.1.8		
	1					
		1	2	3	4	5
		CONSEQUENCE				

Risk ID	Trend	LxC	Approach	Risk Title
5.1.8	⇨	2x3	M	Distributed Test Environment requirements for Integrated Flight Test 4 (FT4) not defined
5.1.17			W	The T-34 (UA Surrogate) for FT3 and FT4 may not be available
5.1.XX			Candidate	Parallel efforts of IHITL data collection, SAA Initial Flight Test and FT3 planning could impact FT3 and FT4 flight test series

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge (will step through details for TC-ITE)
  - TC-ITE
  - Technical Challenges & Progress Indicators
    - TC-SAA
    - TC-C2
    - TC-HSI
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

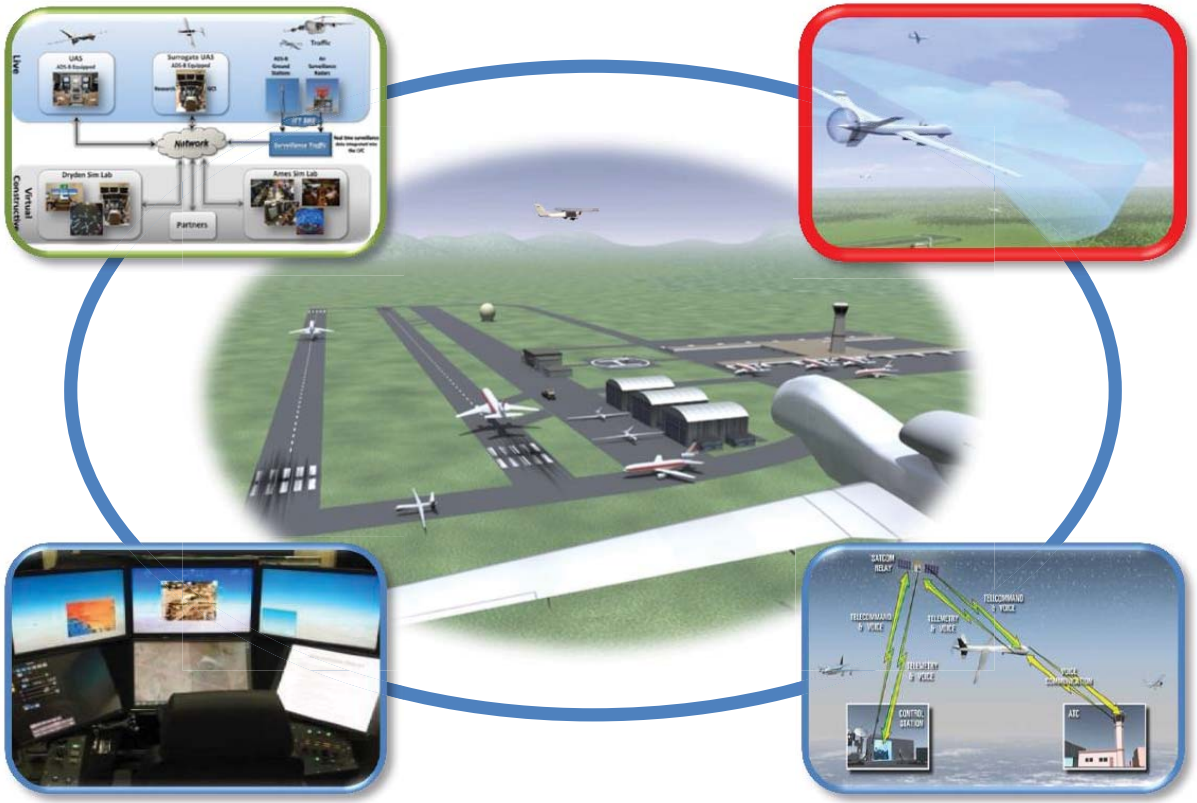
TC-SAA: SAA Performance Standards

RT1 - UAS Integration

- Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

TC-SAA - Provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for sense and avoid (SAA) performance and interoperability.

TC-ITE: Integrated Test & Evaluation

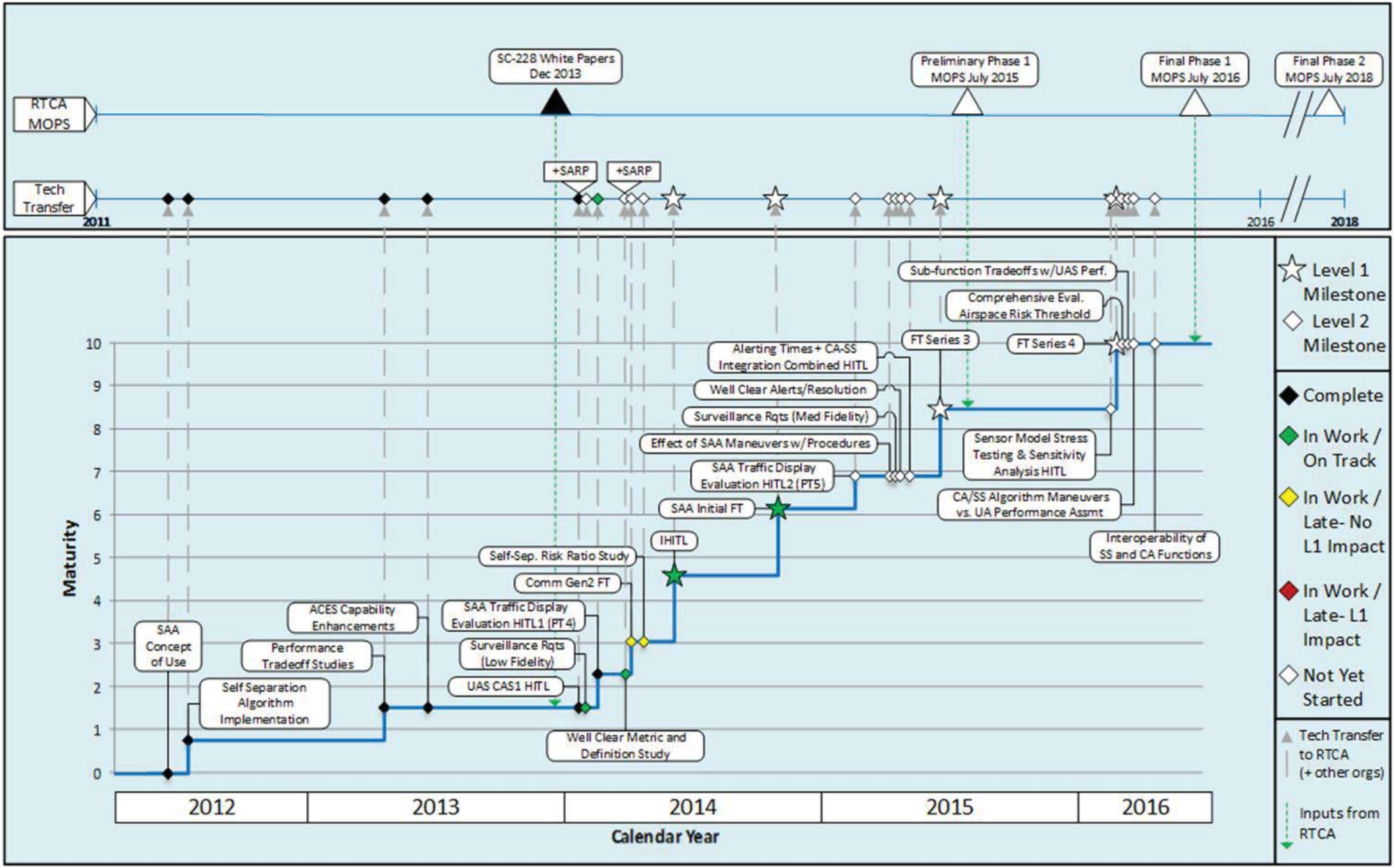


TC-SAA: SAA Performance Standards

TC-HSI: Human Systems Integration

TC-C2: C2 Performance Standards

TC-SAA: Progress Indicator



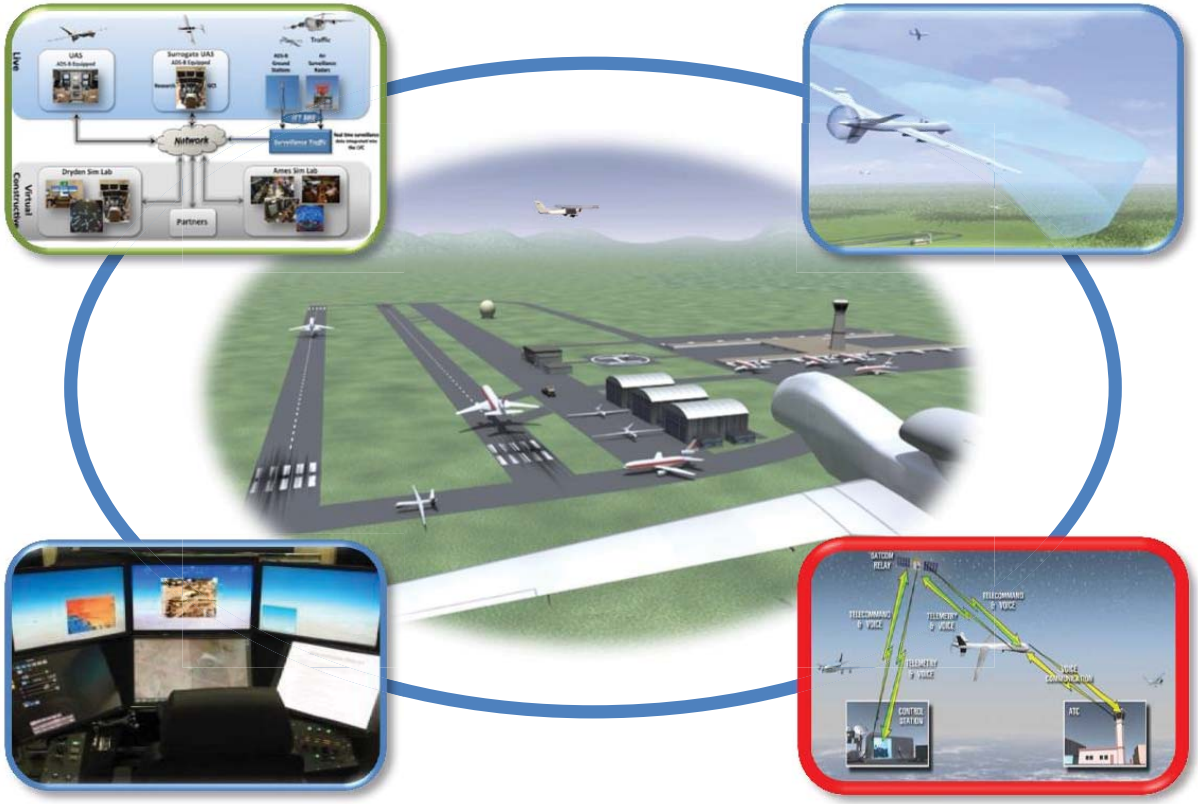
TC-C2: C2 Performance Standards

RT1 - UAS Integration

- Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

TC-C2 - Provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for terrestrial command and control (C2) communication.

TC-ITE: Integrated Test & Evaluation

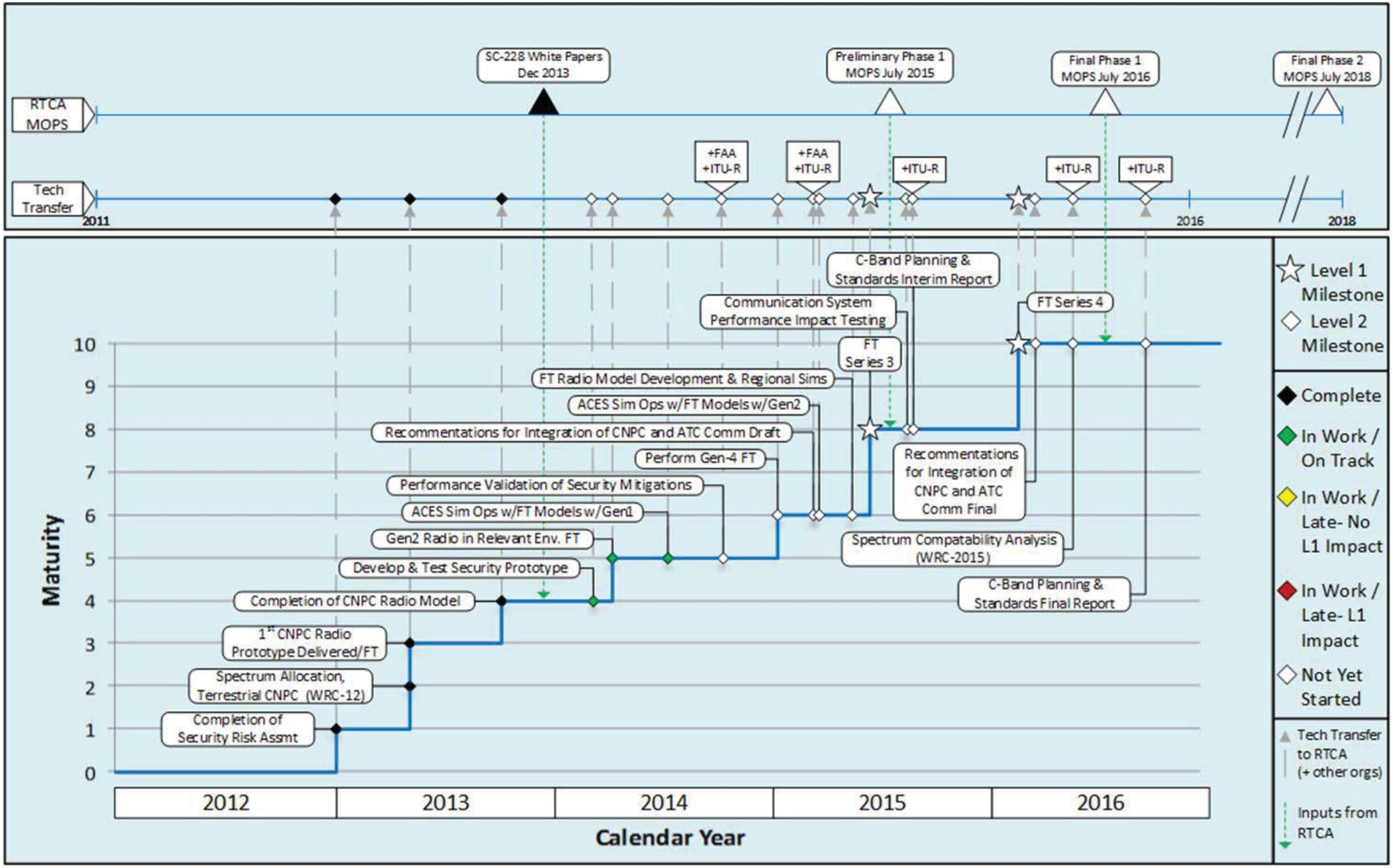


TC-SAA: SAA Performance Standards

TC-HSI: Human Systems Integration

TC-C2: C2 Performance Standards

TC-C2: Progress Indicator



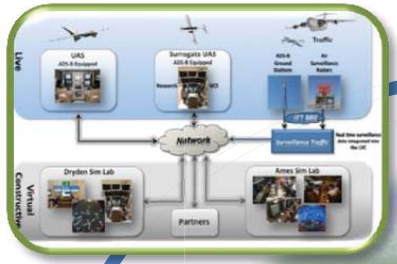
TC-HSI: Human Systems Integration

RT1 - UAS Integration

- Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

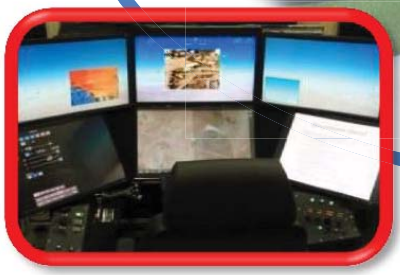
TC-HSI - Provide research findings to develop and validate human systems integration (HSI) ground control station (GCS) guidelines enabling implementation of the SAA and C2 performance standards.

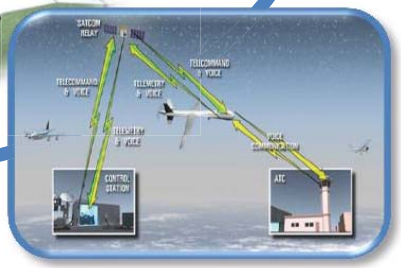
TC-ITE: Integrated Test & Evaluation



TC-SAA: SAA Performance Standards

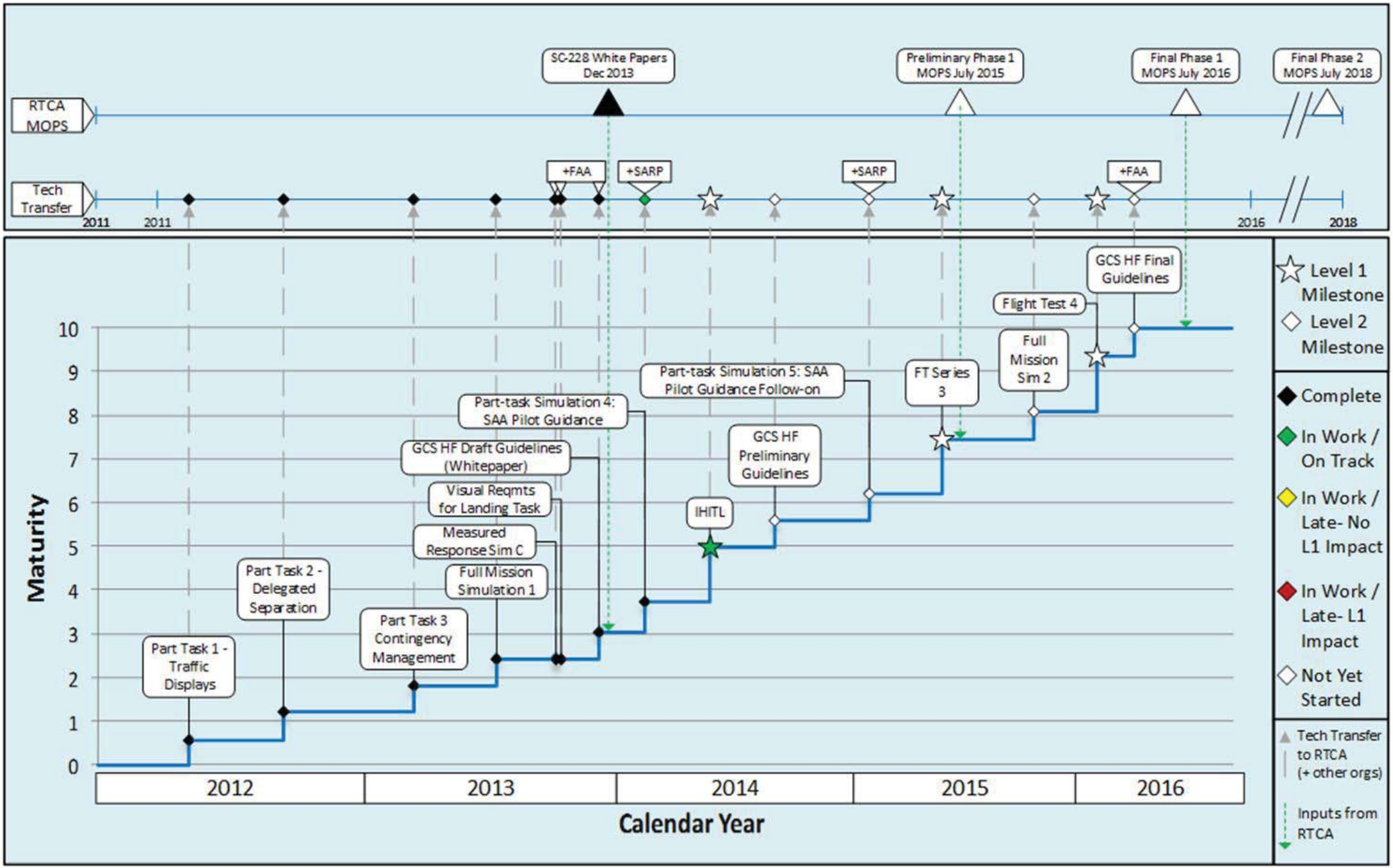
TC-HSI: Human Systems Integration





TC-C2: C2 Performance Standards

TC-HSI: Progress Indicator



Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

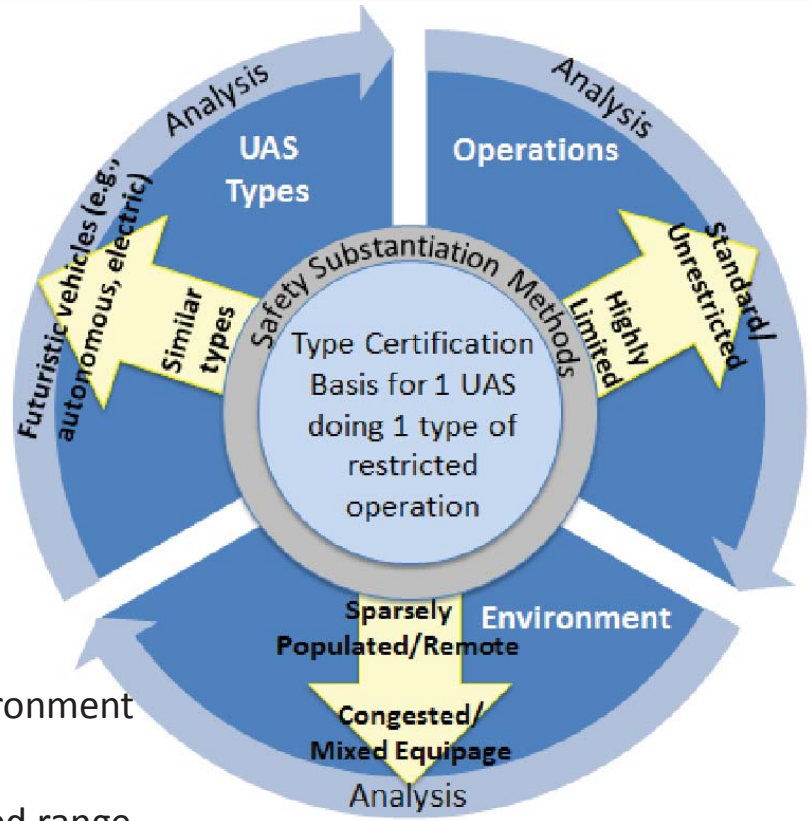
Non-Technical Challenge Work

- Includes far-reaching/higher risk activities with an emphasis on future (post-project) capabilities
- Source for resources should TC work encounter unknown risks requiring additional resources for mitigation
- Long term activities have pre-defined off-ramps/on-ramps to facilitate potential TC work needs
  - Off-ramps
    - Clearly defined breakpoints/stopping places within scheduled activities where work could be stopped, if needed
    - Benefit to the community gained by tasks accomplished prior to breakpoint
  - On-Ramps
    - New proposed activities, for the following fiscal year, that are aligned with the goals of Non-TC work
- Does not have L1 milestones
- Non-TC Work on UAS-NAS Project
  - Certification
  - sUAS
- Management activities book kept as Non-TC work
  - LVC-DE Enhancements

Certification
Far Reaching/High Risk – Analysis

- Core: Type Certification Basis for 1 UAS doing 1 type of restricted operation
  - Requires a realistic core basis for airworthiness certification, i.e. UAS design and operational CONOPS feasible to assess from a certification perspective
- Analysis can target extreme/high-risk changes (furthest from core)
  - Benefit: helps define research needs for technology advances and longer term NAS access
  - Project/HQ can prioritize analysis targets

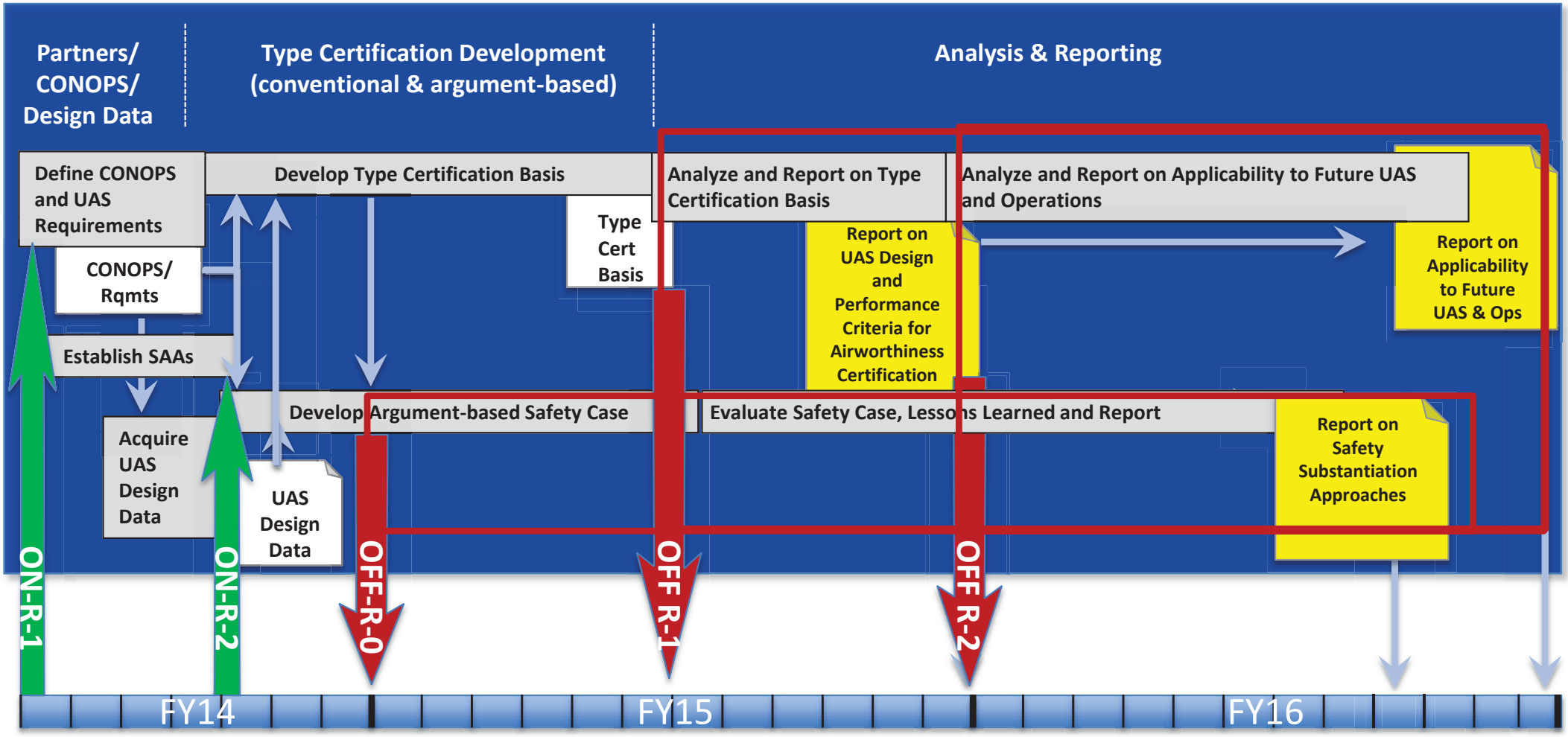
Example UAS Types:
- Self-deterministic navigation
- Alternative propulsion types
- Multi-vehicle control



Example Operations:
- Point-to-point (e.g. package delivery or human transport)
- Loiter (e.g. Comm Relay, Traffic Monitoring)
- Dynamic (e.g. search & rescue, wildlife monitoring)

Example Environments:
- Urban / suburban environment
- Congested airspace
- Large variations in speed range

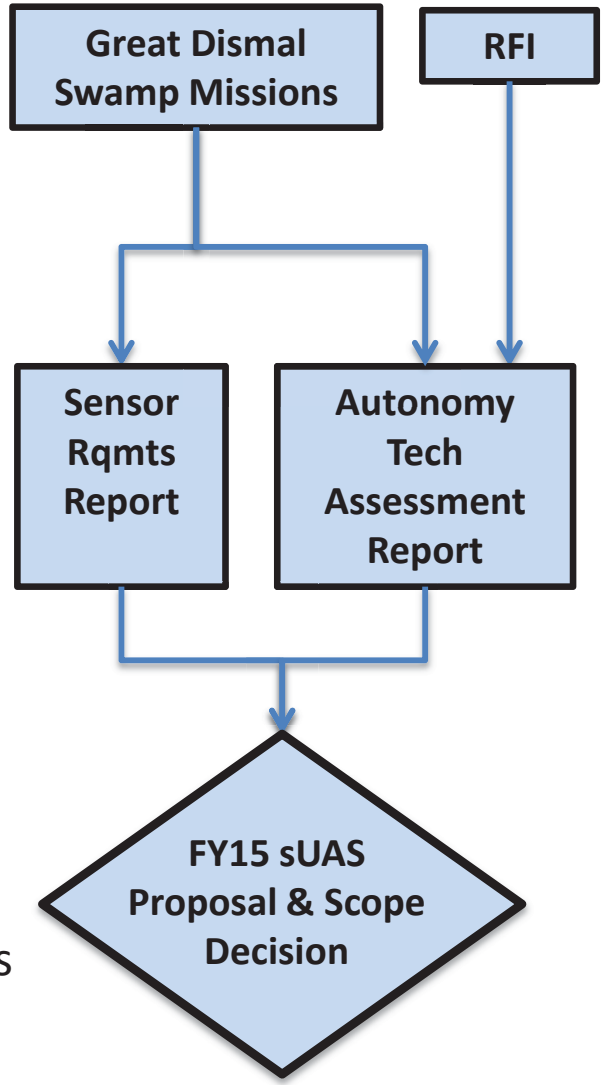
Certification Task/Product View Timeline On/Off-Ramps



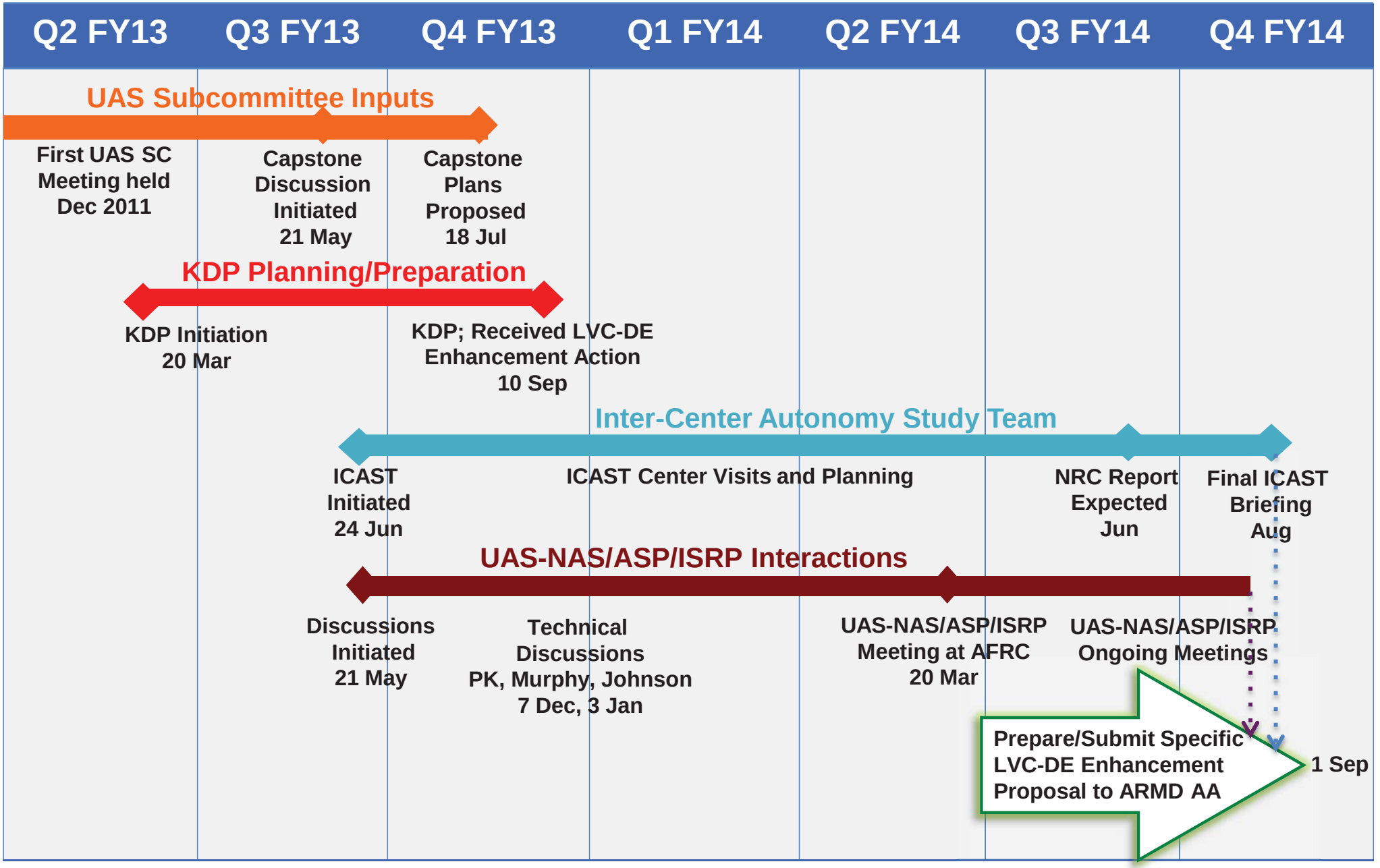
3/14	6/14	9/14	12/14	3/15	6/15	9/15	12/15	3/16	6/16	9/16
Authority to Proceed	Partnership Established	Eliminate Safety Case Work		Stop work after development of type certification basis		Stop work after first deliverable report on the type certification basis		Stop work after any one of the analysis questions. That is, there will be logical breakpoints throughout the analysis phase to stop work.		

Small UAS (sUAS) Effort

- sUAS is an on-ramp activity currently funded for FY14 only
  - Collaboration with USFWS on fire detection in Great Dismal Swamp
  - Conduct experiments to develop sensor requirements for sUAS fire detection airspace integration
  - Develop processes, procedures, and CONOPS for GDS and others to use for later operations in the NAS
- Issue an RFI asking for information on sUAS autonomy technology applications and benefits:
  - What does the technology do and what are the expected benefits over current state-of-the-art?
  - What is required to support the technology with a sUAS?
  - What is the maturity level of the technology?
  - What is the availability of the technology? (Open, FRND, proprietary)
  - How would the developer work with NASA to bring the technology to the sUAS community?
- Use the information obtained to combine with literature searches and the GDS experiments to shape the proposed FY15 work



LVC-DE Enhancement Planning Schedule



Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge
- Non-Technical Challenge Work
- Project Summary
  - Project Office Resource Summary
  - Overall Project Budget
  - Project Top Risks
  - Partnerships and Collaboration
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

Top Risk Matrix and Summary

Risk Matrix

LIKELIHOOD	1	2	3	4	5
5					
4					
3			4.1.8 4.1.9 4.2.8 4.3.3	1.1.10 5.1.20	
2		4.2.9	ISRP 02 1.1.4		
1			ISRP 05		

CONSEQUENCE

Risk ID	Trend	LxC	Approach	Risk Title
1.1.10 (T)	NEW	3x4	M	Output from Test Events has value to Project Stakeholders
5.1.20 (T)	NEW	3x4	M	Unsigned agreement could delay flight test and result in the cancellation of SAA Initial Flight Tests
4.1.8 (T)	⇨	3x3	M	Sense and Avoid Sensor Suite Availability
4.1.9 (T)	⇩	3x3	M	Delay of SAA/SSI Technology Developments Impact to Integrated Test Events
4.2.8 (T)	⇨	3x3	M	Endorsement of HSI GCS Guidelines from a Recognized Standards-based Group
4.3.3 (T)	⇨	3x3	M	Key CNPC Equipment or System Failure
ISRP 02	⇨	2x3	M	Project Focus Changes Due to External Influences

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

Top Risk Matrix and Summary (cont.)

Risk Matrix						
LIKELIHOOD	5					
	4					
	3			4.1.8 4.1.9 4.2.8 4.3.3	1.1.10 5.1.20	
	2		4.2.9	ISRP 02 1.1.4		
	1			ISRP 05		
		1	2	3	4	5
		CONSEQUENCE				

Risk ID	Trend	LxC	Approach	Risk Title
1.1.4 (T)	⇨	2x3	M	The predicted or projected UAS mission profiles and traffic density estimates used by the subprojects for their technology development efforts may not be realistic or accurate
4.2.9 (T)	⇨	2x2	M	Delay of HSI Technology Development Impact to Integrated Test Events
ISRP 05	⇩	1x3	M	Inability to Meet UAS-NAS KDP-2 (Phase 1-to Phase 2 Transition)

Criticality
- High
- Med
- Low

L x C Trend
- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

	Current Risks 5/8/14	Risks presented at KDP 9/10/13
Mitigate	31	31
Watch	2	0
*Top Risks	8 + (2 ISRP)	5

- Changes Since KDP
  - Closed 12 risks
  - Added 14 risks

Current Active Collaborations/Partnerships Status

Partner	Partner POCs	Collaboration/ Partnership Activity
FAA UAS IO	Jim Williams and Chris Swider	Support by FAA leadership, management, and technical SMEs to validate work being done by the Project
FAA R&D Integration	Sabrina Saunders-Hodge	Formal host of partnership agreements and collaborator for Integrated Test Activities
FAA ACAS Xu PO	Neal Suchy	Coordinating on collaboration for ACAS-Xu software and associated flight tests
RTCA SC-228	Working Group Leads	Conduct modeling, simulation and analysis to support the dev. of MOPS
OSD SAA SARP	Steve Cooke and Dallas Brooks	Coordinate government recommendations to RTCA SC-228 and assess SAA research Gaps
General Atomics	Brandon Suarez Scott Edrington	Ikhana equipped with avionics and Proof of Concept SAA system directly supported by UAS-NAS Project
Rockwell Collins	John Moore	CNPC radio development and flight test
AFRL	Mark Draper	Coordinate activities on Vigilant Spirit Control Station
AFRL	Paul Schaeffer	Development of a human interface concept for Jointly Optimal Collision Avoidance (JOCA)
UND	Michael Corcoran	Exploring requirements for safe operation of UAS through a series of case studies, experiments and flight evaluations
USMC VMU2, 1, & 3	Lt. Col. Faught Maj. Springfield	Potential support for survey of Marine Corps use of Shadow and other UAS and Ground Control Stations

Baseline Review Outline

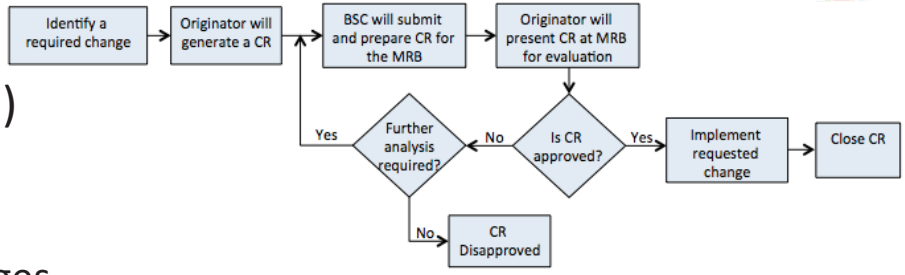
- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge
- Non-Technical Challenge Work
- Project Summary
- Project Control Processes & Governing Documents
- Briefing Summary
- Center Endorsements

Project Control Processes & Governing Documents

- UAS-NAS Project has several processes for the purpose of monitoring and controlling Phase 2 content to ensure a successful execution
- Control processes:
  - Utilize metrics and reporting methods to monitor the Phase 2 execution
  - Are documented in governing Project documents
- Phase 2 Control Processes:
  - Change Management
  - Risk Management
  - Resource Management
  - Management Review Board
  - Schedule Management
  - Technical Management
  - Technology Transfer
  - Non-Technical Challenge Work Management
  - Descope Strategy

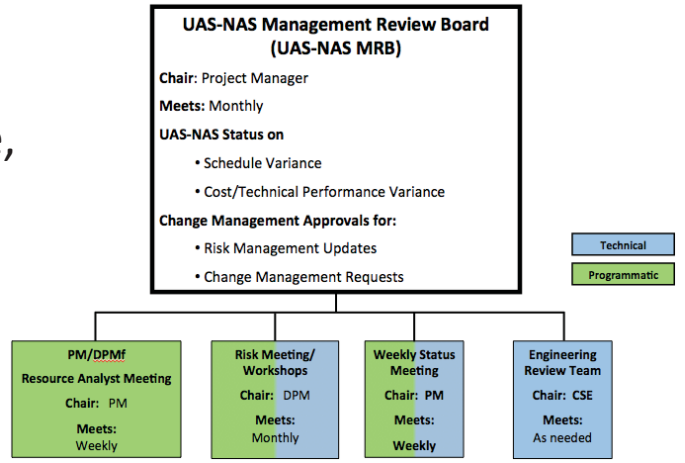
Existing Phase 1 Processes Enhanced for Phase 2

- Change Management
  - Standard process utilizing Change Requests (CR) to manage changes to the following elements:
    - L1 and L2 Milestones
    - Project Goals, Objectives, and Technical Challenges
    - Technical Baseline, i.e. SP objective, approach, deliverables
    - Project Requirements
    - Budget



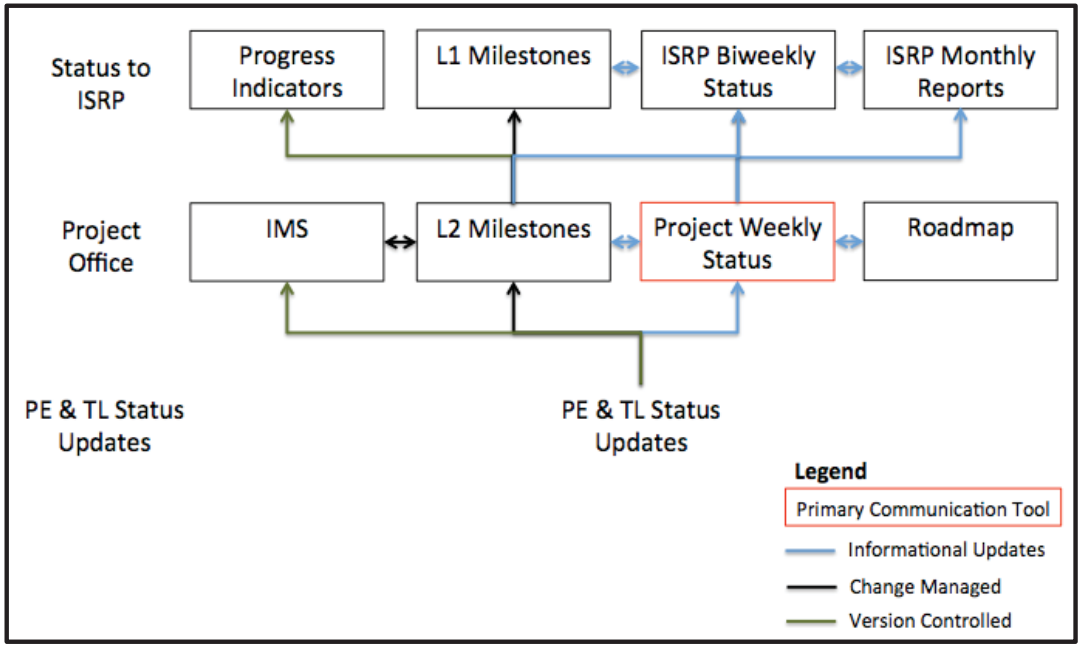
- Risk Management
  - Utilizes a Continuous Risk Management (CRM) process to identify, analyze, plan, track, and control risks
    - Risk Workshops and Risk Review meetings conducted monthly
    - Risks are communicated in ISRP UAS-NAS Risk Review Board, AFRC & Partner Center CMCs

- Resource Management
  - TWP, Budget roll up, and travel spreadsheets used in conjunction with standard tools (PMT, Business Warehouse, and SAP) to generate phasing plans and monitor status
- Management Review Board (MRB)
  - Monthly meeting where CRs and Risks are assessed/ approved and resource status and schedule status are presented



Schedule Management Flow

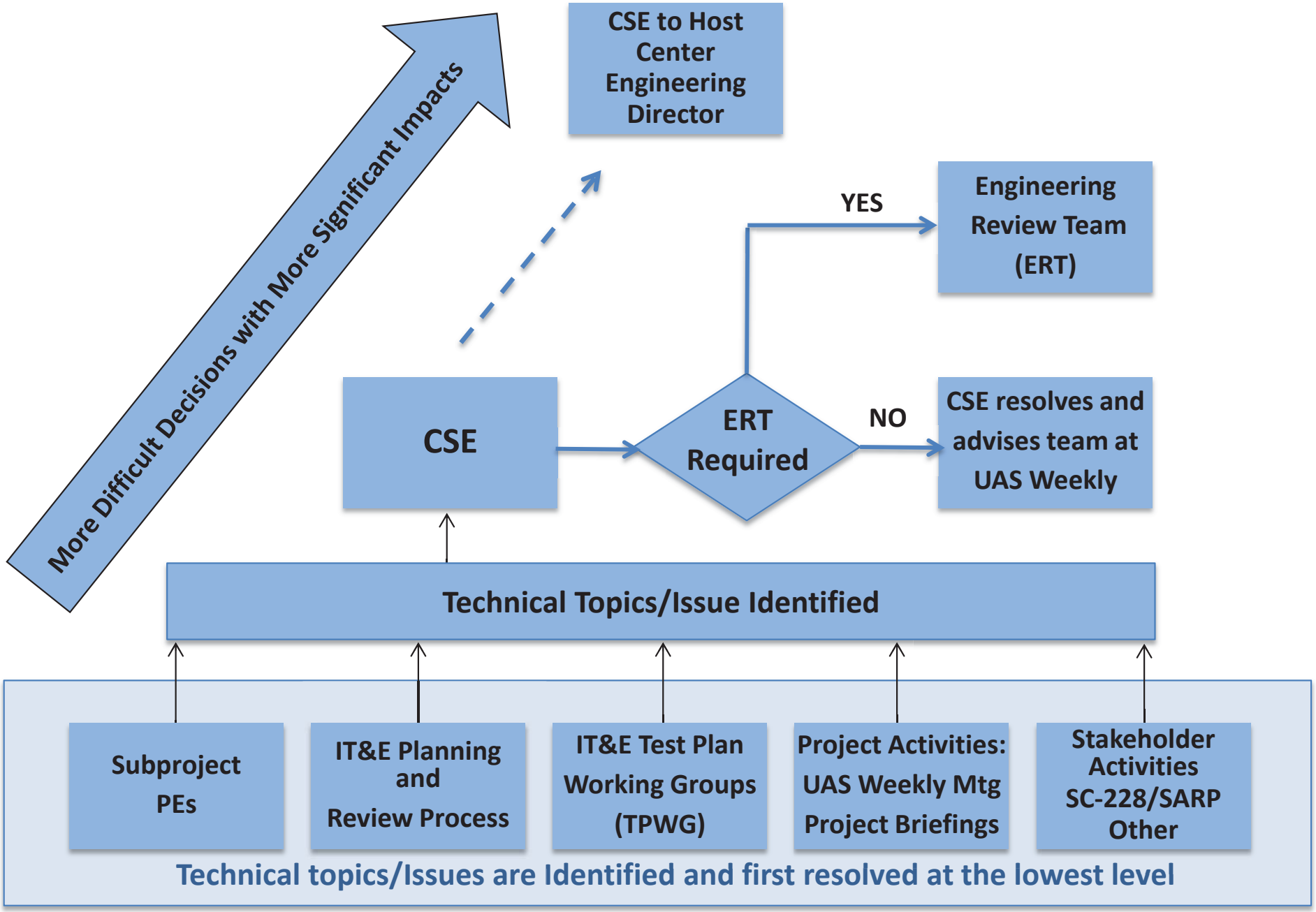
- Project weekly status is the primary means of information flow, schedule status, and updates
- Schedule Packages and Milestones are the primary means of reporting at the project weekly status
- The version controlled IMS contains change managed Milestones



Representative TC Task	M/S Level	Begin Date	End Date	Status/Progress /Concerns
Schedule Package N				Technical, Schedule, Accomplishments, and Issues and Concerns Status
Active Task1		01/01/14	02/15/14	complete
Active Task2		01/20/14	02/28/14	ongoing
Active Task3		02/01/14	03/31/14	ongoing
Deliverable	D	03/15/14	03/15/14	
Milestone	L2	04/01/14	04/01/14	

- Schedule management process is formally documented in the SMP

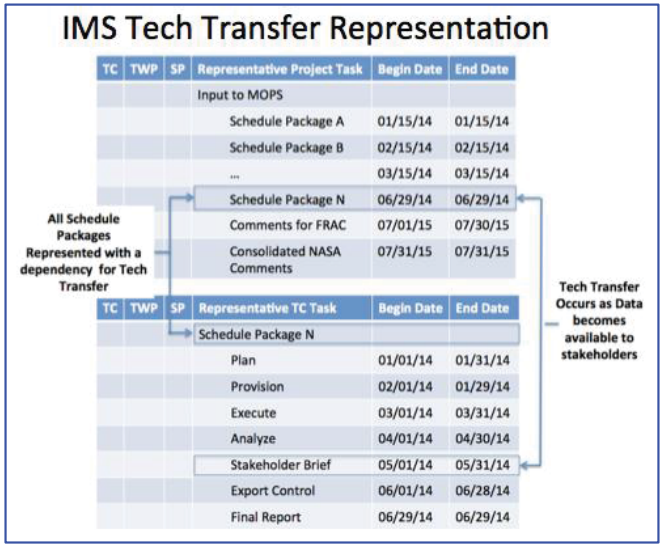
Technical Decision Making Flow



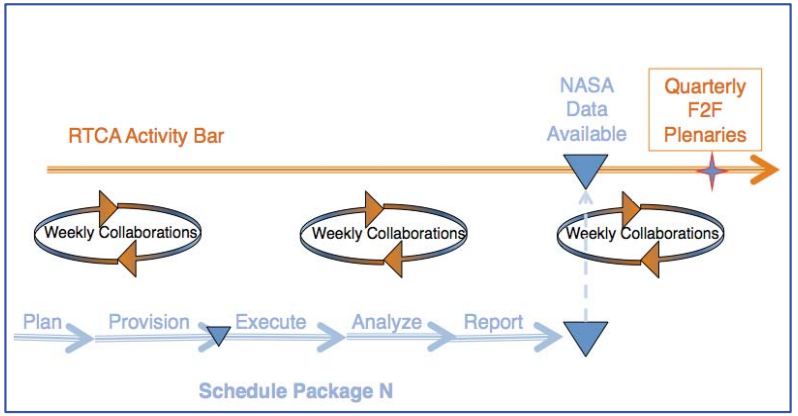
Note: Center CE is a source of technical authority for each PE

Technology Transfer Process

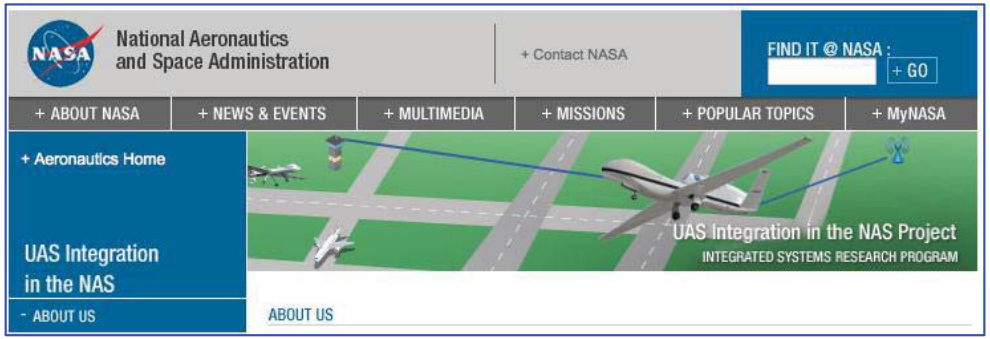
- Schedule Package deliverables are documented in the IMS, PRD, Roadmap, L2 milestones, and PIs and are the foundation of Tech Transfer
- Project IMS specifies the planned date that the Project Engineer (PE) will have "research findings" to provide to a stakeholder as a means of Tech Transfer



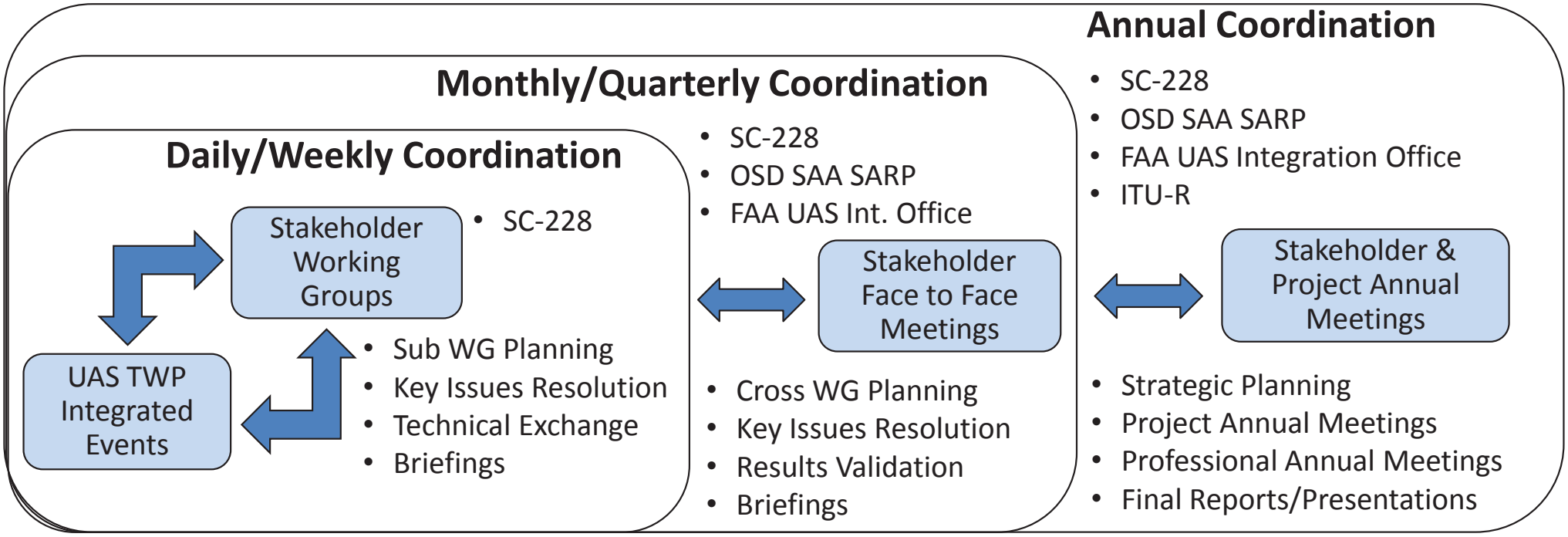
- Schedule Package content is coordinated with stakeholders through regularly occurring collaborations



- NASA ARMD Website is used for publicly releasable material
- Secure email and server will be used for transfer of controlled data (e.g. ITAR)



Technology Transfer Coordination (UAS-NAS to Stakeholder)



RTCA SC-228
- Baseline PRD Content
- Initial Tech Transfer Briefings
- Final Reports

FAA
- Test Plans
- Final Reports

OSD SAA SARP
- Research Findings

ITU-R
- Spectrum Analysis

Formal UAS-NAS Project Deliverables to Stakeholders

Formal Stakeholder Deliverables Influence UAS-NAS

RTCA SC-228
- White Papers
- Preliminary & Final MOPS

FAA
- Integration Road Maps
- Rules and Regulations

OSD SAA SARP
- Recommendations

ITU-R
- Authorization

Non-Technical Challenge Work Process & Reporting

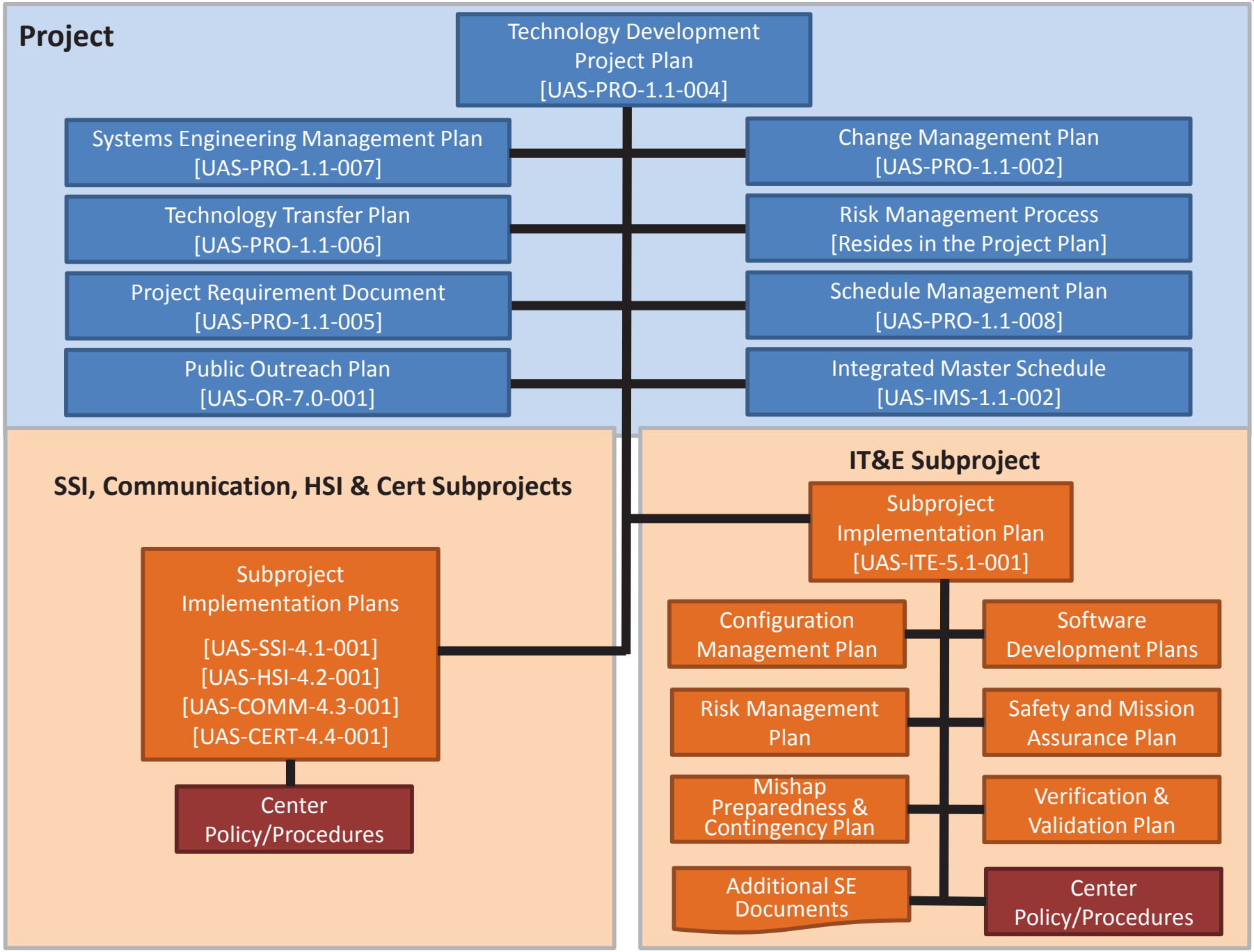
- Process
  - Employment of off-ramps assessed as needs arise per Project descope strategy
  - In August of each year, on-ramps will be evaluated for feasibility of incorporation into the UAS-NAS project portfolio. The following will be assessed:
    - Proposal alignment with Non-TC work goals, overall health and status of TC work, and available resources

- Reporting
  - Project level reporting consists of status every other week at the weekly telecon per the template
  - ISRP/ARMD reporting will consist of status relative to major aspects of the work
    - Monthly reports
    - Annual Reviews

Phase 2 Descope Strategy

- Constraints
  - Project is primarily FTE and WYE workforce – minimal major procurements
- General Strategy
  - Established a robust Project Management approach to identify potential impacts early to ensure successful execution
  - Use partnership/stakeholder collaboration to mitigate the impact of disruptions potentially requiring descope
    - The established relationship with the external community will facilitate the Project's ability to understand, assess, and even negotiate potential outcomes resulting from disruptions
  - Identify risk mitigations to lessen the impact of disruptions by allocating funds to risks
- Descope Strategy
  1. Use reserve strategies to reduce the impact to the portfolio
  2. Descope Non-TC Work
  3. Examine minimum and full success schedule packages and their associated value within the TWP to assess if descope within a TWP is feasible

Project Document Tree



Baseline Review Outline

- Project Overview & KDP/KDP Follow-on Outcomes
- Phase 2 Baseline Development
- Baseline Content per Technical Challenge
- Project Control Processes & Governing Documents
- Project Execution
- Non-Technical Challenge Work
- Briefing Summary & Center Endorsements

Baseline Review Summary

- KDP Elements
  1. KDP review focused on:
     - ✓ How the Project is addressing the UAS Community needs for NAS Access
     - ✓ The Phase 2 technical content and associated resource estimates, schedule, and risks
  2. Baseline review focuses on:
     - ✓ Phase 2 execution plans including project controls for the execution
     - ✓ Readiness to baseline the Phase 2 Portfolio and associated needs, objectives, deliverables, requirements, resource estimates, schedules, and risks
     - ✓ Technical Challenge cost and schedule are adequate estimates that reflect the scope, objectives and requirements.
     - ✓ Phase 2 portfolio has sufficient reserves, addressing both known and unknown risks
     - Center evaluations of ability to execute Phase 2 Portfolio

Project is executing and managing performance against the established baseline and has high confidence of successful execution

Verbal Center Endorsements

- Ames
- Glenn
- Langley
- Armstrong

Baseline Review Decision Request Revisited

- KDP Elements
  1. KDP review focused on:
     - ✓ How the Project is addressing the UAS Community needs for NAS Access
     - ✓ The Phase 2 technical content and associated resource estimates, schedule, and risks
  2. Baseline review focuses on:
     - ✓ Phase 2 execution plans including project controls for the execution
     - ✓ Readiness to baseline the Phase 2 Portfolio and associated needs, objectives, deliverables, requirements, resource estimates, schedules, and risks
     - ✓ Technical Challenge cost and schedule are adequate estimates that reflect the scope, objectives and requirements.
     - ✓ Phase 2 portfolio has sufficient reserves, addressing both known and unknown risks
     - ✓ Center evaluations of ability to execute Phase 2 Portfolio
- Decision the Project is seeking today
  - Approval to proceed with baseline plan

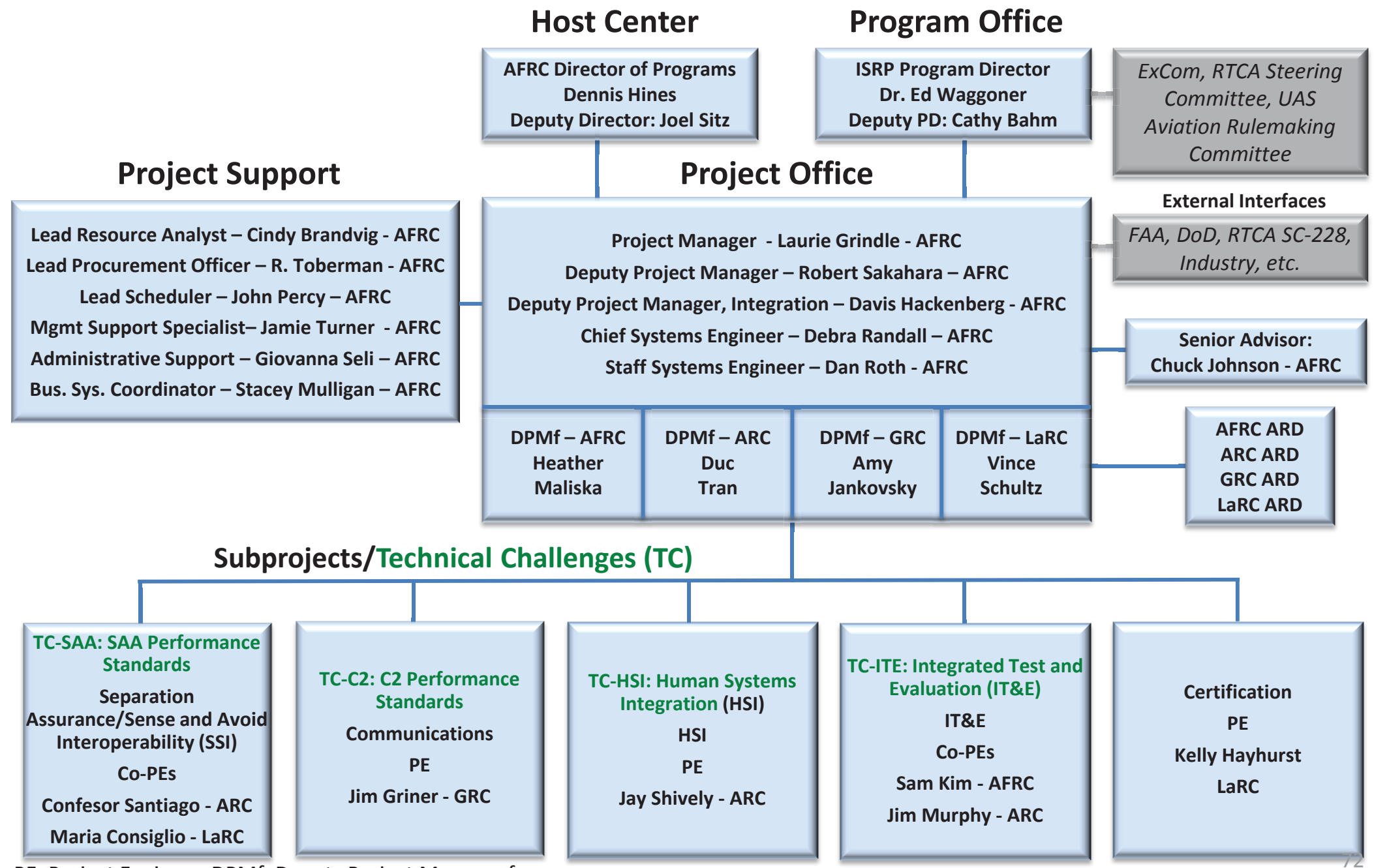
Backup Slides

Success Criteria Index

KDP/Baseline Review Process Success Criteria	Reference Charts			
	TC-SAA	TC-C2	TC-HSI	TC-ITE
TWP needs, objectives, success criteria, requirements, and deliverables support Project Goals and are feasible, executable and balanced with resource and schedule constraints. Requirements are clearly tied to objectives.	KDP	KDP	KDP	KDP
	BU: 102-104	BU: 110-112	BU: 116-117	25-33
	BU: 105-108	BU: 113-114	BU: 118-119	34-35, 37
	10, Project Requirements Document (PRD)			
Implementers, customers, and key stakeholders support the plan.	42, BU: 103-104	44, BU: 111-112	46, BU: 117	31-33, 36
	KDP, 65-66			
Needs, objectives, deliverables and requirements are ready to be baselined and placed under change management.	BU: 103-104	BU: 111-112	BU: 117	31-33
	7-22, PRD			
TWP cost and schedule are adequate estimates that reflect the scope, objectives and requirements. TWP cost estimates have been independently assessed.	BU: 106-108	BU: 113-114	BU: 118-119	34-35, 37
	KDP, 22			
Recommended Phase 2 portfolio has sufficient reserves, addressing both known and unknown risks.	BU: 108-109	BU: 114-115	BU: 119-120	37-39
	47, 56, BU: 130			
Key risks and associated mitigations have been identified and are realistic/appropriate.	BU: 109	BU: 115	BU: 120	38-39, BU: 89-97
	57-58, BU: 98-101, 133-149			
Detailed execution plans are feasible; processes are in place to manage the baselines and risk.	56, 62-69, BU: 151-160			
The team is adequately staffed with the “right” skill mix and understands the importance of the success and cost/schedule adherence.	KDP, BU: 76			
The proposed UAS-NAS Phase 2 Plan is executable within budget and schedule.	BU: 105-108	BU: 113-114	BU: 118-119	34-35,37
	56			

KDP = Information was presented at KDP, BU = Backup Slides

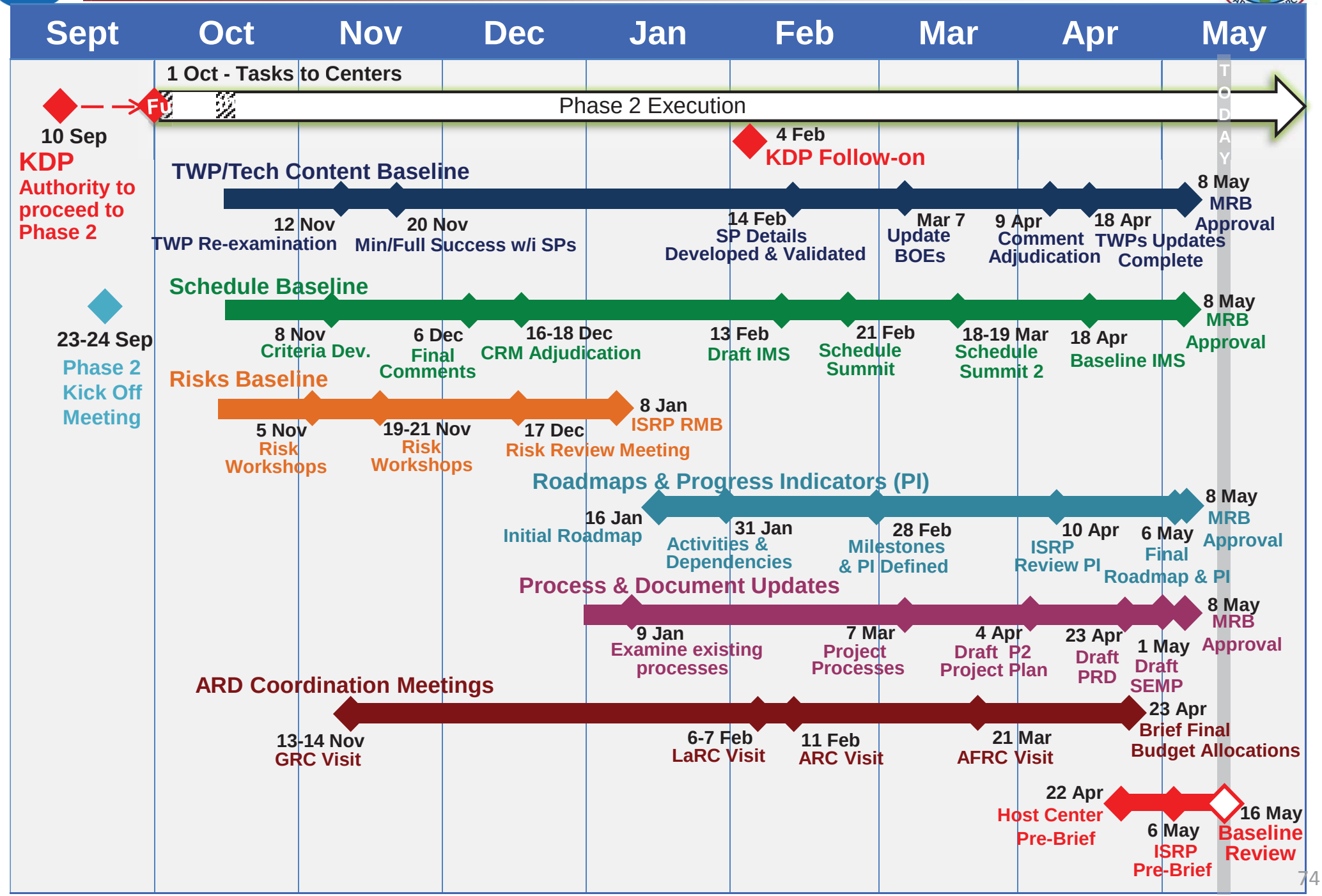
UAS Integration in the NAS Organizational Structure



PE: Project Engineer, DPMf: Deputy Project Manager for

Phase 2 Baseline Development
Backup Slides

Baseline Review Overview Schedule



IMS Decomposition

Technical Challenges (TC)

- Defined through KDP process
- L1 Milestones defined to document essential UAS Integration Milestones
- Progress Indicators comprised of L2 milestones and reflect technical progress towards L1 milestones

Technical Work Packages (TWP)

- Defined through KDP process
- Systematic grouping of related Schedule Packages

Schedule Packages (SP)

- Schedule Packages represent discrete bodies of scope and are the lowest fixed level in the IMS
- L2 Milestones as Execution and Reports
- Contain a framework for the phases of an activity (see below)

Tasks

- All activities within a Schedule Package necessary to complete the scope of the Schedule Package
- Milestones and Deliverables are at the task level
- Every task has an Unique ID

Schedule Package

Phase 2 Technical Challenges

TC-SAA

SAA Performance Standards

- Provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for sense and avoid (SAA) performance and interoperability.

TC-C2

C2 Performance Standards

- Provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for terrestrial command and control (C2) communication.

TC-HSI

Human Systems Integration

- Provide research findings to develop and validate human systems integration (HSI) ground control station (GCS) guidelines enabling implementation of the SAA and C2 performance standards.

TC-ITE

Integrated Test and Evaluation

- Develop a relevant test environment for use in generating research findings to develop and validate HSI Guidelines, SAA and C2 MOPS with test scenarios supporting integration of UAS into the NAS.

Baseline Content per Technical Challenge
Backup Slides

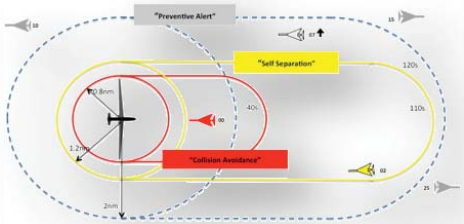
IHITL Configuration 1
NASA Ames and NASA Armstrong Connectivity

Part Task Simulation 4 (PT4)
- Evaluated multiple displays and UAS pilot maneuver guidance concepts for self separation and collision avoidance
- Data collection completed 3/18/14
- Defined scenarios and selection of VSCS for further evaluation in IHITL

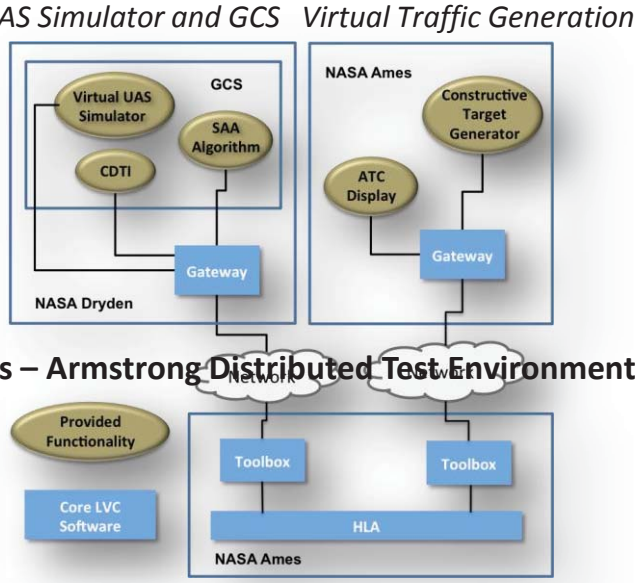
IHITL Configuration 1
- Test Set-up 1: Evaluate and measure the acceptability of SAA equipped UAS to ATC operations.
- Test Set-up 2: Evaluate and measure the effectiveness and acceptability of the SAA algorithm and pilot maneuver guidance display to inform and advise UAS pilots of proximal traffic to maintain well clear.

ZOA (Oakland Center) airspace encounter scenario with UAS conducting a coastal watch mission

Test Setup (same as PT 4)
- SAA Algorithm - Autoresolver
- Displays – VSCS Integrated Traffic Display



Scenario (same as PT 4)
- Class E airspace operations, transition to/from Class A airspace
- Single UAV
- Multiple encounter geometries



Ames – Armstrong Distributed Test Environment

Changes from PT 4
- Distributed test environment with AFRC
- Increasing simulation fidelity
- Test Set-up 2: ATC Subjects
  - Non-cooperative VFR traffic encounters
- Research GCS
  - Eye Tracker instrumentation

Test Duration (June – July 2014)
- Test Set-up 1: ATC – 3 weeks (15 Controllers)
- Test Set-up 2: UAS pilots – 2 weeks (10 pilots)

IHITL Configuration 2

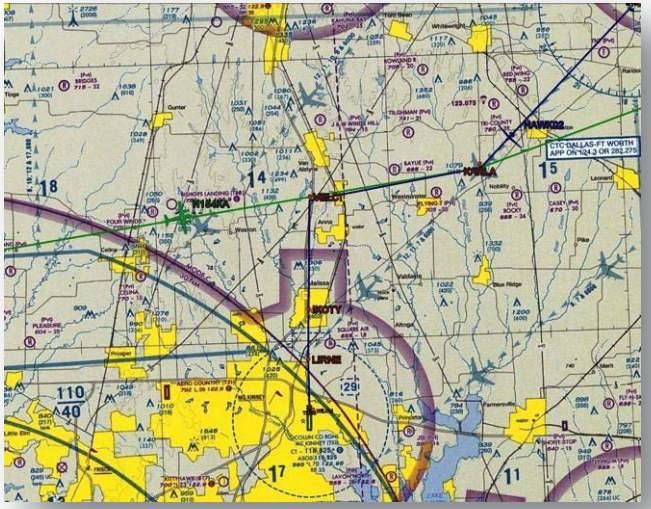
NASA Ames and NASA Langley Connectivity

UAS CAS 1

- Evaluated the effect of simulated SAA-equipped UAS on ATC acceptability and workload with differing horizontal spacing parameters used in the SAA algorithm
- Data collection completed 3/21/14
- Defined well clear distances to be evaluated in IHTIL

IHITL Configuration 2

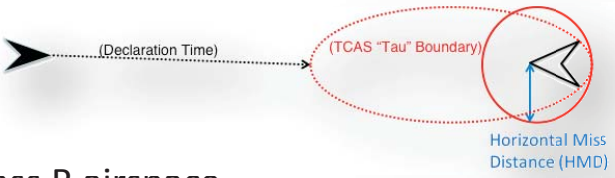
- Conduct a HITL experiment to assess SAA-TCAS interoperability and the impact of communication delay on the execution of self-separation tasks.
  - Are the range of SAA SS maneuvers identified in the UAS CAS 1 experiment's simulation scenarios with no C2 delays acceptable by ATC, acceptable under realistic C2 conditions?
  - Are the TCAS interoperability design requirements still maintained under these delays and in simulated winds?
  - Do C2 delays affect controller perceptions of unsafe conditions?



ZFW (Dallas-Ft Worth) Airspace near Collin Cty Regional / McKinney Airport - head-on encounter scenario

Test Setup (same as UAS CAS 1)

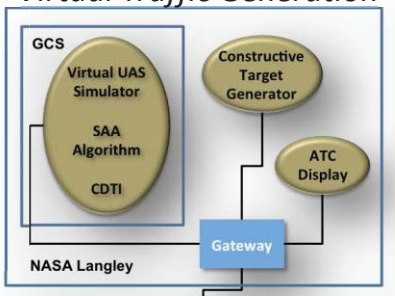
- SAA Algorithm - Stratway+
- Displays - MACS GCS engineering displays



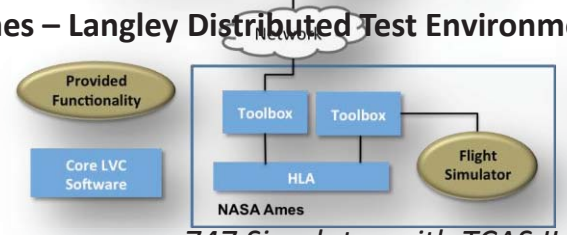
Scenario (same as UAS CAS 1)

- Class E airspace operations in proximity to Class B airspace
- Single UAS
- Multiple encounter geometries

UAS Simulator and GCS Virtual Traffic Generation



Ames – Langley Distributed Test Environment



747 Simulator with TCAS II

Changes from UAS CAS 1

- Distributed test environment
- Increasing simulation fidelity
- C2 delays
- 747 piloted simulator with TCAS II system

Test Duration (June 2014)

- Test Set-up 3: ATC – 3 weeks (6 Controllers)

Flight Test Series 3

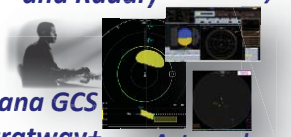
Live Ownship

EDM DRR

AFRC Ikhana

GRC T-34C

Ikhana Data Link
- C2
- Voice
- Health & Status
- Video
- Traffic (ADS-B and Radar)



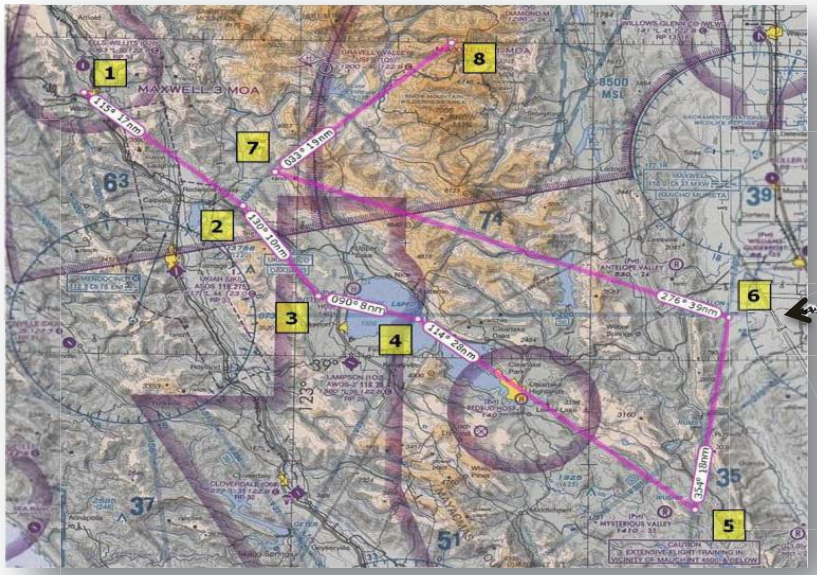
Stratway+

Autoresolver

Ikhana GCS
- Stratway+
- Autoresolver

CNPC Data Link
- C2
- Voice
- Health & Status
- Video
- Traffic (ADS-B)

UAS Pilot as Subject



36 flights and 2 backups (3.5 hr flights)
June – Aug 2015

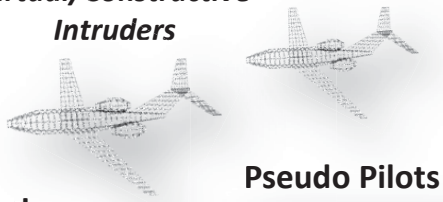
Honeywell King Air
- ADS-B
- TCAS II Instm
- High speed

ADS-B Out

ADS-B Out

Live Intruder
- ADS-B
- Several options
  - NASA King Air
  - NASA T-34C

Virtual/Constructive Intruders



Research GCS
VSCS

Stratway+

Autoresolver

Displays of Proximal Traffic
SAA/DAA Algorithms
Pilot Maneuver Guidance

VPN

Distributed
Environment/Connectivity

ATC as Subject

Pseudo Pilots

Multi-Aircraft Control System

Flight Test Series 4

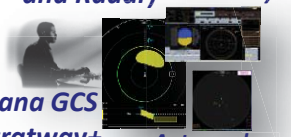
Live Ownship

EDM DRR

AFRC Ikhana

GRC T-34C

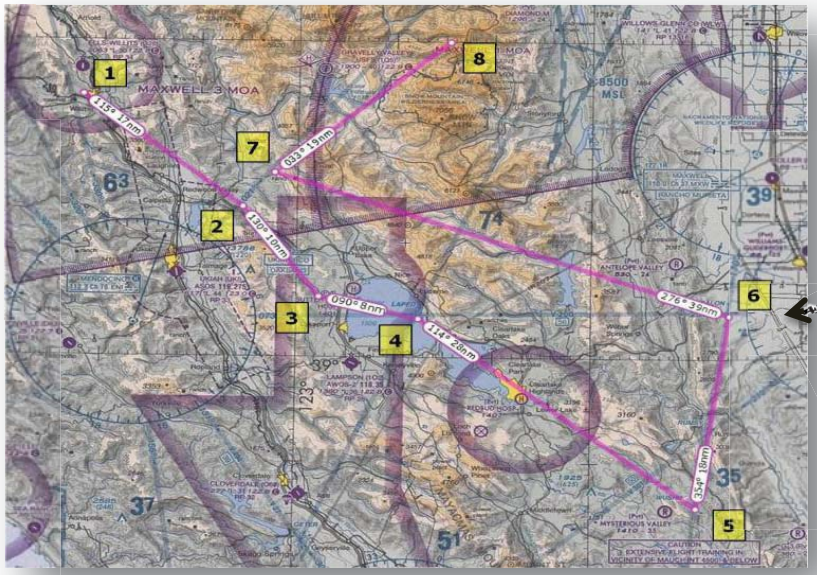
Ikhana Data Link
- C2
- Voice
- Health & Status
- Video
- Traffic (ADS-B and Radar)



Ikhana GCS
- Stratway+
- Autoresolver

CNPC Data Link
- C2
- Voice
- Health & Status
- Video
- Traffic (ADS-B)

UAS Pilot as Subject



36 flights and 2 backups (3.5 hr flights)
Feb – Apr 2016

ADS-B Out

GRC S-3B
- ADS-B
- 2nd CNPC

Remote CNPC GCS

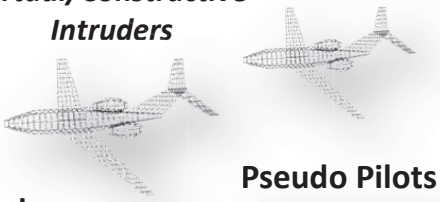
Honeywell King Air
- ADS-B
- TCAS II Instm
- High speed

ADS-B Out

ADS-B Out

Live Intruder
- ADS-B
- Several options
  - NASA King Air
  - NASA T-34C

Virtual/Constructive Intruders



Research GCS
VSCS

Stratway+

Autoresolver

Displays of Proximal Traffic
SAA/DAA Algorithms
Pilot Maneuver Guidance

VPN

Distributed
Environment/Connectivity

ATC as Subject

Pseudo Pilots

Multi-Aircraft Control System

TC-ITE: Flight Test Series 3 & 4

- The Flight Test Series 3 in an operational but controlled environment, demonstrates systems integration and evaluation of UAS concepts and supporting technologies defined within the scope of the UAS in the NAS Project
  - SSI Algorithms and Sensor Models
  - C2 CNPC
  - HSI Displays and RGCS
- Verify Sense and Avoid sensitivity, pilot workload, and maneuver negotiation under live flight uncertainties and the integrated prototype Control and Non-Payload Communication system
- 36 flights and 2 backups (3.5 hr flights)

- The Flight Test Series 4 in an operational but controlled environment, increases the complexity of FT3 and demonstrates systems integration and evaluation of the state of UAS concepts and supporting technologies
  - SSI Controller acceptability of DAA concept
  - C2 CNPC on two aircraft
  - HSI Displays secondary conflicts, traffic density, and weather
- Validate Sense and Avoid sensitivity, pilot workload, and maneuver negotiation under live flight uncertainties and the integrated prototype Control and Non-Payload Communication system
- 36 flights and 2 backups (3.5 hr flights)

NASA Flight Test 3 Goals:
- Conduct integrated flight test series to verify Preliminary DAA and C2 MOPS
- Demonstrate Live, Virtual, Constructive (LVC) distributed test environment
- Demonstrate System integration of Surrogate UAS, RGCS, and SS Algorithms
- Demonstrate Pilot Guidance Maneuvers through real world SS scenarios
- Validate Sensor Models

NASA Flight Test 4 Goals:
- Conduct integrated flight test series 4 to verify and validate Final DAA and C2 MOPS
- Demonstrate Live, Virtual, Constructive (LVC) distributed test environment
- Demonstrate Challenging encounter geometries with 2 or more live aircraft
- Demonstrate Negotiation with UAS pilot and ATC in complex/busy airspace
- Demonstrate two aircraft w/CNPC to assess link performance within the same spectrum
- Demonstrate CA/SS Interoperability

TC-SAA: Overview

Description: Determine the required performance of candidate SS and CA algorithms, SAA surveillance system requirements, performance characteristics of and interactions between SAA sub-functions. Also support definition of sensor and algorithm-agnostic maneuverability requirements and evaluation of the impact of sensor uncertainties and vehicle performance limitations on the execution of SAA maneuvers.

Objectives

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

Approach

- Create new modeling and simulation capabilities in Airspace Concept Evaluation System (ACES) and perform a series of fast-time simulations with ACES.
- Participate in IHITL to obtain human performance metrics SS maneuvers recommended by SAA system.
- Participate in Flight Tests to validate: sensor models and requirements, trajectory prediction performance and SS and/or CA avoidance maneuver effectiveness.
- Conduct batch simulations to evaluate specific maneuver algorithms
- Conduct HITL evaluation of SAA algorithms and pilot guidance procedures.

Deliverables

- UAS performance models & scenarios.
- Fast-time SAA testbed (ACES).
- Evaluations of definitions of well clear and recommendations on which to employ.
- Description of the concept of operations for SAA.
- Data, results, and technical reports from analysis, studies, batch simulations, HITLs, IHITL, and flight tests.
- SAA requirements and recommendations for DAA MOPS.

TC-SAA: High Level Summary (1 of 2)

ID	Schedule Package Title	Approach	Deliverable	MS
S.1.10	Surveillance Requirements (Low Fidelity)	ACES Sim	Brief (SC)	L2
S.1.20	Surveillance Requirements (Medium Fidelity)	ACES Sim	Brief (SC)	L2
S.1.30	Sub-function Tradeoffs w/ UAS Performance	ACES Sim	Brief (SC)	L2
S.1.40	Interoperability of SS and CA Functions	ACES Sim	Brief (SC)	L2
S.2.10	SAA Traffic Display Evaluation HITL1	HITL	Report	L2
S.2.20	IHITL Participation & Data Collection SSI ARC IHITL	HITL	Report	L2
S.2.30	Self-Separation Risk Ratio Study	ACES Sim	Report	L2
S.2.40	FT3 Participation & Data Collection SSI ARC FT3	Flight Test	Report	L2
S.2.50	FT4 Participation & Data Collection SSI ARC FT4	Flight Test	Report	L2
S.2.60	SAA Traffic Display Evaluation HITL2	ACES Sim	Report	L2
S.2.70	Effect of SAA Maneuvers with Procedures	ACES Sim	Report	L2
S.2.80	Comprehensive Evaluation of Airspace Risk Threshold SSI ARC	ACES Sim	Report	L2
S.3.10	Well Clear Metric and Definition Study	ACES Sim	Report	L2

- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones

Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

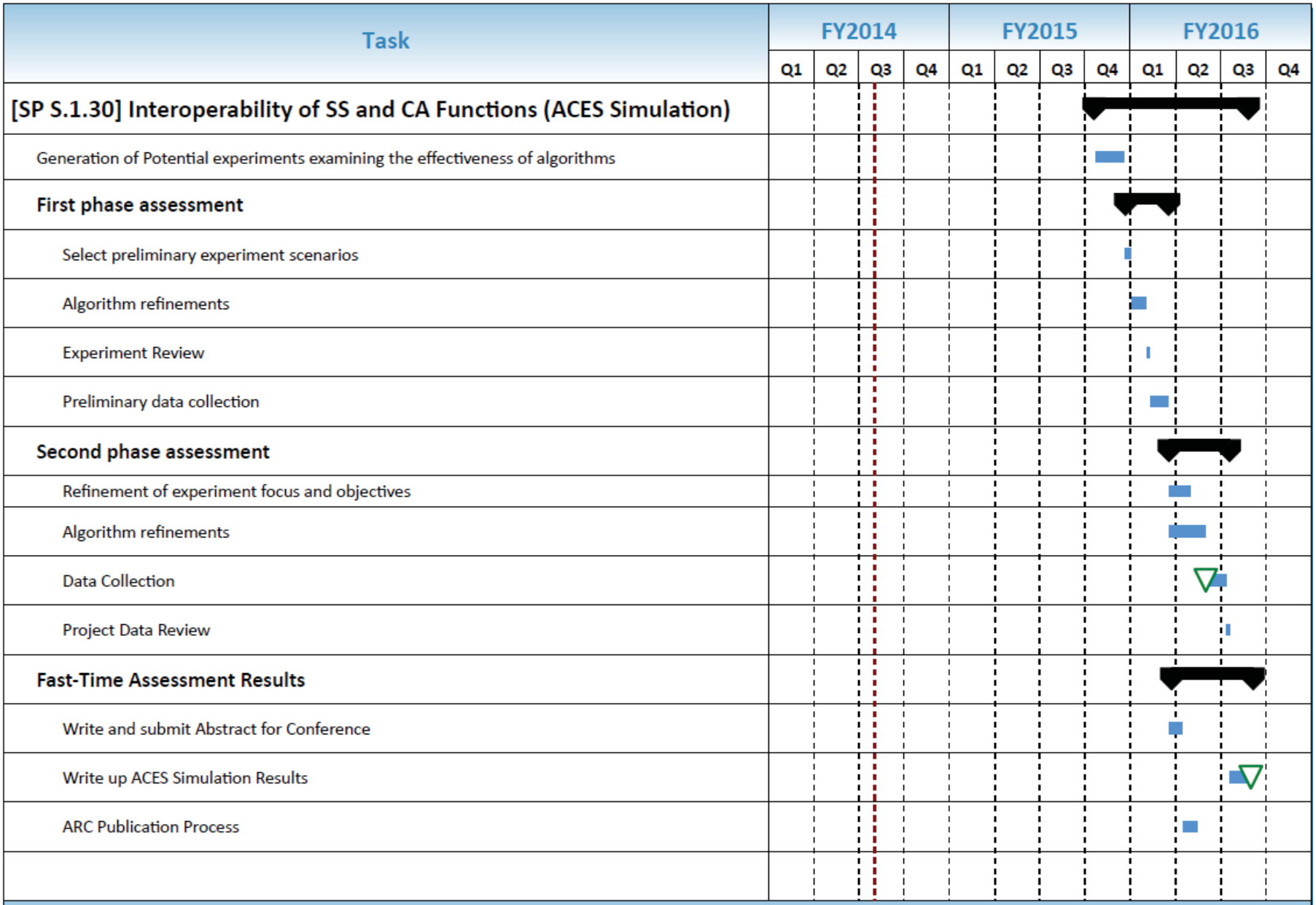
TC-SAA: High Level Summary (2 of 2)

ID	Schedule Package Title	Approach	Deliverable	MS
S.3.20	Well Clear Alerts/Resolutions	ACES Sim	Report	L2
S.4.10	UAS - SAA Trade-off Assessments	Batch Sim	Report	L2
S.4.20	CA/SS Algorithm Maneuvers vs. UA Performance Assessment	Batch Sim	Report	L2
S.5.10	UAS CAS1 HITL	HITL	Brief (SC, S)	L2
S.5.20	Langley Support & Participation in IHITL	HITL	Brief (SC)	L2
S.5.30	Comm Gen2 Flight Test SSI Data Report	Flight Test	Report	L2
S.5.40	SSI LaRC Support & Participation in FT3	Flight Test	Brief (SC)	L2
S.5.50	SSI LaRC Support & Participation in FT4	Flight Test	Report	L2
S.5.60	Alerting Times + CA-SS Integration Combined HITL	HITL	Brief (SC)	L2
S.6.10	SAA Initial Flight Test Participation w/ IT&E	Flight Test	Conference Paper	L2
S.7.10	Sensor Model Stress Testing & Sensitivity Analysis HITL	HITL	Brief (SC)	L2

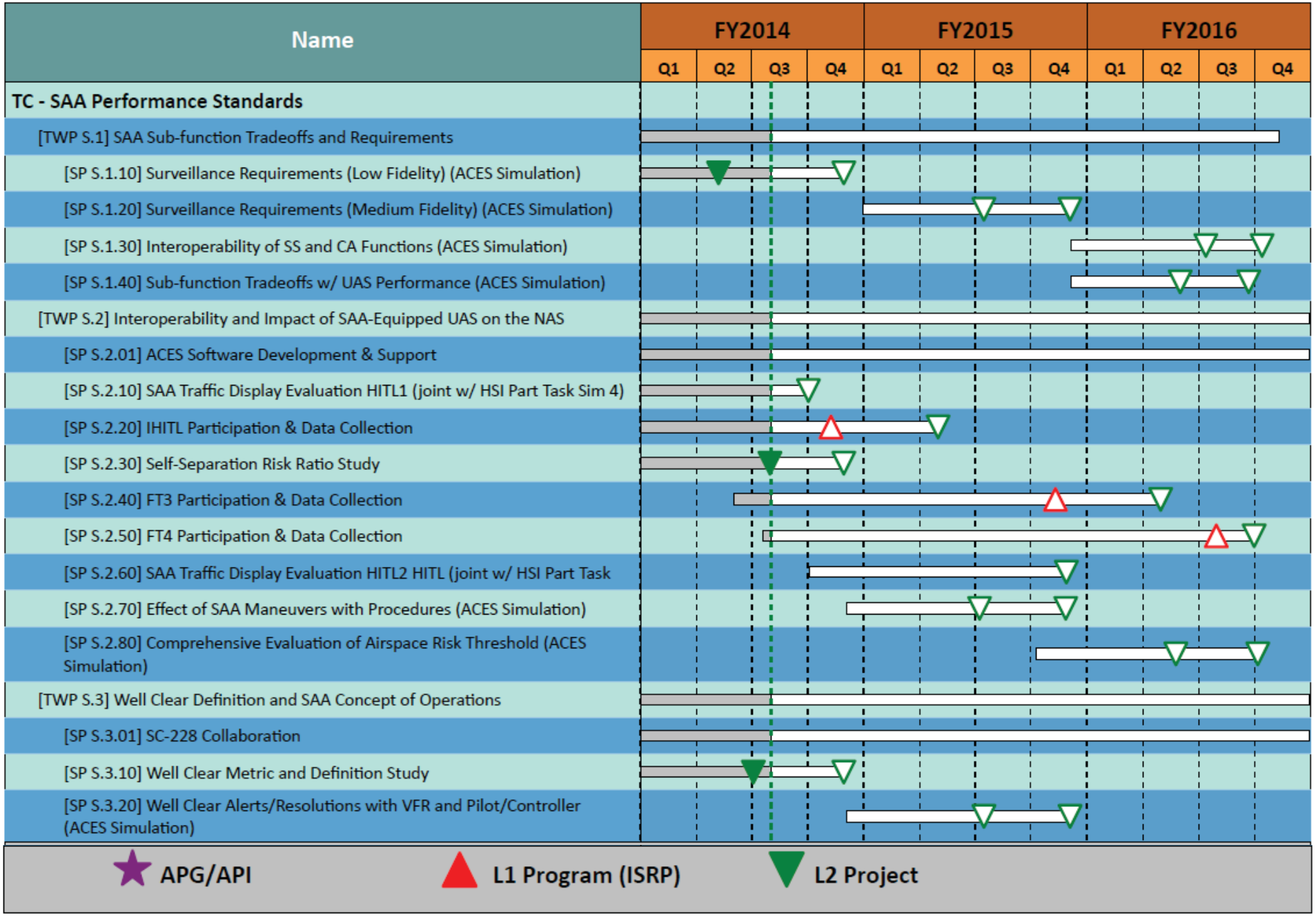
- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones

Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

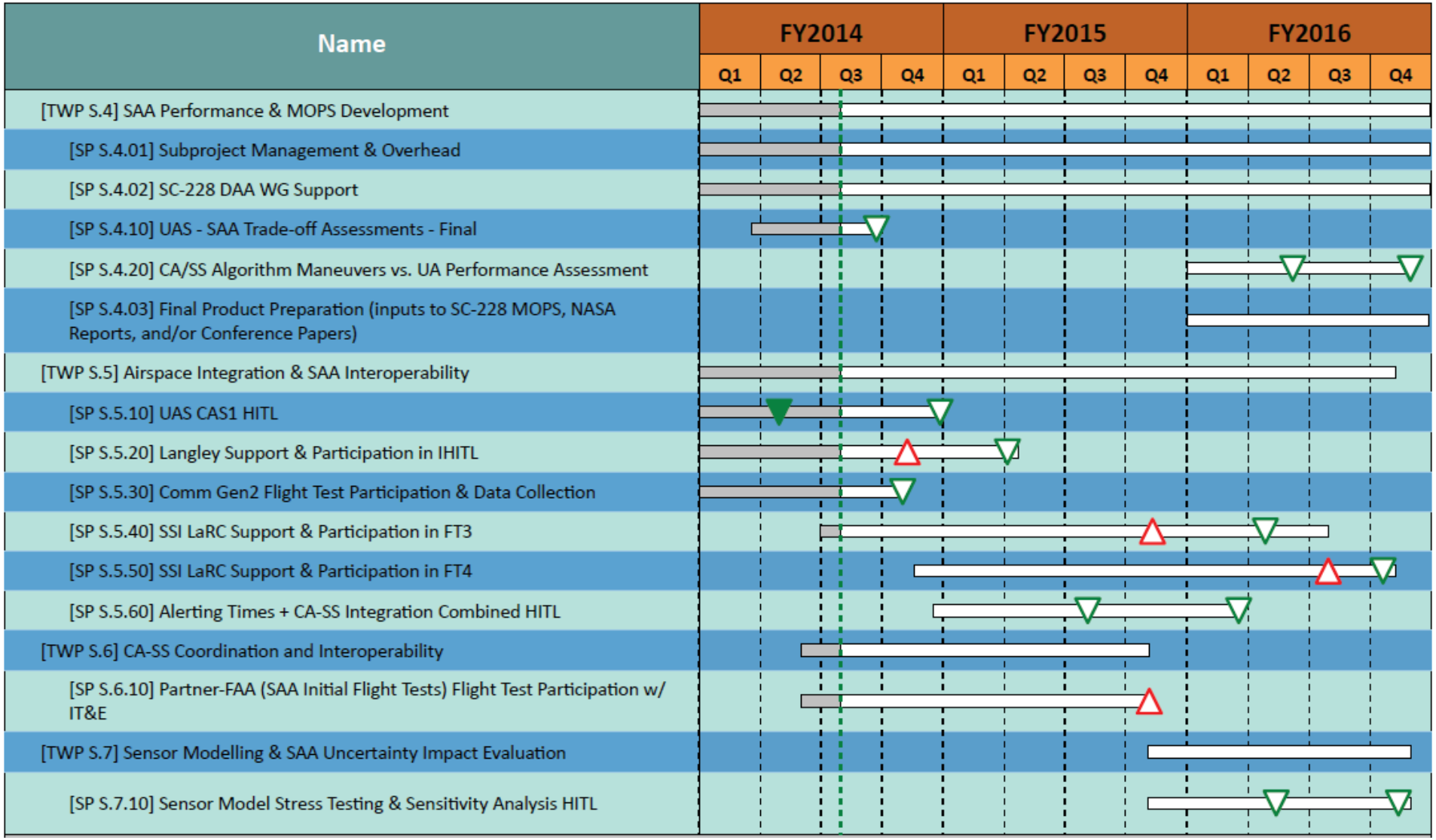
TC-SAA: SP S.1.30 Example



TC-SAA: Schedule



TC-SAA: Schedule (cont.)



APG/API L1 Program (ISRP) L2 Project

TC-SAA: Risk Matrix and Summary

Risk Matrix

LIKELIHOOD	1	2	3	4	5
5					
4					
3			4.1.7 4.1.8 4.1.9 4.1.10		
2			4.1.4 4.1.5		
1					

CONSEQUENCE

Risk ID	Trend	LxC	Approach	Risk Title
4.1.7	⇨	3x3	M	Lack of Collision Avoidance Model Availability and Integration Support
4.1.8 (T)	⇨	3x3	M	Sense and Avoid Sensor Suite Availability
4.1.9 (T)	⇩	3x3	M	Delay of SAA/SSI Technology Developments Impact to Integrated Test Events (IHITL, FT3 and FT4)
4.1.10	⇨	3x3	M	Completion of SAA/SSI Technical Objectives that Rely upon Formal Partnerships
4.1.4	⇨	2x3	M	A test bed for airborne sense and avoid flight tests equipped with the command and non-payload communications radio may not be available
4.1.5	⇨	2x3	M	Availability of unassociated and uncooperative aircraft track data

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

TC2: C2 Performance Standards Overview

Description: Develop and flight test a prototype terrestrial CNPC system to develop and validate performance requirements. Also conduct analysis and propose CNPC security recommendations for civil UAS operations and perform UAS Spectrum analysis and testing. Additionally, develop a simulation environment to perform analysis of a UAS CNPC system and validate the simulation.

Objectives

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

Approach

- Develop and validate candidate UAS CNPC system prototype using RTCA SC-203 WG-2 proposed performance requirements in a relevant integrated test environment and mixed traffic environment.
- Provide information on UAS CNPC development on an on-going basis to maintain/finalize the technical parameters of the UAS LOS CNPC allocation and support ensuring standards developments.
- Develop control communication system link models that predict performance; validate during flight test.
- Verify the performance of a secure terrestrial CNPC System, while interfaced to SAA and HSI components; validate during flight test.

Deliverables

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

TC-C2: High Level Summary (1 of 2)

ID	Schedule Package Title	Approach	Deliverable	MS
C.1.10	Gen2 Radio in Relevant Environment Flight Test	Flight Test	Report	L2
C.1.20	Verify Prototype Performance	Flight Test	Report (SC)	L2
C.1.30	Verify Prototype Performance/Compliance ITU-R Prototype Comm System - Mixed Traffic Environment Flight Test 2	Flight Test	Report (SC)	L2
C.2.10	Develop and Test Prototype Communication Security Test	Lab Test	Report (SC)	L2
C.2.20	Performance Validation of Security Mitigations/ Relevant Flight Environment Security Mitigations	Flight Test	Report (SC)	L2
C.3.10	Spectrum Compatibility Analysis Final Report and Recommendations on WRC-2015	Analysis	Report (SC, W)	L2
C.3.20	C-Band Planning & Standards Final Report	Analysis	Report (SC, W)	L2

- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones

Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

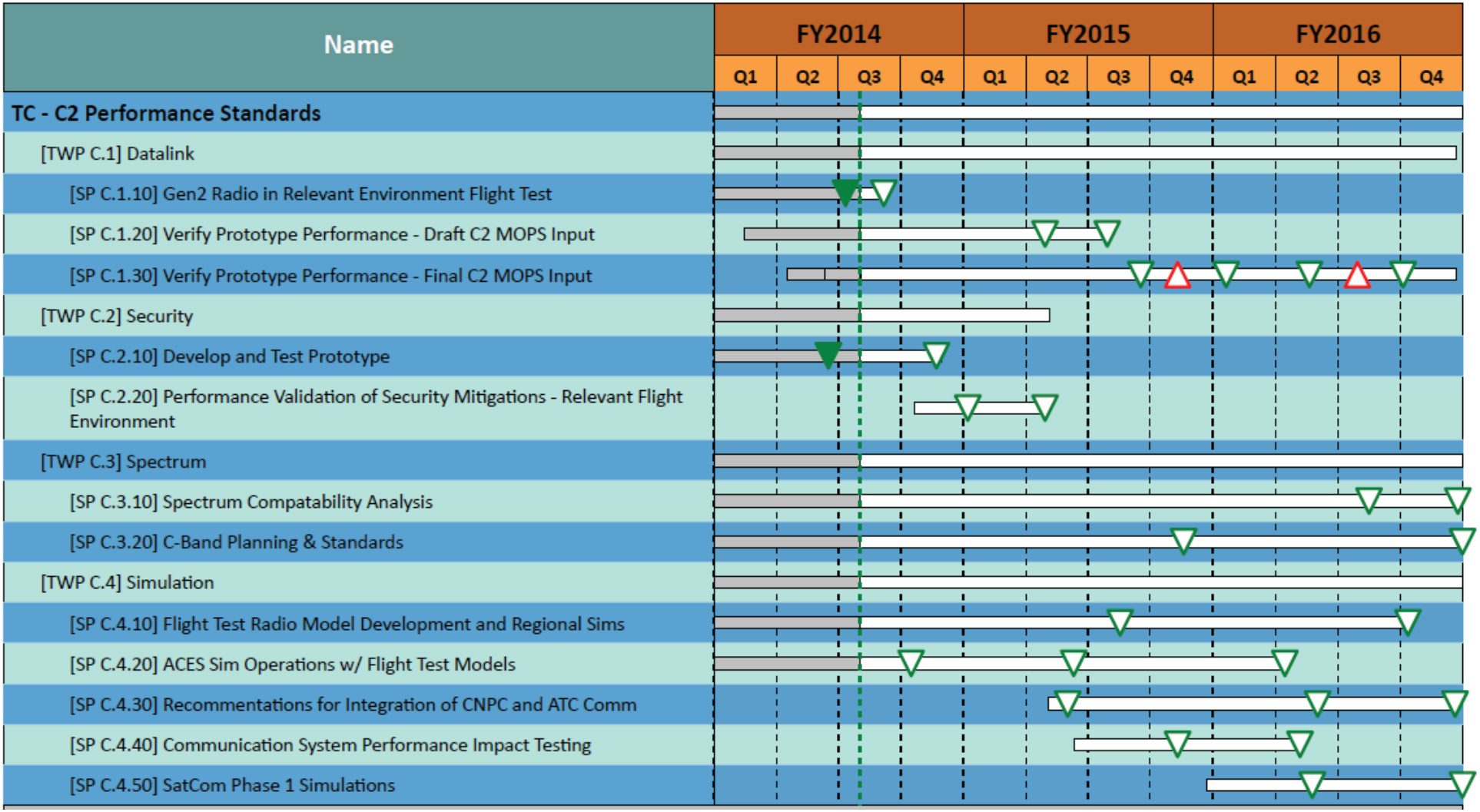
TC-C2: High Level Summary (2 of 2)

ID	Schedule Package Title	Approach	Deliverable	MS
C.4.10	Flight Test Radio Model Development and Regional Simulation - Inputs to Standards	Simulation	Report (SC)	L2
C.4.20	ACES Sim Operations w/ Flight Test Models w/Gen1	ACES Simulation	Report (SC)	L2
C.4.20	ACES Sim Operations w/ Flight Test Models w/Gen2	ACES Simulation	Report (SC)	L2
C.4.20	Large-scale Sims with Gen3 Radio Model	ACES Simulation	Report (SC)	L2
C.4.30	Recommendations for Integration of CNPC and ATC Comm Final Start Execution	Simulation	Report (SC)	L2
C.4.40	ATC and CNPC Comm Performance Impact on NAS Delay/Capacity	Simulation	Report (SC)	L2
C.4.50	SatCom for UAS Simulation	Simulation	Report (SC)	L2

- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones

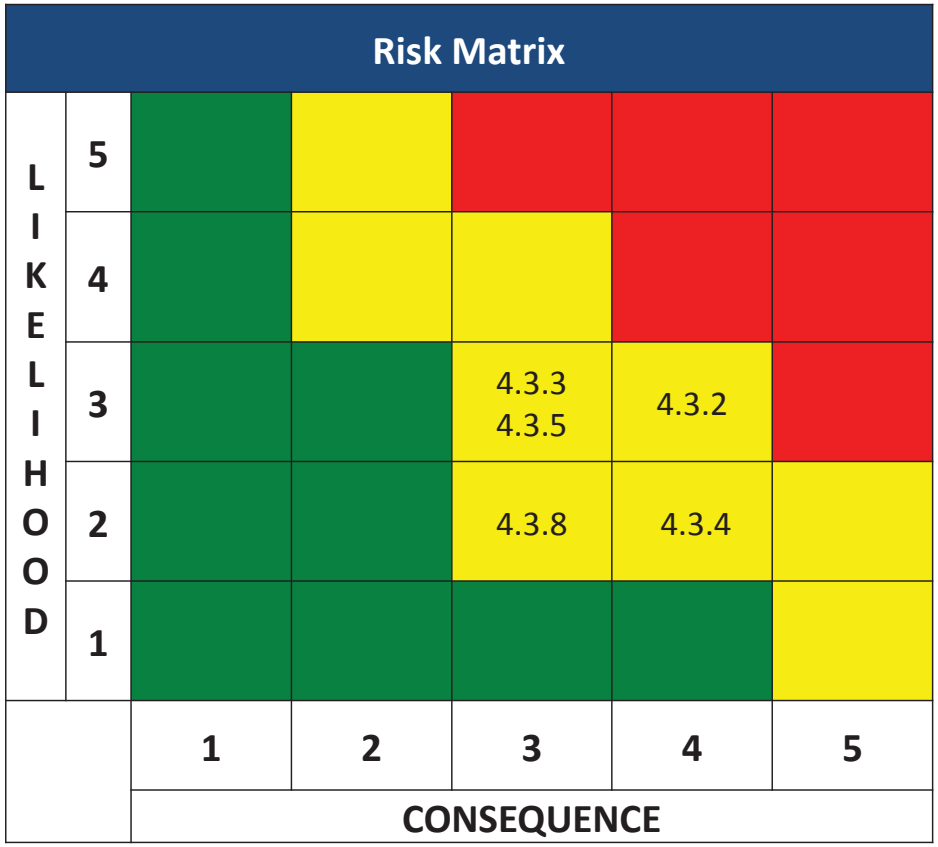
Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

TC-C2: Schedule



APG/API L1 Program (ISRP) L2 Project

TC-C2: Risk Matrix and Summary



Risk ID	Trend	LxC	Approach	Risk Title
4.3.2	⇨	3x4	M	Communication Security Requirements Exceed CNPC Link Bandwidth Constraints
4.3.3 (T)	⇨	3x3	M	Key CNPC Equipment or System Failure
4.3.5	⇨	3x3	M	Additional Spectrum Analysis Requirements
4.3.4	⇨	2x4	M	Availability of OPNET Modeler Expertise
4.3.8	⇨	2x3	M	Radios flight tested in FT3 and FT4 Series may not fully validate MOPS
4.3.6			W	Higher Communications Aircraft Fuel Cost

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

TC-HSI: Human Systems Integration Overview

Description: Develop human factors guidelines including displays, controls, and procedures for operation in the NAS. The overall GCS guidelines will be comprehensive, but will have a specific focus on guidelines for SAA and C2 MOPS. Develop an instantiation of a prototype GCS for use in subproject and integrated testing events.

Objectives

- Develop a prototype GCS that will instantiate the GCS guidelines and serve as GCS for the integrated events.
- Develop guidelines for GCS design and operation in the NAS.
- Apply GCS guidelines towards DAA and C2 MOPS

Approach

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

Deliverables

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

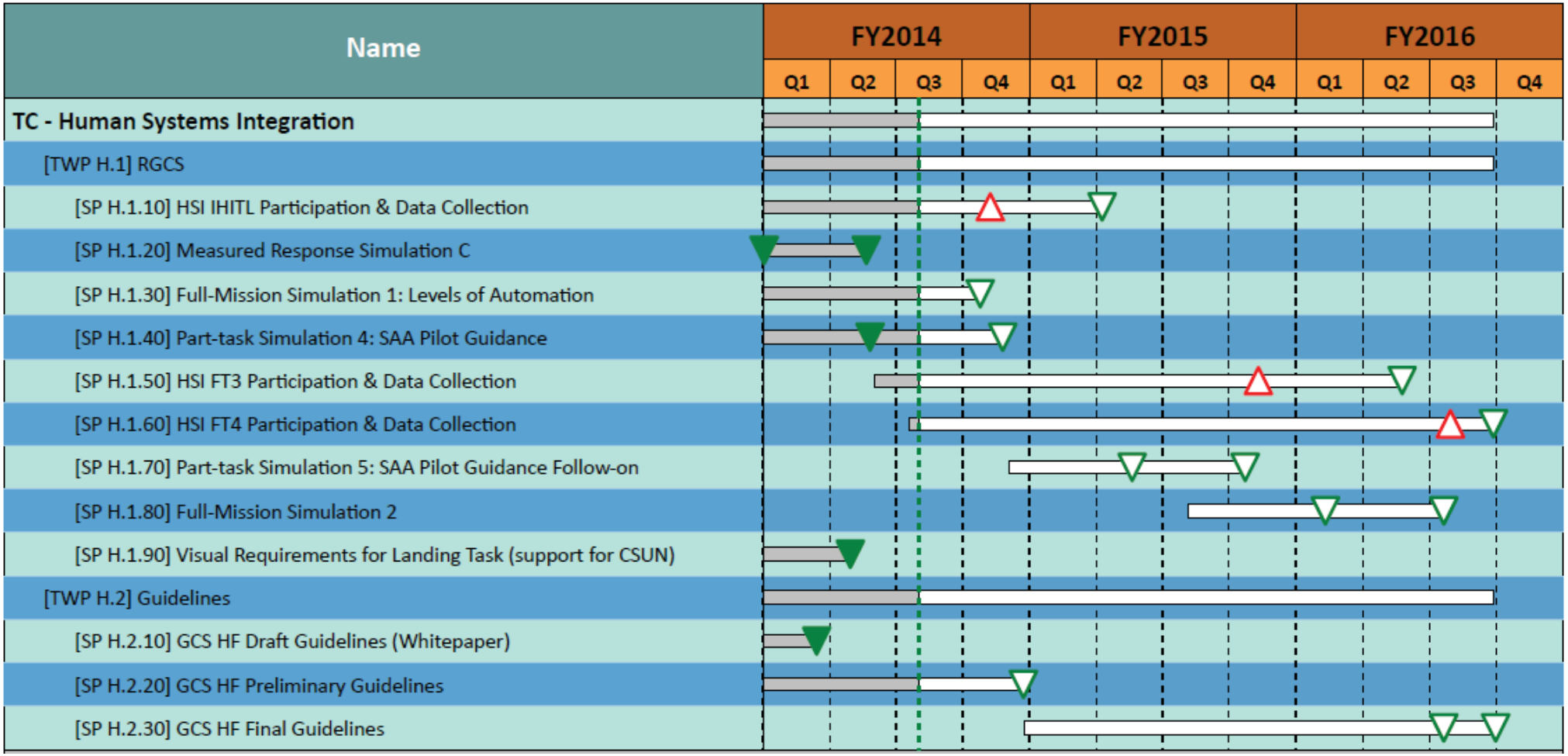
TC-HSI: High Level Summary

ID	Schedule Package Title	Approach	Deliverable	MS
H.1.10	IHITL results HSI	HITL	Briefing (SC)	L2
H.1.20	Measured Response Simulation C	Simulation	Briefing (F)	L2
H.1.30	Compliant Ground Station Full-mission Simulation 1	Full Mission Simulation	Briefing (SC, S)	L2
H.1.40	NAS Compliant Ground Station Part-Task Simulation 4: SAA Pilot Guidance	Part Task Simulation	Briefing (SC, S)	L2
H.1.50	HSI FT3	Flight Test	Briefing (SC)	L2
H.1.60	HSI FT4	Flight Test	Briefing (SC)	L2
H.1.70	NAS Compliant Ground Station Part-Task Simulation 5: SAA Pilot Guidance Follow-on	Part Task Simulation	Briefing (SC, S)	L2
H.1.80	NAS Compliant Ground Station Full-mission Simulation 2	Full Mission Simulation	Briefing (SC, S)	L2
H.1.90	Visual Requirements for Landing Analysis	Simulation	Report (C2)	L2
H.2.10	GCS HF Draft Guidelines	Analysis	White Paper	L2
H.2.20	GCS HF Draft Guidelines	Analysis	Report	L2
H.2.30	GCS HF Final Guidelines	Analysis	Report	L2

- SPs contribute to SC-228 Preliminary and Final MOPS L1 Milestones

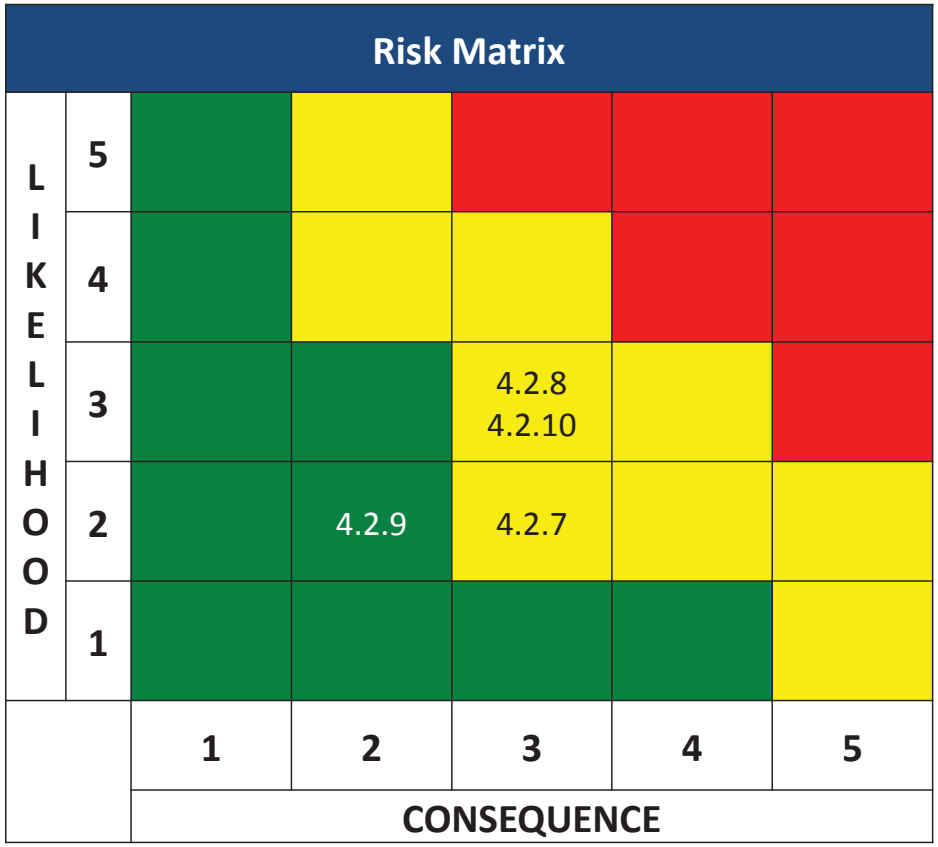
Stakeholder Legend:
C=TC-C2 S=SARP
F=FAA W=WRC
SC=SC-228 PO = Project Office

TC-HSI: Schedule



APG/API L1 Program (ISRP) L2 Project

TC-HSI: Risk Matrix and Summary



Risk ID	Trend	LxC	Approach	Risk Title
4.2.8 (T)	⇨	3x3	M	Endorsement of HSI GCS Guidelines from a Recognized Standards-based Group
4.2.10	⇨	3x3	M	Completion of HSI Technical Objectives that Rely upon Formal Partnerships
4.2.7	⇨	2x3	M	Manned vs Unmanned HSI Measured Response Data Comparison
4.2.9 (T)	⇨	2x2	M	Delay of HSI Technology Development Impact to Integrated Test Events (IHITL, FT3 and FT4)

Criticality

- High
- Med
- Low

L x C Trend

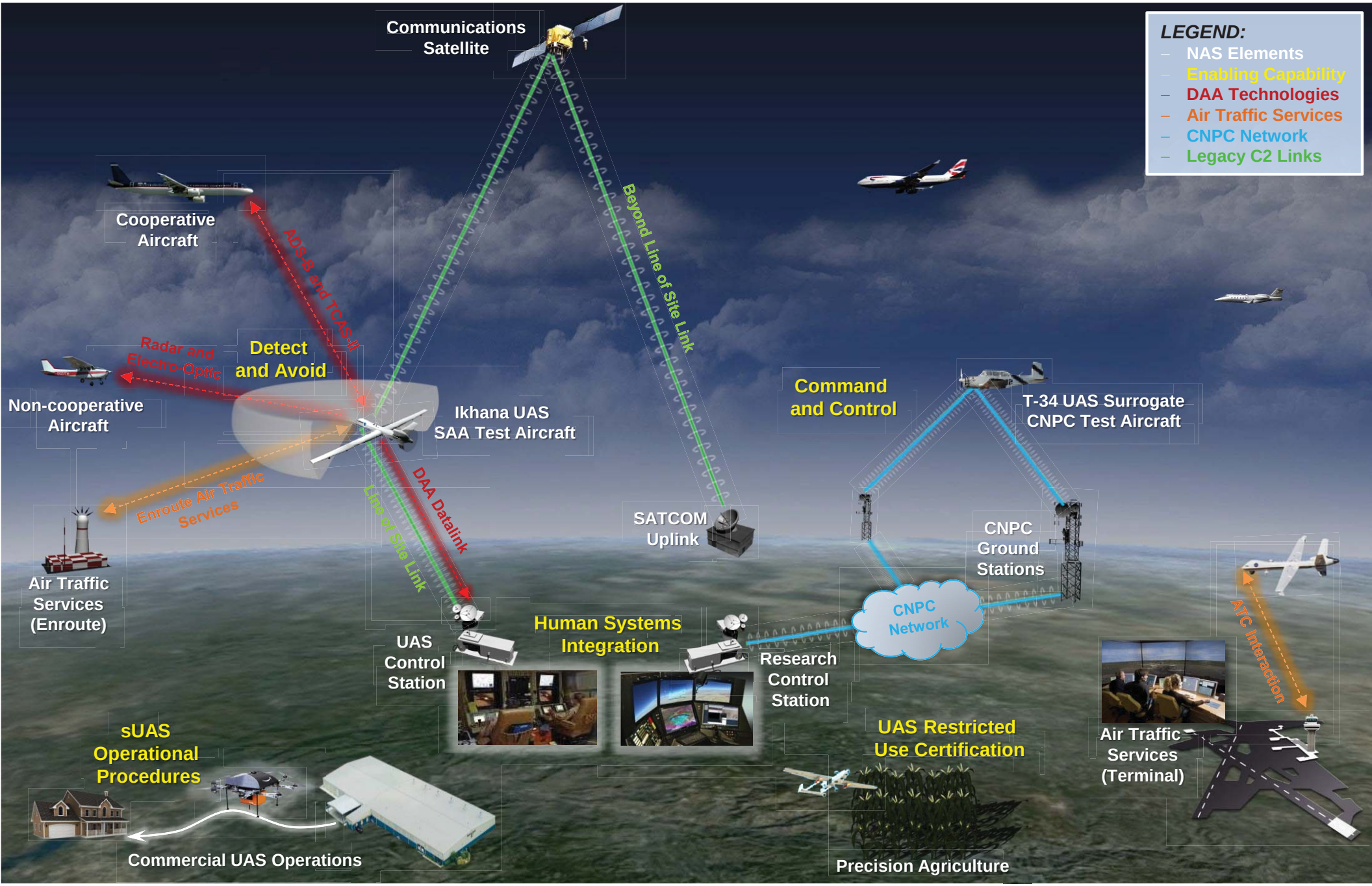
- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

UAS-NAS Project OV-1



TC-ITE: Integration Test & Evaluation Overview

Description: Develop an integrated test environment to develop, test, and explore key challenges and technology objectives of the subprojects technology, developing concepts, technologies, and capabilities in evaluating the overall operation of UAS in the NAS in a relevant environment. And lead the subprojects in the test planning of the integrated test events.

Objectives

- Develop a Live Virtual Constructive (LVC) Distributed Test Environment to integrate and test subproject key technologies in a relevant environment.
- Document the design, objectives, metrics, data collection, and assets for integrated test events.
- Conduct the planning and execution of integrated test events: IHITL, FT3, and FT4.

Approach

- Conduct systematic reviews of integrated test events and associated test planning to ensure readiness and ensure functional, physical and operational performance requirements meet the UAS-NAS Project objectives.
- Define and test airspace and scenario files with researchers.
- Execute and report on integrated test events .

Deliverables

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

Non-Technical Challenge Work
Backup Slides

Support of NASA Agreement with USMC

- Reference: Interagency Agreement between NASA and US Marine Corps (USMC) Unmanned Aerial Vehicle Squadron 2 (VMU 2)
- Purpose:
  - Conduct cooperative research for UAS-related activities including flight-testing, simulation and modeling, and pilot surveys in support of the UAS-NAS and VMU
- Background:
  - Agreement signed off on 7 March 2014
  - Initial survey conducted by LaRC HSI personnel in FY13
  - Plan at KDP was to complete task in 1st Quarter of FY14
    - Due to furlough, delayed and then canceled initial survey and completion of task
- Current Task: HSI Subproject Project Engineer is coordinating this task with a not to exceed cost and no impact to existing work – Now working with VMU 1 & 3 also
  - Observations and evaluations of his current system and operations
  - Workflow analysis of current system and operations
    - Capture workflow
    - Identify human bottlenecks, areas for improvement
    - Identify system bottlenecks, areas for improvement
    - Leverage existing technologies/systems as well as emerging technologies to improve workload
  - Heuristic evaluation of their existing system
  - Application recommendations

Far Reaching/High Risk -- Core

- Need a UAS design and operational CONOPS that are feasible to assess from a certification perspective – so that we have a realistic core basis for airworthiness certification
  - can't be too far reaching
  - but beyond what has been certified or is pending for certification today
- Considering risk/challenge in making UAS platform and operations decisions
  - rotary wing vs. fixed wing
  - weight range/capability beyond RMAX
  - beyond line of sight capability
  - precision aerial application vs. aerial survey
    - shifting weight and chemical issues
    - not necessarily patterned
- Benefit: realistic set of airworthiness standards for commercial UAS ops

Cert Risk Matrix and Summary

Risk Matrix						
LIKELIHOOD	5					
	4					
	3			4.4.6		
	2			4.4.5		
	1					
		1	2	3	4	5
		CONSEQUENCE				

Risk ID	Trend	LxC	Approach	Risk Title
4.4.6	⇨	3x3	M	Completion of Certification Technical Objectives that Rely upon Formal Partnerships
4.4.5	⇩	2x3	M	Availability of Designated Engineering Representatives Resources

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

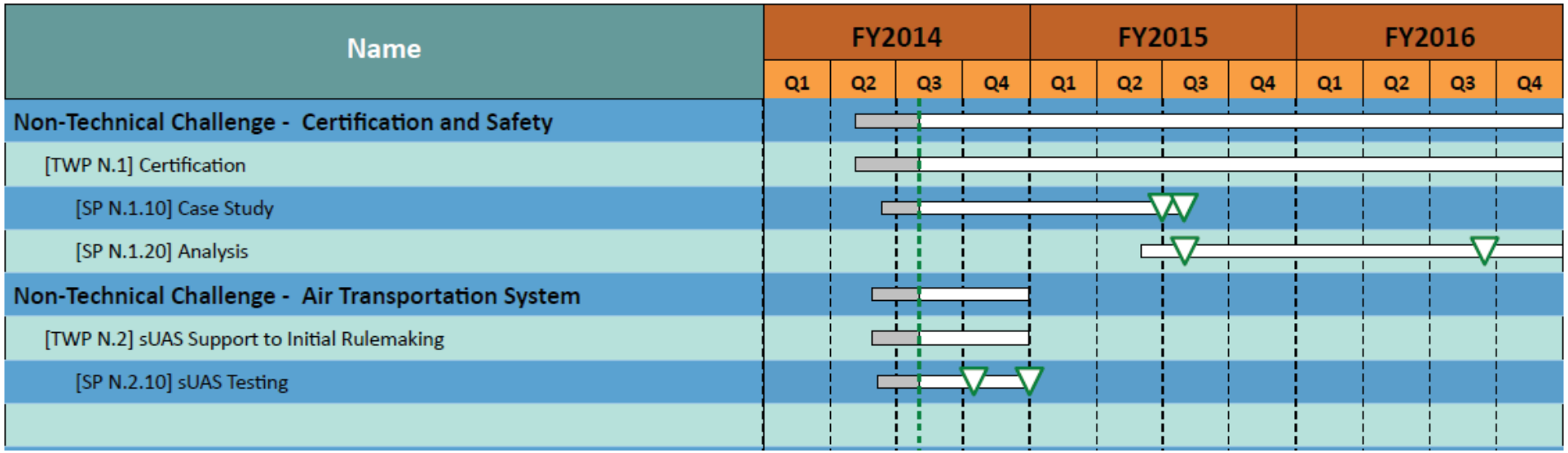
A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

sUAS-Autonomy Far-Reaching Ideas

- Ideas stem from what is required to ultimately achieve a sUAS self-aviating system capable of unattended 24/7 operation beyond visual line of site in urban and rural areas in the NAS
  - Primary areas of focus are: Mission, Environment, Awareness, and Interaction
- Ideas generated from efforts conducted through/by C-UAS, NASA, and academia.

Mission	Environment	Awareness	Interaction
• Fire perimeter mapping STTR (SSCI/MIT) • Fire detection via RETINEX • Soil Moisture mapping (Aero Academy, VT) • Payload directed flight (Ames) • Storm Damage Assessment (NOAA/NWS/VT/LaRC) • Autolocation of survivors (JSC, MSFC)	• Multi-sensor SLAM (C-UAS, Drexel, MIT) • Multi-sensor fusion (LaRC) • Sense-and-Avoid (C-UAS, LaRC, others) • Small UAS sensor SWAP and requirements definition (C-UAS, LaRC, WFF)	• Own Ship Health monitoring & prognostics (Ames/LaRC) • Heuristic flight control recovery (NASA, Aurora, others) • Adaptive response to environment (Seedling) • Auto recharge, refuel & repair	• Minimizing operator workload (C-UAS) • Airspace Integration Autonomy (AOC)

Non Technical Challenges



APG/API L1 Program (ISRP) L2 Project

Project Summary
Backup Slides

Grants and Agreements - Current

[P1/P2]	Grant with University of South Carolina, "Unmanned Aircraft Systems (UAS) Research: The Air to Ground Channel, Robust Waveforms, and Aeronautical Network Simulations"
[P1/P2]	Space Act Agreement between NASA Glenn and the Federal Aviation Administration: Research for Aviation Communications/Navigation/ Surveillance/ Information Systems
[P1/P2]	Interagency Agreement between the Federal Aviation Administration and the National Aeronautics and Space Administration: Unmanned Aircraft Systems Research and Technology Development
[P1/P2]	Interagency Agreement between MIT Lincoln Labs and the National Aeronautics and Space Administration: Integration of ACAS-UA into NASA Airspace Simulations
[P1/P2]	Cooperative Agreement with California State University Long Beach: Human Systems Integration - Measured Response
[P1/P2]	Cooperative Agreement with Rockwell Collins, for the development of Control and Non-Payload Communication System Radio prototypes.
[P1/P2]	Membership with the Center for Unmanned Systems (C-UAS). It is a National Science Foundation (NSF) sponsored research consortium, where the members are able to vote on what projects the center conducts.
[P2]	Space Act Agreement with University of North Dakota for Certification work – in work

P1 = Phase 1, P2 = Phase 2

Project Management Risk Matrix and Summary

Risk Matrix

LIKELIHOOD	1	2	3	4	5
5					
4		1.1.6			
3			1.1.7	1.1.10 1.1.13	
2			ISRP 02 1.1.4		
1			ISRP 05		

CONSEQUENCE

Risk ID	Trend	LxC	Approach	Risk Title
1.1.10 (T)	NEW	3x4	M	Output from Test Events has value to Project Stakeholders
1.1.13	⇨	3x4	M	Baseline Review Preparation Impacts to Milestones and other Project Tasks
1.1.6	⇨	4x2	M	Collaboration with International Organizations
1.1.7	⇨	3x3	M	Negative Public Perception of UAS Flying in the NAS
ISRP 02 (T)	⇨	2x3	M	Project Focus Changes Due to External Influences
1.1.4 (T)	⇩	2x3	M	The predicted or projected UAS mission profiles and traffic density estimates used by the subprojects for their technology development efforts may not be realistic or accurate
ISRP 05 (T)	⇩	1x3	M	Inability to Meet UAS-NAS KDP-2 (Phase 1-to Phase 2 Transition)

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged

(T) Indicates a Top Risk

Approach

A- Accept	RA – Raise
M - Mitigate	E – Elevate
W - Watch	C – Close
R- Research	

Risks Closed Since KDP

Risk ID	Project/ Subproject	Risk Title	Date Closed	Closing Rationale
1.1.8	Project Management	Comprehensive UAS Automation Roadmap (UAR) development	2/25/14	The JPDO has been defunded. The UAR work, including developing the ontology, may be captured under the FAA's NextGen organization. If the work is captured, it will have an internal FAA flavor which will not address the community needs identified during the Phase 2 KDP process. As such, the risk associated with the development of the UAR is no longer relevant to the Project.
1.1.12	Project Management	Additional Workload due to supporting SARP Tasks		TWPs and the SPs for PEs (specifically SSI East/West, HSI) have identified level or effort work to support SARP and work has been added to baseline plan. Davis Hackenberg is a member of the SARP Board. Having established a baseline with our work – SARP attendees (PE) taking on work outside scope of baseline would constitute new work which would require Project Office approval.
4.1.6	SSI	Resources at Langley to support SSI activities	2/19/14	Risk has been fully mitigated. The necessary mitigation steps have been accomplished. Langley Center management has prioritized their hiring and staffing to fully staff this area at Langley. The SSI Team at Langley is now fully staffed to its designated FTE and WYE complements.
5.1.2	IT&E	Connectivity requirements to external partners have not been defined	12/17/13	This risk is recommended for closure as its intent is captured in risks U.5.1.6, U.5.1.7, and U.5.1.8 that delineate lack of requirements definition for IHITL, FT-3, and FT-4 respectively. The lack of defined requirements for the three integrated events are inclusive of external partner requirements and; therefore, makes U.5.1.2 duplicative.

Risks Closed Since KDP Cont.

Risk ID	Project/ Subproject	Risk Title	Date Closed	Closing Rationale
5.1.3	IT&E	The Live-Virtual-Constructive Distributed Environment (LVC-DE) infrastructure lacks a common voice communication system for the integrated human-in-the-loop simulation and flight test series	12/17/13	The IT&E team has developed a common voice communication architecture that meets the requirements for IHITL simulations and flight tests. Employing commercially available analog to digital converters, the Distributed Interactive Simulation (DIS) based VoIP system at Ames, and other NASA centers, will be interfaced to the analog voice system at Dryden that meet the requirements of the IHITL and flight test voice communications plan. The architecture requires procurement of some new equipment at Dryden within the available budget of IT&E.
5.1.5	IT&E	Acceptance of the Distributed Test Environment as a Relevant Test Environment (Representative of the National Airspace System)	5/8/14	Project Management risk U.1.1.10 *Output from Test Events has value to Project Stakeholders*, captures the intent of this risk to get concurrence that the LVC test environment is relevant.
5.1.6	IT&E	Distributed Test Environment requirements for Integrated Human in the Loop simulation (IHITL) not defined	3/25/14	Had final design review. Working to close out RFIs received last week. Mitigation 03 is complete, reducing the LxC to 1x3. Risk is trending down. Rationale for Closure: The IHITL Delta Final Design Review was conducted March 4-5. No RFI's were written to change or add requirements that increase scope. The requirements are considered complete.
5.1.9	IT&E	Required assets for the Integrated Human in the Loop simulation (IHITL) not available during test period	5/8/14	Confirmation, that the distributed test environment architecture and required assets to successfully conduct IHITL simulations have been fully defined and baselined, was received from the PEs during an IHITL Config 1 Weekly Engineering Meeting (2 April) and during an IHITL TIM (4 April).

Risks Closed Since KDP Cont.

Risk ID	Project/ Subproject	Risk Title	Date Closed	Closing Rationale
5.1.12	IT&E	Unable to integrate required component or data feed from sub-projects	9/17/13	Risk combined into three existing risks (U.5.1.9, U.5.1.10, U.5.1.11) and can be closed.
5.1.13	IT&E	Unable to integrate required component or data feed from external partners	9/17/13	Risk combined into three existing risks (U.5.1.9, U.5.1.10, U.5.1.11) and can be closed.
5.1.14	IT&E	Unable to successfully integrate algorithm or display under test for IHITL	12/17/13	This risk is recommended for closure due to its being OBE. The risk was originally written to capture the lack of a common configuration for evaluating the SSI technologies for IHITL. As a result of the Project's decision to utilize the UAS-CAS1 test configuration for a portion of the IHITL, a common integration configuration is unnecessary at this time.
5.1.15	IT&E	Inability to achieve TCAS II Self-separation IHITL Objectives due to lack of an IT Security Authority to Operate (ATO)	5/8/14	The MOU between NASA Ames Simlabs and NASA Langley SGT lab signatures were completed on 2 April 2014. The two laboratories have successfully connected and are testing the data flow in support of the IHITL on a weekly basis, leading up to the May V&V testing.

Risks added since KDP

Risk ID	Trend	LxC	Approach	Risk Title	Date Added
1.1.10	NEW	3x4	M	Output from Test Events has value to Project Stakeholders	5/8/14
1.1.12			C 5/8/14	Additional Workload due to supporting SARP Tasks	1/21/14
1.1.13	⇨	3x4	M	Baseline Review Preparation Impacts to Milestones and other Project Tasks	1/21/14
4.1.9 (T)	⇩	3x3	M	Delay of SAA/SSI Technology Developments Impact to Integrated Test Events (IHITL, FT3 and FT4)	1/21/14
4.1.10	⇨	3x3	M	Completion of SAA/SSI Technical Objectives that Rely upon Formal Partnerships	1/21/14
4.3.8	⇨	2x3	M	Radios flight tested in FT3 and FT4 Series may not fully validate MOPS	1/21/14
4.2.9 (T)	⇨	2x2	M	Delay of HSI Technology Development Impact to Integrated Test Events (IHITL, FT3 and FT4)	1/21/14
4.2.10	⇨	3x3	M	Completion of HSI Technical Objectives that Rely upon Formal Partnerships	1/21/14

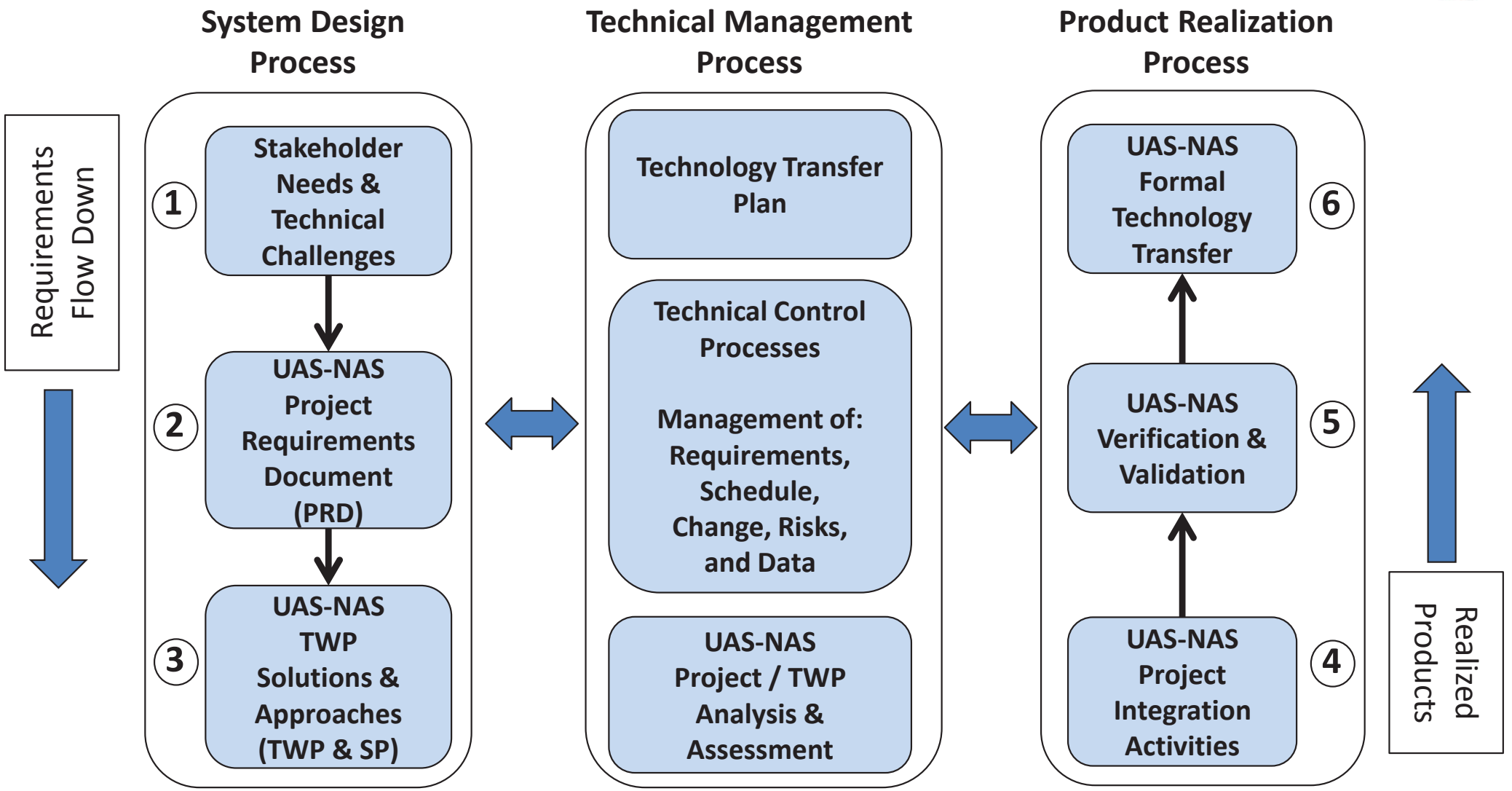
Risks added since KDP Cont.

Risk ID	Trend	LxC	Approach	Risk Title	Date Added
5.1.15 (T)			C 5/8/14	Inability to achieve TCAS II Self-separation IHITL Objectives due to lack of an IT Security Authority to Operate (ATO)	12/17/13
5.1.16	⇨	3x3	M	Completion of ITE Technical Objectives that Rely upon Formal Partnerships	12/17/13
5.1.17 (T)	⇨	1x3	M	The T-34 (UA Surrogate) for FT3 and FT4 may not be available	12/17/13
5.1.19	⇨	4x3	M	Eyetracker System Not Installed in RGCS for IHITL	3/25/14
5.1.20 (T)	NEW	3x4	M	Unsigned Agreement could delay flight test and result in the cancellation of SAA Initial Flight Tests	5/8/14
4.4.6	⇨	3x3	M	Completion of Certification Technical Objectives that Rely upon Formal Partnerships	2/28/14

Project Control Processes & Governing Documents
Backup Slides

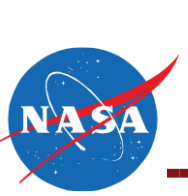
Technical Management

(note: follows 7123.1B SE Engine)



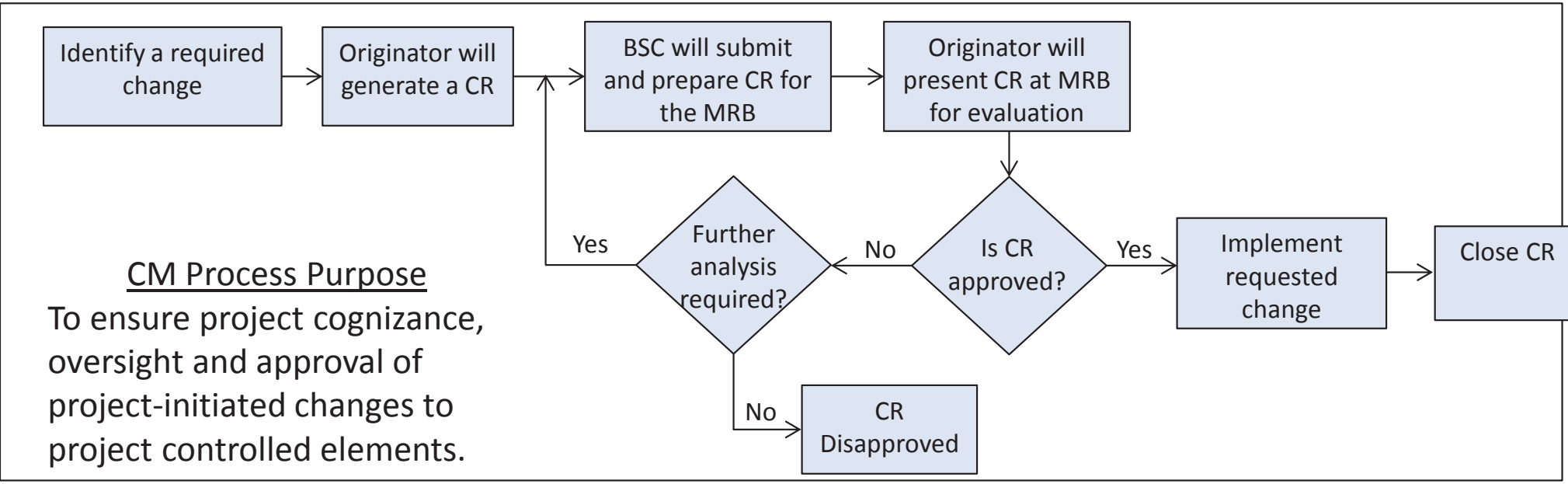
- SE Processes leverage existing Project processes
  - Schedule management, change management, risk management, and PE/TL Status at the UAS weekly telecon
- Technical management process is formally documented in the SEMP

Resource Management



Product	Tool	Benefit
Resource Roll-Up plan by center Resource Roll-Up N2 Comparison	Budget Roll-Up Spreadsheet	• Allows project analysis of resource plan • Provides information for PPBE • Used to disseminate information to analysts • Allows for determination of funding distribution guideline and traceability • Provides Analysts budget plan for input to PMT
Resource Roll-Up by Technical Work Package	Technical Work Package (TWP) Spreadsheet	
Phasing Plans	Project Management Tool (PMT)	• Resources plan vs. actuals by center & subproject • Variance Percentage used for quarterly metric • Monthly Accounting Reports - Armstrong Center Management Council (ACMC) - Management Review Board (MRB)
FTE Report	Business Warehouse (BW) and SAP-NASA Accounting System)	• FTE monthly by center and subproject • Allows for monthly analysis
Planned Travel for All Centers	Travel Spreadsheet	• Tracks Plan vs. actual against allocated budget • Tracks planned, approved, and disapproved • Allows decisions to be made monthly

Change Management Process



CM Process Purpose

To ensure project cognizance, oversight and approval of project-initiated changes to project controlled elements.

Elements of Change Management	Official Location/ Governing Document	Related Documents
L1 Milestones	Program Plan	Project Plan, IMS
L2 Milestones	L2 Milestone Document	IMS
Technical Challenges	Program Plan	Project Plan
Technical Baseline (SP Objective, approach, deliverables)	PRD	Subproject Plans
Project Requirements	PRD	
Budget	Program Plan	Project Plan, Resource Spreadsheet
Project Goals and Objectives	Project Plan	
Note: Management Plans will fall under Change Management Process as well		

- The Project will also be managing documents with version control
- Change management process is formally documented in the CMP

Continuous Risk Management (CRM) process

Risk Review Meetings [Higher Level]
- Alternates monthly with risk workshops
- Status top risks

Risk Workshops [Detailed updates]
- Alternates monthly with risk review meetings
- Workshop held for Project Office and each subproject
- Risk owner will provide a detailed status on active risks

Communication and Documentation
- Management Review Board (MRB)
- ISRP UAS-NAS Risk Review Board
- Armstrong Center Management Council (ACMC)
- Partner Center CMCs

Identify
Identify risk issues and concerns
→ Concerns and Candidate risks identified and documented on risk tracking spreadsheet

Analyze
Evaluate and classify risks
→ Risk Review Meetings and Workshops to analyze risk based upon likelihood and consequence (LxC)

Plan
Decide what, if anything, should be done about risks
→ Risk Approach:
- Accept
- Mitigate
- Watch
- Research
- Raise*
- Elevate
- Close

Track
Monitor risk metrics and verify/validate mitigation actions
→ Risk status reports including:
- LxC score
- Change in trend

Control
Risk decisions
→ Risk decisions

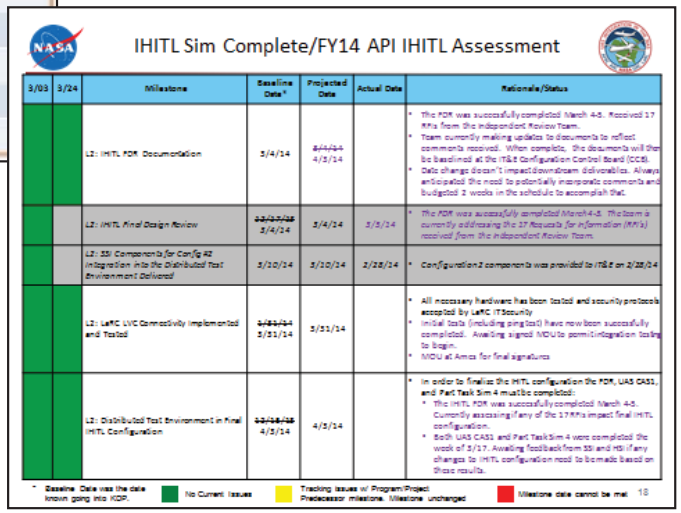
Note: Communication and documentation extend throughout all functions.
**Raise: unique to UAS-NAS Project*

Project Reporting Samples

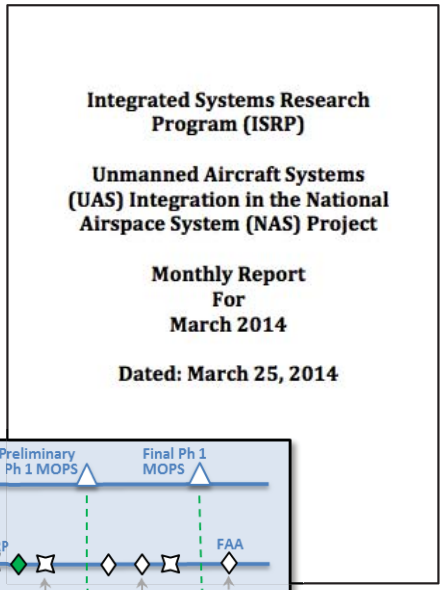
Weekly

Representative TC Task	M/S Level	Begin Date	End Date	Status/Progress /Concerns
Schedule Package N				Technical, Schedule, Accomplishments, and Issues and Concerns Status
Active Task1		01/01/14	02/15/14	complete
Active Task2		01/20/14	02/28/14	ongoing
Active Task3		02/01/14	03/31/14	ongoing
Deliverable	D	03/15/14	03/15/14	
Milestone	L2	04/01/14	04/01/14	

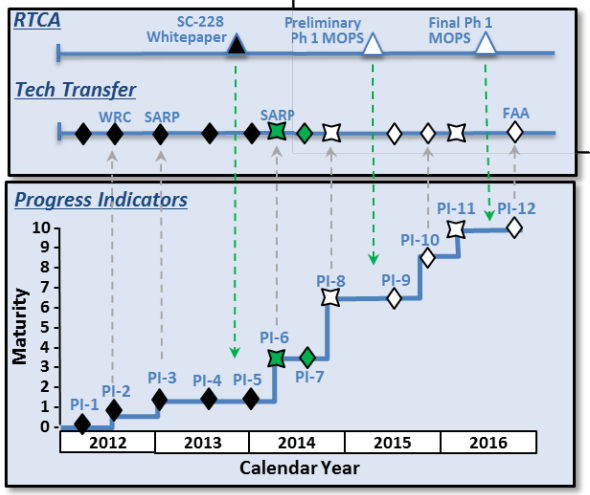
Bi-Weekly



Monthly

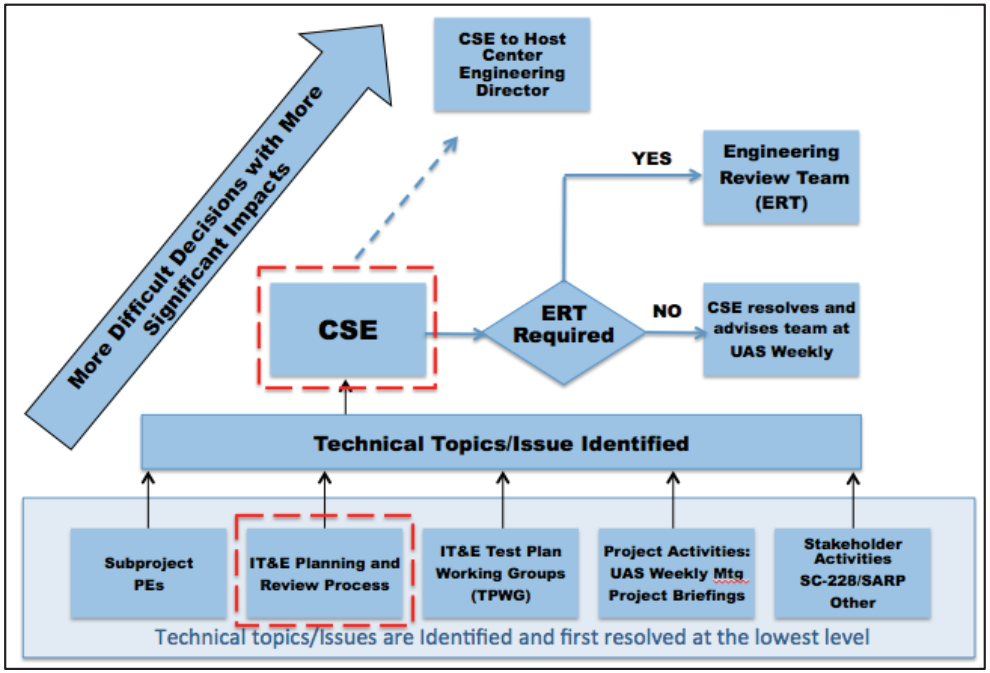


- Weekly
  - UAS-NAS Weekly Telecon PE/TL Status Reporting
- Bi-Weekly
  - UAS-NAS Detailed Status Reporting to ISRP
- Monthly
  - Progress Indicators
  - Monthly Report to ISRP
  - Management Review Board
  - Schedule Roadmap
- Bi-Monthly
  - Armstrong Center Management Council (CMC)



Technical Roles and Responsibilities

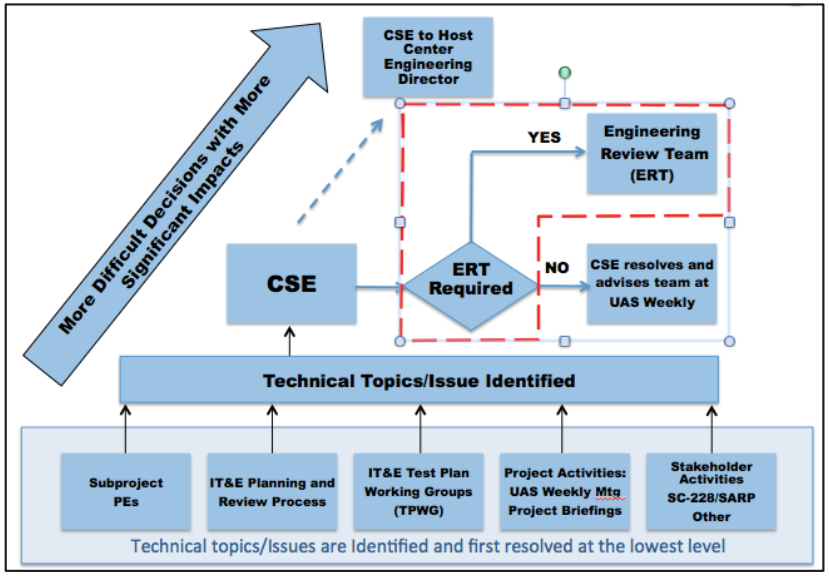
- The UAS-NAS CSE is the primary interface to the Project Manager for technical issues
- CSE delegated authority to the IT&E Team to lead the development of the LVC-DE and lead the integrated test planning effort
- CSE conducts oversight and insight
  - Oversight: CSE provide technical guidance and direction
  - Insight: Maintains knowledge and understanding of all subproject activities



- CSE leverages each Center's internal system engineering processes and procedures, and reviews during the design, development, and implementation of Technical Challenge/subproject events and deliverables internal to that center

Engineering Review Team (ERT) Meeting

- CSE determines if a technical topic/issue requires an ERT
- CSE defines the objective of the ERT meeting
- ERT meeting scheduled with the appropriate personnel to resolve the technical topic/issue
  - Team members (CSE, PEs) discuss the topic/issue
  - Team members consider impacts, pro/cons, alternatives, technical approaches, etc
  - Technical decision path is developed
    - Ad hoc working groups may be assembled
  - Team members develop a recommended solution



- ERT decisions
  - Within cost, schedule, or scope, then CSE advises the team at the UAS Weekly
    - Example: LaRC Connectivity, solution did not impact cost, schedule, or scope
  - Impacts change controlled items cost, schedule, scope (technical content) submitted to MRB for approval
    - Example: sensor suite, SAA Initial Flight Tests
- MRB is the Project decisional board for final approval of recommendations by the ERT

Version Control

- Definition
  - Project's informal process where the owners/authors will identify initial release and subsequent updates to project items for consistency in storage and distribution of the latest version of information
- Utilization
  - Will be utilized for documents not defined as an element of the CM Process per the Change Management Plan
    - Examples: Risk Slide Packages, Integrated Master Schedule (IMS), and Resource Spreadsheet
- Process
  - The document will be denoted with an appropriate title and document number that coincides with the document numbering system
  - An advisory slide will be presented at the Management Review Board (MRB) to address changes made via Version Control

Minimum & Full Success Technical Challenge SPs

Supports Project Descope Strategy

Schedule Package	PE Minimum/Full (M/F) Success
S.1.10	M
S.1.20	M
S.1.30	F
S.1.40	F
S.2.10	M
S.2.01	M
S.2.20	M
S.2.30	M
S.2.40	M
S.2.50	M
S.2.60	F
S.2.70	M
S.2.80	F
S.3.01	M
S.3.10	M
S.3.20	F
S.4.01	M
S.4.02	M
S.4.10	M
S.4.20	M
S.4.03	M
S.5.10	M
S.5.20	M
S.5.30	M
S.5.40	M
S.5.50	M
S.5.60	M

Schedule Package	PE Minimum/Full (M/F) Success
S.6.10	M
S.7.10	M
C.1.10	M
C.1.20	M
C.1.30	M
C.2.10	M
C.2.20	M
C.3.10	M
C.3.20	M
C.4.10	M
C.4.20	M
C.4.30	M
C.4.40	M
C.4.50	M
H.1.10	M
H.1.20	M
H.1.30	M
H.1.40	M
H.1.50	M
H.1.60	M
H.1.70	M
H.1.80	M
H.1.90	M
H.2.10	M
H.2.20	M
H.2.30	M
T.1.01	M

Schedule Package	PE Minimum/Full (M/F) Success
T.1.02	M
T.1.03	M
T.1.10	M
T.1.20	F
T.2.10	M
T.2.20	M
T.2.30	F
T.2.40	M
T.2.50	M
T.2.60	M
T.4.10	M
T.4.20	M
T.4.30	M
T.4.40	M
T.4.50	M
T.4.60	M
T.5.10	F
T.5.20	M
T.5.30	M
T.5.40	M
T.5.50	M
T.5.60	M
T.5.70	M
T.3.10	M
T.3.20	M
T.3.30	M
T.3.40	M

Governing Project Documents

Controlled Documents	Document Number	Document Date	Status
Project Plan Phase 1	UAS-PRO-1.1-001-003	07-29-13	Baselined
Project Plan Phase 2 [Includes Risk Management Process]	UAS-PRO-1.1-004-001	05-08-14	Ready to Route for Signature
Project Requirements Document (PRD)	UAS-PRO-1.1-005-001	05-08-14	Signed
Systems Engineering Management Plan (SEMP)	UAS-PRO-1.1-007-001	05-08-14	Signed
Change Management Plan (CMP)	UAS-PRO-1.1-002-002	05-08-14	Signed
Schedule Management Plan (SMP)	UAS-PRO-1.1-008-001	05-08-14	Signed
Technology Transfer Plan (TTP)	UAS-PRO-1.1-006-001	05-08-14	Signed
Records Retention Schedule	UAS-PRO-1.1-003-003	05-08-14	Signed
Public Outreach Plan	UAS-OR-7.0-001-001	05-08-14	Signed
SSI Subproject Implementation Plan	UAS-SSI-4.1-001-001	TBD	Draft
HSI Subproject Implementation Plan	UAS-HSI-4.2-001-001	TBD	Draft
Comm Subproject Implementation Plan	UAS-COMM-4.3-001-001	TBD	Draft
Cert Subproject Implementation Plan	UAS-CERT-4.4-001-001	TBD	Draft
IT&E Subproject Implementation Plan	UAS-ITE-5.1-001-001	TBD	Draft

Acronyms

AA	Associate Administrator
ACAS	Airborne Collision Avoidance System
ACES	Airspace Concept Evaluation System
ACMC	Armstrong Center Management Council
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-R	Automatic Dependent Surveillance-Rebroadcast
ADRS	Aeronautical Datalink and Radar Simulator
AFRC	Armstrong Flight Research Center
AFRL	Air Force Research Lab
AFSRB	Airworthiness and Flight Safety Review Board
AOC	Airspace Operations Challenge
APG	Annual Performance Goal
API	Annual Performance Indicator
ARC	Ames Research Center/Aviation Rule Making Committee
ARD	Aeronautics Research Director
ARMD	Aeronautics Research Mission Directorate
ASTM	American Society for Testing Materials
ASP	Airspace Systems Program
ATC	Air Traffic Controller
ATO	Authority to Operate
ATS	Air Traffic Services
ATSI	Air Transportation System Interoperability

Acronyms

AUVSI	Association for Unmanned Vehicle Systems International
BLOS	Beyond Line of Sight
BOE	Basis of Estimate
BW	Business Warehouse
C2	Command and Control Subproject
CA	Collision Avoidance
CAS	Controller Acceptability Case Study
CCB	Configuration Control Board
CDR	Critical Design Review
CFR	Code of Federal Regulations
CM	Change Management
CMC	Center Management Council
CMP	Change Management Plan
CNPC	Control and Non-Payload Communications
CONOPS	Concept Of Operations
CONUS	Continental United States
CR	Continuing Resolution/Change Request
CRM	Comment Resolution Matrix/Continuous Risk Management
CSE	Chief Systems Engineer
CSUN	California State University of Northridge
CTD	Concepts & Technology Demonstrations

Acronyms

C-UAS	Center for UAS
DAA	Detect and Avoid
DIS	Distributed Interactive Simulation
DPMf	Deputy Project Manager for
DRM	Design Reference Mission
EAFB	Edwards Air Force Base
EO/IR	Electro Optical/Infra Red
ExCom	UAS Executive Committee
ERT	Engineering Review Team
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FDR	Flight Design Review
FRR	Flight Readiness Review
FT	Flight Test
FTE	Full Time Equivalent
FY	Fiscal Year
GBSAA	Ground Based Sense and Avoid
GCS	Ground Control Station
GDS	Great Dismal Swamp
GRC	Glenn Research Center
HF	Human Factors

Acronyms

HITL	Human-In-The-Loop
HSI	Human Systems Integration Subproject
ICA	Independent Cost Assesment
ICAST	Inter Center Autonomy Study Team
ICD	Interface Control Document
IFR	Instrument Flight Rules
IHITL	Integrated Human-In-The-Loop
IMS	Integrated Master Schedule
ISRP	Integrated Systems Research Program
ITAR	International Traffic in Arms Regulations
ITE or IT&E	Integrated Test and Evaluation Subproject
ITU-R	International Telecommunication Union-Radiocommunication
JOCA	Jointly Optimal Collision Avoidance
JPDO	Joint Planning and Development Office
JSC	Johnson Space Center
KDP	Key Decision Point
L x C	Likelihood x Consequence
L1	Level 1
L2	Level 2
LaRC	Langley Research Center
LOS	Line of Sight
LVC	Live Virtual Constructive

Acronyms

LVC-DE	Live Virtual Constructive Distributed Environment
MACS	Multi-Aircraft Control System
MIT	Massachusetts Institute of Technology
MOA	Memorandum of Agreement
MOPS	Minimum Operational Performance Standards
MOU	Memorandum of Understanding
MRB	Management Review Board
M/S	Milestone
NAS	National Airspace System
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NSF	National Science Foundation
NTSB	National Transportation Safety Board
NWS	National Weather Service
OGA	Other Government Agency
OPNET	Optimized Network Engineering Tools
Ops	Operations
OSD	Office of the Secretary of Defense
P1	Phase 1
P2	Phase 2
PE/Co-PE	Project Engineer/Co-Project Engineer
PGCS	Prototype Ground Control Station

Acronyms

PI	Progress Indicator
PMR	Project Management Review
PMT	Project Management Tool
PO	Project Office
PPBE	Planning Programming Budgeting and Execution
PRD	Project Requirements Document
PT4	Part Task Sim 4
R&D	Research & Development
RFI	Request for Information
RGCS	Research GCS
RMB	Risk Management Board
RTCA SC	RTCA Special Committee
SA	Situational Awareness/Separation Assurance
SAA	Sense and Avoid
SARP	Science and Research Panel
SATCOM	Satellite Communications
SC	Special Committee
SEMP	System Engineering Management Plan
SGT	Stinger Ghaffarian Technologies, Inc.
SLAM	Simultaneous Location and Mapping
SMART-NAS	Shadow Mode Assessment using Realistic Technologies for the NAS
SMD	Science Mission Directorate

Acronyms

SME	Subject Matter Expert
SMP	Schedule Management Plan
SOA	State of Art
SP	Schedule Package
SRR	System Requirements Review
SS	Self Separation
SSCI	Scientific Systems Company, Inc.
STTR	Small Business Technology Transfer Research
sUAS	small UAS
SWAP	Size, Weight, and Power
SWRR	Software Requirements Review
TC	Technical Challenge
TCAS	Traffic Alert and Collision Avoidance System
TCAT	Traffic Collision Avoidance Technology
TOR	Terms of Reference
TPWG	Test Planning Working Group
TRR	Test Readiness Review
TTP	Technology Transfer Plan
TWP	Technical Work Package
UA	Unmanned Aircraft
UAS	Unmanned Aircraft Systems
UASCAS1	UAS Controller Acceptability Study

Acronyms

UAV	Unmanned Aircraft Vehicle
UID	Unique Identification
UND	University of North Dakota
USFWS	U.S. Fish and Wildlife Service
USMC	U.S. Marine Corps
UTM	UAS Traffic Management
V&V	Verification & Validation
VFR	Visual Flight Rules
VLOS	Visual Line of Sight
VPN	Virtual Private Network
VSCS	Vigilant Spirit Control Station
VT	Virginia Tech
WBS	Work Breakdown Structure
WFF	Wallops Flight Facility
WG	Working Group
WRC	World Radio Conference
WYE	Work Year Equivalent
ZFW	Dallas Fort Worth FAA Air Route Traffic Control Center
ZOA	Oakland FAA Air Route Traffic Control Center