



ACERO

Advanced Capabilities for Emergency Response Operations

November, 2024



Wildfire Damage and Impact of Aerial Support



Annual Economic Loss

\$63.5 - \$285 billion per year
[DOC 2017]

\$394 - \$893 billion per year
[Congress 2023]

Homes burned: 3k-8k

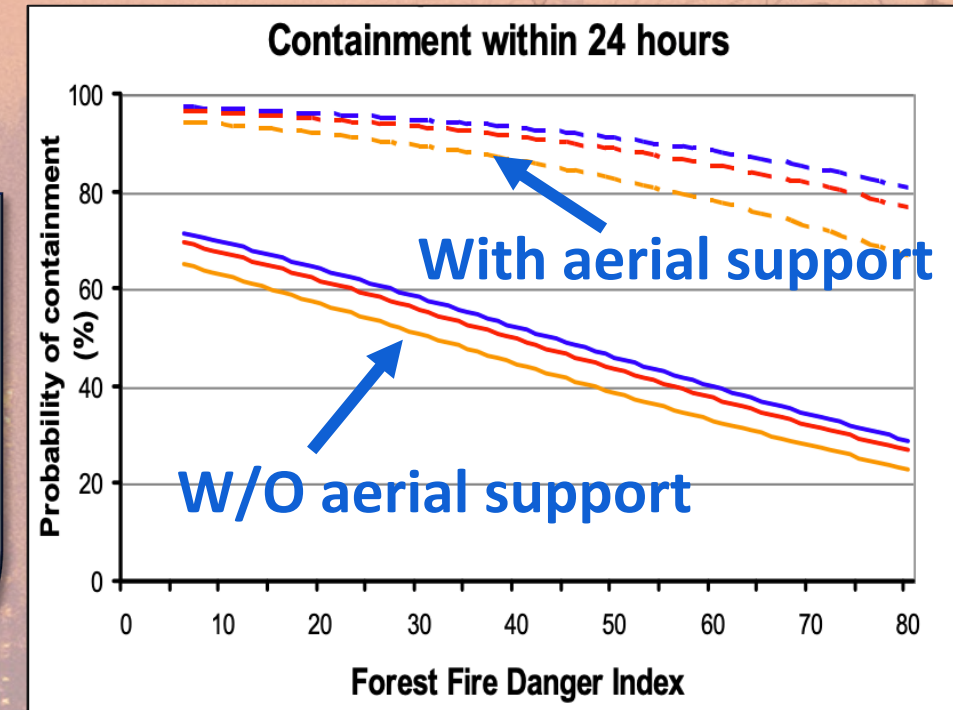
Annual Emissions (CO₂)

100 – 200 M tons
(similar to the total emission
from air travel in US)

Prediction

of extreme fires in US
compared to 2022
[UN EPR 2022]

14% increase by 2030
30% increase by 2050
50% increase by 2100



[Bushfire Cooperative Research Center, Australia, 2009]

We must address the
challenge sooner than later

Air operations can make
significant difference

SATELLITE



DAYTIME OPERATIONS

AERIAL
COMMUNICATIONS



AIR TACTICAL GROUP
SUPERVISOR



Current aerial operations:

- Clear-visibility condition
- Manual and high-workload airspace management
- Limited types of uncrewed operations
- Limited simultaneous operations

TERRESTRIAL
COMMUNICATIONS



TANKER



PILOTED
HELICOPTER



AIRCRAFT
AUTONOMY



DECISION SUPPORT

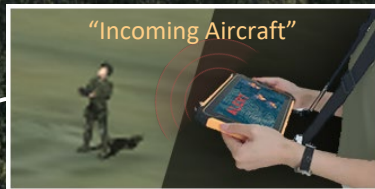
Future States:

- Automated and scalable airspace management system
- Expanded applications for uncrewed aerial systems
- 24-hr BVLOS aerial operations in degraded visual environments

AERIAL
IGNITION



WILDFIRE AIRSPACE MANAGEMENT



NIGHTTIME OPERATIONS

REMOTE
SENSING



LOGISTICS



REMOTELY PILOTED
HELICOPTER



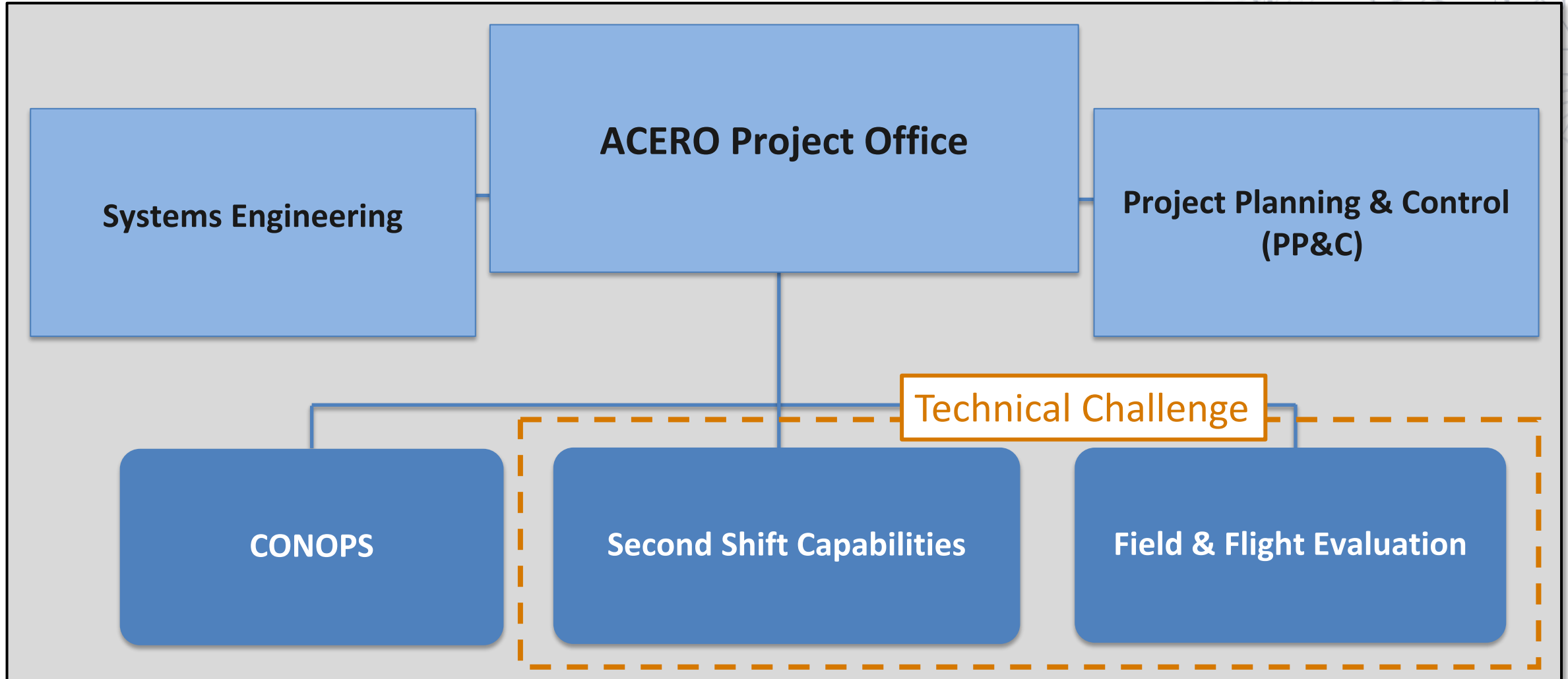
ACERO Project Objectives



- Facilitate interagency Concept of Operations to ensure consistency of operational priorities, technology adoption, and programmatic alignment for national needs
- Develop and evaluate emerging airspace management technology to improve emergency responders' efficiency and safety during a disaster
- Develop and evaluate new mission capabilities using emerging aviation technologies that support 24-hour operations
- Leverage public, private, and philanthropic partnerships and cross-mission directorate technologies to develop and demonstrate prototype capabilities



ACERO Project Team



ConOps



Goal

Lead the development of an inter-agency CONOPS to ensure consistency of operational priorities, technology adoption, and programmatic alignment for national needs

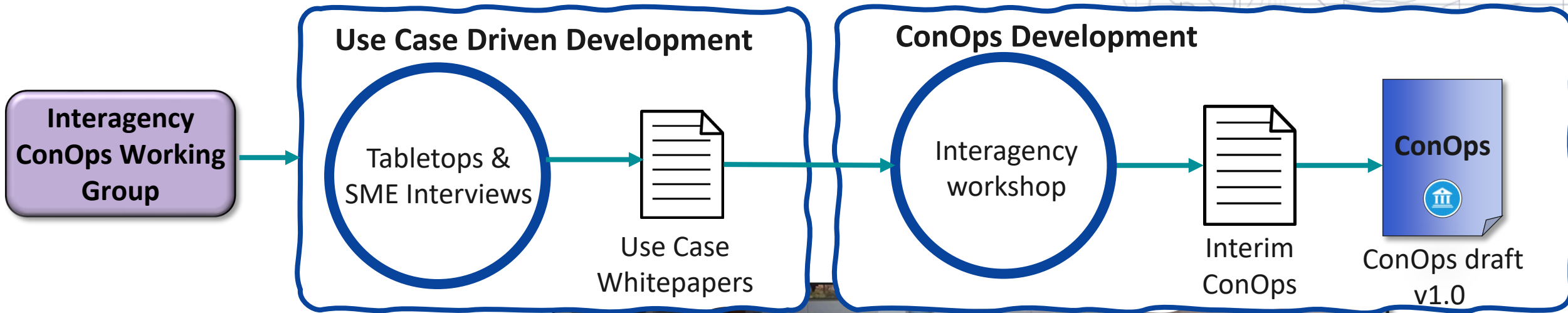
Development Approach

- Facilitate stakeholder interviews, tabletop discussions, and feedback solicitations to document gaps and barriers in current operations and opportunities to address challenges through technology
- Collaboratively develop a science and technology roadmap
- Develop a systems architecture and requirements to support development and testing of the concept of operations

Exit Criteria

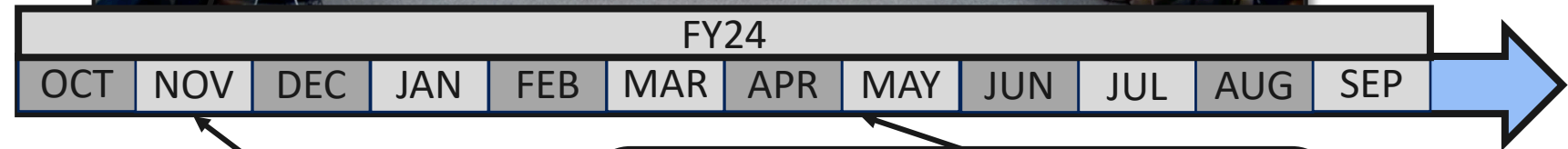
- Technology Transfer of Wildland Fire CONOPS, Systems Architecture, and Science and Technology Roadmap to key Wildland Fire Agencies
- Derived requirements that support ACERO validation testing in relevant environments

Use Case Development – FY24 Accomplishments



Use Cases

Prescribed Burns	✓	FY23
Remote Sensing	✓	
Airspace Management	✓	
Communications	✓	FY24
Logistics	✓	
Suppression	✓	

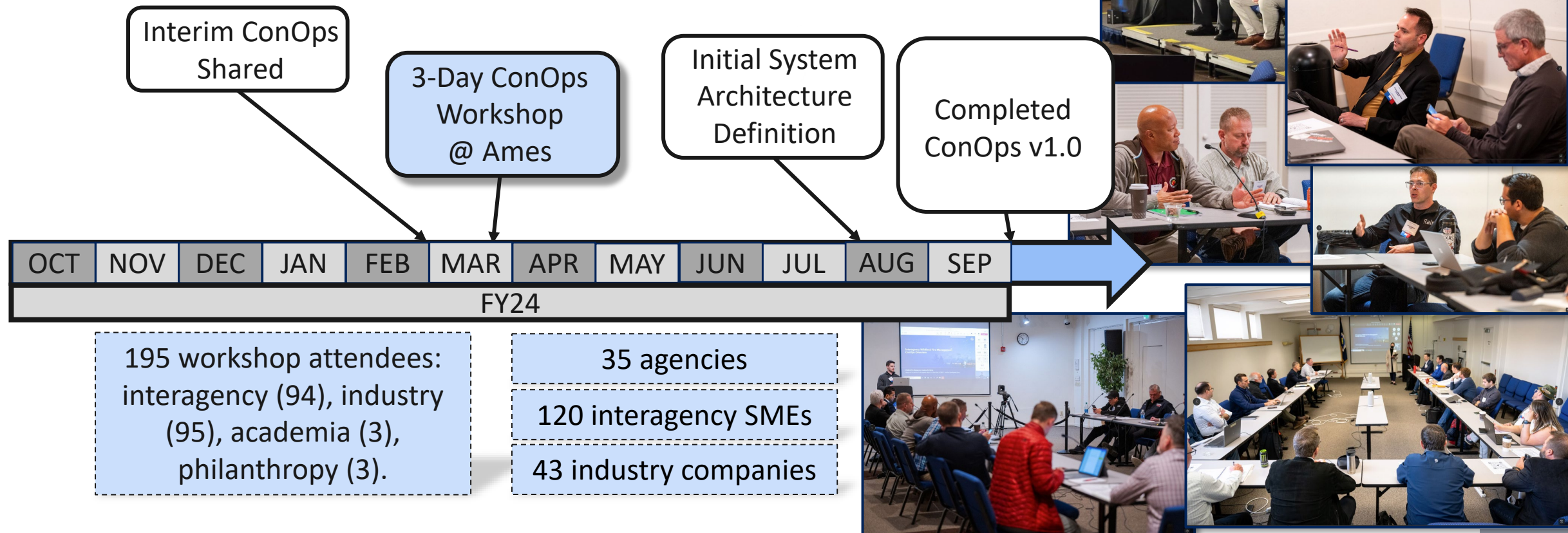


Tabletop @ Ames
28 participants
Communication Use Case

Tabletop in Boise, ID
59 participants
Logistics Use Case
Suppression Use Case

ConOps Development in FY24

- Shared interim WFM Inter-Agency ConOps v1.0
- Hosted three-day Inter-Agency ConOps Workshop
- Initiated initial system architecture definition
- Completed the first draft of WFM Inter-Agency ConOps v1.0



ConOps Outcomes and Impact



Research Activities

Concept Development

- Use Case Roadmap
- Literature Reviews
- SME Interviews
- Tabletop Discussions
- ConOps workshop

Research Transition Team

- Airspace Access Working Group
- Traffic Management Working Group

Products

Concept Documents

- Interim WFM Inter-Agency ConOps
- WFM Inter-Agency ConOps v1.0
- Use Case White Papers
- Initial System Architecture

Research Transition Products

- Advisory Information Concept White paper
- Airspace Operational Environment Assessment Report

Outcomes

Inter-Agency Harmonization

- Shared understanding of desired operational future-states
- Shared understanding of inter-agency capacity for technology adoption

Industry Guidance

- Requirements derived from future-states informs technology investments

The NASA-facilitated Inter-Agency ConOps has earned strong community support and will help agencies and industries coordinate their overarching strategies and align their technology roadmaps.

Technical Challenge

Goal

Develop and evaluate a prototype airspace management system that leverages advanced technology to enable safe and efficient remotely-piloted aerial firefighting operations, including suppression, in degraded visual environments.

Development Approach

- Collaborate with partner agencies and industry to jointly develop prototypes that conform to requirements derived from the CONOPS
- Joint testing with stakeholder partners to evaluate feasibility, performance, and/or usability of prototype technologies

Exit Criteria

- A Second Shift reference prototype that conforms to requirements derived from Inter-agency CONOPS
- A technology transfer to key stakeholders that includes airspace management and system requirements and procedures for remotely piloted suppression operations in degraded visual conditions
- Joint development and testing with industry to support technology transfer

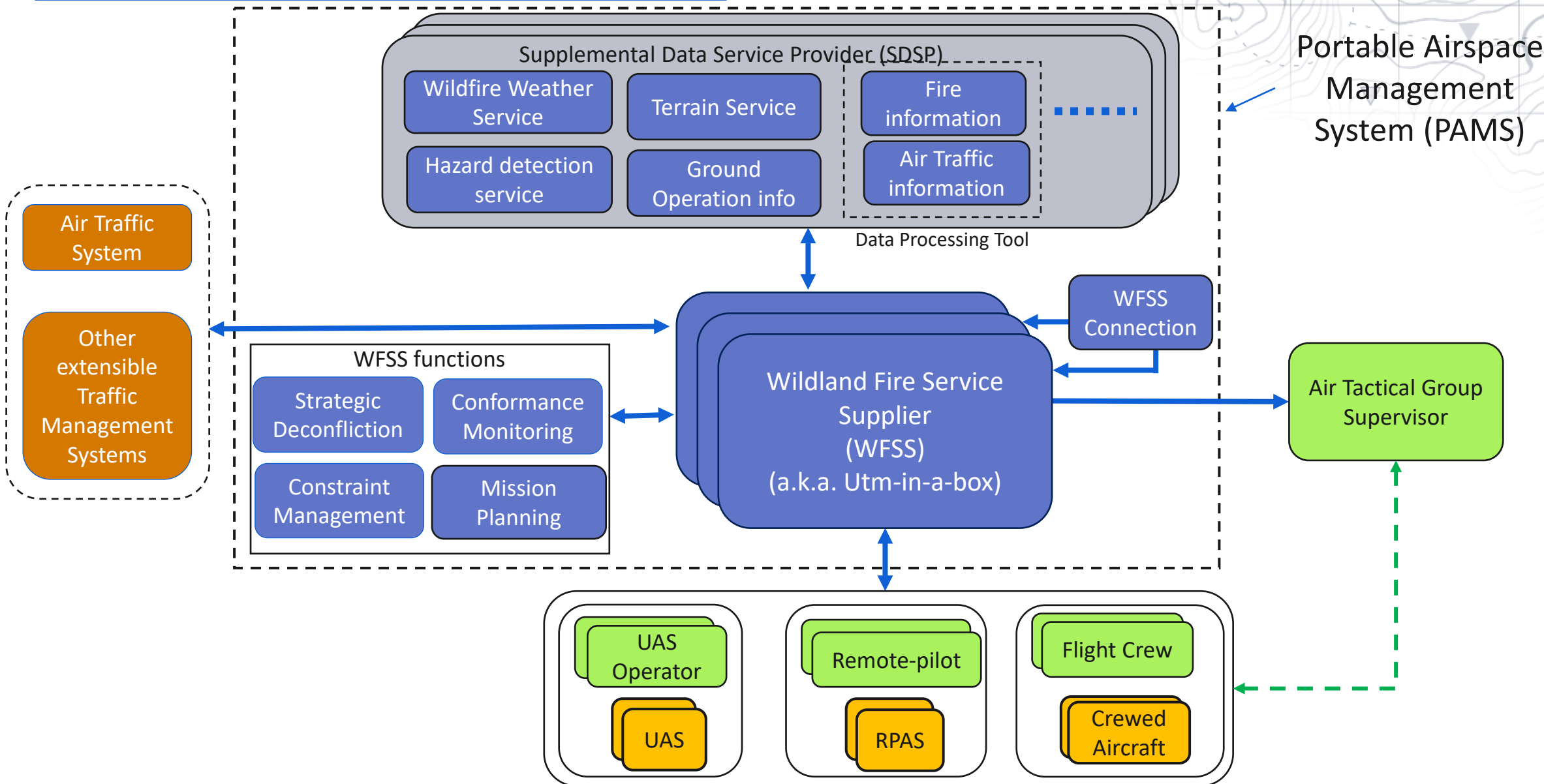
Technical Capability Level Progression



TCL 1 (Q3 FY25)	TCL 2 (Q1 FY27)	TCL 3 (Q3 FY28)	TCL 4 (Q2 FY30)
• Title: Incident Monitoring • Airspace Management System for BVLOS operations in degraded visual environments • Strategic Coordination • Conformance Monitoring • Constraint Management • Mission Planning for logistics and suppression with supplemental data services • Terrain • Fire information • Ground operation information • Wildfire area weather • Obstacle and hazard info • xTM interoperability for transit flights • Suppression operations with remotely piloted aircraft • Airspace Management System Connectivity	• Title: Information sharing • Airspace Management System for BVLOS operations in degraded visual environments • Strategic Coordination • Conformance Monitoring • Constraint Management • Mission Planning for logistics and suppression with supplemental data services • Terrain • Fire information • Ground operation information • Wildfire area weather • Obstacle and hazard info • xTM interoperability for transit flights • Suppression operations with remotely piloted aircraft • Airspace Management System Connectivity	• Title: Logistics • Airspace Management System for BVLOS operations in degraded visual environments • Strategic Coordination • Conformance Monitoring • Constraint Management • Mission Planning for logistics and suppression with supplemental data services • Terrain • Fire information • Ground operation information • Wildfire area weather • Obstacle and hazard info • xTM interoperability for transit flights • Suppression operations with remotely piloted aircraft • Airspace Management System Connectivity	• Title: Suppression • Airspace Management System for BVLOS operations in degraded visual environments • Strategic Coordination • Conformance Monitoring • Constraint Management • Mission Planning for logistics and suppression with supplemental data services • Terrain • Fire information • Ground operation information • Wildfire area weather • Obstacle and hazard info • xTM interoperability for transit flights • Suppression operations with remotely piloted aircraft • Airspace Management System Connectivity

TCL evaluations test increasingly complex missions for 24-hr BVLOS operations in degraded visual environments

Initial System Architecture



Technical Challenge Outcomes and Impact



Research Activities

Concept and Software Development

- UTM-based Wildland Fire Service Supplier (WFSS)
- Decision support capabilities as Supplemental Data Service Providers (SDSP)
- Field deployable portable airspace management system
- Interface between WFSS and SDSP
- Interface between WFSS and ATS, along with other xTMs

Field Testing and Technology Evaluations

- Four TCL Field and Flight Evaluations

Research Transition Team

- Engineering and Test Working Group

Products

System Prototypes

- Prototype Portable Airspace Management System
- NASA WFSS
- Prototype supplemental data services

Data Exchange Specifications

- WFSS-WFSS Specification
- SDSP interface control document (ICD)
- APIs for xTM interoperability
- APIs for connection with WFSS

Research Transition Products

- Information Exchange Architecture Requirements
- Testing Reports & Lesson Learned

Outcomes

Standards

- NWCG – NIAC Committee
- ASTM F38.02

Wildfire Aerial Operation Rule Making

- 24-hr BVLOS operations in degraded visual environment for wildland fire operations

Industry Guidance

- Requirements for system and capabilities supporting 24-hr BVLOS aerial operations
- Requirements for interoperability between WFSS and SDSP

ACERO TC will develop and transfer technology to enable 24-hr BVLOS operations in degraded visual environments and significantly enhance the efficiency of wildfire aerial operations.

TCL 1**Goal**

Evaluate Portable Airspace Management System with basic functions for wildfire aerial operations

Development Approach

- Build initial prototype of portable, field deployable airspace management system
- Collaborate with partner agencies and industry to evaluate prototype systems in operationally-relevant context

Exit Criteria

- Strategic Deconfliction, Conformance Monitoring, and TFR awareness
- Integrated UI and display of flight-operations data, fire data
- Local mesh network to enable necessary data exchanges between prototype airspace management systems

AIR TACTICAL GROUP
SUP

HALE

LOGISTICS

AIRCRAFT
SAFETYAERIAL
IGNITION

WILDFIRE AIRSPACE MANA

"Incoming Aircraft"

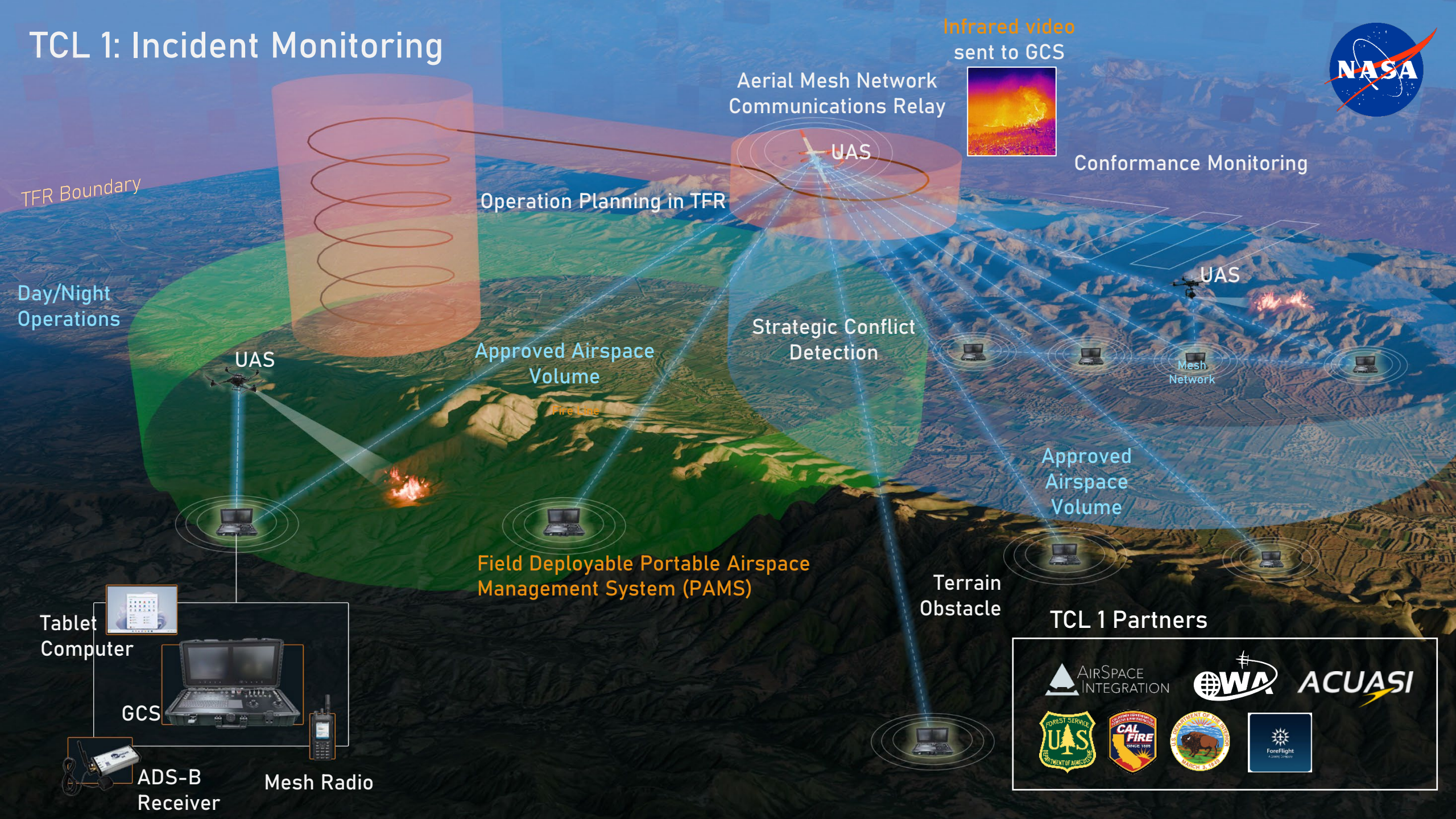
TCL 1: Incident Monitoring - Scenario Development



- Objectives:
 - Evaluate airspace management functions and shared situation awareness (air traffic and fire info) between UAS Operators using field-deployable portable airspace management systems (PAMS)
 - Evaluate using incident awareness and assessment aircraft as a communication relay to extend range of information sharing between UAS operators
- Four Scenarios have been created:
 - *Nominal Information Exchanges – Airspace Management via Local Mesh Network*
 - *Airspace Management – Strategic Deconfliction*
 - *Airspace Management – Conformance Monitoring*
 - *Airspace Management – Temporary Flight Restriction (TFR) Awareness*
- Three concurrent aircraft operations performing multiple missions:
 - Incident Awareness & Assessment (Remote Sensing); Aerial Communications; Aerial Ignition; Weather Sensing

TCL 1 focuses on developing and evaluating basic airspace management functions for wildland fire operations

TCL 1: Incident Monitoring



TFR Boundary

Day/Night Operations

UAS

Operation Planning in TFR

Approved Airspace Volume

Fire Line

Field Deployable Portable Airspace Management System (PAMS)

Aerial Mesh Network Communications Relay

UAS

Strategic Conflict Detection

Infrared video sent to GCS



Conformance Monitoring

UAS

Mesh Network

Approved Airspace Volume

Terrain Obstacle

TCL 1 Partners

Tablet Computer



GCS



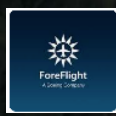
ADS-B Receiver



Mesh Radio



AIRSPACE INTEGRATION

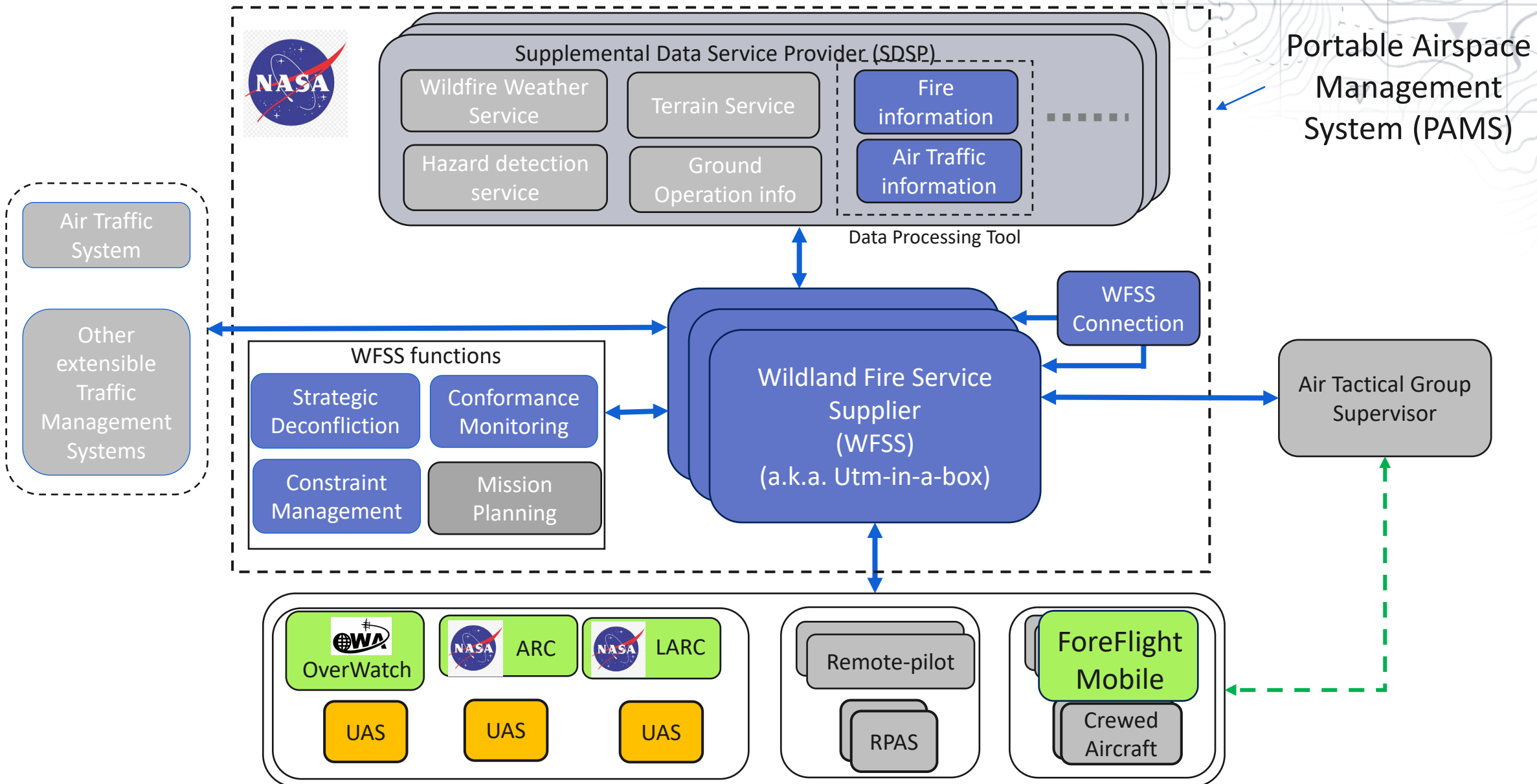


OWA

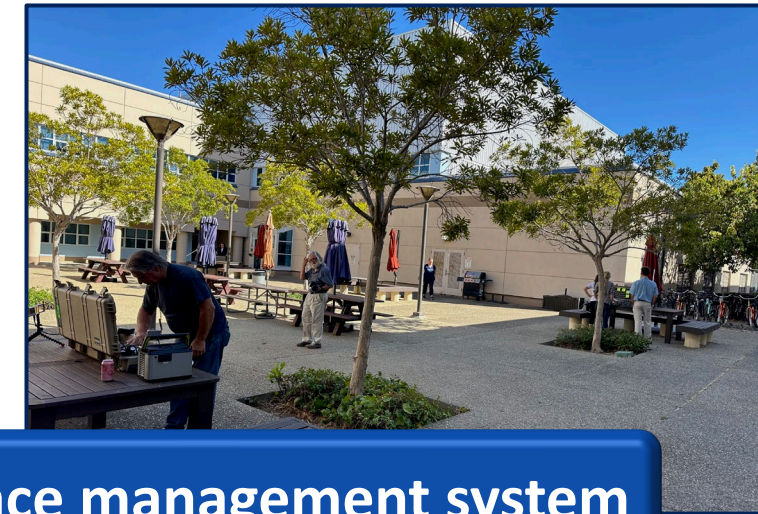
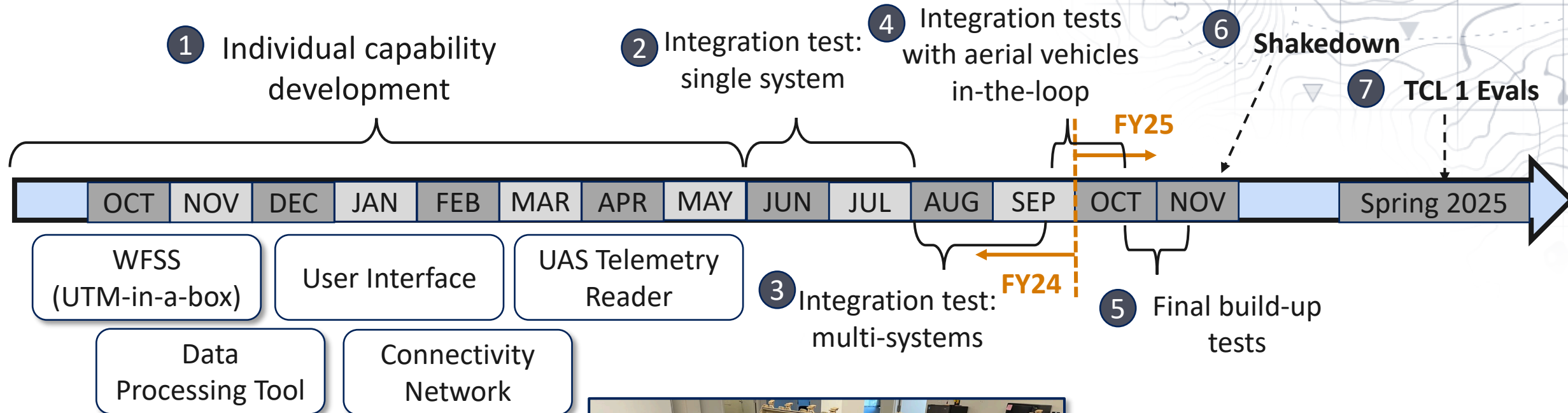
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TCL 1 System Architecture

capabilities tested in TCL 1



Portable Airspace Management System (PAMS) Development



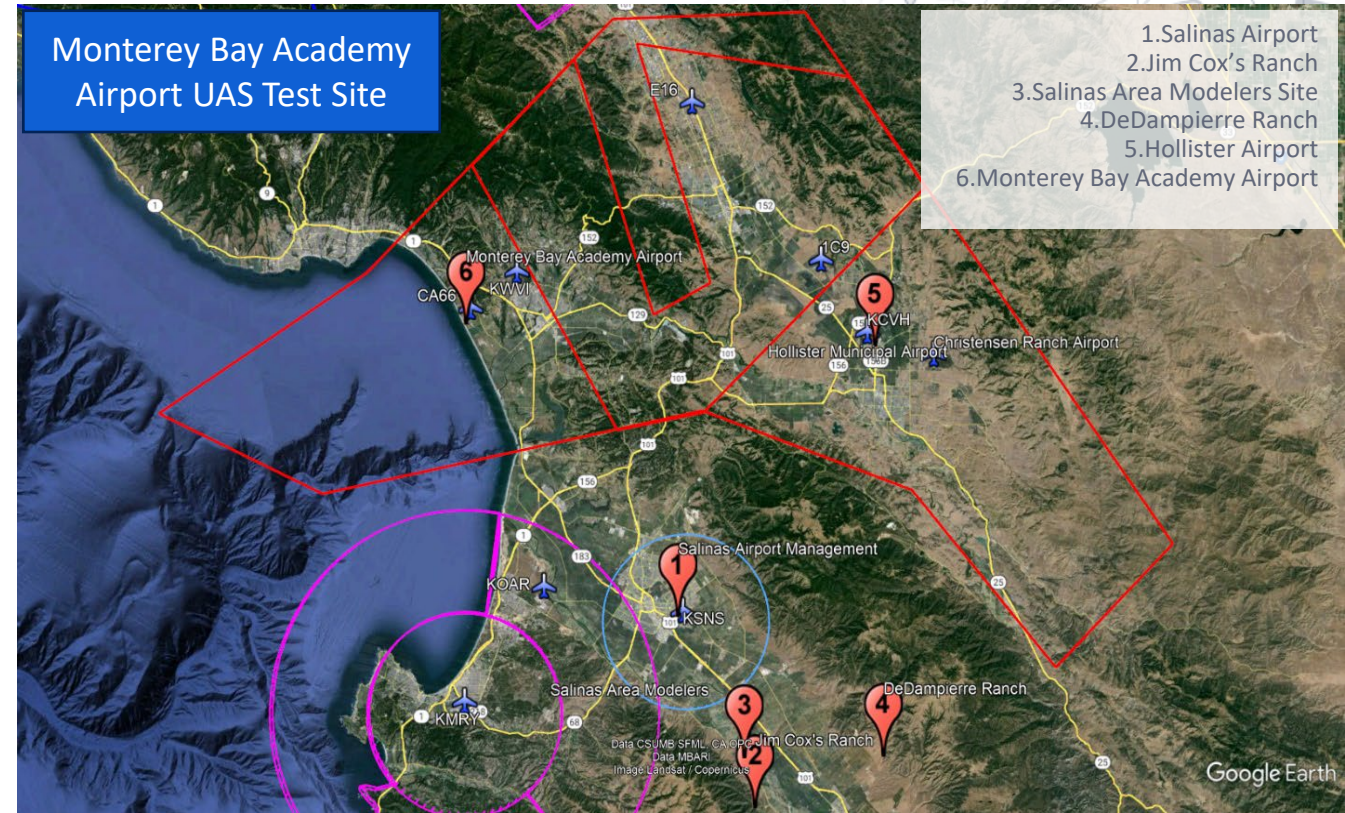
ACERO successfully developed groundbreaking portable airspace management system



Test Site Selection for TCL 1

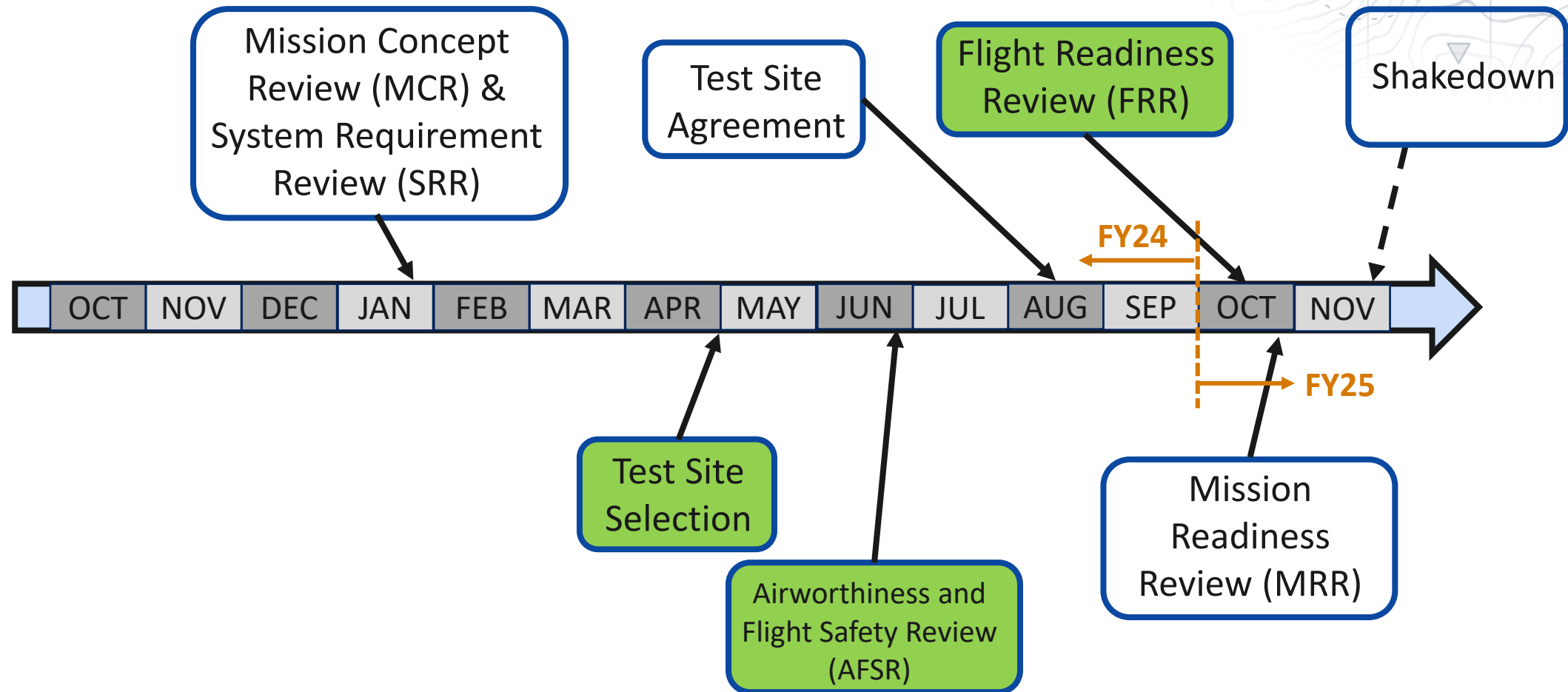


- Site Selection Process
 - 31 sites identified
 - Initial feasibility determined from 18 characteristics and 26 requirements
 - Three sites visited
 - Pendleton, OR; Tillamook, OR; Monterey, CA
 - Final selection criteria
 - Geography, Weather, Facilities, Neighboring Traffic, Logistics/Accessibility, Applicability to future TCLs
 - Site approved in May – Monterey, CA
- Monterey test site collaboration
 - Visited six LRZs in May
 - Agreement established in August
 - Work in progress
 - Flight Readiness Review
 - Mission Readiness Review
 - Airspace Certificates of Authorization (COAs)
 - Logistics support planning



TCL1 test site was successfully selected and contracted

TCL 1 Field and Flight Evaluation Preparation in FY24



ACERO team put tremendous effort to ensure successful TCL 1 preparation.

TCL 1 Outcomes and Impact



Research Activities

Concept and Software Development

- UTM-based Wildland Fire Service Supplier (WFSS)
- Initial decision support capabilities as Supplemental Data Service Providers (SDSP)
- Initial Field deployable portable airspace management system
- Initial connectivity options among WFSS
- Preliminary Interaction between WFSS and SDSP

Field Testing and Technology Evaluations

- TCL 1 Field and Flight Evaluations

Research Transition Team

- Engineering and Test Working Group

Products

System Prototypes

- Initial Prototype Portable Airspace Management System
- Initial NASA WFSS
- Initial prototype decision support functions
- Initial connectivity network needed for wildfire airspace management

Data Exchange Specifications

- WFSS-WFSS Specification
- SDSP ICD: Fire information
- WFSS and Operator Client

Research Transition Products

- TCL 1 Testing Data Collection and Analysis

Outcomes

Standards

- NWCG – NIAC Committee
- ASTM F38.02

Wildfire Aerial Operation Rule Making

- Initial analysis to inform UAS BVLOS operations

Industry Guidance

- Initial requirements for system and capabilities supporting 24-hr BVLOS aerial operations
- Initial evaluation analysis to inform the ConOps development

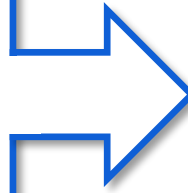
TCL1 initiates the technology development of portable airspace management, paving the way for deeper and broader collaboration in future TCLs

Summary of FY24 Achievements and FY25 Outlook



FY24 Achievements

- Key Decision Point - Project Approval (KDP-PA) review - approval to proceed to implementation (Nov '23)
- National Wildfire Coordinating Group Membership (Feb '24)
- TCL 1 Site Selection (Apr '24)
- Key TCL 1 Partner agreements and contracts established and completed
- Tech Challenge Tollgate passed (June '24)
- Wildland Fire Management Inter-Agency ConOps v1.0 completed (Sep '24)
- Portable Airspace Management System (PAMS) Prototype Developed (Sep '24)



FY25 Outlook

- Continuing Maturation of Inter-Agency ConOps
- Completion of TCL 1 Field Evaluation
 - Shakedown in November 2024
 - Data collection March/April 2025
 - VIP day
 - Data analysis, documentation, tech transfer
- TCL 2 Kick-off and preparation
 - Kick-off meeting December 2024
 - Capability development and site selection
 - Stakeholder engagement for partnerships
 - Leverage TCL 1 Lessons Learned



BUILDING ON NASA RESEARCH TO ENABLE

THE FUTURE OF EMERGENCY RESPONSE

Thank you