



Advanced Capabilities for Emergency Response Operations

ENABLING 24-HOUR WILDLAND FIRE MANAGEMENT OPERATIONS

Dr. Marcus Johnson

Project Manager

07 NOV 2023



Risk

Wildland fires are larger and more frequent, leading to increasingly negative impacts on the economy, public health, and natural ecosystems



Damage

Five of the largest fire seasons on record have occurred within the last 10 years (with over 9M acres burned)

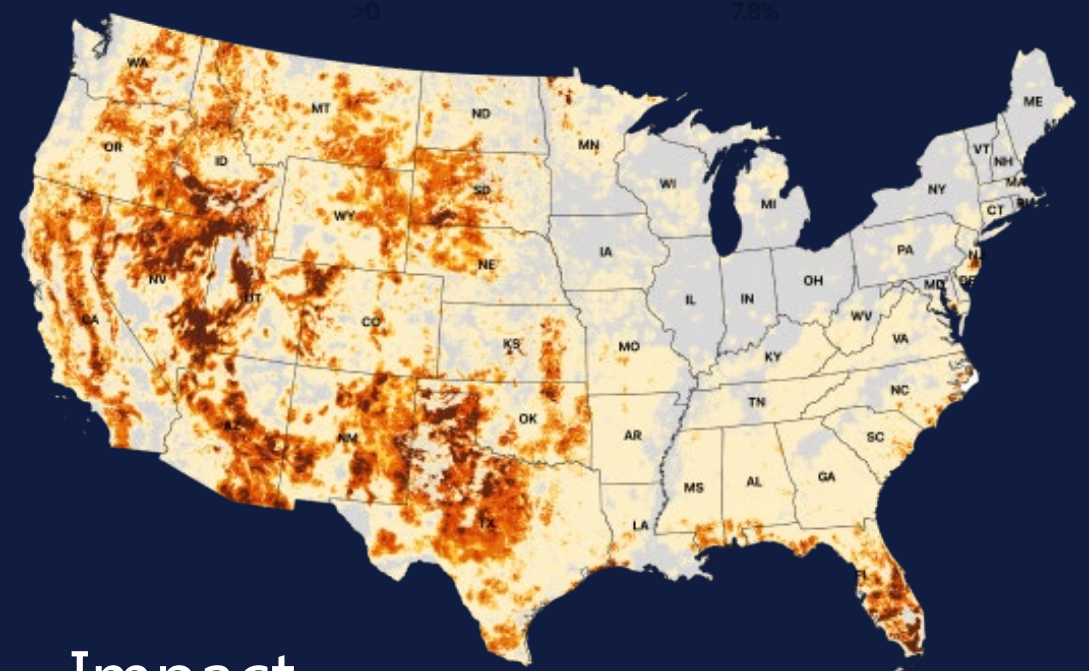


Image credit: First Street Foundation

Impact

- Climate change affects wildfire risk
- Wildfires affect Climate (e.g., CO₂, black/brown carbon)
- Wildfires are costly to US economy
- Wildfires are increasingly impacting where people live

NASA Wildland Fire Management Initiative



► PRE-FIRE

Planning & Monitoring | Prescribed Burns



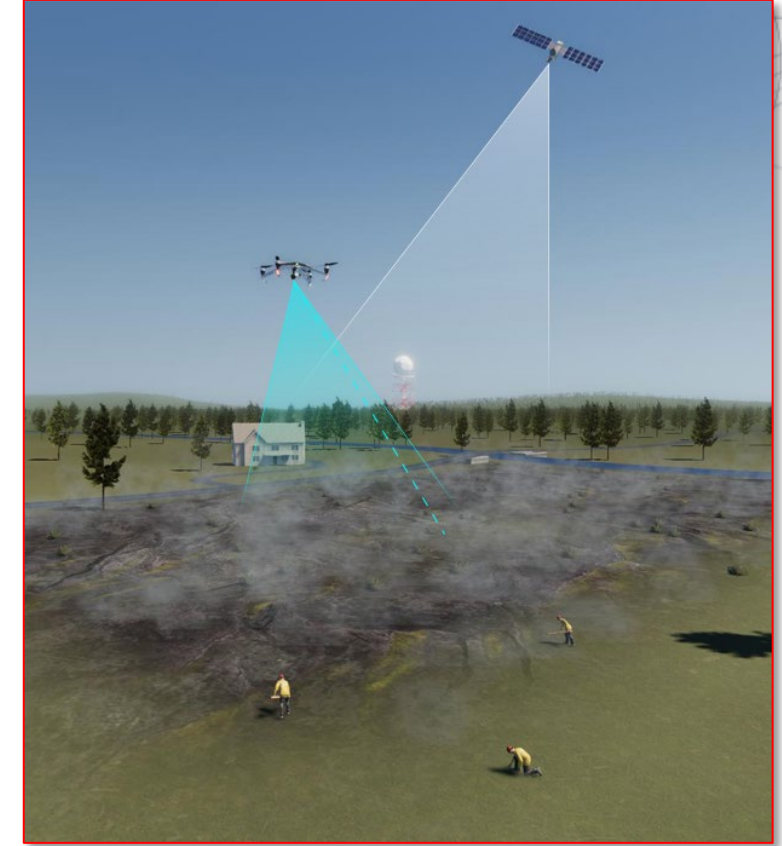
► ACTIVE FIRE

Decision Support & Suppression



► POST-FIRE

Mop-up & Rehabilitation



Collaboration between ARMD, SMD, STMD benefits from the significant discipline expertise to bring innovative science and technology to address challenges in pre-, active-, and post-fire operations.



ACERO's Goal:

Develop, integrate, demonstrate, and transition to operations, NASA and industry aviation technologies to identify, monitor, and mitigate wildland fires and other emergencies, to enhance safety, improve efficiency of operations, and minimize economic loss.



Current Stakeholder Barriers and Impacts

Unclear Technology Integration Path

Duplicative and non-harmonized stakeholder technology investment

Reliability of Fire Monitoring and Communications

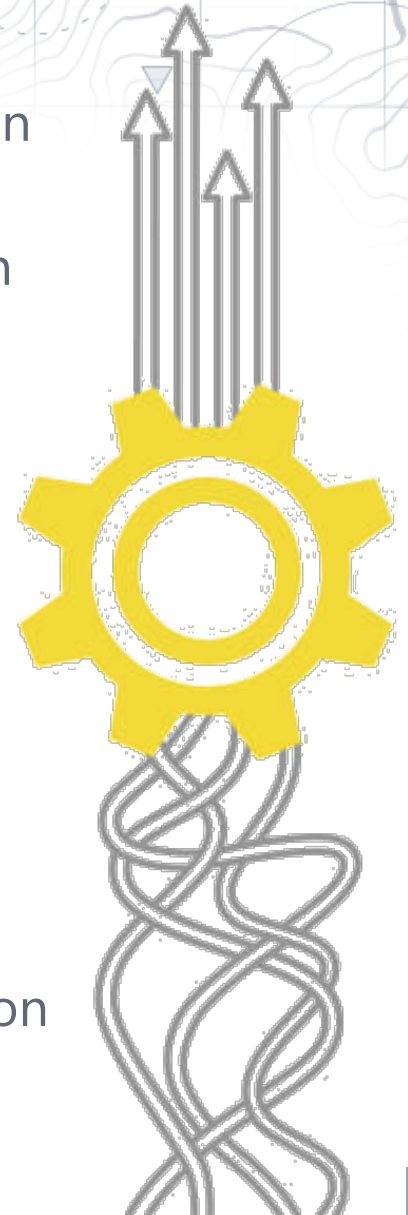
Decision making limited by outdated and incomplete information

Limited Aerial Suppression Support

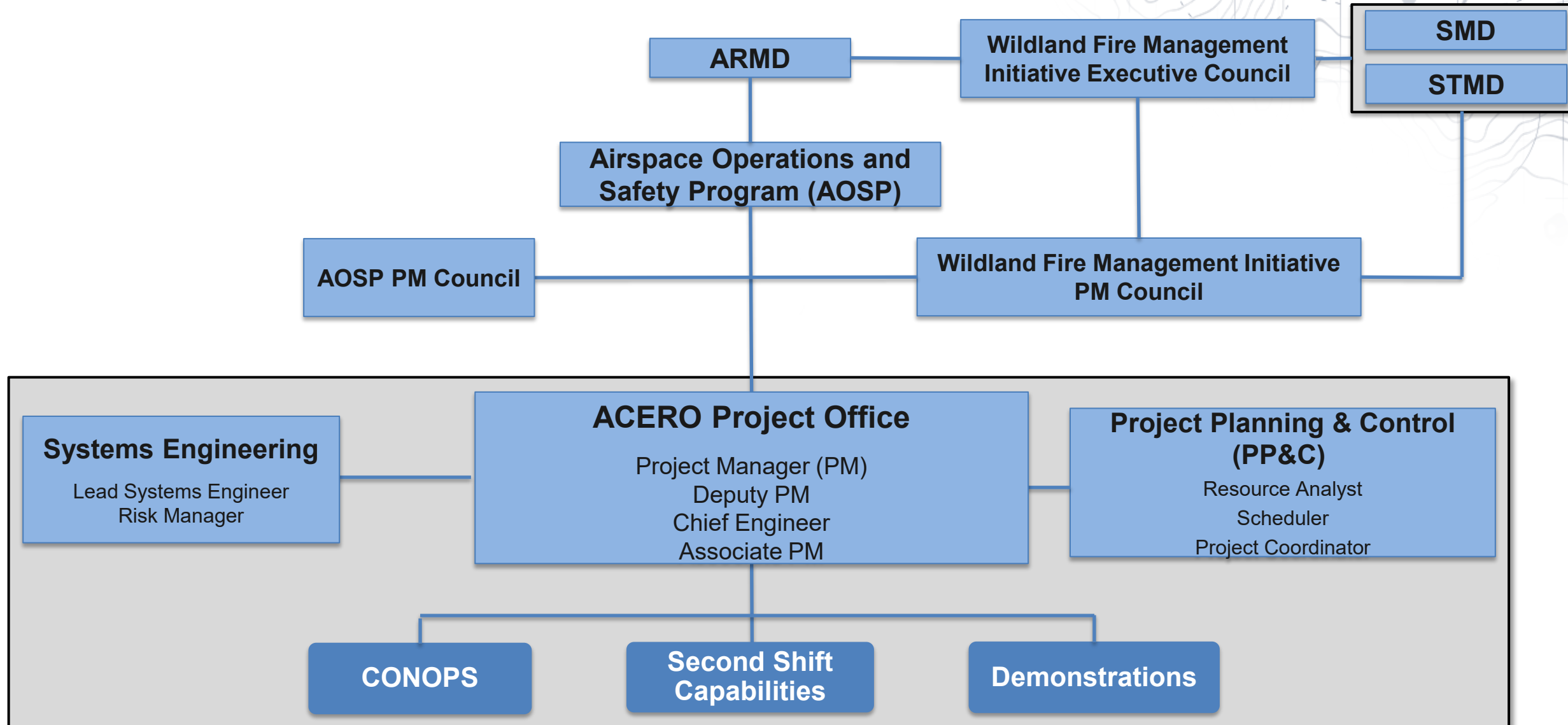
Lack of aerial suppression support for degraded visual environments limits effectiveness in reducing fire intensity and containment

Strategic Alignment

- NASA Alignment:
 - Agency Strategic Goal 3 - Catalyze Economic Growth and Drive Innovation to Address National Challenges
 - ARMD Strategic Thrust 6 - Assured Autonomy for Aviation Transformation
- Other Government Agency Alignment:
 - USFS / DOI - Dingell Act
 - FAA - Reauthorization
 - CAL FIRE - California Emergency Services Act
- Alignment with Independent Recommendations:
 - White House - PCAST Modernizing Wildland Firefighting through Science and Technology report
 - Congress - Wildland Fire Mitigation and Management Commission Aviation Equipment and Final Report



Organization



Project Objectives

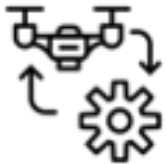
- Develop interagency Concept of Operations to ensure consistency of operational priorities, technology adoption, and programmatic alignment for national needs
- Develop and demonstrate emerging airspace management technology to improve emergency responders' efficiency and safety during a disaster
- Develop and demonstrate 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



Desired End State



Wildland Fire Agencies



Industry

Technology
Transfer

Project
Success

ACERO

Concepts

- Wildland Fire Inter-agency CONOPS
- Systems Architecture
- Science & technology Roadmap

Second Shift Core Technologies

- UTM-in-a-Box
- Communications Architecture and Airborne Comms Solutions
- Suppression Mission Planning Tools
- UAS Hazard Perception and Avoidance

Validated Requirements

- Technology Capability Level Demonstrations of Suppression for Degraded Visual Environments

Standards

Project
Impact



Wildland Fire
Community



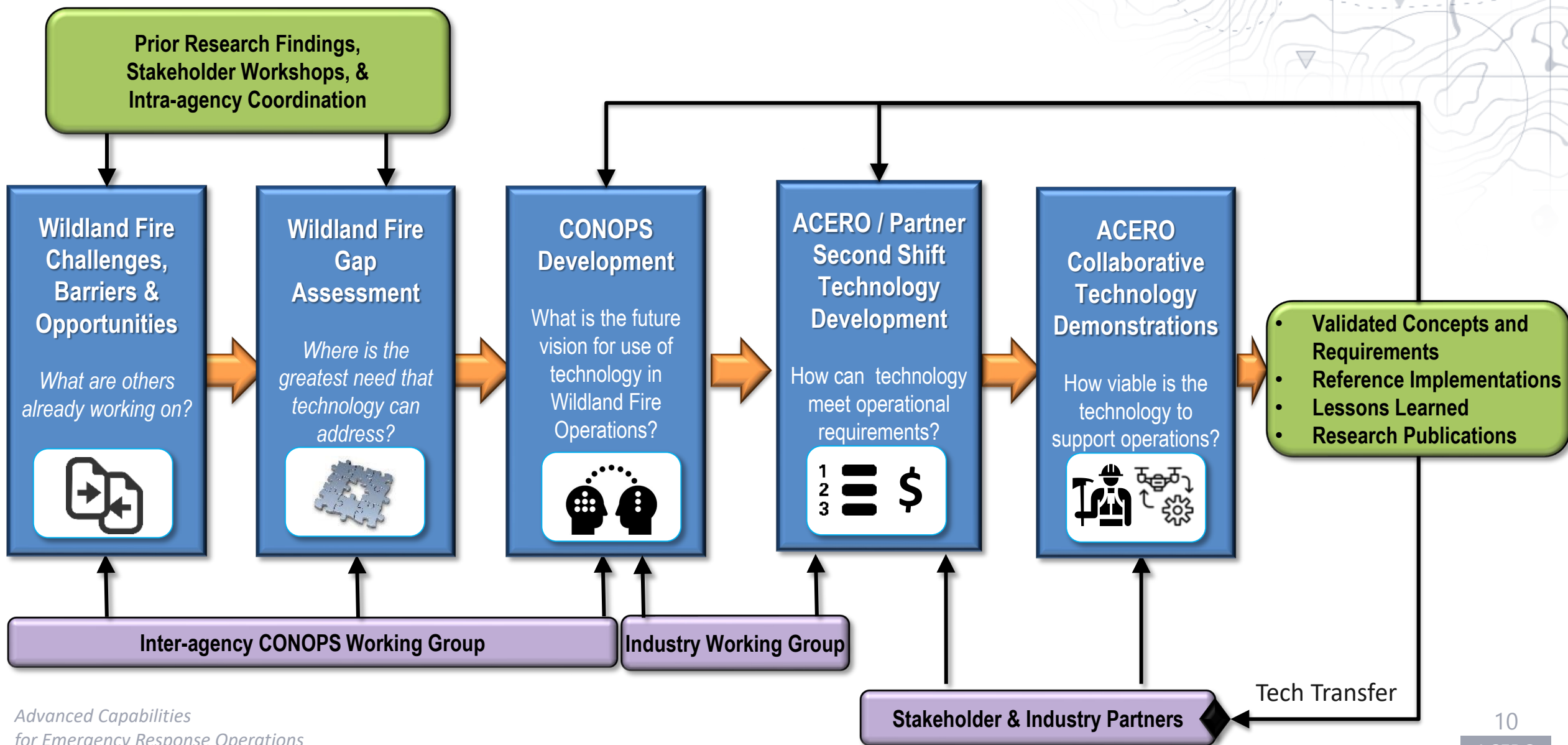
Industry Standards

Project
Evolution



Other Emergency Use Cases

Concept-to-Tech Transfer Approach



Transformation from Current Day Operations



Problem Statement: Current processes are highly manual and limited by lack of common situation awareness, timely information, and effective tools/technologies to support austere conditions

Challenge: Safe integration of UAS in the Airspace

UAS operations informed by technology-enhanced awareness of local airspace constraints & hazards

PREVENT

1 PREDICT

Challenge: Timely Information Sharing

Strategic airspace management (UTM-in-a-box), airborne communication solutions that enable a shared operating picture

Challenge: Degraded Visual Environments (DVE) Reduce Pilot Safety

Integration of UAS-delivered logistics & suppression, enabled through mission-planning tools and aircraft autonomy

SUPPRESS

3 TRACK

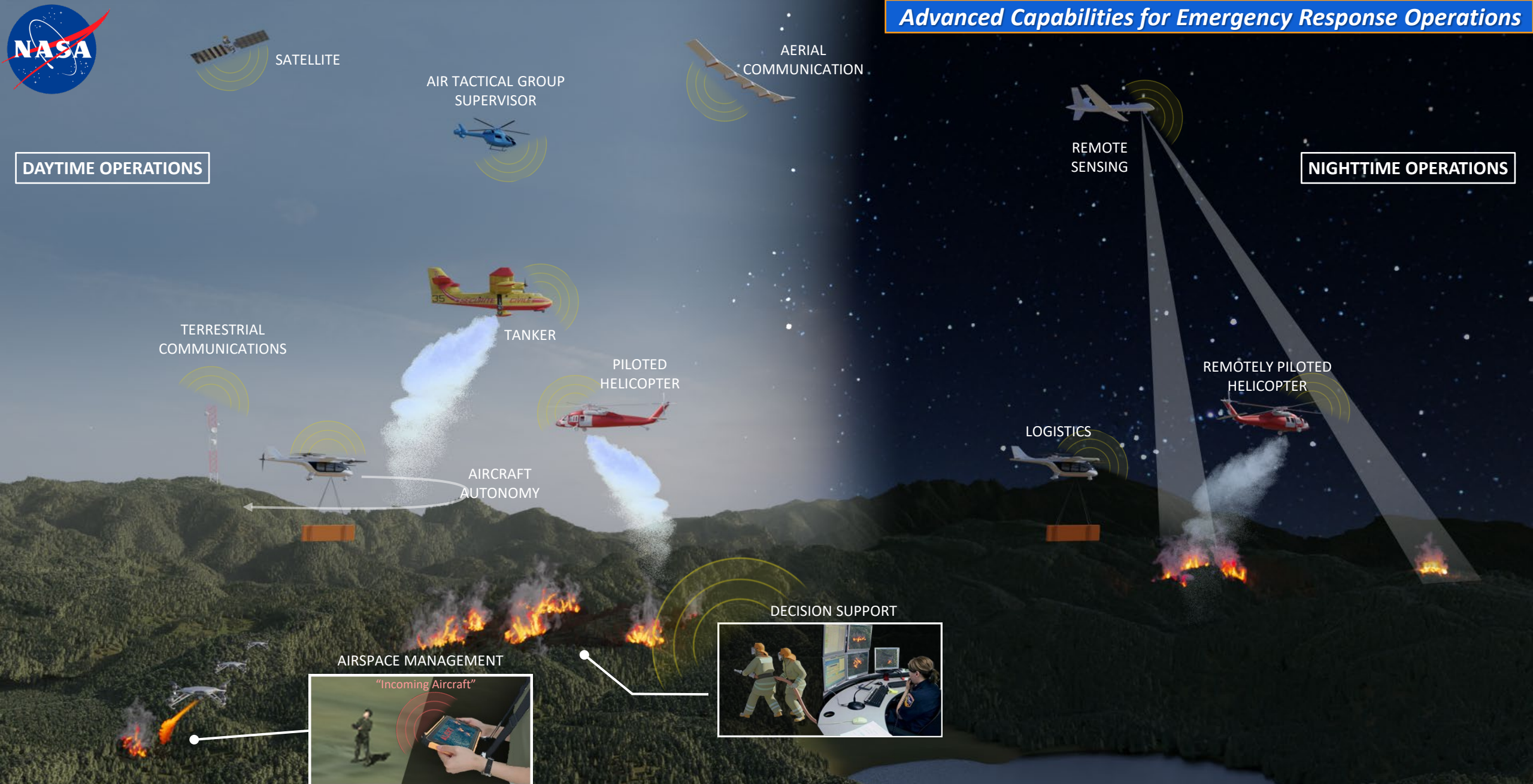
Challenge: Improved Monitoring in DVE

Suppression-effectiveness metrics that inform re-tasking and mission completion

5 SURVEY

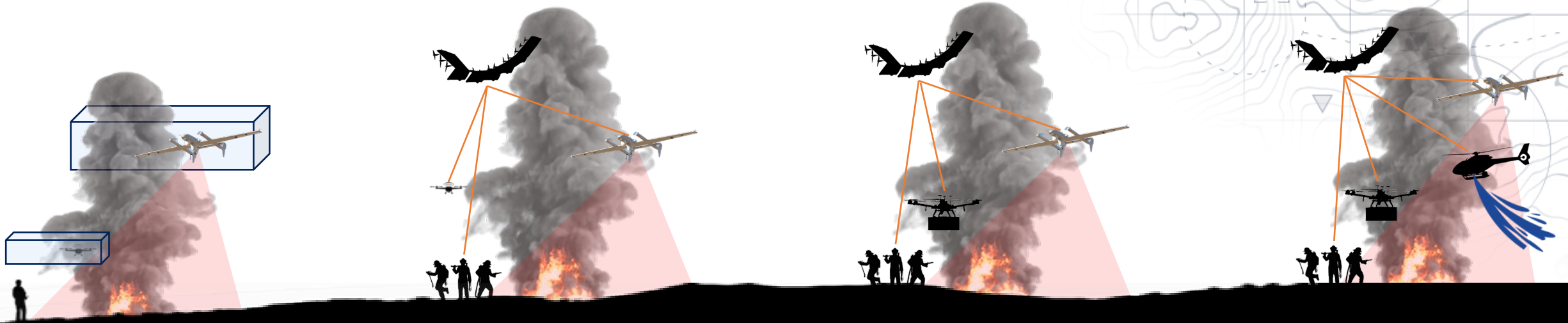
REMEDiate

6



Mission Statement: Develop, integrate, demonstrate, and transition to operations, NASA and industry aviation technologies to identify, monitor, and mitigate wildland fires and other emergencies, to enhance safety, improve efficiency of operations, and minimize economic loss.

Second Shift Concept Use Cases



TCL 1

- **Use Case:** Monitoring
- **Technology:** UTM-in-a-box
- **Enablers:**
 - Local Information Sharing
 - Airspace Management and Aircraft Deconfliction
- **Impact:** Locally shared situation awareness

TCL 2

- **Use Case:** Communications
- **Technology:** Communications Architecture and Aerial Comms Solution for UTM-in-a-box
- **Enablers:**
 - Extended Information Sharing
 - Mission Planning
- **Impact:** Reliable and interoperable mobile communications

TCL 3

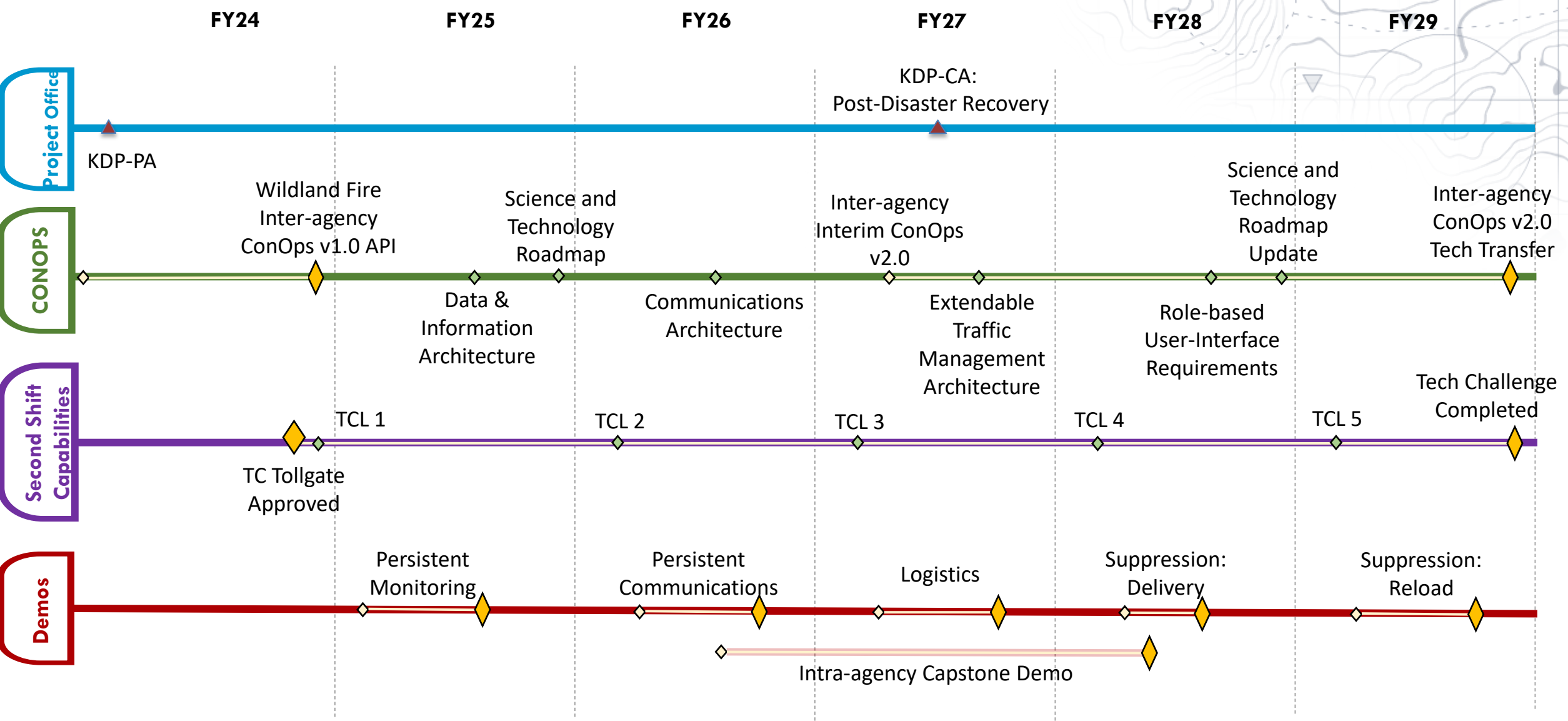
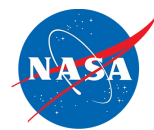
- **Use Case:** Logistics
- **Technology:** Hazard Detection & Avoidance, Mission Planning, & xTM interoperability
- **Enablers:**
 - Mission Tasking
 - Aircraft Transit through NAS
- **Impact:** UAS mission that can transition to and from an incident

TCL 4 & 5

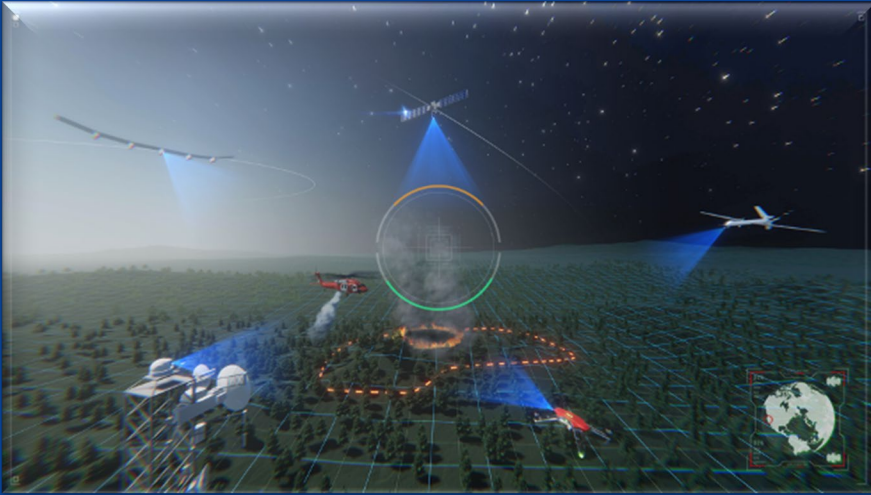
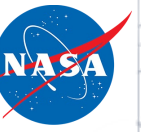
- **Use Case:** Suppression
- **Technology:** Suppression Mission Autonomy
- **Enablers:**
 - Suppressant Delivery & Monitoring
 - Re-tasking & Re-loading
- **Impact:** End-to-End Suppression Operation with remotely piloted aircraft

TCL demonstrations test increasingly complex missions needed for suppression in degraded visual environments

Technical Approach



CONOPS Technical Area



Develop a strategic vision for the use of technologies to support wildland firefighting to inform: wildland fire agency acquisition strategies, the private sector, academia, and philanthropic development efforts toward wildfire science and technology, and future technology validation testing.

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 and demonstrations

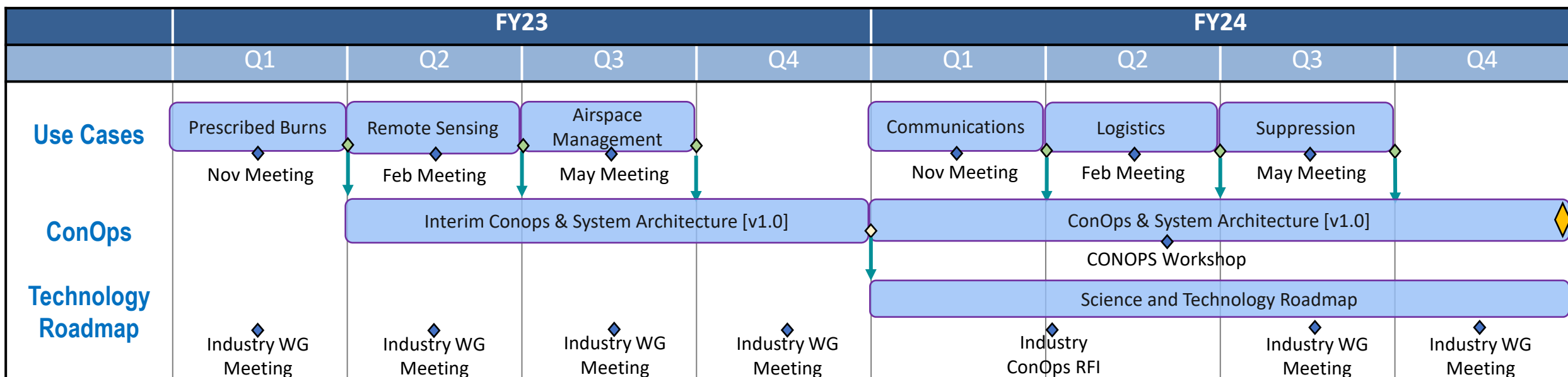
CONOPS Status



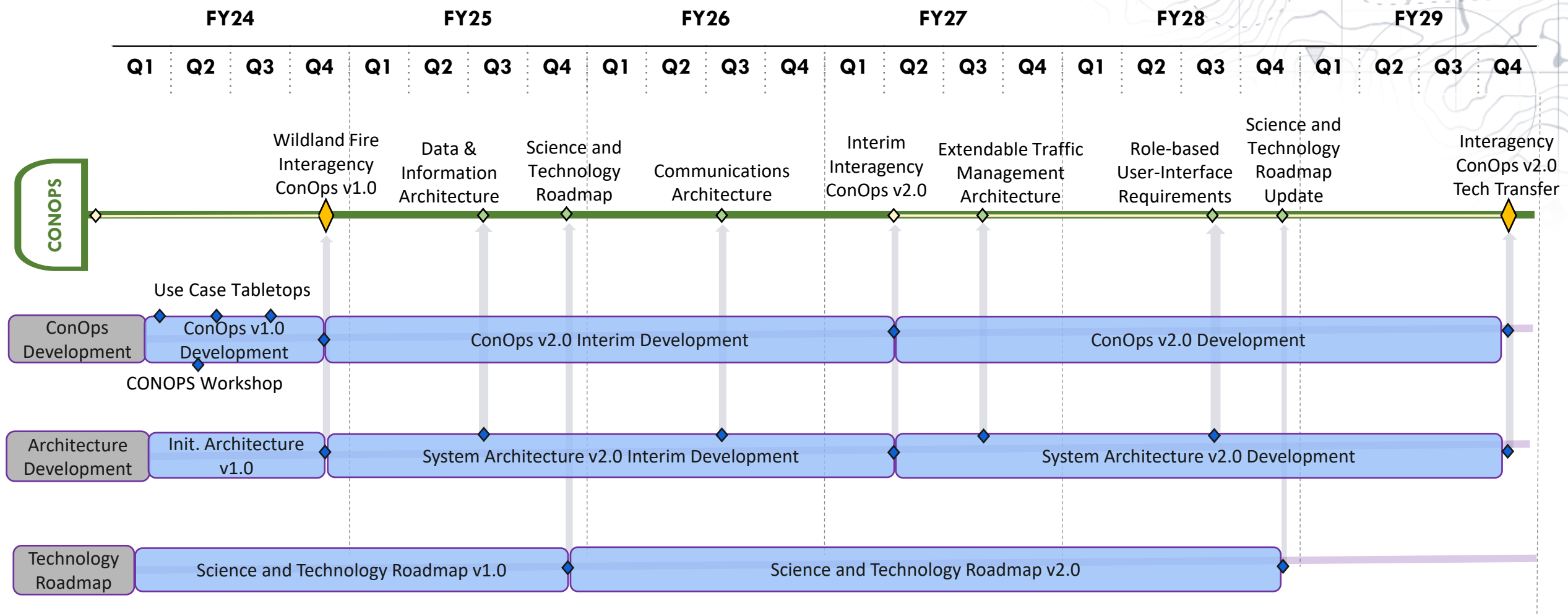
- Interim ConOps drafted and shared with key stakeholder agencies
- Initial Planning for releasing interim ConOps with RFI in Q2 FY24 for industry feedback and Industry Working Group
- Initial Planning for ConOps Workshop for Q2 FY24 underway
- Continue with quarterly industry working group meetings
- FY24 Use Cases in development

Use Cases

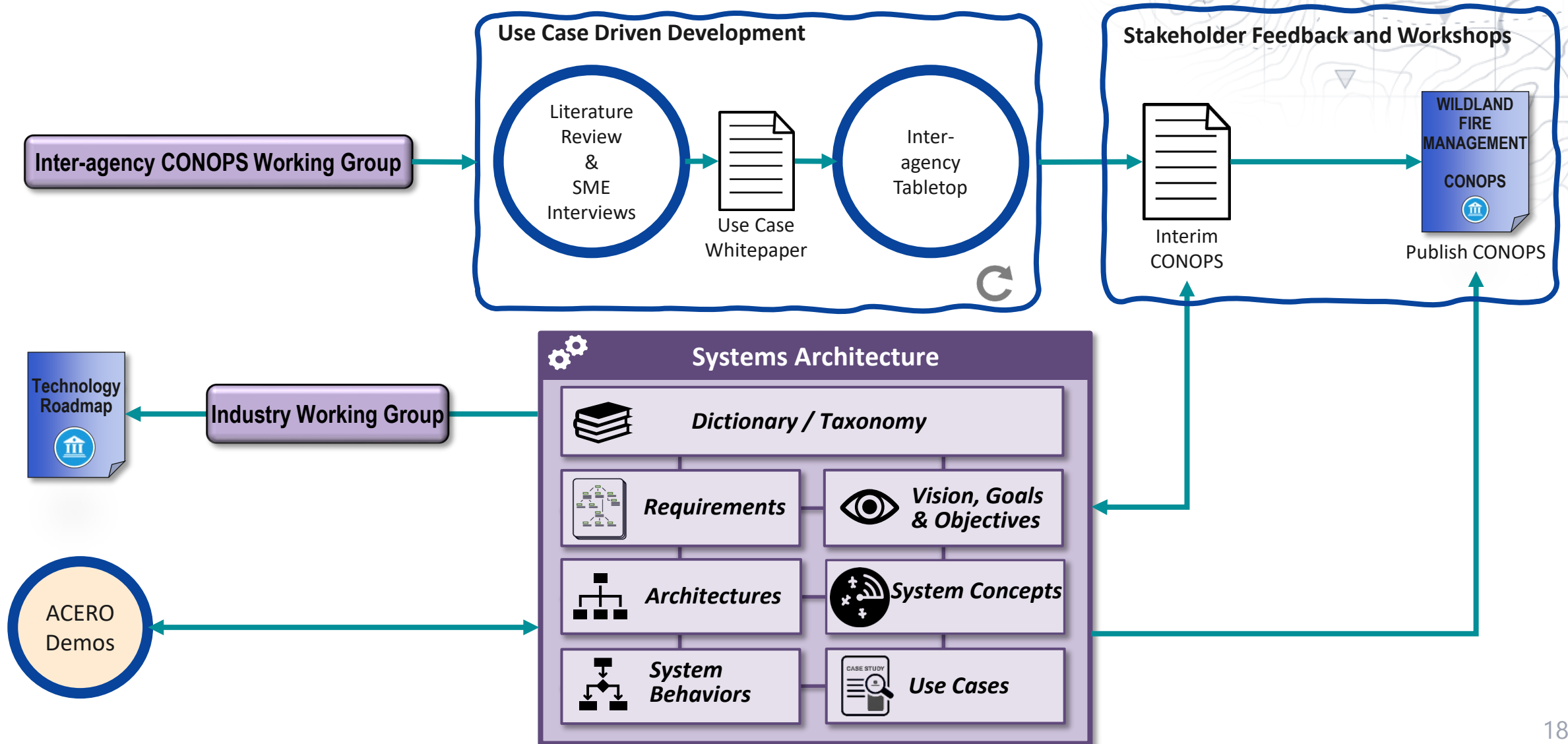
Prescribed Burns	✓
Remote Sensing	✓
Airspace Management	✓
Communications	
Logistics	
Suppression	



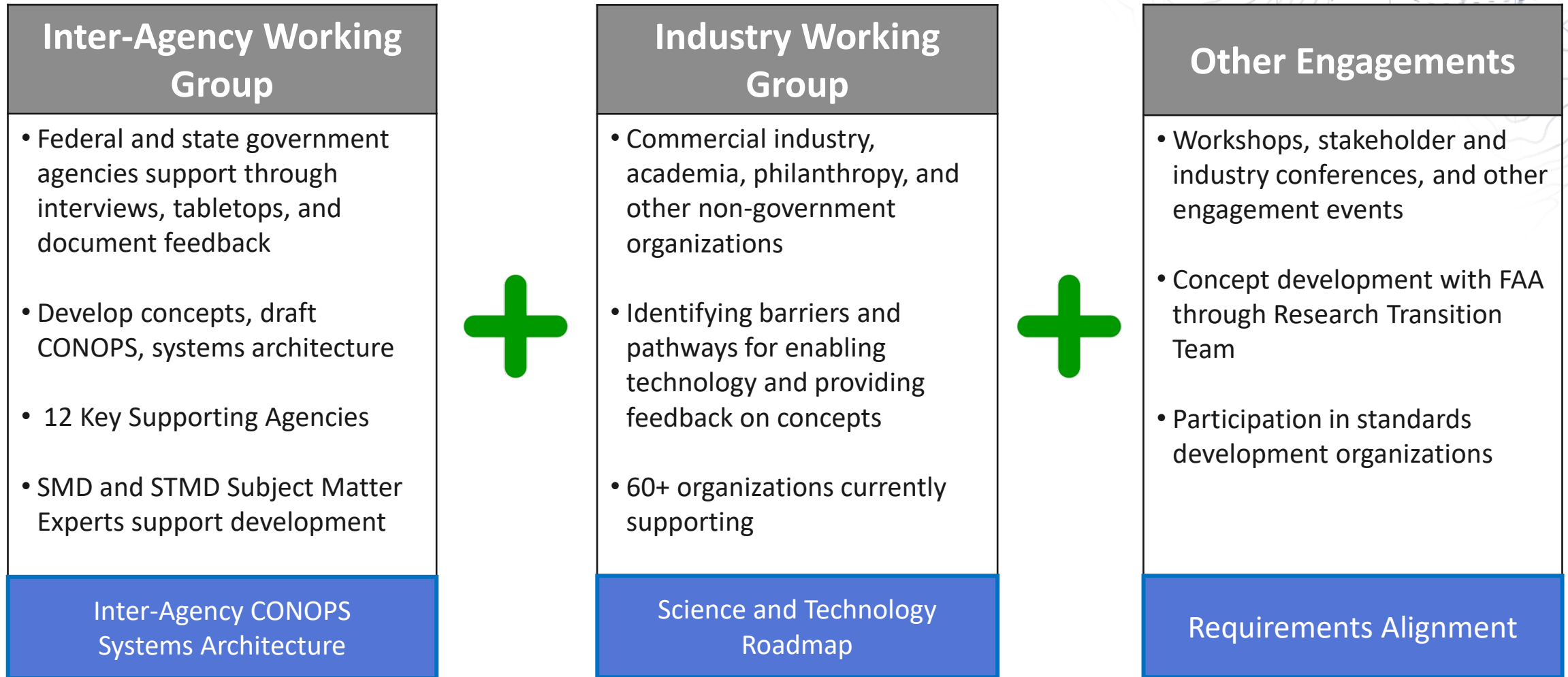
CONOPS Schedule Work Package



CONOPS Deliverables



CONOPS Partnerships and Engagements



Second Shift Capabilities (SSC) Technical Area



Goal

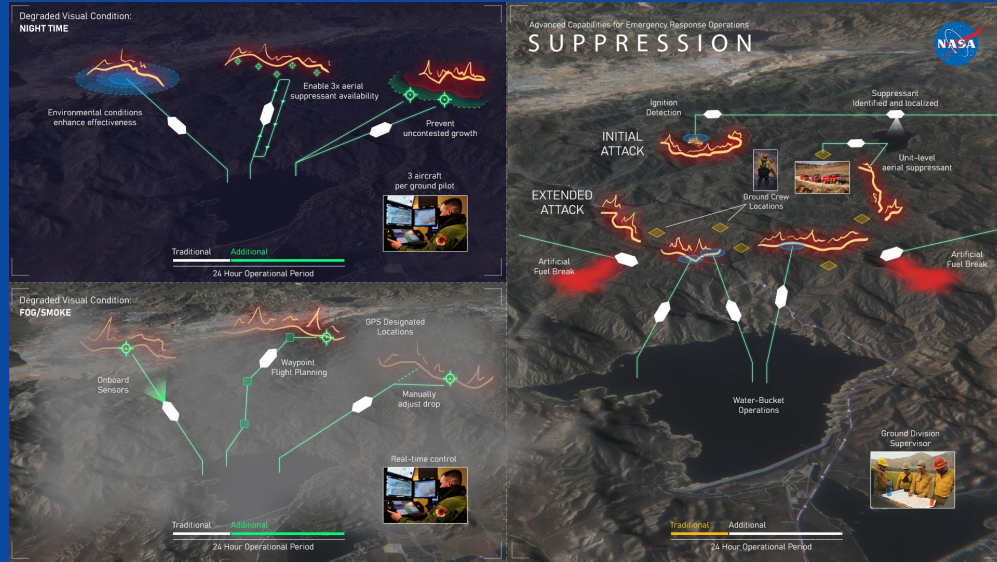
Develop and tech transfer reference prototypes and validated requirements that enable wildland fire suppression with remotely piloted aircraft in degraded visual environments.

Development Approach

- Collaborate with partner agencies and industry to jointly develop prototypes that conform to requirements derived from the CONOPS
- Evaluate the feasibility, performance, and/or usability of prototype technologies
- Provide recommendations to update the CONOPS and requirements based on validated data and field evaluated capabilities

Exit Criteria

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



Technical Challenge

Develop and evaluate a reference prototype that leverages technology to address safe and efficient aircraft operations, flight and airspace management procedures, and ground operations for remotely piloted wildland fire aerial suppression in degraded visual environments.

Technical Capability Level Progression



Aircraft:

Mesh Radio (TCL1):



Thermal Camera



Mobile Network Radio (TCL2):



Comms Payload



UTM-in-a-box: Onboard Processing (TCL3)

Hazard Perception & Avoidance (TCL3)

Suppression Autonomy (TCL 4 & 5)

Equipment Payload



Suppressant



Shared Operating Picture



Remote Pilot



Hand Crew



Air Tactical Group Supervisor



Other Users

Ground Control Station:



Mesh Radio (TCL1):



Mobile Network Radio (TCL2):



UTM-in-a-box:



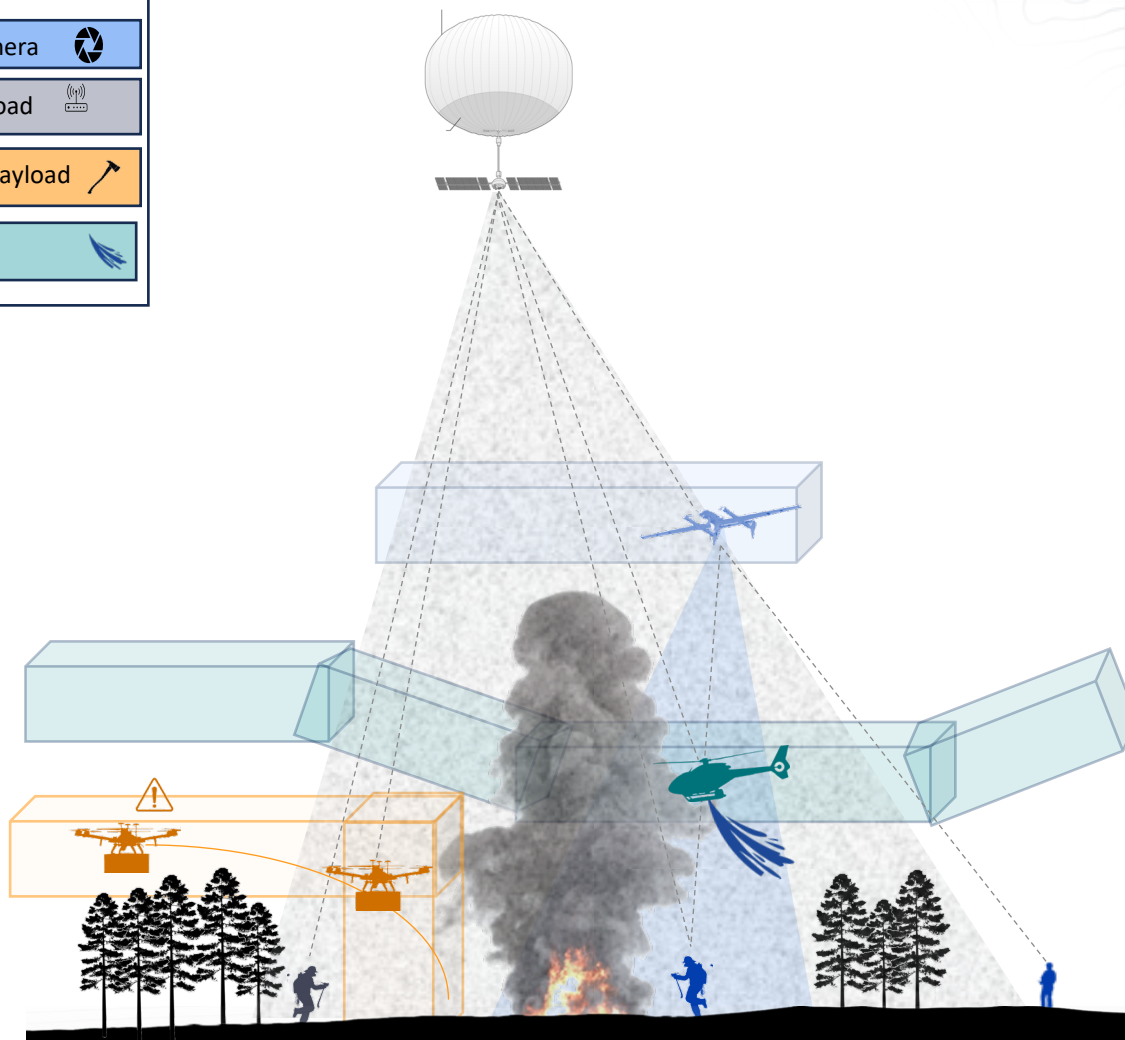
Fire Data Processing (TCL1)

Strategic Deconfliction (TCL1)

Mission Planning: Connectivity (TCL2)

Mission Planning: Delivery (TCL4)

Mission Planning: Re-task (TCL5)



TCL 1

- **Use Case:** Monitoring
- **Enablers:**
 - Local Information Sharing
 - Aircraft Deconfliction

TCL 2

- **Use Case:** Communications
- **Enablers:**
 - Extended Information Sharing
 - Mission Planning

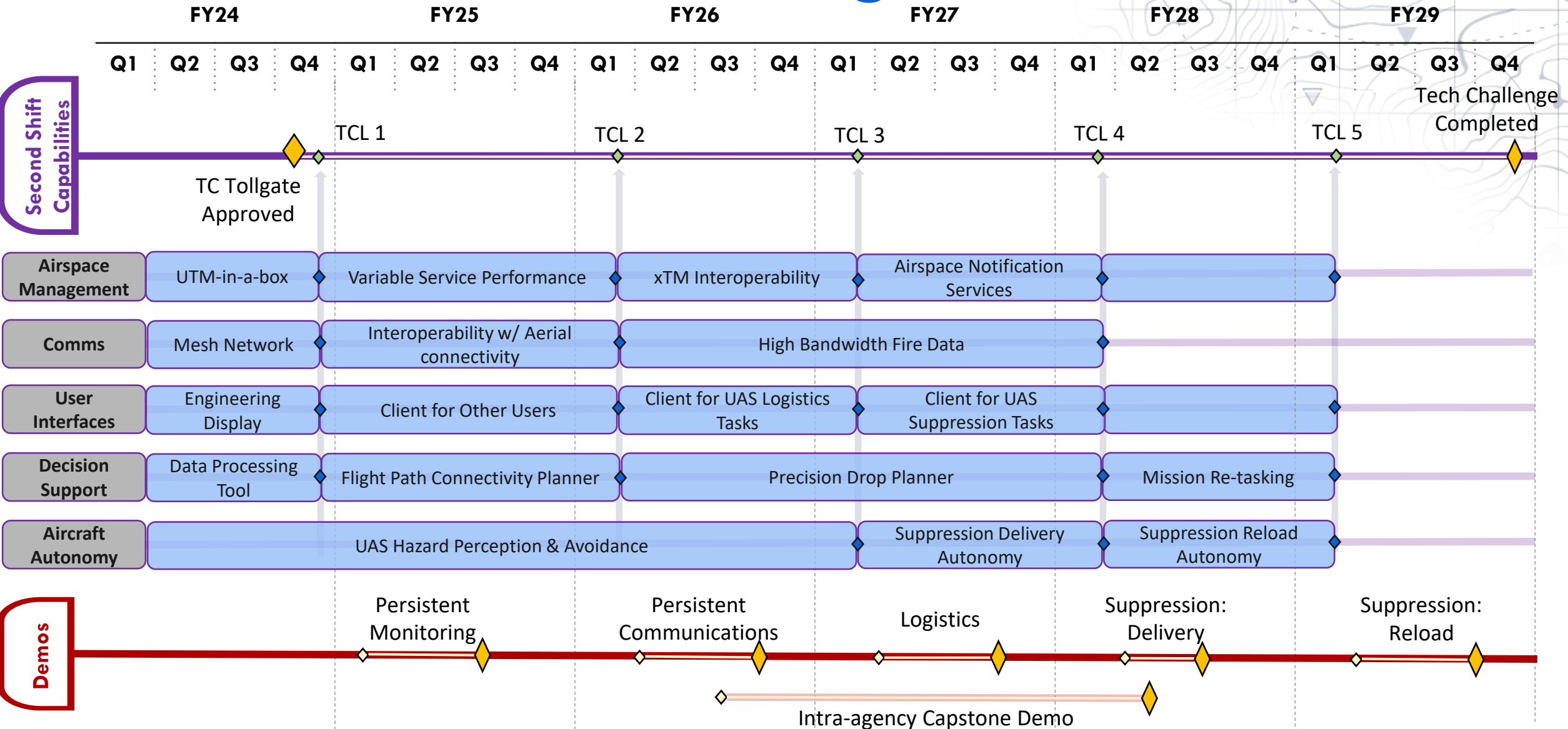
TCL 3

- **Use Case:** Logistics
- **Enablers:**
 - Mission Tasking
 - Aircraft Transit in the NAS

TCL 4 & 5

- **Use Case:** Suppression
- **Enablers:**
 - Delivery & Monitoring
 - Re-tasking & Re-loading

SSC Schedule Work Package



UASP-kit Technology Transfer

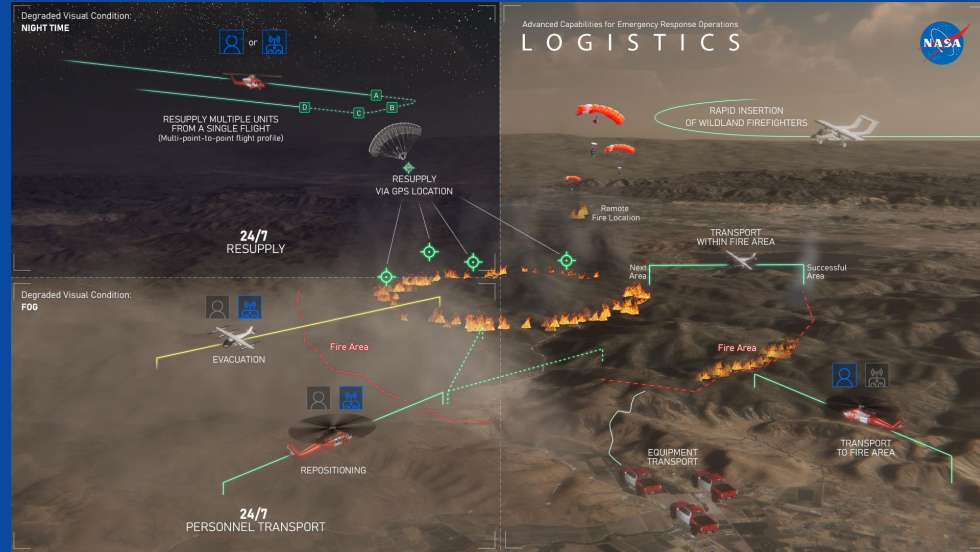


- Technology initially developed under Scalable Traffic Management for Emergency Response Operations (STEReO)
- UAS Pilot kit (UASP-kit) technology enhances situation awareness of UAS pilots by combining operational view of surrounding airspace, air traffic alerts, and wildfire operational maps
- FY23 Deliverables:
 - Validation testing of UASP-kit v2.5 at USFS Aerial Ignition Academy to finalize requirements for technology transfer
 - A selection of this work was published and presented at the 2023 International Symposium on Aviation Psychology
 - Technology transfer of UASP-kit specifications, requirements, and user guidance to USFS



UTM-in-a-box development will build on UASP-kit technology and the unique aspects of wildland firefighting operations

Demonstrations Technical Area



Execute a series of demonstrations in relevant environments that: validate concepts and requirements from the CONOPS, evaluate the feasibility of integrating new technology into wildland fire operations, and support an effective transition of research-to-operations for new aviation technology.

Goal

Validate second shift concepts and requirements by field testing technologies in relevant operational environments to evaluate the system performance, and operational feasibility.

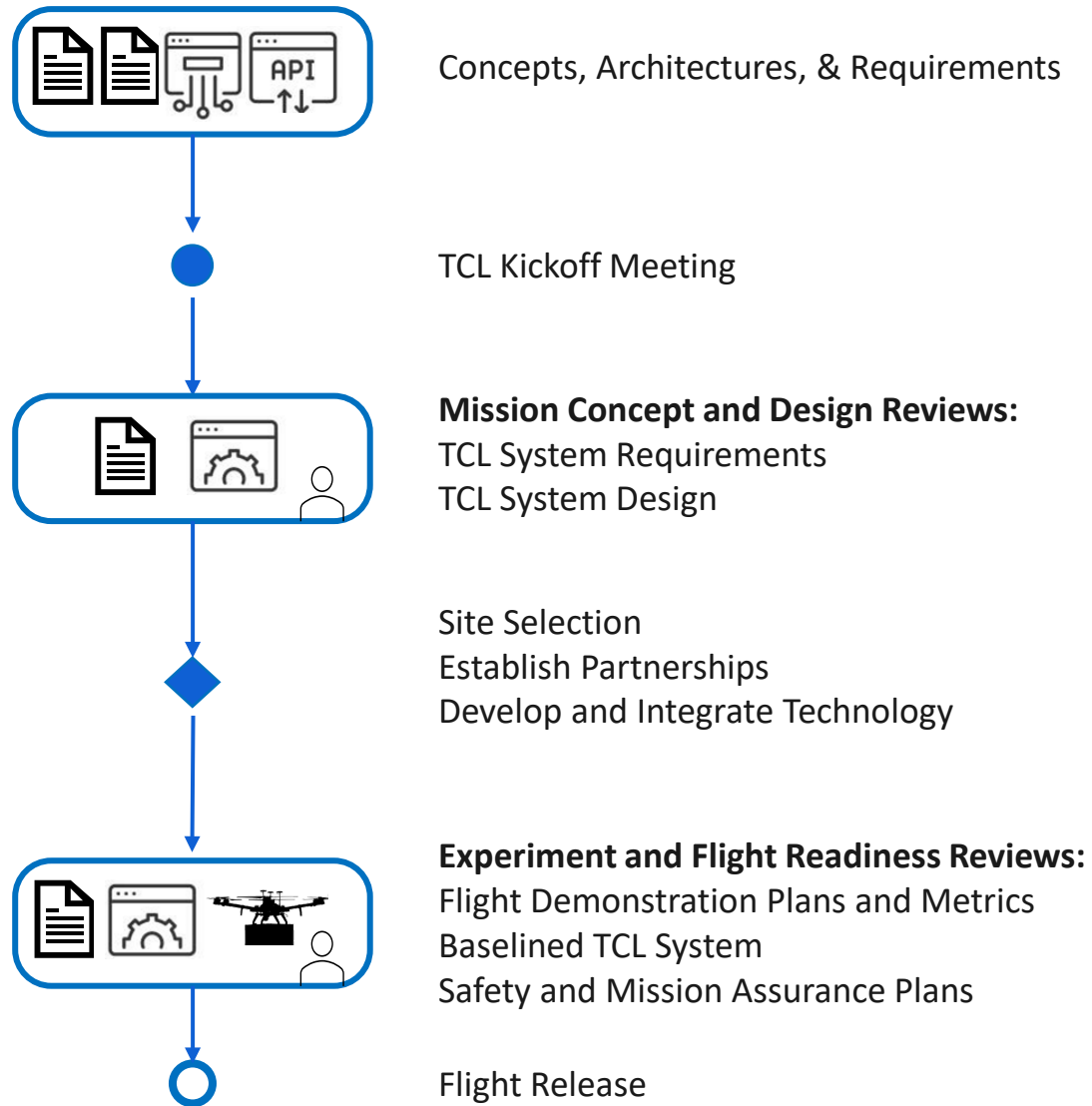
Development Approach

- Leverage technology from partner agencies and industry to improve the integration of NASA's tech transfers into operations
- Identify testing scenarios that capture SSC's objectives and the stakeholder requirements from CONOPS
- Use a combination of established and novel procedures to enable the safe testing of state-of-the-art capabilities and operations

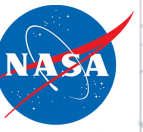
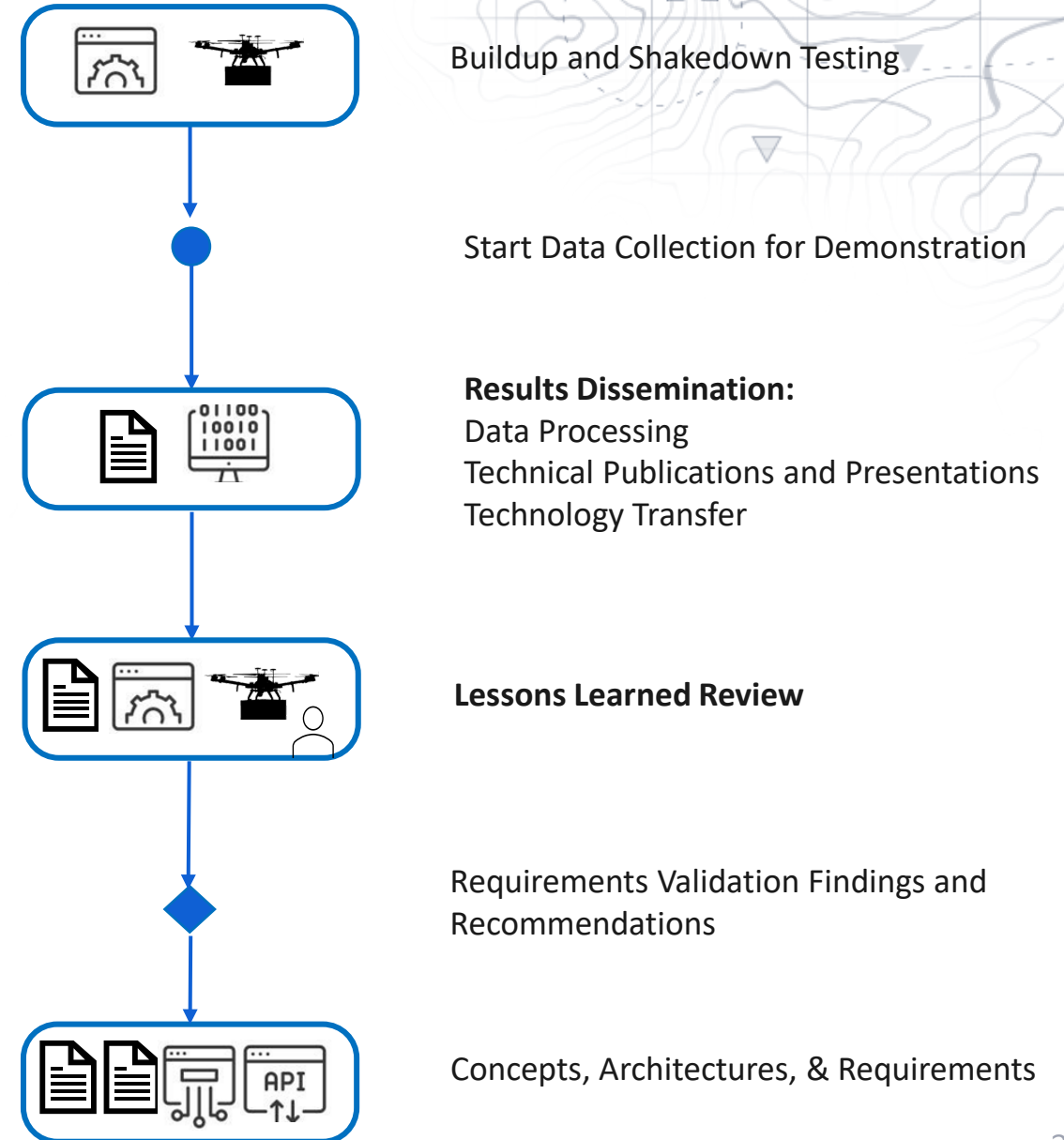
Exit Criteria

- Conduct field evaluations for the persistent monitoring, persistent communications, UAS logistics, and UAS suppression use cases
- Conduct a progression of field tests to enable extended aerial attack for wildland firefighting in degraded visual conditions

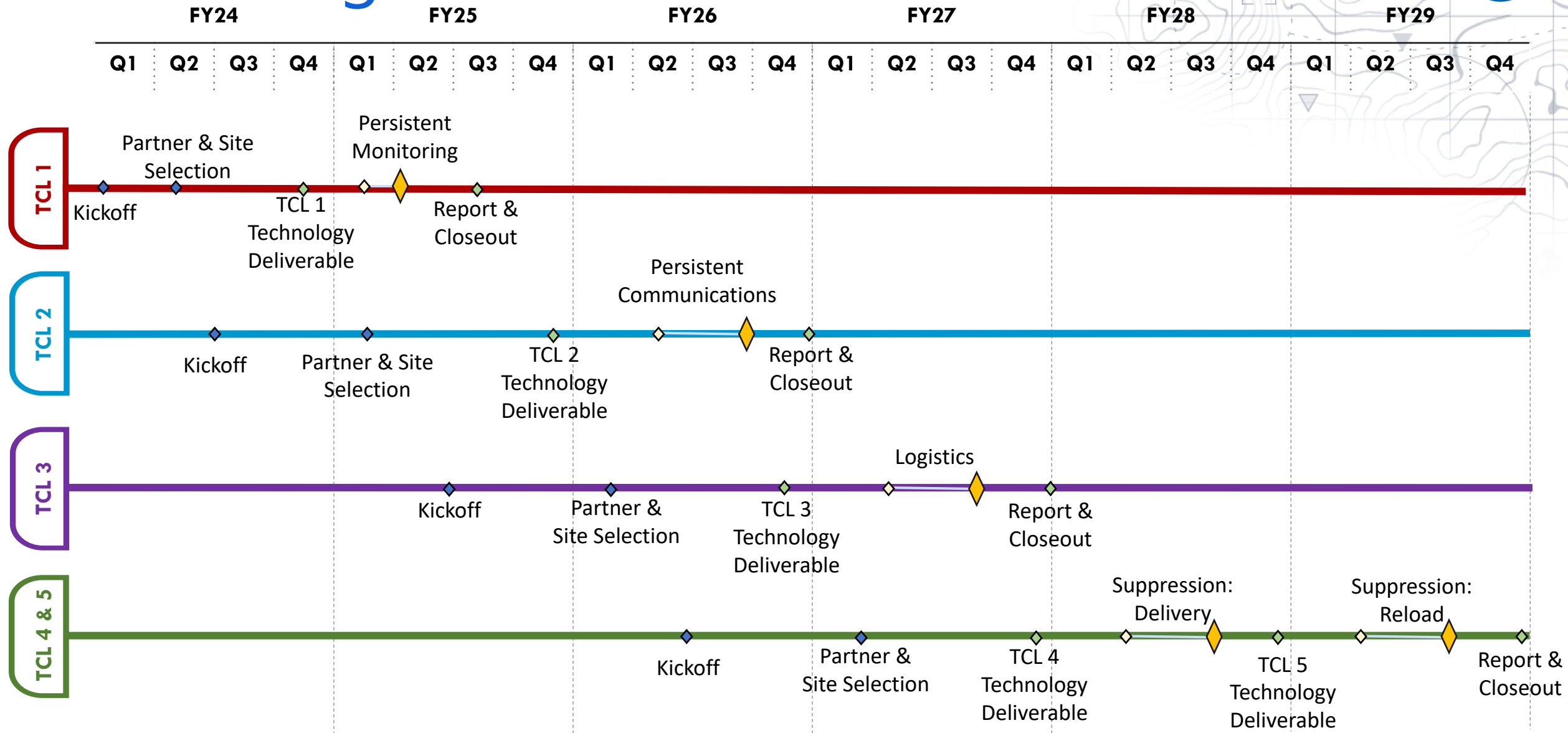
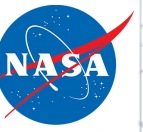
Demonstration Lifecycle



Advanced Capabilities
for Emergency Response Operations



Demo Progression



FY25 Persistent Monitoring TCL-1 Demo: Overview

001A



Objectives

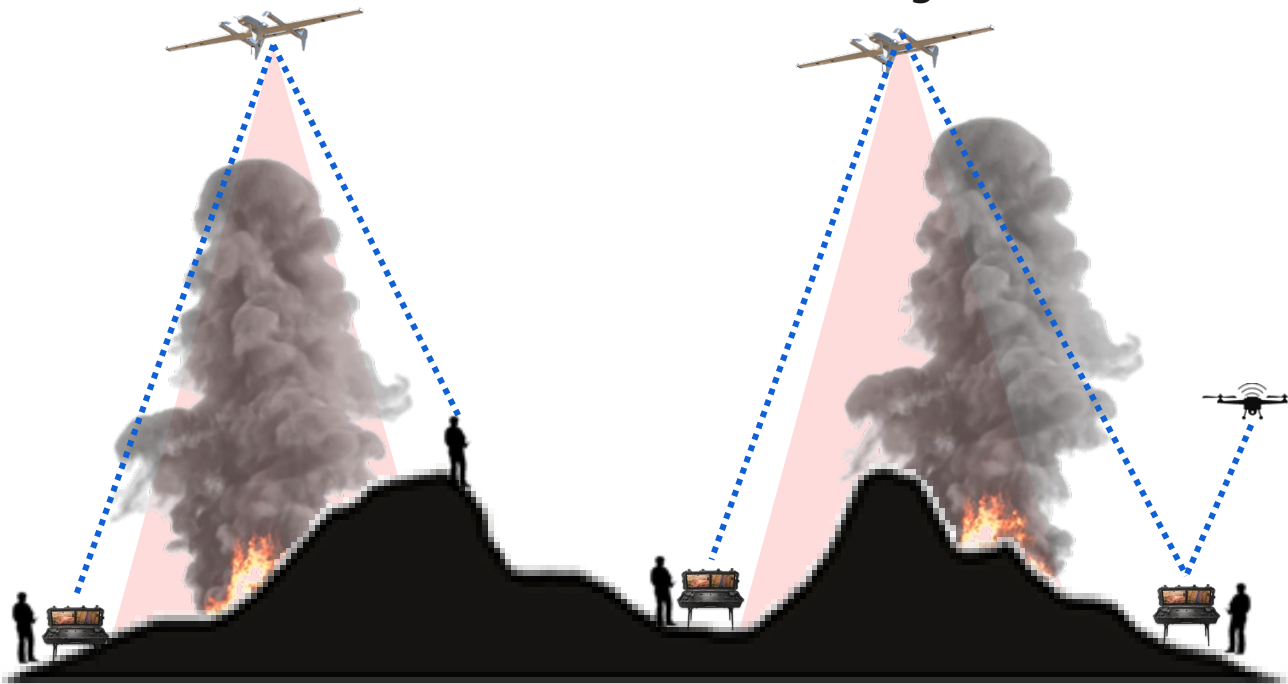
- Demonstrate information sharing (air traffic and fire info) and deconfliction between UAS Operators using UTM-in-a-box information exchanges
- Demonstrate using incident awareness and assessment aircraft as a communication relay to extend range of UTM-in-a-box information sharing

Overview

- **Testing Window:** Q1 FY25
- **Testing Duration:** ~2-3 weeks
- **Stakeholder:**
 - USFS UAS Program & Tools and Technology Group
- **Potential Non-reimbursable Partnerships:**
 - Aircraft: Overwatch Aero
 - UTM Service Provider: Skygrid
 - Situation Awareness Displays: Foreflight / ATAK
- **Tentative Schedule:**
 - FY24 Q1: Kickoff Meeting & Tech Development Starts
 - FY24 Q2: Partnership Agreements, Software Unit Testing
 - FY24 Q3: Ground Testing (Stakeholder Feedback)
 - FY24 Q4: Integration and subscale flight testing (sUAS)

Case 1: Information Sharing

Case 2: Strategic Deconfliction



NASA Wildland Fire Management Initiative Capstone Demonstration



► PRE-FIRE

► ACTIVE FIRE

► POST-FIRE

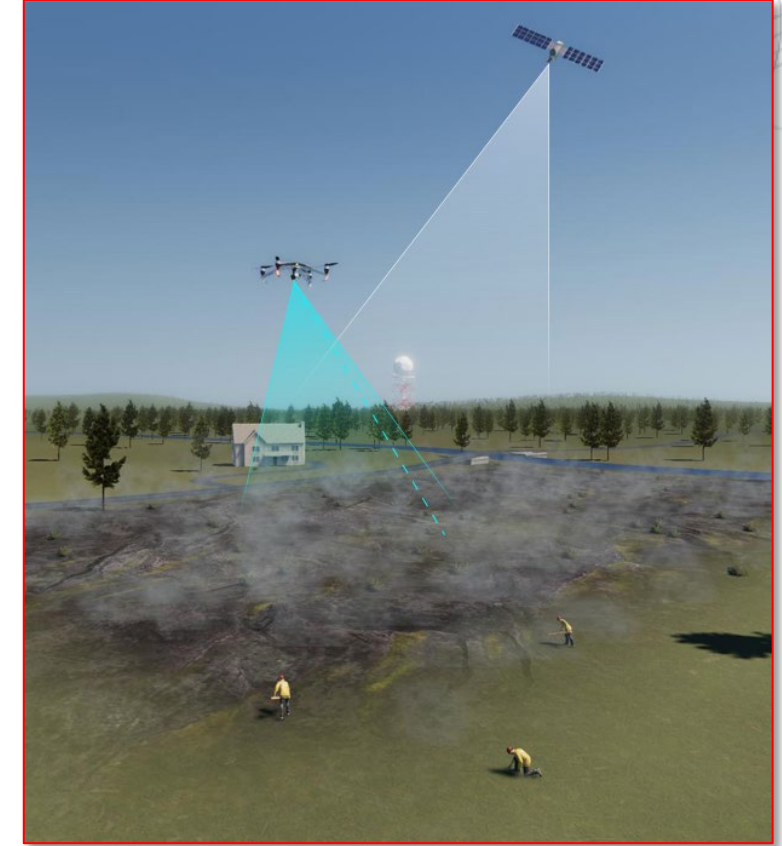
Planning & Monitoring | Prescribed Burns



Decision Support & Suppression



Mop-up & Rehabilitation



Demonstration integrates technology, modeling, and information from across ARMD, SMD, and STMD to enable different phases of a wildland fire operation

NASA Integrated Capstone Demonstration



Integrated Buildup Testing (FY26)

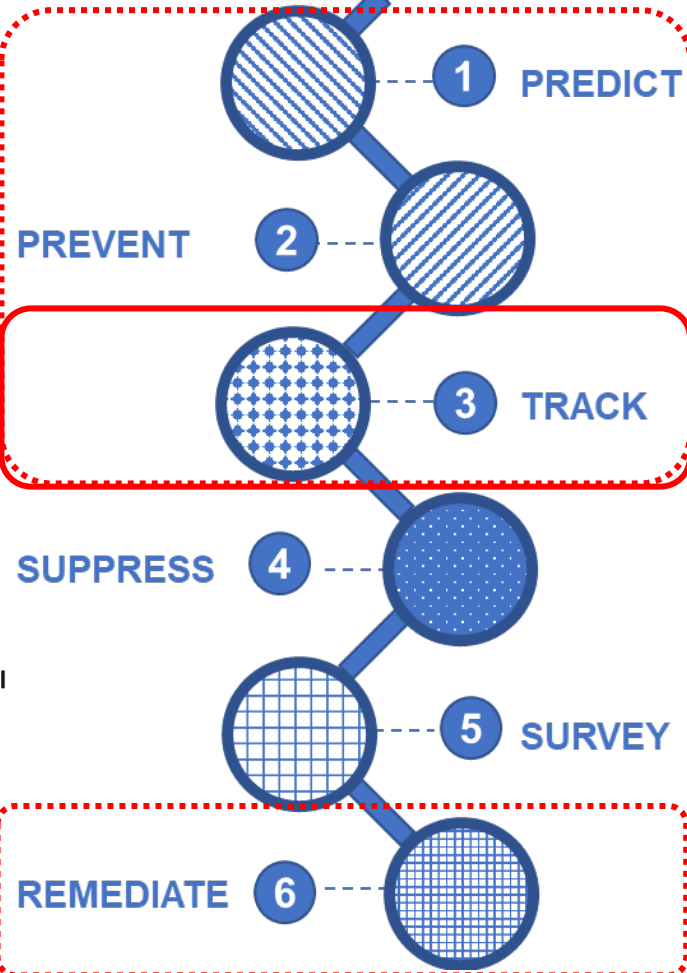
Science Mission Directorate

- Sensing for Modeling
- Sensing for Strategic Decision Making

ACERO TCL2

- UTM-in-a-box with variable service performance
- Interoperability with aerial connectivity
- Flight path connectivity planner
- UTM display for crewed operations

Science Mission Directorate



Advanced Capabilities
for Emergency Response Operations

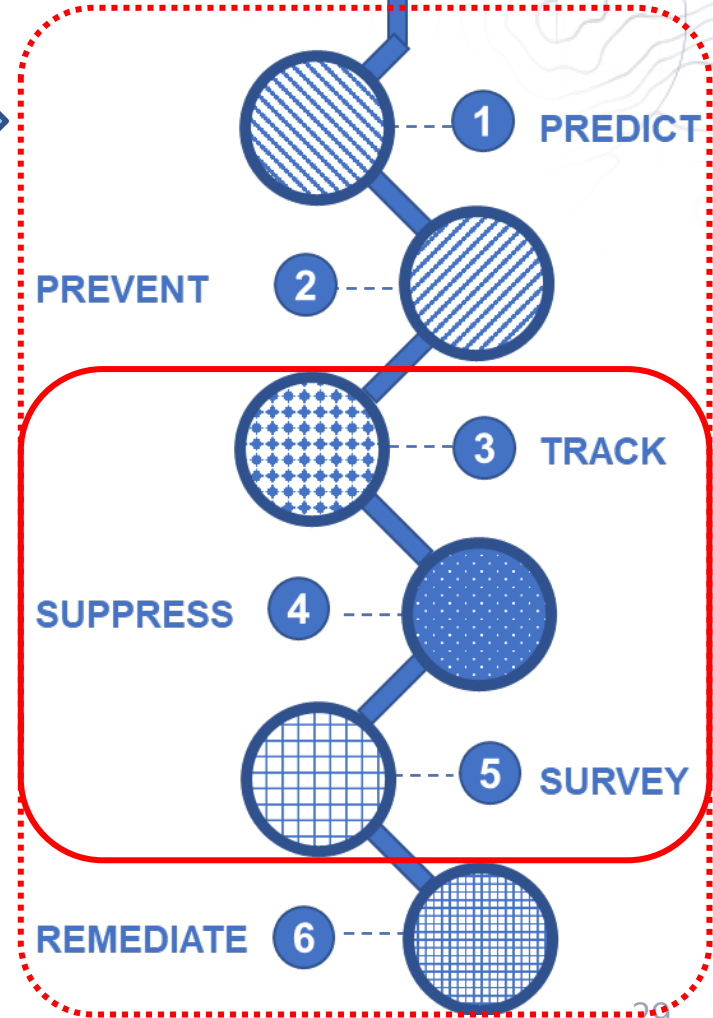
Capstone Demonstration (FY28)

Science Mission Directorate

- Sensing for Modeling
- Sensing for Strategic Decision Making

ACERO TCL4

- Airspace notification services
- UAS display guidance for suppression mission
- Communication of fire information
- Precision Drop Planner
- Suppression Delivery Autonomy



Summary



- Wildfires are a growing global issue and ACERO aims to address these challenges by:
 - Leading the development of an Inter-agency CONOPS and technology roadmap
 - Harmonizing a systems architecture that supports information exchange and improved near-real time response for wildland fire management
- ACERO will focus on development and demonstration of a set of technologies that enable second shift operations in degraded visual environments
 - Airspace Management and Shared Situation Awareness
 - Safety and Mission-related autonomy to support suppression and logistics operations
 - Communications architecture and aircraft-based communication network solution
- ACERO will transfer reference implementations, lessons learned, and validated requirements to key stakeholder agencies, industry partners, and standards development organizations



ACERO

THE FUTURE OF EMERGENCY RESPONSE