

Advanced Capabilities for Emergency Response Operations (ACERO)

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Agenda

- Wildfire Impacts
- Needs Assessment
- Prior and Current Research
- ACERO Approach
- Summary and Discussion

Wildland Fire Impacts

• Increased Severity

- 2015, 2017, and 2020 each had over 10M acres burned
- In 2021: 58k Fires and 7.1M acres burned

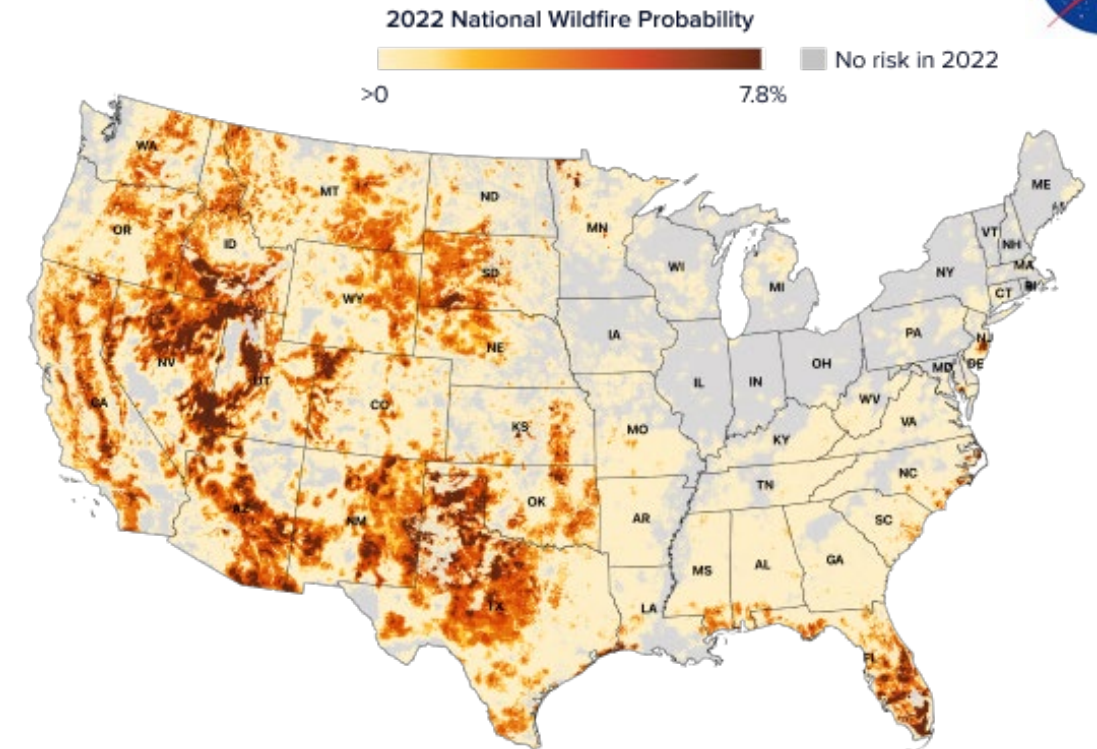
• Increased Costs

- 10-year average: \$2.3B Suppression & \$8.4B Total
- 5-year average: \$2.8B Suppression & \$16.8B Total
- In 2021: \$4.3B Suppression & \$11.2B Total

• Increased Risk

- 1 in 6 homes in the US at risk over the next 30 years
- Wildfires affect Climate (e.g., CO₂, black/brown carbon)
- Wildfires affect Air Quality

<https://fas.org/sgp/crs/misc/IF10244.pdf>
<https://www.nifc.gov/fire-information/statistics>
<https://www.ncei.noaa.gov/access/billions/>



Credit: 5th National Climate Risk Assessment, First Street Foundation

2021 Estimated Costs and Duration

Dixie Fire:	\$637M (over 3 months)
Beckwourth Complex:	\$542M (over 2 months)
Caldor Fire:	\$271M (over 2 months)
Monument:	\$163M (over 2 months)
Bootleg:	\$100M (over 1 month)

Wildfires contribute to climate change and climate change increases likelihood of wildfires



Current State-of-the-Art

NASA, in collaboration with the US Forest Service, conducted a workshop to understand the state-of-the-art, needs, and opportunities to improve wildfire management

- Focused on pre-fire fighting, during fire fighting, and post fire needs
- Identify the needs and challenges of stakeholders at various decision cycles from planning, prediction, detection, tracking, mitigation, suppression, and post-fire remedial efforts
- 154 attendees from other government organizations, academia, industry, and NASA

Main Findings

- Lack of persistent surveillance for fire detection and tracking
 - Lack of persistent communications
 - Lack of persistent aerial operations particularly under poor visibility
 - Lack of airspace technologies to enable multiple types of aircraft operating simultaneously
 - Lower aircraft safety record than other areas of aviation
 - Lack of adequate coordination among multiple government agencies
 - Need a clear plan to mature research for operational use in the field
- Workshop report available at https://nari.arc.nasa.gov/sites/default/files/attachments/NASA%20ARMD%20WILDFIRE%20MANAGEMENT%20WORKSHOP_6.1.2021_v13.pdf

Findings offer insights where research and development could make a significant impact

Relevant Areas: Current Operations and Challenges

Detection, Tracking, Surveillance, and Prediction

- Surveillance - infrequent satellite or aircraft observations
- Fire detection accuracy is not precise enough for effective targeting
- Few models for tracking and predicting fire progress, many are unreliable
- Better sensing is needed, difficult to observe through cloudy conditions
- Data and model fusion is limited – particularly for users in the field



Aerial Suppression Support

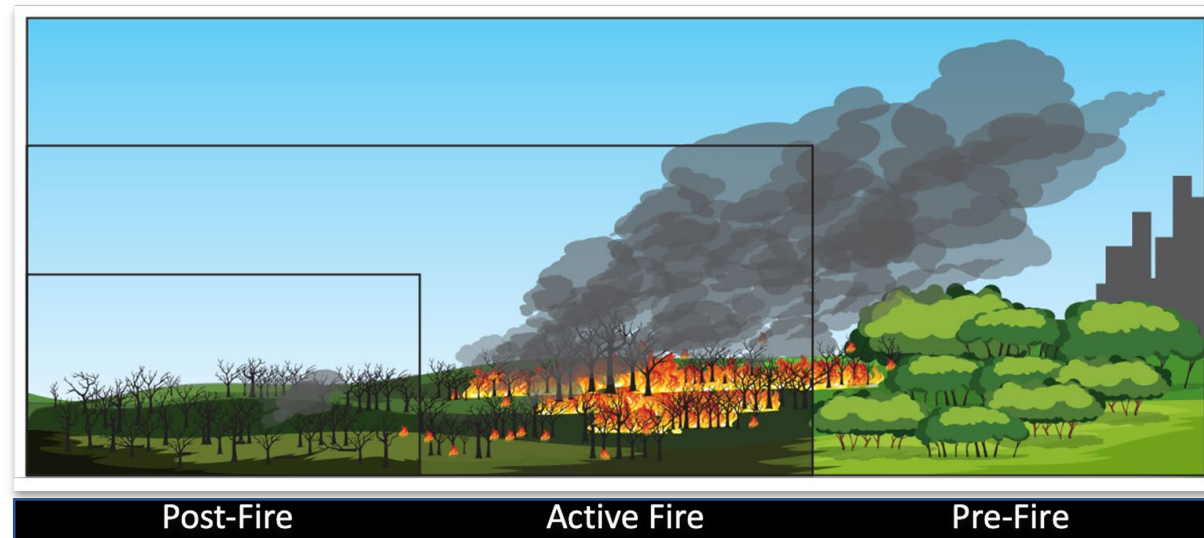
- Duration of aerial firefighting limited to daylight, clear visibility (4-6 hours/day)
- Airspace operations are manual and workload intensive; only a few aircraft allowed at a time
- Not able to accommodate drones in the same airspace as other aircraft
- Lower aircraft safety record in aerial firefighting than other areas of aviation





Challenges Integrating New Technologies

- Diverse set of stakeholders with various needs, constraints, and desires that require interoperability
- Different phases of the wildfire lifecycle create unique challenges and may require a variety of solutions
- Technology solutions need to be simple and easy to use
- Technology solutions must be interoperable and scale to meet the needs of the problem



Damage Assessment &
Recovery

Multi-Fire
Management

Extended Attack

Initial Attack

Fire Detection

Land Management



Prior Research:

NASA-JAXA Collaboration of UAS Traffic Management for Emergency Response

Objectives

- The Japan Aerospace Exploration Agency (JAXA) and NASA partnered to investigate the safe and efficient integration of UAS into disaster relief operations by leveraging NASA's UAS Traffic Management (UTM) System and JAXA's Disaster Relief Aircraft Information Sharing Network (D-NET) system.

Approach

- Established connectivity between D-NET system in Japan and UTM system at NASA Ames that enabled real-time data exchanges for international simulation and testing.
- Participated in live, large-scale disaster drill in Japan with the flight of a helicopter and sUAS operations managed by an integrated D-NET and UTM systems.
- Established the use of UTM as a means for mission planning in an incident command center
- **Period of Performance:** FY16-FY20 & FY22-FY25



Live view from Operations Center in Ehime, Japan of D-NET display with integrated UTM operations and response helicopter in flight as part of 2018 large-scale disaster drill.



2019 Pilot assessment of UTM volume alignment with natural landmarks

Demonstrated the use of UTM as a common situation awareness tool for incident commanders, UAS pilots, and helicopter pilots to support safety during disaster relief operations



Prior Research:

Scalable Traffic Management for Emergency Response Operations (STEReO)

Objectives

- Feasibility study to explore the use of innovative automated air traffic management (ATM) and autonomous vehicle capabilities in wildfire operations.

Approach

- Provide NASA Aeronautics expertise in (1) Communication, (2) UAS Traffic Management (UTM) (3) Autonomy, and (4) Human Factors
- Leverage partnerships for domain expertise and tools
- Develop prototypes for UTM, communication, aircraft tracking, situation awareness displays, and vehicle autonomy to test in partner wildfire training exercises
- **Period of Performance:** FY20-FY22



US Forest Service National Aerial Supervision Training Academy (NASTA) in Mesa, AZ (Spring 2021)



CAL FIRE Aerial Supervision Academy (CASA) in Redding, CA (Spring 2021)

Demonstrated the potential to remove barriers limiting the broader integration of UAS into wildfire operations, which would transfer risk from firefighters



Advanced Capabilities for Emergency Response Operations

DAYTIME OPERATIONS

NIGHTTIME OPERATIONS



SATELLITE

AIR TACTICAL GROUP SUPERVISOR



HALE

TERRESTRIAL COMMUNICATIONS



LOGISTICS



AIRCRAFT SAFETY



TANKER

PILOTED HELICOPTER



REMOTE SENSING

REMOTELY PILOTED HELICOPTER



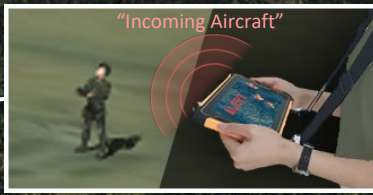
SEARCH AND RESCUE



AERIAL IGNITION



WILDFIRE AIRSPACE MANAGEMENT



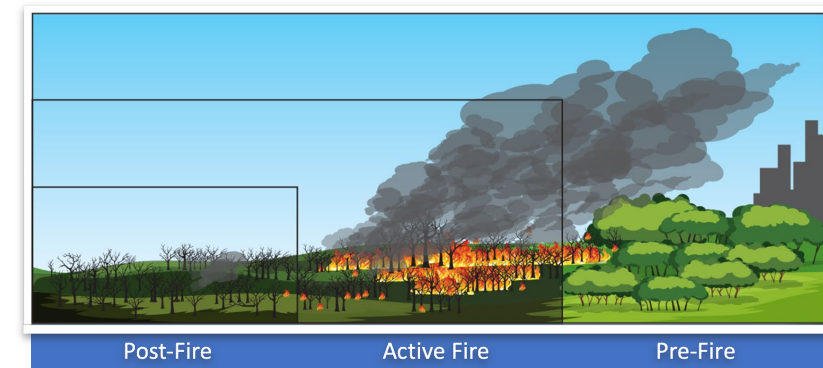
DECISION SUPPORT



GOAL: Develop, demonstrate, and transition to operations, emerging aviation technologies to identify, monitor, and suppress wildland fires, as a means to enhance safety, improve efficiency, and prevent economic loss.

ACERO Objectives

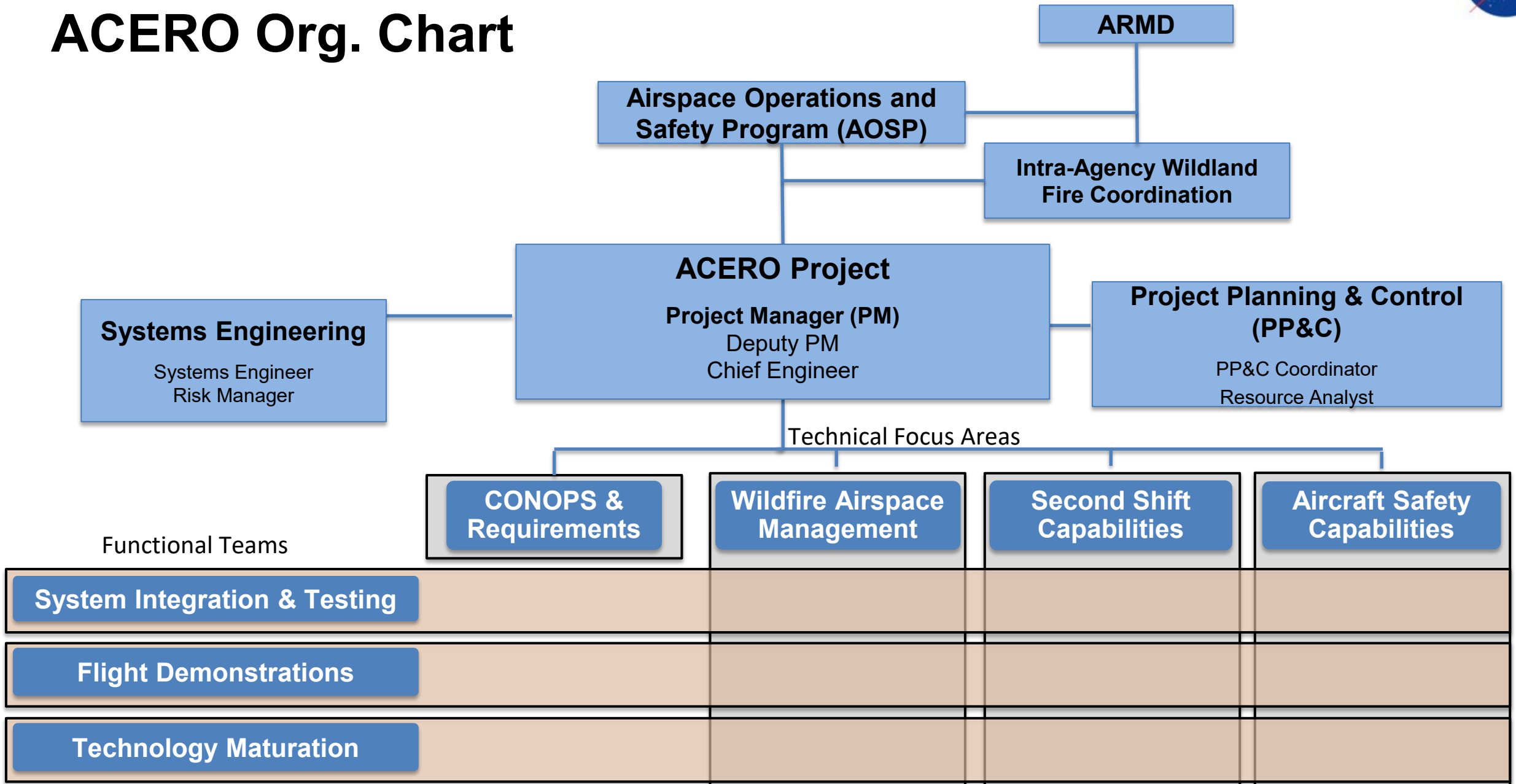
- ❑ Demonstrate emerging airspace management technology to improve emergency responder's effectiveness and safety during a disaster
- ❑ Develop and demonstrate new mission capabilities using emerging aviation technologies that provide resilient and interoperable communication, navigation, surveillance, and mission support to extend disaster response operations (e.g., Second Shift)
- ❑ Integrate NASA Science Mission Directorate Earth Science sensing capability and flight assets, with NASA ARMD airspace and vehicle operations capabilities to enable expanded and scalable aircraft operations
- ❑ Leverage public-private partnerships to develop and test prototype capabilities



ACERO aims to benefit society through the modernization of disaster response operations



ACERO Org. Chart





Technical Scope

Application Readiness Level



CONOPS

Develop interagency concept of operations to ensure consistency of operational priorities, technology adoption, and programmatic alignment for national needs

Wildfire Airspace Management

Develop, mature, and demonstrate technology to modernize airspace management that improves emergency responder's effectiveness and safety

Second Shift Capabilities

Develop, mature, and demonstrate aviation technologies that provide resilient and interoperable communication, navigation, surveillance, and suppression to extend disaster response and recovery for aerial operations

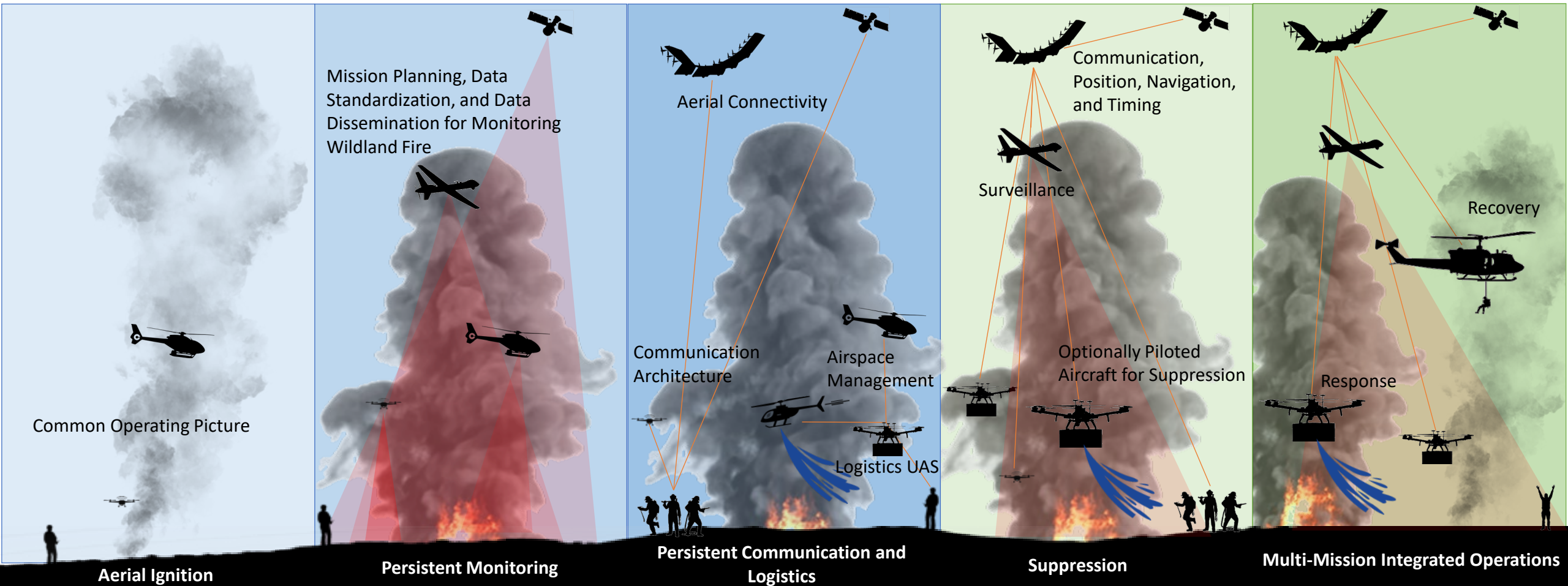
Aircraft Safety Capabilities

Develop, mature, and demonstrate technology that improves aircraft and operational safety during a disaster

Goal: To demonstrate technology that meets operational requirements for stakeholder adoption



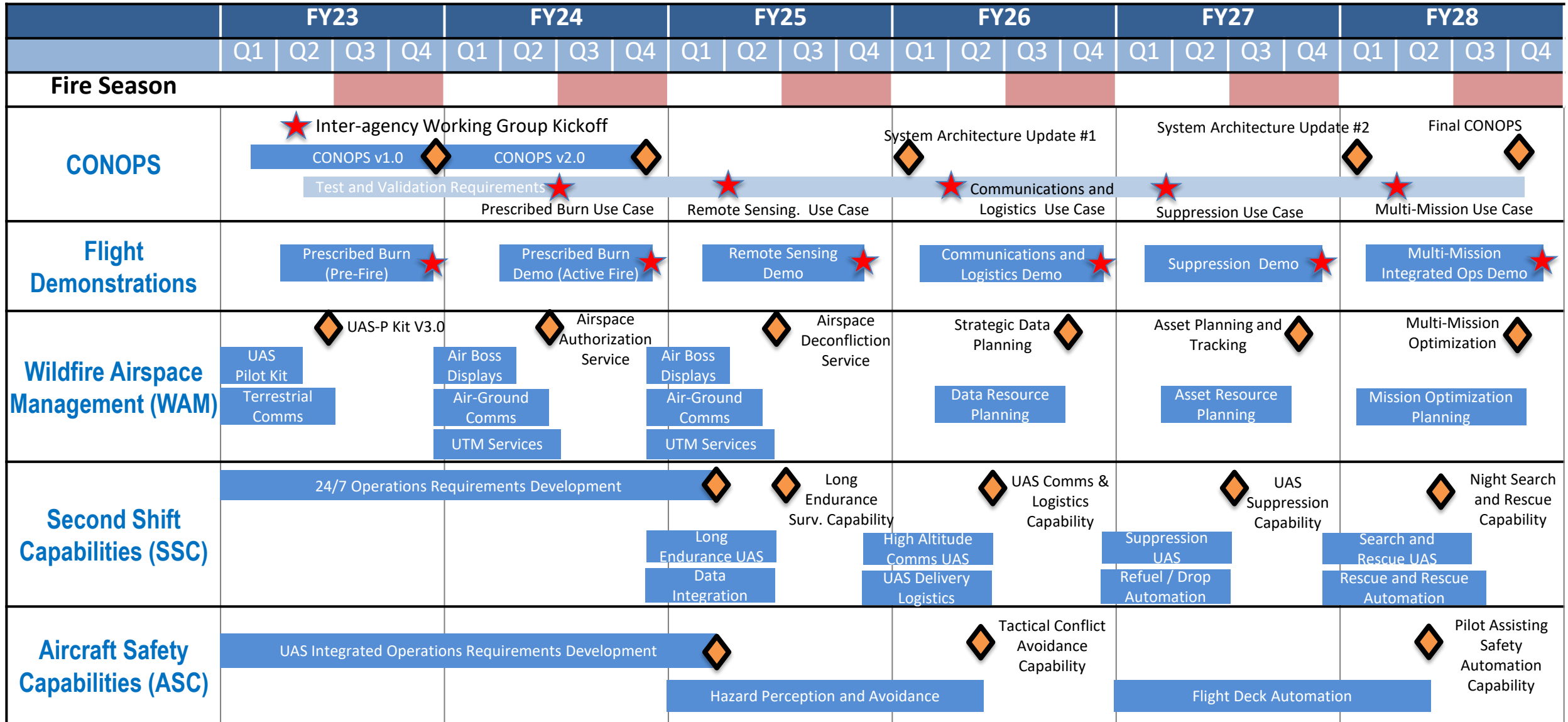
ACERO Use Cases



ACERO will focus on the identification, monitoring, and suppression of wildland fires by developing airspace management and aircraft capabilities for safely integrating remotely and optionally piloted aircraft into the wildland fire operations



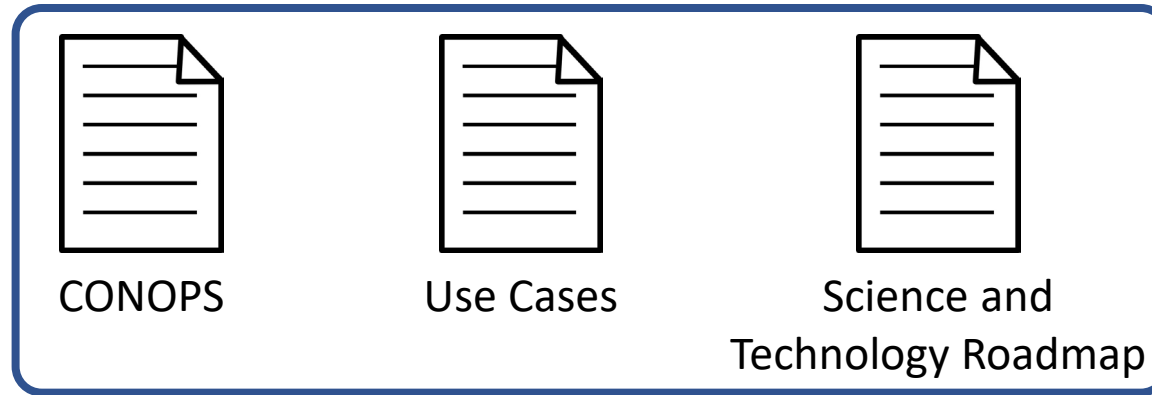
ACERO Approach



★ Milestone Deliverable



CONOPS Intended Use



MISSION



VALUES

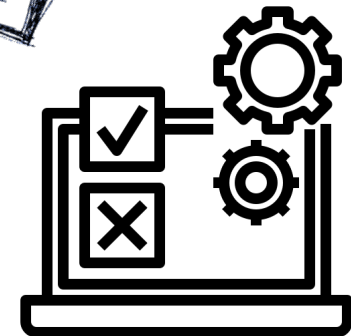


VISION

Documented Stakeholder Vision and Roadmap for Wildland Fire Management to Support Future Implementations / Harmonization / Collaborations



Documented Concepts, Needs, and Requirements to Guide Science and Technology Development



Informs Demonstrations, Validation, and Transition Strategies



Topics for Discussion



Summary

- Wildfires are a growing global issue and NASA must:
 1. Unify the wildland fire community around a future vision for wildland fire management
 2. Develop, mature, and transfer technologies that meet stakeholders needs
 3. Leverage technology and lessons learned from wildfire response for other emergency operations
- ACERO will focus on high impact technology development, demonstration, and technology transfer to the wildland fire stakeholders
- ACERO aims to modernize wildfire operations by focusing on CONOPS, Wildfire Airspace Management, Second Shift Capabilities, and Aircraft Safety Capabilities.
- ACERO will leverage external coordination during formulation:
 - Research Transition Team with the FAA
 - Existing collaborations with USFS , CALFIRE, and JAXA
 - Engagement with industry and academia to understand the current technology state-of-the-art and encourage future collaboration

The ACERO project is currently in formulation and is currently working on an inter-agency CONOPS



Backup



Bilateral Partner Engagement During Formulation



United States Forest Service (USFS)

- 5-year inter-agency agreement (executed 9/2020)
- Goal: Help modernize the USFS aerial operations associated with emergency response



California Department of Forestry & Fire Protection (CALFIRE)

- 5-year non-reimbursable space act agreement (executed 4/2021)
- Goal: Modernize emergency response operations



Japan Aerospace Exploration Agency (JAXA)

- 3-year non-reimbursable space act agreement (executed 9/2021)
- Goal: Conduct research on the integration of manned and unmanned aircraft into emergency response operations



Federal Aviation Administration

- Interagency Research Transition Team (to be executed by Q2 FY23)
- Goal: Conduct research to support the development of a CONOPS and develop interfaces between future airspace management technologies supporting disaster response areas (e.g., TFR) and the air traffic management system.



Sources

- Slide 1:
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Sources

- Slide 3:
 - <https://firststreet.org/research-lab/published-research/article-highlights-from-fueling-the-flames/>
 - 5th National Climate Risk Assessment, First Street Foundation
 - Attribution-Non Commercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0)
- Slide 5:
 - Top: Photo by NASA
 - Bottom: (see slide 1, top)
- Slide 6: Illustration by NASA



Sources

- Slide 7:
 - All three photos provided by JAXA under Space Act Agreement
- Slide 8: Photos by NASA
- Slide 9: Illustration by NASA
- Slide 10: Illustrations by NASA
- Slide 13: Illustration by NASA