Safety Demonstrator Series for an In-Time Aviation Safety Management System

Natasha A. Neogi & Summer Brandt
System Wide Safety Project
Airspace Operations and Safety Program
NASA Aeronautics Research Mission Directorate
January 20, 2023

SWS Overview & TC5

Operational Safety (Thrust 5)

TC-1: ***Predictive Terminal Area Risk Assessment***

TC-2: ***IASMS SFCs for Emerging Operations***

Safety Demonstrator Series
Operational demonstration of and recommendations for requirements and standards necessary to monitor, assess, and mitigate risks to assure safety in disaster-oriented operations.

Current Day

Near Future

Transforme

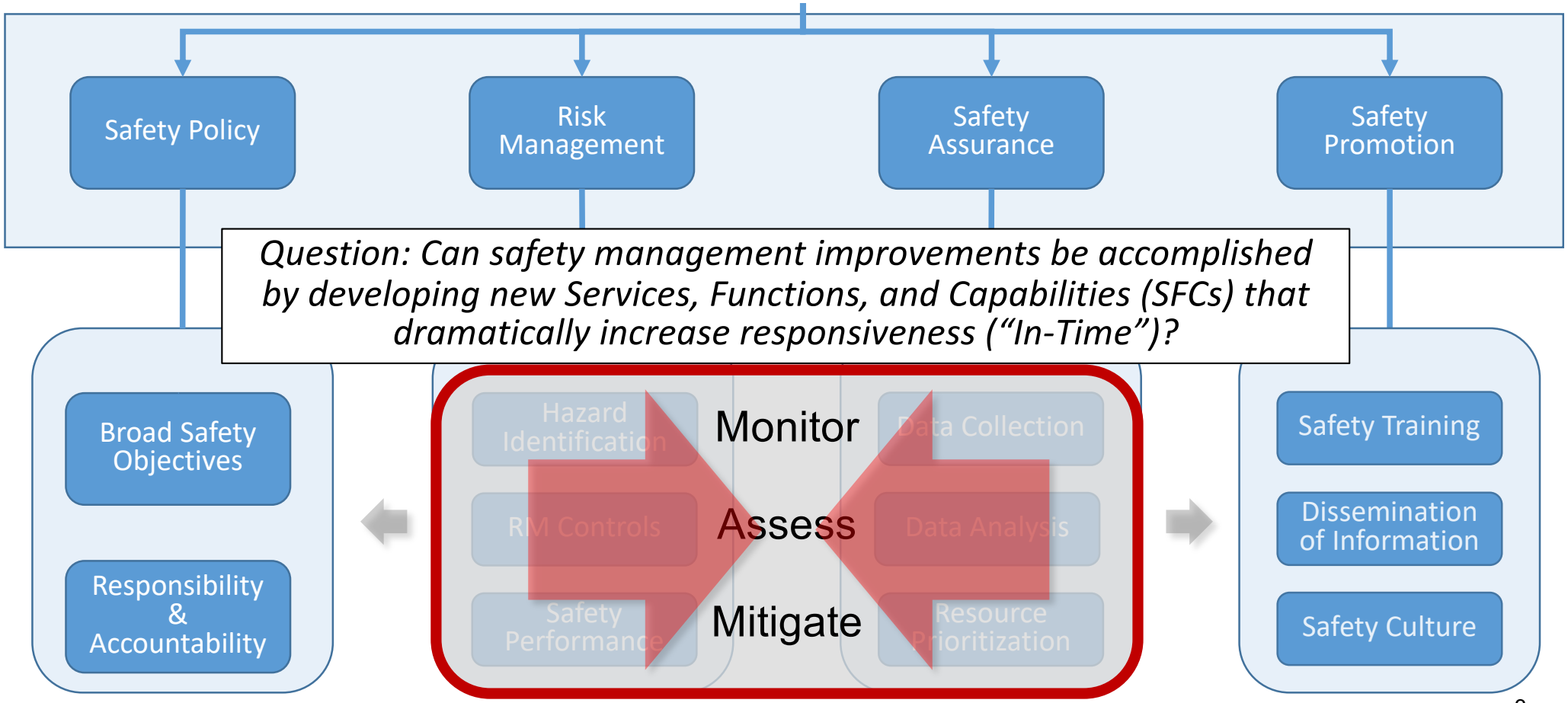
TC-5: Safety Demonstrator Series for Operational IASMS

TC-3: ***V&V for Commercial Operations***

TC-4: ***Complex Autonomous Systems Assurance***

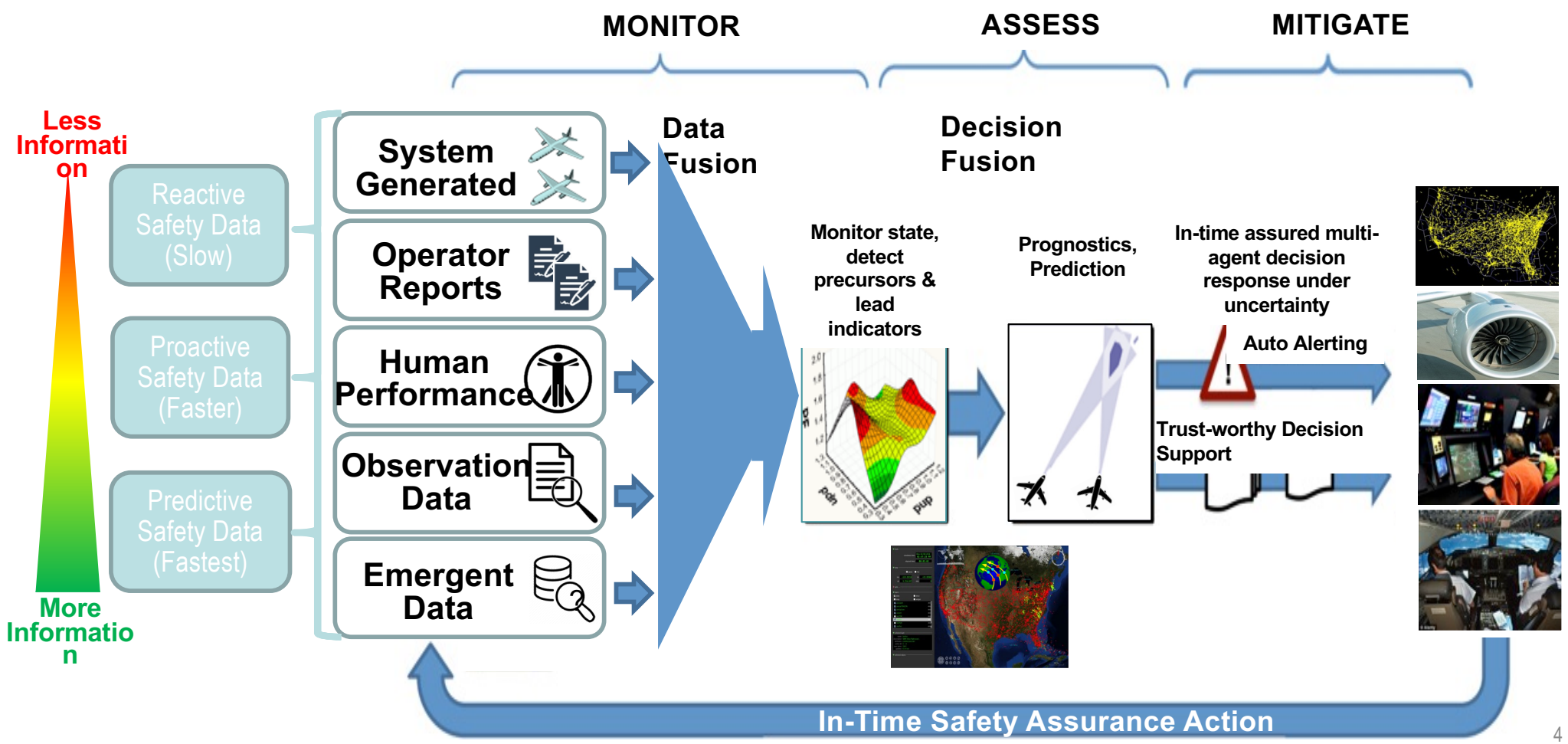
Design Safety (Thrust 6)

In-Time Aviation Safety Management (IASMS)



Ref: National Academies, In-Time Aviation Safety Management: Challenges and Research for an Evolving Aviation System, 2018.

SMS Path to the Future: IASMS



Scheduled Progression

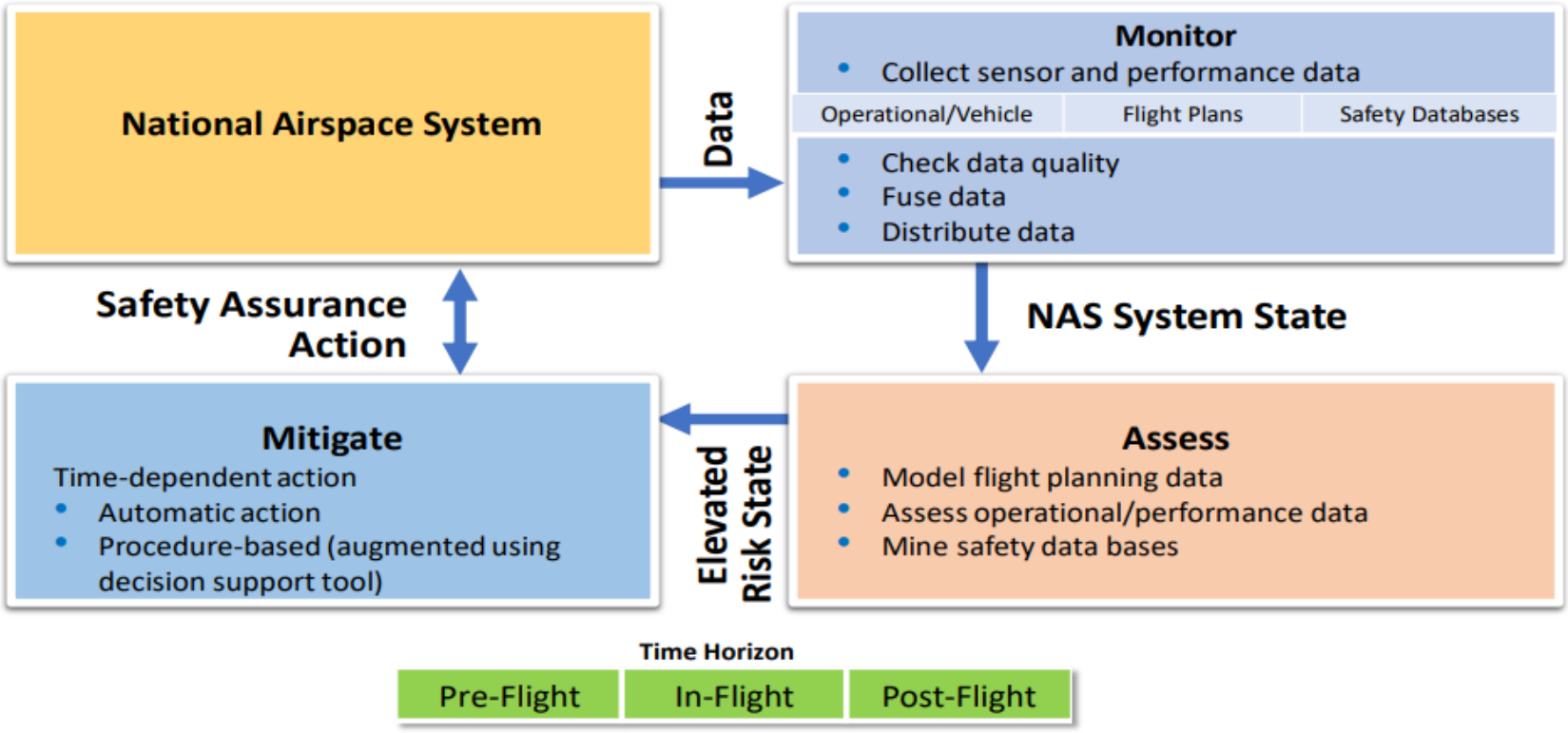
SD-1 (FY 25)	SD-2 (FY 27)	SD-3 (FY 28)	SD-4 (FY 30)
Wildfire Fighting	**Hurricane Relief and Recovery**	**Emergency Medical**	**Urban Disaster Relief**
! HIGH Rural and partially evacuated area	! MED Partially evacuated area	! LOW Urban area	! LOW Urban area
LOW-MODERATE Intensive HMI and lack of commercial flights	MODERATE Numerous agencies coordinating multiple relief efforts	MODERATE Regularly scheduled commercial flights	HIGH - - - - -
? LOW-MODERATE Unknown location of fire; poor visibility	? MODERATE-HIGH Unknown state of terrain; poor infrastructure	? MODERATE All weather operations	? HIGH - - - - -
Environment: Low Visibility, Smoke...	**Environment:** Low Visibility, RF/EMF Hazards, Poor Weather…	**Environment:** Urban Airspace, RF/EMF Hazards…	**Environment:** Degraded Infrastructure, RF/EMF Hazards…
Vehicle & Mission: sUAS, mid-size UAS/ Short Range	**Vehicle & Mission:** sUAS, mid-size UAS, large UAS/ Multiple Days	**Vehicle & Mission:** sUAS, mid-size UAS, large UAS/ Short to Long Range	**Vehicle & Mission:** sUAS, mid-size UAS, large UAS/ Multiple Days
Human Role: High	**Human Role:** Medium	**Human Role:** Low	**Human Role:** Multiple Simultaneous HMI paradigms

! Risk Tolerance Complexity ? Uncertainty

5

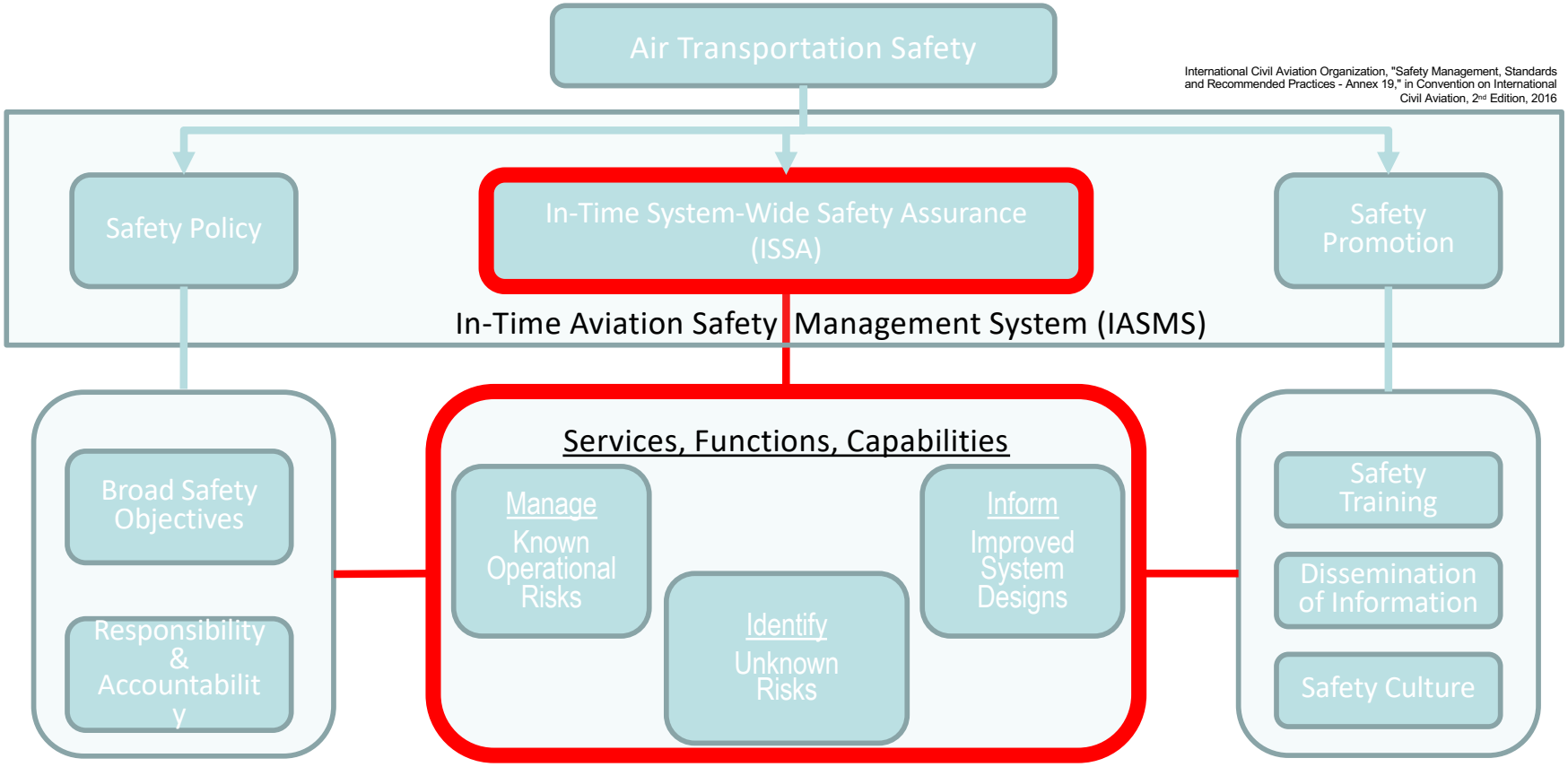
ConOps and Information Flow

Services and Functions enabling new Capabilities



Ref: [20] Ellis, K., et. al., "A Concept of Operations (ConOps) of an In-time Aviation Safety Management System (IASMS) for Advanced Air Mobility (AAM)," AIAA SciTech 2021.

How We Achieve Aviation Safety Tomorrow

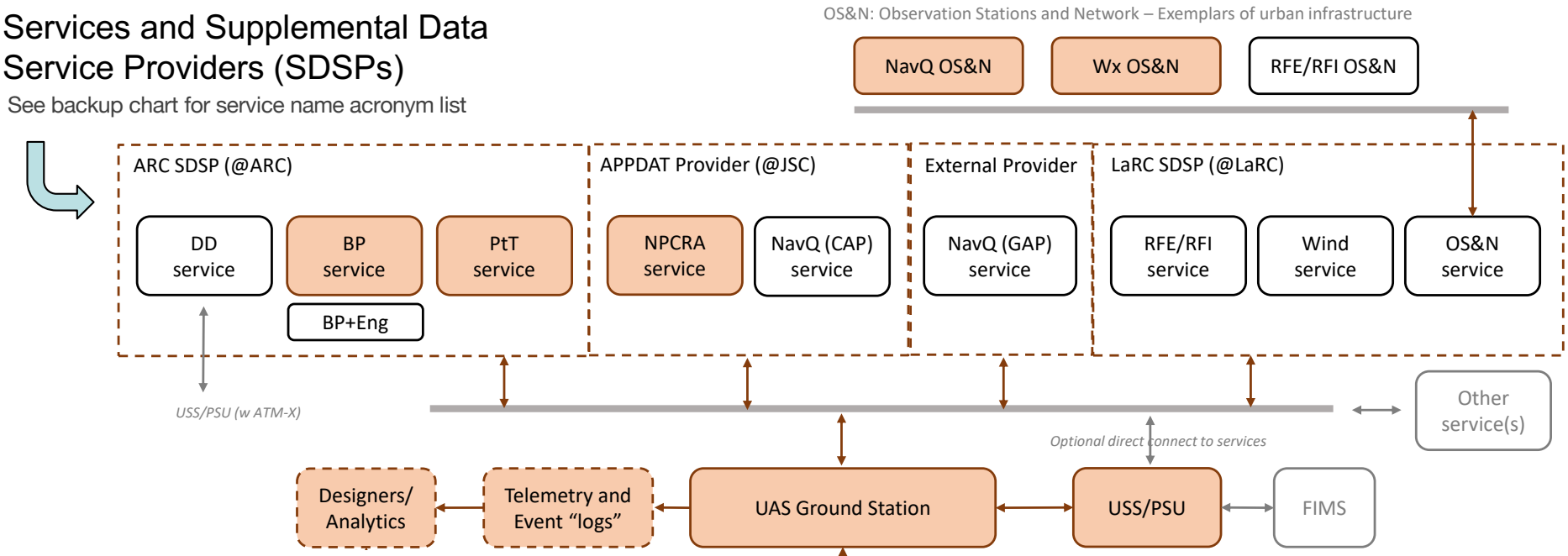


(1) Quickly manage known operational risks at scale; (2) Quickly identify unknown risks; (3) Quickly inform design

Test and Demonstration System

Services and Supplemental Data Service Providers (SDSPs)

See backup chart for service name acronym list



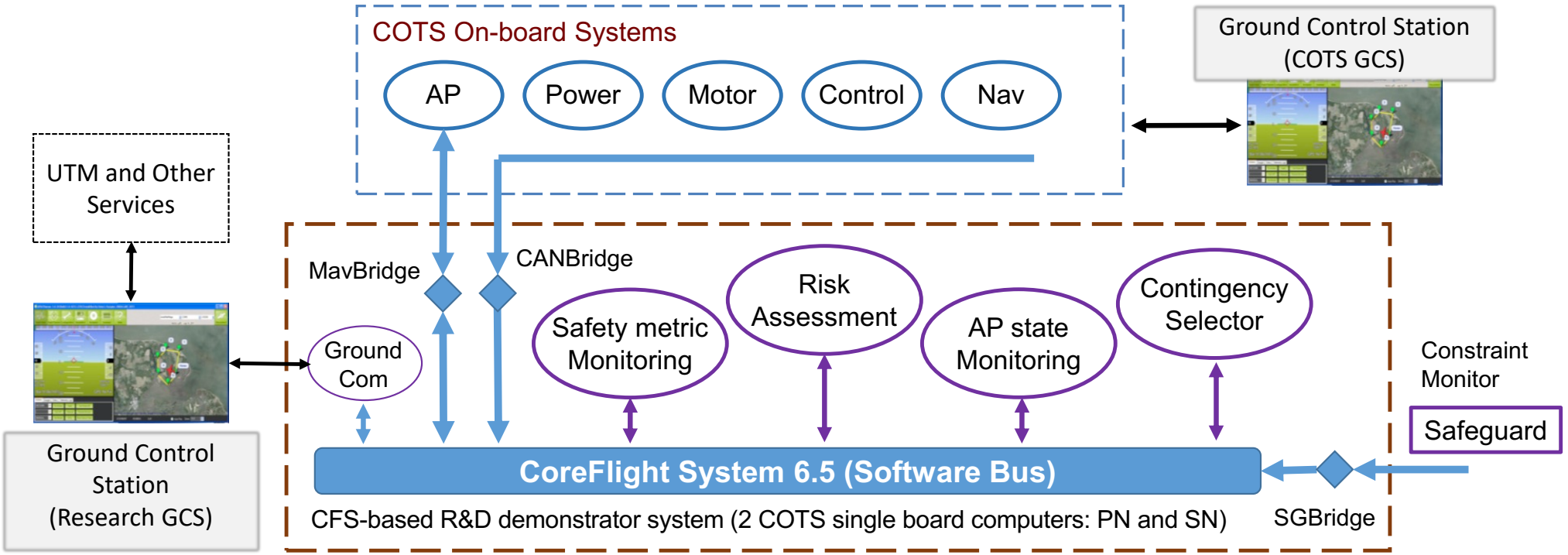
Evaluations:

- >20 developmental SFCs; 4 SDSPs
- Design assurance framework
- Information exchange performance and protocols

Part of Phase 1 and 2 testing

Added for Phase 2 testing

Vehicle System



AP – Autopilot; CFS – CoreFlight System; PN – Primary Node; SN – Secondary Node

AIAA Aviation 2022 Forum Papers

Session ATS-07

(Young) “Flight Testing of In-Time Safety Assurance Technologies for UAS Operations”

(Ancel) “Design/Testing of an Approach to Automated In-Flight Safety Risk Management for sUAS Ops”

(Banerjee) “Probability of Obstacle Collision for UAVs in Presence of Wind”

(Gutierrez) “A High-Perf. Computing GNSS-Aware Path Planning Algorithm for Safe Urban Flight Ops”

Session ATS-09

(Neogi) “Establishing the Assurance Efficacy of Automated Risk Mitigation Strategies”

(plus 4 papers by our partners doing work leading to 2023+ evaluations)

George Washington University; MIT Lincoln Labs; University of Texas (Austin); Vanderbilt University; University of Notre Dame; Iowa State University; Virginia Commonwealth University; and the National Institute of Standards and Technology

Other

(Feldman) “Developing a Dashboard Interface to Display Assessment of Hazards/Risks to sUAS flights”

(Spirkovska) “Urban Air Mobility Airspace Dynamic Density”

Service Name Acronyms (see chart 13)

DD – Dynamic Density service, a service supporting air traffic management safety by tracking (and forecasting) metrics associated with air traffic density for selected airspace volumes.

BP – Battery Prognostics service, a service that tracks and predicts state-of-charge and remaining useful life of onboard power source(s).

PtT – Proximity to Threat service, a service that tracks and predicts proximity (and safety margins) for high-risk areas near the flight path (e.g., the perimeter of vertical structures).

NavQ CAP – Navigation Quality Corridor Assessment of Positioning service, a service that provides estimates of navigation-related performance measures along a user-specified flight corridor and time window.

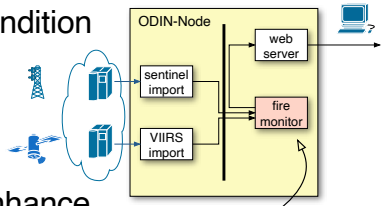
NavQ GAP – Navigation Quality Geometric Assessment of Positioning service, a service that provides estimates of navigation-related performance measures over a user-specified coverage and time window.

RFE/RFI – RF Environment and RF Interference service, a service that provides estimates of RF-related performance measures over a user-specified coverage area and forecast period.

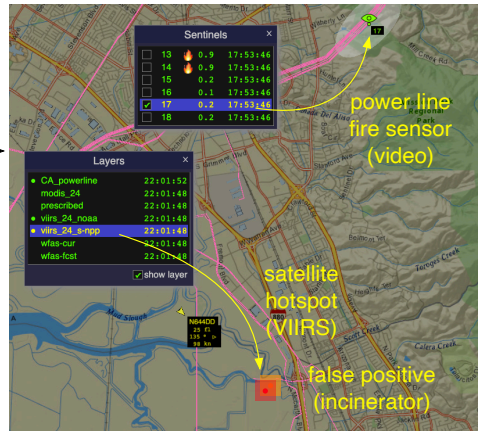
Information Flow Monitoring

Motivation and Objectives

1) Monitor for adverse condition

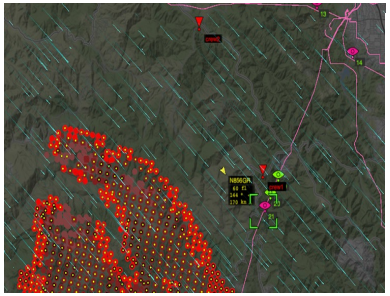


2) Enhance situational awareness



Progress, Status, and Highlights

- Developed sample probabilistic properties and formalizations
- Developing a registry of Wildfire Fighting Data Sources
- Delphire, a small company developing powerline sensors, incorporated ODIN into their presentation to NWCG TFRSAC; preparing for proposal to CalFire.



Approach

1) Monitor for conditions
   - Develop monitorable properties of the wildland firefighting domain
     - Probabilistic properties too
   - Enhance the FRET requirements tool to be able to express them
   - Generate CoPilot real-time monitors

2) Configurable dynamic display of multiple data sources
   - Online Data Integration (ODIN): Just need a browser
   - Data sources such as fire/smoke detectors on powerlines, satellite heat data, 3-d buildings, terrain, air traffic, assets, fire spreading models, weather (wind, ...) …
   - Data age indication on single display

Milestones, Deliverables and Impact

1) Monitor
   - Notations for expressing probabilistic properties, literature review (08/30/2022)
   - Develop probabilistic properties relevant to the firefighting domain (06/30/2022)
   - Prototype probabilistic property spec lang (12/31/2022)

2) ODIN
   - Identify wildfire fighting data sources (07/31/2022)
   - Identify network capabilities (12/31/2022)
   - Identify monitoring requirements (12/31/2022)