



Flight Path Management (FPM) and Digital Flight (DF)

Xwing Interchange Meeting, May 23, 2022

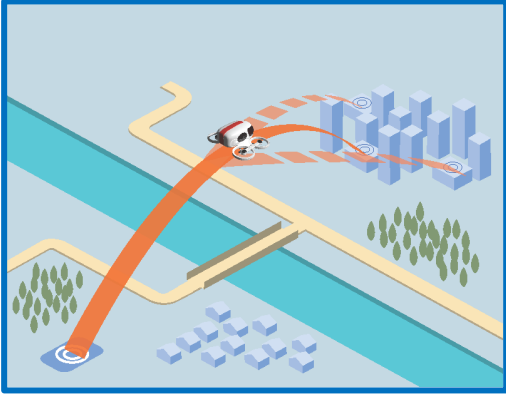


Flight Path Management (FPM) in Context

Functional

AFCM Sub-Project

Mission Management

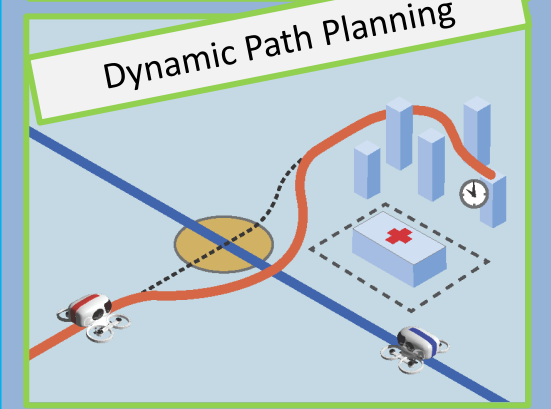


Establish mission objectives
and associated information
requirements

Monitor, decide, revise the
mission parameters as needed

AFCM IPR
Integrated Pilot Requirements

Flight Path Management

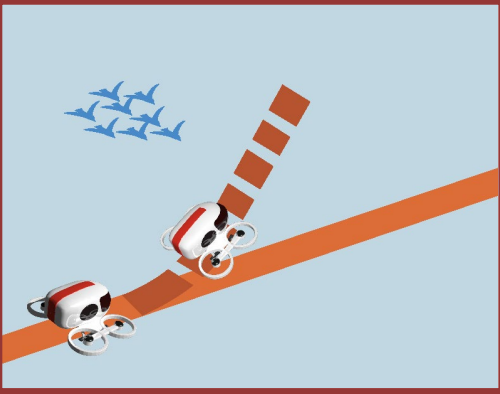


Achieve mission objectives
through flight path creation,
monitoring, and revision

Account for constraints
in the operating environment

AFCM FPM
Flight Path Management

Tactical Operations

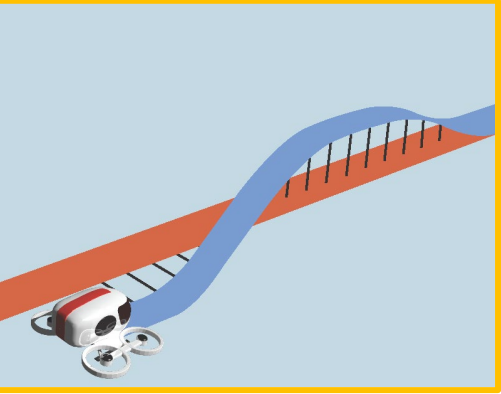


Suspend mission objectives
until safety is restored

Respond to urgent,
unforeseen hazards

AFCM HPA
Hazard Perception & Avoidance

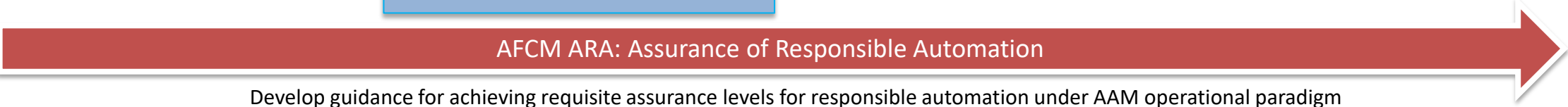
Vehicle Control



Accurately fly the mission plan
Safely fly an established flight path and
land the vehicle

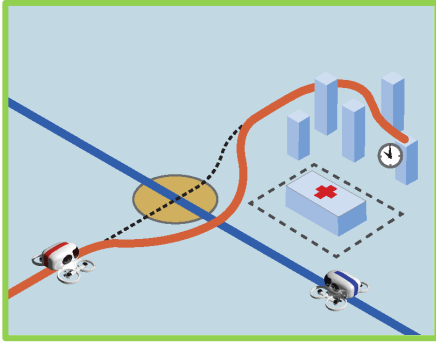
Communicate performance constraints
to FPM, Mission Management

AFCM AHO
Aircraft Handling & Operations





FPM Automation Goals and Objectives



FPM Automation Goals

- **Ensure that a safe and operationally acceptable flight path is available** to the vehicle operator through the life of the flight
- **Achieve mission objectives** within established mission parameters
- **Remain adaptable** to evolving mission objectives, constraints, and external stimuli

FPM Objectives: Create | Monitor | Evaluate | Revise Flight Path to be:

- * Conflict Management
- **Feasible** – Conforms to aircraft performance and range; Complies with airspace structure, rules, and constraints
 - **Deconflicted** – Avoids unsafe proximity to known traffic, terrain, obstacles, weather, and airspace hazards
 - **Coordinated** – Follows cooperative rules and procedures to harmonize with other airspace users
 - **Flexible** – Provides adequate degrees of freedom to enable future flight path changes
 - **Optimal** – Achieves business objectives and preferences of the pilot and fleet operator

Challenge: No certified FPM automation system or industry standards currently exist.

Question: At what point do FPM automation standards become necessary?

Consider: When the operating rules dictate that FPM automation functions are safety-critical*



What Problems are Being Addressed?

Current flight rules and procedures are:

- Not adaptable to meet evolving and diversifying needs for airspace access and operational flexibility
- Not scalable to meet ops tempo and density of new entrants (e.g., UAS, AAM)
 - ATM workload constraints
 - Physical separation constraints
- Not accommodating of future flight concepts (e.g., self-piloted, highly autonomous aircraft)
- Not ensuring operational predictability required for electric-powered aircraft
- Not conducive to capacity growth for runway-independent and non-towered airport operations

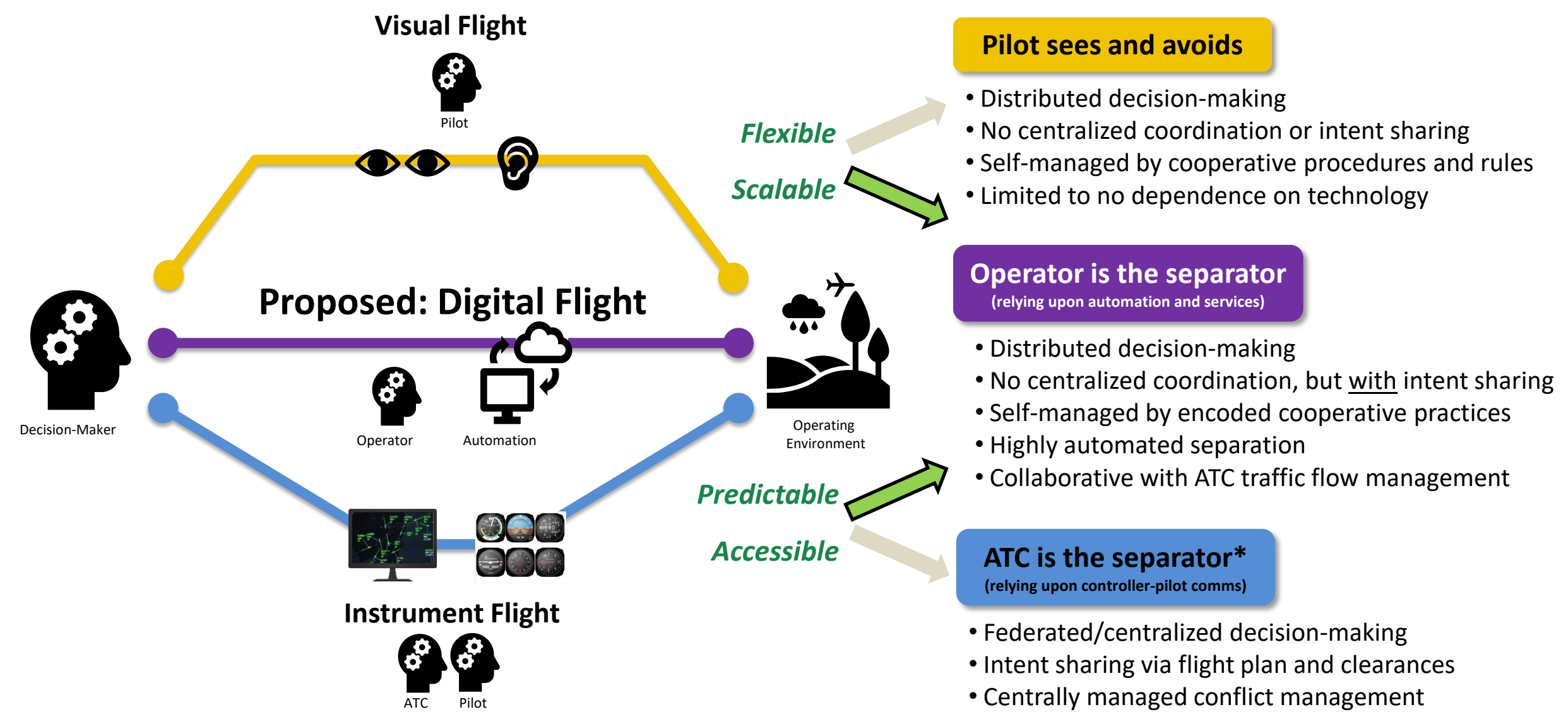
“New and adapted flight rules and procedures will be required to efficiently manage these increasingly dynamic operations of differing priority and types.”

A New Digital Era of Aviation: The Path Forward for Airspace & Traffic Management

-- Airbus and Boeing, 2020



Operating Mode Enabled by Connected Digital Technology



* As defined in ICAO 9854 Global ATM Operational Concept, Section 2.7.18



Digital Flight (DF)

A proposed cooperative operating mode
in which *operators* ensure flight-path safety
through *highly-automated self-separation*
enabled by *connected digital technologies*
and *formal cooperative practices*

in lieu of
VFR's visual procedures and
IFR's ATC separation services

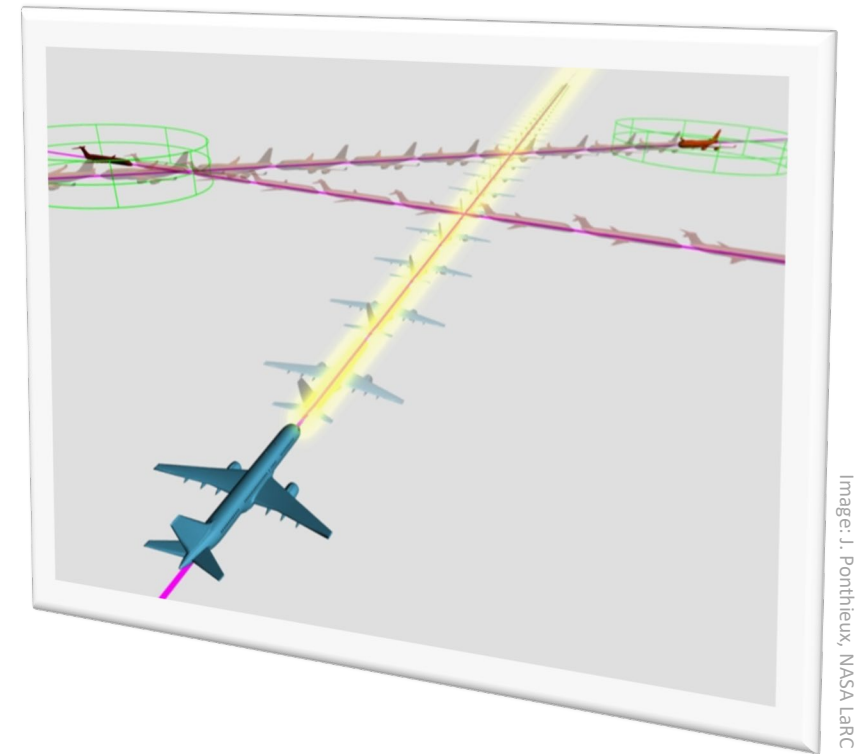
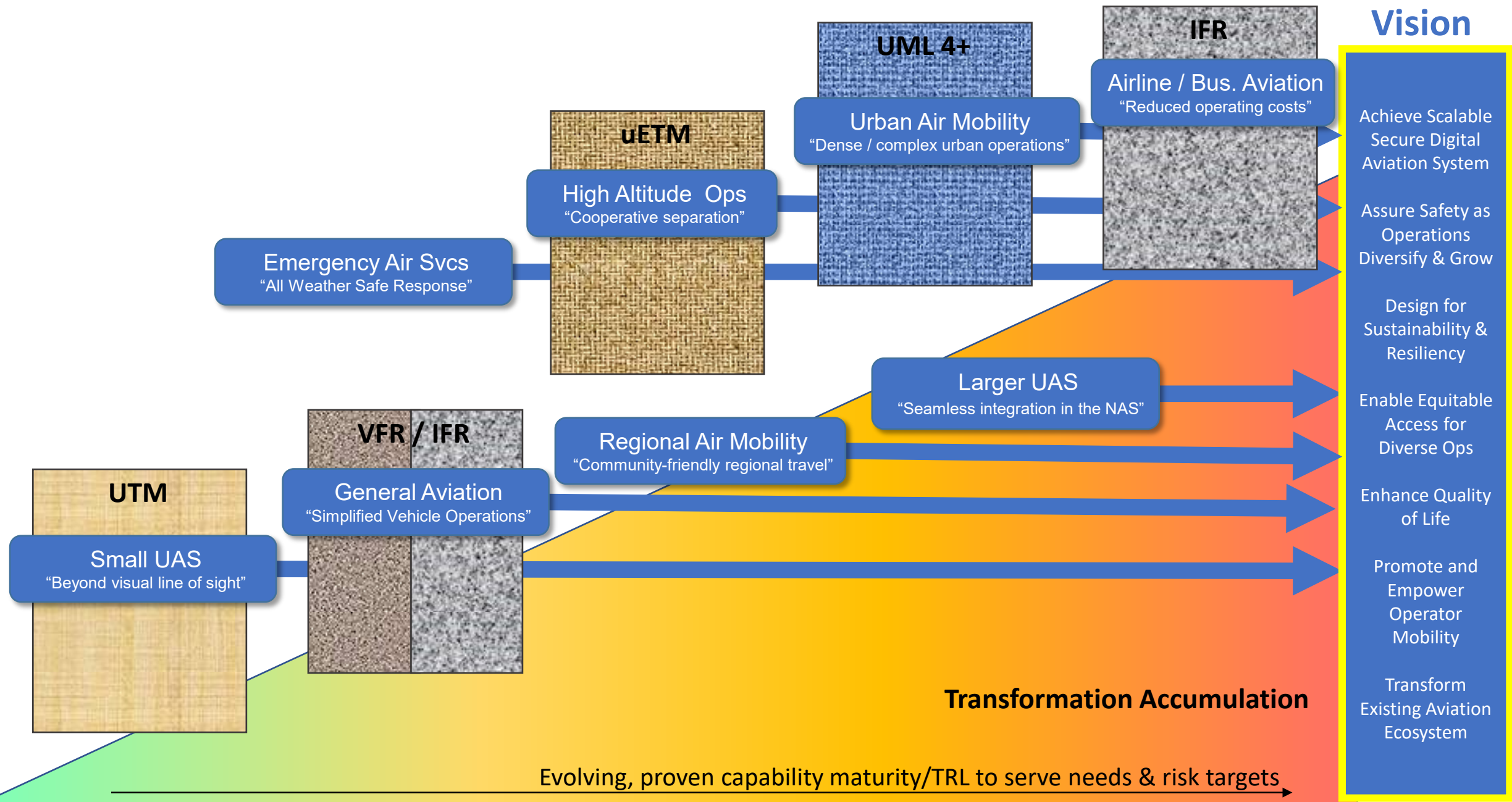


Image: J. Ponthieux, NASA LaRC

Problem: Emerging Patchwork of Operating Modes and Underlying Rules

Sky for All Vision



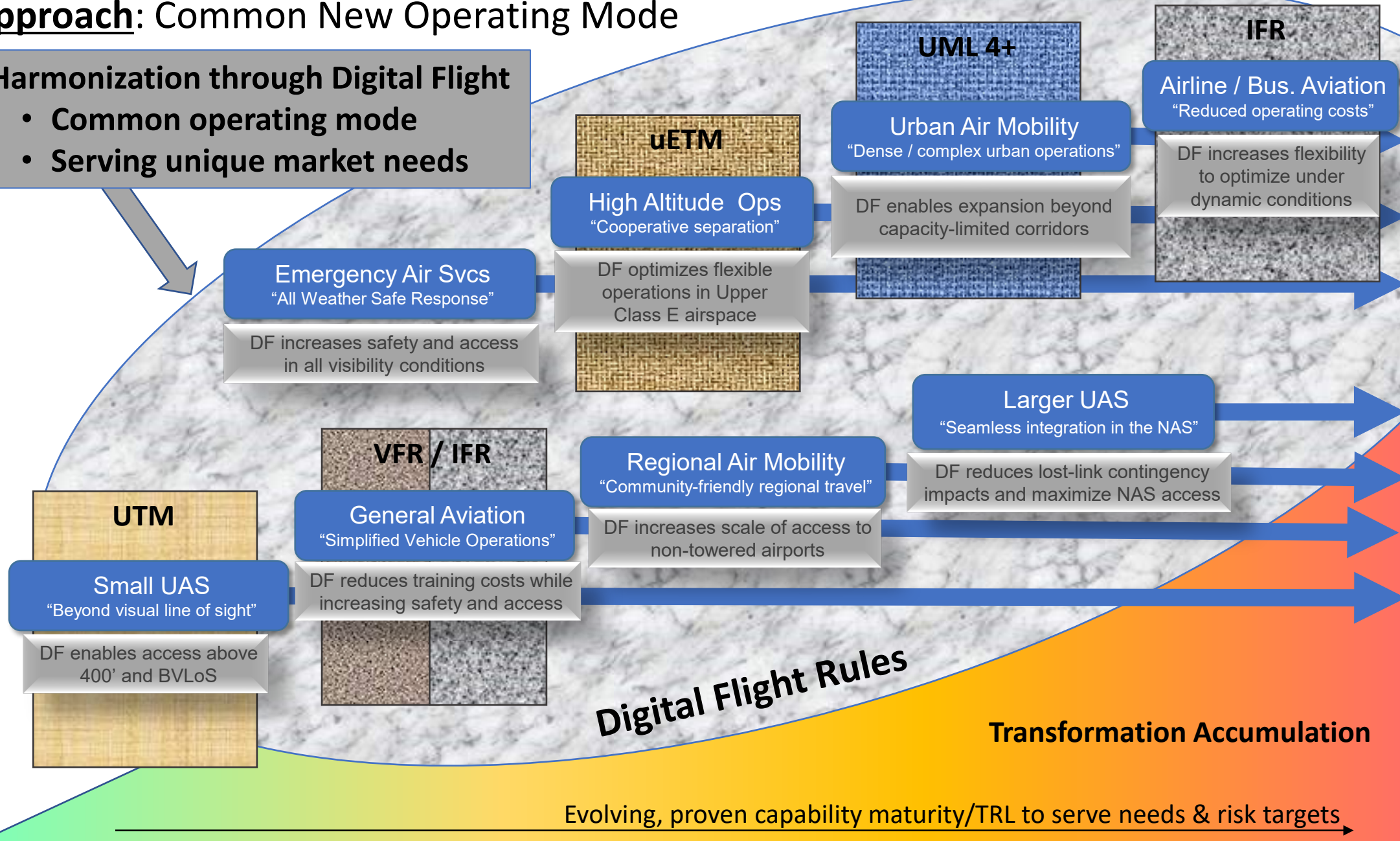
Problem: Emerging Patchwork of Operating Modes and Underlying Rules

Sky for All Vision

Approach: Common New Operating Mode

Harmonization through Digital Flight

- Common operating mode
- Serving unique market needs



Achieve Scalable
Secure Digital
Aviation System

Assure Safety as
Operations
Diversify & Grow

Design for
Sustainability &
Resiliency

Enable Equitable
Access for
Diverse Ops

Enhance Quality
of Life

Promote and
Empower
Operator
Mobility

Transform
Existing Aviation
Ecosystem

Evolving, proven capability maturity/TRL to serve needs & risk targets

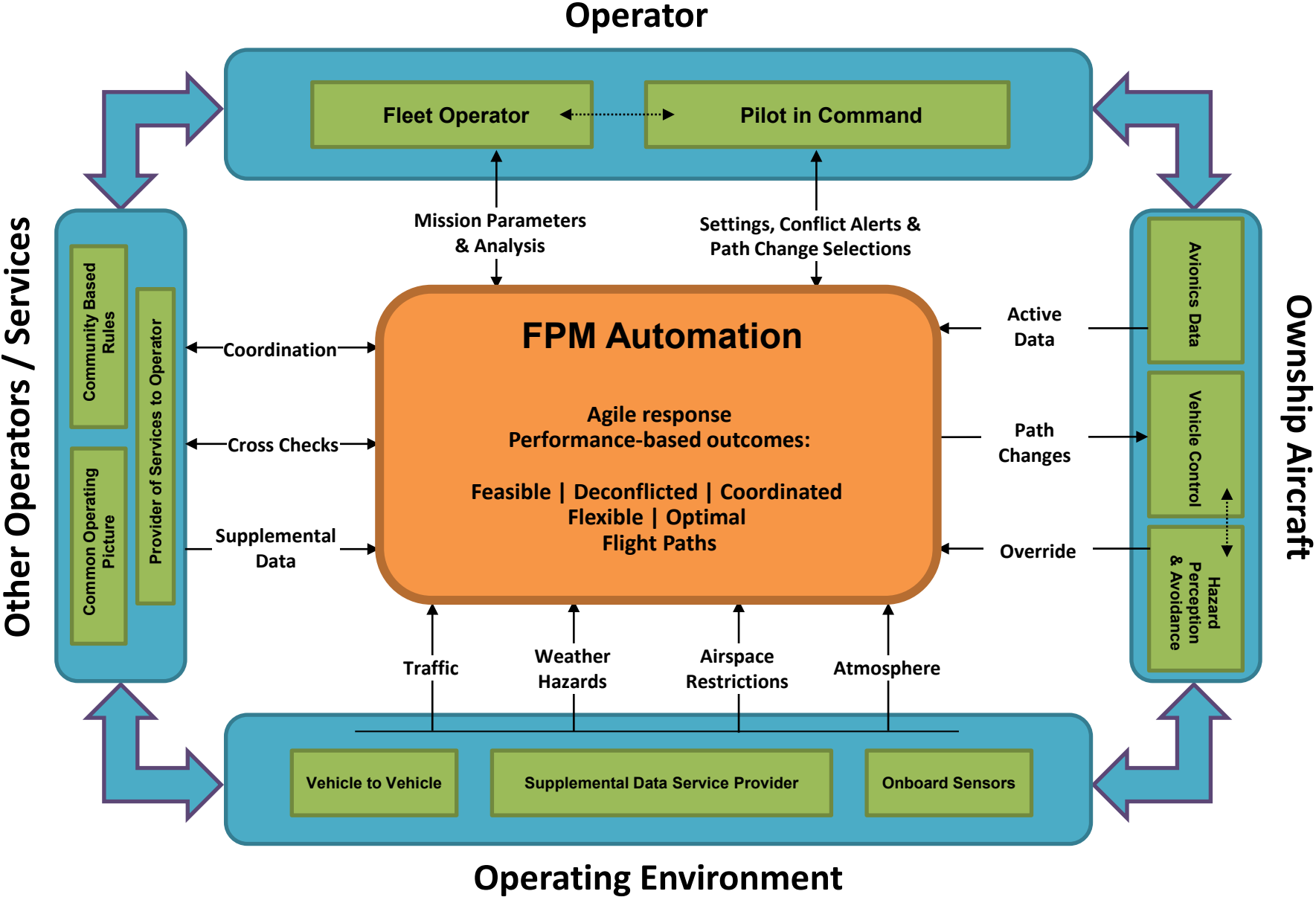


FPM Automation Role in UAM

- FPM Safety Criticality Increases**

 - As UAM Maturity Level (UML) increases
 - As “corridor” capacity and complexity limits are approached or exceeded
 - When operating rules require automation reliance for safety
- FPM Automation Operates at the Intersection**

 - Mission objectives
 - Constraints & coordination
 - Dynamic operating conditions
 - Aircraft capabilities & plan





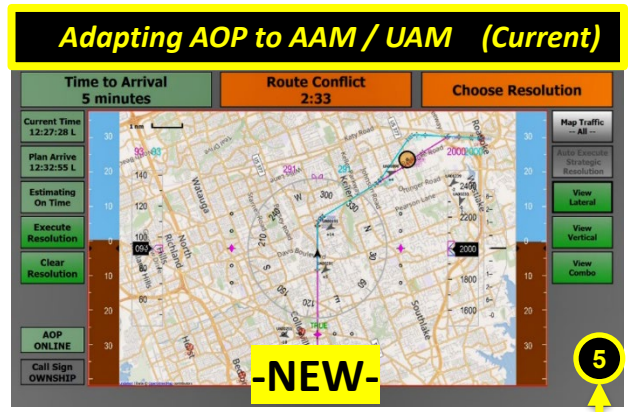
Autonomous Operations Planner (AOP)

Reference Automation System for AFCM FPM Research

AOP Functional Capabilities

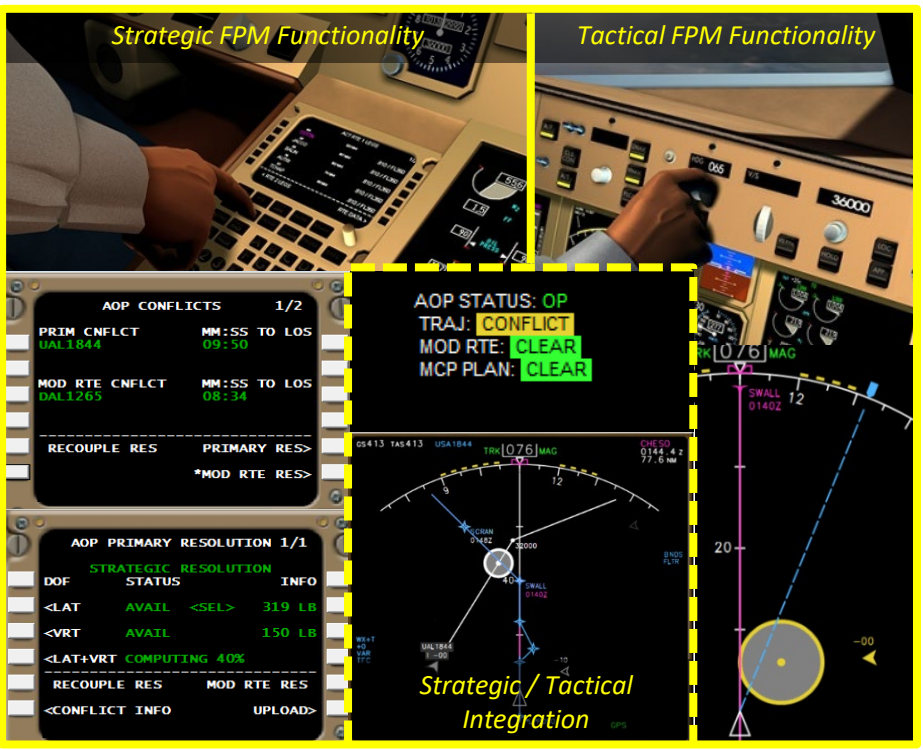
- Predicts trajectories w/ bounded uncertainty
- Detects conflicts w/ traffic & area hazards
- Resolves conflicts strategically & tactically
- Prioritizes safety and coordination
- Complies with arrival time constraints
- Supports conflict-free maneuvering
- Optimizes for time, fuel, and cost index (\$)

- 20+ year history supporting NASA autonomy R&D
- Platform for assessing FPM system requirements
- Advanced algorithms for complex FPM operations



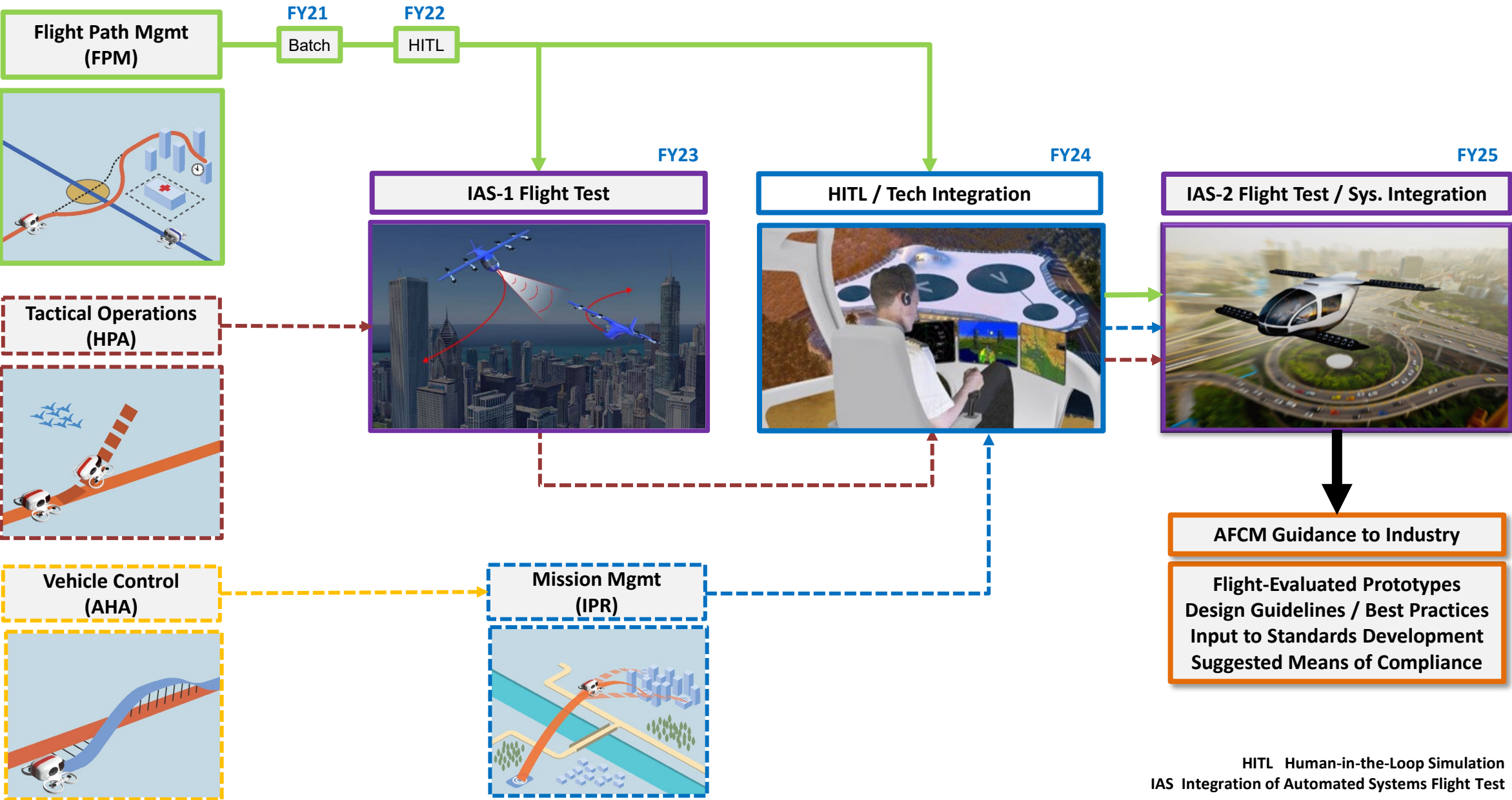
UAM Implementation for UML-4 Research (2019 start)

Initial Implementation for Autonomy Research in Commercial Transport Operations (2001-2019)





AFCM FPM Integration & Testing



HITL Human-in-the-Loop Simulation
IAS Integration of Automated Systems Flight Test