



EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

ATM-X
Air Traffic Management eXploration

ATM-X Overview DLR - NASA Collaboration Year 2 Review

William N. Chan, Project Manager
Shivanjli Sharma, Deputy Project Manager
Kurt Swieringa, Deputy Project Manager for Technology

National Aeronautics and Space Administration



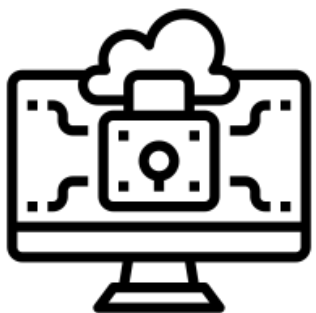
SKY^{for}ALL

TOMORROW'S
AVIATION SYSTEM IS BEING
SHAPED TODAY.





On the Cusp of Transformative Aviation



Advances in flight
software & sensors



Distributed electric
propulsion & batteries
with high energy density



Robust digital
networks

Supporting Multiple Use Cases



Sustainable Conventional Operations



Automated Cargo Operations



Urban Air Mobility



Upper Class E Operations



Digital Services and
Information
Sharing

Evolving ATM Technology for the existing NAS and Developing
Disruptive Capabilities for the Future NAS



Novel Airspace Design
and Frameworks

Communication Links &
Information Protocols

Separation and Flow
Management Algorithms



ATM-X Vision and Goals

Vision: Accelerate transformation to a digitally-integrated air transportation system that enables access and increases mobility for all users

Goal: Catalyze the community to provide an all-access, safe, and efficient airspace system through innovative solutions





ATM-X Project Organization



Air Traffic Management – eXploration

Project Support

Coordinator: Clarissa Thompson
Lead Analyst: Warcquel Frieson
Center Analysts: Brenda McKay,
Meredith Irwin
Schedulers: Natalie Condon,
Donna Gilchrist

Project Office

Project Manager: William Chan
Deputy Proj. Mgr.: Shivanjli Sharma
Deputy Proj. Mgr. - Tech: Kurt Swieringa
Chief Engineer - Dr. Joey Rios

ARD Office

ARC APM: vacant
LARC APM: Dr. Taumi Daniels
GRC APM: Rafael Apaza

Systems Engineering

Lead: Dr. James Chartres
Risk Mgr: Joshua Moody

Sky for All (Vision 2045)

Lead: Shawn Engelland
Dpy Lead: Kurt Swieringa

Sub-Projects

Digital Information Platform (DIP)

SPM: Mirna Johnson
DSPM: Dr. Gilbert Wu

UAM Airspace Management (UAM)

SPM: Kevin Witzberger

DSPM: vacant
PE: Dr. Ian Levitt

Pathfinding for Airspace with Autonomous Vehicles (PAAV)

SPM: Arwa Aweiss
TLs: Tod Lewis,
Rich Coppenbarger

Extensible Traffic Management (xTM)

SPM: Dr. Min Xue
DSPM: vacant
TL: vacant

ATM-X Research Areas



SKY FOR ALL

Digital Information Platform (DIP)

Open-architecture data platform for
advanced data-driven services for all users

Extensible Traffic Management (xTM)

Federated distributed service-based ATM decision-making

Smart Algorithms

Pathfinding for Airspace with Autonomous Vehicles (PAAV)

Seamless, scalable, and robust airspace
integration of increasingly autonomous aircraft

Urban Air Mobility Airspace Management (UAM)

Collaborative ATM decision-making for UAM traffic management



77:14:26
Wind: 22mph
Humidity: 65%

Smart Algorithms

Urban Air Mobility
Airspace Management



UAM Airspace (2021 - 2025)



Develop Early Airspace UML Traffic Management



Support Thrust 1: Safe, Efficient Growth in Global Operations

Support Thrust 6: Assured Autonomy for Aviation Transformation

Today's air traffic management system cannot accommodate UAM operations that will scale over time

NASA will develop and demonstrate community-informed, extensible UAM traffic management enabling low-to-medium density operations (UML2 & early UML3) and deliver validated requirements to the FAA and Industry

Impact

- Help ensure the airspace is ready when the vehicles are ready
- Empower US-based airspace partners to participate early and take a leading role in spreading the NASA-fostered concept internationally



UAM Airspace Research Approach



AURA

PC-12 Data
Collection
Feb 2023

Research to enable digital
communication for
airspace operations

Collaborative simulations with industry to
develop software and community-based rules
for cooperative conflict management

Development of
a UAM airspace
research
roadmap, new
airspace
constructs, and
procedures



Development of
prototype capabilities
and research to
inform requirements
for operator services

Evolving the Airspace Towards UML-4



UAM FY22 Accomplishments

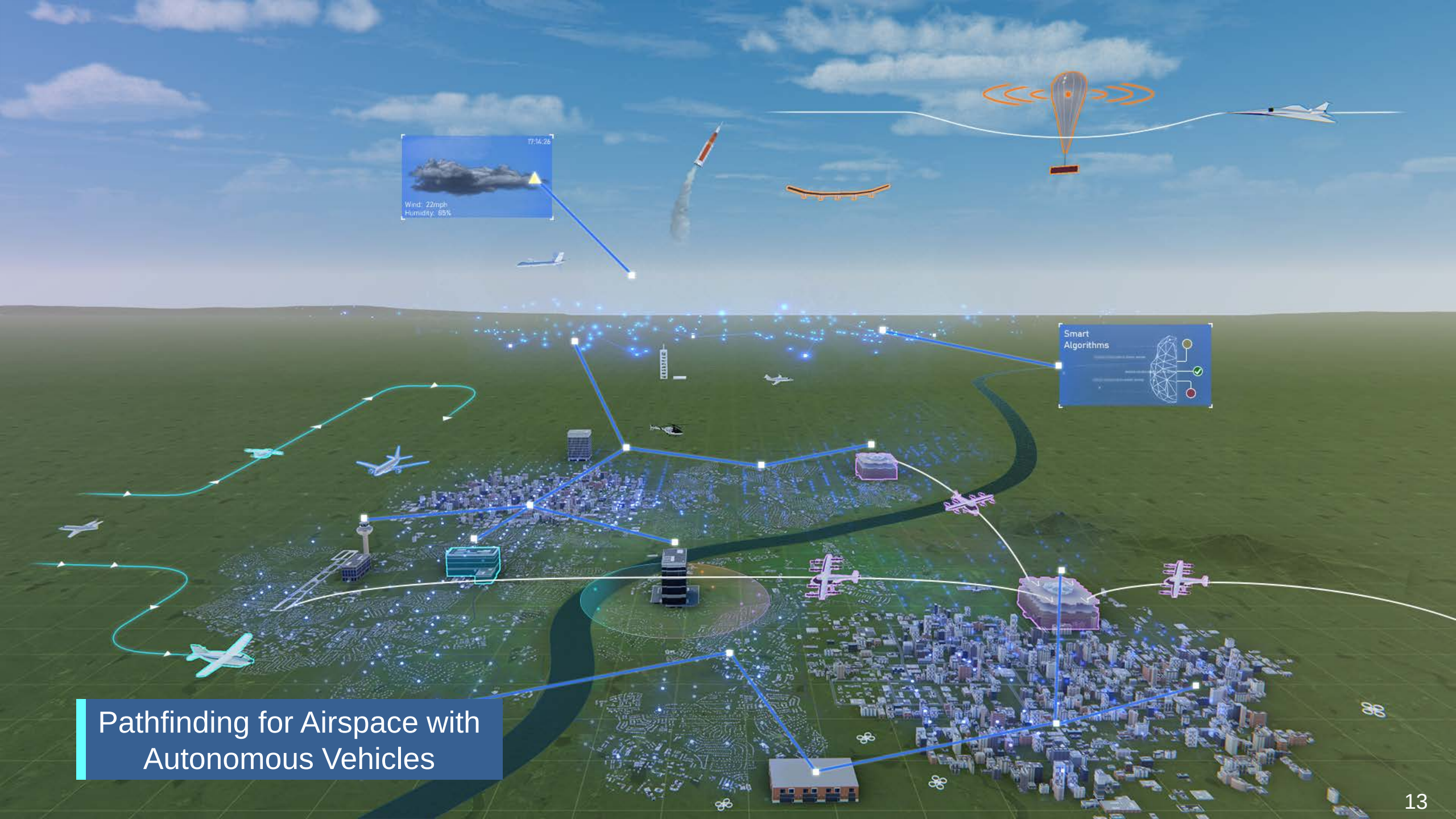


Defining a Stakeholder Informed Path Towards UML-4 Airspace

- ✓ Published UAM Airspace Roadmap V1.2 (June, 2022)
- ✓ Published Secure Airspace publication focused on UAM Secure Airspace Immutable Secure Data Exchange highlighting testing a results and results of a blockchain based model
- ✓ Completed and signed IA between NASA and FAA William J. Hughes Tech Center

Ensuring Stakeholder Acceptance of Airspace Technology

- ✓ Published Technical Memorandum “Near Term Urban Air Mobility Use Cases in the Dallas Fort-Worth Area” in collaboration with FAA and Joby (June, 2022)
- ✓ Completed X4 Collaborative Simulation with Strategic Conflict Management in collaboration with seven partners for National Campaign
- ✓ Implemented and tested SWS Safety Density Metric in X4
- ✓ Delivered updated Provider of Services for UAM and airspace structures data for National Campaign-1
- ✓ Flight test plans developed with Aura Networks including location analysis and communications performance requirements using PC-12 aircraft



Pathfinding for Airspace with Autonomous Vehicles



Pathfinding for Airspace with Autonomous Vehicles (2022 - 2026)

Regional Increasingly Autonomous Flight Operations



Support Thrust 6: Assured Autonomy for Aviation Transformation

The existing air traffic management system does not provide routine access for autonomous vehicles in integrated airspace

Develop concepts, procedures, and technology to enable airspace access for air cargo operations with targeted autonomy in lower complexity airspace shared with conventional aircraft

Impact

Accelerate the US leadership and Industry growth for increasingly autonomous cargo operations at regional airports in the NAS

Reduce the current barriers to scalability by enabling “file and fly” operations with increasingly autonomous aircraft



Motivation for Pathfinding for Airspace with Autonomous Vehicles

Opportunity for Regional Air Mobility

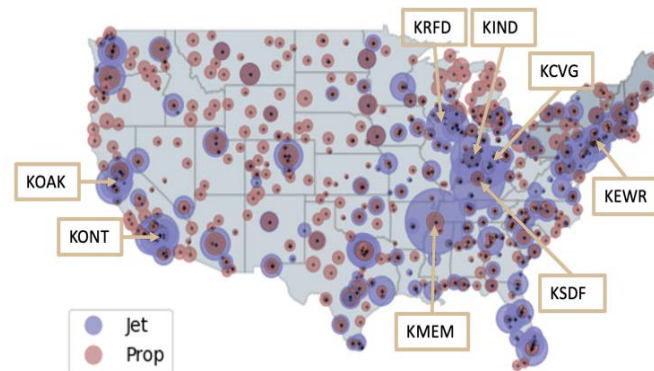
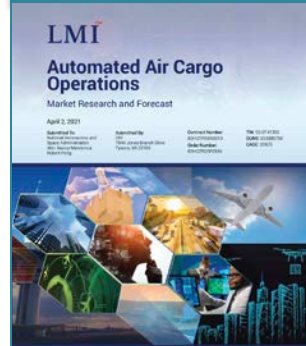
Your local airport is closer than you may realize



"increase the safety, accessibility, and affordability of regional travel while building on the extensive and underutilized ... local airports"

Source: Regional Air Mobility - <https://sacd.larc.nasa.gov/ram/>

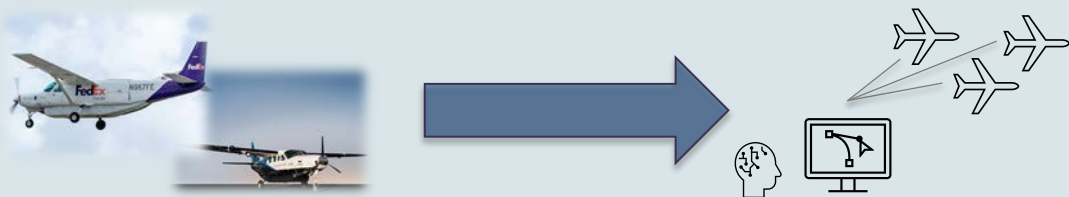
Regional Cargo is an Initial Use Case



- Most promising use case was regional cargo distribution
- Focus on CTOL operations between regional airports shared with conventional IFR and VFR flights

Source: Automated Air Cargo Operations Market Research and Forecast
<https://ntrs.nasa.gov/citations/20210015228>

Industry is Developing Increasingly Automated Aircraft for Regional Cargo



Desire to quickly progress from optionally piloted to remotely piloted to remotely supervised (e.g., m:N)



Operations using conventional airports require airspace integration with IFR and VFR traffic



PAAV Research Needs



Strategic Trajectory Management

Today

Use of **voice communications** and **tactical vectors** for separation and flow management are not scalable to autonomous operations

Future

Data link, digital information sharing, and strategic trajectories that enable separation and management of increasingly autonomous operations (e.g., m:N)

Contingency Management

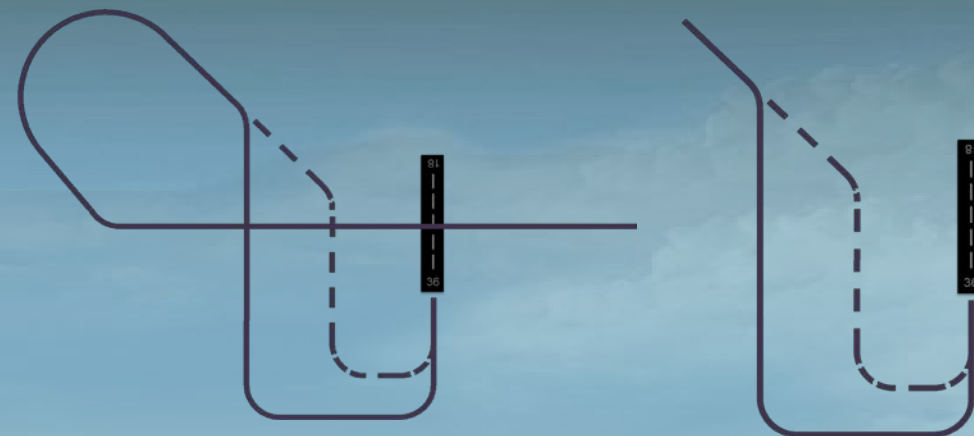
Today

Lost C2 link procedures are **mission specific** other contingencies dealt with through **special accommodations**, which are not scalable

Future

Standardized and predictable mitigations such as lost C2 link and lost ground-based surveillance for DAA (e.g., in traffic pattern)

Traffic Pattern Integration



Today

Pilot expertise and judgement used to fly the traffic pattern, maintain appropriate spacing, and communicate intent

Future

Automation and digital information used to integrate with IFR and VFR aircraft in the traffic pattern and maintain spacing



PAAV FY22 Accomplishments



Concept Development

- ✓ Assessed cargo traffic using a year's worth of data
- ✓ Four Tabletop exercises with subject matter experts (Aug 2020 - May 2022)
- ✓ Completed PAAV Concept Document v1 that identifies challenges and potential solutions for airspace integration of increasingly autonomous aircraft

Research and Development

- ✓ Contributed to RTCA SC-228 lost C2 link guidance
- ✓ Conducted fast time simulations focused on characterizing baseline system impacts due the introduction of remote cargo operations into the NAS
- ✓ Two PAAV Special Sessions at AIAA Aviation 2022 (6 NASA papers)

Stakeholder Engagement

- ✓ Established agreement with Northrop Grumman
- ✓ Established agreement with Ohio Department of Transportation
- ✓ Conducted two technical interchange meetings with Northrop Grumman

DIP

Digital Information
Platform





Technical Challenge (FY22 - 27)



Develop digital information platform for aviation services



Thrust 1: Safe, Efficient Growth in Global Operations

Hard to access and decipher data to provide advanced digital services for efficient airspace operations that is impeding NAS transformation

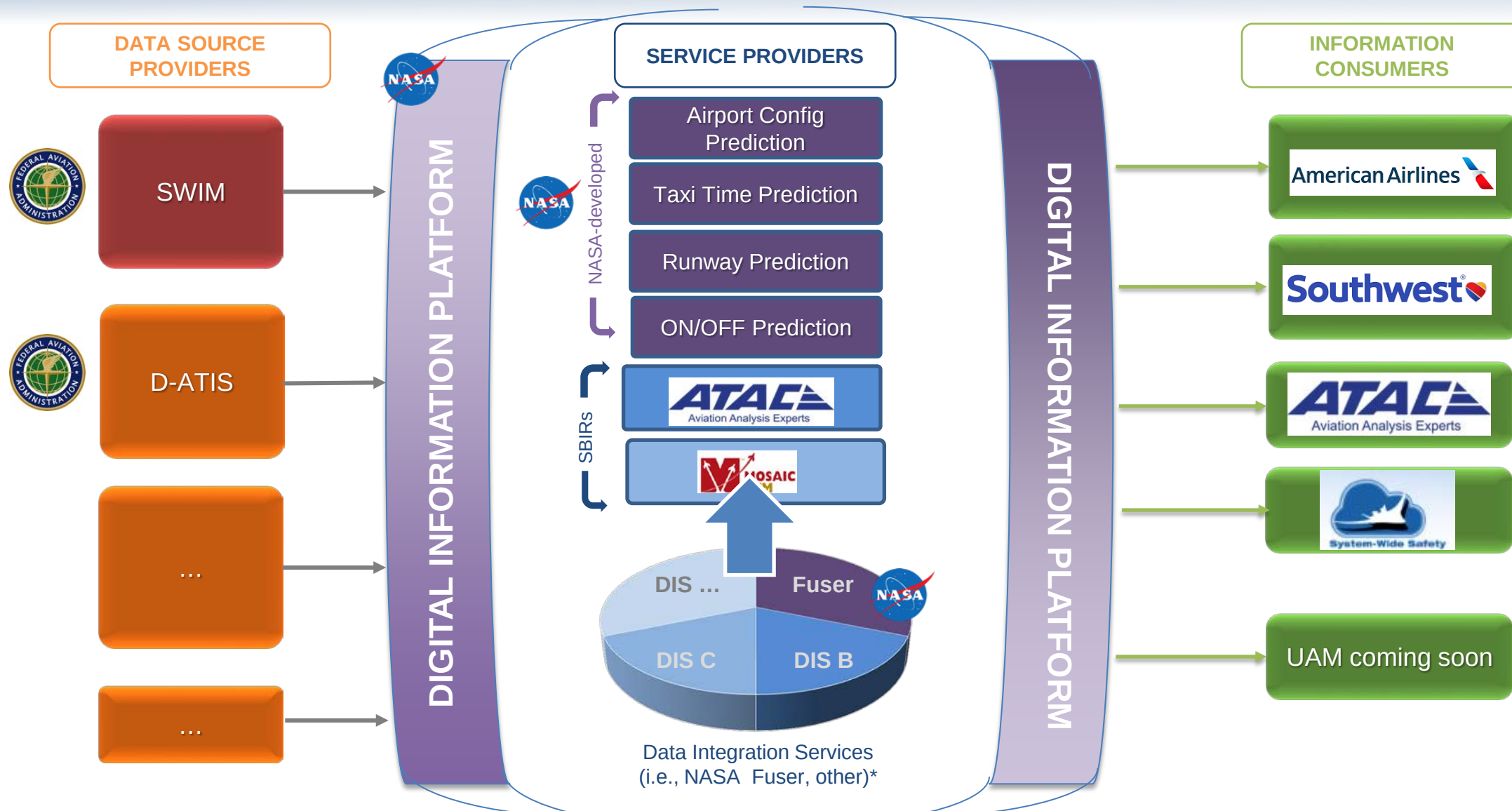
NASA will develop and demonstrate stakeholder-informed, digital information platform critical to catalyze an ecosystem of aviation services that improve airspace operations and deliver validated requirements to airlines, industry and the FAA

Impact

- Demonstrated sustainable aviation benefits for air traffic operations
- Data foundation necessary for FAA Info-Centric NAS towards Vision 2045
- Improved access to airspace information to accelerate the development of innovative air traffic management services



DIP Ecosystem Progress as of 2022



DIP portal is live and being leveraged by consumers today.



DIP Research Areas



NASA Led DIP-Enabled Demos for Sustainability



“SFNP-Ops Demos”

Ground and flight deck services focused on improving the sustainability of aviation operations

Industry Led Partner Service Evaluations



“PS Evals”

Integration and demonstration of Partner services with DIP for validation of the platform

University Challenges



Development of innovative solutions and advanced algorithms for aviation services

Reference Digital Information Platform (DIP)



Development of a platform for advanced, data-driven, digital services for flight operators and service consumers



DIP FY22 Accomplishments



Building Partner Cohort and DIP vision

- ✓ Expanded Flight Operator partnership cohort with Announcement for Collaboration (ACO)
- ✓ Agreed on technical approach with FAA to conduct sustainable airspace operations in another airspace

Platform Development and Release

- ✓ Achieved sustainability benefits with service-oriented architecture and ML-based predictions
- ✓ Concrete step to more easily access integrated data by moving Fuser to Amazon Web Services Cloud
- ✓ Validating design of DIP architecture with industry input

Advancing Technologies

- ✓ Applied machine learning to create building blocks for more advanced services
- ✓ Analyzed ML services from North Texas to other top airspaces



ATM-X

Air Traffic Management eXploration





Backup Slides



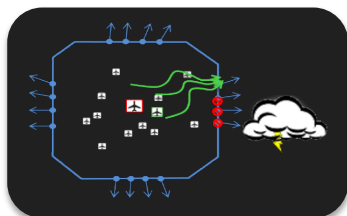


NASA Led DIP-Enabled Demos for Sustainability

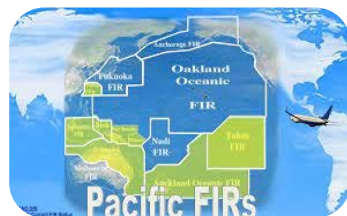


GLOBAL Aviation Industry's Goal:
Governments adopt 2050 net-zero carbon
goal for air transport

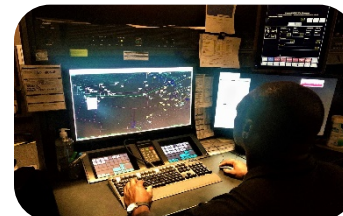
*ICAO, 2022



**Collaborative Digital
Departure Reroute
(SFNP-Ops-1, FY22-25)**



**Sustainable Oceanic
Airborne Re-Routing
(SFNP-Ops-2, FY26)**



**Irregular Ops Recovery/
Disruption Management
(SFNP-Ops-3, FY27)**



**4D Trajectory Optimization
(SFNP-Ops-4, FY28)**

SFNP-Ops = Sustainable Flight National Partnerships - Operations

**DIP supports Sustainability Goals: Deliver reduction in emissions and fuel of aviation
operations through digital services technology**



xTM

Extensible
Traffic Management





xTM Technical Challenge (FY22 - FY27)

xTM in the NAS



Support Thrust 1: Safe, Efficient Growth in Global Operations

Technical Challenge

New vehicles and missions cannot achieve scalable, safe, and efficient operations that seamlessly co-exist with traditional vehicles until xTM systems are further developed and integrated with conventional ATM

Develop technologies and requirements for xTM system framework and services, and demonstrate complex interactions of xTM operations and conventional ATM operations in overlapping airspace

Impact

- Transform the NAS to accelerate introduction of the next wave of vehicles and missions
- Enable the FAA to reach their modernization goals to integrate xTM and conventional ATM operations

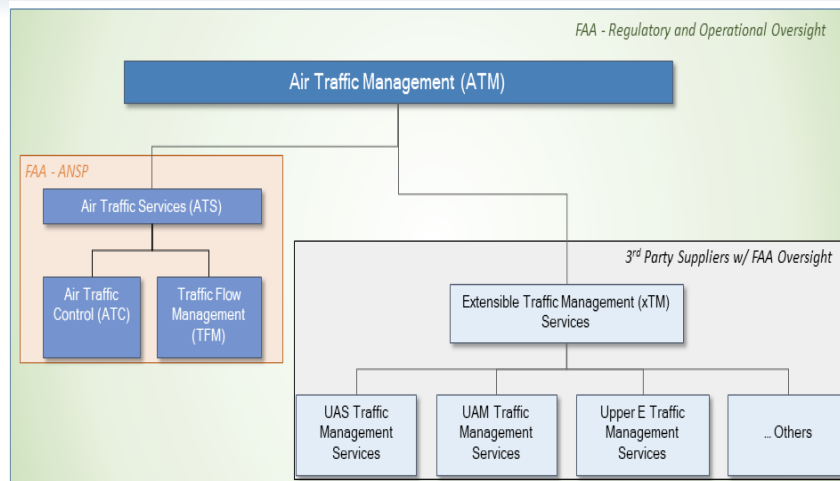


The Need for xTM and Cooperative Operations in Upper Class E



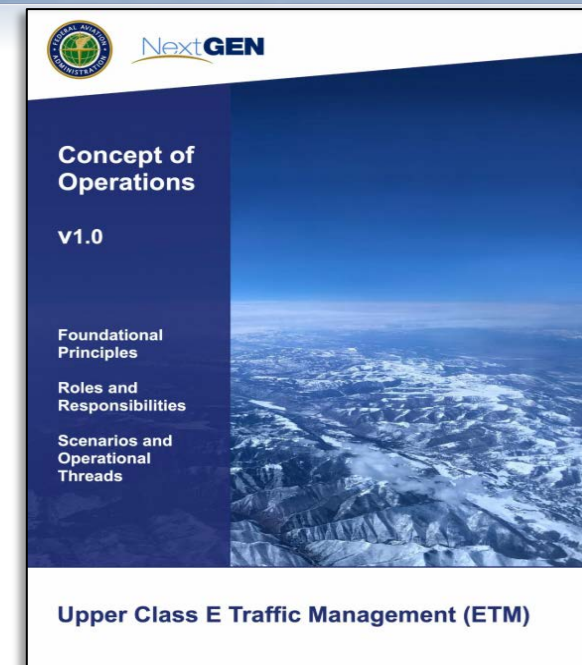
“...UTM...has provided a much broader opportunity to rethink the concept of ATM for all users.”

Airbus and Boeing: A New Digital Era of Aviation, June, 2020



“New extensible traffic management (xTM) ...such as UAS Traffic Management (UTM) and UAM, will allow emerging operations to coexist with conventional ATM by sharing fully integrated and interoperable information.”

FAA, Charting Aviation's Future: Operations in an info-centric NAS, June 2022*



“...To ensure safe and efficient service provision for current, and expanded operations, ...FAA is exploring an upper Class E Traffic Management (ETM) concept.” May, 2020

UTM principles and core properties are generalized to become Extensible Traffic Management (xTM) and applied to manage other operations



xTM Sub-Project Research Areas

xTM Maturation and Expansion

Mature existing xTM systems and expand xTM to new domains



2021 Upper Class E Traffic Management (ETM) Workshop (July 21 – 22, 2021)

xTM and ATS Integration

Increase xTM coordination with ATS to improve the flexibility and efficiency of xTM operations





FY22 xTM Accomplishments



Building Partner Cohort and xTM vision

- ✓ Developing community informed xTM-ATS interactions framework through industry engagement, conferences, and FAA quarterly meetings (29 industry participants)
- ✓ Expanding ETM Partnerships resulting in interest from Raven Aerostar
- ✓ Improving Coordination Towards Enabling ETM with Regular FAA engagements and completing ETM RTT deliverables

Making Progress on advancing xTM Framework

- ✓ Progress towards developing ETM standards and development of strategic deconfliction algorithm and Cooperative Operating Practices for Upper Class E
- ✓ Refining community informed ETM concept and technologies with industry via collaborative simulations in FY23+
- ✓ Addressing key technical barrier for UTM BVLOS by developing planning algorithm for safe and efficient operations based on size of UTM operational volumes