National Aeronautics and Space Administration

NASA Aviation Day
Four Transformations for Sustainability, Greater Mobility, and Economic Growth

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Senior Organizational Development Specialist

Wednesday, September 13, 2023

www.nasa.gov

Four Transformations for Sustainability, Greater Mobility, and Economic Growth


NASA
X-59
HIGH-SPEED COMMERCIAL FLIGHT

Commercial Supersonic Technology Project

Lori Ozoroski, Project Manager

Peggy Cornell, Deputy Project Manager

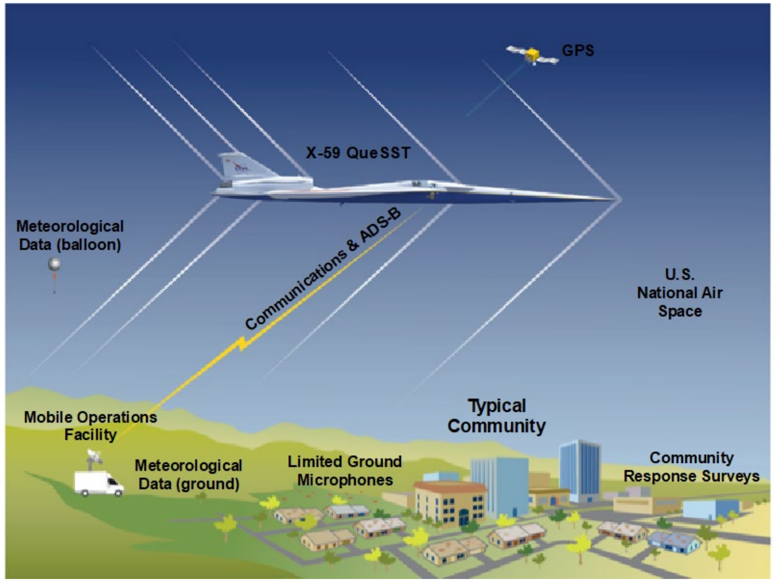
Gautam Shah, Supersonic Overflight & Community Response Sub-Project Manager

Larry Cliatt, Acoustic Validation Sub-Project Manager

Langley Research Center
Ames Research Center
Armstrong Flight Research Center
Glenn Research Center

Commercial Supersonic Technology Project

- The Commercial Supersonic Technology (CST) Project is the leader for tools and technologies to help achieve practical, affordable commercial supersonic air transport
- Near-term focus is on overcoming the technical and regulatory barriers to quiet supersonic flight over land
  - Critical Commitment to deliver data to FAA & ICAO on community response to quiet overflight sounds
- CST's contribution of the coordinated development of tools, test hardware and methodology is key to the overall Quesst Mission success
- CST is also working to address longer term research leading to the development of increasingly capable supersonic commercial aircraft

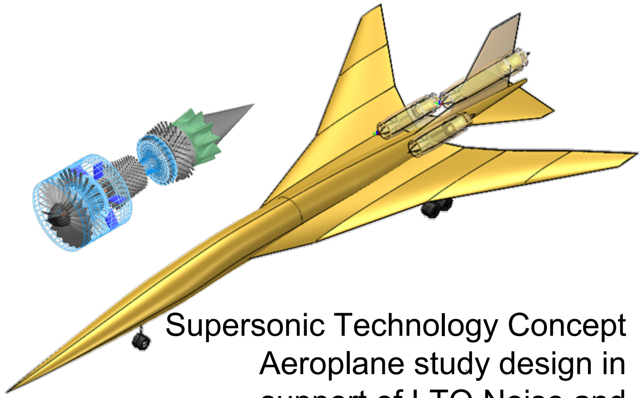


Community Testing

The vision of the Supersonics Community is a future where fast air travel is available for a broad spectrum of the traveling public.

Future supersonic aircraft will not only be able to fly overland without creating an "unacceptable situation" but compared to Concorde and SST will be efficient, affordable and environmentally responsible.


Application of Computational Tools


Supersonic Technology Concept Aeroplane study design in support of LTO Noise and Emissions research

Barriers to Practical Supersonic Commercial Aircraft

Environmental Barriers

Airport Noise
- Noise levels not louder than subsonic aircraft at appropriate airports

Sonic Boom
- Design for low noise sonic boom
- Understand Community Response

High Altitude Emissions
- No or minimal long-term impact at supersonic cruise altitudes

Efficiency Barriers

Light Weight, Durable Vehicles
- Low airframe and propulsion weight in a slender flexible vehicle operating at supersonic cruise temperatures

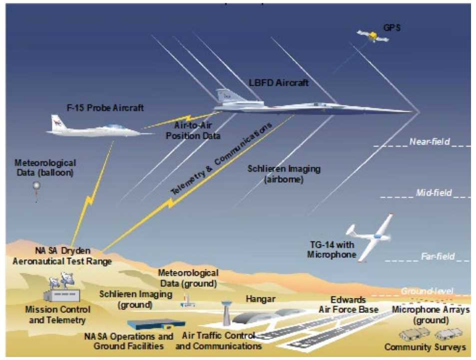
Efficient Operations
- Airspace-Vehicle interaction for full utilization of high speed

Efficient Vehicles
- Efficient airframe and propulsion throughout flight envelope

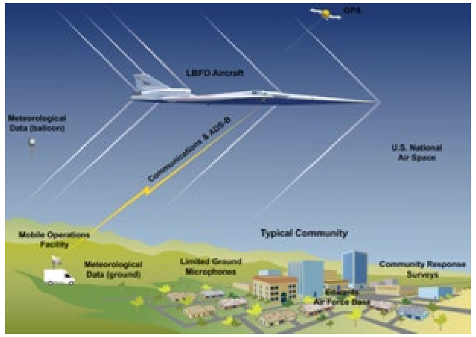
Solutions to barriers drives selection of our Research Themes

Quesst Mission Overview

Phase 1 – Aircraft Development – *In progress (FY18-23)*
- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion



Phase 2 – Acoustic Validation – *Preparation in progress (FY18-23) & Execution FY23-24*
- Aircraft operations & support, range Ops, support aircraft
- In-flight measurement capabilities
- **Ground measurement capabilities**
- **Validation of X-59 boom signature and prediction tools**
- **Development of acoustic prediction tools for Phase 3**



Phase 3 – Community Response Testing
Preparation in progress (FY19-24), Execution FY24-26
- Aircraft operations & support, deployment logistics
- **Ground measurement capabilities**
- **Ground crew operations**
- **Noise exposure design**
- **Community response surveys**
- **Data analysis and database delivery**

Systematic Approach Leading to Community Testing

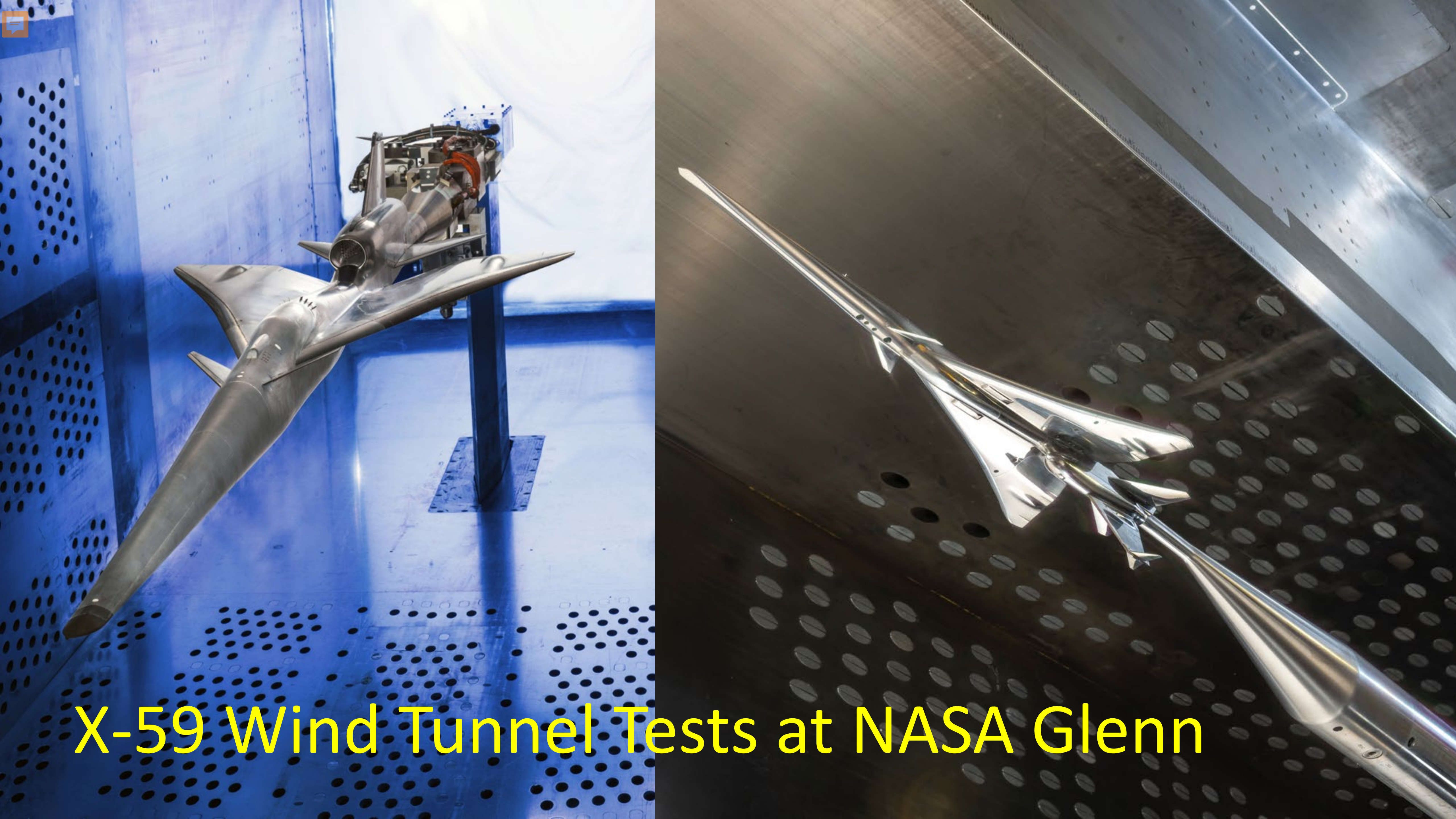
QUESST

LBFD - Low Boom Flight Demonstrator Project
Integrated Aviation Systems Program

FDC - Flight Demonstrations & Capabilities Project
Integrated Aviation System Program

CST - Commercial Supersonic Technology Project
Advanced Air Vehicles Program


F414
Engine
X-59
NASA
N859NA
859
X-59 QUESST Mission
Low Boom Flight Demonstration
QUESST
NASA Glenn supports X-59



X-59 Wind Tunnel Tests at NASA Glenn


QUESST


ULTRA-EFFICIENT AIRLINERS

Advanced Air Transport Technology Project

Dale Van Zante, Project Manager, Melinda Cagle, Deputy Project Manager

Scott Anders, Chief Technologist for Airframe

Ezra McNichols, Chief Technologist for Propulsion (acting)

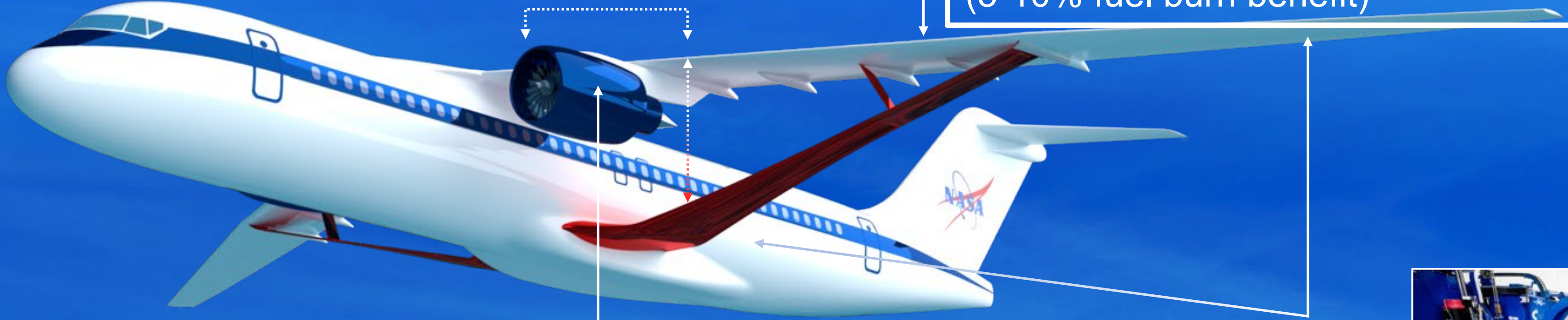
Glenn Research Center, Langley Research Center, Ames Research Center, Armstrong Flight Research Center

Subsonic Airliner Technologies

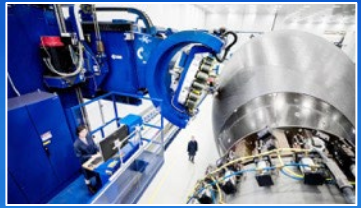
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of airliners

Integrated Aircraft System Efficiency
Propulsion Airframe Integration Opportunity

Aerodynamic Efficiency
Transonic Truss-Braced Wing
(5-10% fuel burn benefit)

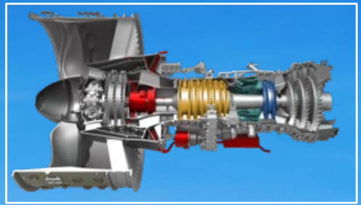


Weight
High-Rate Composites
(4-6x manufacturing increase)



Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit

Engine Efficiency
Small Core Gas Turbine
(5-10% fuel burn benefit)



Electrified Powertrain Flight Demonstration

Turning hybrid electric commercial aircraft into a reality!

Electrified Powertrain Flight Demonstration

SCOPE

- Demonstrate integration of megawatt-class electrified aircraft propulsion (EAP) systems
- Leverage advanced airframe systems to strengthen regional & single-aisle aircraft markets
- Assess gaps in regulations/ standards to support future EAP certification requirements

BENEFIT

- Accelerate U.S. industry technology readiness and competitiveness
- Enable new standards that are needed for EAP-based aircraft certification
- Identify and address key risks associated with hybrid electric technologies

APPROACH

- Engage with U.S. industry to integrate and demonstrate megawatt-class EAP machines in flight
- Engage with FAA, SAE, ASTM, etc. to contribute data that inform EAP standards & regulations

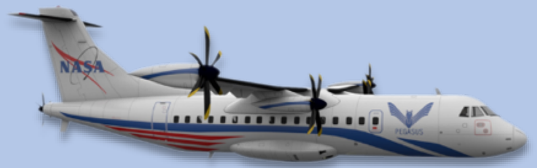
Electrified Powertrain Flight Demonstration

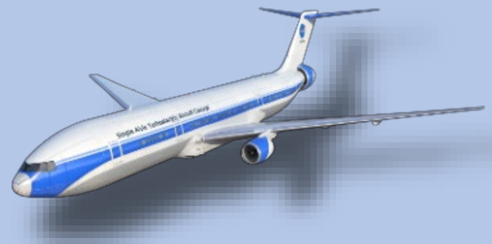
EPFD GOALS

Accelerate US industry technology readiness and competitiveness

2030-2035 Entry-Into-Service: **Thin haul, regional and next generation Sustainable Aviation markets**

EPFD Partner Markets





Market	Regional Air Mobility	Regional Turboprops & Turbofans	Single Aisle
Passengers	*1-19*	*20-150*	*150-more*
Speed	*≈150-250 mph*	*≈300-400 mph*	*≈500-700 mph*
Range	*≈100-500 miles*	*500-1500 miles*	*1500-3500 miles*
Power	*≈1MW*	*1 to 5 MW*	*3 to 30MW*
Heat	***≈200 kW heat***	***200kw to 1MW heat***	***600kW to 6MW heat***

NASA Sustainable Flight Demonstrator (SFD) Project

Rich DeLoof
NASA SFD Project Lead Systems Engineer
SAE Mobility & Energy Conference – Sept. 13, 2023

Why invest in Sustainable Flight Demonstrator?

- For decades Government, Industry, and Universities have been working advanced commercial aircraft concepts focused on lowering fuel burn & emissions
- Due to many factors, these configurations have not made it to market
- NASA launched the SFD project to:
  - Partner with industry to retire technical risk
  - Inform industry decisions associated with next generation single-aisle seat class product for 2030s entry into service
  - Maximize the potential to meet environmental goals articulated in the U.S. Aviation Climate Action Plan
- Boeing Transonic Trussed Braced Wing (TTBW) selected through competitive proposal process

Required Key Learnings

Wing
- Thin Wing Integration
- Relevant High Lift Systems Architecture
- Fuel System Integration

Aeroelasticity
- Tool and Model Validation
- Static Loads Methods Validation

Structures
- Internal Loads Model Validation
- Primary Architecture & Joint Design Validation

Performance, S&C and Handling Qualities
- CFD & Aero Performance Validation
- Flutter Characteristics
- Lateral Stability Characteristics
- Typical Flight Envelope Operability

Propulsion- Integration
- SAF Fuel System Compatibility
- Pylon Fail-safe Integration

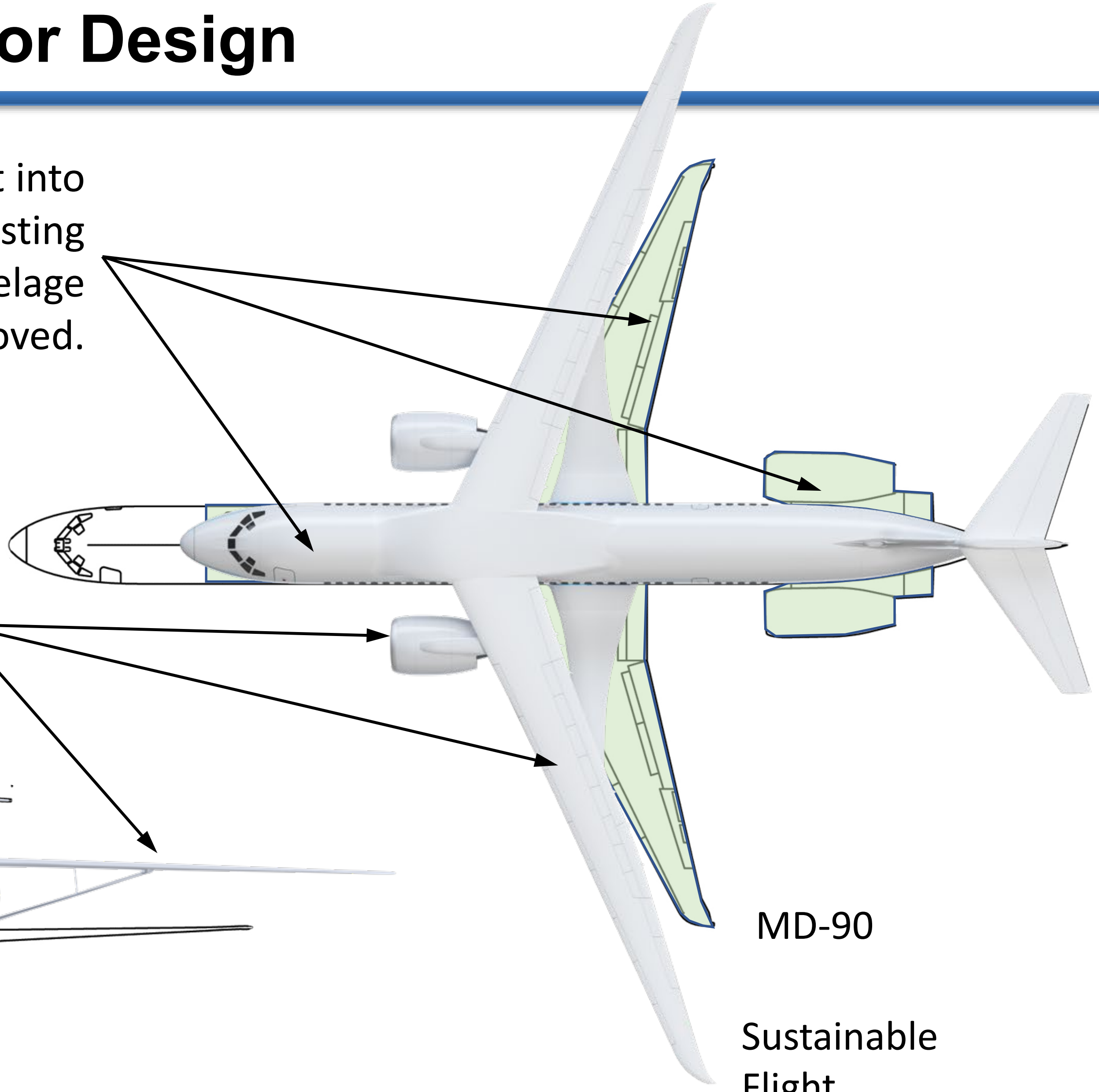
Certification/Crashworthiness
- Strut Fail Safety Requirements
- High Wing/Truss Crush Loads

When combined with expected advancements in propulsion systems, materials and systems architecture, the TTBW configuration could reduce fuel consumption and emissions **up to 30%** relative to today's most efficient single-aisle airplanes.

X-66A SFD Demonstrator Design

Boeing will modify MD-90 aircraft into the SFD Demonstrator aircraft. Existing wings, aft engines, and fuselage sections will be removed.

SFD modification includes addition of Transonic Truss-Braced Wing and subsystems, modern turbo-fan engines, and instrumentation.



MD-90

Sustainable Flight Demonstrator

HyTEC

Hybrid Thermally Efficient Core

HyTEC Project Overview

Dr. Kenneth Suder
HyTEC Technical Advisor and GRC Senior Technologist

September 13, 2023

Hybrid Thermally Efficient Core

Goal:

- The Hybrid Thermally Efficient Core (HyTEC) Project accelerates the development and demonstration of advanced aircraft engine core technologies to enable sustainable commercial flight with reduced emissions and fuel consumption.

Objectives:

- Achieve **5-10% fuel burn reduction** versus 2020 best in class.
- Achieve **up to 20% power extraction** (4 times current state of the art) at altitude to optimize propulsion system performance and enable hybridization.
- Demonstrate the effective and efficient operability of high blend **(>80%) Sustainable Aviation Fuels (SAFs)** in 2030s EIS combustors.

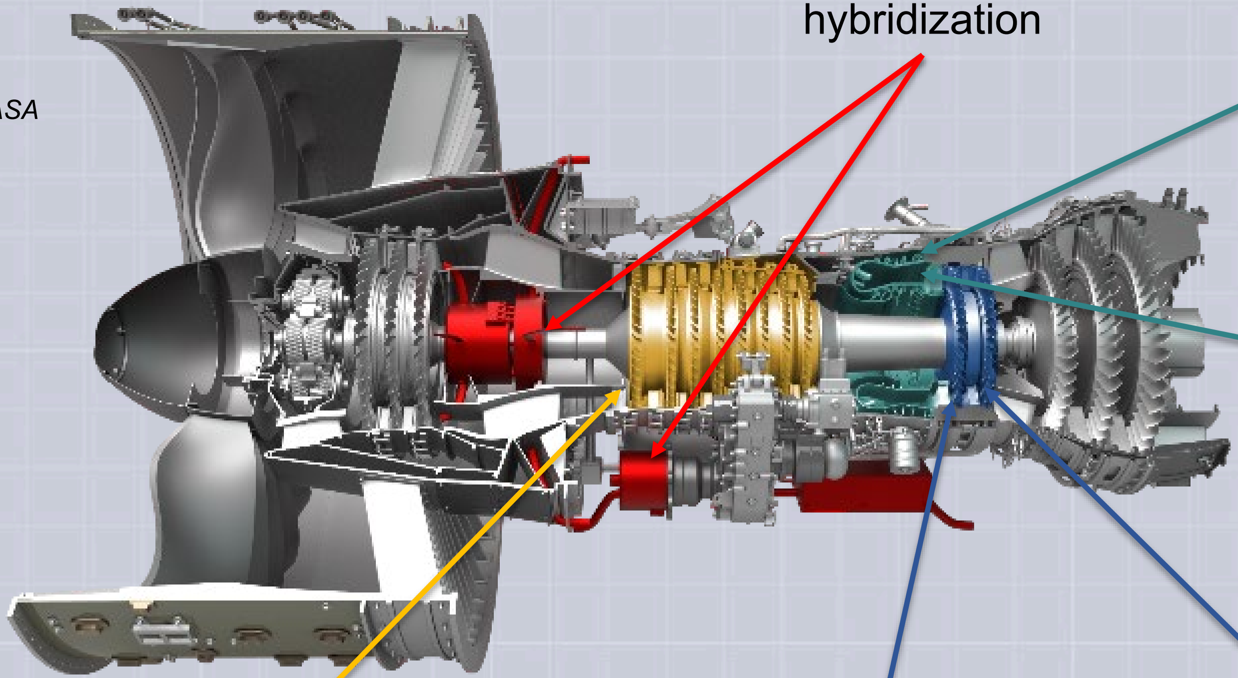
HyTEC Metrics

- Small core technologies aligned with future single-aisle propulsion products
- Target engine thrust of 25,000 – 35,000 lb_f (B737 class)

Key Performance Parameter (KPP)	Full Success Single Aisle ~2035 EIS
Engine Bypass Ratio	> 15
Engine Overall Pressure Ratio	> 50
HPC Exit Corrected Flow	< 3 lbm/s

Partner with industry to mature and demonstrate enabling technologies for sustainable flight.

HyTEC Technology Portfolio



Credits: NASA

Turbofan Power Extraction
Power Extraction to enable hybridization

Combustion Technologies
- Sustainable aviation fuel compatibility
- Compact design for small core engines

Enhanced Combustor Materials
Ceramic matrix composites (CMC)/ Environmental Barrier Coatings (EBC) liners for combustors to increase performance and durability.

High Pressure Turbine (HPT) Materials
CMCs/EBCs for turbine components to increase temperatures and efficiency.

High Pressure Compressor (HPC)
Casing treatments and advanced designs to enable operability with optimized efficiency and performance

Advanced HPT Aerodynamics
Enable more efficient turbine operation by developing advanced blade and cooling designs and aerodynamic features.

https://www.nasa.gov/aeroresearch/programs/hytec


FUTURE AIRSPACE AND SAFETY

NASA System Wide Safety (SWS)

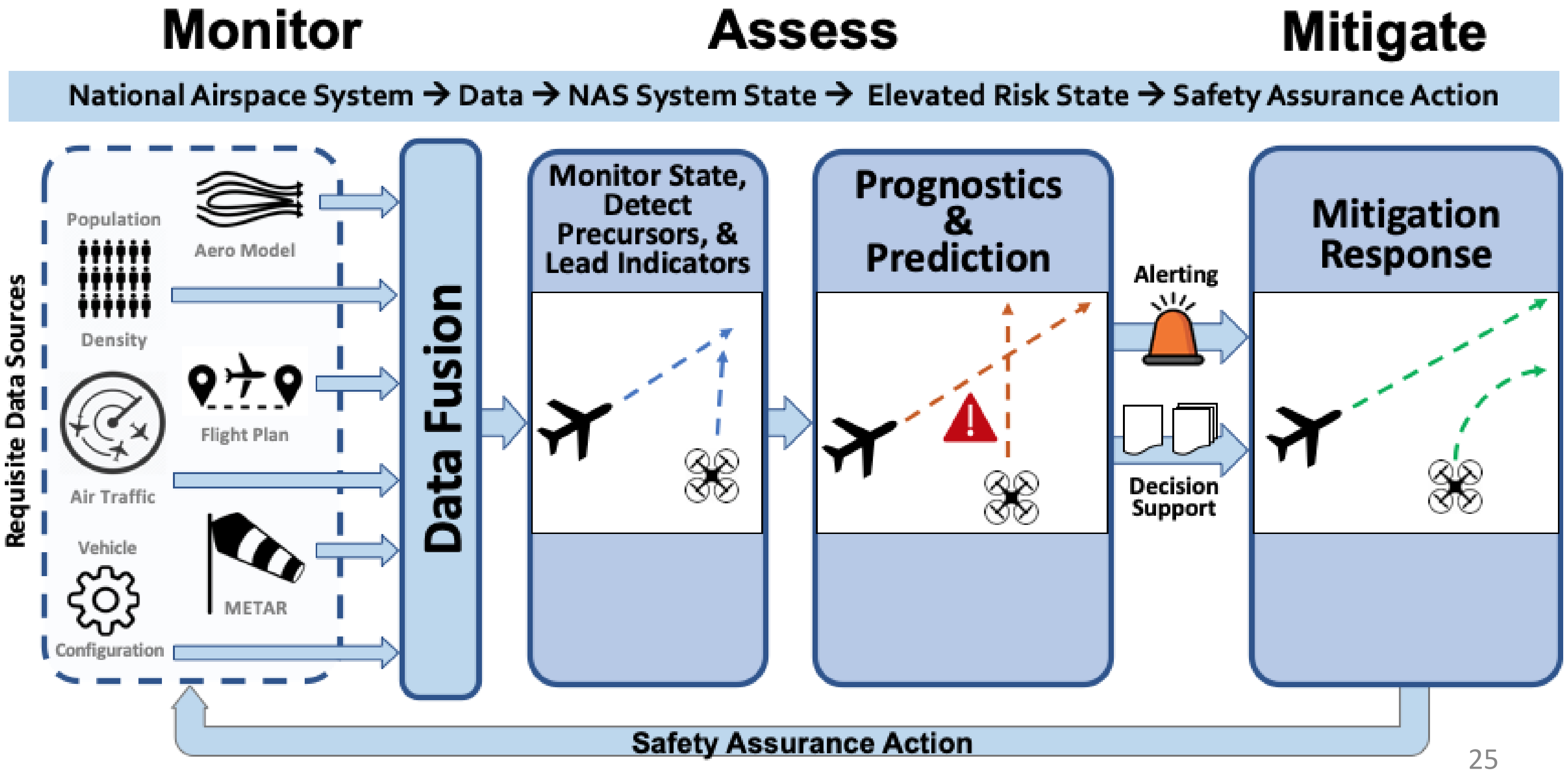
In-Time System-Wide Safety Assurance (ISSA)

Working to Achieve Three Incremental Milestones

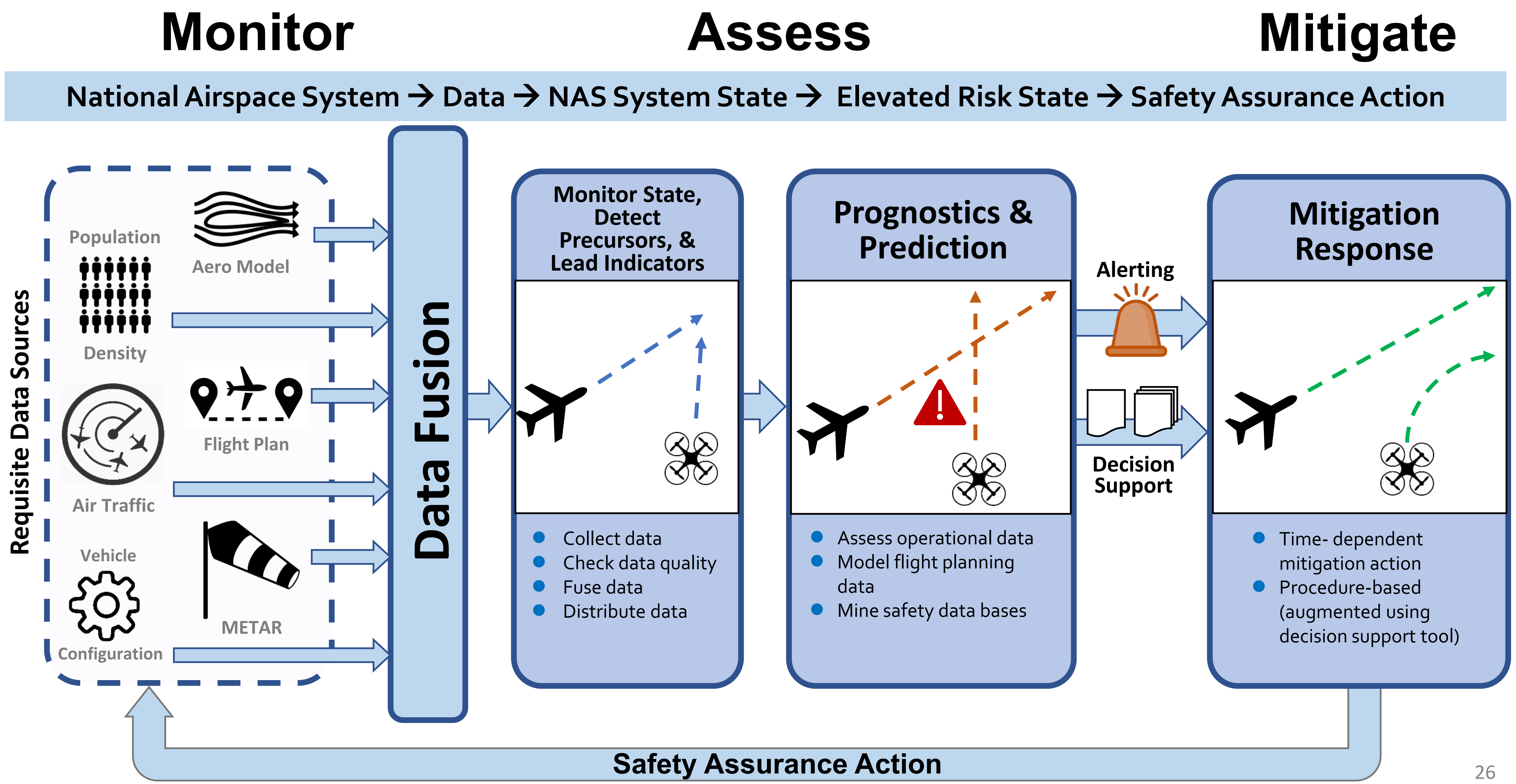
1. Domain-Specific Safety Monitoring and Alerting Tools
2. Integrated Predictive Technologies with Domain-Level Applications
3. Adaptive In-Time Safety Threat Management

Objective:

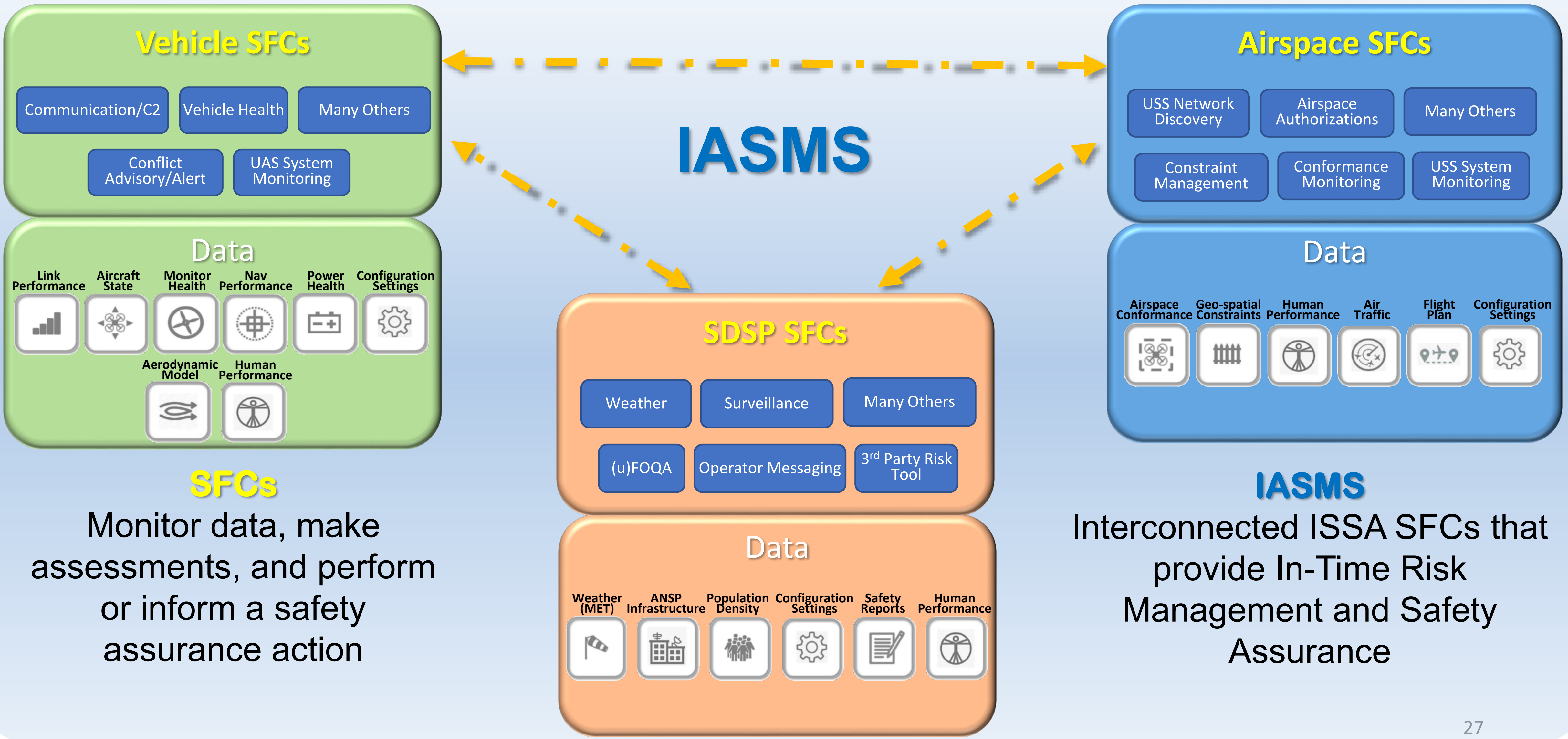
Proactively mitigate risks and demonstrate innovative solutions while ultimately ensuring safety to the community on the ground and in the National Air Space



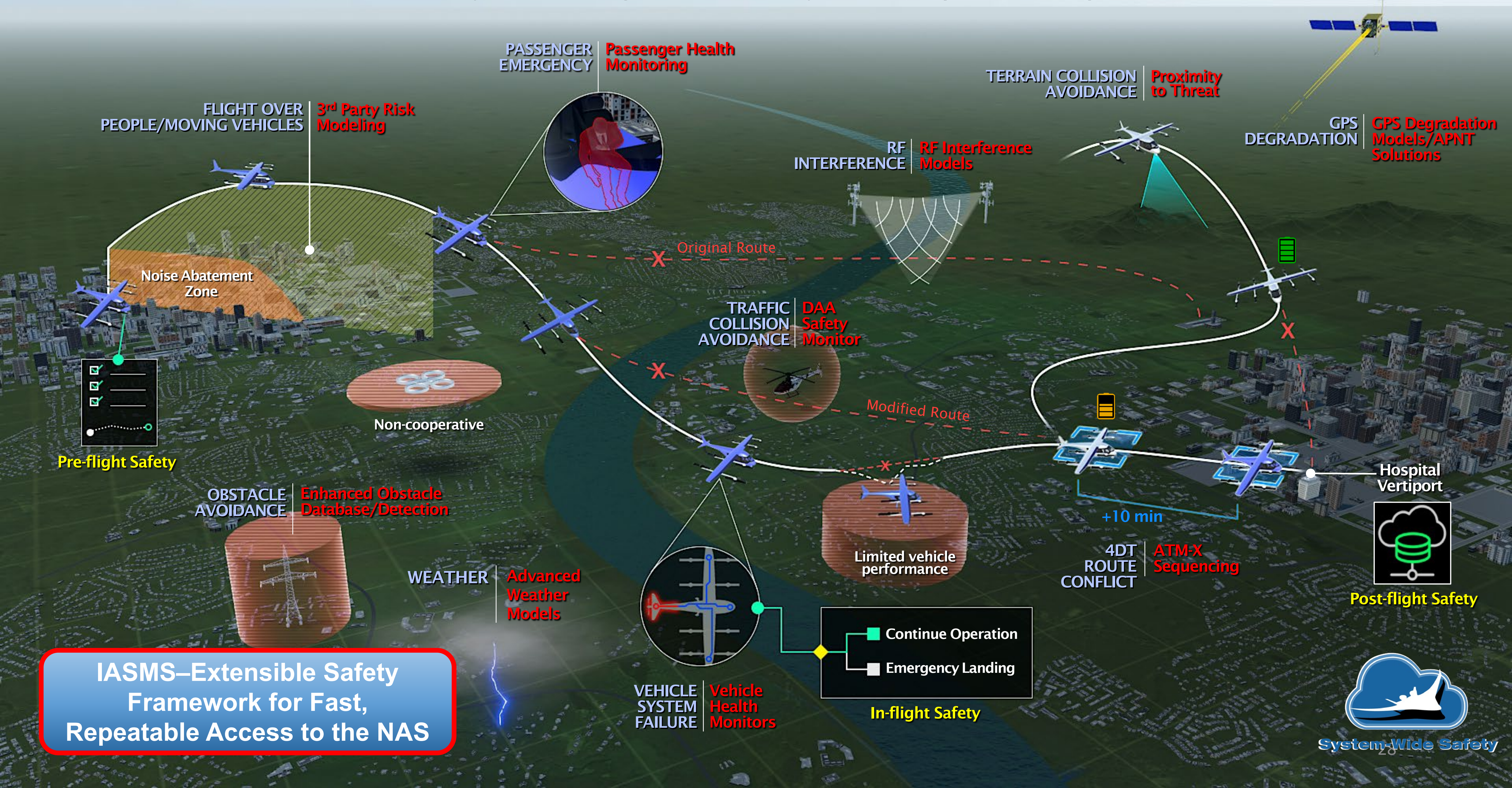
Services, Functions & Capabilities (SFCs)



Service-Oriented Architecture



In-Time Aviation Safety Management System (IASMS)



IASMS–Extensible Safety Framework for Fast, Repeatable Access to the NAS

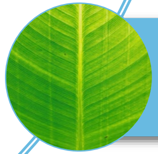
Air Traffic Management – eXploration (ATM-X):
The Future of Air Traffic Management


Scalable to meet future demand


Adaptable to accommodate new types vehicles and operations


Safe operations for diverse users


Resilient to uncertainty, degradation, and disruptions


Sustainable user-preferred trajectories that minimize impact on the environment

Supporting Multiple Use Cases

Sustainable Conventional Operations

Automated Cargo Operations

Routine sUAS Operations

Upper Class E Operations

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

- Digital Services and Information Sharing
- Novel Airspace Design and Frameworks
- Communication Links & Information Protocols
- Separation and Flow Management Algorithms

Revealing the future of aviation

Convergent Aeronautics Solutions

Sep 13, 2023

Kurt Papathakis
Deputy PM, CAS

Thinking differently to revolutionize aviation

Explores the unknown – Converges disciplines & industries – Advances disruptive concepts

Societal Needs

Policy Topics

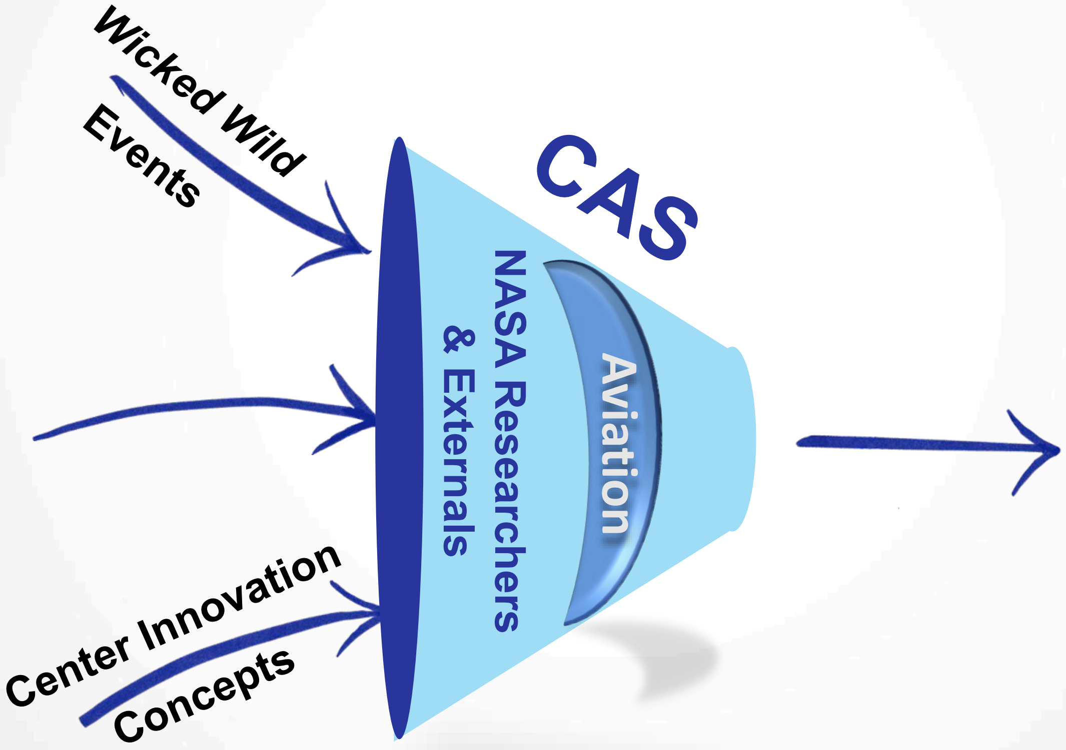
Emerging Trends

New Capabilities

Threats & Weaknesses

Market Movements

Scientific Discoveries



Prospect Wicked problems spaces

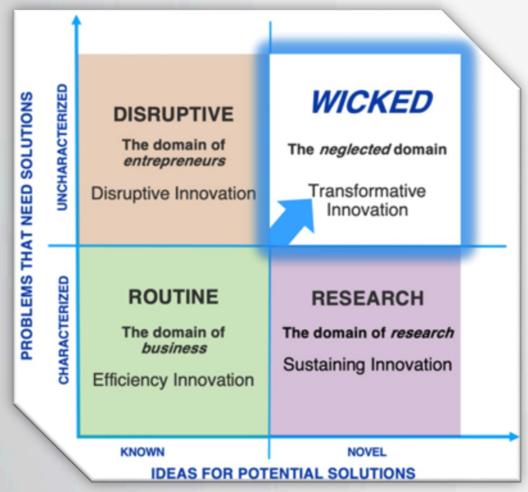
Execute early-stage experiments with ***Transition*** potential

Swing for the ***Transformative*** fences… from and for aviation

Pillars of CAS Innovation Driving Decisions

Discovering systems-level, transformational impact for aviation

Wicked Problems



Solving wicked problems will lead to transformation in aviation.

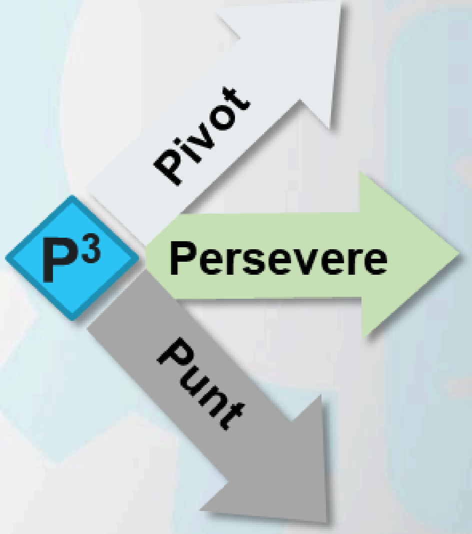
D-V-F Intersection

Socially desirable.
Economically viable.
Technically feasible.

Barrier-Breaking Experiments

Identify barriers.
Formulate hypotheses.
Test barriers.

Aggressive Agility



Succeed quickly.
Fail quickly.
Learn and adapt.


M
METRO
ADVANCED AIR MOBILITY

Revolutionary Vertical Lift Technology Project
GRC Aviation Day 2023

Revolutionary Vertical Lift Technology Project

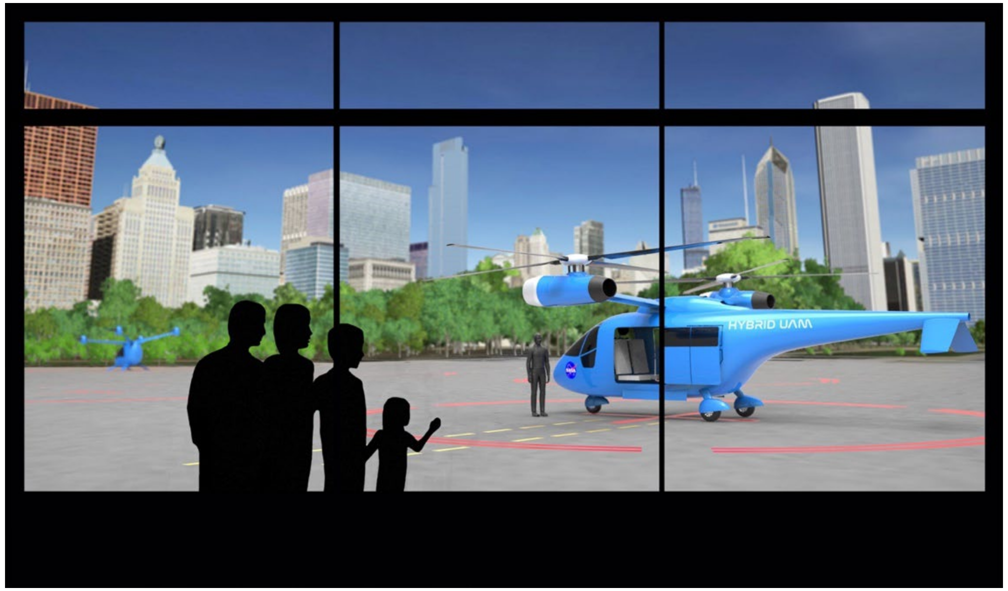
Develop and Validate Tools, Technologies and Concepts to Improve Future Vertical Lift Vehicles

Vision

Our vision is to create a future where VTOL configurations operate quietly, safely, efficiently, affordably, and routinely as an integral part of everyday life.

Scope

- Technologies that address noise, safety, environment, and efficiency
- Non-conventional light and medium vertical lift configurations



NASA RVLT Project Research Areas

Ames Research Center

- Aeromechanics
- System Analysis
- Computational Methods
- Experimental Capability
- Flt Dyn & Ctrl
- Acoustics

Armstrong Flight Research Center

- UAM Handling and Ride Qualities
- UAM Electric System and Flight Control Integration

Glenn Research Center

- Hybrid/ Electric Systems
- Electro-Mech Powertrains
- Icing
- System Analysis
- Impact Dynamics
- Acoustics

Langley Research Center

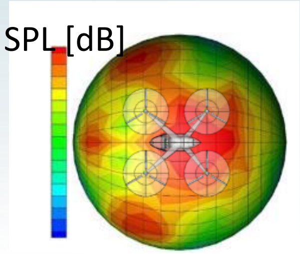
- Acoustics
- Computational Methods
- Aeromechanics
- Experimental Capability
- Impact Dynamics
- System Analysis

NASA's RVLT Project Provides Tools and Design Practices for UAM eVTOL Vehicles

Noise Research

Human Response to UAM Noise

UAM Acoustic Impacts

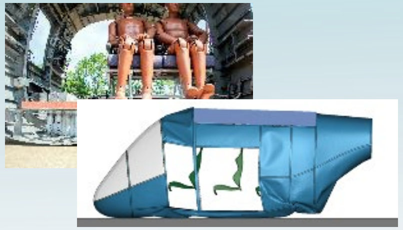


Predictive Tools for UAM Noise

Safety Research

Electric Powertrain Reliability

Handling Qualities



Crashworthiness & Occupant Protection

Share technical insights and lessons learned

INDUSTRY

SDOs

ACADEMIA

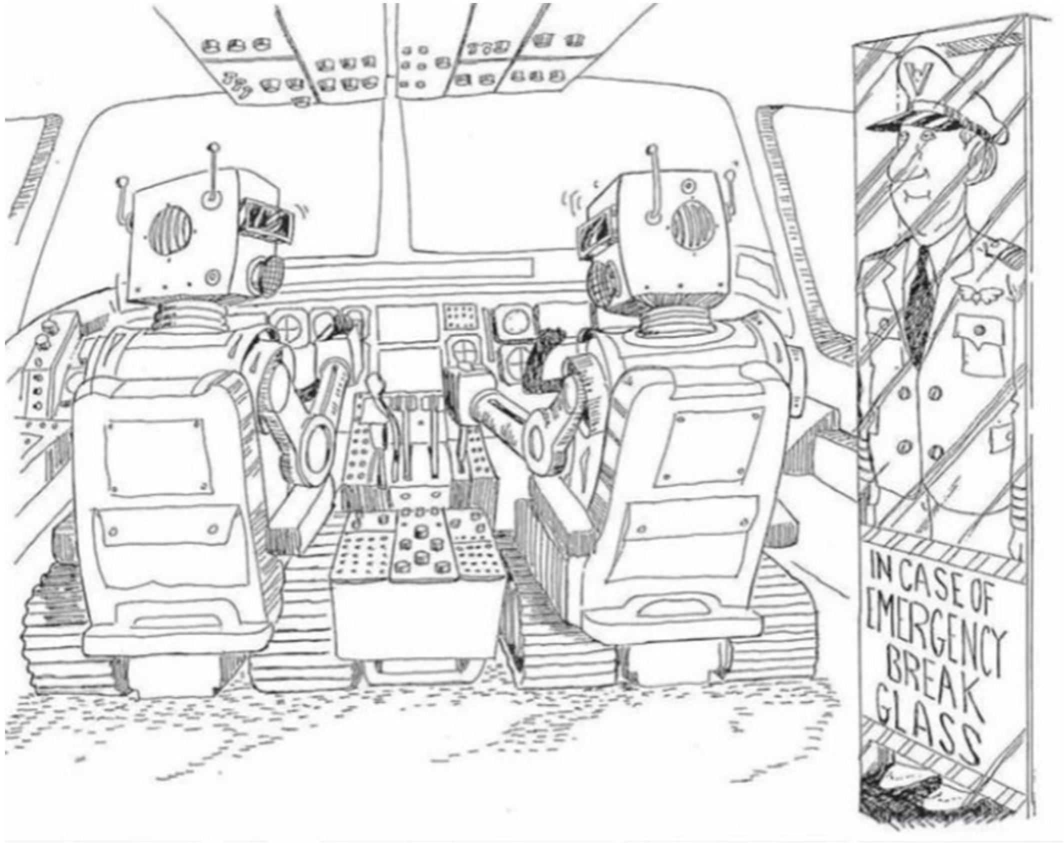
FEDERAL AVIATION ADMINISTRATION

Delivering Tools and Technologies to the eVTOL Community

AAM Automation & Autonomy Challenges

Unique Operational Environment

Pilots Currently Monitor & Backstop Essentially All Automation

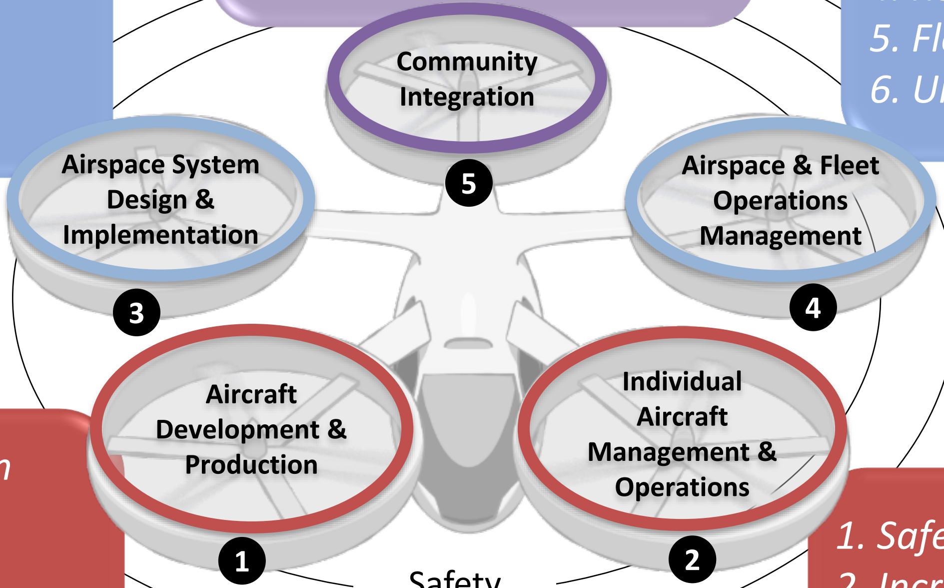


AAM Framework and Barriers

1. *Airspace Design*
2. *Operational Rules, Roles, & Procedures*
3. *CNSI & Control Facility Infrastructure*
4. *UAM Aerodrome Design*

1. *Public Acceptance*
2. *Supporting Infrastructure*
3. *Operational Integration*
4. *Local Regulatory Environment & Liability*

1. *Safe Airspace Ops*
2. *Efficient Airspace Ops*
3. *Scalable Airspace Ops*
4. *Resilient Airspace Ops*
5. *Fleet Management*
6. *Urban Weather Prediction*



1. *Aircraft Design & Integration*
2. *Airworthiness Standards & Certification*
3. *Aircraft Noise*
4. *Weather-Tolerant Aircraft*
5. *Cabin Acceptability*
6. *Manufacturing & Supply Chain*

1. *Safe Urban Flight Management*
2. *Increasingly Automated Aircraft Operations*
3. *Certification & Ops Approval*
4. *Ground Ops & Maintenance*

Safety
Security
Affordability
Noise
Automation
UAM Aerodromes
Regulations/Certification

Aircraft & Aircrew
Airspace
Community Integration
Pillar number

Four Transformations for Sustainability, Greater Mobility, and Economic Growth


NASA
AERONAUTICS
WITH YOU WHEN YOU FLY