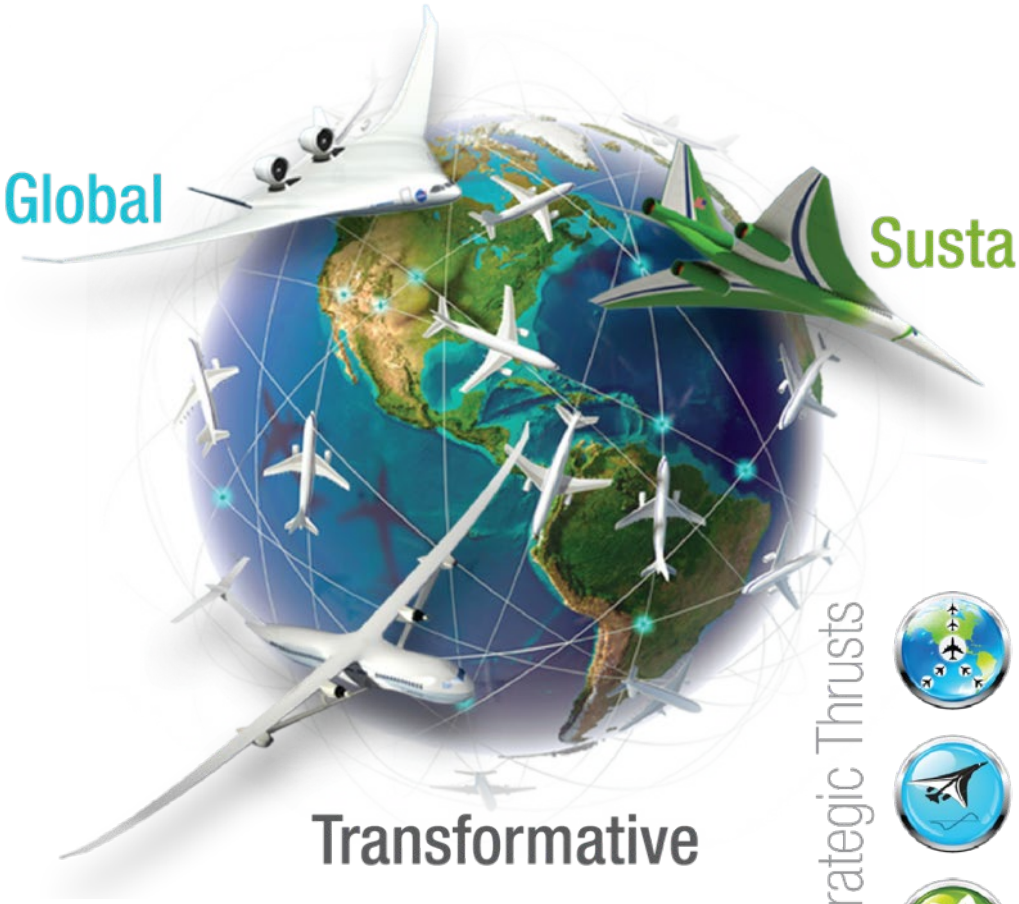
NASA Update

FAA REDAC E&E Subcommittee Meeting
Airlines for America, Washington, DC
March 20, 2019

Dr. Richard A. Wahls, Strategic Technical Advisor, Advanced Air Vehicles Program
NASA Aeronautics Research Mission Directorate

NASA Aeronautics

Vision for Aviation in the 21st Century



ARMD continues to evolve and execute the Aeronautics Strategy *https://www.nasa.gov/aeroresearch/strategy*

6 Strategic Thrusts

- Safe, Efficient Growth in Global Operations
- Innovation in Commercial Supersonic Aircraft
- Ultra-Efficient Commercial Transports
- Transition to Alternative Propulsion and Energy
- In-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

U.S. leadership for a new era of flight

NASA Aeronautics Research Programs

Aligned with Strategic Thrusts

MISSION PROGRAMS

Airspace Operations & Safety

AOSP

Safe, Efficient Growth in Global Operations

In-Time System-Wide Safety Assurance

Advanced Air Vehicles

AAVP

Ultra-Efficient Commercial Vehicles

Innovation in Commercial Supersonic Aircraft

Transition to Alternative Propulsion and Energy

Integrated Aviation Systems

IASP

Flight research-oriented, integrated, system-level R&T that supports all six thrusts

X-planes/ test environment

SEEDLING PROGRAM

Transformative Aeronautical Concepts

TACP

High-risk, leap-frog ideas that support all six thrusts

Critical cross-cutting tool development

Assured Autonomy for Aviation Transformation

FY 2020 Budget Request - Aeronautics

$ Millions	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Aeronautics	**$690.0**	**$725.0**	**$666.9**	**$673.6**	**$680.3**	**$587.1**	**$587.0**
Airspace Operations and Safety	118.7		121.2	130.6	133.5	136.2	138.9
Advanced Air Vehicles	237.7		188.1	203.3	212.2	219.3	224.2
Integrated Aviation Systems	221.5		233.2	209.4	202.2	97.1	87.2
Transformative Aeronautics Concepts	112.2		124.4	130.3	132.3	134.6	136.7

FY 2018 reflects funding amounts specified in Public Law 115-41, Consolidated Appropriations Act, 2018, as adjusted by NASA's FY 2018 Operating Plan.

FY 2019 reflects funding as enacted under Public Law 116-06, Consolidated Appropriations Act, 2019

Note: PBR FY20 and beyond budget decrease relative to FY19 is result of AETC transfer out of ARMD

supersonics

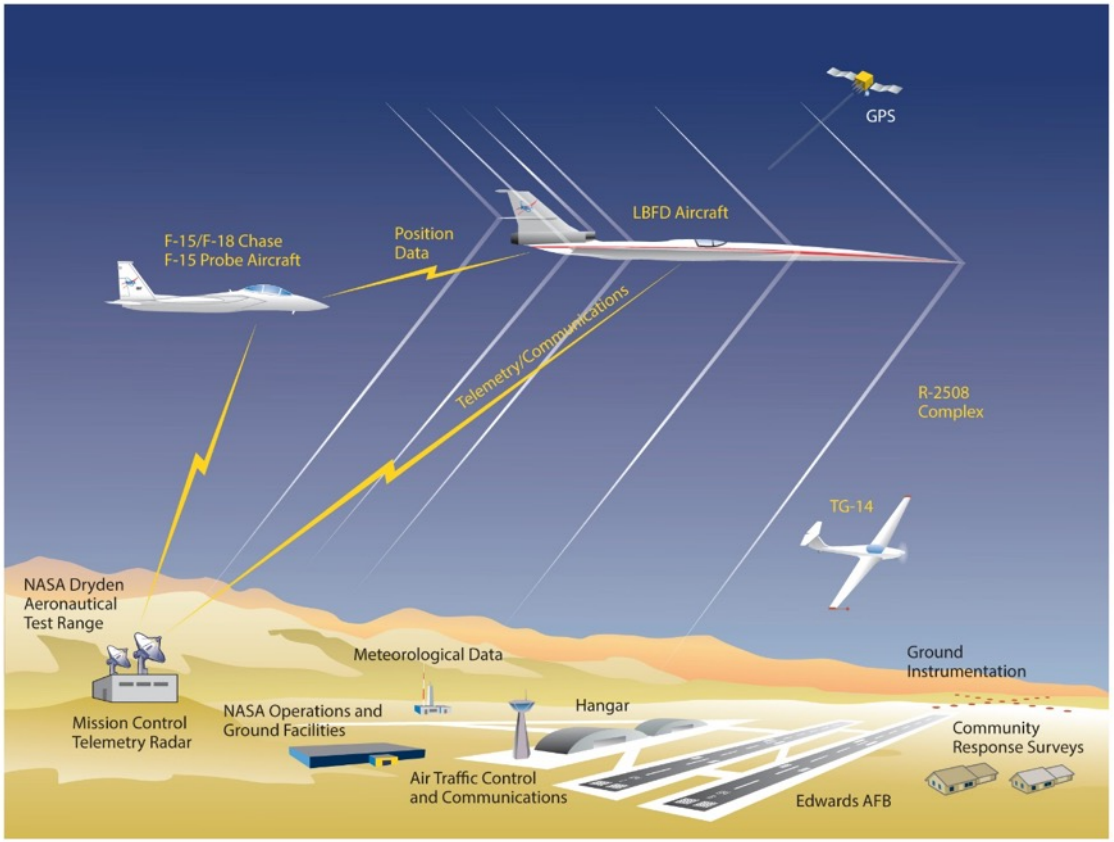
value via speed at cruise

Low-Boom Flight Demonstration Phases

Phase 1 - Aircraft Development
- Detailed Design
- Fabrication, Integration, Ground Test
- Checkout Flights
- Envelope Expansion

Phase 2 – Acoustic Validation
- Measuring and characterizing the sonic ~~boom~~ thump

Phase 3 – Community Response
- Initial community response overflight study
- Multiple campaigns over representative communities and weather across the U.S.



Overcoming the Barrier to Supersonic Overland Flight

Low-Boom Flight Demonstrator (LBFD) Phases

- Completed Preliminary Design Review
- Awarded Design and Build Contract to Lockheed Martin
- Completed KDP-C major review baselining project
- Initiated initial fabrication and final design
- Completed Community Response Risk reduction testing (Galveston, TX in Nov 2018)
- First Flight planned for FY 2021

X-59 QueSST (Quiet SuperSonic Technology)

Measuring Community Response to Quiet Supersonic fight

Risk Reduction for Future Community Testing with the X-59

Objective

- Perform risk reduction **community response flight test**
- Address risks associated with **community engagement, remote operations, noise exposure estimation, and social survey**

Preparation Activities

- Outreach to local government and citizens
- Approvals for environment impact and use of citizens in research
- Subject recruitment (500 participants desired)
- Develop "citizen science" and educational activities for residents
- Develop F-18 dive maneuver to replicate X-59 "sonic thump"
- Prepare automated, weatherproof recording equipment
- Organize a large deployment of personnel and equipment

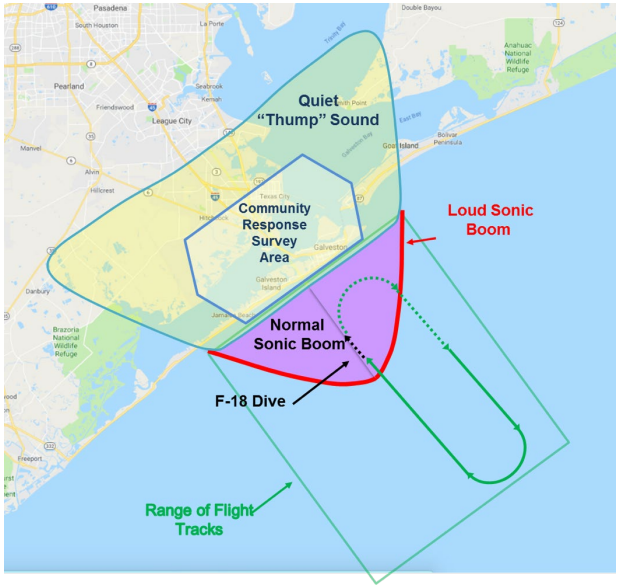
Status

- Flight series conducted Nov. 5-15
- 22 Flights over 9 fight days, 52 "sonic thump" events
  - Sound exposures (estimated) 60 to 90 PLdB
- Robust survey response and public participation

Significance

- First large-scale community based test of response to supersonic noise in over 25 years
- Large response database, and many lessons learned to be shared with the international community

Quiet Supersonic Flight 2018
Galveston Texas



Partners: Applied Physical Sciences, Penn State Univ., DOT Volpe, Gulfstream, Eagle Aeronautics, KBRwyle, Gaugler Consulting

ICAO/FAA Interaction and Technical Support

Landing/Takeoff Noise and Emissions Procedures for Supersonic Transport

Objective

- Analyze representative near-term commercial supersonic design space to inform CAEP regulators with LTO performance for use in Type Certification process.

Approach

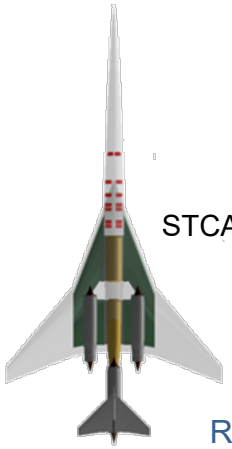
- Use conceptual supersonic derivative mixed flow turbofan based on CFM56-7B and down-sized Boeing N+2 vehicle.
- Assess certification margins using conventional & advanced procedures for noise (WG-1).
- Assess certification margins using current Rich-Burn & advanced Lean-Burn combustor emissions for both conventional & advanced takeoff procedures (WG-3)
- Interact with industry for consensus on methods/assumptions

Status

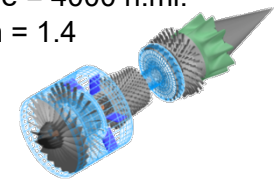
- Advanced takeoff procedures will be helpful in achieving Chapter 4 noise levels, but will require departures from subsonic standards/ reference procedures
- Existing subsonic CAEP/4 levels of LTO emissions appear achievable near-term, depending on regulation times-in-mode for take-off, climbout, approach, taxi.

Significance

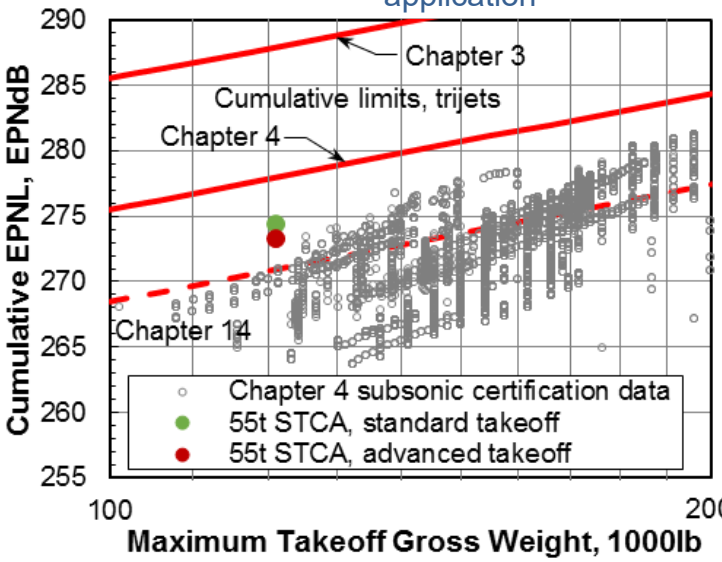
- NASA results are key to moving forward with CAEP gap analysis



STCA1: Range = 4000 n.mi.
Mach = 1.4



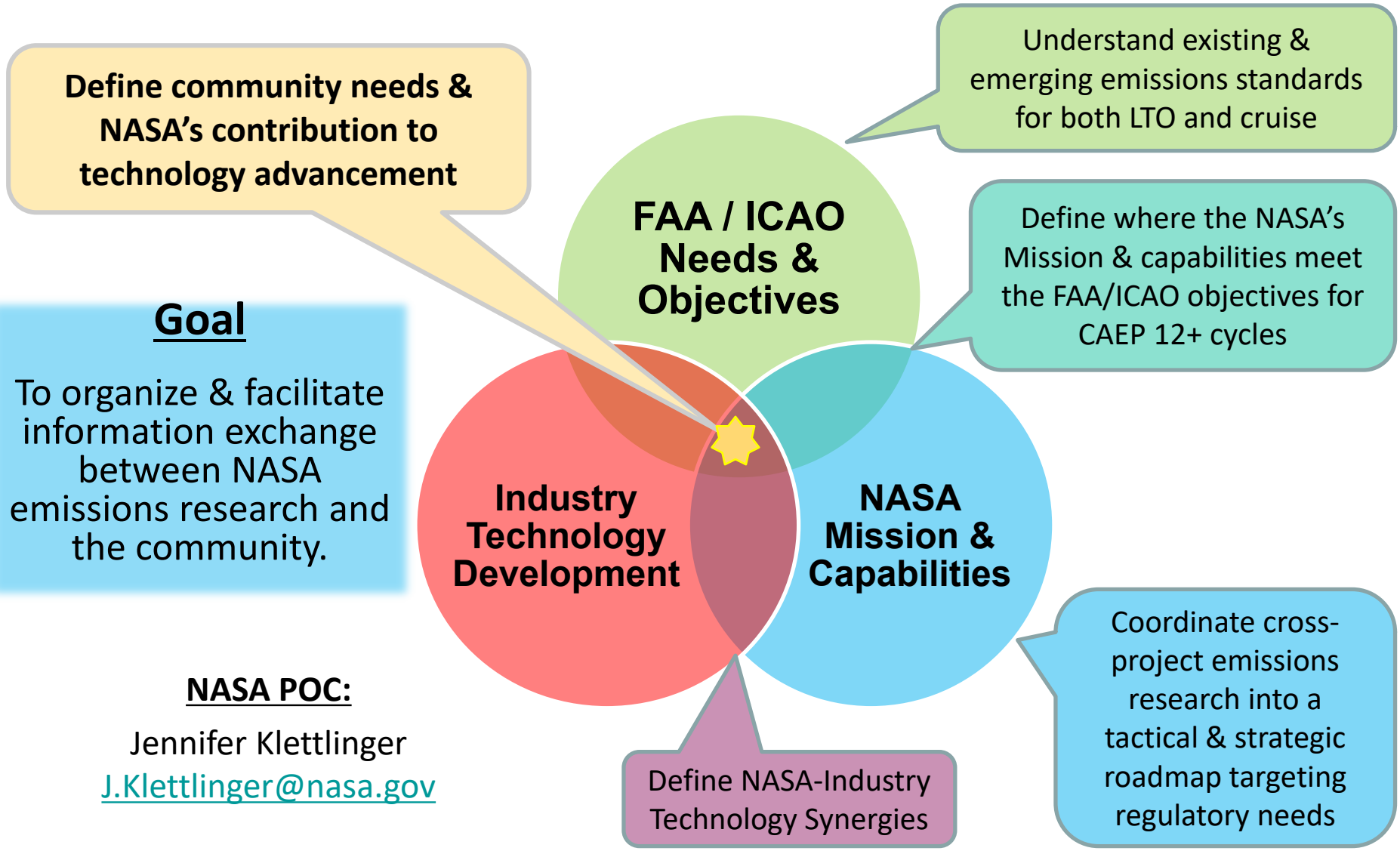
Redesigned CFM56-7B low-pressure spool for supersonic application



55t STCA EPNL predictions (with wing shielding) compared to Chapter 4 data.

ICAO/FAA WG-3 Interaction and Technical Support

Supersonic and Subsonic Emissions



NASA POC:

Jennifer Klettlinger

J.Klettlinger@nasa.gov

subsonics (transports)

the 24/7 global backbone
of air transportation
now and into the foreseeable future

Electrified Aircraft Propulsion Industry Day

December 6, 2018 Tysons, VA

Objective: Conduct a focused market assessment with U.S. Industry regarding the potential for electrified aircraft to include electric drive train, power distribution, and energy storage concepts to be used, in whole or in part, as primary propulsion for fixed-wing, passenger-carrying transport aircraft. Identify overlapping interests for potential NASA/Industry/University collaboration

NASA POC: Fayette Collier, Ph.D.
Associate Director for Flight Strategy
Integrated Aviation System Program, ARMD, NASA
fayette.s.collier@nasa.gov

OUTCOME:

Digesting information and assessing options in context of several budget scenarios

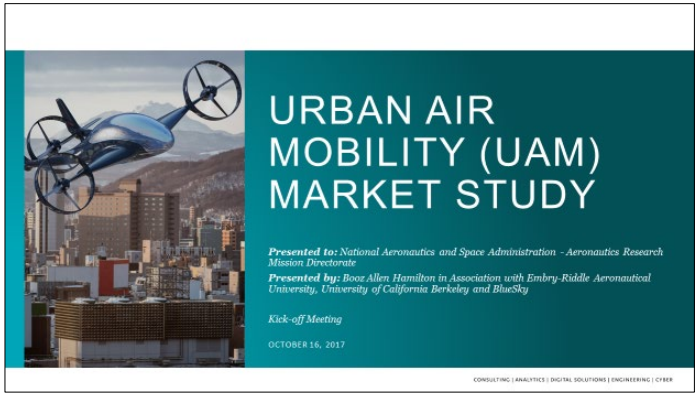
vertical flight

value through accessibility

UAM Market Studies

- ARMD has funded two Urban Air Mobility market studies that included several air taxi/metro models, air ambulance, and last-mile package delivery
- Studies include:
  - A range of urban areas and business models, technology requirements, legal and regulatory barriers, social acceptance issues
  - Assumptions for issues such as autonomy, batteries, weather, infrastructure, operating costs, passenger adoption rates, etc.
- Generally speaking, UAM markets were found to have viable and profitable use cases.
  - By ~2028 “air metro” could be profitable and by ~2030 result in ~750M annual passenger trips in 15 metro areas
  - Air ambulance model may not be profitable, but have high impact on public good
  - By ~2030 “last mile package delivery” could be profitable and result in ~500M deliveries annually
  - Large variability across studies based on differences in assumptions, e.g., infrastructure

presentations available @ https://www.nasa.gov/uamgc



UAM Reference Missions

Non-Passenger Carrying Reference Missions


e.g. PUBLIC SAFETY VEHICLES

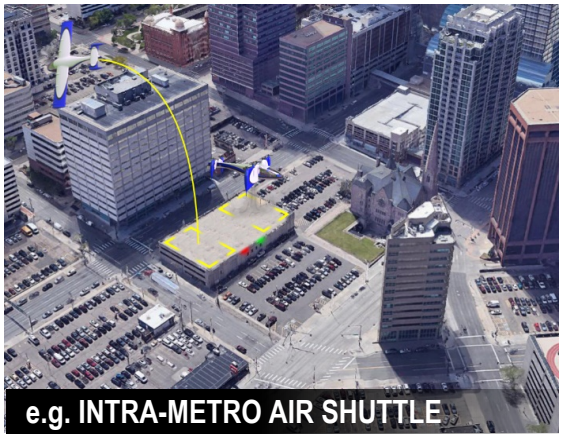

e.g. SMALL PACKAGE DELIVERY


e.g. UAS MULTI-PACKAGE DELIVERY

INITIAL STATE **INTERMEDIATE STATE** **MATURE STATE**

Passenger Carrying Reference Missions


e.g. AIR MEDICAL TRANSPORT


e.g. INTRA-METRO AIR SHUTTLE


e.g. UBIQUITOUS INTRA-METRO TAXI

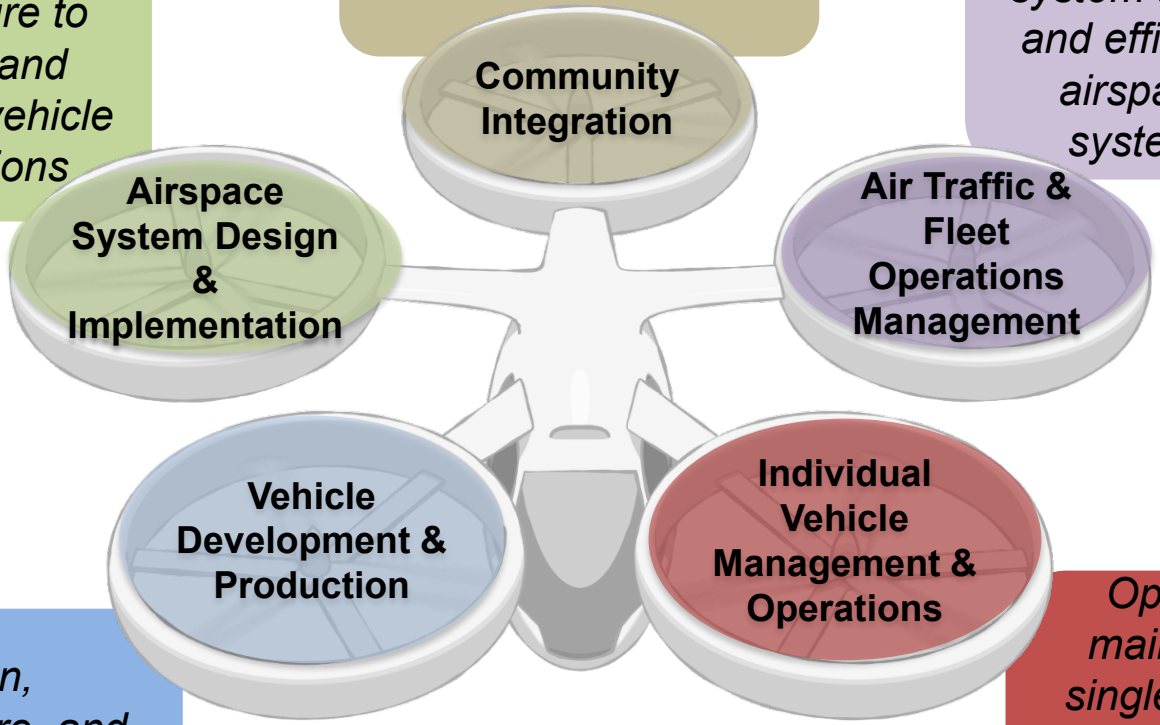
NASA UAM Vision and Framework

Policy, Certification, and Technical Challenges For Operating in the National Airspace System

Design, development, and implementation of infrastructure to enable safe and efficient multi-vehicle UAM operations

Societal integration and acceptance of UAM operations

Operations and management of multiple vehicles within a UAM system that enable safe and efficient sharing of airspace and other system resources



Design, manufacture, and system readiness of UAM vehicles

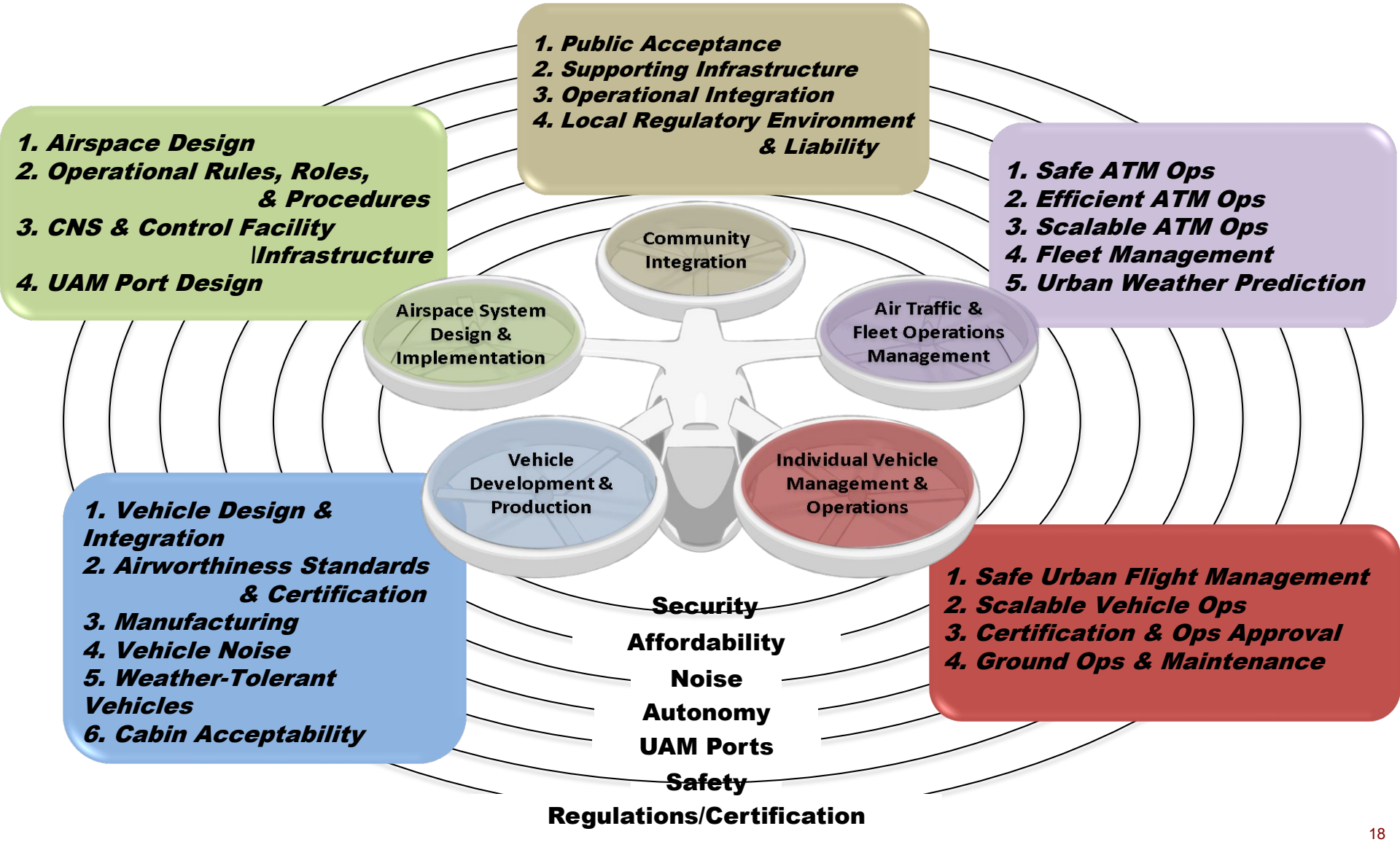
Operations and maintenance of a single UAM vehicle, independent of the sharing of airspace or other system resources

Urban Air Mobility (UAM) Vision
Revolutionize mobility within metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo

"Development" ←

→ "Operations"

NASA UAM Framework and Barriers



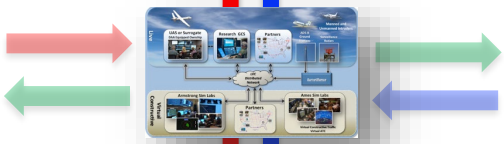
The UAM “Grand Challenge” Series

- Challenging the industry to execute ecosystem-wide systems level safety and integration scenarios
- Raises the water level for all
- Builds knowledge base for requirements and standards
- No purse or prize money

Grand Challenge (GC) Series Overview

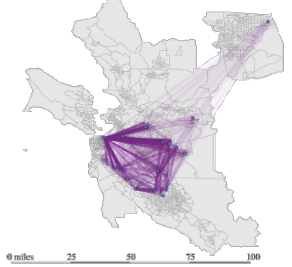
Vehicles

functional UAM vehicles with threshold level of demonstrated airworthiness



Airspace Management

airspace and air traffic management technologies and services built and simulated to a threshold level of UAM ATM requirements



Safety and Integration Scenarios

airworthiness processes and realistic UML-4 scenarios designed in concert with the FAA, with range(s) and Testbeds as a UAM proving ground

Stakeholder Integration

societal integration and acceptance of UAM Operations including public acceptance, supporting infrastructure, operational integration, standards organizations, the local regulatory environment, etc.

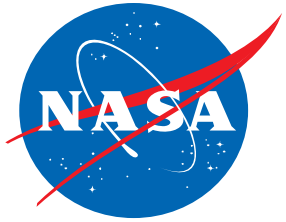
Industry Provided

NASA Provided

Ecosystem Wide Support

Other Important Items

- Shutdown has a major impact (more than day for day)
- Overall support from key Stakeholders is strong
- On the verge of completing several projects
  - Advanced Composites
  - UAS in the NAS
  - Airspace Demonstrations
- Focusing smaller vehicle research around the urban mobility mission (multiple projects)
- Continued Agency support for our larger testing facilities


NASA