



EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

**NASA Overview/Update
FAA ASCENT Meeting
October 2018**

**Angela Surgenor
Technical Integration Manager, Advanced Air Vehicles Program
NASA Aeronautics Research Mission Directorate**



Brief Outline

- Global Growth in Aviation
- NASA Vision and Strategy
- FY2019 Budget Request
- Supersonic Low Boom Flight Demonstrator (LBFD)
- NDMAX Alternative Fuels Flight Campaign
- Subsonic Transport Technology Strategy
- Enabling U.S. Leadership in Subsonic Transport Markets
- Emerging Markets – Integrated Challenges

Global Growth in Aviation



2017

4 BILLION

PASSENGER TRIPS

2036

7.8 BILLION

PASSENGER TRIPS

41,030

New Aircraft Deliveries

\$6.1 Trillion

Market Value

Asia-Pacific
Market is Nearly

40%

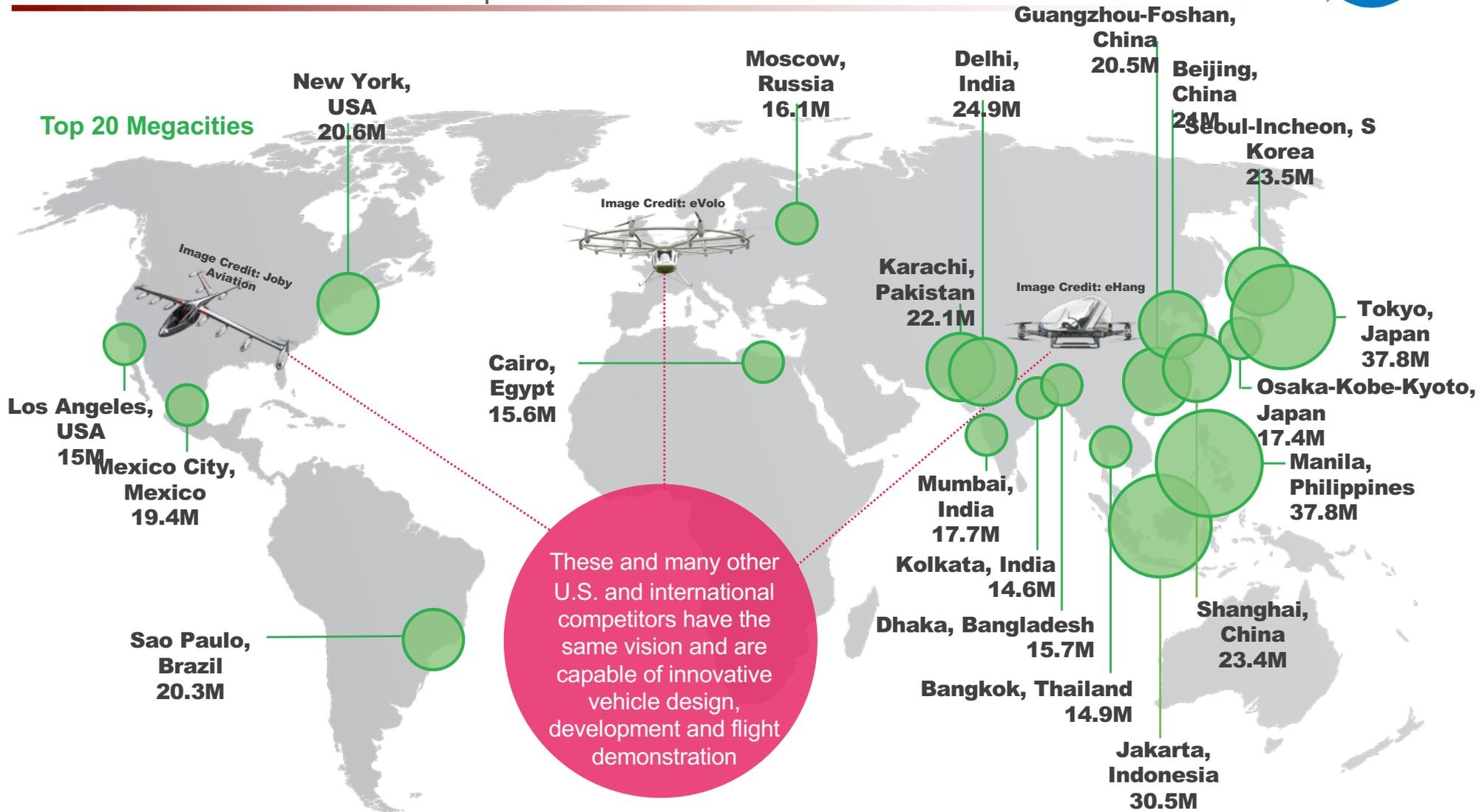
of New Aircraft
Deliveries

78%

of New Aircraft
Deliveries are
Single Aisle Class
(including Regional
Jets)

Urban Air Mobility

Global Race to Achieve Leadership



Large projected market—McKinsey analysis of demand by 2030 in 15 major U.S. cities:

- 500 Million annual UAS package deliveries
- 750 Million annual passenger trips

Extrapolation to the global market would likely increase demand by 5 to 10x

Market: Large UAS & HALE

HALE UAS

Upper E
Airspace

Market: Large Transport
& Large UAS

Supersonic
Manned Aircraft

Subsonic
Fixed wing

Class A
Airspace

Large UAS

International
Airport

Small
airport

Market:
Thin/Short Haul

Helicopter

Airport

Large
UAS

Weather Tolerant
Operations

Weather Tolerant
Operations

Asia

U.S.A.

Weather Tolerant
Operations

Droneport

Airport

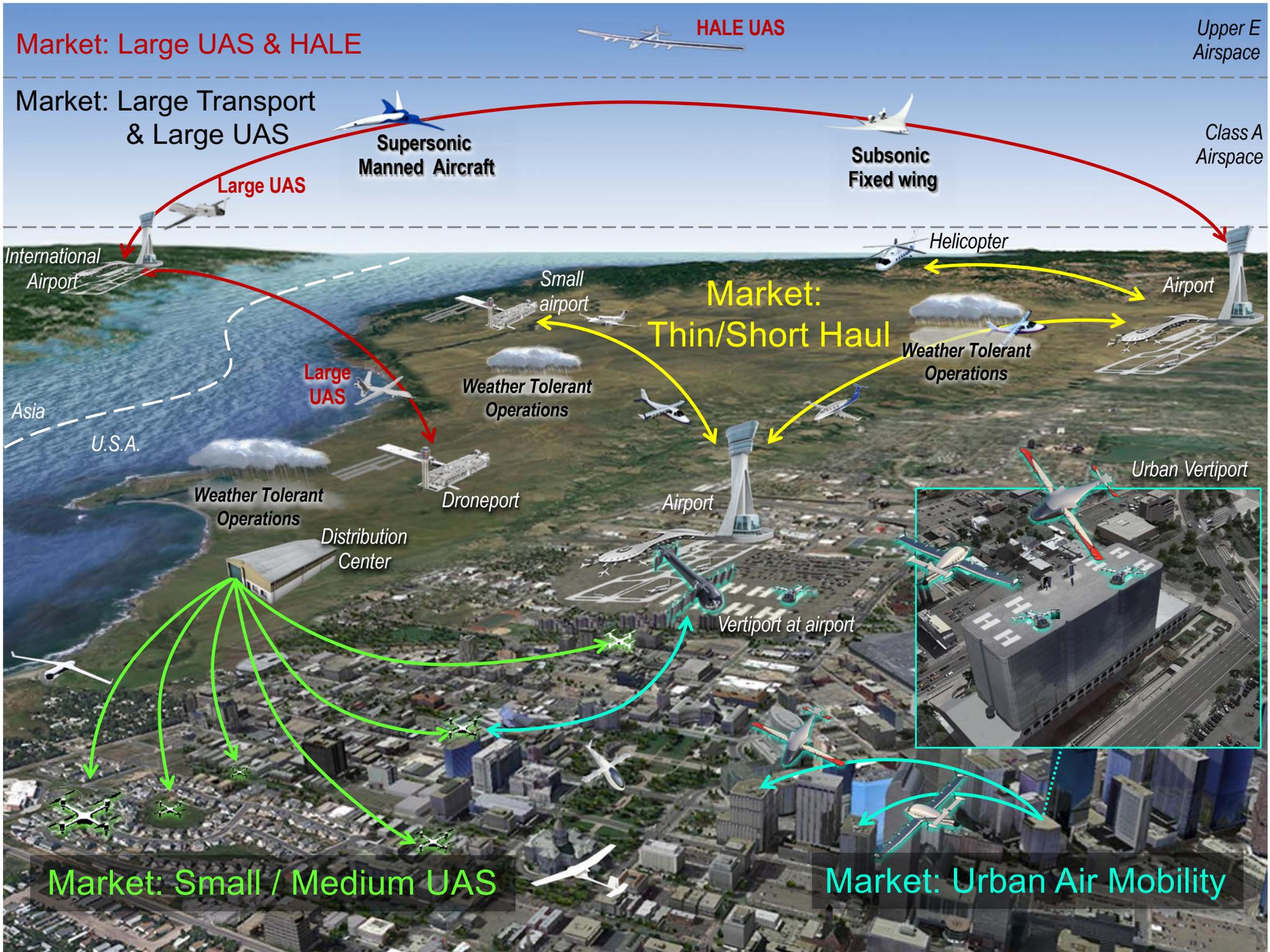
Urban Vertiport

Distribution
Center

Vertiport at airport

Market: Small / Medium UAS

Market: Urban Air Mobility



NASA Aeronautics Strategic Implementation Plan

Continues to Guide NASA Aeronautics Investment



Key Trends (Not Exhaustive)

Aviation Mega-Drivers

Analysis & Community Dialogue

Strategic Thrusts

Community Vision

Increasingly Urbanized World

Rising Global Middle Class Driven by Asia-Pacific

Urban Transportation Increasingly Congested



**Industry / Gov't Execs
What's Needed?**



1. Safe, Efficient Growth in Global Operations



2. Innovation in Commercial Supersonic Aircraft

Continuing Pressure to Reduce Noise and Local Air Quality Impacts

Aviation Industry Sets Challenging CO₂ Reduction Goals through Mid-Century



**Industry / Gov't SMEs
What's Possible?**



3. Ultra-Efficient Commercial Aircraft



4. Transition to Alternative Propulsion and Energy

Networked Com and Sensors, Embedded Artificial Intelligence, and Big Data Converging with Traditional Systems and Technologies



Systems Analysis



5. In-Time System-Wide Safety Assurance



6. Assured Autonomy for Aviation Transformation

ARMD Research Programs & Strategic Thrusts



MISSION PROGRAMS

Airspace Operations & Safety

Projects

- Airspace Technology Demonstrations
- UAS Traffic Management
- System-Wide Safety
- ATM-X

Advanced Air Vehicles

Projects

- Advanced Air Transport Technology
- Advanced Composites
- Revolutionary Vertical Lift Technology
- Commercial Supersonic Technology
- Hypersonic Technology

Integrated Aviation Systems

Projects

- Unmanned Aircraft Systems Integration in the National Airspace System
- Flight Demonstrations and Capabilities
- Low Boom Flight Demonstrator

SEEDLING PROGRAM

Transformative Aeronautical Concepts

Projects

- Convergent Aeronautics Solutions
- Transformational Tools and Technologies
- University Innovation

NASA Aeronautics Vision for Aviation in the 21st Century



ARMD Strategy

<https://www.nasa.gov/aeroresearch/strategy>



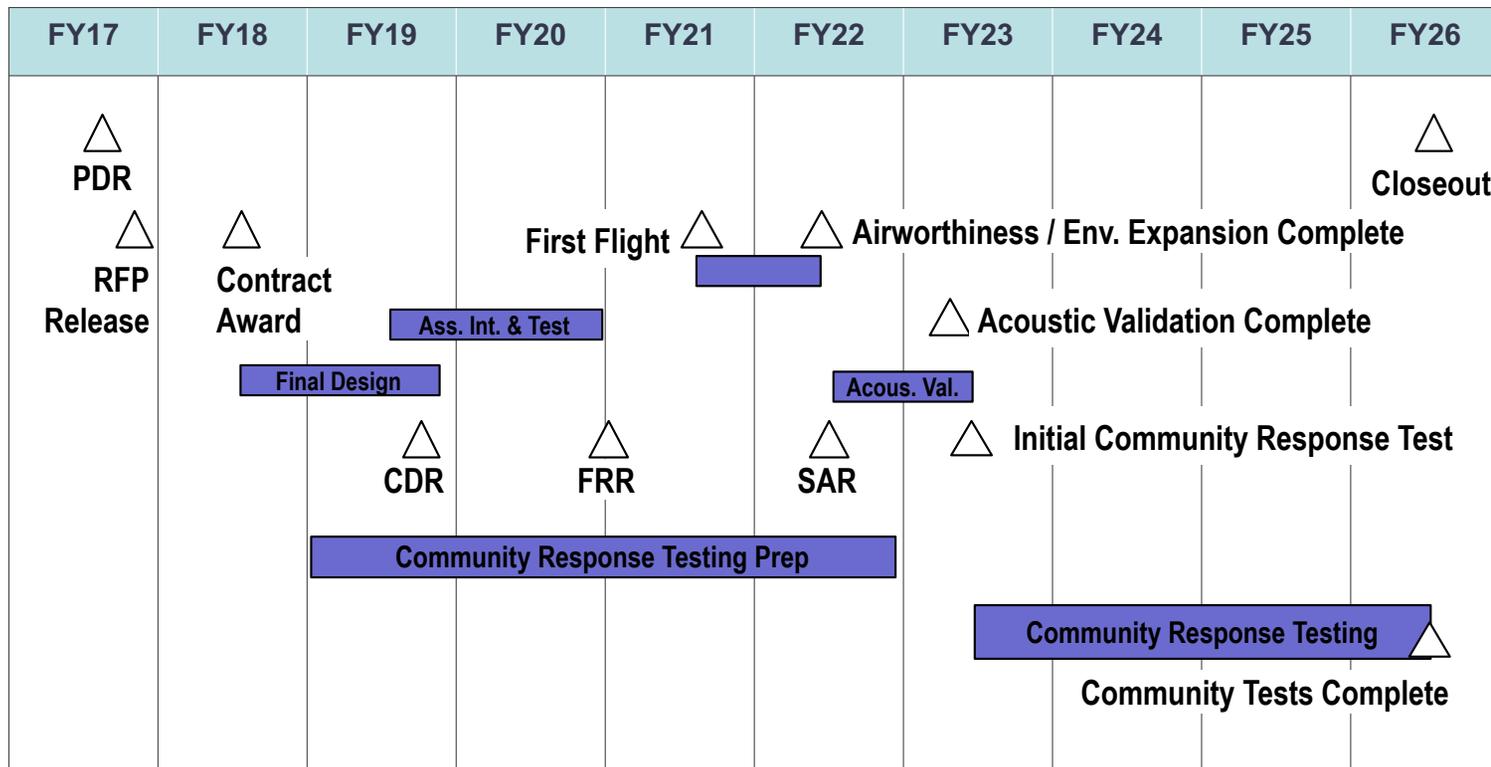
FY 2019 Budget Request - Aeronautics

\$ Millions	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
Aeronautics	\$656.0	\$685	\$633.9	\$608.9	\$608.9	\$608.9	\$608.9
Airspace Operations and Safety	140.6		90.8	96.2	120.4	122.7	122.9
Advanced Air Vehicles	274.6		230.6	248.5	257.1	257.8	258.3
Integrated Aviation Systems	125.0		189.2	154.1	106.6	103.3	102.5
Transformative Aeronautics Concepts	115.8		123.3	110.1	124.9	125.1	125.1

Low Boom Flight Demonstrator (LBFD) Update



- Completed Preliminary Design Review FY17
- Project teams established and formulation activities on track
- Awarded Design and Build Contract early 3rd Quarter FY 2018 to Lockheed Martin
<https://www.nasa.gov/press-release/nasa-awards-contract-to-build-quieter-supersonic-aircraft>
- First Flight planned for FY 2021



NDMAX (NASA/ DLR Multidisciplinary Airborne Experiment Alternative Fuels Flight Campaign



Technical Need:

To address FAA and NASA research needs for ground and cruise-emission measurements for improved models

Objectives:

- Determine how sustainable alternative jet fuels effect aircraft emissions at typical cruise altitudes and speeds.
- Establish links between contrail characteristics and aircraft soot emissions including differences between older and newer engines
- Study effects of aircraft particle emissions on cirrus cloud properties downwind of flight corridors
- Examine the effects of background aerosols on contrail formation and growth

Schedule:

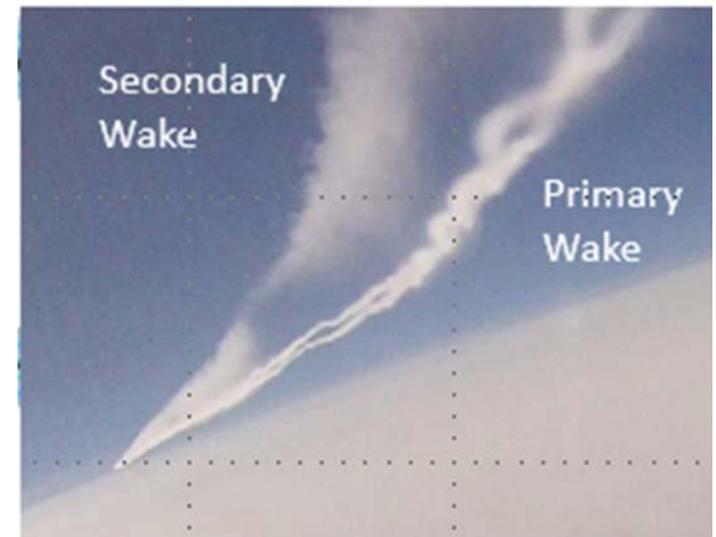
- January/ February 2018- Flight Campaign
- October 2018-Discussion of Results followed by preparation of reports.



A320 Emissions and Contrail Sampling Exceeded Expectations

Outcome:

- Conducted 7 joint sampling flights in restricted airspace over Germany , 39 flight hours.
- Tested 4 different fuels in DLR A320 ATRA
- Emissions and contrail data were obtained for all fuels at altitudes of 26, 32 and 38kft
- Made measurements at two thrust levels and at separation distances ranging from 2.5 to 20 NM
- Over 1000 distinct wake/plume crossings were accomplished
- Broad international participation with 120 scientists from NASA, DLR, Max Planck Institute, Universities of Oslo, Innsbruck and Missouri S&T, NRC-Canada, Boeing, and Aerodyne Research
- Data analysis in progress, but preliminary results showing a strong correlation between soot particles and contrail ice crystal concentrations



Subsonic Transport Technology Strategy



Prove out transformational, integrated propulsion and airframe technologies

Current Generation

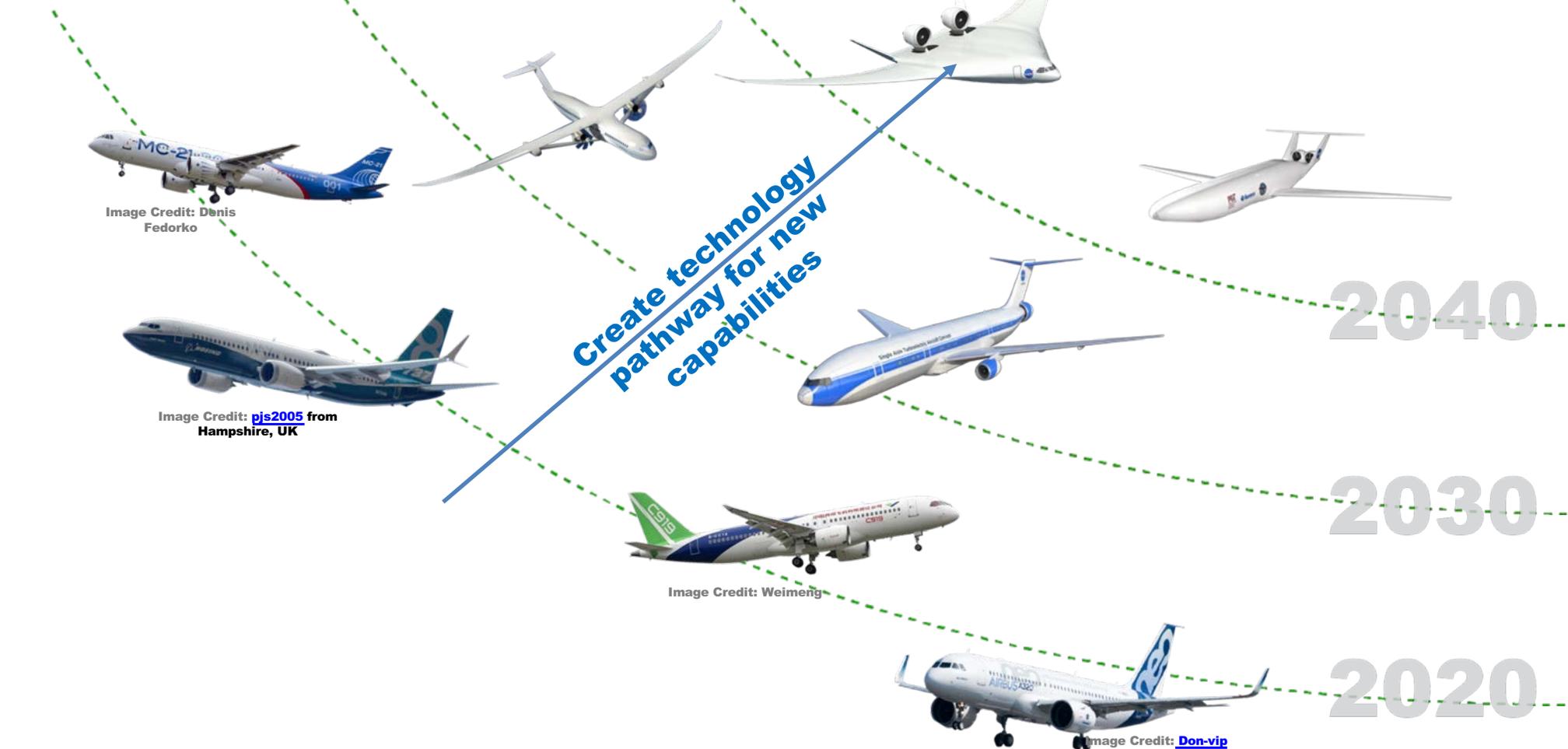
**Next Generation
-Transitional-**

**Future Generations
-Transformational-**

Energy usage reduced by more than
60%

Harmful emissions reduced by more than
90%

Objectionable noise reduced by more than
65%

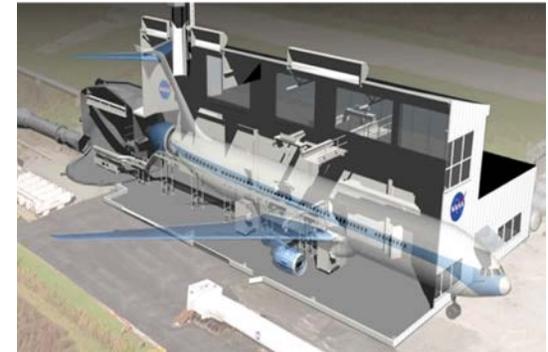


Enabling U.S. Leadership in Subsonic Transport Markets

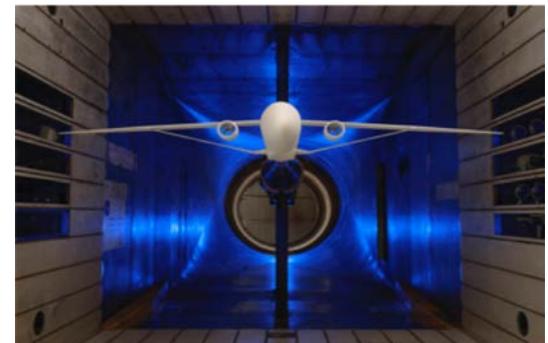


- Suite of 5 key technologies coupled into transformative configurations will win the subsonic transport future
 - Light Weight, Very High Aspect Ratio Wings
 - **Propulsion – Airframe Integration, especially Boundary Layer Ingestion**
 - Tailored Non-Circular Fuselage
 - **Electrified Aircraft Propulsion**
 - **Small Core Turbine Engines**

- ARMD is advancing these key technologies to create market opportunities



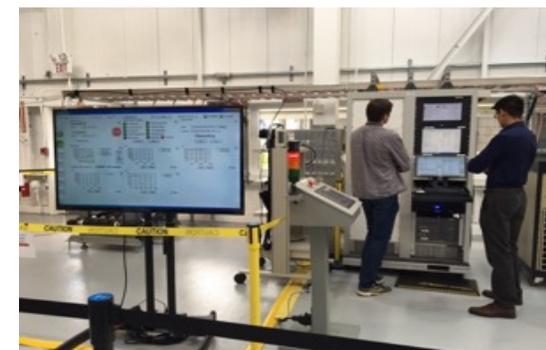
NASA Electric Aircraft Testbed (NEAT) Facility



Very High Aspect Ratio Wing



Boundary Layer Ingestion

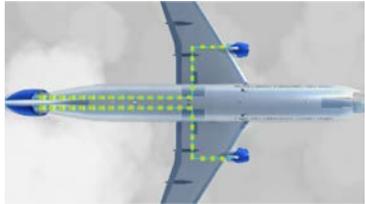


Hybrid Electric Propulsion

Electrified Aircraft Propulsion Strategy for Single Aisle Aircraft



Initial Focus on Turboelectric Aircraft



Concept definition & system analysis

Novel integration and BLI

MW flight-weight electrical component development

Integrated system testing

Advanced cores with large power extraction



Potential Flight Demo



Potential single aisle aircraft



Hybrid electric option to be considered with advances in battery technology

MW-level High Efficiency/Power Density Electric Machines & Flight-weight Power System/Electronics

- Explore conventional & non-conventional topologies; Integrate novel thermal management; Demonstrate component maturation
- Develop/demonstrate powertrain systems and components; High voltage, MW power electronics, transmission, protection

Enabling Materials

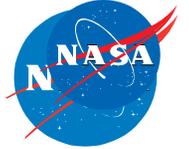
- Insulators & conductors for high power & altitude components; Nanocomposite magnetic materials for targeted machines and drives

Integrated Subsystems

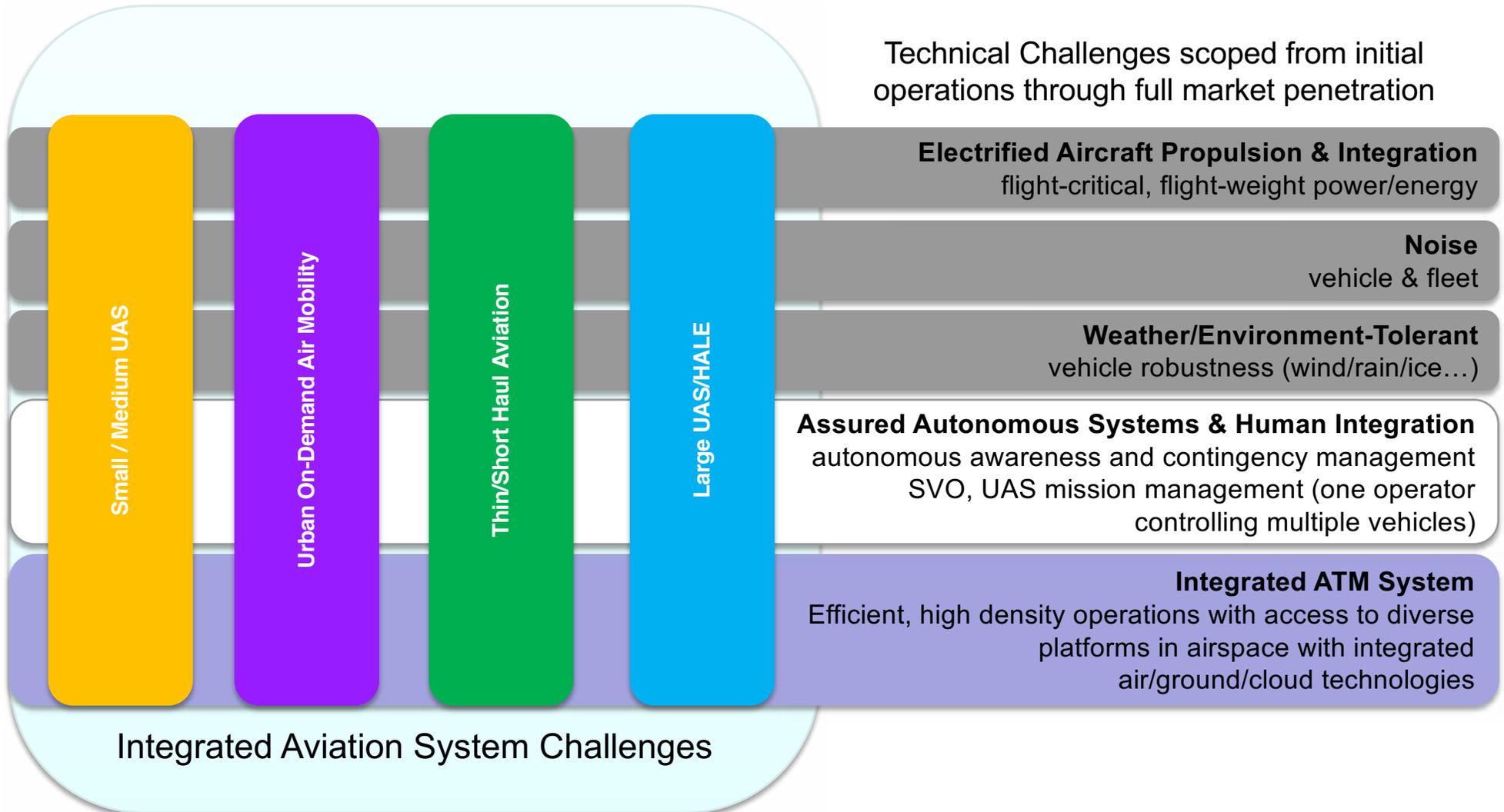
- Explore component interactions, power management, & fault management

Emerging Markets - Integrated Challenges

NASA ARMD Programs pivoting to address complex challenges



ARMD has developed a holistic understanding of the challenges for enabling the enormous potential of emerging aviation global market opportunities



DAWN OF NEW ERA OF AVIATION

Exciting times

Investing in our future - laying the groundwork for Aviation in 2040
Many challenges... present many opportunities... across many markets

Technologies

Many broadly applicable and some uniquely enabling technologies
Convergence from other sectors into aviation

Vehicles, Operations, Energy, Smart Systems

Bringing new value through the air