National Aeronautics and Space Administration

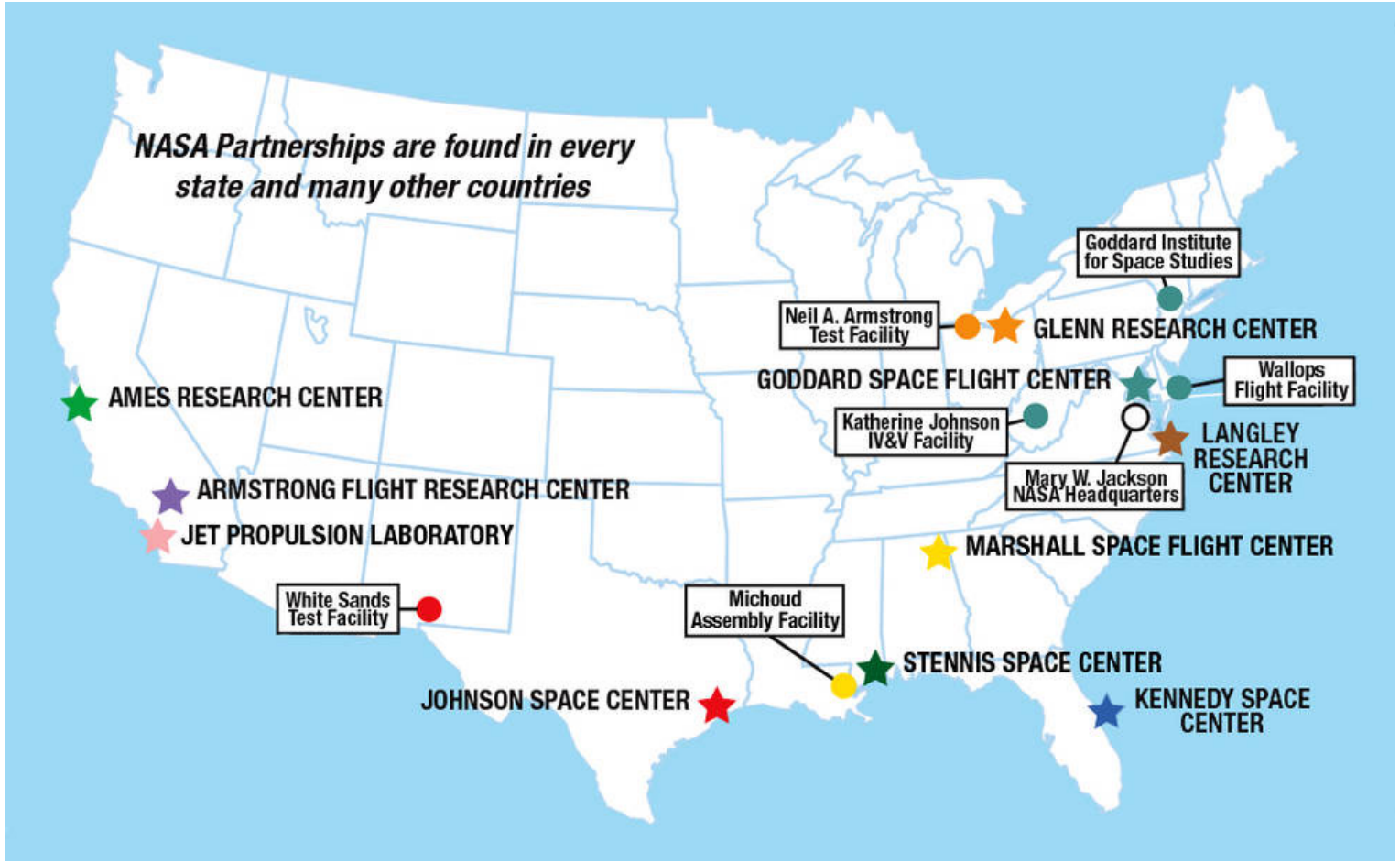
EXPLORE FLIGHT
WE'RE WITH YOU WHEN YOU FLY

Seeking Innovation Beyond the Leading Edge in Aeronautics at NASA

Anna-Maria Rivas McGowan, Ph.D.
Agency Senior Engineer For Complex Systems Design
Learning and Innovation Research Activities Lead for the Convergent Aeronautics Solutions Project

PDMA Virtual Innovators Conference and JPIM Research Forum
January 15, 2022

NASA Facilities and Centers



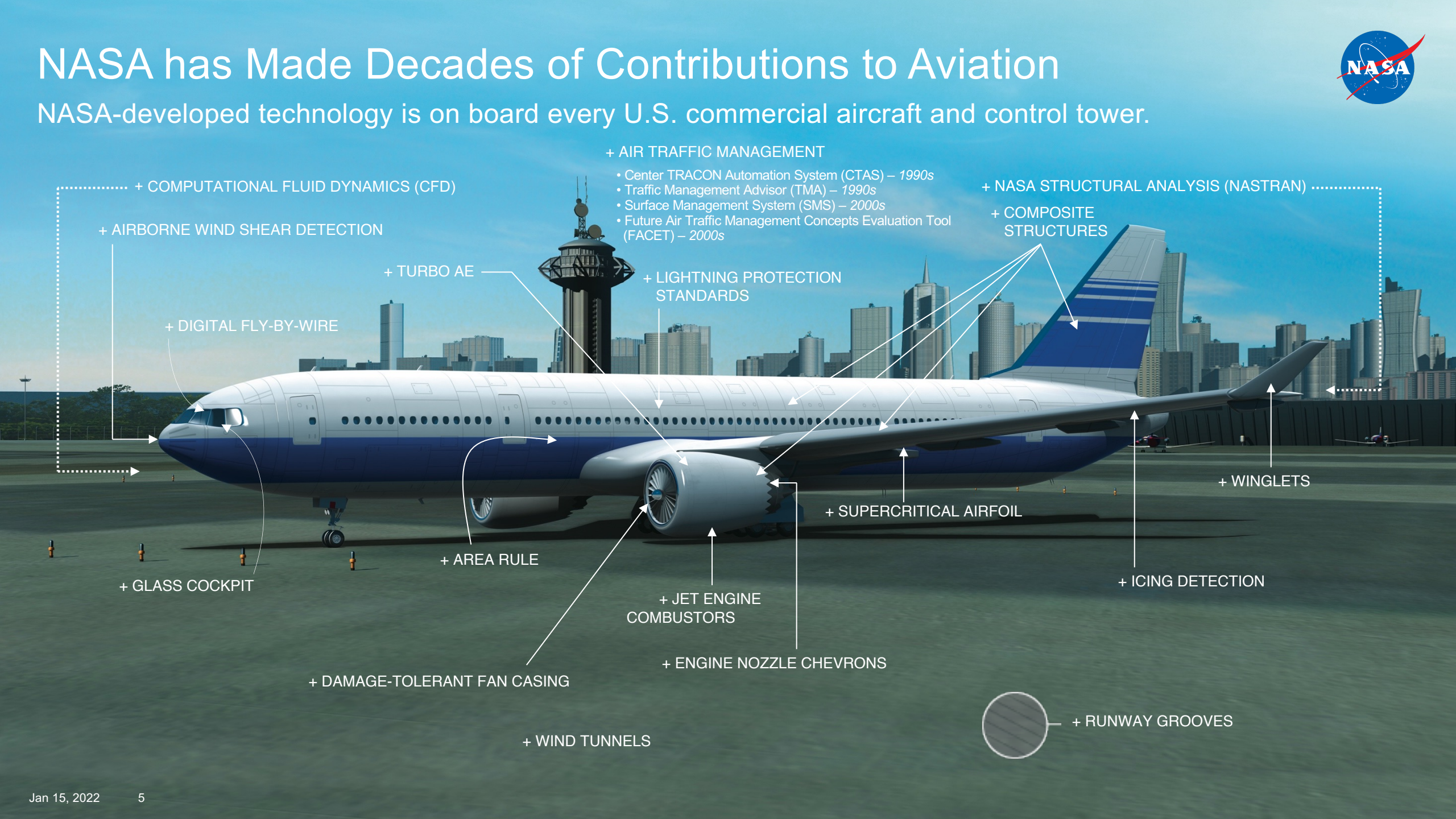
National Aeronautics and Space Administration

NASA *Aeronautics*
Aeronautics Research Mission Directorate


NASA technology is on board every U.S. commercial aircraft and air traffic tower.

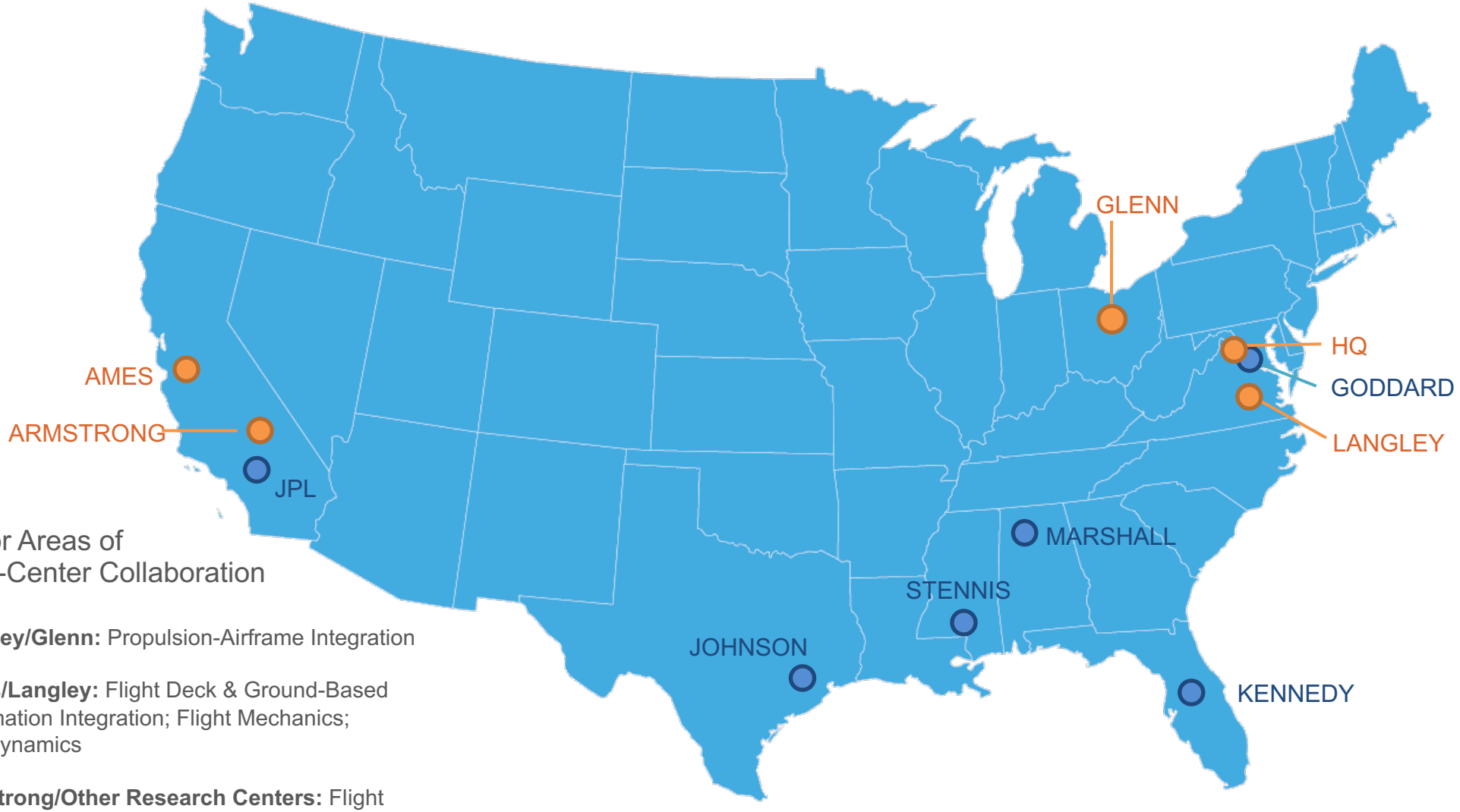
NASA has Made Decades of Contributions to Aviation

NASA-developed technology is on board every U.S. commercial aircraft and control tower.

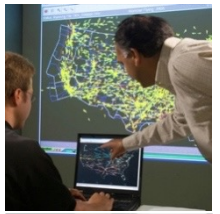


Where Does NASA Aeronautics Research Happen?

Aeronautics research takes place at four of NASA's centers.

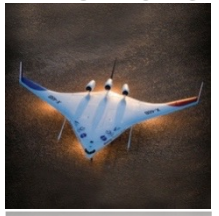


AMES



ATM Research and Technology & Integration

ARMSTRONG

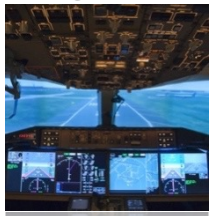


Flight Research

GLENN

Propulsion Research and Technology

LANGLEY



Vehicle Research and Technology

Major Areas of Inter-Center Collaboration

Langley/Glenn: Propulsion-Airframe Integration

Ames/Langley: Flight Deck & Ground-Based Automation Integration; Flight Mechanics; Aerodynamics

Armstrong/Other Research Centers: Flight Experiment Integration

Aviation is Vital to our Nation's Economy

Pre-COVID

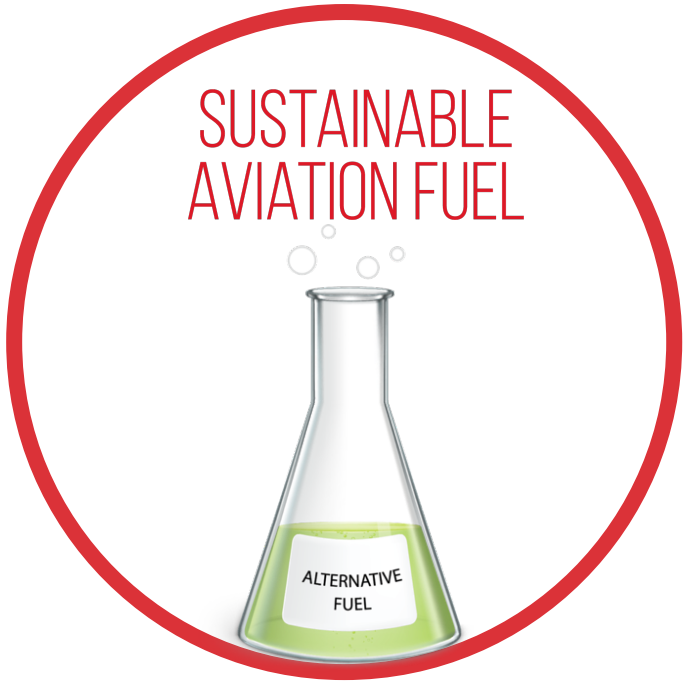
- $78 billion positive trade balance; the largest positive trade balance of any U.S. manufacturing sector
- $1.8 trillion total U.S. economic activity
- 10.9 million direct/indirect jobs
- 21.3 billion tons of freight transported by U.S. airlines in 2019

ARMD Overview Video

Aviation Industry Pillars for a Sustainable Future

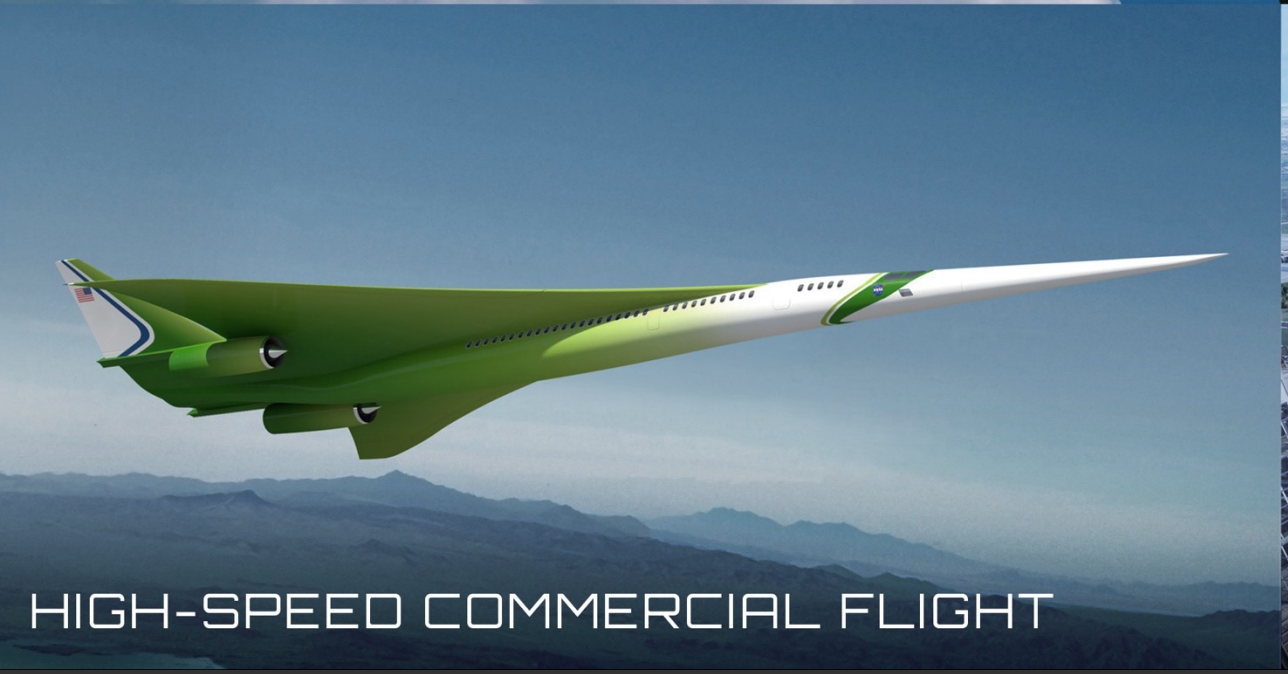
Global Aviation Industry's GOAL: 50% reduction in carbon emissions by 2050 relative to 2005
and **possible net zero emissions by 2060 through these three means**

NASA = Primary Role



NASA = Supporting Role

NASA = Primary Role



Four Transformations for Sustainability, Greater Mobility, and Economic Growth

Credit: DOD

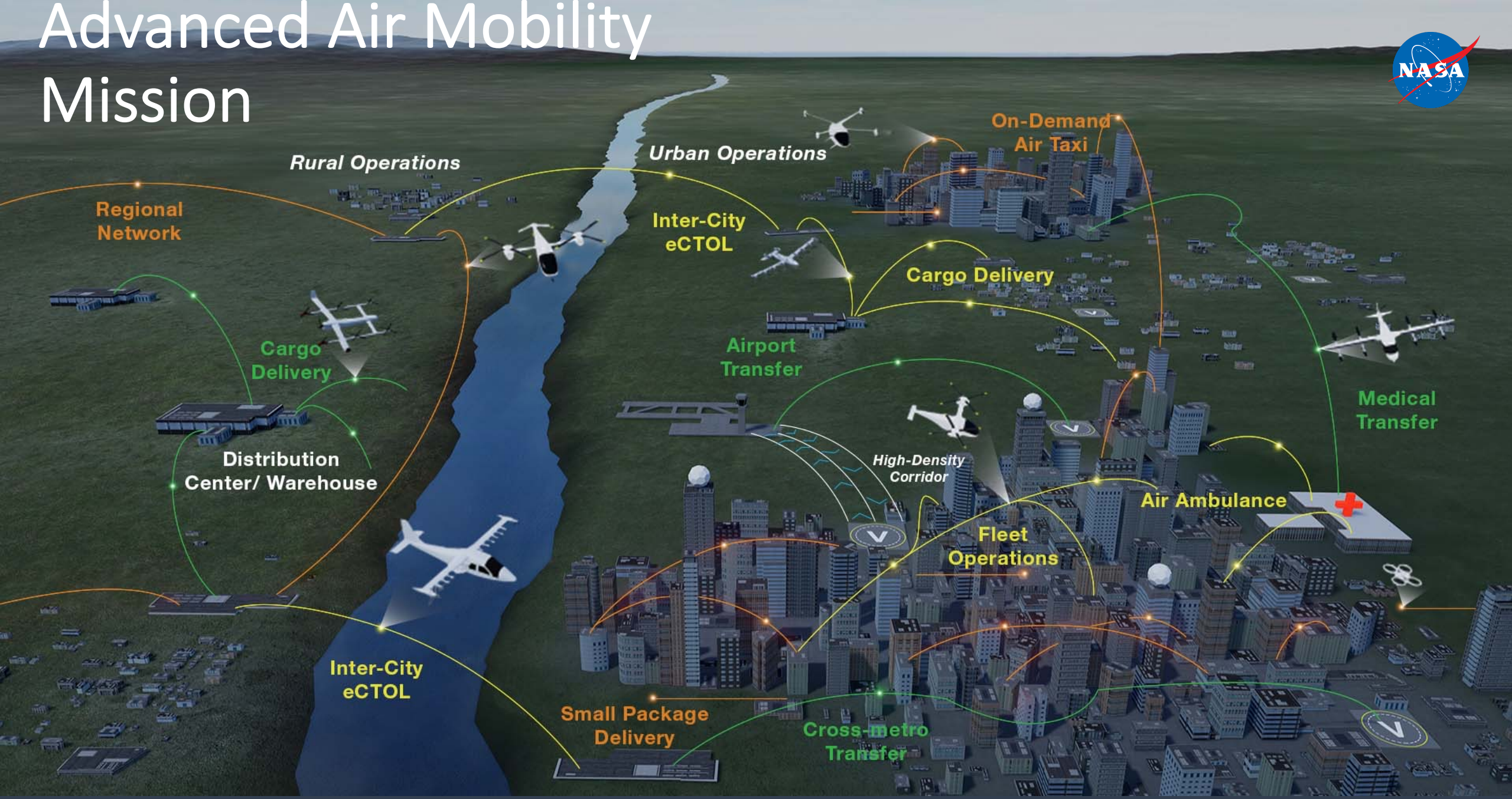
Seeking Innovation Beyond the Leading Edge

System-Level Innovation

The Future of Flight: Advanced Air Mobility

AAM Video

Advanced Air Mobility Mission



Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions

System-Level Innovation

Interdependencies

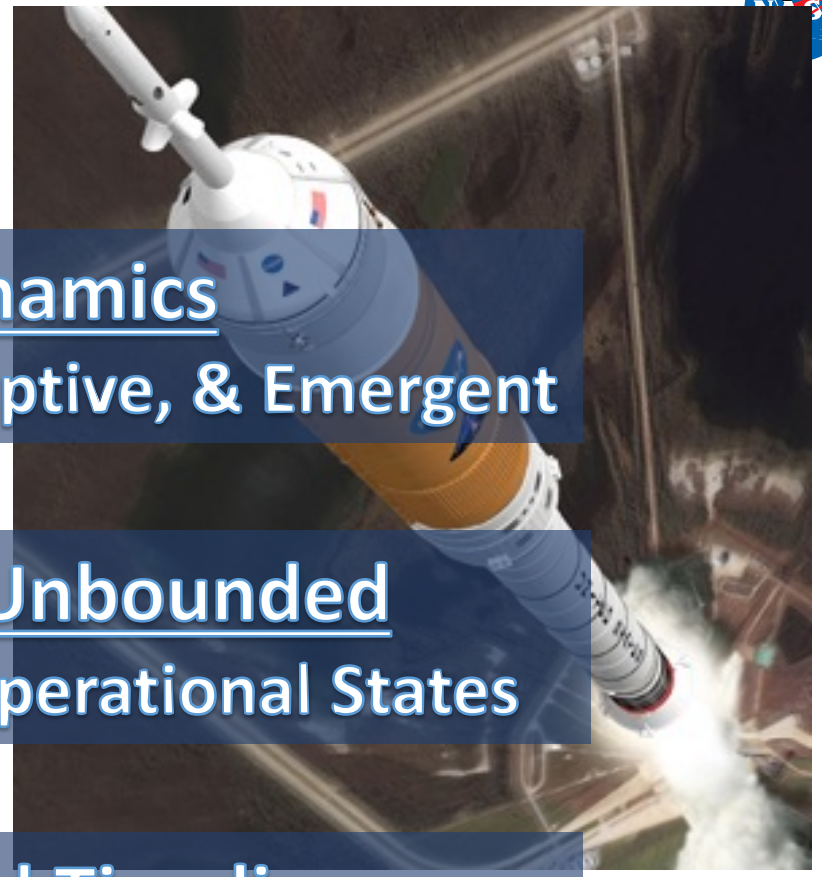
Interconnectivities

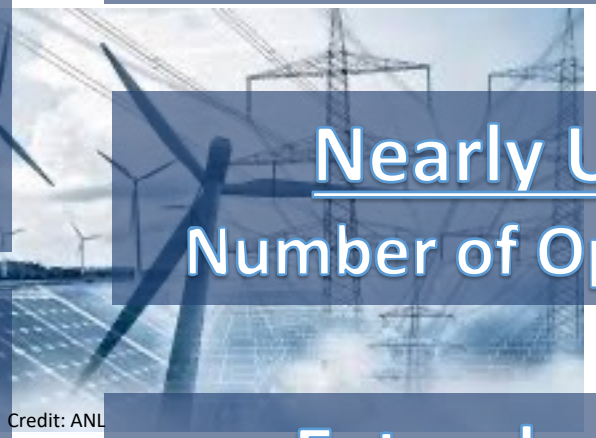
Interactions

Interoperability

Dynamics

Nonlinear, Adaptive, & Emergent





Nearly Unbounded

Number of Operational States

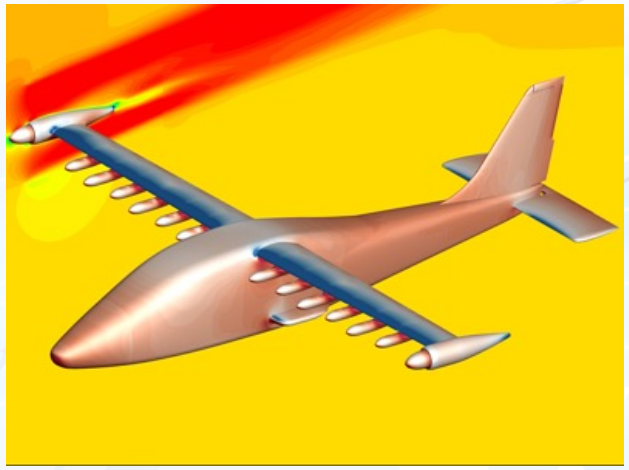
Credit: ANL

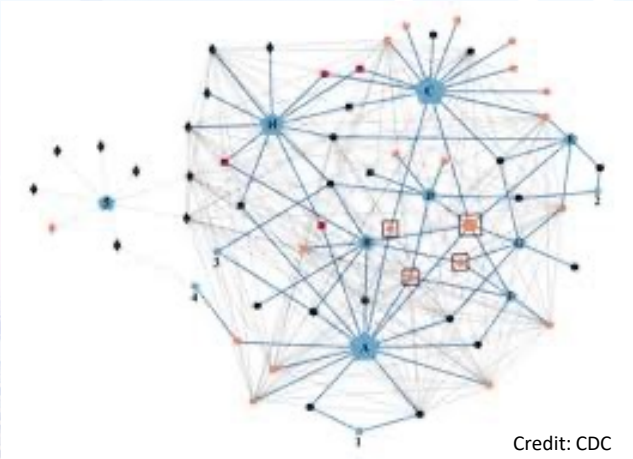
Networks and Ecosystems

Credit: FDOT

Extended Timelines

Large-Scale Complex Engineered Systems




Credit: CDC


Credit: NIST

System is defined as much by the <u>interactions of components</u> as the components themselves

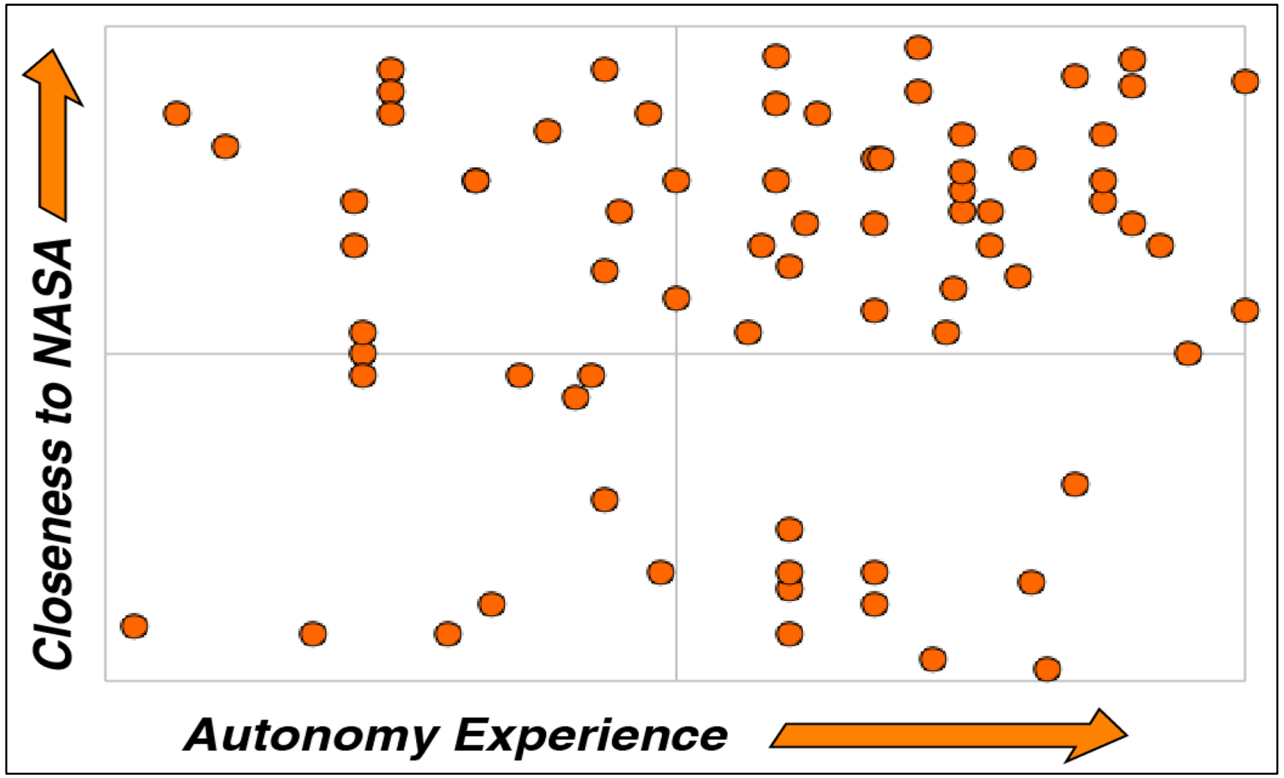
"Portions of the envisaged system are known to all,
but all of it is known to none."
(K. Weick, 1993)

Aeronautics Helping to Solve Key Problems In Multiple Areas

CAS Video

New Markets
New Opportunities

Discovering the Customers and Their Needs

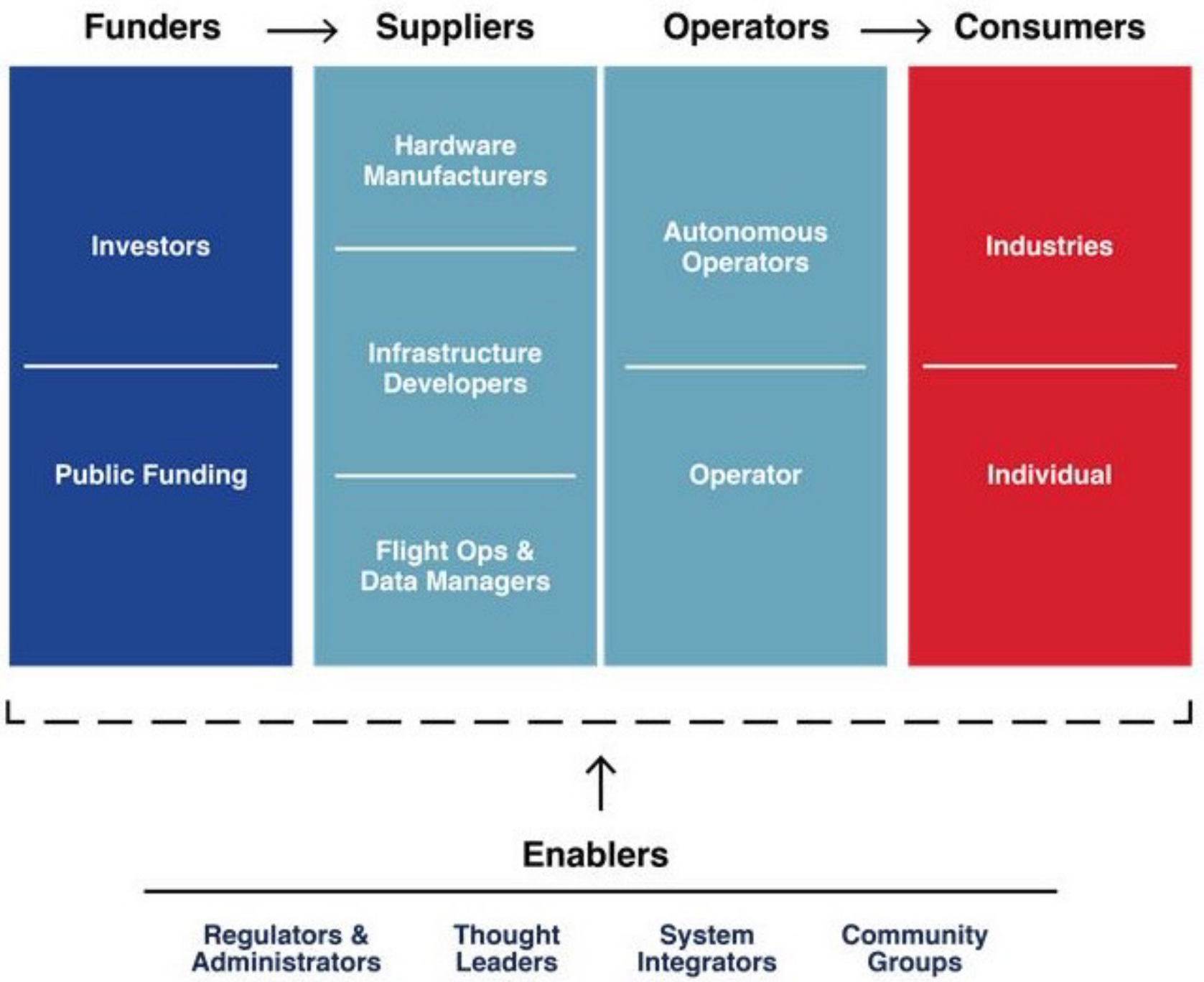


- NASA Researchers & Leaders
- Other Gov't Agencies
- University Researchers
- Hobbyists
- First Responders
- Defense Contractors
- Small Businesses
- Community Colleges
- City Planners
- Architects
- …more

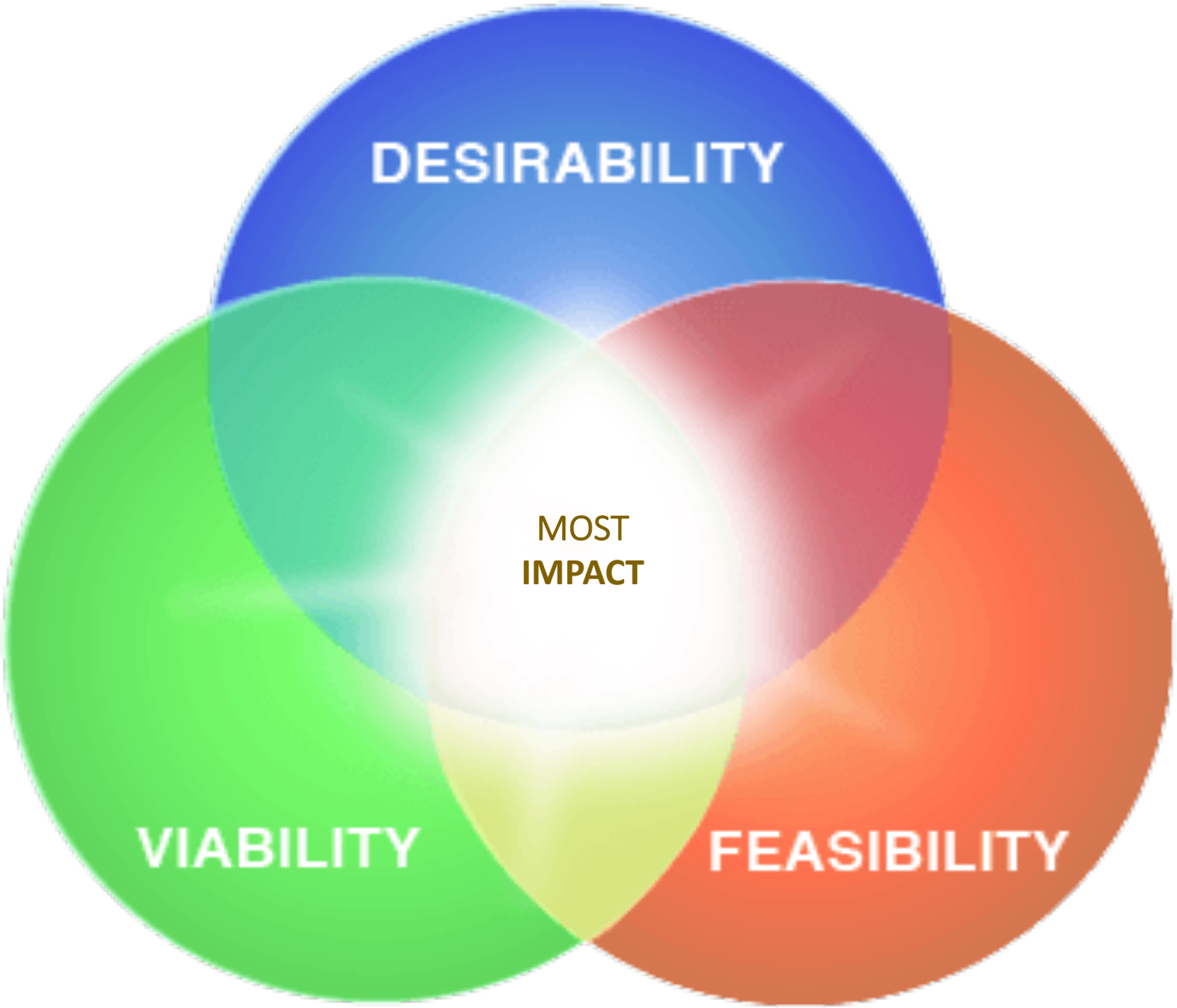
70 Interviews

With Traditional & Non-Traditional Users & Stakeholders

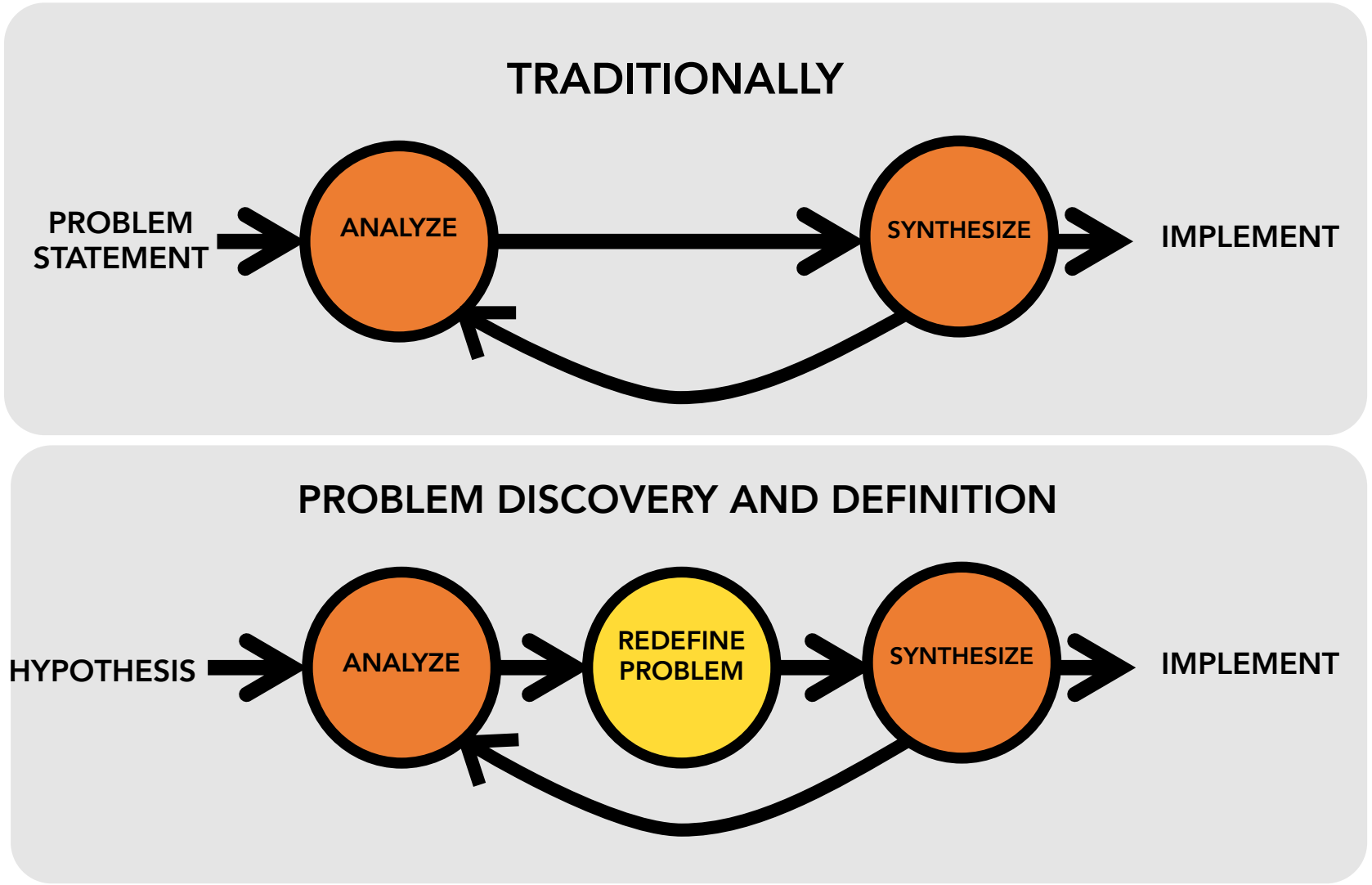
Example Ecosystem



Holistic Perspectives


DESIRABILITY
MOST
IMPACT
VIABILITY
FEASIBILITY

Problem Discovery and Re-definition Are Central

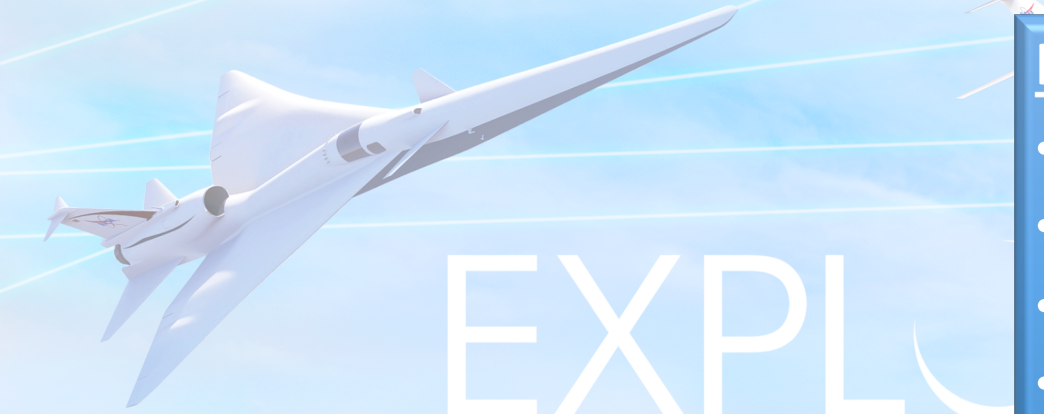


"I need a faster horse."

A better transportation system

Interdisciplinary

Interdisciplinary Work



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Key influencing factors:

- **Organizational** (Incentive system, structures, practices, etc.)
- **Social** (Trust, relationships, networks, information sharing, etc.)
- **Cognitive** (Confusion, understanding, etc.)
- Notable: technical factors (math & computer models, etc.) are important but not as critical as the above

(McGowan, 2014)

Uniqueness:

- The *Interdependence* of Disciplines = Inherently Interactive
- Co-construction of new knowledge
- Is not the opposite of specialization (Rafols & Meyer, 2009)
- Disciplinary methods, assumptions, theories are often challenged, then changed (Lattuca, 2001; Repko, 2012)
- Unknown – unknowns are common

Making Interdisciplinarity Work

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Ignorance

- Inherent – due to venturing into new areas
- Discomforting
- Culturally not well received
- *Useful*
  - Creativity: Allows for less constrained ideation
  - New learning about old areas of expertise: Questioning is good!
  - Discovery of new capabilities and solutions
- Can be rewarding
  - Due to break throughs and learnings fostered
  - If social challenges are addressed

Social Capital

- Mutual regard and respect
- Reciprocity
- Trust
- Fun
- Selfless helping of others
- Relationship

Absolutely critical


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Questions?
www.nasa.gov