National Aeronautics and Space Administration

NASA Advisory Council Meeting
Aeronautics Committee Report

Mr. John Borghese
Chair
NASA Headquarters
December 7th, 2017

Aeronautics Committee Membership

Mr. John Borghese

Chair,
Rockwell Collins

Dr. John Paul Clarke

Georgia Institute
of Technology

NEW MEMBER

Dr. Eric Ducharm

GE Aviation

Dr. Michael Francis

United Technologies

Dr. Greg Hyslop

The Boeing Company

Dr. Karen Thole

Pennsylvania State
University

Dr. David Vos

Tebogo

Areas of Interest Explored at Current Meeting

Topics covered at the Aeronautics Committee Meeting held on November 15-16, 2017 at the AERO Institute, Palmdale, CA:

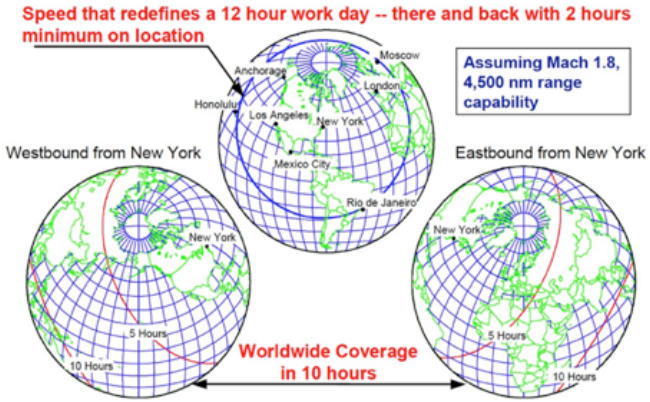
- Low Boom Flight Demonstrator*
- System Wide Safety Assurance Project*
- Hypersonics*
- Autonomy Thrust*
- FY18 Work Plan

* These topics have related findings provided by the Aeronautics Committee

Commercial Supersonic Flight

Why?: Commercial supersonic flight represents a potentially large new market for aircraft manufacturers and operators world-wide

- Global demand for air travel is growing, which places a demand on speed.
- Supersonic aircraft will be excellent export products that can be capitalized on by the US to support a positive balance of trade



- New supersonic products lead to more high-quality jobs in the US.
  - Large potential market predicted:
  - Technology leadership will lead to development of larger, more capable airliners.
- **The government plays a central role in developing the data needed for regulation change that is essential to enabling this new capability.** In addition, NASA technology has enabled US industry to be positioned to be the leader in the new market.

Barriers to Commercial Supersonic Flight

- Planned introduction of supersonic commercial transports in 1970's brought the problem of sonic boom noise to public attention
- Community overflight tests in the US and elsewhere showed sonic boom noise to be unacceptable leading to supersonic overflight restrictions
  - US: FAA Regulation (FAR) prohibits supersonic flight over US
  - Worldwide: ICAO Assembly Resolution – "No unacceptable situation for the public due to sonic boom"
- Other challenges to commercial supersonic flight exist including economic viability and operations in the NAS

Concorde

U.S. SST

These barriers can now be addressed with modern technology

Low Boom Flight Demonstrator

40+ years of NASA led investment and technical progress
has created an opportunity to overcome the sonic boom restriction

Outcome Elements

- Demonstrate that noise from sonic booms can be reduced to a level acceptable to the population residing under future supersonic flight paths.
- Create a community response database that supports an International effort to develop a noise based rule for supersonic over land flight

LBFD Project Goals and Objectives designed to support
ARMD Technical Challenges and NASA Strategic Outcomes

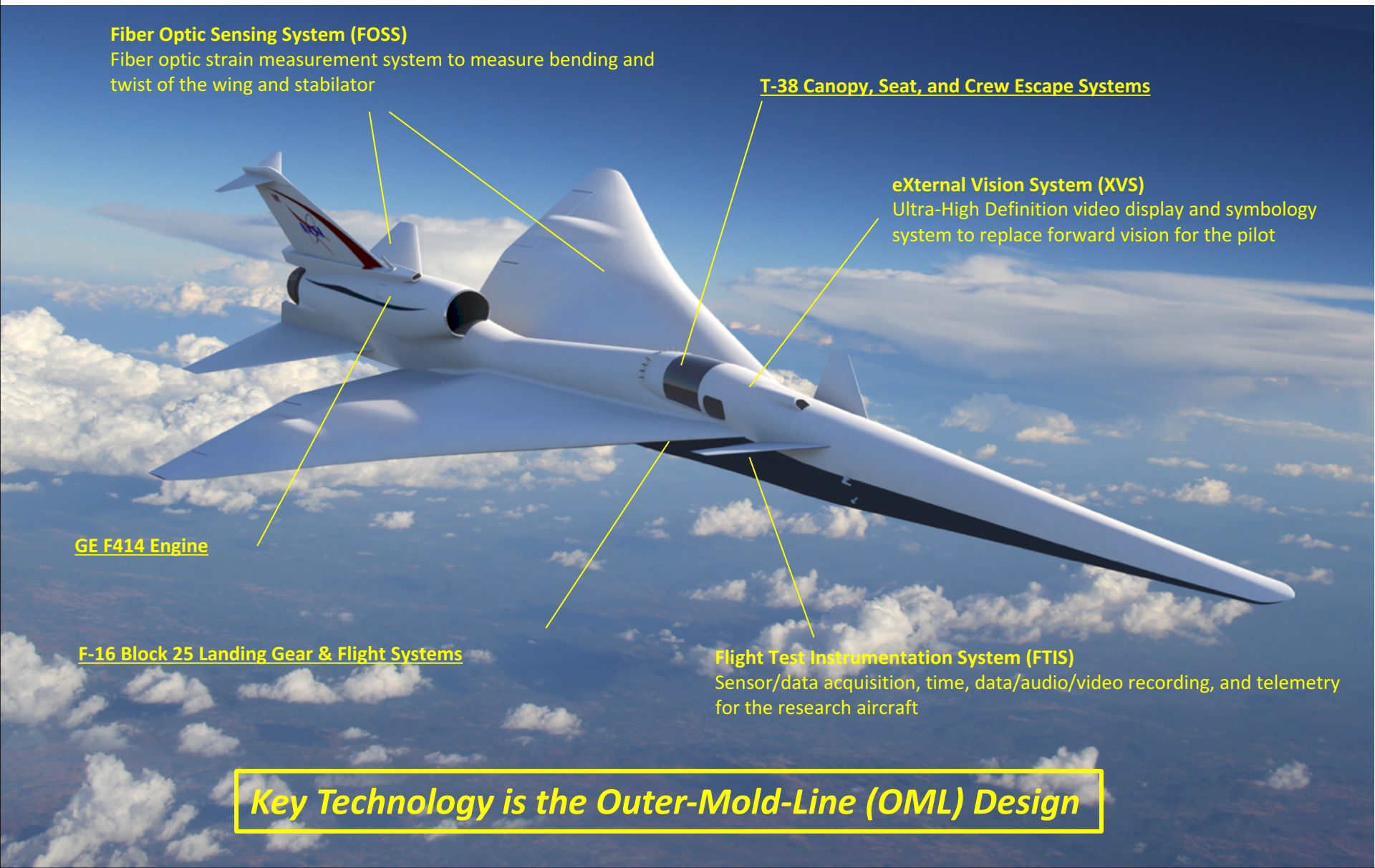
Low Boom Flight Demonstrator Tests: Three Objectives

- Validated Hardware for overflight testing (supersonic acoustic signature generator)
- Development of Test Methodology
- Community Response Data

End-of-Program Success Criteria developed for a range of outcomes

Success Criteria	Vehicle Req'ts	Min Success	Full Success
Measured loudness level (PLdB) of the sonic boom ground signature throughout the nominal supersonic cruise carpet	SRD-2	≤ 80	≤ 75
Supersonic cruise Mach number	SRD-5	≥ 1.35	≥ 1.40
Baseline mission at standard day conditions, includes two supersonic cruise passes of 50 nm in length and spaced a minimum of 20 minutes apart	SRD-6,11,12 ConOps	Out/in-bound cruise ≥75 nm	Out/in-bound cruise ≥125 nm

Overview of NASA-Provided Flight Systems and GFE for QueSST Preliminary Design Concept



Key Technology is the Outer-Mold-Line (OML) Design

X-Plane Governance

- **ARMD AA charged the Chief Engineer to develop a Governance Model**
  - Best Practices Evaluated
  - Used a tailored approach to 7120
- **A cross-center "virtual" Systems project office (vSPO) will manage the project, directly reporting to the HQ Program Director.**
- **The LBFD project has adopted an Independent Review Board (IRB) that will persist throughout the life of the project**
- **The IRB is standing, meaning that the membership is intended to remain intact throughout the life of the project**
  - IRB members will be verified as independent of the project and free of conflict of interest.
- **The IRB will perform an independent assessment on the entire scope of the LBFD project – including technical, cost, schedule and risk.**

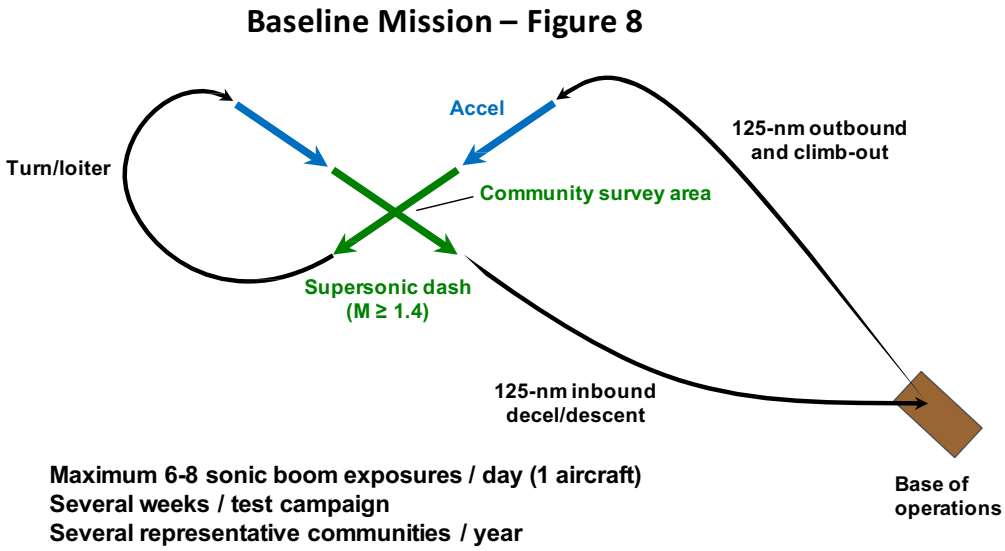
ARMD Feels that a Tailored Independent Review Board Is Sufficient to Provide Independent Oversight for the Project Life Cycle to the Mission Directorate

Baseline Mission Rationale

Technical

- **NASA's Baseline Mission**: a mission profile for "typical" standard day conditions.

  A subsonic climb and cruise outbound of 125 nm at best speed and altitude for maximum specific range was selected as the "typical" distance between the base of operations and the starting point of acceleration to the desired supersonic cruise condition



- **Full Success** – Baseline Mission with ≥125 nm outbound cruise/climb-out is desired to maintain sufficient range for operational flexibility during Phase 3 operations

- **Min Success** - Baseline Mission with ≥75 nm outbound cruise/climb-out provides sufficient range for the aircraft to conduct a subsonic climb and acceleration to the starting point for the supersonic test run. Community locations available for Phase 3 planning would likely be limited by this more restricted distance from the base of operations

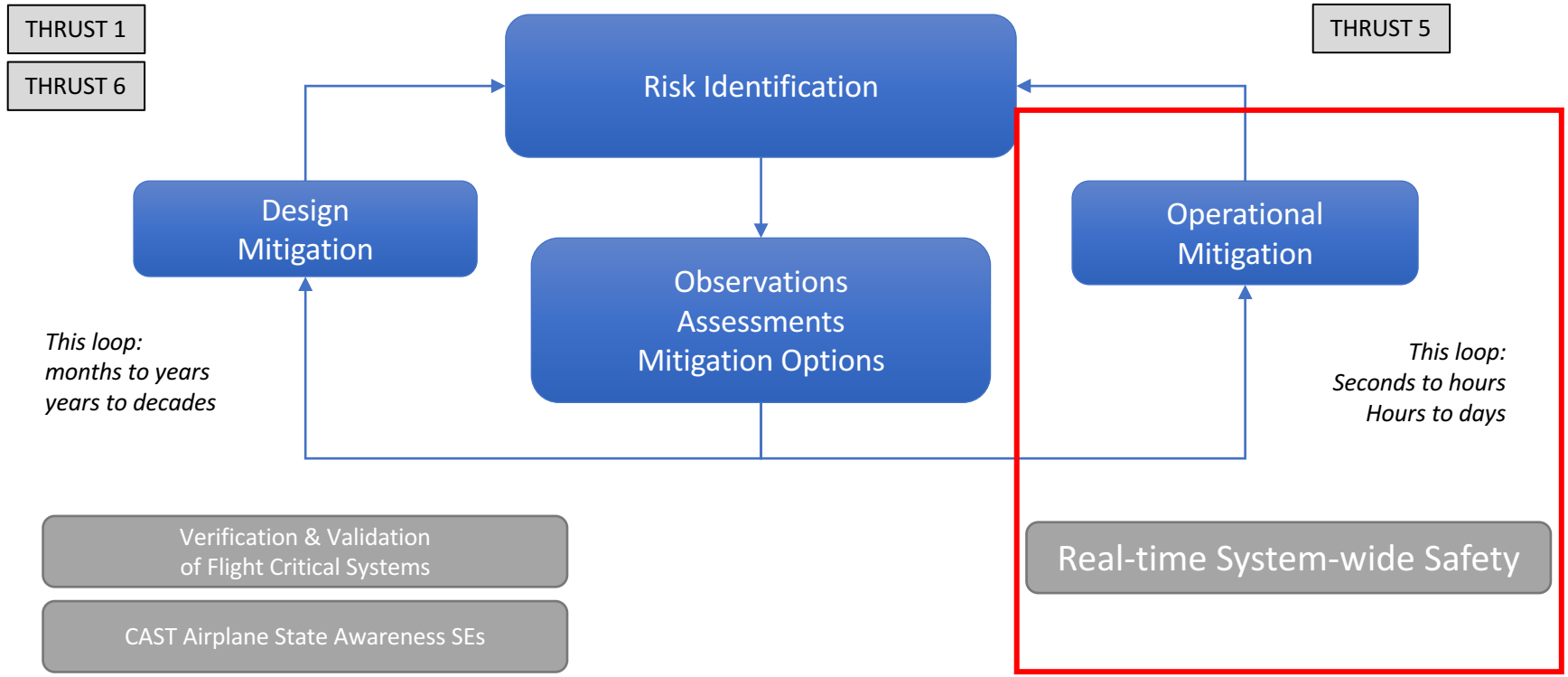
Top Issues & Mitigations

- vSPO staffing
  - Four key positions unfilled
  - PP&C Lead in work, Ops Lead and LSE have acting team members
  - Contracting officer needed by December
- Budget/reserves
  - Risk workshops scheduled
  - PPBE20 process to set budget prior to baselining
  - Contract price definitized by early spring
- GFE Assumptions
  - Detailed GFE plan in work
  - Set expectations with prime contractor
  - Fund project reserves
- Boom signature performance
  - NASA in-house technical assessment team
  - Prime contract incentive fee plan
  - Preserve design and operational mitigations

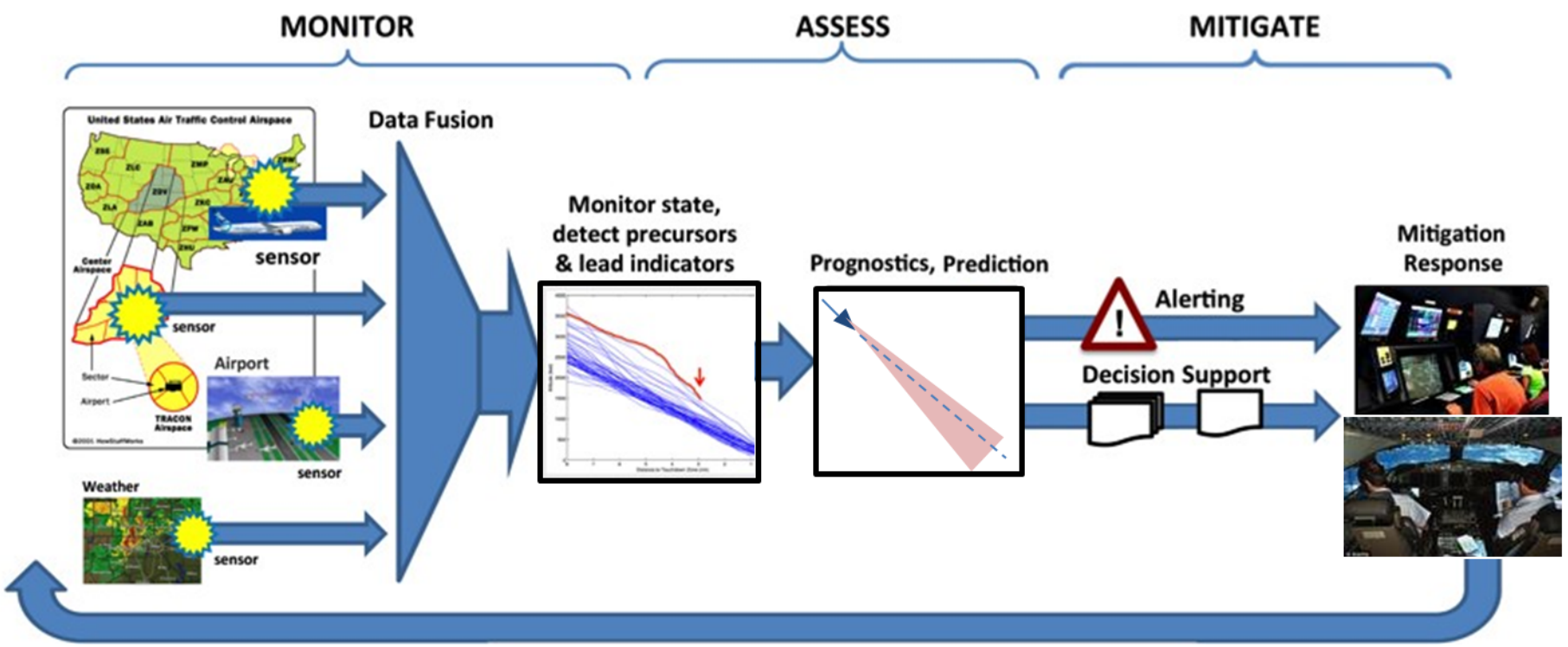
Committee Finding for ARMD AA – Low Boom Flight Demonstrator

The Committee expressed excitement and applauds the progress of the Low Boom Flight Demonstration (LBFD) project and is looking forward to staying abreast on the future steps. The Committee emphasized the importance of community outreach and provided examples on how to involve students to learn about NASA efforts. The Committee also applauds the single chain of command employed on LBFD as being important to the success of such a large program as well as using the best talents across ARMD locations but cautioned NASA to take careful consideration as to how the virtual office is set up so that there is a clear understanding of the line of authority. The Committee also applauded outreach from other parts of NASA as well as the risk reduction underway and suggests that risk reduction projects be funded to the extent necessary since NASA hasn't developed a manned X-plane recently.

System-wide Safety Project Planning Strategy



Real Time System Wide Safety Project Concept



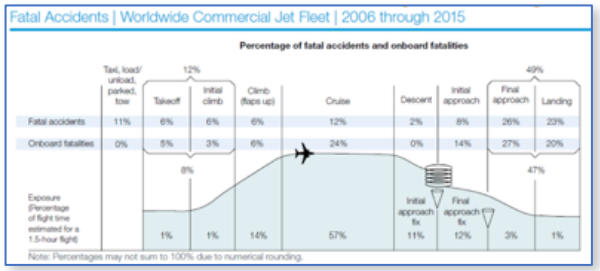
Focus on the First Two High Impact Technical Areas

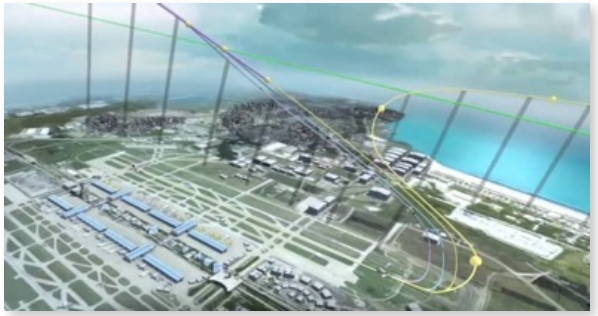
In-Time Terminal Area Risk Management

In-Time Safety Nets for Emerging Operations

Impact/Benefit – Terminal Area Operations

- Recent findings and recommendations
  - 88% of fatal accidents in TA (2006-2015)
  - 42 CAST Safety Enhancements def. since 2007
  - FAA Automation Working Group findings
  - AvSP Tall Poles studies (2010, 2013) [rev. (2016)]
- Proactive mitigation of future TA risks
  - Domain of most-likely unknown unknowns regarding transformation to ARMD/AOSP vision (ATM+1,2,3) (e.g. TBO, UAS in the NAS)
- Potential non-safety benefits
  - Quick-turn operational efficiencies at airports can be discovered, developed, and enabled with justifiable (data-driven) confidence
  - Reduce requirements for costly infrastructure
  - Safety technologies are more likely to be implemented when they also demonstrate positive return on investment





Committee Finding for ARMD AA - System Wide Safety Assurance Project

The Committee finds that the System Wide Safety (SWS) project has progressed well and provides an opportunity to get students excited about engineering. Specifically, the Committee encourages NASA to partner with universities in generating data – data is hard to get and it could be a space that universities can help fill. The Committee cautions NASA to engage with the machine learning community with particular focus on false alarms in the system. The Committee agrees with NASA's focus on Terminal Area Operations with emphasis on the most critical needs in traditional aviation and UTM (UAS Traffic Management) for near term needs to support unmanned and autonomous systems. The Committee recognizes that SWS is a big challenge and agrees with the approach to start with a few tasks first to gain an understanding of the effectiveness of the technology. The SWS team should also keep abreast of new algorithms and approaches in this rapidly moving technology area.

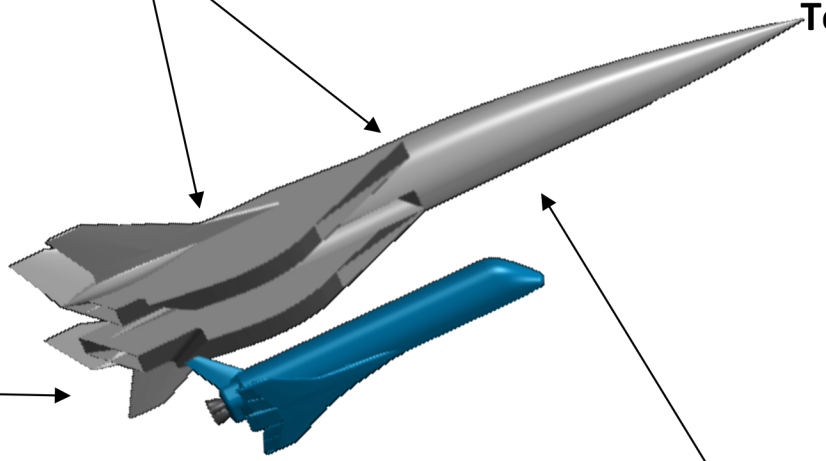
Hypersonics is a Broad Mission Area

HYPERSONICS

- **Blunt Body Re-entry**
- **Unpowered Atmospheric Flight**
- **Powered / Sustained Atmospheric Flight**

Multiple NASA Missions require
Mastery of Hypersonic Flight

Common Barriers to Full Spectrum of Reusable Hypersonic Applications



High Temperature, Durable Materials

Vehicle Technologies

System Level Design, Analysis, Validation

Propulsion Technologies

Thermal Protection Systems

NASA Focus Area

NASA investment

Minimum NASA Investment

Advances are being made in key areas laying the ground for a flight demonstrator that will be eventually needed to prove the concept.

Why NASA?

- NASA has developed the skilled workforce and several key facilities needed to help the Nation maintain pre-eminence in hypersonic technology development.
- NASA's hypersonics capability, coupled with a healthy research program, enables future military, civil and commercial missions and helps sustain U.S. preeminence in this strategic technology.
- NASA is in an excellent position to re-invigorate and engage future workforce
- The cost for the DoD to replicate and develop similar capabilities will require additional resources and delay current R&D efforts.

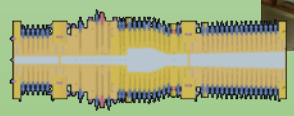
NASA Research Leverages and Supports National Activities

Flight Test

- Most similar to operational environment
- Least available, but most valuable data

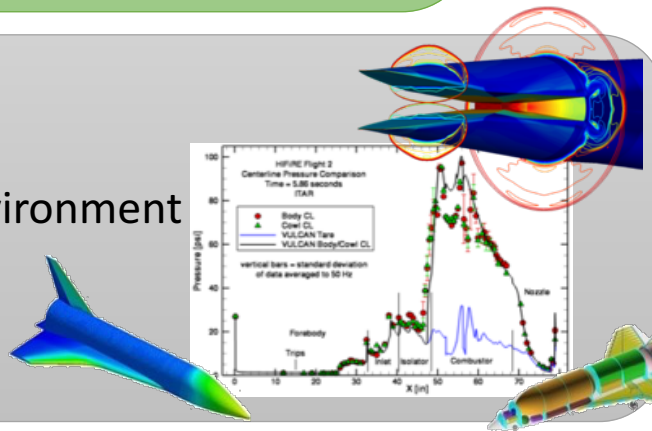
Ground Test

- Not a perfect match to operational environment
  - Vitiation
  - Test duration
  - Test conditions
  - Scale



Modeling & Simulation Tools / Fundamental Research

- Not a perfect match to operational environment
  - Static geometry
  - Boundary conditions
  - Match improves with test data



Feedback knowledge

Hypersonics Summary

- NASA has a long history of working closely with the DoD to develop a National Hypersonic Capability.
- While the near-term application for hypersonics is military related, NASA supports the National Strategy in the near term with unique expertise and facilities.
- At the same time NASA can leverage the DoD investments in flight projects to greatly enhance fundamental research
- The new Hypersonics Technology project is well coordinated with National Efforts and is advancing research in key technologies

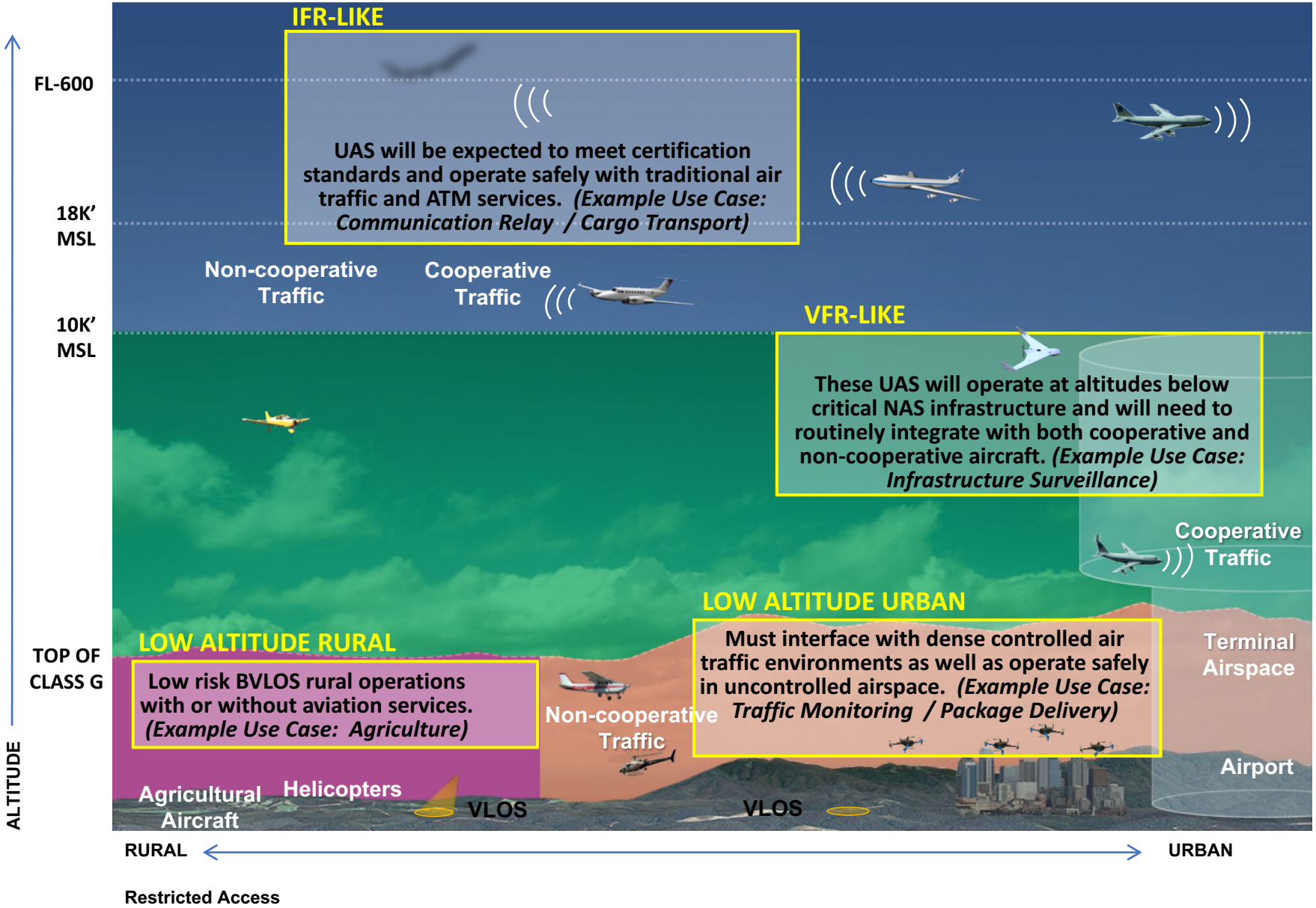
Committee Finding for ARMD AA – Hypersonics Project

The Committee believes that the work that NASA is doing is important in order to maintain US supremacy in Hypersonics by developing tools, technologies and methodologies as well as training the future workforce in this area. The project has a clear focus on the understanding of the fundamental physics of transition for multi-mode hypersonic engines and other key hypersonic phenomena and technologies and NASA has an opportunity for important technology validation. NASA also has a focus on the important challenge of understanding and validating the quantification of uncertainty, as minor changes can have a significant impact to vehicle performance. The Committee expressed concern that NASA project personnel have to access to the data collected even in cases where the data is sensitive. The Committee also suggested outreach opportunities with universities in this important area for the US

Emerging Markets – The Challenge

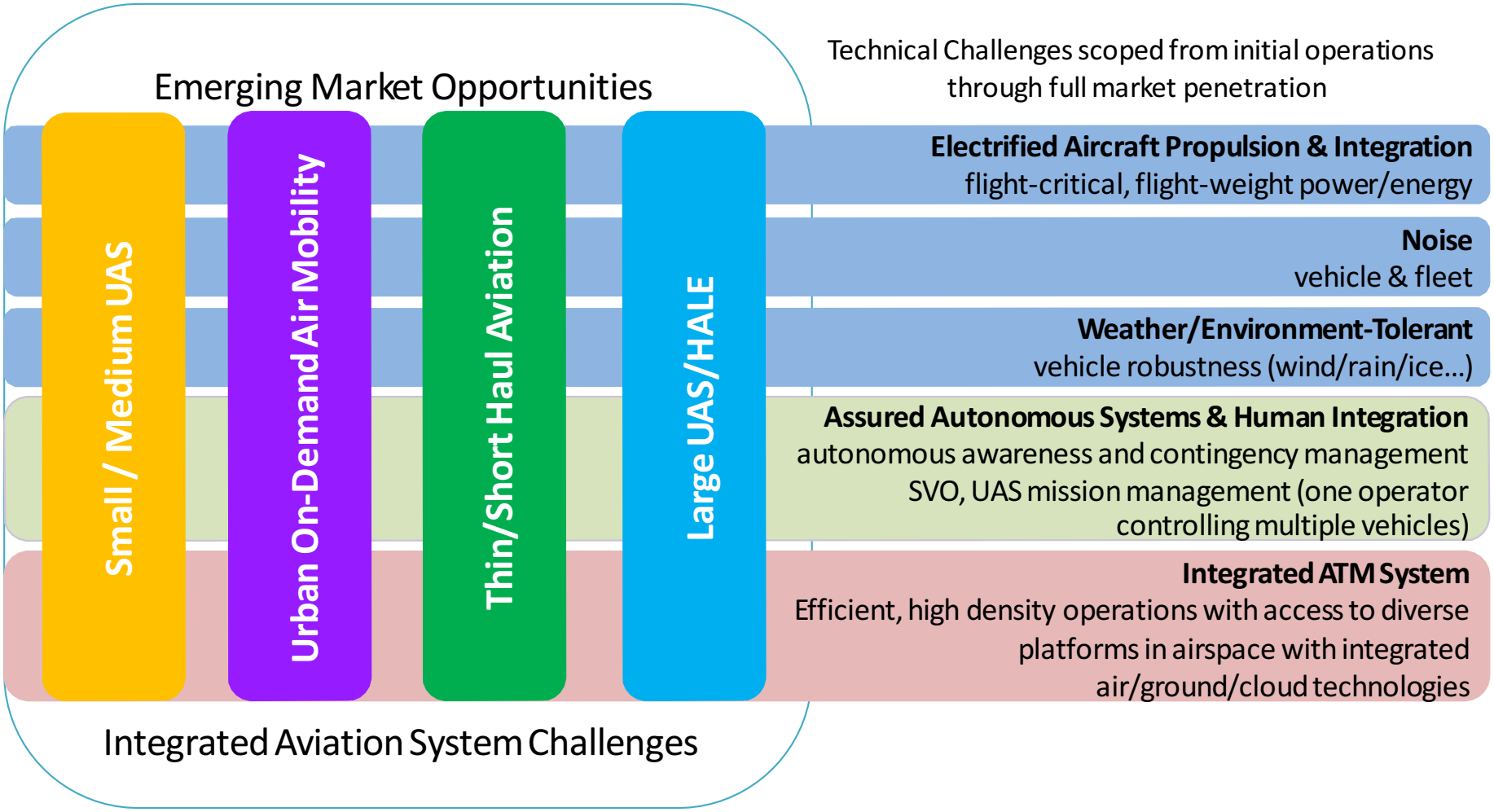
- Provide users the flexibility to operate when and where required
- Cost effectively accommodate thousands of times the number of vehicles flying today
- Ensure all forms of aviation will be as safe as commercial air transport is today

Future Civil UAS Airspace Environment



Emerging Markets - Integrated Challenges

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



Virtual Mission Development and Integration Office (vMDIO) for Urban Air Mobility

vMDIO Mission

Facilitate a "One ARMD" approach to enable the emergence and growth of safe, practical urban air mobility (UAM)

vMDIO Charter

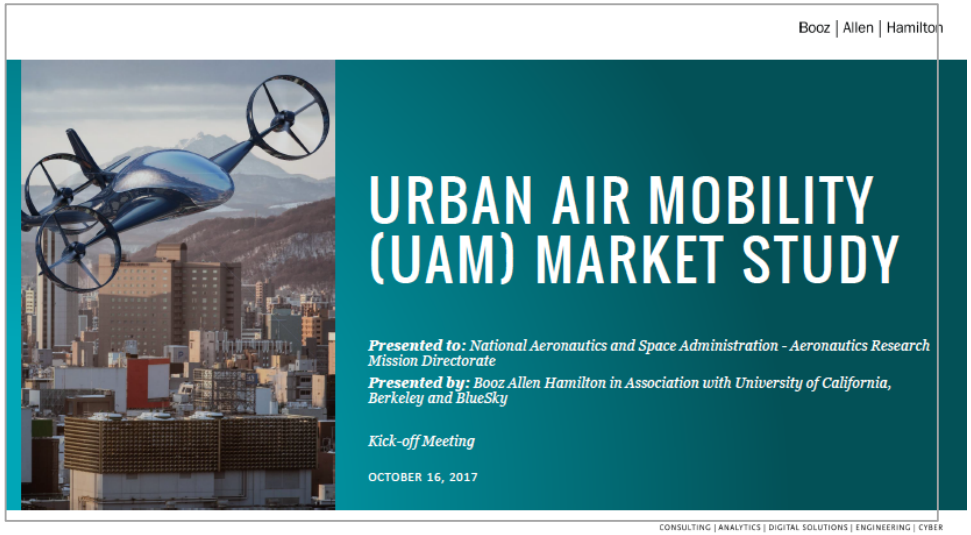
- Assess UAM requirements and identify key barriers to UAM market emergence and growth
  - Vehicle technologies
  - Airspace operations and integration
  - Safety and certification
  - Autonomous systems
- Facilitate cross-ARMD planning to coordinate contributions and encourage integration
  - Initiate market assessment studies; develop operational concepts, system architecture, and scenarios; develop prize objectives, and provide insight that supports research planning
- Facilitate consistent "One ARMD" communications with the external community

Contributing Programs / Projects

- Airspace Operations and Safety Program (AOSP) – UAS Traffic Management (UTM) Project; Air Traffic Management – Experimental (ATM-X) Project; System-Wide Safety (SWS) Project
- Advanced Air Vehicles Program (AAVP) – Revolutionary Vertical Lift Technology (RVLT) Project
- Integrated Aviation Systems Program (IASP) – UAS in the NAS Project, Flight Demonstrations and Capabilities (FDC) Project
- Transformative Aeronautics Concepts Program (TACP) – Transformative Tools and Technologies (TTT) Project

UAM Market Studies

- ARMD recently kicked off two Urban Air Mobility market studies
  - McKinsey & Company with NEXA Capital Partners, Georgia Tech ASDL, and Crown Consulting. Study will be complete in approximately 4 months.
  - Booz Allen Hamilton with UC Berkley, and Bluesky. Study will be complete in approximately 12 months.
- Focus of the Studies
  - Market evaluation for a range of urban areas and business models
  - Assessment of legal and regulatory barriers
    - Operator certification
    - Privacy concerns mitigation
  - Assessment of social acceptance issues
    - Perception of safety
    - Comfort with autonomy
    - Noise and pollution levels
  - Assessment of technology requirements
    - Vehicle requirements
    - ATM and ground infrastructure
    - Supply chain viability



Committee Finding for ARMD AA – Autonomy Thrust

Recommendation

The Committee agrees that this NASA research in autonomous vehicles and autonomy is important for the US. Because of new technology, market demand and industry investment, autonomy and autonomous vehicles could change aviation similar in scope to the birth of aviation. Because of these dynamics, the committee agrees with the approach to have independent evaluations of the autonomous vehicle market and recommends that NASA harmonizes the two studies so that they have the same time frame to get more value added.

Major Reasons for the Recommendation

Currently the two studies are in a different time frame – 4 months vs 12 months. The thought is that there might be some sharing of information and discussion of outcomes which will be beneficial for NASA to balance ideas off each other during the study. Given the fast moving pace of these new entries and the uncertainty they bring to aviation, the committee also recommends that ARMD identify issues and gaps that need to be addresses regardless of the studies' outcomes

Consequences of No Action on the Recommendation

The studies will lack the benefit of a healthy discussion on any differences in outcomes. If the studies result in different outcomes at different time periods, there will be uncertainty on which outcome should be used for NASA technology investment.

2017 NAC Aeronautics Committee Work Plan - Completed

SPRING	SUMMER	FALL
ARMD integrated strategy for UAS **(Completed)**	ARMD FY18 Budget **(Completed)**	System Wide Safety Assurance Project **(Completed)**
On-Demand Mobility **(Completed)**	NAH Planning and Management Status **(Completed)**	Low Boom Flight Demonstrator (LBFD) **(Completed)**
Advanced Composites Project **(Completed)**	University Leadership Initiative **(Completed)**	Autonomy Thrust **(Completed)**
New Administration and Transition Update **(Completed)**	Airspace Technology Demonstrator (ATD) **(Completed)**	Hypersonics Update **(Completed)**




2018 NAC Aeronautics Committee Draft Work Plan

SPRING	SUMMER	FALL
System Wide Safety (SWS) Report (may be moved to a later date)	Urban Air Mobility Strategy	New Aviation Horizons Subsonic Demonstrators
ARMD FY19 Budget & Overview of ARMD Strategy	Challenges & Prizes Strategy	ATM-X
Electric Aircraft Technology Development	UAS Update	Low Boom Flight Demonstrator (LBFD)
Advanced Materials & Structures Research		**Vertical Lift Noise**




BACK-UP

Acronyms

- AvSP – Advanced Systems Project
- CAST – Commercial Aviation Safety Team
- IFR – Instrument Flight Rules
- GFE – Government-Furnished Equipment
- LSE – Lead Systems Engineer
- NAH – New Aviation Horizons
- T3A ST – Thrust 3A – Subsonic Transport
- T3B VL – Thrust 3B – Vertical Lift
- TA – Terminal Area
- TBO - Trajectory Based Operations
- UAM – Urban Air Mobility
- UTM – Unmanned Aircraft Systems (UAS) Traffic Management
- VFR – Visual Flight Rules
- VLOS – Visual Line Of Sight
- vSPO – Virtual Systems Project Office

NASA Aeronautics

NASA Aeronautics Vision for Aviation in the 21st Century

6 Strategic Research and Technology Thrusts

T1 

Safe, Efficient Growth in Global Operations

- Enable full NextGen and develop technologies to substantially
- Reduce aircraft safety risks

T2 

Innovation in Commercial Supersonic Aircraft

- Achieve a low-boom standard

T3A ST
T3B VL 

Ultra-Efficient Commercial Vehicles

- Pioneer technologies for big leaps in efficiency and environmental performance

T4 

Transition to Alternative Propulsion and Energy

- Characterize drop-in alternative fuels and pioneer
- Low-carbon propulsion technology

T5 

Real-Time System-Wide Safety Assurance

- Develop an integrated prototype of a real-time safety monitoring and assurance system

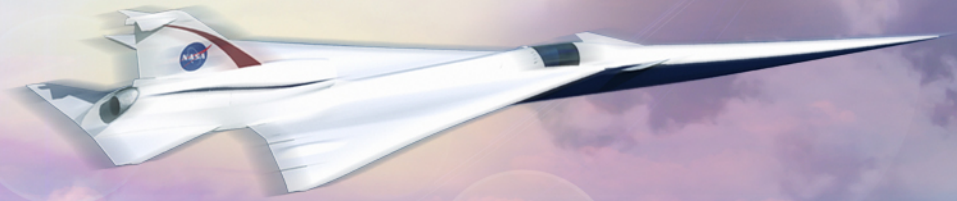
T6 

Assured Autonomy for Aviation Transformation

- Develop high impact aviation autonomy applications

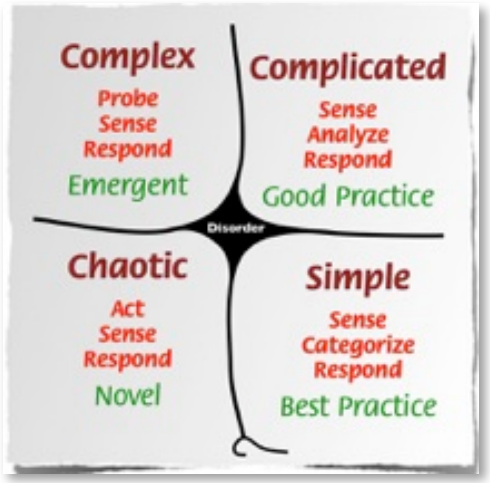
NASA Aeronautics is smart business for our nation

- NASA reduces risk for industry to adopt
- Advanced technologies make U.S. aircraft competitive to domestic/international airlines
- U.S. aviation industry, government, non-traditional industry join forces
- Partners key to NASA's aeronautics strategic vision
- Partnering advances U.S. technology leadership



System Wide Safety (SWS) Objectives

Explore, discover, and understand the impact on safety of growing complexity introduced by modernization aimed at improving the efficiency of flight, the access to airspace, and/or the expansion of services provided by air vehicles.



Snowden's (IBM) Cynefin model to help understand cause-and-effect

Develop and demonstrate innovative solutions that enable this modernization and the aviation transformation envisioned by ARMD through proactive mitigation of risks in accordance with target levels of safety.

Ref: Commercial Aviation Safety Team, risk reduction projections