National Aeronautics and
Space Administration

NASA Innovation Framework and Center Innovation Fund

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NASA Armstrong Flight Research Center

- ***"We leverage our Atmospheric Flight expertise to advance technology and science for the benefit of NASA and the Nation"***

- AFRC contributions to NASA's Strategic Plan (version 2018)
  - "...AFRC enables Earth science researchers to improve ..understanding of our planet...helps ensure the success of SMD's Earth Science Mission..."
  - "…engages in NASA's efforts to promote the commercialization of space..."
  - "...develops aero-convergent solutions for low-cost access to LEO..."
  - "...other space-related efforts...provides the developmental flight instrumentation...
  - "...new ways to increase the efficiency of flight research..."
  - "...provide Federal regulatory agencies the data...to allow unmanned aviation systems...to fly regularly in the NAS..."
  - "...looks... for opportunities to validate unique early stage technology..."

NASA Innovation Framework

2013 Barriers to Innovation at NASA

Risk-averse culture	• Management/workforce conservatism and oversight bodies drive costs and create more incremental steps
Short-term focus	• Immediate mission needs (for example, meeting level 1 requirements) often must take priority over development of future capabilities
Instability	• Changes in decisions and direction set by external stakeholders as well as tactical decisions have dried the innovation pipeline and led to a cycle of technology start/stops
Lack of Opportunity	• Fewer flight opportunities have reduced available pathways for infusion of innovations. Technology demonstrations historically come and go, yet have spurred some of the revolutions in NASA history
Process Overload	• Excessive administrative burdens can stagnate innovators; process owners have become gatekeepers instead of enablers
Communication Challenges	• Organizational silos, 'not invented here' thinking, and lack of commonality in IT and communication technologies for linkage
Organizational Inertia	• Cultural tendency to stay the course and a lack of trust often portray innovation as a threat; need to balance the risk with reward

What is Innovation from a NASA perspective?

Transforming Original Ideas into Value

- Not limited to technology areas
- Significantly improves ability to accomplish Agency Mission
- Changes the status quo but not criticism of the status quo
- Scalable, progress through sharing, not secrecy
- Customers/Stakeholders willing to support with resources

Innovation is not a single "Eureka" moment
Three core Steps to Innovation
- Discovery of an insight
- Engineering of a Solution
- Transformation of an industry or Field

What is the Innovation Framework?

Enterprise wide approach to innovation throughout the Agency

- Link original ideas from throughout the Agency to Mission and Mission Support goals/objectives
- Provide mechanism to identify and strategically manage the barriers to innovation
- Increase communication and knowledge sharing
  - Best practices
  - Lessons learned
  - Optimize impact of innovation related activities
  - State of the art assessments, etc…
- Reduce overhead associated with data entry and reporting
- Leverages existing Agency resources
- Agile development process involving representatives from stakeholders

Strategic Management of the Innovation Portfolio

TECHNOLOGY

PROCESS

Transformative NEW TECH - NEW PROCESS	Disruptive EXISTING TECH - NEW PROCESS
Revolutionary NEW TECH - EXISTING PROCESS	Continuous EXISTING TECH AND PROCESS

Innovation

What We Heard From Experts About How They Foster Innovation

- Focus innovation activities around "pain points" in an organization –
  - What are the biggest challenges that need help to solve
  - Online "problem market" to capture ideas
  - Sit management, technical people, and customers together when possible to clarify areas to focus innovation
- Improve decision velocity – minimizing steps and sign offs for decisions improves speed and increases ownership
- Build trust in organization
  - Building transparency – helps to win trust back from management
  - In private sector employees get punished for no risk taking – w/i government risk/failure is discouraged seen as "waste of taxpayer money"
- Communicate the benefits of innovation
  - Provide Mechanism to link stakeholder challenges to ideas
  - Important to promote storytelling

Humility is the key to winning the competition

Progress is predicated on sharing, not secrecy

No great innovation without great people

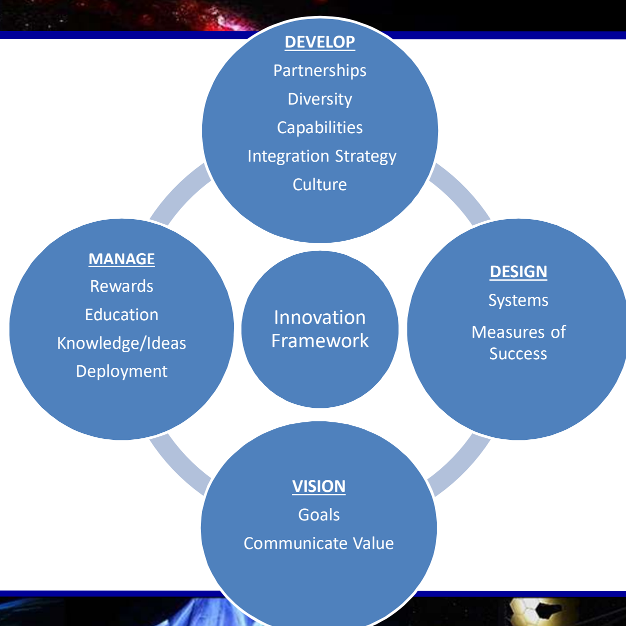
Foster diversity & partnering

Trust is the best infrastructure for innovation

Proposed Solutions to Innovation Impediments

- Allow, recognize, and reward innovation
- Projects & innovation funding
- Process streamlining
- Engage the public
- Open communication (knowledge-share) and stovepipe reduction
- Corporate time for creative thinking
- Innovation labs & creative spaces

Innovation Framework Intended to Facilitate



What will framework look like?

- Web based communications platform
  - Easy to use
  - Government cloud
  - Sharepoint
  - Mobile App
  - Automated reporting
  - Efficient data entry – linked to other resources
- Provides information on innovation initiatives throughout the Agency
  - Working with Mission and Mission Support Directorates to determine what information is most useful to be able to assist in guiding future activities
  - Increase employee engagement on innovation opportunities and best practices
  - Facilitate diversity and collaboration
  - Online idea management methodologies to strategically address barriers to innovation
  - Emerging trends
  - Upcoming innovation events, capture events –post videos, posters

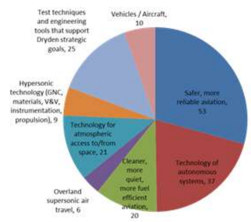
Center Innovation Fund

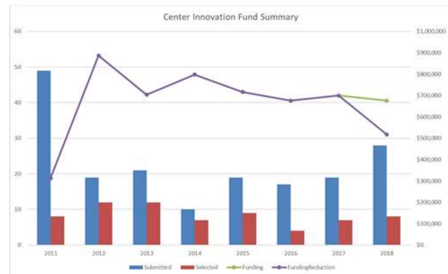
Center Innovation Fund Established 2011

Lack of Opportunity

- Fewer flight opportunities have reduced available pathways for infusion of innovations. Technology demonstrations historically come and go, yet have spurred some of the revolutions in NASA history

- **Objective:** Stimulate and encourage creativity and innovation within NASA Armstrong to address technology needs of the Agency and the Nation
- Funding ~$700k, 2FTE
- Proposals
  - Average 19/year , Total Program 182
  - Select only 8-9/year, Total 67
- Technical and Non-Technical Submitted
- Lean more to technical on selections
  - A few have been non-technical





Electric Aircraft Systems Technology Development

NASA Dryden Flight Research Center

Jonathan Barraclough (RF), Yohan Lin (RF), James Murray (RA)

STATUS QUO

Problem: Current aircraft are loud, polluting, inefficient, and rely on fossil fuels

Electric Propulsion is a new and emerging field – no focused research to advance state of art for general aviation and transport technologies

No clear understanding of scope and driving parameters for design and optimization

NEW INSIGHTS

- Recent advances in electric propulsion for automotive use have resulted in lightweight-powerful electric motors, lightweight batteries that could be used for aircraft
- Electric propulsion has high probability of becoming mainstream, akin to electric cars
- NASA can help lead U.S. efforts by advancing the design, test, and safety standards for this new technology

•Investment will mature TRL to 5/6 and provide products to N+3 vehicle design

ACHIEVEMENT

MAIN ACHIEVEMENT:
- Advance electric propulsion technology
- Establish approach and methodology for testing
- Provide test capability to internal and external customers
- Understand configuration optimization problems on a smaller scale before moving to larger scale by providing basic research "answers"
- Provide flight test platform for ARMD research
- Technology products with maturity levels that enable advancement toward large transport and general aviation aircraft, as well as N+3 vehicles

HOW IT WORKS:
- Develop in house NASA expertise by building an electric propulsion test stand and work with LaRC/GRC to test new propeller and motor configurations, controller and battery technologies, acoustic levels and evaluate energy consumption
- Determine best test approach, perform systematic testing akin to airfoil testing during NACA days, and publish results.
- Leverage STTR to convert TG-14 as an electric propulsion test bed that accommodates different architectures
- Perform flight testing to validate ground data
- Feed forward to N+3 design and publish/share results with industry

ASSUMPTIONS AND LIMITATIONS:
- It is assumed that novel/non-traditional aero-dynamic, aero-propulsive and aero-structural concepts will need to be employed to complement the advantages of electric propulsion to reach maximum performance.

QUANTITATIVE IMPACT

Potential customers:
- NASA centers, Boeing, Lockheed, Northrop Grumman (Large aircraft manufacturers interested in providing fuel-efficient aircraft)
- Cessna, Diamond, Piper etc. (mid-size aircraft manf.)
- Rotorcraft manufacturers

Quantitative metrics:

	Current	Goal
PMPGe	60	200
Noise (dBA)	60@500ft	60@250ft
NOx	X	X – 70%

Technology Goals

Big Picture Goal:
Multiple manned/unmanned full-scale/sub-scale flying research prototypes that will lead to the integration of technology on to full-scale production prototype for commercial use.

CIF lead to knowledge to advance Electric Systems Technology

- Transition to the Aeronautics Research Mission Directorate
- Knowledge gained from testing electric systems helped in the advocacy and development of the X-57

Tecnam P2006T

Primary Research Aerodynamic Design To Lower Drag

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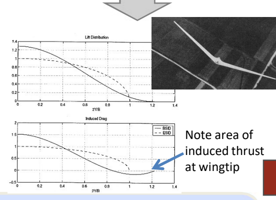
2013

STATUS QUO

Problem: Spanload of aircraft use an optimal formulation that was derived and developed about 100 years ago. The difficulty is that the formulation is not incorrect, but is simply insufficient. A more integrated approach (one using aerodynamics as well as structures and controls) results in an immediate savings of 8-11% in profile and induced drag. However, cascading the effects throughout the aircraft and leveraging the systems that can be eliminated may result in airframe weight savings of 20-30%. Use on propulsion systems can results in ~13% efficiency improvement.



NEW INSIGHTS

- Use of an alternate spanload formulation may result in substantial drag and weight savings.
- Two alternatives for this formulation exist, and insight to one shows the correct approach.
- NASA can provide data to validate this breakthrough game-changing approach (while this approach has been applied before, NO FLIGHT DATA EXISTS AS YET).

Technology Development Overview

CONCEPT:

- Build and fly a simple subscale model with appropriate instrumentation to demonstrate the feasibility of the concept. Use of flight instrumentation to demo the applicability and feasibility of this approach. Finally by use of flight data to validate this alternate spanload approach as being correct in all aspects of design by demonstration of the integrated controls solution.

OBJECTIVES:

- Flight demonstration of a bell spanload using twist to achieve the desired spanload at the design point and provide flight data of this disruptive technology

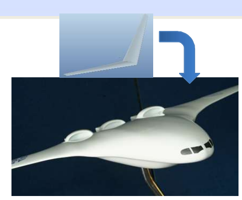
TECHNICAL APPROACH:

- Build a subscale (~4m span) sailplane/glider model with the appropriate twist, sweep, and spanload for the airframe.
- Instrument the aircraft with sufficient sensors and data recording that flight mechanics data can be derived from the results
- Fly the aircraft to gather flight research data at various flight conditions to show the envelope of validty for the spanload/twist concept
- Analyze the data such that the coupling of the yaw and roll control are demonstrated (this is only possible if the correct spanload has been achieved)
- Compare the flight derived data to the analytical predictions of the spanload and roll/yaw control power

QUANTITATIVE IMPACT

System Benefits

- Decrease in induced and profile drag of 8-11% over classically designed elliptical spanloads
- Decrease in structural weight of 8-10% with no change in airframe approach, or 25-40% reduction in airframe weight with full benefit propagated throughout the design
- Applied to propulsion systems results in ~13% efficiency gain
- Demonstrate applicability and viability of tail elimination with full coordinated flight



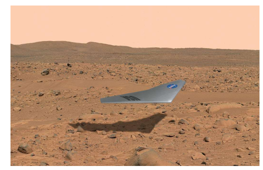
TECHNOLOGY GOALS

Big Picture Goal:

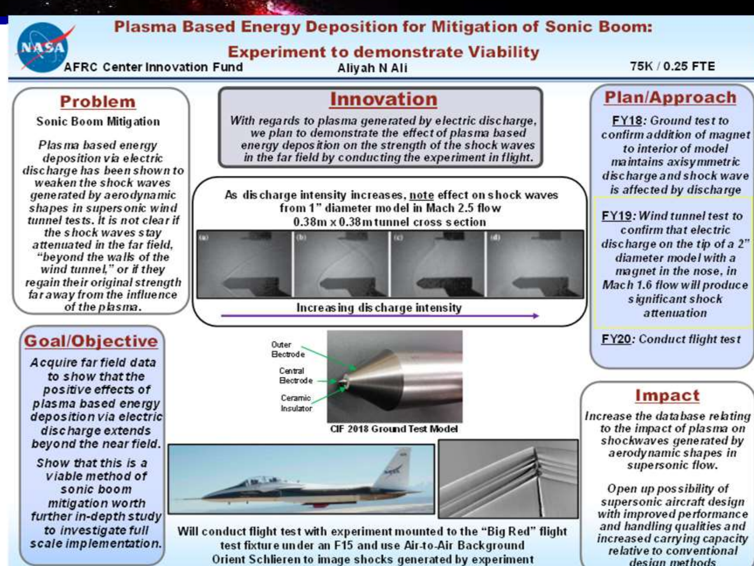
- Reduce drag (8-11%)
- Reduce weight (20-30%)
- Increase propulsive efficiency (~13%)
- Eliminate tails (drag and weight)
- Simplify systems
- Reduce total lifecycle costs
- Reduce total carbon footprint (~43-62%)

PRANDTL Wing Technology

- The effect is far reaching and can impact fields such as bioengineering, marine engineering, and power systems. In aircraft alone, 11% reduction in total aircraft drag due to spanload, elimination of the tail results in another 20-30% efficiency gain, and then 15.4% improvement in propulsive efficiency, the total efficiency increase is on the order of 60%, a substantial reduction in carbon footprint.
- Current studies include looking at the Prandtl design for flying in a Mars atmosphere
  - Collaborating with JPL on a swarm configuration
- Other applications include fan blades to reduce noise and increase efficiency initial testing shows an 88% reduction in additional noise and increase airflow.



Plasma Based Energy Despositino for Mitigation of Sonic Boom



New for FY18 and continuing for FY19

Summary

- Innovation is an important part of the NASA culture
- Continuing to improve and foster that culture at all levels
- Center Innovation Fund is one way to provide a pathway for ideas

- We continue to look for ways to collaborate with other Government Agencies
- Edwards Technical Symposium is one way to develop our local relationships in innovation and technology development.