AVT-RSY-323 Research Symposium on Hybrid/Electric Aero-Propulsion Systems for Military Applications

NASA Electrified Aircraft Propulsion Efforts
Ralph H. Jansen, Dr. Cheryl L. Bowman,
NASA Glenn Research Center
Sean Clarke,
Armstrong Flight Research Center
David Avanesian, Dr. Paula Dempsey, Dr. Rodger W. Dyson
NASA Glenn Research Center
Introduction

- NASA is investing in research to enable Electrified Aircraft Propulsion (EAP).
  - NASA is working across a range of markets
  - The overarching strategy is to create enabling technology, demonstrate this technology in flight-test vehicles, and transfer the knowledge to industry for future products
  - Electrified aircraft propulsion has varying impact on air vehicle design depending on the key requirements of the market that the vehicle is intended to serve

![Figure 1-1: Benefits of Electrified Aircraft Propulsion by Market](image)

- Market: National/International
  - Impact: Fuel Burn/Emission Reduction
- Market: On demand mobility
  - Impact: New mobility capability
- Market: Regional
  - Impact: Revitalization of smaller routes
Hybrid Gas Electric Subproject of Advanced Air Transport Technology Project

• The Hybrid Gas Electric Propulsion subproject (HGEP) was created in 2014 to
  - find a viable transport-class EAP aircraft concept
  - identify barrier technologies
  - advance the technology readiness level of those barrier technologies.

• Approach
  - study aircraft concepts and identify potential aerodynamic efficiency gains
  - investigate powertrain architectures
  - develop the fundamental components that will enable broad improvements in aircraft power systems
X-57 Maxwell

- X-57 “Maxwell” is a technology demonstrator aircraft
  - Supported by the NASA Flight Demonstrations and Capabilities Project
  - uses a crew-rated electric propulsion system designed to augment the aircraft performance in the high speed cruise condition
  - will develop best-practices knowledge for passenger applications of electric propulsion technologies
  - will demonstrate the principles to achieve an 80% reduction in energy required per passenger-mile in the 150-knot speed class

Figure 2.2-2: X-57 Maxwell with Mod II systems integrated including electrified powertrain.

Figure 2.2-3: X-57 cockpit includes new instrument panel configured to manage the electric powertrain.
**X-57 Spiral Development Approach**

**Mod 1**
- Ground validation of DEP high lift system

**Goals:**
- Establish Baseline Tecnam Performance
- Pilot Familiarity

**Mod 2**
- Flight testing of baseline Tecnam P2006T

**Goals:**
- Establish Electric Power System Flight Safety
- Establish Electric Tecnam Retrofit Baseline

**Mod 3**
- DEP wing development and fabrication

**Goals:**
- Flight test electric motors relocated to wingtips on DEP wing including nacelles (but no DEP motors, controllers, or folding props)

**Mod 4**
- Flight test with integrated DEP motors and folding props (cruise motors remain in wingtips)

Achieves Primary Objective of High Speed Cruise Efficiency

**Achieves Secondary Objectives**
- DEP Acoustics Testing
- Low Speed Control Robustness
- Certification Basis of DEP Technologies

Figure 2.2-1: X-57 Spiral Development Approach
Revolutionary Vertical Lift Technology (RVLT) Project

- Overarching project goal
  - to develop and validate tools, technologies, and concepts to overcome key barriers for vertical lift vehicles

![Image: RVLT Concept Vehicles]

Figure 2.3-1: RVLT Concept Vehicles
Revolutionary Vertical Lift Technology (RVLT) Project

• Activities

➢ Part of the RVLT Project focus is to perform research that informs standards for electric and hybrid-electric propulsion systems of eVTOL

➢ NASA designed four UAM concept vehicles of varying payloads, range, type and propulsion systems to identify crucial technologies, define research requirements, and explore a range of propulsion systems

➢ Developing electrical ports in Numerical Propulsion System Simulation (NPSS)

➢ Development of magnetic gearing for use in the propulsion architectures of eVTOL
Potential EAP Benefits for Commercial and Military Applications

- **Potential Commercial Benefits**
  - hybrid/electric propulsion is considered to be a promising technology for fuel, emissions, and noise reduction in support of the challenging goals established by 2050 EU Flightpath/SRIA, NASA ARMD Strategic Implementation Plan, and the US Air Force ATTAM programs

- **Potential Military Benefits**
  - Potential benefits are expected in the areas of vehicle signature reduction (lower noise, lower exhaust signature),
  - usage in enhanced flight environments
  - minimized human-in-the-loop workload by offering a platform compatible with future goals of autonomous operations facilitation
  - maintenance cost reductions, and performance burst/dash energy.
  - Additional synergies are likely when used in conjunction with energy weapons.
SUAS Power / Propulsion Goals

Figure 2.4-1: Unmanned Aerial System Sizes

Figure 2.4-2: SUAS Power/Propulsion Goals
Conclusion

- NASA is broadly investing in Electrified Aircraft Propulsion (EAP)
- NASA investments are guided by a combination of potential market impacts and technical key performance parameters.
- The impact of EAP varies by market and NASA is considering three markets: national/international, on-demand mobility, and short haul regional air transport.
- Technical advances in key areas have been made that indicate EAP is a viable technology.
- Flight research is underway to demonstrate integrated solutions and inform standards and certification processes.
- Significant progress has been made to reduce EAP adoption barriers and further work is needed to transition the technology to a commercial product and improve the technology so it is applicable to large transonic aircraft.
Acknowledgments

- The activities in this paper are sponsored by the NASA Aeronautics Research Mission Directorate under the Advanced Air Vehicles Program and the Integrated Aviation Systems Program.