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

NASA Electrified Aircraft Propulsion Efforts
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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

![Diagram showing different markets and impacts of electrified aircraft propulsion](image)

**Figure 1-1:** Benefits of Electrified Aircraft Propulsion by Market

- **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
- Flight testing of baseline Tecnam P2006T

Goals:
- Establish Baseline Tecnam Performance
- Pilot Familiarity

Mod 2
- Ground and flight test validation of electric motors, battery, and instrumentation.

Mod 3
- DEP wing development and fabrication
- Flight test electric motors relocated to wingtips on DEP wing including nacelles (but no DEP motors, controllers, or folding props).

Goals:
- Achieves Primary Objective of High Speed Cruise Efficiency

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

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

Figure 2.2-1: X-57 Spiral Development Approach

Spiral development process
- Build – Fly – Learn
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
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.
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