ARMD Transformative Aeronautics Concepts Program

CONVERGENT AERONAUTICS SOLUTIONS PROJECT

Multifunctional Structures for High-Energy Lightweight Load-bearing Storage

Patricia Loyselle
PI (GRC)

Diana Santiago
Co-PI (GRC)

Erik Olson
Co-PI (LaRC)

September 19-20, 2017
Contents

• M-SHELLS Overview
  – Project Summary
• M-SHELLS Team
• M-SHELLS Concept
  – Battery-supercapacitor hybrid development
  – Structural energy storage development
  – Multifunctional design, analysis & demonstration
• System Benefits
• Failures & Challenges
• Next Steps
But How?

Hybrid Supercapacitor

✔ Enhancements through nanotechnology

TRUE MULTI-FUNCTIONALITY

Structural Energy Storage

✔ Energy storage components bear structural load
M-SHELLS Team

- Ceramic and Polymer Composites (GRC)
- Materials Chemistry & Physics (GRC)
- Multiscale & Multiphysics Modeling (GRC)
- Environmental Effects & Coating (GRC)
- PV & Electrochemical Systems (GRC)
- Power Architecture & Analysis (GRC)
- Thermal Protection Materials (ARC)
- Case Western Reserve University
- University of Cincinnati

- Aeronautics Systems Analysis (LaRC)
- Structural Mechanics & Concepts (LaRC)
- Structural Dynamics (LaRC)
- Advanced Materials & Processing (LaRC)
- Aeronautics Systems Engineering (LaRC)
- Mechanical Systems (LaRC)
- Structural & Thermal System (LaRC)
- Fabrication Technology Development (LaRC)
- UAS Operation Office (LaRC)

Plus many NASA Co-ops & interns
Next-Generation NASA Engineers Developing Next-Generation Materials

• Validation of next-generation materials found in literature
• Development of sealing techniques for cells
• Optimization of electrode materials to improve energy and power density
• Experimentation with advanced electrode manufacturing/scale-up procedures
• Continued development of next-generation structural energy storage components
• Modeling of mechanical and electrochemical properties, and systems analysis, for hybrid structural energy storage systems
Hybrid Supercapacitor
Structural Energy Storage
Multi-functionality

- Smaller gapping than previous concepts
- Virtually no gaps between elements
- GVS Mat
System Benefits

• Lighter-weight battery/structure combination
  – Positive multifunctional mass savings
• Hybrid = faster charge time
• “Free energy” stored within airframe
• Not limited to aircraft structure integration
  – You can put it in the seats, you can put it in the floor, put it in the ceiling, or why not a door?
Failures & Challenges
Next Steps

• Continued development and adoption of next-generation structural materials
  – Nanowire, structural separator/electrolyte, composites
• Advanced structural designs and systems modeling/analysis
• Additive manufacturing