High Performance Flywheels – A New Spin On Space Based Energy Storage

Nanotechnology and Energy: Storage and the Grid
Rice University
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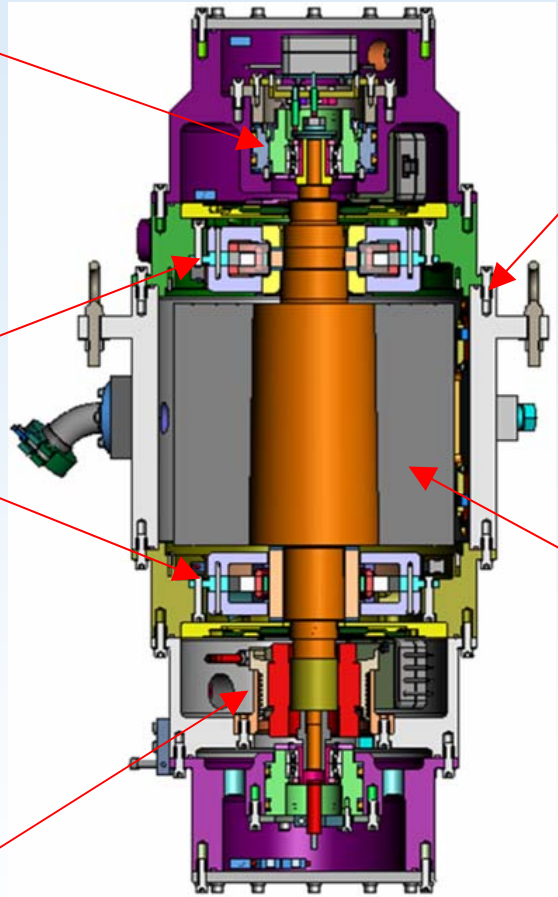
Spacecraft Flywheel System And Our Team

Auxiliary Bearings – carry launch and touchdown loads

University of Toledo

Magnetic Bearings – provide non-contact suspension of the rotor

Texas A&M



Motor/Generator – efficiently transforms electrical energy to mechanical energy and back to electrical energy

NASA Glenn Research Center

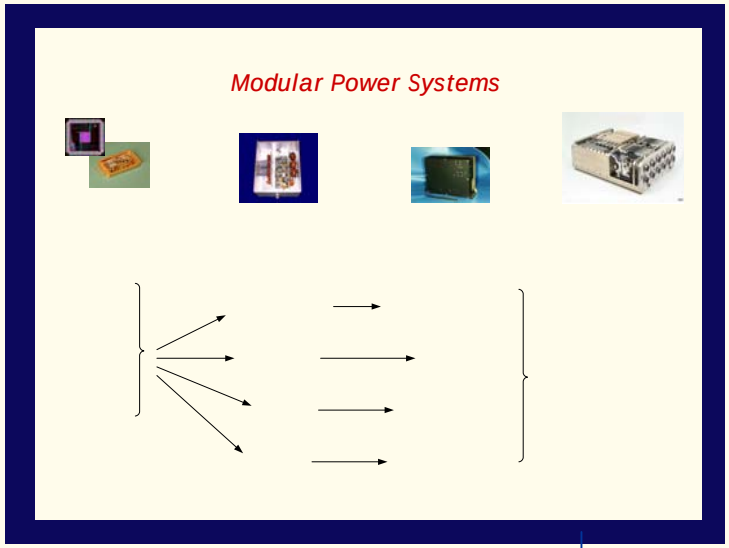
Housing – Lightweight aluminum housing provides spacecraft mechanical and thermal interface

NASA Glenn/University of Toledo

Composite Rotor – stores energy. Designed for long life, safety without containment, light-weight hubs, design and cert. standards

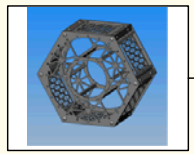
University of Texas - CEM

Why Flywheels - Integrated System Solutions



IPAC Integrated Power and Attitude Control
IP²AC Integrated Power, Propulsion and Attitude Control
MFS Multi-Functional Structure

Spacecraft Structure



Energy Storage

IPAC

Hi V Bus
+
IPAC

IP²AC

MFS

Momentum Storage

Tethers/ Electric Propulsion

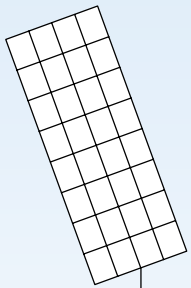
Modular Modular Mod

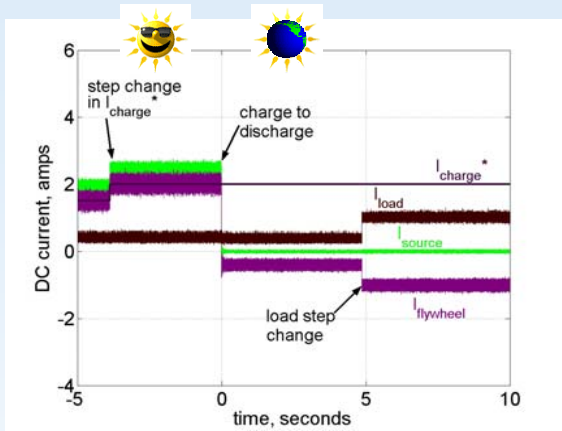
Integrated Power and Attitude Control System

Sources

Provide Energy

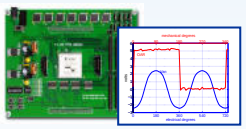
GRC Solar Array Field





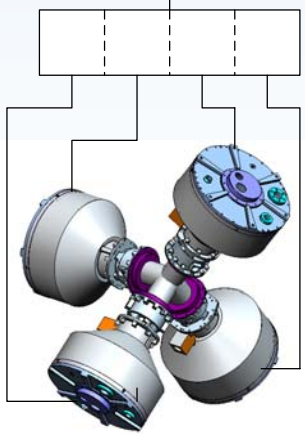
Loads

Consume Energy



Flywheel Avionics

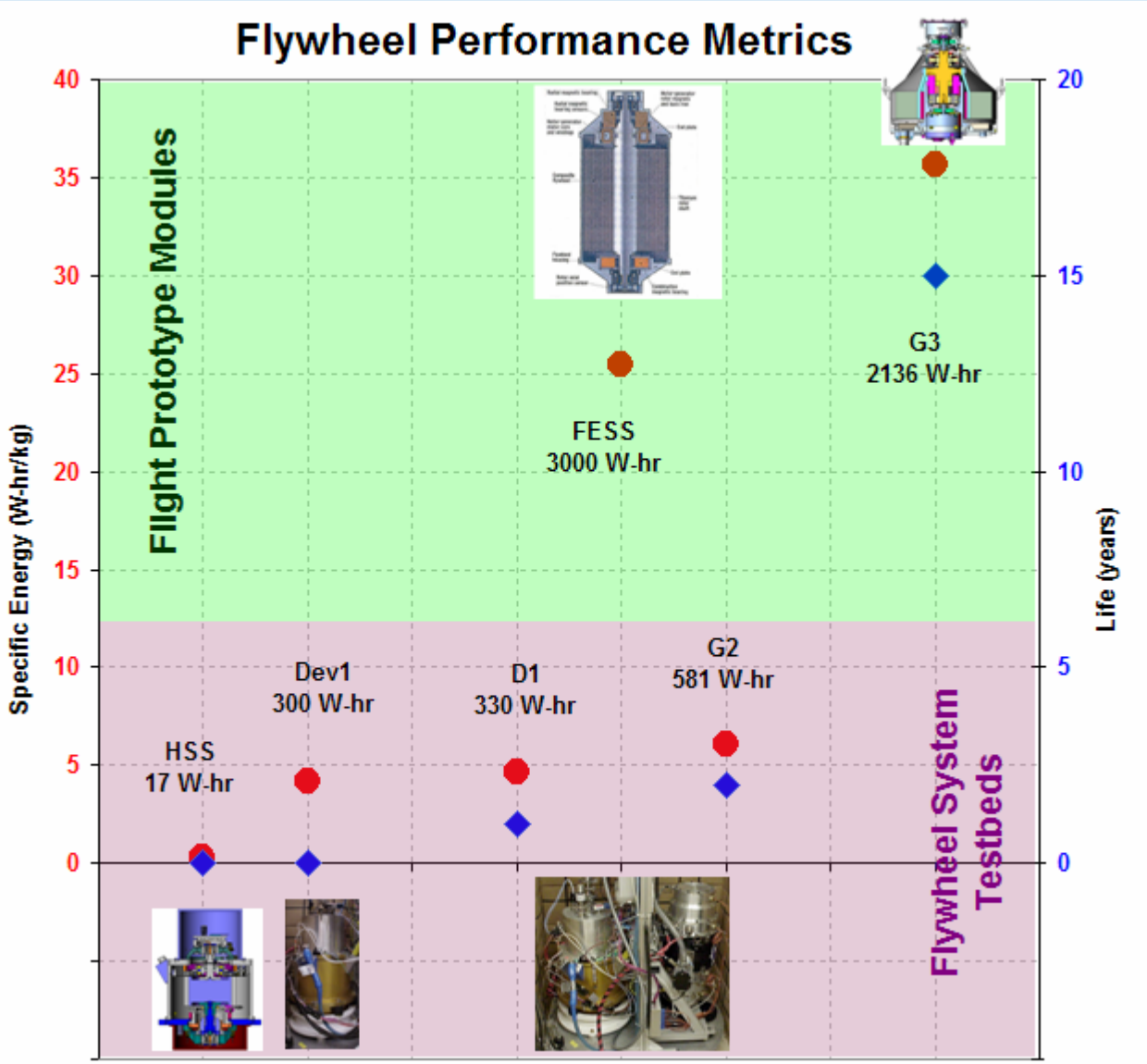
Transform Electrical to Mechanical Energy



Flywheel Modules

Store Energy and Momentum

Progress on Performance



Flight Prototype Modules

- *EM Fidelity*
- *Based on Flight Requirements for ISS and Commercial S/C*

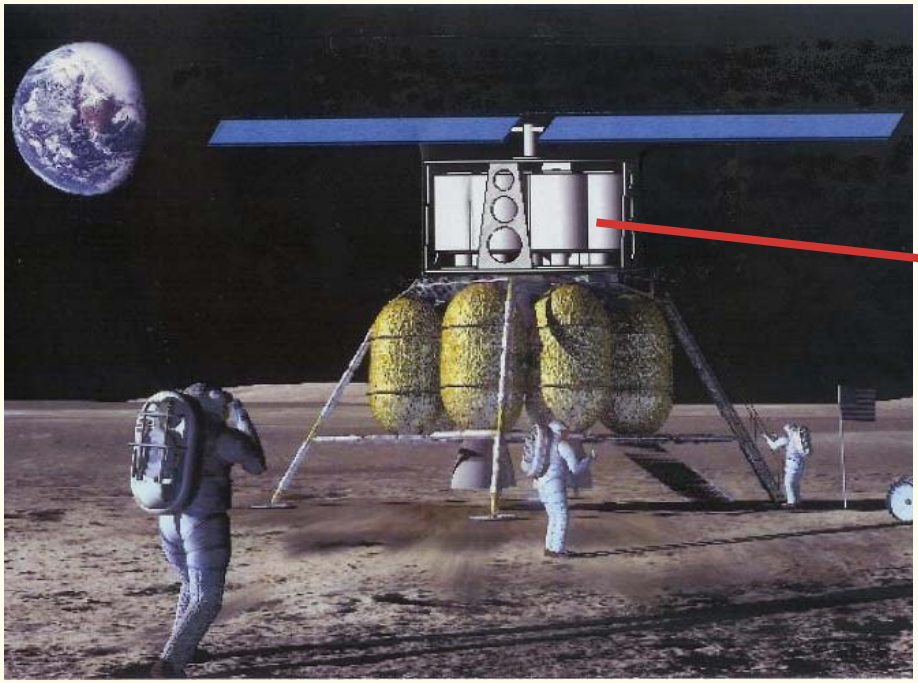
Flywheel System Testbeds

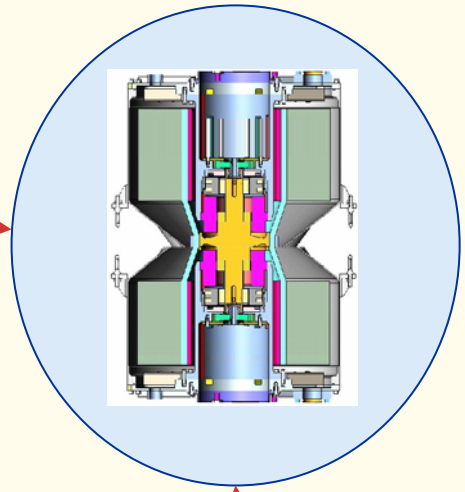
- *Laboratory H/W Fidelity*
- *Based on System and Lab Test Requirements*
- *IPAC*

Surface Planetary Power Study

- Objective
  - Determine Potential Solar Power Options For Manned Operations On Lunar Surface
  - Requirements Included Environmental And Science Power During Insolation And Eclipse (354 Hour Night)
  - 25 kW Baseline Utilized PV And Fuel Cell Power System
  - Power System Mass Constrained Based On Lander Capability
- Flywheel System Parametric Study
  - Study Data And Projections From NASA And Boeing Company
  - Carbon Nano-tube Composite Rotor
  - Superconducting Magnetic Bearings
  - Iron-less Permanent Magnet M/G
  - Micrometeorite Shield Based On JSC Transhab

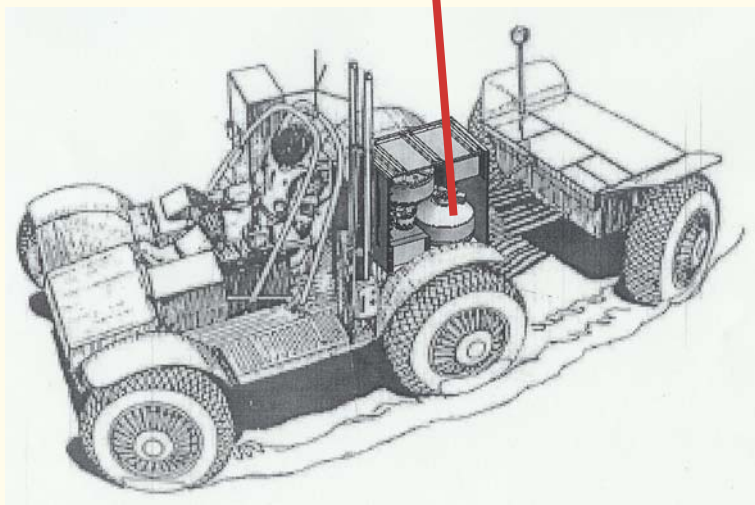
Surface Planetary Power





Flywheel System	
Energy Storage	10,600 kW-hr usable
Power	30 kW for 14.75 days
Mass	8066 kg
Specific Energy	1315 W-hr/kg
Number of Units	20
Operating Speed Range	83k to 250k rpm

System Mass Breakdown	
Rotor and M/B	5368 kg
Motor/Generator	84 kg
PMAD	122 kg
Cryocooler	120 kg
Meteor Shield	1112 kg
Strut Mass	1260 kg



Concluding Remarks

- Study Results For Solar Power System (Both Fuel Cell And Flywheel Storage) Indicate Potential For Non-nuclear Lunar Power
- Flywheel Storage With Advanced Carbon Nano-tube Rotors Has Potential To Double Power System Capacity On Single Lander
- NASA Glenn Research Center In Conjunction With UT-CEM, TAMU, UT, CSU, Boeing Pursuing Development Of Advanced Testbed To Demonstrate Advanced Flywheel Technologies For Space Applications