“The scope of the Committee includes all NASA programs that could benefit from technology, research and innovation.”
T&I Committee Meeting Participants
November 15, 2012

- Dr. William Ballhaus, Chair
- Dr. Erik Antonsson, Northrop Grumman
- Dr. Randall Correll, Consultant
- Dr. Dava Newman, MIT
- Mr. Gordon Eichhorst, Aperious Partners, LLC
- Dr. Matt Mountain, HST Institute
- Dr. Mary Ellen Weber, Stellar Strategies, LLC
- Dr. Susan Ying, The Boeing Company
T&I Committee Meeting Presentations

- Update on Advance Exploration Systems Program (AES) – Mr. Jason Crusan, Director, AES, HEOMD

- Update and Discussion of Space Technology Program – Dr. Michael Gazarik, Director, NASA Space Technology Program

- Office of the Chief Technologist Update – Dr. Mason Peck, NASA Chief Technologist

- Briefing on Mars Science Lab (MSL) and overview of technology’s role in the mission – Dr. Dave Lavery, Program Executive, MSL

- Update on Space Technology Research Grants program – Ms. Claudia Meyer, Program Executive

- Hypersonic Inflatable Aerodynamic Decelerator, with focus on the MSL Entry, Descent, and Landing Instrumentation (MEDLI) and Inflatable Reentry Vehicle Experiment 3 (IRVE-3) – Dr. Neil Cheatwood, IRVE-3 Principal Investigator
Space Technology Programs

- Game Changing Development
- Technology Demonstration Missions
- Small Spacecraft Technology
- Space Technology Research Grants
- NASA Innovative Advanced Concepts (NIAC)
- Center Innovation Fund
- Centennial Challenges
- Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR)
- Flight Opportunities
Space Technology Hardware & Testing

BOOM Fabrication

SAIL Fabrication

BIRD focal plane arrays

Model of 3-kW Non-Flow-Through Fuel Cell

Composite Strut Structural Testing

Popular Science Invention of the Year

Exoskeleton

Water Droplet Visualization Test

Testing at 300 MPH
Space Technology Research Grant Program
Engaging the Nation’s Universities

148 awards
29 states
1 U.S. Territory
57 universities
Technology Success: HIAD

Top left, Technicians at NASA’s Wallops Flight Facility mated the components of the Inflatable Reentry Vehicle Experiment-3 (IRVE-3) into the nosecone and sounding rocket. Bottom right, Images of IRVE-3 successfully inflated, reconfigured to generate lift prior to atmospheric entry, and demonstrated re-entry steering capability.

Project Summary: NASA’s Hypersonic Inflatable Aerodynamic Decelerator project (HIAD) focuses on the development and demonstration of hypersonic inflatable heat shield technologies through analysis, ground-based testing and flight tests.

FY 2012 Milestone: On July 23, 2012, the Inflatable Reentry Vehicle Experiment (IRVE-3) successfully demonstrated key technologies, including flexible TPS materials for hypersonic entry conditions, attachment, and inflation mechanisms, along with high-strength, lightweight, inflatable bladder materials capable of withstanding high temperatures.

NASA/Government/Commercial Application: IRVE-3 will provide foundational data to develop and integrate HIAD technology, enabling future missions that require delivering larger mass/payloads to destinations with sizable atmospheres, or accessing Mars at higher elevations.

Partnerships: NASA is working with Airborne Systems/HDT Global, Oceaneering and Bristol Aerospace on this project. NASA, as well as other industry partners, could incorporate this technology for future ISS or LEO down mass applications or planetary science and exploration missions.
# Rover Family Portrait

<table>
<thead>
<tr>
<th></th>
<th>Pathfinder</th>
<th>MER</th>
<th>MSL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rover Mass</strong></td>
<td>10.5 kg</td>
<td>174 kg</td>
<td>950 kg</td>
</tr>
<tr>
<td><strong>Driving Distance (req’ t/actual)</strong></td>
<td>10m/102m</td>
<td>600m / 35,345m</td>
<td>20,000m/TBD</td>
</tr>
<tr>
<td><strong>Mission Duration (req’ t/actual)</strong></td>
<td>10 sols/83 sols</td>
<td>90 sols/3,132 sols</td>
<td>687 sols/TBD</td>
</tr>
<tr>
<td><strong>Power / Sol Instruments / Mass</strong></td>
<td>130 w/hr</td>
<td>499-950 w/hr</td>
<td>~2500 w/hr</td>
</tr>
<tr>
<td><strong>Data Return</strong></td>
<td>2.9 Mb/sol</td>
<td>50-150 Mb/sol</td>
<td>100-400 Mb/sol</td>
</tr>
<tr>
<td><strong>EDL</strong></td>
<td>Ballistic Entry</td>
<td>Ballistic Entry</td>
<td>Guided Entry</td>
</tr>
</tbody>
</table>

*EDL*: Entry, Descent, Landing
Technology Success: One of Many on Mars

Curiosity with chutes deployed during descent to Mars surface

Curiosity's heat shield during descent
MSL Technology Advancements: Mars Technology Program Heritage

Increased Landing Accuracy

Power systems providing significantly greater mobility, operational flexibility and enhanced science payload.

Mars Reconnaissance Orbiter (MRO) returns over 3 times as much data as five missions put together

Improved spatial and spectral resolution (from 300-1000 m/pixel to 20 m/pixel)

Ensuring precise and safe landings for larger payloads

Entry, Descent and Landing

Advanced actuators

Advancements in scientific instruments

Rover navigation and mobility

ChemCam – Chemistry & Camera

CheMin – first x-ray view of Martian soil

MSL Technology Advancements:

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- Advanced actuators
- Advancements in scientific instruments
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- ChemCam – Chemistry & Camera
- CheMin – first x-ray view of Martian soil
EDL Technologies:
- PICA TPS
- Heat shield
- Instrumentation
- Precision
- Landing
- Parachute
- Descent
- Engines
- Descent Radar
- Sky Crane
Multi-Mission Radioisotope Thermal Generator
Defining the Combined AES/STP Portfolio

Human Architecture Team: Design Reference Missions

Strategic Knowledge Gaps: Guide robotic precursor activities

ISS Expert Working Group: Plans ISS technology demos

HEOMD Time Phased Investment Priorities

Strategic Space Technology Investment Plan: used to balance Agency investments

STP / GCD ETD: Matures component technologies

STP / TDM ETD: Matures system level technologies

AES Program: Prototype systems development & testing

Exploration Flight Systems
FY12 Accomplishments
Crew Mobility Systems Domain

**MMSEV:** Evaluated habitability and mobility during tests on air bearing floor

**Suitport:** Conducted differential pressure tests of two suitport concepts with Z-1 spacesuit.

**EVA:** Assessed mobility of Z-1 space suit in partial gravity aircraft flight tests.

**EVA:** Designed prototype Portable Life Support System for advanced spacesuit.
Strategic Space Technology Investment Plan (SSTIP) Summary

• 20-year horizon, investment guidance for the next four years
• Framework:
  – Goals
  – Capability Objectives
  – Technical Challenges
• Four-year investment approach
  – 70% - 8 Core technologies represent 12 of 16 NRC top priority recommendations
  – 20% - Adjacent Technologies: Not part of the Core but are part of the NRC’s 83 high priorities
  – 10% - Seeding Innovation: Smaller Investments in remaining technologies in the roadmaps that were not part of the NRC’s 83 high priorities.
Major missions we’re flying today (e.g. MSL) dependent on technology investments made years ago.

- Enabled by a rich base of technologies developed over a 20 year period
  - Sojourner to Spirit/Opportunity, to Curiosity
  - Many other examples on MSL and JWST

- NASA should maintain a corporate memory on technology infusion into key missions to justify future investments to OMB/Congressional decision makers.
T&I Committee Findings for the NASA Advisory Council

- NASA technology shelf depleted over the last decade due to a lack of investment. NASA has begun to correct this over the last three years (e.g., Space Technology Program (STP)).
T&I Committee Findings for the NASA Advisory Council

- Committee is impressed with progress in the STP
  - Two years ago—just talking process
  - Today—program executing, achieving milestones and delivering technologies
  - STP has maturity, momentum and some budget stability
  - Need to enhance engagement with commercial space
  - Question: if 85% of milestones being met on tech demos, are we setting the right risk posture for advancing technologies? If we increase risk, the stakeholder community must be conditioned to accept some failures.
• When NASA executes key missions, it should be enriching the Nation’s technology base.
  – Question to ask in program formulation—what new technologies are we advancing by this mission?
• In spite of the challenges, it is advantageous to insert technology measurement into flight missions to sharpen engineering analysis/design tools
  – MEDLI on MSL
  – OEX on Shuttle
Success of the Space Technology Research Grants program is encouraging

- Mentorship has been a key to success
- However, lack of hiring slots impedes refreshing of NASA technical workforce
• The organizational construct of STMD and OCT makes sense to the committee
  – Separation of line and staff responsibilities