History of Life and Physical Sciences Research Programs at NASA

David L. Tomko, Ph.D.
Program Executive for Human Research Program
Advanced Capabilities Division
Exploration Systems Mission Directorate, NASA Headquarters
NASA Life and Physical Sciences Vision - 2000

“To create a virtual, interdisciplinary program at NASA focused on biology, bring together physics, chemistry, biology and engineering to foster interdisciplinary research. We will use this natural synergy among disciplines to enable fundamental discoveries, and to develop new understandings, research opportunities, technologies, and products to advance our understanding of life and our place in the universe.”

--NASA Administrator
• The Office of Life and Microgravity Science and Applications (OLMSA) Enterprise will consist of the full spectrum, from basic through applied, biological, physical, chemical, and biomedical research.

• Builds and strengthens strong academic community involvement in NASA’s science and technology mission.

• Establishes the organization needed to facilitate effective use of ISS facilities for targeted scientific and technology questions.

• Establishes the organization needed to transfer scientific and technology results for Earth-benefits.

• Revolutionary solutions to science and technology problems are likely to emerge from scientists, clinicians, and engineers who are working at the frontiers of their respective disciplines and are also engaged in dynamic interdisciplinary interactions.

  – DARPA has successfully used this approach.
### Space Life and Physical Sciences Organization & Program Content – Post-SpaceLab Era 2000+

#### Physical Sciences in Space
- **Fundamental Research**
  - Fundamental Physics
  - Materials Science
  - Fluid Physics
  - Combustion Science
  - Exploration Research
- **Biomolecular Physics**
  - Atomic and Molecular Processes in Biosystems
  - Biological Sensing Phenomena
  - Cellular Components
  - Assembling Mechanisms
- **Biotechnology & Earth-based Application**
  - Cellular Biotechnology
  - Macromolecular Biotechnology
  - Earth-based Applications

#### Space Fundamental Biology Research & Applications
- **Space Genomics & Cellular Function (animal & plant)**
  - Molecular Structures and Physical Interactions
  - Molecular Biology
  - Cell Biology
- **Adaptation & Response to Space (animal & plant)**
  - Developmental Biology
  - Organismal & Comparative Biology
  - Neurobiology
- **Space Biology of Complex Systems (animal & plant)**
  - Evolutionary Biology
  - Space Environment Ecology

#### Space Biomedical Research and Applications
- **Space Biomedical Research**
  - Biomedical Physiology
  - Behavior and Performance, Group Dynamics
  - Radiobiology
  - Human Clinical Research
  - Space Human Factors Engineering
- **Manage NSBRI**
  - Countermeasures Development
- **Space Medicine Research (Medical Care Solutions to Code M Requirements)**
  - Flight Crew Health Care Delivery Research
  - Flight Crew Health Care Systems Research
  - Space Medical Research
- **Spacecraft Habitability, Planetary Habitat, Environmental Health**
  - Advanced Env. Monitoring and Control
  - Advanced Life Support (includes food production, waste management)
  - Toxicology, Microbiology
  - Advanced EVA
  - Radiation Protection
  - Bio-Plex

**Plus Divisions of Research Integration and Policy/Program Integration**

**COMMON FUNCTIONS:** Cross-disciplinary Science and Technology Working Group; Commercial Space Centers; Education & Outreach, Unique Facilities Utilization, International Science and CSC Research Collaborations
### FY 2000 Actual Budget

<table>
<thead>
<tr>
<th>Program/Projects</th>
<th>Funding Level (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLMSA Total</td>
<td>$264.9M</td>
</tr>
<tr>
<td>Advanced Human Support Technology</td>
<td>$30.1M</td>
</tr>
<tr>
<td>Biomedical Research &amp; Countermeasures</td>
<td>$48.2M</td>
</tr>
<tr>
<td>(Construction of Facilities Included)</td>
<td></td>
</tr>
<tr>
<td>Gravitational Biology &amp; Ecology</td>
<td>$37.8M</td>
</tr>
<tr>
<td>(Fundamental Biology)</td>
<td></td>
</tr>
<tr>
<td>Microgravity Research</td>
<td>$108.4M</td>
</tr>
<tr>
<td>Space Product Development</td>
<td>$14.4M</td>
</tr>
<tr>
<td>Health Research</td>
<td>$8.7M</td>
</tr>
<tr>
<td>Mission Integration</td>
<td>$17.4M</td>
</tr>
</tbody>
</table>
President’s FY2003 Budget Request directed:
- NASA to engage the scientific community and establish high-priority science objectives for OBPR
- Focus on improving scientific productivity

ISS Management and Cost Evaluation (IMCE) Task Force Recommendation directed:
- OBPR to establish scientific research priorities and,
- Develop executable research program consistent with those priorities

ReMaP assessed research priorities and productivity for the entire scientific, technological, and commercial portfolio of NASA’s Biological and Physical Research Enterprise and provided recommendations on how to achieve the greatest progress in high-priority research
Historical Context: OBPR Research Review

ReMaP Finding: Categorization of Highest Priority Research

Enables Human Exploration of Space
- Radiation Health
- Behavior and Performance
- Advanced Life Support
- Clinical / Operational Medicine

Intrinsic Scientific Importance or Impact
- Propulsion and Power
- Integrated Physiology
- Environmental Monitoring and Control
- Organismal and Comparative Biology

- Phase Transformation
- Condensed Matter
- Fundamental Laws
- Kinetics Structure & Transport
- Fluid Stability & Dynamics
- Energy Conversion
- Cell and Molecular Biology
Space Life and Physical Sciences
Budget Funding Levels - ReMaP Time (2002-2004)

OBPR Budget Distribution (FY02)

OBPR Total Budget for Research Divisions
$481 M (Excludes Multi User Systems and Support: 163M)

OBPR Research & Technology Budget
$265.5 M

OBPR ISS Research Capabilities
Budget $215.5 M

- Bioastronautics
- Fundamental Space Biology
- Physical Sciences
- Space Product Development
Historical Context - Transformation of OBPR into HSRT

Office of Biological and Physical Research

Transformation of Research Programs from Discipline-based to Product Line-based

Biomedical Research & Countermeasures
Advanced Human Support Technology
Fundamental Space Biology
Fundamental Physics
Fluid Physics
Combustion Science
Materials Science
Biotechnology

Human Systems Research and Technology

Human Health & Countermeasures
Exploration Biology
Autonomous Medical Care
Radiation Health
Advanced Life Support
Advanced EVA
Advanced Environmental Monitoring & Control
Contingency Response and Habitats
Space Human Factors
Human Behavior & Performance
System Engineering & Integration

BSR: Biological Sciences Research
PSR: Physical Sciences Research
HHP: Human Health and Performance
LSH: Life Support and Habitation
HSI: Human Systems Integration
OBPR/HSRT Re-Alignment Timeline

VSE 14 JANUARY 2004

OBPR RE-ALIGNMENT

1 AUGUST 2004 CREATION OF HSRT

OBPR-ESMD INTEGRATION

26 JANUARY 2005 HSRT ZBR RESULTS

OMB/HILL BRIEFINGS on ZBR Results

11/04 2/05 5/05 8/05

Reduction in non-Exploration research elements in OBPR portfolio. Elimination of fundamental:
Fluid Physics
Combustion
Materials Science
Macromolecular Biotechnology (PCG)
Physics (LTMPF)
Reduction in ISS research utilization (MUSS)
June 25, 2004 Op Plan Change

Reduction in Animal and Cell Biotechnology research elements. Further Reduction in:
Fluid Physics
Combustion
Materials Science
Atomic Physics (Atomic Clock)
Reduction in ISS research utilization (MUSS)
May 10, 2005 Op Plan Change

OBPR: Office of Biological and Physical research; HSRT: Human Systems Research and Technology
• Bringing the Exploration Vision to Reality - The Administrator will plan and implement an integrated, long-term robotic and human exploration program structured with measurable milestones and executed on the basis of available resources, accumulated experience, and technology readiness. To implement the vision, NASA will conduct the following activities

• Exploration Activities in Low Earth Orbit
• Space Shuttle - Focus use of the Space Shuttle to complete assembly of ISS
• International Space Station - Focus U.S. research and use of ISS on supporting space exploration goals, with emphasis on understanding how the space environment affects astronaut health and capabilities and developing countermeasures

• Space Exploration Beyond Low Earth Orbit: The Moon
• Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system;
• Conduct the first extended human expedition to the lunar surface no later than 2020;
• Use lunar exploration activities to further science, and to develop and test new approaches, technologies, and systems, including use of lunar and other space resources, to support sustained human space exploration to Mars and other destinations.

• International and Commercial Participation
• Pursue opportunities for international participation and commercial opportunities to support U.S. space exploration goals;
• International Space Station and exploration missions beyond low Earth orbit
Space Life and Physical Sciences
Program Content – Exploration Era

FY 2006 Budget Structure for Advanced Capabilities

Human Systems Research & Technology Theme
- Human Health and Performance $299M
- Human Systems Integration $207M
- Life Support and Habitation $301M

Prometheus Nuclear Systems & Technology Theme
- Advanced Systems & Technology $35M
- Deep Space Exploration Capability $285M

Exploration Systems Research & Technology Theme
- Advanced Space Technology $356M
- Technology Maturation $306M
- Robotic Lunar Exploration $134M
- Centennial Challenges $34M

FY 2007 Budget Structure for Advanced Capabilities

Human Systems Research & Technology Theme
- Human Health and Performance $135M
- Human Systems Integration $14M
- Life Support and Habitation $70M

Exploration Systems Research & Technology Theme
- Exploration Technology Development Program $277M
- Prometheus Power & Propulsion $7M
- Lunar Precursor Robotic Program $235M

FY 2008 Budget Structure for Advanced Capabilities

Human Research Program $150M

Exploration Technology Development Program $287M

ISS Life and Physical Science Research $38M

Lunar Precursor Robotic Program $187M

FY 2009 Budget Structure for Advanced Capabilities

Human Research Program $152M

Exploration Technology Development Program $264M

ISS Life and Physical Science Research $45M

Lunar Precursor Robotic Program $56.3M

Note: Reflects transfer of Innovative Partnerships during FY06; transfer of Centennial Challenges during FY 07
## Space Life and Physical Sciences
### Budget Funding Levels – Exploration Era

**NOA $ in millions**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration Systems FY09 President's Budget</td>
<td>2,829.8</td>
<td>3,299.5</td>
<td>3,505.4</td>
<td>3,737.7</td>
<td>7,048.2</td>
<td>7,116.8</td>
<td>7,666.8</td>
</tr>
<tr>
<td><strong>Constellation Systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constellation Systems Program</td>
<td>2,092.4</td>
<td>2,675.8</td>
<td>3,033.1</td>
<td>3,252.8</td>
<td>6,479.5</td>
<td>6,521.4</td>
<td>7,080.5</td>
</tr>
<tr>
<td>Commercial Crew and Cargo Program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial Crew and Cargo</td>
<td>2,051.2</td>
<td>2,545.3</td>
<td>2,880.1</td>
<td>3,221.5</td>
<td>6,479.5</td>
<td>6,521.4</td>
<td>7,080.5</td>
</tr>
<tr>
<td>Advanced Capabilities</td>
<td>737.4</td>
<td>623.7</td>
<td>472.3</td>
<td>484.9</td>
<td>568.7</td>
<td>595.5</td>
<td>586.3</td>
</tr>
<tr>
<td>Lunar Precursor Robotic Program</td>
<td>235.4</td>
<td>187.1</td>
<td>56.3</td>
<td>35.5</td>
<td>16.7</td>
<td>16.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Human Research Program</td>
<td>148.7</td>
<td>149.6</td>
<td>151.9</td>
<td>152.8</td>
<td>153.2</td>
<td>158.7</td>
<td>162.7</td>
</tr>
<tr>
<td>Exploration Tech Development</td>
<td>353.4</td>
<td>287.0</td>
<td>264.1</td>
<td>296.6</td>
<td>398.8</td>
<td>420.2</td>
<td>407.1</td>
</tr>
</tbody>
</table>

*Note: FY 2007 Budget Actuals; FY 2008 Budget per current Agency Operating Plan; FY 2009 Enacted Budget; FY10-13 columns per FY 2009 President's Budget to Congress*
Space Life and Physical Sciences
Where are we now?

**ISS Re-alignment and Narrowing of R&T Focus**

### 2002 OBPR ISS Portfolio

<table>
<thead>
<tr>
<th>Total OBPR</th>
<th>966</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Research Investigations</td>
<td>809</td>
</tr>
<tr>
<td>Flight Research Investigations</td>
<td>157</td>
</tr>
<tr>
<td>Ground/Flight Ratio</td>
<td>5:1</td>
</tr>
</tbody>
</table>

**ISS R&T primary focus:**
- Biomedical
- Basic Physical Sciences
- Fundamental Biological Sciences

### 2008 ISS Portfolio

<table>
<thead>
<tr>
<th>Total</th>
<th>285</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Research Investigations</td>
<td>201</td>
</tr>
<tr>
<td>Flight Research Investigations</td>
<td>84</td>
</tr>
<tr>
<td>Ground/Flight Ratio</td>
<td>2.5:1</td>
</tr>
</tbody>
</table>

**ISS R&T primary focus:**
- Exploration Biomedical
- Exploration Technology Testing
- Non-exploration Research

Data from taskbooks: http://taskbook.nasaprs.com/Publication/welcome.cfm
## Space Life and Physical Sciences
Where are we now?

<table>
<thead>
<tr>
<th></th>
<th>2002 Flight Experiments</th>
<th>2008 Flight Experiments</th>
<th>Hardware (Canceled/Stowage)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fundamental Space Biology</strong></td>
<td></td>
<td></td>
<td>Advanced Animal Habitat (AAH), Plant Research Unit (PRU), Biomass Production Unit (BPU), Cell Culture Unit (CCU), Avian Development Facility (ADF), Habitat Holding Rack (HHR), Laboratory Support Equipment (LSE)</td>
</tr>
<tr>
<td>•Animal</td>
<td>26</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>•Plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>•Microbial/Cell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biomedical Research and Countermeasures</strong></td>
<td>38</td>
<td>32</td>
<td>OPCGA, All crystal growth hardware (PCAM, DCAM, HD-PCG)</td>
</tr>
<tr>
<td><strong>Biotechnology</strong></td>
<td>11</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Combustion Science</strong></td>
<td>20</td>
<td>15</td>
<td>FEANICS, MGCA (Multiuser Gaseous Combustion Assembly) CFM (Candle flames in Microgravity) FSDC (Fiber Supported Droplet Combustion)</td>
</tr>
<tr>
<td><strong>Fluid Physics</strong></td>
<td>23</td>
<td>16</td>
<td>Colloidal Expts. on LMM, Granular Flow Module for FIR, MOBI on FIR</td>
</tr>
<tr>
<td><strong>Fundamental Physics</strong></td>
<td>13</td>
<td>0</td>
<td>LTMPF, Atomic Clocks</td>
</tr>
<tr>
<td><strong>Materials Science</strong></td>
<td>23</td>
<td>5</td>
<td>Quench Module Insert for MSRR, SPD Expt. Module (MSRR furnace), Gravity-limit for MSG</td>
</tr>
<tr>
<td><strong>Advanced Human Support Technology</strong></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
## History of Life and Physical Sciences Research Programs at NASA (past decade)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background</strong></td>
<td>Research for U.S. excellence in Space Life and Physical Sciences defined by NRC and public Advisory groups</td>
<td>Research for U.S. excellence in Space Life and Physical Sciences defined by NRC and public Advisory groups</td>
<td>Applied research and technology necessary to enable space exploration defined by Exploration Systems Architecture Study (NASA)</td>
</tr>
<tr>
<td><strong>Guiding Principles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Program Content</strong></td>
<td>Broad and deep life and physical sciences portfolio</td>
<td>Broad life and physical sciences portfolio prioritized to optimize ISS utilization</td>
<td>Applied science and technology restricted to near-term exploration needs</td>
</tr>
<tr>
<td><strong>Budget Funding Levels</strong></td>
<td>Roughly $250M shared equally between Life &amp; Physical Sciences</td>
<td>Roughly $500M shared equally between Life and Physical Sciences</td>
<td>$150M Human Research (exploration), $30M Non-Exploration Life and Physical Science (does not include environmental control and life support)</td>
</tr>
<tr>
<td><strong>Organization Structure</strong></td>
<td>Life and Physical Sciences Divisions report to Associate Administrator (AA) who reports to NASA Administrator</td>
<td>Life and Physical Sciences Divisions report to AA who reports to NASA Administrator</td>
<td>Programs managed at Centers by directors who report to ESMD AA</td>
</tr>
</tbody>
</table>