National Aeronautics and Space Administration

Space Life and Physical Sciences Research and Applications Division

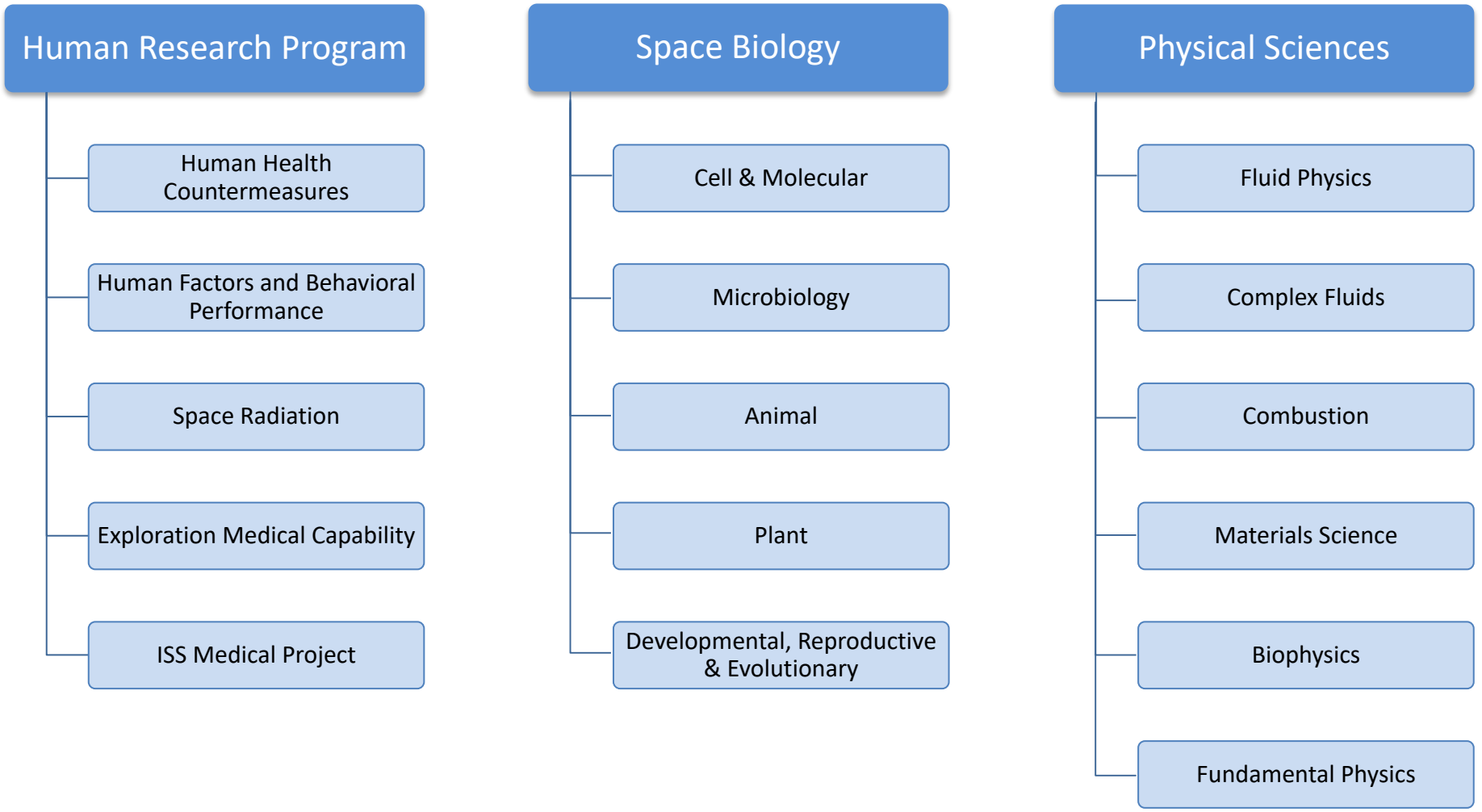
March 26, 2018

Craig Kundrot, Ph.D.
Director, Space Life and Physical Sciences Research & Applications
Human Exploration & Operations Mission Directorate

Outline

- **Recent SLPSRA activities**
- **Midterm assessment of implementation of Decadal Survey**
- **President's Budget Request**
- **NASA Strategic Plan**
- **Lunar Orbital Platform - Gateway**
- **SLPSRA Strategic Plan**
- **Conclusion**

Space Life and Physical Sciences Research and Applications Division



Tasks and Workforce

Program	Tasks	PIs	Co-Is	Post Docs	PhD students	Masters students	Bachelor students
Human Research Program	188	156	565	74	120	35	64
Space Biology	77	66	142	44	50	27	132
Physical Sciences	99	92	143	48	113	27	56
Total	364	314	850	166	283	89	252
							1,954

https://taskbook.nasaprs.com/Publication/index.cfm

HRP: Exploration Exercise (ATLAS)

current ISS exercise hardware – CEVIS, TVIS, ARED

ATLAS will replace ISS exercise hardware for exploration

- **Fall 2017 – Functional breadboard unit delivered to HRP**
- **16 Jan 2018 – Authority To Proceed (ATP) to PDR**
- **27 Feb 2018 – PDR initiated at GRC**
- **Mar 2020 – Flight Hardware to CH&S SMT**

HRP: Crew Performance after Landing

- n=36 returning crewmembers (19 USOS, 17 Rus) from 17 Soyuz landings
- Every returning crewmember exhibits vestibular/cerebellar and sensorimotor decrements
- Every crewmember experiences landing-related motion sickness
- There is considerable variations between crewmembers performance
- Strength is likely not the limiting factor because of current in-flight exercise countermeasures
- **Emergency egress during/after a water landing will present a significant risk to astronaut safety**

SB: Rodent Research-9 and Biospecimen Sharing

- **Flew 20 mice for ~30 days**
- **Evaluate physiological changes in the brain, eye, and lymphatic system, and knee/hip degradation.**
- **Returned live for dissection in Primary Investigator's lab**

RR-9 PI TISSUE LIST

DELP

1. Brain
2. Basilar arteries
3. Cerebral arteries
4. Choroid plexus
5. Parietal cortex
6. Coronary arteries
7. Basal veins
8. Jugular Veins
9. Cervical lymphatics
10. Carotid artery

WILLEY

1. Hind limbs

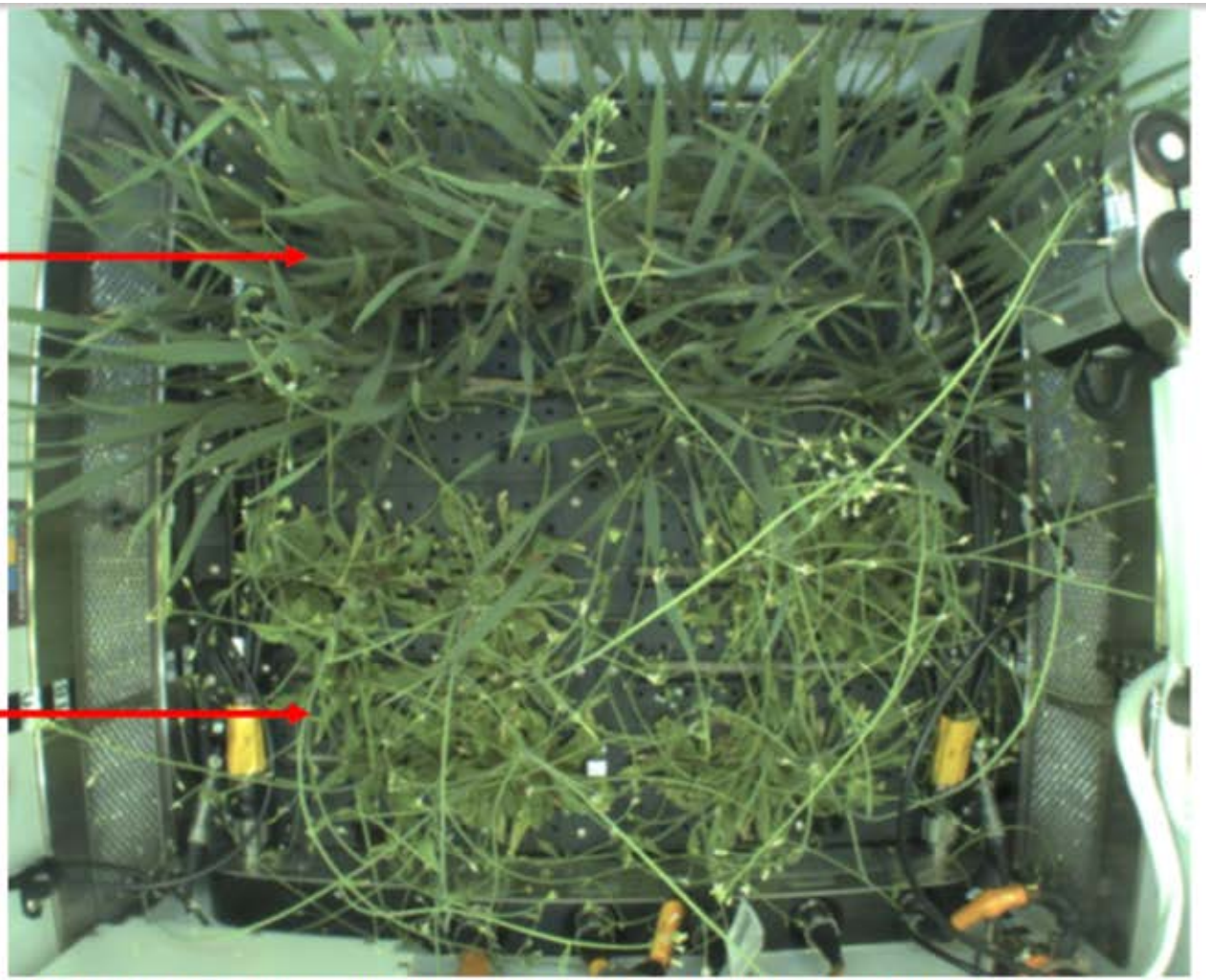
MAO

1. Blood serum
2. Eyes

RR-9 BSP TISSUE LIST

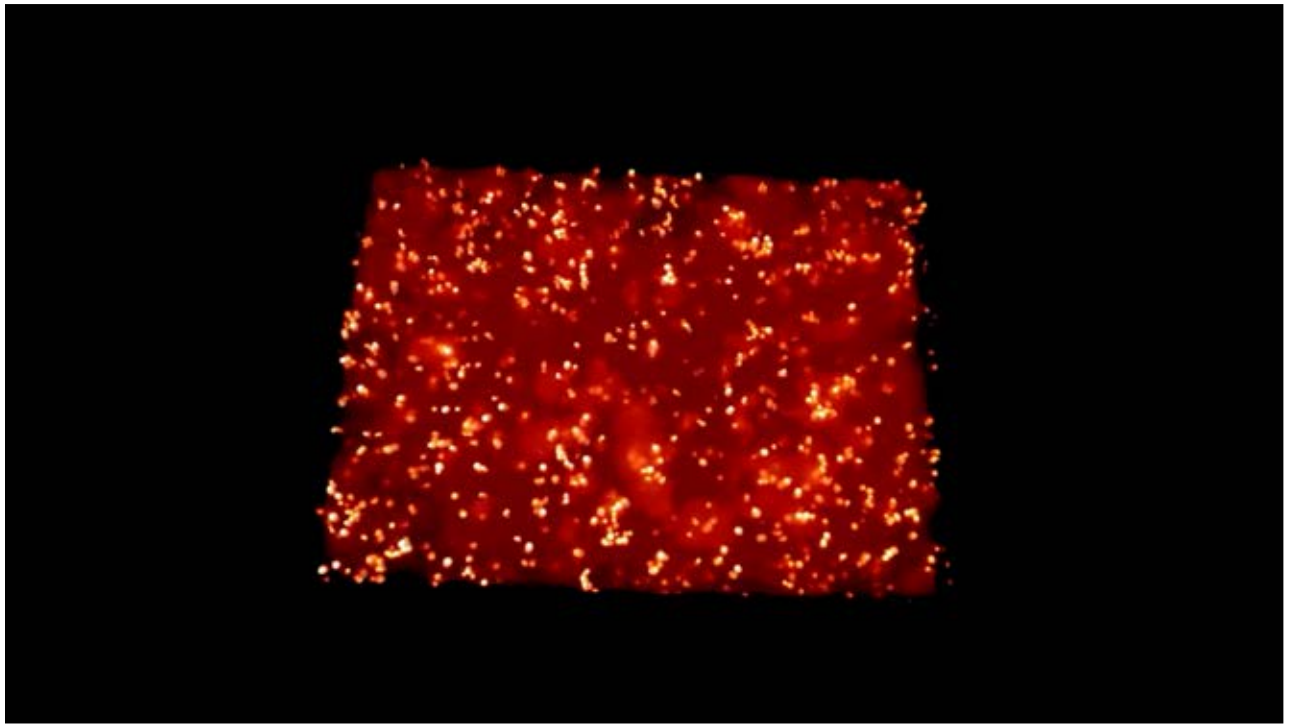
1. Abdominal lymphatic nodes
2. Adrenal glands
3. Aorta (abdominal and thoracic)
4. Axillary lymph nodes/ lymphatics
5. Blood serum
6. Calvaria
7. Cecum
8. Cephalic lymphatics
9. Colon
10. Cribriform plate of head
11. Diaphragm
12. Duodenum
13. Esophagus
14. Fat (abdominal/brown adipose)
15. Feces
16. Femur
17. Heart
18. Humerus
19. Ileum
20. Inguinal lymph nodes/lymphatics
16. Jejunum
17. Kidneys
18. Liver
19. Lungs
20. Mandible
21. Mesentery
22. M. gastrocnemius
23. M. Extensor digitorum (EDL)
26. M. longissimus dorsi
27. M. quadriceps vastus lateralis
28. M. soleus
29. M. splenius
30. M. tibialis anterior
31. Pancreas
32. Paw
33. Rectum
34. Skin dorsal
35. Skin femoral lateral
36. Spine/pelvis
37. Spleen
38. Stomach
39. Tail
40. Testis
41. Tibia
42. Thymus
43. Whiskers with skin

SB: Advanced Plant Habitat



- The Arabidopsis started on 1/22/18 and this is about 5 weeks of growth. The Dwarf wheat was started on 2/7-8/18 and this is about 3 weeks of growth.

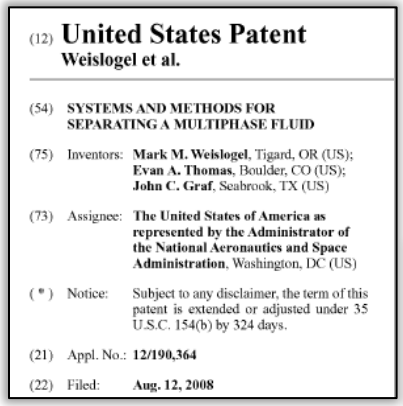
PS: Advanced Colloids Experiment (ACE-T6)



- First experiment using 3D confocal upgrade to the Light Microscopy Module
- Principal Investigator: Mathew Lynch, Principal Scientist of Procter and Gamble
- Four patent applications pertaining to product development and shelf life in work
- Partnership with P&G and CASIS

PS: Capillary Flow Experiments

- **CFE and CFE-2 (PI: Prof. Mark Weislogel, Portland State University):**
  - Investigated large length scale capillary flows and phenomena in low gravity.
  - Obtained data as it pertains to fluids management systems such as fuels and cryogen storage systems, water collection and recycling, thermal control systems, and materials processing in the liquid state.
  - Operated from 2005 to 2017 in Maintenance Work Area by over 35 astronauts in over 100 ~3hr operations on ISS.
- **Resulting Spinoffs from research:**
  - Microgravity urine collection device patent, ISS coffee and espresso cups and machines, plant watering system, ISS water “ping pong” outreach
  - IRPI, LLC, a small company has completed 40 capillary fluidics space projects
    - Developed SE-FIT (Surface Evolver-Fluid Interface Tool).
      - Graphical Interface for using a Surface Area Minimization Code
      - Prebuilt Geometries including tanks, CFE experiments, fundamental science, etc.
  - More than 40 peer reviewed publications and conference papers


(12) **United States Patent**
Weislogel et al.

(54) SYSTEMS AND METHODS FOR SEPARATING A MULTIPHASE FLUID

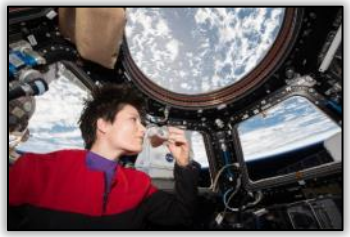
(75) Inventors: **Mark M. Weislogel**, Tigard, OR (US); **Evan A. Thomas**, Boulder, CO (US); **John C. Graf**, Seabrook, TX (US)

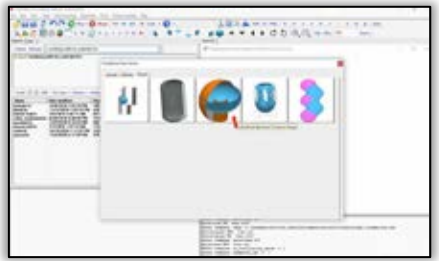
(73) Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 324 days.

(21) Appl. No.: **12/190,364**

(22) Filed: **Aug. 12, 2008**





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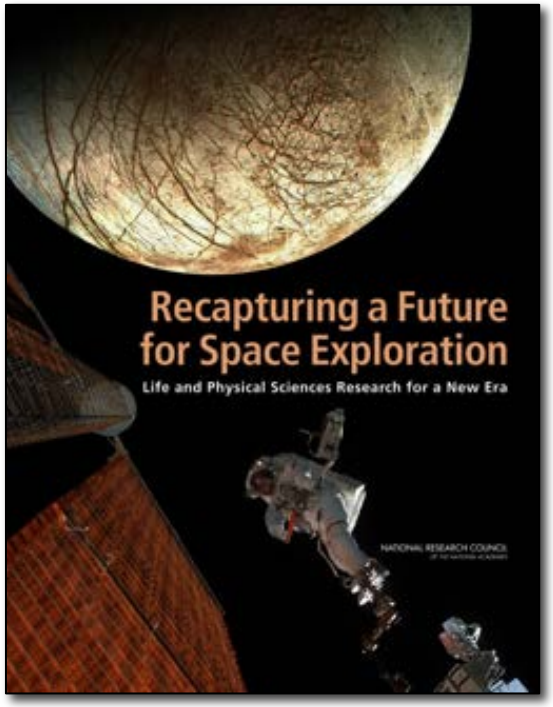
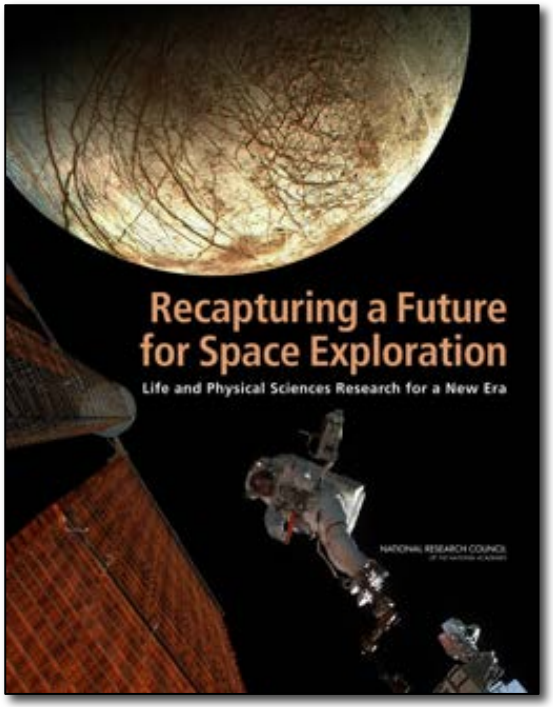
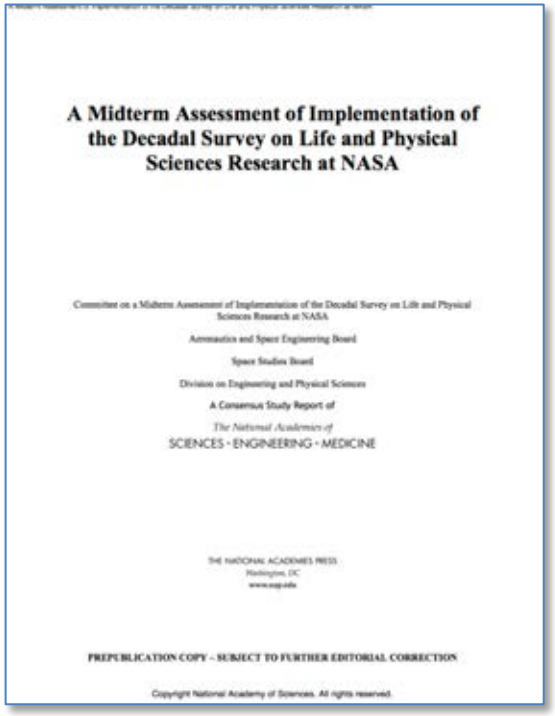


Decadal Survey: Midterm Assessment




A Midterm Assessment of Implementation of the Decadal Survey on Life and Physical Sciences Research at NASA

Committee on a Midterm Assessment of Implementation of the Decadal Survey on Life and Physical Sciences Research at NASA

Aeronautics and Space Engineering Board

Space Studies Board

Division on Engineering and Physical Sciences

A Consensus Study Report of

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

THE NATIONAL ACADEMIES PRESS
Washington, DC
www.nap.edu

PREPUBLICATION COPY – SUBJECT TO FURTHER EDITORIAL CORRECTION

- **Midterm Assessment of Implementation of the Decadal Survey on Life and Physical Science Research at NASA**
  - Released December, 2917
  - 12 Findings
  - 13 Recommendations

https://www.nap.edu/catalog/24966/a-midterm-assessment-of-implementation-of-the-decadal-survey-on-life-and-physical-sciences-research-at-nasa

Midterm Assessment

- **Recommendation 5-11: NASA should aggressively lead in the 46 research priorities for deep space exploration identified in Table 4.1 of this midterm report to provide as much "pull" as possible for exploration enhancement using space life and physical sciences. NASA should, for example, lead in the development of microgravity-adapted biological and physical systems, making maximum use of all available platforms, including the International Space Station, specifically for the science behind the design and implementation of microgravity-optimized operation.**

- **Agree**
  - This is a helpful prioritization to guide the allocation of SLPSRA resources
  - The (Earth analog | LEO | BLEO) breakout works well with the SLPSRA "stepping stone" approach
  - SLPSRA is working in many of these areas
    - Many with well established "pull' from other NASA programs
    - Some are well-positioned to obtain "pull"
    - A few need to be "pushed" to NASA programs with results and analysis before other programs will "pull" for such work

Midterm Assessment

- **Recommendation 5-12: The committee recommends that a cautious approach be used when shifting the NASA research portfolio more toward those types of experiments necessary for deep space exploration, so as to maintain the benefits of important basic experiments, especially those uniquely enabled by International Space Station microgravity and already in progress, which may in the long term have the potential for major impacts in fundamental physical science.**

- **Agree**
  - Part of SLPSRA's mission is to pioneer scientific discovery for other government agencies, commercial companies, and international partners.
  - Therefore, areas like fundamental physics are an important part of the SLPSRA portfolio.
  - Moreover, such research helps develop the future commercial workforce and be the foundation of future generations of space technologies.

Midterm Assessment

- **Recommendation 5-8: In order to maximize the implementation of decadal survey priorities within its constrained resources, NASA should continue to be mindful of the full range of platforms (including drop towers, aircraft, balloons, suborbital vehicles, and free-flyers) and terrestrial analogs and ground-based laboratories available for decadal survey research.**

- **Agree**
  - SLPSRA is actively pursuing utilization of the full range of research platforms.
  - We currently utilize many terrestrial facilities, drop towers, aircraft, sub-orbital vehicles and free-flyers, and are increasing our utilization.
  - We have recently solicited for new Space Biology research in aircraft, on balloons, and in terrestrial microgravity simulators.
  - We are actively considering research on platforms such as
    - the U.S. Air Force X37-B
    - commercial platforms (e.g., New Shepard , Cygnus, DragonLab, Dream Chaser)
    - international partner platforms (e.g., Eu:CROPIS, BION M-2).

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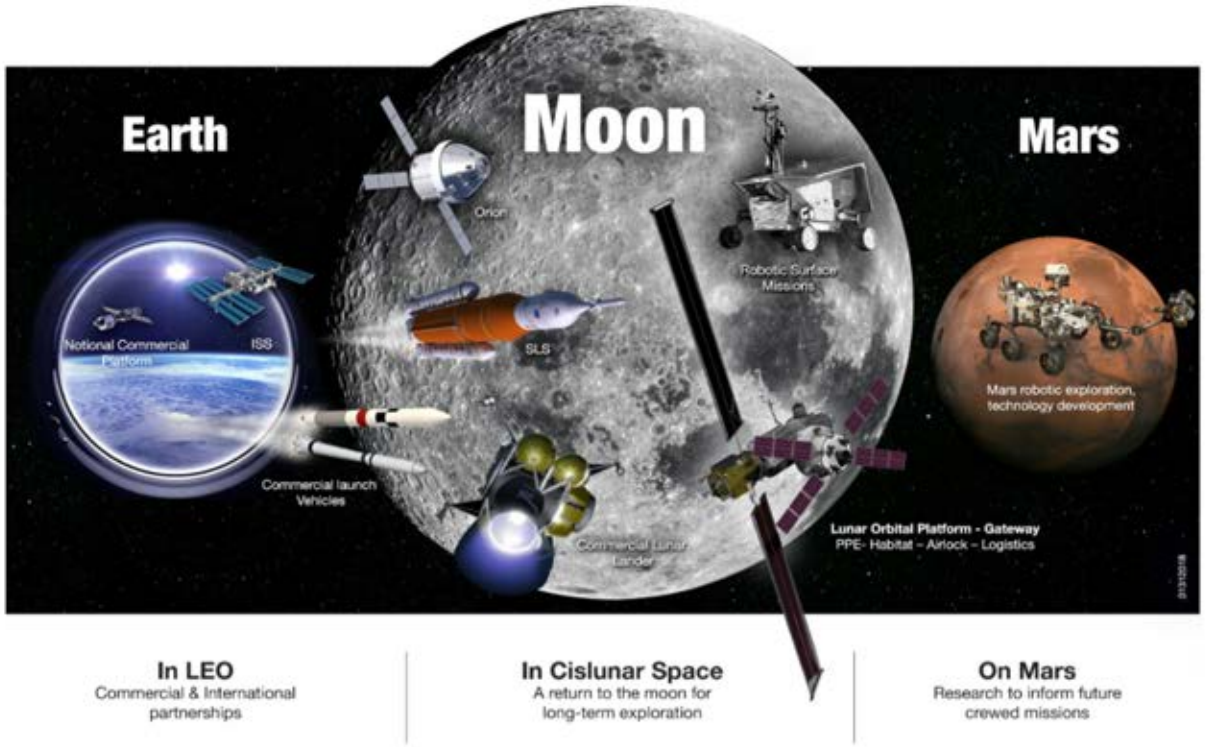

President's Budget Request for FY19

- **Budget**
  - Human Research Program (HRP)
    - Unchanged at $140M / year
  - Biological and Physical Sciences (BPS)
    - Within ISS Research budget line
    - Presumed unchanged at ~$80M / year
- **Restructuring options for HEOMD + STMD**
  - 1) Two Directorates
    - Exploration Operations Mission Directorate
      - ISS, LEO operations, and cross cutting support areas
      - Presumably includes BPS
    - Exploration Systems and Technology Mission Directorate
      - Deep space mission elements and technology developments needed for sustainable human exploration
      - Includes HRP in Exploration Research & Technology (right)
  - 2) One Directorate
    - HRP in ERT and separate BPS with ISS/LEO
- **Examining moving BPS with HRP to ERT**

FY 2019 Structure
Exploration Research & Technology
Early Stage Innovation and Partnerships
Agency Technology and Innovation
Early Stage Innovation (includes AES)
Partnerships and Technology Transfer (includes AES)
Technology Maturation (includes AES)
Technology Demonstration
Restore/In-Space Robotic Servicing (ISRS)
Laser Comm Relay Demonstration (LCRD)
Solar Electric Propulsion (SEP)
Small Spacecraft, Flight Opportunities & Other Tech Demonstration (includes AES)
Human Research Program
SBIR and STTR

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NASA Strategic Plan

- **Strategic Objective 1.2: Understand Responses of Physical and Biological Systems to Spaceflight**
  - Conduct a robust program of space-based research to
    - advance technologies that enable space exploration
    - pioneer uses of the space environment to benefit life on Earth
  - The space flight environment stresses physical and biological systems in many ways, including microgravity and space radiation
    - Understanding the responses of physical and biological systems to these stressors is necessary for designing and executing longer, more distant human space flight missions..
    - These stressors can also be used as experimental tools to enable scientific discovery with applications here on Earth
  - The first stages of progress toward achieving this strategic objective will be clearly measured by the formulation of agreements between
    - the research programs
    - the internal NASA customer (for enabling exploration) or external organizations (for scientific discovery)
  - Final accomplishment of the research objectives will be measured by showing how the research products address the original agreement's needs.

Strategic Objective 1.2

NASA 2018 Strategic Plan Framework		
Theme	**Strategic Goal**	**Strategic Objective**
DISCOVER	EXPAND HUMAN KNOWLEDGE THROUGH NEW SCIENTIFIC DISCOVERIES.	1.1: Understand the Sun, Earth, Solar System, and Universe. 1.2: Understand Responses of Physical and Biological Systems to Spaceflight.
EXPLORE	EXTEND HUMAN PRESENCE DEEPER INTO SPACE AND TO THE MOON FOR SUSTAINABLE LONG-TERM EXPLORATION AND UTILIZATION.	2.1: Lay the Foundation for America to Maintain a Constant Human Presence in Low Earth Orbit Enabled by a Commercial Market. 2.2: Conduct Exploration in Deep Space, Including to the Surface of the Moon.
DEVELOP	ADDRESS NATIONAL CHALLENGES AND CATALYZE ECONOMIC GROWTH.	3.1: Develop and Transfer Revolutionary Technologies to Enable Exploration Capabilities for NASA and the Nation. 3.2: Transform Aviation Through Revolutionary Technology Research, Development, and Transfer. 3.3: Inspire and Engage the Public in Aeronautics, Space, and Science.
ENABLE	OPTIMIZE CAPABILITIES AND OPERATIONS.	4.1: Engage in Partnership Strategies. 4.2: Enable Space Access and Services. 4.3: Assure Safety and Mission Success. 4.4: Manage Human Capital. 4.5: Ensure Enterprise Protection. 4.6: Sustain Infrastructure Capabilities and Operations.

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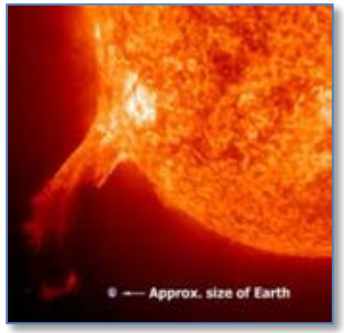
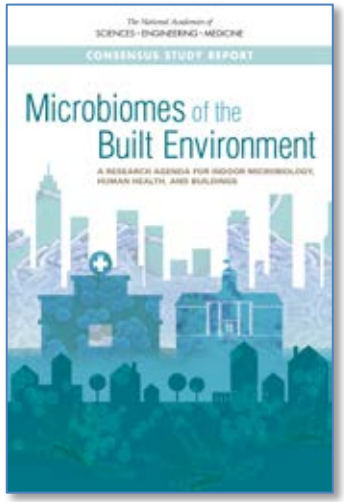
Lunar Orbital Platform – Gateway Workshop

- **SLPSRA HRP and Space Biology**
  - 46 of 110 papers presented
  - Coordinating with Astrobiology and Planetary Protection through Life Science Research Capability Team
- **Scientific Opportunity**
  - Strong ties to Decadal Survey
  - Deep space radiation: spectrum and dose rate
  - Biological response to radiation and countermeasures
  - Microbiome of built environment (MoBE)
- **Gateway Considerations**
  - Internal and external payloads
  - Limited volume, power, crew time, dormant periods, cold stowage, sample return
  - Desire for glovebox, microscopes, freezers, wetlab, remote operations, high capacity data transmission, robotic tasking, automation, etc.
- **Collaboration between basic science, human health, technology development, mission planners**





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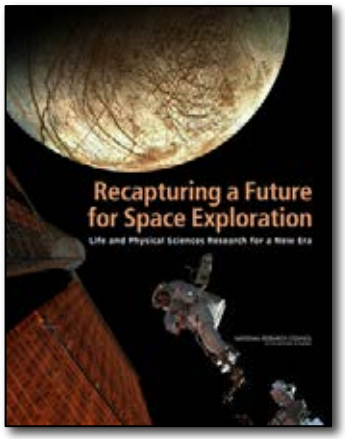
Purpose - Unchanged

- **Vision**
  - We lead the space life and physical sciences research community to enable space exploration and benefit life on Earth

- **Mission**
  - Enable exploration to expand the frontiers of knowledge, capability, and opportunity in space
  - Pioneer scientific discovery in and beyond Low Earth Orbit to drive advances in science, technology, and space exploration to enhance knowledge, education, innovation, and economic vitality



Goals – In Work

1. Enable exploration by providing research and technology development products to meet the known needs for future exploration mission needs

2. Enable exploration by demonstrating to stakeholders how emerging knowledge and technology could improve the execution and reduce the risks of exploration missions

3. Pioneer scientific discovery by refining the use of space for research and technology development across the full range of established and new spaceflight platforms

4. Pioneer scientific discovery by helping other organizations utilize the spaceflight environment effectively

CASIS

5. Maintain key scientific and engineering capabilities f NASA and the Nation

Implementation Emphases - Original

- **Open Science**
  - Maximize community participation in the **formulation** of investigations where feasible
    - Co-Principal Investigator Teams
    - Topical Teams
    - Science Definition Teams
  - **Disseminate and reuse** data, tools, and samples post-project
    - GeneLab
    - Physical Science Informatics
    - Life Sciences Data Archive
- **Partnerships**
  - Generate pull for enabling exploration; identify adopters for pioneering scientific discovery
  - Leverage resources
  - Access new experimental platforms
  - Strengthen technical foundation

Implementation Principles - Expanded

1. **Ensure Scientific Integrity**

2. **Maximize Open Science**

GeneLab
Open Science for Exploration

3. **Cultivate Partnerships**

NIH BARDA ИМБП DLR CASIS P&G

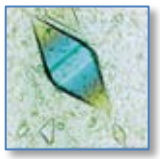
4. **Use Stepping Stones**





5. **Be an Early Adopter of New Spaceflight Platforms**


6. **Facilitate Commercialization of Space by Making Research Available to Commercial Companies**



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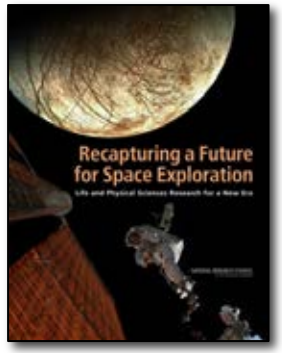
Conclusion

- **SLPSRA is executing valuable research**
  - To enable exploration
  - To pioneer scientific discovery
  - Guided by the Decadal Survey
  - Guided by NASA-identified needs
- **The Midterm Assessment of the Decadal Survey**
  - Prioritization & implementation advice
- **President's Budget Request for FY19**
  - Budget appears stable
  - Re-organization could separate HRP and BPS
- **Lunar Orbital Platform – Gateway**
  - Deep space radiation provides new opportunities for biological research
- **SLPSRA Strategic Plan**
  - Supporting the post-ISS and beyond LEO era




Thank You