NASA Advisory Council (NAC)

Meeting of the

Human Exploration and Operations Committee

Research Subcommittee

NASA Headquarters, Washington, DC

Meeting Minutes

July 20, 2015

David Longnecker, Chair

Bradley Carpenter, Executive Secretary

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Meeting of the NAC Human Exploration and Operations Committee

Research Subcommittee

July 20, 2015
NASA Headquarters
Washington, DC

Opening

Dr. Bradley Carpenter, Executive Secretary of the Research Subcommittee (RS) of the NASA Advisory Committee (NAC) Human Exploration and Operations Committee (HEOC), welcomed the Subcommittee members.

Dr. David Longnecker, Chair of the Subcommittee, also welcomed the meeting participants. Members attending the meeting in addition to Dr. Longnecker were Dr. M. Katherine Banks, participating by phone; Dr. James A. Pawelczyk, a new member; Dr. Stein Sture; and Dr. Kathryn Thornton. Sitting in for Space Life and Physical Sciences (SLPS) Division Director Dr. Marshall Porterfield was Dr. Angel Otero, Deputy Division Director.

NASA Status

Dr. Otero explained that NASA SLPS cannot now do rodent research on ISS because of the large crew time requirement. Therefore, SLPS will conduct rodent research on the ground until crew time becomes available. NASA is seeking input on the next best model organism and is also looking at restarting a ground program. This situation grew out of a new priority process for ISS resources. The Center for the Advancement of Science in Space (CASIS) gets 50 percent of the crew time, with subsequent priorities being the Human Research Program (HRP), technology demonstrations, international commitments, and recommendations from the SLPS and Science Mission Directorate (SMD) Decadal Surveys (DSes).

Rodent research requires a time minimum that cannot be met under these circumstances, so the decision was made to not do it for now. In a couple of years, the commercial crew program should result in an extra crew member on ISS, but NASA is still concerned that that person will not be able to devote sufficient time to rodent research. SLPS is seeking community and RS input while investigating other venues such as suborbital. Dr. Longnecker found the situation rather sobering. Dr. Pawelczyk agreed and asked if it would be possible for the RS to obtain a list of the descoped projects. Dr. Otero replied that nothing had yet been descoped. While Principal Investigators (PIs) were already selected to do rodent research projects, NASA was trying to determine how they might be used and how to collaborate with CASIS. SLPS has funds and CASIS has crew time, so there might be a way to work together. He added that much of the crew time in rodent research involves husbandry, which is very time consuming.

Contractually, NASA has an agreement with CASIS, which focuses on non-NASA or commercial applications. SLPS can help CASIS identify fundamental research that could go in the commercial direction.. When we identify a PI who can work with them we create a win-win situation of funding and time.

Dr. David Tomko, Program Scientist for Space Biology, said that one advantage of ISS is the ability to do more complex work, such as manipulation of animals, sacrifice on orbit, and quick-freeze of animal

tissues. There is a whole class of science that cannot be done without this capacity. The community has fought hard for the ability to do rodent research on ISS.

Dr. Longnecker observed that the life science component also requires crew training. Dr. Otero said that SLPS has not yet had time to think strategically about this development. The Division is reaching out to the community for input. Dr. Tomko added that another issue is the fact that the selected projects were peer reviewed. Having those PIs do different projects would negate the peer-review element, but a re-review would also be problematic. Still, the Division does not want a cadre of investigators, it wants peer-reviewed experiments.

Dr. Carpenter explained that CASIS also does work for the national labs, other Federal agencies, and the private sector. Dr. Sture noted that animals require substantial care, and wondered if there might be research into how to reduce that. Dr. Carpenter explained that the habitats are not cleaned on orbit; instead, they are periodically changed. However, catching a mouse in microgravity is a trick. Transfer of a mouse from the transporter that brings the mice from Earth to the habitat on the iSS can more than one hour per mouse, and it generally takes two astronauts each a full day to do simple surgeries on four mice.

Physical Sciences

Dr. Mark Lee listed 11 important physics questions identified by the National Research Council, 5 of which can be examined on the ISS through precision measurements. Of the four DS recommendations in this area, NASA has chosen quantum gas as being the most productive. Dr. Lee described how these gases, which follow quantum physics, might be studied on ISS. NASA is buildingthe Cold Atom Lab (CAL) for delivery to ISS in 2017., CAL will produce the lowest measurable temperatures in the universe. The temperature within a black hole is lower in theory than CAL will achieve, but is beyond experimental confirmation. CAL passed the critical design review (CDR) and will be launch-ready in 2017. The NASA Research Announcement (NRA) has selected seven highly competitive proposals for the CAL. SLPS is working closely with the science community in this rapidly moving field. This work cannot be done on the ground.

Dr. Lee next discussed investigations into the nature dark energy and dark matter that are possible using the CAL facility. There are many theories on dark energy at the moment. One leading theory, the "chameleon theory," posits the existence of a "chameleon particle" with a variable effective mass dependent on the local energy density. On Earth the range of the particle's force may be under a millimeter, but in open space the range of the force could have a galactic length scale. . The key technique for measurement is to create a highly accurate and precise measurement of gravitational attraction, in whichthe dark energy is expected to produce a deviation. The CAL will have to continue upgrading and developing to stay with what is needed by the science community.

CAL1 will be launched in early 2017, but it will need to upgrade quickly to CAL2 and beyond. For longer term follow-ons, accuracy must be continuously improved. CAL will always carry forward dark matter/dark energy research. The long-term goal is to use ISS as a lab for precise measurements using atom interferometry and high accuracy. CAL is a $48 million investment in hardware, but to be really useful on dark energy, it will need continuing improvement.

Dr. Frank Chiaramonte presented an overview of biophysics, combustion science, fluid physics, complex fluids, and materials science. These areas have been restored to the budget over time, mapping to a plan that responds to the recommendations of the DS. SLPS recently held workshops in materials, combustion, and fluids. Out of these efforts are committee reports, a strategic plan based on those reports, the physical

sciences research plan, and recommendations for higher priority research. There is now modest funding for NRAs, and the Division would like to issue another NRA in 2017. Dr. Chiaramonte described the materials lab workshop, which covered six disciplines: biomaterials; glasses and ceramics; granular materials; metals; polymers and organics; and semiconductors. Attendees reviewed NASA's current programs and made recommendations.

As part of the larger effort, SLPS is placing data from prior flight experiments into a database, which complies with a new Federal initiative, though the Division began this work prior to that directive. The database is open to the public. An NRA on informatics was released in June and will go for 2 years, although it will also close periodically for review.

Dr. Longnecker asked if there has been a rejuvenation of new investigators entering the field. Dr. Chiaramonte replied that there was a gap. This work is expensive, and continuous hardware investments could enable more frequent NRAs. Some of the calls will target students.

The materials science workshop led to a formal collaboration with the National Institute of Standards and Technology (NIST), as well as with CASIS, covering metals, semiconductors, glasses and ceramics, and biomaterials and liquid crystals. The workshop also led to a thermophysical properties measurements initiative. The demand for this research is strong.

The 10-year plan shows the direction for adding new research capabilities. Biophysics is a modest program with only five projects at this point; the workshop led to the decision to grow the area, especially in biofilms and biomaterials scaffolding. Long-range plans include 3-D bioprinting and fluids for biology. NASA is leveraging the complex fluids area with ESA, and has initiatives in foams, granular flows, colloids, and liquid crystals.

Combustion science has five areas with some ongoing and pending projects. The workshop recommended doing more on fire safety and materials flammability for exploration. The proposal is for a more sophisticated facility in a new Microgravity Wind Tunnel (MWT). The Advanced Exploration Systems (AES) Division is working on fire safety as well. Fluid physics is classical study area. The Space Technology Mission Directorate (STMD) is also working in this area.

A graphic of the program over the next 5 years showed the ISS crew time partnerships. These are essential to getting the work done. The program is also having dialogues with the Russians. Collaborations leverage funding.

The effort to move data into open science will take several years, though showing the number of scientists using it could help accelerate funding. The international partners are interested, but that is mostly ESA. The NIST relationship is promising, and the workshops have helped the program become more oriented to translational work.

Space Biology

Dr. Tomko explained that the Space Biology Program has closely adhered to the DS recommendations. Every space biology research task must comply with the President's executive order for open data, which is enabled through NASA's GeneLab project. Spaceflight alone enables centrifugal research, which has been recommended but not sufficiently supported through access to ISS and crew time. Nor has the program been able to establish the recommended ground-based programs. NASA is trying to enlarge the research community through outreach.

Of the Space Biology Research Plan for 2016 to 2025, the three clearest recommendations are from the plant and microbial biology area. There are 11 recommendations in the animal and human biology area, which is more complex, and three recommendations in the cross-cutting issues area. Since 2010, the Space Biology Program has had a number of major accomplishments, including competitively solicited research; conduct cutting-edge research on ISS; developing cutting-edge technologies to improve the conduct of biological research in space; issuing NRAs to re-engage the U.S. space biology community; and collaboration with international partners and other agencies. The rodent experiments have been an important source of science contributions.

The program has been successful in reaching new investigators, as 70 percent of the proposers to the last two NRAs were new to space biology; 64 percent of those who were new passed, and 66 percent of those who were new and passed were funded. The program has done all of the high-priority work from the 2010 plan. There are now 92 funded space biology research projects across seven areas. Dr. Tomko reviewed the objectives for each of the seven areas, along with the expected outcomes and examples:

- Microbiology – to determine the effect of spaceflight on microbial life, processes, and community dynamics, with the example of high dimensional geology to understand the functional response of Salmonella to long-term multigenerational growth in the chronic stress of microgravity ;
- Cell and molecular biology – to determine how the space environment affects life at the cellular and molecular levels, the example being a study of the impact of real microgravity on the proliferation of human neural stem cells and derived-oligodendrocytes;
- Plant biology – to understand plant and microbial growth in spaceflight environments and physiological responses to those environments, shown by the epigenetic change in Arabidopsis in response to spaceflight differential cytosine DNA methylation of plants on ISS;
- Animal biology: vertebrate – to understand the basic mechanisms that vertebrates use to adapt to spaceflight, circadian rhythm study and gastrointestinal microbiota in mice as the example;
- Animal biology: invertebrate – to understand the basic mechanisms that invertebrate animals use to adapt to spaceflight, with the example of using waterbears to identify biological countermeasures to stress during multigenerational spaceflight;
- Developmental, reproductive, and evolutionary biology – to determine how spaceflight affects these processes, and to study transmission across generations of structural and functional changes induced by exposure to space during development; an example looks at the evolution of bacteria in space over subsequent generations; and
- Cross-cutting: systems biology omics and GeneLab – to gather spaceflight genomic data, RNA, and protein expression; develop necessary systems for analysis and modeling; enable discovery of molecular networks influenced by space conditions; and engage the community and general public. An example is an integrated omics-guided approach.

NASA's vision for space biology is to expand the scientific knowledge base for space application and for the improvement of life on Earth. Goals involve competitively solicited research that builds on prior investigations. The program will issue regular NRAs and seek collaborations, relying on the DS recommendations in selecting research that will provide the best results. Investigations will span the range of platforms. Open access science is an important element in achieving NASA's space biology objectives.

Dr. Tomko closed by noting that the program is increasing partnerships in order to facilitate productivity, and hopes to generate the data needed by the external community and to partner with CASIS for commercial productivity. It is important to develop the next generation of space biologists as well.

Human Research

Dr. William Paloski, Manager of HRP, described the program's current status. HRP has a Program Commitment Agreement with NASA and can count on a basic budget from year to year. For the Agency's Mars exploration effort, HRP is focused on getting people safely to Mars. The HRP mission is to enable space exploration beyond low-Earth orbit (LEO) by reducing risk to human health and performance. This is very much an applied research program, with some fundamental work where gaps are identified. It is essentially risk reduction.

HRP is within the SLPS Division and also interacts with the Office of the Chief Health and Medical Officer (OCHMO) within NASA, as well as the independent National Space Biomedical Research Institute (NSBRI). There have been a lot of personnel changes within the program recently.

While HRP work is distributed across the NASA centers, by far the largest portion is at Johnson Space Center (JSC). Collaboration has increased within the Agency, as well as with CASIS and international partners. A new Multilateral Human Research Panel for Exploration (MHRPE) will put together sharing agreements among the various countries. NSRBI has about $20 million of annual funding. In 2017, the cooperative agreement with NSRBI will end and the work must be competed. NASA will seek a forward-looking organization that considers risky, game-changing investments.

HRP releases annual research announcements and Human Exploration Research Opportunity (HERO) appendices. About 75 percent of the research portfolio is solicited and the rest is directed. That varies by area, however. Key deliverables fall into eight areas. The publication metrics gauge what HRP has gained in knowledge from the work funded. Space radiation accounts for about half of the publications.

The Program relies on a human research roadmap. Evidence leads to understanding of risk to crew members, identification of knowledge gaps that go out as research solicitations, tasks and proposals, and deliverables. HRP has been very careful to have continuous feedback and review. The recently reconstituted Human System Risk Board (HSRB) meets weekly and reviews the current risks.

Because there are so many missions, it is necessary to define them. Dr. Paloski used the example of the evolvable Mars campaign, in which the Program developed design reference mission (DRM) categories and identified four areas of concern. A continuous loop process leads to acceptance or more research. The five primary stressors to human space explorers align with HRP elements, though behavioral health and performance cuts across all of them.

Dr. Paloski showed the HSRB risk assessment rubric, based on the three-color stoplight chart, and gave the example of mission health and performance, which had elements in all three colors. HRP also relies on an integrated path to risk reduction. Among the risks, radiation exposure is expected to take the most time to solve. Space weather knowledge and shielding are good enough to counter acute radiation exposure, but the rest is problematic. The team is looking at raising the accepted risk level if the crew is informed. Behavioral conditions also constitute a long-term issue. Technologies are improving for in-flight medical capabilities, but food and nutrition issues linger. Human system interaction design is another issue. The delayed communications require a lot of work. And there needs to be layout in the habitable volume considerations. Regarding the inter-cranial hypertension vision problems that create visual impairment, HRP is working on that and expects to have an answer.

Dr. Paloski showed some of the ISS metrics and projects, including the 1-year mission and the twin study. The global community is very interested in doing exploration, including the Russians, with whom NASA has a project to examine crew members in a medical tent upon landing.

HRP has proposed at least five additional 1-year missions using at least 10 crew members. The twins study was a target of opportunity that brought in some of the best proposals ever. Selected proposals address such topics as immune changes in space, cognition, genome analysis, markers of atherosclerosis, and more. HRP is also down-selecting to three advanced exercise concepts to replace the large device currently in use on the ISS.

Spaceflight analogs include altered gravity analogs, such as what can be done at a new facility in Cologne. HRP is also looking at Isolated, Confined, Extreme (ICE) analogs, working with NSF to use Antarctic facilities for isolation studies. The NASA Space Radiation Lab at Brookhaven National Laboratory (BNL) simulates space radiation. In addition, NASA is evaluating other U.S. facilities that could be used. Three international working groups have supported efforts that include an international artificial gravity workshop.

Discussion
Dr. Paloski explained that an example of a retired biomedical risk is electrical shock, which NASA has come to prevent via engineering. For radiation, the Agency can set standards for shielding thickness and materials, though thickness is counterproductive and even harmful at a certain point.

Dr. Sture asked about gender response to radiation, bone loss, and other issues. Dr. Paloski said that there have not been enough women in space to evaluate this well, but there have been some evident sex differences. Vision impairment and intracranial pressure (VIIP) affects women far less, for example, but it was unclear whether this is due to anatomical factors, exercise, or something else. Dr. Bette Siegel of NASA said that she led a study on the differences. While the number of women on long-duration flights is small, the investigation did not see a significant difference in bone loss and muscle atrophy. VIIP was much more common in men.

Discussion

Dr. Longnecker praised the presenters and told them that the RS could provide input if needed. Dr. Sture added that it was gratifying to see that top researchers are engaged in NASA physical science research. The standards of having peer-review, merit-based research with talented people ensures that the best are engaged. That is really important.

Dr. Longnecker agreed and asked if the life/biological sciences people felt the same. Dr. Pawelczyk replied that the sharing of resources and opportunities with CASIS is of concern, because governments and scientists are in this for the long haul, and the commercial side is not. Dr. Longnecker said that it is indeed difficult to get basic life sciences work done on ISS. Dr. Paloski said that HRP has enjoyed a high priority, but CASIS gets 50 percent of the resources on ISS. NASA interprets that as including crew time, which has left the other areas scrambling. The expectation is that the increase in the ISS crew to seven, expected when NASA's commercial crew capability comes on line, will help mitigate the crew time issue, but that is 2 or 3 years off.

Dr. Porterfield confirmed that the 50 percent includes crew time. This has required SLPS to replan rodent research and collaborate with CASIS to plan joint projects. Dr. Pawelczyk said that it is hard to say that NASA is doing translational research without having mammalian research.

Dr. Tomko explained that difficulties with fouled food and water dispensers in the ISS rodent environment caused issues, and NASA no longer has the "glove box" that it once used for rodents. Dr. Otero noted that a portable glove box should be available in 2017. Dr. Porterfield added that obtaining this device is taking a long time. Single or limited hypothesis experiments can drive up the cost. Dr. Otero described the difficulty in sharing mice with CASIS. As long as the priorities stay where they are, SLPS will not have the needed time.

Dr. Tomko said that if NASA were to constrain the science, the Agency would cheat itself and the government. It is not possible to do some things, like fly giraffes for example, but HRP has a lot of team experiments with mice. Dr. Otero added that the community provides ideas that lead NASA to push for them. Dr. Pawelczyk said that there seems to be some commercial potential that would warrant more collaboration with CASIS, freeing up time for other areas. Dr. Longnecker agreed that the more commercial approaches should be aligned with CASIS.

Regarding basic biological science, Dr. Paloski said that there is a working group that is discussing it with the goal of a joint solicitation. VIIP is a high priority. Dr. Tomko added that the Japanese are sending up male mice with a centrifuge, based on ground studies that look promising. Dr. Longnecker observed that there are great examples of moving between a human issue and an animal model, resulting in a strong solution. He gave the example of an anesthesia issue that was solved abruptly once the right animal model was discovered. So there is potential value in trying to work back and forth in these processes.

Public Comment

Dr. Longnecker opened the meeting to public comment. Mr. Robert Zimmerman (affiliation missing) spoke, explaining that he put together the NASA technology transfer program for biomed back in the 1970s. NASA does not really have a recruiting program for new scientists, so he was glad to see the new efforts in that area. He also asked if he could obtain additional information from the presentations in order to help leverage technology transfer. Dr. Carpenter suggested he contact Dr. Tomko.

Committee Deliberation

Dr. Longnecker asked about the likely audience for the integrated research program document that was sent to the RS members. Dr. Porterfield said that it is for the investigator pool, as well as for internal and government stakeholders. The outside research community is reviewing it and has helped create it. This, with the DS, should describe SLPS efforts and goals. Dr. Carpenter added that if the Office of Science and Technology Policy (OSTP) has to develop a strategic plan for research, they would ask for this plan.

Regarding a potential need for an informatics plan in the NRAs, Dr. Porterfield said that Federal guidelines require a data-sharing plan from NASA PIs, so the GeneLab will provide the informatics tools they will need. Dr. Tomko explained that a data management plan is now an NRA requirement.

Dr. Paloski noted that he is concerned with the integration of risks and stove-piping, and possible interactions among risks. A single hazard can affect multiple risks. Dr. Tomko shared the concern that there could be cascading borderline risks. There have been microbes with altered virulence, for example. This is an issue, especially when they come in contact with astronauts with impaired immune systems. Dr. Pawelczyk said that what disturbs him is that half of the research time might not be focused on these pressing problems. There is nothing compelling CASIS to address this. Dr. Carpenter explained that the CASIS objective is not to help NASA mitigate risk, it is to develop a broad base of users.

Dr. Longnecker asked Dr. Siegel if HEOC is aware of these limitations. She replied that HEOC hears that things are fine though there are issues. It would be helpful to provide the NAC with information about the quality of the research.

Adjourn

The meeting was adjourned at 3:57 p.m.

Appendix A
MEETING ATTENDEES

Committee Members
Present
Chair: Dr. David Longnecker
Dr. M. Katherine Banks*
Dr. James Pawelczyk
Dr. Stein Sture
Dr. Kathryn Thornton
Executive Secretary: Dr. Bradley Carpenter
**participated via teleconference*

NASA Attendees
Francis Chiaramonte
Steven Davison
Mark Lee
Angel Otero
William Paloski
Marshall Porterfield
Bette Siegel
David Tomko

Appendix B

Research Subcommittee Members

Dr. David E. Longnecker, C*hair*
Association of American Medical Colleges (AAMC) and member of the National Academy of Sciences Institute of Medicine (IOM)

Dr. Bradley Carpenter, *Executive Secretary*
NASA

Dr. Robert A. Altenkirch
The University of Alabama in Huntsville

Dr. M. Katherine Banks
Texas A&M University

Dr. Jeffrey A. Hoffman
Massachusetts Institute of Technology

Dr. James A. Pawelczyk
Pennsylvania State University

Dr. Stein Sture
University of Colorado at Boulder

Dr. Kathryn Thornton
University of Virginia

Appendix C
Presentations

1. *Fundamental Physics Presentation*, Mark Lee
2. *Physical Sciences Presentation,* Francis Chiaramonte
3. *Space Biology Research Plan,* David Tomko
4. *Human Research Program Status Update*, William Paloski

Appendix D

Agenda

NASA ADVISORY COUNCIL
RESEARCH SUBCOMMITTEE MEETING
NASA Headquarters
Room 6H41A
Washington, DC 20546
Monday, July 20, 2015

Committee Public Meeting

9:00 a.m.	Opening	Dr. Longnecker, Dr. Carpenter
9:10 a.m.	NASA Status	Dr. Porterfield
9:45 a.m.	SLPS Research Plans	Dr. Porterfield
9:50 a.m.	Physical Sciences	Dr. Lee, Dr. Chiaramonte
11:00 a.m.	Space Biology	Dr. Tomko
12:00 noon	Lunch	
1:00 p.m.	Human Research	Dr. Paloski
2:30 p.m.	Discussion	
3:30 p.m.	Public Comment	
3:45 p.m.	Committee Deliberation	
4:15 p.m.	Adjourn	