
2013 Advanced Environmental Health/Advanced Food Technology Standing Review Panel

Research Plan Review for:

*The Risk of Adverse Health Effects Due to Alterations in Host-Microorganism Interactions and
The Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System*

Status Review for:

*The Risk of Adverse Health Effects of Exposure to Dust and Volatiles During Exploration of
Celestial Bodies*

Final Report

I. Executive Summary and Overall Evaluation

The 2013 Advanced Environmental Health/Advanced Food Technology (AEH/AFT) Standing Review Panel (from here on referred to as the SRP) participated in a WebEx/teleconference with members of the Space Human Factors and Habitability (SHFH) Element, representatives from the Human Research Program (HRP), and NASA Headquarters on November 22, 2013 (list of participants is in Section IX of this report). The SRP reviewed the updated research plans for the Risk of Adverse Health Effects Due to Alterations in Host-Microorganism Interactions (Host Microbe Risk) and the Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System (Food Risk). The SRP also received a status update on the Risk of Adverse Health Effects of Exposure to Dust and Volatiles during Exploration of Celestial Bodies (Dust Risk).

Overall, the SRP was impressed with the strong research plans presented by the scientists and staff associated with the SHFH Element. The SRP also thought that the updated research plans were thorough, well organized, and presented in a comprehensive manner. The SRP agrees with the changes made to the Host Microbe Risk and Food Risk portfolios and thinks that the targets for Gap closure are appropriate.

II. Critique of Gaps and Tasks for the Risk of Adverse Health Effects Due to Alterations in Host-Microorganism Interactions

- 1. Have the proper Gaps been identified to address the Risk?*
 - a. Are all the Gaps relevant?*
 - b. Are any Gaps missing?*
- 2. Have the appropriate targets for closure for the Gaps been identified?*
 - a. Are the interim stages appropriate to close the Gaps?*
- 3. Have the proper Tasks been identified to fill the Gaps?*
 - a. Are the Tasks relevant?*
 - b. Are any Tasks missing?*
- 4. If a Gap has been closed, does the Rationale for Gap Closure provide the appropriate evidence to support the closure?*

Gaps and Tasks:

AEH 10: We need to determine the efficacy of current countermeasures and the need for

countermeasure development based on changes in microbial populations and characteristics.

- The SRP thinks this Gap is relevant and appropriate.

Tasks:

- Development of Spaceflight Foods with High Microbial Concentrations – Completed Task
- SWAB E-049 A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft Environment – Completed Task
- Efficacy of Antimicrobials on Bacteria Cultured in a Spaceflight Analog – PI: Mark Ott, Ph.D. – NASA Johnson Space Center
- Delivery of Probiotics in the Space Food System – PI: Grace Douglas, Ph.D. – NASA Johnson Space Center

AEH 12: We need to determine if spaceflight induces changes in diversity, concentration, and/or characteristics of medically significant microorganisms associated with the crew and environment aboard the International Space Station that could affect crew health.

- The SRP is pleased to see some microbiome work is being done, but still encourages more work in this area be done. These studies would enable a better estimation of the degree of microbiological risk to the astronauts.
- **Suggested new task:** Some of the SRP members suggest a new radiation study on non-human primates looking at the effects of microgravity on microorganisms.
 - A well-designed Earth based study is needed to look at effects of radiation on flora and microbiome.

Tasks:

- Human Health Countermeasures (HHC), NASA Flight Experiment Research Contributing to Microbial Risk Modeling – Completed Task
- Development of Spaceflight Foods with High Microbial Concentrations – Completed Task
- Study of the impact of long-term space travel on the astronaut's microbiome – PI: Herman Lorenzi, Ph.D. – J Craig Venter Institute, Inc.
- SWAB E-049 A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft Environment – Completed Task
- Free Water Events on Mir and ISS – PI: Mark Ott, Ph.D. – NASA Johnson Space Center
- Data Mining – Completed Task

AEH 13: We need to determine which medically significant microorganisms display changes in the dose-response profiles in response to the spaceflight environment that could affect crew health.

- The SRP thinks this Gap is relevant and appropriate.

Tasks:

- Evaluating the Spaceflight Infectious Disease Risk Potential of Pathogenic and Commensal microorganisms using *Caenorhabditis elegans* as a Human Surrogate Model for Infection – PI: Jennifer Barrila, Ph.D. – Arizona State University

AEH 14: We need to determine how physical stimuli specific to the spaceflight environment, such as microgravity, induce unique changes in the dose-response profiles of expected medically significant microorganisms.

- The SRP thinks this Gap is relevant and appropriate.

Tasks:

- Microbial Characteristic Workshop – Completed Task
- Evaluation of Host-Pathogen Interactions During Exposure to Microgravity Analogues – Arizona State University Grant – Completed Task
- Validation of Procedures for Monitoring Crewmember Immune Function (Integrated Immune - SMO 015/SDBI 1900) – PI: Clarence Sams, Ph.D. – NASA Johnson Space Center
- Host-Microbe Virulence – Cellular Studies – Planned Task
- Host-Microbe Virulence – Microbial Mutation – Planned Task

AEH 15: Current microbial standards identifying microbial risk limits need to be updated and microbial requirements need to be developed to include new technologies and future mission scenarios.

- The SRP thinks this Gap is relevant and appropriate.

Tasks:

- Next Generation Microbiology Requirements – PI: Duane Pierson, Ph.D. – NASA Johnson Space Center
- Free Water Events on Mir and ISS – PI: Mark Ott, Ph.D. – NASA Johnson Space Center

III. Critique of Gaps and Tasks for the Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System

1. Have the proper Gaps been identified to address the Risk?

- a. Are all the Gaps relevant?*
- b. Are any Gaps missing?*

2. Have the appropriate targets for closure for the Gaps been identified?

- a. Are the interim stages appropriate to close the Gaps?*

3. Have the proper Tasks been identified to fill the Gaps?

- a. Are the Tasks relevant?*
- b. Are any Tasks missing?*

4. If a Gap has been closed, does the Rationale for Gap Closure provide the appropriate evidence to support the closure

Gaps and Tasks:

AFT1: We need to determine how processing and storage affect the nutritional content of the food system. (Previous Title: How can the food system deliver the required level of nutrition throughout the mission?)

- The SRP thinks this Gap is relevant and appropriate.

Tasks:

- Effects of Processing and Subsequent Storage on Nutrition – PI: Maya Cooper, Ph.D. – NASA Johnson Space Center
 - The SRP was wondering how Vitamin D, Vitamin K, Calcium, and Potassium were deficient in the ISS menu right after processing. Were these deficient in the formulations (no fortification or not present in foods tested) or were they removed during processing?
 - Minerals should be fairly stable to processing unless they are lost in cook water, washing, etc.
- Stability of Pharmacotherapeutics and Nutrition Compounds - Nutrition – Completed Task
- Understanding Kinetics of Nutrient Degradation in Foods – Planned Task
 - The SRP thinks this task should also look at Vitamin C, since it is unstable and is a key micronutrient that will decrease over time.
- Understanding Kinetics of Nutrient Degradation in Foods-2 – Planned Task
- Technical Integration of Gap1 Activities – Planned Task
- Literature review of factors affecting food and nutrient stability – PI: Maya Cooper, Ph.D. – NASA Johnson Space Center
 - The SRP thinks that there may be some information from United States Army Natick R&D Command (NATICK) for retort pouches or freeze dried foods that have not been published and if it is possible to obtain some of this in addition to published research, it might be beneficial.
- Bioavailability of Nutrients in Food – PI: Monica Leong – NASA Johnson Space Center
 - The SRP again recommends contacting NATICK to see if they have some information on this topic from some of their past research.
- Effect of Space Radiation on the Nutrition and Quality of the Food – Completed Task

AFT3: We need to determine how the sensory and psychosocial acceptability of the food system changes due to microgravity, processing, storage, choice, and eating environment. (Previous title: How can the acceptability of the food system be maintained throughout the mission?)

- The SRP thinks this Gap is relevant and appropriate.

Tasks:

- Effects of Retronasal Smelling, Variety, and Choice on Appetite and Satiety – PI: Jean Hunter, Ph.D. – Cornell University
- Factors Contributing to Food Acceptability and Consumption, Mood, and Stress on Long-term Space Missions – PI: Zata Vickers, Ph.D. – University of Minnesota
 - The SRP thinks that there are other methods than surveys that would be excellent ways to assess the research questions. These include Qualitative Multivariate Analysis (QMA) techniques. There are multiple ways to get information that are appropriate for a smaller number of participants. (Product Innovation Toolbox, Beckley, Paredes, Lopetcharat. 2012. *A Field Guide to Consumer Understanding and Research*, Iowa: John Wiley & Sons, Inc.)
- Validation of Sensory Metrics during Exploration Missions – Planned Task
- Integrated Bioregen Acceptability – Planned Task

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- Contribution of factors affecting food acceptability and satiety in spaceflight – Planned Task

AFT4: We need to identify the methods, technologies, and requirements that will deliver a food system that provides adequate safety, nutrition, and acceptability for proposed long-duration Design Reference Mission operations. (Previous title: What technologies can be developed that will efficiently balance appropriate vehicle resources such as mass, volume, and crew time during exploration missions with the safety, nutrition, and acceptability requirements?)

- The SRP thinks this Gap is relevant and appropriate.
- The SRP thinks that the AFT group should try to identify food companies that may already be making and selling nutrient-dense food items for convenient consumption (such as sports bars).
- The SRP recommends looked into the line of adult nutritionals in the form of shelf-stable "milk shake" type beverages that are made and sold by Abbott Nutritionals in Columbus, OH (formerly, Ross Laboratories).

Tasks:

- A Multipurpose Fruit and Vegetable Processing System for Advanced Life Support – Completed Task
- Advanced Cookware and Techniques for Food Preparation at Reduced Pressure and Gravity – PI: Susana Carranza, Ph.D. – Makel Engineering, Inc.
- Bulk Overwrap Packaging – Completed Task
- Comparative Packaging Study – Completed Task
- Development of a Bioregenerative Food System – Planned Task
- Development of a Multipurpose Extruder/Press Food Processing System – Completed Task
- Development of Spaceflight Foods with High Microbial Concentrations – Completed Task
- Dual Use Packaging – Completed Task
- ElastiGlass Barrier Film and Food Processing Techniques for the 3 to 5 Year Shelf-Stable Food Package – Completed Task
- Flexible High-Barrier Polymers for Food Packaging – Completed Task
- Food Processing vs. Packaged Food System Trade Study – Completed Task
- Packaged Food Mass Reduction Technology Development – PI: Monica Leong – NASA Johnson Space Center
- Packaged Food Mass Reduction Trade Study – Completed Task
- Reheating and Sterilization Technology for Food, Waste and Water – Completed Task
- Total System Approach – Completed Task
- Vegetable Testing – Planned Task
- Non-Thermal Sanitation By Atmospheric Pressure Plasma – PI: Ross Remiker – Orbital Technologies Corporation
- Non-Thermal Sanitation By Atmospheric Pressure Plasma Phase 3 – Planned Task
- Advanced Cookware and Techniques for Food Preparation at Reduced Pressure and Gravity Phase 3 – Planned Task

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- Thermostabilized Food Study – Completed Task
 - Department of Defense (DoD) Collaboration – PI: Grace Douglas, Ph.D. – NASA Johnson Space Center
 - The SRP thinks that this is an excellent collaboration because the DoD has so much expertise that can be shared.
 - Integration of Product, Package, Process, and Environment: A Food System Optimization – PI: Maya Cooper, Ph.D. – NASA Johnson Space Center
 - The SRP thinks that there are other non-thermal processing technologies that the PI may want to consider, including x-ray.
 - Frozen fruit has high quality if done rapidly, in a commercial operation. Refrigeration can accelerate starch retrogradation and might be more of a problem with shelf life for some foods.
 - Stabilized Foods for Use in Extended Spaceflight: Preservation of Shelf-Life, Nutrient Content and Acceptability – PI: Ann Barrett, Ph.D. – U.S. Department of the Army
 - Food Fortification Stability Study – PI: Monica Leong – NASA Johnson Space Center
 - Functional Foods Baseline and Requirements Analysis – PI: Maya Cooper, Ph.D. – NASA Johnson Space Center
 - Packaging Technology Watch – PI: John Glass – NASA Johnson Space Center
 - Prepackaged Resources – PI: Maya Cooper, Ph.D. – NASA Johnson Space Center
 - Bulk Packaging – Planned Task
 - Bioregen Repts Develop – Planned Task
 - Food System Database – Planned Task
 - Delivery of Probiotics in the Space Food System PI: Grace Douglas, Ph.D. – NASA Johnson Space Center
 - Effect of Space Radiation on the Nutrition and Quality of the Food – Completed Task
 - Suited Contingency Ops Food – PI: Patricia Catauro – NASA Johnson Space Center
 - Suited Contingency Ops Food-2 – PI: John Glass – NASA Johnson Space Center

AFT5: We need to identify tools or methods that can be used or developed to help mission planners and vehicle developers determine the most effective combination of methods, technologies, and requirements to balance crew food system needs with vehicle resources.

- The SRP thinks this Gap is relevant and appropriate.
- The SRP agrees with the need to shift the focus on extending shelf-life of foods to the use of the natural refrigeration in space and think the research being conducted and considered by the AFT Portfolio is keeping this option in mind as they continue their shelf-life investigations. At some point, the SRP does think that more careful consideration of how the natural refrigeration of space (very low temperatures) can be used during long-duration space travel of many months or years.

Tasks:

- Trade Space Lit Review – Planned Task
- Trade Space Develop – Planned Task
- Trade Methodology Recommendations – Planned Task

IV. Discussion on the strengths and weaknesses of the IRP and identify remedies for the weaknesses, including answering these questions:

Is the Risk addressed in a comprehensive manner?

- The SRP thinks that the Risk is addressed in a comprehensive manner.

Are there obvious areas of potential integration across disciplines that are not addressed?

- The SRP still recommends that the Host Microbe group should interact more with the immune and radiation disciplines in the HRP. If these interactions are there, they are still not obvious to the SRP.

V. Evaluation of the progress in the IRP since the 2012 SRP meeting.

- The SRP is very pleased with the progress made to both the Host Microbe and Food Risks since the 2012 SRP meeting. There is very good progress in the research plans and the issues identified in 2012 were addressed.

VI. Additional Comments regarding the Risk of Adverse Health Effects of Exposure to Dust and Volatiles during Exploration of Celestial Bodies Status Review

Although little data were presented on the Dust Risk, the SRP was pleased with the progress on testing the lower doses of lunar dust in their risk assessment. The presentation stated that the data is currently being evaluated and the SRP would like to have been given access to the recently published data to evaluate the results.

VII. 2013 AEH/AFT SRP Research Plan Review (WebEx/Telecon): Statement of Task for the Risk of Adverse Health Effects Due to Alterations in Host-Microorganism Interactions and the Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System

The 2013 Advanced Environmental Health/Advanced Food Technology (AEH/AFT) Standing Review Panel (SRP) is chartered by the Human Research Program (HRP) Chief Scientist. The purpose of the SRP is to review the Space Human Factors and Habitability (SHFH) Element's section of the current version of the HRP's Integrated Research Plan which is located on the Human Research Roadmap (HRR) website (<http://humanresearchroadmap.nasa.gov/>). Your report will be provided to the HRP Chief Scientist and will also be made available on the HRR website.

The 2013 AEH/AFT SRP is charged (to the fullest extent practicable) to:

1. Based on the information provided in the current version of the HRP's IRP, evaluate the ability of the IRP to satisfactorily address the Risk by answering the following questions:
 - A. Have the proper Gaps been identified to address the Risk?
 - i) Are all the Gaps relevant?
 - ii) Are any Gaps missing?
 - B. Have the appropriate targets for closure for the Gaps been identified?
 - i) Are the interim stages appropriate to close the Gaps?
 - C. Have the proper Tasks been identified to fill the Gaps?
 - i) Are the Tasks relevant?
 - ii) Are any Tasks missing?
 - D. If a Gap has been closed, does the Rationale for Gap Closure provide the appropriate evidence to support the closure?
2. Identify the strengths and weaknesses of the IRP, *and* identify remedies for the weaknesses, including answering these questions:
 - A. Is the Risk addressed in a comprehensive manner?
 - B. Are there obvious areas of potential integration across HRP disciplines that are not addressed?
3. Please evaluate the progress in the IRP since your 2012 SRP meeting.
4. Please comment on any important issues that are not covered in #1, #2, or #3 above. If addendum questions are provided in section X below, please address each of the questions as fully as possible.

Additional Information Regarding This Review:

1. Expect to receive review materials at least four weeks prior to the WebEx conference call.
2. Participate in a WebEx conference call on November 22, 2013 from 3:00 pm – 6:00 pm ET.
 - A. Discuss the 2013 AEH/AFT SRP Statement of Task and address questions about the SRP process.
 - B. Receive presentations from the SHFH Element and participate in a question and answer session.
3. Prepare a draft final report (within one month of the WebEx/teleconference) that contains a detailed evaluation of the current IRP specifically addressing items #1, #2, #3, and #4 of the SRP charge. The draft final report will be sent to the HRP Chief Scientist and he will forward it to the appropriate Element for their review. The SHFH Element and the HRP Chief Scientist will have 2 business days to review the draft final report and identify any misunderstandings or errors of fact and then provide official feedback to the SRP. If any misunderstandings or errors of fact are identified, the SRP will have 10 business days to address them and finalize the 2013 SRP Final Report. The 2013 SRP Final Report will be submitted to the HRP Chief Scientist and copies will be provided to the SHFH Element that sponsors the AEH and AFT Portfolios and also made available to the other HRP Elements. The 2013 SRP Final Report will be made available on the HRR website (<http://humanresearchroadmap.nasa.gov/>).

VIII. 2013 AEH/AFT SRP Status Review (WebEx/Telecon): Statement of Task for the Risk of Adverse Health Effects of Exposure to Dust and Volatiles during Exploration of Celestial Bodies

The 2013 Advanced Environmental Health/Advanced Food Technology (AEH/AFT) Standing Review Panel (SRP) will participate in a Status Review that will occur via a WebEx/teleconference with the Human Research Program (HRP) Chief Scientist, Deputy Chief Scientist and members of the Space Human Factors and Habitability (SHFH) Element. The purpose of this review is for the SRP to:

1. Receive an update by the HRP Chief Scientist or Deputy Chief Scientist on the status of NASA's current and future exploration plans and the impact these will have on the HRP.
2. Receive an update on any changes within the HRP since the 2012 SRP meeting.
3. Receive an update by the Element or Project Scientist(s) on progress since the 2012 SRP meeting.
4. Participate in a discussion with the HRP Chief Scientist, Deputy Chief Scientist, and the Element regarding possible topics to be addressed at the next SRP meeting

The 2013 AEH/AFT SRP will produce a report/comments from this status review within 30 days of the 2013 update. These comments will be submitted to the HRP Chief Scientist and copies will be provided to the SHFH Element that sponsors the AEH Project and also made available to the other HRP Elements. The 2013 SRP Final Report will be made available on the Human Research Roadmap public website (<http://humanresearchroadmap.nasa.gov/>).

IX. AEH/AFT SRP Research Plan Review WebEx/Teleconference Participants

SRP Members:

Howard Kipen, M.D., M.P.H. (chair) –Rutgers – Robert Wood Johnson Medical School
Harriet Burge, Ph.D. – EMLab P&K
Dennis Heldman, Ph.D. – The Ohio State University
Jeffrey Laskin, Ph.D. – Rutgers – Robert Wood Johnson Medical School
C. Glen Mayhall, M.D. – University of Texas Medical Branch, Galveston
James Pestka, Ph.D. – Michigan State University
Anna Shvedova, Ph.D. – National Institute of Occupational Safety and Health
Art Teixeira, Ph.D. – University of Florida

NASA Johnson Space Center (JSC):

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Jennifer Rochlis Zumbado, Ph.D.
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Susan Steinberg, Ph.D.
Lisa Stephenson
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Jessica Vos

NASA Headquarters (HQ):

Bruce Hather, Ph.D.
Steve Davison, Ph.D.

NASA Research and Education Support Services (NRESS):

Tiffin Ross-Shepard

X. 2013 AEH/AFT Standing Review Panel Roster

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