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# 2015 Advanced Environmental Health/Advanced Food Technology Standing Review Panel

Research Plan Review for:

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

## Final Report

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### I. Executive Summary and Overall Evaluation

The 2015 Advanced Environmental Health/Advanced Food Technology (AEH/AFT) Standing Review Panel (from here on referred to as the SRP) met for a site visit in Houston, TX on December 14 – 15, 2015. The SRP met with representatives from the Space Human Factors and Habitability (SHFH) Element and members of the Human Research Program (HRP) to review the updated research plans for the Risk of Adverse Health Effects Due to Host-Microorganism Interactions (MicroHost Risk) and the Risk of Performance Decrement and Crew Illness due to an Inadequate Food System (Food Risk). During the meeting, the SRP also met with the vehicle engineers to discuss possible food storage options.

The SRP would like to commend Dr. Oubre and Dr. Douglas for their detailed presentations, as well the frank, refreshing, and comprehensive engineering presentation. This gave much needed perspective to the food storage issues and reassured the committee about NASA's approach to the problem. In terms of critiques, the SRP remains unconvinced about the rationale for probiotic use other than for specific applications supported by the literature. It is not clear what gap or problem is being addressed by the use of probiotics, and the rationale for their use needs to be clearly rooted in the available literature. The SRP thinks that if low-Earth orbit is associated with immune system impairment, then there may additional risks linked with the use of probiotics. It is not clear to the SRP how NASA will determine if probiotics are having their intended beneficial effect. A similar concern is raised as to what gaps or problems are being addressed by "functional foods". Mixed infections, rather than single species infections, which can augment severity of disease, also represent a significant concern. Overall, the SRP considers this to be a strong program that is well-organized, well-coordinated and generates valuable data.

### II. Critique of Gaps and Tasks for the Risk of Adverse Health Effects Due to Host-Microorganism Interactions (MicroHost Risk)

- A. *Have the proper Gaps been identified to mitigate the Risk?*
    - a. *Are all the Gaps relevant?*
    - b. *Are any Gaps missing?*
  - B. *Have the gap targets for closure been stated in such a way that they are measureable and closeable?*
    - a. *Is the research strategy appropriate to close the Gaps?*
  - C. *Have the proper Tasks been identified to fill the Gaps?*
    - a. *Are the Tasks relevant?*
    - b. *Are there any additional research areas or approaches that should be considered?*
    - c. *If a Task is completed, please comment on whether the findings contribute to addressing or closing the Gap.*
  - D. *If a Gap has been closed, does the rationale for Gap closure provide the appropriate evidence to support the closure?*
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## **Gaps and Tasks:**

- The SRP finds that all of the Gaps are relevant.
- The SRP finds that the gap targets for closure are measurable and closeable.
- The Gaps appear to be heavy on measurements, and in the end, the meaning of these measurements may not be easily understood. The SRP encourages the MicroHost group to re-examine what matters and what can be measured, so that the group can interpret the data.
- The SRP finds that there is significant overlap between Gaps MICRO-02, MICRO-03, and MICRO-04.
- The SRP has identified the following missing Gaps:
  - There has been continued progress made in understanding that the virulence of some pathogens is increased under simulated microgravity environments and when studied in the International Space Station (ISS). Some of these findings were confirmed in a mouse model of infection. These data support the findings of other investigators and provide proof-of-concept in the context of the individual pathogen strains that have been studied. However, there is an emerging question as to whether and how these findings relate to the real-world setting where these pathogens encounter complex microbiota and other human ecological and environmental conditions. Thus the SRP suggests that a focus should be on conditions that more closely mimic the complex ecosystem conditions found in healthy humans, and on mixed infections and infections in the presence of complex microbiota (concept of polymicrobial infections). Studies have shown that there are both agonistic and antagonistic effects of microbes during infection, and their cross-talk dictate the outcome of an infection. This should be added to the research portfolio as a Gap.
  - The functionality of host immune cells in terms of modulating bacterial clearance is another area which represents a Gap.

### **MICRO-01: We need to determine the efficacy of current countermeasures and the need for countermeasure development based on changes in microbial populations and characteristics. (Formerly AEH 10)**

- The SRP finds that this Gap is relevant.
- The SRP finds that there is over-emphasis on probiotics and encourage the MicroHost team to conduct a balanced search of the literature in this area to justify the emphasis on probiotics.

### **Tasks:**

- Probiotics in Space Workshop – Planned Task
- Probiotic Development and Testing – Planned Task
- Probiotic Flight Validation – Planned Task
- Delivery of Probiotics in the Space Food System – Completed Task
- Microbial Control Methods – Planned Task
- Efficacy of Antimicrobials on Bacteria Cultured in a Spaceflight Analog – Completed Task
- SWAB E-049 A Comprehensive Characterization of Microorganisms and Allergens in

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Spacecraft Environment – Completed Task

- Development of Spaceflight Foods with High Microbial Concentrations – Completed Task
- Microbial Risk Assessment and Integration – Completed Task
- Effect of low shear modeled microgravity (LSMMG) on the probiotic *Lactobacillus acidophilus* ATCC 4356 – PI: Grace Douglas, Ph.D., NASA Johnson Space Center

**MICRO-02: 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. (Formerly AEH 12)**

- The SRP finds that this Gap is relevant.
- The SRP finds that it is important to know if immune function is related to time spent in microgravity, specifically with respect to long duration missions (longer than those spent on the ISS).
- It is important to measure host immune and other clinical and physiological parameters in a deliberate and standardized fashion, so that assessments of microbiota composition can be effectively interpreted. It is likely that changes will be discovered in microbiota composition of the crew during and/or after space missions; however, if there are insufficient clinical and physiological data, the relevance of these changes will be unclear.
- Be sure not to ignore radiation-induced changes in immune function due to mutations. It is not clear to the SRP that the radiation literature has been fully accessed.

Tasks:

- Quantitative Risk Assessment Study for Surface Risk – Completed Task
- HHC, NASA Flight Experiment Research Contributing to Microbial Risk Modeling – Completed Task
- Microbial Flora Changes and Impact to Crew Health in Space - Workshop – Planned Task
- Microbiome Ground Study – Planned Task
- Microbiome Flight Validation – Planned 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
- SWAB E-049 A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft Environment – Completed Task
- Free Water Events on Mir and ISS – Completed Task
- Data Mining – Completed Task
- Comprehensive Quantitative Risk Assessment Study for Surface Risk – Planned Task

**MICRO-03: 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. (Formerly AEH 13)**

- The SRP finds that this Gap is relevant.

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- The SRP recommends monitoring astronauts for carrier status of potential pathogens (e.g., Methicillin-resistant *Staphylococcus aureus* (MRSA), Methicillin Sensitive *Staphylococcus aureus* (MSSA), other staph, streptococci, *Neisseria meningitides*, candida, and herpesviruses, such as herpes simplex virus (HSV), cytomegalovirus (CMV), and Epstein-Barr virus (EBV)); and vaccinate as appropriate (zoster and pneumococcus).
  - It is crucial to optimize data collection during quarantine. Astronauts should have their microbiota characterized and monitored (nasopharynx, saliva, skin, stool, and vagina) prior to, and during quarantine. Similar microbiome measurements studies should be continued during spaceflight and after return so that comparative analysis could be performed.
  - In addition, microbial (microbiota-wide) and host gene expression should be assessed to determine how transcriptomes change during space exploration. Consideration should be given to the isolation in culture of reactivated herpesviruses and pathogens whose relative abundances increase significantly.
    - If possible, other non-coding small RNAs that modulate bacterial virulence should be studied in context of mixed infections.

Tasks:

- Evaluating the Spaceflight Infectious Disease Risk Potential of Pathogenic and Commensal microorganisms using *Caenorhabditis elegans* as a Human Surrogate Model for Infection – Completed Task
- Diversity of Microorganisms Impacted by Spaceflight Culture – Planned Task
- Flight Validation of Diversity of Microorganisms Impacted by Spaceflight Culture
- Alterations in Host Microbe Interactions Workshop – Planned Task
- The impact of modeled microgravity and prior radiation exposure on cytomegalovirus reactivation and host immune evasion – PI: Richard Simpson, Ph.D., NASA Johnson Space Center

**MICRO-04: 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. (Formerly AEH 14)**

- The SRP finds that this Gap is relevant.

Task:

- Microbial Characteristic Workshop – Completed Task
- Evaluation of Host-Pathogen Interactions During Exposure to Microgravity Analogues -- ASU Grant – Completed Task
- Validation of Procedures for Monitoring Crewmember Immune Function (Integrated Immune - SMO 015/SDBI 1900) – Completed Task
- High Dimensional Biology to Understand the Functional Response of *Salmonella* to Long-Term Multigenerational Growth in the Chronic Stress of Microgravity – PI: Cheryl Nickerson, Ph.D., Arizona State University
- Alterations in Host Microbe Interactions Workshop – Planned Task
- Flight Validation of Virulence Mechanisms – Planned Task

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- CM Testing to Mitigate Virulence Changes – Planned Task
  - Combined Effects of Microgravity Analogue Culture and Incremental Oxygen Levels on Bacterial Pathogen Adaptive Responses – PI: Cheryl Nickerson, Ph.D., Arizona State University
  - Host-Microbe Host-Microbe Virulence Mechanisms – Planned Task

**MICRO-05: 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. (Formerly AEH 15)**

- The SRP finds that this Gap is relevant.
- The SRP finds that if it is not already being done, ground-based astronauts should be monitored for disease. Future and planned research should be based on what is already known.
- The SRP suggests that airborne fungal population assessments should be addressed using spore trapping, as well as by culture. The SRP has recommended this previously. Hypersensitivity disease (especially hypersensitivity pneumonitis) does not depend on viability. If there is active growth of fungi within the spacecraft, then airborne spore concentrations could become very high and settling would not occur. Other risk factors for this disease are unknown.

Tasks:

- 2 x 2015 Molecular Microbial Monitoring Hardware Demonstrations – PI: TBD
- Next Generation Microbiology Requirements – Completed Task
- Next Generation Microbial Requirements I – Workshop – Planned Task
- Next Generation Microbial Requirements II - Workshop – Planned Task
- Free Water Events on Mir and ISS – Completed Task

**III. Critique of Gaps and Tasks for the Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System Risk of Inadequate Design of Human and Automation/Robotic Integration (Food Risk)**

- Have the proper Gaps been identified to mitigate the Risk?*
  - Are all the Gaps relevant?*
  - Are any Gaps missing?*
- Have the gap targets for closure been stated in such a way that they are measureable and closeable?*
  - Is the research strategy appropriate to close the Gaps?*
- Have the proper Tasks been identified to fill the Gaps?*
  - Are the Tasks relevant?*
  - Are there any additional research areas or approaches that should be considered?*
  - If a Task is completed, please comment on whether the findings contribute to addressing or closing the Gap.*
- If a Gap has been closed, does the rationale for Gap closure provide the appropriate evidence to support the closure?*

**Gaps and Tasks:**

- Overall, the SRP finds that the Gaps and tasks for this Risk are relevant and appropriate.

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**Food-01: We need to determine how processing and storage affect the nutritional content of the food system. (Previous Title: AFT1 - How can the food system deliver the required level of nutrition throughout the mission?)**

- The SRP finds that this Gap is relevant.
- The SRP compliments the Food researchers for progress on this Gap as indicated by the literature reviews, research completed, and overall progress.
- The outcomes have defined the time limitations in delivery of key nutrients needed to meet needs of the crew during long-term space travel. These challenges have been evaluated against the limits of mass and volume for space travel. The nutritional stability has been evaluated by considering product formulations, alternative processes, packaging, environmental exposure and the potential for food products grown in space.

Tasks:

- Bioavailability of Nutrients in Food – Completed Task
- Effects of Processing and Subsequent Storage on Nutrition – PI: Maya Cooper, NASA Johnson Space Center
- Literature review of factors affecting food and nutrient stability – Completed Task
- Nutrient kinetic and degradation integrated analysis of all Gap1 Activities – Planned Task
- Vitamins B1 and K Degradation in Spaceflight Foods: Establishment of Prediction Models and Prevention Strategies – PI: Hang Xiao, Ph.D., University of Massachusetts, Amherst
  - This task should provide important models for prediction of stability of these key nutrients in various food matrices associated with space foods. Potential for expansion of this approach is clear for planned task.
- Understanding Kinetics of Nutrient Degradation in Foods-2 – Planned Task
- Effect of Space Radiation on the Nutrition and Quality of the Food – Completed Task
- Stability of Pharmacotherapeutics and Nutrition Compounds – Nutrition – Completed Task
- Integrated Nutrition: Development and Provision of Functional Foods to Mitigate Bone Loss on ISS Missions – PI: Scott Smith, Ph.D., NASA Johnson Space Center

**Food-02: 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: AFT3 - How can the acceptability of the food system be maintained throughout the mission?)**

- The SRP finds that this Gap is relevant.
- Response to this Gap has been pursued by the funding of two external tasks. Although the research for one of the tasks has been completed (J. Hunter), it is important to acquire the results and the recommendations identified in this Gap. It will be difficult to move forward on this Gap without information from this report. The second task (Z. Vickers) has been delayed, and may be modified to provide information for this Gap. The highest quality, variety and acceptability of foods (appearance, texture, flavors) that compare to crew members' familiar foods should continue to be a goal of the research.
- The SRP encourages the food researchers to consider partnerships with research institutes in an effort to leverage research outcomes from the broader scientific community. In

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addition, these collaborations would provide opportunities for input on existing NASA Research Announcements (NRAs) with focus on areas of broad interest, including diet-microbiome and immunity in the context of designing foods with high acceptability. This approach could be cost effective and provide deeper levels of scientific inquiry. Most important, the approach would access researchers with expertise that might not respond to a NASA NRA.

Tasks:

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

**Food-03: 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: AFT4-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 finds that this Gap is relevant.
- The SRP recommends that the food researchers place a renewed emphasis on achieving the highest possible food quality and acceptability, after assuring that food safety goals have been met. This emphasis would be consistent with meeting the nutritional and acceptability needs for the long duration space travel.
- In order to pursue this direction, the SRP has proposed the following recommendations:
  - The development of a variety of foods beyond shelf-stable foods preserved by traditional retort processing. Alternative processes, such as microwave-assisted-thermal-sterilization (MATS) and pressure-assisted-thermal-sterilization (PATS) need to be pursued to demonstrate anticipated quality improvements.
  - Pasteurization or hot-fill of acid and acidified foods should be demonstrated as an alternative to retort processes. These products should require relatively mild pasteurization or hot-fill thermal processes, and quality advantages should be significant.
  - Packaging should not become a limitation to achievement of improvements in product quality. Alternative packaging materials are available to overcome the impacts of the process on packaging. Packaging materials with sufficiently low glass transition temperatures (TG's) will tolerate temperatures in space, and should be evaluated. Polymers including polyethylenes, nylons, and nano-polymers will retain flexibility and properties over a range of temperatures.
  - Packaging options for “master packs” should be considered and use secondary packaging with high barrier films. Then, the MATS process can be used with materials that are non-metalized for primary packaging.

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- Dehydrated products, such as beverages, dried soups and snacks, should be considered in an effort to provide a broader variety of foods. These types of products assist in reducing mass and volume, and are shelf-stable. Dry products can be bulk packaged and reconstituted and used by several crew members within a given day.
  - Fermentable foods, such as yogurt or smoothies made with yogurt and fruit, contribute to the diversity and variety of foods available to crew members, and could be taken aboard as dehydrated products. These products are an important contribution to the gap on acceptability and could be appropriate vehicles for probiotic and/or prebiotic strategies to promote optimal health of crew.
  - Current efforts with functional foods should continue to be aligned to provide broader impact on preventive health targets or promotion of health. Consideration should be given to formulating products with optimal levels of bioactive compounds when such a level can be defined by existing science. Current literature suggests opportunities to mitigate risk of cataracts, bone loss, neurocognitive and cardio-metabolic health.
  - Opportunities to leverage phytochemically-dense food materials should be pursued and can be expanded to include tea and coffees for polyphenolics. Snacks such as fruit leathers are lightweight and may contain phytochemically-dense materials, and provide a variety of textures. (Note that the opportunity to leverage unique fruits such as “autumn olive berries” make excellent fruit leathers with high lycopene content).
  - A long-term assessment of functional foods to evaluate the preventative benefits for eyes, brain function, bone, and cardio health is recommended. These assessments should include the potential for interactions among ingredients and the impacts on product stability, bioavailability, and bioactive components.
  - The SRP recommends continued exploration of partnerships with other agencies in an effort to build basic scientific knowledge to respond to Food Gaps in food, nutrition and health. One key area for collaborative exploration would be on the microbiota-diet-environment. Research at the National Institutes of Health (NIH) may be useful in developing insights into targets for translation to food-based systems for modifying the microbiome for positive health outcomes. This approach could help develop outside expert panels to inform on key relevant issues and consult on translation science. A literature review to identify research of interest to NASA would assist in establishing.

Tasks:

- Advanced Cookware and Techniques for Food Preparation at Reduced Pressure and Gravity – Completed Task
- KSC - Pick & Eat Expansion – Planned Task
- DoD Collaboration – PI: Grace Douglas, Ph.D., NASA Johnson Space Center
- Dwarf Fruit Production Study – PI: Gary Stutte, Ph.D., NASA Kennedy Space Center
- Effect of low shear modeled microgravity (LSMMG) on the probiotic *Lactobacillus acidophilus* ATCC 4356 – PI: Grae Douglas, Ph.D., NASA Johnson Space Center
- Food Fortification Stability Study – PI: Takiyah Sirmons, Ph.D., NASA Johnson Space Center
- Prepackaged Food System Database – Planned Task

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- Functional Foods Baseline and Requirements Analysis – PI: Maya Cooper, NASA Johnson Space Center
  - Pick-and-Eat Salad-Crop Productivity, Nutritional Value, and Acceptability to Supplement the ISS Food System – PI: Gioia Massa, Ph.D., NASA Kennedy Space Center
  - Integration of Product, Package, Process, and Environment: A Food System Optimization – Completed Task
  - Meal Replacement Mass Reduction and Integration Acceptability Study – PI: Takiyah Sirmons, Ph.D., NASA Johnson Space Center
  - Non-Thermal Sanitation By Atmospheric Pressure Plasma – Completed Task
  - Packaging Configuration – Planned Task
  - Pick and Eat - System Integration – Planned Task
  - Pick and Eat Crop Selection Study – Completed Task
  - Pick and Eat Salad Crop Testing – PI: Ray Wheeler, Ph.D., NASA Kennedy Space Center
  - Stabilized Foods for Use in Extended Spaceflight: Preservation of Shelf-Life, Nutrient Content and Acceptability – PI: Ann Barrett, Ph.D., U.S. Army Natick Soldier Systems Center
  - Surface Food System - Surface Crop Expansion Beyond Pick and Eat - Mission Validation – Planned Task
  - Surface Food System - Processing and Preparation - Mission Validation – Planned Task
  - Surface Food System - Surface Crop Expansion Beyond Pick and Eat – Planned Task
  - Surface Food System - Ingredient Functionality/Formulation – Planned Task
  - Surface Food System - Processing and Preparation – Planned Task
  - A Multipurpose Fruit and Vegetable Processing System for Advanced Life Support – Completed Task
  - Bulk Overwrap Packaging – Completed Task
  - Comparative Packaging Study – Completed 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
  - Effect of Space Radiation on the Nutrition and Quality of the Food – 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 Trade Study – Completed Task
  - Packaged Food Mass Reduction Technology Development – Completed Task
  - Reheating and Sterilization Technology for Food, Waste and Water – Completed Task
  - Suited Contingency Ops Food – PI: Patricia Catauro, NASA Johnson Space Center
  - Suited Contingency Ops Food - 2 – Completed Task
  - Thermostabilized Food Study – Completed Task

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- Total System Approach – Completed Task
  - Delivery of Probiotics in the Space Food System – Completed Task
  - Integrated Nutrition: Development and Provision of Functional Foods to Mitigate Bone Loss on ISS Missions – PI: Scott Smith, Ph.D., NASA Johnson Space Center
  - Automated Bulk Processing – Planned Task
  - Hurdle Approach: Formulation, Processing, and Storage Scoping – Planned Task
  - Hurdle Approach: Formulation, Processing, and Storage – Planned Task
  - Mass Reduction Food System Reformulation – Planned Task
  - Bioregenerative Food System Database – Planned Task
  - High-Protein And Polyphenol Bar Formulations: Utilizing Whey Protein-Polyphenol Ingredients – Planned Task
  - The Integrated Impact of Diet on Human Immune Response, the Gut Microbiota, and Nutritional Status During Adaptation to Spaceflight – PI: Grace Douglas, Ph.D., NASA Johnson Space Center

**Food-04: 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 finds that this Gap is relevant.
- The SRP is very pleased with the initial feasibility assessment for cold storage of foods for the Mars mission. Cold storage for both refrigerated and frozen foods can contribute significantly to diversity of food products available to crew members, and the gaps associated with acceptability of foods. In addition, these products would contribute to the overall emphasis on food quality. Frozen foods provide the potential for extended shelf-life (3-5 years) of many products with water activities of 0.85 or greater.
- Since the “acceptability” of food is a high priority for crew members, storage at 0°C or lower can contribute to this goal and provide retention of nutrients that degrade more rapidly at ambient temperatures. Based on previous research, acceptable shelf life of up to three years can be achieved with frozen food products. If 50 percent of the foods could be preserved using low temperature storage, the diversity of high quality and safe foods for crew members would be increased significantly.
- The use of “natural” refrigeration to maintain low temperatures for storage of frozen foods provides an array of product opportunities to the food researchers. When considering this option for storage of food products, several factors must be recognized and require investigation:
  - Food products to be transported on a space mission should be quick frozen in advance of transport to ensure that the optimum controlled freezing processes are provided for quality retention.
  - Reformulation of products, including freeze-thaw stable starches or resistant starches, to ensure maximum quality retention should be considered.
  - Unique packaging studies may be required to ensure that the appropriate packaging materials are used for storage of food products at the very low temperatures of space (< -80°C). Polymers including polyethylene, nylons, and nano-polymers should retain flexibility and properties at these low temperatures.

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- After a literature review and a review of commercial stabilizing ingredients for freeze/thaw, a limited number of shelf-life investigations may be needed to ensure that storage temperatures below  $-40^{\circ}\text{C}$  do not have unanticipated negative impacts on food quality attributes.
  - Current investigations on nutrient stability, quality retention and acceptability should be expanded to include storage temperatures over a range of temperature as low as  $-80^{\circ}\text{C}$ .
  - The study on factors contributing to food acceptability (Z. Vickers, University of Minnesota) should be activated to evaluate the acceptability of frozen foods that have been stored at temperatures as low as  $-80^{\circ}\text{C}$ .

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:**

- A. Are the Risks addressed in a comprehensive manner?
- The SRP finds that the Risks are addressed in a comprehensive manner and that both the MicroHost and Food disciplines are doing a good job at trying to alleviate the Risks. Host- and vehicle-associated microbial community assessments should take advantage of rapid advances in molecular methods, including DNA sequencing and mass spectroscopy.
- B. Are there areas of integration across HRP disciplines that are not addressed that would better address the MicroHost and Food Risks?
- Although the MicroHost group discussed integrations with the immune discipline, the SRP thinks additional interactions and discussions should occur.

**V. Evaluation of the progress on the MicroHost and Food Risks Research Plans since the 2014 SRP meeting**

- The SRP is very impressed with the progress made in the IRP to both the MicroHost and Food Risks since the 2014 SRP meeting.
- The SRP finds that there has been very positive progress on Research Gaps Food-01 and Food-02. The stability of nutrients in the food supply for long-term space travel is evident, and the potential for production of fresh products is becoming more feasible.
- The challenges associated with acceptability and variety of foods during long-term space travel needs continued investigation, and the SRP has provided a series of recommendations for consideration. The opportunity to incorporate space for frozen and refrigerated foods creates the potential for an expanded array of products for the crew members. Demonstrating the stability of these foods should be given a high priority by the Food research team.

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## **VI. 2015 AEH/AFT SRP Research Plan Review: Statement of Task for the Risk of Adverse Health Effects Due to Host-Microorganism Interactions (MicroHost Risk) and the Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System (Food Risk)**

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The 2015 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 Risk of Adverse Health Effects Due to Host-Microorganism Interactions (MicroHost Risk) and the Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System (Food Risk) sections of the current version of the HRP's Integrated Research Plan (IRP) which is located on the Human Research Roadmap (HRR) website (<http://humanresearchroadmap.nasa.gov/>). Your report, addressing each of the questions in the charge below and any addendum questions, will be provided to the HRP Chief Scientist and will also be made available on the HRR website.

### **The 2015 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 make progress in mitigating the Risk by answering the following questions:
  - A. Have the proper Gaps been identified to mitigate the Risk?
    - i) Are all the Gaps relevant?
    - ii) Are any Gaps missing?
  - B. Have the gap targets for closure been stated in such a way that they are measurable and closeable?
    - i) Is the research strategy appropriate to close the Gaps?
  - C. Have the proper Tasks been identified to fill the Gaps?
    - i) Are the Tasks relevant?
    - ii) Are there any additional research areas or approaches that should be considered?
    - iii) If a Task is completed, please comment on whether the findings contribute to addressing or closing the Gap.
  - 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, but not limited to, answering these questions:
  - A. Is the Risk addressed in a comprehensive manner?
  - B. Are there areas of integration across HRP disciplines that are not addressed that would better address the Risk?
  - C. Other
3. Based on the updates provided by the Element, please evaluate the progress in the research plan since the last SRP meeting.

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4. Please comment on any important issues that are not covered in #1, #2, or #3 above, that the SRP would like to bring to the attention of the HRP Chief Scientist and/or the Element.

**Additional Information Regarding This Review:**

1. Expect to receive review materials at least four weeks prior to the meeting.
2. Attend a meeting in Houston, TX on December 14 - 15, 2015.
  - A. Discuss the 2015 AEH/AFT SRP Statement of Task and address questions about the SRP process.
  - B. Receive presentations from the HRP Chief Scientist (or his designee), the Space Human Factors and Habitability (SHFH) Element, and participate in a question and answer session, and briefing.
3. Prepare a draft final report (approximately one month after the meeting) that contains a detailed evaluation of the current IRP specifically addressing items #1, #2, and #3 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 review the draft final report and identify any misunderstandings or errors of fact and then provide official feedback to the SRP within two weeks of receipt of the draft report. If any misunderstandings or errors of fact are identified, the SRP will be requested to address them and finalize the 2015 SRP Final Report as quickly as possible. The 2015 SRP Final Report will be submitted to the HRP Chief Scientist and copies will be provided to the SHFH Element and also made available to the other HRP Elements. The 2015 SRP Final Report will be made available on the HRR website (<http://humanresearchroadmap.nasa.gov/>).

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## VII. 2015 AEH/AFT Standing Review Roster

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### Panel Chair:

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