**Fiscal Year:** FY 2009  
**Task Last Updated:** FY 02/18/2009

**PI Name:** Bingham, Gail E Ph.D.  
**Project Title:** Validating Vegetable Production Unit Plants, Protocols, Procedures and Requirements Using Currently Existing Flight Resources  
**Division Name:** Space Biology  
**Program/Discipline:** SPACE BIOLOGY  
**Program/Discipline--Element/Subdiscipline:** SPACE BIOLOGY--Advanced human support technologies  
**Joint Agency Name:**  
**TechPort:** No  
**Human Research Program Elements:** None  
**Human Research Program Risks:** None  
**Space Biology Element:**  
1. Cell & Molecular Biology  
2. Microbiology  
3. Plant Biology  
**Space Biology Cross-Element Discipline:**  
1. Developmental Biology  
**Space Biology Special Category:**  
1. Bioregenerative Life Support  
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**PI Organization Type:** UNIVERSITY  
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**Organization Name:** Utah State University  
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**PI Address 2:** Space Dynamics Laboratory, 1695 North Research Park Way  
**PI Web Page:**  
**City:** North Logan  
**State:** UT  
**Zip Code:** 84341  
**Congressional District:** 1  
**Comments:**  
**Project Type:** FLIGHT  
**Solicitation:** 2003 Space Biology 03-OBPR-01  
**Start Date:** 01/01/2004  
**End Date:** 07/31/2011  
**No. of Post Docs:** 0  
**No. of PhD Degrees:** 0  
**No. of PhD Candidates:** 1  
**No. of Master’ Degrees:** 0  
**No. of Master's Candidates:** 2  
**No. of Bachelor's Degrees:** 0  
**No. of Bachelor's Candidates:** 3  
**Monitoring Center:** NASA KSC  
**Contact Monitor:**  
**Contact Phone:**  
**Flight Program:** ISS  
**Flight Assignment:**  
NOTE: per PI, project transferred to KSC management (5/2008 report)  
NOTE: Per PI, end date is 7/31/2011; changed 8/24/2007  
NOTE: corrected end date to 07/31/2007 per PI (1/07)  
**Key Personnel Changes/Previous PI:**  
**COI Name (Institution):**  
Garland, Jay (Life Support Group, Kennedy Space Center)  
Bates, Scott (Department of Psychology, Utah State University)  
Bugbee, Bruce (Department of Plants, Soils and Biometeorology, Utah State University)  
**Grant/Contract No.:** NNJ04HG03G  
**Performance Goal No.:**  
**Performance Goal Text:** The primary objectives of the Lada VPU P3R experiments include advancing the Technology Readiness Level (TRL) of...
The primary objectives of the Lada VPU P3R experiments include advancing the Technology Readiness Level (TRL) of our plant species and support equipment, developing a Hazard Analysis and Critical Control Point (HACCP) plan for use of plant materials grown in the cabin, and measuring the non-nutritional value of various plants and plant presentation approaches. These studies will be carried out in both flight and ground studies. Plants Identify, flight-qualify and optimize the support requirements for the vegetable and flower plant varieties that are most likely to be utilized to meet flight crew needs (wants) and that fit within the hardware resource limitations that exist on the ISS and will exist on the CEV. This work will validate the technology readiness level of our available cultural practices to provide reliable, low-cost, stimulating products for crew well being. What plants can tolerate existing cabin ethylene levels without adding the cost of ethylene scrubbers? Will seed-producing plants be genetically stable over the 500 to 600 day mission?

Food Safety Identify the threat levels and validate the procedures and protocols required to allow US astronauts to eat space-grown vegetables. Determine how to implement these procedures to maximize crew mental health benefits with minimum mission costs. What procedures and hardware need to be in place to assure crew health on a long flight?

Non-Nutritional Value Quantify the mass value that should be assigned to the non-nutritional effects of plants in a spacecraft cabin. How much vegetable yield is required for a measurable boost to crew response under the isolation and stress of long-term space missions? How should this stress-relieving resource be presented (open or closed, single crew tended or multiple access) to maximize its value? Is this resource of value to all crew members, or is there a subset that prize the experience much more highly?

The objectives will provide the data necessary to qualify plant products for authorized consumption on the ISS by US crewmembers. The Lada hardware and the cooperative agreement with IBMP have been shown to provide ideal, continuing opportunity to investigate many of the plant, procedure, protocol, and food safety requirement (PSR) issues associated with meeting crew livability requirements.

The Lada VPU P3R uses existing hardware on the ISS (Lada) and leverages our cooperative agreement with the Institute of Biomedical Problems (IBMP) in Moscow.

Research Impact/Earth Benefits:

Plants not only provide food, but for many they provide comfort and relaxation – a diversion from the stress of required activities. In the past, NASA has researched the option of including a Vegetable Production Unit (VPU) as a component of the life support system of their long-duration space flight vehicles. A previous road mapping exercise identified priority 1 and 2 Critical Path Risks for which plant materials and growth support activities could provide solutions. For at least some people plants provide significant non-nutritional benefit to long-duration crews. These values are currently based only on anecdotal and untested observations that need verification. Part of the benefit may be a small fresh food source, which makes food safety issues important. The VPU study addresses these Critical Path risks, and in the process of monitoring microbial accumulations around Lada also contributes to crew health risk knowledge and reduction.

Understanding the oxygen to water balance in the root zone applies not just in space, but in terrestrial agriculture as well. There is an acute need to optimize the efficiency of water use in agriculture, and leach-free experiments can be conducted only in space. This project will facilitate the understanding of how to better irrigate (precision watering) and fertilize different plants. The experiment also has considerable environmental implications as the ISS cabin is the ultimate setting for practicing recycling of plant, soil, water, and atmospheric resources.

The most significant milestone of 2008 was launching the ground astronaut survey and freezing plant samples (barley and mizuna) in MELFI on the ISS. During the formulation phase of this study, we successfully built a world-class team and established the foundation agreements to allow US university, industry and NASA scientists to work together with IBMP and Moscow University scientists to conduct the research required to meet the mutually agreed upon objectives of this effort. Lada continues to provide valuable plant material on the ISS.

Our Russian colleagues have continued to work closely with us and to provide opportunities for us to join in their research, such as in the planned Mars 500-Day Chamber Study. The Lada VPU P3R team has successfully demonstrated its ability to meet or exceed all of the program objectives and is positioned to develop the data required to allow mission and systems designers to understand the optimum functionality and mass value of living plants in the crew environment during long-term space flight activities. The Russian IBMP will accommodate preflight preparation and the launch of all hardware and materials. The growing of the plant material in Lada, collection of plant tissue, and transfer of plant matter to the Minus Eighty Degree Laboratory Freezer for ISS (MELFI) will be carried out by Russian ISS crewmembers.

Freezing the plant samples is necessary for the detailed chemical nutrition and microbiological material load analysis that are part of the VPU P3R experiment. The Russian crewmembers will collect the plant samples approximately two weeks before the designated Shuttle return. The plant samples will be packed in NASA approved freezer bags before being transferred to the MELFI. The frozen samples will be transferred to the Space Shuttle and maintained frozen for return. The VPU P3R experiment includes an analysis of the Lada root modules that have been on orbit, specifically to characterize root growth patterns in microgravity and measure the growth of opportunistic organisms. Like the plant samples, the root modules will be packaged appropriately by the Russian ISS crewmembers in a Russian provided return bag before being transferred to NASA.

Rationale for HRP Directed Research:

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