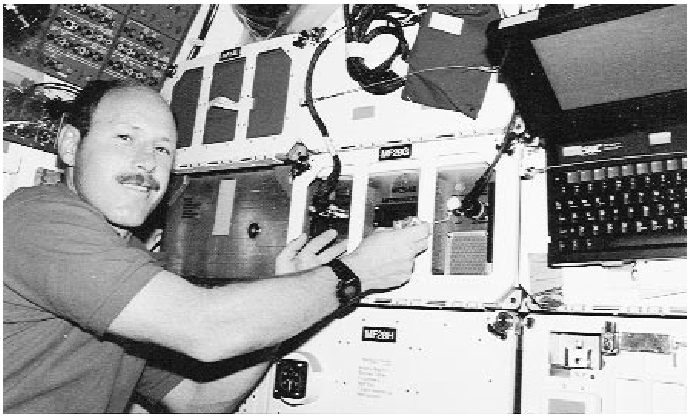
Astroculture™

Principal Investigator: Dr. Raymond J. Bula,
Wisconsin Center for Space Automation and Robotics
Madison, Wisconsin



Pilot Ken Bowersox Activating the Astroculture Experiment on USML-1

Purpose: To evaluate performance in microgravity of a unit for supporting growth of plants and to study how starch accumulation in plants is affected by the microgravity environment

Significance: As our stays in space become longer, it will be necessary to grow plants to minimize the cost of life support. Plants can help provide food, oxygen, and pure water and can also assist in removing carbon dioxide from human space habitats. However, since fluids behave differently in microgravity, plant watering systems that operate well on Earth do not function effectively in space.
A useful plant growth system must be able to deliver nutrients to the plants without releasing solutions into crew quarters.

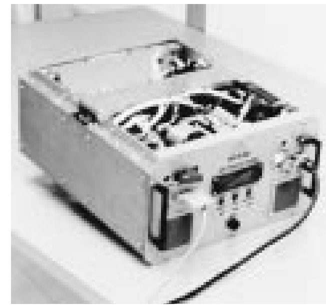
Such a system must also be capable of controlling levels of moisture in the air — or *humidity*. Excessive levels of humidity can damage experiments and equipment, while insufficient humidity can have a detrimental effect on plants. The moisture in the air also represents a valuable on-orbit commodity that could be recycled as condensed water for cooking, drinking, or as a source of water for plants. Additionally, electrical power is a valuable resource on orbiting spacecraft. This requires that plant growth systems must be able to provide light as efficiently as possible.

The Astroculture™ experiment flying on this mission contains three subsystems that address these issues and provide superior environmental control for plant growth in an inexpensive and reliable spaceflight package. First, the experiment's water and nutrient delivery system uses porus tubes with different pressures to ensure a proper flow through the rooting matrix. This system has already proven itself to be effective during long-duration flights in the microgravity environment. Second, the efficient subsystem for controlling moisture in the growth chamber humidifies and dehumidifies the air without needing a gas/liquid separator, which is required by all other systems currently in use, to recover the condensed water. Third, the lighting subsystem uses light-emitting diodes (LEDs) to provide high levels of light within the limits of electrical power available on orbit and with greater safety than any other light sources currently used by space-based plant growing facilities. The experiment package is sealed, with cooling provided by an experiment heat exchanger and carbon dioxide (necessary for photosynthesis) supplied from a storage tank.

This equipment will be used to grow potato plants as part of a cooperative experiment with the Secondary Payload Programs of NASA's Life and Biomedical Sciences and Applications Division to obtain data on the nature of starch accumulation in microgravity. Starch is an important energy storage compound in plants, and there are some indications that starch accumulation in plants is restricted in microgravity. To investigate this phenomenon, small potatoes will be grown in the Astroculture™ facility. They will develop from potato leaf cuttings with auxiliary buds, which can be induced to develop small tubers filled with starch in 10 to 15 days. The experiment will evaluate rates of photosynthesis, movement of photosynthesis products from leaves to tubers, conversion of sugars to starch in storage organs, and enzyme activities for the formation and degradation of starch. Investigators also will study the number, size, shape, and distribution of starch grains and the structures that form starch (*amyloplasts*).

This flight of the Astroculture™ hardware is the last of a series of tests to evaluate each of the critical subsystems needed for the construction of a reliable plant growth unit. Astroculture™ flew on the First United States Microgravity Laboratory and the Spacehab-1 and -2 missions, during which lighting, humidity, pH, nutrient supply and composition, and carbon dioxide and atmospheric contaminant subsystems were validated. After the experiment is flight-qualified on this mission, a functional plant growth unit will be available for sale or lease to commercial enterprises.

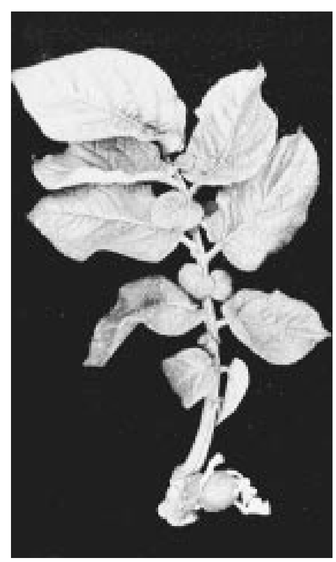
The technologies used in the Astroculture™ flight unit have already resulted in several commercial products for use on Earth. The lighting subsystem has been the basis of the development of a unique lighting system for photosynthesis research. The lighting



Astroculture™ Hardware

technology is also being used in some novel medical applications, ranging from measuring blood sugar levels to use in photodynamic therapy for cancer patients. Other applications of the Astroculture™ technology include improved dehumidification/humidification units, water-efficient irrigation systems, and energy- efficient lighting systems for large scale commercial nurseries.

Method: A flight unit capable of providing the environmental conditions required for plant growth will be used to grow potato plants. The crew will periodically monitor the status of the environment in the plant chamber and the development of the plants.



This tuber was grown from a potato leaf during a 2-week period, approximately the same amount of time USML-2 will be in orbit.