SPACE GARDENING

Researchers are investigating the possibility of turning spacecraft into miniature farms that would provide the necessities of life on future space missions

BY JULIE ANN MILLER

Freeze-dried bananas, rehydrated turkey tetrazzini and thermostabilized beef steak were among the culinary delights on the menu last month for the space shuttle astronauts. Stocking the larder for future ventures into space, however, will be more of a challenge: Such ventures may require that a dozen or more persons leave the earth for several years. In those cases, the weight of the necessary food, water and gases could keep the project from getting off the ground.

An obvious solution to the problem is to develop a regenerative life support system —one that produces the necessities of life continually throughout the mission. Now, in an effort to find a practical way of developing such a complex system, Nationa. Aeronautics and Space Administration investigators have joined forces with researchers from various universities to launch the Controlled Ecological Life Support System Research Program.

The CELSS Program, under the direction of Robert McElroy of NASA's Ames Research Center in Moffett Field, Calif., includes research in food requirements, production and processing and waste management. In most life-support scenarios, these components are integrated in a cycle, with body wastes serving as the raw materials from which food is produced. The space vehicle then becomes either a specialized chemical manufacturing plant or a miniature farm.

The mini-agricultural approach probably is the best near-term bet, McElroy says. Chemical breakdown of wastes and synthesis of artificial food, he explains, requires too extensive a knowledge of the fine points of human nutrition — which trace chemicals are toxic and which nutrients are required in small doses over a long period, for example. In addition, psychological problems might arise from repeated fresh-from-the-test-tube meals. Eating space-grown vegetables seems to be the more palatable solution, McElroy says. "Why go with things we are not used to eating, when we could go with plants we are used to?"

But developing a space garden is no simple task. Construction of the necessary closed ecological system that would be productive for years is much more difficult than merely choosing seeds and adding dirt and water. After all, earth itself is a closed ecological system. Here, the relatively constant conditions are maintained by a proper balance of organisms and flux among natural forces, such as winds, storms, the oceans and the atmosphere — a system of seemingly far too grand a scale to mimic in a spacecraft greenhouse.

Still, researchers have taken steps toward this distant goal. Several years ago, for example, Soviet scientists tested a preliminary biological life support system that sustained three people for six months with oxygen, water and "a certain amount of grain and vegetables" (SN: 11/13/76, p. 314). The scientists concluded that their experiments "established beyond question that a small, steadily operating, essentially closed system ... involving man is quite feasible."

A sort of plant space suit is shown below in the photograph and diagram.

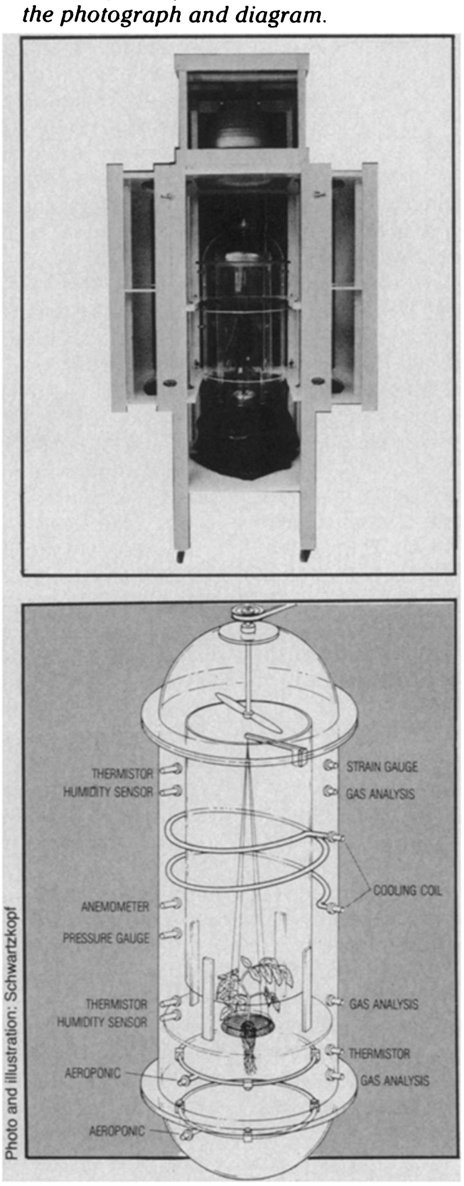

Photo and illustration: Schwartzkopf

The Soviet experience demonstrates a more or less holistic approach in the development of a closed ecological life support system. Another method, the reductionist approach, is to divide and conquer. Using this approach, researchers divide a potential support system into individual components, develop separate control systems for each and then use these controlled components as the building blocks from which a complete ecological system can be constructed.

CELSS researchers now are working on one such building block — a sort of plant "space suit," or chamber for growing plants under completely defined conditions. "Surprisingly, this has not been done before," McElroy says. While light and temperature previously have been monitored, levels of oxygen, carbon dioxide and soil minerals never have been as adequately monitored as in the new chamber, he says.

The chamber — developed by McElroy and Steven H. Schwartzkopf and Paul E. Stofan of the University of New Hampshire at Durham — basically is one plastic cylinder inside another. Inside this chamber, environmental factors — humidity, pressure and respiratory gases, for example — are monitored and controlled by a computer that handles 16 channels of input.

"As might be expected, one of the major problems with a chamber of this sort is leakage," Schwartzkopf and Stofan report. However, they say their chamber is improved in that regard, although not yet perfect. The rate of leakage is 0.15 percent of the volume per hour — less than 1 percent that of a typical growth chamber. Another major problem the researchers encountered involved the chamber's high humidity conditions: Water condensed inside several electrical connections. Finally, "Positioning sensors in the chamber is difficult because of the rather cramped quarters."

Nonetheless, the researchers have observed a tomato plant in their agricultural space suit. The plant was grown on a screen disk suspended in the center of the chamber, nutrient solution was sprayed onto the roots and a strain gauge recorded the total wet weight of the growing plant. The plant could grow to a height of 30 inches.

In order to eventually expand this type

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of chamber into an autonomous community, investigators will have to anticipate and provide for the plants', and perhaps animals', every need, McElroy says. But little is known about the interactions of plants with other plants and with soil bacteria. In addition, says McElroy, only a junction of ecological and engineering ventures can succeed in creating a suitable life support system, and clashes between these two fields have impeded progress in the past. The engineering faction, a strong force within NASA, has shown less interest in creating proper ecological balances than in building machines, McElroy explains. This "you-develop-a-box-that-turns-waste-into-good-stuff-and-you-fly-it" approach tends to ignore processes painstakingly developed by eons of evolution, he says.

McElroy is trying to maintain a program that includes both the ecology and engineering viewpoints. But even with that union, he faces a major obstacle: The precise factors influencing plant growth often are not pursued vigorously because there is little economic incentive to do so. That these factors can and are being pursued is demonstrated when the economic stakes *are* high enough. The greenhouse that supplies the flowers for the Rose Bowl parade, for example, ships during the last week in December buds that cooperatively open January 1. Says McElroy, "That's a pretty fine art." □