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Invasion of the Sensor Pods

Science: The plastic boxes look like the kind used to store leftovers. But inside are sophisticated devices to record scientific data—whether in the Huntington Gardens or on the surfaces of other planets.

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A sensor pod nestled in a Huntington Gardens nursery keeps track of the environmental conditions that support carnivorous plants around it. Such pods, linked by electronic webs, could be used to study life in remote places on Earth--or to look for life on other planets with more precision than satellites could manage.

The shiny green hummingbirds and huge bumblebees at Huntington Botanical Gardens probably won't even notice the silent invaders imported from the Jet Propulsion Laboratory. Twelve plastic pods hidden among exotic greenhouse plants are part of a field test of a new technology called a wireless sensor web. The pods constitute an infrastructure that researchers hope will be useful in looking for life on other planets or studying life in hard-to-reach places on Earth.

The idea may fulfill part of NASA's goal to set up a "virtual presence" throughout the solar system. The scientists imagine that one day, groups of pods can be deployed or dropped from rovers or landing spacecraft (or from planes in remote corners of Earth).

These webs of pods could monitor biological activity--in the form of released respiratory gases--on a planet's surface with a resolution and sensitivity not attainable by satellites.

Each pod consists of a solar-powered rechargeable battery, a communication board and a microprocessor with several sensor wires extending from it. All of this is housed in a small plastic box like those that you might use to hold leftovers.

Through the sensors, the pods at the Huntington collect data on the various microclimates in the greenhouses. The sensors can detect humidity, soil and air temperatures, soil moisture, light levels and oxygen and hydrogen sulfide gases.

Every five minutes, each pod records this information and then transmits it back to a "mother node." This node is a specialized pod connected by a serial port to a field computer. The mother node synchronizes the pods with one another.

Kevin A. Delin, project leader, and Shannon P. Jackson, project engineer, developed the technology at JPL.

Jackson and Delin started out with scaled-down versions of the pods housed in toy containers from gum ball machines. When four of those tiny pods and a mother node worked in the lab, Delin knew they could proceed with building the prototypes.

Jackson--whose hands, according to Delin, "can do almost anything with electronics"--began constructing a pod. He had to think of a way to keep the sensitive hardware dry and still expose the device's solar panels to sunlight.

"I thought, 'We have to put this in something,' so I went to hardware stores. And then, as I was walking down the grocery store aisle, I thought, 'This is perfect--clear and waterproof,' " Jackson said.

He attached solar panels to the bottom of a plastic box (which would become the top of the pod). He then painted the rest of the box white to keep the inside from heating up.

All of the hardware for the pods can be bought off the shelf, which makes mass production highly feasible, he said. The pods "talk" to each other

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like walkie-talkies over a radio frequency with a range of about a quarter-mile. Because wireless technology is progressing rapidly, producing pods with greater range can only get easier, Delin said.

JPL chose Huntington Gardens in San Marino as the field test site because the microclimates there range from desert to semitropical to cool. One pod is in what's called the "carnivorous bog," a box filled with insect-trapping pitcher plants and Venus' flytraps.

The experiment has been running continuously since May 18, with excellent results. "We're actually taking good data, and this is just a field test," Delin said.

Theresa Trunnelle, nursery manager at the Huntington, said the pod data are as accurate as temperatures recorded by her standard equipment, a sensor hanging in the middle of the greenhouse. And, she added, the pods have the advantage of being portable, so they can take measurements in different areas of the structure.

"We like to think [this will give] us a greater understanding of the world around us," said Jim Folsom, director of the Huntington Gardens. Folsom said he believes the wireless sensor web has "remarkable potential" in the areas of agriculture, horticulture and the study of local environmental changes. In one possible use, he envisions a web of pods tracking heat changes in a city.

Folsom is not the only one who sees possibilities for the new technology. "We're most interested in the potential for sensors on other planets. We have every hope that it will allow us . . . to detect life," said Pamela Conrad, an astrobiologist at JPL.

The search for life on other planets in our solar system is focused on detecting microbes within rock or ice. With a wireless web of sensors, scientists say, a pod placed directly next to a rock could detect trace amounts of gases given off by any microbes inside.

Kevin A. Delin of the Jet Propulsion Laboratory displays a tiny sensor that can be used to study microclimates.

Conrad also sees a wide range of possibilities on Earth, including studying the evolution of the atmosphere and monitoring seismic activity. She noted that one advantage of web technology is the ability to take many measurements over a large area simultaneously.

The wireless sensor web is extremely versatile, developers say, because pods can be added, removed, repaired or upgraded without interrupting the flow of information from the rest of the web.

The technology can be adapted to fit almost any situation. Right now, it can cover a range about as big as a football field.

And because the web operates essentially on its own, it will allow noninvasive measurements in sensitive environments and continuous measurements at remote locations, such as the bottom of the ocean.

Another special feature of the sensor webs is that each pod communicates with its neighbors. Because the data must "hop" from one pod to the next on the way to the mother node, each pod receives and uses information from others in the web. "You can think of each little pod as a pixel in a bigger picture," Delin said.

This sharing of information not only lets the web "heal" itself if one member breaks down, but also permits pattern recognition. For instance, a sensor web could be an "intelligent" smoke detector that tells exactly where and when a fire started and how best to evacuate the area.

JPL scientists see this as an additional NASA application for monitoring conditions on space shuttles and stations. However, Delin said, he believes the commercial and environmental uses on Earth are much more likely to speed the development of the technology than a trip into space.

"The bus to Mars is expensive and crowded [with other experiments]," he said. And, like most buses, who knows when the next one will come along?

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More information on wireless sensor web technology is available at: http://sensorwebs.jpl.nasa.gov.

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