Visionary Counting on Unmanned Vehicles

By Rich Tuttle

Bill Stone, the founder of Stone Aerospace, has a vision—several visions, in fact—and unmanned vehicles play a part in a number of them.

His Austin, Texas-based company developed and built the DEPTHX robot that last May conducted the first comprehensive exploration of the world's deepest sink hole, El Zacaton in Mexico. It brought back enough data to keep scientists enthralled for some time.

An unmanned system based on DEPTHX (DEep Phreatic—meaning underwater cave—THermal eXplorer) will be tested in Antarctica beginning next year to help determine the suitability of such a device to meet, in about 20 years, what's been called the ultimate robotic challenge: exploring the ice-covered ocean of Europa, a moon of Jupiter. Scientists believe there's a high probability of detecting the first life off Earth in that remote and ancient sea. That's one vision. The challenges would fill a book: melting through many kilometers of ice just to get to the ocean, for instance. That will be addressed in the Antarctica experiments. But DEPTHX does seem to have demonstrated the possibility of clearing two other key hurdles—surviving in a three-dimensional, unexplored environment without external navigation aids; and carrying out science experiments autonomously.

DEPTHX's abilities are two generations beyond those of the Spirit and Opportunity rovers on Mars right now, Stone says in an interview.

Every move of the Mars vehicles is based on a carefully prepared script. But, Stone says, "in the case of Europa, it can't be that way."

The computer brain of a Europa probe would have to be wired to achieve "global" objectives, he says. The list might include mapping the entire area within a 500 kilometer radius of entry into the ice, from surface to bottom; gathering detailed data on the ice sheet above; and compiling a full record of the environmental parameters within that zone.

And, Stone says he would tell the probe, "if something really interesting happens within the context of this hierarchical decision-to-collect philosophy that we developed for DEPTHX, grab a sample—and while you're driving home we want you analyze it and tell me what you found." This is the same thing a couple of humans would be told. "That's exactly right," Stone says. "And we think we've made a big step towards that with DEPTHX, and NASA realizes it."

In fact, Stone Aerospace was funded by NASA in 2005 to develop a prototype of an autonomous underwater vehicle for Europa as part of its astrobiology program. The three-foot-wide, 1.5-ton DEPTHX is one of the steps along the

way. The Antarctica diver, known as ENDURANCE (for Environmentally Non-Disturbing Under-ice Robotic ANtarctiC Explorer), was initially going to have a shape reminiscent of half a loaf of bread, but recent changes make it look a lot like the ellipsoid-shaped DEPTHX.

Here's another Stone vision involving robots: Extracting huge amounts of water from ice at Shackleton Crater at the south pole of the moon. Why? To convert it to rocket fuel for gas stations in Earth orbit that would fill up spaceships on various missions, including flight to other planets in the solar system.

These stations "could create an entirely new industry, and provide the final key for opening space for general exploration," Stone says. The idea is to get there before NASA does and corner the market on the new age.

With cheap and easy access to fuel, the thinking goes, the gas stations would see lines of customers. They might include, in addition to NASA, China, India, Japan, Russia, and private companies.

NASA has announced its plan to return to the moon by 2024. But, says Stone, "The successful conclusion of that mission will result in infrequent visitation of the moon by a small number of government scientists and pilots. It will leave us no further along in the general expansion of humanity into space than we were 50 years ago. Something fundamental has to change if we are going to see common access to space in our lifetime." (He made those comments at a conference in Monterey, Calif., last March.)

Stone figures it's possible to begin an industrial moon water extraction business in seven years. He has formed Shackleton Energy Co. to do the work.

The work would involve two phases. The first phase would cost an estimated $110 million to $115 million, with the money coming from private sector "angels," according to a person familiar with the idea. In this phase, robots would explore and map the 19-kilometer-wide, 2-kilometer-deep Shackleton Crater, where a sensor on the Pentagon's Clementine flyby mission of 13 years ago picked up a very strong signal of hydrogen.

"That signal was so strong it could only have been produced by 10 trillion tons of water buried in the sediment, collected over millions and billions of years by the impact of asteroids and comet material," Stone said at the conference.

If the robots confirm that such a vast store of water is in fact there, the next step would be the more ambitious phase two, which would cost serious money: $15 billion. It would come from private "super angels." This list is shorter than that of mere angels, numbering only a dozen or so. Individuals in the billionaire category would be sought because corporations might not be willing to risk alienating shareholders by participating in such a plan.

In any case, the idea of phase two would be to send a team of people to Shackleton to mine and process the water and convert it on the spot into propellants and consumables. Spacecraft would shuttle the products to the orbiting gas stations. Because the spacecraft and the stations would operate between the Earth and the moon and wouldn't have to deal with the rigors of re-entry, they would be inflatable types to help keep cost down.

The first mission of phase two would be one for the history books. "I intend to lead that expedition," says Stone, 54, a scientist with a distinguished record of terrestrial exploration, with and without robots. NASA funded the DEPTHX project, and the National Geographic Society sponsored a 1999 Stone exploration of underwater caverns at Wakalla Springs, Fla. A "digital wall mapper" used at Wakalla Springs produced the first ever 3D map of a cave, and was a predecessor of DEPTHX. By going to such forbidding holes as Zacaton, Stone says in the interview, "we're exploring the last frontier on this planet." Whether they're under water or not, "they are extremely remote. You're talking three-, four-month expeditions in places where you might be as many as six, seven, eight days one-way travel from the surface. So in that sense, it's more remote than working on the Moon. I have a feel for what real exploration means in our time."

The list of challenges of working on the Moon—like that of sending a probe to Europa—is a long one. Powering the robots as they explore Shackleton in phase one is among them. Except for the rim, the creater never sees the sun. This means the robots can't use solar cells, as Spirit and Opportunity do today on Mars. Fuel cells won't work either, because the robots would do their prospecting non-stop for a relatively long time, perhaps half a year.

Nuclear power seems to be the answer, but presents its own problems. For one thing, any hint of a plan to use nuclear power would probably spark protests. A Europa effort might be similarly affected, because nuclear power appears to be the only way to melt through miles of ice.

Then there's the problem of just getting nuclear power packs in the first place. They would ideally be small radioisotope thermoelectric generators (RTGs). They might come from Russia, which launched a number of RTG-powered Radar Ocean Reconnaissance Satellites (RORSATs) during the Cold War to keep an eye on U.S. Navy ships.

In fact, anti-nuclear sentiment in the U.S. might drive the launch of moon-bound robots to Russia. If the program is successful, Moscow might appreciate the resulting flow of cash.

Nuclear power would probably also be required for the manned second phase of the effort. Few other options seem capable of to meeting the demand for continuous power to mine and live in the cold, harsh conditions. Humans and equipment for phase two might be landed on the sunlit rim, as they would

under NASA's plan, but they would still have to descend into the gently sloping crater to work.

In any case, both phases would be supported by a communication satellite relay system that would link humans and machines to Earth.

Robots are vital for certain kinds of jobs, Stone says, but their real power is often best expressed when they are used in concert with people.

"Completely eliminating the human from the loop removes what is the essence of space, which is the possibility of personally satisfying your curiosity about the universe," he says.

"If you ask me why I keep doing terrestrial expeditions, it's because of that excitement of being out there," he says. On the other hand, "you send robots to places where a couple of conditions exist. Number one, our propulsion technology does not make it economically feasible to send people there. Two, there are lethal environments to humans." The surface of Europa is a good example. "The radiation field is enough there to kill you, or give you a lethal dose, within five minutes, unless you've got specific shielding against that, which would be difficult to carry."

At the same time, if conditions one and two are not major considerations and it makes financial sense for people to go on a mission, then, "Yes, you really ought to go yourself. I believe that we have that justification for the moon. I don't think we have it for Mars. Not yet."

Stone says he has "no fear" of any particular area of technology. Stone Aerospace "could build re-entry vehicles tomorrow; we could build lunar systems tomorrow. That's not arrogance. It's just that I've been through enough systems and situations in 30 years of working [in government and industry] that I know how to pull the teams together to do these things."

This, he says, is why Stone Aerospace was able to develop DEPTHX in three years, rather than the seven to 10 he says it would have taken a big aerospace company. "We don't need much in the way of administrative management. What we do is bring in experts in various areas, and they then bring their own sub-teams in to do various things, and then we all work periodically together, either by telepresence or by having them actually come on site. They move in out. There are no permanent employees."

Stone Aerospace, he says, is not structured, "for example, to build 5,000 tanks for the government. What we are structured to do is to make breakthroughs, and we can do that, in the cases like DEPTHX and ENDURANCE."

Stone says nuclear power is the "linchpin" to working on the moon and sending a probe to Europa. It's a sticky issue because it "has to do with our collective

sense as a nation, with paranoia" about this source of power.

Interviewed in mid-June, just after the success of DEPTHX and just before he debriefed NASA about the Zacaton mission, Stone said he was "on a mission" to send to NASA Headquarters and Congress the message that, "if we don't pull our heads out of the sand as a nation and get on with the development of both reliable, compact radio-thermal and planetary power supplies, we're going to be passed up.

"If you want a good example, go back 500 years. Columbus tried desperately for years to get funding from Italy, and nobody there was very interested at all."

He finally sparked the interest of Spain. "And do you know what happened? For 150 years after" Columbus sailed to new horizons, Spain "had hegemony over the entire world." Columbus's trip "initiated the entire thing. And I can tell you right now that [the same kind of thing is] going to happen in our lifetime. If we don't go first, somebody else will."

Rich Tuttle is the former editor of Aerospace Daily & Defense Report and a frequent contributor to Unmanned Systems magazine.