On mythical wings: Pedaling to Greece

The mythical Greek inventor Daedalus escaped from the island of Crete on wings he had fashioned from feathers and wax. Next year, if all goes well, a somewhat more sophisticated human-powered aircraft will take off from Crete — on a 69-mile flight across the Mediterranean Sea to the Greek mainland.

The proposed flight, called the Daedalus project, would be three times longer than the current world distance record for a human-powered aircraft. That record was set during the Gossamer Albatross's 1979 flight across the English Channel (SN: 6/16/79, p. 390).

"Such a flight is technically, physiologically, meteorologically and logistically feasible," says a report released this week. The completion of this feasibility study, sponsored by the Massachusetts Institute of Technology (MIT) and the Smithsonian Institution in Washington, D.C., marks the end of the Daedalus project's first phase. A small group of volunteers, centered at MIT, is now preparing to design, build and test a craft suitable for the journey.

Several features make this new airplane different from previous designs. Powered by a man or woman pedaling a bicyclelike mechanism that turns a propeller, the airplane will have an electronic flight-control system. This would enable it to fly at night or in light fog, when the calm air necessary for flight is more likely to occur.

Because Crete's northwestern coast is very rugged and has few beaches, the airplane must also be strong enough to be launched safely from a cliff. However, throughout most of its flight, the plane would skim the sea's surface at a height of 15 feet or so.

The craft, constructed from lightweight materials, would weigh about 68 pounds. As now envisioned, its wingspan would be 102 feet. For this project, MIT engineer Mark Drela designed a new airfoil that, according to his computer simulations, should slice through the air 30 percent more efficiently than previously used airfoils. "We tried to squeeze every last bit of performance out of this airfoil," says Drela. The Daedalus team is also using a new graphite composite as the main supporting element in the wings to provide the necessary stiffness.

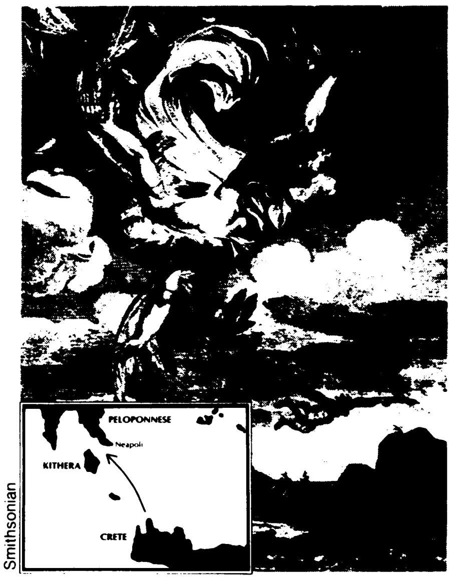
This new technology could eventually lead to unmanned planes that cruise high in the atmosphere for months at a time. At 70,000 feet or more, such vehicles could make atmospheric measurements or act as spy planes and communications centers (SN: 11/10/79, p. 327). "Someday, you may even see something like this in an [unmanned] airplane that can fly in the Martian atmosphere," says Daedalus project leader John S. Langford, who works for the Institute for Defense Analyses in Alexandria, Va.

The project has also provided useful data on the limits of human endurance. The Daedalus pilot would have to generate a quarter of a horsepower for at least four hours; that's roughly equivalent to running two marathons, one right after the other. Laboratory tests at the Yale University medical school in New Haven, Conn., showed that a few "elite" athletes could make the flight. "Physiological limits don't seem to be encountered," says human factors engineer Steven R. Bussolari of MIT. "The best candidates would come from endurance events that involve cycling." Keeping the pilot cool may turn out to be the biggest problem.

Another concern was the weather. Looking at historical weather data, the team established that March, April or September would be the best months for an attempt. "The summer is slightly better for [low] winds, but it's too hot, even at night," says Langford. "The soonest that we could do it would be the spring of 1987."

The Daedalus team has selected several potential takeoff and landing sites. Automatic weather stations at a few of the sites are now providing detailed information about local weather conditions.

One thing the Daedalus team wants to avoid is the fate of Icarus, the son of Daedalus. Icarus suffered a structural failure when he climbed too high and the sun melted the wax holding his feathery wings together. Daedalus himself, however, made it. *— I. Peterson*



Smithsonian

While Icarus crashed into the sea, his father, Daedalus, flapped his way to safety. The map shows the proposed route that a new human-powered aircraft is to take to commemorate Daedalus's feat.

Electric currents transported quantally

The discovery of quantum effects at the beginning of this century divided the world of physics into two quite different domains, the microscopic and the macroscopic. In the microscopic domain — that of atoms, molecules and structures smaller than atoms — changes in physical quantities occur in a jumpy fashion: They go by the quantum, the least change possible in a given situation. The macroscopic domain is the familiar world of large objects, where changes can be, or can seem to be, smooth and continuous. Until a couple of years ago, objects that behaved quantally were all given by nature; things built by humans belonged to the macroscopic order. Now, working in the borderland between the two domains, physicists have learned to construct objects that behave in a quantum fashion.

These somewhat macroscopic quantum objects are tiny metal wires and rings and tiny metal-oxide semiconductors (MOSFETs). William J. Skocpol of AT&T Bell Laboratories at Holmdel, N.J., calls the MOSFETs "nanolaboratories for quantum transport effects," implying they are a billionth the size of ordinary laboratories. The rings are typically 8,500 angstroms across (the length of one wave of red light) and made of wire 500 angstroms thick. The quantum transport effects involve electrons that make electric currents in these devices, and those currents behave quite strangely compared with currents in ordinary electric wires. The effects were described last week at the American Physical Society meeting in Las Vegas, Nev.

In these very small pieces of metal, quantum mechanical wave effects become important. Every object in the quantum mechanical domain is both a wave and a particle, and the strange effects come from the behavior of the waves associated with electrons. The source of resistance of concern in these experiments is impurities, foreign atoms. When electrons hit impurities they are knocked out of their paths and they scatter. An electron encountering a lot of impurities executes a random walk. It may even backscatter, as Skocpol points out, and return to its starting point. If one regards electrons as waves, the scattered waves may be split, and when they recombine, if they are still in phase with each other, they will reinforce each other, but if they are out of phase they will cancel each other. This wave interference effect alters the electrical conductance of the metal.

In the macroscopic domain, the effects of individual impurities should average out. Physicists thought they had understood conductance: It should depend on the metal, its temperature and the relative proportion of impurities in it. It should not depend on the locations of individual impurities. According to A. Douglas Stone of the State University of New York at Stony Brook, "[T]his plausible and long-standing belief is clearly mistaken." In these small samples the conductance depends strongly on the locations of individual impurities. "Each specific sample has a conductance that goes with that impurity configuration," Skocpol says. Magnetic fields can tune the phases of the electron waves. Using varying magnetic fields, the experimenters study the effects of the impurities. Each sample yields its own "magnetoprint," a unique relation of conductance to changes in magnetic field. Sometimes changing just one impurity can have a greater effect than changing the whole sample.

These are wave-coherence effects, occurring because the electron waves "remember" their phases, rather than losing them in the averaging process as they were expected to. The ring experiments sought a particular coherence effect, the Aharonov-Bohm effect. Experts had said that averaging the effects of impurities would destroy the coherence necessary for this effect also.

In experiments looking for the Aharonov-Bohm effect (SN: 3/1/86, p. 135), the ring encloses a magnetic field. The current is split to go around the ring both clockwise and counterclockwise. In this geometry the conductance of the ring should oscillate with quantized changes of the magnetic field. As Sean Washburn of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., describes it, they kept finding an oscillation that was half what they were looking for. Stone repeatedly advised them to make the rings larger so that the magnetic field would not actually penetrate the metal. When they finally did it, they found the Aharonov-Bohm oscillations. The rings, it seems, will produce both kinds, depending on the geometry and the field configuration. In one case, it seems, electrons go around the ring once; in the other case they backscatter and go around twice. At Yale University ring experiments with indium and silver have been done by Daniel Prober and collaborators. They see the non-Aharonov-Bohm effect in all their rings but the Aharonov-Bohm only in silver.

Summing up the significance, Prober calls these experiments "a first bridge between the quantum mechanical world of atoms and molecules and the larger-scaled world in which we live. . . ." He foresees new classes of devices that "will take their operating principles not from the behavior of semiconductors, but rather from the quantum mechanical world of atoms and molecules."

— D.E. Thomsen

Retiring reactors: What's the cost?

Nuclear reactors don't live forever. Once their owners decide to shut them down permanently — a procedure known as decommissioning — there are three basic options: dismantling the plant and burying its parts; "mothballing," or storing, the plant for 10 to 50 years before dismantling; and permanently "entombing" the plant in concrete walls where it stands. Today, none of these options is inexpensive or politically attractive. Moreover, the growing need to choose among them and to resolve their relative costs "is getting less attention than it deserves," according to a report released this week by the Washington, D.C.-based Worldwatch Institute.

More than a dozen power reactors have already been retired worldwide. Within 15 years, says the report's author Cynthia Pollock, 66 more are likely to be decommissioned. Dismantling has just begun on the 72-megawatt Shippingport Atomic Power Station outside Pittsburgh — the first commercial U.S. nuclear plant and the world's largest dismantling project to date.

However, despite the apparent readiness to decommission Shippingport, which the Energy Department says is not a typical dismantling project, Pollock reports that not one of the 26 nations using nuclear power "is adequately prepared" to cope with decommissioning today. The primary issues facing the owners of retired plants are high costs and locating communities willing to accept their radioactive refuse.

Right now, the report notes, no country has a plan for disposing of the high-level wastes now stored at any reactor. And then there is the additional issue of where to send the more than 3,000 cubic yards of low-level radioactive wastes that would result from the dismantling of a used plant. In the United States, home to most of the world's nuclear plants, low-level-waste sites are prohibited from accepting materials contaminated with long-lived radioactive species. Moreover, all three U.S. low-level-waste sites currently in operation are seeking to limit the volume of wastes they must accept in the near future, especially from out-of-state generators (SN: 1/11/86, p. 22).

In the long run, Pollock expects that the financial uncertainties — not only how much it will cost to decommission a large commercial plant but also whether a utility will be able to afford those costs when a plant's retirement time arrives — will prove less important than the radwaste issue. However, with cost estimates ranging from $50 million to $1 billion or more per reactor, the report says, "nuclear decommissioning could be the largest expense facing the utility industry." Pollock asserts that the industry's lack of decommissioning experience with the large 1,000-megawatt plants that are typical today makes most current decommissioning-cost projections little more than guesses based on "varying degrees of wishful thinking." For this reason, her report recommends that utilities begin collecting money from their users as soon as possible and hold it in escrow to fund the plant's decommissioning costs.

While few argue with the report's general intrepretation of the radwaste issue, some criticize its assessments of uncertainties — both technical and financial — associated with decommissioning. For example, the report asserts that further research and new technologies will be necessary for the dismantling of large-scale plants. But Robert Shaw, a manager in the Palo Alto, Calif.-based Electric Power Research Institute's nuclear division, told SCIENCE NEWS that after analyzing this issue, "we came to the conclusion that nuclear plants can be dismantled in a very safe way with techniques and technologies that have already been proven."

Moreover, he says, the industry's experience in repairing large plants and decommissioning small plants — like Shippingport — involves activities "that in many instances would parallel the kinds of things that one would need to do in order to decommission a large plant." By piecing together these experiences, utilities "can come up with very reasonable cost estimates," ones that are much smaller than some of those considered in the Worldwatch report. Dave Harward of the Bethesda, Md.-based Atomic Industrial Forum, an industry group, put "reasonable" utility estimates of decommissioning a large plant at only up to about $170 million.

Pollock counters that current decommissioning technology involves many technologies that are still in their infancy and often almost prohibitively costly — like robotics for remote handling of very radioactive equipment. As to her citation of potentially exaggerated cost estimates, she says that at least one of her sources was from within the nuclear industry itself. The French Atomic Energy Commission's decommissioning director, she says, reported at an international meeting last year that his cost estimates for decommissioning, using available techniques, "would be at least 40 percent of the cost to build [a plant]" — a figure that for new U.S. plants could easily exceed $1 billion.

— J. Raloff