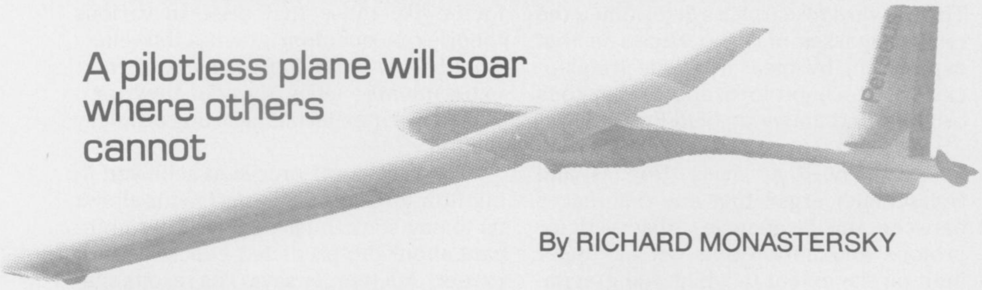
Voyage Into Unknown Skies

A pilotless plane will soar where others cannot



By RICHARD MONASTERSKY

Sometime this summer, a plane called *Perseus* will sweep over the Mojave desert at the uninspiring speed of 30 miles per hour. The lanky, long-winged craft will rise a few hundred feet above the ground, and perhaps even top 1,000 feet – hardly a recordbreaking altitude.

But beyond that modest maiden voyage, *Perseus'* designers have set their sights on truly ambitious missions into some of the most dangerous parts of the atmosphere. The winged robot, a hodgepodge of borrowed technology and parts, is designed to fly higher than any other nonmilitary airplane, reaching altitudes of more than 25 kilometers (82,000 feet). Its vertical range and the absence of a pilot make *Perseus* ideal for carrying scientific instruments into the middle of the Antarctic ozone hole and other places where humans have never flown.

Atmospheric researchers have no problem dreaming up ways to use such a unique and inexpensive machine. "It has developed a very strong backing in the scientific community," says James Anderson of Harvard University, an atmospheric chemist who designed the instruments *Perseus* will carry on its first scientific mission. "It's really an idea whose time has come."

If *Perseus* succeeds, it may forever alter the way researchers probe the skies. John S. Langford, the aeronautical engineer who conceived the project, has drawn up plans for an entire fleet of these unmanned planes, some designed to fly for months on end and others that could reach altitudes of 35 km or higher.

The inspiration for *Perseus* arose from two planes that couldn't have been more different from each other.

In April 1988, a Greek cycling champion pedaled a flimsy-looking craft called *Daedalus* from the island of Crete to the island of Santorini, 116 km away, in a marathon journey that tripled the distance record for human-powered flight. *Daedalus,* developed by Langford and his colleagues at the Massachusetts Institute of Technology, owed its success to computer-designed wings that gave the plane a remarkable ability to remain airborne while powered only by its internal human engine (SN: 4/30/88, p.277).

Several months before the *Daedalus* feat, and halfway around the world, a revamped U.S. spy plane called the ER-2 completed a series of extremely dangerous piloted missions into the outer margins of the Antarctic ozone hole. This high-flying laboratory collected air samples in the polar stratosphere, providing scientists with the evidence they needed to prove that chemical pollutants cause the ozone hole.

To Anderson and other ozone investigators, the missions carried out by that NASA ER-2 demonstrated the scientific value of high-altitude aircraft. The flights also revealed the need for a plane that could reach even higher.

Therein lies the connection with Langford and *Daedalus.*

Although *Daedalus* flew no more than a few meters above the sea, Langford knew its wing shape would also work at extreme altitudes. That's because both *Daedalus* and high-flying jet planes such as the ER-2 confront the same basic problem: not enough air. Planes get their lifting power – the ability to stay aloft – from air flowing over their wings. Most create airflow by propelling themselves forward at high velocity. But because the human-powered *Daedalus* averaged only 30 km per hour (about 19 mph), relatively little air passed over its wings. To compensate, its engineers fashioned an extremely efficient wing shape, providing maximum lift at low speed. The unique design keeps air flowing smoothly over the wing surface, with relatively little drag-producing turbulence.

A plane flying at an altitude of 25 km, where the air is about one-thirtieth as dense as air at the ground surface, would face a similar challenge. Langford reasoned that the technology that made *Daedalus* a success could also help atmospheric researchers obtain information from high altitudes. He contacted Anderson, and the *Perseus* project took off.

Aurora Flight Sciences Corp. in Alexandria, Va., looks more like a software firm than an aircraft factory. In this glamorized garage space, personal computers appear to outnumber personnel. It's the kind of office where a few spindly plants struggle to survive and probably won't last the month. Founded by Langford in 1989, Aurora is designing and constructing the *Perseus* craft.

Unlike big aircraft companies, which can sink several hundred million dollars into designing a new plane, Aurora hopes to produce three *Perseus* planes for a total of less than $3 million. To reduce costs, they've tried to borrow off-the-shelf parts and designs instead of developing custom elements, making the plane a sort of patchwork of hand-me-down technology.

Because *Perseus* and *Daedalus* face similar airflow problems, the Aurora team can use the special wing design of the human-powered plane. *Perseus* will get its heart – the motor – through another technological transplant. At one point, the design group planned on borrowing a Honda motorcycle engine. Now they're considering a motor from an unmanned plane used by the military. In either case, the high-flying craft will carry canisters of liquid oxygen, since the air at its target altitudes is too thin to sustain combustion in the engine.

Loaded up with fuel and scientific instruments, *Perseus* will weigh about 400 kilograms (880 pounds) – almost as much as a Harley-Davidson motorcycle with a rider. Aurora is building the plane with extremely lightweight but strong materials such as graphite and kevlar (the stuff of bulletproof vests), and project planners have dispensed with any equipment they deemed unnecessary. Most noticeably absent are the numerous safety features required for manned flight.

At sea level, the plane will fly at a poky pace of 48 km per hour. Even migrating geese fly faster than that. At an altitude of 25 km, *Perseus* will sustain speeds of about 280 km per hour, still slow compared with most planes.

On takeoff, it won't cruise down the runway like a commercial jet bound for Miami. The plane's giant propeller is so long that it can't turn freely while the craft remains on the ground. So *Perseus* will take off in the manner of some sailplanes, pulled forward with the help of a winch-driven cable until it's airborne, at which time the motor will engage and the cable will release the craft.

Perseus can carry only enough fuel for the upward journey, a steep climb that should take about 90 minutes. One flight plan calls for it to cruise at an altitude of 25 km for an hour or so, until it runs out of fuel. Then comes a two- to three-hour glide back to Earth. Although a technician on the ground can command the vehicle remotely, *Perseus* will largely pilot itself, using an onboard flight computer that carries preprogrammed plans. As the plane flies, the computer will determine the plane's location by receiving signals from Global Positioning System satellites (SN: 12/8/90, p.358).

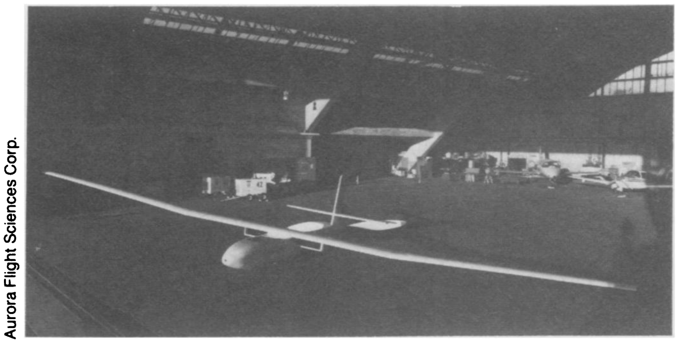
Langford believes unmanned planes like *Perseus* can offer some critical advantages over other high-altitude research craft.

Scientific research balloons – some of them 100 times bigger than the Goodyear blimp – haul heavy instruments to extreme altitudes. Yet these uncontrollable vessels follow the whim of the winds, often heading in unwanted directions. What's more, researchers can launch them only in the calmest conditions – a rare occasion in the Antarctic and other regions prone to bad weather. Investigators often must wait days for suitably light winds.

Jet airplanes such as the ER-2 face different problems. Although the celebrated ex-spy plane has proved invaluable on its ozone expeditions, it cannot reach altitudes of more than about 20 km. Over much of the globe, that's too low for studying the critical section of the stratosphere where most of the ozone resides.

Perhaps even more limiting are the safety considerations that apply when any plane carries a human pilot. On many of its research missions, the single-engine ER-2 has ventured into remote and risky territory. During the Antarctic flights, says Anderson, "if that engine had failed in any way, you would have lost the pilot's life. It was so cold there that even if the pilot bailed out successfully, he would be dead from exposure before he even reached the ground."

Unmanned planes, on the other hand, can fly into zones where no one would dare send a pilot.



Aurora Flight Sciences Corp.

Perseus gets its push from a propeller on the tail of the plane, allowing scientific instruments onboard to sample clean untainted air through a hole in the nose.

Under current plans, *Perseus* may earn its wings in the skies over Antarctica during mid-1993. A transport jet will carry three copies of the plane, broken down into sections, to McMurdo Station at 72°S. From there the planes will fly to the heart of the stratospheric ozone hole, collecting air samples in an area previously explored only by balloons and satellites.

The plane will also spend considerable time at the opposite end of the world, probing the skies above the Arctic. Although this region has yet to suffer the kind of wholesale ozone destruction seen each spring in the Antarctic, scientists worry that ozone holes may develop there as atmospheric levels of chlorine pollution reach even greater concentrations during the next few decades. ER-2 expeditions to the Arctic have already detected some ozone loss during winter (SN: 3/24/90, p.183).

If the polar regions seem far away, consider the stratosphere over our own heads. *Perseus* will fly into this zone as well, assisting in studies of the slow erosion of the ozone layer over the northern midlatitudes. Satellite and ground-based measurements indicate that the wintertime ozone concentration over this portion of the world – which includes the United States, Europe, the Soviet Union and large parts of China – dropped by several percent between 1969 and 1986 (SN: 3/19/88, p.183).

Scientists don't have enough information yet to determine whether chlorine pollution caused that decline, but many suspect such a link. If they're right, the erosion may accelerate as chlorine levels continue to rise.

A proposal by aircraft companies to build a fleet of supersonic commercial jets poses another potential threat to the ozone over the United States and other midlatitude regions. These planes, flying at several times the speed of sound, would shave hours off a journey between Tokyo and London. But because they travel in the lower stratosphere, their exhaust could possibly lead to ozone destruction over the midlatitudes. A NASA-directed research project is currently investigating whether the high-speed planes would present an appreciable threat.

A major chunk of the funding for launching the *Perseus* project comes from that same research program, says Michael J. Prather of the NASA Goddard Institute for Space Studies in New York City. Like most other researchers in this field, Prather sees considerable potential in the *Perseus* project. "If they can do it, it will be a great new opportunity for all of the atmospheric sciences," he says.

At a cost of three planes for $3 million, the *Perseus* venture carries a relatively economical price tag, says Langford.

Balloons might seem cheaper at $15,000 to $100,000 apiece. But their price adds up because each can fly only once. What's more, in harsh regions such as Antarctica, scientists often cannot recover instruments released by the balloons. A balloon-borne equipment package can cost several hundred thousand dollars.

Perseus is reusable, and after producing the initial three planes, the Aurora designers believe they could build subsequent versions for under $500,000 each.

Langford notes that these planes won't last as long as commercial jets, which make thousands of trips before their retirement. Aurora hopes to obtain about 50 research flights from the planes involved in difficult missions and perhaps hundreds of flights from those engaged in more routine work. But if a *Perseus* plane accomplished only three flights, it would still represent an economically viable alternative to balloons, Langford says.

Its many virtues notwithstanding, the high-flying plane can only carry a skimpy 50-kilogram load of instruments and will spend relatively short periods of time at its peak altitude. "*Perseus* is too small to be the ultimate solution," Langford says.

The Aurora team has sketched out designs for a virtual fleet of unmanned planes, each serving a particular need. Another model of *Perseus,* for instance, could fly for several days at slightly lower altitudes. Storm experts hope to send it above the tops of hurricanes, into the region that apparently controls the movement of these storms. A larger plane called *Theseus* could fly even higher than the original *Perseus* and could carry a payload of more than 200 kilograms. Much farther down the road, a solar-powered plane called *Odysseus* might float over the globe on year-long flights, carrying instruments for extended investigations previously conducted only by satellites.

But before these models can come to life, *Perseus* must prove itself – a process that may take several years. Aurora has yet to build the actual research plane; it has only produced a "proof-of-concept" craft for use in the tests this summer. With sufficient funding, Aurora says it can have a high-altitude version ready to fly within two years.

A number of aeronautical experts outside the project have voiced support for the *Perseus* venture. "What Langford is proposing is a very important and reasonable challenge," says Paul B. MacCready, who heads AeroVironment, Inc., in Monrovia, Calif. "The only question is: Is it medium-hard or very hard? It's not a trivial project."

MacCready has fashioned many award-winning cars and planes, including the *Gossamer Albatross,* the first human-powered plane to cross the English Channel. "I'm very confident in the *Perseus* project's success," he says, "but it will take a fair amount of effort."

Langford and his co-workers, undaunted by that challenge, maintain high hopes for their slender craft as they await its first date with the winds. □