Helios, Taking Power From The Sun

For most aerospace buffs, California's Mojave Desert is a place of speed. This is where the sound barrier was broken in 1947, where the X-15 pushed itself to the edge of space in the 1950s and '60s, and where the Space Shuttle made its first landings (and still returns on occasion).

In California's Mojave Desert, engineers at NASA's Dryden Flight Research Center are refining the Helios solar-powered aircraft. It's an unmanned vehicle that looks too fragile to fly. NASA sponsors the project, with the majority of the work done by AeroVironment in Monrovia, CA. Some of the flight-testing on the Pathfinder and the Centurion/Helios Prototype was conducted at Dryden. The remaining work is now planned for the Navy's Pacific Missile Range Facility on the island of Kauai, Hawaii.

"We're trying to grow this concept into a much larger airplane, an airplane that's capable of not only flying under solar power, but also higher than anything before," said John Del Frate, the Solar Powered Aircraft Project Manager at Dryden.

Modern electronics are becoming so small and reliable that complex payloads can be put on unmanned aircraft that operate for extended periods at high altitudes. The aircraft will stay in the air for 6 months at a time, be brought down for maintenance, and sent back up again.

Such a vehicle could **loiter**, as pilots put it, over an area, making detailed observations of the environment around the clock. Unlike satellites, the payload would always be over the target. Or, it could carry a communications relay station to link people in remote locations without the cost of building cell phone towers.

The first challenge was building an airplane light enough to do the job and be powered by electric motors.

Batteries were used first as the power source. But, batteries have to be recharged or replaced, and even the best weigh too much for efficient aircraft operations. So, the challenge is to tap into the Sun. "The existing battery technology is too heavy. We would not be able to get off the ground with it. Even the very best of the lithium-ion batteries are too heavy."

"Ten million dollars worth of solar arrays are being installed on the airplane," Del Frate continued. These silicon-crystal solar arrays will give the aircraft the capability of going

up to 100,000 feet (30.5 km). That will set all kinds of flight records. Assuming that we're successful, it will be breaking the **SR-71's** records" for sustained-altitude fixed-wing flight at 80,258 feet (24.5 km).

The Helios Prototype will carry a water tank, gas tanks, an **electrolyzer,** and a fuel cell in addition to the solar cells. The electrolyzer's function can be demonstrated in a high school chemistry lab: Electricity passes through the water and splits the water molecules into hydrogen and oxygen atoms. In the Helios **regenerative** power system, only a third of the electricity from Sunlight will power the motors. The other two-thirds will run the electrolyzer.

"All day long, the electrolyzer converts water into hydrogen and oxygen, which are stored in separate tanks under pressure," he said. "Then, at nighttime, you reverse the process." The hydrogen and oxygen are recombined in the fuel cells to produce electricity for the motors, water for the next day's fuel regeneration, and waste heat. (No energy storage system is completely efficient, so half of the energy going into the regenerative system is lost as waste heat.)

"It's a **closed system**. You don't have to get recharged or get more fuel."

Helios will carry two independent systems weighing about 220 pounds (100 kg) each. It's a powerful system; each kilogram of the system can deliver about 400 watts of electricity per hour. Del Frate expects that as the regenerative system is refined, it will peak at 800 watt-hrs/kg.

Don't look for this to be on store shelves, though. It's a sophisticated system with lots of plumbing, valves, pumps, and controls. Del Frate is optimistic that eventually it will be as reliable as a household refrigerator, another complex system that we take for granted.

The project builds on the successes of the solar-powered Pathfinder—with a wingspan of just 98.4 feet and six electric motors—and the Pathfinder Plus aircraft that flew in the 1990s. On Aug. 6, 1998, Pathfinder Plus set an altitude record of 80,201 feet for a solar-powered aircraft.

Most recently, NASA and AeroVironment developed Centurion, a 200-foot wingspan aircraft flown in 1998 to verify the handling qualities and performance of a lightweight all-wing aircraft. Centurion was rebuilt and renamed Helios Prototype.

Helios has a span of 247 feet, greater than a Boeing 747, yet it is only 12 feet long. The **wing chord** (length from leading to trailing edge) is 8 feet, is less than a foot thick, and stands about 6 feet tall. All told, it weighs less than a small car—about 1,500 pounds.

Airspeed is 19 to 25 miles per hour, and the cruising altitude is 50,000 to 70,000 feet. The goal, though, is 100,000 feet, an altitude that the Helios team will reach in the summer of 2001.

Hopefully, private industry will want to take the design and the technology and build its own platforms for communication relays or to search for natural resources. "They're looking for a platform that they can put their telecommunications payloads on board, similar to what you would have on a satellite, and it would serve a variety of different communications needs—cell phones, TV, Internet, third-generation mobile, etc." The National Oceanic and Atmospheric Administration is interested in weather observations, including hurricane tracking.

The work won't be over then. Del Frate said the solar arrays could be more efficient since they actually work better on cloudy days. This is because Helios is above the clouds that reflect Sunlight to the underside of the solar cells. The airframe also can be made lighter, some systems made more reliable, and moving parts reduced.

"Another reason for optimizing the aircraft is that it will give the aircraft a larger operational region to work 12 months out of the year," Del Frate added. "I expect commercial operations to start in equatorial regions, and as the system matures, the added efficiencies will allow it to operate at higher and higher latitudes."

Just as the winter hemisphere of Earth intercepts less Sunlight per unit of surface area because it is at an angle, a solar-powered aircraft will intercept less Sunlight during winter and more during summer. The bigger hurdle will be storing solar energy so Helios can fly at night.

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC99-43140-11 Date: August 18, 1999 Photo by: Tom Tschida
Closeup of the Helios Prototype on lakebed

"So better solar cells, energy storage system, less weight, bigger wing span, etc., all combine to enable the Helios to cover more and more of our globe," Del Frate added.

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