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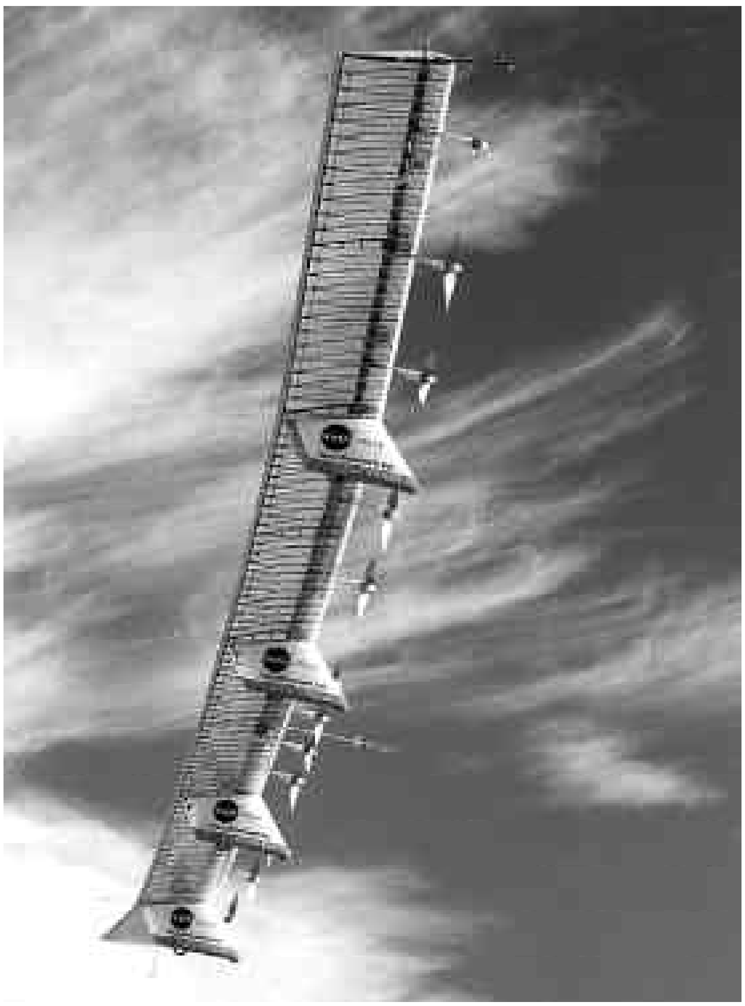
CENTURION — Reaching the New Century on Solar Power



Centurion in flight, NASA photo by Tom Tschida.

Project Summary

Envision an aircraft that can fly at the edge of the atmosphere for hours on end, slowly and silently soaring while its sensors and instruments record data for scientists on the Earth some 19 miles below. Envision it doing so on a renewable, virtually inexhaustable energy source that is non-polluting—the energy of the Sun.

Welcome to the world of Centurion, a unique remotely piloted solar-powered airplane being developed under NASA'S Environmental Research Aircraft and Sensor Technology (ERAST) program at the Dryden Flight Research Center, Edwards, Calif. Under the ERAST Joint Sponsored Research Agreement, NASA Dryden has joined with AeroVironment, Inc., headquartered in Monrovia, Calif., to design, develop, manufacture and conduct developmental flight tests of the Centurion, the first aircraft believed capable of achieving sustained horizontal flight at altitudes of 90,000 to 100,000 feet. Being able to fly at these altitudes would meet an ERAST goal of developing an ultra-high altitude aircraft which could meet the needs of the science community to perform upper-atmosphere environmental data missions.

Centurion has been designed to not only reach extreme altitudes, but to do so while carrying 100 pounds of remote sensing and data collection instruments for use in scientific studies of the Earth's environment. It also is capable of carrying 600 pounds of sensors, telecommunications and imaging equipment up to 80,000 feet altitude, and of performing multi-week flights at the north or south poles during summer.

Under its agreement with AeroVironment, NASA Dryden is responsible for monitoring and oversight of the Centurion development project. Dryden also is responsible for ensuring the safety of flying and ground operations, coordination of facilities, development of potential payloads that could be carried by the aircraft, and conducting independent reviews of aircraft systems and operations.

The ERAST Program

ERAST is a NASA initiative designed to develop the new technologies needed to continue America's leadership in the highly competitive aerospace industry.

The primary focus of ERAST is on the development of slow-flying remotely-operated aircraft which can perform long-duration science missions at very high altitudes above 60,000 feet. These missions could include remote sensing for earth sciences studies, hyperspectral imaging for agriculture monitoring, tracking of severe storms, and serving as telecommunications relay platforms. The most extreme mission envisioned would reach altitudes of 100,000 feet.

A parallel effort is developing lightweight, microminiaturized sensors which can be carried by these aircraft.

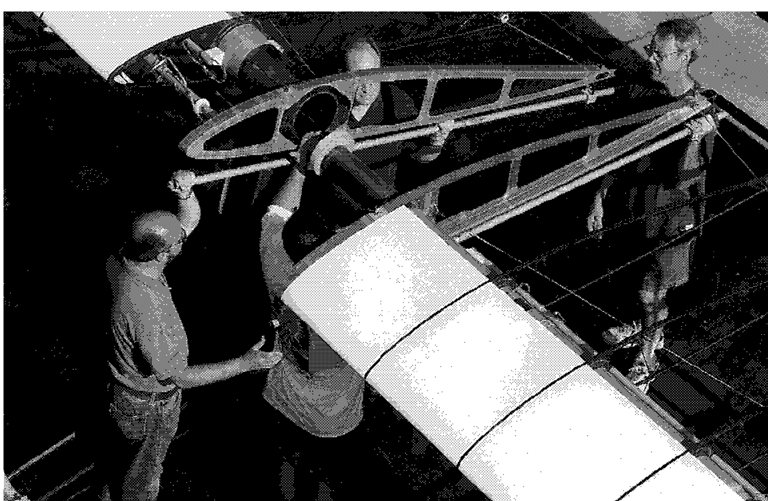
Additional technologies considered by the joint NASA-industry ERAST Alliance include lightweight materials, avionics, aerodynamics and other forms of propulsion suitable for extreme altitudes and duration.

Although ERAST Alliance member firms are responsible for aircraft development and operation, NASA has primary responsiblity for overall mission and program success. As such, NASA provides overall program leadership, major funding, individual project management, development and coordination of payloads and oversees operational safety. NASA also is working long-term issues with the Federal Aviation Administration and developing technology to make operation of these remotely operated aircraft in national airspace practical.

Aircraft Description

The Centurion is a state-of-the-art advance on the technology first developed in the Pathfinder flying wing and its follow-on, the Pathfinder-Plus, that set an unofficial world altitude record for solar-powered aircraft of 80,201 feet in the summer of 1998. The altitude was also the highest ever achieved by a propeller-driven aircraft.

Like its immediate predecessors, Centurion is a lightweight, solar-powered, remotely piloted flying wing aircraft that demonstrates the technology of applying solar power for long-duration, high-altitude flight. It is considered to be a prototype technology demonstrator for a future fleet of solar-powered aircraft that could stay airborne for weeks or months on scientific sampling and imaging missions.



Although it shares many of the design concepts of the Pathfinder, the Centurion has a wingspan of 206 feet, more than twice the 98-foot span of the original Pathfinder and 70 percent longer than the Pathfinder-Plus' 121-foot span. At the same time, it

Assembly of the Centurion structure at AeroVironment's Simi Valley Design and Development Center maintains the eight-foot chord (front to rear distance) of the Pathfinder wing, giving the Centurion wing an aspect ratio (length-vs.-chord) of 26 to 1.

Other visible changes from its predecessor include a modified wing airfoil designed for flight at extreme altitude and four underwing pods to support its landing gear and electronic systems, compared with two such pods on the Pathfinder. The flexible wing is primarily fabricated from carbon fiber and graphite epoxy composites and Kevlar. It is built in five sections, a 44-foot-long center section and middle and outer sections just over 40 feet long. All five sections have an identical thickness that is 12 percent of the chord, or about 11.5 inches, with no taper or sweep. The outer panels have a pronounced 10-degree dihedral (upsweep) to assist in lateral stability, and a slight “washout,” or upward twist, at the tips of the trailing edge to prevent tip stall on landing or in turns.

Solar arrays that will cover most of the upper wing surface will provide up to 31 kilowatts of power at high noon on a summer day to power the aircraft’s 14 electric motors, avionics, communications and other electronic systems. Centurion also has a backup lithium battery system that can provide power for between two and five hours to allow limited-duration flight after dark. Initial low-altitude test flights at Dryden in 1998 are being conducted on battery power alone, prior to installation of the solar cell arrays.

Centurion flies at an airspeed of only 17 to 21 mph, or about 15 to 18 knots. Although pitch control is maintained by the use of a full-span 60-segment elevator on the trailing edge of the wing, turns and yaw control are accomplished by applying differential power—slowing down or speeding up the motors—on the outboard sections of the wing.

The “Eternal Airplane”

Although Centurion represents the state of the art in solar-powered flight at present, it is just another rung on the ladder towards achieving semi-perpetual flight for extended-duration science studies, an ultimate goal of the ERAST program and of AeroVironment’s solar aircraft developments.

The next steps will be “Centelios” and “Helios,” the planned follow-on vehicles to Centurion.

The Centelios, a transitional aircraft like the Pathfinder-Plus, will be a hybrid between the Centurion and the Helios. The Centelios will be an upgrade of the Centurion, but with a rechargeable fuel-cell energy storage system installed to provide electrical power for night flying. A sixth wing section, increasing wingspan to about 250 feet, will be required to carry the additional weight of the fuel cell system. The Centelios will be designed to remain aloft above 60,000 feet altitude for at least four days and nights, meeting an ERAST Level I milestone currently set for the year 2005.

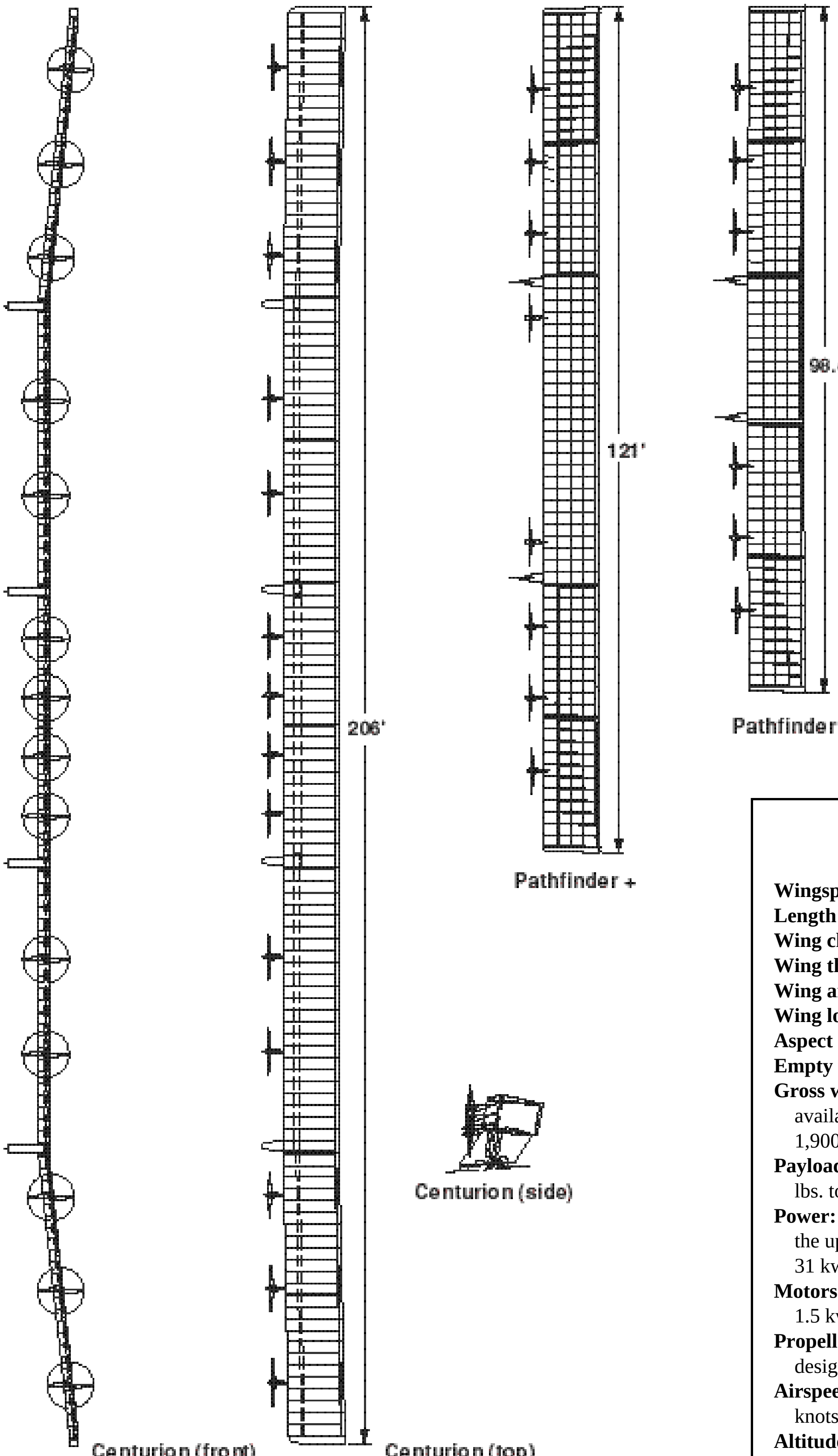
The Helios is intended to be the ultimate “eternal airplane.” Helios will be designed to fly for up to four months at a time at altitudes from 50,000 to 70,000 feet while carrying a 200-pound payload. It can operate year-round in the tropics, and up to the north and south poles during local summers. Similar to the Centurion in design, the Helios would have a slightly longer wingspan of about 220 feet and refinements to increase long-term systems reliability.

For Helios to achieve its mission, however, advanced fuel cell technology with increased efficiency and lower weight will be required. Since the weight of battery systems makes them impractical, the focus is on improving the efficiency of lightweight hydrogen-oxygen fuel cells and electrolyzers, whose weight is about half of battery systems of comparable capacity. Once such fuel cell systems are developed, the ultimate solar flying machine, capable of flying day and night for months on end, can become reality.

Program Management

The ERAST program is sponsored by the Office of Aeronautics and Space Transportation Technology at NASA Headquarters, and is managed by the NASA Dryden Flight Research Center, Edwards, Calif. Sensor technology development is headed by the NASA Ames Research Center, Moffett Field, Calif. The Centurion was designed and manufactured by AeroVironment, Inc., Monrovia, Calif., at the firm’s Design and Development Center in Simi Valley, Calif.

Comparison of Centurion to Pathfinder and Pathfinder +



Aircraft Specifications

Wingspan: 206 feet (61.8 meters).
Length: 12 feet (3.6 meters).
Wing chord: 8 feet (2.4 meters).
Wing thickness: 12 percent of chord.
Wing area: 1,648 sq. ft.
Wing loading: 0.66 pounds/sq. ft.
Aspect ratio: 26 to 1.
Empty weight: About 1,175 lbs. (529 kg).
Gross weight: Varies depending on power availability and mission profile; approximately 1,900 lbs. for a mission to 80,000 feet altitude.
Payload: Varies depending on altitude; about 100 lbs. to 100,000 ft., 600 lbs. to 80,000 feet.
Power: Bi-facial solar cells, covering 80 percent of the upper wing surface, maximum output about 31 kw (Initial test flights battery-powered.).
Motors: 14 brushless direct-current electric motors, 1.5 kw (2 hp) each.
Propellers: two-blade, wide-chord, laminar-flow designed for high altitudes, 79 in. diameter.
Airspeed: Approx. 17-21 mph (27 to 33 km, 15-18 knots) cruise.
Altitude: Up to 100,000 feet (30 km, 19 miles).
Endurance: About 14 to 15 hours, daylight limited with two to five hours on backup lithium batteries.
Primary materials: Carbon fiber and graphite epoxy composite structure, KevlarTM, styrofoam leading edge, plastic film covering.