The Special Helios Prototype Edition

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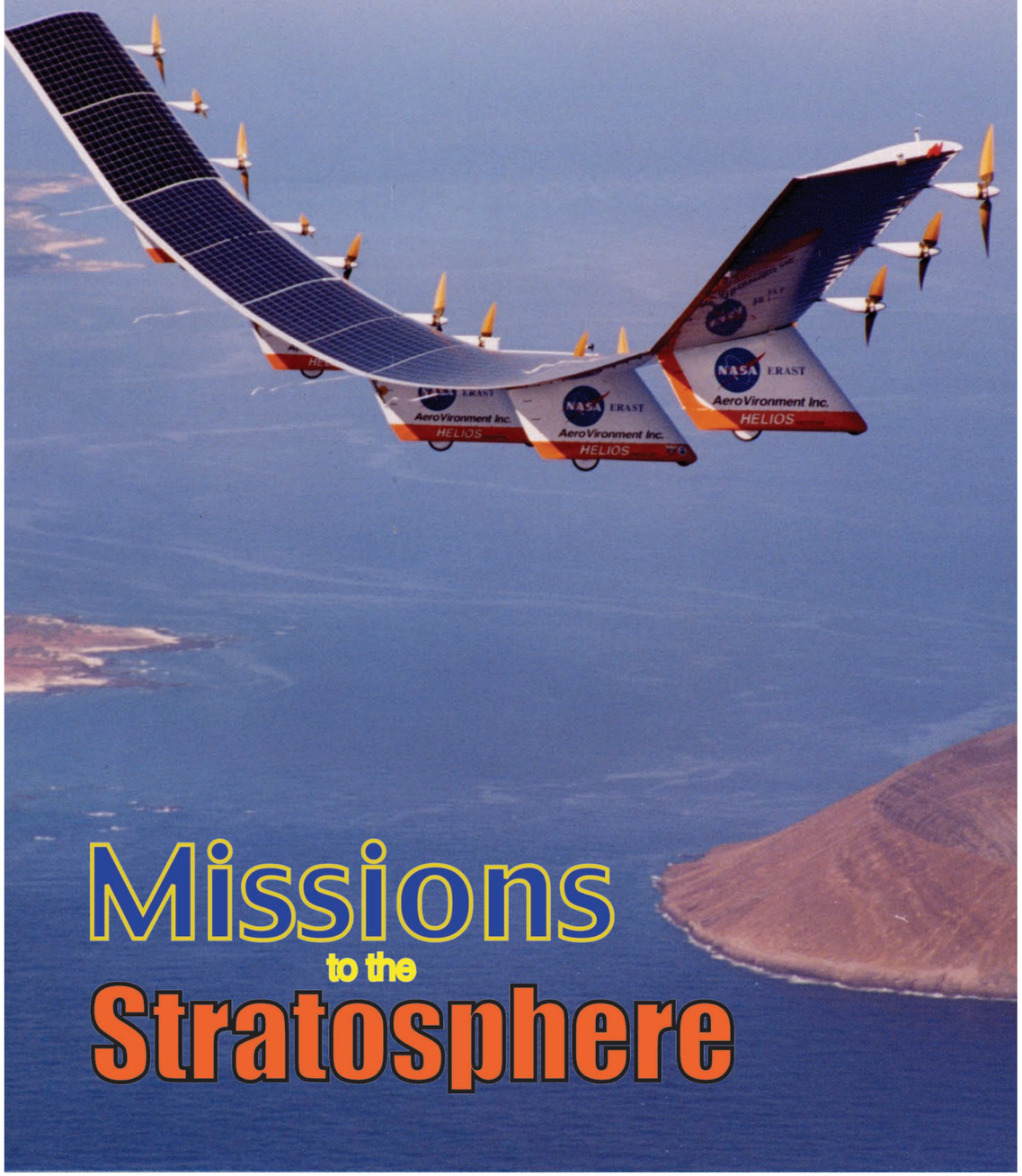


Missions to the Stratosphere

ED01 0230-3 NASA Photo by Carla Thomas

The Helios Prototype Aircraft begins a northerly climb over Ni'ihau Island, Hawaii.

Conquer the Night

■ Fresh off a record flight last summer, the project seeks to post another record in 2003

By Jay Levine
X-Press Editor

The Helios Prototype set an altitude record at 96,863 feet and made a run as a candidate for one of aviation's greatest prizes, the Collier Trophy.

So what does a project team do for an encore? That's what the Helios Prototype Team began to answer even before the record flight – to again demonstrate new abilities by initiating activities toward a duration flight that will exceed a day and night cycle above 50,000 feet during Summer 2003.

"Technically it's a very challenging mission. We will probably set up well before the summer. We fully expect to see some problems that require us to go back to the shop and test facilities and fix them and come back and fly. For that reason, it would be good to be close to test stands and suppliers to maximize our opportunities to meet our mission goals," said John Del Frate, solar-powered aircraft project manager.

The Helios Prototype spent about seven hours above 50,000 feet on its record breaking high-altitude flight Aug. 13, 2001. However, the mission in 2003 is expected to see the aircraft for at least 14 hours above 50,000 feet with different systems and procedures.

"This is a whole new ballgame for us because we are trying to conquer the night. The longer mission will require multiple shifts and therefore a much larger team. This mission also has more hazards associated with it. We will be looking at issues we have not had to deal with

See Night, page 9

Helios Prototype commercialization near

By Jay Levine
X-Press Editor

As NASA looks at ways to develop technology for transfer to the commercial sector, the Helios Prototype could prove to be a model. NASA has sought to eliminate some of the risks to assist in the development of technology that could have nearly unlimited potential, said John Del Frate, solar powered aircraft project manager.

In addition to its uses for science, the Helios Prototype also is seen as a potential way to watch enemies and assist in fire fighting, emergency services and disaster analysis. And the aircraft could lead to a communications revolution (See related story).

"To a certain degree, it's like the Wright brothers. Like them, I don't think we really understand how this technology can be applied when it's fully matured. I can easily imagine thousands of these aircraft circling the skies. I think a lot of that will depend on the mission's value versus the aircraft's cost," he said.

That's some of the promise of the Helios Prototype. The aircraft is intended to be a long-duration, high-altitude bird that can loiter in the upper atmosphere above 50,000 feet – well above normal air traffic and most importantly above most of the weather, Del Frate said.

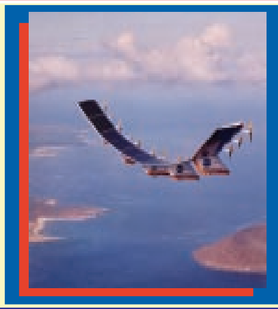
It's clear a mature and validated Helios could have a number of benefits for "any mission requiring an eye in the sky," he said.

Helios could be an asset for crop management; keep tabs on environmental changes; monitor fisheries, coral reefs, and forests; collect air samples; and conduct meteorology research and assist with mapping missions and disaster analysis.

The solar wing could also fly over a hurricane with sensor arrays to determine its direction and save money and resources in limiting evacuations, monitoring intensity and giving real-time information. Helios could be key to learning to accurately predict the location of a hurricane landfall.

"You can imagine Helios could be heavily used at the lower latitudes, especially around the equator," Del Frate said.

Inside



Cover

Nick Galante took this stunning image during a functional checkout flight of the Helios Prototype as the team prepared for a record altitude flight of 96,863 feet. See pages 6-7 for a tribute to the record-breaking mission and the men and women who helped make it possible.

EC01 245-2

ERAST: Projects validate uninhabited aircraft can fly high, for long durations, and can detect and avoid other aircraft

Proteus

Altus II

Predator B, Altair

Helios Prototype

By Jay Levine
X-Press Editor

From science missions to revolutionizing telecommunications, the Dryden-sponsored Environmental Research Aircraft and Sensor Technology (ERAST) Program has had a hand in researching some of the most innovative science aircraft to rule the skies without an onboard pilot.

Since its inception in 1994, the program has seen the maturation of a family of solar-electric powered aircraft, an assortment of unconventional uninhabited aircraft and a number of firsts in altitude and duration. Before the program wraps up in 2003, it is expected to see a first flight of the Predator B derivative Altair and a fuel-cell powered aircraft flight by the Helios Prototype Team.

A proposed follow-on program would seek to prove systems and procedures for a series of recommendations that will assist the Federal Aviation Administration in setting policies to ensure this new breed of aircraft flies safely, said ERAST Program Manager Jeff Bauer. The recommendations also will cover establishing criteria for uninhabited aircraft certification to fly in the national airspace.

Three elements define ERAST – solar-powered aircraft, consumable fuels vehicles and subsystems development, Bauer said.

The solar-electric powered aircraft effort has delivered a record altitude flight of 96,863 feet Aug, 13, 2001, for the Helios Prototype, in a flight that originated from the U.S. Navy's Pacific Missile Range Facility (PMRF) on the Hawaiian island of Kauai.

A series of research flights in 2003 are expected to validate a fuel-cell system designed to permit the Helios Prototype to fly long-duration missions. The long duration flight is expected to show that the solar wing can eventually fly multi-week or multi-month operations.

Consumable fuel aircraft include the development of the General Atomics Altair vehicle. Evolved from the Predator and Predator B, the development of the aircraft is seen as a way to meet Earth Science requirements. A first flight for the Altair is expected this summer.

"It marks a significant improvement over the Predator B and the Predator. It will have redundancy (in avionics) where past systems did not," Bauer explained. "Predator B is developed and has increased its capability. It has proven its worth. Customers have stepped forward for that vehicle."

The Altair will have an extended wing that will span 84 feet for high-altitude missions up to 52,000 feet. The aircraft also might be used to further research an Air Force collision avoidance system called the Autonomous Aircraft Collision Avoidance System.

The success of the ERAST Program also extends to the Altus aircraft. The Department of Energy has purchased the aircraft and the Navy is using Altus aircraft, Bauer said.

In addition, the Pathfinder-Plus and the Altus have completed science experiments in the national airspace.

ERAST's final element is subsystems. "We are developing the types of subsystems we believe will be required to allow these aircraft to operate in the national airspace system. The development of these advanced subsystems has a number of elements. The first is looking at potential policies and regulations and documenting how these vehicles might operate with other piloted airplanes," Bauer said.

A second element is looking at missions like the Las Cruces, New Mexico, mission in March, where the Proteus Aircraft served as a surrogate uninhabited aerial vehicle (UAV) and used onboard systems to identify potential collisions with other aircraft and allowed the remote operator to avoid the potential collision (see accompanying story).

One of the challenges that Bauer sees for UAVs is the complications of access to the national airspace and the lack of policies and procedures to regulate this growing area of aeronautics. Standardizing policies and making UAV operation and validation more routine are some of the challenges ahead for the FAA.

See ERAST, page 8

Flight research validates UAV technologies

By Frederick A. Johnsen
News chief

An aircraft with a science fiction look but an Antelope Valley birthplace flew over New Mexico March 13 in a flight that made strides toward showing uninhabited aircraft can safely share the skies with other aircraft in the national airspace.

Proteus, an aircraft built at Scaled Composites in Mojave, Calif., detected other approaching aircraft as an uninhabited aerial vehicle (UAV) stand-in. The detection enabled the aircraft's ground controller to successfully maneuver the remote aircraft away from a collision course.

"We believe this is the first time a remotely piloted airplane has been maneuvered away from a collision course based on onboard sensors detecting a collision potential," said Environmental Research Aircraft and Sensor Technology (ERAST) Program Manager Jeff Bauer.

EC02 0057-53 NASA photo by Tom Tschida

Proteus flies over the mountains near Las Cruces, N.M.

The Proteus aircraft was used as a surrogate UAV as several other test airplanes, including a high-speed NASA F/A-18 jet, approached from different angles to give sensors on Proteus the opportunity to detect the presence of aircraft on collision courses.

Proteus relayed information to the ground controller at the Las Cruces, N.M., airport, who had sufficient data displayed on a computer screen to enable him to pick a safe new course for Proteus.

The other aircraft included a Dryden T-34C and Scaled Composites' Beech Duchess business aircraft.

The flight demonstrated Dryden-sponsored ERAST Program goals including an effort to validate UAVs

See Proteus, page 9

The solar-powered Gossamer Penguin flies on Rogers Dry Lake Bed during this flight on July 25, 1979. Ray Morgan, a Dryden consultant and former vice president of AeroVironment is chasing the Penguin by bicycle in the center of the image.

ECN 13413
NASA Photo by Bob Rhine

Compiled by the Public Affairs Office

Solar-powered aircraft might one day revolutionize the way people think about aviation, solar energy and industries that rely on them. NASA's Environmental Research Aircraft and Sensor Technology (ERAST) Program, which is managed by Dryden, is helping to lead that revolution.

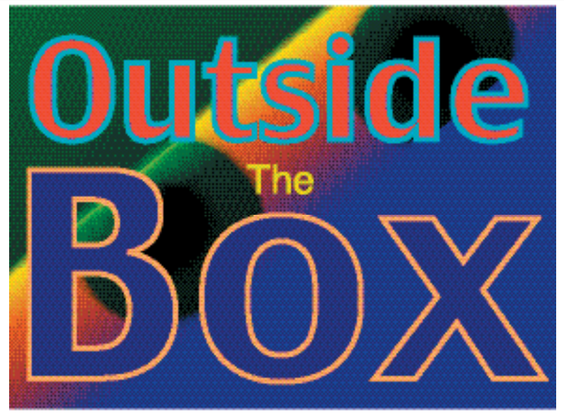
Dryden's role started in support of the human-and solar-powered aircraft being pioneered in the late 1970s by industry partner AeroVironment Inc. of Monrovia, Calif. AeroVironment, founded in 1971 by the ultra-light airplane innovator Paul MacCready, has achieved several altitude records with its Solar Challenger, Pathfinder, Pathfinder-Plus and the Helios Prototype.

Dryden played a key role in the maturing of the Pathfinder and follow-on solar-powered flying wings developed by AeroVironment under the ERAST banner.

MacCready, a former gliding champion whose Gossamer Albatross crossed the English Channel using human power in 1979, saw solar power as a way to "help business and government recognize and meet their environmental and energy objectives." MacCready remains the Chairman of the Board at Aero-Vironment.

In the beginning…

The first flight of a solar-powered aircraft took place on November 4, 1974,



Human-and solar-powered flight looked to discover new frontiers

when the remotely controlled Sunrise II, designed by Robert J. Boucher of AstroFlight Inc. flew after a launch from a catapult.

Following this event, AeroVironment took on a more ambitious project to design a human-piloted, solar-powered aircraft. The firm initially took the human-powered Gossamer Albatross II and scaled it down to three-quarters of its previous size for solar-powered flight with a human pilot controlling it. It made sense to use the design because in early 1980 the Gossamer Albatross had participated in a flight research program at Dryden in a program conducted jointly by the NASA Center and Langley Research Center, Hampton, Va. Some flights included use of a small electric motor for power.

Gossamer Penguin

The scaled-down aircraft was designated the Gossamer Penguin. It had a 71-foot wingspan compared with the 96-foot span of the Gossamer Albatross. Weighing only 68 pounds without a pilot, it had a low power requirement and thus was an excellent test bed for solar power.

AstroFlight Inc. of Venice, Calif., provided the power plant for the Gossamer Penguin, an Astro-40 electric motor. Robert Boucher, designer of the Sunrise II, served as a key consultant for this aircraft and the Solar Challenger. The power source for the initial flights of the Gossamer Penguin consisted of 28 nickel-cadmium batteries, replaced for the solar-powered flights by a panel of 3,920 solar cells capable of producing 541 watts of power.

The battery-powered flights took place at Shafter Airport near Bakersfield, Calif. MacCready's son Marshall, who was 13 years old, served as the initial pilot for these flights to determine the power required to fly the airplane, optimize the airframe/propulsion system, and train the pilot. He made the first flights on April 7, 1980, and made a brief solar-powered flight on May 18.

The official project pilot was Janice Brown, a Bakersfield school teacher and a charter pilot with commercial, instrument and glider ratings. She checked out in the plane at Shafter and made about 40 flights under battery and solar power.

The project moved to Dryden in late July, although conditions there also were not ideal. Brown finished the testing, and on Aug. 7, 1980, she flew a public demonstration of the aircraft at Dryden in which it went roughly 1.95 miles in 14 minutes and 21 seconds.

It marked the first sustained flight of an aircraft relying solely on direct solar power. It provided the designers with practical experience for developing a

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Morgan recalls solar plane's beginning

By Jay Levine
X-Press Editor

Ray Morgan took a short sabbatical from his job as a Lockheed Skunk Works engineer in 1980 to lead a one-shot solar aircraft project expected to last just eight months.

But Morgan never returned to Lockheed. Instead, Morgan was encouraged to begin the Solar Applications Division in Simi Valley for Paul MacCready's AeroVironment. MacCready is a pioneer in human-and solar-powered aircraft and founder and chairman for AeroVironment (see related story).

It was intended that Morgan would make two aircraft for DuPont, which ultimately resulted in the Solar Challenger Aircraft that set an altitude record of 14,300 feet. And on July 7, 1981, it achieved its goal when the solar powered aircraft flew 163 miles from Paris across North France and the English Channel to Kent, England (see related story above).

Morgan became one of the major influences on the development of solar aircraft with a solid vision. He retired from the Simi Valley division in 2000 (now referred to as the Design Development Center to reflect the variety of projects completed there), on the division's 20th anniversary and currently is a consultant to Dryden's John Del Frate on the Helios Prototype Project and Center Director Kevin Petersen for management systems.

His vision for the solar aircraft was clear from the start: "I believe ultimately they can be operated on a daily basis doing useful missions, particularly in the stratosphere. At the time I left we had proven that the approach was viable from the standpoint of the flight vehicle design and the flight control system design. And what was yet to be done was the energy storage development that would allow continuous operation."

See Morgan, page 9

A New Day

Efforts underway to commercialize Helios Aircraft and the stratosphere

By Jay Levine
X-Press Editor

When the Helios Prototype validates its long-duration mission ability in 2003, aircraft builder AeroVironment will be ramping up its commercial venture to fill the skies with solar-electric aircraft.

SkyTower, a subsidiary of AeroVironment developed to commercialize the solar-electric wing, sees Helios as an 11-mile-high communications tower that will fill a niche in the telecommunications market, said Stuart Hindle, SkyTower's vice president of strategy and business development.

Building off AeroVironment's work for NASA, this fourth generation solar-electric aircraft is about ready to rule the skies. Its promise – broadband services including high-speed internet access for a fraction of the cost of currently available options and the potential for other services like video phones and high definition television.

"The net result is the lowest cost broadband access, period. The record setting NASA research flights have proven the technology to be reliable and flexible and the huge gigabit/second communications capacity makes a compelling economic case to use SkyTower for local access infrastructure," said Tim Conver, SkyTower chief executive officer.

Fiber optics systems are cost effective as pipelines of information between cities. However, a bottleneck exists to moving the information from those data pipelines to flow to the user at low cost, Hindle said.

"We truly believe, as well as do telecom industry experts, that this is a revolutionary technology for bridging the last mile. The last mile is the term for the portion of the telecom network system that has the least amount of bandwidth and the highest cost – connecting from an end switch to the end users, whether residential users or business users," Hindle said.

SkyTower could open that bottleneck by partnering with existing communication companies and startup companies to establish that link between the fiber optic lines and the end users.

A fully operational Helios will operate at about 60,000 feet, above the weather and traffic, and act like a stationary satellite, but without the time delay. Helios can provide 50-to 300-mile diameter coverage areas – the footprint of a major city and more, Hindle said.

"When we use the words revolutionary and breakthrough, we are not using those terms loosely. A single SkyTower platform, because of its proximity to Earth, has over 1,000 times the local broadband capacity that a typical satellite would have using the same frequency spectrum," he said.

Photo Courtesy of SkyTower

This is one of the promotional images SkyTower is using to present its product.

SkyTower is in advanced discussions with service providers in several geographic areas and plans to launch its first test network in 2004, or early 2005.

"A network in a single region will be supported by multiple aircraft to ensure 24 hour operation, 7 days a week. Once the system is proven in a single market, we will then ramp up worldwide," Hindle said.

"These aircraft give our partners instant network abilities and the ability to easily upgrade and maintain their systems. Also Helios is reusable. If a market becomes no longer economically viable, the Helios could be deployed somewhere else," he explained.

AeroVironment's partnership with NASA has been invaluable, Conver and Hindle said.

"A key thing for us is the partnership with NASA. Through NASA funding support we have been able to buy down a lot of risk, especially on the aircraft side, by demonstrating that our platform is viable to operate in the stratosphere. Now that we've flown to almost 97,000 feet – well above the 60,000 feet to 70, 000 feet that we plan to operate at – it provides a very strong statement that this isn't some paper concept. This hardware already exists," Hindle said.

AeroVironment's collaborative process with NASA is a model for others to follow, Conver said.

"NASA collaboration moved the project along. People involved in this from the beginning are pursuing the dream of eternal flight. The spinoff technology will include lower costs for high efficiency solar cells, regenerative and fuel cell energy storage, high efficiency motors and DC-DC converters. It also is a viable business opportunity, opening the stratosphere for the first time for science, environment, telecom-munications and reconnaissance. The government has been the force to pull through this breakthrough technology and now we are pushing into the commercial market with production engineering and business development," Conver said.

SkyTower was formed in October 2000 as a subsidiary of AeroVironment focused on commercial telecom opportunities based on solar aircraft technology. AeroVironment will also provide its solar-electric UAVs to the government for broadband com-munication, long-term, high-altitude reconnaissance and disaster monitoring and emergency communications. This technology can complement the mix of existing UAVs and satellites used so successfully by adding increased duration and bandwidth," Conver said.

For additional information on SkyTower, refer to the company's Web site at www.skytowerglobal.com

AeroVironment: This creative environment for thinkers has developed innovative aero concepts

By Jay Levine
X-Press Editor

To make an unconventional aircraft that looks like a flying chocolate bar and is powered by motors about as powerful as a hairdryer, it takes an unconventional team with a different view of what an airplane should be.

That's what makes the AeroVironment Team stand out. They have quirky and forward thinking people who are comfortable coming up with creative solutions and have the talent to make those solutions work. This mix of unconventional thinking and technical excellence has defined AeroVironment and the products the company creates.

AeroVironment Founder and Chairman Paul MacCready is proud of his company's accomplishments.

"We seem to be getting into the right field. Now it is moving the way that it should, but it is surprising it took so long," he said of the solar-powered aircraft effort he began more than two decades ago.

MacCready is one of the major influences on the development and maturation of human-powered aircraft and the development of a family of solar-powered aircraft that is setting the standards for flying in the stratosphere.

AeroVironment operations began small – the company hired people as consultants on early projects like the Gossamer Condor that was started in 1976 and completed a year

See AeroVironment, page 11

EC99 44868-3 NASA Photo by Tom Tschida

AeroVironment Chairman Paul MacCready shows a cross-section of one of the solar aircraft's spars.

A Change in the Weather

By Jay Levine
X-Press Editor

When it comes to flight research, nothing flies without the weatherman.

Dryden has four meteorologists who are assigned to the Center's projects to help the research teams determine when it is best to fly – and when the conditions just aren't right to conquer a new aeronautical first.

On the record breaking Helios Prototype mission in Hawaii, weather gurus Ed Teets, NASA, and Casey Donohue, AS&M, monitored the skies to ensure the Helios team had the best conditions to reach new heights.

Less than a month after Donohue married Gretchen Gorke, duty called in Kauai, Hawaii, without his new bride. He was tasked to monitor the weather for anticipated Helios Prototype flights. And Teets and his wife Elisa were anxiously awaiting the birth of the couple's first child, a son, Connor, who was born Sept. 7, 2001.

Meanwhile, the weather staff, which also includes Chris Ashburn, AS&M, and Jack Ehernberger, NASA, was stretched with three major projects, including the X-40, the X-43A and an Airborne Sciences mission.

Flight research challenges required Donohue to make several more trips to Hawaii to assist the Helios Prototype Team and use the tools at his disposal to tell project planners what they could expect.

NASA Photo Courtesy of Casey Donohue

"For looking at surface winds we used portable wind towers, a wind profiler called a sonic detection and ranging (SODAR), which is like radar, but it uses sound. For forecasting upper level winds and clouds we used Internet resources such as the University of Hawaii and National Weather Service in addition to grabbing the latest satellite information. Rawinsonde instruments are used to measure wind speeds, wind direction, wind pressure, temperature and humidity," Donohue said.

Weather balloons also are valuable tools in weather prediction.

"We launch daily while on deployment. We use them as we get closer to flight day to look for trends in the upper level winds and jetstreams for the potential for turbulence and look for humidity to seek out cloud heights. On flight day we launch at least six. We launch the first at about 1 a.m. and it goes to peak altitude when the balloon bursts, usually above 100,000 feet. Two to three balloons before take off are reviewed for the presence of turbulence and trends," he said.

And the early morning work pays dividends.

"Mission planners look at the information we provide them on wind direction and wind speeds and they plot the mission. That information allows them to make a footprint of where the aircraft could land and ensures that the mission stays out of populated areas. Sun angle also is important because the airplane is solar powered. They need to know where the sun is going to be and fly the aircraft in the right direction to maximize the aircraft's solar power," Donohue said.

EC02 066-1 NASA Photo by Tom Tschida

The weather team has an important role in flight research. The team includes, from left, Chris Ashburn, AS&M, Ed Teets, NASA, Jack Ehernberger, NASA and Casey Donohue, AS&M. At top is an image of the Helios Prototype heading into the sun.

Donohue was in Hawaii for three and four weeks twice and several times for a week or two in between. Teets arrived about three days before the anticipated flight days and he and Donohue traded off long shifts to keep an eye on the weather.

"We were there to support the project for long hours. One person cannot realistically do it all. We were there about 27 hours for the record flight," Teets said.

"Casey had the first half of the flight and I had the second half of the flight."

Winds shift and sometimes dramatic changes in weather can happen. Enter the weatherman.

"Several times with 30 to 45 minutes to either takeoff or landing we have had to alert the project to reposition on another runway," Teets said.

The weatherman is an important member of the team, and he has to get up before the birds (especially the research ones) to assist mission planners to make some of the calls on flight day.

"My days start at 2 a.m. I will look over the data from the weather balloons and from satellite pictures for the first weather briefing of the day when the flight directors, pilots and crew chief gather at the hangar prior to aircraft rollout, which occurs about 3 a.m. A final briefing is given about two hours before takeoff," Donohue said.

The weather team is in action for as many as eight hours before a flight and two hours after it is complete. Because Helios is a lightweight aircraft, the team wants to be aware of changes in the winds. In fact, the Helios Prototype Team treats a move to and from the hangar as if the aircraft was in the sky in terms of weather awareness.

"When you do your homework well enough, it usually takes care of itself. We pretty much know what to expect," Teets said.

In fact, the team has supported flights of the AeroVironment family of solar wings in Hawaii since 1997.

"We have some of our own data that we have collected in Kauai. We can forecast at what time in the morning when the wind speeds will exceed limits and nail it to the minute. This can be done because, in general, the wind patterns at PMRF are quite repeatable and consistent during the summer," Donohue added.

And the job is never done. Donohue is working to compare climatology of potential sites for a Helios deployment next summer for the solar wing's anticipated extreme duration flight. Climatology comparisons include looking at season averages for winds, clouds and temperature.

ERAST... from page 3

NASA's partnership between the FAA and Ames Research Center, Mountainview, Calif., can assist the FAA by recom-mending policies and procedures for the integration of UAVs to fit into the sky of the future. Follow-on programs might include the continuation of fuel cell development for the anticipated eternal aircraft of the future and an increase in autonomy for UAV aircraft and more partnering with the other NASA Centers and the U.S. Department of Defense to combine specialties in these areas, Bauer said.

The solar concept might allow an aircraft to fly for several weeks in the next five years. However, it could take a decade for the maturation of the tech-nologies that will ensure the eternal aircraft can serve the missions that scientists, business people, strategists and environmentalists see for the aircraft.

"Once you develop the energy storage systems, it will be possible to have a reliable aircraft that is operable for months at a time," Bauer said.

Bauer credits the success of the program with its structure and the partnerships that make it up.

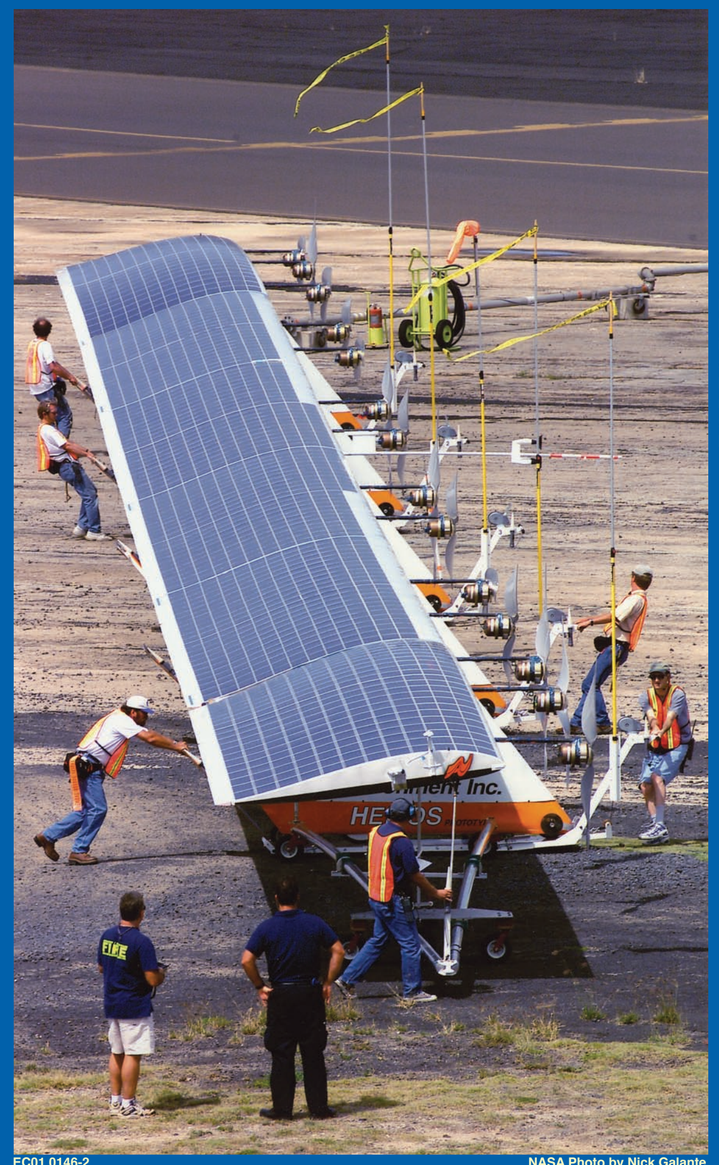
"One of the major attributes of the program is the alliance of government and industry. ERAST is not a contract. We work collectively to develop what's best for the group and the community," he said.

Partners in the ERAST Program have included AeroVironment, Inc., Aurora Flight Sciences, American Technology Alliances (AmTech), General Atomics Aeronautical Systems and Scaled Composites, several suppliers, the U.S. Air Force, the U.S. Navy, The U.S Department of Defense, the U.S. Department of Energy and universities.

A new record – 96,863 feet

Aug. 13, 2001

EC01 247-29 NASA Photo by Carla Thomas



EC01 0146-2 NASA Photo by Nick Galante

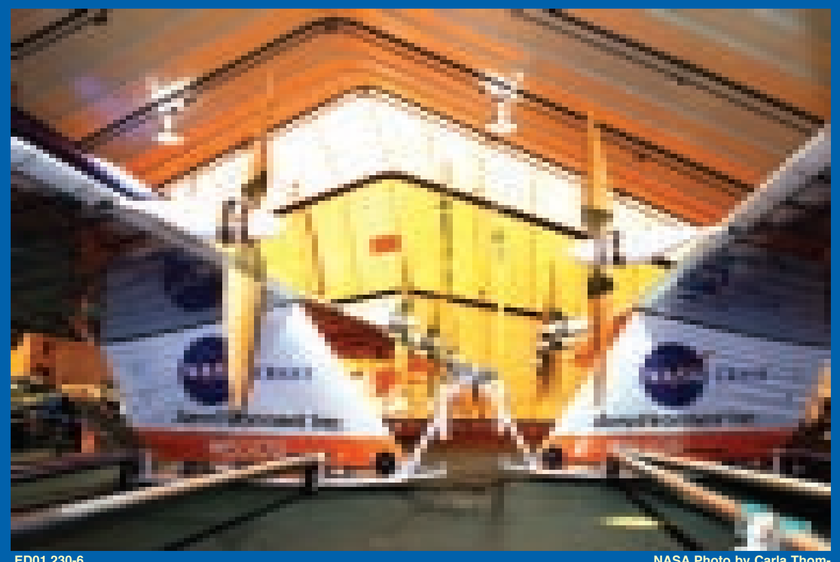
Center, the Helios Prototype flies by the western shore of Ni'ihau, which also is known as the "Forbidden Island." The island is privately owned, but the Helios Team has agreements to land on several locations in backup scenarios.

At left, ground crew members maneuver AeroVironment's Helios Prototype during functional checkouts prior to its first flights under solar power from the U.S. Navy's Pacific Missile Range Facility in Kauai, Hawaii. More than 1,800 panels containing 64,120 bi-facial cells, fabricated by SunPower of Sunny-vale, Calif., were installed on the solar- powered aircraft to provide electricity to its 14 motors and operating systems.

At right, the Helios Prototype returns from its record altitude flight.

Center, bottom, the Helios Prototype is stored in a hangar at the U.S. Navy's Pacific Missile Range Facility in Kauai, Hawaii until flight day arrives. Helios has a wing span of 247 feet, or larger than the wing span of a Boeing 747-400.

EC01 247-17
NASA Photo by Nick Galante



ED01 230-6 NASA Photo by Carla Thom-

EC01 247-20 NASA Photo by Nick Galante

The Helios Prototype Team consists of, row one, from left, Derek Lisoski, Bob Curtin, Rik Meininger, Claire Olores, Marshall MacCready and Meadowsweet Levi. In the second row are Casey Heninger, Bob Barta and Jim Daley. Row three includes Casey Donohue, Jenny Baer-Riedhart, Ken Cross, Ed Teets, Win Banning and Vince Nishina. In row four are Ken Carbine, Dale Tietz, Mandy Cannone, Bart Rusnak,Brian Matsumura, Greg Faith, Shaun Arakaki, Wolfgang Kniedl and Kirk Flittie. The fifth row features Mark Shipley, Dana Taylor, Cliff Cates, Greg Kendall, Jason Mukherjee and Stefano Paris. The back row consists of Patrick Wright, John Del Frate, Ray Morgan, Wyatt Sadler and Earl Cox.

Night... from page 2

before, like charging flammable gases to high pressure before we launch," Del Frate said.

The Helios Prototype is a solar wing that resembles a yardstick with a wing span of 247 feet, or larger than that of NASA's 747 and will demonstrate a fuel cell-based power system to permit the aircraft to fly at night.

AeroVironment, NASA's partner and the aircraft's builder, is developing the fuel-cell-based power system. The fuel-cell based power system is a step toward flying an eternal airplane that could be sent on missions spanning months, said Del Frate.

These capabilities are developed as part of Dryden's Environmental Research Aircraft and Sensor Technology (ERAST) Program that began in 1994.

Because the mission does not require the aircraft to fly as high as the mission in 2001 did, the Helios Prototype will be modified to run with about 8 to 10 motors versus the 14 motors it flew with on the record altitude flight.

The Helios Prototype team opted to remove some of the solar cells on the forward portion of the wing to reduce drag. A single pod replacing the existing center pod will contain the new power system.

"We have to provide power to systems and motors all the time. At night time, where are you going to get that power? When the sun goes down, you carry batteries or you carry something else. What we are doing is something else. Batteries are so heavy that we determined a long time ago that even with the best batteries we could barely get off the ground. The fuel-cell-based power system will be incorporated into one pod to provide the power," Del Frate said.

"We have to provide power to systems and motors all the time. At night time, where are you going to get that power? When the sun goes down, you carry batteries or you carry something else. What we are doing is something else."

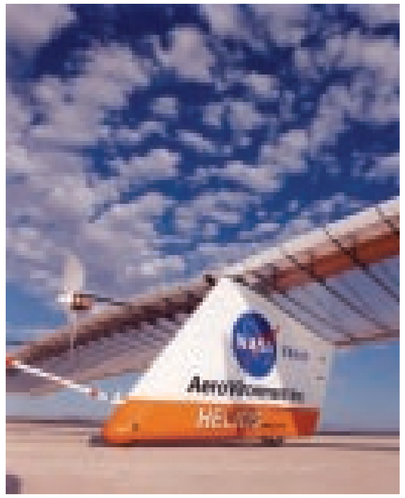
John Del Frate
Dryden's solar-powered aircraft manager

The team also will take on a new configuration. Rather than two main flight teams that switch about every three hours, the duration flight probably will require two 12-hour shifts each with two teams that alternate. Each flight crew could be twice as large because in addition to monitoring the basic aircraft, the flight crews also will be monitoring the power system.

In addition to training people for the Helios Prototype mission, AeroVironment currently is training people for work on another of the company's family of high flying solar wings, the Pathfinder Plus, in Kauai, Hawaii. Scheduled for two commercial demonstration missions outside of the ERAST Program, the Pathfinder Plus will provide a flight platform for a Japanese agency that wants to test some of their communications payloads in the stratosphere. The aircraft also will carry a remote sensing instrument for Clark University, Worchester, Mass., to monitor coffee crops. That mission is funded by NASA's Code Y.

"It's gratifying to see commercial use of the solar flying wings. Ultimately the real commercialization of the airplane will blos-som when it can rou-tinely fly extreme duration flights because that's how you get the costs down. If you launch an airplane to the stratosphere for a single day and come back down after dark, it's going to be cost prohibitive unless you have a very high-value mission. But once you are able to fly an airplane for two weeks to several months at a time, your life cycle costs come way down and so do the costs per flight hour. All of a sudden it becomes very attractive," Del Frate said.

An aircraft with multi-week to multi-month flight capability opens the door to a new way of Earth monitoring. Helios could serve as a platform for disaster relief and crop monitoring, or follow the eye of a hurricane.



EC99 45140-11 NASA Photo by Tom Tschida

Before record-setting altitude flights in Hawaii, the Helios Prototype flew at Dryden. This image was taken prior to the installation of solar cells.

Morgan... from page 4

Analysis showed the candy bar shape of the solar wings was optimum because it would catch the maximum sun with minimum weight, yet tolerate atmospheric turbulence like an "air mattress on the ocean," Morgan explained.

"The biggest challenge was proving it (the solar wing) was a viable approach – to have something extremely light, large and apparently fragile that could operate past the jet stream and into the stratosphere and back down again. We needed it to be large and light to be able to fly under solar power. We did it with a unique approach. It appears to be a monolithic, flimsy airplane, but it functions like a lot of small airplanes flying in formation with relatively flexible structural links between them," Morgan said.

A number of accomplishments were notched during Morgan's tenure with AeroVironment.

"Our first flight with Pathfinder into the stratosphere above 50,000 feet at Dryden worked out as we predicted. From a technical standpoint that was the big leap since we hadn't been over 1,000 feet above the ground before," he said.

Other big events happened in Hawaii.

"We intended to fly two flights above 65,000 feet in 1997 when we were doing our planning in 1996. And we predicted our first flight day would be June 9. On June 9, 1997, we flew above 67,000 feet and a month later, in July, our second flight reached 71,530 feet. We flew back- to-back record flights on our first two attempts and that felt pretty good," he said.

And Morgan still believes the solar airplanes are an amazing sight.

"I did the original layout for the Pathfinder in 1980 and I have seen those designs fly for nearly 20 years. Yet every time I see one take off, I'm astounded it works and works as well as it does. The Helios Prototype saw extreme turbulence right above the runway on its first high-altitude flight last summer and it just kept going," he said.

Ray Morgan was one of the driving forces in developing solar-electric powered aircraft. Although retired from AeroVironment, he still has an active role as a consultant to John Del Frate on the Helios Prototype Project.

EC97 44287-86
NASA Photo by Nick Galante

Development of the remotely piloted solar-powered wings also has claimed another remarkable achievement.

"The legacy of our program is we never had a catastrophic event in flight test. We never crashed an airplane," Morgan said.

Proteus... from page 3

are safe and compatible with piloted airplanes. The ERAST Team is developing a series of UAVs that could one day provide low-cost tele-communications relay services, environmental monitoring, and even remote border surveillance in ways that are impractical or impossible for piloted aircraft today.

NASA ran the tests in Las Cruces, N.M., with partners New Mexico State University, the U.S. Navy, and commercial partners Scaled Composites and MTSI, Inc.

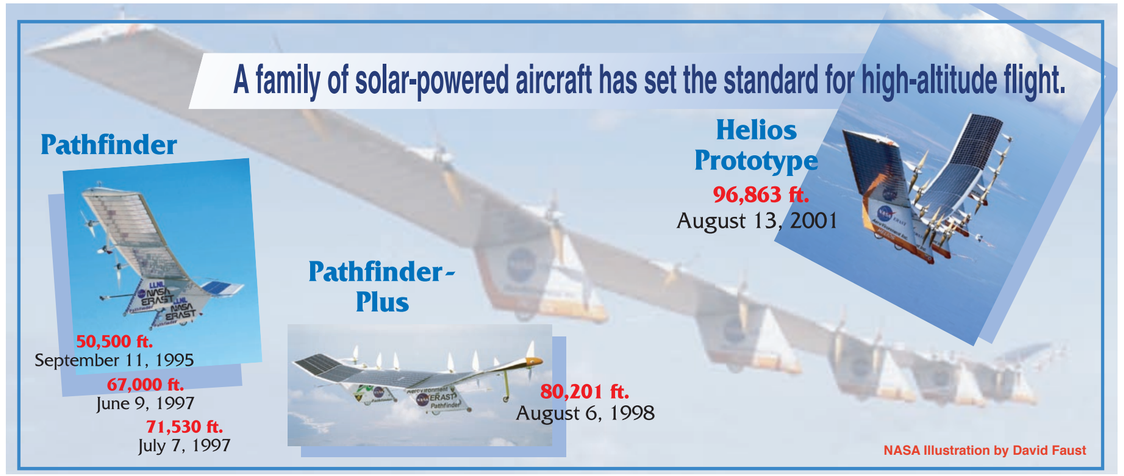
During the New Mexico tests, all the aircraft carried pilots for an additional safety margin, but a remote controller on the ground operated Proteus. In about 18 approach scenarios singly or in converging groups of two, airplanes approached Proteus from a variety of angles and altitudes, providing the ground controller with sometimes complex problems to solve to keep his aircraft out of harm's way. In all cases, the ground controller was able to safely maneuver Proteus. In reality, the approaches had a built-in safety margin of separation, but the sensors on Proteus could treat these as genuine airspace threats to validate the equipment.

"We believe this is the first time a remotely piloted airplane has been maneuvered away from a collision course based on onboard sensors detecting a collision potential."

Jeff Bauer
Environmental Research Aircraft and Sensor Technology (ERAST) Program Manager

The primary sensor used is the Skywatch HP traffic advisory system, a radio-based device that relies on common transponder radio signals from other aircraft to detect collision potential. Other sensors on Proteus used infrared or radar technology to pick out aircraft without transponder signals. Bauer said an optimized detect, see and avoid (DSA) suite for operational UAVs would probably rely on a combination of radio and non-radio sensors. Another expected benefit of this research is a reduction in the cost of DSA equipment to make it practical to use in more aircraft, whether piloted or remote, he said.

The introduction of UAVs into the national airspace must be approved by the Federal Aviation Administration. The UAV testers gathered in New Mexico believe they are a step closer to achieving that approval as a result of these tests.



Box... from page 4

more advanced, solar-powered aircraft, since the Gossamer Penguin was fragile and had limited controllability.

Solar Challenger

Using the specific conclusions derived from their experience with Gossamer Penguin, the AeroVironment engineers designed Solar Challenger, a piloted, solar-powered aircraft strong enough to handle both long and high flights when encountering normal turbulence. As compared with the Penguin's 71-foot wingspan, Solar Challenger had only a 46.5-foot wingspan, but it had a huge horizontal stabilizer and a large enough wing area to accommodate 16,128 solar cells.

Solar Challenger set an initial altitude record of 14,300 feet. More spectacularly, on July 7, 1981, the solar-powered aircraft flew 163 miles from Corneille-en-Verin Airport north of Paris across the English Channel to Manston Royal Air Force Base south of London, staying aloft 5 hours and 23 minutes.

Using in-house computer programs, AeroVironment engineers Peter Lissaman and Bart Hibbs designed the unusual wings and stabilizers, which they made flat on top to hold the solar cells. Hibbs developed the aerodynamic design for the propeller with another in-house computer program. The result was a "smooth and docile" aircraft that dropped in a steady, wing-level attitude when stalled and rapidly regained unstalled flight.

AstroFlight Inc. again provided the motor, and the DuPont Company, which produced many of the advanced materials for the Gossamer Albatross, Gossamer Penguin, and Solar Challenger, sponsored the project. Brown remained one of the pilots, but Stephen R. Ptacek, who brought to the project over 4,600 hours of flight in a variety of aircraft, was at the controls during the record-setting cross-channel flight in 1981.

Pathfinder

In 1981, the U.S. government funded a classified program to look into the feasibility of long-duration, solar-electric flight above 65,000 feet altitude. AeroVironment designed a flying wing airplane designated HALSOL (High-Altitude SOLar), built and tested three subscale models and a full-scale prototype on battery power. HALSOL proved the aerodynamics and structures, but subsystem technologies, principally for solar arrays and energy storage, were inadequate. HALSOL was then mothballed, but in the future it would become possibly the most valuable test bed for evolving solar and uninhabited aerial vehicle (UAV) technologies.

After a decade in storage, the HALSOL flying wing was resurrected in 1993 for a short-lived development program under the auspices of the Ballistic Missile Defense Organization. Its first flights with a small number of solar arrays assisting the batteries occurred that year.

When funding for the program ended after a few months, the HALSOL, now renamed the Pathfinder, became part of NASA's ERAST Program to develop remotely piloted, long-duration aircraft for environmental sampling and sensing at altitudes above 60,000 feet. Pathfinder was then modified with additional solar arrays spanning its entire 98-foot-long wing and other upgrades. It was then brought back to Dryden for another series of developmental flights in 1995.

On Sept. 11, 1995, Pathfinder exceeded Solar Challenger's altitude record for solar-powered aircraft when it reached an altitude of 50,500 feet, setting a new altitude record for solar-powered aircraft. The National Aeronautic Association presented the NASA-industry team with an award for one of the "10 Most Memorable Record Flights" of 1995.

After additional upgrades and one checkout flight at Dryden in late 1996, Pathfinder was transferred to the U.S. Navy's Pacific Missile Range Facility, (PMRF) on Kauai, Hawaii, in April 1997. Kauai was chosen as an optimum location for testing the solar-powered Pathfinder because of the high levels of sunlight, available airspace and radio frequencies and the diversity of terrestrial and coastal ecosystems for validating scientific imaging applications. While in Hawaii, Pathfinder flew seven high-altitude flights from PMRF, one of which reached a then world altitude record for propeller-driven as well as solar-powered aircraft of 71,530 feet on July 7, 1997.

Pathfinder-Plus

During 1998, the Pathfinder was modified with longer wings, improved motors, and more efficient solar arrays and renamed the Pathfinder-Plus. On Aug. 6, 1998, the aircraft flew to a record altitude for propeller-driven aircraft of 80,201 feet on the third of a series of developmental test flights from PMRF. (That record held until Aug. 13, 2001 when Aerovironment's follow-on aircraft, the Helios Prototype, flew to a new altitude record certified at 96,863 feet.) The goal of the flights was to validate new solar, aerodynamic, propulsion and systems technology developed for Pathfinder's successors.

The Pathfinder-Plus is a hybrid of Pathfinder technology and items developed for Centurion/Helios Prototype. The most noticeable change was the installation of a new 44-foot-long center wing section that incorporated a high-altitude airfoil

See Box, page 12

EC98 44776-40 NASA Photo by Tom Tschida

Before it was the Helios Prototype, it was called Centurion (see story) and it came to Dryden for checkout flights in 1998.

EC99 4514015 NASA Photo by Tom Tschida

Helios Protoype Team works a 1999 mission at Dryden.

AeroVironment... from page 5

later, he explained. When MacCready was developing the Gossamer Albatross the project required managers and a full staff. Then came the successful Solar Challenger and operations were growing large enough that full-time employees were required.

"The development of solar aircraft lead to the development of the AeroVironment division in Simi Valley. That's where Ray Morgan lived and he was available to head up the division and charge ahead," MacCready said.

Although Solar Challenger was a success, it wasn't enough business to ensure the division's survival, he said. AeroVironment did what any fledgling company would do – it sought out work. The division retained its strengths and staff by building a pterodactyl for the IMAX movie "On the Wing." It was developed at a loss, but the income kept the company's core aviation elements intact, MacCready explained.

AeroVironment has five air and ground vehicles that are part of the Smithsonian's permanent collection (see related story). The non-aviation part of AeroVironment, which has grown faster than the aviation part, involves electric vehicles and devices for ground use.

"Then the aviation programs became bigger and better. The division grew significantly with the High Altitude Solar Energy (HALSOL), a classified program that looked at the use of the solar wing as a platform for missile defense," MacCready said.

But HALSOL required technologies that were not yet available and it was mothballed. Later it evolved into Pathfinder and Pathfinder Plus for the NASA Environmental Aircraft and Sensor Technology (ERAST) Program managed by Dryden.

Bob Curtin took over as manager of the division in 2000 and Aero-Vironment's Helios Prototype flew to 96,863 feet on Aug. 13, 2001 (see related story).

Smithsonian features 5 AV projects

Five AeroVironment vehicles/ models are part of the permanent Smithsonian Institution Exhibits.

- **The Gossamer Condor** in 1977 won the Kremer prize for the first controlled human-powered airplane flight.
- **The Gossamer Albatross** in 1979 won the company a second Kremer prize for a human-powered flight across the English Channel.
- **The Solar Challenger** in 1981 achieved the first solar-powered distance flight of 163 miles from Paris to the Royal Air Force Base in Manston, England.
- **Quetzacoatlus Northropi** (QN) in 1985 replicated the flight of the largest winged prehistoric bird (a 36-foot wingspan), the pterodactyl, for an IMAX film "On the Wing."
- **The Sunraycer** in 1987 won the first trans-Australian solar-powered car race in 4.5 days, two days ahead of its nearest competitor.

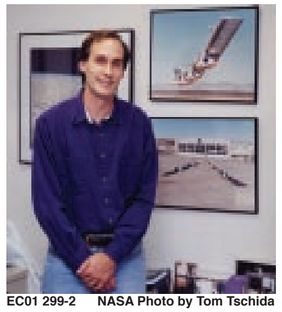
The company is preparing for yet another change – full production. Through its commercial arm, SkyTower, it is expected that the Helios will go into production as the telecommunication platform solution to overcome the "the last mile" barriers facing the tele-communications industry.

EC99 44868-7 NASA Photo by Tom Tschida

AeroVironment Founder and Chairman Paul MacCready and his son, Marshall, MacCready, show some of the company's unusual aircraft.

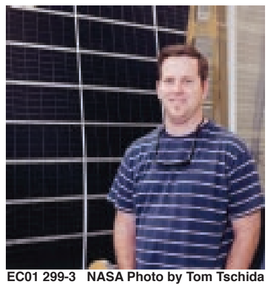
EC97 44287-149 NASA Photo by Nick Galante

AeroVironment Vice President Bob Curtin is a hard worker, which led to his promotion in 2000. Above, he checks procedures during a 1997 Pathfinder flight in Hawaii.



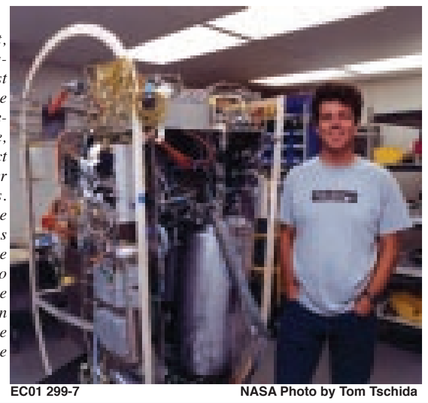
EC01 299-2 NASA Photo by Tom Tschida

Kirk Flittie, AeroVironment ERAST program manager, seeks ways to maximize commercial usage of the Helios Prototype and other AeroVironment products.



EC01 299-3 NASA Photo by Tom Tschida

Jim Daley, AeroVironment engineer and project manager for the solar arrays used on the solar-powere aircraft, led the development of the fuel-cell powered Helios Prototype.



EC01 299-7 NASA Photo by Tom Tschida

Doug Profitt, project manager for the first energy storage pod for the Helios Prototype, said his project offers a number of challenges. However, he said he enjoys his job and he is working to overcome the challenges in developing the energy storage pod.

EC01 299-5 NASA Photo by Tom Tschida

Rik Meininger, from left, who is the program manager for design, construction and flight research of Centurion and the Helios Prototype, and Bill Parks, who is the chief engineer for Centurion and the Helios Prototype, show an image of the Helios Prototype returning from its record mission.

NASA mission inspires students

By Michelle Davis
Aerospace Education Specialist

NASA is reaching out to inspire people with its aerospace projects by initiating a number of teacher, student and community opportunities.

Dryden's Education Office offers programs on NASA research to teachers, students and institutions like museums and science centers. In 1997, the Dryden Education Office began informing the national education community of the Environmental Research Aircraft and Sensor Technology (ERAST) Program.

Working closely with the ERAST program managers on Pathfinder and later the Helios Prototype, the traveling road show was developed. The plan included an educators' guide with lesson plans, a poster with a flyable model on the back (see graphic on how to build one), Web pages and an interactive demonstration for student assemblies and community events.

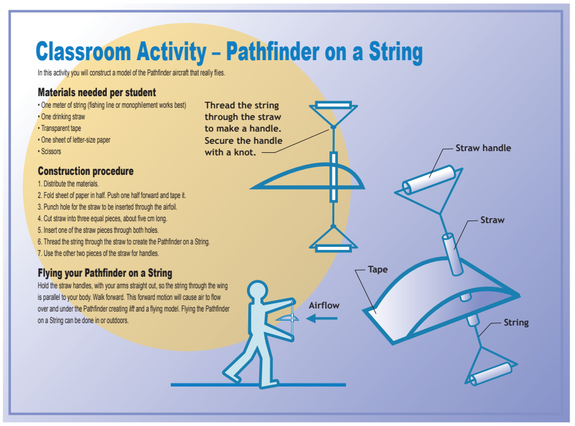
Many teachers are excited by the materials and one educator said, "The handouts are very interesting and will be incorporated into teaching the chapter 'Wings … Rockets' in my grade level. I am especially grateful for the really neat posters that my students will be sure to enjoy."

Communities directly impacted by Dryden's exciting flight research programs were offered the outreach activities. The Pathfinder and Helios educational programs were conducted at several under-represented and rural schools of the Hawaiian Islands. The programs were in high demand and offered by request.

"It was great to have two people from Dryden come out to my school's area. It is very rare to have speakers present that are so close to the school and community," said another teacher participant.

At left, a group of Hawaiian teachers builds Pathfinder paper airplanes during a teacher workshop at Dryden. Below, this illustration shows how to make an airfoil.

EC00 249-57
NASA Photo by Tom Tschida



NASA Illustration by David Faust

More than 1,000 students toured the Pathfinder hangar at the Pacific Missile Range Facility (PMRF) during an educational open house wrapping up the Pathfinder outreach in 1997. Since then, hundreds of teachers and students have toured the PMRF hangar and the NASA hangar when the aircraft have been at Dryden.

On December 10, 1997, the Pathfinder solar airplane altitude world record flight of 71,500 feet was dedicated to the memory of Lt. Col. Ellison Onizuka and the youth of Hawaii.

To ensure a lasting educational presence in Hawaii, NASA Pathfinder and Helios Prototype displays have been constructed at the Kauai Children's Museum and at the Bishop Museum in Honolulu.

A group of 25 Hawaiian educators was chosen to attend a two-week workshop at Dryden in 2001. During this workshop, the participants toured Dryden facilities, spoke with scientists and engineers, and learned how to incorporate NASA resources into their curriculum.

"My two weeks at Dryden were the most memorable I've ever experienced as a teacher," said Wes Kawata, who attended that workshop.

ERAST, Pathfinder, and Helios Prototype education programs have also reached the local California audience. To find out more about teacher and student opportunities visit the Dryden Education Home Page at http://www.dfrc.nasa.gov/trc/index.html

Planning is underway to continue the legacy of the Pathfinder/Helios edu-cational programs. These outreach activities have accomplished an awareness of what NASA does and how NASA's unique programs and missions can inspire future generations of scientists and engineers.

Box ... from page 10

designed for Centurion/Helios Prototype. The new section was more than twice as long as the original Pathfinder center section and increased the overall wingspan of the craft from 98.4 feet to 121 feet.

The new center section was topped by more efficient silicon solar cells developed by SunPower Corp., Sunnyvale, Calif. The cells can convert 19 percent of the solar energy they receive to electrical energy to power the craft's motors, avionics and com-munication systems. That compares with about 14 percent efficiency for the older solar arrays that cover most of the surface of the middle and outer wing panels from the original Pathfinder. Maximum potential power was boosted from about 7,500 watts on Pathfinder to about 12,500 watts on Pathfinder-Plus.

In addition, the Pathfinder-Plus was powered by eight electric motors, two more than had powered the previous version of Pathfinder. Designed for Centurion, the motors are slightly more efficient than the original Pathfinder motors.

Centurion/Helios Prototype

Centurion, the next iteration in the AeroVironment family of high flying solar wings, was intended as a transitional step to the ultimate goal: the Helios. The aircraft was designed to demonstrate both extreme-altitude and long-endurance flight. It is considered to be a forerunner of a fleet of solar-powered aircraft that could stay airborne for weeks or months on scientific sampling and imaging missions or while serving as tele-communications relay platforms.

Centurion shared much of the design concepts of the Pathfinder, but sported 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. After initial low-altitude airworthiness tests at Dryden in late 1998, AeroVironment modified the Centurion with a sixth wing section and a fifth landing gear and systems pod, and renamed the craft the Helios Prototype. The additional wing section would provide room for additional solar arrays that AeroVironment engineers believed would be necessary to power the craft to ultra-high altitudes near 100,000 feet, the milestone that NASA had set. With the additional wing section, the Helios Prototype spans 247 feet, more than 30 feet longer than a Boeing 747-400.

The Helios Prototype's wing airfoil is designed for flight at extreme altitude. The flexible wing is primarily fabricated from carbon fiber and graphite epoxy composites and Kevlar. Its six sections are 41-foot-long. All the sections have an identical thickness that is 12 percent of the chord, or about 11.5 inches, with no taper or sweep. The Helios design involves a minimum of moving parts, high redundancy and solid-state control systems.

The Helios Prototype flies at an airspeed of 19 to 27 mph cruise at low altitudes, up to 170 mph true air speed at extreme altitude. Although pitch control is maintained by a full-span segmented 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, 8 to 14 motors, each rated at only about 2 horsepower, drive the Helios Prototype.

On Aug. 13, 2001, the Helios Prototype flew to a new altitude record certified at 96,863 feet during an almost 17-hour flight from PMRF. Though short of the hoped-for 100,000 feet altitude, the milestone flight sustained horizontal winged flight more than two miles higher than any previous non-rocket-powered aircraft.

Both NASA and AeroVironment foresee Helios derivatives functioning as non-polluting, reconfigurable "atmo-spheric satellites" both for atmospheric and environmental science missions and for commercial telecommunications relay services.

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