National Aeronautics and Space Administration

THE ARMSTRONG X-PRESS

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# Tecnam delivered

## Aircraft that will become X-57 is now in California

**By Matt Kamlet**
Armstrong Public Affairs

NASA engineers and visionaries watched as the Tecnam P2006T – the future all-electric X-57 Maxwell – was uncrated at a small airport on the central coast of California and slowly rolled out.

The arrival marks a critical milestone in NASA's Scalable Convergent Electric Propulsion Technology and Operations Research (SCEPTOR) project, in which the electric propulsion integration and conversion of the Tecnam into the X-57 will commence.

The event signifies a large step toward NASA's goal of developing and validating technologies that will make aviation more efficient, quieter and more environmentally friendly, through the Aeronautics Research Mission Directorate's New Aviation Horizons initiative.

The aircraft, which will be converted into the first manned X-plane to feature a distributed electric propulsion system, was shipped from Naples, Italy, and arrived at Empirical Systems Aerospace's (ESAero) facility at Oceano Airport, near Pismo Beach, California, on July 19.

**AFRC2016-0212-100** **NASA/Ken Ulbrich**

*Preparations are underway to inspect, weigh and balance the Tecnam fuselage before it heads to Mojave, California, for wing integration.*

Upon arrival and unveiling, engineers from NASA Armstrong and Langley Research Center in Virginia, many of whom have been working on the distributed electric propulsion project for several years, got their first look at the aircraft.

"We're all really excited. We get to see in person what we've been modeling for so long," said Sean Clarke, principal investigator for the X-57 project out of NASA Armstrong. "We've been looking forward to this for years now, so there's been a lot of anticipation, and to have it out here in front of us is a relief."

Upon arrival, the P2006T underwent a thorough inspection, followed by weight and balance testing. The testing occurred at

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# Flight Test 4 is complete

**By Matt Kamlet**
Armstrong Public Affairs

As the wheels of NASA's Ikhana Unmanned Aircraft System (UAS) touched down June 30, a two-month flight test series came to a close, concluding an essential stage in the agency's research into technologies that support safe integration of UAS into the National Airspace System (NAS).

Flight Test Series 4 (FT4), which took place at Armstrong, began on April 26, consisted of 19 flights over nine-weeks. The flights tested Detect-and-Avoid (DAA) algorithms developed by NASA, General Atomics Aeronautical Systems Inc., Honeywell, and other industry partners that, for the first time, could validate Minimum Operational Performance Standards (MOPS), established by RTCA Special Committee 228.

The algorithms successfully generated precise alerts necessary for the pilot controlling the Ikhana from the ground to remain well clear and avoid collisions.

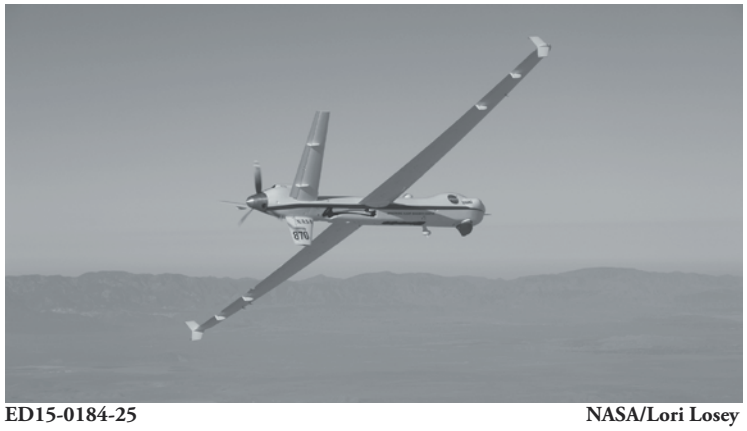
Two different NASA-developed algorithms were tested in the flight test series. The Java Architecture for Detect and Avoid Extensibility and Modeling (JADEM), algorithm was developed by NASA's Ames Research Center in California and works as an "auto-resolver" integrated with a pilot display. This algorithm is paired with the Vigilant Spirit Control Station display, developed by the Air Force Research Lab, which provides a tool for pilots to observe traffic and avoid in-flight conflicts.

The other algorithm tested in FT4 was the NASA Langley Research Center's Detect and Avoid Alerting Logic for Unmanned Systems (DAIDALUS), which helps determine conflicts and calculates the maneuvers necessary to maintain a safe distance between aircraft. NASA Langley is in Virginia.

To test these algorithms, over 260 scripted encounters were performed between the Ikhana and manned "intruder" aircraft. These intruders included NASA's B200 King Air, T-34C, G-III and TG-14 aircraft, a Honeywell C-90 King Air, and a U.S. Air Force C-12 King Air. The aircraft all flew pre-determined flight paths, which subsequently triggered the DAA alerting and maneuver guidance logic for Ikhana's pilot, allowing the aircraft to avoid collisions. The use of the DAA system onboard Ikhana demonstrated an airborne capability that can be achieved to make UAS flight as safe as or safer than current NAS operations.

**AFRC2016-0138-1** **NASA/Carla Thomas**

*NASA's Ikhana remotely piloted aircraft (front, right) is situated with five flight "intruders," which include NASA's TG-14 (front, left), T-34C (front, center), B-200 King Air (back, left), Gulfstream-III (back, center) and a Honeywell C-90 King Air (back, right).*



**ED15-0184-25** **NASA/Lori Losey**

*Ikhana flew 19 missions to test and validate algorithms developed to provide advanced Detect-and-Avoid alerts to UAS pilots on the ground.*

The intruders were equipped with different surveillance systems that identified them as either cooperative or non-cooperative aircraft, which is a real life aspect of NAS operations.

Cooperative aircraft include those intruders capable of sharing their location, such as an Automatic Dependent Surveillance Broadcast (ADS-B) system, Traffic Alert and Collision Avoidance System (TCAS), or a transponder facilitating traffic detection and resolution. Non-cooperative aircraft refer to intruders who either are not equipped with these systems, or have system failures and require an alternative means of detection.

Including intruders with mixed equipage in the testing represents a more challenging environment, in which not all aircraft feature cooperative systems, according to Sam Kim, NASA's UAS-NAS Integrated Test and Evaluation project engineer.

"The only sensor currently being used to detect non-cooperative aircraft is the onboard air-to-air radar, and because the radar has limited detection ranges and uncertainties compared to cooperative sensors, the timeline for alerting and enabling pilot reaction is more compressed," said Kim.

In addition to pilot intervention, a number of encounters tested the DAA system's interoperability with automatic collision avoidance maneuvers, performed using TCAS. The TCAS maneuvering was one of the objectives for testing and the collision avoidance performed successfully. Mike Marston, lead operations engineer for Armstrong's Integrated Test and Evaluation, who supported the flights as chief test conductor, indicated that TCAS testing was necessary, given the autopilot's capabilities.

"An advantage of an unmanned aircraft is that it has an advanced autopilot system," Marston said, "so we can take that system and insert automatic maneuvering and allow the aircraft itself to perform that maneuver, which is currently a climb or descend maneuver."

FT4 applied data collected from its predecessor, Flight Test Series 3, and was conducted following several years of groundwork efforts between NASA and its partners on the UAS-NAS project, including GA-ASI.

"Flight Test 4 was the culmination of over five years of intense research and development on behalf of GA-ASI and our partners," said David R. Alexander, president of Aircraft Systems, GA-ASI. "We are very proud to be a part of this historic flight test campaign."

Data collected from the flight test series will be used by RTCA SC-228 to define DAA performance standards as a first phase to enable routine NAS access for UAS.

# DC-8 begins ATom mission

**By Marshall Murphy**
Armstrong Public Affairs

The DC-8 and its crew this month will visit the tropics, the North Pole, Antarctica, South America and Greenland as part of the Atmospheric Tomography (ATom) airborne science mission.

NASA Armstrong hosted media representatives on July 7, giving them an overview of how the DC-8 will provide a science platform for the ATom airborne science mission.

ATom Deputy Principal Investigator Michael Prather and project manager Dave Jordan briefed media at Armstrong's Palmdale facility. Media also toured the modified DC-8 airborne laboratory that will fly ATom's set of 20 scientific instruments.

ATom will study pollution in the lower atmosphere and its effects in the creation of greenhouse gases. Greenhouse gases, such as methane and ozone, trap heat and raise global temperatures. Although a moderate amount of ozone prevents excessive solar radiation from reaching Earth's surface, too much ozone can prevent heat from leaving Earth's atmosphere. Discovering the origins of greenhouse gases will help scientists better understand climate change.

**AFRC2016-0225-1** **NASA/Jim Ross**

*The DC-8 has begun the month-long ATom airborne science missions.*

Although climate simulations attempt to predict the rate of greenhouse gas production, ATom will test those predictions with real-world data, Prather said.

"This mission specifically goes after the core aspect of the models, which is the models' ability to predict changes in ozone and methane based on human pollution," he said.

ATom will crisscross the globe over the next four years in different seasons to gather a diverse selection of data. The mission will focus on remote areas, particularly vast stretches of ocean where unique chemical processes could disproportionately produce greenhouse gases.

By focusing on oceans, ATom will collect a range of data representative of the entire planet, Prather said.

"The parcels of air over the Pacific are a whole range of chemical reactivity," he said.

The ATom team will publicly release the experimental data, which scientists can interpret into new findings about Earth's climate.

# Dinius wins Armstrong scholarship

**By Jay Levine**
X-Press editor

The NASA Armstrong Employee Exchange Council has presented its 2016 Thomas W. Finch Memorial Scholarship Award to Katelynn Dinius.

Dinius is a 2016 graduate of Paraclete High School in Lancaster. She is planning to major in mechanical engineering at California Polytechnic State University, San Luis Obispo, in the fall.

"I have liked math since elementary school, and I looked for majors to fit my interests," she said. "Mechanical engineering looks like a good fit, and I would really like a

**Scholarship, page 7**

**AFRC2016-0205-1** **NASA/Lauren Hughes**

*Katelynn Dinius, second from left, accepts the 2016 NASA Armstrong Exchange Thomas W. Finch Scholarship from Center Director David McBride. From left are Clint Dinius, Dinius, McBride, Joe Dinius and Dede Dinius.*

# News at NASA

## RS-25 tests a success

NASA engineers conducted a successful developmental test of RS-25 rocket engine No. 0528 July 29, to collect critical performance data for the most powerful rocket in the world – the Space Launch System (SLS). The engine was tested during a 650-second firing on the A-1 Test Stand at NASA's Stennis Space Center, near Bay St. Louis, Mississippi. It marked another step forward in development of the SLS, which will launch humans deeper into space than ever before, including on the journey to Mars. Four RS-25 engines, joined with a pair of solid rocket boosters, will power the SLS core stage at launch. The RS-25 engines used on the first four SLS flights are former space shuttle main engines, modified to operate at a higher performance level and with a new engine controller, which allows communication between the vehicle and engine.

NASA conducted a series of developmental tests on the engine last year before testing a flight engine that will be used on its second test flight, known as Exploration Mission-2 (EM-2). EM-2 will be the first crewed flight of NASA's Orion spacecraft, launching on the SLS. A second series of developmental tests began July 14. A team of NASA, Aerojet Rocketdyne and Syncom Space Services engineers and operators conducted the test. Aerojet Rocketdyne is the prime contractor for the RS-25 engines. Syncom Space Services is the prime contractor for Stennis facilities and operations.

Courtesy of Eric Staudenmeir

*A monument has been created to remind Antelope Valley residents of the Space Shuttle Challenger loss and the sacrifice and bravery it takes to forge new frontiers. In the center of the artwork, called Astral Challenger, California artist Shana Mabari is pictured with her creation commissioned by the City of Lancaster.*

# Astral Challenger

## Artwork salutes Challenger and Antelope Valley aerospace

**By Jay Levine**
X-Press editor

Space Shuttle Challenger and its seven-member crew were lost Jan. 28, 1986, when the orbiter came apart 73 seconds after its launch from the Kennedy Space Center in Florida.

It is a loss that remains fresh in the minds of the families and friends of the crew and to a number of people in the Antelope Valley. The fleet of orbiters were assembled and returned for major maintenance and modifications for decades in Palmdale and most of the landings in the early days of the program were at Edwards Air Force Base.

Challenger and its crew were honored in 1987 with the renaming of 10th Street East north of Avenue M in Lancaster, as Challenger Way. Earlier this summer Astral Challenger, a memorial, was erected at Avenue L and Challenger Way to remind Antelope Valley residents of the sacrifice and bravery it takes to forge new frontiers.

"Astral Challenger is a great tribute to Challenger and the STS-51L crew," said George Grimshaw, who was a former shuttle manager at Armstrong. "As NASA makes plans to go to Mars and uses commercial services to deliver supplies and crews to the ISS, it is very important to remember those who gave their lives in pursuit of the many benefits space

affords us. We honor them when we learn from the problems of the past and apply what we have learned to further our work in space."

California artist Shana Mabari was commissioned to design the piece that she considers to be a part of the continuum of the Light and Space movement that originated in California in the 1960s.

"Astral Challenger is conceived as a monumental landmark to both honor the legacy and ongoing achievements of the aerospace industry in Lancaster and the high desert around it, and to commemorate the 1986 Space Shuttle Challenger flight," she said. "The rocket-shaped sculpture has eight vibrant blue acrylic panels for the seven lives lost in the disaster, plus one more to collectively represent the family members and friends who still grieve."

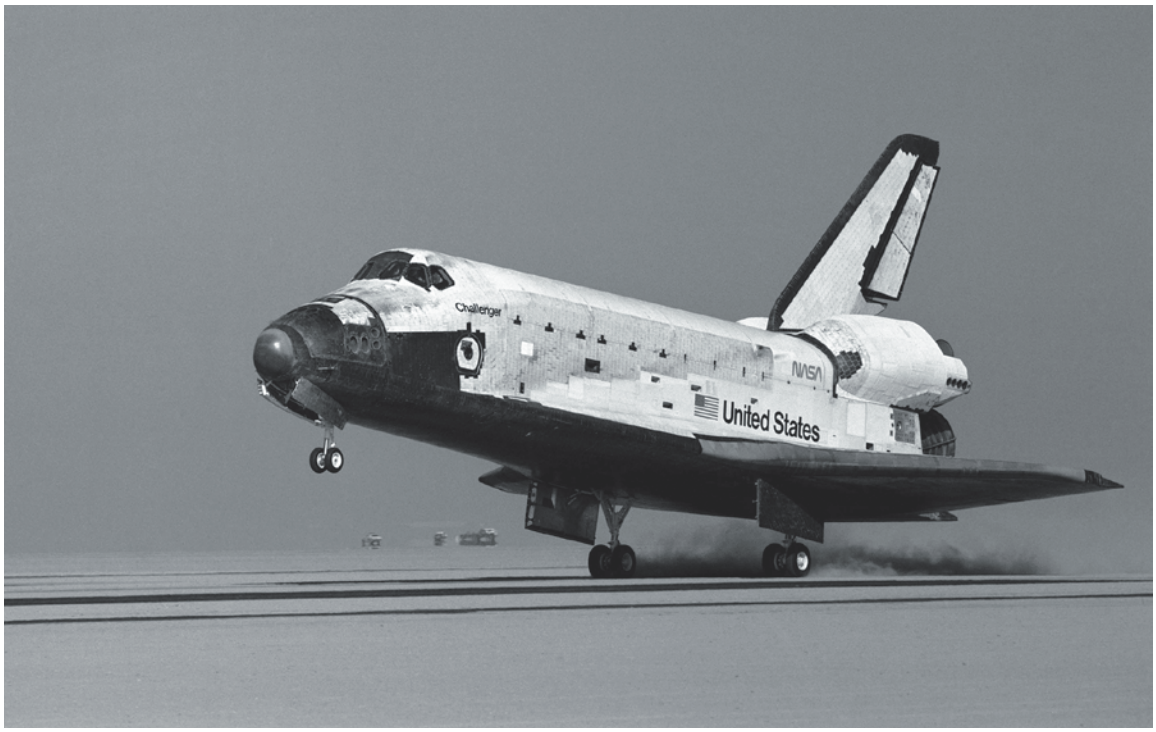
Astral Challenger is 20-feet tall and is illuminated from dusk until dawn with LED lights. The permanent public art is the first that the City of Lancaster commissioned for its new Art in Public Places initiative.

"I consulted extensively with legendary Southern California-based fabricator Jack Brogan on initial design concepts and fabrication specifics," Mabari said. "The fabrication process and material selection was a poetic layering of engineering specifics to create the seamless curved silhouette of the sculpture from top to bottom. Incorporating light into the work allows the piece to have both a daytime and nighttime personality. It is as if I created two sculptures at once, and every decision along the way took each into consideration."

The airframe that would become Challenger was originally built for structural tests and was known as STA-99 (Structural Test Article) and was not intended for flight, Grimshaw explained. However, it was decided that the vehicle would be redesignated OV-099 and named Challenger.

Challenger was the second

**Astral Challenger, page 6**




**61a-s-0139** **NASA**


**EC79-10370** **NASA**

**Courtesy of George Grimshaw**

*Top, Space Shuttle Challenger makes a landing at Edwards Air Force Base Nov. 6, 1985.*

*Above, Space Shuttle Columbia makes the overland travel from the Rockwell International (now The Boeing Company) facilities in Palmdale to Edwards Air Force Base along 10th Street East in Lancaster, which was later renamed Challenger Way following the loss of that orbiter.*

*At left, George Grimshaw, a former NASA Armstrong shuttle manager, recalled some of his experiences with Challenger.*

# Astral Challenger... from page 5

orbiter, but was responsible for a lot of firsts in the shuttle program, such as first use of lightweight external tanks and solid rocket boosters (STS-6), first spacewalk from a Shuttle (STS-6), first deployment of a tracking data relay satellite and Sally Ride became the first woman in space (STS-7).

The orbiter also had the first five (STS-7) and seven (STS-41G) member crews, first night launch and landing of a shuttle (STS-8), Guion Bluford became the first African-American in Space (STS-8), the first untethered spacewalk (STS-41B), first in-flight capture, repair and release of a satellite (STS-41C) and Kathryn Sullivan was the first woman to walk in space (STS-41G).

The center's shuttle landing and recovery team supported all 10 of Challenger's missions, including five lakebed and two runway landings.

For Grimshaw, the most memorable of those landings was STS-61A, Challenger's last landing at NASA Armstrong, then called NASA Dryden. A decision was made to tow the orbiter back to the center via the lakebed. Tests had validated the area of the lakebed was hard enough to tow over.

"Challenger's nose wheels, and then main tires, began to sink to the point that the tow bar over extension alarm went off and we had to stop towing," Grimshaw recalled. "The tow bar was reset and the tug driver tried to resume the tow, but Challenger wouldn't budge and the alarm went off again."

Innovation was required.

"In order to get Challenger on to the shuttle ramp, Charlie Baker, who was the shuttle area manager at the time, brought out several sheets of 1-inch plywood," he explained. "Challenger was jacked up and a sheet of plywood was slid under the nose wheels and the left and right main wheels, and then Challenger was lowered. Then, another sheet of plywood was placed in front of each of those sheets of plywood. We resumed towing ops very slowly."

It was a complex operation.

"As Challenger's wheels rolled off one series of plywood and onto another, we moved the plywood left behind and placed it front of the sheet of plywood the wheels were on," Grimshaw said. "We continued this rotation until all of Challenger's wheels were on the concrete of the Shuttle Area ramp. That was the last time we used this route to get the orbiter to Dryden."

For those people who drive by the monument, they will have an opportunity to remember the sacrifices of the seven brave souls who challenged the unknown and think about the next generation of astronauts waiting for their chance to discover new frontiers in space.

NASA

*The STS-51L crew was lost 73 second after launch on Jan. 28, 1986. Crewmembers included, front row from left, Michael J. Smith, Francis R. Scobee and Ronald E. McNair. In the back from left are Ellison S. Onizuka, Sharon Christa McAuliffe, Gregory B. Jarvis and Judith A. Resnik.*


NASA

*The NASA Space Shuttle program has had a number of successes, but Space Shuttle Columbia broke apart 16 minutes from landing on Feb. 1, 2003. From left, the crew included David Brown, Rick D. Husband, Laurel Blair Sutton Clark, Kalpana Chawla, Michael P. Anderson, William C. McCool and Ilan Ramon.*

# Newman experiences SOFIA mission

**By Dava Newman**
NASA deputy administrator

NASA science takes many shapes, and we're always pushing the boundary of what is achievable. I've just had an incredible opportunity to take part in one of our amazing missions that is gazing beyond our solar system in a unique way.

The flying observatory called SOFIA, the Stratospheric Observatory for Infrared Astronomy, was in Christchurch, New Zealand, to study parts of the universe more easily visible from the Southern Hemisphere. It carries a 2.5-meter telescope inside a Boeing 747SP jetliner to observe the cosmos at infrared wavelengths. These observations are not possible from the ground, because water vapor in Earth's atmosphere absorbs almost all the infrared light before it reaches the ground's surface. SOFIA flies above 99 percent of this water vapor, at 38,000-45,000 feet in altitude, while carrying some of the world's most powerful instruments not currently available on space-based observatories.

These unique capabilities enable scientists to study the origins of our universe in ways that no other observatory can. I flew with the SOFIA team as they observed multiple targets in space: a nova (explosion of a star) in the constellation Sagittarius; one of the biggest stars known, named Eta Carinae, that will explode as a supernova relatively soon; and a large, newly forming star called IRAS 16562-3959. The science flight lasted ten hours, and at 61 degrees south latitude we witnessed the amazing aurora australis.

**Courtesy of the U.S. Embassy New Zealand/ Ola Thorsen**

*NASA Deputy Administrator Dava Newman flies aboard the Stratospheric Observatory for Infrared Astronomy.*

In addition to its powerful observing capabilities, SOFIA also has the unique ability to allow guest investigators, educators, journalists, and other related professionals to fly on an observing mission and see the research process first hand. The educators fly on the observatory as part of NASA's Airborne Astronomy Ambassadors (AAA) program, a competitive professional development opportunity designed to implement active teaching methods, inspire students, and enhance scientific literacy for learners of all ages. The educators take what they learn on SOFIA back into their classrooms and communities to convey the value of scientific research, the importance of scientific and design processes, and the wide variety of science, technology, engineering, and math (STEM) career paths available to students.

This program brings the excitement, challenges, discoveries, and teamwork of SOFIA operations to the public on a national and international scale. Indeed, SOFIA itself is a partnership between NASA and the German Aerospace Center (DLR) – our wonderful partner in many areas that also flies educators to the stratosphere aboard this incredible airborne science observatory. This one-of-a-kind program seeks excellence by promoting both advancement and literacy in science, technology, engineering, art, mathematics, and design (STEAMD) to prepare a 21st century, interdisciplinary workforce.

SOFIA investigates the infrared universe to make discoveries light years away. It's an example of vital NASA science expanding our journey of discovery – and I look forward to following its scientific discoveries in the years ahead.

## Scholarship... from page 3

job in aerospace."

The annual scholarship provides $2,000 a year for up to four years for attendance at a four-year college or university. The recipient must maintain a minimum grade-point average of 3.0 or higher to retain the scholarship. Applicants must be high school seniors whose parents work at Armstrong.

Her parents said they couldn't be prouder.

"I am really excited for her," said Dede Dinius, her mom, and an Armstrong visual information specialist. "She has always been financially aware and now she has earned some contributions toward her education. I am excited for her that her hard work has been acknowledged."

Clint Dinius, Katelynn Dinius' dad, added, "I'm thankful for NASA Armstrong's support of Katelynn's education."

Dinius earned a 4.28 grade-point average and was valedictorian of her graduating class. She earned the Principal Award for academic achievement every semester, the Curriculum Award of Excellence and the Advanced Placement Calculus Subject Award. She also was a member of the national English, Spanish and honors societies and the California Scholarship Federation.

She also is a member of Mu Alpha Theta (the United States mathematics honors society). During her last semester at Paraclete Dinius was part of the Lockheed Martin Corp. Conceptual Design Internship program.

Dinius was awarded a Certificate of Special Congressional Recognition from California Senator Steve Knight and a scholarship from the Society of Woman Engineers. She was actively involved in the Rosamond Civil Air Patrol and tutored students, as well as taking piano lessons and ballet classes.

She lettered as a member of the varsity cross-country and track teams. Dinius was an active member of the Key Club, Irish Club, Drama Club and the Environmental Club. In addition, she was a news editor for Clete News and communications officer and retreat leader for the Campus Ministry. As part of her involvement in her church youth group, she does monthly community service projects.

The exchange council scholarships are named for former Armstrong employees, with honorees selected on a rotating basis, such as Finch this year. Finch was a center engineer who specialized in stability and control and worked on aircraft such as the X-5, the XF-91 and the legendary X-15 rocket-powered aircraft. Scholarship funds are raised from council activities, including proceeds from vending machines, the Armstrong Gift Shop, cafeteria sales and fundraising events.

# Tecnam... from page 1

ESAero, the prime contractor for the X-57 project. Having the aircraft in front of them allowed engineers to verify the modifications that had been made to the design during the fabrication process, which will make integration of the electric propulsion system possible.

ESAero Vice President of Operations Trevor Foster, who is the company's principal investigator on X-57, says the excitement level has reached new heights since the aircraft's arrival.

"I've never worked on a NASA X-plane before, this is a very exciting experience for me," Foster said "It has become very real for everyone to actually have some hardware to touch. Everything up until now has been on paper and photographs, so everyone is very excited and looking forward to the next several years."

Once final inspections at ESAero are complete, the aircraft will be transported to Scaled Composites in Mojave, California, where it will undergo the first modification into a fully electric airplane with the stock Tecnam configuration. This will allow the team to validate the safety of the all-electric power system and two large motors in flight before the new wing is integrated. The planned final version will feature 12 small, electric-driven propellers along a high-aspect ratio wing's leading edge and two larger electric cruise motors out on the wing tips.

The experimental high-aspect ratio wing is being designed at NASA Langley and fabricated by Xperimental LLC in San Luis Obispo, California. The wing's electric propellers will be used to generate lift during takeoff and landing only, while the two outboard motors will be used during cruise.


**AFRC2016-0212-85** **NASA/Ken Ulbrich**

*The Italian Tecnam aircraft fuselage, P2006T, was unloaded from its shipping container after its arrival in California and will be integrated with the wing for electric propulsion to become the X-57, or Maxwell.*

The wing will be integrated onto the fuselage once the electric power validation flights are complete. The vehicle will be powered by a battery system, developed by Electric Power Systems of the City of Industry in California.

The current phase of integration is a power system risk reduction for the final configuration. This includes replacing the two inboard reciprocating engines with electric motors, which are under development by Joby Aviation in Santa Cruz, California. Once the electric integration for this phase takes place, the aircraft will undergo ground tests to analyze the system. Flight tests for this initial modification are planned for the spring of 2018.

X-57 is the result of research and testing done through the Convergent Aeronautics Solutions' (CAS) sub-project SCEPTOR, which falls under the Transformative Aeronautics Concepts Program. NASA's goal of meeting and overcoming the challenges of today's aviation starts with potentially revolutionary ideas, and CAS was instrumental in supporting the idea of zero-carbon-emitting distributed electric propulsion.

"I am very excited that NASA Aeronautics has started the Convergent Aeronautic Solutions project where cross-center teams can propose revolutionary ideas that if feasible, can graduate that new technology into one of the mainstream aeronautics projects for further research and validation," stated NASA Armstrong Deputy Aeronautics Research Director Starr Ginn.

"Unboxing the airplane today was an exciting milestone for those of us who have been advocating for several years the need to design, build and fly an electric airplane, and understand the system integration challenges, technology gaps and showcase a new area of vehicle design space with distributed electric propulsion."

SCEPTOR will become the first CAS sub-project to graduate to the Flight Demonstrations and Capabilities project under the Integrated Aviation Systems Program, and X-57 will be the first of a series of increasingly larger electric aircraft in support of the New Aviation Horizons initiative.

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