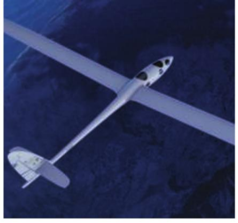

GLIDING HIGHER
PERLAN MISSION TARGETS 90,000FT ABOVE THE ANDES
FEATURE P24

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LOFTY AMBITIONS

Visitors to EAA AirVenture will be the first to glimpse Perlan 2, a glider that aims to take sustained flight to more than 90,000ft and the edge of space

HOWARD SLUTSKEN VANCOUVER

Making its debut at EAA AirVenture 2015 is a new aircraft that is destined to shatter records. The Airbus-branded Perlan Mission II will use a little-known meteorological phenomenon called the Stratospheric Polar Night Jet to reach and fly at 90,000ft – piloted, winged and sustained flight at over 27,400m.

Perlan 2 will fly higher than the Lockheed U-2 or SR-71, but it is not an exotically-shaped or scramjet-powered superplane. It is a glider.

The idea for the record flight attempt – expected to be staged next summer in Argentina – goes back 60 years, to when a young gliding instructor called Einar Enevoldson volunteered as line-crew in the US Air Force-funded Sierra Wave Project, in Bishop, California.

Back then, the mountain wave weather phenomenon was little understood, and two Pratt-Read PR-G1 gliders were flown into the wave to gather meteorological and observational data, reaching altitudes as high as 44,255ft.

When strong winds cross a mountain range, the effect can be the same as a river current flowing over rocks: the air gets pushed into an invisible wave behind the range. Unique, lens-shaped lenticular clouds are formed. The air inside the wave is smooth but surrounding air can be violently turbulent.

Now an 83-year-old USAF and NASA flight test veteran, Enevoldson is leading a team of test pilots, programme managers and meteorologists in an attempt to achieve the first unpowered flight to over 90,000ft.

"You could see in the highest waves, it seemed that there was some major motion going on in the atmosphere at very high

Perlan 2 will exploit mountain wave winds in a bid to reach a record 90,000ft

Airbus Perlan Mission II

altitude. Something was impinging on top of the wave field," says Enevoldson.

After a long and varied career as a USAF fighter and test-pilot at the NASA Flight Research Center at Edwards AFB in California, Enevoldson joined Grob Aircraft in Germany.

RESEARCH

In 1988, he was the test pilot for Grob's G-520 Egrett, an early "SigInt" aircraft capable of flying at 50,000ft for 8h. He also flew the Grob Strato 2C, a prototype high-altitude research aircraft.

Still focused on high-altitude flight, in the early 1990s Enevoldson saw a LIDAR image taken from an aircraft flying along the Arctic Circle. "It clearly showed the wave nature of the clouds at 80,000ft," he says. "So I said that we should build a pressurised glider and fly up to 80,000ft. I began looking for funding for the project, and eventually met Steve Fossett.

"After a serious negotiation lasting about 10 seconds, we decided to do it," he laughs. With Fossett's support, Enevoldson founded the Perlan Project, Inc, a not-for-profit aeronautical exploration and atmospheric scientific research organisation.

Rather than starting with a pressurised design, the Perlan 1 was a modified DG Flugzeugbau DG-505m glider. Double-glass canopies were installed to eliminate frost-over, along with a NASA high-altitude oxygen system and other mission-specific equipment. Enevoldson and Fossett wore pressure suits borrowed from NASA Dryden, and the team went to New Zealand for three seasons.

Although data suggested that the best and strongest waves were there, Perlan 1 only reached 30,000ft.

> **"I began looking for funding for the project, and eventually met Steve Fossett"**
>
> **EINAR ENEVOLDSON**
> Perlan

"Steve wanted this to happen, and never gave up," says Enevoldson. "We had no data from South America, but we looked at a map and saw El Calafate, in Patagonia, Argentina, at 50˚ south. The first year, we went there too late, but on the first flight of the second year [29 August 2006], we flew right into the primary wave, and went up to 34,000ft, climbing at 2,000ft/min."

But as the glider climbed through 36,000ft, the pilots' pressure suits became progressively stiffer, and they found it increasingly difficult to manipulate the controls and equipment. "This was as expected, but more troublesome than we had hoped," he says.

"We were cold and tired," he says. "We were actually at 51,500ft, and we knew our altimeters were accurate." After the 5h flight, the data recorders were sent off for verification. However, a calculation error reduced the record-setting altitude to 50,671ft.

The Perlan team recognised that a pressurised glider would be needed to reach higher altitudes. Some thought was given to "beefing up" an Alexander Schleicher ASH-25 glider, but the decision was made to create the Perlan 2, a purpose-built pressurised glider. The Perlan 1 was eventually donated to Seattle's Museum of Flight, where it is on display.

Tragically, in September 2007, Steve Fossett was killed while flying in the Sierra Nevada mountains in California. And although the design and construction of Perlan 2 continued, funding began to dry up. Looking for new partners, the project team met with Airbus in early 2014. Ken McKenzie, deputy chairman and senior vice-president for strategy and corporate development for US-based Airbus Group Inc, and a glider pilot himself, was in the initial meeting.

» "Before the meeting, I said 'you can't fly a glider to 90,000ft'," recalls McKenzie. "When we finished the meeting we said, 'how much do you need?' We were so enthralled with the vision they had, and what they had accomplished so far, that we had to be a part of this."

At EAA AirVenture 2014, the project officially became the Airbus Perlan Mission II. "For us, one of the key tenets of this project is the exploration and excitement of doing something that's never been done before," says McKenzie. Within the company, the mission is part of Airbus Group Innovations, with McKenzie overseeing Airbus' involvement.

With funding in place to ensure the construction of Perlan 2, the glider's components were taken out of storage and moved to RDD Enterprises in Redmond, Oregon, where assembly was completed in June.

PRESSURISED

Perlan 2 is constructed almost entirely of carbonfibre, primarily using pre-impregnated carbon sheeting and tapes. The glider has a 25.6m (84ft) wing made up of four custom airfoil sections, with an aspect ratio of 27. The airframe is designed to handle +6/-4*g* loads. With an empty weight of 574kg (1,260lb), the gross weight will be approximately 816kg with two pilots and full mission equipment on board. The cabin is a sealed compartment and will be pressurised to 8.5psi, giving a maximum in-cabin altitude of 14,000ft.

"I decided a conventional [glider] canopy wouldn't work for a pressurised cabin," says Enevoldson. "I had a pretty good idea of what the cabin should look like." Perlan 2's cabin has plug doors and rounded windows, set in a configuration that has been successfully flight-tested by masking the canopy of conventional gliders to match the new aircraft's design.

"A lot of people compare our cabin design to SpaceShipOne," says Morgan Sandercock, project manager and pilot. "A couple of years ago at Oshkosh, I got the chance to shake Burt Rutan's hand. He said, 'you're using the same materials to solve the same problems, so of course it looks the same!'"

Inside Perlan 2's cabin, the pilots will use a closed-loop rebreather system adapted from existing underwater breathing technology, with each pilot on an independent system. The system feeds 100% oxygen, and will scrub carbon dioxide and moisture from the pilots' exhalations. A second tank, containing ordinary compressed air, will feed "make-up" air into the cabin, dealing with expected leakage and preventing the oxygen content of the cabin air from exceeding 26%.

The closed-loop system is very efficient, says Sandercock. "Using the rebreather function the pilots can breathe for 8h. But if there's a failure and we have to go to an open-loop mode, we've got 20min in the system for an emergency descent." In open-loop, the pilots will breathe directly from the oxygen tank, bypassing the rebreather system.

The pilots will use a custom-designed life support system display to monitor and control the glider's pressurisation and breathing systems, and an LX Avionics LX-9000 vario-navigation system will be the primary flight and information display. Perlan 2 will not be equipped with an autopilot, but a yaw damper will be fitted. The scientific instrument package will be mounted aft of the pressurised cabin, utilising a CubeSat frame.

When meteorological data recommends a launch (*see panel above*), the mission profile will see Perlan 2 towed about 100km from El

Enevoldson (*left*), Fossett and Perlan 1

Airbus Perlan Mission II

WAVE SCIENCE

HOW CAN A GLIDER CLIMB TO THE EDGE OF SPACE?

IT ALL starts with the winter weather in Antarctica.

Glider pilots around the world regularly climb to altitudes above 20,000ft, or even 30,000ft, flying in the strong lift found in mountain wave conditions. But for Perlan 2 to reach 90,000ft, the pilots will need to jump into an express elevator in the Andes, romantically named the Stratospheric Polar Night Jet.

"The polar vortex comes alive in Antarctica in the winter due to the tremendous cooling at the poles, the sinking of the air, and the rotation of the globe," explains Dr Elizabeth Austin, atmospheric physicist and the founder and president of Nevada-based WeatherExtreme Ltd. She joined the Perlan Project in 1998 as chief meteorologist, and developed the weather models used in both the Perlan 1 flights and the upcoming Perlan 2 missions to El Calafate next year.

"You get these sharp temperature contrasts, and with the globe rotating, the jet starts to form," says Austin. "It circles the pole, and gets these kinds of tails that scoop away from it, and it wiggles and wobbles. Sometimes it pulls away and become this tight jet, and sometimes it spreads out." The polar night jet starts around 30,000ft in the mid- to upper-tropopause, and climbs well into the stratosphere, as high as 130,000ft to 140,000ft. The core winds of the night jet can reach an astonishing 260kt.

A number of meteorological factors will have to line up in order to provide the optimal conditions for Perlan 2's flights, according to Austin. Prefrontal conditions have to occur during the relatively short, winter daylight flying time, and the polar vortex and night jet have to be very active and over Argentina. The lower level jet and resulting wave have to line up just beside, but not under the night jet, and the orientation of both, relative to the Andes mountain range, is important.

Perlan 2's pilots will climb in the lower level wave before penetrating the lift generated by the night jet. If the polar vortex and the low level jet stream are not properly aligned, the pilots will likely have to transition through an area of weak climb around 50,000ft. But if the conditions are exceptional, then the horizontal and vertical wind speeds in the night jet will increase with altitude. "There's also a zone where we may experience 'breaking waves'," says Austin. "As the waves get higher and higher, they actually bend windward, and if they get steep enough, they will break. It creates extreme turbulence, and could tear an aircraft apart."

Getting accurate, timely data to feed the weather model will be a challenge, says Austin. "The closest [balloon] sounding is about 300 miles northeast of El Calafate, and

Mountain waves form distinctive lens- shaped clouds, seen here over the Sierra Nevadas

the next closest is 600 miles north. A bunch of them are launched on the Antarctic continent, but those are inside the vortex. We're hopefully going to launch our own soundings from upwind, which will transition through the atmosphere we're going to be flying in." All of the weather data will be fed into modeling software called the Weather Research and Forecasting System, which will forecast conditions out for 48h at very high resolution. "We're going to be watching it, not just to guide us when to launch, but where to tow," she adds.

Austin says that the science generated by the Perlan 2 missions will increase knowledge of our climate. "We're going to be studying ozone, because we're on the edge of the ozone hole. We're going to learn about the structure of the stratospheric mountain waves and the breaking waves. We'll learn how breaking waves impact energy, and transfer heat and chemicals to and from the troposphere. That's an important part of improving climate models, because [current] climate models don't take breaking waves into consideration." ■

Calafate, with a release altitude of around 10,000ft, says Jim Payne, chief pilot. Payne, also an ex-USAF fighter and test-pilot, thinks nothing of spending a day in a Schempp-Hirth Arcus glider, and flying a record-setting 972nm (1,800km) by running up and down the Sierras from Minden, Nevada.

TROPOPAUSE

"We expect the roll response to be slow at low altitude; any glider with that span is sluggish," says Payne. Perlan 2's wing is designed to be most efficient in the 50,000ft range, with a 200ft/min minimum sink rate, reflecting data that shows the weakest climb will be in that altitude region, just above the tropopause.

Once the glider penetrates the wave, there are two basic flying strategies. If the opposing wind speed is less than the glider's best-performance speed, the pilots will crab back and forth to stay in the best climb region. But if the pilots can match the wind speed, "you park there and go up like an elevator", Payne says.

Stall speed of Perlan 2 is predicted to be 33KIAS at 90,000ft, with its never-exceed speed at 56KIAS. "We'll figure out the minimum sink speed, and then we'll know what to fly. I won't be surprised if we spend a lot of time at 36-38KIAS," says Payne.

Although the indicated airspeeds are low, the true airspeeds will add to Perlan 2's records. That 36KIAS is equivalent to 242kt (447km/h), true airspeed. The opposing wind speed is expected to be above 200kt, so "as we get high, we'd better be pointed west", chuckles Payne.

Sandercock agrees: "It's about 1,000km from El Calafate to Port Stanley in the Falkland Islands. Downwind, we could do that in a couple of hours."

Payne, Enevoldson, Sandercock and Perlan 2's other pilots will fly in the aircraft's pressurised cabin dressed as they do for lower-altitude wave flights: in ski clothing, with down boots and electrically-heated socks. The cabin's carbonfibre-sandwich construction may provide good insulation against the expected -57°C (-70°F) outside air temperature, says Payne. "The human body is like a 100W light bulb, and with the avionics in the cabin there's actually a chance we might have a problem with too much heat in the cabin."

> **"If you can match the wind speed you park there and go up like an elevator"**
> JIM PAYNE
> Chief pilot

If an emergency descent from 90,000ft is ever required, Perlan 2 is equipped with a drogue parachute that has two separate activation circuits. Payne explains: "It's sized so that we can come straight down at 80KIAS – 80 indicated at 90,000ft is pretty damn fast; a lot of sink rate!" In the case of a catastrophic airframe failure, the aircraft is also equipped with a ballistic parachute that is designed to be deployed at 10,000ft.

Perlan 2 will be on display at AirVenture, and will head back to Oregon for initial flight testing in August. Payne will make the first flights, and once the glider's basic performance is determined, it will be fitted out with the pressurisation and other mission-related systems. The base will shift to Minden in January 2016, to flight test all of the glider's systems, and also to prepare ground crews and pilots.

»

The cabin is pressurised to 8.5psi

The team will move to El Calafate in June 2016. "Hopefully we'll get to at least 40,000ft in the Sierras. But when we get to Argentina, we're not going straight to 90,000ft," says Payne. The incremental test programme will see Perlan 2 carefully increase altitude before going for the 90,000ft goal.

TRANSONIC

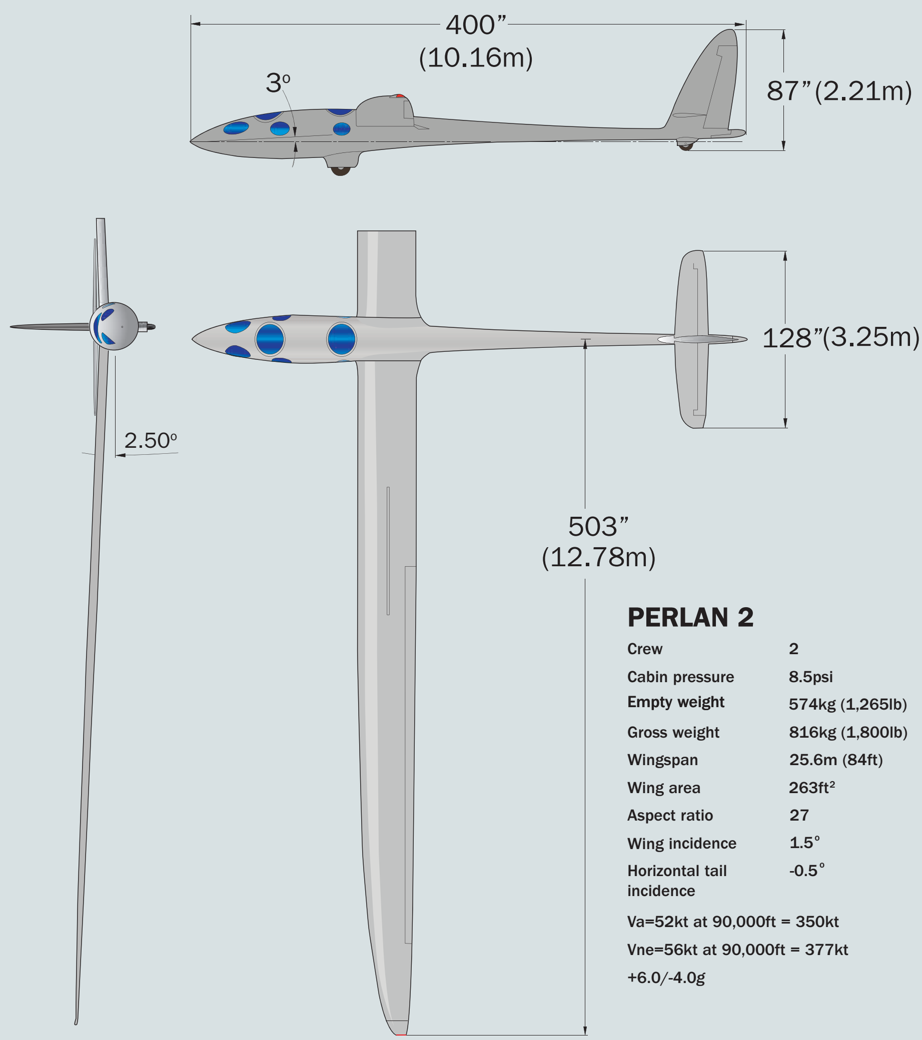
After that, Perlan 2 will continue to fly missions, between 90,000ft and 100,000ft. Once regular operations are established, scientists may fly in the back seat to operate research instrumentation. Flight at 100,000ft and above may be possible, but Perlan 2 is likely to need new, transonic wings to reach that goal.

One might wonder what can be learned from flying a glider into the stratosphere. The mission's goals are meteorological research, aeronautical exploration and aerodynamic advancement, with a strong emphasis on education to inspire future generations to pursue careers in mathematics, science and research.

Construction in Oregon will be followed by flight testing in Nevada

Airbus Perlan Mission II

PERLAN 2 DESIGN



PERLAN 2

Crew	2
Cabin pressure	8.5psi
Empty weight	574kg (1,265lb)
Gross weight	816kg (1,800lb)
Wingspan	25.6m (84ft)
Wing area	263ft²
Aspect ratio	27
Wing incidence	1.5°
Horizontal tail incidence	-0.5°

Va=52kt at 90,000ft = 350kt

Vne=56kt at 90,000ft = 377kt

+6.0/-4.0g

Airbus's McKenzie says: "Continuous flight in that realm is something that we don't know anything about. As we look to the future, with airspace becoming more and more congested, we may have to start looking higher and higher. As well, the atmospheric parameters above 90,000ft approach those on Mars, so if we're working on a spaceplane for a Mars mission, we can prove the concepts here. The data that is gathered will be a very useful outcome of the project. And I think Perlan 2 will strike a chord with the general public."

> **"Continuous flight in this realm is something that we don't know anything about"**
>
> **KEN MCKENZIE**
> VP, strategy & corporate development, Airbus Group Inc

Dennis Tito has already seen 90,000ft on the altimeter, twice, during his Soyuz flights to and from the International Space Station in 2001. Tito is a major contributor and sponsor of the Perlan Project, and obtained his glider licence just a few years ago, at the age of 68.

He will be another of Perlan 2's pilots, drawing on his 650h mountain wave gliding experience during the missions. Tito hopes that Perlan will inspire a new generation. "Everything I've accomplished in my career can be linked to that interest as a young person. I don't see us having the kind of inspiration in the area of spaceflight today that we had 50 years ago. What can we do that would be new and exciting, to inspire young people? I think Perlan is one opportunity."

"I think of this as an exploration," Enevoldson adds. "There are parts of the earth that we haven't explored, and I'm an explorer." ■