The Worl

Dr. Daniel Johnson
(All photos by author.)

Every piece of good advice has a sad story behind it.

— Einar Enevoldson

rld's Baddest Towplane

This article is based primarily on interviewing Einar, supplemented with information from Ed Warnock (CEO of the Perlan Project), Jim Payne (chief pilot), Morgan Sandercock (Australian engineer & pilot who did CPR on the project after Steve Fossett was lost), Dan Gudgel (WxDan and amazing aviator), Arne Vasenden (Egrett tow pilot), Mike Malis (engineer in perpetual motion and pilot), several others, and the ubiquitous Internet. All first-person statements are quotes of Einar. All errors are my own misunderstandings.

Once upon a long time ago, I (DrDan) ran a little club with my Blanik L-13. Occasionally a guy with a Piper Pacer would tow for us. On a warm Wisconsin day, we'd climb only in thermals. We were exquisitely thankful for the farm fields surrounding the airport.

At the other extreme is the Grob G-520 Egrett. It can haul your one-ton two-lardbutt ship at 75 kt and 1,500 ft per minute higher than you'd care to go – flight level 300, 30,000 ft above sea level pressure – and then that elevator slows down for the next two or three miles of altitude. B-A-D ....

In August and September 2018, an Egrett flown by Arne Vasenden towed the Perlan 2 pressurized glider on 9 flights. The first, a test flight, released at only 11,000 ft. The other 8 tows reached from 40,000 to 45,100 ft – the highest

tows ever undertaken (though the FAI doesn't keep track of such records). See the table below.

Why tow this high? Is it cheating to take such a high tow?

When I was a student, taking a tow over 2,000 ft AGL seemed to be acknowledgement of being Not Good Enough (to find and work a thermal), and in any case, a high tow made everyone in line wait longer.

The Perlan missions have had a unique problem: Their goal is to fly in *stratospheric* wave. To do this, one needs hardly point out, they need to reach the stratosphere.

Here's the problem: they have discovered that traditional (tropospheric) mountain lee wave is *not* synchronized to the wave of the stratospheric polar night jet, and *rarely* does lift in the tropospheric jet and stratospheric jet line up across the tropopause. The Perlan pilots have many times spent hours toiling in mountain lee wave without traversing the tropopause into the good stuff. This gets old, no matter how much fun is wave flight.

In Perlan 1, Steve Fossett and Einar Enevoldson were able to climb across the tropopause just once in two years – and set a world record to 15,460 meters (50,722 ft), with lift continuing above (they reached their own equipment, fatigue, and cold limit, not the top of the lift).

The Perlan 2 team were also able get across into the stratospheric wave just once in their first two years – and set a world altitude record at 15,902 meters (52,172 ft), with lift continuing above, having reached their self-assigned test-progression limit.

To achieve stratospheric gliding flights has been the dream of Einar Enevoldson for more than 25 years, with many barriers, mostly money, but especially the tropopause. What could be the solution? Obviously, towing into the stratosphere! But with what towplane? How high a tow?

The tropopause varies in altitude with the seasons and latitude. In winter, in southern Argentina, it's between the high 20s and low 40s thousand ft above sea level. No existing towplane has been able to get there.

Great minds think alike (though fools seldom differ). After last season, Arne Vasenden, hearing about the 2017 record in Texas, thought to himself, *The Egrett would be just right for that job.* Meanwhile, the Perlan team was having internal discussions about acquiring a turbine airplane such as an Air Tractor. In a flippant comment in

Perlan Flights		Altitude			2018
Flt #	Date	Tow FL	Max GPS (ft)	Max FL	Duration (hr)
0046	13 Aug	110			0.6
0047	14 Aug	400			3.2
0048	17 Aug	438			3.0
0049	20 Aug	428		472	5.3
0050	26 Aug	422	60,699	620	5.6
0051	28 Aug	402	63,776	638	5.1
0052	02 Sep	443	74,298	761	5.1
0053	10 Sep	441		454	3.0
0054	12 Sep	451	60,538	629	3.0

Table: 2018 Perlan 2 tows and flight altitude, duration.

an email, Jim Payne said, "What we really need is an Egrett." The rest of the team agreed and Einar volunteered to call his contacts at Grob, who said to call Arne – and it came to pass that Mike Malis designed a tow system, and the crew of AV Experts, LLC, installed it in the tail of Egrett Number One and achieved FAA Form 337 approval – and the rest is 2018 history.

The backstory.

Einar Enevoldson – Air Force fighter jock, glider pilot, NASA high-altitude test pilot flying all kinds of exotic airplanes, nearing retirement age – one day got a phone call from a soaring guy he'd heard of, with the most distinctive East Texas accent he had ever heard. (Later, the "Grobies" made good natured imitation of him by speaking with a cigar lighter in their mouths.) "I got an interesting proposition for you. Meet me at midnight at the Holiday Inn, in San Bernardino, next Tuesday." This was interesting ....

AC Williams, with his wife Mary, ran the famous soaring operation at Caddo Mills, TX, in his spare time away from E-Systems, an electronics company in the spook business.

As the U.S. Grob dealer, he was an ideal middleman. It turned out that E-Systems had been contracted to create an airplane for the Luftwaffe, to loiter close to the East German border 24/7, monitoring electronic traffic. E-Systems would design and build a ton of electronics gear, Garrett would provide a turboprop, and Grob would wrap an airplane around the whole caboodle.

Grob had asked AC to find a test pilot (the soaring community has always harbored many interesting and talented characters), so AC went off to Tehachapi, the gliderport nearest Edwards Air Force Base, to ask for a recommendation from Larry Barrett, who ran the glider operation with his wife Jane. Einar had recently done a BFR with Larry, who recommended him. Einar modestly says, "I was very proficient and did a lot of things well." AC followed up.

The basic challenge was twofold: The U-2 could do the job, but was far too expensive. On the other hand, the USAF was the purchasing agent for the Luftwaffe, and unless they could purchase an off-the-shelf aircraft, would have to wade through a vast and expensive bureaucratic flight test certification program. They devised an end run: Grob would build and certify an airplane, which would then be "off the shelf" when purchased.

AC showed up at the Holiday Inn with a briefcase full of stuff. Einar was keenly aware that sometimes a test pilot would retire from the military or NASA and, unaware of the depth of support at Edwards, sign up with a less-well-resourced private-enterprise program and get himself killed. So he was very cautious. But AC lined up all the players. Garrett; the German flight-test organization; the German flutter institute; E-Systems; the Air Force; Grob – all with sound credentials.

He was wanted half time to assist with design decisions. Einar had a good boss at NASA, willing to let him work at Grob alternate months. He agreed to give it a try. AC said, "There will be tickets to Munich in 2 weeks at the airport. You pick 'em up."

When he got to Germany, Einar found Grob to be technically a pretty solid organization who offered fair compensation. After years with the Air Force and NASA, the idea of creating a product for a customer was an appealing change. The engineers were skilled and approachable. After working half-and-half for a year, Einar retired from NASA in 1986 and stayed with the new airplane.

It was over a year before there was a prototype to fly in 1987. A lot of

Einar Enevoldson

Einar Enevoldson is a kind and gracious man who has done amazing things in airplanes and who has been sadly grounded by some aspects of the expected physical senescence, which we all hope to reach eventually.

You will enjoy reading the details of his life in *Soaring Beyond the Clouds* by Bertha Ryan, herself a soaring legend. Basically, Einar is a California boy who was a soaring pilot first, at El Mirage, then joined the Air Force. He flew the T-6 trainer and the F-86, of course. In 1958 he was selected to fly speed-to-altitude records in the F-104, and set a personal altitude record of 89,000 ft (measured by radar).

He has an MS in aeronautical and mechanical engineering. Subsequently he attended the world's original – the Empire Test Pilot School at Boscombe Down, England. He worked there as a test pilot after he completed training. He said about aerodynamic modeling, "One of the things you learn from testing airplanes is that nothing is quite true."

After retiring from the Air Force in 1967, he worked at the NASA Dryden Flight Test Center under Paul Bikle, whom he'd known since youth at El Mirage. Life there was very interesting, with work on remote piloting, development of the supercritical wing foil, fly-by-wire engineering, and variable wings. He was able to fly such critters as the X-24B lifting body, the AD-1 with the oblique wing. He participated in extensive stall and spin research and PIO problems.

He retired from NASA to help Grob develop the Egrett and later the Strato 2C, designed to fly at 78,000 ft for up to 48 hours, the worst airplane he has ever tried to fly. He was more frightened before the second flight that before the first, but learned its nuances and reached 69,000 ft in it.

After that, he began his campaign to soar in a glider to 90,000 ft – the Perlan Project. More on that in future issues, if our intentions are transformed in to reality.

www.perlanproject.org

things needed to be improved in order to reach Einar's goal of making an airplane that was easy to fly: a pilot had to take off in all weather, climb to 50,000 ft, loiter in a racetrack for 8 hours, then descend through the weather in 20 minutes.

In 1987, that prototype set the turboprop altitude record at 16,329 meters / 53,574 ft. *(The Grob Strato 2C, not related to the Egrett, has flown to 68,867 ft, but there has been no attempt to document the higher altitudes for an FAI record. It was an extremely ambitious research aircraft. It had two 400 hp reciprocating engines, 5 blade 20 ft diameter props, and a 3-stage turbocharger system that delivered sea level temperature and pressure at 80,000 ft. It was designed to fly 60 hr at 60,000 ft and 8 hr at 80,000 ft. An election changed the German government and the project was cancelled.)*

Flying the prototype was an ordeal. The cockpit was unpressurized, so a hard (inflated) pressure suit was needed. There was no air conditioning and the sun up there is hot. Einar's face plate, even on "full hot," was like looking through a shower door, and after the flight he could pour a pint of sweat out of his boots.

The European FAA staff, Einar notes, were pretty smart guys and good to work with. They achieved full FAA certification in the normal way under FAR Part 23 (for unknown reasons, but logically, as a motorglider) and began production. Then in November 1989, the Berlin wall fell; the mission for which the Egrett had been built wasn't needed. It took a year and a half to cancel the program, at which time five had been built. All were sold.

The two-seater was sold to the Flinders University of South Australia in Adelaide. Einar and a wonderfully experienced and skilled Australian pilot, Noel Roediger, ferried it to the buyer.

The most interesting aspect of that flight was that they happened to arrive in Mumbai the day the Pakistanis set off their first atomic bomb. The ferry pilots didn't know anything about that. After Einar got back home, his office said that the State Department had been trying frantically to find out where they were, because "we" had an American and an Australian flying a German spy plane right past the location where the Pakistanis were setting off their atomic weapon – "what the hell are you guys doing there?" They apparently suspected some kind of a plot.

They laid over one day to see the sights, then went on to Calcutta for a day, then on to Kuala Lumpur, and then to Bali and stayed overnight. In the wee hours of that night they heard paper rustling, and under the door was slipped a message from the American *charge d'affaires* that said, "Bring one suitcase and be at the airport at 8 AM – we're going to fly all Americans out."

The Indonesians were having some difficulties – they were afraid a revolution was about to start. There had been quite a bit of turmoil further east.

The Australian got a different message from his foreign office – "All the unrest is further east and you're okay." So they just left a little early. It was a happy feeling when the wheels were in the wells.

They made many stops because the Egrett's range was not great – about 1,600 miles for the two-seater they were flying (about 1,300 miles for the single-seater). It was designed for endurance, not for range.

Einar ferried one across the north Atlantic, a delivery to Texas. Between flight level 260 and flight level 400,

a certified altimeter is required, so he had to fly at least flight level 430 over the Atlantic. The Egrett cruises at 0.40 - 0.42 Mach – "take your lunch – that's slow." An advantage for this slow turboprop is that, at 50,000 ft, there's frequently not much wind to retard westbound progress.

"I don't get bored. I enjoy scenery and I look out the windows a lot. And I stay busy because I'm nervous: I'm checking things continually, doing what-ifs. I don't have a lot of long, boring flights."

He didn't have a single-sideband radio, only VHF, so he was getting people to relay messages to Air Traffic Control, ATC/Center. When he checked in with the Newfoundland center, he said "I'm going to be at 50 west at 1625 hr," which a Learjet relayed for him. About 15 minutes later, the Learjet radioed saying, "Center asked – 'That's two hours from now – Is that correct?'" Einar replied, "Yeah, I know."

Another time, he was listening to airliner radio traffic, and he heard a pilot say, "Center, what's that airplane way up there with the skinny long wings that's flying so slowly?" Einar says, "I didn't tell him. I just let Center handle that."

Flying qualities.

"It's a good airplane – sort of a clunker, an 18-wheeler. I had quite a bit to do with how it flies. I wanted to make it as foolproof and easy to fly as possible because a pilot flying the designed mission would have to take off in perhaps bad weather, climb to 50,000 ft, fly a racetrack for eight hours every other day, then descend through stinko weather at the end of the shift."

It has a superb autopilot that does excellent coupled approaches, something that would be welcomed by a pilot after 8 or more hours in the air.

It has a 1759 SHP Garrett turboprop flat-rated to 750 hp. It can climb at 1,500 ft/min to about 28,000 ft, decreasing after that, reaching 48,000 ft in 48 minutes, but then it takes another hour to get 50,000 ft when loaded with 2 tons of mission gear and full tanks. Interestingly, it has the same climb rate from 70 kt to 130 kt.

"It's not *fun* to fly – it's not a nimble airplane. The controls are heavy down low, but light at high altitude. But you can do what you need to do, and it will handle pretty severe conditions – in turbulence, and crosswinds, and all that.

"It handles turbulence pretty well. I have flown in clear air turbulence that was reported as 'extreme' – the flexible wings take some of the sharpness out of it. It's very stable – you just kind of rattle along and take your bumps and it's okay. But I've never flown it in a thunderstorm – I would definitely avoid that.

"I have flown in some severe clear icing – it handles that, but just barely. That was around flight level 230. The handling doesn't change as ice accumulates because the deicing system works pretty effectively.

"The manufacturer made some special deicing boots and took great care to make them smooth and conformable to the leading edge. I never

The Former Highest Tow

In late 1997 and early 1998, a research project investigated a tow-launch concept that reached more than 20,000 ft. "The pilot of the C-141 tow plane was Maj Stu Farmer. The tow rope was 1,000 foot Vectran. The pilot of the F-106 Delta Dart was Mark Stucky, a Marine pilot, NASA test pilot, and now Virgin Galactic test pilot. The F-106 performance on tow was quite different from that of a sailplane. There appeared to be a lower and an upper bound on the tow angle between the two airplanes. Flight beyond these bounds would cause divergent pitch and sometimes roll oscillations. Fortunately, the oscillation amplitude would increase slowly enough that the pilot was able to recognize the problem and correct for it by flying back within the bounds. The C-141 pilot could not feel the effects of the F-106 doing normal small-amplitude maneuvers on tow."

Reference: https://www.f-106deltadart.com/eclipse.htm

The Egrett Towplane Resource

Airborne Resources is a collection of aircraft that can serve as test beds for data acquisition, among which is the Egrett. It is owned by Roberta Vasenden, for whom her husband Arne Vasenden is chief pilot and co-manager. They seem to collaborate well on all things.

https://www.geoint.community/members/airborne-resources-inc

Roberta is a humble physicist particularly interested in climatologic research using remote sensing. Arne is a humble pilot particularly interested in flying, at which he's very skilled and deeply experienced. (Though incomplete because he's not had time to finish a glider rating.)

Their business takes them many different places, wherever cutting-edge remote sensing is required. This means that their charming, newly-minted teen Elisa gets to see the world while being schooled in the Aviation Nomads tradition.

We're grateful that they were willing to abandon their business for two months in order to create success for Perlan 2.

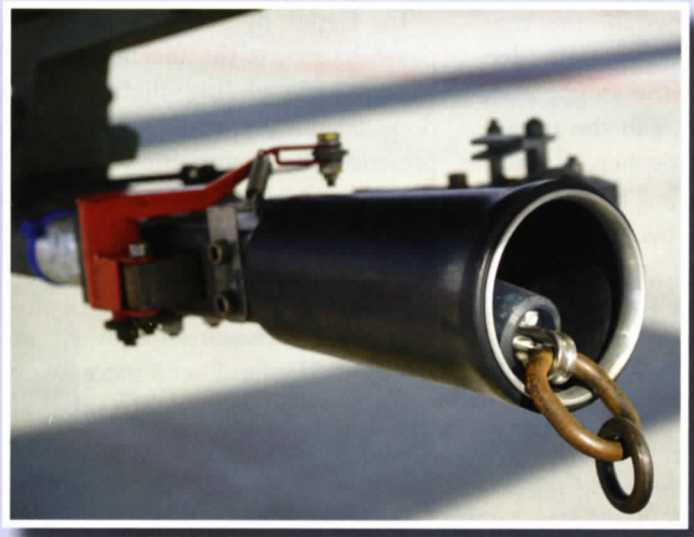
The Tow System

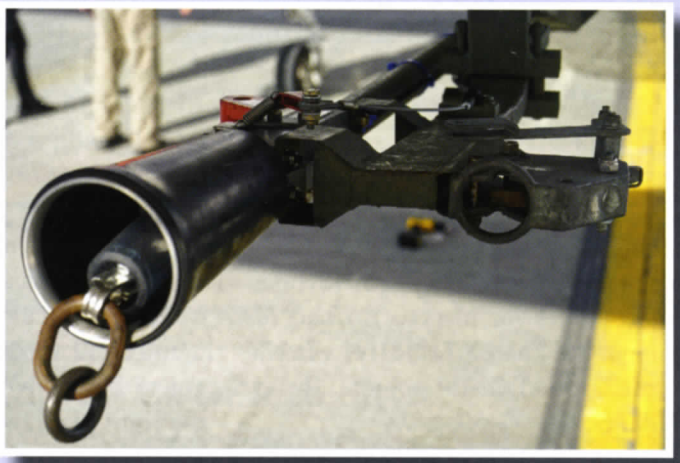
The personally kinetic engineer, Mike Malis, was tasked with fitting Egrett with a tow system. He was given straightforward design goals: 300 ft of tow rope, plus being safe, effective, and reliable. And oh, yes, it would have to work all the way to -70 °C and beyond 40,000 ft.

This had never been done, and there are (as you may have guessed) no computer models to predict the high altitude cold-soaked behavior of a tow system. He could only make a good design and wait to discover its foibles – which it had (as you may have guessed).

He obtained a fine used TOST reel, and designed a mount on which to place it inside the Egrett's tail. To get 300 ft of rope on this reel required a smaller diameter of rope that it had been designed for; 3mm Spectra would fit.

A metal weak link inside a thick vinyl shield rests in a trumpet when reeled in.





A backup system was constructed using a Schweizer tow hook with a cockpit release. The Perlan team was discouraged by the airport personnel from using this because formal permission from Ground Control to drop the rope would be complicated to obtain, and might trigger objections, delay, and requirements hard to meet.

We now know that

(a) Frost collects on the chilled rope from the turbine exhaust and puffs away in a cloud when the glider pilot releases from tow. Or clanks (alarmingly) on the nose.

(b) The weak-link shield becomes brittle when cold and shatters easily. Fiber-reinforced vinyl survives.

(c) The Spectra first stacks in a triangle on the reel (no level-wind), and it's very slippery, so falls off to one side or the other. Perhaps because the heavy weak-link is violently flopping around after release, the tension on the reel is unsteady, favoring loops that can escape the reel and wrap around the axle.

(d) The weak-link gyrations can tie an overhand knot in the rope, hindering retrieval.

(e) The electric motor driving the reel is not enthusiastic when cold-soaked to -70 °C.

(f) The temperature effects on the system can't be tested on the ground.

(g) Next season there will be a stronger motor and other tweaks to reduce snags on this big reel.

Thanks to Mike Malis for engineering ingenuity and continual analysis.

thought you could maintain laminar flow with deicing boots, but we did a lot of oil-flow tests with the boots, and it had pretty much the same laminar flow regions as the prototype without boots. This amazed me.

"In development, I had to fly with some big protuberant ice shapes made of Styrofoam that stuck about a foot off the leading edge. They were really draggy and the airplane shook and rattled a lot, but it did stay in the air.

"There were no 'good' crosswinds at the Grob airfield – about 12 kt maximum. The airplane will handle more than that, but it will get to be a handful. It has no nose wheel steering, so taxiing it in a crosswind is going to be more difficult than getting it onto the ground. It has a huge vertical tail, so there is very

strong weather-cocking. In a strong crosswind, you have to use a lot of downwind brake. Extended or fast crosswind taxiing can burn out the downwind brake, so getting a tug is a good idea.

"The flaps are designed for a rapid descent. They rotate about 70°, just like some gliders' landing flaps (the Schreder HP series for instance). I had to demonstrate that I could be wheels on the ground in 20 minutes from 50,000 ft.

"The cold at high altitude is very significant operationally. You have to test everything at low temperature. The standard is -55 °C, and yet at -60° a device may not work, and -70 °C isn't unusual. I understand that the Egrett that flew in El Calafate could not use full flaps because extending them in high-altitude knocked the generator offline. Could that be the temperature? And it's a mystery why that didn't simply pop the circuit breaker.

"I flew the prototype for about six months in Texas. At one point we were testing the alternator, and to do this they put a big stove under the airplane to absorb about 10 kW. I was flying at about 50,000 ft and turned it on. Bang! It blew the generator offline. I had no transponder and only a handheld glider radio. With that I was able to talk to Fort Worth Center. The prop gives the airplane a pretty good radar signature, so after a couple of turns he said, 'Okay, I gotcha,' and he gave me descent. This was 5 PM on a Friday afternoon, right over Fort Worth. He said, 'I would've had to divert 500 airplanes if I hadn't been able to find you on radar.'

"There is an old NASA principle: Don't troubleshoot in flight. At Edwards, I just landed and let someone figure it out. On the other hand, you've got to be flexible. There are times, in the right place, when you can do a lot of good by some careful, intelligent troubleshooting in flight.

"The production airplane is comfortable – it's pressurized and roomy and the air conditioning works well."

The Egrett is ideal for Perlan flights.

As a general rule, all the interesting weather is confined to the troposphere, including mountain lee wave. It's topped by the tropopause, a boundary layer between the troposphere and the stratosphere. In the winter this may be as low as 25,000 ft, and in the summer or over the equator about 60,000 ft.

The stratosphere is stable and for years was thought to be devoid of interesting weather. But in the middle of the twentieth century, it was discovered that a stratospheric jet stream forms in the stratosphere during the polar night – the Polar Night Jet.

It is known to form wave over mountainous regions – Norway, New Zealand, the Andes – but one important discovery of Perlan 1 and 2 is that it is not *linked* to mountain lee wave, so that there is rarely continual wave lift from the lee wave of the troposphere to the stratospheric wave. This is the reason for the rare successes of Perlan 1 and 2, which took "normal" tows of about 10,000 ft, in reaching the stratospheric Polar Night Jet wave – there's no "tube of lift" reaching from valley slope to beyond 100,000 ft.

Because Perlan intends to study the aerodynamics, meteorology, and atmospheric chemistry of the stratosphere and this jet, it's frustrating to spend hours (3-5) and weeks (6-8) in tedious climbs to the tropopause only to find no bridge through it.

The Egrett, by traversing the tropopause barrier, is the means by which stratospheric gliding flights can be done reliably, dependent only on the presence of stratospheric wave. If the upper-atmosphere wave structure is there, Egrett can drop Perlan in its lower reaches.

During 2018, with tows to the stratosphere, when the wave was "working," Perlan 2 set 3 successive altitude records in 6 days. The pilots and the whole team were full of joy.

"Egrett tow is very expensive by normal standards but it saves the project a lot of money. We could get 10 flights into the stratosphere in one season, while without the Egrett it would take 3 seasons or more."

Links:

First Egrett tow of a glider
https://www.youtube.com/watch?v=q-1qBOUMfwo

Wikipedia
https://en.wikipedia.org/wiki/Grob_G_520

2018 Perlan 2 U-Tube videos
https://tinyurl.com/Perlan2videos