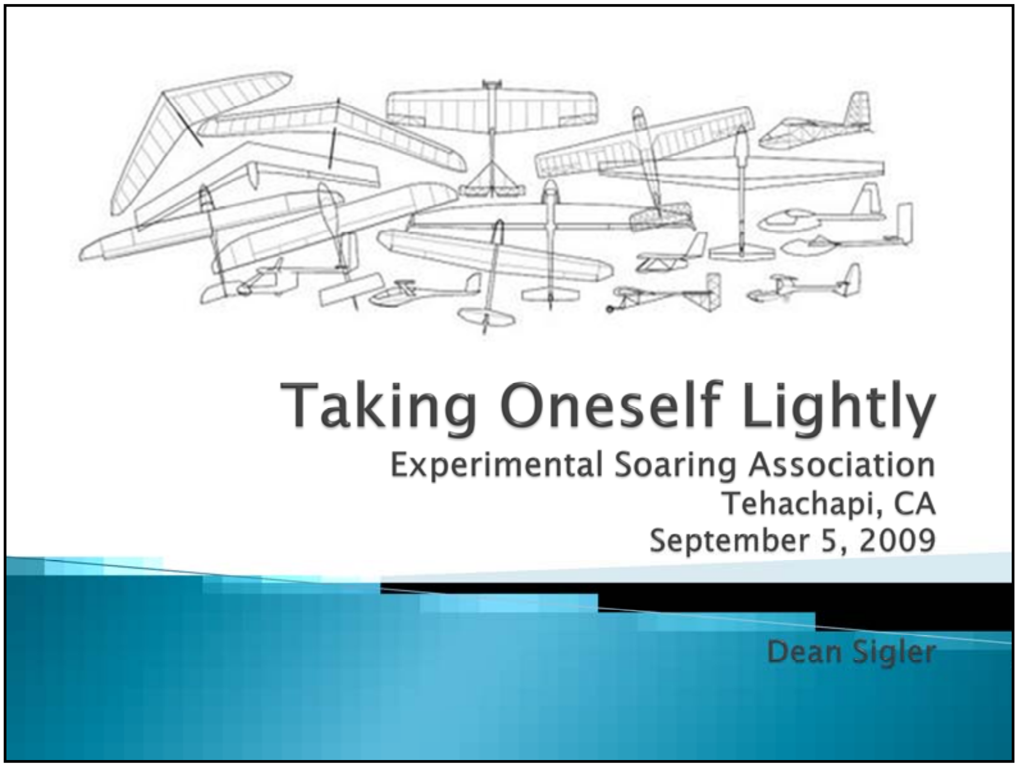
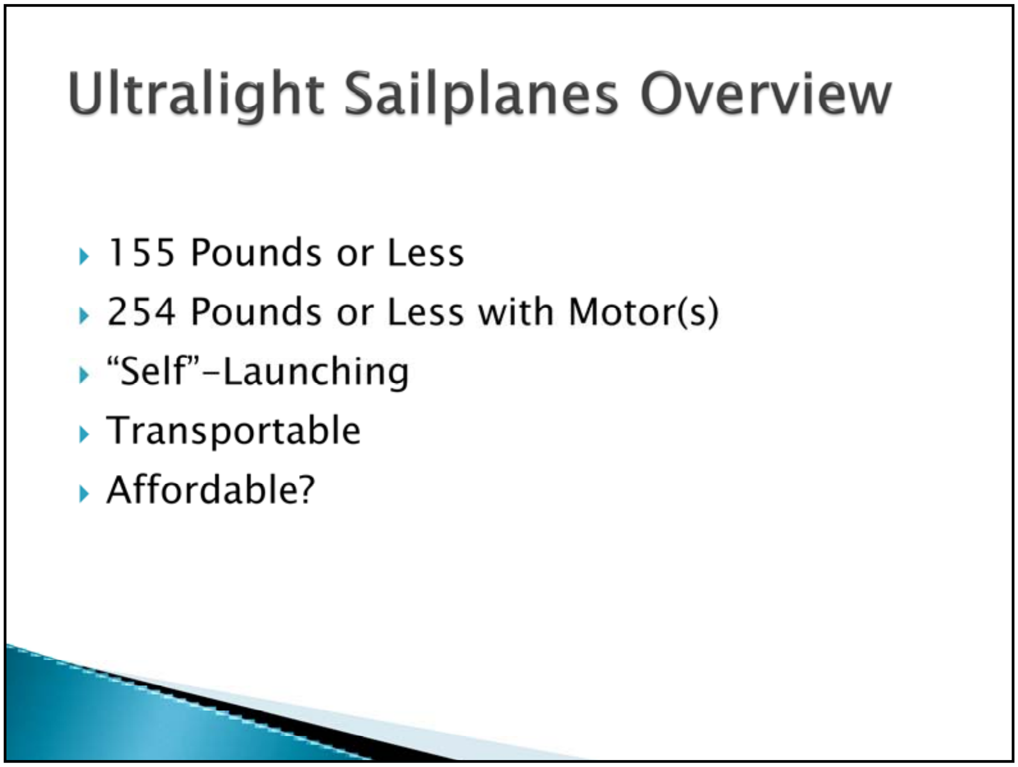


My presentation reflects my life-long interest in ultralight aircraft, especially low wing loading, low power exemplars. There are three major parts to this, including an overview of old and new approaches to light gliders and sailplanes, a glance at electric motors and technology that might find application in our pursuit, and a look at larger motors and heavier craft that will help define our electric aircraft future. Nothing, however, extends beyond that which will be found in the light sport aircraft realm, showing what can be done with lightweight structures and highly efficient powerplants.

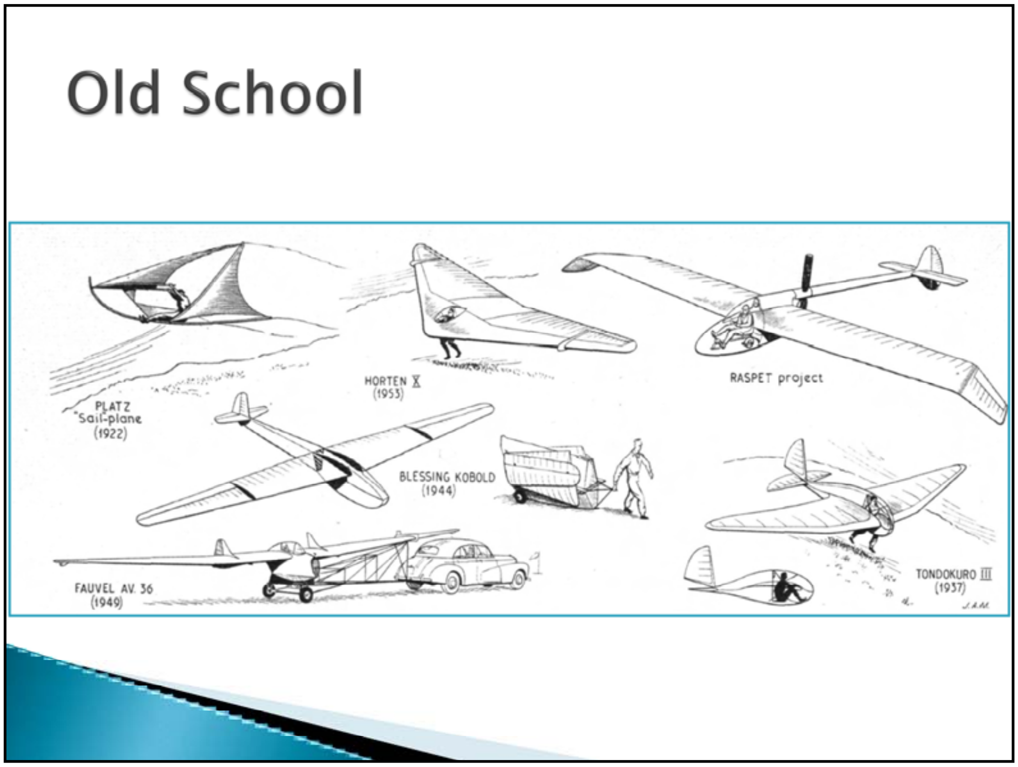


We'll first examine the quest to develop a light weight, possibly small glider or sailplane that allows ease of use, including self-launching and ease of assembly. These are functions of small size, light weight components, and simplicity of design.

Such light sailplanes would ideally be "self"-launching, either through true "self"-motivated efforts, such as foot launching, or through some means such as slope-rolling starts, self-actuated bungee launches, or some other means. A secondary consideration would be to use the smallest number of ground resources required to gain flight.

Such devices would need to be easily transported, with the ideal being some form of car-top enclosure to protect and haul the craft from site to site.

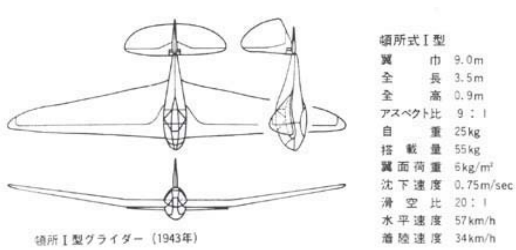
Finally, we need to find ways to make these aircraft affordable – with a dream goal of $10,000 or less. A $20,000 or more "toy" does not resonate well in the average household, and most hobbyists are relegated to lower-cost alternatives to denying their spouse and family the necessities.



Old School

As this 1954 illustration from *Flight International* shows, almost all "solutions" to lofting oneself into the air in an unpowered or low-powered way have been tried, some many years ago. Even the attached article was looking back at efforts by people like G. Blessing to make a sailplane that could be transported on German rail lines in the baggage car. "On landing, the pilot could fold the fuselage in half and the wings into four pieces; with the addition of a spare wheel the whole thing was turned into a two-wheeled wheelbarrow measuring 3 x 1 x 1.35 metres and weighing 275 lb; he could then pull it by hand to the nearest railway station. An inflatable cover protected it from rough handling in the luggage van, and an integral tow-bar permitted it alternatively to be towed by motor cars or even motor cycles in the normal manner."

Tondokuro was a Japanese enthusiast who started a series of microlight, foot-launched gliders in the late 1930's and continued through the war years. Judging from specifications for his machines, he was himself a microlight package, and this low payload, low AUW allowed for extremely low span loading.



Note that with a 9.3 meter (about 30.5 feet) span and an all-up weight of 80 kg (176 pounds), the span loading would be 5.77 pounds per foot, or 0.19 pounds per foot span squared!

Old School

The ULF-1, a 1970's design by Dieter Reich, uses a great many "fiddly bits" to provide a light-weight, strong structure. Its ability to be foot launched, or towed by creatures or vehicles with as little as one literal horsepower, provide for its continued popularity.

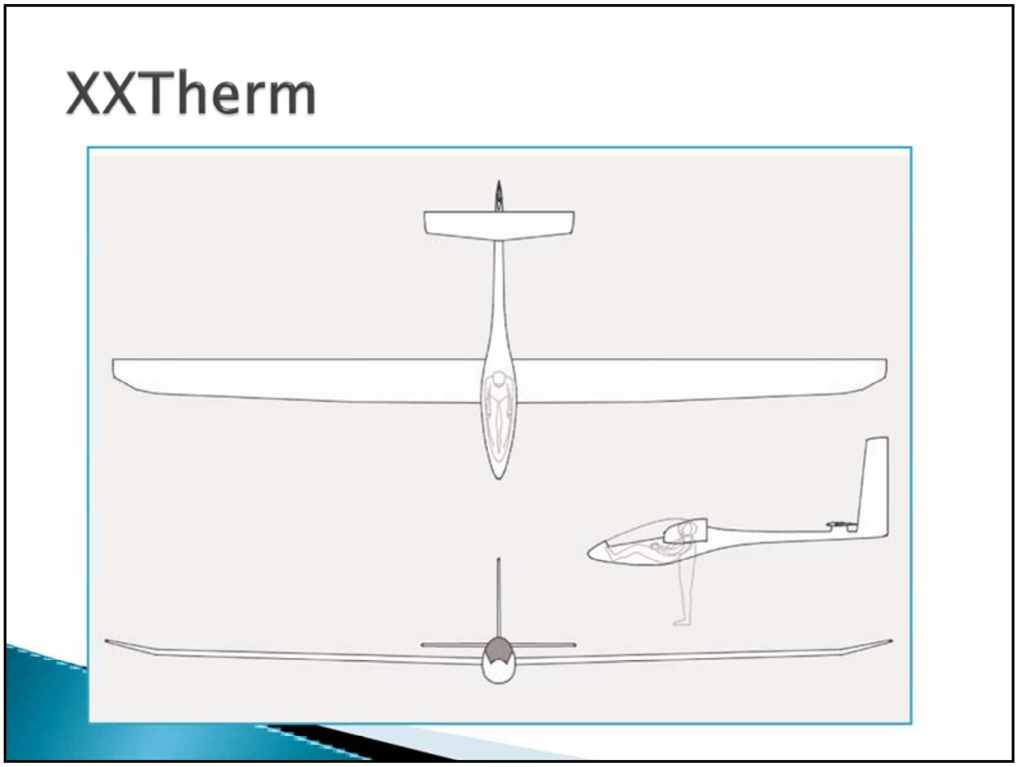
One video on the Internet shows an example flying in ground effect on a small, probably industrial-type engine. Plans are available from the designer.

Harking back to Tondokuro, Yasushi, who lives in Nagoya, Japan, wears his Carbon Dragon proudly. He built this in a double-car garage and has test flown it on car tow.

Both aircraft have the capability of being foot launched, but use structures that limit the ability of the pilot to actually perform a safe, unimpeded takeoff. This becomes a limitation that needs to be addressed in any such design.

The VJ-23 was the penultimate Volmer Jensen design. Plans were featured in a national magazine, and powered versions have flown on go-cart engines, including one flown across the English Channel.

http://www.eel.de/english/home_en.htm

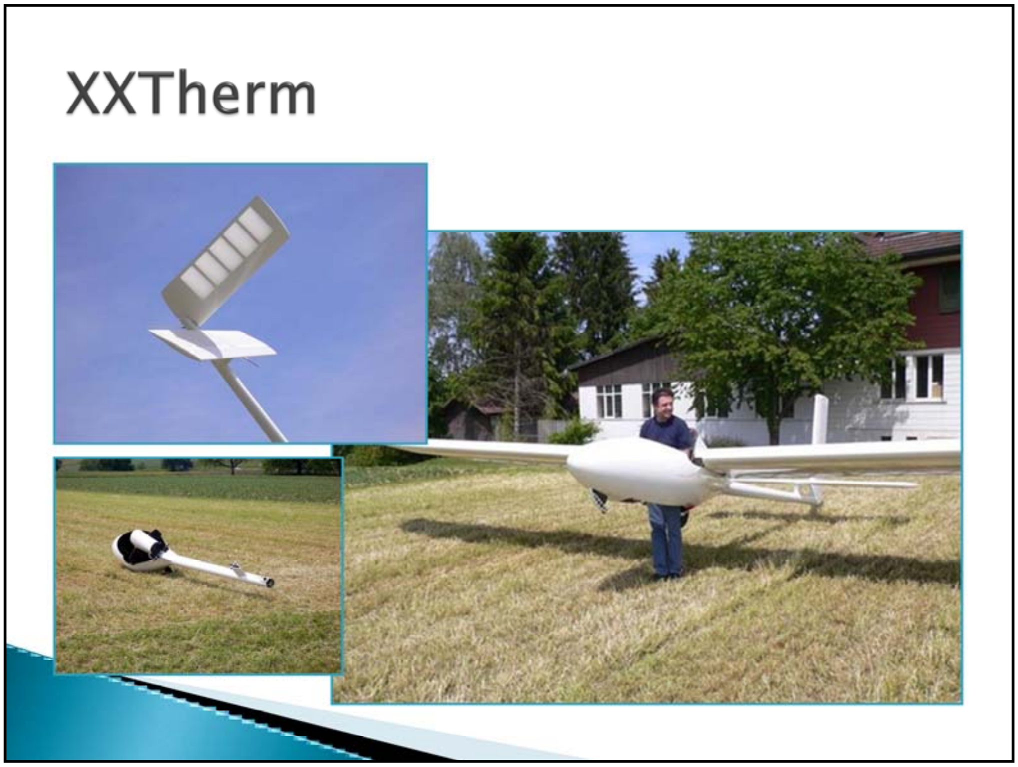


XXTherm is a Swiss design with moderately good performance, designed primarily for sport flying with the goals of achieving, "maximum flight pleasures, no use of big infrastructure and extern[al] help… and the independence of hang gliding with the comfort of sailplanes."

The designers hoped for safety, intuitive control (based on standard three-axis controls), foot launching and slow speed control to allow the use of flying sites normally associated with hang gliders, stable behavior and a low pilot workload.

Their structural design uses honeycomb and fiberglass cloth for a strong, reliable airframe.

http://www.xxtherm.ch/



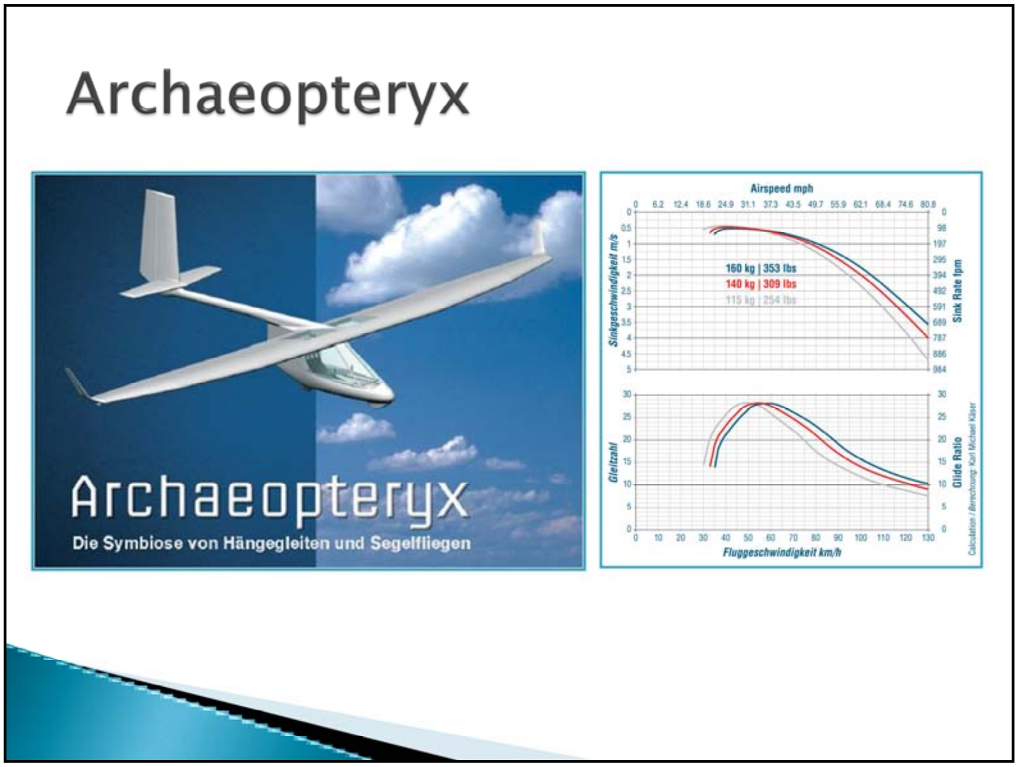
Using reasonably inexpensive fiberglass and honeycomb core materials, the builders managed to keep the weight to 80 kg (176 pounds), a little over the ultralight limit for American sailplanes, and a bit of a haul to achieve foot launch other than in a heavy breeze. They hope, in later iterations, to achieve a 50 kg empty weight.

They have incorporated an escape and rescue package, including a parachute for the airplane. This allows retrieving a fairly undamaged pilot and airframe – unless it disintegrates in flight. Although the airplane is broken down into four parts for the wings, and two demountable tail sections, the craft still requires a small trailer for transportation.

- Span 12 m
- Length 5.5 m
- Height 1,7 m
- Wing area 13,1 m2
- Weights Overall system 80 kg of load 30 kg (prototype)
- Pilot weight 50-100 kg
- Take-off weight 130-180 kg
- Surface loading 9.9-13.7 kg/m2
- Load factor (examined) +6.3, -4,5 g

Performance data

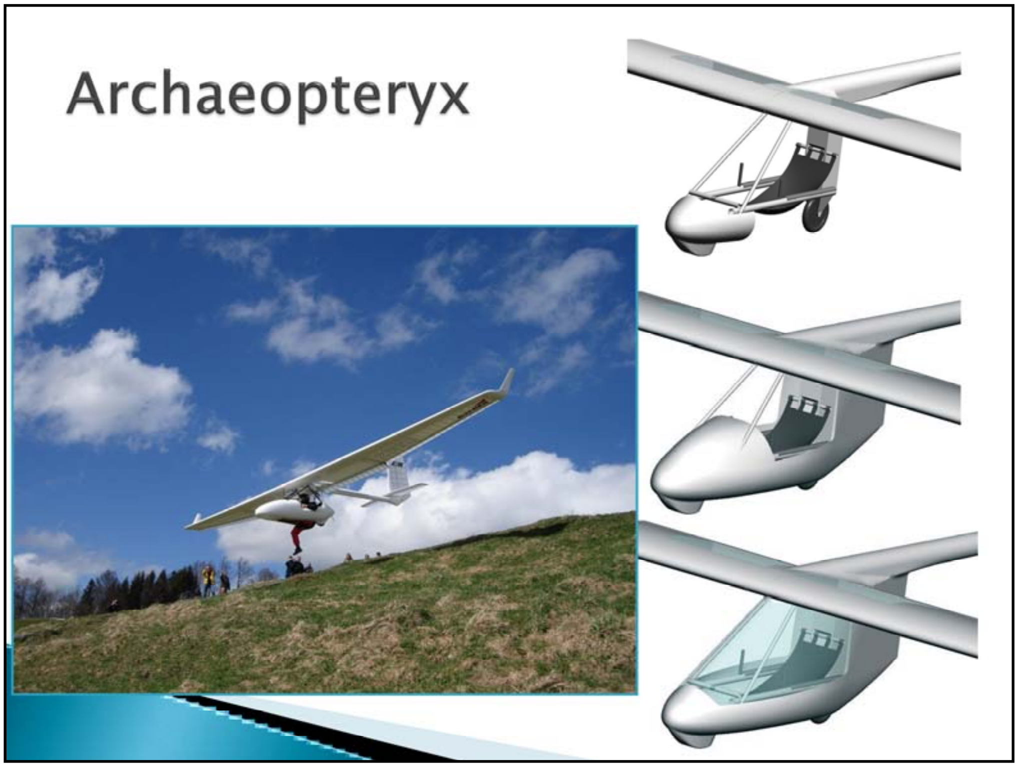
- Minimum speed 30 km/h
- Maximum speed 100 km/h
- Smallest sinking 0,55 m/s
- Lift/drag ratio 27



Archaeopteryx is another Swiss design, again with modest (by competition sailplane standards) performance, and the capability of being foot launched. Like the XXTherm, its structure is primarily composite, with fabric covering on the wing and tail surfaces.

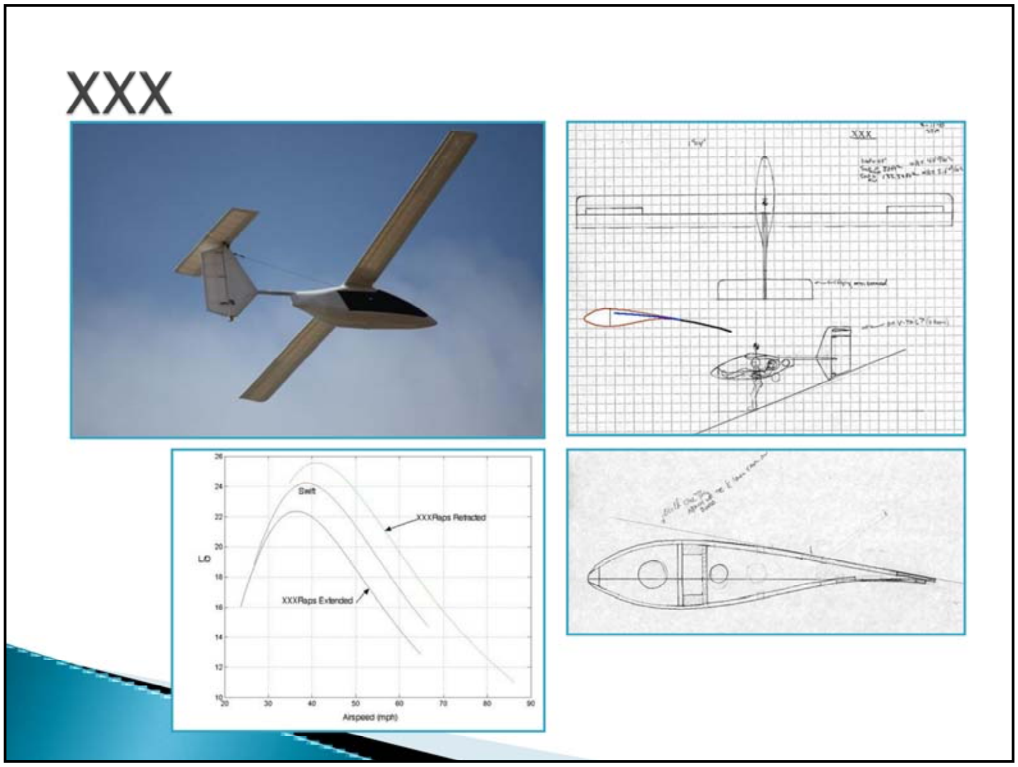
Note that the performance curves indicate a 98 foot per minute best sink rate and a 28:1 best glide ratio at speeds between 25 mph and 32 mph, depending on weight, which can vary between a low 254 pounds to 353 pounds. Note again the low span loading. Even at the highest permissible weight, span loading is only 8.02 pounds per foot or 0.182 pounds per foot span squared – a little better than that achieved by Tondokuro.

http://www.ruppert-composite.ch/english/

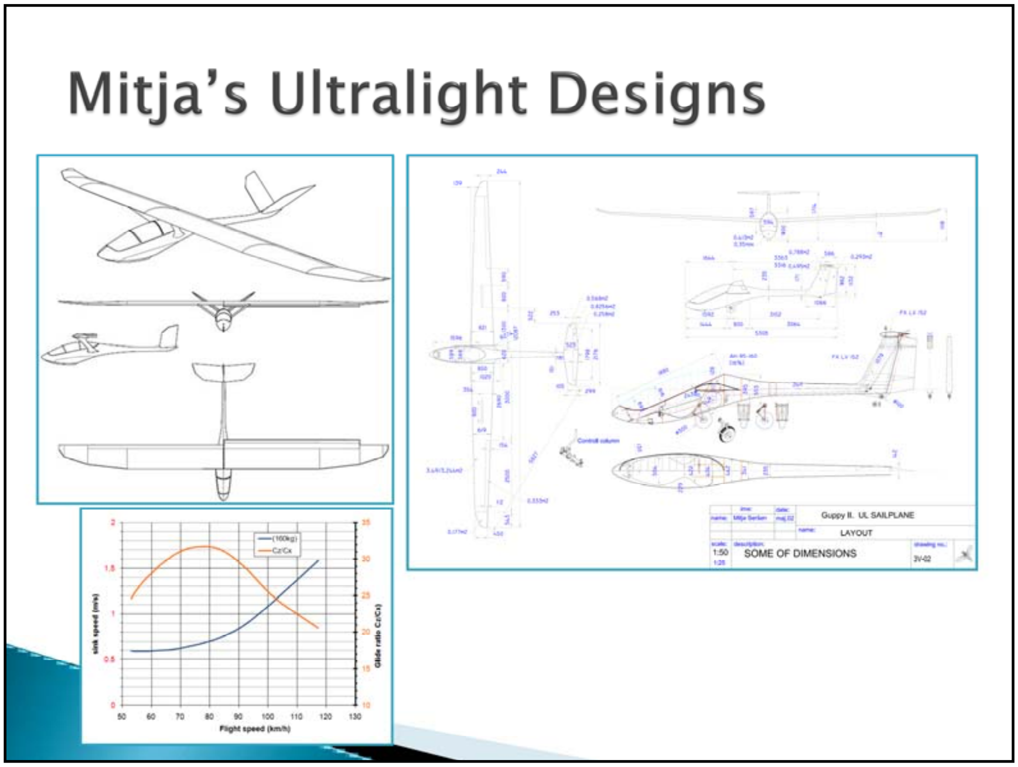


The designers incorporated some flexibility into the design, allowing for various levels of streamlining, empty weight, and performance.

Total Span		13.6 m | 44.6 ft
Length		5.7 m | 18.7 ft
Height		2.9 m | 9.5 ft
Wing Area		12.8 m2 | 138 sq.ft
Empty Weight	(Standard Version)	46 kg | 101 lbs
Cockpit Fairing	(Race Version)	4 kg | 9 lbs
Rescue System		5 kg | 11 lbs
Wing Loading	min TOW max TOW	9.0 kg/m2 | 1.8 lbs/sq.ft 12.5 kg/m2 | 2.6 lbs/sq.ft
Take off Weight	min max	115 kg | 254 lbs 160 kg | 353 lbs
Pilot Height	min max	1.65 m | 5.4 ft 1.95 m | 6.4 ft
Pilot Weight	min max	55 kg | 121 lbs 100 kg | 220 lbs
Load Factor	pos neg	+ 5.3 g - 2.65 g
Stall Speed	min TOW max TOW	30 km/h | 18.6 mph 35 km/h | 21.7 mph
max Speed	Vne	130 km/h | 81 mph
Minimum Sink Rate	min TOW max TOW	0.44 m/s | 87 fpm 0.51 m/s | 100 fpm
Glide Ratio	best with Air Brake	28 5
Minimum Turn Radius	at 45 deg bank	15 m | 50 ft



XXX was a design that appeared to have some promise, but the designer's email no longer elicits a response. Appearing like an amateur-built version of the Saqqara, this concept was to use a large retractable sail to allow light-wind soaring and low landing and takeoff speeds. Note the shape of the tail to enable taking off from a slope. The designer was attempting to equal or best the performance of the Swift.

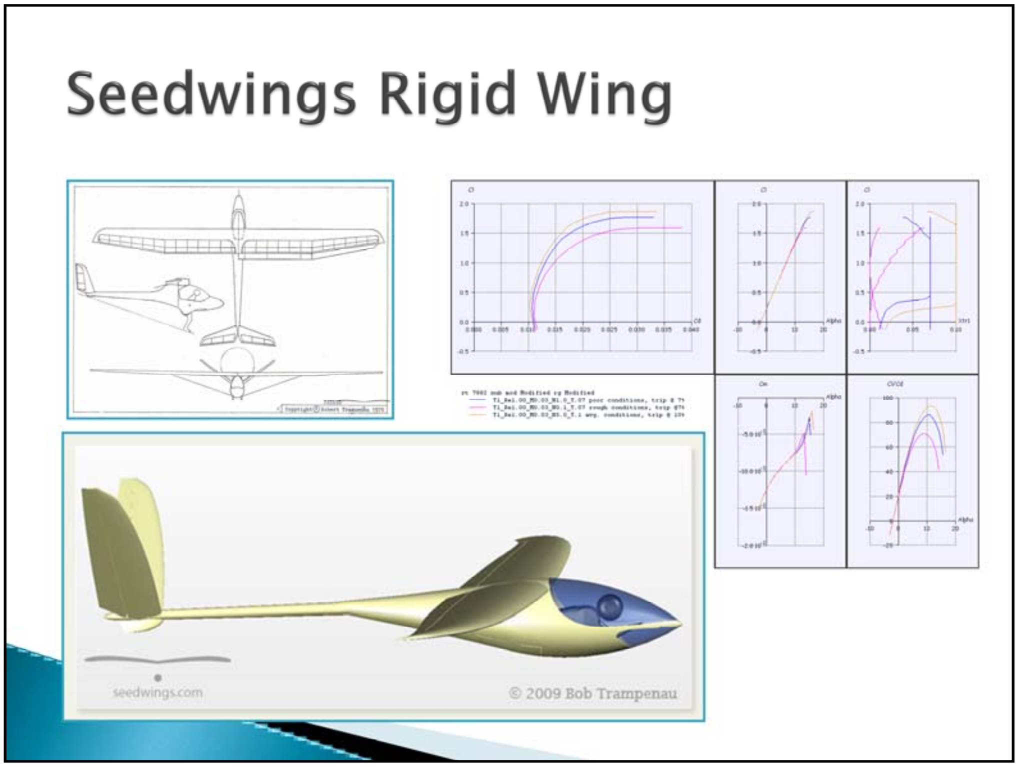


Mitja Sersen, an enormously creative individual in Slovenia, has been designing real and possible hang gliders and sailplanes for years.

His foot-launched concept includes large flaps, simple construction of metal and fiberglass with fabric covering, and an interesting attachment for the wing.

His more recent effort is a high-performance compact sailplane, somewhat in the spirit, at least, of the Sparrowhawk.

http://ultralajt.webs.com/



Bob Trampenau has pursued the idea of an ultralight sailplane for the last 30 years. I was excited by the design of the Petrel in the late 1970's, only to have that design disappear from view. He shares the latest design idea, which would be a variation on a flat-top hang glider design, with similar box spar construction, but far more streamlined style. The pilot lies in a prone position .

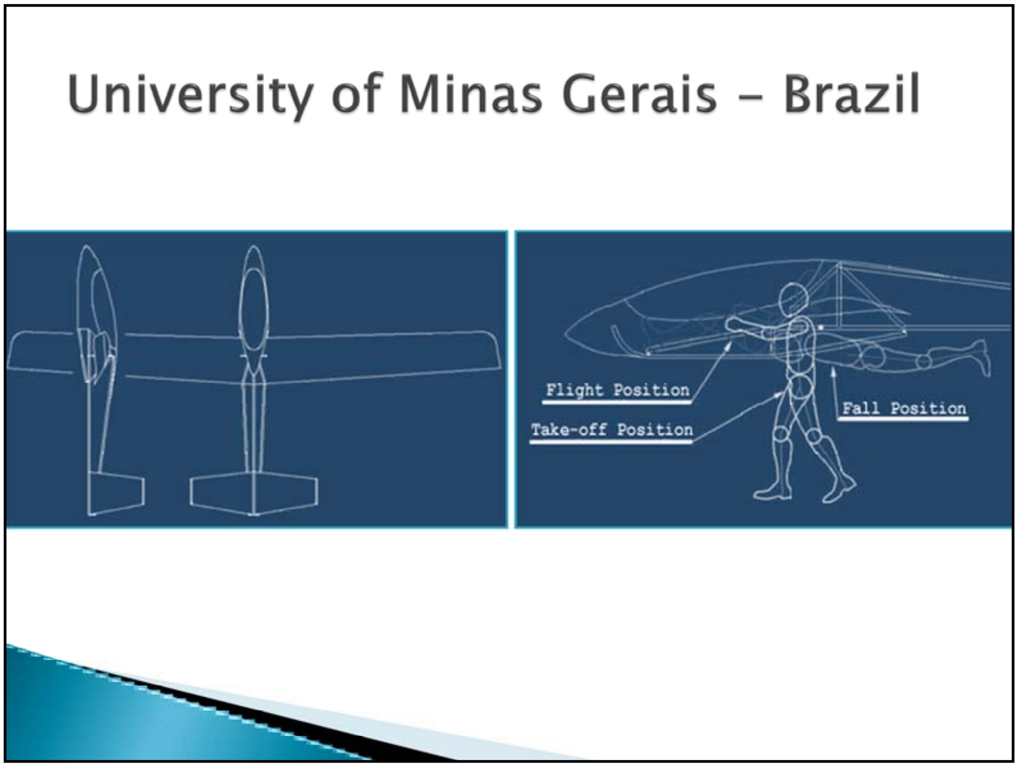
The tail boom is of particular interest, with a carbon fiber cloth inside layer sandwiched between two layers of titanium foil, making for an extremely light, strong assembly.

"This root hang glider foil is 11.05 %thick at 17.3 % back and has 3.25% camber at 22.5 % back. Pitch stability, high lift and low cruising drag are all controlling factors in the final shape. The wing tip foil at half the Reynolds number produces the same or more lift at slightly higher Cd due to lower Re and its zero lift angle of attack produces 2+ degrees of aerodynamic twist compared to the root foil Cm value.

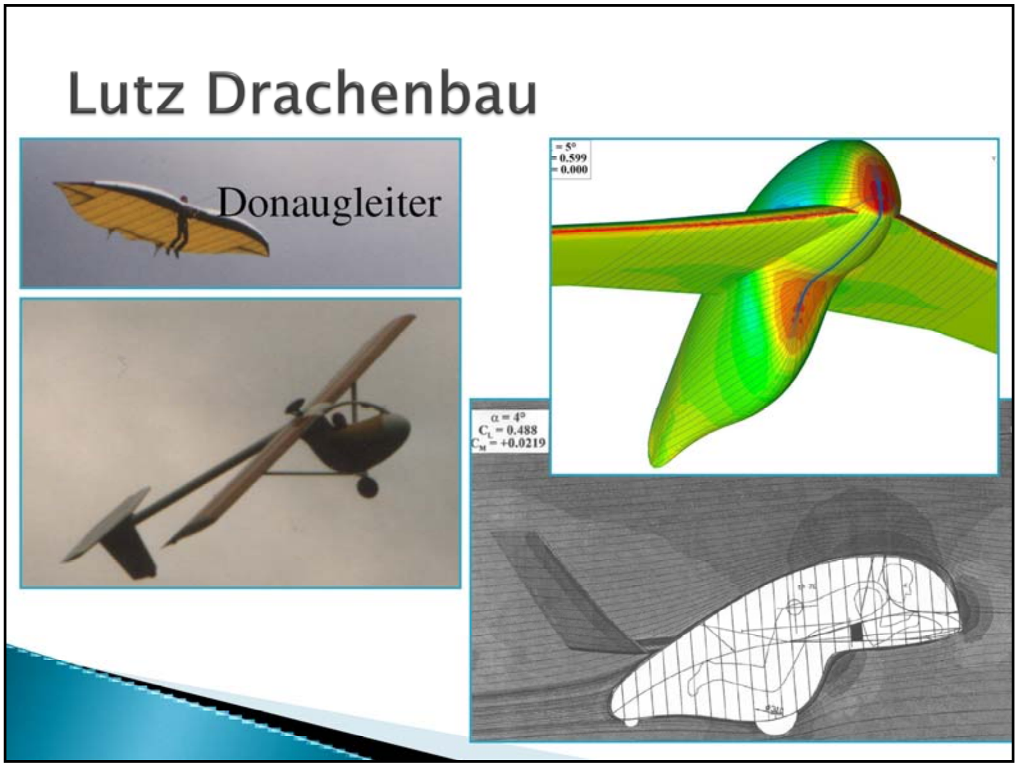
By the nature of hang glider sail construction, we can not expect laminar flow to exist beyond about 10% back on both the top and bottom. I am working on a system to insure improved conditions back to about 10 to 15%."

In a discussion with me at Tehachapi, where I presented this paper, Bob suggested that improved leading edge technology, using carbon fiber, could extend the range of laminarity considerably.

www.seedwings.com



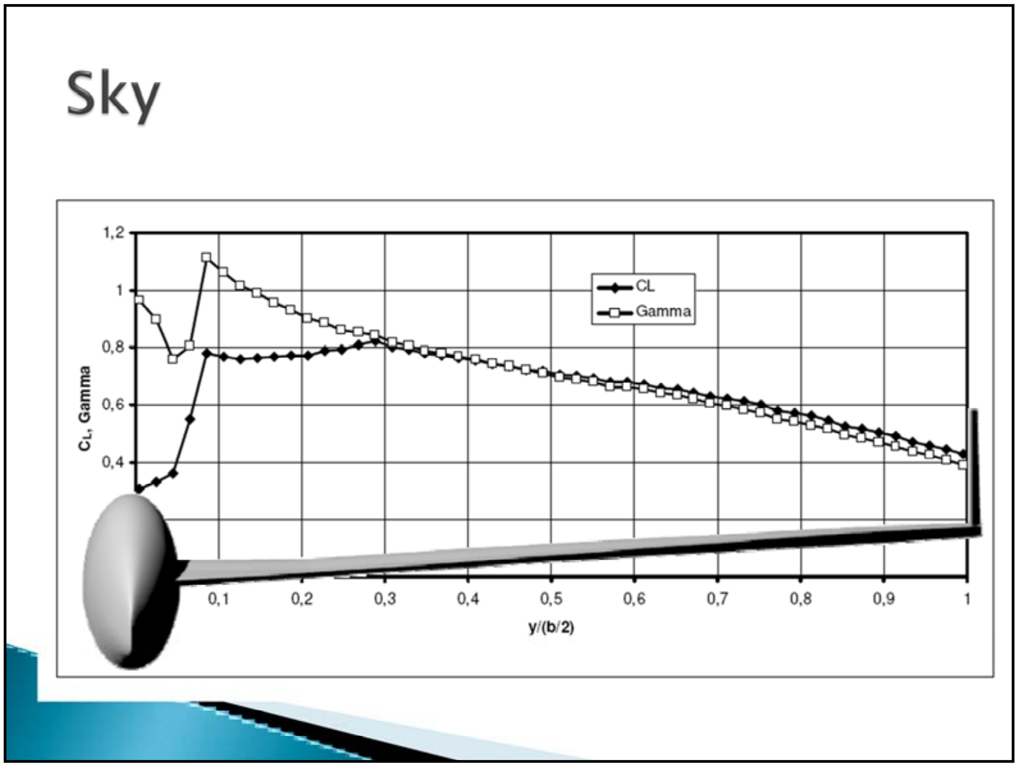
This ultralight design from Brazil has a supine pilot position, but takes into consideration the possibility that all foot launches may not be happy ones. Note the pivot position for the pilot, and the aptly-named "fall position." The cutaway "step" which allows the craft to drop on the prone pilot without causing too much damage is a clever safety item, although it might compromise aerodynamics.



Julu (Lower Left)
The running take-offable aircraft JüLu-1 (Jürgen Lutz 1). I had to recognize that in this single airplane the disadvantages [of] sail and kite flies were united.

Donaglieter (Upper Left)
Technical designer: Jürgen Lutz
Designer: Jürgen Lutz
Pilot: Jürgen Lutz
Span: 9m
Flügeltiefe max: 3,8m
Unloaded weight: 18kg
Mass pilot: 65kg
Surface loading: 3,3kg/m⊃2;
Minimum speed: 24Km/h
best lift/drag ratio: 10
The aircraft is characterized by extreme lightweight construction. With a surface loading of 3,3kg/m⊃2; it might be the aircraft with the smallest surface loading (man-basic aircraft, cantilever wing).

http://www.lutz-drachenbau.de/



"Technical data:

•Span: 10,3m

•Wing area: 8m ²

•Aspect ratio: 13,3

•Unloaded weight: 70kg

•Additional load min: 60kg

•Additional load max.100kg

•Surface loading min: 16,3kg/m ²

•Surface loading max: 21,3 kg/m ²

•Minimum speed: 54km/h

•Maximum speed: 180km/h

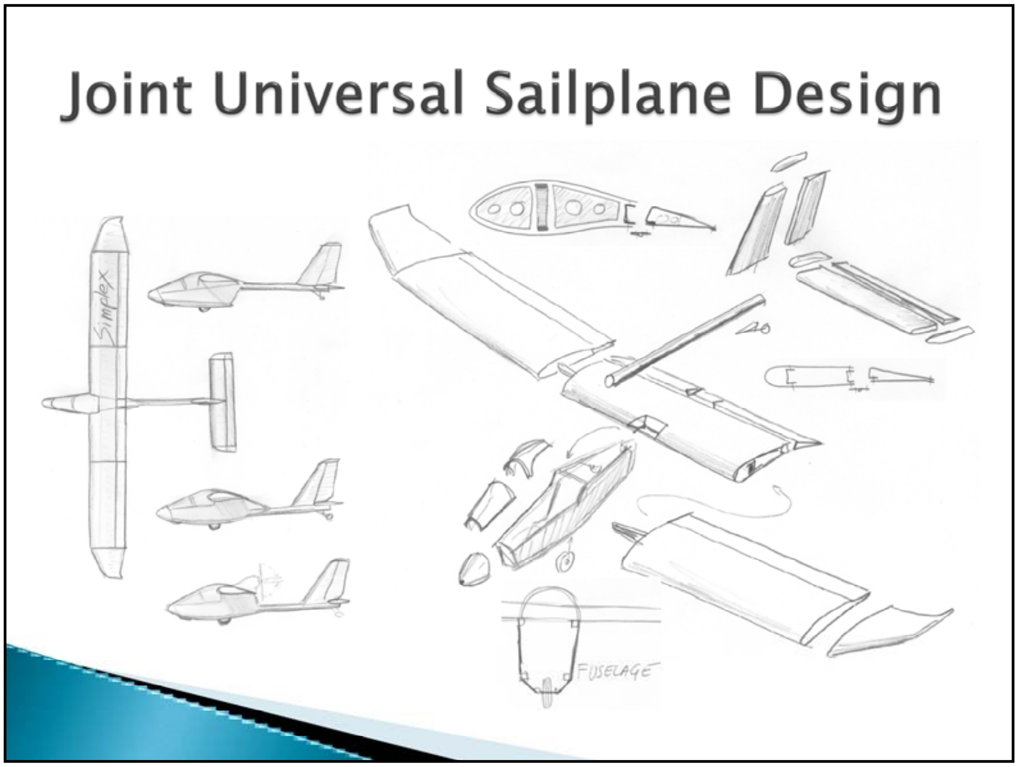
•Best sliding approx.: 25

•Minimum sink: 0,75m/second

The polar one is counted on maximum surface loading."

The Sky is shown here tied to a roof rack on a VW station wagon, with its fuselage pod attached to the one wing. Two removable parts of the pod would be carried inside the car.

Lutz visualizes using a small internal combustion engine or electric drive to allow self launching when hopping off a hill is not practicable.



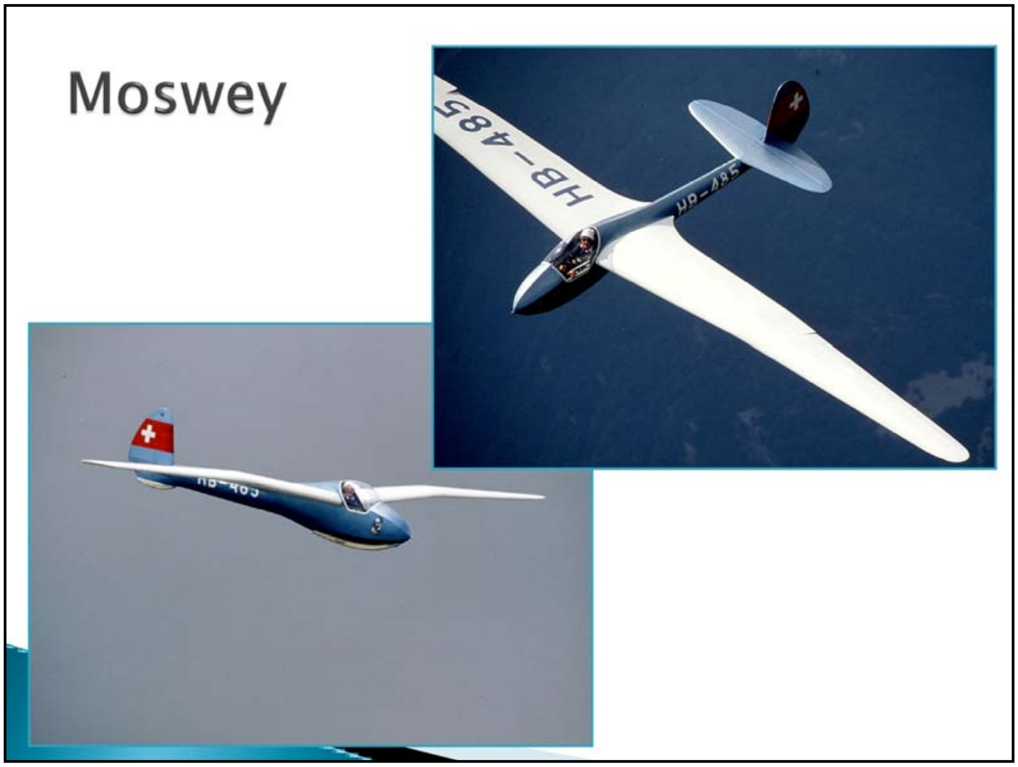
Mitja Sersen has invited designers world wide to participate in designing a simple sailplane. Simplification being hard, there hasn't been significant effort past the formulation of the idea. Modern materials such as Graphilite® and traditional materials such as aluminum and wood could make such a design possible, though.

Note that the wings are composed of units no longer than 10-feet in length, with construction in home workshops a definite part of the design scheme. Refinements could be added at the builder's convenience, improving the aerodynamics and the performance in a progressive fashion.

The Spectrum Freedom shows a high-tech variety of what can be thought of as ultimate geodesic construction. According to Dudley Smith of Bell Helicopters, this type of construction is high cost and high tolerance because of the CNC filament winding that takes place.

Obviously, for our projected sailplane, somewhat less costly means are required.

The GFW3 is being constructed by a Dr. Warner in Germany to meet ultralight sailplane standards, from what I can glean from the DULV website. Although the photograph is the only reference to the craft, I noted the 45-degree angles of the criss-crossed fiber elements in the nose cone. Could this be a type of geodesic lay-up within the fiberglass or carbon matrix?



Loving old sailplanes, I turn to the past for inspiration for my future design.

Moswey sailplanes were built in Switzerland from about 1930 to some time after 1945. They were stressed to 12g's, and featured quality workmanship. According to Martin Simon's *Sailplanes 1920-1945*, "The metal fittings in particular were made with utmost precision and fitted like the parts of a high class watch."

With a span of 14 meters, a length of six meters, and an empty weight of 130 kg (276 pounds), the sailplane was compact and light.

This type of design, with its smooth fuselage lines and more modern wing and tail planforms, would lend itself to a geodesic construction technique.

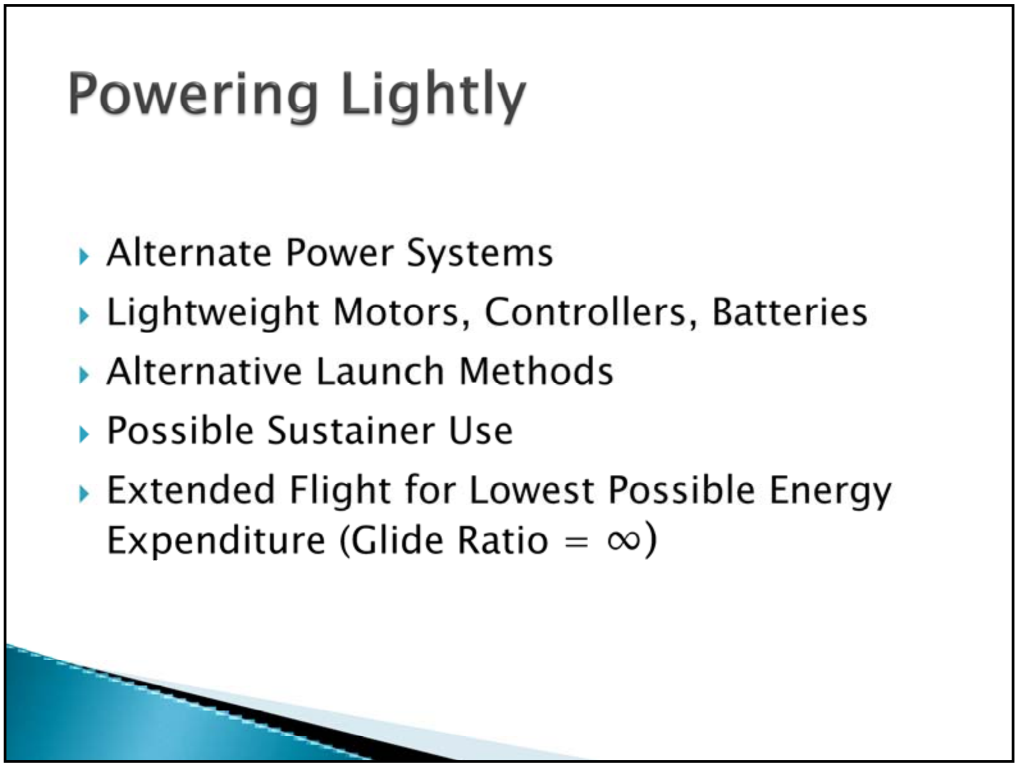
NOTE: My presentation on Outlaw Airmen and Geodetic Airplanes is available in a .pdf version. Email me at muchcatfur@comcast.net.

The Hutter 28 was a similar design to the Moswey, but smaller and lighter. Its length of only 4.75 meters (15.6 feet) and span of 12 meters (39.37 feet), coupled with its empty weight of 88 kg (193.6 pounds) makes it a design worth contemplating.

Although it was named the H28, its anticipated glide ratio, the prototype disappointed with a measured 23.4:1. A later, Danish refinement did manage 27.2:1, almost redeeming the name.

The narrow cockpit relied on the placement of the wing root to provide adequate elbow room for the pilot.

Again, my interest comes about because of the potential of a small, light, semi-geodesic construction for the fuselage that could maintain the light weight and smooth lines of the original.



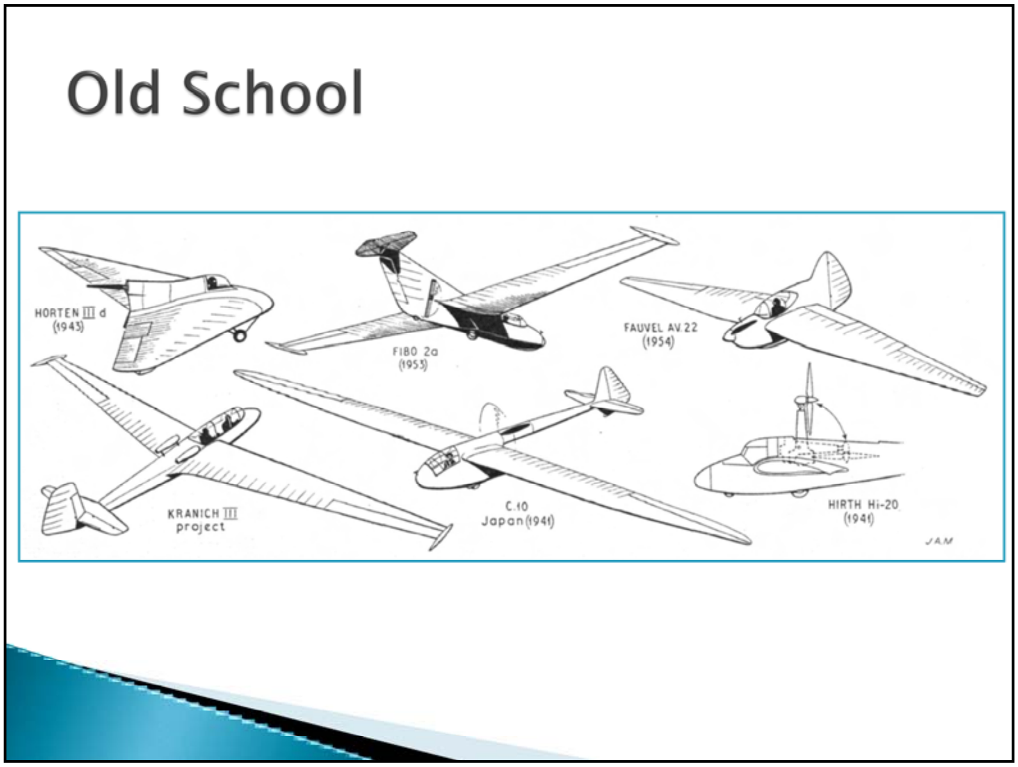
Referring to my presentation from last year, we next look at small motors, but only to show a direction I'm investigating for my own airplane. An enormous, and growing number of motors and controllers is coming about in the model airplane world, and cross-pollination in other interest areas sometimes brings about inspiration in one's primary area of study.

Ron Van Sommeren listed the following potential vendors in response to a query for a 12-16 kW motor that could power a hang glider.

http://www.freeair.cz/ENGLISH/HCS%20C%2010000-15000W-AJ.html
http://www.rs-e-motoren.de/
http://www.plettenberg-motoren.com/
http://www.hacker-motoren.com/
http://www.lehner-motoren.com/
http://www.scorpionsystem.com/
http://www.modelmotors.cz/
http://www.pjs.cz/
http://www.innov8tivedesigns.com/ (65mm series are underway)
http://www.neumotors.com/
http://www.flyware.de/

I added

http://www.astroflight.com



Again, reverting to the past, we see that almost every conceivable approach to self-launching or sustaining flight has already been tried. History sometimes gives us answers for our current problems.

Plettenberg has an interesting spinner that completely surrounds the motor, and provides a central hole that cools the motor, a bit like Kurt Tank's original design for the FW-190. A recent addition is the use of a thrust vectoring servo, similar to what is installed on the A-I-R Atos using Dr. Eck's motor.

There is the possibility of using two in wing-mounted pusher configuration on something like a Mitchell Wing or Swift. A similar spinner is available for the Terminator and Predator, allowing similar configurations with up to 15 hp.

http://www.plettenberg-motoren.com/UK/index.htm

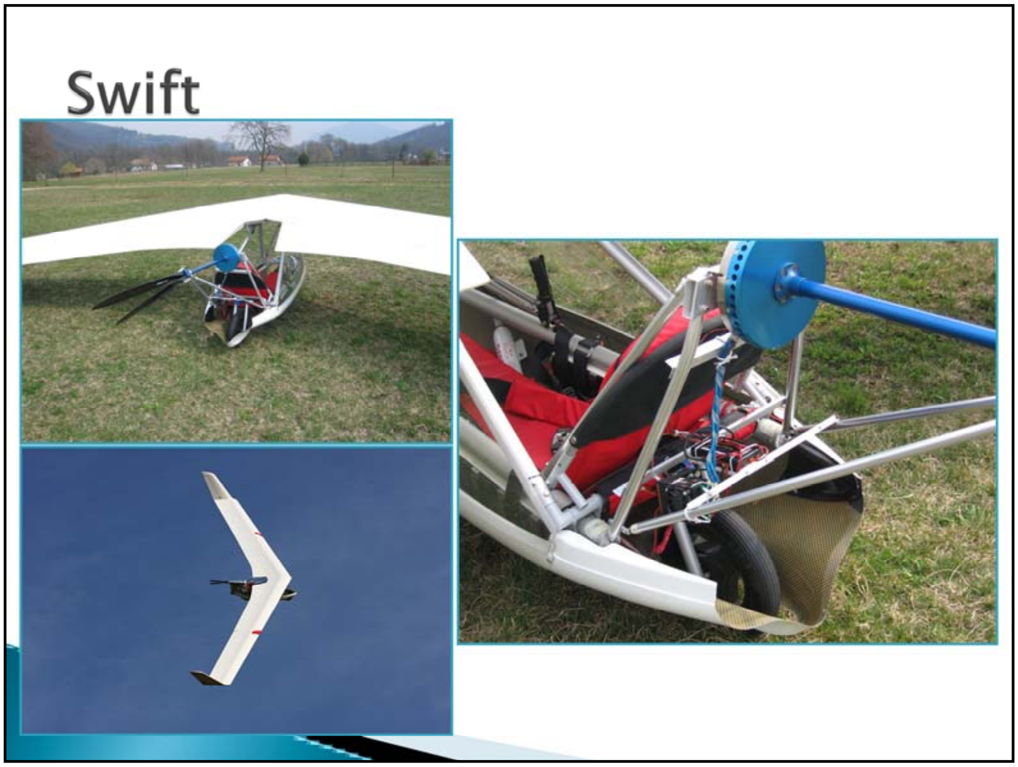
The A-I-R Mosquito, fitted with the HPDirect 10 with a direct drive to a folding propeller, and Saft lithium polymer batteries gives approximately 10 minutes of running time, enough for an 800 meter climb. Toni Roth notes that the system is not any heaver than a backpack unit with a conventional two-stroke engine.

There is some indication that the unit has the possibility of vectored thrust, as indicated in the following:

"For … Atos we developed and [built] an electronically steered introduction tail unit, integrated cockpit control members and intelligent servo mechanisms also here automation and avionics for more efficiency and the correct flight feeling."

http://www.a-i-r-usa.com/index.asp?ID=4243

http://www.a-i-r.de/index.php



“Yes I use the Engine from Eck and the Control System from Geiger, also the folding 1,4 m prop from Geiger, that is made for this engine.

“I use the A123 Cell (16s12p, 1450 Wh) to get up to 1000m from the Ground. And the good thing about this type of Cell is that I really can fast charge them. It takes for a full charge just about 16 minutes. So the charging time is always less then the flying time (in zero wind conditions).

“The weight of the Electric System: Engine 3.8 kg, Controller and Management system 0,8 kg, Propeller 1,3 kg, Battery 16 kg. Engine mount 2,5 kg.

“The weight of the electric Swift is 90 kg.

”The flying characteristic is the same to the free flying (footlaunch) version. Also the Aerodynamic is as good as the footlaunch version. It is really fun to fly this machine and specially the slow flying behavior is very good. For weak thermal conditions it is a very good machine.”

Email from Manfred Ruhmer

http://www.swift-light.at/

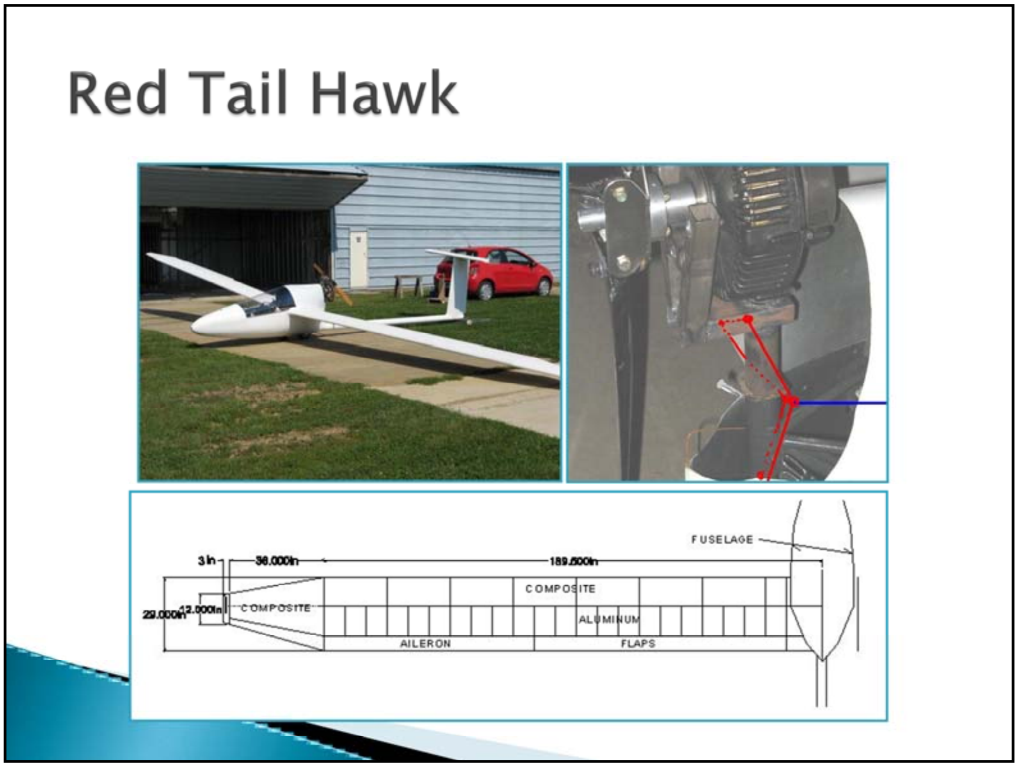
"The photo you mentioned is an aircraft build by a builder and pilot whose name is Wolfgang Uhl. Richard was invited to France one year by his friend, Johan Prins, who took Richard around to see the various builders of the Mitchell Wing B-10 and U-2. He was very impressed by Wolfgang's meticulous building technique but didn't ask to fly it since it was such a beautiful and personal aircraft.

"Richard was so proud when Don Mitchell made it into the soaring society hall of fame. I'm sorry that I don't have a photo available of Richard flying a U-2. He put many hours into flying them in Porterville, CA when he was working as the general manager and test pilot of both the B-10 and U-2 (along with Steve Patmont). Richard loved both aircraft. Since they both had great glide ratios, he would turn the engine off and glide around before turning it back on again, which he said he had great fun (not everyone should do that!!!).

"It would be nice if his name came up at some point as his passion was for the Mitchell Wings for 30+ years and was like a son to Don Mitchell. Jim Meade, owner of the original company was a tremendous help in getting us on our feet when we were first married and Richard wanted to do what he loved, to be involved in flying Mitchell Wings.

"I wish I had all the stories he used to tell. I will slowly be compiling his information which he has kept over the years and hopefully put together a booklet on him, Don Mitchell and his beginnings with the beautiful, elegant Mitchell Wings."

Email from Carol Avalon, Richard's Widow



One customer of Randall Fishman's, Jerry Booker, an airplane designer in southern Illinois, has mounted his motor on a retractable arm on his Red Tail Hawk motorglider, and is nearing flight testing. He uses the same motor, controller and battery pack as that on Fishman's Moni, but should have slightly greater endurance because of the lower span loading of his aircraft.

A reader of his RTH Yahoo Group, Paul F. Ralph, has designed a 33:1 motorglider, the Mew Gull, and has done a series of estimates for power required with a similar electric motor. He has also created a battery/fuel chart that is helpful in analyzing weight and expected duration for different power-pack configurations.

http://groups.yahoo.com/group/RedTailHawkUltralightSailplane/

"I have been doing crow hops with my electric powered homebuilt sailplane. I have yet to try the first flight in my Red Tail Hawk, but it is looking real good from the testing, and the flight could happen any day now.
From this experience so far, I have to say that I think any future that "soaring for most of the rest of us" might have is in relatively simple, medium performance sailplanes, which are self-launched with electric power.
"Adequate e-power technology is here now, and works fine as it is, but will probably get a little lighter with more purpose-built motors and newer battery technology. Granted the cost of the electric power package is very high right now, but that is mostly in the battery, which should come down rapidly with all the electric car development going on.
"Self-launching with e-power is as simple as it is ever going to be to get air-born in a sailplane. It is relatively quiet, so less disturbance for the neighbors. It is probably more reliable than any other power source. It is a one-person operation, so you can fly anytime you want, no need for help. It can easily operate with other airport traffic.
"If we want to help the "cause" of more people soaring, I think what is needed is a production version of something similar to my Red Tail Hawk concept. Not the same construction, size, or even configuration necessarily, but as a medium performance, simple, durable, easy to fly, and optimized for self launching with e-power design, in a quick build kit."

The AL-12ME is a Lithuanian ultralight sailplane with an English motor, assembled and optimized by a French company, Electravia. It flew with its electric powerplant for the first time in January, 2009, and stayed up under power one hour and seven minutes on a Lynch GMPE 102, 26 horsepower motor and a three kWH battery pack. The motor, controller and wiring weigh 13 kg (28.6 pounds) and the battery pack adds 23.5 kg (51.7 pounds). Electravia claims the electric power pack adds only 18 kg over the weight of a conventional two-stroke powered version of the airplane.

http://www.alatus.electravia.fr/ANGLAIS/ZAperformances.html

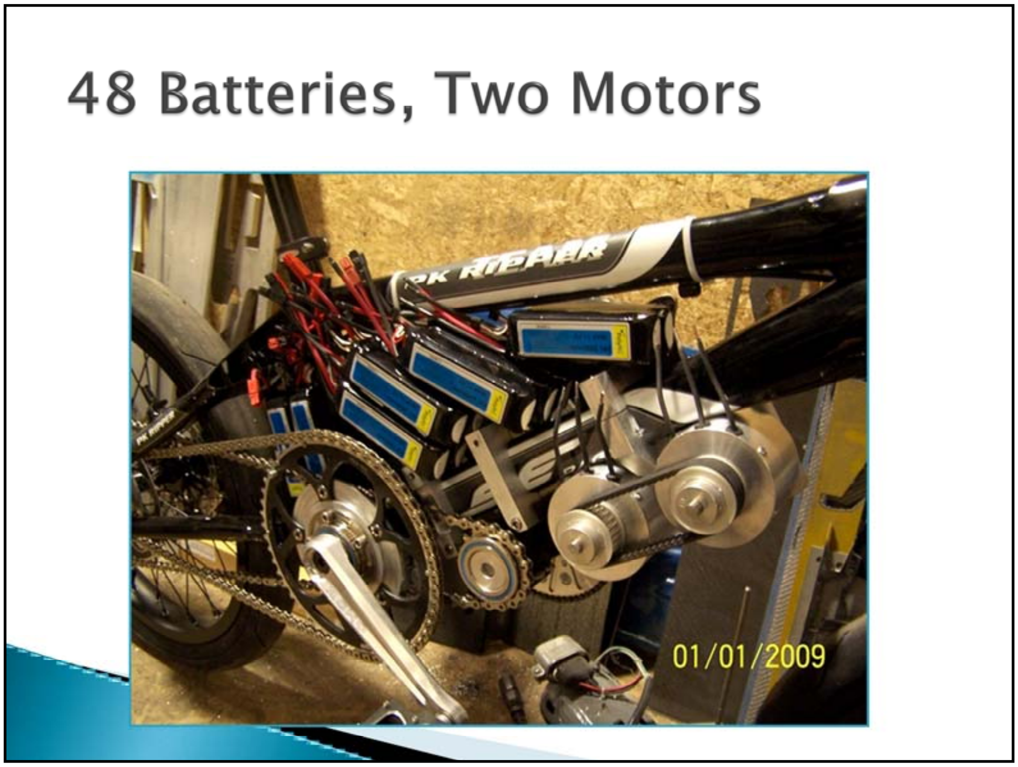
Matt Schumaker is a bicyclist and machinist who does beautiful work, as shown here. He came to my attention last year with a recumbent bike powered by a single AXI 5345/14 motor, which was capable of putting out up to 4 kW (in short bursts) and drove the bike through his single-stage reduction drive. The bike was capable of going 35 mph and showed brisk acceleration on the half-Coke-can-size motor.

He experienced a great deal of difficulty from choosing first, a too-thin toothed belt for his drive. Several iterations brought it to a width that allowed pedal to the metal acceleration without shredding the drive belt. Second, he found that lengthy leads between the controller and motor fried several expensive 110 Amp motor controllers. As the drive system became more reliable, he switched to a Plettenberg Terminator outrunner capable of putting out 6kW from a two-pound spinning mass, running through a much larger Hydra controller.

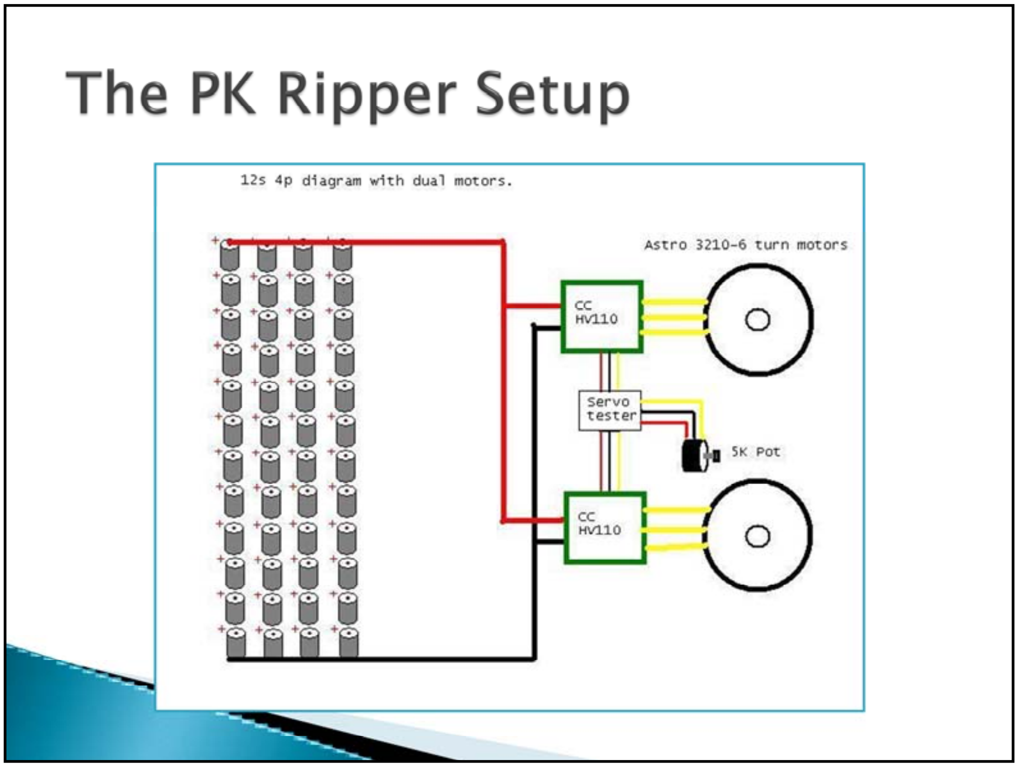
http://www.recumbents.com/WISIL/shumaker/default.htm

According to the Icare web site, the Terminator is capable of producing 37 pounds of thrust at 36 Volts and 118 Amps.

http://www.icare-rc.com/plettenberg_terminator.htm



Matt's next effort was a two-motor mountain bike with a two-stage reduction system. With a pair of Astro-Flight 3120 motors, he has almost 12 horsepower at his command, and unbelievable amounts of torque.



The circuit diagram shows the manner in which a single potentiometer and servo tester (which emulates the pulse width modulation of the controllers) can control the output of the 48 cell battery pack and control the speed of the twin motors.

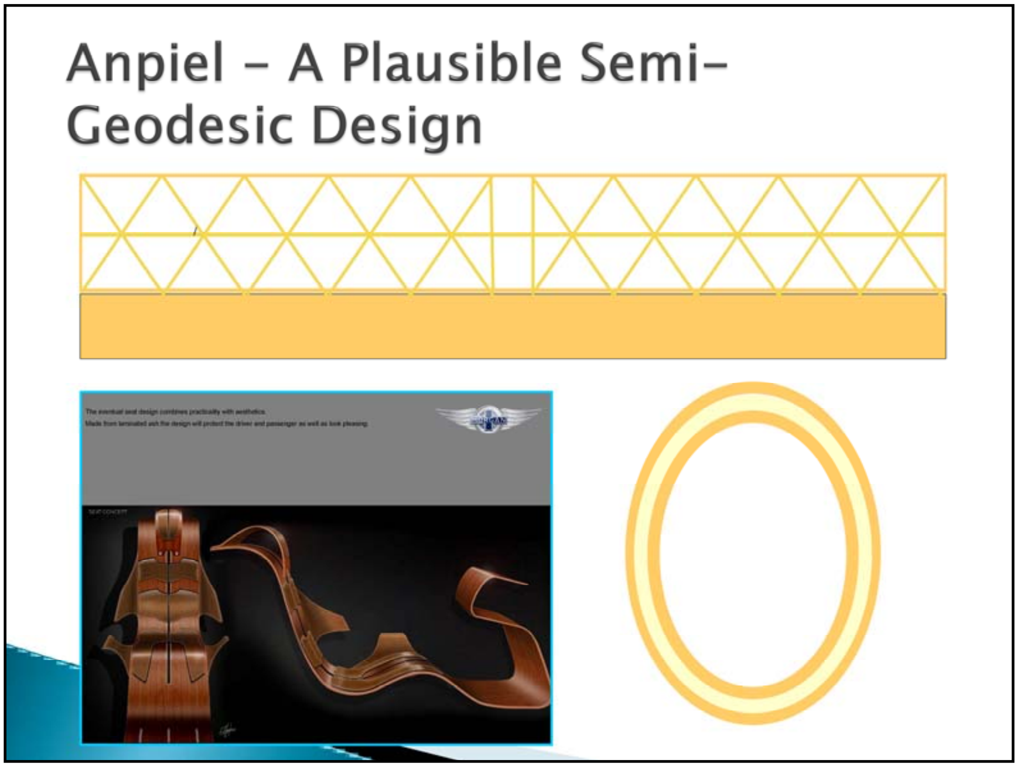
Each Astro-Flight 3210 motor weighs 32 ounces, is 3.2 inches in diameter, and 2 inches long. These compact motors can put out a peak 3 kW at about 10,000 rpm. Each motor costs $399.00 from Astro-Flight.

"This is production KMX E-trike #1. I have gone toward a very modular layout of my drive for single or double motors. So, with various motor sizes and single or double capability, there are many variations to choose from. For this trike, I am going crazy with two Astro 3220 three turn motors. I will run two Castle Creations HV140 controllers with caps added, and 12S (48 volt) 50AH of lipo. The target weight of the trike will be 85 pounds total including the 50ah pack….

"Anyway, the trike will be an honest 12,500 watts. I will gear it for 40mph. Acceleration should be brutal. I am guessing the range at 25mph should be close to 100 miles (a minimum of 80 miles for sure)."

Matt sells his single-stage drives (without motor) for $225.00, his dual-stage unit for $385.00, and his dual-motor drive for $400.00. He sells his trike, in its most powerful form, for $6,500.00, and will custom build a lower-powered version for around $3,500.00. The Astro-Flight 3220 motor, which weighs the same as a 3210 and puts out twice the 3210's power, costs $799.00.

When asked if he had considered making propeller hubs for his units, he said he had no interest in that line – but that I was the fourth person to ask.



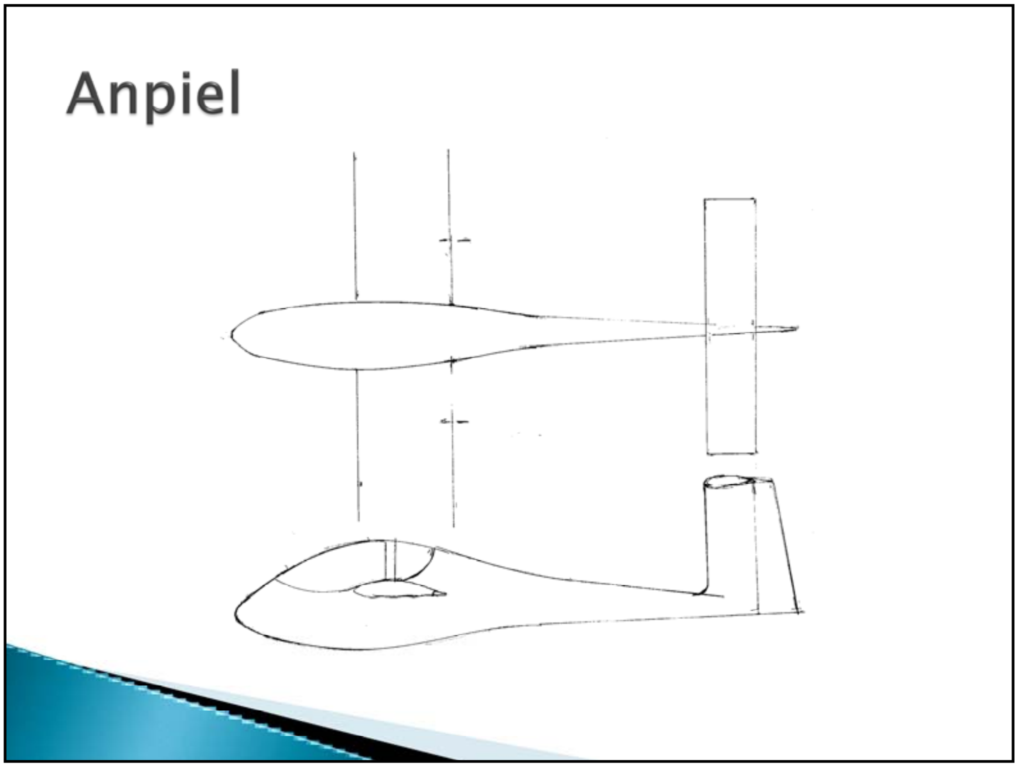
My own design is called Anpiel, after the angel who guards all creatures that fly. This is not some trendy, new-age angel, but a genuine evanescent being listed in the *Dictionary of Angels*, a roster of 17,000 heavenly creatures from scripture or literature and compiled by Gustav Davidson.

To make the airplane buildable by me, not a craftsman of note, I'm designing it mostly of wood, to be held together mostly with non-epoxy glues, since my wife and my lungs can not tolerate certain elements of these otherwise admirable adhesives.

When the weather gets nice enough next spring, I hope to lay up the spars using Graphilite pultrusions and epoxy lay-ups, but that will be the primary use of non-wood components.

There is some epoxy and carbon tow in the construction of the elliptical formers that will comprise the fuselage inner frame. The darker wood represents spruce, with a carbon tow interface between it and the balsa core. This should give a light, stiff structure, with again, only minimal use of epoxy, to bond the tow to the core element.

The nose, back to the rear wing spar, will be a Mosquito-like lay-up of flat-laid balsa and veneer, emulating the arrangement of cross-laid veneers (self cut and planed) used in boat cold molding. The seat will resemble a sandwich version of the seat used in the Morgan Life-Car, a fuel-cell powered futuristic version of the classic English sports car. The original is made of English Ash, and would probably outweigh the fuselage structure I envision.



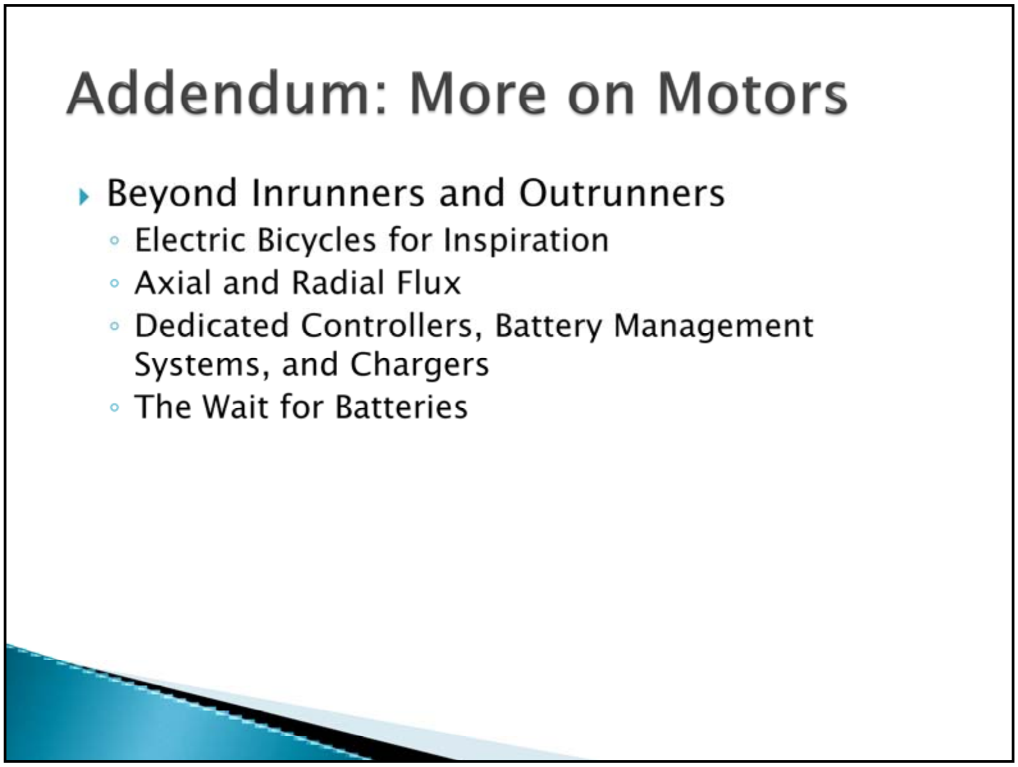
The rough three view indicates that I don't yet know how to lay out coordinates in a CAD program, or perform the delicate art of tying points together with neatly splined lines. That's next, and will allow me to loft the frames with some accuracy.

The craft will use a NACA 63-3-618 airfoil, and have a ply or ply/balsa sandwich d-tube, as will the tail sections. I'm investigating the possibility of molding a double-ply lay-up like the Steen Skybolt people in Florida use to make a tough, non-warping leading edge.

The portion of wing and tail aft of the spar, and the fuselage aft of the rear spar mounting frame, will be a simple geodetic format, with 1/8-inch or 1/16-inch strips counter wound around the formers that define the shape. Using the two light-weight approaches to construction, I hope to achieve a fuselage and vertical tail weight of 45 pounds, and a horizontal tail weight under six pounds.

There will be two motors and controllers, throttled from a single potentiometer, much like Matt Shumaker's dual-motor bike drives. The motors, located on the trailing edge, will have folding propellers and do not contribute to additional friction drag on the fuselage or tail. As new technology comes along, they are also easily upgraded.

The craft will use a Strojnik style tandem landing gear, and have a lightweight tow hook in the nose.



I gave a talk at the Electric Aircraft Symposium in San Carlos in April, and had over 55 slides detailing the many options available today. What follows is a sampling of areas of progress from before and since the Symposium. To review my entire talk, see the CAFÉ Foundation web site.

http://cafefoundation.org/v2/ea_eas_2009.php

"We have used where possible large model aircraft components. We use two German Plettenberg predator motors direct driving Czech carbon Mejzlik 31"x12" three blade props, and Jeti spin 200 controllers. My 'electric brains' is Dr Paul Robertson and he has designed a battery management system. We have 24kg of Kokham cells that give us about 3.2Kwhr of energy. Motors are only 1.6Kg so the total installation is similar weight to a stock Rotax 185 Lazair.

"Motors are rated at 10kw so we were expecting strong climb performance – however during rig testing we let some smoke out and found that they wont do it for long! Winding temps climb very quickly and cant hold full power for more than about 20 secs. Max continuous power seems to be about 6kw. Paul R designed some software to monitor the temps and we select full power and the power is varied to keep under temp as required.

"Initial acceleration is good whilst the motors give full power and the Lazair pops off and up to 50' quite quickly. The motors then hit max temps and throttle back. Its then a game of flying exactly on min sink speed and gently wafting up at 100-150fpm. With no lift and my 200lbs we get about 25 mins duration.

"Noise is extremely low and vibration almost non existent – a very pleasant experience to fly – seems to fit exactly the airchair flying experience ethos!

"We are also well down on prop efficiency, so a redrive to swing bigger props is a logical step, and should give us around 30% more efficiency. With electric motors and the absence of vibration or power pulses chain drives may be the best system for light weight and minimal drive losses.

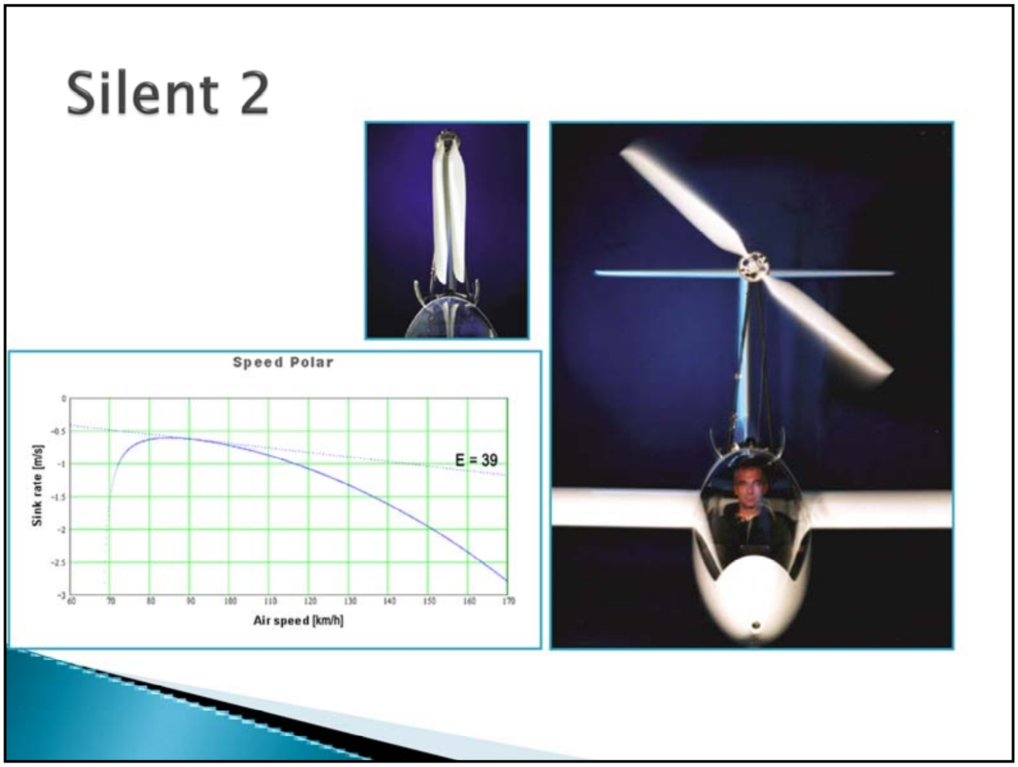
"When the power runs out and we glide, with no compression the props windmill furiously and are like two drogue chutes and the glide is a real plummet – which is a shame after spending 25mins to get all the height to then throw it away so quickly! So prop brakes are one of the first mods to make to improve duration."

Paul Dewhurst, responding to questions in the Yahoo Airchair discussion group

Mark Brierle had this budget approach to electric flight at last year's Tehachapi gathering, but did not make a demonstrable presence with it. The picture, by Mark Kanzler, is of the motor and controller on display at this year's Arlington, Washington, air show.

He has flown this craft within the last few months, and reports breaking ground in 55 feet, climbing at 270 feet per minute, and being able to stay aloft for 11 minutes on a small lithium battery pack. He reports running at 4.5kW at 55 mph.

http://www.thundergull.com/



Technical data

drive unit:			
motor:	performance:	13 kW	
	speed:		3400 U/min
	weight:	8.5 kg	
propeller:	diameter:	1.92 m	
	speed:		1300 U/min
batteries:	weight:	35 kg	
	energy:	4.1 kWh	
charge time:	onboard charger: 5 h		
	external	140min at 220V	
glider:			
dimensions:	wing span:	12 m	
	wing area:	10.3 m^2	
	aspect ratio:	14	
weights:	empty:		195 kg
	max. take of:	300 kg	
	max. wing load: 29.2 kg/m^2		
performance			
at 280 kg	V-max:	180 km/h	
	V-min:		65 km/h
	min. sink	0.75 m/sec at 72 km/h	
2.0 m/sec at 150 km/h			
	max. ratio	>30, at 95 km/h	
	45° to 45° roll: 2.5 sec		
	take off FAI:	<300 m (over 15 m)	
	take off roll:	150 m	
	max climb:	2.2 m/sec	
	max. altitude reach: 2000 m		
	max. distance reach:	80 km	

This top motor is promising because of its Oxford roots, being designed by graduate students with the intended purpose of selling rights to private manufacturers. Its high power-to-weight ratio is interesting enough, but further modeling, based on the same factors that led to the demonstrated output of 50 kW, suggests that at higher revs, the motor could put out up to 150 kW. It is currently being tested on the prototype of the Morgan Life Car.

http://www.scienceoxfordnetworks.com/news-publications-news-articles/oxford-electric-motor-set-for-track-tests

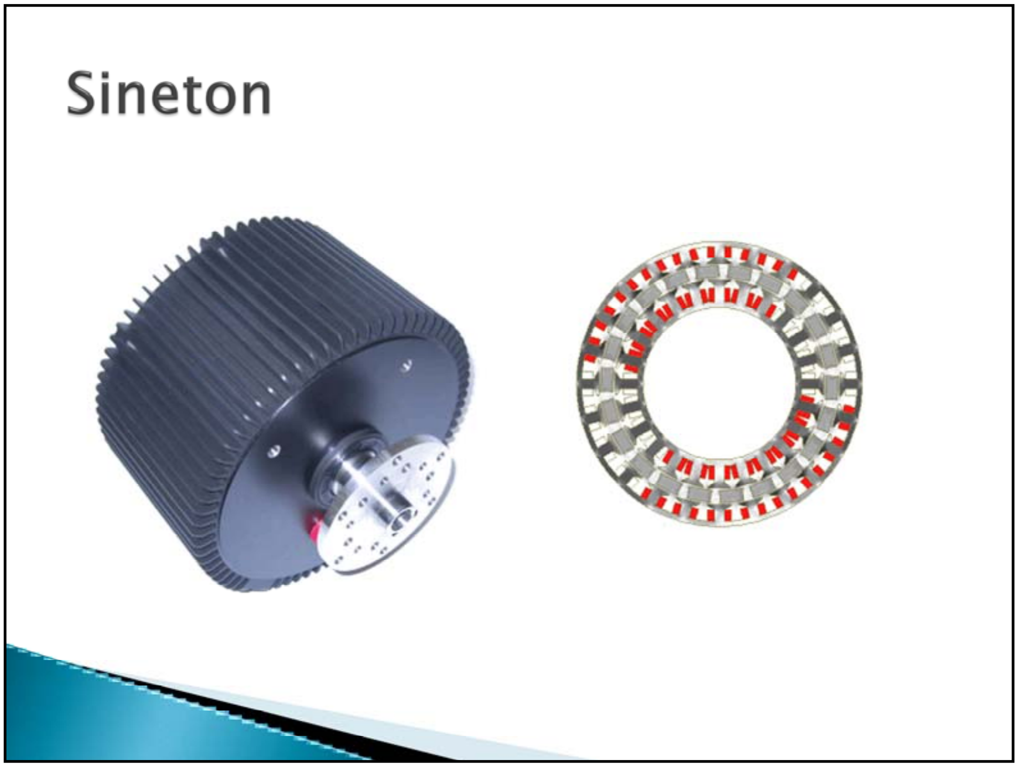
http://www.isis-innovation.com/licensing/3056.html

Apex Drive Laboratories uses a dual stator-single rotor design, with U-shaped core. The dual permanent magnets on the rotor and the patented U-shaped core help produce high torque at low RPM. A dedicated controller can use Hall-effect commutation for high torque at low speed, or sensorless control for high-speed systems.

Their DD31w motor weighs 84 pounds and puts out a peak of 46 kW, or 61.7 hp and a continuous output of 31.3 kW, or 46 hp. Its peak torque is of interest, though. With 576 Nm (425 ft-lbs) peak and 157 Nm (117 ft-lbs) continuous, the motor produces this at relatively low RPMs.

Recently, the company recently received a $250,000 commercialization grant from the Oregon Nanoscience and Microtechnology Institute (ONAMI) for its patented micro-channel liquid cooling approach.

http://www.apexdrivelabs.com/



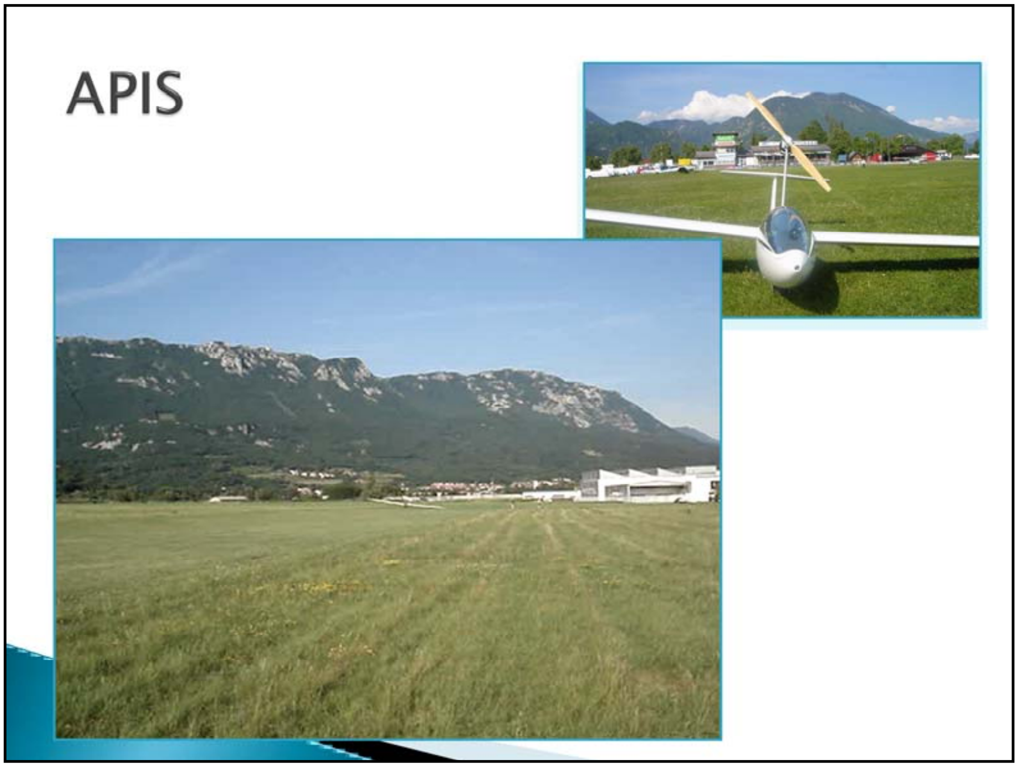
A30K016 is a three-phase brushless permanent magnet synchronous electric motor. It has been developed to directly drive a propeller on the Electro Taurus airplane developed at Pipistrel.

"The primary design goal was to minimize weight resulting in a motor weighting 15,8 kg including a propeller flange. A30K016 has nominal torque of 160 Nm and short-time peak torque in excess of 200 Nm. It has been designed for shaft rotational speeds up to 1800 RPM. It can deliver 30 kW of nominal power at 1800 RPM when exposed to an coaxial air flow of at least 90 km/h."

Roman Susnik was instrumental in the design of the motor used on the Pipistrel Taurus, a two-seat self-launching sailplane. He has developed a line of 20-, 30-, and 40-kW motors which are large outrunners in concept. He has also developed controllers specifically for these motors. He recently announced the introduction of a 60kW unit in the same size and weight range.

http://www.sineton.com/www/

http://www.glider-one.si/index.php?option=com_content&task=view&id=58&Itemid=87



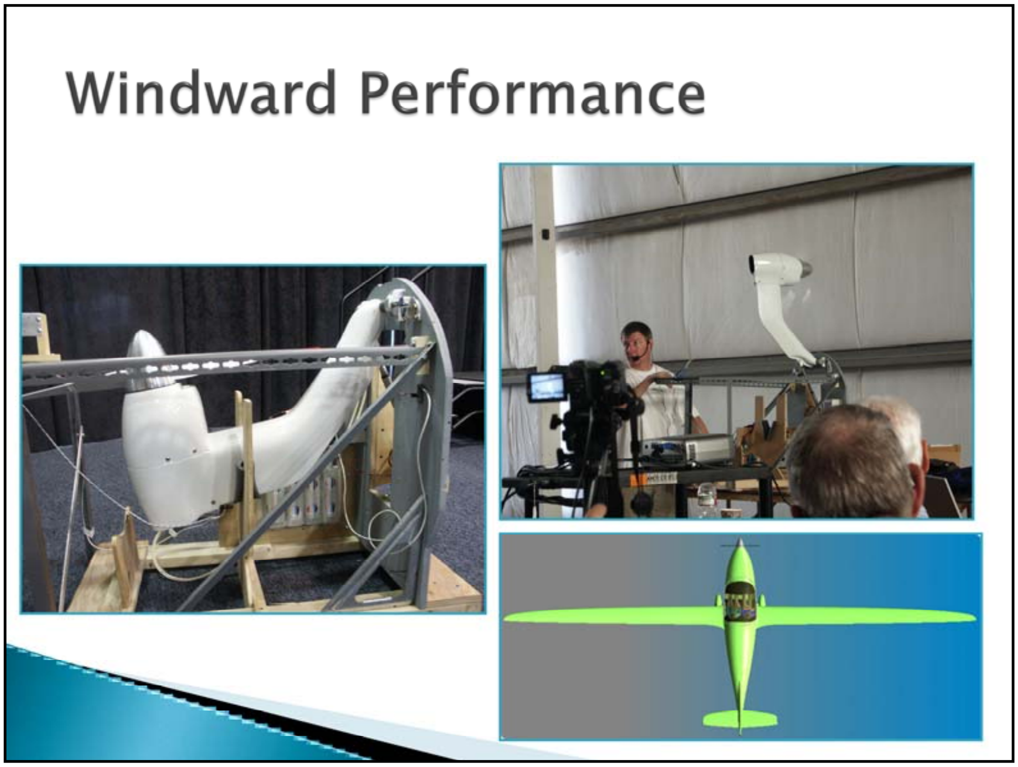
APIS, a Slovenian firm, has a variant of the Silent, which uses an Emrax motor and wooden propeller. The small size of the motor helps to lessen the drag penalty for the motorized configuration.

Randall Fishman displayed his prototype at Oshkosh this year, sharing honors with the Yuneec and Sonex craft. His 50 kW motor and purpose built controller nest in the compact motor compartment, and the spacious cockpit shows an electronic instrument panel, highly appropriate for this airplane. Performance is similar to that of the Yuneec 430.

[*http://www.electraflyer.com/#*](http://www.electraflyer.com/#)

"The controller can commutate the motor in two different ways: using Hall effect sensors to determine the magnet core's position in relation to the coils, or using the motor's back-EMF to sense rotor position, eliminating the need for Hall sensors. The AeroConversions controller will initially employ a Hall effect sensor-equipped motor, but back-EMF controlling will also be explored to potentially further simplify the AeroConversions motor design. The AeroConversions controller will also provide in-cockpit monitoring of battery power levels to the pilot."

http://www.aeroconversions.com/e-flight/



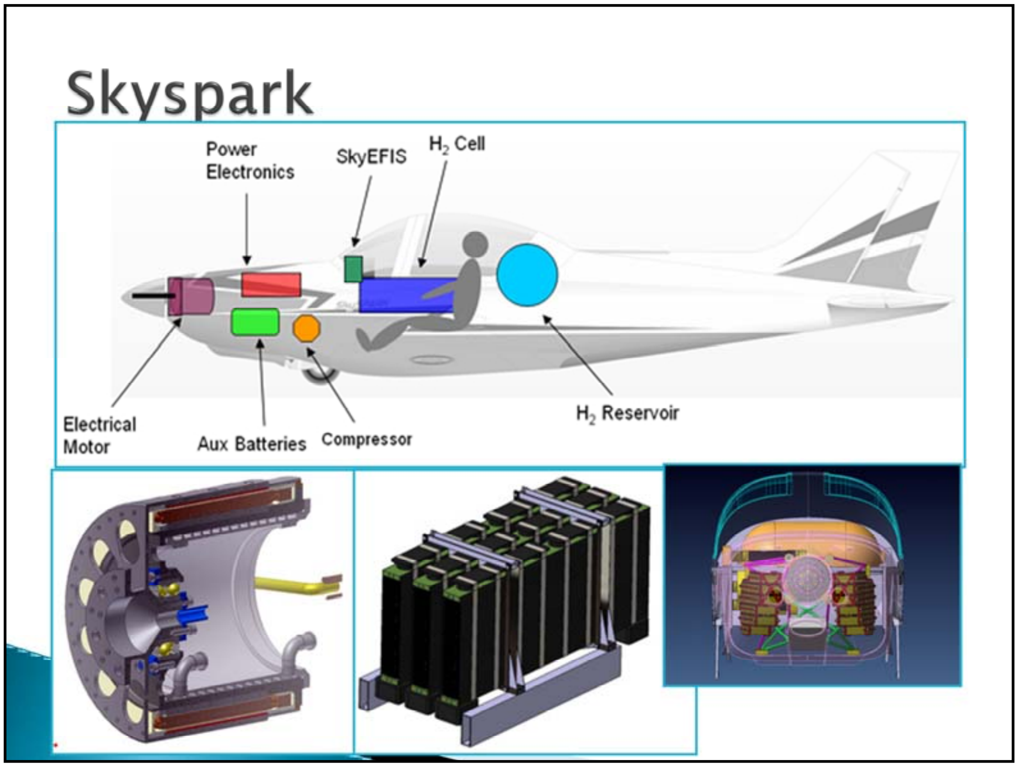
Greg Cole, like Randall Fishman, is accomplishing as an individual the kinds of things that seem to require factory and even government backing in other circumstances. He has tested a dual-motor arrangement on the Sparrowhawk, and has developed a single 15 horsepower, retractable unit of well-streamlined form. His two-seat Goshawk could become the best performing electric craft. Again, this American entrepreneur is achieving something that equals or bests others with government and university backing on a large scale.

http://www.windward-performance.com/

Motor

Motor Designation:	Power Drive 10	Power Drive 20	Power Drive 40
Item No.:	PD10 P	PD20 T	PD40 T
Power (Kw):	10Kw	20Kw	40Kw
Power (Hp):	13HP	27HP	54HP
Type:	Direct Drive Brushless	Direct Drive Brushless	Direct Drive Brushless
Control:	Internal Sensor	Internal Sensor	Internal Sensor
Diameter:	160mm	200mm	240mm
Weight:	4.5Kg (10 lbs)	9Kg (20 lbs)	17Kg (37.5 lbs)
Voltage:			
- Mirium	50V	50V	100V
- Maximum	75V	75V	150V
- Optimum	66V	66V	133V
Current Drain:			
- Maximum:	180A	285A	285A
- Cruise:	55A	180A	180A
Bearing Qty:	3	2	2
Propeller Hub Diameter:	50mm	100mm	100mm
Propeller Screw size:	M6	M8	M8
Propeller Screw Qty:	4	6	6
Mounting Dimensons:	Ø 140mm	Ø 170mm	Ø 200mm
Plug System:	E-Plug (OEM)	E-Plug (OEM)	E-Plug (OEM)

Matching controllers weigh from 1.5 to 7 kg. Battery packs weigh 13 kg (28.5 pounds), and can be placed in series or parallel configurations to power larger power units. The paramotor, for instance, might use one pack, while the EP430 could use up to six.



Skyspark set a world's record for electric aircraft, as reported in the project's web site.

"Very large attendance for the SkySpark flight early today. Maurizio Cheli managed to fly during 8 [minutes] reaching a top speed of 250 km/h, a record for a 100% electrically powered aircraft. The Pioneer Alpi 300 is powered by a 75-kW electric motor using brushless technology and lithium polymer batteries.

"This successful flight is only an intermediate step of the programme. The team will now focus on the next goal: the hydrogen fuel cells powered engine."

This fall, the team, composed of industry and University of Turin personnel, will attempt a speed record using only hydrogen fuel cells in place of the batteries. The motor is of particular interest.

"Sicme Motori, technological partner of SkySpark, is producing the Valentino engine, which will be propelling the aircraft. This prototype, which stems out of the cooperation with the Electrical Engineering Department of the Polytechnic of Torino, is very light and has a high performance: it only weights 25 kg and features a maximum power of 65 kW at a speed of only 2500 rpm.

"Valentino is the crowning jewel of 45 years of industrial experience focused on research and innovation. "Sicme Motori is one of the first companies on the international scene to apply Direct-Drive technology to electrical engines" states Alberto Sola, Chairman of Sicme. 'This has allowed us to do without the gearbox, guaranteeing a maximum energetic efficiency'. Gearless motors reduce maintenance needs enormously, have remarkable environmental advantages, guarantee outstanding performance and absence of noise, even at low power regimes.

"Valentino is a Direct-Drive motor (synchronous, with permanent magnets) of a brushless kind. This means that, in contrast with a brush motor, it does not need electronic switches embedded on the main rotor in order to work. It uses particularly sophisticated materials, has an external rotor, and is cooled by liquid."

http://www.skyspark.eu/web/eng/index.php

From the University of London Press Release:

"Master of Engineering (4th year) project students have modified an aircraft to fly on electric power, in association with Anglia Sailplanes and AeroElvira Ltd.

"The first flights took place on 20/21 September. Test pilot, Derek Piggott, described the modified aircraft as a 'delight to handle'.

"The aircraft was modified by the addition of 8 underwing pylons attached by removable straps. The pylons were fitted with 16 propellers (280 mm in diameter) driven by electric motors and powered by lithium-ion batteries supplied by Ripmax PLC. The motors were activated by a wireless link by the pilot in the cockpit. A permit-to-fly was issued by the British Gliding Association.

"The project involved over 3 MEng Project groups over a period of 5 years, including for example the following students (now all graduates): Ross Shepherd, Stefan Wurwal, Mark Saunders, Hamza Baker, Mikel Alonso, Morten Christiansen, Sami Ghamloush, Mehrtash Lotfian, Mohammad Ali Sarkandi, Junaed Wahid."

News date: 24 September 2008

Graupner 900's used in this experiment cost $60 each, so the motor cost was $960.

http://www.pprune.org/aviation-history-nostalgia/343843-edgley-ea-9-optimist.html
http://www.qmul.ac.uk/news/newsrelease.php?news_id=1122

.

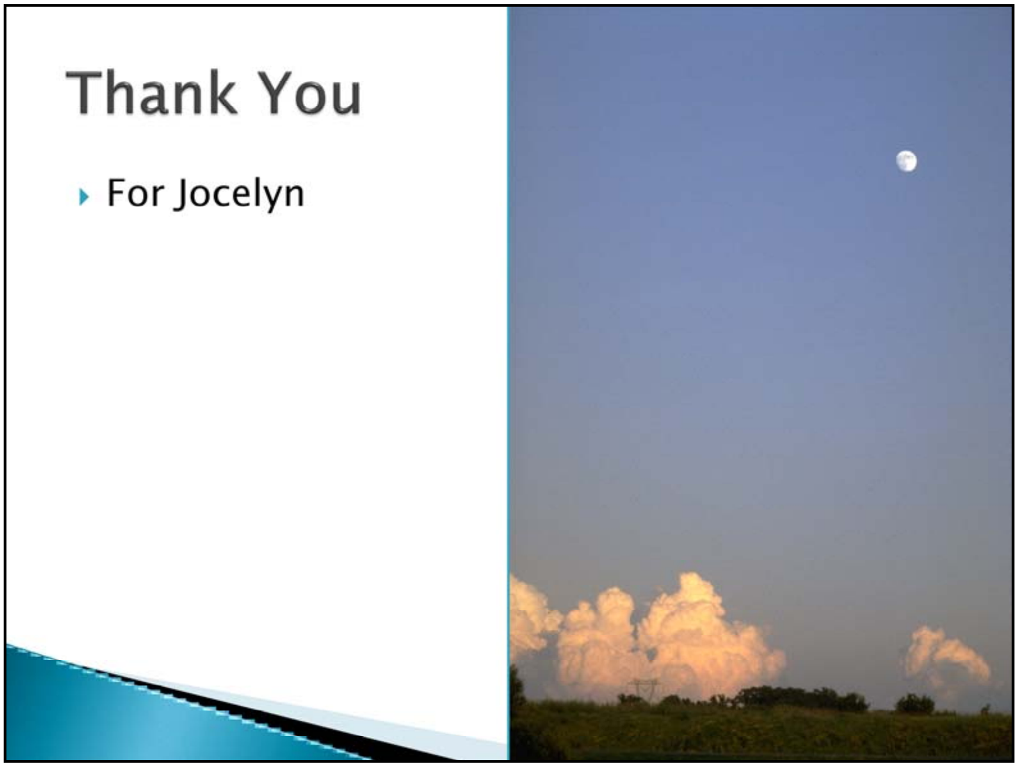
Imagine a lovely spring morning, a small meadow with the first puffy cumulus clouds of morning billowing overhead. A few small cars with long boxes tied to their roof racks park at one end, followed by a few scooters.

The drivers and passengers begin to pull sleek, light sailplanes from the boxes, then assemble their parts into flight-worthy vehicles. One scooter driver sets up his 400-cc two-wheeler on a concrete pad at the end of the field opposite the cars and now-assembled aircraft, a second person runs a brightly-colored tow-line back to the waiting sailplanes, and the first craft is towed 1,000 feet into the air, releasing above the small group.

The day is not quite ready for soaring, and the sailplane returns to earth after 15 minutes of gentle circling above the field. A second airplane, a flying wing, is already in the air, but it too returns after searching for thermals.

A third and fourth pilot try their luck in the two machines, and connect with the currents, then sail away for several hours of chasing thermals. When they return, the rest of the group has brought out a picnic lunch, and the pilots refresh themselves while the next group goes flying. It goes like this until twilight falls, and the assemblage dismantles the planes, packs them away and leaves the meadow in its solitude.

Does this have to be a dream, or can it be the new reality of soaring?



In our desire to gain a pure form of flight, we approach this challenge with the humble acknowledgement that we owe so much to so many.

My wife Anne comes first on this list, for her continuous encouragement of my writing and design.

Thank you to Bruce Carmichael, for talking me into giving my first presentation two years ago at Tehachapi and for providing ongoing mentoring.

Thank you to Dr. Brien Seeley, who gave me the opportunity to speak at the Third Annual Electric Aircraft Symposium. Like the crowd at Tehachapi, the group was a supportive, enthusiastic one, crucial to helping further our common dreams.

Thank you to Andy Kesckes, who provides the means for getting these presentations into visual and written forms, and who does a lot to make us all look good.

Thank you to my friends in Portland, who provide gentle correction and a second set of eyes.

And, as always, I thank my granddaughter Jocelyn, for whom I wish I could have been the role model she was for me.