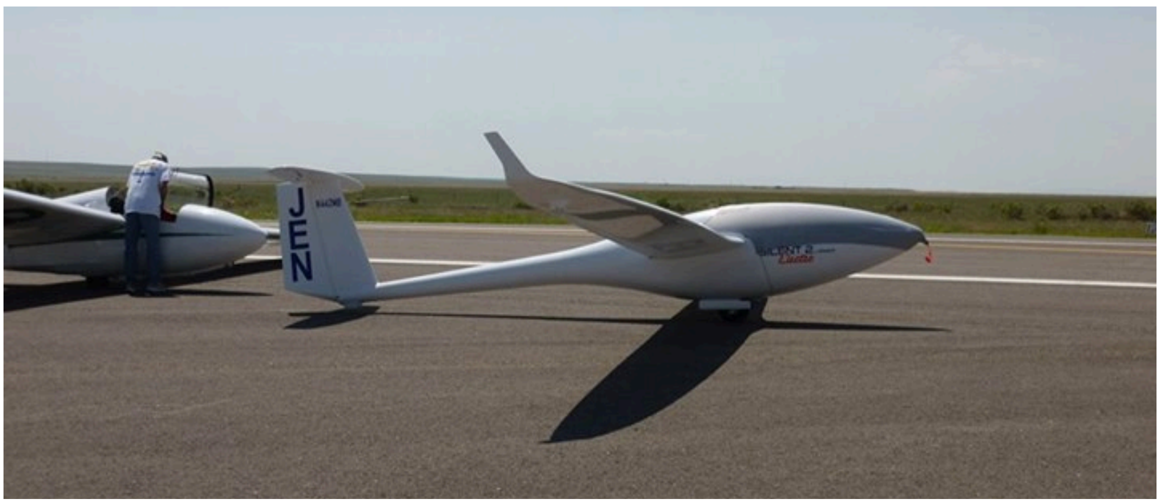
Flying the FES-equipped Silent 2 *Electro*: Finally, we can have it all!!

A while back, I had read that a nearly 700 lb (315 Kg) sailplane equipped with an all-electric FES (Front Electric Self-launching) system had demonstrated serious climb rates (around 400 fpm, or 2 m/s) as well as multiple launches on a single charge; and I remember thinking at the time: “This is the future: All the advantages of self-launching and self-retrieving without any of the drawbacks of retractable pylon-mounted propellers or IC (Internal Combustion) engines.” Thus, I was anxiously waiting for an opportunity to see one or to talk with the owner of one, to verify my expectations; let alone an opportunity to actually fly one. So, you can imagine my surprise and interest when Leo Benetti-Longhini, the US agent for both Alisport Srl. and Jonker Sailplanes (Pty) Ltd., offered me a chance to try the first Silent 2 *Electro* to arrive in the US, contest number JEN (it is a smart man who names his gliders after his wife), and to fly it at Moriarty, NM, during the 13.5m Class Super-Regional!!!

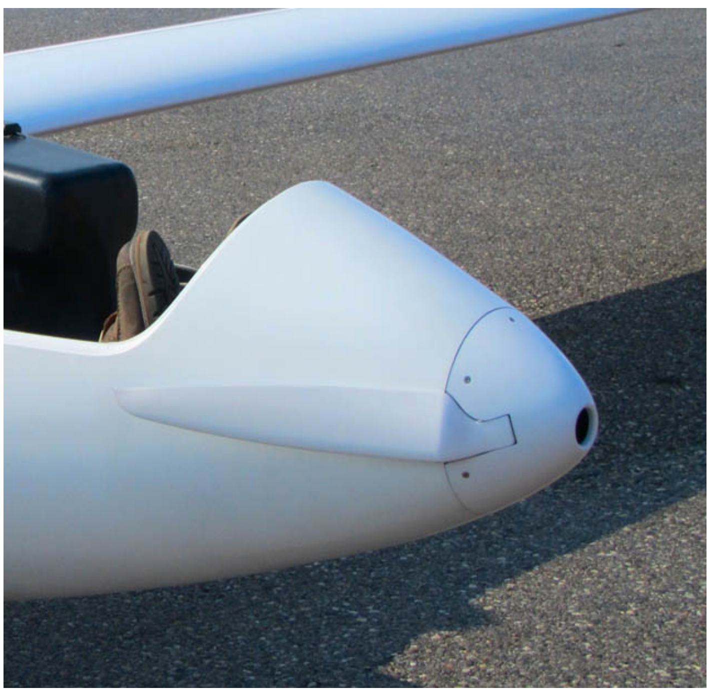


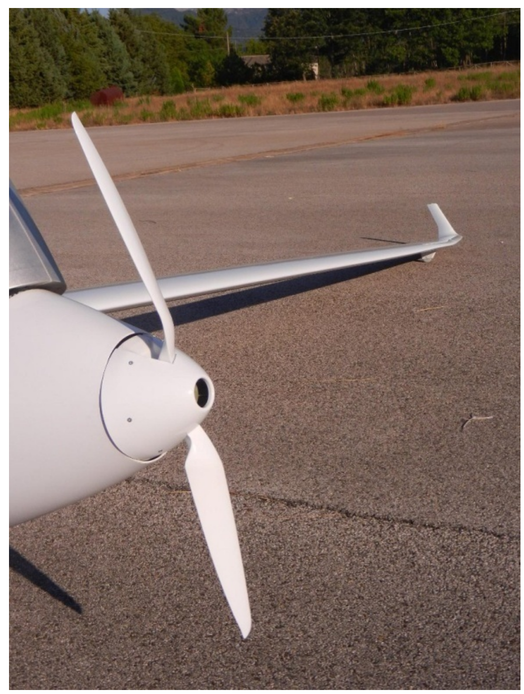
JEN on the grid at Moriarty

The *Electro* and FES

The all-electric FES concept with a nose-mounted folding propeller provides much more than just another design for self-launching or sustainers: it allows the near-instantaneous switch between pure soaring flight and powered flight, with practically no degradation of the glide performance at any time during either type of flight and, most importantly, during the transition between the two phases of flight. Pilots who have only flown pure gliders may not immediately appreciate the radical change provided by this feature, but I am sure that all those who have experienced the deployment time of a pylon and its significant drag when extended, or have sweated the delayed start or, worse, the refusal to start, of an IC engine, all at the worst possible time during cross-country soaring -- i.e., when you are low and looking at your out-landing field -- will instantly grasp the point. For me, it makes an enormous difference in the way I can now envision Soaring, and I believe it has the potential to revolutionize the way we practice Soaring in the future.

I knew of Alisport’s record of innovative designs (for example, I had previously marveled at their dynamically balanced single-blade propeller that is used on the Silent 2 Targa), so I was not surprised that they would be among the first to achieve the feat of an all-electric self-launcher. They accomplished that several years back with the Silent AE-1, which used a retractable pylon-mounted propeller powered by an electric motor and batteries, all located in a conventional engine bay aft of the cockpit. What they have now achieved with an FES on their Silent 2 *Electro*, however, is a beauty of very smart, efficient, user-friendly and elegant design: The very compact permanent magnet brushless DC motor is only about 4 inches (10 cm) thick and 8 inches (20 cm) in diameter, yet can deliver close to 30 hp (22 kW) of power while weighing only about 18 lb (8 Kg). Thanks to its small size, it fits in the fuselage nose in front of the rudder pedals and direct-drives (no transmission) the glider nose cone that serves as the rotating hub for a two-blade propeller about 40 inches (1 m) in diameter. The propeller blades are hinged on the nose cone so that they fold snuggly alongside the nose when not used. The centrifugal force deploys them automatically when the motor starts turning, and their forward traction force keeps them extended when the motor runs. The airstream brings them back alongside the nose when the motor stops. The blades are hinged in such a way and fit so snuggly along the nose that they probably don't create more drag than, say, pushing open the little scoop that some canopy windows have, or sticking a small part of your hand out the window to get more air. LZ Design of Slovenia produces the electric motor, propeller blades, and the battery packs, all specifically designed for the *Electro* FES system.

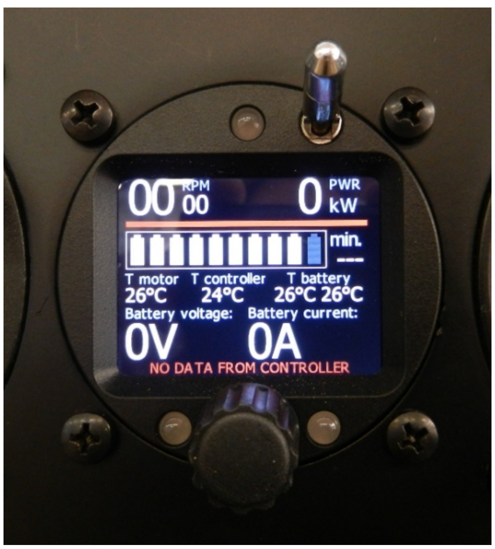




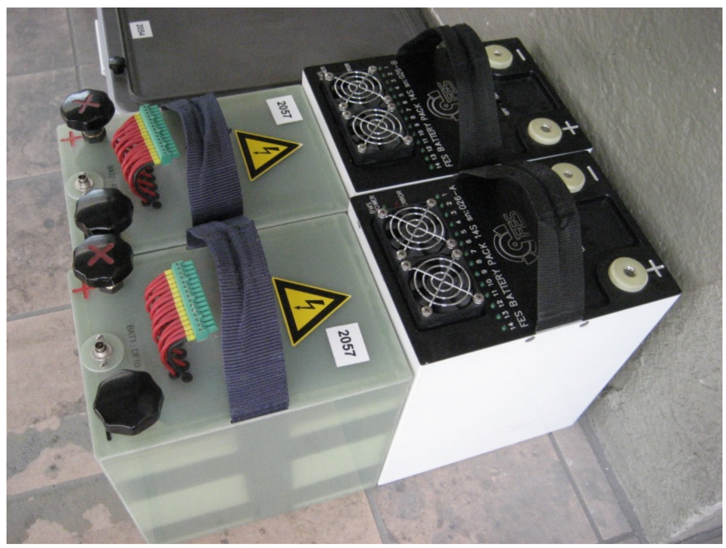
The propeller blades in retracted and extended positions

The on-board energy is contained in two LiPo (Lithium-Polymer) batteries, each about the size of a big car battery and weighing about 34 lb (15.5 Kg). They are connected in series and provide a total of 4.3 kWh of electric energy storage. This is sufficient for the nearly 700-lb (315 Kg) sailplane to self-launch and climb a total of about 5000 ft (1500 m) with a climb rate of around 400-500 fpm (2-2.5 m/sec); in other words, perform several typical launches with one charge or, more practically, perform one launch and have some extended level-flight capability for self-retrieving. The batteries are housed in the fuselage near the wing spar coupling and compensate for the nose-mounted motor weight in keeping the general location of the C.G. range. They are easily removed, and easily connected. Connecting the charger and charge controller is also straightforward.

The nicest part of the system is the pilot interface and overall operations. Aside from a key-operated master switch to turn the motor controller on and enable operation, the interface system consists of a single panel-mounted interface instrument. It fits in a ø2¼-in (ø57 mm) hole and includes its own on/off switch, a bright electronic display screen and one single rotary knob. The screen displays the temperatures of the batteries, motor, and controller, the motor speed (in rpm), the battery voltage (in V), and the current (in Amps) and power (in kW) applied to the motor. The rotary knob, similar to the volume knob of a radio, controls the power applied to the motor and is the single control for all start, stop, and power-control operations. A safety interlock prevents power from being applied to the motor if the canopy is open. A simpler and easier to operate system would be hard to imagine.



The pilot interface display, on/off switch (top) and power-control rotary knob (bottom).

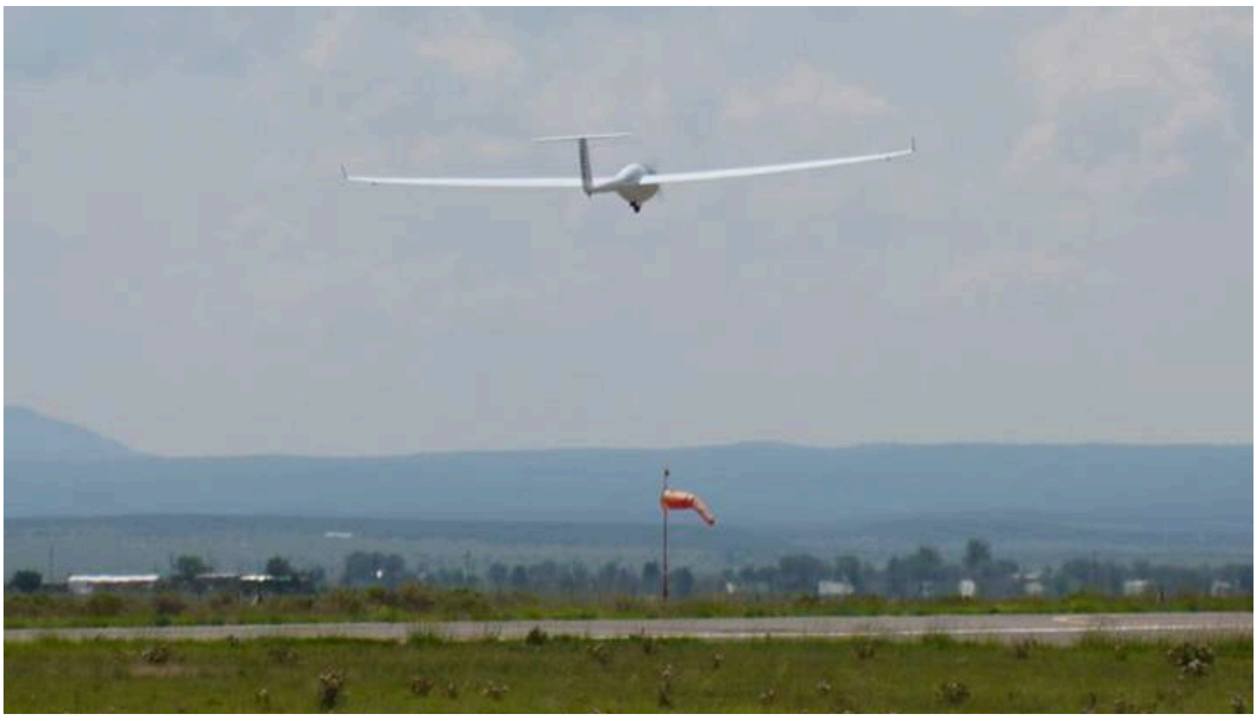


Two batteries of the previous design (on the left) and two batteries of the latest version with integrated charge controllers (on the right).

Assemble, and there you go

I arrived in Moriarty a full week before the contest, and settled in the hangar, which Leo had kindly coordinated with my wonderful hosts, Bob and Marly Carlton and Mark Mocho. After a good night of sleep to recoup from the long two-day drive, I was anxious to fly and practice for the contest and to fine-tune the *Electro* for racing. Mark helped me assemble, which was a breeze. At 70 lb (32 Kg) each, the carbon fiber wings are very light, and all controls are automatic hook-up. There is even a Mylar strip already set at the wing root to seal the gap with the fuselage, so no tape is needed at the wingroot gap. The wing tips with winglets are a straightforward insert-and-tape job. One bolt at the horizontal stabilizer and Voila! After a thorough pre-flight inspection, I drove to the runway threshold point using the tow-out gear, and then parked the car. No need to check on availability of a towplane or cable, etc.: Settle in, do pre-takeoff checks, close the canopy, announce departure on the radio, turn the power knob, and there you go. With electric, there is no need for warm-up or pre-takeoff engine runs, so it is really a “get settled and go”. Mark held my wingtip on that first takeoff, but the ship has wingtip wheels that keep the tips well off the ground, so on the later practice days I did all by myself and took off with wing down, and no helpers. Ahhh, you can’t beat the freedom and convenience of self-launchers!

High altitude
Moriarty airport is at an altitude of 6200 ft (1890 m). Neither Leo nor I had seen any reports of all-electric self-launching at such altitudes. I knew that the electric motor would not be affected by altitude like IC engines are. The only effect I expected from low-density air would be on the propeller, similar to the effect between TAS and IAS, which between 6000 and 8000 ft would be minimal. With a 7500 ft (2.25 Km) runway and a 10-15 knot wind straight with the axis of the runway, the conditions on my first day at Moriarty were certainly ideal to experiment. However, I had in my mind the memory of an IC engine motorglider self-launching at a Western US contest about ten years ago in similar air density conditions: About mid-length of the runway, the wheel lifted off the ground but the ship never went higher than a foot or two, and we soon had to rush and extirpate the pilot from the glider wedged in the barbwire fence at the edge of the airport. So, I took it very cautiously and, prior to launch, drove my car along the taxiway, picking up easily recognizable landmarks for my eventual abort and land-back decisions. It turned out to be more of a better-safe-than-sorry precaution because, wind helping, I was off the ground in less than 400 ft (120 m); and by mid-field I was passing through 300 ft (90 m) climbing happily at about 400 fpm (2 m/s).



Self-launching at Moriarty (6200’ altitude), here with a crosswind of about 12 kts.

Recharging

This turned out to be the simplest and safest "refueling" of any self-launcher or sustainer glider that I ever flew. I have to admit that I have never been fond of pouring gasoline from a tank to another, messing with funnels, fuel lines, spills, and the smell of all that. Additionally, I have always strongly disliked having to store a gasoline container in the back of my car or in the front of the trailer, both of which would often stay in the sun all day. So, recharging the *Electro* was a most pleasant and welcome aspect, both from the safety and convenience point of view. If there is an electrical plug nearby and you have a long enough extension cord, then charge the batteries on board. Otherwise, the batteries are easily removed. Connecting the charger and charge controller is also straightforward. For comparison, my pure gliders each have two batteries for the instruments. Here the two engine batteries also power the instruments, so the process of recharging the *Electro* is no different and in my opinion brings no additional burden than recharging the two batteries of my pure glider.

A full charge from a fully discharged battery takes about three hours, and I verified this short time during the practice days. During the contest I never needed to self-retrieve, and my self-launches typically used only about one-fifth of the available on-board energy (leaving me about 40-45 minutes of level flight, or about 40-50 miles (65-80 Km) for self-retrieve purposes, plenty to reach another thermal, get home directly, or reach an airport from any place in the task area and avoid a land-out in the "boonies," of which there are plenty around Moriarty). Coming back to the hangar every day I would hook up the charger and then go and deliver my flight log to the office. At my return, about 45 minutes or an hour later (given the inevitable "hangar flying" and story-of-the-day sharing with friends), the system showed full charge. So, these charge times showed good agreement with the factory-claimed fast recharge times. Also, at our average USA rates of about $0.10 per kWh, and assuming even a low 30% efficiency of the charging system, a charge of the full 4.3 kWh costs less than $1.50 -- $0.30 for my launches using 1/5th battery storage -- which will hardly break the bank as the cost of your next launch (or launch plus retrieve).

Overall, the recharging is a big plus with me for the all-electric, mostly for the safety and convenience, compared with IC engines systems. The very favorable launch cost compared with pure gliders, or the self-retrieve cost compared with the cost of an aero-retrieve or even car retrieve if the case would occur, represents a nice additional plus, notwithstanding the environment-friendly aspect of the all-electric energy use.

Maintenance

At the end of the practice period and before the first contest day, I decided to check on any potential maintenance that the FES would require during the contest. The manual says: "The motor requires no maintenance." In fact, opening or doing any disassembly of the motor would void the warranty. The manual recommends changing the propeller blades every fifty hours, which at my average of three minute per launch (typically between 2 and 4 min) correspond to about 1000 launches, less of course the occasional self-retrieve events. LiPo batteries are claimed to withstand 1500 charge cycles before their capacity degrades to about 80% of their original rating, which still leaves a significant capacity, certainly sufficient for one or two launches on a single charge. So, overall not much to do, except for the visual inspection of the propeller blades and hinges on the nose cone before each flight for cracks or nicks due to foreign objects. Thinking about it, the two blades and hinges, and the motor shaft are the only moving parts of the system, compared with probably hundreds of moving parts for IC engines, and the maintenance requirements certainly show the difference.

In-flight engine stops and restarts

The whole process of shutting down the *Electro* FES engine consists in turning the power knob to zero, and that is it. Quite a simplified procedure, lower demand for pilot attention, and smaller time to complete, compared with what I had experienced when stopping and retracting the pylon-mounted propeller of an IC engine sustainer-equipped glider that I flew at a previous contest in Europe.

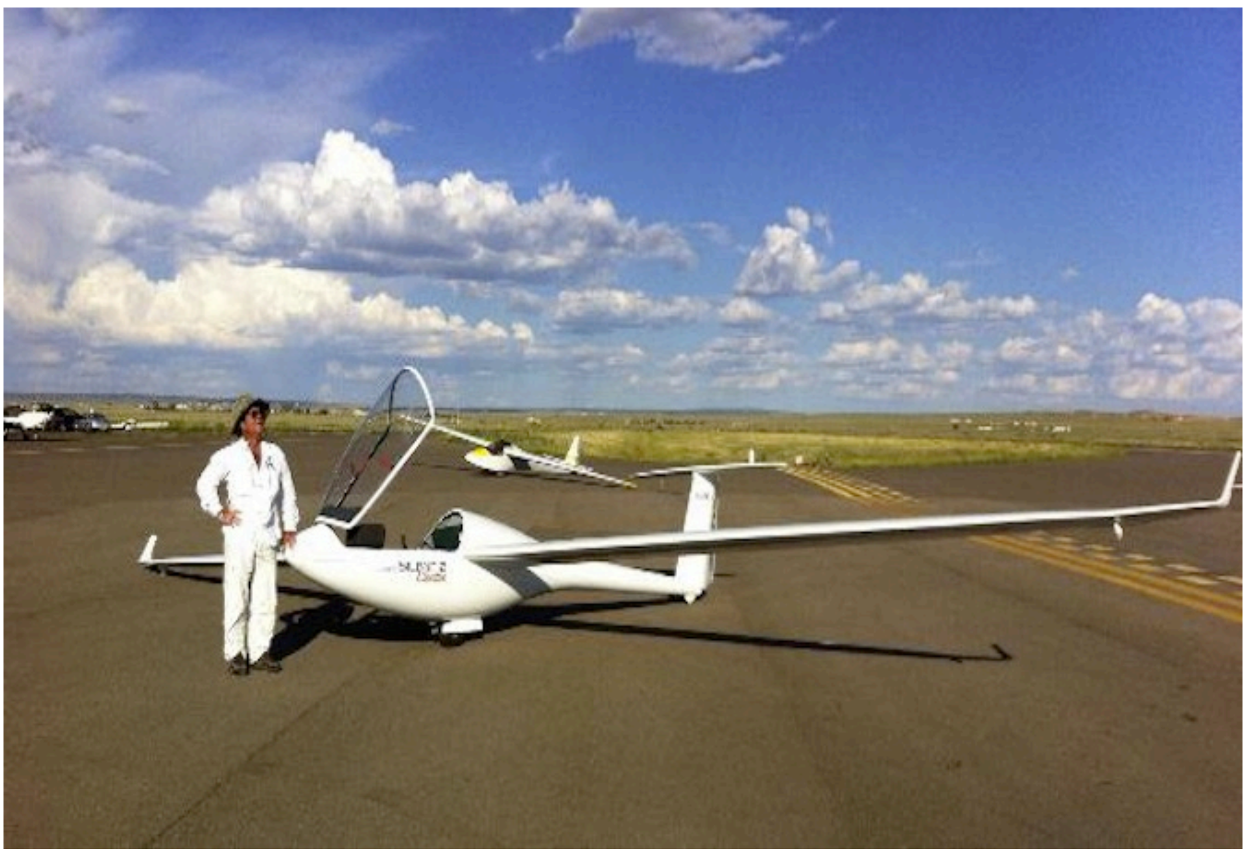
The instantaneous restart capability of the *Electro* FES, with no pylon to deploy, is where all the difference is. When I flew the IC engine sustainer-equipped glider in the contest in Europe, I had of course practiced in-flight restarts during the practice period. And so did I with the *Electro* at Moriarty. But the real test of the process really comes when a restart is needed on course during a racing task. During the European contest I had to abort three tasks and restart the IC engine sustainer in flight. All three restarts went well, although the fifteen or so seconds needed to complete the process of running the checklist, slowing the glider down to between 90 and 100 Km/h (48.5 and 54 kts), flipping the switches, waiting for the pylon to deploy, then accelerating to windmill the propeller fast enough to start the engine, felt like an eternity. Particularly so because, when the deployment is started, decisions must then happen at a quicker pace. With the pylon extended, the ship's L/D goes from a happy 40ish/1 to something probably in the single digit or low teens, and you are on the ground quite quickly if a glitch in the process occurs and the engine does not start. I guess one can practice and eventually become comfortable with this sudden change of flight configuration, but it is a drawback of pylon systems that has always bothered me.

The other thing that bothered me when using the IC engine sustainer is that for fifteen seconds, at the worst possible time, i.e., when low and getting ready for a possible land-out, I had to devote all my attention to a process that is quite exacting (with the sustainer for example, when they say "between 90 and 100 Km/h," they meant it! Stray a couple of Km/h away from the range and the overload circuit breaker of the deploying motor would pop, leaving you with a partially extended pylon and a need to redo the whole process). In other words, in an attempt to avoid a land-out event that included some uncertainty and hazard, I had to switch all my attention away from my most precious safety asset, my field, to put it on another process that included just as much uncertainty and hazard! Safety-wise, I have not settled that trade-off in my mind.

Twice at Moriarty, I got low on task and detoured toward landable areas, flipping the FES master switch on, just in case. Then, at no time did I have to turn my attention away from examining my field. Both times, I found a thermal just before reaching my restart altitude threshold, but if I had not, the only required process would have been to turn the power knob. Most importantly, if the motor had not started, I would have continued my approach with no change in the flying characteristics of the ship and landed in the same configuration as I use for all my landings. When dealing with an unknown landing field, these two aspects carry a lot of safety points in my mind.

Summary (for now)
There are several other comparison areas between the FES and pylon-equipped or IC engine based systems that I could include here, all favoring the FES in my mind based on my experiences. But this article is already quite long, so I will leave them for a sequel or Part 2 article to cover them later. Needless to say, I believe that the *Electro* FES feature of immediate start, stop, and power control, without any degradation of the flying characteristics at any time during the various phases of flight, and requiring no more time and attention than turning your radio on and off, introduces a capability for much greater safety in cross-country soaring, not only when compared with other self-launchers or sustainers equipped with pylons or IC engines, but also when compared with pure gliders.

I think we can now have it all: all the advantages, none of the drawbacks!!



The end of the last contest day at Moriarty: What a fabulously enjoyable and revealing experience this contest has been, thanks to Leo, Jen and JEN.

Two more features of the *Electro* that I love and just have to mention here
The first is the gear-retraction mechanism. It is not a sliding rod mechanism, but a handle hinged on the left armrest. It pivots forward and aft and lays snuggly under the pilot's left

forearm. I was a bit skeptical when I first looked at the mechanism, expecting to have to apply some strength to actuate the system. But to my amazement, it is a two-finger job, incredibly smooth and effortless! Someone at Alisport does know his/her stuff in designing actuation and locking mechanisms!!

The other is the flaperon-trim system. The entire stabilizer tilts up or down when the flap handle is moved fore and aft, coupling the stabilizer pitch with the flap setting. This results in incredibly smooth transitions from slow to fast flight with practically no stick motions. Very impressive and efficient! Check Alisport's website for photos of the "variable-incidence" stabilizer: www.alisport.com

Happy flights.
François

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Editor's comments:
François won the 13.5m contest in Moriarty with a significant 1000 point overall lead (see the SSA website for results <http://www.ssa.org/Contests> and Alisport's website <http://www.alisport.com/eu/eng/silent2electro.htm> for additional photos). For our readers based in North America, Alisport reportedly will have a Silent Electro on display at the SSA Convention in Reno, Nevada from February 27th to March 1st, 2014. For those unable to attend, Bill and Rand will be providing event coverage.