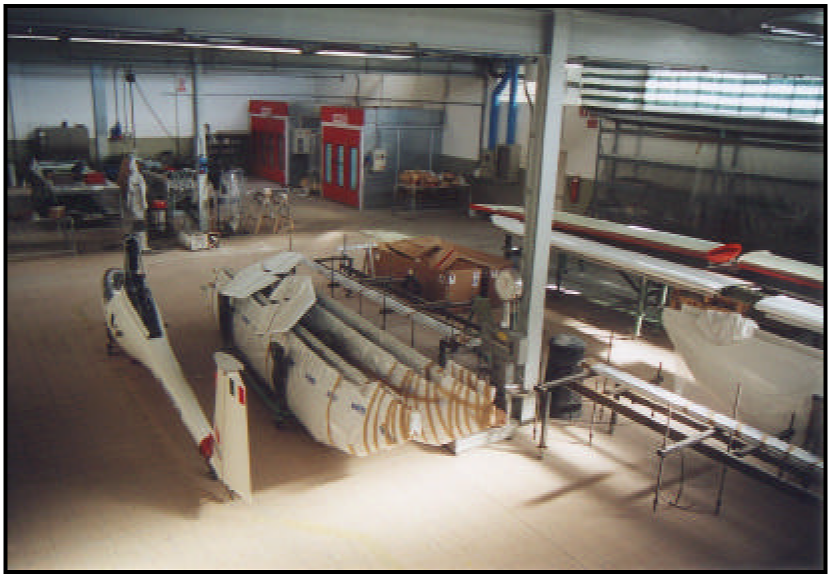
Alisport's "Silent"

Introduction

The development of the Silent goes back to the early 90's and its roots can be found in Walter Mauri's light sailplane called the "Dream". The 12m composite airframe is shared by three aircraft variants: (1) the pure sailplane which meets the FAI Class DU take-off weight requirement of 220kg (with an average pilot), (2) the 28hp fuel-injected self-launch Silent-IN (with a single-blade teetering propeller), and (3) the 13kW DC electric self-launch Silent-AE1 (developed in partnership with AirEnergy of Germany). All three versions are available ready-to-fly while the pure sailplane & fuel-injected self-launcher are also available as quick-build kits. Of note is that the pure sailplane kit can be upgraded to the self-launching Silent-IN at a later date (more on these later). At present there are no plans for a kit version of the electric self-launcher, but it is being considered.

Silent in flight over the Italian Alps.

The aircraft are produced by Alisport Srl. of Cremella, Italy, located just north of Milan in the beautiful Lake Como region. In case you are wondering what's in a name, "Ali" is the plural of "ala", Italian for "wing". The company's founders emphasize the philosophy of affordable, fun, and light composite sailplanes. The Alisport US office is located in the aviation friendly city of Tullahoma, Tennessee and opened in October 2001. The Baltimore, Maryland facility is used as a logistics center and is the primary import location. An additional facility in San Jose' is used for delivery to west coast customers.



Alisport factory – autoclaves in far corner extend outside of building.

Alisport factory – final assembly area.

Construction

The aircraft structure is primarily composite with some use of metal reinforcement and welded sub-structures where needed. The sandwich core fiberglass wings are vacuum bagged and use high temperature epoxy cured in factory autoclaves. The fuselages are laid-up by hand using room-temperature epoxy and a combination of glass and carbon reinforcement. The cockpit pod is made entirely of fiberglass for improved crashworthiness. Carbon fiber is used extensively in the fuselage tail-boom and tail. Additionally, carbon fiber is used for components requiring increased stiffness (ex. flaperons and, for the self-launchers, the engine-bay doors).

Testing

The Silent airframe has undergone thorough analysis (Milan Polytechnic University) and testing (both by the factory and independent parties). The factory performed complete in-house destructive tests of the wings to confirm that the structure met design loads (the ratings are +5.3/-3.0, +4.6/-2.6, +4.3/-2.3 respectively for the three aircraft at gross weight). Note that the Italian RAI (equivalent of the FAA) requires no independent testing of the aircraft since the Silent falls within the Italian equivalent of our proposed Sport Category. However, for Germany, independent structural tests to failure under supervision of the LBA (German equivalent of the FAA) were required. The tests are noteworthy in that they are performed at a temperature of 54°C (129°F)! All tests met or exceeded the 1.5 safety factor requirement. The structural test program also included fuselage drop testing, stabilizer load testing, and control system load testing. A certificate was issued by the LBA showing conformance with the requirements. More recently, successful flutter tests have been performed by an academic flight group in Italy.

Wing load test with free movement of flaperon – booth heated to 54°C.

Wing torsional bending test.

Controls

All wing and elevator controls connect automatically. The wing spars overlap and two pins are used to connect the spars. The horizontal stabilizer is simply placed onto the top of the vertical stabilizer and a pair of pins in the former connects to a pair of bushings in the latter. A single bolt with spring-loaded retainer is used to secure the horizontal stabilizer to the vertical. The elevator ingeniously mates with the control arm yoke.

Stabilizer connections – elevator engages in bow-shaped control yoke.

Roll control is accomplished initially through a torque tube that passes under the seat via a universal joint; followed by pushrods connected to a mixer located between the full-span carbon-fiber flaperons (one would correctly expect the roll rate to be very high). The mixer provides two flaperon positions: 0° for take-off, climb, and landing plus a -7° reflex position for cruise. Landing flaps are not necessary since the large wing area and light weight already permit slow landings.

Cockpit side controls – door lock and blade stop next to seat harness.

The elevator control uses a Teleflex™ cable. The sealed "cable" has a steel strip supported by ball bearings along its entire length. It is smooth, extremely strong, and has no backlash. The cable, which runs continuously from the stick to the elevator horn, is unique in that it can only flex in one plane and thus follows the fuselage centerline, ultimately curving up the vertical stabilizer. Pitch trim is via a spring located beneath the seat pan and connected to the control stick.

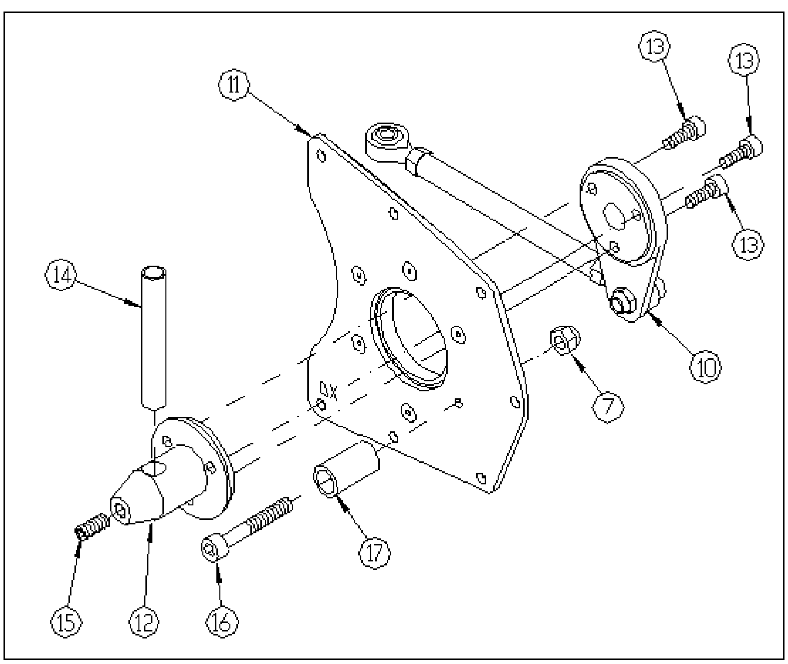
The air brakes are traditional and extend from the upper surface only. Full aft travel also activates the main wheel brake. Hard braking simply pitches the fuselage forward until the nose-wheel touches.

The rudder control is traditional via cable. The pedal cluster is adjustable via a ball detent pin. A steerable tail-wheel is an available option for the self-launch versions.

Kits

The kits are advanced quick-builds and the factory publishes 350 hours for the Silent and 500 hours for the Silent-IN. These times are conservatively based on double the factory hours needed to complete the aircraft from the kit stage. A Silent-IN kit was recently delivered to a builder in California who plans on keeping a detailed log, so we'll see a benchmark build time in the very near future.

Since the kits are quick-builds, the logical question is whether they meet the 51% rule. At the time of this writing the kits had completed an inspection by the MIDO and met all requirements on the FAA checklist. The exception to this was that the Construction Manual was not completely translated (the Flight Manual, however, is complete). Final FAA approval is simply pending completion of the translation which will be complete by the time this article is published. The manual is profusely illustrated with photos and CAD drawings (example shown below).



Control drawing from the construction manual – air brake linkage.

The Alisport kit approach is to perform all critical construction steps at the factory. Any tasks that impact structural integrity, rigging, alignment, or are of higher fabrication risk are performed with factory tooling. For example, the wing halves are closed and autoclave cured with the spar bushings and root pins bonded in position. The fuselage halves are joined, wheel wells and the cockpit pan bonded in place, most bulkheads and the vertical stabilizer spar are bonded, and the perimeter frame is bonded to the acrylic canopy. Most of the composite work required of the builder involves bonding of a few bulkheads and some pre-molded panels (there is no cloth lay-up in the traditional sense). The majority of these pre-molded components are used to reinforce the engine-bay of the Silent-IN. All tubular steel structures (from the air-brake linkage arms to the engine pylon of the Silent-IN) are provided in pre-welded and powder coated form.

Silent-IN Particulars

The "IN" kit adds a fully engineered and complete powerplant system to the pure sailplane. In addition to the standard flight controls and instruments, it includes the engine, reduction drive with pulleys, patented single-blade propeller, welded and painted pylon, extraction/retraction electromechanical actuator, fuel-tank & fuel system components, wiring, switches and panel, throttle, tachometer/hourmeter, and sealed battery. The engine bay doors and the composite panels mentioned previously are also included.

Silent-IN panel – indicator lights, pylon up/dn, master, ignition, & start.

The Alisport A300efi single-cylinder engine has a fully mapped electronic ignition and fuel injection system specifically developed for the self-launch application. Various sensors provide signals (ambient pressure, intake-air temperature, cylinder-head temperature, flywheel rpm, and throttle-body butterfly-valve position) to the Full Authority Digital Engine Control. The FADEC system manages the engine and optimizes mixture and timing. There is no choke or mixture and the pilot has single-lever power control. The system also limits rpm when necessary (progressively during warm-up and in flight if airspeed is too high).

The single-blade propeller is unique in that it teeters. The propeller hub is attached to the pulley shaft such that the propeller blade can pivot fore and aft slightly.

The counterweight is located slightly aft of the pivot point and thus counteracts both centrifugal and thrust forces. The pivot transmits only the propeller thrust and torque loads to the pulley shaft (no bending loads due to one-sided thrust). When running the propeller constantly seeks a position based on the combination of engine rpm and airspeed (even through a single revolution). All high dynamic forces are thus dissipated in the propeller hub and do not reach the pulley shaft. The angular variation from a flat disc is less than -0.75° to +0.30°. The only time the propeller moves to a limit position is when the engine is shut down in flight and the air loads push the blade aft, or during preflight inspection. Incidentally, the propeller "mushroom" counterweight uses a high-density tungsten core to minimize size.

Patented single-blade teetering propeller.

An unexpected feature of the counterweight is that its wake affects the blade in an advantageous manner. Specifically, it affects the innermost (most twisted) portion of the blade under static and low speed conditions (i.e. initial ground-roll). As a result, the propeller (and therefore the engine) can reach a higher static rpm, allowing the engine to develop more power and thrust from the start of the take-off roll. Since the aerodynamic interference progressively diminishes as forward speed increases, it also results in a surprisingly constant rpm throughout the powered airspeed range. It is also noteworthy that the single-blade substantially shortens the required length of the engine-bay doors. This further reduces the necessary amount of structural reinforcement to the tail-boom.

Of further interest is that the factory performed a complete theoretical and experimental vibration analysis of the engine/propeller combination. Ground vibration tests were performed with the system instrumented with accelerometers. The results are published in Technical Soaring (Vol. 23, No. 2, 04/99) and make for interesting reading.

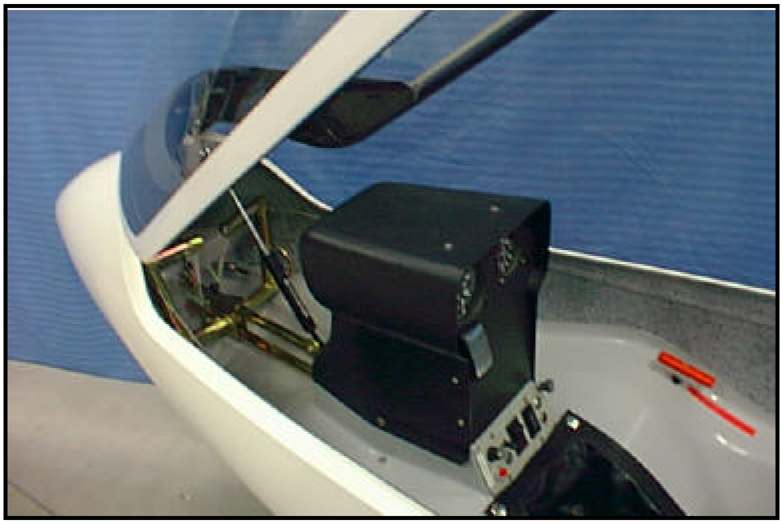
The addition of an engine to the light self-launch sailplane poses some interesting constraints. The first is the relationship with aircraft size. The multi-cylinder engines presently available on the market are not practical for use in light sailplanes without the weight causing a domino effect and ultimately impacting the entire aircraft weight (note that Rotax no longer offers a single-cylinder engine). On the other hand, power in the 25 to 30 hp range is a necessity for decent climb performance, hence the need for a larger displacement light-weight single-cylinder engine. The drawback, however, to a single is engine vibration and the corresponding risks of mounting one on top of a pylon.

Locating the engine at the upper end of a pylon can cause an unwelcome c.g. shift between the deployed and retracted positions plus the pylon can behave somewhat like a tuning fork. Both of these can be accommodated with correct design. Alisport's solution to these and the vibration concerns of a single-cylinder (beyond the vibration reductions from the teetering propeller) was to locate the engine both within and at the base of a welded pylon. This places the engine close to the pylon's rubber isolators, yet the cylinder and head are exposed to the propeller blast for cooling. In addition to this, the Alisport engine is fitted with an external counter-rotating balancer shaft located adjacent to the crankcase. The resulting engine vibration level is exceptionally low for a single-cylinder two-stroke. The drive gear on the crankshaft is aluminum and the driven gear is Nylatron™ creating a gear pair that does not require lubrication (if fact, lubrication is detrimental to gear life).

A300efi fuel-injected engine installation.

Latest Developments

Due to multiple requests by self-launcher customers and also pure sailplane customers not particularly concerned about meeting the FAI Class DU weight requirements, Alisport has recently developed a tip-up canopy. The canopy uses a gas strut to assist lifting the canopy. A jettison handle is provided on the right side of the cockpit, adjacent to the pilot's thigh (this will likely be moved up to the canopy frame to avoid accidental confusion with the tow-rope release). Pulling the handle allows the gas strut to push the leading edge of the canopy upward so that it is jettisoned. It can also be removed this way for service access. The hinge mechanism can be retrofitted to the standard removable canopy.



New tip-up canopy.

An improved steerable tail-wheel will be available soon for the self-launch versions (replaces existing steerable tail-wheel). The wheel is connected to the rudder via a pushrod and reportedly permits a tight turning radius of 6.5 meters (only a half meter more than the semi-span). It will also permit the glider to be pushed backwards easier.

New version of the steerable tailwheel.

In addition to the canopy and new tail-wheel, recessed footwells for the floor-pan have been developed. This molded panel provides heel space for pilots with larger feet (or bulky shoes) and also improves the seating comfort slightly.

Leo Benetti-Longhini is the US representative for Alisport Srl. and runs the Tullahoma, Tennessee office. He holds an advanced engineering degree, has over six years of composites experience including mold-making, is actively involved in wind-tunnel design and testing, and speaks fluent Italian. He can be reached via the internet at info15@alisport.com.