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The Substitute for Span: A 1000 km triangle in five hours

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Summary

A clever variable geometry glider is proposed that is expected to have sufficient range in wing loading to permit such a flight. A flying model is described as an initial proof-of-concept.

There has never been a substitute for wing span – from Robert Kronfeld's 30 m Austria of the 1920's to Hans Werner Grosse's 30 m ETA of the 21st century. Maximum cross-country glider performance has invariably been linked to huge wingspans, and as a result, all of today's super ships have long, thin, high aspect ratio wings.

Now, try to imagine a glider of only 15 m wingspan, able to carry enough ballast to provide a massive wing loading of 77.58 kg/m^2. Naturally, at that wing loading it will not be able to climb. But, what if the same glider, after dumping that ballast in order to climb at a more modest 44.33 kg/m^2, was then able to achieve inflight replenishment of that ballast, before it heads off on its next straight glide, again at 77.58 kg/m^2? Impossible? Not for the J-5.

W. A. T. "Fritz" Johl (from Constantia, South Africa, Fig. 1) contends that sailplane design is in the doldrums and that all sailplanes look and perform in the same way. He asserts that only two directions that are available for progress are boundary layer suction and variable geometry.

Fritz Johl's J-5 glider, utilising a completely new variable geometry wing, has been designed with a goal of flying a 1000 km triangle in thermals within a time frame of not more than five hours. The thermals used for calculation purposes are of the typical strength found during an average South African summer.

The J-5 glider is not just a theoretical "paper concept" that is too complex to build and fly. To date, a fully functional quarter-scale model has undergone successful proof-of-concept test flights at Worcester Airfield (Fig. 2) and further full-scale wing sections are currently under construction. This radio controlled model is equipped with extensive telemetry to record speed, altitude, rates of climb and descent, temperature and control deflections, capable of continuous data transmission to a ground-based PC (Fig. 3). The PC is equipped with a fully simulated real-time cockpit instrument display, and logs all the transmitted flight data for subsequent analysis.

The J-5's utilisation of variable geometry does not mean it resembles the variable geometry gliders of the past - some highly successful as those previous designs were created for specific conditions.

Neither is the J-5 simply a development based on those earlier ships which were notorious for their high pilot workload in flight.

While the concept of variable geometry is not new, the J-5 is a completely new design which proves that this concept is not merely a quaint aerodynamic fad that has been flirted with, found lacking for most practical purposes, and consigned to history.

The J-5 proves that variable geometry is the 21st century alternative to the long, high aspect ratio wings of the super ships. The existing model is the proof-of-concept for the low aspect ratio wing super ship – a concept that develops the principle of variable geometry by expanding/contracting the wing chord at both the leading edge as well as the trailing edge of the wing. Instead of increasing the aspect ratio, the main design parameter has been to decrease it.

J-5 designer Fritz Johl, a Fellow of the Royal Aeronautical Society, is no new-comer to "alternative" glider design deviating from mainstream thinking.

Older pilots will probably recall his successful partnership with the late Pat Beatty on the innovative and ground-breaking BJ2, BJ3 and BJ4 gliders that performed so successfully from the late 1950's through to the early 1970's. These were essentially "research gliders", revolutionary designs in their day, but they were never intended for series production.

They did, however, break existing performance records, outperforming the rest of the gaggle in competition by significant margins. So revolutionary were the BJ gliders that they held both multiple South African and world records and in their day were, without doubt, the fastest gliders in the world.

Over his long career in aviation, Fritz Johl has accumulated over 8000 hours of flying instruction, having flown no less than 60 aircraft types as diverse as Tiger Moths and Spitfires.

Turning 90 in July 2011 has not hindered his passion for continuing with his aircraft research and design. His study is crammed with text books, papers and files on aerodynamics and aircraft design, and while his slide rule has made way for a modern computer, he has again maximised technology by creating his own highly complex aeronautical design and analysis spread sheets.

Returning to the J-5, how then does the fixed-span wing of the 15m J-5, without the assistance of any ballast manage, to alter its loading from approximately 44 to 77?

The simple answer is by nearly doubling its wing area, on demand by the pilot, in flight. This amazing feat is accomplished by expanding and contracting the wing chord at both the trailing and leading edges. The leading edge extends the chord forward between 20-30%, and a Fowler flap extends the chord backward by 50% (Fig. 4). The complement of leading and trailing edge extension thus provides a massive increase in the contracted wings chord – a ratio of 1.75. The trick here is to do all this while still preserving the laminar flow in the expanded and contracted configurations.

The average reader cannot be blamed for their scepticism with regard to how this virtual metamorphosis of the wing is made possible in practical, everyday engineering terms. Here, as with the pure aerodynamics of the design, genius comes to the fore.

Early attempts to manufacture variable geometry wings were hindered due to the unavailability of suitable, high strength plastic material.

In this new design, the entire ship is constructed of composite materials, much of the work being computerised. Without this it could not have been built to a sufficiently accurate standard. No concessions have been made for the fact that this is a model.

All parts, wings, spars, levers and controls have been dimensioned and constructed as envisaged on the full size aircraft. So, for example, the wing profile is the NACA NLF 0416, entirely unsuited to the low Reynolds Numbers applicable to the model. Although the sophisticated on board telemetry does permit flight performance analysis (Fig. 5), this is only of interest as a model and is in no way indicative of the performance of the full size aircraft.

The tapering outer wing sections have anhedral (negative dihedral, Fig. 6). The anhedral is a primary necessity, as it is not possible to design a taper wing that will expand and contract its surfaces without the anhedral. Secondly, it protects the wing when it is in expanded mode while on the ground, preparing for take-off and after the landing run. Tiny wheels are incorporated into the wingtip-fences in place of the more usual skids.

In retracted, or high speed mode, the outer skin of the wing leading edge is moved (extends) backwards over the main wing surface, much like a glove. To extend the leading edge into expanded or thermal mode, its entire length is moved forward by a set of pivoted levers (also of composite construction), which are positioned along its length and attached along the main spar and operated by a single rod. The same rod extends and contracts the Fowler flap. The action of the leading edge against the wing is therefore seamless through its entire transition from retracted to extended.

At the trailing edge in high speed mode, a Fowler flap fits snugly below the trailing edge of the fixed central portion of the wing. As with the leading edge, its extension is activated by a set of pivoted levers, also rod-operated (the same rod used for the leading edge). Once full extension is reached, it forms a flush-fitting, but extended aerofoil section together with, and identical to, that of the main wing.

The Fowler flap does not perform the function of a conventional camber-altering device. The wing has only two configurations – either extended, or contracted - high speed or climb modes.

The wing is attached to the fuselage on top of a central pylon. The pylon is a consequence of the anhedral in order to get ground clearance for the wing tip. This provides an added bonus of making for simple rigging, and obviates any possible aerodynamic interference that could be caused by a conventional wing-to-fuselage interface.

The pylon is further necessary for satisfactory lateral stability. It also facilitates the automatic connection of the controls in the fuselage with those in the wing, via vertical torque tubes. This configuration facilitates maximisation of the wing expansion system without loss at the fuselage.

Effective lateral control is achieved with upper surface only aileron-spoilers, which operate independently of the Fowler flaps (Fig. 6).

The entire mechanism for expansion and contraction is operated by two electric motors housed inside the centre section of the wing. This facilitates a quick transition from retracted to extended modes and removes the heavy workload that dogged the pilots of older variable geometry designs.

Due to the mechanisms required to operate the chord expansion and contraction, there are no conventional airbrakes.

The landing approach is controlled, and controlled is the operative word, by the deployment of a variable area (and hence variable drag) tail parachute. Not only can the area of this parachute be adjusted by the pilot in flight, but it can also be completely retracted back into the fuselage by the pilot. It is housed in its own separate container in the length of the fuselage and has a positive sprung mini-chute deployment system.

The rudder too is a unique design. It has the appearance of a conventional, all-moving hinged surface, but in actual fact it is of "split" construction. It comprises two equal half-skins, each side being an extension of the corresponding side of the tail fin. The result is a moving surface that is contiguous with the fin, without hinges or gaps which could cause disturbance in the airflow. It is the intention finally to extend the use of this system to all the control surfaces.

Some pilots may be familiar with the saying that "if it looks right, it will fly right". Whether viewed in "climb or speed" mode, the J-5 has the appearance of a serious soaring machine, coupled with a certain elegance possessed only by aircraft that are designed to soar.

Fritz Johl we salute you, and wish you well in this, your 91st year!

Figure 1 Fritz Johl and his J-5 wing.

Figure 2 Quarter-scale model of the J-5 in flight.

Figure 3 Personal computer displaying inflight data telemetered from the model.

Figure 4 (Top) Fowler flap retracted, (Bottom) Fowler flap extended.

Figure 5 Rig for flight-performance analyses.

Figure 6 Anhedral of the outer wing panels and the upper-surface-only aileron-spoilers extended on the port wing.