Europa Classic Trigear Conversion to an Experimental Amateur Built Light Sport Aircraft (EABLSA) by use of Vortex Generators normally used for STOL Modifications

Testing Dates 3 January 2010 thru 15 September 2010

Test Aircraft: N12AY Europa Classic Kit
Power plant: Rotax 914
Propeller: Warp Drive three blade 64 inch wide chord

This test was conducted to determine the feasibility of modifying a Europa Classic or XS kit aircraft to Light Sport Aircraft (LSA) standards. Experience has shown that the Europa kit aircraft is an efficient comfortable cruising aircraft with pleasing lines and superb flight characteristics. Many LSA aircraft are limited in cruise speed, strength, efficiency and comfort, which the Europa is not. The criteria for an aircraft to meet LSA, is in Ref 1 at the end of this document.

Aerodynamically, the Europa wing is capable of generating a 1.7 Cl. Simple solution of the lift equation indicates the aircraft should stall at approximately 49 Knots for the XS and 53 for the Classic allowing for the slight differences in wing area. The LSA criteria set for the by the Federal Aviation Authority (FAA) calls for a controllable stall at 45 KIAS. My experience with adding vortex generators (VGs) to the Zenith and Piper Aircraft for STOL operations showed that a full length set of VGs, properly placed can lower the stall speed 5-8 knots. The application of VGs should bring the stall speed of the Europa down to just meet the criteria listed in Ref 1.

Since the maximum continuous power setting of the 914 is 73.5 KW or 95 HP the next problem is achieving a propeller setting that will absorb the power but limit the Europa to 120 Kts IAS cruise at sea level. The Warp Drive Blade was selected and a quick calculation indicated that a tip pitch setting of about 29.5 degrees would absorb takeoff power, allow a 120 Knot max continuous speed at sea level. The power settings for the 914 were also adjusted as was the blade angle to simulate a 912S which has very similar torque and horse power at max continuous power settings.

Final hurdle is the weight. Ref 1 indicates that the maximum gross weight cannot exceed 1320 LBS. For the Classic trigear a nominal empty weight is possible at 850 lbs with very little equipment, interior comforts, paint and filler. This would yield a useful load of 470 lbs. This is an acceptable useful load to most LSA pilots. The XS Europa is nearly 50 lbs heavier due to wing construction differences and at 900 lbs empty weight, the useful load drops to a mere 420 lbs. This allows 100 pounds of fuel and 320 lbs of passengers and baggage. Not reasonable for the US market. Since the Classic can still deliver a reasonable load, tests continued. The XS will need a lighter wing to be sure for an acceptable load, or very light construction with little or no interior trim or instrumentation.

Initial testing centered on calibrating the airspeed indicators and pitot static installations. A long pitot tube was added to the leading edge for initial tests and checked against the normal XS pitot location. Pitot calibration flight test were done using a cockpit static source and by checking both pitot tubes by swapping pitot lines in the aircraft during flight. The XS pitot tube position is quite accurate down to 50 Knots and indicates 2 knots slow at 40 Knots. Airspeed indicators were a digital Blue Mountain Gen 4 calibrated and a Winter 20-200 Kt indicator. Static position is normally in a free stream tube cross drilled near the pitot. The static differences were tested down to 40 knots by disconnecting the static tube and comparing pitot mounted static source to cockpit static air. At airspeeds below 70 KIAS the differences in static sources was negligible. Below 70 and down to 40, cockpit static air was quite accurate. Extensive GPS ground runs were made in slow flight to determine airspeed calibrations as were timed runs down Lakeland Airport's runway to determine both elevation and airspeed accuracy before testing commenced.

Initially three types of vortex generators were employed. The Niagra Aero VGs were rejected for their large size and poor shape and fit. A smaller sized VG was necessary. Two other manufacturers of plastic VGs were selected and it was found their gluing technique was permanent and not very easy to reposition without damaging paint. Finally, the plan was to add glider wing tape to the wing and glue the VGs to the tape to allow repositioning and prevent damage to the paint finish. I found the Micro Vortex Generators were very expensive, but worked quite well. For cost considerations, the experimental types sold by Aircraft Spruce (used on the RV kit aircraft) are essentially the same as the Micro Vortex Generators and are acceptable. A manufacturer was found and the above vortex generators were modified with an under cambered base to fit the Europa wing shape. They are also the most cost effective at about $130 US per set. 3M provided an excellent glue system which allowed repositioning and a less messy installation method. The Glue kit is the 3M 468MP. See attached pictures at Ref 2.

Positioning of the VG on the wing was determined from previous experience. Normally, VGs work very well from 5%-10% chord depending on the height of the VG. Stoll Speed and Piper both use about 7-8% (1/2 inch high VG), and Niagra and Vortex use 8-9%, but their VGs are taller at nearly and inch. Tape would be placed on the wing with the leading edge at 7% and the tip of the VG resting on the leading edge. This puts the center of the VG at about 8%.

Testing would take place with the VGs placed as follows:

Test one positions the VGs over the aileron only portion of the span at a spacing of 60mm between VGs. The VGs will be set on the wing at a 15 degree angle to the spar.

Test two extends the VGs to the root using the 60mm spacing across the aileron, and then 90 mm spacing to the root. Operationally, VGs on the root section make entering the Europa Trigear a bit awkward as a step is necessary to step over the VGs. I decided to remove the inboard VGs from the root to 60cm (about 24 inches) out from the fuselage to allow a smooth slide on and off the wing, and get the side benefit of more turbulence and buffet over the stabilator for a good stall indicator.

Test three would change the spacing of the VGs to all of them at 60mm spacing from tip to the root less the 60cm for entry and exit.

N12AY, the test aircraft, normally stalls at a Calibrated A/S of 55 at 1370 lbs. It has no rig problems and a straight ahead stall. At 1320 lbs. the stall speed is 53 KCAS.

During test one, with the VGs over the ailerons only, the plane wing rocks like a century series fighter and the burble is a pounding on the tail plane that is quite a shake. The wing rock is probably too much for a novice and could lead to an abrupt wing drop if he attempts to jamb in aileron in an attempt to level the wings. Stall is difficult to get exact and it averages 48 Knots at 1320 lbs. Clearly more VGs were necessary.

Test two, with VGs all along the LE of the wing from the tip to two feet prior to the fuselage, see Ref 2 photo. The pre stall warning burble is quite pronounced (due to the clean root section of the wing) and the stall is 46 Kts CAS clean at 1320 lbs. Pre stall warning burble is a comfortable rumble on the stabilator, stall is indicated by a slight nose rise, a bit of yaw wandering followed by a smooth break. Aileron control is still possible during the break, indicating the 60 mm spacing provides a more aggressive boundary layer adhesion. One problem with the VGs encountered during slow flight and low speed operations is the plane feels so rock solid that one can get complacent and find himself out of airspeed with a high sink rate. At the stall, the deck angle is about 18 degrees nose high. Slow flight at 47 knots is capable with excellent aileron control even at bank angles of 10 degrees. The stall is still two knots too high for the LSA criteria. However, if temperature corrections and precise calibrations using ground radar and lasers were made, the stall may meet minimum criteria.

Test three was conducted and found similar indications as test two until right up to the stall. Burble over the stab was more pronounced and the stall occurred at 44 KCAS. The stall with 60mm spacing is sharper, with a slight rise, then a quick break. The wing will drop with the slightest out of center ball coordination. Slow flight was capable at 45KCAS and was easily controllable. The deck angle was again very high at near 19 degrees. With the slightest of power, the aircraft remains very controllable up to stall allowing a very slow approach to landing allowing very short roll outs. Full flap stall fell below 40 KCAS and is estimated at 38 KCAS. This allows a very slow 52 KIAS approach with a small amount of power and very good short field performance with touchdowns below 40 KIAS in ground effect and a very short roll out.

A fourth test was made by lowering the flap about 3/8 inch down to determine its affect in lowering the stall. The droop of the aileron was not accomplished. With this amount of flap droop, the stall speed is unaffected for all practical purposes, but the deck angle is notably lower at stall by some 3 degrees.

Cruise speed tests followed. First the main gear pants and nose pants were removed and the cruise speed checked. Max continuous was lowered to 105 KIAS. The wheel pants were reinstalled along with the wing speed kit and the max continuous cruise was 122 Knots at sea level. The propeller limited the engine speed capping the speed at 122. Decreasing the pitch on the prop to 29.25 degrees allowed for a 120 Knot max cruise. It appeared that the VGs, slowed the aircraft down about 10 knots from its original configuration using a fixed pitch propeller.

Pattern speeds with configuration two or three allow a 70 knot downwind and base no flap, a 60 knot no flap final, and no flap touchdowns of about 50. Although the aircraft is capable of slower touchdown speeds, the deck angle is quite high, and the tail will drag at touchdown in an attempted full stall landing. A full or half flap approach and landing is recommended.

As stated above, in the pattern, the aileron control and smoothness is deceptive. The aircraft gives no indication you are getting slow until just prior to the stall at about 47 to 50 KIAS. This could give the novice or less disciplined pilot a false sense of security and allow his airspeed to bleed off to the point where he no longer has stabilator authority to arrest the ensuing sink rate resulting in a possible hard landing.

For normal full flap approaches for normal or even STOL patterns, I found that entering downwind at 80 KIAS was acceptable for visibility and control. Adding full flaps abeam the touchdown zone allowed the aircraft to bleed speed nicely, provide for good visibility and reduced workload during the final turn. Lowering the flaps and trimming for a 70 KIAS glide for the final turn provides good handling and a proper sink rate carrying a the small bit of power from downwind (80 knot downwind power setting clean is maintained which was 20 inches and 4000 RPM). The final turn (base leg and base to final) speed of 70 is comfortable, and allows for more time to transition to a clean glide in the event of engine failure. On final the standard 1.15 times the stall speed is a bit low for me (40 Knot stall x 1.15 = 46 Knot final) and the nose angle is a bit high requiring more fiddling with trim and power, so I found 50 Knots to be quite comfortable, with a bit of power. Round out at 50 allows the speed to bleed quite nicely and allow a level out in ground effect still flying and touchdowns of 40 are possible in a trigear. Those using the VGs on a mono or conventional should have no problem sticking the tail wheel down first to aid directional control. However, the deck angle of the mono may prevent achieving slower touchdowns than 45 KIAS.

Takeoff with the VGs is very comfortable, with little or no sink after getting airborne at 50 IAS. Trim changes are the same as with the clean wing. Climb angle for a short field takeoff is quite high at a 15 degree deck angle and a 65 knot clean climbout.

Great caution should be used in these climb outs for if an engine failure should occur, the pilot must push over aggressively to nearly 10 degrees nose down to preserve airspeed sufficient to round out and flare to a forced landing. That is nearly a 25 degree push over.

Conclusions:
The Classic Europa with its lighter wing construction and 1300 lb gross weight or 1320 with Mod 52 is an ideal candidate for an LSA conversion using VGs alone. Configured with a 912 (80 HP) Rotax, a light weight wood prop, limited instrumentation and a light weight interior, the aircraft kit is perfect for an EABLSA. These tests have proven that the Classic Europa kit aircraft meets the stall, payload, and cruise requirements set forth by the LSA restrictions, and is therefore an acceptable EABLSA. Built light, the XS aircraft should also be acceptable.

Future Europa LSA aircraft designs should consider the VGs over the slots due to their ease of installation, and lack of complexity and cost of construction. Another consideration would be to use carbon fiber construction in the XS wings to save weight. Also an elimination of the current flap mechanism and a remolding of the wing to allow a very simple split flap for some lift and mostly drag, as lowering the stall below 45 knots is not really necessary. The split flap would allow for more drag and de-acceleration, as well as a steeper approach. Perhaps a simple lever could be installed in the cockpit for flap extension for lightness and ease of construction.

As for current Europa owners desiring to convert their aircraft to an LSA, the rules are very specific. The aircraft must never have been registered or operated, if a flying aircraft, outside LSA criteria. Much discussion was had with the US Federal Aviation Agency about converting existing aircraft to LSA. After lengthy discussions all XS monowheel aircraft now flying may never be converted to an EABLSA because it had been flown as a retractable. Any aircraft registered with a gross weight over 1320 lbs, with a constant speed prop or ever flown at speeds outside LSA criteria are never eligible for EABLSA. Only unregistered, VG equipped, fixed gear, fixed prop aircraft can qualify. During flight test, VGs and prop settings can be made to ensure the aircraft meets LSA criteria, and once flight testing is finished, however, the aircraft configuration cannot be changed. Many hours of discussion and examples were used to set down the criteria. A propeller change from fixed to ground adjustable is considered a major change by the FAA maintenance division, while the flight and airworthiness divisions are unconcerned as long as the LSA criteria is still met. This confusion is not applicable to the SLSA or ELSA aircraft, as their configuration is set by the factory, and by the rules set forth in maintenance and owner assembly, which states essentially that the owner may not change the configuration set forth by the manufacturer.

It is my hope, that Europa pursue a modification using the VGs and instruction manual for a STOL version or slow speed handling package, and a Mod kit for new or un-built or unregistered Europa XS or Classic kits to allow pilots to build to meet the LSA criteria. This mod would not impact our Motor Glider conversion as that allows a higher gross weight, cruise speed, heavier engines and complex retractable gear, constant speed propeller choices, and additional avionics and interior choices for the performance minded pilot.

References:

Ref 1.

Title 14
FAA Part 1
1.1 abbreviations

Light-sport aircraft means an aircraft, other than a helicopter or powered-lift that, since its original certification, has continued to meet the following:

(1) A maximum takeoff weight of not more than-

(i) 1,320 pounds (600 kilograms) for aircraft not intended for operation on water; or

(ii) 1,430 pounds (650 kilograms) for an aircraft intended for operation on water.

(2) A maximum airspeed in level flight with maximum continuous power (V_H) of not more than 120 knots CAS under standard atmospheric conditions at sea level.

(3) A maximum never-exceed speed (V_{NE}) of not more than 120 knots CAS for a glider.

(4) A maximum stalling speed or minimum steady flight speed without the use of lift-enhancing devices (V_{S1}) of not more than 45 knots CAS at the aircraft's maximum certificated takeoff weight and most critical center of gravity.

(5) A maximum seating capacity of no more than two persons, including the pilot.

(6) A single, reciprocating engine, if powered.

(7) A fixed or ground-adjustable propeller if a powered aircraft other than a powered glider.

(8) A fixed or autofeathering propeller system if a powered glider.

(9) A fixed-pitch, semi-rigid, teetering, two-blade rotor system, if a gyroplane.

(10) A nonpressurized cabin, if equipped with a cabin.

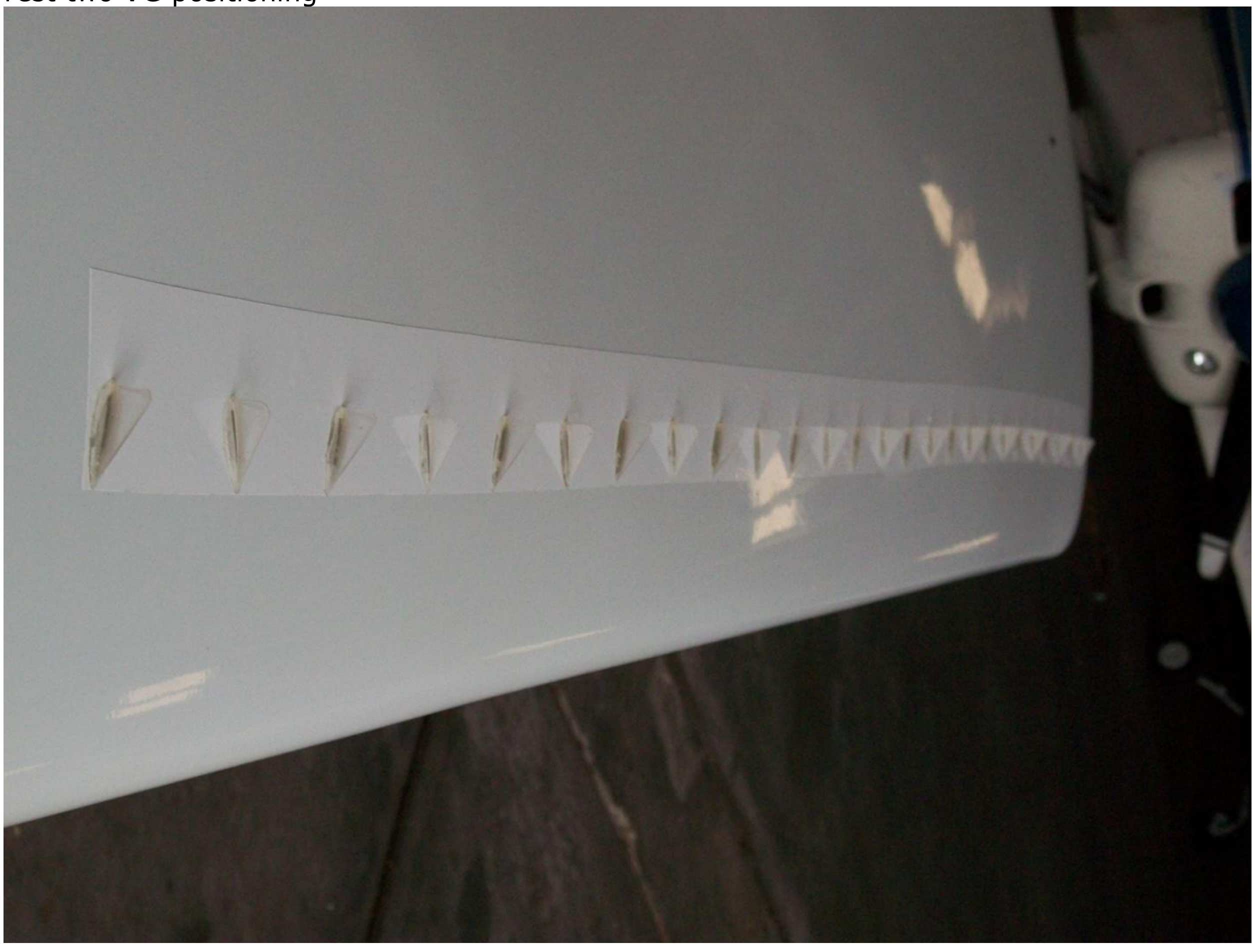
(11) Fixed landing gear, except for an aircraft intended for operation on water or a glider.

(12) Fixed or retractable landing gear, or a hull, for an aircraft intended for operation on water.

(13) Fixed or retractable landing gear for a glider.

Ref2,
Photo of Stol Speed VGs installed on glider wing tape.

Ref 3
Test two VG positioning



Ref 3
Stol Speed VGs showing break in spacing at the aileron to flap joint position during test 2.