The Addition of Vortex Generators for STOL performance and or for Meeting the Light Sport Aircraft Rules

This modification allows the Europa XS or Classic aircraft to operate with a greater stall margin and better low speed characteristics. For those owners operating out of very short runways or tight landing patterns requiring steep approach paths or slow speed maneuvering the addition of vortex generators (VGs) will improve safety margins.

General Background:
Aerodynamically, the Europa wing is capable of generating a Coefficient of Lift (Cl) of 1.7. This allows the Europa to stall at approximately 49 Knots for the XS and 53 for the Classic aircraft (1300 lb gross weight). The differences between the stall speeds are due to the slight differences in wing area, gross weight and shape.

VGs are small vertical fins attached at an angle to the airstream just aft of the leading edge of the upper surface of the airfoil. These VGs generate tiny vortices which thicken and add energy to the boundary layer allowing the wing to achieve a higher stalling angle of attack and thereby more lift (higher Cl) and a lower stall speed. The positioning, spacing and angle of the VGs on the wing is critical for proper handling characteristics, pre-stall warning and stall speed reduction.

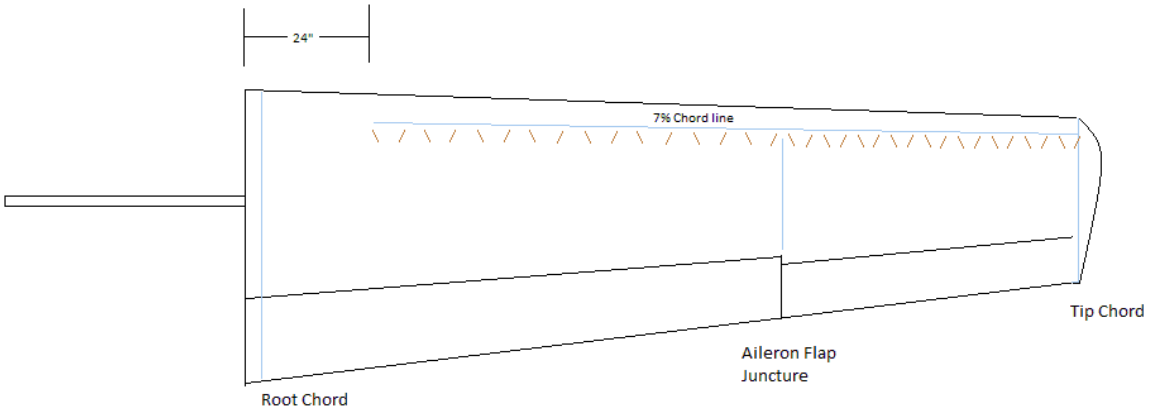
This modification will provide guidance on the spacing and positioning necessary to achieve optimum low speed handling characteristics.

General Configurations:
For both configurations presented below, the VGs will be set on the wing at a 15 degree angle to the chord (and relative wind) at a point which is 8 percent back from the leading edge. Spacing between the VGs will be set at 60mm starting from the wing tip (the joint between the main wing and wing tip or outboard end of the aileron if the joint is not visible) to the aileron and flap intersection for both configurations. Appendix 1 contains the specifics of the installation procedure.

The VGs from the aileron flap juncture to the root are positioned in either of the two configurations below:

Configuration 1:
Configuration one is a handling optimization configuration which allows excellent pre-stall warning, enhanced slow speed flight characteristics and also lowers the stall speed nominally 8 knots.

Configuration one, increases the spacing of the VGs from the aileron and flap chord line (where the VGs stopped) to 90mm and continues that spacing to a point 60 cm (about 24 inches) from the root or fuselage side (see drawing below).



Operationally, VGs may be placed all the way to the root section, which would lower stall speed a bit more, but make entering the Europa Trigear a bit awkward as the VGs would limit ingress and egress and require a step on the fuselage or on the ground to step over the VGs. By terminating the inboard VGs at least 60cm (about 24 inches) from the fuselage, allows a smooth slide on and off the wing for people entering and exiting as well as for gear loading. This 60 cm gap also allows the aerodynamic side benefit of more turbulence and buffet over the stabilator just prior to the stall, which gives an excellent pre-stall indicator. In testing, this configuration reduced the stall speed by 8 knots. The previous clean stall speed of the Classic was observed to be reduced from 53-55 Knots IAS (depending on 1320-1370 lbs. gross weights) to 46-47 Knots IAS at 1320-1370 lbs. Slow flight characteristics are noticeably enhanced and aileron control is quite positive up to the stall. Pre-stall buffet is comfortable beginning at about 3-4 knots prior to stall speed. A pronounced pre-stall warning buffet occurs just prior to the stall with little wing rock, nose rise or wing drop. Slow flight and gentle turns are very controllable down to 47 knots with little wing rock or buffet while maneuvering at shallow bank angles. Stall break is very smooth with little wing drop even with

slight yaw angles. Normal cruise speed and top speeds are reduced 5 knots to 10 knots depending on engine type, propeller settings, aircraft weight and manifold pressures.

Configuration 2:
Configuration 2 is primarily intended for the builder who desires to have his, as yet unregistered, kit aircraft fly under the new US Light Sport Aircraft (LSA) criteria. The Europa Classic or XS can meet the LSA rules as an Experimental Amateur Built Light Sport Aircraft (EABLSA) providing it meets the requirements of the LSA class aircraft when the final testing is complete (see Ref. 1). Essentially the criteria requires that an LSA aircraft is limited to a top speed of 120 Knots at maximum continuous power setting, and a clean stall speed of 45 knots. Further, the aircraft must be of fixed gear and have a fixed or ground adjustable prop. Finally the maximum takeoff or gross weight cannot exceed 1320 pounds (see Ref 1). All these limitations can easily be met by the Europa Classic or XS provided care is taken to keep the empty weight down and the VGs are placed as in configuration 2.

Unfortunately, existing Europa aircraft must have <u>continuously</u> met (or attempted to meet) the requirements set forth by the FAA CFR 14 Light Sport Aircraft requirements. This means current flying aircraft which are or have been <u>operating</u> as a retractable mono wheel, and or are or have been equipped with a constant speed propeller or have been registered above 1320 lbs, do not meet the LSA requirement, as the aircraft has not <u>continuously</u> met the LSA requirements.

Configuration 2 places all the VGs at a 60 mm spacing from a point 60 cm (24 inches) from the wing root extending to the tip. The center of the VGs are still positioned at 8 % cord at a 15 degree angle to the chord/relative wind as before. The clean stall speed of this configuration for the Classic aircraft is lowered from 55 Knots to 45 Knots IAS, a 10 knot improvement. The pre-stall buffet is more pronounced and wing drop is similar to the clean wing. Slow flight near the stall has a bit more buffet, a small amount of wing rock and nose rise occurs just at the stall. Maximum continuous cruise rpm power settings of 5500 yields speeds with a 912 Rotax of 115 Kts, and 120 Kts with a 912S with the propeller pitch set to achieve 5200 RPM static using a three blade 64 inch Warp Drive Propeller. If a speed kit is added, the aircraft may exceed the LSA required 120 Kts maximum.

Documentation required for either configuration:
Once the VG configuration is installed, the owner must test fly and annotate in the aircraft log book the aircraft meets LSA criteria. The stall speeds, both flaps up and flaps down, should be annotated in the aircraft log book and the pilots handbook via pen and ink change, or added pages to reflect the installation of the VGs and gross weight and cruise speed limitations.

Appendix 5 has a provided checklist mod page. Flight testing is the desired method for determining the posted handbook stall speed and landing approach speeds, and the handbook approach and landing techniques, if any, modified as appropriate. Our testing indicated that the recommended approach and landing techniques need not be modified.

Note: The flight characteristics with the vortex generator modification have been found to be benign with the addition of VGs but each owner may inadvertently deviate slightly from the installation directions in this modification and find small variances from what is printed in the text above.

This modification should not be used to try to compensate for a poorly rigged aircraft or be used to compensate for poor handling characteristics due to building errors. Installation and instrument errors of the airspeed indicator should be checked via ground and flight test also. For those builders preferring that an experienced test pilot conduct their flight testing, flight test guidelines may be obtained from the LAA or or FAA (see Ref. 2). Aircraft owners are responsible for proper documentation.

Appendix 1:

Preparation and installation of Vortex Generators (VGs) on the Europa XS or Classic Aircraft.

The installation of the VGs can be done with the wings on the aircraft, but is easier with the wings removed and the spar visible. The 3M adhesive used in this installation is well suited for use by the experimenter and allows for installation mistakes and once attached, holds up over continued use.

The Europa wing is a tapered wing and the installation of the VGs on a curved surface with a tapered wing and getting the angles optimum is a bit tricky unless you have a jig. Appendix 2 and 3 are cutouts to use as a jig for placement of the VGs at the proper angle and spacing. Normally the sweep of the Europa wing is very close to 90 degrees to the fuselage centerline and the jig in Appendix 2 is sufficient. If the sweep of the wing is pronounced follow the procedures in Appendix 4.

Preparation of the VGs:
The individual VGs may either be left straight out of the box (nearly clear acrylic) or may be painted as required. Sanding preparation is not normally necessary as the VGs are quite smooth. However, a bit of burnishing with 320 grit sandpaper or white scotch bright abrasive cloth is necessary for good paint adhesion. Prime and paint in accordance with your paint manufacturer's directions using a thin coat of paint to prevent runs or chipping. Double side sticky tape works well for holding the VGs during painting as they are quite light and will be blown away by the air gun.

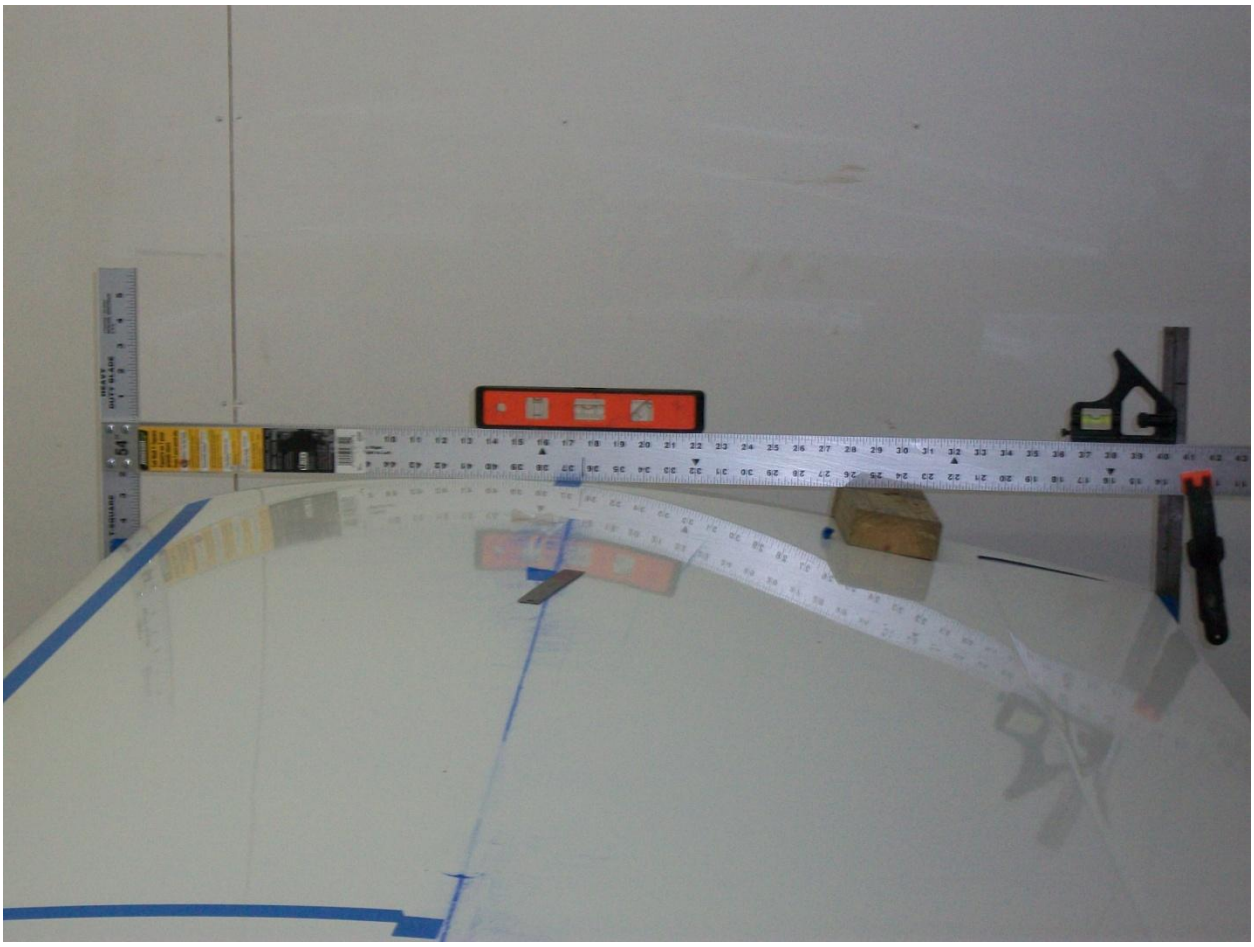
Preparation of the Wing:
Clean the wing from the spar to the leading edge and wipe with denatured alcohol or a pre-painting preparation solvent to clean any residue or wax from the surface.

Once the wing is cleaned, snap a chalk line or equivalent down the wing spar. This line is normally 90 degrees to the airflow over the wing and will be the reference line for our chord measurements and layouts.

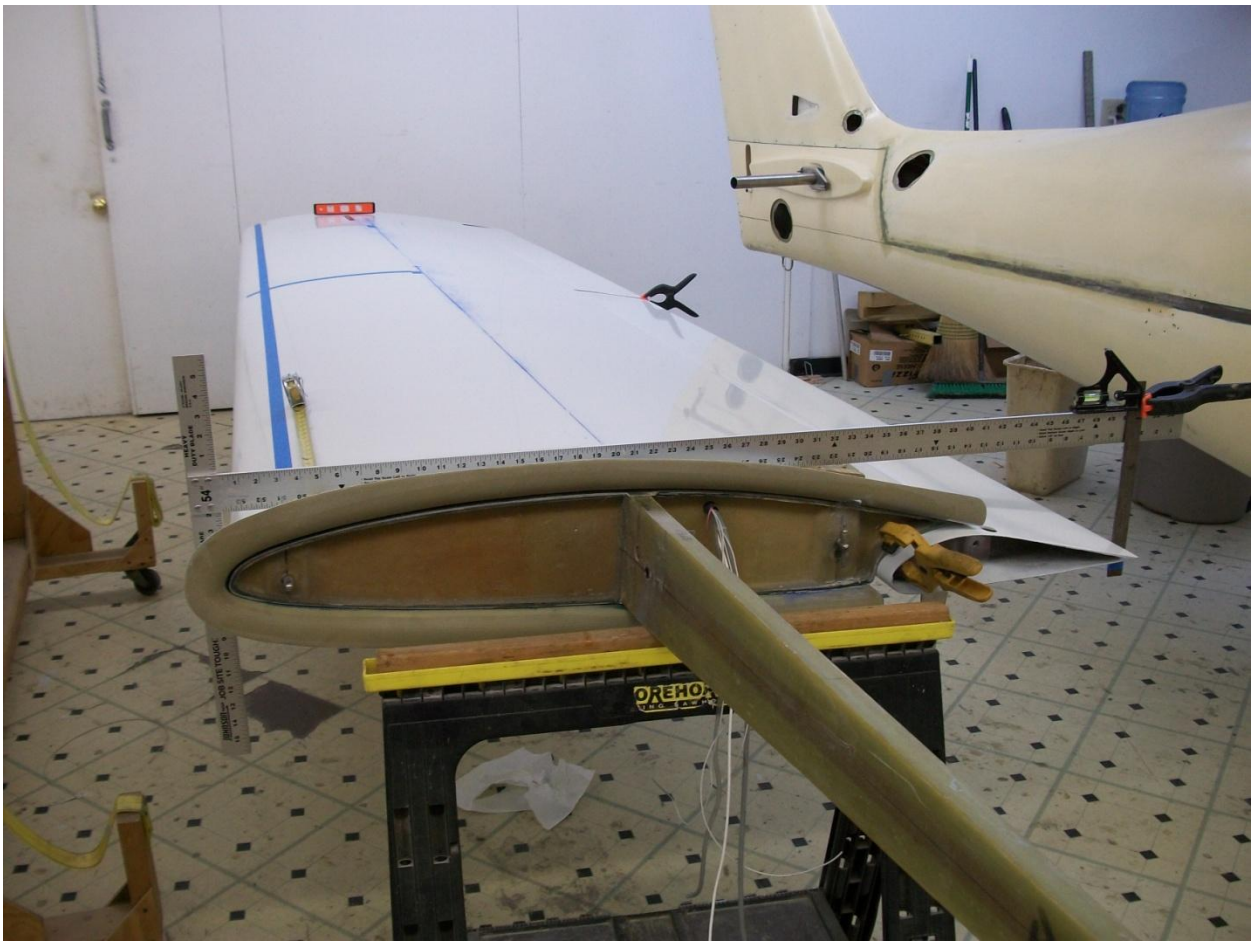
Next, using a T square, snap a line on the wing or use tape (one inch blue 3M clean release painters tape, or similar) to make a chord line 90 degrees to the spar line near the root area, the tip and for good measure at the junction of the aileron and flap.

Measure from the leading edge to the trailing edge, at all three chord lines marked. Multiply those distances each by .07 (or 7%) to determine where the leading edge of the VG will be placed. *Normally the tip is 40 inches and the root area just outside the wing fillet is 50 inches so one can use a tip measurement of 2.8 inches and 3.5 inches for the 7% chord line.*

Note: Placing the VG leading edge at 7% places the center of the VG near 8%.



Determining chord length. Use a T square and a level. Measure down from the square to determine chord length.



Wing laid out for gluing showing root chord technique for determining chord length.

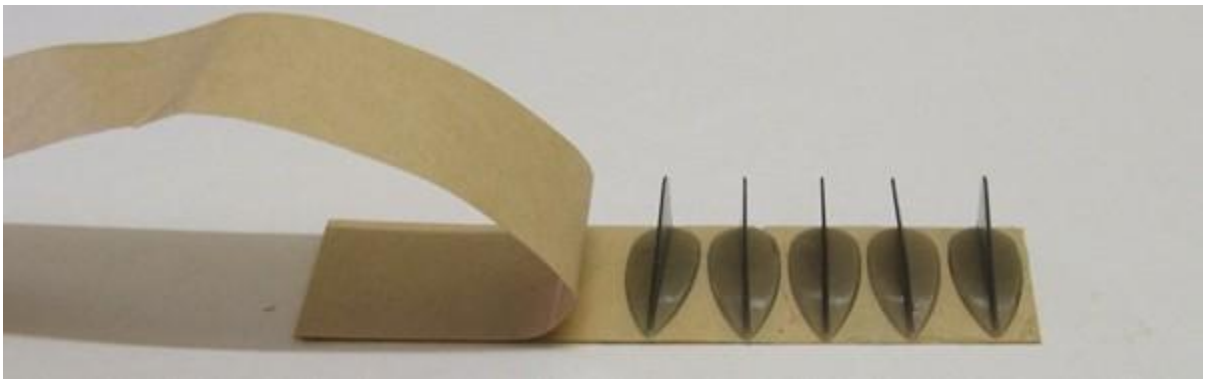
Now place a mark at each of those distances above. Pull a tape line down the wing with the trailing edge of the tape aligned with your 7% chord marks. Good quality painters tape will leave a very straight line, whereas glider wing tape or vinyl tape does not. If you didn't plan ahead, and your chord line tapes are on the wing where the VGs are to be placed, remove the tape that interferes. You are now ready to place the VGs on the wing.

The ideal temperature for applying this adhesive to the wing surface is between 60°F (15°C) and 100°F (38°C). If the temperature is below 50°F(10°C) the adhesive may not 'flow' properly for a good bond. If it's too cool use a heat gun or hair dryer to carefully warm both the wing surface and the VG.

Clean the bottom contact surface of each VG with denatured alcohol in preparation for bonding.

With a sharp trimming knife, or scissors, slice or cut the supplied 3M adhesive sheets (marked as 3M 468MP with 200MP adhesive) lengthwise into 25mm (1in.) wide strips.

Peel back the shiny-side backing of the strip as you place the VGs side-by-side across the strip, and press them firmly onto the adhesive.



Placing on the 3M glue strip

Use a sharp trimming knife, cut around each VG, right through the backing under the adhesive. Sharp scissors are also ideal for this, but the glue tends to stick to the blades after a few cuts, so clean the scissors with denatured alcohol frequently.

Turn the VG over and rub the backing firmly with a fingernail to press the adhesive onto the VG and expel any air bubbles.

Placing the VGs on the wing.

The jig provided in Appendix 2 takes into account the leading edge sweep and the desired angle of 15 degrees from the chord line and allows rapid installation of the VGs.

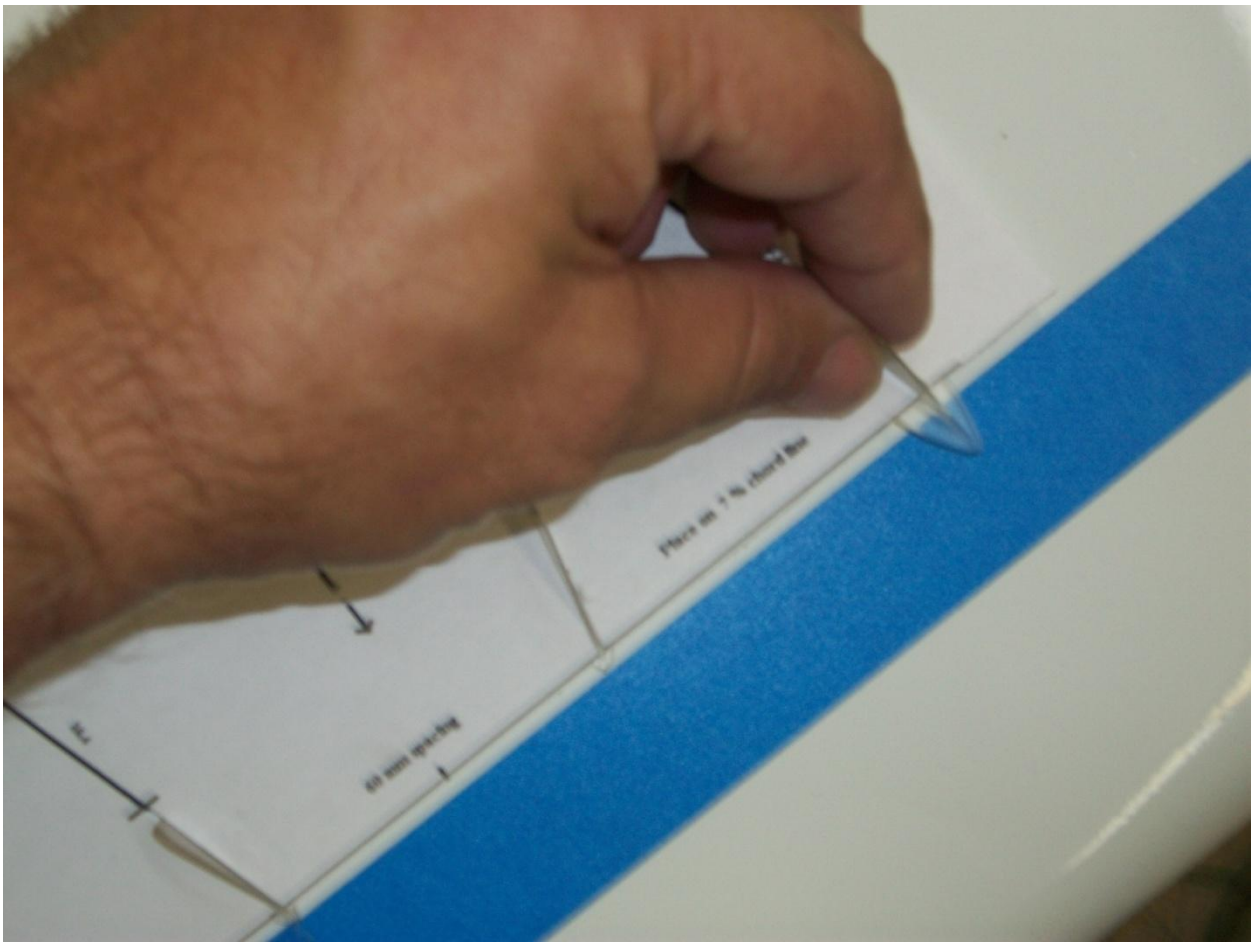
Prepare the jigs by cutting down the center and separating the port and starboard jigs. Next cut along the 7% line and cut out the lines up to the marks which allows a slot to place the VG into while placing them on the wing.

Begin installation from the tip by using the 60 mm template for the port or starboard wing as appropriate. Note that the jig has an arrow which points to the tip. The jig takes into account the slope of the leading edge and positions the VGs at the correct angle to the relative wind. Your initial starting point should always be at the junction of the wing and formed wingtip tip chord line. That is the line where the wingtip extends beyond the aileron outboard end.

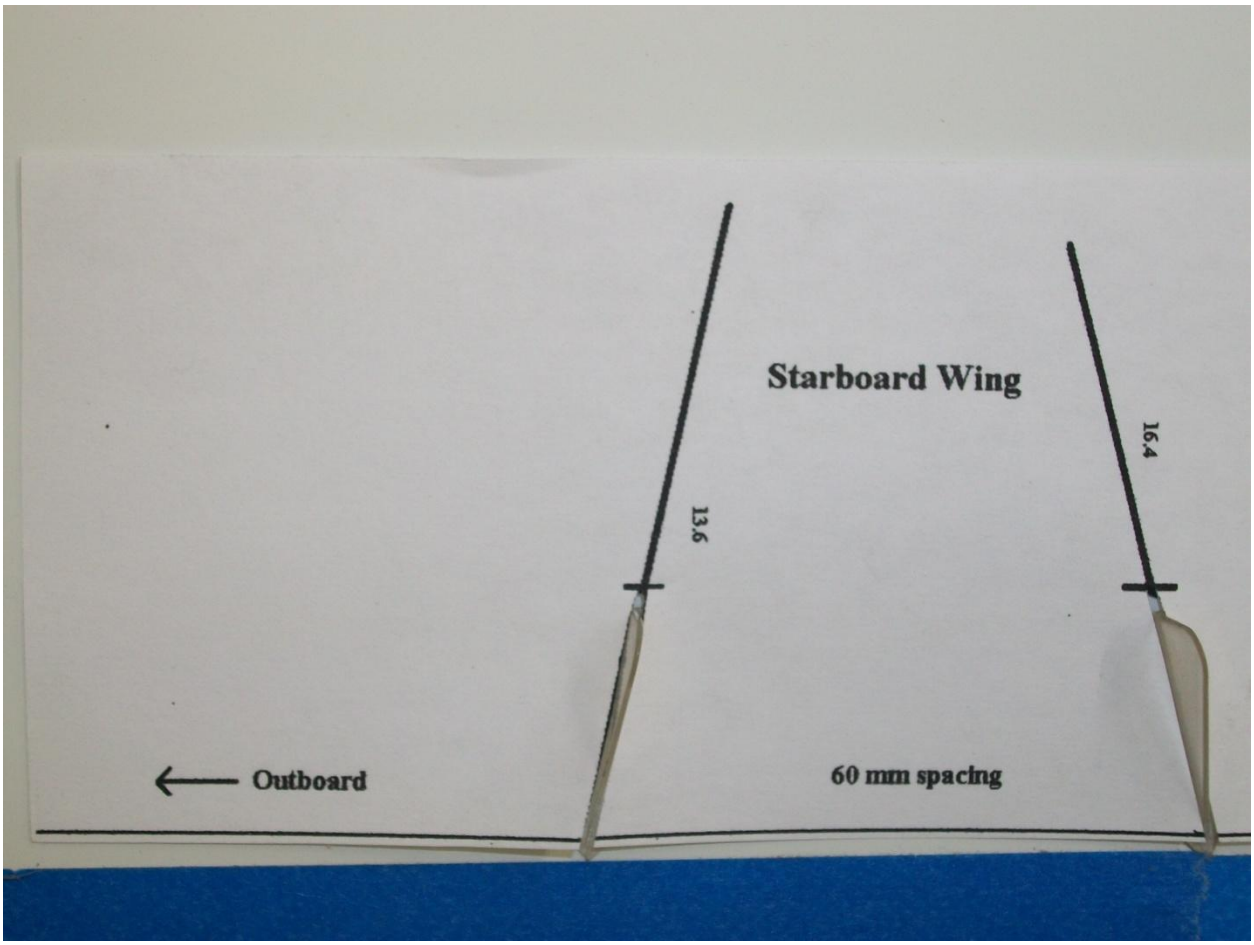
Placing the VGs

Place the first VG tip at the 7% tape line starting at the wingtip chord line. Place the template jig over the VG and align the jig on the tape line. Stick the VG lightly to the surface. Next slide the second VG into the slot and place it in place as the

photo shows. Continue in this manner until the VGs are placed all along the leading edge from the tip to the root for configuration 1 or until the inboard end of the aileron chord point. (See photos below.)



Remember, for configuration one, use the 60 mm spacing template up the aileron / flap juncture, then switch to the 90 mm template to continue to a point 60cm or about 24 inches from the fuselage side.



Note the slot which keeps the VGs in position.

For configuration two, the Light Sport Aircraft Modification, continue with the 60 mm spacing to the point 60 cm or about 24 inches from the fuselage side.

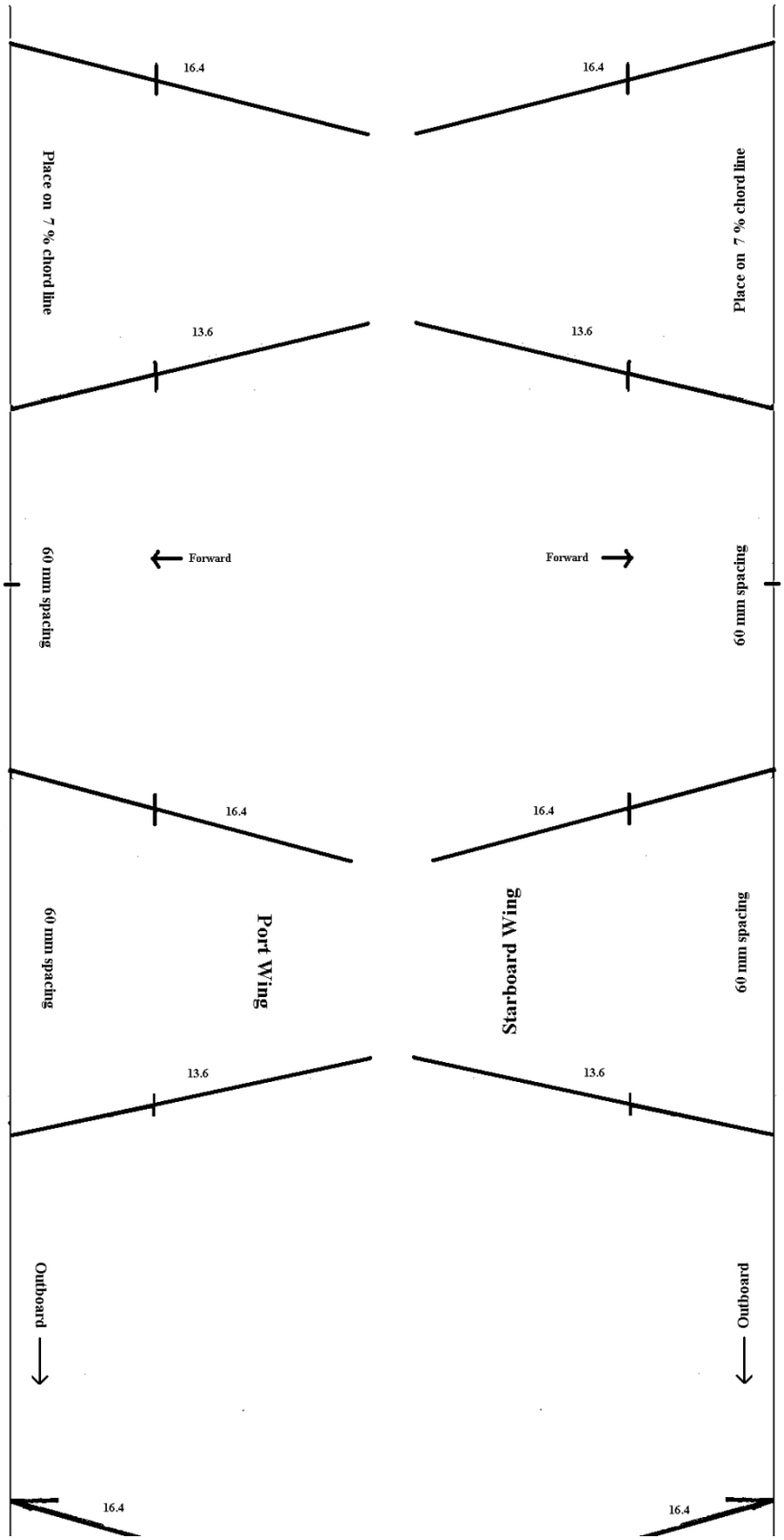
The 3M adhesive is remarkable. It allows you to reposition the VGs if you make a mistake, or decide to change your spacing. Simply peel off the VG without damage to your paint. If you would like to experiment, use glider wing tape or releasable vinyl tape set on the wing at 7% to attach the VGs to and your paint will never be touched. Glider wing tape will not normally damage quality paints.

Glider wing tape used for experimenting

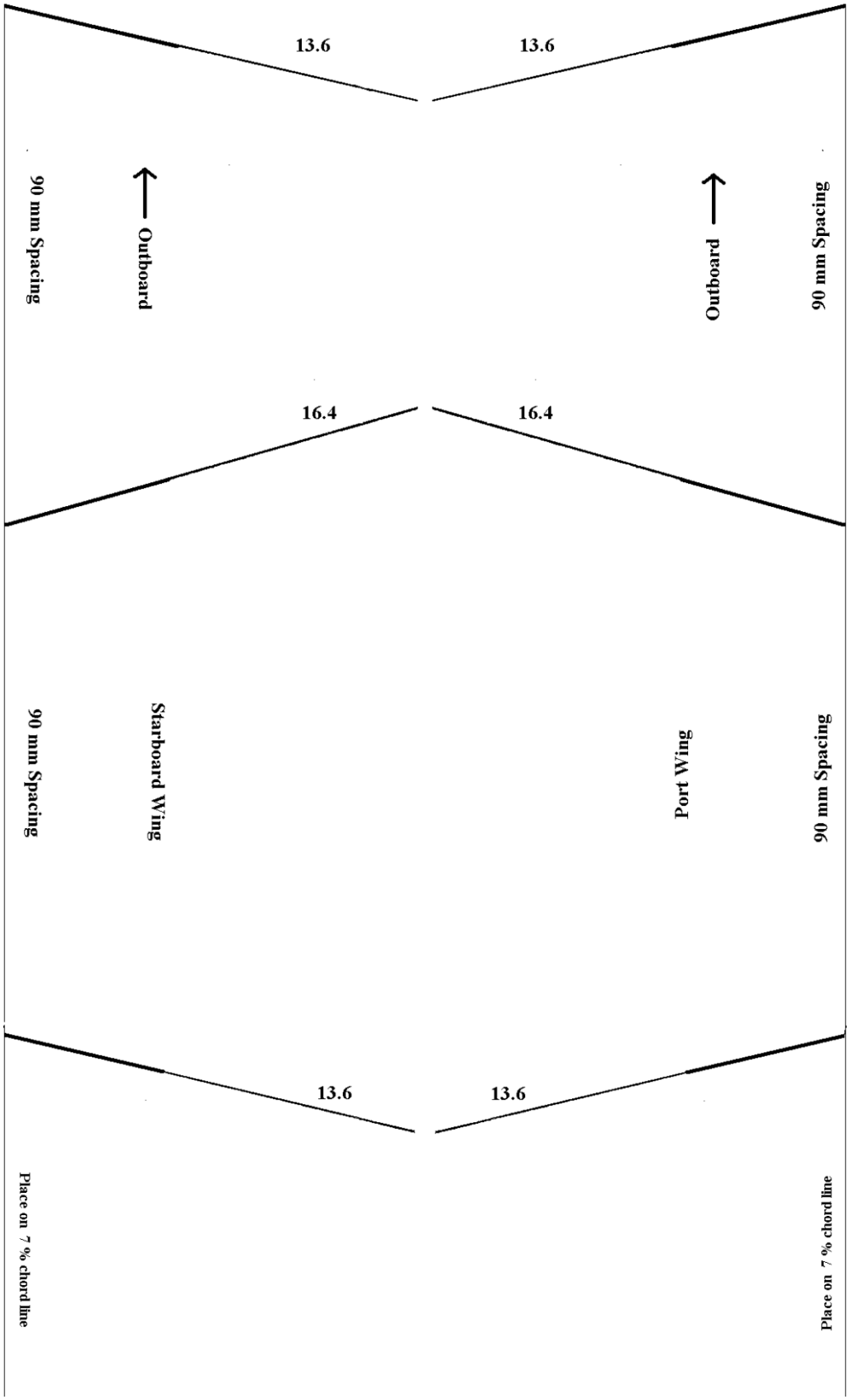
When both wings are finished, go back and push down on the VGs and ensure they are secure to the surface. Your installation is now complete.

Reference 2 contains suggested flight test program guidance to aid pilots in flight testing experimental aircraft or for a builder to use to guide his test pilot in an organized manner and verify the flight characteristics.

Appendix 2:


16.4
16.4
Place on 7 % chord line
Place on 7 % chord line
13.6
13.6
60 mm spacing
Forward
Forward
60 mm spacing
16.4
16.4
60 mm spacing
Port Wing
Starboard Wing
60 mm spacing
13.6
13.6
Outboard
Outboard
16.4
16.4

Appendix 3:


13.6
13.6
90 mm Spacing
Outboard
Outboard
90 mm Spacing
16.4
16.4
90 mm Spacing
Starboard Wing
Port Wing
90 mm Spacing
13.6
13.6
Place on 7 % chord line
Place on 7 % chord line

Appendix 4.
Adjusting for sweep angles forward or back drawings is under construction!

Appendix 5. Under construction!

After flight test and completion of the phase one testing,
The following should be added to the log book:

This aircraft complies with Europa Aircraft Mod XX and is equipped with Vortex Generators for STOL performance.

Section 2 of the Owners Manual is modified as follows:

With Vortex Generators installed the V speeds are modified as follows:
Vs1 (Stall speed power on or off, clean configuration) _____Knots IAS

Vs2 (Stall speed power on or off, full flap configuration)_____Knots IAS

If the aircraft is modified to meet the the LSA category, the new minimums below apply and are added to the above:

Maximum Takeoff Weight 1320 lbs.
Maximum Landing Weight 1320 lbs.
Green arc on airspeed markings modified to: 45-120 Kts. or as observed.
White arc on airspeed markings modified to: 40-83Kts. or as observed
Yellow arc on airspeed markings modified to: 120-165 Kts

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.

Ref 2:
Flight Testing References for home builders:

1. US Department of Transportation Federal Aviation Administration Advisory Circular AC-90-89 Amateur-Built Aircraft Flight Testing Handbook. Available as an on line download or in print. (See www.faa.gov)

2. Light Aircraft Association of the UK flight testing information sources available at: http://www.lightaircraftassociation.co.uk/acatalog/Aerodynamics_and_Flight_Testing.html

3. Europa Owner's Manual (Pilot Handbook) Section 9.