SERVICE BULLETIN 112, SUPPLEMENT A (MANDATORY)

NOTE: This Service Bulletin supplements and expands on the information presented in Service Bulletin 112. **Any specifications, limits, or requirements published in this Service Bulletin supersede those published in Service Bulletin 112.**

I. DESCRIPTION

A. SUBJECT:

Center of Gravity Location and Longitudinal Stability and Control for Glasair II-S FT Aircraft

B. APPLICATION:

Glasair II-S FT Aircraft through serial number 2184

C. PROBLEM DESCRIPTION:

As described in Service Bulletin 112, the empty weight c.g. of the Glasair II-S tends to be too far aft. This aft empty weight c.g. location limits the weight of baggage and, in some instances, passengers that can be carried while maintaining adequate flight stability for all flight regimes. We believe that the potential for difficulty in some flight conditions (heavily loaded in turbulence, or partial-panel IFR, for example) demands that we take steps to improve the stability of the Glasair II-S.

D. STABILITY AND CONTROL UPDATE

1. RESULTS OF OUR RESEARCH AND FLIGHT TESTS

Based on flight test results with the original horizontal tail, a new horizontal tail was designed with a 32% increase in area. Calculations indicated that this increase should result in an aft shift of the stick-fixed neutral point of approximately 6%.

NOTE: A neutral point is a c.g. location at which an airplane has neutral pitch stability. (Refer to Service Bulletin 112 for a discussion of stability.) The stick-fixed neutral point is the point of neutral stability when the pilot holds the stick in a fixed position. The location of the stick-fixed neutral point is determined by measuring the elevator angle needed to fly a trimmed condition.

The new horizontal tail design was submitted to flutter analysis before modification of our II-S. Results of this analysis indicated an acceptable margin of flutter safety and led to a redistribution of balance weights, with a reduction in the total balance weight required.

We then conducted a flight test program for the new tail to verify the published Vne speed and to provide data for determining the increase in stability with the new tail.

The airplane was flown to Vne while exciting the control surfaces and no evidence of vibration was observed.

Measurements of elevator position at different speeds and c.g. locations were made to provide data to determine the stick-fixed stability. Measurements of stick force were taken at different speeds and c.g. locations, both in level flight and in high g turns, to provide data to measure stick-free stability. In addition, different teams of pilots flew the airplane at various aft c.g. locations to supply a subjective "feel" evaluation.

NOTE: The stick-free stability point is the point of neutral stability when the pilot flies the airplane hands off. It is determined by measuring the stick force needed to fly a trimmed condition. The stick-free neutral point will be forward of the stick-fixed neutral point. Measurements of the stick force needed to maneuver at higher load factors (g's) are used to determine a third neutral point called the stick-free maneuvering point, which is the c.g. location at which the pilot does not need to exert any force on the stick to enter accelerated flight (pull-up or pushover). The stick-free maneuvering point usually lies between the stick-fixed and the stick-free neutral points.

Evaluation of the flight test results showed that the stick-fixed neutral point is at 39.5% MAC with the new horizontal tail. This represents a 5.5% shift aft, reasonably close to the predicted 6%.

Evaluation of the stick-free results led to a choice of 31.5% MAC as the new aft c.g. limit for the Glasair II-S with the new horizontal tail. There is no hard rule on setting the aft c.g. limit. Most textbooks say that it is desirable to have the aft c.g. limit forward of all three of the neutral points, but in actual practice this is not always so. Subjective pilot evaluation has a part in the final choice. It is generally desirable to keep the aft c.g. limit forward of the maneuvering point. Although the data for our prototype, N902S, has proven somewhat difficult to interpret (because of the light control forces and some system friction) the maneuvering point appears to fall at about 31.5% MAC, which is close to the acceptable stability point identified by pilot evaluation during test flights.

Other benefits of the larger horizontal tail include:

A. Greater control harmony that provides a better balance between the pitch and roll forces needed to fly the Glasair II-S. Also, the higher stick force per G helps to prevent accidental over-controlling.
B. Greater elevator authority at low speeds that allows the pilot to take advantage of the lower stall speeds provided by the wing tip extensions and the slotted flaps.

2. CENTER OF GRAVITY LIMITS

As the result of the flight tests both before and after installing the larger horizontal empennage, we have decided to set the following **MANDATORY** flight c.g. limits for the Glasair II-S:

For Glasair II-S aircraft with the original horizontal empennage:

Forward flight c.g. limit....................13.5% MAC
Aft flight c.g. limit....................28.5% MAC

For Glasair II-S aircraft with the new, larger horizontal empennage:

Forward flight c.g. limit....................13.5% MAC
Aft flight c.g. limit....................31.5% MAC

WARNING: The unmodified Glasair II-S FT must not be operated with the flight c.g. aft of 28.5% MAC. A Glasair II-S FT that has had the new, larger horizontal tail installed must not be operated with the flight c.g. aft of 31.5% MAC.

E. WEIGHT AND BALANCE INFORMATION

This section summarizes the new flight c.g. limits and also presents some supplemental information to help you decide which of the proposed solutions you will implement to ensure that your flight c.g. is always within limits. Refer to Service Bulletin 112 for more information.

1. FLIGHT C.G. LIMITS, GLASAIR II-S FT

NOTE: Some of the limits published below differ from the limits published in Service Bulletin 112. The limits published here supersede those published in Service Bulletin 112.

WARNING: Compliance with the center of gravity limits published here is MANDATORY.

Flight c.g. Limits:
(for II-S kits through serial number 2177 with the original horizontal tail)
Forward....................Station 82.21 (13.5% MAC)
Aft....................Station 88.88 (28.5% MAC)

Flight c.g. Limits:
(for II-S kits through serial number 2177 with the large horizontal tail)
Forward....................Station 82.21 (13.5% MAC)
Aft....................Station 90.22 (31.5% MAC)

Flight c.g. Limits:
(for II-S kit serial numbers 2178 through 2184 with the original horizontal tail)
Forward....................Station 83.71 (13.5% MAC)
Aft....................Station 90.38 (28.5% MAC)

Flight c.g. Limits:
(for II-S kit serial numbers 2178 through 2184 with the large horizontal tail)
Forward....................Station 83.71 (13.5% MAC)
Aft....................Station 91.72 (31.5% MAC)

NOTE: On Glasair II-S kit serial numbers 2178 through 2184, the wing is mounted 1.5" farther aft than on earlier II-S kits.

NOTE: Use the following formulas to calculate aircraft c.g. with respect to the MAC:

Glasair II-S FT kit serial numbers through 2177:

$$\text{Aircraft c.g. (\%MAC)} = \frac{(\text{c.g. Station} - 76.20) \times 100}{44.5}$$

Glasair II-S FT kit serial numbers 2178 through 2184:

$$\text{Aircraft c.g. (\%MAC)} = \frac{(\text{c.g. Station} - 77.70) \times 100}{44.5}$$

2. GLASAIR II-S FT SPECIFICATIONS

Mean Aerodynamic Chord (MAC) .... 44.5"

Station of Wing Leading Edge at MAC: 76.20
(for II-S kits through serial number 2177)

Station of Wing Leading Edge at MAC: 77.70
(for II-S kit serial numbers 2178 through 2184)

Various Standard Moment Arms: (Glasair II-S FT)

Oil (1.9 lb/qt)	Station 44.00
Fuel, Main Tank, through kit 2177 (6.0 lb/gal)	Station 82.35
Fuel, Main Tank, kits 2178 through 2184	Station 83.85
Fuel, Header Tank (6.0 lb/gal)	Station 65.75
Fuel, Wing Tips, through kit 2177 (6.0 lb/gal)	Station 87.33
Fuel, Wing Tips, kits 2178 through 2184	Station 88.83
Firewall (forward face)	Station 60.00
Baggage	Station 124.00
Passengers	Station 108.00
Instrument Panel	Station 85.00
Nose Wheel Axle	Station 41.25
Main Gear Axles, through kit 2177	Station 95.38
Main Gear Axles, kits 2178 through 2184	Station 96.88
Cowling Split Line (Attach Flange Joggle)	Station 58.00

NOTE: The positions of the main and nose gear axles will be slightly different for each individual Glasair II-S FT. The builder must determine these dimensions, using the procedures described in Service Bulletin 112.

Weights and Standard Arms for Various Components and Accessories, Glasair II-S FT:

ITEM	WEIGHT	ARM
200 hp Engine, Injected	324.0	39.09
180 hp Engine, Injected	301.0	38.86
160 hp Engine, Injected	289.0	39.05
160 hp Engine, Carbureted	285.0	38.59
150 hp Engine, Carbureted	268.0	38.91
Wing with Main Gear (Empty Tanks)	308.8	96.29
Wing with Main Gear (kits 2177 through 2184)	308.8	97.79
Fuselage Splice for Engine Move	8.0	67.25
Constant Speed Propeller and Governor	58.4	22.07
Wooden Propeller and Extension	17.6	19.47
Sensenich Propeller and Extension	39.0	19.49
Cowling, Exhaust, Eng. Mount, Spinner	52.9	47.84
Battery	30.0	55.13
Firewall and Fuel Filter	8.5	59.75
Nose Gear Installation	32.4	42.50
Wing Tip Extensions (Empty)	23.0	93.00
Tip Extensions (kits 2178 through 2184)	23.0	94.50
Short Wing Tips	4.3	93.00
Short Wing Tips (kits 2178 through 2184)	4.3	94.50

Weights and Standard Arms for Various Components and Accessories: (Continued

ITEM	WEIGHT	ARM
Autopilot Pitch Servo	3.3	154.75
Elevator Trim Box, Manual	1.1	92.50
Trim Box (kits 2178 through 2184)	1.1	94.00
Electric Trim Installation	2.3	171.20
New Stabilizer Weight Increase	2.1	211.87
Stabilizer Extension Weight Increase	5.0	211.87
Elevator Weight Reduction	-1.7	219.56
Internal Tail Structure Weight Reduction	-1.6	217.83
Elevator Actuator Arm Weight Reduction	-0.7	219.56
Elevator Hinge Weight Reduction (each hinge)	-0.1	219.56

NOTE: The internal tail structure weight reduction refers to the savings achieved by following the revised laminate schedule for the aft fuselage bulkhead and the forward and aft vertical fin shearwebs, as described in Service Bulletin 112.

II. SOLUTIONS

Since the aft empty weight c.g. location of the unmodified Glasair II-S may not permit loading the airplane with heavy occupants and baggage and flying with low fuel without exceeding the aft c.g. limit, this section will describe some solutions to provide a more effective use of the full c.g. range of the Glasair II-S aircraft.

NOTE: We have decided to specify none of the proposed solutions as mandatory. Rather, the builder is free to choose which solutions (if any) to implement to meet the **mandatory** flight c.g. limits.

A. LARGER HORIZONTAL STABILIZER AND ELEVATOR

We have enlarged the horizontal stabilizer and elevator area by 32% on our Glasair II-S RG prototype, N902S, which has resulted in a 5.5% aftward shift of the stick-fixed neutral point, as confirmed by flight tests. All of the pilots who have flown the airplane with the larger tail agree that the elevator authority has been increased, which improves the low speed handling characteristics of the airplane. Our pilots also report increased stick force per g, as predicted, so that the elevator control feels more balanced with respect to the aileron control. Most important of all, our pilots confirm that the pitch stability in the aft c.g. condition is greatly improved.

To enlarge the horizontal empennage on our prototype, we bonded on extensions to the stabilizer tips (8" per side), using standard composite airframe panel repair techniques. Then, instead of modifying our old elevator panels, we fabricated a pair of the new, longer elevator panels to mount to the modified stabilizer. In accordance with recommendations from the aerodynamicist who did the flutter analysis on the enlarged horizontal empennage, we reduced the size of the counterweights at the elevator tips so that they equal only 15% of total mass balance. In addition, we added a central, internal counterweight attached to the elevator actuator arm to achieve a total of 94% mass balance. The new elevator counterweight system reduces the total weight needed in the elevator counterweights by approximately 1.15 lb.

Modifying the stabilizer will require approximately 180 hours of rather exacting work. If you have not completed all of the bulkheads and shearwebs that secure the horizontal stabilizer in the fuselage, you may want to consider cutting out your old horizontal stabilizer and building up a new, larger stabilizer from scratch. An experienced Glasair builder who removed and reinstalled a horizontal stabilizer in a finished Glasair tells us that the job required about 100 hours to complete. If you have not yet installed your horizontal stabilizer in the fuselage, it will certainly require less time to build complete new stabilizer and elevator panels.

Building a new stabilizer will result in a weight increase of just over 2 lb. Adding on to your existing stabilizer will result in a weight increase of about 5 lb. If you choose to install the new tail, you will use the new elevator and counterweight system whether you modify your existing stabilizer or build a new one. The new elevators and counterweight system provide a weight savings of approximately 1.7 lb.

Builders who elect to enlarge their horizontal tails will have to analyze the costs (both in time and in money) and the benefits of building a new horizontal stabilizer versus modifying the existing one. To assist you in your analysis, the following table lists the prices of the various options available. Refer to the list of components on pages 4 and 5 for the weight savings or increases of the different options.

NOTE: The prices for airframe components offered in this service bulletin apply only for the purposes of completing work recommended by this service bulletin and will be available only to Glasair II-S builders with kit serial numbers through 2184. Also, the special prices will remain in effect until December 31, 1993. After December 31, 1993, Stoddard-Hamilton Aircraft will no longer be offering the reduced prices.

Price List for Horizontal Tail Components:

ITEM	PART NUMBER	PRICE
Horizontal Stabilizer Kit	302-0202-501	$1195.22
Horizontal Stabilizer Extension Kit	302-0228-501	$887.25
Aluminum Elevator Actuator Arm	552-3401-101	$39.57
Stabilizer Hinge Bracket (each)	552-4424-101	$10.44

NOTE: The Horizontal Stabilizer Kit supplies complete new horizontal stabilizer panels; the Horizontal Stabilizer Extension Kit supplies extension panels to add 8" onto both tips of your existing horizontal stabilizer. Both kits include new elevator panels, all the necessary premolded fiberglass parts, the new internal counterweight arm, lead for the counterweights, new outboard hinge assemblies, and all necessary hardware. We are now manufacturing all of the elevator hinge assemblies from aluminum, so you also have the option of replacing the inboard and center hinges on each side with lighter weight hinges, if desired. Order six hinges if you are not installing the new tail but want the lighter hinges; order four hinges if you want to replace the inboard and center hinges when installing the new tail. All II-S kits after serial number 2057 already have the aluminum actuator arm.

Sample Aircraft C.G. Estimates with the Larger Horizontal Tail

To see the benefits provided by installing the larger horizontal tail, perform calculations to estimate where the empty weight c.g. and the flight c.g. will be on your finished airplane. The following example illustrates how to estimate the empty weight c.g. of your airplane, based on the empty weight and empty weight c.g. of the example Glasair II-S FT discussed in Service Bulletin 112, and using the list of components and accessories, with their weights and arms, on pages 4 and 5. The example Glasair II-S FT is equipped with a 160 hp injected engine, a Sensenich fixed pitch metal propeller, an autopilot, and electric trim; its empty weight and empty weight c.g. were derived from data from the first customer built Glasair II-S FT.

NOTE: The following example c.g. calculations are estimates. Since it is nearly impossible to predict in advance the weights and arms of all the components that go into a finished airplane, the actual c.g. of your airplane will certainly be different. Such calculations should provide a good enough rough estimate of the finished c.g., however, so that you can decide which combination of the proposed solutions will be necessary to keep your flight c.g. within the specified limits.

Example 1:

In this example, we estimate the empty weight c.g. for an airplane similar in all respects to the example II-S FT in Service Bulletin 112, except that the new horizontal tail surfaces have been installed. For this estimate, we assume that the revised laminate schedule has been used to install the horizontal stabilizer. To perform the calculations, start with the specifications for the example II-S FT and add or subtract the weights and moments of the new tail components.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1300.0	85.01	110516
Stabilizer Weight Increase	2.1	211.87	445
Elevator Weight Reduction	-1.7	219.56	-373
Internal Tail Weight Reduction	-1.6	217.83	-349
TOTAL	1298.8		110239

$$\text{c.g.} = \frac{110239}{1298.8} = \text{Station } 84.88$$

Now, we can use this empty weight c.g. location to estimate what the flight c.g. would be in the critical load configuration. Conditions: Minimum fuel (8 gal in header tank), no fuel in main tank, 8 qt. oil (included in empty weight), 340 lb total of pilot and passenger, 80 lb baggage.

NOTE: For your calculations, use the actual weights of the pilot and passenger who will normally fly in your airplane.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1298.8	84.88	110239
Pilot and Passenger	340.0	108.00	36720
Fuel (Aux. Tank)	48.0	65.75	3156
Fuel (Main Tank)	0.0	83.85	0
Baggage	80.0	124.00	9920
TOTAL	1766.8		160035

$$\text{c.g.} = \frac{160035}{1766.8} = \text{Station } 90.58$$

$$\text{c.g. (\%MAC)} = \frac{(90.58 - 76.20) \times 100}{44.5} = 32.3\% \text{ MAC}$$

The c.g. is aft of the limit for the airplane in this example. Besides the new horizontal tail, this airplane would need additional modification to meet the flight c.g. limits in the critical load configuration. With a constant speed propeller, the flight c.g. in the critical load configuration would be at 30.8% MAC, which is within the limits.

B. MOVING THE WING AFT

Another option builders can choose to meet the flight c.g. requirements is to move the wing aft 1.5". This change moves the center of gravity envelope aft with respect to the fuselage and shifts the empty weight c.g. forward by about 2.5% of MAC. We have not yet moved the wing aft on our II-S RG prototype, but we plan to in the near future. After we have accomplished the modification, we will be better able to assist builders in performing the modification themselves. At this time we have instructions available for repositioning the wing cutout reinforcement longerons (which we have done on a customer's II-S), and for reconfiguring the seat back and the instrument panel. The only other major work required to move the wing is to reposition the wing root fairings, if they have already been installed. Following is a list of prices for various components needed to move the wing.

NOTE: These prices apply only for the purposes of completing work recommended by this service bulletin and will be available only to Glasair II-S builders with kit serial numbers through 2184. Also, the special prices will remain in effect until December 31, 1993. After this date, Stoddard-Hamilton will no longer be offering the reduced prices.

Price List for Wing Move Components:

ITEM	PART NUMBER	PRICE
Wing Cutout Longeron Replacement Kit	382-0112-501	$88.52
Instrument Panel Mod Kit	382-0112-502	$10.20
Wing Fairing Replacement Kit	382-0112-503	$104.12

NOTE: Moving the wing aft results in a negligible change of the airplane's empty weight.

NOTE: Refer to Service Bulletin 112 for a description of the work necessary to move the wing. We estimate that it will take about 100 hours to move the wing on a nearly completed airplane, based on information supplied by a Glasair builder who accomplished the wing move, including removing and reinstalling the wing root fairings. Moving just the wing cutout and reinforcement longerons took our shop about 30 hours on a customer's Glasair.

NOTE: With the wing moved aft, use the following specifications to calculate the flight c.g.:

Station of Wing Leading Edge at MAC: 77.70

Flight c.g. Limits (for II-S aircraft with the original, small tail):
Forward .... Station 83.71 (13.5% MAC)
Aft .... Station 90.38 (28.5% MAC)

Flight c.g. Limits (for II-S aircraft with the new, large tail):
Forward .... Station 83.71 (13.5% MAC)
Aft .... Station 91.72 (31.5% MAC)

For Glasair II-S FT aircraft on which the wing has been moved aft 1.5", use the following formula to calculate aircraft c.g. with respect to the MAC:

$$\text{Aircraft c.g. (\%MAC)} = \frac{(\text{c.g. Station} - 77.70) \times 100}{44.5}$$

Sample Aircraft C.G. Estimates with the Wing Moved Aft

To help yourself decide whether or not to move the wing aft on your airplane, perform calculations to estimate where the empty weight c.g. and the flight c.g. will be. The following examples illustrate how to estimate the empty weight c.g. of your airplane, based on the empty weight and empty weight c.g. of our example Glasair II-S FT, and using the list of components and accessories, with their weights and arms, on pages 4 and 5.

NOTE: Again, the following example c.g. calculations are estimates. Do not expect these calculations to provide more than rough, ball-park values for the positions of the empty weight c.g. and the flight c.g.

Example 2:

In this example, we estimate the empty weight c.g. for an airplane similar in all respects to our example II-S FT, except that the wing has been moved aft 1.5", the 180 hp engine is installed instead of the 160 hp engine, a constant speed propeller is installed instead of the fixed pitch Sensenich propeller, and manual trim is used instead of electric trim. Use similar procedures as in Example 1: start with the specifications for our example II-S FT; subtract the weights and moments of the wing at the old location, the 160 hp engine, and the electric trim system; add the weights and moments of the wing at the new position, the 180 hp engine, and the manual trim system.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1300.0	85.01	110516
Wing	-308.8	96.29	-29734
Wing	308.8	97.79	30198
160 hp Engine	-289.0	39.05	-11285
180 hp Engine	301.0	38.86	11697
Sensenich Propeller	-39.0	19.49	-760
Constant Speed Propeller	58.4	22.07	1289
Electric Trim	-2.3	171.20	-394
Manual Trim	1.1	94.00	103
TOTAL	1330.2		111630

$$\text{c.g.} = \frac{111630}{1330.2} = \text{Station } 83.92$$

Now, we can use this empty weight c.g. location to estimate what the flight c.g. would be in the critical load configuration. Conditions: Minimum fuel (8 gal in header tank), no fuel in main tank, 8 qt. oil (included in empty weight), 340 lb total of pilot and passenger (use the actual weights of the pilot and passenger who will normally fly in your airplane for your calculations), 80 lb baggage.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1330.2	83.92	111630
Pilot and Passenger	340.0	108.00	36720
Fuel (Aux. Tank)	48.0	65.75	3156
Fuel (Main Tank)	0.0	83.85	0
Baggage	80.0	124.00	9920
TOTAL	1798.2		161426

$$\text{c.g.} = \frac{161426}{1798.2} = \text{Station } 89.77$$

$$\text{c.g. (\%MAC)} = \frac{(89.77 - 77.70) \times 100}{44.5} = 27.1\% \text{ MAC}$$

For the airplane in Example 2, the c.g. is within the specified limits for a Glasair II-S with the original, small horizontal tail. An airplane similar to the one described here, therefore, would only need the wing moved aft 1.5" to remain within the c.g. limits in the critical load configuration. Enlarging the horizontal tail would not be necessary. As the following quick flight c.g. calculation shows, however, enlarging the existing horizontal tail in addition to moving the wing would permit moving the battery from the firewall to the tail cone aft of the baggage bulkhead. This would open up space in the engine compartment and would also move the battery away from the heat of the engine.

ITEM	WEIGHT	STATION	MOMENT
Loaded Airplane in Example 2	1798.2	89.77	161426
Stabilizer Extension Weight Increase	5.0	211.87	1059
Elevator Weight Reduction	-1.7	219.56	-373
Lightweight Stabilizer Hinge Brackets	-0.4	219.56	-88
Battery on Firewall	-30.0	55.13	-1654
Battery in Tail	30.0	150.00	4500
TOTAL	1801.1		164870

$$\text{c.g.} = \frac{164870}{1801.1} = \text{Station } 91.54$$

$$\text{c.g. (\%MAC)} = \frac{(91.54 - 77.70) \times 100}{44.5} = 31.1\% \text{ MAC}$$

Example 3:

In this example, we use similar procedures to estimate the empty weight c.g. and the flight c.g. for a Glasair II-S FT with the wing moved aft 1.5", a 160 hp injected engine, a Sensenich fixed pitch propeller, manual trim, and no autopilot.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1300.0	85.01	110516
Wing	-308.8	96.29	-29734
Wing	308.8	97.79	30198
Autopilot Pitch Servo	-3.3	154.75	-511
Electric Trim	-2.3	171.20	-394
Manual Trim	1.1	94.00	103
TOTAL	1295.5		110178

$$\text{c.g.} = \frac{110178}{1295.5} = \text{Station } 85.05$$

Now, we use this empty weight c.g. location to estimate what the flight c.g. for this airplane would be in the critical load configuration.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1295.5	85.05	110178
Pilot and Passenger	340.0	108.00	36720
Fuel (Aux. Tank)	48.0	65.75	3156
Fuel (Main Tank)	0.0	83.85	0
Baggage	80.0	124.00	9920
TOTAL	1763.5		159974

$$\text{c.g.} = \frac{159974}{1763.5} = \text{Station } 90.71$$

$$\text{c.g. (\%MAC)} = \frac{(90.71 - 77.70) \text{ X } 100}{44.5} = 29.2\% \text{ MAC}$$

For the airplane in Example 3, the c.g. is outside the aft limit for a Glasair II-S with the original, small horizontal tail. An airplane similar to the one described here, therefore, would need additional modifications to meet the flight c.g. requirements. This airplane would meet the flight c.g. requirements with the larger tail installed. A similar airplane with a constant speed propeller would have a flight c.g. in the critical load configuration at 27.7% MAC, which is inside the c.g. envelope.

C. MOVING THE ENGINE FORWARD

Another option, although one that requires considerable work as well as the ability to accurately jig parts in relation to each other and to complete high quality composite airframe panel repair procedures, is to move the engine forward 6". This would involve cutting the fuselage forward of the windshield, moving the firewall 6" forward, and splicing in a new fuselage section to fill the gap. Glasair II-S kits with serial numbers 2200 and above all have 6" added to the fuselage forward of the windshield to accomplish this engine move. We intend to move the engine forward 6" on our factory II-S RG prototype (N902S) in the near future, so that our demonstrator will be the same as the kits we are currently producing. One of our builders has already accomplished this modification on his own initiative; he tells us that it took him about 100 hours to complete the work. Another benefit of this modification is increased space to install or service the avionics and instruments (or to expand the header tank, if that is the builder's preference).

Sample Aircraft C.G. Estimates with the Engine Moved Forward

To help yourself decide whether or not to move the engine forward on your airplane, perform calculations to estimate where the empty weight c.g. and the flight c.g. will be, as shown in the following examples.

Example 4:

In this example, we estimate the empty weight c.g. for an airplane similar in all respects to our example II-S FT, except that the engine has been moved forward 6", the constant speed propeller is installed instead of the Sensenich propeller, and manual trim is used instead of electric trim.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1300.0	85.01	110516
Fuselage Splice	8.0	67.25	538
160 hp Engine	-289.0	39.05	-11285
160 hp Engine	289.0	33.05	9551
Sensenich Propeller	-39.0	19.49	-760
Constant Speed Propeller	58.4	16.07	938
Cowl, Exhaust, Eng. Mount, Spinner	-52.9	47.84	-2531
Cowl, Exhaust, Eng. Mount, Spinner	52.9	41.84	2213
Battery	-30.0	55.13	-1654
Battery	30.0	49.13	1474
Firewall and Fuel Filter	-8.5	59.75	-508
Firewall and Fuel Filter	8.5	53.75	457
Nose Gear Installation	-32.4	42.50	-1377
Nose Gear Installation	32.4	36.50	1183
Electric Trim	-2.3	171.20	-394
Manual Trim	1.1	92.50	102
TOTAL	1326.2		108463

$$\text{c.g.} = \frac{108463}{1326.2} = \text{Station } 81.78$$

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Now, we can use this empty weight c.g. location to estimate what the flight c.g. would be in the critical load configuration. Conditions: Minimum fuel (8 gal in header tank), no fuel in main tank, 8 qt. oil (included in empty weight), 340 lb total of pilot and passenger, 80 lb baggage.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1326.2	81.78	108463
Pilot and Passenger	340.0	108.00	36720
Fuel (Aux. Tank)	48.0	65.75	3156
Fuel (Main Tank)	0.0	83.85	0
Baggage	80.0	124.00	9920
TOTAL	1794.2		158259

$$\text{c.g.} = \frac{158259}{1794.2} = \text{Station } 88.21$$

$$\text{c.g. (\%MAC)} = \frac{(88.21 - 76.20) \times 100}{44.5} = 26.9\% \text{ MAC}$$

For the airplane in Example 4, the c.g. is within the specified limits for a Glasair II-S with the original, small horizontal tail. An airplane similar to the one described here, therefore, would only need the engine moved forward 6" to remain within the c.g. limits in the critical load configuration. Enlarging the horizontal tail or moving the wing would not be necessary.

Example 5:

In this example, we use similar procedures to estimate the empty weight c.g. and the flight c.g. for a Glasair II-S FT with a 160 hp injected engine moved forward 6", a Sensenich fixed pitch propeller, manual trim, and no autopilot.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1300.0	85.01	110516
Fuselage Splice	8.0	67.25	538
160 hp Engine	-289.0	39.05	-11285
160 hp Engine	289.0	33.05	9551
Sensenich Propeller	-39.0	19.49	-760
Sensenich Propeller	39.0	13.49	526
Cowl, Exhaust, Eng. Mount, Spinner	-52.9	47.84	-2531
Cowl, Exhaust, Eng. Mount, Spinner	52.9	41.84	2213
Battery	-30.0	55.13	-1654
Battery	30.0	49.13	1474
Firewall and Fuel Filter	-8.5	59.75	-508
Firewall and Fuel Filter	8.5	53.75	457
Nose Gear Installation	-32.4	42.50	-1377
Nose Gear Installation	32.4	36.50	1183
Autopilot Pitch Servo	-3.3	154.75	-511
Electric Trim	-2.3	171.20	-394
Manual Trim	1.1	92.50	102
TOTAL	1303.5		107540

$$\text{c.g.} = \frac{107540}{1303.5} = \text{Station } 82.50$$

Again, we use this empty weight c.g. location to estimate what the flight c.g. for this airplane would be in the critical load configuration.

ITEM	WEIGHT	STATION	MOMENT
Empty Airplane	1303.5	82.50	107540
Pilot and Passenger	340.0	108.00	36720
Fuel (Aux. Tank)	48.0	65.75	3156
Fuel (Main Tank)	0.0	83.85	0
Baggage	80.0	124.00	9920
TOTAL	1771.5		157336

$$\text{c.g.} = \frac{157336}{1771.5} = \text{Station } 88.82$$

$$\text{c.g. (\%MAC)} = \frac{(88.82 - 76.20) \times 100}{44.5} = 28.4\% \text{ MAC}$$

For the airplane in Example 5, the c.g. is just inside the aft limit for a Glasair II-S with the original, small horizontal tail. An airplane similar to the one described here, therefore, would need no additional modifications to meet the flight c.g. requirements.

D. PROPELLER OPTIONS

If you have installed (or had planned to install) a fixed pitch wooden propeller on your Glasair II-S kit, you can realize a significant forward shift of the empty weight c.g. by installing either a fixed-pitch metal Sensenich propeller or a constant speed Hartzell propeller.

NOTE: At this time, the Sensenich propeller is only available for the Lycoming O-320 series engines (150/160 hp).

Changing from a wooden propeller to the Sensenich propeller will shift the c.g. forward by approximately 2.4% MAC. Changing from a wooden propeller to a constant speed propeller will shift the c.g. forward by approximately 4.3% MAC.

NOTE: The standard constant speed propellers available for the Lycoming IO-360 series engines (180/200 hp) and the aerobatic constant speed propellers available for all engines have shorter built-in extensions than the fixed pitch propeller extension. Using these constant speed propellers, therefore, requires using the shorter Glasair engine cowling.

E. CONCLUSION

The Glasair II-S aircraft have been significantly improved compared to the earlier Glasair I kits. Premolded canopy frames and a better latch system, an enlarged airframe, and additional structure for crash protection have all increased the value of the II-S kits. Unfortunately, these same improvements have also increased the weight of the Glasair II-S; a typical II-S weighs as much as 150 lb more than a similarly equipped Glasair I. Besides contributing to the weight and balance and stability problems that prompted this service bulletin, the additional weight tends to reduce the airplane's performance. For this reason, we recommend that you install a 180 hp or 200 hp Lycoming IO-360 series engine on your Glasair II-S. Using a smaller engine not only will result in reduced performance, but also will tend to exacerbate the aft c.g. problem.

In this service bulletin, we have tried to provide the necessary information to enable you to calculate an estimate of your finished airplane's c.g. depending on the powerplant, propeller, and accessories you plan to install. With this estimate, and by working examples like the ones presented in this service bulletin, you should be able to make an informed decision concerning what modifications might be necessary on your airplane and what the most cost-effective modifications will be. If you have any questions, or need assistance in working through these calculations, call our builder support line (206/435-8536) during normal builder support hours and ask for Chris Klix or Terry Hiatt.

Once again, we sincerely apologize for the problems with the Glasair II-S. The good news is that we are very pleased with the improvements we are making in the airplane. The pilots who have flown our II-S with the new tail unanimously agree that the improvements to the handling characteristics would make the larger tail a worthwhile modification even in the absence of any c.g. problems. There is a significant increase in stability and less chance of over-controlling, yet the controls are still light, responsive, and harmonized in pitch and roll.

We've worked hard to research solutions in as timely a manner as possible. Our continued commitment is to deliver the necessary parts to you as soon and as inexpensively as we can.

Due to expected large volumes of orders, we are going to need help in formulating priorities for shipments. When placing an order, please note the month when the parts are needed. We will try to accommodate all requests as best we can. We have already received many calls from builders who need the parts immediately. We will prioritize the shipments by need as well as by kit number. In other words, if kits 2002, 2020, and 2100 all request immediate shipment of parts, the earlier kits will receive priority. We hope that all builders will accurately evaluate their time requirements so that we will be able to satisfy all requests. Since the service bulletin was not finished and individual calculations could not be completed until now, any requests for parts made before receipt of this service bulletin must be made again. Please call our parts department to place your order.