

Development and design history of the SGS 2-32 sailplane

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The SGS 2-32 is a two-place, high performance, all metal sailplane. It was designed to have good cross country characteristics as well as altitude capability for wave soaring, and has a high range of useable speeds and also terminal dive brakes for such operations. Pilot comfort, safety and vision were not sacrificed for extreme performance. It was designed to have as high a performance as is consistent with a thoroughly useful and durable aircraft. In the following discussion, I will try to show how the design evolved and our experience will probably strike a familiar note to other designers.

Evolution of living things follows a pattern of development as needs of environment indicate. It can be said that a sailplane design evolves similarly as the needs of its environment indicate. Schweizer sailplane designs started in 1928-1929. The Schweizer Brothers, Paul, Ernest and William were interested in aviation and fascinated by the «new» sport of gliding which had been rapidly developed in Germany after World War I. The first three (3) designs, SGU 1-1, 1-2, 1-3 were learning efforts of the Schweizer's in their teens without formal Engineering education. These designs were wooden primary and secondary gliders applying whatever information was available in current literature.

Few original features were incorporated in these designs. The apprentice is not normally in a position to be original. These designs were built in 1929-1934. In the period of 1933-1936 a more serious interest in sailplane design evolved particularly from the point of view of greater strength and reliability and producibility of metal designs. Metal aircraft design was rapidly evolving in the 1930's. The high cost of labor in the U.S.A. strongly indicated that plywood, wood and glue methods would not be suitable under economic conditions existant both from the point of view of material cost and labor. For example, today the cost of 1/16" plywood is over \$.60 per sq. ft., Aluminium Alloy sheet .025" thick costs about \$.21 per sq. ft. and has the advantages of higher strength and durability and the capability of being formed economically by machinery as well as other advantages.

A note of explanation on the design numbering system for Schweizer Aircraft is given here. In the SGS 2-32 designation the first S is obvious and the G is for Glider, the second S is for Sailplane or performance type. The 2 indicates the number of seats and the last number, 32, means the design number. The SGU 2-22E is thus design number 22 and a 2 passenger utility glider. The E indicates minor configuration changes in production. The SGS 1-23H-15 is design No. 23 single place sailplane, H revision of the design with the span reduced to meet the 15 m standard class span. There are gaps in the design numbers of the ships actually built, but this is due to the fact that every design

is not always actually built even though it was developed to a stage where a number was assigned. (See table 3 for the design list to date which explains this.)

The next design built was the SGU 1-6, the first aluminium alloy design. This ship won a design prize in 1937 in a contest sponsored by Warren Eaton. In building this glider, equipment was developed to stamp sheet metal parts and due to limited funds, techniques were developed for fabricating the structure with means available. For example: Since no power riveting equipment was available, the number of rivets was kept to a minimum and extensive use was made of self tapping sheet metal screws which were quite satisfactory. The ship flew satisfactorily, but again the design was a step in acquiring design experience. It had some features, such as a 2-wheel landing gear for better ground handling which permitted unassisted take-off. It had a closed cockpit for the pilot; the tail boom was a single piece of large diameter extruded aluminium tubing. Before this design was completed, it became apparent that the fuselage design was too complex for an economical training glider. At that time, the Hütter H-17 was being produced. This was a design that had many merits and helped influence the next design. The SGS 1-7, which was started before the SGU 1-6 was complete, was flown a few months after the SGU 1-6. A smaller, simpler design was desirable, but it was felt that the H-17 was too small and badly handicapped with a full load of a heavy pilot and parachute and instruments required as soaring techniques developed. The 1-7 evolved as a small utility sailplane with a simple steel tube fuselage. It was quite successful as far as flight characteristics go. The ship was handicapped to some degree with a heavy load even though it was larger than the H-17. The choice of airfoils was probably not the best; the NACA 2415 was used.

It may be pointed out that in the last 30 years, piloting technique has developed to the point that judgements on design suitability made then would not be valid now. The degree of development of pilot skills has an important bearing on design. The 1-7 did not get into production because of the growing demand for a 2-seat sailplane. One of the SGU 1-7's is still flying after 27 years of service.

In the 1930's, gliders got a bad reputation in the U.S.A. since the market was flooded by cheap, poorly engineered gliders and with many homemade gliders in the hands of people without training or supervision, a large number of accidents occurred. Many onlookers considered gliding a mild form of suicide. It impressed us with the necessity of safe designs and the need for a good 2-place sailplane for properly training pilots. It took many years to convince some people that the single place solo technique was not the best.

The first Schweizer 2-place design was the SGS 2-8 and was first flown in 1938. It was built for the Airhoppers Club of New York City.

In all, 55 of these aircraft were built including a number for the Air Force and Navy as training gliders. The Air Force designation was TG-2 and it is largely known by this name. The SGS 2-8 has a steel tube and aluminium alloy structure with some fabric covering. The second pilot was behind the main spar in a shoulder wing with strut bracing. It proved to be a very useful sailplane with sufficient performance to set a number of 2-place distance and altitude records and it did quite well in competition with higher performance sailplanes. It was designed to stand up in training service and we know of some that have logged 3-4000 hours of training service, are still flying today and will probably continue for many years more.

A designer learns much from his mistakes and some of the faults of the SGS 2-8 follow:

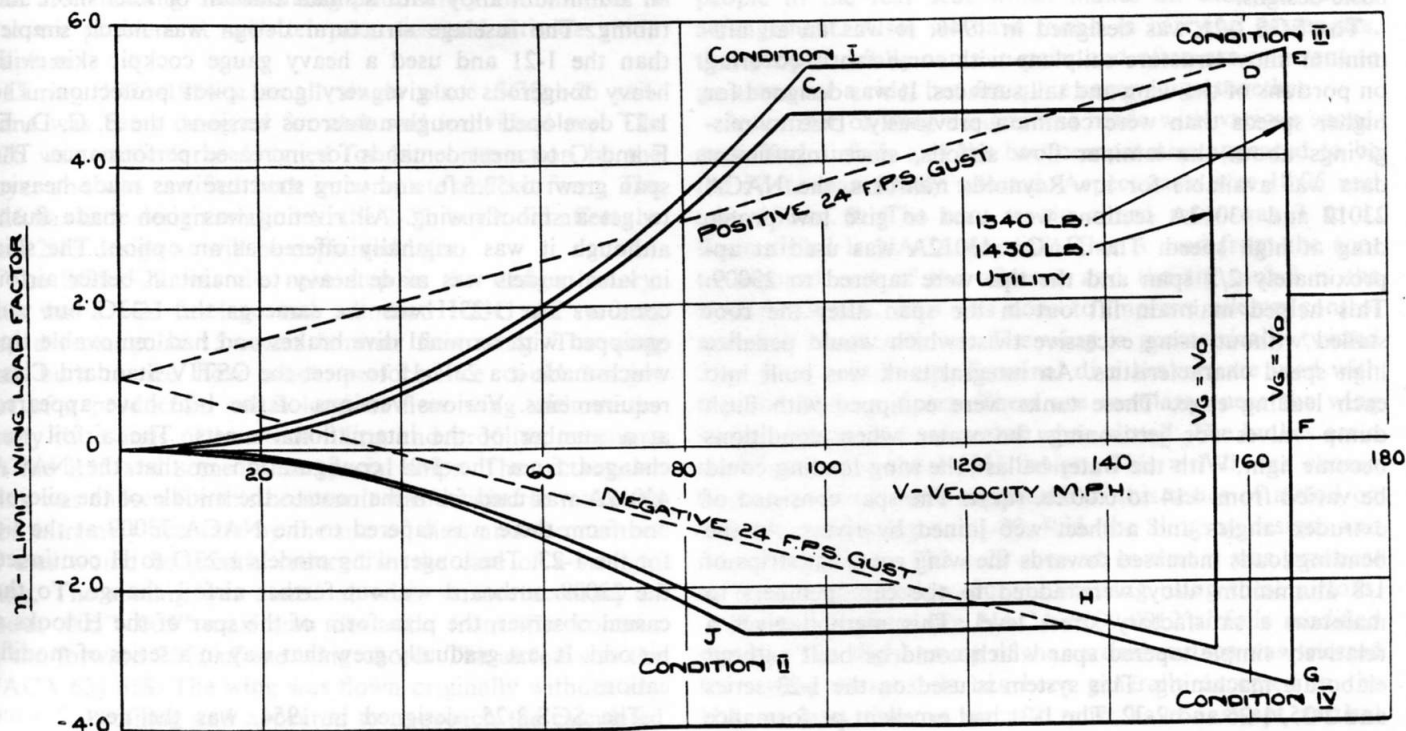
It soon became clear that for winch towing and training flight, the instructor was in a very poor position. He could see only back and down and up in winch towing and the visibility left much to be desired on approach. The ship was largely used for aero-towing and the wide chord ailerons gave very heavy stick forces at aero-tow speeds. A large amount of negative twist was built into the wing in an attempt to get good stall characteristics, but the real fault was too much rudder and insufficient vertical stabilizer area. The high degree of twist was a handicap as cross-country cruising speeds increased since with the low wing loading speeds over 70 m.p.h. produced negative lift at the tips which is not helpful in attaining good high speed performance. The production of the 2-8 was stopped by the aluminium wartime priorities which allotted very limited amounts of aluminium for training aircraft. In the mean-

time, at the request of the Air Force, a new military training glider was designed with wood and steel structure, the SGS 2-12 (military TG-3A). This was designed principally for aero-towing. Many of the design faults of the 2-8 were corrected in this design. It had better stall characteristics. It had better visibility for the instructor and better high speed characteristics. A total of 114 of these were built. They were equipped with both rudder and elevator trim for multiple towing. The experimental versions were equipped with a tow release on the tail to be used in multiple tandem towing, but this was not incorporated in the production models. The wood construction used was satisfactory for the wing and control surfaces, but too costly for civilian production. The SGS 2-12 showed that a heavy 2-place sailplane (800 lb empty weight) was capable of good performance. It held a number of U.S. altitude and distance records including a world altitude record. There is a considerable number still in service, but they are more popular for local flying since the weight makes the task of rigging and derigging unpopular.

After the war, a large number of SGS 2-8's and SGS 2-12's were sold to the civilian market as surplus aircraft at very low prices. This effectively ended our intention of producing an improved version of the SGS 2-8 designated the SGS 2-18.

To meet the need for a good, safe 2-place trainer, the model SGU 2-22 was designed in 1945. This was basically an enlarged version of the SGU 1-7 with a better airfoil. The NACA 43012A section was used. The high wing tandem design puts the instructor practically on the forward center of gravity so that there is no noticeable change in trim when the student is solo. The basic mission of this design is to train pilots safely and it has done this very well with an excellent safety record. Performance in this design was secondary, but it is sufficient to give excellent soaring

Fig. 1. Model SGS 2-32 basic flight envelope



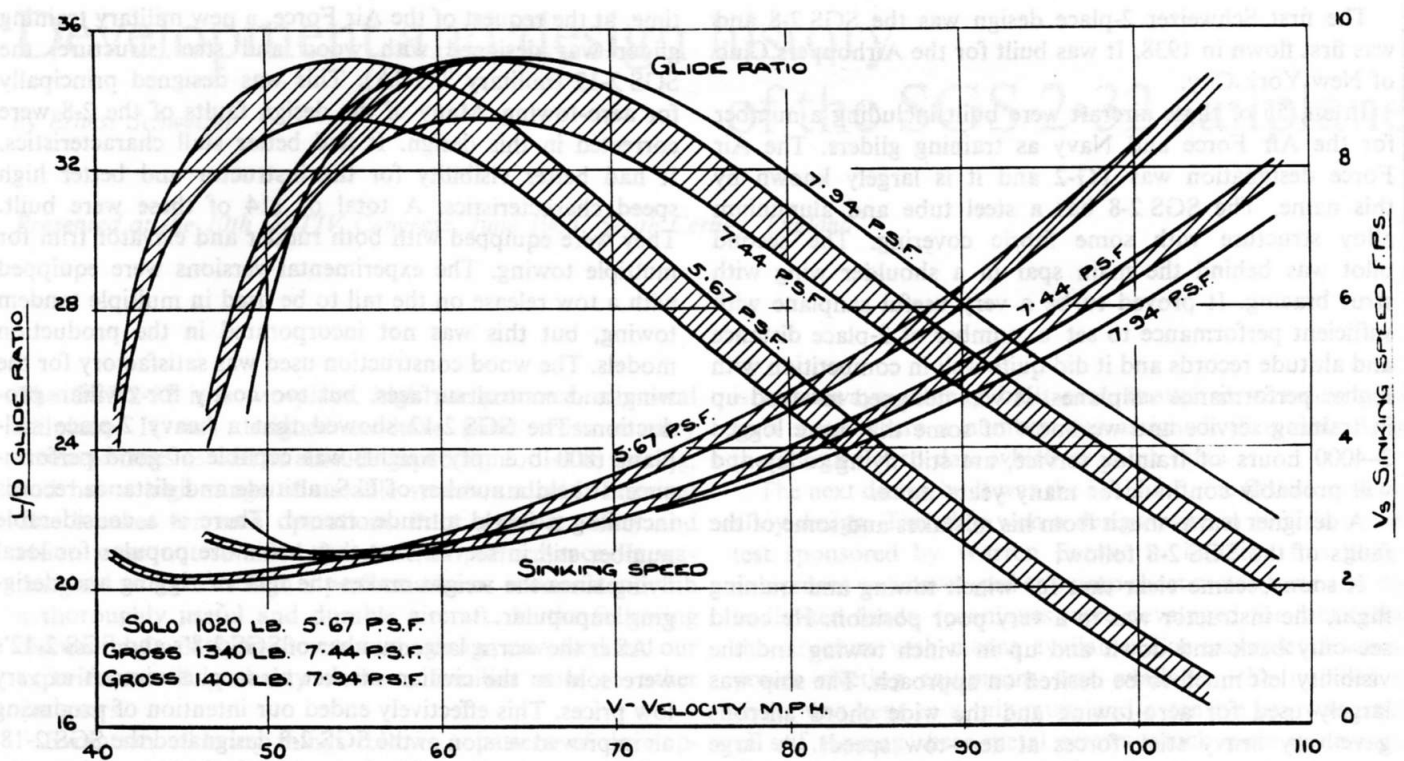


Fig. 2. Model SGS 2-32 performance curves

including some Gold C distance flights. The 2-22E is currently in production in increasing numbers. In the two (2) subsequent 2-place designs, SGS 2-25 and SGS 2-32, primary training characteristics were not considered important since the need for this is adequately covered by the SGU 2-22.

While the immediate design ancestors of the SGS 2-32 are the 2-25 and 1-29, some comments will be made first on the SGS 1-21 and SGS 1-23 series since they are also basic designs.

The SGS 1-21 was designed in 1946. It was an all aluminium alloy structure sailplane with some fabric covering on portions of the wing and tail surfaces. It was designed for higher speeds than were common previously. Due to misgivings about the laminar flow airfoils, since insufficient data was available for low Reynolds numbers, the NACA 23012 and 43012A sections were used to give low profile drag at high speed. The NACA 43012A was used at approximately 2/3 span and the tips were tapered to 23009. This helped maintain lift out in the span after the root stalled without using excessive twist which would penalize high speed characteristics. An integral tank was built into each leading edge. These tanks were equipped with flush dump valves for jettisoning the water when conditions become light. With the water ballast, the wing loading could be varied from 4.14 to 6.00 lb. sq. ft. The spar consisted of extruded angles and a sheet web joined by rivets. As the bending loads increased towards the wing root, flat strips of 1/8 aluminium alloy were added to the cap members to maintain a satisfactory stress level. This method gives a relatively simple tapered spar which could be built without elaborate machining. This system is used on the 1-23 series and 2-25, 1-26 and 2-32. The 1-21 had excellent performance

and Richard Comey used it to win the Nationals in 1947 in Texas and made one flight over 300 miles. The same aircraft also won the Nationals in 1957 flown by Stanley Smith. Two of these were built. It was decided that a more economical sailplane could better justify the investment of certifying and tooling so that the SGS 1-23 was produced in 1948. While it was not as fast as the 1-21, it could do better in thermals and was a good allround sailplane for the moderate span of about 44 ft. The structure was substantially all aluminium alloy with a small amount of steel sheet and tubing. The fuselage structural design was much simpler than the 1-21 and used a heavy gauge cockpit skin with heavy longerons to give very good pilot protection. The 1-23 developed through numerous versions, the B, C, D, E, F and G to meet demands for increased performance. The span grew to 52.5 ft. and wing structure was made heavier to get a smooth wing. All riveting was soon made flush, although it was originally offered as an option. The skin in later models was made heavy to maintain better airfoil contour. The 1-23H was the same as the 1-23G but was equipped with terminal dive brakes and had removable tips which made it a 23H-15 to meet the OSTIV Standard Class requirements. Various versions of the 1-23 have appeared at a number of the international meets. The airfoil was changed from the 1-21 configuration in that the NACA 43012A was used from the root to the middle of the aileron and from there was tapered to the NACA 23009 at the tip for the 1-23. The longer wing models 1-23D to H continued the 23009 outboard without further airfoil change. To the casual observer, the plan form of the spar of the H looks a bit odd. It just gradually grew that way in a series of modifications.

The SGS 2-25, designed in 1954, was the next 2-place

design and it was basically a 1-23D design scaled up 1.20 to give a span of 60 ft. and used a fuselage similar to the 1-23 but with tandem seating arrangements. The pilot's positions were a close tandem somewhat in bobsled fashion similar to the Piper Cub airplane. The fuselage width was 28 inches, and while acceptable for normal flying, it was rather tight for high altitude flight where heavy boots and clothing were required.

The basic wing design of the 1-23D was used except that the wing tapered simply from 43012A at the center of the aileron to the 23012A at the tip. The original weight was about 780 lb. empty, but it has flown over 1400 lb. gross so that the maximum wing loading was about 6 lb. sq. ft. At the higher wing loading, it had very good cruise speeds. The 2-25 competed in England in 1954 and France in 1956, and was used in wave research by the Air Force. It had quite a few hours of flying at altitudes over 40,000 ft. The 2-25 had excellent allround performance and handling characteristics, but it was not certified or put into production because it was felt that there was insufficient market to justify the costs involved. In retrospect, I feel that our biggest design mistake was in not using a laminar flow airfoil since in a sailplane of this size, the larger Reynolds numbers would have permitted a considerably better performance. At the time it was designed and built, in a very short time it was decided not to gamble on a new airfoil, but to use the proven wing design. Some interesting things were learned in its high altitude operation at Bishop. The extreme low temperatures encountered, -100°F. , caused the dive brakes to lock closed due to the use of steel torque tubes in aluminium bearings at the dive brakes. This was solved by using abnormal clearances at normal temperatures. The ailerons were driven by push-pull tubes so no difficulty was experienced there, but the elevator system was operated by cables and these became slack and caused some stability problems. After a fairly rapid descent from 40,000 ft. the metal skins became very wrinkled because the skin warmed up much more rapidly than the massive aluminium spar. The skin directly over the spar remained frosted for some time after landing. Maintaining pilot safety and comfort is a severe problem at such temperatures and altitudes in a sailplane.

During 1953-1954 a small single place SGS 1-26 sailplane was being designed for club and individual use. The 1-26 was particularly designed for kit construction by the buyer and was certified both in complete and kit form. The 1-26 has little design relation to the 2-32, but it did affect the final 2-32 design as will be explained later.

The SGS 1-29 was the next step in the design history. This was a 1-23 fuselage with standard 1-23G tail surfaces and a rectangular 15 meter laminar flow wing. The wing was built to see how much performance could be got out of a production metal laminar flow wing without the costly thousands of hours of filling and profiling necessary on the RJ5 and some other special ships. The rectangular wing was chosen for this because it was decided to make the ribs extremely accurate by the use of dies, and the number of dies would be greatly reduced in the case of a straight wing. The tooling was aimed at wing surface accuracy of about $.003''$ -. $.005''$ maximum deviation from true contour in the forward 75% of the wing chord. The airfoil was the NACA 63₃ 618. The wing was flown originally without any filling or profiling and appeared to approach the calculated

performance quite closely. Afterwards some profiling and filling was done, but no major change in performance could be attributed to this. The rectangular wing, as would be expected, was more sluggish in roll response and required more vertical tail surface than normal. This is from a critical point of view. On the whole, the 1-29 has excellent performance for its span and has served its purpose as a step in development.

In 1962, a design study was made on a 2-place sailplane. The 1-26 had been highly successful and a number of pilots asked for a "2-26" sailplane which would be a good club and family sailplane. The idea was for characteristics similar to a 1-26 in a two-place at low cost. A questionnaire was sent out to a large number of soaring people to get their interest. We soon concluded that the majority of interested people wanted a higher performance ship rather than a light condition sailplane, and since we could not afford, at this time, to produce both types it was decided to proceed with a prototype of the 2-32. The fuselage was designed first, drawing again on the 2-25 experiences. Careful consideration was given to the job the 2-32 was expected to do by prospective owners and the practical problem of efficient construction.

The tandem arrangement of seating was chosen. While some designers prefer the side-by-side seating, it was felt the minimum fuselage drag could be obtained by the tandem arrangement. We were interested in getting as much performance as possible out of a reasonable size aircraft and the extreme loading requirements could best be met with this arrangement without the use of movable ballast. Present day designers of high performance sailplanes are using the reclining fuselage design because it helps improve the performance of a given design compared to the more conventional arrangement. I feel, however, the tandem arrangement offers a more pronounced advantage over the side-by-side arrangement in drag reduction than the case mentioned above. Drawing on 2-25 experience, it was decided to increase the maximum fuselage width from $28\frac{1}{2}''$ to $32''$. This also made it possible to carry two small to average size people in the rear seat which makes an excellent family arrangement. Also, we have found in carrying passengers, that people usually come in pairs and often are reluctant to go alone for a ride, but are quite eager to go together.

A number of wing designs was made with various spans, areas and airfoils and the best compromise appeared to be the 57 ft. span finally selected. Aspect ratio was 18.05 and area 180 sq. ft. The root to tip chord ratio was 3 to 1. Basic airfoil is NACA 63₃ 618. This is used from the root to inboard end of the ailerons and the tip airfoil is the NACA 43012A. This was done to improve aileron control and stall characteristics. The wing is geometrically twisted $2\frac{1}{2}^{\circ}$ from root to tip. Terminal dive brakers are used with top and bottom doors. These are ventilated near the wing surface hinges and are sealed when closed. The brakes are a modification of the 1-23H design. This airfoil was chosen because there is more experience in this series of airfoil on sailplanes including our 1-29, RJ5, the Slingsby designs and numerous others. The 1-29 showed us that it was practical to build a production aluminium wing using these airfoils.

The tail surfaces are NACA 0009-0012 airfoils modified slightly. The slight sweep of the vertical surface was selected for styling reasons. It has been generally accepted in the U.S. at least that an aircraft must have a swept vertical

surface. The horizontal surfaces are all moving with anti-servo trim tabs.

The 2-32 was designed basically for aero-tow launching. It is not now equipped with a C.G. tow hook which would be absolutely necessary for auto-winch towing, but it is not anticipated that there will be much demand for this. The landing gear is the normal skid and wheed type using a 600x6 airplane wheel with hydraulic brake. Sufficient room was allowed in the structure for possible future use of a retractable wheel.

The prototype was flown July, 1963, and preliminary flights indicated that it showed promise of meeting design expectations.

During the next 5 months, the prototype was extensively flown and tested. A number of minor modifications were made. Some of these items were as follows:

The rudder chord was slightly increased. A number of minor trial modifications were made on the dive brakes to get better balance of opening and closing forces. Rudder control gearing was changed. The aileron gearing was changed. The light aileron forces were very low so that greater aileron response could be obtained without excessive stick forces. It was found necessary to spring the tail wheel because in flaring out with the dive brakes on the approach, the tail touched first. To avoid the use of an excessively large wheel, a spring arrangement was necessary. There were a number of more minor changes during this period. The prototype was flown by a large number of more experienced pilots to get their reactions and criticism. Sufficient soaring flights were made to evaluate its all-round performance. An advantage of a 2-place sailplane at this stage of development is that the test pilot can take other pilots along without the risk involved in letting other pilots fly a new single place aircraft.

Late in 1963, at Schweizer Dealer Annual Meeting, the decision was made that the 2-32 would be certified and put into production.

Intensive engineering and flight testing for the final design was then begun. A sufficient number of design changes had to be made so the prototype could not economically be rebuilt to conform to the final design. It was decided to use the No. 2 aircraft for the final flight test aircraft and this was to be built from production tooling while the bulk of the necessary flight work was done with the modified prototype. Early flight tests were for safety reasons limited to 120 m.p.h. until a vibration and flutter survey was completed. This indicated the need for mass balancing the rudder as well as the ailerons and stabilators which were originally balanced. When this was accomplished, the airspeed calibration was completed and dive tests were made to required design speeds and above. The design speed was 166 m.p.h. and the ship was flown up to about 180 m.p.h. The dive brakes were evaluated and found to have an actual terminal velocity of 158 m.p.h. at full gross weight of 1340 lb. This is 95% of max. design dive speed. It was also necessary to run flight flutter tests on the wing with dive brakes open up to terminal velocity. This was an exciting chore for the test pilot, in this case Bernie Carris. Terminal velocity represents a sinking speed of 14,000 ft./min. and required tows to 12,000 ft. In some of these flights, the ship was on the ground again 3 or 4 minutes after release from tow. Brakes were opened at design dive speed 166 m.p.h. with no difficulty. The complete flight program was com-

pleted early in 1964 and included all required FAA tests including structural control, spins, dives, dive brake tests, flutter climbs, air-speed position calibration and general handling characteristics. The official FAA flight tests had to wait for the production prototype since FAA test pilots are authorized to check new aircraft only after complete structural approval is issued by FAA engineering.

The structural approval of the 2-32 was based on FAA Part 05 and the FAA Basic Glider Criteria Handbook. The structure was completely checked by stress analysis and all the major components were static tested as well. This included the wing, fuselage, tow mechanism and all control surfaces. These tests were entirely satisfactory. The wing panel tested attained ultimate load in 3 conditions: Positive high angle, positive low angle and negative low angle conditions. After ultimate loads there was no appreciable set only a few rivets showed some yield. This was about as expected since calculation indicated a margin of safety at ultimate of about 25 to 30%.

In designing this type of metal wing, we have found that it is necessary to keep the stress in the spar compression caps under 5000 psi for unit load factor. This keeps the skins unbuckled for most soaring maneuvers and average gusts. Since the spar modulus of rupture can readily attain 60-65,000 psi, the ultimate load factor is considerably higher than the required design load factors, 8-8.25.

The required limit load factors and speeds are shown on the V.G. diagram from the basic report on loads. You will note that this diagram is somewhat different as to gust loads and speeds from most European requirements. With metal structure, the safety factor is 1.50 and additional factors as required for fittings and joints, etc.

The various design load factors and surface loadings are listed on Table 1. In the production redesign, the gross weight was increased to provide for the pilot and equipment requirements indicated by our customers. The tests on the prototype were based on this weight and the corresponding speeds. The only structural change required by this was a slightly heavier spar to keep the stress level down as mentioned before.

The original horizontal tail surface was rectangular and of short span to permit trailering without removal of this surface. However, it was found with the range of C.G. required, this surface was insufficient and there were also some objections from the esthetic point of view in that the design was not in keeping with the styling of the aircraft. The new surface is of larger span and tapered. It was incorporated for the final test program on the prototype.

The production prototype was completed in June, 1964, and the FAA tests were promptly completed and the FAA Type Certificate was received in June, 1964.

While Schweizer Aircraft Corporation is known for its production of sailplanes, they actually represent only about 15% of the total business. The 2-32 developed represented a considerable investment by the company. About 15,000 hrs. of engineering was expended up to the time the type certificate was received. A large amount of time had been spent in development of the prototype and testing and modifying it. About 21,000 hours were used to build production tooling. This is set up so that the estimated production man hours is 1100 to fabricate parts and assemble the sailplane. Due to high U.S.A. labor costs, it is necessary

to use extensive tooling and up-to-date manufacturing methods.

Some discussion follows on detail design and design factors. In general, the 2-32 follows closely on all metal construction practice using semimonocoque fuselage, single spar, metal covered wing and largely, metal control surfaces.

The fuselage, in addition to the required FAA design loads, is carefully designed for pilot safety in the event of accidents. There are some who do not consider it necessary to design beyond regulation minimums for pilot protection, particularly since it may be assumed that if properly flown there is little possibility of serious incidents. We feel, however, that all pilots are not the best pilots and even good ones make mistakes under the pressure of competition. We feel that it is desirable to build in as much pilot protection as possible in the form of energy absorption characteristics of the design.

The following are the approximate design objectives for the design of the forward section of the fuselage. The main pilot's section is designed for 40xG.W. head on. This is progressively reduced as we go forward to the nose. It is expected that the nose will fail progressively under impacts so that a reasonable amount of energy will be absorbed without critical injury to the occupants. An additional requirement is a load of 30° upward and aft of 20xG.W. A side load of 30° aft of the same magnitude is also considered. One reason for the depth of the fuselage is to give sufficient depth under the pilot's to prevent unnecessary spinal injuries in hard landings and accidents with relatively flat impact trajectory. It is simply impossible to provide any protection if the pilot is sitting an inch or two over the bottom of the fuselage or over a structural or control system part. This is a price we feel should not be paid on a production sailplane. I am digressing on the subject, however, as pilot safety design is comprehensive enough to justify its own papers. It should be noted that the above general practices have been carried out in more recent designs and have proven to be life savers.

As mentioned before, all structure is metal with metal skins except the rudder and ailerons which are of aluminium alloy structure with a covering of Ceconite. This is a synthetic fabric with long life. The mass balances are internal and considerable weight is saved by the use of the fabric covering.

The bulk of the structural aluminium is 2024-T3 Alclad. For reasons of bearing and high yield strength 2014-T6 and 7075-T6 are used in the main spar and some fuselage extrusion. We have been questioned on the use of 7075-T6 as being subject to fatigue failure.

This can be critical in powered aircraft where the load factors are often much lower and the normal working stresses much higher. In the case of a sailplane at less than 5000 PSI unit working stress in the spar, the fatigue life at 3 g should be in the order of about 10,000,000 cycles which represents conservatively 50,000 flight hours.

Most of the structure is joined riveting. The bulk of the rivets are A17ST rivets which can be driven in the hard condition to facilitate repairs away from the factory. Some high strength steel fastenings are also used in areas where they are justified. They are used, for example, in the last rivet on spar cap laminations to prevent progressive failure.

To insure long life, all aluminium parts are chemically treated for corrosive resistance, and for paint bond and

then painted with Zinc Chromate primers. The external skins are also enameled.

The control system has ball bearings throughout the aileron system and the long push tubes in the wing are guided by nylon rollers to minimize friction in the system. To help insure a rigid flutter free system, no cables are used in the aileron system. The dive brakes are operated by a system of push-pull tubes and torque tubes and are connected automatically when the wing is put in place. Elevator, rudder and trim controls are operated principally by cable systems.

The cockpit is designed to give adequate room for any reasonable sized pilot and as mentioned before, will handle two (2) small to average size persons in the rear seat for passenger flights. To get the full advantage of the strong nose design, it is necessary to use adequate belt and shoulder harness equipment. The 2-32 is equipped with military belt and harness which will restrain the pilot in the order of 40 g. A large instrument panel is located forward and the rear pilot position is such that he can fly on the forward instruments. The panel is large enough to permit positioning the instruments to make this practical. Usually several of the instruments, especially the variometer are duplicated. There are provisions so that a few optional instruments can be mounted for the rear pilot.

A console is available for radio and oxygen equipment below the instrument panel. There is also some room along the sides of the cockpit for equipment. A large number of optional equipment items are available. Most ships are equipped with 90 channel transistorized radios. Oxygen systems of various capacity are used. Other items are directional Byro's, ADF equipment, survival gear, navigation and cockpit lights. A canopy lock is available to prevent pilferage on the ground. For hard surfact runways, an auxiliary wing tip wheel is available.

The normal weight empty is 865//, but some of the heavily equipped ships are over 1000// empty weight. This indicated a need for additional gross weight if the owner wishes to carry three (3) people without the necessity of removing equipment. Work is now in process to increase the gross weight from 1340// to 1430// in the Utility Category. This means slightly reduced placard speeds and cloud flight would not be permitted at this weight. Under good thermal conditions, this weight would permit higher cruising speeds.

At the date this was written, 16 aircraft have been delivered. One 2-32 was towed from Elmira to Hayward, California (near San Francisco) behind a Super Cub in 32 hours of flying time. Recently, another 2-32 was ferried from Elmira to Chicago in 4½ hours, 600 air miles. This flight was towed with a Beech Bonanza at 8-9000 ft. This flight was flown largely hands-off with a light bungee on the stick since the towing speeds of over 130 were a little above the normal range of trim.

The comparison data on all the 2-place designs is shown on Table II. This will give the comparative characteristics of all these aircrafts.

The 2-32 is expected to have a long production life, but this is not intended to indicate that it is the ultimate in 2-place design. Our experience with this design to date clearly indicates that it has considerable growth potential and when time and economic conditions permit, new designs can be produced. We feel that it is prudent to get considerable service experience to perfect the existing design and to

evaluate the technical improvements in sailplanes on a whole before proceeding with the next step. Meanwhile, new designs are projected against this time. A good sailplane is the result of the combined efforts of pilots, manufacturing, personnel and engineers.

Design List

Model No.	Description	Date Built	No. Built
SGP 1-1	Original Primary Wood	May 1930	1
SGU 1-2	Long Wing (40')	1932-1934	1
SGU 1-3	"Brick" Utility	June 1933	1
SGU 1-4	Utility	—	—
SGU 1-5	Utility	—	—
SGU 1-6	Metal Tail Boom Utility	May 1938	1
SGU 1-7	Metal Wing Utility (Cruller)	June 1937	2
SGS 2-8	Metal 2 Place (Military Version TG-2)	July 1938	57
SGU 1-9	Utility	—	—
SGC 8-10	8 Place Cargo	May 1941	—
SGC 15-11	15 Place Cargo	May 1941	—
SGS 2-12	2 Place TG-3A & XTG-3 Wood Wings, Training Glider	April 1942	3 XTG-3 111 TG-3A
SGC 6-14	Small Troop Transport	Dec. 1942	—
SGC 1-15	TG-3A Modified for Cargo	April 1943	—
SGU 1-16	Utility	April 1943	—
SGS 1-17	1 Place Medium Purpose Sailplane	Jan. 1944	—
SGS 2-18	2 Place Sailplane Projected	July 1944	—
SGU 1-19	Utility 2 Spar Wing	April 1944	50
SGU 1-20	Tapered Wing 1-19	July 1946	2
SGS 1-21	High Performance Sailplane	June 1947	2

SGU 2-22	2 Place Utility Sailplane	Nov. 1945	51
SGU 2-22	2 Place Utility Sailplane	Nov. 1945	51
SGU 2-22A	2 Place Utility Sailplane		3
SGU 2-22C	2 Place Utility Sailplane		75
SGU 2-22CK	2 Place Utility Sailplane		28
SGU 2-22E	2 Place Utility Sailplane		55
SGU 2-22EK	2 Place Utility Sailplane		7
SGU 2-22EK	2 Place Utility Sailplane	Nov. 1945	7
SGS 1-23	Single Place All Metal	June 1948	20
SGS 1-23B	Single Place All Metal Long Wings	April 1952	1
SGS 1-23C	Single Place All Metal Long Heavy Wings	June 1952	1
SGS 1-23D	Single Place Improved 1-23B	March 1953	12
SGS 1-23E	Long Wing 1-23D	May 1954	1
SGS 1-23F			1
SGS 1-23G			8
SGS 1-23H			8
SGS 1-23-15			16
SGS 1-24	Single Place All Metal High Performance	May 1953	1
SGS 2-25	2 Place High Performance All Metal	June 1954	1
SGS 1-26	1 Place Metal & Fabric Sailplane	Jan. 1954	22
SGS 1-26A			115
SGS 1-26B			113
SGS 1-26C			53
S 2-27	2 Place Light Airplane	Sept. 1955	—
S 7-28	7 Place Airplane Cargo	1955	—
SGS 1-29	Laminar Flow High Performance Sailplane	July 1958	1
S 1-30	Single Place Airplane	Aug. 1958	1
S 2-31	Two Place Airplane	June 1960	1
SGS 2-32	Two Place Sailplane	July 1962	16

Table I

	High Performance Category	Utility Category
Gross Weight	1340 lb.	1430 lb.
Empty Weight	865 lb.	865 lb.
	475 lb.	565 lb.
Design V _D	166 m.p.h.	155 m.p.h.
	268 km/hr.	250 km/hr.
Position Maneuver Factor	5.33 Limit	4.67 Limit
	8.00 Ult.	7.00 Ult.
Gust Factor Positive	5.50 Limit	4.99 Limit
	8.25 Ult.	7.485 Ult.
Negative Maneuver Factor	-2.67 Limit	-2.33 Limit
	-4.00 Ult.	-3.50 Ult.
Gust Factor Negative	-3.50 Limit	-2.99 Limit
	-5.25 Design	-4.485 Design

Required speeds, load factors and surface design loads of SGS 2-32

	High Performance Category	Utility Category
Aileron Surface Loading	32.2 Limit	28.2 Limit
	48.3 Ult.	42.3 Ult.
Horizontal Tail Loading	40.0 Limit	35.0 Limit
	60.0 Ult.	52.5 Ult.
Vertical Tail Surface Loading	31.9 Limit	27.9 Limit
	47.9 Ult.	41.9 Ult.
Dive Brakes	143.5 Limit	124.9 Limit
	215.25 Ult.	187.4 Ult.
Landing Gear Factor	4. Limit	4. Limit
	6. Ult.	6. Ult.

Table II

Type designation	TG-2 SGS 2-8		TG-3 SGS 2-12		SGU 2-22E		SGS 2-25		High Perf. SGS 2-32		Units	
	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.
Wings												
Span	15.9	52.0	16.5	54	13.1	43	18.3	60	17.4	57	m	ft
Area	19.9	214	22	237	19.5	210	21.5	231	16.7	180	m ²	ft ²
Aspect ratio	12.6	12.6	12.3	12.3	8.8	8.8	15.6	15.6	18.05	18.05	n. d.	n. d.
Root chord	1.53	60	1.53	60	1.53	60	1.46	57.5	1.45	57	m	in
Tip chord	0.61	24	0.92	36	1.53	60	0.51	20	0.48	19	m	in
Mean aerodynamic chord	1.33	52.4	1.38	54.3	1.52	60	1.25	49	1.05	41.2	m	in
Wing section root	NACA 4412		NACA 4416		NACA 43012A		NACA 43012A		NACA 63,618			
Wing section mid									NACA 63,618			
Wing section tip	NACA 4412		NACA 4412		NACA 43012A		NACA 23009		NACA 43012A			
Dihedral	3.0		4.5		1.5		3.5		3.5			deg
Taper ratio	2.5		1.7		1.0		2.85		3.0		n. d.	n. d.
Aerodynamic twist	6.0		3.0		3.0		2.5		2.0			deg
Construction											Metal cantilever, single spar, metal covered	

Type designation	TG-2 SGS 2-8		TG-3 SGS 2-12		SGU 2-22E		SGS 2-25		High Perf. SGS 2-32		Units		
	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.	Metr.	Eng.	
Ailerons													
Span	4,64	15,2	4,68	15,35	3,02	9,95	4,35	14,35	3,28	10,75	m	ft	
Area (total)	3,95	42	3,23	35	1,80	19,5	2,30	24,6	1,37	14,7	m ²	ft ²	
Mean chord						12	0,26		0,21	8,2	m	in	
Max. deflection up	25		30		38		36		29			deg	
Max. deflection down	15		15		18		18		13			deg	
Mass balance degree					None		100	100	100	100		%	
Mass balance method					None		Arm balance		Internal weight				
Construction									Metal, fabric covered				
Horizontal tail													
Span	2,90	9,5	3,05	10	2,36	7,75	2,74	9	3,20	10,5	m	ft	
Area of elevator and fixed tail	2,22	23,9	2,76	29,6	1,91	20,5	1,83	19,7	2,04	21,9	m ²	ft ²	
Area of elevator	0,96	10,3	1,22	13,1	0,86	9,25	0,84	9,03	All moving tail		m ²	ft ²	
Max. deflection up	28		30				30		19½			deg	
Max. deflection down	22		30				30		9½			deg	
Mass balance degree							None		100	100		%	
Mass balance method							None		Distributed				
Tail arm, ¼ m.a.c. wing-¼ m.a.c. tail							5,01	197	4,93	194	m	in	
Elevator trimming method	None		Trim tab				Spring bungee		Tab				
Vertical tail													
Area of fin and rudder	1,45	15,6	1,56	16,8	1,21	13,0	1,35	14,5	1,35	14,5	m ²	ft ²	
Area of rudder	1,20	12,9	1,06	11,4	0,65	7,0	0,65	7,0	0,67	7,2	m ²	ft ²	
Tail arm							4,7	185	4,55	179	m	in	
Max. deflection			30				30		29			deg	
Construction									Metal frame, metal covered fin, fabric covered rudder				
Aerofoil section									NACA 0009				
Fuselage													
Max. width	0,61	24	0,65	25,5	0,72	28,3	0,72	28,3	0,81	32,0	m	in	
Overall length	7,70	25,3	8,27	27,1	7,63	25,0	8,53	28,0	8,15	26,7	m	ft	
Max. cross section							0,71	7,6	0,81	8,7	m ²	ft ²	
Undercarriage type	Fixed wheel with brake		Fixed wheel with brake		Skid/Fixed wheel		Fixed wheel with brake		Fixed unsprung wheel and skid. Wheel brake				
Max. height at cockpit									1,22	4,0	m	ft	
Construction	Steel tube fabric								Metal monocoque, side opening blown canopy				
Drag producing devices													
Type	Spoilers		Spoilers		Spoilers		DFS airbrakes single spoiler		Conventional upper and lower spoilers with gap				
Span (total)	1,37	54			1,79	70,7			2,78	109,8	m	in	
Area (total)	0,18	2,0			0,23	2,5		0,45	4,8	0,96	10,3	m ²	ft ²
Are devices speed limiting?	No		No		No		No		Yes				
Location	Tip of wing		Tip and bottom of wing		Tip of wing		Tip and bottom of wing		Tip and bottom of wing				
Weights													
Wings	96	212	200	440	95	210			168	381	kg	lb	
Fuselage	86	190			94	208			158	348	kg	lb	
Tailplane and elevator	10	22			7	15			24	53	kg	lb	
Equipped weight	205	450	355	780	213	470	332	734	377	831	kg	lb	
Max. load	185	410	200	440	172	380	175	386	231	509	kg	lb	
Max. permissible flying weight	390	860	555	1220	408	900	507	1120	610	1340	kg	lb	
Max. wing loading	19,5	4,02	25,2	5,17	20,9	4,28	23,6	4,85	650*	1430*	kg/m ²	lb/ft ²	
									38,7*	7,94*			
Limiting flight conditions													
Design gliding airspeed	129	80	177	110	166	103	215	134	267	166	km/h	mph	
									250*	155*			
Placard aero-tow speed	112	70	145	90	148	92	195	121	193	120	km/h	mph	
Winch launch speed	87	54	100	62	111	69	124	77	No winch launch with present hook				
Cloud flying permitted?	No		Yes		No		Yes		Yes				
									No*				
Permitted aerobatic manoeuvres							No restrictions		No restrictions				
Spinning permitted	No		Yes		Yes		Yes		Yes				