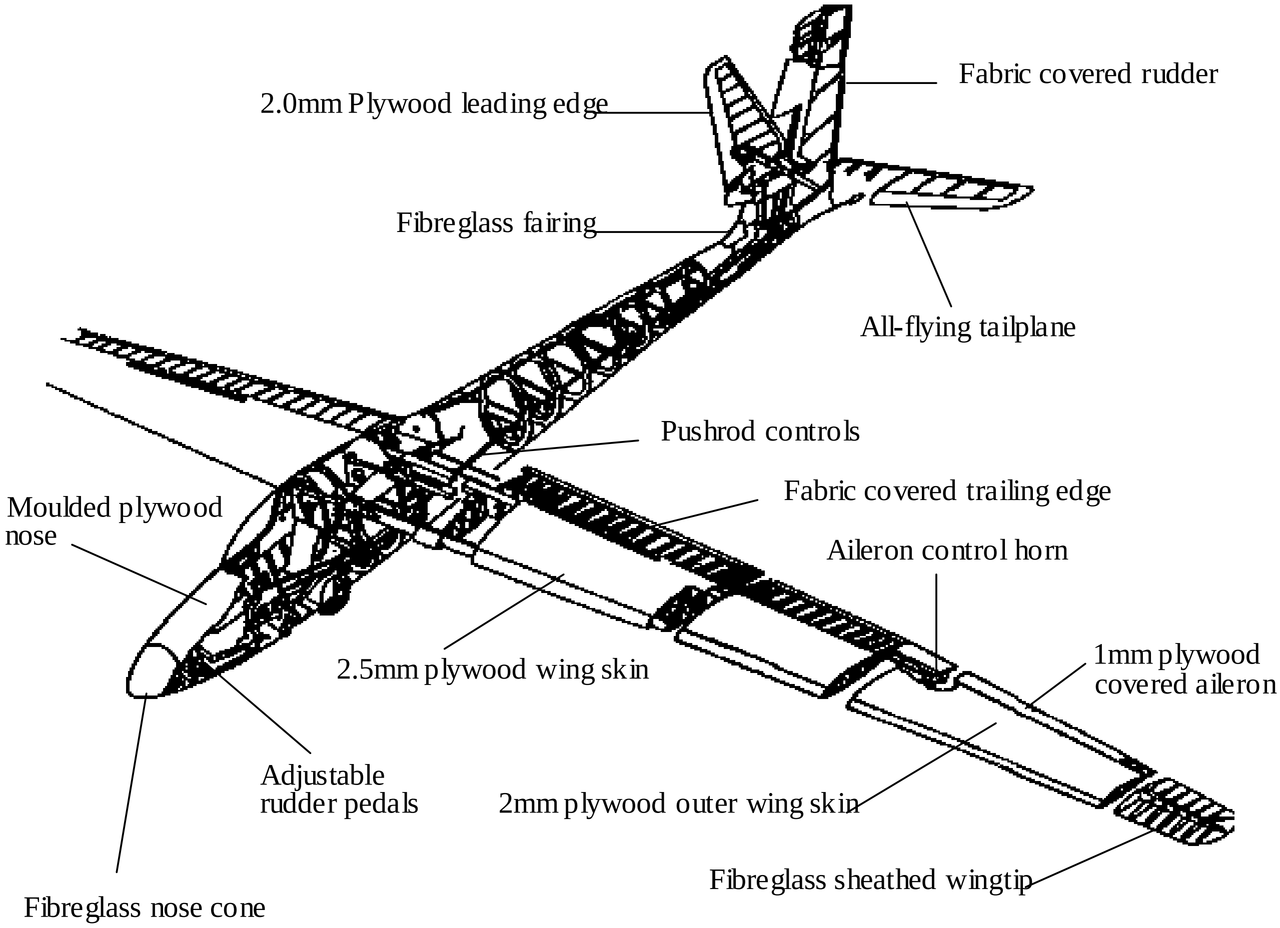
CHAPTER 7 - BASIC AIRWORTHINESS

GLIDER CONSTRUCTION

Wood

Wooden gliders are no longer made commercially and the skills necessary to manufacture and maintain them are fast disappearing. There is nothing at all wrong with wooden gliders, apart from the above comments, and there are still plenty of them in service all over the world. Typical timbers used in glider construction are Spruce, Douglas Fir, Mahogany, Klinki Pine and Beech. Glues used in wooden gliders include Casein (a milk derivative), Resorcinol (a two-part synthetic glue requiring heat to cure the join) and nowadays one of the many Epoxy adhesives, such as Epiglue. Examples of wooden gliders flying in Australia are - Kookaburra and Boomerang (Australian), Skylark and Dart (British) and Ka6 (German).

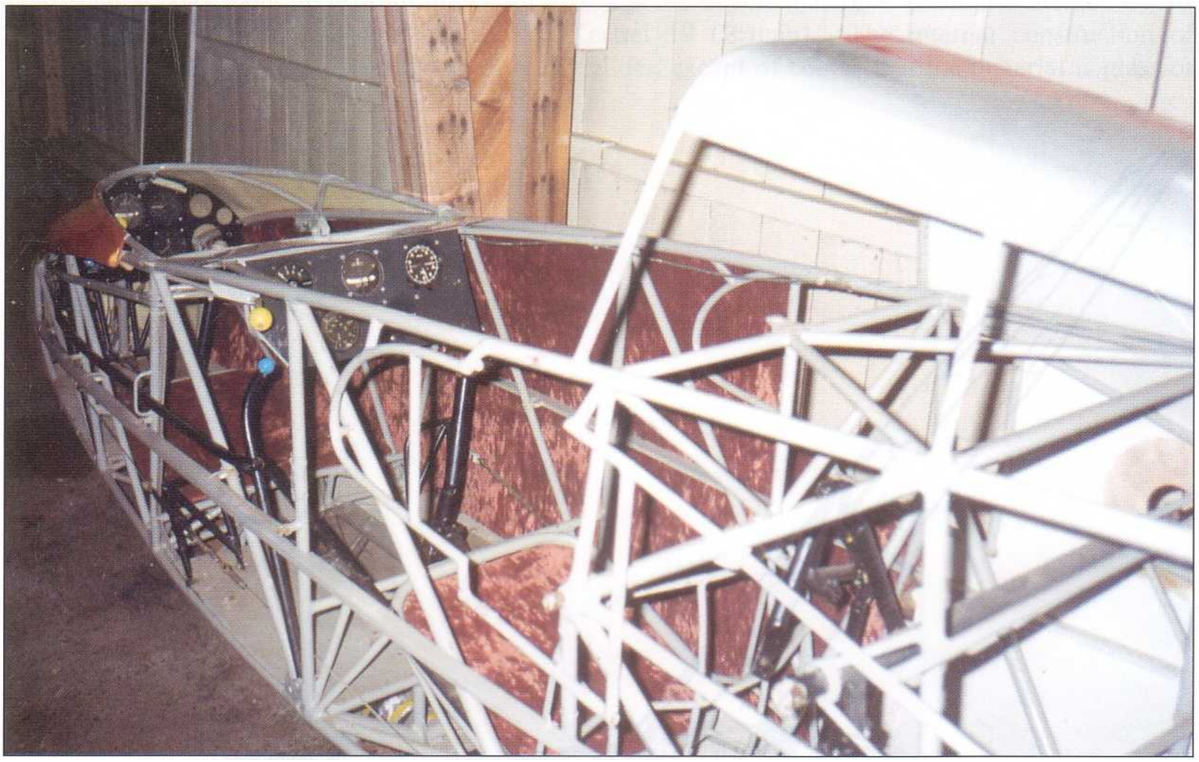
An example of wooden glider construction (Boomerang) is shown here.



Schneider ES 60 BOOMERANG

Combined wood/steel-tube

Some gliders combine wooden wings and tail, with a fuselage of welded steel-tube construction. The steel-tube fuselage is covered with fabric. The illustrations below show (i) the front fuselage section of a Scheibe Bergfalke 2/55, and (ii) a Schleicher Ka3.

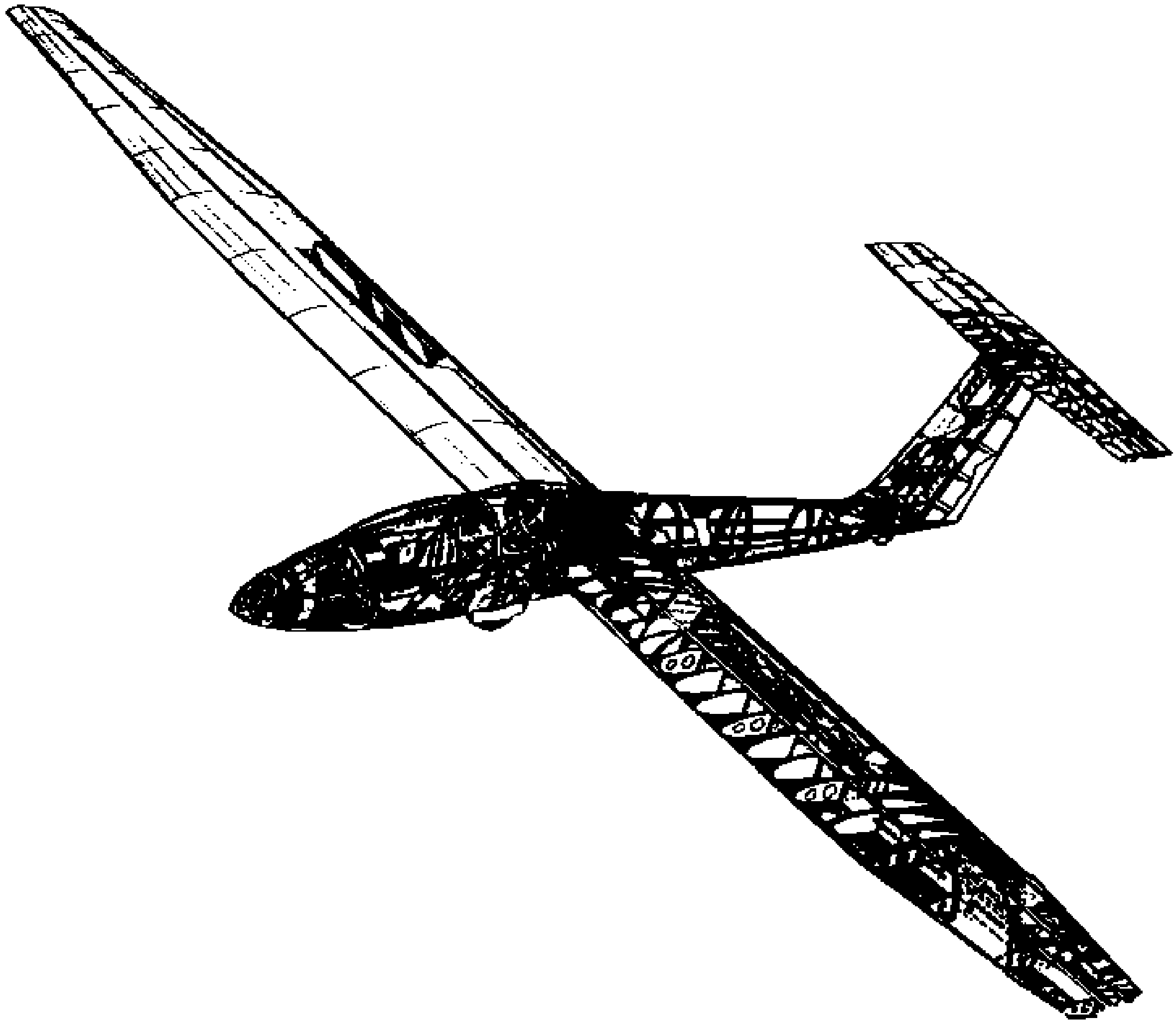


(i)

(ii)

Metal

Metal gliders are usually constructed of riveted aluminium alloy, although special metal-to-metal bonding may also be used on some designs. Examples include Blanik (Czechoslovakia), IS28B2 (Romania) and Pilatus B4 (Switzerland). The Pilatus B4 appears below: -

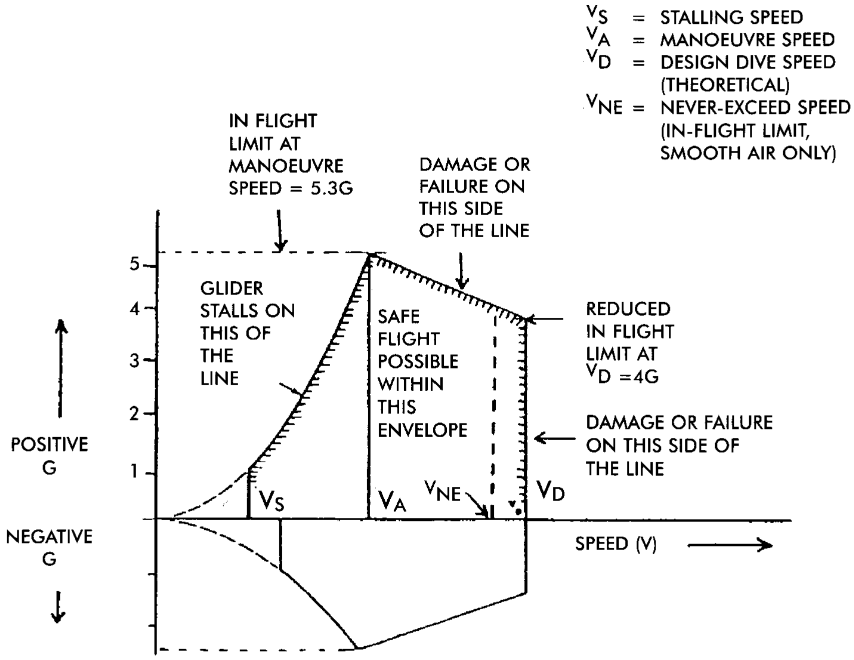


Composite

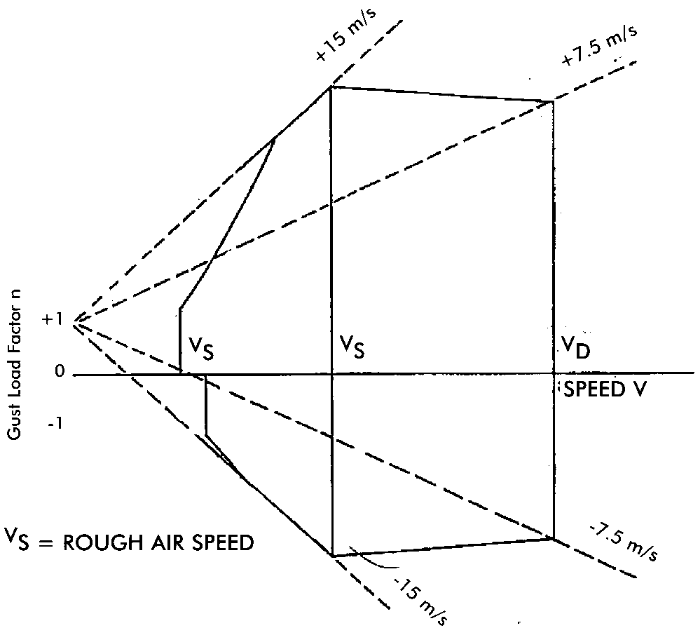
Composites are those materials usually known as glassfibre or carbonfibre. These consist of fibres of glass or carbon set in a resin (usually epoxy) and they offer enormous strength, great accuracy of shape and the ability to be constructed on a production line basis. Almost all modern gliders are of composite construction, and about 70% of all gliders in Australia are of this material. Examples include Cirrus and Libelle (Germany), Jantar (Poland) and Kestrel 19 (Britain). The internal construction of composite gliders is similar to a timber or metal glider, except of course that the material is glass or carbon fibre.

FLIGHT LOADS AND GLIDER LIMITATIONS

A glider is amazingly strong for its weight; that is its structure is very efficient. However it is not infinitely strong and certain limitations have to be placed on it if the flight loads are not to exceed the glider's capability to withstand them. This leads to an "envelope" of permissible speeds and load-factors (G loadings - see Glossary) within which the glider must be operated if its structural integrity is to be retained. Such an envelope, defining the glider's manoeuvring limitations in smooth air, is known as the MANOEUVRE ENVELOPE and a typical example is shown here:-



If the air is not smooth, in other words if gusts are present, additional stresses are applied to the glider. These are defined in the diagram below.



The information from the manoeuvre and gust envelopes of any given glider is extracted and presented to the pilot in the form of a simple cockpit placard

GLIDER LIMITATIONS PLACARDS.

A typical glider speed and manoeuvres limitations placard appears below:-

Airspeed Limits - Twin Astir

Never Exceed Airspeed	135 Kts
Maximum Rough-Air Speed	108 Kts
Maximum Manoeuvring Speed	92 Kts
Maximum Aerotow Speed	92 Kts
Maximum Winch/Autotow Speed	64 Kts
Maximum Speed with Airbrakes Open	135 Kts

The permitted aerobatic manoeuvres will also be displayed, either on the same placard or on a separate one alongside. The maximum (and possibly the minimum) weak link strength will be displayed, internally on the placard and externally next to the release hook(s).

Indicated airspeed and true airspeed

As altitude increases, the atmospheric temperature, pressure and density decrease. This means that the pitot pressure, measured at the opening of the pitot head on the glider, will be progressively less as the altitude increases, even though the glider is moving through the air at the same speed. Reduced pitot pressure means a lower indication on the airspeed indicator.

Therefore, as altitude increases, there is an increasing error between the speed shown on the airspeed indicator and the actual speed the glider is travelling at through the air.

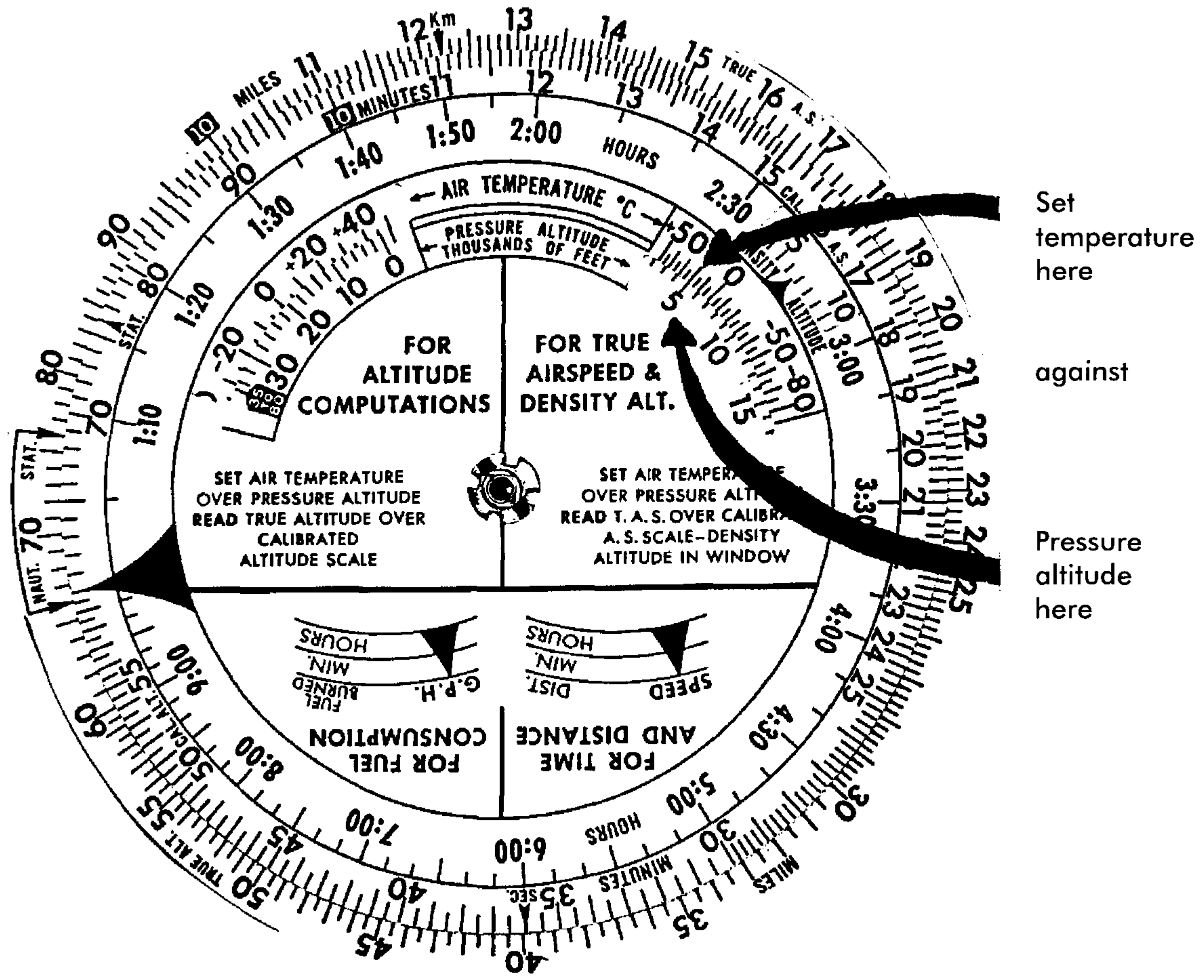
The speed shown on the airspeed indicator is called, fairly obviously, INDICATED AIRPSPEED (IAS). The actual speed at which the glider is travelling through the air is called the TRUE AIRSPEED (TAS).

There is no means of reading true airspeed on a glider instrument, unless the glider happens to have an airspeed indicator which has a sliding scale around its periphery for the purpose. Such instruments are common in modern light aircraft but very rare in gliders.

Calculating TAS from IAS involves applying an altitude and temperature correction to the reading on the airspeed indicator. This correction is easily calculated on a navigational computer. These computers are commonly used by light aircraft pilots, but again are seldom used by glider pilots.

One side of a Navigation Computer is for the purposes of "dead-reckoning" navigation. Thus it contains the compass rose and all the provisions for applying the wind-velocity to heading/track calculations. That side does not concern us here.

The other side of the computer comprises a circular slide-rule, commonly known as a "prayer wheel". An example of the IAS/TAS correction section of a typical prayer wheel is shown overleaf.



In the example shown here, a glider is flying at 5,000ft at an air temperature of 20 degrees and an IAS of 70 knots. Setting air temperature against pressure altitude in the right-hand window, then reading true airspeed on the outer speed scale from 70 knots on the inner speed scale, it will be seen that the glider is actually flying through the air at just over 77 knots.

The errors build up as altitude increases. A glider flying at the same 70 knots IAS, but at an altitude of 10,000ft and assuming a temperature at that altitude of 0 degrees C, results is a TAS of 82 knots.

Now lets go wave-flying. We are at 25,000ft and still flying at 70 knots. The temperature is -15 degrees C. Using these numbers, the prayer-wheel will tell us that we have a TAS of 108 knots. We are starting to creep up toward the glider's Vne; in fact we would be at Vne if the glider happened to be, say, a Club Libelle.

Does this matter? Surely the Vne is based on actual indications on the airspeed indicator, rather than some mysterious computation which most pilots don't understand anyway. This is generally true, except for one factor - flutter.

Flutter is an alarming and possibly destructive phenomenon which results from oscillations of a control surface exciting a main surface of the glider. For example, the ailerons could flutter and excite the wing into very large excursions up and down, which may eventually result in damage or complete failure. A similar interaction could occur between the elevator and the tailplane or the rudder and the fin. The onset of flutter can be rapid and can build up to destructive levels very quickly. It is a phenomenon better avoided than experienced.

What has this do with the IAS/TAS argument? Because flutter is an inertial problem, the value of inertia stored up in the aileron/wing or elevator/tailplane is a function of the TAS of the glider, not its indicated speed. The mathematics are not for this book, but you can take it as read that the INDICATED Vne of the glider must be reduced as altitude increases, in order to keep the flutter problem at bay.

Many modern gliders take this into account and their cockpit placards show a reducing Vne with increasing altitude. If you are going high, make sure you know the amounts by which you must reduce this Vne, especially if you are wave-flying and might need to use high speeds to jump wave-caps.

What about the older gliders and those modern ones which do not display this information to the pilot? You must still take a reducing Vne into account when flying at high altitude, but you will have to work it out for yourself. It is safe to say that there are likely to be few problems up to 10,000ft, but above that height you must shave increasing amounts off the Vne. As a guide of how much to shave off, if you don't have a prayer-wheel, take about 1.5% per 1,000ft off the placarded values.

Just to complete the IAS/TAS argument, it is not only flutter which might prove troublesome at altitude. Two other things should be taken into account when flying high:-

1. Rough air can be encountered during wave-flying, so SLOW DOWN if you meet clear air turbulence.

2. The reduction in air density results in a reduction in aerodynamic damping, which can adversely affect the natural stability of the glider. Some designs which have very light elevator forces and are only marginally stable in pitch at low altitudes may exhibit actual instability when flown at high altitude. This will be at its most marked when flying at a high TAS.

Remember, at high altitude, what you see is not what you get.

Why not beg, borrow or steal a navigation computer from a power-pilot friend and work out a few examples for yourself?

WEIGHT AND BALANCE

As well as observing placarded speed and manoeuvre limitations, a glider also has to be operated within strict limitations of weight and balance. A pilot must be thoroughly familiar with these limitations on each glider he flies.

The following basic definitions are relevant: -

Empty weight	-	the glider's empty weight, equipped to fly, without pilot, parachute or removable ballast.
Gross weight	-	the maximum flying weight
Maximum pilot weight	-	the heaviest pilot with parachute that can be accommodated without exceeding gross weight or moving the CG out of limits.
Minimum pilot weight	-	the lightest pilot with parachute that can be accommodated without fitting removable ballast.
Removable ballast	-	Lead or steel blocks or cushions which can be fitted and secured in order to bring a pilot up to the minimum pilot weight.
CG range	-	the range of movement of the centre of gravity, presented to the pilot in terms of a maximum and minimum pilot weight. In the case of two-seaters, a sliding scale is often used in order to take into account the varying weights in each cockpit.

A typical weight and balance placard follows –

Payload (Pilot & Parachute) - Twin Astir

Maximum flying weight	**650 kg**	**1435 lb**
Minimum front cockpit for all flight	**70 kg**	**154 lb**
Maximum load front	**110 kg**	**242 lb**
Maximum load back	**110 kg**	**242 lb**

The maximum permitted weight must not be exceeded. The maximum pilot weight is important too, because it is likely that if it is exceeded the glider will be flown outside its forward CG limit. This may make it impossible to trim the glider to minimum sink speed and could make it difficult to flare the glider on the landing. More seriously, it could also result in the maximum calculated flight loads on the tailplane being exceeded.

The consequences of flying a glider outside the aft CG, that is with too light a pilot, are even more serious and could result in loss of control. The implications of flying a glider outside the aft CG limit are as follows.

- It will be unstable in pitch and possibly uncontrollable.
- It may be difficult or impossible to trim to a safe speed near the ground.
- If a spin is deliberately or accidentally entered, it may be impossible to recover.

NEVER fly a glider below its minimum pilot weight. If your weight is marginal and you are not sure whether you are quite heavy enough, add some ballast.

AIRWORTHINESS DOCUMENTATION

The normal way of certifying the airworthiness of a glider is by issuing it with a Certificate of Airworthiness (C of A). To qualify for the issue of this document, the glider must be constructed to an accepted airworthiness code, such as OSTIV or JAR22 (see Glossary of Terms). Each individual glider is issued with a C of A, which is the source of the speed and weight limitations listed on the cockpit placard. Certificates of Airworthiness are issued for an indefinite period, but the day-to-day validity of the document from the pilot's point of view depends on the glider being maintained to GFA standards. Such maintenance is usually carried out annually and this fact is recorded in another document, which is carried in the cockpit of the glider (see "Maintenance Release").

Some gliders may not qualify for the issue of a C of A. There may be a variety of reasons for this, such as modifications to the structure or the installation of an add-on engine for self-launching. Such gliders may be issued with a Permit to Fly while engineering information is gathered to assess the suitability of the new machine for the issue of a full C of A. Permits usually, but not always, apply limitations to a glider which are not present in the case of a glider with a C of A. They are also issued for limited periods only (12 months, perhaps) and not for the indefinite period of a C of A.

The Maintenance Release

This document certifies that the glider is being maintained in accordance with GFA requirements. It also validates the C of A or Permit to fly of the glider. It is issued by a GFA-qualified inspector and is renewed on completion of the relevant inspection. If a Maintenance Release is present in the glider and is within its validity period, the glider is legal to fly. Check this before flight.

Although it may be legal to fly, the glider is not necessarily airworthy to fly. For example, it may have suffered a heavy landing on its last flight the previous day and there may be damage present which, for some reason, the last pilot did not report and did not enter into the Major Defects section of the Maintenance Release. It is therefore a requirement for a glider to receive a Daily Inspection before it is allowed to fly on any given day. Each pilot flying the glider must check that the Daily Inspection has been carried out, before carrying out his own walk-round inspection prior to flight.

MAINTENANCE RELEASE PART 1	**TYPE** K 2 B	**VH-** GHO

In accordance with the GFA Manual of Standard Procedures this Maintenance Release is issued following the completion of an annual inspection certified on GFA Form 2 dated ....

Issued by: BENDIGO GLIDING CLUB		**Date of issue:**	12.12.95
Signed [illegible]	**1109 G:** 1125	**Date of expiry:**	11.12.96

EVALUATION FLIGHT REPORT

This aircraft may not be flown other than for an evaluation flight unless this evaluation flight report is completed and any defects found recorded as Major/Minor defects as appropriate and Major defects corrected.

- ☑ **General Handling at all speeds**
- ☑ **Stall**
- ☑ **Run to V_{NE}**
- ☑ **Spins (if applicable)**

PILOTS SIGNATURE [illegible] **DATE** 17.12.95

This Maintenance Release is issued subject to the conditions that the following maintenance and daily inspections as required by the GFA Manual of Standard Procedures are performed on the glider/powered sailplane during the period this Maintenance Release is in force.

The Daily Inspection Record (GFA Form 1)

This is used to certify that a glider has received a Daily Inspection from a suitably qualified person. Check that the correct date appears alongside the Inspector's signature. If the correct date does not appear there, do not fly the glider - make some enquiries.

DAILY INSPECTION RECORD			GFA FORM 1		
A signature and authorisation number on this form certifies, in accordance with the GFA Manual of Standard Procedures that at the start of a day's flying and after each rigging a Daily Inspection has been performed and the glider is considered fit for flight.					
SIGNATURE & AUTHORISATION NUMBER	DATE	SIGNATURE & AUTHORISATION NUMBER	DATE	SIGNATURE & AUTHORISATION NUMBER	DATE
[illegible] G1125	12/12/95				

The Maintenance Release and the Daily Inspection Record share the same common booklet, which is kept in the glider at all times. It is a very important document and forms the link between the inspector who looks after the airworthiness of the glider and the pilot who flies it.

WEAK LINKS

A weak link is inserted into the cable or tow-rope for the purpose of protection of the glider against overstressing during the launch. The specified maximum weak link strength will be found on the glider's limitations placard.

FLUTTER

As discussed in the IAS/TAS section, flutter is an oscillation of a control surface which causes a sympathetic oscillation of the main flying surface to which it is attached. For example, a fault in the aileron circuit could cause aileron/wing flutter or an elevator could cause tailplane flutter. The cause may be faulty balancing of the control surfaces, excessive control system free-play or flying the glider outside its placarded limitations.

At any altitude, the general recommendation if flutter is experienced is to SLOW DOWN. When you get back to the airfield, ground the glider and advise an airworthiness inspector or the Duty Instructor.

GROUND HANDLING - AIRWORTHINESS IMPLICATIONS

The primary purpose of proper ground handling is to protect the glider from being damaged by the obvious hazards of strong winds and collision with obstacles. However it is possible to cause hidden damage to gliders by the wrong kind of ground handling, damage which may not be apparent to the person handling the glider but which may accumulate to the extent that some other pilot may end up suffering the consequences. A few hints on what not to do are in order.

> Never apply large forces in a fore and aft direction at the wingtip. The most common application of this wrong technique is when two people are ground-handling a glider and they both pull forward or backward on each wingtip. Because of the long wingspan, this puts enormous stresses on the wing-root fittings, stresses which the designer did not intend.
>
> Do not lift a glider by its tailplane. Once again this causes stresses which are not designed for.
>
> Do not sit on the leading edges of parked gliders. It is primary structure and, although it will withstand pushing, it will not tolerate the full weight of a person sitting on it.
>
> If a glider gets bogged and a vehicle is used to pull it out of the soft ground, attach towropes to both towhooks of the glider to spread the load and avoid local overstressing of the towhook installation.

RIGGING AND DE-RIGGING

There is no intention of going into any detail in this guide about the actual mechanism of rigging and de-rigging a glider. There are too many types of gliders in service to attempt that. Pilots learn the specific detail of rigging and derigging in their clubs and that system works very well.

However, every time a glider is rigged after an outlanding or a period in the workshop, it must receive a Daily Inspection. Even if it lands out twice or more in a day, this still applies.

No D.I., no fly.

THE WALK-ROUND INSPECTION

Before starting the pre-takeoff checks, the pilot should walk around the glider to check for any obvious damage. This damage may be in one of the following categories :-

1. In-flight overstress caused by mishandled aerobatics, flying too fast in rough air or possibly the onset of flutter.
2. Heavy landing damage.
3. Damage accumulated during the day's routine operations.

In cases 1 and 2, it is likely that any such occurrences would be reported by the pilot(s) involved. However, this does not always occur and all pilots should develop a healthy curiosity about the overall condition of any aircraft which they fly.

The walk-round inspection need not take very long, a couple of minutes at most. Start at the cockpit and work around the glider in an anti-clockwise direction. You will be looking for the following signs of damage:-

Heavy landings

Signs of overstress where the wings join to the fuselage. Gliders which have a wing carry-through structure in the fuselage (e.g. Blanik, Bocian, IS28B2) may also show signs of stress in this structure. The reason for damage in this area is the tendency of the wings to move rapidly forward and downward in a heavy landing.

Signs of damage to the fuselage in the vicinity of the undercarriage.

Signs of wing damage due to the rapid downward flexing of the wing. In fabric covered gliders, this damage often shows itself as broken trailing edges.

In-flight overstress

Signs of excessive 'G' loading in aerobatics, often in the form of cracking around the edges of the airbrake box, although there may also be other obvious signs. Check upper and lower wing surfaces.

Signs of overspeeding. One likely place to find damage will be underneath the tailplane, where there may be some signs of compression failure of the skin due to the large download on the tailplane which most gliders experience at high speeds. Overspeeding may also have caused flutter, which may manifest itself in loose control surface hinges and other similar damage.

Routine operations

Signs of damage from rocks thrown up by cable drogue-chutes during winch/auto take-offs.

Signs of fasteners working loose on fairings or hatches, usually due to operations on rough ground.

General advice

If suspicious about anything you find on a walk-round inspection, don't fly the glider. Have it inspected by a qualified inspector. It's better to be down here wishing you were up there than to be up there wishing you were down here.

DAILY INSPECTIONS - POLICY

General

It is a GFA requirement that all gliders receive a Daily Inspection (DI) before flying. The person carrying out the inspection must be adequately trained and hold a Daily Inspector authorisation.

A Daily Inspection is required:-

1. Before the first flight of the day.

2. After rigging the glider.

Common sense suggests that a decent Daily Inspection helps to prevent accidents, by showing up significant faults in the glider before it flies. A person holding DI authorisation therefore plays an important part in accident prevention. Such a person must operate with a high degree of integrity, as the glider is being inspected for everyone's benefit on that day, not just for one individual.

Pre-requisites for becoming a Daily Inspector

1. Be a member of GFA.

2. Be a solo pilot or have suitable background experience (e.g. L.A.M.E. or aircraft apprentice) to assist in obtaining the authorisation.

3. Be at least 15 years of age.

4. Satisfactorily undertake a test as to his/her competence.

Procedure for becoming a Daily Inspector

As well as experienced airworthiness inspectors, any gliding instructor of Level 1 or higher rating is authorised to assist in the training of Daily Inspectors. By this means, a person may learn about DIs during flying training. The reference for the training is the Daily Inspector handbook.

When the training has been completed, the person undertakes an independent competence test.

If the test is satisfactory, the person's logbook is appropriately endorsed. If not satisfactory, the person is returned for further training.

DAILY INSPECTIONS - PRACTICAL

Purpose

There are five reasons for carrying out a Daily Inspection, viz,

1. To check for progressive deterioration caused by fair wear and tear.
2. To check for unserviceabilities or sudden deterioration which fall outside the category of fair wear and tear.
3. To check for unreported damage.
4. To check that the glider is correctly rigged and the control circuits are properly connected and locked.
5. To check that there are no tools or other loose objects lying around after maintenance.

When carrying out a DI, it is sometimes difficult to work out how far to go, how deep an inspection to do. Using the above five points as a guide, the answer is to go deep enough to satisfy your curiosity as to whether the glider can safely fly, without going to the extent of starting to overhaul it. A DI is basically a visual inspection, using only those tools which are necessary to gain access to essential parts of the structure, such as wing roots or underneath nose fairings.

All gliders receive at least an annual in-depth inspection and we strongly encourage pilots to carry out walk-round inspections before flight. The DI therefore bridges the gap between the two. The five points listed will now be covered in more detail.

Progressive deterioration, fair wear and tear

Typical items on a glider which can deteriorate slowly over a twelve-month period are:

- Wear in control cables
- Lack of lubrication
- Ingress of dirt into control circuits
- Excessive free play in hinges and bearings
- Signs of fatigue in metal structures
- Cracking at stress points in all structures
- Frayed or worn harnesses

This list is not exhaustive, but will give a good idea of the kind of thing to look for under the heading of fair wear and tear.

Unserviceabilities, sudden deterioration

Examples of sudden deterioration include:-

- Broken release springs
- Water or insect nests in pitot/static systems
- Instrument or radio failure
- Flat tyres
- A failed component in a control circuit

Again, not exhaustive, but gives an idea of what can happen suddenly and unpredictably in normal service.

Unreported damage

This is outside the category of normal service and occurs when the glider is either flown outside its permitted limits or is damaged in some way on the ground. Examples include:-

- In-flight overload, typically caused by mishandled aerobatics or flying too fast in rough air.
- Heavy landing
- Ground loop on take-off or landing
- Storage damage ("hangar rash")

Correct assembly and rigging

Although always important, particular attention must be paid to this category if the glider has just been rigged, such as following an annual inspection or after a cross-country outlanding. Examples of items in this category which require checking are:-

- Controls are properly connected. This is checked by one person firmly holding each control surface in turn, while another person tries to move the stick or pedals in the cockpit.
- No restriction in the movement of the controls and the range of movement is correct
- Controls operate in the correct sense. Several cases have occurred of gliders becoming airborne with reversed controls, having escaped several stages of inspection.
- Pins are safety-locked and any tapered pins are fully home
- Locknuts are in safety
- Turnbuckles are correctly locked and in safety
- Castellated nuts are properly connected and safety-locked
- Hatches and access panels are securely fastened after use

Loose objects, tools, etc

This heading is really self-explanatory. A DI Inspector must have a high degree of curiosity, bordering on suspicion, when it comes to the possibility of things lying around inside gliders. A torch is handy for DIs, for poking around in some of the darker recesses, provided of course that the DI inspector doesn't leave it in the glider!

Dirt in the cockpit can be as hazardous as any other solid object, when it comes to the possibility of jamming a control circuit. Dried mud and clumps of grass off pilots' feet can work their way under floorboards and end up among pushrods, torque tubes and cables, where they can get up to all sorts of mischief. Vacuum-cleaning of cockpits is a regular DI chore and must not be by-passed just because you are not in the mood or the power-point is far away. The risk of jammed controls far outweighs any inconvenience in keeping the interior of the glider clean.

Finally

Talk to your club instructors or airworthiness inspectors about DI training. Such training gives a good insight into the construction and control systems of the aircraft you fly, and may encourage you to seek more extensive qualifications in the airworthiness field. It will also make you a more informed and sympathetic pilot. The reference document for learning about DIs is the GFA Daily Inspector's Handbook.