Glider Trailer Design

1. Overview

This document has been written to record cumulative experience of the Adelaide University Gliding Club in maintaining and building glider trailers.

The club has traditionally operated older gliders acquired in the second hand market. Generally these have been purchased complete with their existing trailer. Almost universally these units have shown us how not to design a trailer!

During 1996 two trailers were built from scratch within the club. This exercise has caused significant review of trailer requirements and considerable examination of every trailer we have come across to glean good ideas.

The ideas presented here show the way we have gone and some of the reasons why.

Alternatives are also presented. These concepts should not be considered the pinnacle of development. We continue in our quest for better, easier and cheaper ways of moving our gliders around.

Certifiable limits of trailers for Australian roads are generally given in a Vehicle Standards Bulletin (VSB) issued by the Department of Transport and Communications Federal Office of Road Safety. The VSB is titled "Building Small Trailers" and covers trailers up to an Aggregate Trailer Mass (ATM) of 4.5 tonnes. This should be the governing document unless you operate a 4 engine glider. If you're thinking about building a trailer get a copy of this document before you start.

2. Design Concepts and Regulations

2.1 Size and Size Limits

Obviously trailer size is determined by the size of the derigged sailplane components to be carried. Minimizing the size of the box reduces towing drag loads and trailer weight. Don't reduce internal clearances too far or "trailer rash" will be a permanent problem. Clearances between components less than 50mm potentially cause difficulty.

Size limits of trailers are given in Clause 17 of the VSB. All glider trailers are built as "pig" trailers (trailers with a single central axle group).

Trailers for single seaters generally won't have a problem complying with the dimensional limitations. 2 seater trailers generally won't have a problem with the overall length, width and height limits (11m x 2.5m x 4.3m). Unfortunately every 2 seater trailer around exceeds the 3.7m maximum rear overhang limit described in Clause 17.2 of the VSB. It is impossible to design a sensibly balanced, towable 2 seater trailer without exceeding this limit. The GFA has been negotiating this detail with the Road Authorities with the aim of obtaining a specific exemption to allow glider trailers to have an overhang up to 5m.

2.2 Weight Limits

Trailer weights are not specifically limited by the VSB other than the document ATM limit of 4.5 tonnes. Your ultimate limit will depend on your towing vehicle/towbar combination. It should be noted that vehicle manufacturers fit different towing packs depending on requirements. ie not all Commodores have the same towing capability! Some Australian states also limit trailer weight at the weight of the towing vehicle.

Trailer brake requirements depend on trailer weight and are described in item 4.4 below.

2.3 Weight Distribution

Weight distribution is the primary item which controls stability of the trailer at speed.

Some references suggest 10% of the trailer weight should sit on the draw bar. For a typical single seat glider/trailer combination this is likely to pan out around 80kg. For a 2 seat glider/trailer combination it increases to around 120kg.

Unless you are going to tow the trailer with a truck these figures are too heavy! AUGC experience has shown that 70kg on the drawbar will generally produce stability at speeds up to 110 km/hour. This is still too much weight to place on the drawbar of the average 6 cylinder sedan unless load sharing bars are used.

Glider trailers are towed in two conditions - empty and loaded. There is a tendency when working out where to place the axle to forget the empty case. Axle location under the trailer should in fact be set up for the empty case and the placement of the sailplane components within the trailer should be arranged to achieve appropriate draw bar load in the loaded condition. This effectively means that the centre of gravity of the components should be just about over or slightly forward of the axle position determined for the empty case.

2.4 Structural Loads

Dynamic loads applied to the trailer in service are dependent on all sorts of parameters which are difficult to quantify. Experience indicates that if the trailer is designed to accept 6g loads long term integrity is achieved.

For an enclosed trailer practical sections used to build the "box" give strengths in excess of that theoretically required.

Draw bar and glider fitting design should be checked for compliance with the 6g requirement. AUGC experience has shown that corrugated gravel roads will expose any deficiencies!

Suspension mounting onto the "box" should have the loads distributed over a reasonable length of the lower trailer longeron.

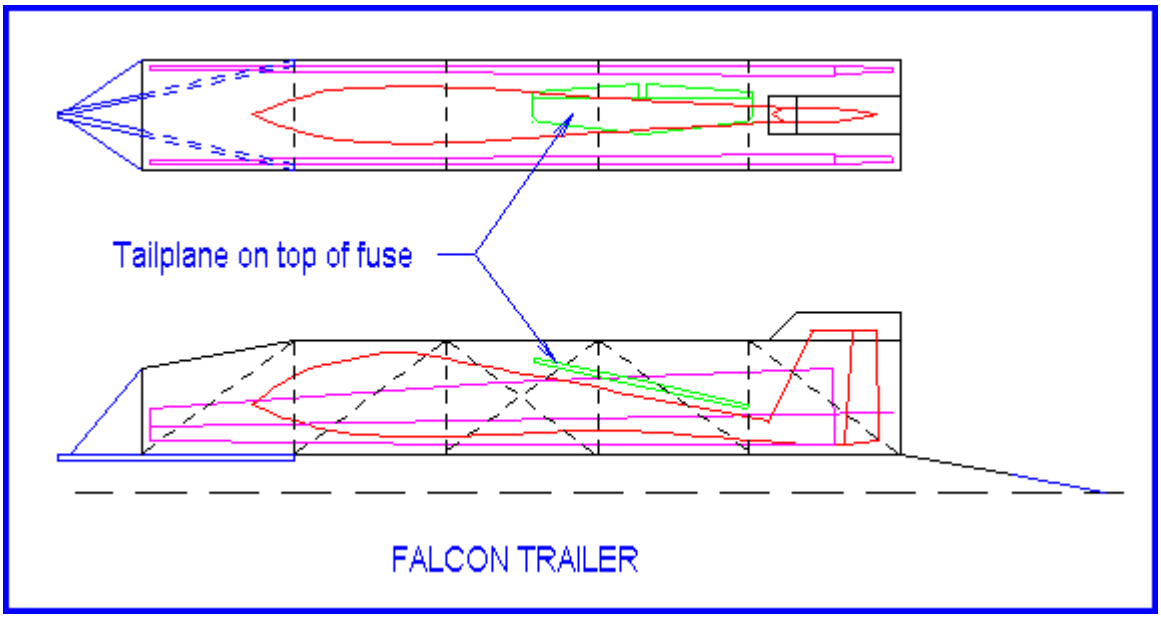
2.5 Glider Placement in Trailer

In item 2.3 it was suggested that the Centre of Gravity of the glider components in the trailer should end up over the axle. The outcome of this for most gliders is that the front end of the fuselage will be at the same end of the trailer as the wingtips.

For rigging convenience and to accommodate the height of the fin the majority of gliders have the fuselage run nose first into the trailer. Good balance requires the wing tips to also go in first.

Generally the length of the "box" is determined by the length of the wings. The fuselage has some room to move fore and aft. Advantage can be taken of this to balance the trailer in the loaded condition. Some 2 seaters have a fuse longer than the wings. The principle still holds.

The other item that needs consideration when arranging components in the trailer is the tailplane. There is a strong argument to use a trailer configuration which allows the tailplane to be removed from the glider during derig and placed directly in its final trailer mounting point. Having to temporarily stow it while the rest of the derig is completed is fraught with risk when derigging in the wind and rain in a remote paddock at 10 o'clock at night! This suggests a mounting point near the front of the trailer. An alternative which achieves the same outcome is to build tailplane trailer fittings which mount the tailplane on the top of the rear fuse (see below). The tailplane is thus secured before the rest of the derig proceeds.



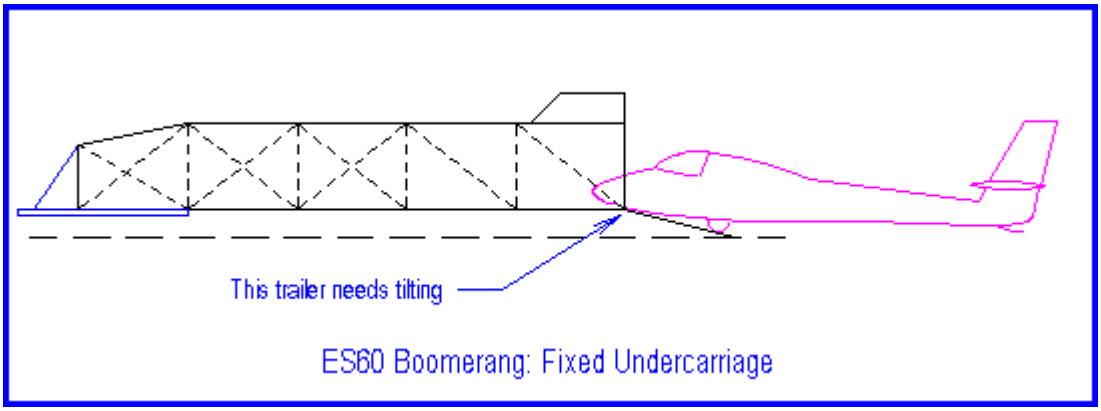
2.6 To Tilt or Not to Tilt

Walk around any glider trailer park and it will be observed that some trailers have tilting arrangements for rigging/derigging and some don't.

Tilting is required in some cases to ensure the underside of the forward fuse clears the rear lip of the trailer without using a difficult to stow long ramp. It also makes it a bit easier to handle the wings in and out without damaging the leading edge on the trailer lip. The downside is the drawbar arrangement is more complex and effort is required to tilt the trailer.

For retractable undercarriage aircraft sitting in a fuse cradle with the wheel retracted in the trailer, tilting is not usually required to clear the underside of the forward fuse. In this circumstance tilting drawbar arrangements are probably not worth the complexity. On the other hand aircraft standing on their undercarriage in the trailer usually require the trailer to be tilted to comfortably clear the lip when running the fuse in/out.

It is strongly recommended that the need to tilt be carefully considered at the design stage. This is best done with an accurate side view drawing (see below) of fuselage and "box". CAD packages make these sort of exercises easy, but for CAD challenged trailer designers a scale side elevation of the trailer and a matching cut out scale side view of the fuse can be used to check clearances as the fuse is moved in and out of the box. If the trailer is built with close tolerance during roll in/out it will only take slightly uneven ground to cause "trailer rash".



3. Construction Materials

3.1 Framing

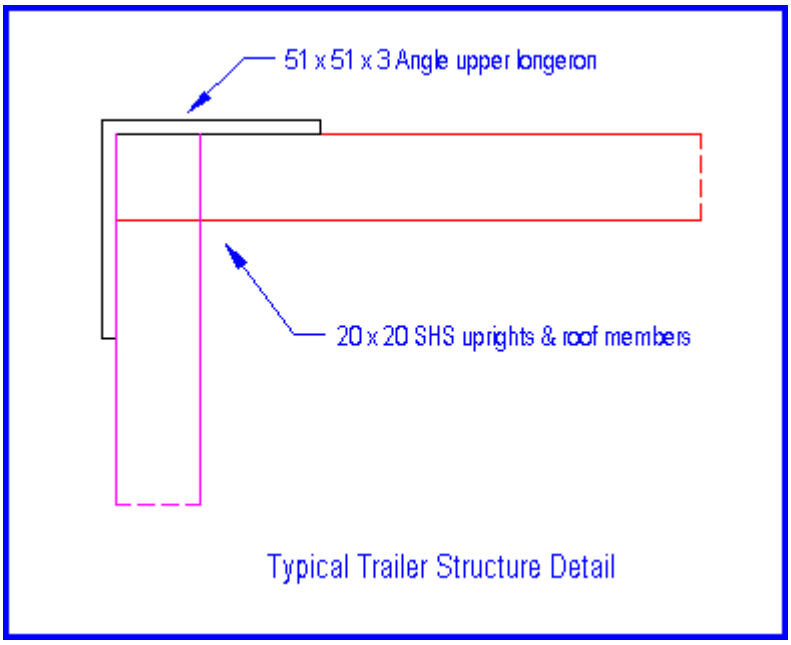
Since trailer framing is universally constructed in steel (apart from a few exotic FRP trailers) it is merely a matter of selecting suitable sections to minimise construction effort.

Many gliding trailers are put together with volunteer (read amateur) labour. This should be recognised in the design phase. Fancy structurally critical butt welds are beyond the capability of most amateur welders. It pays to keep to fillet welds where possible and arrange for twice as much weld length as normal to cover the poor welding quality! Welding heat causes frames to twist as they are assembled. Welding in the right sequence will enable the twist to be minimised in the completed job. The welding job will be greatly enhanced if a MIG welder is used.

Recent AUGC trailers have been built using the following:

- 50 x 50 x 3mm steel angle longerons.
- 20 x 20 Square Hollow Section (SHS) uprights & roof members
- 25 x 25 Rectangular Hollow Section floor members
- 32 x 32 x 3 steel angle frames to accept doors
- 20 x 20 SHS door frames

The use of the angles for longerons enables easy fabrication. The floor, upright and roof members can be fillet welded to the legs (see below) of the angle. Because steel is supplied in 6 or 6.5m lengths a joint is required in the longerons to achieve a "box" approximately 8m long (single seater). While we have butt jointed the angle we reinforce the joint on the inside of the angle with a short length of smaller angle.



3.2 Cladding

With cladding the following choices are available:

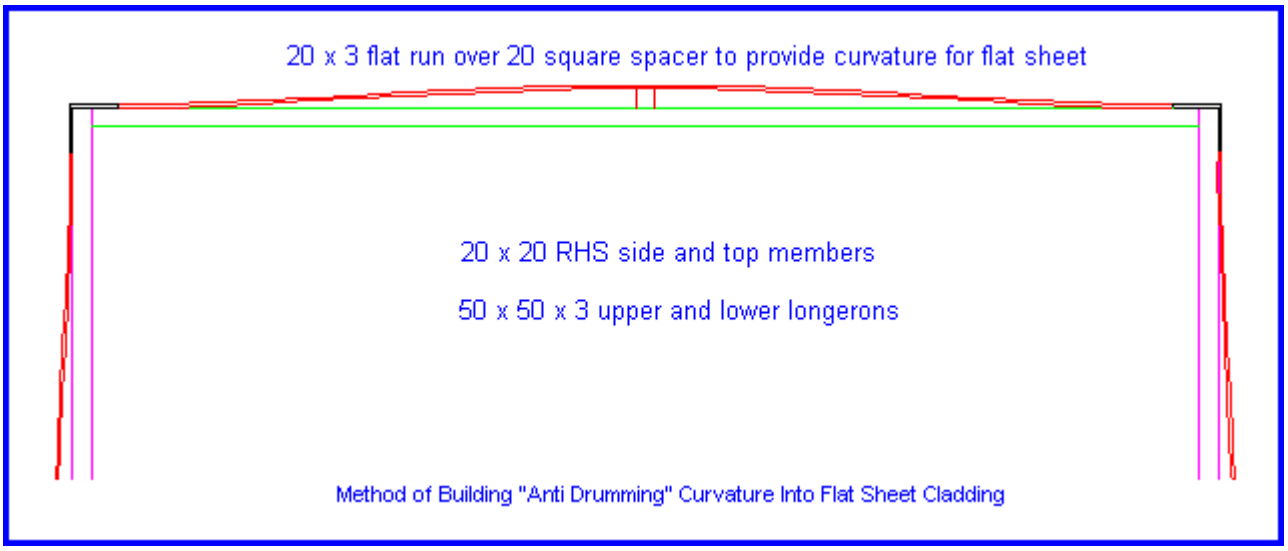
- Ribbed aluminium sheet
- Plain aluminium sheet

- Ribbed galvanised steel sheet
- Plain galvanised steel sheet

The basic choice between aluminium and steel sheet is a trade off of weight against cost. Aluminium cladding is likely to end up 1/2 - 2/3 the weight of steel, however this is at a substantial cost premium. For a single seat glider trailer steel cladding works out around 100kg. Use of aluminium will reduce trailer weight by about 40 - 50kg (5% of laden trailer weight).

The other essential choice to be made is between using ribbed sheet and plain sheet. Where ribbed sheet is used a low rib pattern is normally selected. Ribbed sheet avoids the problem of "drumming" which will be encountered with plain sheet unless some technique is employed to minimise it. On the other hand plain sheet is much easier to water and dust seal at the ends and corners of the "box" and at the lower edge of fin extensions.

Where plain sheet is used two methods of avoiding drumming are available. Either cross break the panels or build in a small amount of curvature (see below) in the walls and roof.



When galvanised steel sheet is used it can be procured with either a natural galvanised finish of with a colorbonded finish. White colorbond is worth the additional cost since it eliminates the need to paint the trailer.

3.3 Floor

Trailer floors have traditionally been built from either marine ply or deep rib galvanised steel roofing cladding. From the AUGC experience of older trailers it is obvious that galvanised steel survives the test of time better. It is also considerably cheaper than ply and weighs about the same.

Whatever floor material is used it should be fixed in position with silicon sealant under the joints to prevent dust ingress.

3.4 Running Gear

Suspension, axle and tow hitch equipment should be procured from a reputable supplier of this type of equipment. When you go to order the axle you will need to know the width of the "box" so the correct axle length can be selected. The other item to be selected will be

the type of wheel rims. Be sure to select a common rim type. Exotic rims lead to difficulty in the future procuring replacement tyres and wheel bearings out the back of Burke when they pack up during the retrieve from a dirty downwind dash!

Two seater trailers will require either a dual axle with a load sharing suspension or a heavy wheel/axle combination. A set of Landcruiser wheels and matching axle work well on a two seater trailer. The extra height of the suspension lifts the tail of the trailer giving better ditch clearance.

The springs are best fixed to down facing steel channel members which are bolted in turn to the lower trailer longerons. This enables final adjustment of axle position to achieve suitable unladen trailer drawbar load.

4. Design Details

4.1 Fixing of Cladding

Traditional fixing of cladding uses Blind ("Pop") rivets. Provided reasonably heavy rivets are used and they are set at centres of 150mm or less they seem to handle the test of time well. If you are building a new trailer go and hire a pneumatic riveter unless you are into body building. With the movement of the trailer structure in service some rivets will leak water. This problem can be easily overcome by placing a small amount of silicon sealant under each rivet head before it is squeezed up.

A more recent alternative for fixing cladding is 3M brand double sided tape. This avoids drilling the cladding. This tape forms a very powerful bond from the moment it is pressed against a surface. If a sheet is a little out of place you won't be able to move it! We have seen a 5 year old trailer with this type of fixing and it still seemed in good order. This tape cannot be applied when the ambient temperature is low.

4.2 Sealing Against Dust & Moisture

Most old trailers leak and ingest dust. Once a leak manifests itself in a trailer it is often difficult to locate and permanently rectify. This combined with the dust left over from summer creates a generous layer of mud on the trailer floor. The resulting high humidity plays havoc with a glider stored in the trailer.

Unless consideration is given to water and dust sealing at all stages of design and construction most new trailers will also leak.

Trailer sealing is best achieved by minimising the total number of joints and by paying close attention to the ones which can't be avoided. Joints are minimised by cladding where possible with full length / full width cladding materials.

The following should be adhered to when building a trailer:

- Lap all joints so water stays outside the trailer.
- Place silicon sealant in all joints before closing up.
- Silicon seal under rivet heads (see 4.1).
- Design door closures to take a good quality easily fixed rubber door seal.
- Don't forget to seal the floor and service access holes.

4.3 Ventilation

Designing a trailer which is well sealed causes another problem. Ventilation of the trailer becomes a necessity. If left unventilated excessively high temperatures will develop in the trailer on sunny days. Also any moisture which gets in won't be able to escape. No matter how well sealed the trailer is the glider will be less than perfectly dry when put away on occasions.

Ventilation openings should be designed with the following in mind:

- They should admit copious quantities of air.
- They should not admit water or dust.
- They should be arranged to pass air through from one end of the trailer to the other.

One method to achieve these aims is to place a set of fixed metal louvres at each end of the box, and back the louvres on the inside with filter material of the type commonly used on refrigerated room airconditioners. The louvre area at each end should be at least 500mm square to achieve a reasonable airflow. Fixing of the filter panel should allow easy removal for cleaning / replacement, but air should not be able to by-pass around the edges of the filter.

4.4 Brakes

Under the terms of the VSB all trailers require brakes except single axle trailers with a Gross Trailer Mass (GTM) under 750kg. This implies that just about all glider trailers require some form of brakes. Possibly a trailer for a small aircraft such as a PW5 could be built under this limit.

Trailers up to 2 tonnes GTM can utilise over-run brakes. Even 2 seater trailers come in under this limit, so that this type of brake conforms with the requirements of the VSB. It should be noted that brakes are required on all four wheels when a twin axle arrangement is utilised.

Hydraulic Brake lines should be routed along the trailing or top edge of the axle. Lines on the leading edge or underside are subject to damage when the trailer is towed through farmers paddocks. For the same reason it is best to route the main line through the inside of the trailer box in such a manner that it won't conflict with aircraft securing fittings.

Be sure to obtain hydraulic flexible hoses from a reputable trailer fittings dealer. These hoses must conform with rigid standards.

4.5 Lights

Under the requirements of the VSB most glider trailers will require the following lights:

- Rear Position (Tail) Lamps
- Rear Registration Plate Lamp
- Stop Lamps
- Direction Indicator Lamps
- Side Marker Lamps

The first four of the above can be bought as a combination light. This saves a lot of rule interpretation and fitting time. The following should be borne in mind when fitting combination lamps:

- The amber Direction Indicator Lamp should be at the top if mounted vertically or the outside if mounted horizontally.
- The Combination unit must be mounted a minimum of 350mm and a maximum of 1500mm above ground.
- They must be mounted symmetrically about the centreline of the trailer at least 600mm apart and within 400mm of the outer edge of the trailer (including wheel guards).
- The number-plate must be mounted so that the clear panel in the side of one combination light illuminates the plate.
- The Brake Lamp has a greater power than the Tail Lamp. Be sure to wire these correctly.

Combination Lamps are available with either festoon or bayonet lamp fittings. Do yourself a favour and spend a couple of extra dollars for the bayonet fittings since the lamps won't fall out of their fittings each time you tow across a paddock.

Trailers over 7.5m overall length (all glider trailers) require 3 Side Marker Lamps down each side. These should show amber to the front and red to the rear. These lamps must be within 1500mm of ground level. There is an advantage in placing these lamps near their upper height limit, to keep them clear of mud sprayed up from wheels and so they are clear above farmers fence height in case someone misjudges and rubs the side of the trailer on a gatepost.

4.6 Wiring

Generally a glider trailer should be wired for 7 pin connection. 7 core trailer wire is readily available. Standard pin out is as follows:

Pin	Function	Wire Colour
1	Left turn	Yellow
2	Reverse	Black
3	Earth	White
4	Right turn	Green
5	Electric brakes	Blue
6	Stop lamps	Red
7	Tail/side lamps	Brown

Once clear of the drawbar wiring should be routed through the inside of the trailer box in such a manner that it won't conflict with aircraft securing fittings.

Since wiring on the drawbar and rear door is readily damaged it pays to mount a 7 slot terminal strip inside the box at each end of the trailer where it can be readily accessed even when there is a glider in residence. Run a 7 core cable between these and then wire the lights and the plug from the terminal strips. This has the following advantages:

- Wiring on the rear door and drawbar is readily damaged. This arrangement allows easy replacement.
- Fault tracing is made easy.
- A convenient terminal is available for connecting side lights.
- Someone coming along after you can easily work out the wiring scheme especially if you number the terminal strips from 1 to 7 and stick to the standard wire colours.

The VSB requires that an earth connection be made via the trailer plug rather than rely on the trailer coupling as the earth. There is a strong argument to wire the earth to each lamp fitting. This is not very difficult and minimises problems over time. The most difficult lighting problem to track down is one due to a faulty earth.

Wiring should be secured with plastic cable ties at least every 600mm. Use grommets where wiring passes through drilled holes. A suitable alternative to grommets is silicon sealant. This also water and dust proofs the penetration.

In spite of being one nation Australia has 3 railway gauges and 3 different 7 pin trailer plugs. They all work fine but if you go to collect a trailer from another state you will almost certainly encounter a different plug to the socket on your car. Be prepared and keep a collection of plugs in the boot!

4.7 Spare Wheel

Looking around a glider trailer park you will find as many different locations to mount the spare as there are trailers.

The following should be borne in mind when selecting the position to mount the spare:

- The spare must be readily accessible when needed without having to remove the glider from the trailer to get at it.
- Remember when selecting the location that a wheel is likely to be wet and muddy when removed and stowed.
- Don't mess up the balance of the trailer by carelessly locating the spare. The spare is a reasonably heavy item. Its location can improve the balance of an otherwise poorly balanced trailer.
- The position selected should allow the pressure in the spare to be checked and topped up without dismounting the spare from the trailer.
- A spare mounted on the outside may suffer some UV degradation over a long period of time.
- A spare mounted inside the trailer must be secured or it is likely to move around and damage your prized possession.
- A spare mounted on the outside is more subject to being purloined by someone who forgot to keep their spare inflated.

With these items in mind the following positions are commonly successful:

- Mounted on the side of the trailer somewhere near the nearside wheel.
- Mounted on the front outside or drawbar of the trailer.
- Mounted inside the front of the trailer if a sufficiently large front access opening is available.
- Slung in a mounting under the nearside of the trailer immediately fore or aft of the axle.

4.8 Draw Bar

The draw bar of a trailer has a habit of being an afterthought. This is unfortunate since it is probably the most critical part of the structure. AUGC has seen a couple of drawbar failures over the years. Of course they always occur on a rough road beyond the black stump.

In 2.3 above a drawbar load of 70kg is suggested, while in 2.4 a design allowance of 6g is

suggested. Given these two figures your club engineer will tell you that you are going to have a large bending load in the drawbar where it passes under the leading edge of the trailer in the case of a cantilevered 'A' frame. This will necessitate the frame being fabricated from heavy steel sections.

Heavy drawbar sections can be avoided by placing one or two compression struts from near the coupling to the upper leading edge of the trailer. In the case of non tilting trailers it is easiest to run one strut up to each top corner of the box. This allows the compression load in the strut to be transferred directly into the upper longerons of the box. In the case of tilting trailers a single strut which doubles as a tilt support is usually easier. The top leading edge of the box may need to be strengthened to carry the load of the strut applied in the centre.

Whether the trailer tilts or not it is easiest to take the "A" frame back to the tail end of the first bay of the trailer. This provides a substantial point to connect the "A" frame to the trailer. In the case of tilting trailers the bar can be made to pivot at this point. For non tilting trailers each arm of the frame requires fixing to the lower edge of the box at the leading edge. This fixing will not carry heavy loads and does not need to be very sophisticated.

4.9 Wheel Guards

The wheel guards on a trailer should not be treated as an afterthought. Their function is to protect other road users against thrown up mud, stones and other items. The VSB has a diagram defining the area to be protected. Conventional guards will suffice provided a mudflap is fitted which comes down to within 230mm of the ground. Guards must cover the full width of the wheel.

Due to the length of glider trailers and the need to drag them through some tight farmer's gates it is not uncommon for the mudguards to conflict with gate posts. If a sheetmetal mudguard is directly mounted on the trailer cladding this is likely to result in a bent guard and a rip in the cladding.

A superior mounting is achieved if a pair of triangular angle iron frames are bolted to the lower longeron of the box and the mudguard fixed to the frames with a space between the inner edge of the guard and the trailer cladding. This has the advantage of providing a robust deflector and if damage does occur the frame and mudguard can be unbolted and replaced.

4.10 Tyres

The tyres selected for the trailer should be robust and capable of carrying the applied loads. When considering tyres remember that glider trailer wheels are subject to combinations of the following:

- Half the weight of the trailer (A dual axle splits this).
- Cross winds which apply considerable extra load on the downwind tyre.
- Extreme road temperatures on the way to a summer competition.
- Consistent high speed operation.
- Towing through rough paddocks.

There is no ideal glider trailer tyre. Some people swear by radial ply tyres while others claim a trailer is more stable on cross plies. Probably tyres will be adequate provided they have the following features:

- A manufacturers load rating significantly above your calculated requirement.
- A manufacturers speed rating above the speed the trailer will be towed at (An 'L' category tyre is rated to 120km/hour).
- They are not retreads (retreads always separate on the way to the summer competition).
- All tyres (including the spare) are identical.

4.11 Painting

Painting of the trailer has the following two functions:

- Corrosion protection
- Making it look good (Hiding the construction blemishes!)

Significant corrosion is most likely to occur in the structure rather than the cladding. In particular corrosion will get to the steelwork under the floor where mud accumulates. When building a trailer the framework should receive a robust anti corrosion coat before the cladding is put on. It is impossible to do a satisfactory job afterwards. If you have the means to move your frame around after fabrication and you want to avoid a boring job consider taking it to an industrial operator who can do an electrostatic spray job on your new creation.

If you didn't buy galvabonded cladding (see 3.2) you will need to give your trailer a spray job after cladding. Appropriate paint can be obtained from any commercial/industrial paint supplier.

4.12 Safety Markings

Since glider trailers are routinely towed on country roads it is useful to place a warning message on the tail to inform following vehicles they are in for a longer than average overtake when they pull out. A collection of reflectorised markings on the rear helps wake up drivers who come up behind you at night and encourages them to dip their high beam when they are sitting on your tail.

4.13 Door Latches

An examination of trailers parked on any airfield will reveal multiple ways of latching a door closed.

The following issues need to be kept in mind when selecting latches:

- Threaded fasteners have a bad habit of ending up with stripped threads.
- Trailer boxes flex in service causing problems with high precision devices.
- Any component which is removable will get lost in an afterdark derig.

One successful device for the main door is a pair of cam lock fittings of the type commonly found on horse floats. These are rugged and pull the door up well against the seal.

Whatever device is selected be sure to provide adequate clearance for fingers and knuckles when operating the latch.

5. Construction Process and Registration

5.1 Logical Construction Order

The following is suggested as a sensible construction order:

- Design first, Construct second!
- Fabricate side frames of box.
- Stand side frames up and add in floor and roof members(keep it square!).
- Add draw bar and minor steelwork including mounting points for aircraft fittings.
- Paint frame.
- Install floor cladding.
- Clad and flash box.
- Paint box.
- Fit axle, coupling, brakes, wheels, spare wheel and mudguards.
- Align wheels.
- Fit lights and wire trailer.
- Register trailer.
- Construct aircraft fittings.
- Use for a couple of months then bring back into the workshop to rectify errors in design and construction!

5.2 Construction Time

Amateur scratch building of a trailer for a single seat glider is a fair undertaking. Work out how many hours it will take you and double the number! A dedicated construction team of 2 is probably ideal. A lone builder will need help occasionally to roll the frame over and help with those other tasks which require two sets of hands. More than 3 will probably end up like a committee and get in each other's way!

5.3 Wheel Alignment

Once the trailer is towable it is useful to take it to an organisation with the equipment to accurately check the axle alignment in relation to the tow hitch. This will save on tyre wear. The adjustable axle position design described in item 3.4 provides for final alignment.

5.4 Registration

When construction is completed the final act is to get it registered. Provided you have complied with the requirements of the VSB this won't be a major drama.

The VSB requires the trailer to be fitted with a plate showing the following information:

- Manufacturers Name.
- Trailer Model.
- Vehicle Identification Number (VIN is obtained from the registering authority).
- Date of Manufacture.
- Aggregate Trailer Mass.
- The statement "This trailer was manufactured to comply with the applicable Australian Design Rules".

The plate must be non-corrosive metal fixed by riveting or welding to the structure. Lettering must be engraved, embossed etc and at least 2.5mm high.

The same plate or a separate one must carry tyre placard information. Tyre information

required is as follows:

- Tyre size designation and rim profile.
- Recommended cold inflation pressure (kPa).
- Load carrying capacity of the axle group.
- The statement "The tyres fitted to this vehicle shall have a speed category not less than 'L' (120km/hr)".

Following registration the registration plate should be fixed on the tail so that no part of the plate is more than 1300mm above ground. See 4.5 above for details of registration plate lighting. The registration label holder should be mounted on the left side of the trailer.