The Search for the Ideal Glider Tug - The Development and Testing of eTug

Introduction

In 2005 a syndicate was formed to see if something practical could be done to create an automotive-engined aircraft that would reduce the rising costs of aerotowing and be able to be certified by CASA and replicated for a number of clubs.

Knowing of the history of Autotug in Queensland, we approached Dave Sharples and asked him to join and oversee the project with us.

We named the project eTug (short for “enviro-Tug”) because we intended that it should have a “friendlier” footprint than current tugs – apart from being a lot cheaper to operate, it must be quieter, more efficient in terms of tows-per-engine-hour, more fuel-efficient, cause less impact and erosion damage to grass strips and deposit no lead into the atmosphere.

We have had questions from many people about the project, so this document aims to summarise how we arrived at the specifications for eTug, to answer questions about the other possibilities we examined and to report on the progress and cost benefits of the prototype.

The aircraft we examined which are described here are all well-known, certified and competent as GA aircraft. However, our interest was to evaluate them against the special set of requirements that we developed for our “ideal glider tug”.

As well as applying our own experience, we have talked to a lot of people in the gliding movement with experience in pretty well every method of aerotowing.

The conclusions we reached as a result are set out here, in the progress of the development of eTug.

Specifications and Performance

Towing a glider into the air behind a tug aircraft appears to be a relatively simple process to define and specify. In reality, it is. In the discussion of the theory, however, it attracts all sorts of methods that often reflect the personal interests of the theorists rather than the dispassionate evaluation of the available possibilities. And it should be noted that the original automotive-engined glider tug, Autotug, after flying for 17 years with a Ford Javelin V6 engine, has now been modified to run a GM LS1 5.7 litre V8 engine.

As a syndicate interested in finding the most effective way of reducing aerotow costs, we set out to specify the requirements as objectively as possible, as well as to apply advances in engine technology that have emerged since.

We looked at Eastern Australia, and the rather particular needs we have for aerotowing, and at Lake Keepit specifically as a good example of the requirements of the gliding movement. Here they are:

We need an aircraft which is:

- Proven to be robust and simple to fly
- Powerful enough to tow at high climb rates and suitable speeds for glider pilots
- Has sufficient power to easily tow heavy two-seat and heavily-ballasted Open Class gliders
- Capable of rapid turnaround for highest possible number of tows per hour (more than twelve) both to satisfy demand as well as to reduce the costs of towing
- Robust and powerful enough to paddock-retrieve at the height of summer, without any doubt of its capacity to do this
- Fuel-efficient

- Quiet
- Simply maintained
- Cheaply maintained
- Affordable for a gliding club to buy

So, knowing what we needed, here is what we looked at:

<u>Jabiru</u>

A syndicate was formed in Lismore some years back to evaluate the suitability of this type for aerotowing. This project had significant factory backing, with the factory delivering a specifically-modified 6-cylinder 115hp Jabiru.

The evaluation revealed that the aircraft was difficult to control on tow at anything less than 70 kts, making things more difficult for the glider pilot. At this speed, its rate of climb was too low for it to operate as a useful glider tug in terms of time-to-release, producing an unacceptably low rate of tows per hour. Fuel consumption appeared to be encouragingly low, but when considered against a greatly reduced tows-per-hour rate, the advantage was nullified. Further disadvantages were doubts about its ability to paddock retrieve, and its light weight and construction.

The factory acknowledged that for safety, the tricycle undercarriage would need to be converted to tail-dragger configuration because of concerns about possible failure of the nose wheel assembly particularly in operations from rough grass strips.

Other modifications suggested and subsequently produced by the factory included increasing the length of the wings and the surface area of the ailerons, and strengthening the tail assembly to better withstand towing stresses. Whether these modifications will render the aircraft suitable to tow to our specifications remains to be seen. Subsequent test flights conducted at Kingaroy indicated that climb rates were inadequate, and in any case, the cost of the modifications appear to increase the total price of the package to well above $120,000. We understand the modification has not remained in production.

<u>Tecnam – P 92 Echo Super and P 96 Golf</u>

Initially, this looked quite hopeful in that the factory was offering purpose-built aerotow adaptations. Two models were evaluated in NZ, and as far as smooth-strip towing was concerned appeared to perform adequately. However, with no capacity to paddock retrieve (on cold days, let alone hot) and a price tag exceeding A$140,000 for what is a lightweight and arguably not notably robust airframe, we eliminated it from our contenders list. (Interestingly, the two Tecnams which started towing in NZ appear now to be operating on a very limited basis, and our contact with a number of NZ clubs suggests that no new orders have or are likely to be placed.)

<u>Cessna 150</u>

Two Queensland clubs have converted Cessna 150s to Cessna 150/180 tugs. Their experience as recounted to us is that the airframe, particularly the tail assembly, will not stand up over time to glider towing stresses. The Kingaroy club Cessna has had the tail section rivets replaced twice in less than 2000 hours. No further rivet replacement is possible, so the empennage has been bolted, apparently. It is said that the next repair will require complete replacement of the empennage. Its tricycle undercarriage will not allow rough paddock retrieves. While inexpensive to buy, the model is now 60 years old and becoming scarce, and in any case, the shortcomings outlined here took it out of contention for us. Kingaroy has re-engined its Autotug with an LS1 engined.

<u>Cessna 150</u> – Subaru engine

Boona club investigated this combination and found the engine was so heavy the aircraft could never meet W & B limits. The project was abandoned.

<u>Super Cub - 180</u>

The performance of this aircraft is similar to that of the Aviat Husky (see below) – relatively low rates of climb and low numbers of tows per hour. In addition, it is also becoming a collectors' item, and is consistently increasing in cost, putting it out of consideration.

<u>Husky</u>

Looked at in the light of our specifications list, the Husky's shortcomings are:

- Lack of robustness. LKSC had a number of structural failures with their Husky, the last resulting in the aircraft being written off
- Tows at low climb rate
- Descent rate also low
- Hard to achieve high tows-per-hour
- Operates at the limits of its capabilities in hot-weather paddock retrieves
- Expensive to maintain
- No locally available parts

On the positive side, it is relatively quiet and fuel-efficient (although the low number of tows per hour reduces this latter benefit completely).

Changing the engine to an automotive type was considered, but rejected as impractical because of the shortcomings listed.

<u>Pawnee</u>

This aircraft meets the requirements of the specifications list if the Lycoming engine is replaced with a high-powered automotive engine. In all other respects it fulfils the requirements.

The Pawnee is an ag-strip cropduster. It was designed to carry up to a tonne of fertiliser into the air off rough farm strips. It is enormously strong. It is a very easy aircraft to fly. There are currently over 70 of them on the register in Australia with an unknown number in sheds and hangars as a spare parts source. The type is still in production via the holder of the Type Certificate in Buenos Aires, Argentina.

One major advantage is that Pawnees are cheap. This is because they are being supplanted in agriculture by larger, turbine-driven aircraft and so have ceased to be generally viable as cropdusters. Our experience suggests that they are all for sale, and at reasonable prices.

The Pawnee is also, however, the tug of choice of many of the gliding clubs in Australia, New Zealand and UK. (In NZ and UK, despite exposure to "lighties" as tugs, some clubs we have contacted are reverting to Pawnees).

The Pawnee's capability to achieve high numbers of tows per hour is noteworthy. On one occasion at Lake Keepit, a Pawnee flown by Ian McPhee performed 84 aerotow launches in a single day. However, the Lycoming engine requires time spent gradually cooling after glider release that limits it to about 7.5 launches to 2,000' in one engine hour.

Its paddock-retrieve capability is outstanding, because it was designed with rough, short landing areas in mind and it was built to withstand the stresses that these operations generate.

In its existing form, though, the Pawnee does have shortcomings. All of them are engine-related.

The Lycoming aircraft engine is expensive to buy, fuel, maintain, repair and fly. It's also noisy (European clubs don't use this sort of engine in tugs because of increasingly onerous noise legislation).

In glider towing, the Lycoming has to operate close to its performance limits, constantly. The result is that few Lycoming engines reaches its 2000-hour overhaul level without first needing new cylinders or a top overhaul. Shock cooling on descent is a permanent problem that increases turnaround time and, if not handled well by the pilot, results in cylinder and cylinder head cracking. All of these problems and processes are costly and a pilot distraction reducing circuit lookout and safety. A top overhaul can run to $20,000. The 2000-hour overhaul costs between $60,000 and $70,000. Spare parts are expensive, as is avgas. And the result of all of these expenses is that an aerotow launch is more costly than it should be.

The solution to all these problems is to dispense with the Lycoming, and install a proven, inexpensive, powerful, modern, extensively tested, readily available, easily maintained automotive engine that is also cheap to run to drive the Pawnee. This conversion process is now approved by the authorities, but there is a specific program to be followed which will provide certification of the modifications.

The perfect candidate for this job is the General Motors LS3 Chevrolet V8 alloy engine (better known in Australia as the Generation 3-4). GM have produced 14 million of these engines over the period to now. The company has spent billions of dollars developing, testing, refining and manufacturing it. The LS3 engine capacity is 6.2 litres. It develops 380hp at 5700rpm. It is fitted to a range of high-powered GM vehicles including the SS Commodore and Monaro. Outside of motor cars, it powers a remarkable selection of utilities, trucks, dragsters, airboats and aircraft. Complete with prop-drive unit (PSRU) it weighs in within a few kilograms of the 235 Lycoming engine.

It was this combination of airframe and engine the eTug syndicate decided to proceed with. In taking this course, we recognised at once that eTug would be quite different from Autotug. The immediate success of eTug encouraged Autotug to fit the same LS1 V8 engine.

<u>The Prototype – Conversion and Advantages</u>

The conversion of our first aircraft, VH-CUR, commenced at Bundaberg in 2005 with Dave Sharples and Ian Watson performing the work and creating the solutions to the need to accommodate water-cooling and other automotive engine peripherals within the airframe. An LS1 engine was fitted initially.

In an aircraft application like ours, the LS1 engine runs at about two thirds of its maximum rpm and power output. It operates on climb at 3800 to 4100 rpm, with a power output of about 260hp at the propeller. The LS3 engine is capable of running at this rate indefinitely, and has demonstrated that it can do in numerous applications (incidentally, the 235hp Lycoming delivers only 195hp at the propeller on climb, giving the LS3 a significant power advantage; ground static thrust test show VH-CUR produces 60% more thrust than a Pawnee 235).

The engine drives a 3-bladed carbon-fibre propeller through a 2:1 reduction drive, producing propeller rotation up to 2,050 rpm. At this speed we have found the engine’s consumption of 95 octane unleaded petrol to be about 20% less than a Lycoming engine. And, this is achieved with a considerable increase in launch rate.

Quite apart from fuel consumption, cost savings and power advantages, there is another important benefit of a water-cooled engine. At top of climb, the pilot simply closes the throttle and descends to the field as fast as he wishes. This is because there is no shock-cooling effect to manage. So with faster climb rates and considerably faster descent rates and better positioning, the turnaround time between tows is significantly reduced, enabling a minimum tows-per-hour rate of more than fourteen. Rates at Gliding Club of Victoria have been as high as fifteen/hr.

In operational terms, the LS3 conversion offers other advantages over the Lycoming. The Pawnee is already an easy aircraft to fly and land. Along with the LS3, we are adding a number of features that will improve safety and efficiency. Improved visibility of the aircraft in flight will be provided by high-intensity strobe lights positioned above and below.

In terms of costs, too, the statistics are persuasive. For a 6-cylinder Lycoming rebuild – say $55,000 to $70,000. For a complete replacement of an LS3 engine – around $10,000 (short engine $5,000). LS3 maintenance, too, is vastly cheaper than maintaining a Lycoming. No matter what the service intervals, the automotive engine is intrinsically cheaper to service, and has the advantage of considerably lower parts and consumables costs. With the addition of platinum spark plugs, the 100-hourly cost is limited to 6 litres of oil, an oil filter and 3 fuel filters. (With platinum plugs, EFI and no lead in the fuel, there is no plug fouling.) In service we have found oil consumption is negligible.

The advantages continue to mount: consider the noise factor. At a prop speed of only 2000rpm, the LS3 engined Pawnee is quieter in flight and on the ground than any equivalently powerful GA aircraft.

On the airfield, it creates considerably less erosion and impact damage because its landing rolls can be shorter and more direct, its positioning manoeuvres can be considerably shorter.

A final benefit – perhaps not quite as important, but a benefit nonetheless – is that using unleaded mogas will reduce the amount of lead deposited into the atmosphere, so providing a useful environmental effect as well as an 80% saving in fuel cost. The 40% Federal Road Tax on unleaded fuel is rebateable.

In combination, these benefits and advantages have convinced us that the LS1 (now LS3) - engined Pawnee represents the efficient and cost-effective future of glider towing in this part of the world. This view is reinforced by the budgets for the final cost of the converted aircraft will not exceed $90,000 to $100,000 each.

This estimate is based on:

- the conversion being performed by the eTug syndicate for quality control and security of IP
- conversion of a PA-25 235, 250 or 260 minus aero engine and mount. It should also be noted that Pawnees fitted with wing tanks require more complex plumbing and pump peripherals which will increase the costs slightly
- the converted aircraft delivered to the purchaser ready-to-fly at Lilydale, Vic.
- Is limited to engine related costs as all airframe costs are the same for LS3, or Lycoming engines

Having completed the second conversion; CASA having provided a legislative avenue for building an unlimited number of eTugs for certification in the Limited Category as a glider tug .

We named the project “enviroTug”, or eTug for short, because with its significantly reduced fuel consumption, unleaded fuel, reduced impact and erosion damage, better pilot conditions, safer and quieter operation and considerable cost savings, it does have a friendlier environmental footprint which is worthy of note.

The bottom line advantage, though, should ultimately accrue to the clubs that fly it and the pilots who are towed by it. In aggregate, our budget comparisons and projections indicate that eTug will cut the cost of aerotows to less than half. That means twice the launches for the prices being paid now, or putting half of what pilots are spending now back in their pockets. And all with an aircraft that is built for the job, and which works the way gliding folk need it to work. The higher launch rate means one eTug will nearly do the work of two PA25-235 Lycoming engined tugs. No longer frustrated glider pilots waiting on the grid for a launch.

Financial Benefits

Engine:

This summary of the estimated cost savings which will result from using eTug as opposed to a Lycoming-engined PA25 is based on a 2,000 hour timeframe – the normal life of a Lycoming engine, current fuel prices are as at Benalla, May 2019:

Fuel	$	$
PA25 – Avgas at 72l/hr @ $2.40/l	345,600	
eTug – Vortex 95 at 58 l/hr @$1.05/l*		
*Road Tax deleted	121,800	
	Savings	223,800

Maintenance (Engine only)		
PA25 – Top overhaul @ $20,000		
– Rebuild @ $70,000		
– Total	$90,000	
eTug – Overhaul engine	8,000	
	Savings	$82,000
Extra Tows		
eTug - +6 tows/hr @ say $45 per tow**		$540,000
Total Estimated Financial benefits with eTug per 2,000 hours		$845,800

(GST excluded)
**Compared with a PA25 - 235

It looks very much to be the right aircraft/engine for the job.

Airframe:
While it is true that the costs to maintain the airframe appear to be the same for either Lycoming, or LS3 engines, eTugs certified in the Limited Category will be maintained differently and can be maintained at club workshops by suitably qualified members, or outsiders. The higher launch rate of the LS3 distributes the airframe costs over a larger number of launches so creating a substantial saving per launch:

If airframe and engine maintenance costs on average $2,200 to $3,000 per 100 hours the total cost saving over the 2,000 hours will be $44,000 to $60,000 and this saving will be distributed over many more launches than was possible with a Lycoming engine.

More easily understood is that: after recovering the Federal Road Tax, bulk purchasing of 95 octane fuel and allowing that the eTug burns 58 litres per hour instead of 72 litres per hour and the launch rate is nearly double, the fuel cost per launch is 21% of an avgas-powered Lycoming engine. Lower cost launches provides a more affordable sport to less wealthy members and potential members, club activity rises. Air experience flights are less daunting to the public than steep winch launches.

Progressing the Project

At the time of writing the eTug syndicate has converted our second Pawnee, VH-PIJ, which has now completed over 100 engine hours. We have had approaches from three clubs in Australia and two in NZ who are interested in talking to us about Pawnee conversions for them.

The eTug Group
Sydney
September 2020