BY BILL COLLUM

21st CENTURY MOTORGLIDERS

This month in Soaring Tech, Mike Borgelt treats us to a view of next-generation motorglider technology. Many of us may know Mike as the driving force behind Borgelt instruments, one of the world's premier suppliers of soaring electronics. What may be less known is that Mike is an accomplished soaring competition pilot, and is currently working on a variety of new soaring-related technologies.

Mike had his first glider ride in a Slingsby T31b 50 years ago when he was 9 years old. He began taking glider lessons in late 1966 and soloed in 1967. After graduating from the University of Western Australia in 1970 with a degree in physics he spent 3 years working with the Royal Australian Air force as a civilian meteorologist. During that time he acquired his first sailplane, a Salto, and began investigating electronic variometers before spending some time on the staff of the atmospheric sciences department of an Australian university. In 1978 he and his wife Carol moved to South Australia and started Borgelt Instruments to manufacture electronic variometer systems. Borgelt Instruments continues to create new and innovative soaring solutions to this day.

Mike was the Australian 15-Meter Class Champion in 1981, flying his Mini Nimbus, and won the South Australian regionals in 1985. His win there led to a trip to Uvalde, Texas to fly in the US 15-Meter Class Nationals in 1986. Subsequently he became interested in self launching sailplanes and put a Fischer TOP system on his Ventus C 17.6. He also flies a Nimbus 3DM, and owns a Bede BD4 for family transportation.

Today, Mike continues to design cutting-edge soaring technologies. In addition to electronic systems he has spent quite a bit of time researching and designing sailplane powerplants. I'm sure you will find his views on 21st Century Motorgliders a fascinating glimpse into an exciting future.

See you on the porch,
—Bill Collum

21st Century Motorgliders

Mike Borgelt
Toowoomba, Australia

"Why not put a little engine on it?"

That's often the very sensible comment of the uninitiated when first exposed to soaring and sailplanes after the complications of launching, land-outs, and retrieves are explained to them.

Over the years there have been many attempts to do just that. The Carden Baynes Scud 3 was one of the first motorgliders built in the mid 1930's. In 1940 the Hirth Hi 20 based on the MiniMoa and GoVier was a laudable effort with a very neat engine installation. Nothing much happened for another 30 years or so until the SF27M followed a few years later by the PIK20E. Both were quite practical self launching motorgliders.

So why aren't self launchers more popular? Cost is one reason. The difference in cost between a modern sailplane and the self launch version runs around US$70,000. For less money you can buy a used Cessna tow plane and have your partner learn to fly it!

Why the cost? The weight of the engine, propeller, retraction, and reduction mechanisms contributes significantly to the mass of non lifting parts. The large hole in the fuselage needs reinforcement, adding even more weight. The higher mass of the non lifting parts requires a stronger spar. The sailplane rapidly gains weight. On some 18-meter ships the extra mass due to the self launch capability amounts to more than 200 pounds (about 90 Kg). There is also a lot of custom engineering required to mount the engine and related systems, and this all comes at a cost.

There are also operational concerns. Small two stroke motors are not well-known for their reliability or their ability to start on demand. The drag created by a deployed but not operating engine is significant. Once an engine is cranked out and the prop starts windmilling, you may as well be in a Cessna with a failed engine.

Electric motors are seen by some as a solution. The motor should start every time at least! Note however that you do not drive around in an electric automobile. Producing an electric propulsion system that develops significant power for a useful duration is not an easy task. The problem is primarily one of energy storage. Batteries are heavy. In comparison to designing an electric airplane, building electric cars is easy. That is, if only someone would solve the battery problem.

Modern lithium batteries are close to solving this problem, but you still end up with a heavy installation due to the mass of the batteries. In the case of the electric self launcher these are likely to be in the wings. All 100+ kilograms of them! Such an aircraft will still have a very limited range and climb ability. There is also the limited life of the batteries to consider, and the significant expense of periodically replacing the battery pack. Time will tell if this is a viable approach. It is certain that the Antares 20E and electric Silent represent significant milestones in the development of practical electric-powered sailplanes.

None of these approaches, however, are a solution for the existing large motor-less glider fleet. The Fischer TOP was one good effort in this regard but the gross weight of the sailplane was limited and there was a drag penalty.

Some new options may be on the horizon. Since the early 1980's the R/C model world has seen the development of small gas turbine (microjet) engines which now find application not only in R/C models but also in much more sophisticated, and heavier, UAVs.

Early microjet engines required both propane fuel and compressed air for starting and gave only a few kilograms of thrust. These little jewels have now evolved into reliable, electric start, digitally controlled engines needing only standard jet fuel for running and starting, and producing thrust in the 20 to 40 kilogram range. Rotating parts are designed and tested to minimize the chance for uncontained failures and operating experience has shown these not to be an issue. Inspection intervals are annually or every 50 operating hours (far greater than typical motor glider 25 hour inspections) with main bearing replacement at this time. Engines with 200 running hours have shown no signs of unexpected wear. Engine prices compare favorably to those for a typical motorglider-type two stroke engine. This means that a dual microjet installation can be cheaper than current factory motorglider options.

The use of microjects has become an attractive option for launching single seat gliders of up to 18m wingspan if two engines are used. A single engine could be used for a sustainer or "turbo" use (a real one at last!) but given the simplicity of the installation, self launch ability, and the inherent redundancy & reliability of two engines, it is believed the single engine option will have limited appeal.

The remainder of this article applies to single seat gliders of up to 18m wingspan and gross weights up to 600Kg. I had long been following the small turbine developments by looking at the ads in R/C Jet International. When the advertised thrust got to around 20Kg I began to think seriously about the possibilities. Then I saw the clip of Bob Carlton's Jet Silent on the web and, in response, posted the statement "I have seen the future of gliding." I've since had email correspondence with Bob and I think we owe him a debt of gratitude for his pioneering work.

The Silent has a gross weight of 290Kg (638 pounds) and Bob is using 2 x 20Kg thrust engines. Performance seems to be quite adequate. Since seeing Bob's film clip I've been waiting for manufacturers to come up with higher thrust engines suitable for the heavier conventional sailplanes.

Until very recently 23.5Kg was the highest thrust production engine you could buy (AMT Netherlands Olympus 2). This is marginal. I made contact with a manufacturer in Australia but the business ran into some problems and the promised 25 + Kg engines never made it into production before the business closed its doors. However the designer found a way of increasing the thrust on the AMT 23.5 Kg engine to around 27.5Kg by some subtle internal modifications to the gas flow path inside the engine.

I've insisted on jet fuel start, not propane as I don't think we need the possibilities of fuel-air explosions should there be a propane leak. This had been tried before, but one of the consequences of jet fuel instead of propane is that you need spark ignition instead of a glow plug to get reliable starts every time. This had caused problems as the spark firing had been causing resets of the digital engine controller during the start sequence. This problem has been remedied by rewiring the spark circuit back to the battery on its own separate circuit. The spark unit itself is based on model airplane spark ignition parts.

So we now have a jet fuel, electric start, spark ignition engine producing around 27.5 Kg (60.5 pounds) thrust that is the same size as Bob Carlton's 20 KG (44 pounds) thrust engines.

Two of these engines are about to be fitted to my Ventus C A 17.6, initially fixed to a saddle bolted to the pick up point for the existing TOP motor pod. Once power on testing has been done we'll arrange to retract them.

So what will be the characteristics of the Ventus C A 17.6 TJ?

The empty mass of the glider is 270Kg (594 pounds). The engines are around 3.5 Kg (7.7 pounds) each with electric fuel pumps and spark ignition units. That makes roughly 12Kg, or about 26 and a half pounds for the whole installation including some structural reinforcement around the turtledeck holes and fuel bags in the wings, increasing empty weight to 282kg (620.4 pounds) plus the weight of the fuel carried.

Calculations show that about 4Kg (8.8 pounds), or a little more than a gallon of fuel is required for takeoff and climb to 2000 feet. This compares favorably with a launch behind a Piper Pawnee which takes about the same time and burns about 6 to 8 liters (about 1.5 to 2 gallons) of avgas.

Retrieve cruise will be about 0.3 Kg, or 2/3rds of a pound of fuel burned per minute, so allow 20 Kg (44 pounds or roughly 5 gallons) of fuel for one hour's cruise on one engine at 50 to 60% thrust. This will fly the glider in level flight at about 90 -100 KIAS. It is uncertain as to the best strategy for best range here but the level flight cruise is necessary if there are meteorological or airspace limits on how high you can climb.

So all we need is 30 litres, or about 8 gallons of fuel: one gallon for launch, 5 gallons for a 100-mile retrieve, and a couple of gallons for contingencies. The fuel used is Jet A1 with 5% jet oil. The engine is lubricated by a small amount of fuel/oil mix bled through the bearings. The whole installation with full fuel will only add 36Kg, or less than 80 pounds to the glider.

Compared to the piston/prop motor glider, the drag caused by a deployed but non-running engine will be low due to the small engine diameter and lack of a propeller. This fact alone makes for easier operational use and increased safety.

Installation will be easier in existing gliders as the holes in the structure to retract the engines will be small and major structural alterations will be avoided. There is no huge increase in the mass of non lifting parts. The weight of one engine may be saved by using recent improvements in battery technology for the avionics /jet start/fuel pump power supplies. Safe lithium cells will replace 2 x 7 A-h 12 v sealed lead acid batteries which weigh over 5 Kg and can be replaced by less than 2kg of Lithium cells.

The thrust loads will be divided into two areas, not one, and a structural spine will be left on the centreline of the turtledeck.

Preliminary performance calculations show that single engine performance will result in rates of climb of around 200fpm so two engines makes for highly desirable redundancy with twin-engined safety. Asymmetric thrust will not be a problem as the glider is not highly powered and the engines are close to the centreline. The single engine best rate of climb speed will be around 75 knots while two engine climb speed will be around 100 knots at 650 to 850 fpm depending on flight weight. Neither speed is particularly critical and unlike piston/propeller motorgliders, is well above the stall speed.

Outlanding avoidance will be a significant benefit as only one of two engines is required to start for the glider to fly away from low altitude, making the probability of an outlanding remote indeed. Retrieves will be more economical than a car/trailer retrieve (around half the fuel consumption) and about one quarter the fuel consumption of an aerotow retrieve. The potentially hazardous outlanding is avoided. The low drag and automatic nature of the engine start process should have huge safety benefits in this high pilot workload situation. The engines may also be started and idled with no effect on durability so starting the engines on entering the traffic pattern will give a glider true go-around capability for the first time.

The combination of ability to cope with one engine failure during launch and still climb, the high climb speed well above stall with lots of energy, almost complete avoidance of field landings, and the previously absent ability to go-around when landing (with twin engine safety and redundancy) are expected to bring huge safety benefits to soaring.

There is a small concern about takeoff roll mainly to do with rolling friction, but comparison with the TOP thrust vs. airspeed curve shows that at above 40km/hr (22 knots) the jet thrust exceeds the thrust of the TOP. The net effect is that the jet will achieve lift-off speed (about 43 knots) in a shorter distance than the TOP, which already meets JAR 22 takeoff requirements easily at 430 Kg on representative single seat composite gliders.

There is also the possibility to power the wheel with a small electric motor, again from model airplane technology. This will boost the initial part of the takeoff roll and also provide taxiing capability.

Based on R/C model and UAV flight experience it is anticipated that noise will not be an issue in the typical case of overflight at full power at 300m, but this will be tested and confirmed.

TOP experience shows that the profile drag of the rather large TOP unit is 2 Kg at 100 knots where the clean glider drag is about 16 kg. Mounted in the aft wing root area it is anticipated that the twin jet installation when extended will have a drag increment on the glider at 100 knots of 0.8kg (5% of the clean glider) or less (engines are only 130mm diameter and externally are reasonably clean).

For added performance, slightly larger engines of 40 Kg thrust each are becoming available. Future advancements in microjet technology may quickly make their use practical on heavier, 2-seat sailplanes too.

The huge advantage of the microturbines is the possibility to convert existing sailplanes and make soaring a real 21st century sport. Nobody really likes launch queues, dependence on tow pilots and tow planes, and the hazards and inconvenience of outlandings. The aim is to go soaring, not launching or retrieving, and we've been stuck with the inconveniences because the technology of "putting a little engine on it" has been lacking until now.

I anticipate that the microturbine technology outlined above will make soaring far more accessible, convenient and safe. It surely needs to be to continue to thrive into the 21st century.