With Malcolm McBride
Airworthiness Engineer

COCKPIT DECISION-MAKING v REHEARSAL

Malcolm looks at engineering failures which required fast decision-making in the cockpit

What's the connection between a 19th century church organ, a recorder, a Cessna Citation and me? When I asked the LAA's Chief Inspector this question, he immediately said, "Hot air!" Well, Ken Craigie is pretty smart. But if you're interested in my own answer, please read on!

In aviation, it's better to think through possible failure modes when the pressure's off, so, if you're still chewing over the above question, let me put you out of your misery; the answer is 'rehearsal'.

I realised the value of rehearsal as a young cadet trying to learn to fly an aeroplane but, quite often, being rather slow on the uptake. I was pretty good at the 'poling', it was 'list remembering' that made me look a bit second-rate. So I learnt fairly quickly that it was much cheaper to learn a checklist, in the bath for example, rather than being bellowed at for things wrong on the downwind leg!

I still remember the 'drill', another name for rehearsal, that one went through starting the Gipsy Mk 10 bolted into the front of a tired looking de Havilland Chipmunk. 'Fuel on, brakes on, throttle set, mags off... thumbs down (to the ground crew... those were the days), priming.' I suppose, in these slick days where it's considered best not to be too demonstrative, this might seem over-the-top, but not going through the correct starting procedure has just cost one LAA member an awful lot of money in repair bills, and that particular story could have ended up a lot worse than it actually did.

I can remember one instructor saying, "What are you going to do when the engine fails?" Being well rehearsed, in the bath (if you remember), I immediately said, "Land, straight ahead, sir."

"Don't be a twit McBride, there's a wood at the end of the runway."

Here LAA'er Jez Cooke formally briefs his co-pilot before a departure from Turweston in the privately-owned Cessna Citation XLS biz jet he flies in his day job. Jez explained that should something go wrong during the flight then the appropriate emergency 'drills' need to have been discussed and rehearsed beforehand. "When things go wrong, for example an engine out during the take-off, the actions taken to ensure the safety of the crew and passengers need to be automatic," he explained. "Just before I open the throttle on my LAA Midget Mustang I always call out 'eventualities', as it makes me think, where will I go if the engine quits." *(Photo: Malcolm McBride)*

"Fuel on – Brakes on – Switches off – Clear to prime." It is essential for safety to get into the habit of doing pre-start, or in this case pre-prime, checks. Not doing this may lead to disaster if you forget to do something... like priming an engine with the mag switches on or pushing the starter with the throttle wide open.

Was there? I hadn't taken any notice! Since those days I've always said to myself quietly before take-off, 'What am I going to do when the engine fails?' This little 'drill' has saved my bacon a couple of times already!

But first, before we get into the engineering depths, let me tie up my 'connections' story. If you are a regular reader of this monthly safety column, you will know that I'm a bit of an amateur musician. Mostly, I play alto sax, but have

always dabbled a bit with other woodwind instruments, especially old ones. One instrument I've always enjoyed playing is the recorder... "What I want," explained the Vicar, "is for you to come in after prayers. I will give you a little sign, perhaps a raised eyebrow... it will sound lovely. After one verse, which you can make last as long as you like, give the nod to the organist and he'll accompany the congregation in song."

On the due date, one Sunday morning a couple of weeks ago, I arrived early and sought out the organist to chat it through. He, it has to be said, was rather flustered, but heard me out. "What I will do, with your permission," I explained, "is to start tapping the rhythm two bars before your entry. Would you like to rehearse it?"

Looking astonished, perhaps that I should feel this necessary for such a simple thing, he, in a rather fatherly, round-lipped way replied, "No, no, no! That'll be fine." Then, turning his attention to some stop adjustment, muttered, "Now, where's that choirmaster?"

I was clearly dismissed.

I duly positioned myself out of harm's way at the back of the church and, as the service tracked along its well-worn route, kept my eyes on the vicar. Soon enough, with total silence in the church, I noticed the pre-agreed 'eyebrow' signal and off I went. As it turned out, the vicar was right and it did sound very special.

A couple of bars before the end of my bit, I caught the eye of the organist who, in true organist fashion, raised both hands above the keyboard in complete readiness. One, two, three and four. Poised hands descending... this guy knows his stuff... I stop playing, his hands hit the keys.

What followed was, well, absolute silence. The muttering from the congregation started just after the shuffling; one or two enthusiastic singers had started, anticipating, but not receiving, backing – but the song diminished to the spoken word. The organist's face slowly started changing colour as he, and everybody else, realised he'd forgotten to turn the organ blower on!

You might imagine the scene as the hovercraft-like blower motor brought the huge instrument back to life. I made a swift exit as quietly a possible and as soon as I was able, thinking to myself that it would have been better if we had had a rehearsal.

This is a picture of the Pioneer 300 after it had been pulled clear of the shipping container, the damage to the spinner and propeller is obvious as was the damage, after cowling removal, to the engine bearers. After an impact like this it is essential that every part of an airframe is checked as damage can occur a long way from the actual impact point. *(Photo: Toby Wilcox)*

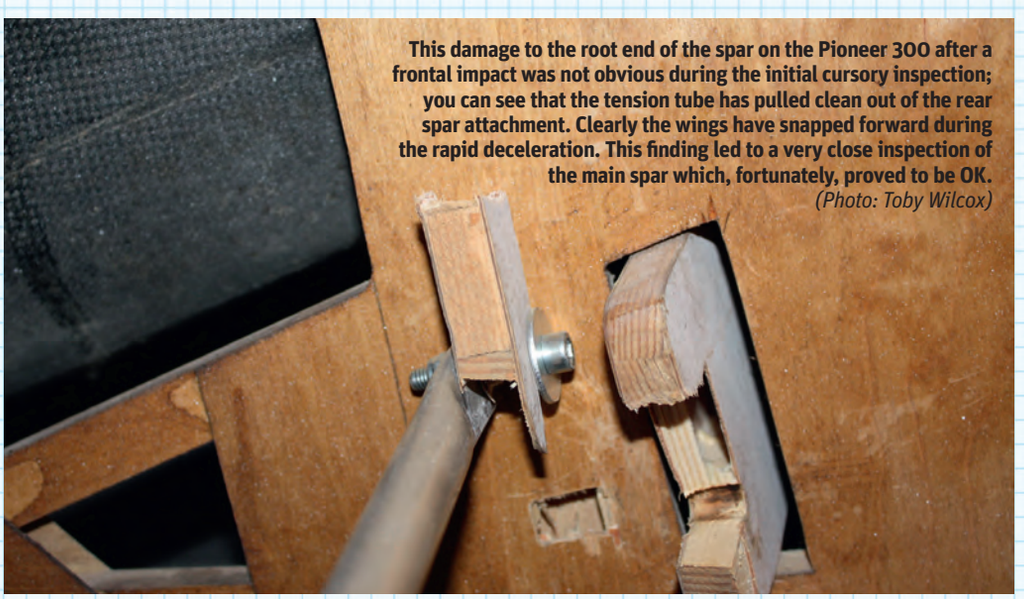
LOSS OF CONTROL ON START-UP IN PIONEER 300

When I joined the LAA as the Airworthiness Engineer, I'd been out of aviation for some time and had therefore missed the Rotax 'Nine Series' invasion. I must admit to being quite taken aback when I discovered that in my absence, they were even cramming this power unit into the back of trikes (my name for weightshift microlights), which seemed then (and now actually) completely over-the-top.

The first time I got to 'have a go' in an aircraft fitted with a 912 was with Francis Donaldson, the LAA's Chief Engineer, on a local air test. I cannot remember exactly what the purpose of the test was, it doesn't really matter, but Francis generously said, "Here, you do it."

OK. Throttle set, etc, push the starter... the engine fired, the engine roared (exaggeration) up to three-quarters power and the aircraft rolled forward, gathering speed. Rather startled by this sudden over-enthusiasm under the cowling, I grabbed the throttle and hauled it back to the idle stop; I managed to bring the aircraft to a halt fairly quickly and, fortunately, no harm was done.

We worked out what had happened as our heart rates returned to normal. I have a habit of loosening the throttle friction before start-up, Francis hadn't noticed this. I had set the throttle but, because of the unusual throttle spring arrangement on this engine, a feature I was not aware of, the throttle is strongly biased to full throttle. The bias was strong enough to (albeit slowly) overcome the drag in the throttle operating linkage and open the throttle quietly without anybody noticing. I made a note that this aircraft would have failed the air test ➤➤



This damage to the root end of the spar on the Pioneer 300 after a frontal impact was not obvious during the initial cursory inspection; you can see that the tension tube has pulled clean out of the rear spar attachment. Clearly the wings have snapped forward during the rapid deceleration. This finding led to a very close inspection of the main spar which, fortunately, proved to be OK. *(Photo: Toby Wilcox)*

as far as I was concerned because I considered this a dangerous feature. What I didn't realise at the time was, by doing this, I was stepping into an ideological hornet's nest.

"No, no!" exclaimed one Rotax agent, "This is a safety feature 'designed' in."

I hadn't heard of 'designer' throttles before on light aircraft, but it was explained that it was far better for a throttle to go to full throttle if the operating cable failed than the engine power fall to idle. Thinking that it was better to design a system where the throttle cable couldn't fail and wondering if there were any 'drills' for managing a flat-out engine in the air, I remained unconvinced.

Earlier this year I had a call from LAA Inspector Roger Targett, asking how he should manage the serious damage to a Pioneer 300 that had just been wheeled into his repair shop. I asked how the damage was done as we hadn't had any recent report featuring Pioneer aircraft. Roger explained that the aircraft had been started and the power had gone straight to full. The owner, a chap new to the aircraft type, was caught by surprise and the aircraft had surged forward across a taxiway crashing into a large shipping container, completely destroying the rear spar connections of both wings. Fortunately, the pilot only suffered minor injuries, but it was some months before the aircraft returned to the air.

The pilot, a very experienced glider pilot, was unaware that this was a 'reportable' accident, perhaps thinking that because he wasn't airborne it didn't count as one. Regular readers will know that this isn't the case; if there's an intent to fly and there's an incident, there's a legal obligation on the captain to inform the Air Accidents Investigation Branch. I spoke to the owner after he had recovered his equilibrium; here's his story in his own words.

I decided to have a fly. The weather was CAVOK. The time was 11.45am. My pre-flight inspection completed exteriorly, I sat in the aircraft and worked through the checklist carefully. On this occasion the engine did not start. I decided to complete the DI and start again, which I did.

The throttle was closed, i.e. pulled fully toward me, I thought. I turned the key, the engine immediately burst into full power. The aircraft rushed forward, onto the apron, across the taxiway and into a steel container, even with the brake on. The brake is set on this aircraft with a small lever on the middle consul. It seems that I had not tightened the lock enough on the throttle. The damage to the aircraft was extensive.

The lesson for me is to never start an engine unless the aircraft is facing a very clear area. Ironically, I was intending to fit toe-brakes, which may have given me a little more time.

Since the accident, many people, including you, have told me of the likelihood of this happening with the Rotax engine, due to the strong spring on the carburettor.

Yours truly...

I think that the primary reason for this expensive incident is that the pilot failed to go through the pre-start drill from the beginning on his second attempt at starting the engine. This is a common human error in this type of incident and, perhaps, the primary lesson to be learnt here is that if, for any reason, you interrupt an operation before completion, it's essential that you restart an operation from a fixed reference point... normally the beginning!

The real reason for the 'bias' on the Rotax engines is, of course, the fact that the carburettors used are designed to be pull only, in other words, the return is powered by a spring. Nigel Beale, the UK agent for Rotax engines points out that a simple way to address this issue is to have a balancing spring in the throttle cable system, which counters the action of the carburettor spring, for as long as cable remains attached. This way the carburettor spring only takes over in the event that the cable breaks, and in normal operation the pilot is spared the need to keep tight hold of the throttle control when starting and taxying.

Still wondering whether a bias to full power was a good idea, and thinking that I hadn't heard of a throttle cable failure on an aeroplane recently so it probably wasn't important, I received a call from an owner who had just enjoyed an interesting flight in a Glasair during an initial air test. You've guessed it, the throttle control had failed.

GLASAIR SUPER IIS RG: THROTTLE LINKAGE FAILURE

I received this letter from Les Hitchins, who is just coming to the end of the build of his Glasair. Les has spent a lifetime in aviation, first as an RAF boy entrant at Cosford, completing the Mechanics then the Fitters courses then as a Flight Engineer on both the Short Sunderland and the Avro Shackleton. An interesting career. Les started building the Glasair as a retirement project; his last job was as a Flight Engineer working for Virgin Atlantic 'managing' a Boeing 747.

Certainly the Glasair must fall at the top end of the performance/complexity spectrum of homebuilt machines and, in my view anyway, hats off to anybody with the stamina required to complete this one tonne, 260mph machine. Les first registered his project in November 1997 and the aircraft first took to the sky under an LAA Permit Flight Release Certificate (PFRC) in October 2011. As I write, it is just about to restart the test flight programme after mechanical changes to the engine controls.

I have slightly edited the letter...

Dear Malcolm...

I have to report that my aircraft made an emergency landing at RAF Brize Norton. The aircraft was flying on a PFRC and was flown by LAA Test Pilot, Dan Griffith, with myself as observer. The aircraft had done 5 hours of flying when, in the vicinity of Chipping Norton, we lost control of the throttle.

The power available was set to approximately 60%, which gave us the healthy speed of 140kt and we had ample time to weigh up all our options. Brize Norton was close and offered a 3,000m runway so an emergency was declared and an uneventful landing made at that airfield.

An investigation was made after landing and the throttle had become detached from the injector throttle arm. The bolt, which attached this arm, was found later in the cowling with the thread stripped. The condition of the bolt looks like it had been subjected to a torsional load...

In my view there are two possibilities for a stripped bolt.

1. The nut used, which should have been an imperial threaded AN363 (10-32) may have mistakenly been a similar-looking metric size and the threads were stripped when assembling. I feel that this is highly unlikely as all my hardware is UNF, so I dismissed this.

2 The other possibility that sprang to mind was the

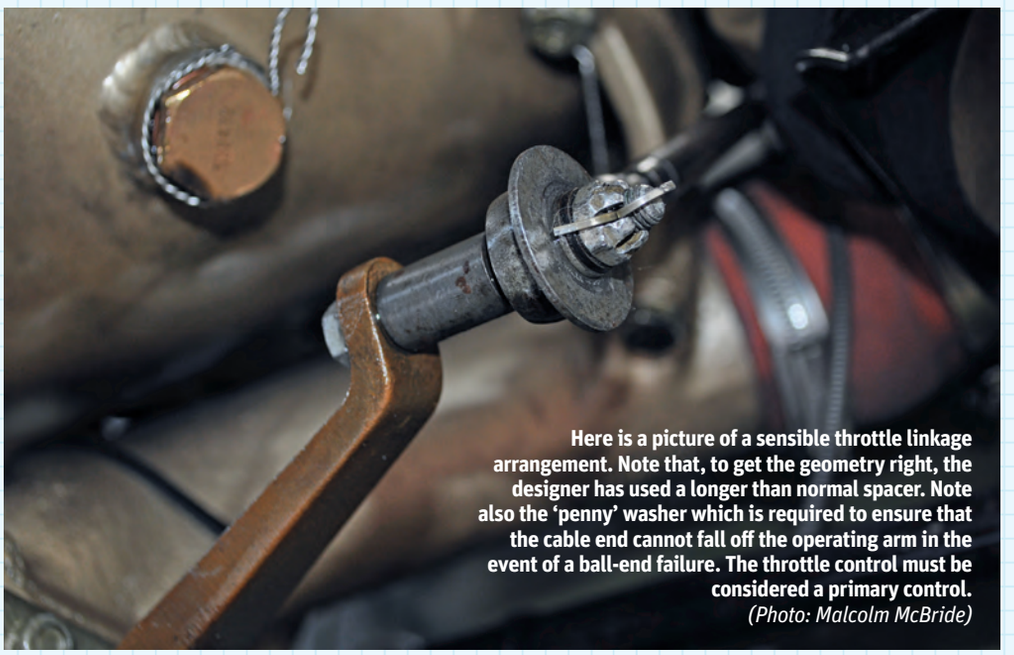
Here is the control connection to the mixture control on a Marvel Schebler carburettor... it was a bit difficult to get enough light on it but I hope that you can see that this connection, whilst adequate for a mixture control, may not be for a throttle linkage. *(Photo: Malcolm McBride)*

geometry of the control may have overstressed the bolt/nut attachment, stripping the thread. I reassembled the control with the same components and I found that the angle that the control made at the throttle closed position was slightly bowing the push-pull control and, as I suspected, putting a large stress on the attachment.

To rectify this latter problem, I have changed the throttle arm which has a much smaller step, which reduces the angles. I have also changed the bolt to an AN3-7 with a castle nut and split pin.

I have attached the offending bolt for your examination.

Regards, Les.



Here is a picture of a sensible throttle linkage arrangement. Note that, to get the geometry right, the designer has used a longer than normal spacer. Note also the 'penny' washer which is required to ensure that the cable end cannot fall off the operating arm in the event of a ball-end failure. The throttle control must be considered a primary control. *(Photo: Malcolm McBride)*

Here is a picture of the throttle attachment bolt that failed on the Glasair IIS RG during an initial air test, you can see that the threaded portion has stripped. The most likely explanation for this is that a metric nut was used by mistake, an easy mistake to make. After the failure the owner decided to completely review the throttle linkage geometry to ensure that unnecessary side loads were removed at all points in the range. *(Photo: Malcolm McBride)*

I spoke to Dan, the LAA's Chief Test Pilot, who flew the aircraft for its test flight; he explained that the real problem was that the gear and flap-limiting speed was 140mph and the throttle setting meant that the airspeed in level flight was something over 160mph. The good thing was that, because the throttle wasn't biased in any way, there was 'ample time to weigh-up the options.' Dan managed, by 'pulling' some high-g turns, to get the speed down below Vf and therefore was able to get the flaps and gear down.

The aircraft had departed from Enstone, which has a superb 1,100m east-west asphalt runway; this was an obvious option for an emergency landing. Dan however decided to declare an emergency and opt for Brize Norton, a military airfield only minutes away. Dan explains, "In an emergency situation always choose the best option, Brize's runway is 3,000m longer… an extra 6,000ft to get something difficult right in." Dan added, "Should the worst happen and you do get it wrong, there's a superb emergency service back-up."

I agree with the choice made completely, and the general advice is superb…

Dan managed to get the aircraft on the approach to Brize and, at about 300ft over the beginning of the runway, pulled the mixture back to idle cut-off, landing the slippery machine, engine out, in the middle of the runway – even managing to juggle with the mixture to roll clear at the next taxiway… textbook, well done.

I've taken a couple of shots of the bolt Les sent in to us. If you recall, Les felt that there were two reasons why this primary control system had failed, I vote for the first one, the wrong nut, although I agree that it is essential to get the operating geometry absolutely correct before committing to flight. It seems very unlikely that the forces that could be applied by the pilot could be anything like strong enough to strip a 3/16in bolt. Les, and his inspector have now changed the throttle arm and bushed the connection correctly, so that there are no tight spots through the lever's operating range.

This is an example where rehearsal wasn't really needed as there was plenty of time to formulate a plan. Also, it is an example where a throttle linkage has failed and the power setting has remained the same. If you recall, in the case of the Pioneer, the throttle was biased to full.

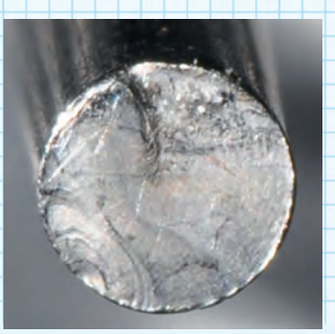
Just to round this story off, guess what? We've just had another throttle linkage failure; this time the pilot, LAA member Paul Jones, having rehearsed his field landings regularly in his capacity as CFI at the Derby Aero Club, did a fantastic job landing the aircraft in a field after the engine quit.

MURPHY REBEL ELITE: THROTTLE CABLE FAILURE

Well, the engine didn't actually quit, that wouldn't be completely fair on the Wilksch WAM 120 three-cylinder, diesel unit, it just went back to idle, which has a very similar effect. In the case of the WAM engine the injector unit is biased to closed so, in our general discussion around the very great benefits of rehearsal and the debate about the pros and cons of throttle bias, we now have a 'full house' of things to think about.

Paul was conducting general handling checks, including stalls, on this virtually brand new Murphy Rebel Elite before completing the pre-certification flight test. I took a quick look at the database and noted that there ➤

When I first heard about the cable failure on Nigel Smith's diesel-powered Murphy Rebel Elite, I felt sure that the cable had pulled out of the fitting. This proved not to be the case when Nigel found the broken end. Piano wire is manufactured from tempered high carbon steel (sometimes referred to as 'spring steel) with an ultimate tensile strength of at least 300,000psi. Nigel's throttle cable was made from 14swg wire which means that it shouldn't fail before a load of about 900lb is applied to it… not likely, even during a jam case. You can see, from this photo, the mode of failure: the notch (at about seven o'clock) has led to a stress concentration and this cable has probably failed because of fatigue in bending. How this could have occurred is a bit of a mystery. The picture right shows the point of failure. *(Photo: Malcolm McBride)*



are four other Elites flying but we have eleven other aircraft under construction by LAA members. This kit-built aircraft was registered with the LAA by airline pilot Nigel Smith in 2003 and is the only example (so far) of a Wilksch-powered Elite flying.

After Nigel had recovered his aircraft (and informed the AAIB of the incident) he wrote to me explaining what he had found.

Hi Malcolm,
As promised a description of my failure that led to the forced landing yesterday. The power control (and standby power/fuel shutoff) in my aircraft are single core (piano wire type) cables with spiral surrounds, similar to ACS part No A-820 05-09436.

They are attached to the engine via a wire grip (ACS 05-16000) and an Aurora type rod end bearing. The spiral surround on the cables is terminated exactly at the control levers side of the 3 post securing bracket mounted on the engine.

In cruise at about 1,500ft the power cable broke at the point where it exits the wire grip (as shown by the pointer in the picture). The short length inside the wire grip was removed later during examination – the cable had not simply pulled out of the wire grip.

The engine wound down to idle, and the test pilot (Paul Jones from Derby) did a superb job in landing it undamaged in a 205m field of longish grass. The broken cable was refitted and after extensive power checks the aircraft was flown out of the field and returned to Derby.

I would recommend that anyone using single core cables of this type ensure that a spring is fitted to the control arms on the engine to ensure the power and fuel shut off arms will travel to full open under spring action in the event of a cable brake.

I am also changing the power cable in mine to a Cessna type threaded end multi core cable.

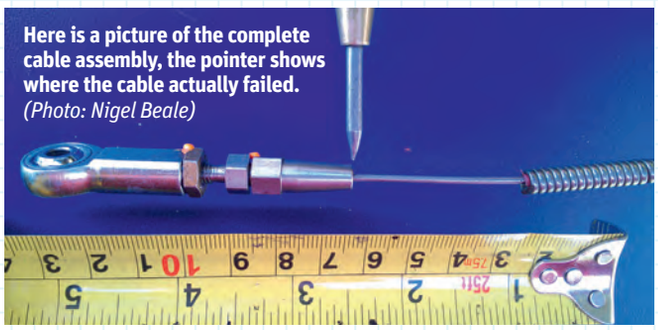
Best Wishes, Nigel.

Nigel seems to feel that the pilot would have been in a better position if the engine had gone to full power rather than idle and implies that this should be a design feature where single core actuating cables are used. I have a slightly different view, based upon the premise that the throttle control is a primary control and any design needs to take this into account; failure shouldn't be an option.

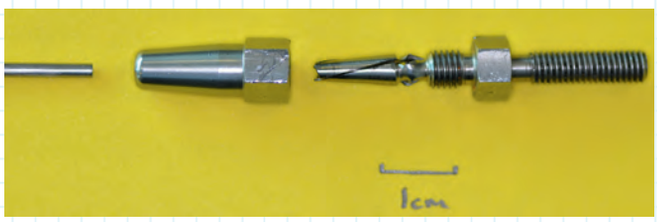
We have seen, on our journey this month, three failures (well, four if you count our errant organist) that centre on the failure of throttle control. Two of the failures ended up in forced landings fortunately, primarily due to good pilotage, with no lasting damage. One failure ended up with injury and substantial airframe and engine damage; the common feature with all these incidents was that the aircraft were new to the owners.

I asked Nigel where I should send the throttle cable as I had finished examining it – he suggested the LAA's Black Museum... "I'm re-designing the throttle with an appropriate operating cable." I think that this is a good idea and I'm looking forward to seeing Nigel's machine when he brings it over to Turweston shortly for a handling evaluation.

Fair winds! ■



Here is a picture of the complete cable assembly, the pointer shows where the cable actually failed. *(Photo: Nigel Beale)*



Here is a picture of the Wire Grip type end fitting used on the piano wire throttle cable from the Wilksch WAM engine that failed during a test flight on Nigel Smith's Murphy Rebel Elite, putting the aircraft into a field. I've not seen this type of connector before. You can see that the piano wire (left in the picture) is pushed through the barrel into the tapered clamp. I was very impressed with the clamping force applied to the piano wire even when only hand tight although, whilst this sort of fitting might be OK for a heater control I personally don't think that it should be used on a primary control. Nigel, incidentally, had already made that decision before chatting to me and he has now replaced the throttle cable with a Teleflex cable. One good thing about this type of fitting is that a standard ball end can be used which, in my view, has to be better than crushing the cable between a nut and bolt, an often-seen tertiary control system practice. *(Photo: Malcolm McBride)*

G-ONIG is in the paintshop as I write

LAA ENGINEERING SCALE OF CHARGES

LAA Project Registration	
Kit Built Aircraft	£300
Plans Built Aircraft	£50
Issue of a Permit to Test Fly	
Non-LAA approved design only	£40
Initial Permit issue	
Up to 390kg	£320
391 - 499kg	£425
500kg and above	£565
Three seats and above	£630
Permit renewal	
Up to 390kg	£105
391 - 499kg	£140
500kg and above	£190
Three seats and above	£210
Modification application	
Prototype modification	£45
Repeat modification	£22.50
Transfer	
(from CofA to Permit or CAA Permit to LAA Permit)	
Up to 499kg	£135
500 kg and above	£250
Three seats and above	£350
Four-seat aircraft	
Manufacturer's/agent's type acceptance fee	£2,000
Project registration royalty	£50
Category change	
Group A to microlight	£135
Microlight to Group A	£135
Change of G-Registration fee	
Issue of Permit Documents following G-Reg change	£45
Replacement Documents	
Lost, stolen etc (fee is per document)	£20

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