THE CREATION OF A FORMAL TEST FLYING SYSTEM WITHIN THE BRITISH MICROLIGHT AIRCRAFT ASSOCIATION AND A DISCUSSION OF THE SPIN TESTING OF MICROLIGHT AIRCRAFT

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Synopsis

The UK microlight aircraft community, under the guidance of the British Microlight Aircraft Association (BMAA), has developed a formalised system for the training and qualification of civil test pilots on this class of aircraft. This system is unique in Britain where most of the rest of the industry relies upon a pool of military-trained test aircrew, most of whom have no experience of microlight aircraft.

This paper describes the system operated by the BMAA for the training and qualification of test aircrew. It also goes on to describe the issues of spin evaluation of microlights, which has recently been required for the first time by changes to UK regulations. The results from three certification spinning programmes, the third only just begun, are presented, along with the BMAA's recommended schedule for the spinning evaluation of such aircraft.

Introduction

Microlight Aircraft in the United Kingdom (some of which are also known as "Small Light Aeroplanes, or SLAs) have been classified historically as fixed wing aircraft with an MTOW not exceeding 390kg, and a wing loading or no more than 25 kg/m². More recently this definition has been altered by the introduction of a revised definition of an MTOW not exceeding 450kg for 2-seaters, or 300kg for single-seater, and Vso not exceeding 35 kn CAS. Of approximately 3500 such aircraft in the UK, about 3100 are under the airworthiness supervision of the British Microlight Aircraft Association (BMAA), through delegation from the UK CAA. These aircraft fall into three categories: weightshift (also known as flexwing), 3-axis, and powered parachute (see figure 1 below). The three are flown on a single license, but with separate type ratings.

Figure 1, Classes of microlight aircraft

Fig. 1a, typical weightshift microlight (Mainair Blade)

Fig. 1b, typical 3-axis microlight (Thruster T600N)

Fig. 1c, typical powered parachute microlight (Buckeye)

In 1997 a review was made of the way in which test flying was carried out within the community of 3,100 aircraft and 4,500 pilots that is the British Microlight Aircraft Association. This review was carried out by the incoming BMAA Chief Technical Officer, an experienced FTE, who also happened to be a Microlight Pilot.

The approach at that time was found to be largely very informal. Using standard test schedules (see figure 2 below), testing would often be carried out by the owner (so long as they had a reasonable number of hours on type) or a local Flying Instructor or Airworthiness Check Pilot.

Figure 2, extract from a standard flight test schedule

4a. FLIGHT TEST - stability and control (3 axis)

4a.1	Gradually to full right roll control and opposite yaw control	IAS: (Trim speed)	Control forces and deflections keep increasing with sideslip: (YES / NO)
4a.2	Gradually to full left roll control and opposite yaw control	IAS: (Trim speed)	Control forces and deflections keep increasing with sideslip: (YES / NO)
4a.3	Gradually to full right roll control and opposite yaw control	IAS: (Approach speed)	Control forces and deflections keep increasing with sideslip: (YES / NO)

The examination of this system concentrated upon two areas, safety and reporting competence.

Safety

Although an FTE primarily regards his Test Pilot as a calibrated report writing tool, there is no doubt that he also would prefer the return of the aircraft. Despite the lack of formal test flying training the rate of accidents to microlight aeroplanes under testing was remarkably low. Where accidents did happen, reports indicated that these had generally been handled in a competent manner by the handling pilot.

The indications were that a high standard of microlight pilot training in the UK was responsible for this, combined with an unusual safety culture. Throughout their training, microlight pilots (who after all are flying single engined aircraft with uncertified engines) are subject to regular engine failure practice, usually with PFLs being continued to treetop or hedgetop height. A healthily "macho" culture pervades British microlighting, where pilots pride themselves on the ability to handle engine failures and other in-flight emergencies without further aircraft damage and practice these regularly. This, combined with a class of aircraft capable of emergency landings in incredibly small (100m) fields led to a minimal accident rate, even in the case of in-flight failures during testing.

Reporting Standards

This is the area where the BMAA's previously informal approach to flight testing broke down badly. Even where flight test schedules comprised of simple "tick-box" or "hole-filling" sheets, large amounts of information was missing or ambiguous.

The approving Engineer was often forced to go back to the assessing pilot several times for further information because of a complete lack of understanding of what had been required. Typical misunderstandings included pilots who believed a spiral stability test was a test of the aircraft's ability to recover from a spiral dive, failure to identify pitch or force stall cues, the word "satisfactory" written across a page of detailed questions, or extremely subjective assessment of longitudinal static stability. The high proportion of "unacceptable" flight test reports was unsustainable.

Invention of a test flying system

It was decided in the first instance to define three grades of "assessing pilot". These were classed "Test Pilot Class 1", "Test Pilot Class 2", and "Check Pilot". With further refinement this was broken down as follows: -

Test Pilot Class 1 or TP1

Qualified to carry out first flights of new aircraft types as well as lesser tests. This will be a highly experienced microlight pilot able to recognise flight test characteristics and able to produce clear and concise flight test reports.

Normally such a person should have at least 500 flying hours as captain of aircraft in the same or similar classes as those which he or she is to be qualified to test.

Test Pilot Class 2 or TP2

Qualified to carry out first flights of production aircraft and tests where flying qualities may have been modified as well as lesser tests. This should be an experienced microlight pilot able to recognise flight test characteristics and able to produce clear and concise flight test reports.

Normally such a person should have at least 300 flying hours as captain of aircraft in the same or similar classes as those which he or she is to be qualified to test.

Check Pilot

Qualified to fly aircraft on which they have sufficient experience for validation of a permit to fly, or for assessment of low risk modifications (such as new propeller configurations).

A competent microlight pilot,with at least 150 hours as captain of microlight aircraft and no recent record of dangerous or illegal flying.

The Check Pilot qualification already existed and some 200 pilots were qualified in this category. Two existing test pilots, who had previously carried out considerable company development test flying as well as BMAA test flying were automatically placed into the TP1 category; however this left a huge gap in the middle (and only two pilots capable of carrying out testing on new aircraft types).

It was then decided, as a means to determine who amongst the existing "Check Pilot" community was competent to enter the TP2 category, to examine invited individuals. An open-book examination was prepared in consultation with the CAA, which was set to about 20 such individuals who had carried out assessment flying in the past at various levels. Whilst less in-depth and with only limited mathematics, this examination covered some performance elements, and all of the planning, handling, and trial management subjects which might be met on an approved Test Pilot School course. Additional site selection, and flexwing stability subjects were also included.

To the considerable embarrassment of all concerned, only one person passed this examination (a former microlight manufacturer's company TP who was at the time the reigning world single-seat microlight champion with some 5400 hrs in microlight aircraft). This concentrated the mind and as an initial solution, a self-paced training syllabus was produced (Reference #1), this particularly makes use of References #2 - #5. This, together with arranged availability of experienced flight test personnel managed to create two further class 2 test pilots - a sufficient number to handle most test flying being conducted at that time, although sadly they proved to be geographically concentrated in one part of the country.

Further Development of the Test Flying System during 1999 and 2000

As the supply of people already within the microlight community who understood the issues involved in test flying started to dry up, various other events tended to increase the amount of test flying required. In addition, the lack of test pilots in certain parts of the UK, particularly Scotland and the North of England became something of an embarrassment. Two events however alleviated this, one planned, one merely fortunate.

- It was decided by the BMAA to initiate short, highly intensive training courses for prospective test pilots. The first of these was in early 2000 and was extremely well received.
- A number of former military or civil test pilots started to notice and identify this new microlight test flying system as a suitable part-time diversion from either retirement or airline flying.

Although military or heavy aircraft test pilots are not automatically suitable for microlight test flying, it is usually easier to train an experienced test pilot to fly microlights than a microlight pilot to carry out test flying. Nonetheless, both avenues are proving fruitful and at present the BMAA, after 3 years, has 3 class 1 test pilots, 5 class 2 test pilots, and around 200 check pilots. To place this in perspective, the BMAA has at any time 15 - 20 aircraft around Britain under "approval" test conditions, and conducts 2000 - 2500 airworthiness check flights annually.

The Future of the BMAA Test Flying System

- The BMAA will continue with the fruitful short, intensive test flying courses for it's more experienced check pilots - probably hoping to train around a dozen per year (of which perhaps 20% may make it to TP2 status).
- The pairing of ex-military test pilots with limited microlight experience, with experienced microlight pilots with limited testing experience has been attempted and may yet prove a highly fruitful method for generating useful test aircrew.
- For certain tasks the use of an FTE in conjunction with an unusually qualified pilot has proved useful where no suitable TP could reasonably be available (e.g. the testing of special flying controls for amputee pilots). Although not currently being explored, in-house training of several new FTEs may also be useful, particularly where these can simultaneously act as safety pilots.
- From late 2000, it is intended to run an annual "standardisation" seminar, to permit the geographically scattered BMAA test pilots to present papers and compare notes upon safety lessons learned.
- The next area for examination will be the standard of airworthiness check flying. From 2001 it is hoped to introduce mandatory training and assessment of new check pilots (probably around 1 day per pilot) and an approximately biannual mandatory seminar to ensure consistent standards and promulgation of best practice.
- At present discussions are well advanced between the BMAA and Royal Aeronautical Society with regard to recognition of the BMAA test-flying qualifications for appropriate RAeS membership grades.

Recent Experiences In the Spinning Evaluation of Microlight Aircraft

I came to microlight flying late in life, and became a Flying Instructor. After a couple of years doing part time instructing at a local flying club, I learned of the need for microlight test pilots, and offered myself for qualification. I had been a helicopter test pilot, but there are very great differences in the requirements for microlight handling and certification. I eventually qualified for a Test Pilot Second Class appointment, just at the time when there was a burst of spin testing being planned.

I had hoped to be able to report on the results of spin testing three aircraft. However, the third programme has only just begun, having been delayed because of weather. It is hoped that it will be under way in the near future.

X'Air

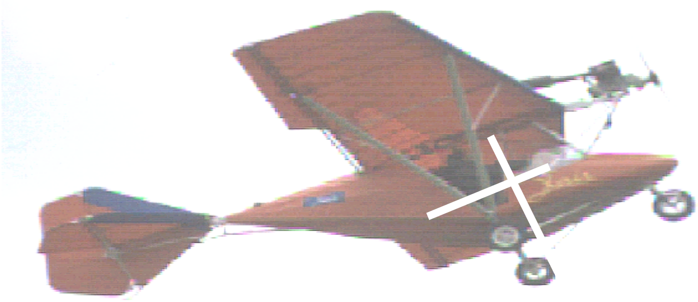
The Indian company, Raj Hamsa has designed and built a kit-plane two seat enclosed cockpit microlight which is called the "X'Air". Several British companies and individuals began to import the aircraft, and it was necessary to introduce Permits to Fly for the type. It was being introduced at the newly acquired higher MAUW of 450kgs, and it needed to satisfy the requirement in British Civil Airworthiness Requirement S221:

"For any aeroplane that is not controlled by weightshift:

a) The aeroplane must be able to recover from a one-turn erect spin or a 3 second erect spin, whichever takes longer, in not more than one additional turn, with the controls used in the manner normally used for recovery….

b) It must be impossible to obtain unrecoverable spins with any use of the controls"

Figure 3, Raj Hamsa X'Air.
(Crossed lines show approximate horizontal and vertical CG positions)



Note distance from prop!

Safety Considerations

Microlights are placarded that no intentional spinning or aerobatics are permitted, and I certainly had no experience of spinning microlights. We were very conscious of the safety implications of the test programme, and stuck pretty much to the guidance contained in the BMAA's Technical Information Leaflet No 25,Guidance on the Spin Testing of Microlight Aircraft.

The crew for these initial tests was BMAA CTO Guy Gratton and TP Second Class Tom Porteous. (I think if I had been the CTO I would have insisted on a TP First Class!!) We waited for a day in which there was clear air up to 5000ft, at least in patches. This altitude permitted us to establish in a spin and gave us time for several combinations of recovery control input should standard recovery action be unsuccessful.

For the event of unsuccessful recovery, the aircraft was fitted with a Ballistic Recovery System located within the fabric-covered fuselage. Its purpose was to bring the whole aircraft and its occupants gently to earth in the event that a spin was entered from which the aircraft could not be recovered. The system is activated by a pull handle in the cockpit, ballistically launching a drogue and parachute through the fabric side wall of the fuselage, the whole being secured to the centre section of the wing. My worry about using this system is that once it is deployed, the pilot has no control over where the combination parachute and aircraft will land. However, the use of personal parachutes was not an option during these first tests, and so we went along with this arrangement.

We tried wearing hard helmets for the tests, but found that the cockpit size was very restricting, and we decided do forego this protection and wore only intercom headsets.

Spin Tests

The BMAA recommend that tests as detailed in Fig 4 are completed.

Figure 4 , Recommended test grid for a "simple" microlight aircraft spin evaluation (minimum 48 spins)

	No. turns			Entry		Mishandled Spin				Mishandled recovery		
Spin No. (a)	¼-½ turn (b)	1 turn (c)	2 turns (d)	std entry (e)	Entry from steep turn (f)	½ in-spin aileron (g)	½ out-spin aileron (h)	Cruise Power (i)	Full Power (j)	Stick held back (k)	Full power (l)	Full opposite rudder held in (m)
#1	X			X								
#2		X		X								
#3			X	X								
#4		X			X							
#5		X			X			X				
#6		X		X				X				
#7		X		X					X			
#8			X	X					X			
#9		X		X			X					
#10		X		X		X						
#11			X	X						X		
#12			X	X								X
#13		X		X							X	
#14			X		X			X				

(1 each L & R; tests #1-#5 carried out at fwd; then mid, then aft CG; tests #6 - #14 at aft CG only; aircraft considered 'spin resistant' if test #8 is reached without a successful spin entry.)

The first spin test flight in the X'Air was with the CG 7'' forward of datum. We were able to climb to 5000ft agl between some large cumulus clouds, and commenced the tests. The aircraft showed that it was capable of spinning both left and right, with normal entry conditions of power off, wings level by use of aileron, full rudder in the direction of spin and control stick hard back against the aft stop at about three knots above the stall (Vs 32kias). After one turn of the first spin, standard spin recovery action was taken. No sooner had the rudder control reached the central position en route to full deflection in opposition to the spin than the aircraft immediately came out of the spin. This happened each time we began our recovery, and we reached the conclusion that for this microlight, the normal spin recovery action was to centralise the controls and ease out of the ensuing dive. In all recoveries, the spin ceased after about half a turn. Height loss was in the order of 400ft and time from entry to recovery was about 4 seconds.

Our report concluded that in all spins, rotation ceased immediately upon centralisation of the controls. The aircraft then slowly regained the level flight attitude without any further pilot input, taking 4 – 5 seconds to do so. The 1 turn spins to the left were at a constant rate of 10 seconds per turn, and the maximum normal acceleration experienced during the spin and recovery was +2g. The pitch attitude was approximately 45° nose down during the spin, and the characteristics were stable, with no noticeable tendency to tighten or become oscillatory. To the right, a rate of 7 seconds per turn was noted, and the maximum acceleration during the spin and recovery was 2.5g. Pitch attitude was the same as to the left, with no noticeable oscillations, but the spin did seem to be tightening and increasing in rate. Care had to be exercised during the recovery because of the low Vne, 83kts.

We completed 8 spins on this trip, before we both noticed an unusual high vibration. We discontinued the tests and returned to base. Nothing unusual could be found on the aircraft, and we put the vibration down to normal microlight characteristics, and a bit of pilot concern on initial spin trials!.

A few days later, additional spins were tested, with CG 6", 5" & 4" forward of datum. Entries were with and without power and some were with controls being deliberately mishandled. Some spins were of two turns, and it was established that there was a tendency when extending the number of turns for the spin to become a spiral dive. In total, 44 spins were flown during the whole spinning programme, and the aircraft obtained its type acceptance.

Thruster T-600

The Truster T-600 is a development of the Thruster TST, and is approved for MAUW of 450kgs. In its basic form, it has an enclosed cockpit. This aircraft is the product of Thruster Air Services which operates its own test organisation under approval of the CAA. The test programme included spinnning with tests from S & L power off and on, spins from turning flight power off and on, and spins with outspin and inspin aileron. In all, 36 spin attempts were required at forward CG and 36 at aft CG.

Safety Considerations

The aft fuselage consists of a sturdy tube at the end of which there is the tailplane and fin/rudder. A BRS was fitted to the outer back wall of the cockpit. This time there was no fabric to be burst open in the event the parachute had to be deployed.

On this occasion, the owner of Thruster Air Services, who is a microlight pilot as well as an engineer, acted as test observer. He came along also because I had not flown a Thruster before, and his company strip is very short with high hedges at the threshold! Nevertheless, I do not recommend that you take along an engineer who has intimate knowledge of the construction of the microlight you are about to spin. He spent half his time in the spin saying "I never knew the wings would do that!"

Tests

The day of the tests could not have been more perfect. Early during the first series of tests, there were a few small cumulus clouds with their bases just above 5000ft. However, these quickly burned off, and for the rest of the day there was not a cloud in the sky, nor was there any turbulence. The programme went so well that we completed all 72 spin attempts on that day.

For the forward CG series, we locked 14kgs of lead forward of the rudder pedals, and for the aft CG tests, we secured 1.4kgs to the tail skid. The aircraft has a nose wheel, so the skid would not bump over the ground and dislodge the ballast.

We found that, at forward CG, 22 out of 36 attempts to spin were successful, ie we obtained a true spin. At aft CG, 17 attempts out of 36 were successful. Most of the unsuccessful entries resulted in spiral dives, and 3 attempts resulted in the aircraft's refusal to do other than wallow around. These were at forward CG to the left, power at idle, in-spin aileron, and at aft CG to the right with ailerons neutral, one with power at idle and one with power for level flight. Of the successful spin entries, we found, again, that the aircraft recovered before the full standard spin recovery control input could be effective, and, as in the X'Air, the recovery action was to centralise the controls. Height loss was again about 400ft from entry to recovery, recovery took about half a turn and time from spin entry to recovery was about 5 seconds.

Thruster Development

Floatplane Version

The Thruster now comes in a floatplane variant. In order to keep within the 450kgs weight limit, the enclosure of the cockpit has been removed. This means that there is no place to locate the BRS, and so we are stuck with using personal parachutes for the floatplane spin tests.

Because the spinning characteristics of the “open cockpit” thruster were unknown, we decided to spin this variant in its wheeled version before configuring it as a floatplane. We hired parachutes for the short spin evaluation flight from a gliding school, and were pleasantly surprised that we were able to sit in reasonable comfort for the tests.

It soon became apparent that the open cockpit version spun just like the enclosed version. The sideslip effect was very noticeable after about half a turn of the incipient spin.

Figure 5, Thruster T600 Floatplane variant

Floatplane Considerations

I have not flown a floatplane yet, but have read extensively, particulary the writings of Darrel Stinton. If anyone in our audience has experience of floatpalne operation or testing, I would be grateful to discuss the project with them.

With no practical experience of spinning floatplanes and because of the change in disposition of weight due to the 60kgs weight of the floats, our design engineer has commissioned a mathematical study of the moments of inertia which will affect the rotation of the aircraft. To give us some insight into the “before and after” effects, we have obtained the 1940s test report of spinning a float-equipped Spitfire. The results were contained in a concisely worded Conclusion to the Report,

“The spinning characteristics of this aircraft are similar to those on the landplane and are satisfactory.

In all cases tested, recovery after two turns was effected in a maximum of 2¾ turns, with a corresponding height loss of 3000ft"

Fuselage Fill-in

Another project with the Thruster is to redesign the area aft of the cockpit, and fill-in the area with a lightweight fuselage. It is calculated that this will increase the cruise speed by about 20%. This will increase the cruise speed to about 72kts. Vne for the Thruster is 80kts, and so we will carry out tests to increase the Vne. I'm assured that this will be achievable, because when the Thruster was originally introduced into the UK, the Vne was 100kts. I have no idea why it was reduced to 80.

Conclusion

In this short article we have shown you how the British Microlight Aircraft Association deals with the qualification and appointment of test pilots, and what we have done by way of spin testing these small aircraft.

References

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#3 Flight Testing Homebuilt Aircraft, Vaughan Askew (ISBN 0-8138-1308-5)
#4 FAA AC90-89A, Amateur-Built Aircraft and Ultralight Flight Testing Handbook
#5 FAA AC23-8, Flight Test Guide for Certification of Normal, Utility, and Acrobatic Category Aeroplanes.
#6 BMAA Technical Information Leaflet No. 25, Guidance on the Spin Testing of Microlight Aircraft