CAA Review into AAIB Recommendation 2017-003

Requirement

Following the tragic accident involving Hawker Hunter G-BXFI at the Shoreham air show in 2015, the handling differences between different aircraft types were reviewed.

Accordingly, the following Safety Recommendation was made by AAIB:

> *Safety Recommendation 2017-003. It is recommended that the Civil Aviation Authority review the grouping of aircraft types in display authorisations to account for handling and performance differences it considers significant.*

The CAA response to AAIB 2017-003 was:

> *The CAA will review the list of different categories of aircraft relevant to a pilot display authorisation, including renewal, and assess the impact of differing handling techniques between each category. This is a complex piece of work and so we will conduct this review, publish our findings and amend our procedures by December 2017.*

In response to AAIB Safety Recommendation 2017-003, the CAA has reviewed 22 aircraft categories relevant to pilot display authorisation to consider any differences in handling characteristics. In 21 of the 22 categories, the review confirmed that existing provisions were effective. Additional work was undertaken on Category G, which has now been divided into two sub-categories: straight wing aircraft by type and swept-wing aircraft by type, ensuring that any differing handling characteristics are appropriately characterised.

This report contains a summary of the CAA's findings and concludes the CAA's work on AAIB 2017-003.

Analysis

The CAA has undertaken the following analysis:

The CAA will review the list of different categories of aircraft relevant to a pilot display authorisation, including renewal.

The CAA's category analysis considered a broad range of aircraft types, from light piston engine aircraft to jet training aircraft, helicopters to microlights. Rather than splitting the aircraft by category, the aircraft were split by handling characteristics. The aircraft were therefore considered as follows:

- Fixed wing aircraft of straight wing design
- Fixed wing aircraft of swept wing design
- Rotary Wing Aircraft (helicopters)

- Gyroplane aircraft
- Hang Gliders and Paragliders
- Microlight aeroplanes
- Powered Parachutes, Powered Paragliders and Powered Hang Gliders

Helicopters (Category L), Gyroplanes (Category M), Hang Gliders and Paragliders (Category O and Y), Microlight aeroplanes with weight shift control (Category T and V), Powered Parachutes, Powered Paragliders and Powered Hang Gliders (Category W1, W2 and W3) were considered as part of this review, however as their wing designs do not exist in multiple categories, they are considered to be bespoke and separate in their handling characteristics. Therefore, the main cross category handling[1] difference resulted from whether the aircraft was of straight or swept wing design. As handling characteristics were dependent on wing design, after the analysis was complete, all but one of the 22 different aircraft categories relative to pilot Display Authorisations were considered to be fit for purpose (see table at Appendix A). The one area that was identified as requiring further work was Category G (Jet) aircraft due to it containing types of aircraft that were considerably different in their handling characteristics, namely the differences between straight and swept wing jet aircraft.

Therefore, to reinforce the existing aircraft category list, the CAA GA Unit has now elected to split Category G aircraft into:

- Straight wing jet aircraft, now Category G1, and
- Swept wing jet aircraft, now Category G2

This applies to initial issue of a Display Authorisation, renewal and upgrades. This change will result in pilots that wish to display aircraft both categories now being required to maintain currency in each category rather than be able to remain current on a straight wing jet (Category G1), and also being able to display in a Swept Wing Jet (Category G2) which was previously the case.

The CAA will assess the impact of differing handling techniques between each category.

In parallel with reviewing the different categories of aircraft relevant to a pilot Display Authorisation, the CAA GA Unit considered the impact of differing handling techniques between each category. There are many types of different wing subsets, those normally flown at civil air displays fall into four main categories:

- Straight
- Elliptical
- Swept
- Delta

Currently there are no delta wing aircraft flying on the UK display circuit and elliptical and Straight wing aircraft exhibit similar handling. The analysis therefore compared the differences between the fundamental wing types (straight and swept) in various phases of flight most pertinent to display flying namely: turning, looping, stalling (high Angle of Attack (AoA)) and low speed flight (see Appendix B for details). The review of the performance of the wing design focussed on changes in radii, ‘g’ exposure times, induced drag, the effect of speed and energy, in addition to slow speed / high AoA flight; all assessed across the spectrum of aircraft categories.

[1] Aircraft types with similar handling characteristics but present in different categories.

Findings

Once complete, the CAA's analysis confirmed the different handling characteristics between straight and swept wing aircraft and therefore reinforced the splitting of Category G (Jet) Aircraft into Category G1 (Straight wing jet aeroplanes specified by type) and Category G2 (Swept wing jet aeroplanes specified by type). Not only does the split assist in determining appropriate Display Authorisation renewal and upgrades, more importantly it also ensures that differing handling characteristics are appropriately categorised.

As it was shown that all straight wing (including elliptical) aircraft demonstrated and exhibited similar handling characteristics, the CAA GA Unit has concluded that for pilots that fly different aircraft in the **same category**, the handling techniques are complementary.

For pilots that fly different aircraft in **different categories** (now that Category G has been split), handling techniques were considered to be far enough apart to require specific training on an aircraft in each category.

In addition, the handling techniques by category are supported by the currency and recency requirements implemented since 2015 as part of the CAA's Air Display Review.

Procedures

CAA procedures are being amended to reflect the splitting of Category G into G1 and G2. The source document for the Display Authorisation Categories is CAP 403 which is currently undergoing its annual review. These changes will be reflected in Edition 15, which is due for publication in DRAFT in January 2018. Additionally, the Display Authorisation Certificates that are issued to Display Pilots have also been amended to reflect the change in categories.

Conclusion

The CAA has reviewed the list of different categories of aircraft relevant to a pilot Display Authorisation, both at the initial issue and renewal stages and has subsequently split Category G (Jet) Aircraft into Category G1 (Straight wing jet aeroplanes specified by type) and Category G2 (Swept wing jet aeroplanes specified by type). Additionally, the impact of differing handling techniques between each category has been analysed by the CAA and it was concluded that handling techniques in same category aircraft are complementary, whereas handling techniques in different category aircraft are far enough apart to require training in that aircraft type. This analysis also reinforced the decision to split Category G. These changes will be incorporated into edition 15 of CAP 403, due for publication in DRAFT in January 2018. Whilst it is acknowledged that further analysis is required to build on the basic analysis, in order to fully understand the handling characteristics and techniques associated with swept wing aircraft in the display environment, this report now concludes the CAA GA Unit's work on AAIB 2017-003.

- Appendix A - Aircraft Categories for Display Authorisation
- Appendix B – Differences between straight and swept wing aircraft

Appendix A

Aircraft Categories for Display Authorisation

Category	Group
	Single-Engine Piston Aeroplanes (SEP)
A B C	Less than 200 hp Between 200 and 600 hp Exceeding 600 hp
	Multi-Engine Piston Aeroplanes (MEP)
D E F Z	Less than 300 hp total Between 300 and 600 hp total Single Pilot Exceeding 600 hp total, specified by type Multi-crew Exceeding 600 hp total, specified by type
	Jet Powered Aeroplanes
G1 G2 H	Straight wing single engine jet aeroplanes specified by type Swept wing single engine jet aeroplanes specified by type Multi-engine jet aeroplanes specified by type
	Turbo-prop powererd Aeroplanes
I J	Single-engine turbo-prop aeroplanes specified by type Multi-engine turbo-prop aeroplanes specified by type
	Helicopters and Gyroplanes
L M	Helicopters specified by type Gyroplanes specified by type
	Gliders, Hang Gliders and Paragliders
N O Y	Gliders of all types Hang Gliders of all types Paragliders of all types
	Microlight Aeroplanes
T U V	Microlight aeroplanes of all types with weight shift control Microlight aeroplanes of all types with three axis control Microlight aeroplanes of all types with hybrid control
	Powered Parachutes, Powered Paragliders and Powered Hang Gliders
W1 W2 W3	All types of Trike Unit Powered Parachutes All types of foot launched Powered Paragliders All types of foot launched Powered Hang Gliders

Table reproduced from Chapter 10 of CAP 403

Appendix B

Differences between straight and swept wing aircraft

Reference

Royal Air Force Air Publication 3456 – The Manual of flying.

General

Swept wing planforms are used on high-speed aircraft and may take the form of either a sweptback wing, or a delta. The reason for the use of these planforms is their low drag at the higher speeds. However, the high speed/low drag advantages are gained at the cost of a poorer performance at the lower end of the speed range.

Design

The main reason for employing sweepback as a wing planform is to improve the highspeed characteristics of the wing. Unfortunately, this can have adverse effects on the amount of drag produced at the higher range of AoAs. A swept wing presents less camber and a greater fineness ratio to the airflow, it therefore produces less lift and requires a greater speed through the air to generate the same amount of lift as a straight wing aircraft. The consequences of this are reduced low speed performance and increased stalling speed. Swept wing designs have some undesirable characteristics near the stall such as minimal stall warning, rapid onset, deep stall and the requirement for more height to recover from the stall.

Handling

In a swept wing aircraft, if a pilot makes a small adjustment to the aircraft's attitude by, for example, raising the nose slightly, the lift will be increased slightly, but there will be a large increase in drag which will result in a rapid fall off in speed, and a large increase in power to restore equilibrium. In fact, the stage may be reached where the use of full power is insufficient to prevent the aircraft from descending rapidly.

It follows that swept wing aircraft can be challenging to fly in a slower flight regime, particularly one where the wing is under high g loading and presented at high AoA to the airflow (ie maximum performance turning).

Comparison

The table below compares the handling characteristics of straight and swept wings in the following regimes of flight:

- Turning
- Vertical manoeuvring
- Stalls
- Low speed flight

	Straight wing	Swept wing
Turns	Small radius, low induced drag, ability to sustain high g for a shorter period	Large radius, high induced drag and therefore potential significant airspeed loss, ability to sustain high g for a longer duration
Loops	Lower apex height, predictable apex height in a straight loop from a given pull up airspeed and power setting	Higher apex height with significant variability from given entry conditions as a function of the g onset rate during pull-up
Stalls	Usually predictable and stable, with no adverse characteristics (such as wing drop, deep stall) can usually be flown deliberately and recovered easily such that recoveries can be practised	Usually not cleared for intentional stalling practise. May have an angle of attack limit. May depart from controlled flight at the stall with little or no warning
Low Speed Flight	Normally exhibits benign handling characteristics across the full speed range	Can be challenging to fly in a slower flight regime, particularly one where the wing is under high g loading and presented at high AoA to the airflow

Conclusion

The analysis has determined that to fly a swept wing aircraft requires different knowledge and handling techniques, especially when manoeuvring at low speed, high g and high AoA; which is the environment in which a display aircraft spends the majority of its time. It therefore follows that handling techniques apply across the spectrum of straight wing aircraft categories as the techniques are complementary. However, swept wing aircraft handling techniques should be considered in isolation as they pose unique handling challenges.

That said, whilst straight wing handling techniques between different categories may be broadly similar, due to the spectrum of aircraft involved, handling techniques are suitably far apart to require training on that particular aircraft. For example, whilst the handling techniques required to fly a Tiger Moth are similar to that of a Strikemaster (they are both straight wing aircraft), due to the fact that they are vastly different in performance and therefore in different categories, training on each aircraft would be required.