

AAIB Bulletin S1/2016

SPECIAL

ACCIDENT

Aircraft Type and Registration:	Hawker Hunter T7, G-BXFI	
No & Type of Engines:	1 Rolls-Royce Avon Mk 122 turbojet engine	
Year of Manufacture:	1959 (Serial no 41H-670815)	
Location:	Near Shoreham Airport, West Sussex	
Date & Time (UTC):	22 August 2015 at 1222 hrs	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Serious)	Passengers - N/A Others - 11 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	14,249 hours (of which 40 were on type) Last 90 days - 115 hours Last 28 days - 53 hours	
Information Source:	AAIB Field Investigation	

1 Introduction

The aircraft was taking part in a flying display at Shoreham Airport during which it conducted a manoeuvre with both a vertical and rolling component, at the apex of which it was inverted. Following the subsequent descent, the aircraft did not achieve level flight before it struck the westbound carriageway of the A27. Eleven people on the ground were fatally injured.

Special Bulletin S3/2015 was published on 4 September 2015 to provide preliminary information about the accident gathered from ground inspection, radar data, recorded images and other sources.

This Special Bulletin contains facts which have been determined up to the time of issue. It is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents and should be regarded as tentative and subject to alteration or correction if additional evidence becomes available.

A further Special Bulletin, S4/2015, was published on 21 December 2015 to highlight findings of the AAIB investigation regarding ejection seat safety and the maintenance of ex-military jet aircraft, and to assist the Civil Aviation Authority in its 'Review of UK Civil Air Displays' (the CAA Review) announced on 9 September 2015.

On 28 October 2015 the Civil Aviation Authority (CAA) published Civil Aviation Publication (CAP) 1351 - 'CAA Review of Civil Air Displays: progress report', setting out the progress it had made in its review to date, and explaining the next steps it would be taking.

On 26 January 2016 the CAA published CAP 1371 - 'UK Civil Air Display Review: Actions that impact on UK civil air displays in 2016'.

The AAIB investigation of the accident to G-BXFI is an independent process but it has and will continue to inform the CAA Review.

The AAIB recognises that as well as being enjoyed by large numbers of spectators and participants, flying displays are also considered to provide important economic and educational benefits¹. The sole purpose of an AAIB investigation is to improve aviation safety by determining the causes of accidents and serious incidents to make Safety Recommendations intended to prevent recurrence. It does not therefore consider the balance between those benefits and improvements.

This Special Bulletin considers public protection and safety management at flying displays. A final report will be published in due course.

Fourteen Safety Recommendations are made.

2 Risk management of flying displays

The 2015 annual report of the CAA General Aviation Unit referred to its:

'...statutory duties to ensure the safety of those who are affected by GA, not least, third parties on the ground and passengers.'

Article 162 of the Air Navigation Order (ANO) 2009 states:

'...no person may act as the organiser of a flying display (in this article referred to as 'the flying display director') without first obtaining the permission² of the CAA for that flying display.'

Relevant guidance to Flying Display Directors (FDD) and others involved in the organisation of flying displays is provided by the CAA in CAP 403 - 'Flying displays and special events: A guide to safety and administrative arrangements'. The 13th edition, current at the time of

Footnote

¹ Response of the Royal Aeronautical Society to the CAA air display charges consultation, 29 February 2016.

² Referred to as 'an Article 162 permission' in this Special Bulletin.

the accident to G-BXFI, was published in February 2015 and refers to itself as ‘a complete rewrite of CAP 403’. Its introduction stated:

‘Participating in or organising flying displays and special events carries a heavy responsibility. Safety is paramount; not only that of the participants, but arguably even more important, that of the spectators, whether paying or not.’

And:

‘Displays must be carefully planned both on the ground and in the air and nothing should be considered without careful thought to ensure that it is safe.’

Air displays may be large events, or part of large events, and involve the hazards associated with any mass participation event. CAP 403 highlights that, in addition to aviation specific safety management, normal event safety management processes should be followed. CAP 403 states:

‘The information contained in the Health and Safety Executive (HSE) Event Safety Guide – known as the Purple Guide³ – applies to flying displays.’

Following an application to hold a flying display the CAA may authorise an individual to be the Flying Display Director (FDD) if it is satisfied that the person is suitable. CAP 403 states that the FDD is ‘the person responsible to the CAA for the safe conduct of a flying display’ and:

‘Before a Permission can be issued, the CAA must be satisfied that: A person is fit and competent as an FDD, having regard in particular to his previous conduct and experience, his organisation, staffing and other arrangements, to safely organise the proposed flying display.’

When applying to the CAA for a display permission the FDD completes an application form and certifies that the display will be organised in accordance with CAP 403. The application includes a map showing where the FDD intends the ‘display line’ to be positioned. The display line is a line defining the closest a display aircraft should approach the crowd. Where the display line is not clearly delineated by a paved runway or other obvious line feature it should be marked. When the CAA issues an Article 162 permission it specifies where the display line should be located in relation to spectators at the event but not to others who may be at risk.

In its regulation of general aviation, the CAA uses the hierarchy of protection described in the European Aviation Safety Agency (EASA) GA Safety Strategy. This outlines six stakeholder categories in descending order of priority for protection:

Footnote

³ The Purple Guide is now published by the Event Industry Forum.

1. *Uninvolved third parties*
2. *Fare-paying passengers in CAT⁴*
3. *Involved third parties (e.g. air show spectators, airport ground workers)*
4. *Aerial work participants / air crew involved in aviation as workers*
5. *Passengers (“participants”) on non-commercial flights*
6. *Private pilots on non-commercial flights’*

In relation to flying displays, this hierarchy accords a higher priority to the uninvolved general public than to air show spectators, who in turn have a higher priority than performers, such as display pilots, who are either Aerial Work participants or private pilots on non-commercial flights.

2.1 *Management of the 2015 Shoreham Airshow*

The 2015 Shoreham Airshow was organised by a company formed for that purpose. This company leased the aerodrome from the operator of Brighton City Airport (Shoreham) for the period surrounding the displays. The organiser contracted a safety consultancy to produce an Event Plan, an Emergency Response Plan, risk assessments for the ground operations and to liaise with the emergency services. An Emergency Services Group (ESG), comprising members of the local emergency services, the local authority and others, provided comment on the Event Plan and Emergency Response Plan. Elements of the event, other than the flying display, required a licence from the local authority.

The FDD booked the display items, arranged ‘the Article 162 permission’ from the CAA, was responsible for the flying activity, attended the ESG meetings and a ‘table-top’ simulated emergency response exercise, and conducted a risk assessment for the flying display.

2.2 *Risk assessments*

The Health and Safety Executive (HSE) states that risk assessments should be conducted by a competent person and defines such a person as:

‘...someone who has sufficient training and experience or knowledge and other qualities that allow them to assist you properly. The level of competence required will depend on the complexity of the situation.’

CAP 403 states:

‘Displays must be carefully planned both on the ground and in the air and nothing should be considered without careful thought to ensure that it is safe. A risk assessment procedure is included to help in this process.’

This process was included in Appendix A to CAP 403, which among other things provided tables for deciding levels of severity and likelihood of an occurrence.

Footnote

⁴ Commercial Air Transport.

The Purple Guide, referred to above, states that organisers should:

‘Carry out a systematic assessment of the risks to employees, volunteers and the public.’

Both CAP 403 and the Purple Guide have similar five-step processes which the CAA stated it intended should be conducted by the event organiser.

CAP 403 states:

- 1. Identify the hazards associated with activities contributing to the event, where the activities are carried out and how they will be undertaken*
- 2. Identify those at risk and how they may be harmed*
- 3. Identify existing precautions*
- 4. Evaluate the risks*
- 5. Decide what further actions may be required, i.e. mitigation’*

Where identified risks require mitigation the HSE and other safety organisations use a hierarchy of control, as follows:

- 1. Elimination (e.g. Remove the hazardous element entirely)*
- 2. Substitution (e.g. Replace the material or process with a less hazardous one)*
- 3. Engineering Controls (e.g. Separate the hazard from others by enclosing or guarding)*
- 4. Administrative Controls (e.g. Use warning signs, briefings and procedures)*
- 5. Personal protective clothes and equipment (Not relevant for this accident)’*

2.3 Risk assessment of the Shoreham flying display

The risk assessment for the flying display element of the 2015 Shoreham Airshow stated, in part:

‘For the effective safety management of Flying Display Operations at Shoreham RAFA Air Display 2015 it is essential that all Airshow-specific aircraft operation, both on the ground and in the air are assessed and the risk quantified.’

The risk assessment document listed 10 hazards that had been identified and subject to risk assessment:

- Airside unauthorised access*
- Mid-air collision – Display and non-display aircraft*
- Mid-air collision display formation*
- Ejector seat impacts crowd*
- Loss of control due to pilot disorientation*
- Location road and local built up areas*
- Public assembly on the A27 and local roads*
- Aircraft crash outside the airfield boundary*
- Fast jet collision into crowd area*
- Fatigue amongst key staff’*

Each hazard was considered based on a probability of occurrence and the severity of the consequence. A risk tolerability matrix was then applied which defined the risk associated with each hazard as either:

- *'acceptable (may be continued without further reference)*
- *unacceptable (positive actions must be taken to reduce the risk to an acceptable level before the activity is undertaken)*
- *review (review must be undertaken at the earliest opportunity in an effort to reduce the risk to an acceptable level)'*

The risk assessment for the 2015 Shoreham Airshow did not show the range of hazards presented by different display aircraft that formed the display and did not consider specifically where the hazards would occur or who would be exposed to them. There was no evidence of an attempt to consider either a hierarchy of protection or control.

CAP 403 stated:

'The simple procedure detailed at Appendix A [to CAP 403] should suit most flying display and Special Events needs.'

It did not provide detailed guidance on the conduct of risk assessments in relation to flying displays.

Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-031

It is recommended that the Civil Aviation Authority review and publish guidance that is suitable and sufficient to enable the organisers of flying displays to manage the associated risks, including the conduct of risk assessments.

The CAA stated to the AAIB that it is in the process of improving its guidance.

The FDD for the Shoreham display had been responsible for previous flying displays, is a display pilot and Display Authorisation Evaluator (DAE), and was formerly Head of the CAA General Aviation Department. He stated to the AAIB that he believed the risk assessment for the 2015 Shoreham Airshow was compliant with CAP 403, and the CAA had granted an Article 162 permission for the event.

The AAIB commissioned a review, by the Health and Safety Laboratory, of the risk assessment for the 2015 Shoreham Airshow. The review also considered the equivalent risk assessments for the 2013 and 2014 Shoreham Airshows but did not compare these with risk assessments for other flying displays. Its report stated:

'It was found that the Shoreham Airshow Air Display Risk Assessment contained a number of deficiencies compared to what would have been expected for a risk assessment to control risks to the public.'

And:

'It is not clear that those who assessed the risks and recorded the assessment had a full understanding of the purpose of the risk assessment.'

There is no requirement in CAP 403 for a risk assessment to be submitted to the CAA when applying for approval to hold a display. The CAA informed the AAIB that when considering applications for air displays, and when attending air displays to conduct audits, it did not inspect or request copies of hazard logs or risk assessments.

The FDD of the Shoreham flying display was the FDD at two flying displays after 22 August 2015, for which he applied to the CAA for Article 162 permissions. The risk assessments he presented in support of these applications were not materially different from that for Shoreham. Nevertheless, Article 162 permissions were issued in both cases and the FDD stated that he interpreted this as confirmation these risk assessments were considered fit for purpose.

The CAA is responsible for ensuring that an FDD has the required competencies to manage the safety of the display, amongst other tasks. The CAA stated that:

'Currently a FDD is assessed on the basis of the personal knowledge of the CAA's Flight Display Inspector about the individual, his competence and capabilities and any other specific intelligence from prior activities. Also taken into account are the arrangements being made for the flying display...There is currently no written policy document that describes selection criteria for a person in relation to acceptance as a FDD'

Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-032

It is recommended that the Civil Aviation Authority specify the safety management and other competencies that the organiser of a flying display must demonstrate before obtaining a Permission under Article 162 of the Air Navigation Order.

The CAA stated that it held a workshop as an element of a pre-season symposium in February 2016 as part of its strategy to improve the selection criteria for FDDs.

2.4 CAA enhanced risk assessment

The CAA stated that prior to the accident to G-BXFI it did not require to see risk assessments completed by FDDs.

On 24 August 2015, following the accident to G-BXFI, the CAA instigated an enhanced risk assessment process, to be carried out by CAA assessors. This process was applied to all displays conducted in 2015 after that date and the CAA has stated that it will continue to

be applied during the 2016 display season. On 21 January 2016 it provided a copy of this process to the AAIB, with a list of the display sites where additional risks and mitigating actions had been identified since its implementation.

The enhanced risk assessment process required the CAA assessor to focus on the proximity of infrastructure and transport links, such as major roads, to the display line. The CAA stated that this activity relied on information provided by FDDs, including features shown on maps.

There were no site visits and the process did not benefit from local knowledge of the display sites and their surroundings. The enhanced process did not require the assessor to allocate probability or consequence to the identified hazards, as would be expected in a risk assessment, made no reference to a hierarchy of protection or control, and did not consider which groups of people would be exposed to the identified hazards.

Where the CAA's enhanced risk assessment identified a hazard to major roads in close proximity to a site, the stated risk mitigation for those sites was that traffic must be '*actively managed*' to avoid congestion. At the 2015 Shoreham Airshow, traffic management was in place and traffic at the accident site had been flowing. This indicated that traffic management was not an effective risk mitigation.

In some cases the CAA, in issuing an Article 162 permission, changed the position or orientation of a display line. There was no evidence, in these cases, that the CAA or the FDDs for those events, had assessed how this might change the risks involved or who was ultimately responsible for the safety of the chosen line, thereby introducing the potential to confuse the ownership of risk and to diffuse responsibility⁵.

Therefore, the following Safety Recommendation is made:

Safety Recommendation 2016-033

It is recommended that the Civil Aviation Authority introduces a process to ensure that the organisers of flying displays have conducted suitable and sufficient risk assessments before a Permission to hold such a display is granted under Article 162 of the Air Navigation Order.

2.5 Identifying where the activity will take place

CAP 403 states that risk assessments should:

'Identify the Hazards associated with activities contributing to the event, where the activities are carried out and how they will be undertaken'.

Footnote

⁵ Diffusion of responsibility occurs when responsibility for an action is divided between several individuals or organisations with the result that each assumes another is taking necessary action.

The Shoreham FDD was an experienced display pilot but was not provided with, or was not aware of, the sequence of display manoeuvres that the pilot of G-BXFI intended to perform. Without prior knowledge of G-BXFI's display routine or the ground area over which the pilot intended to perform it, it was not possible for the FDD to identify the specific associated hazards, where the various aerobatic manoeuvres would be conducted, and therefore to determine which groups of people would be exposed to those hazards and to what extent.

The AAIB has explored regulation of flying displays in other countries where there is some regulation of flying display activity. The circumstances in these countries may be different to those in the UK, but they nevertheless provide examples of alternative frameworks. Transport Canada (the aviation regulator in Canada)⁶, requires organisers of flying displays to provide the following information at least 10 days before the intended flying display:

'sequential listing of all manoeuvres to be flown by the performer, including:

- (i) the distance of each manoeuvre from spectator areas, including, where applicable, the point of entry into and recovery from each manoeuvre,*
- (ii) the point of entry to, and departure from, the flying display area, where applicable,*
- (iii) the directions of flight relative to the spectator areas,*
- (iv) the location of water drops, pyrotechnics, helicopter rappelling and similar operations relative to the spectator areas,*
- (v) the maximum and minimum speeds for the entire performance, and*
- (vi) the minimum altitudes for each manoeuvre to be performed'*

2.6 Accident to Hawker Hurricane G-HURR

Following the accident to Hawker Hurricane, G-HURR, at Shoreham on 15 September 2007, the AAIB issued the following Safety Recommendation⁷:

Safety Recommendation 2009-052

It is recommended that the UK Civil Aviation Authority requires that the sequence of manoeuvres for a flying display is clearly specified in advance of the display and provided to the display organiser and that the sequence is practised prior to displaying to the public.

The CAA accepted this recommendation and in its formal response to the AAIB stated that it would amend CAP 403 at Edition 11 as follows:

'a) the Flying Display Director during the planning phase of the event will be required to consider and manage pilot display programmes.

Footnote

⁶ Canadian Aviation Regulations (CARs) 2015-1 Standard 623 – Special Flight Operations, Division I Special Aviation Events Chapter One Air Shows.

⁷ AAIB Aircraft Accident Report 6/2009.

d) the Flying Display Director is charged with circulating, prior to the event a written brief to all participants which will include details of manoeuvres to be flown at the event that are known and have been practised...'

When published, Edition 11 of CAP 403 did not include that sentence, but stated:

'The event organiser and the Flying Display Director will, in particular need to consider and make arrangements for...m) pilot display programmes'

In Edition 11 and subsequent editions of CAP 403 the phrase '*pilot display programmes*' had replaced the words '*details of manoeuvres*'. The term '*pilot display programmes*' is not defined in CAP 403.

When interviewed during the course of the G-BXFI investigation, the CAA and the 2015 Shoreham FDD interpreted this phrase in different ways. The definitions they provided did not refer to a sequence of manoeuvres.

2.7 Reactive control of flying displays

CAP 403 states:

'The impromptu, ad hoc, unrehearsed or unplanned should never be attempted.'

Paragraph 2.10 of CAP 403 states:

'It is very strongly recommended that a Flying Control Committee (FCC) is utilised at display of 7 or more items⁸. The roles of the FCC are:

- a) to assist the FDD in monitoring display standards;*
- b) to provide specialist knowledge for specific display items; and*
- c) to offer in-depth opinion in the case of infringement of the regulations.'*

Paragraph 2.14 of CAP 403 states:

'The FCC should have the clear authority of the Event Organiser to curtail or stop, on the grounds of safety, any display item or, in extreme cases, the whole flying display.'

The Article 162 permissions for the 2014 and 2015 Shoreham flying displays included the condition that:

'no aircraft shall take part in a Flying Display pursuant to this Permission over any building or vessel which the commander has reason to believe is occupied by persons'

Footnote

⁸ An item is a display act which may consist of one or more aircraft flying together.

Furthermore, G-BXFI's Permit to Fly, issued by the CAA included the condition:

'The aircraft shall not be flown over any assembly of persons, or any congested area of a city town or settlement...'

Also, the ANO states:

'Congested area' in relation to a city, town or settlement, means any area which is substantially used for residential, industrial, commercial or recreational purposes.'

Video footage of a previous display of G-BXFI at the 2014 Shoreham Airshow indicated that the majority of the aerobatic manoeuvres (including steeply banked turns) were conducted away from the airfield, over areas accessible to the public and outside the control of the display organisers. Footage and tracks determined from radar data showed that the aircraft overflow residential areas along the A259 south of Shoreham Airport several times and in one manoeuvre overflow the central area of the town of Lancing at an angle of bank in excess of 90°. (Figure 1). The pilot was not instructed to stop this display. Either these regulatory infringements were not detected by the display organisers or were not understood.

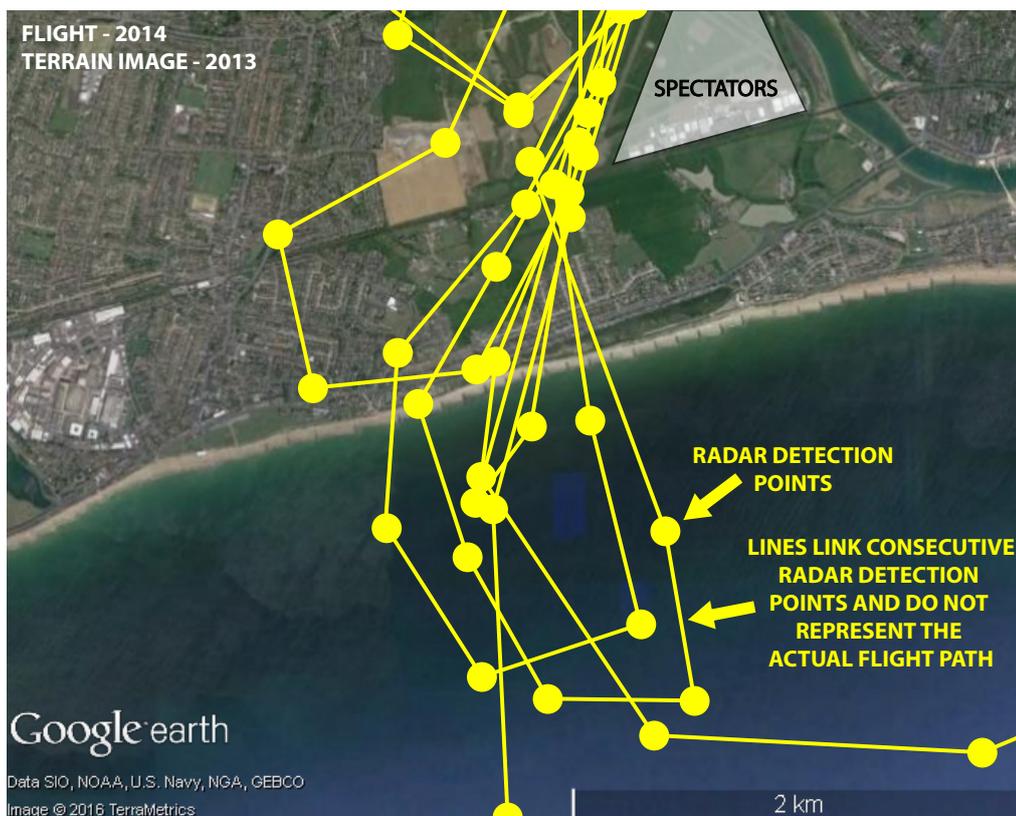


Figure 1

Overflights of congested area by G-BXFI during 2014 Shoreham flying display

2.8 Provision of information to the organisers of flying displays

It is not possible to conduct a comprehensive risk assessment without knowing the intended sequence of manoeuvres and the ground area over which the pilot intends to perform them, and the specific hazards created by each displaying aircraft. Evidence from the 2014 Shoreham display indicated that it was not possible for G-BXFI to complete the intended sequence of manoeuvres while complying with the condition of its Permit to Fly; not to overfly congested areas. Knowledge of its intended routine would have enabled the FDD to determine if its attendance at the flying display was appropriate.

Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-034

It is recommended that the Civil Aviation Authority specify the information that the commander of an aircraft intending to participate in a flying display must provide the organiser, including the sequence of manoeuvres and the ground area over which the pilot intends to perform them, and require that this be done in sufficient time to enable the organiser to conduct and document an effective risk assessment.

The Article 162 permission issued by the CAA allows for a deviation from certain aspects of the Rules of the Air only on the display line and then only as allowed by the individual pilot's Display Authorisation (DA). It does not allow for deviation from the Permit to Fly of the display aircraft either in terms of overflight of normally prohibited areas or of operation outside the aircraft's flight manual.

A sample of flights by other aircraft at the 2015 Shoreham display and elsewhere showed that infringements of this nature were not confined to one aircraft, pilot or venue. A similar issue was previously identified by the Ministry of Defence Service Inquiry into the loss of Hawk XX179 near Bournemouth on 20 August 2011⁹. It found that, during the flying display prior to the accident, at least one aircraft of the Royal Air Force Aerobatic Team had been '*in contravention of extant Regulations governing flight over Congested Areas*'. This was not considered to be a deliberate breach of regulation but due to the pilot believing they were cleared to do so by their display permission. However, they were not and the Service Inquiry commented that '*the societal risks associated with such manoeuvring had not been fully considered.*'

Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-035

It is recommended that the Civil Aviation Authority require operators of Permit to Fly aircraft participating in a flying display to confirm to the organiser of that flying display that the intended sequence of manoeuvres complies with the conditions placed on their aircraft's Permit to Fly.

Footnote

⁹ Service Inquiry: accident involving Red Arrows Hawk T Mk1 XX179 near Bournemouth on 20 August 2011 published 18 December 2012.

3 Minimum heights

A pilot's DA states the minimum height at which the holder may fly during a display. The CAA commented that this is intended to be an absolute minimum, not a target. The CAA informed the AAIB that the pilot must comply with the Rules of the Air when not on the display line¹⁰. Consequently, depending on the aircraft type and length of the display line, the minimum height listed on the pilot's DA might not be achievable over the entire length of the display line, if at all.

In its enhanced risk assessment of flying display sites conducted after the accident to G-BXFI, the CAA referred to '*normal rules of the air*' applying away from the display line as a mitigation related to aircraft overflying roads. The risk assessment for the 2015 Shoreham Airshow identified '*compliance with the Rules of the Air*' as a mitigation for the hazard of an '*Aircraft Crash Outside the Airfield Boundary*'. This information suggests that both the CAA and the Shoreham FDD, separately, assumed that pilots would only descend to their approved minimum height over the display line. The risk assessment appears to have relied upon this protection to manage the risk associated with flight at low heights during the flying display.

European Union Regulation 923/2012 issued on 26 September 2012 sets out the Standardised European Rules of the Air (SERA). Section 3, paragraph 3105 '*Minimum heights*' states:

'Except when necessary for take-off or landing, or except by permission from the competent authority, aircraft shall not be flown over the congested areas of cities, towns or settlements or over an open-air assembly of persons, unless at such a height as will permit, in the event of an emergency arising, a landing to be made without undue hazard to persons or property on the surface. The minimum heights for VFR flights shall be those specified in SERA.5005(f)...'

Section 5 paragraph 5005(f), requires aircraft under Visual Flight Rules (VFR) to be at minimum heights of either 500 ft or 1,000 ft depending on other conditions¹¹.

The European Aviation Safety Agency '*Acceptable Means of Compliance (AMC) and Guidance Material to the Rules of the Air*' published in July 2013 states:

'The permission from the competent authority to fly at lower levels than those stipulated in SERA.5005(f) and SERA.5015(b) may be granted either as a general exemption for unlimited number of cases or for a specific flight upon specific request. The competent authority is responsible for ensuring that the level of safety resulting from such permissions is acceptable.'

Footnote

¹⁰ Aircraft must *always* comply with the Rules of the Air except in an emergency, and the exemptions available to aircraft participating in flying displays are part of those Rules of the Air. The CAA statement in this context is taken to mean the Rules of the Air that apply other than at flying displays.

¹¹ 5005(f) states: Except when necessary for take-off or landing, or except by permission from the competent authority, a VFR flight shall not be flown: (1) over the congested areas of cities, towns or settlements or over an open-air assembly of persons at a height less than 300 m (1 000 ft) above the highest obstacle within a radius of 600 m from the aircraft; (2) elsewhere than as specified in (1), at a height less than 150 m (500 ft) above the ground or water, or 150 m (500 ft) above the highest obstacle within a radius of 150 m (500 ft) from the aircraft.

On 13 August 2015¹² the CAA, as the competent authority in the UK, issued 'Official Record Series 4-1124' (ORS4-1124) relating to SERA. It stated in paragraph 4:

'Flying Displays, Air Races and Contests

The Civil Aviation Authority permits, under SERA.3105 and SERA.5005(f), an aircraft taking part in a flying display, air race or contest to fly below 150 metres (500 feet) above the ground or water or closer than 150 metres (500 feet) to any person, vessel, vehicle or structure if it is within a horizontal distance of 1,000 metres of the gathering of persons assembled to witness the event.'

The effect of this exemption to the low flying rules for aircraft taking part in displays is to remove the minimum height and separation requirements within 1,000 metres (1 km) of the event.

The EASA AMC requires the competent authority to ensure that the resulting level of safety is acceptable. The CAA has not provided any risk assessments or other relevant documentation to support its decision to issue the exemption, but stated:

'Rule 5 and Rule 6 of the Rules of the Air Regulation 2007 were the relevant rules in place in the UK prior to the publication and implementation of the SERA rules. These rules had been in place since at least 1996 and there was no evidence to suggest that these rules were inherently unsafe.'

In August 2005 a glider (BGA 4665), involved in an air race in Leicestershire, struck and fatally injured a person standing outside the boundary of the aerodrome at which it was operating. The AAIB report¹³ stated:

'the root cause was the practice of flying too low outside the confines of the airfield and resorting to pop-up manoeuvres to clear obstacles.'

Five Safety Recommendations were made, including the following:

Safety Recommendation 2006-120

The Civil Aviation Authority should clarify and publicise whether permission from the Authority is required before exemption from the 500 feet low-flying rule in accordance with Rule 5 (3)(f) is applicable.

In an interim response, in April 2007, the CAA indicated that it accepted this Safety Recommendation stating:

'the CAA intends to change Rule 5 (3)(f) as it is unsatisfactory in its present form.'

Footnote

¹² Although the ORS exemption was issued in August 2015 this continued a previous UK derogation from the EU standards.

¹³ Glider BGA 4665, published in AAIB Bulletin 2/2007.

However, Rule 5(3)(f) was not changed until superseded by the SERA, and the permission in ORS4-1124 has the same effect as Rule 5(3)(f). Consequently the regulations currently in force do not reflect the view that aircraft must comply with the '*normal rules of the air*' when not on the display line. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-036

It is recommended that the Civil Aviation Authority remove the general exemptions to flight at minimum heights issued for Flying Displays, Air Races and Contests outlined in Official Record Series 4-1124 and specify the boundaries of a flying display within which any Permission applies.

4 Regulatory oversight

4.1 Accident rates at flying displays

The CAA does not define a target acceptable level of safety¹⁴ for UK air displays. Although it records and monitors all accidents it does not monitor the accident rate for display flying, the number of display items or the number of hours flown by civil display aircraft in any year. It estimated that the overall UK general aviation fatal accident rate between 2005 and 2014, including display flying, was approximately 1.5 fatal accidents per 100,000 flying hours.

CAA records show that in 2015 there were 254 'Article 162 permissions' granted. These included approximately 1,480 individual civil display items¹⁵.

There were two fatal accidents at organised displays in 2015, however, considering a longer period and assuming the planned 2015 activity was typical¹⁶ there has been 1 fatal accident per 2,960 display items in the period 2008 to 2015.

The International Council of Air Shows (ICAS), the flying display industry body in the United States of America (USA) and Canada, estimated that in the USA the civil air display accident rate is 1 fatal accident per 5,600 display items¹⁷.

The AAIB has estimated the fatal accident rate in the UK, expressed in hours, by assuming that a display item has an average duration of 8 minutes.

Over the ten years to the end of 2015 there were nine display accidents in which the aircraft was destroyed and either a fatal or serious injury resulted. This equates to one such accident per 219 display hours or 456 such accidents per 100,000 flying hours of which historically 55% have involved fatalities.

Footnote

¹⁴ Acceptable level of safety is a safety management concept which '*provides the minimum safety objective acceptable to the oversight authority to be achieved by operators.*'

¹⁵ This included 1,730 items approved at civil displays minus approximately 250 UK military items at civil air displays. It was not possible to correct for foreign military or items approved but which did not perform due to weather, technical failure or other reasons.

¹⁶ The average number of Article 162 displays for each of the previous 6 years was 235.

¹⁷ ICAS estimate for the period 2008-2015, excluding parachutists, wing walkers, military and air races.

65% of UK display accidents involved the aircraft crashing outside the area controlled by the organisers of the display. This equates, at 2015 levels of activity, to one display aircraft crash in an area accessible to the public every 1.7 years.

4.2 Accident rates for GA activities other than flying displays

The CAA publishes a General Aviation policy framework which includes the following statement:

'A series of questions have been developed to ensure that we minimise the risks to those we are required to protect; that our regulation is consistent; and that we do not gold-plate European regulations. We are focused primarily on protecting third parties from risks associated with GA activities, whilst enabling GA participants to manage their own risks'¹⁸.

The policy framework is designed for considering changes to existing legislation and includes at Annex B a risk matrix to assist in decision-making. This states that an event that is likely to happen more often than once per 100,000 operational hours is '*probable*' and an event that involves '*multiple deaths, usually with the loss of the aircraft*' is considered '*catastrophic*'. Risks of this nature are considered to be '*high / unacceptable*' and the policy framework states '*if such a risk is at a high level using the criteria in Annex B, STOP*'.

5 Air display separation distances

5.1 UK air display separation distances

CAP 403 states the minimum separation distances required between the crowd line and relevant display line based on the speed of the displaying aircraft (see Table 1). These separation distances have been unchanged for several years.

AIRCRAFT SPEED	CAA	FAA
Less than 100 kt	100 m	152 m
100 - 200 kt	150 m	152 m till 156 kt then 304 m
200 - 300 kt	200 m	304 m to 245 kt then 457 m
Above 300 kt	230 m	457 m

Table 1

UK and US separation distances.

The CAA commissioned a study in 1993 to assist it in determining if the distances in CAP 403 were appropriate (referred to here as the 1993 Study¹⁹).

The 1993 Study considered a structural failure, during a display flight, of two different aircraft types: a fast jet travelling at 350 kt and a single piston-engined aircraft travelling at 100 kt. Computer modelling predicted the distance that debris would travel until the debris reached

Footnote

¹⁸ <http://www.caa.co.uk/General-aviation/Safety-information/General-Aviation-Policy-Framework/> Accessed Jan 2016.

¹⁹ Airshow Separation Distances, Cranfield Aviation Safety Centre, July 1993.

a height of 5 feet above the surface. No allowance was made for the aircraft being in anything other than level flight²⁰. The modelling assumed each aircraft was making a level, 4G turn onto its respective display line, separated from the crowd by the relevant distance shown in CAP 403. Table 1 shows these distances.

The Study concluded that:

'The current issue of CAP 403²¹, 'Flying Displays: A Guide to Safety and Administrative Arrangements', reference 2, includes regulations concerning minimum crowd line to display axis distances that are well judged and for the majority of conditions appear to offer a sensible compromise between airshow attractiveness and safety'

The study did not determine the likely number or severity of casualties. It showed that in the circumstances considered, and in the case of both types of aircraft, substantial pieces of wreckage such as engines would cross the crowd line. In the case of the fast jet aircraft it was predicted that the engine(s) would enter the crowd area by at least 130 m. (Figure 2).

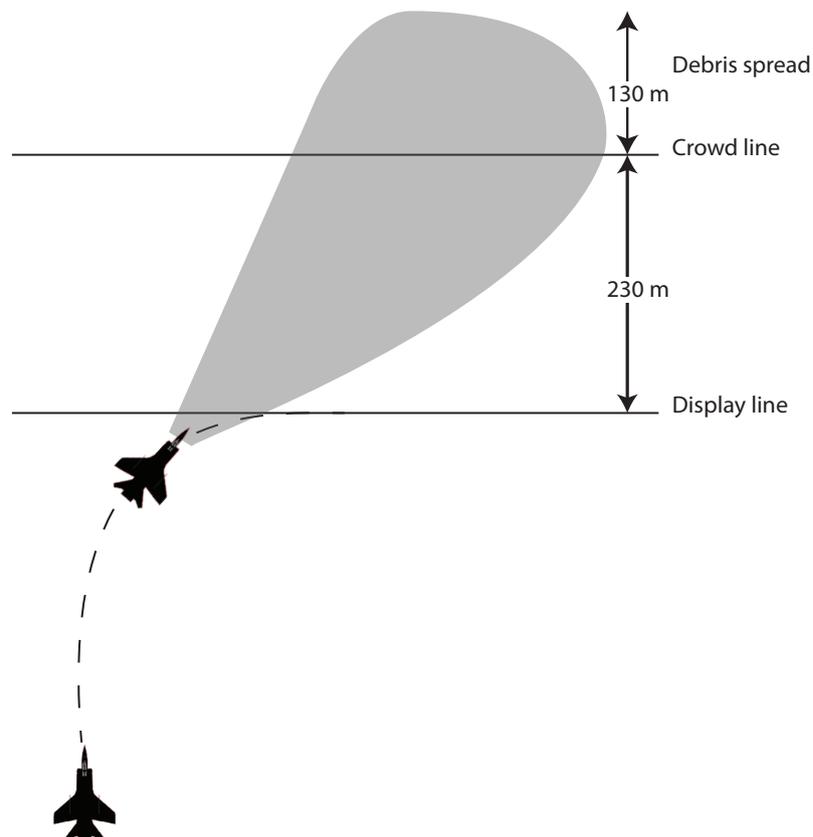


Figure 2

Debris modelling based on the 1993 Study

Footnote

²⁰ As an aircraft flightpath increases towards 45° above the horizon any debris or accidentally released component, such as a drop-tank, will travel further.

²¹ Current at that time.

A CAA Air Display Review, conducted in 1996, considered the 1993 Study to be '*generally supportive*' of the existing crowd separation distances and no changes were made.

5.2 *Alternative modelling*

The FAA requires different separation distances based on a wreckage scatter pattern model. This results in minimum crowd separation distances, for aerobatics in fast jet aircraft, which are approximately double the current UK standards (see Table 1). UK distances are based on the aircraft's speed at that moment, which varies during the display, whereas FAA distances are based on a set speed category, simplifying the monitoring of compliance.

Alternative, more sophisticated, wreckage scatter pattern models have been developed by special event organisers. Those for military range safety and civil spaceflight purposes involve injury prediction.

5.3 *On-crowd energy*

The UK Military Aviation Authority (MAA) requires a minimum separation distance of 450 m for military fast jet aircraft participating in air displays with a flightpath toward the crowd²². NATO, Transport Canada and Australia's Civil Aviation Safety Authority use similar minimums (see Figure 3). The FAA does not permit fast jet displays by civil operators to have on-crowd energy vectors for aerobatic flight.

In 2015, before the accident to G-BXFI, the MAA commissioned an external consultancy to review its flying display separation distances and develop models and tools relevant to its current aircraft. This review has not yet reported.

In 2012 the AAIB investigated the accident to North American Rockwell OV-10B Bronco, G-BZGK, which occurred during a display practice. Control of the aircraft was lost during a rolling manoeuvre that started parallel to the planned crowd line and resulted in a flightpath towards the crowd area before the aircraft struck the ground. Although the aircraft crashed outside the crowd area large parts of it, including the fuselage and engines, crossed the crowd line. In otherwise identical circumstances they would not have crossed a crowd line determined to US separation distances.

The CAA-commissioned 1993 Study, the FAA model and aircraft accident experience all show that the current UK civil separation distances will not always protect the crowd. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2016-037

It is recommended that the Civil Aviation Authority require that displaying aircraft are separated from the public by a sufficient distance to minimise the risk of injury to the public in the event of an accident to the displaying aircraft.

Footnote

²² Sometimes referred to as on-crowd energy or an on-crowd energy vector.

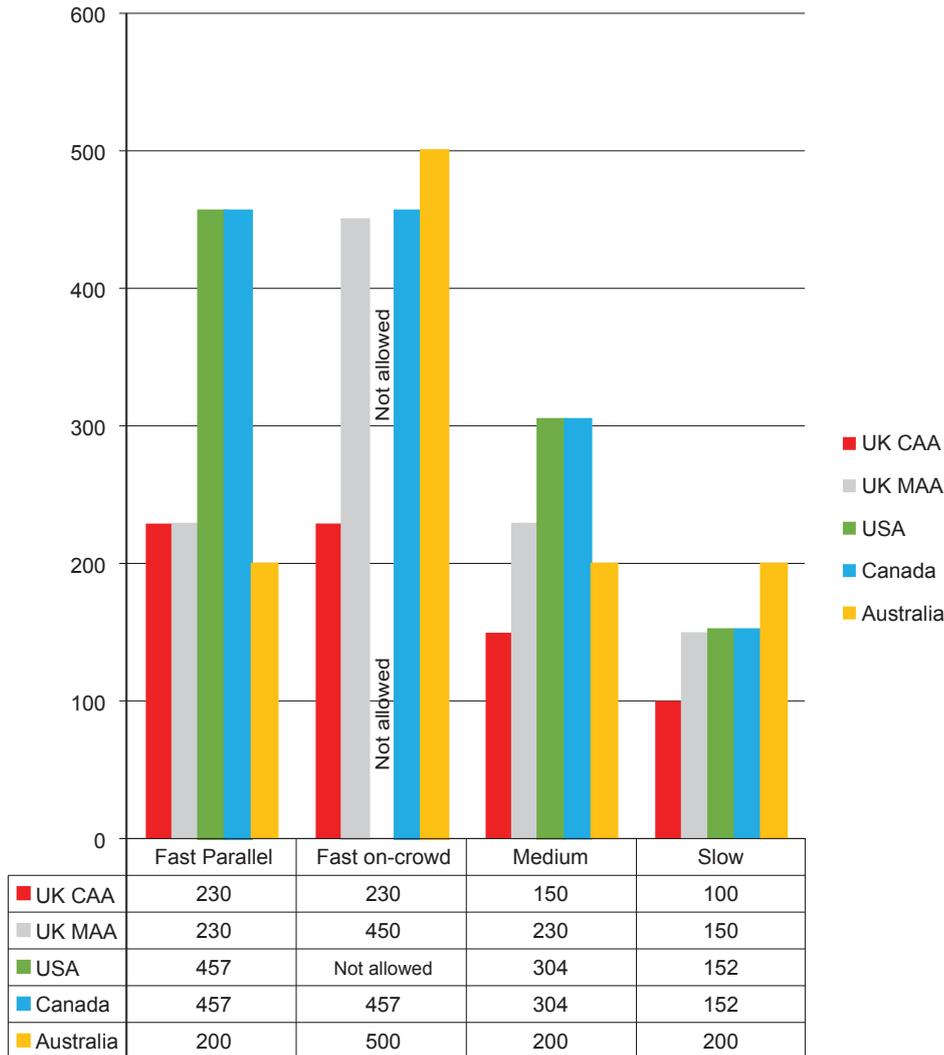


Figure 3

Comparative air display separation distances in metres

5.4 Non-participant third-parties and secondary crowds

Fatalities occurred when G-BXFI impacted the ground in an area which was open to the public, involving those who had stopped at the junction of the A27 and Old Shoreham Road to view the flying display and those who were passing by on the A27. CAP 403 requires display organisers to consider:

‘The proximity of congested areas, particularly if they include schools or hospitals.’

It also states:

‘At many events... the congregation of spectators, outside the airfield boundary, on the live-side may give organisers cause for concern...it is recommended that the event organiser anticipates this during the planning process and takes necessary steps to reduce it by, where possible blocking the view from obvious vantage points.’

CAP 403 makes no explicit safety provision for the public who choose to view a flying display from an area that is not part of the official crowd area, other than to advise they be discouraged as stated above. Conversely, the FAA requires that organisers separate the display and secondary spectator areas. These are defined in the FAA FSIMS 8900 Section 33 as follows:

*'Secondary Spectator Areas: Any area, not designated as a primary spectator area, where people have a natural tendency to gather to observe the event. This includes, but is not limited to, private property or property not under the control of the event organizer, public roads and private access roads.'*²³

The 2015 Shoreham Airshow organisers knew that the junction of the A27 was a popular location from which to view the display. The AAIB was informed that in previous years several hundred people had been observed at this road junction and in the grounds of a nearby, now closed, public house. The display organisers and the local emergency services had been concerned about the road traffic risk to these crowds and the display organisers had taken steps to minimise the number of people in this area.

The same arrangements had been in place for several years and had restricted the view of the airfield, placed various signs in the area²⁴ (Figure 4) and used stewards to ask people to move on. However, neither the organisers nor the police had requested or been granted the legal power to prevent people from being in this area and their efforts did not prevent a gathering at the A27 junction.



Figure 4

Sign at A27 / Old Shoreham Road junction

Footnote

²³ Unlike the primary crowd area permission may be given for display aircraft to overfly the secondary crowd area if at height of more than 500 ft with wings-level and climbing.

²⁴ It is believed that the sign wording had been agreed with the West Sussex Police Emergency Planning Officer at least five years previously.

Discouraging spectators from congregating in certain areas outside the airfield has been unsuccessful and therefore cannot be relied upon as an effective risk mitigation measure. The enhanced risk assessment process introduced by the CAA, following the accident to G-BXFI, acknowledges the problem of secondary crowds however, the efficacy of this approach is doubtful as the Shoreham display organisers were already taking action in relation to an area that was well known to involve crowds. Had FAA style protection of a secondary crowd area been imposed then G-BXFI would not have been permitted to display in this area. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-038

It is recommended that the Civil Aviation Authority specify the minimum separation distances between secondary crowd areas and displaying aircraft before issuing a Permission under Article 162 of the Air Navigation Order.

5.5 Non-participant third parties

The CAA's risk hierarchy designates uninvolved third parties as being the most protected group. However, at many locations display-line to crowd-line separation distances result in the aircraft, and thus the associated risk, being moved away from spectators and towards non-participant public. This appears at odds with the CAA risk hierarchy by transferring risk towards the non-participant. Without the provision of additional protections, any increase in the current CAP 403 distances might further reduce safety for non-participants. Therefore it is necessary for the display aircraft to remain safely clear of these non-participant public locations and above a height at which they will not present a hazard to those on the ground.

Both the FAA and Transport Canada require that flying display-related aerobatic flight, below normal heights²⁵, must be conducted within a designated volume of airspace known in Canada as a '*flying display area*' or in the USA as an '*aerobatic box*'. The UK does not require a specific minimum height for aerobatics, whether display related or not. The Canadian requirements are set out in CAR 20151 Standard 623 as:

- (a) the certificate holder has control of the property that underlies the airspace of the flying display area;*
- (b) the property underlying the flying display area is kept clear of all persons other than essential personnel;*
- (c) buildings inside a flying display area that are normally occupied by non-essential personnel are kept vacant during the execution of a flight program; and*
- (d) access roads that lead to property underlying the flying display area are blocked by crowd control personnel'*

In this way the Transport Canada and FAA systems seek to protect the area below displaying aircraft.

Footnote

²⁵ The FAA prohibits aerobatic flight below 1,500 ft agl, Transport Canada prohibits aerobatic flight below 2,000 ft agl.

If an aerobatic flying display area had been defined at Shoreham the looping and rolling manoeuvre conducted by G-BXFI could have been required to remain within it. Alternatively if, during the planning stage, it was identified that the aerobatic elements of the proposed display by G-BXFI could not be completed within that box there would have been an opportunity to refuse or modify its display.

Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-039

It is recommended that the Civil Aviation Authority require the organisers of flying displays to designate a volume of airspace for aerobatics and ensure that there are no non-essential personnel, or occupied structures, vehicles or vessels beneath it.

6 Pilot standards

Flying displays may place aircraft in proximity with crowds and congested areas. Although display separation distances can offer some protection from aircraft that break-up in flight they offer reduced protection against loss of control. Therefore, it is important that pilots achieve and maintain the appropriate competence.

6.1 Conflicts of interest

In 2014 the pilot of G-BXFI was evaluated in relation to his Display Authorisation (DA) by a member of the same display team. This was also the case for the pilot involved in the 2015 fatal accident to Folland Gnat T.Mk1 G-TIMM²⁶ at a flying display at Oulton Park, Cheshire.

EASA regulation and CAA policy for examiners in areas other than display flying requires the examiner to avoid any potential conflict of interest in their role.

For example, CAA Standards Doc 24(A) Version 2 '*Policy and Guidance for Examiners*' states, at section 5.1:

'Examiners shall not conduct skill tests or assessments of competence of applicants for the issue of a licence, rating or certificate to whom they have provided flight instruction for the licence, rating or certificate for which the skill test or assessment of competence is being taken or when they have been responsible for the recommendation for the skill test, in accordance with FCL.030(b). Examiners shall not conduct skill test, proficiency checks or assessments of competence whenever they feel that their objectivity may be affected". Examples of situation [sic] where the examiner should consider if his objectivity is affected are when the applicant is a relative or a friend of the examiner, or when they are linked by economical interests / political affiliations etc...'

Footnote

²⁶ The fatal accident to G-TIMM is being investigated separately, a report of which will be published in due course.

Also, CAP 804 - 'Flight Crew Licensing' Part 1, Part F - 'Skill Tests' states:

'1 Where applicants for a Part-FCL or UK National Licence or a rating to be included in a licence are required to pass a Skill Test, this shall be with an appropriately qualified Flight Examiner. With the exception of skill test for Microlight privileges and other NPPL privileges, examiners shall not test applicants to whom they have given more than 25% of the flight instruction for the qualification applied for.'

In the USA and Canada the Aerobatic Competence Examiner (ACE) system is administered by industry body ICAS rather than by the regulators. The ICAS ACE manual Version 8 (dated April 1 2015), requires examiners to:

'Confirm that the applicant is not a family member, team member, employee, aerobatic student, or an individual being mentored by, and/or who may have a financial involvement with, the ACE who has been asked to conduct the evaluation. Although ACEs are authorized to make these determinations themselves, ICAS urges evaluators to err on the side of not conducting the evaluation if there may be even an appearance of a conflict of interest. If an ACE believes that he/she requires some independent assessment on this issue, he/she is urged to contact ICAS headquarters. The headquarters staff will be directed to also err on the side of avoiding even the perception of a possible conflict of interest when making these determinations.'

The CAA stated:

'The flying display community in the UK is a small group of individuals who are often well known to each other and the potential for conflicts of interests will always exist to some degree.'

Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-040

It is recommended that the Civil Aviation Authority require Display Authorisation Evaluators to have no conflicts of interest in relation to the candidates they evaluate.

6.2 Maintaining pilot competence

Many display pilots either fly, or have flown, multiple types or classes of aircraft. Renewal of a DA on one type or class of aircraft renews the DA on all the types that the pilot's DA has listed. Therefore a display pilot may be assessed to renew their DA on single-engined piston aeroplanes and this would also renew their DA for a fast jet that they had not flown for several years. There can be significant differences in flying techniques and in particular energy management, between different types or classes of aircraft. This policy is different from common CAA aviation practice where a proficiency check for one type or

class is only valid for that type or class and pilots must therefore be assessed separately for aircraft requiring different flying techniques. The pilot of G-BXFI had last renewed his DA in a different aircraft type. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-041

It is recommended that the Civil Aviation Authority require a Display Authorisation to be renewed for each class or type of aircraft the holder intends to operate during the validity of that renewal.

CAP 403 states:

'The FCC should have the clear authority of the Event Organiser to curtail or stop, on the grounds of safety, any display item or, in extreme cases, the whole flying display.'

The CAA does not require that these occurrences should be reported or investigated, and where it is made aware of them it does not record them formally or report on them. It stated that:

'Matters of concern for FDDs and display pilots are often discussed informally with the CAA. Furthermore, FDDs and display pilots have the opportunity to discuss specific or general concerns at the post-season display symposium.'

The purpose of occurrence reporting is to improve aviation safety by ensuring that relevant safety information relating to civil aviation is reported, collected, stored, protected, exchanged, disseminated and analysed. At the time of the accident this function was performed in the UK by the Mandatory Occurrence Reporting Scheme. Since November 2015 occurrence reporting in the UK and the rest of Europe has been governed by Regulation (EU) No 376/2014. It defines an occurrence as:

'Any safety-related event which endangers or which, if not corrected or addressed, could endanger an aircraft, its occupants or any other person and includes in particular any accident or serious incident;'

Commission Implementing Regulation (EU) 2015/1018 lists reportable occurrences, but does not specify those relating to flying displays. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-042

It is recommended that the Civil Aviation Authority publish a list of occurrences at flying displays, such as 'stop calls', that should be reported to it, and seek to have this list included in documentation relevant to Regulation (EU) No 376/2014.

The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 specify the duty to report certain occurrences, including serious incidents, to the AAIB. The Annex to Regulation (EU) No 996/2010 – ‘*on the investigation and prevention of accidents and incidents in civil aviation*’, lists examples of serious incidents, including:

‘a near collision requiring an avoidance manoeuvre to avoid a collision or an unsafe situation or when an avoidance action would have been appropriate.’

In 2014 a display by the pilot of G-BXFI, in another aircraft type and at a different venue, was stopped by the FDD of that display following concerns about the execution of a manoeuvre. A CAA Flight Standards Officer (FSO) was present but did not witness the occurrence.

Following an informal discussion with the pilot later that day the CAA took no further action and did not formally record the occurrence. The occurrence was not otherwise investigated and was not reported to the AAIB. It may not have been apparent to those involved that the duty to report could apply to such occurrences at flying displays or they may have concluded that this occurrence was not reportable. Nevertheless, the occurrence could have provided an opportunity to explore the pilot’s continued competence.

The FAA publishes a relevant policy:

‘When an airshow performer is involved in an accident or incident that occurs during any portion of an airshow routine at a public aviation event,... the performer’s competency to hold a Statement of Acrobatic Competency is in doubt.

Rescission of FAA Form 8710-7. *If the incident that gave reason to doubt the airman’s competency is of a serious nature, it may be necessary to immediately rescind the performer’s FAA Form 8710-7 pending reevaluation.*

- 1) Any incident that occurs during any portion of an airshow routine that directly threatens the safety and well-being of spectators, regardless of damage or injury, shall be grounds to rescind a performer’s FAA Form 8710-7.*
- 2) Any incident that occurs during any portion of an airshow routine that arises from flagrant and willful disregard for FAA safety rules and policy and/or when a performer exhibits an attitude of recidivism concerning FAA safety rules and policy shall also be grounds to rescind a performer’s FAA Form 8710-7.*
- 3) Concerning accidents or incidents at air shows, the FSDO that issued the FAA Form 7711-1 for the event shall immediately rescind the performer’s FAA Form 8710-7. It is important that this be completed before the next opportunity for the performer to perform at a public event.’*

If a pilot's approval is revoked, the industry body ICAS requires that the examiner committee will appoint the examiner and that:

'In all cases, the ACE Committee will ensure that the designated ACE is not the ACE who had previously evaluated the applicant.'

The CAA has no equivalent written policy or formal process. Therefore the following Safety Recommendation is made.

Safety Recommendation 2016-043

It is recommended that the Civil Aviation Authority introduce a process to immediately suspend the Display Authorisation of a pilot whose competence is in doubt, pending investigation of the occurrence and if appropriate re-evaluation by a Display Authorisation Evaluator who was not involved in its issue or renewal.

6.3 Monitoring of safety standards

CAP 403 states:

'The CAA GA Unit is required to inspect and monitor safety standards at a number of events annually.'

On 28 October 2015 the CAA published CAP1351 - 'CAA Review of Civil Air Displays: progress report', which stated that:

'CAA experts visit a significant number of air displays each year to:

- *monitor safety standards*
- *confirm the rules are being complied with*
- *identify measures that might further enhance safety standards'*

The CAA informed the AAIB that in 2014 it gave permission for 281 displays and attended 4 of them (1.4%)²⁷. In 2015 the CAA attended 18 of the 254 displays (7.1%).

By comparison, regulatory staff of the US Federal Aviation Administration (FAA) attend every authorised display²⁸. The FAA states that:

'The inspector's responsibility is to provide adequate safety oversight of the aviation event and to ensure compliance with the provisions of the waiver or authorization [sic].'

Footnote

²⁷ The CAA provided evidence of having attended a fifth event, which was a model flying display.

²⁸ The FAA occasionally waives this requirement, in specific circumstances, generally for fewer than 10 events each year.

Determining the appropriate level of regulatory oversight of an activity requires an understanding of the level of risk it presents. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-044

It is recommended that the Civil Aviation Authority establish and publish target safety indicators for United Kingdom civil display flying.

7 Further investigation

The AAIB continues to investigate the accident to G-BXFI and will report any significant developments as this progresses.

Published 10 March 2016

AAIB investigations are conducted in accordance with Annex 13 to the ICAO Convention on International Civil Aviation, EU Regulation No 996/2010 and The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996.

The sole objective of the investigation of an accident or incident under these Regulations is the prevention of future accidents and incidents. It is not the purpose of such an investigation to apportion blame or liability.

Accordingly, it is inappropriate that AAIB reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

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