Air Accident Report No: 1/2017

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Report on the accident to Hawker Hunter T7, G-BXFI near Shoreham Airport on 22 August 2015

Registered Owner and Operator:	Canfield Hunter Ltd
Aircraft Type:	Hawker Hunter T7
Nationality:	British
Registration:	G-BXFI
Place of accident:	A27, Shoreham Bypass, at the junction with Old Shoreham Road, North of Shoreham Airport
Date and Time:	22 August 2015 at 1222 hrs (Times in this report are UTC[1] unless stated otherwise)

Introduction

The accident was reported to the Air Accidents Investigation Branch by Shoreham Air Traffic Control.

In exercise of his powers, the Chief Inspector of Air Accidents ordered an investigation to be carried out in accordance with the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 and the European Regulations EU996/2010 on the investigation and prevention of accidents and incidents in civil aviation. The sole objective of the investigation under these Regulations is the prevention of accidents and incidents and not the apportioning of blame or liability.

The AAIB dispatched a team of investigators and support staff to the accident scene to commence an investigation immediately.

Summary

At 1222 UTC (1322 BST) on 22 August 2015, Hawker Hunter G-BXFI crashed on to the A27, Shoreham Bypass, while performing at the Shoreham Airshow, fatally injuring eleven road users and bystanders. A further 13 people, including the pilot, sustained other injuries.

Footnote

[1] Coordinated Universal Time.

The AAIB investigation considered the circumstances in which the aircraft came to be in a position from which it was not possible to complete its intended manoeuvre, and the reasons for the severity of the outcome.

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 benefits[2].

A safe flying display relies on the training and experience of the participating pilots, the airworthiness of the aircraft, and the planning and risk management of the event. Regulations, guidance and oversight provide the framework for these activities.

The aircraft was carrying out a manoeuvre involving both a pitching and rolling component, which commenced from a height lower than the pilot's authorised minimum for aerobatics, at an airspeed below his stated minimum, and proceeded with less than maximum thrust. This resulted in the aircraft achieving a height at the top of the manoeuvre less than the minimum required to complete it safely, at a speed that was slower than normal.

Although it was possible to abort the manoeuvre safely at this point, it appeared the pilot did not recognise that the aircraft was too low to complete the downward half of the manoeuvre. An analysis of human performance identified several credible explanations for this, including: not reading the altimeter due to workload, distraction or visual limitations such as contrast or glare; misreading the altimeter due to its presentation of height information; or incorrectly recalling the minimum height required at the apex.

The investigation found that the guidance concerning the minimum height at which aerobatic manoeuvres may be commenced is not applied consistently and may be unclear.

There was evidence that other pilots do not always check or perceive correctly that the required height has been achieved at the apex of manoeuvres.

Training and assessment procedures in place at the time of the accident did not prepare the pilot fully for the conduct of relevant escape manoeuvres in the Hunter.

The manoeuvre was continued and the aircraft struck the ground on the northern side of the westbound carriageway of the A27 close to the central reservation with a ground track at a slight angle to the direction of the road. When it struck the ground it broke into four main sections. Fuel and fuel vapour released from the fuel tanks ignited. In its path were vehicles that were stationary at, or in the vicinity of, the traffic lights at the junction with the Old Shoreham Road, and pedestrians standing by the junction.

The pilot did not attempt to jettison the aircraft's canopy or activate his ejection seat. However, disruption of the aircraft due to the impact activated the canopy jettison process and caused the ejection seat firing mechanism to initiate. The seat firing sequence was not

Footnote

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

completed due to damage sustained by its firing mechanism during the impact. The seat was released from the aircraft and the pilot was released from the seat as a result of partial operation of the sequencing mechanism. Some of the pyrotechnic cartridges remained live and were a hazard to first responders until they were made safe.

The investigation found that the aircraft appeared to be operating normally and responding to pilot control inputs until it impacted the ground. Defects in the altimeter system would have resulted in the height indicated to the pilot being lower than the actual aircraft height at the apex of the manoeuvre.

Information included in a previous AAIB report indicated that there had been several cases involving the type of engine fitted to this aircraft where an un-commanded reduction in engine speed had occurred and subsequent engineering investigation did not establish a clear cause. This investigation was unable to determine whether a reduction in engine speed recorded during the accident manoeuvre was commanded by the pilot.

The aircraft's engine was subject to a Mandatory Permit Directive (MPD) which imposed a calendar life on the engine type, and provided an option to extend that life using an Alternative Means of Compliance (AMOC). Proposals for an engine life extension using an AMOC inspection programme had to be approved by the regulator. Related tasks were being conducted by the maintenance organisation, but the regulator had not approved the operator or its maintenance organisation to use an AMOC to this MPD.

The investigation found that defects and exceedences of the aircraft's operational limits had not been reported to the maintenance organisation, and mandatory requirements of its Airworthiness Approval Note had not been met. During prolonged periods of inactivity the aircraft's engine had not been preserved in accordance with the approved maintenance schedule. The investigation identified a degraded diaphragm in the engine fuel control system, which could no longer be considered airworthy. However, the engine manufacturer concluded it would not have affected the normal operation of the engine.

The aircraft had been issued with a Permit to Fly and its Certificate of Validity was in date, but the issues identified in this investigation indicated that the aircraft was no longer in compliance with the requirements of its Permit to Fly.

The investigation found that the parties involved in the planning, conduct and regulatory oversight of the flying display did not have formal safety management systems in place to identify and manage the hazards and risks. There was a lack of clarity about who owned which risk and who was responsible for the safety of the flying display, the aircraft, and the public outside the display site who were not under the control of the show organisers.

The regulator believed the organisers of flying displays owned the risk. Conversely, the organiser believed that the regulator would not have issued a Permission for the display if it had not been satisfied with the safety of the event. The aircraft operator's pilots believed the organiser had gained approval for overflight of congested areas, which was otherwise prohibited for that aircraft, and the display organiser believed that it was the responsibility of

the operator or the pilot to fly the aircraft's display in a manner appropriate to the constraints of the display site.

No organisation or individual considered all the hazards associated with the aircraft's display, what could go wrong, who might be affected and what could be done to mitigate the risks to a level that was both tolerable and as low as reasonably practicable.

Controls intended to protect the public from the hazards of displaying aircraft were ineffective.

The investigation identified the following causal factors in the accident:

- The aircraft did not achieve sufficient height at the apex of the accident manoeuvre to complete it before impacting the ground because the combination of low entry speed and low engine thrust in the upward half of the manoeuvre was insufficient.
- An escape manoeuvre was not carried out, despite the aircraft not achieving the required minimum apex height.

The following contributory factors were identified:

- The pilot either did not perceive that an escape manoeuvre was necessary, or did not realise that one was possible at the speed achieved at the apex of the manoeuvre.
- The pilot had not received formal training to escape from the accident manoeuvre in a Hunter and had not had his competence to do so assessed.
- The pilot had not practised the technique for escaping from the accident manoeuvre in a Hunter, and did not know the minimum speed from which an escape manoeuvre could be carried out successfully.
- A change of ground track during the manoeuvre positioned the aircraft further east than planned producing an exit track along the A27 dual carriageway.
- The manoeuvre took place above an area occupied by the public over which the organisers of the flying display had no control.
- The severity of the outcome was due to the absence of provisions to mitigate the effects of an aircraft crashing in an area outside the control of the organisers of the flying display.

The AAIB has published three Special Bulletins (SB) highlighting areas of concern that required timely consideration.

SB 3/2015, published on 4 September 2015, 13 days after the accident, reported initial information about the occurrence.

SB 4/2015, published on 21 December 2015, dealt with the safety of first responders to the accident scene, the maintenance of ejection seats in historic ex-military aircraft and issues regarding the maintenance of ex-military aircraft on the UK civil register. Seven Safety Recommendations were made.

SB 1/2016, published on 10 March 2016, considered the risk management of flying displays, minimum display heights and separation distances, regulatory oversight and piloting standards. It contained a further 14 Safety Recommendations, and was published to inform the air display community ahead of the 2016 air display season.

A further 11 Safety Recommendations are made in this report.

Findings

Operational aspects

1. The pilot was licensed and authorised in accordance with the requirements existing at the time of the accident to operate the Hawker Hunter at flying displays.

2. It was the pilot's fifth aerobatic display in a Hunter during the 2015 season and the only public display he carried out that day. He met the recency requirements specified in CAP 403.

3. The accident occurred during a manoeuvre involving pitching and rolling components, intended to be a 'bent loop', at the apex of which the aircraft was inverted.

4. Flight trials indicated that the apex height for a looping manoeuvre with a 90° track change on the upward vertical was 300 to 400 ft less than for a straight loop with all other parameters constant.

5. The accident manoeuvre started and finished outside the aerodrome boundary, over an area not controlled by the organisers of the flying display.

6. A general permission granted by the CAA provided an exemption from the Standardised European Rules of the Air, permitting flight below 500 feet up to 1 km from the display gathering.

7. The pilot's display authorisation for the Hunter stipulated a minimum height for executing aerobatics of 500 ft.

8. The manoeuvre started approximately 900 m from the display line at a height of 185 ±25ft agl.

9. The pilot's declared minimum entry speed for the manoeuvre was 350 KIAS. The aircraft entered the manoeuvre at approximately 310 KIAS.

10. Engine speed varied during the upward first half of the manoeuvre. This was contrary to the pilot's declared technique of using full thrust.

11. The manoeuvre could have been abandoned during its upward first half if an un-commanded reduction in thrust had occurred and been detected.

12. There was no evidence of a pre-existing mechanical defect that would have prevented the engine from responding to pilot throttle inputs. However, the fuel pump governor diaphragm showed significant signs of ageing and chemical attack such that it could no longer be considered airworthy.

13. Information included in a previous AAIB report (EW/C98/6/1) indicated that there had been a number of cases involving the Avon Mk 122 engine where engine speed had dropped and subsequent engineering investigation had not established a clear cause. Therefore, an uncommanded reduction in thrust during the accident manoeuvre could not be ruled out.

14. In tests, the left altimeter under-read by approximately 100 feet. It also exhibited lag and stickiness in its operation both during testing and on a previous flight. Overall, these defects would have resulted in the altitude indicated to the pilot being lower than the actual aircraft altitude at the apex of the accident manoeuvre.

15. The right altimeter had a latent defect which meant it was no longer providing a synchronising signal to the left altimeter.

16. No other technical defects were identified that were relevant to the accident.

17. The minimum height loss during the downward half of a looping manoeuvre in the Hawker Hunter is between 2,600 and 2,950 feet (including 100 ft for instrument reading error), when flown at the values of aircraft mass and density altitude relevant to the accident.

18. The pilot stated that he required a minimum height of 3,500 ft at the apex of the manoeuvre to ensure that he completed it 500 ft or more above the ground (as required by his display authorisation).

19. The aircraft achieved an apex height of approximately 2,700 ft.

20. The airspeed at the apex of the accident manoeuvre was 105±2 KIAS, which was at the lower end of the pilot's declared airspeed range of 100 to 150 KIAS.

21. The aircraft was lower than required at the apex because it entered the manoeuvre below the target airspeed, because less than maximum thrust was applied during its upward half, and because any rolling element initiated before the aircraft reached the upward vertical would have further reduced apex height.

22. The entry height of the manoeuvre was consistent with the 200ft minimum height on the pilot's DA for a Jet Provost; the apex height and speeds on the accident manoeuvre were consistent with those flown in the Jet Provost the previous weekend.

23. The pilot stated that he would abandon a 'bent loop' manoeuvre if the minimum entry speed, or the minimum gate height at the apex, were not achieved. He did not abandon the accident manoeuvre when these minimums were not achieved.

24. It is possible that the pilot misread or misinterpreted speed and height indications during the manoeuvre, or recalled those for a different aircraft type.

25. The pilot had not previously rolled the Hawker Hunter at the low airspeed encountered at the apex, and was not sure that a roll could be achieved at that speed.

26. Flying an escape manoeuvre is not the same as flying planned manoeuvres such as a half Cuban 8.

27. Flight trials indicated that a rolling escape manoeuvre was possible up to four seconds after the aircraft passed the apex of the accident manoeuvre.

28. The pilot had not practised flying escape manoeuvres in the Hunter.

29. The operator's Operational Control Manual did not contain information about performing aerobatic manoeuvres and associated escape manoeuvres.

30. The previous two renewals of the pilot's display authorisation were not performed on the Hawker Hunter.

31. The g experienced by the pilot during the manoeuvre was probably not a factor in the accident.

32. The aircraft struck the carriageway of the A27, Shoreham Bypass, in a wings level, nose-high attitude at a speed of approximately 225 kt.

33. The aircraft collided with bystanders, road users and vehicles at the junction of the A27 and Old Shoreham Road, in an area outside the control of the flying display organisers. Eleven people were fatally injured and 13 others, including the pilot, were injured as a result of the accident.

Organisation of the flying display

34. The organiser of the flying display had obtained the permission of the CAA required by Article 162 of the Air Navigation Order (ANO).

35. The CAA, pursuant to Article 162, had permitted the Flying Display Director (FDD) to act as the FDD for the 2015 Shoreham Airshow, having

assessed him as 'fit and competent', but had no written policy or procedure for making that determination.

36. The FDD believed that the risk assessment for the flying display was compliant with CAP 403. However, the risk assessment was not suitable and sufficient to manage the risks to the public.

37. The risk assessment did not consider which aircraft would be displaying, where they would operate and to whom they would present a hazard.

38. The FDD did not know the intended sequence of manoeuvres to be flown by the accident pilot, and the edition of CAP 403 in force at the time did not indicate that he should.

39. The risk assessment and risk management guidance provided to display organisers in CAP 403 requires improvement.

40. The risk assessment relied upon compliance with Rule 5 of the Rules of the Air (that no aircraft should fly closer than 500 ft to any person, vehicle, vessel or structure) to mitigate the hazard presented by aircraft displaying over areas outside the control of the organisers.

41. The FDD was not aware that, under a permission granted by the CAA, the aircraft was exempt from this rule when within 1,000 metres of a gathering of persons assembled to witness the event.

42. The CAA did not require to see or approve risk assessments before issuing a permission to hold a flying display in accordance with Article 162 of the ANO.

43. The CAA recommended in CAP 632 that operators of Permit to Fly ex-military aircraft adopt a safety management system (SMS). It did not require them to have one.

44. The operator of the aircraft did not have an SMS or a documented alternative.

45. The General Aviation Unit of the CAA did not have an SMS.

46. The planned display of G-BXFI at the 2015 Shoreham Airshow was similar to that in 2014, in which the location of the aircraft's manoeuvres did not comply with its Permit to Fly.

47. The operator did not have a process to ensure that the manner in which the aircraft was operated during flying displays would comply with the conditions of its Permit to Fly.

48. The CAA did not require persons outside the area controlled by the organisers of the flying display to be protected from the hazards associated with it.

49. The CAA granted the organisers of the 2015 Shoreham Airshow permission to hold a flying display. However, the CAA considers that the principle reason for rejecting an application is safety, and that the proximity of congested areas and heavily used major roads must be taken into account in determining the viability of the site of a flying display. The A27 is a heavily used major road, carrying approximately 58,500 vehicles per day.

50. The organisers of the 2015 Shoreham Airshow recognised that the junction of the A27 with the Old Shoreham Road was a popular gathering point for secondary crowds.

51. Measures taken by the organisers probably reduced the size of the crowd that gathered at the A27 junction, however, there were a number of people standing at the junction of the A27 and Old Shoreham Road during the flying display.

52. Approximately 40% of the land area within 2 km of Shoreham Airport meets the definition of a 'congested area' given in the ANO.

53. The Flying Control Committee had no means of accurately determining the height and speed of displaying aircraft and had to rely on its judgement and experience to monitor their performance.

54. The rescue and firefighting resources in place responded promptly to the accident.

55. The CAA had no means of determining the safety of flying displays other than by attending them. It attended 7% of the flying displays it approved in 2015 and 2.8% of those it approved in 2014.

56. The CAA had not established an acceptable level of safety performance for display flying.

Engineering aspects

Matters related to the accident sequence

57. The pilot did not command an ejection.

58. The aircraft was probably outside the operational envelope of the ejection system during the downward portion of the accident manoeuvre.

59. Activation of the canopy jettison system and the ejection seat was initiated by damage to the cockpit and seat structure sustained during impact.

60. The ejection sequence did not complete due to damage sustained to the ejection seat gun during the impact.

61. The pilot and ejection seat were released from the cockpit during the later stages of the impact sequence and the ejection seat automated release features acted to release the pilot from the seat before it came to rest.

62. Some pyrotechnic cartridges in each of the ejection seats remained live after the aircraft came to rest.

63. Information about the dangers of the ejection seats and other hazards associated with G-BXFI was not available to the organisers of the flying display and therefore could not be passed on to the first responders.

Maintenance and airworthiness

64. The ejection seat manufacturer's recommended installed cartridge life was two years with a maximum total (shelf) life of six years. This recommendation was included as a limitation in the aircraft's AAN, which formed the basis for its certification. The maintenance organisation had adopted a six-year installation life for ejection seat cartridges. This extension to the installed life had not been documented in accordance with the maintenance organisation's procedures, nor had it been approved by the CAA.

65. At the time of the accident, the two-year installed cartridge life had been exceeded by more than 4½ years and the six-year total life had been exceeded by more than a year.

66. The CAA was not aware of the extension to the ejection seat cartridge lives.

67. The CAA did not have a documented procedure for approving extensions to ejection seat cartridge lives but stated that applications for extensions would be considered on a case-by-case basis, and would only be granted for a short period upon proof that new cartridges were on order.

68. The maintenance organisation had new cartridges available, which had not been fitted to the ejection seats in the aircraft.

69. CAP 632 requires the pilot escape systems of swept-wing jet aircraft, such as the Hawker Hunter, to be 'fully serviceable'. The use of time-expired ejection seat cartridges meant that the ejection seats fitted to G-BXFI did not meet this requirement.

70. The practice of using time-expired ejection seat cartridges in civil-operated ex-military aircraft was not confined to G-BXFI or its maintenance organisation.

71. The engine fitted to G-BXFI was not preserved during periods of inactivity as required by the aircraft's approved maintenance program.

72. Neither the operator nor the maintenance organisation had an approved Alternative Means of Compliance with the Mandatory Permit Directive related to engine life (MPD 2001-001).

73. The maintenance organisation did not have access to the previous operator's AMOC. It based scheduled maintenance tasks on entries in the aircraft maintenance records associated with MPD 2001-001.

74. The maintenance organisation submitted a proposal for an AMOC to MPD 2001-001 to the CAA which in turn requested this be resubmitted to include additional tasks detailed in CAP 562 Leaflet 70-80. However, no further application to the CAA was made by the maintenance organisation.

75. The serial number of the right altimeter did not match that recorded in the technical records.

76. Engine rpm exceedences occurring during a test flight in 2011 were not reported or investigated.

77. There was no formal or documented monitoring of engine performance, either during engine ground runs or in flight, which would enable engine performance deterioration to be identified.

78. Video evidence showed that the g-meter fitted to the aircraft was defective during the accident flight and in September 2014. No related defects had been reported or recorded, and the maintenance organisation stated that it was not aware of any.

79. The AAN and Permit to Fly required the fatigue state of the aircraft to be recorded after each day's flight. The maintenance organisation read and recorded the fatigue state once each year; between these readings, monitoring of high fatigue inducing events relied on the pilots reporting high loads seen on the g-meter.

80. The aircraft was being operated with the aileron trim position indicator inoperative.

81. The aircraft had been operated with the flaps extended at speeds exceeding the limit for doing so. This had not been reported in the aircraft technical log.

82. The maintenance organisation issued a Certificate of Validity to the Permit to Fly. At the time of the accident the aircraft did not meet airworthiness requirements or the conditions of its Permit to Fly.

83. CAA oversight of the maintenance organisation and the operator did not identify the deficiencies with the aircraft's airworthiness.

84. The maintenance organisation did not have an established safety management system and was not required to have one.

85. The diaphragm of the fuel pump governor had degraded due to the combined effects of age and chemical attack. The engine manufacturer concluded that it would not have prevented the engine from operating

normally but considered that it had exceeded its known predictable functional capability and its continued integrity would be severely affected.

86. MPD 2001-001 was published to mitigate the effects of ageing on the Rolls-Royce Avon series of engines, including the engine fuel systems.

87. The AMOC approved for a previous operator of the aircraft did not include routine inspections of the condition of engine fuel systems. This inspection regime, continued by the current maintenance organisation, did not identify the degradation of the fuel pump governor diaphragm.

88. The aircraft was fitted with underwing drop tanks made from phenolic asbestos. This hazard had not been identified.

Causal factors

- The aircraft did not achieve sufficient height at the apex of the accident manoeuvre to complete it before impacting the ground, because the combination of low entry speed and low engine thrust in the upward half of the manoeuvre was insufficient.
- An escape manoeuvre was not carried out, despite the aircraft not achieving the required minimum apex height.

Contributory factors

- The pilot either did not perceive that an escape manoeuvre was necessary, or did not realise that one was possible at the speed achieved at the apex of the manoeuvre.
- The pilot had not received formal training to escape from the accident manoeuvre in a Hunter and had not had his competence to do so assessed.
- The pilot had not practised the technique for escaping from the accident manoeuvre in a Hunter, and did not know the minimum speed from which an escape manoeuvre could be carried out successfully.
- A change of ground track during the manoeuvre positioned the aircraft further east than planned producing an exit track along the A27 dual carriageway.
- The manoeuvre took place above an area occupied by the public over which the organisers of the flying display had no control.
- The severity of the outcome was due to the absence of provisions to mitigate the effects of an aircraft crashing in an area outside the control of the organisers of the flying display.

Safety Recommendations

The following Safety Recommendations were made in Special Bulletin S4/2015 on 21 December 2015. The CAA responded to each in FACTOR F1/2016, published on 8 April 2016.

Safety Recommendation 2015-041

It is recommended that the Civil Aviation Authority require operators of ex-military aircraft fitted with ejection seats or other pyrotechnic devices operating in the United Kingdom, to ensure that hazard information is readily available which includes contact details of a competent organisation or person able to make the devices safe following an accident.

The CAA responded as follows:

'The CAA accepts this recommendation. To ensure that hazard information is readily available for aircraft participating in flying displays, the CAA will amend the certificate supplied to the Flight Display Director by a pilot participating in a flying display to identify the pyrotechnic devices fitted to the aircraft and the contact details of a competent organisation or person able to make the devices safe (or advise on doing so) following an accident. The revised form will be published before the end of April 2016 as part of an amendment to CAP 403.

The CAA is currently reviewing how best to ensure that the same information is readily available for aircraft not participating in flying displays. This review will be completed before the end of June 2016.'

The AAIB has categorised the response to this Safety Recommendation as *'Adequate – closed'.*

Safety Recommendation 2015-042

It is recommended that the Civil Aviation Authority review the guidance in CAP 632 with respect to ejection seats and the means by which operators of ex-military aircraft equipped with them comply with this guidance. This review should include:

- The benefits and hazards of aircrew escape systems in civilian-operated aircraft
- The use of time-expired components
- The availability of approved spares
- The seat manufacturer's guidance on deactivating its historic products
- Adoption of a dedicated Maintenance Approval for persons or organisations competent to perform ejection seat maintenance.

The CAA responded as follows:

> *'The CAA accepts this recommendation and is undertaking a review of ejection seat safety as part of the Air Display Review. This review includes consideration of each of the specific points highlighted by this recommendation and will be completed before the end of December 2016.'*

The AAIB has categorised the response to this Safety Recommendation as '*Adequate – closed*'.

Safety Recommendation 2015-43

It is recommended that the Civil Aviation Authority establish a process for the effective dissemination of ex-military jet aircraft experience and type-specific knowledge to individual maintenance organisations.

The CAA responded as follows:

> *'The CAA accepts this recommendation. By December 2016, the CAA will establish and promote a process for the more effective dissemination of ex-military jet aircraft experience and type-specific knowledge between individual maintenance organisations.'*

The AAIB has categorised the response to Safety Recommendation 2015-043 as '*Adequate – closed*'.

Safety Recommendation 2015-44

It is recommended that the Civil Aviation Authority define a minimum amendment standard for the technical publications for each ex-military jet aircraft type operated on the United Kingdom civil register.

Following the publication of FACTOR F1/2016 Issue 2 the CAA's response is as follows:

> *'Working in conjunction with industry, the CAA will establish a minimum amendment standard for the technical publications for each individual ex-military jet aircraft operated on the UK civil register. The established standard will be recorded in the Airworthiness Approval Note (AAN) for each aircraft.*
>
> *The CAA will complete this work by December 2018.'*

The AAIB has categorised the CAA response to Safety Recommendation 201544 as '*Adequate – closed*'.

Safety Recommendation 2015-45

It is recommended that the Civil Aviation Authority require that an ex-military jet aircraft's maintenance programme be transferred with the aircraft when it moves to another maintenance organisation to ensure continuity of the aircraft's maintenance.

Following the publication of FACTOR F1/2016 Issue 2, the CAA's response is as follows:

> *'The CAA is developing a proposal for consultation with industry to introduce a new requirement into BCAR Section A to require a maintenance programme to be transferred with an ex-military jet aircraft if it moves to a new maintenance/ continuing airworthiness management organisation, or new owner/operator.*
>
> *Subject to the outcome of the process of industry consultation, the CAA intends to implement this requirement by April 2018.'*

The AAIB has categorised the response to Safety Recommendation 2015-45 as '*Adequate – closed*'.

Safety Recommendation 2015-046

It is recommended that the Civil Aviation Authority review the effectiveness of all approved Alternative Means of Compliance to Mandatory Permit Directive 2001-001.

Following the publication of FACTOR F1/2016 Issue 2, the CAA's response is as follows:

> *'The CAA will require ex-military jet aircraft maintenance organisations and/ or continuing airworthiness management organisations to conduct a review of their approved Alternative Means Of Compliance (AMOC) to MPD2001-001. Following such a review, each of these affected organisations must make application for a new AMOC in accordance with a new MPD to be issued which will supersede MPD2001-001.*
>
> *The review process will be completed by April 2018.'*

The AAIB has categorised the response to Safety Recommendation 2015-46 as '*Adequate – closed*'.

Safety Recommendation 2015-047

It is recommended that the Civil Aviation Authority review its procedures to ensure that a '*Permit to Fly-Certificate of Validity*' is valid when it is issued.

Following the publication of FACTOR F1/2016 Issue 2, the CAA's response is as follows:

> *'Responsibility for ensuring that a 'Permit to Fly-Certificate of Validity' is valid when issued sits with the approved maintenance organisation and not the CAA. An organisation approved by the CAA to conduct an airworthiness review on such aircraft is granted the privilege, under its approval, to declare to the CAA that a particular aircraft complies with the requirements of BCAR Section A Chapter A3-7, which includes completing a physical survey of the aircraft and a documented review of its records to determine its airworthiness status. The CAA is not required to validate the work carried out under this approval before a Certificate of Validity is issued. Instead, an organisation's compliance*

with these requirements, including the adequacy of declarations, is audited as part of CAA's continued oversight activity.

Therefore, in order to deliver the intent of this safety recommendation, the CAA will review both the design and implementation of its oversight activity in respect of approved maintenance organisations and the process by which documents such as Permit to Fly Certificates of Validity are issued by approved organisations.

By April 2018, the CAA will conclude this review, and, should any changes be necessary, identify the date by which they will be implemented.'

The AAIB has categorised the response to Safety Recommendation 2015-47 as '*Adequate – closed*'.

The following Safety Recommendations were issued in Special Bulletin S1/2016 on 10 March 2016. The CAA responded to each in FACTOR F4/2016, published on 9 June 2016.

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.

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response is as follows:

'The CAA will review the findings contained in the HSL reports on the management of risk, in conjunction with the conclusions of its post-implementation review of UK Civil Air Displays. The CAA will complete this review and publish any updated guidance by April 2017.'

The AAIB has categorised the response to Safety Recommendation 2016-31 as '*Adequate – closed'.*

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.

In FACTOR F4/2016, published on 9 June 2016 the CAA made the following response to Safety Recommendation 2016-032:

'The CAA accepts this recommendation.

The CAA will 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. This will be completed by the end of March 2017.'

The AAIB has categorised the response to Safety Recommendation 2016-31 as '*Adequate – closed'.*

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.

The CAA responded in FACTOR F4/2016 as follows:

'The CAA accepts this recommendation that organisers of flying displays must conduct suitable and sufficient risk assessments.

It remains the responsibility of organisers of flying displays to conduct suitable and sufficient risk assessments. The CAA has introduced a new risk assessment process for display applications together with a new risk assessment template and a revised display application form. These are designed to make it clearer to organisers of flying displays the nature of the risk assessment that must be completed. The revised process was published alongside the guidance 'Flying displays and special events: A guide to safety and administrative arrangements' in March 2016.'

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response to the Safety Recommendation is as follows:

The CAA has already introduced enhanced risk assessment guidance to assist event organisers when conducting such risk assessments. The CAA cannot carry out its own risk assessments in respect of every application for a display (and so cannot "ensure" that suitable and sufficient risk assessments have been carried out) and has introduced a process so that, when considering an application for a Permission to hold a display under Article 86 of the Air Navigation Order 2016 (previously Article 162 of the Air Navigation Order 2009), the CAA considers whether the application aligns with the CAA's guidance.

The CAA intends also to review the findings of the HSL reports in conjunction with the conclusions of the CAA's own postimplementation review of UK Civil Air Displays in order to consider whether any updated guidance on the management of risk is necessary (see FACTOR response to Safety Recommendation 2016-031 above).

The CAA will clarify the responsibilities of organisers / FDDs in this respect during this review and complete and publish any updated guidance by April 2017.

For the 2017/2018 seasons the CAA will review each risk assessment submitted with an application for a display against the specified criteria notified in CAP 403. Where those criteria are not met, the CAA will request further information from the applicant or, where necessary, not grant a permission for that display.'

The AAIB has categorised the response to Safety Recommendation 2016-31 as '*Adequate – closed'.*

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 is done in sufficient time to enable the organiser to conduct and document an effective risk assessment.

The CAA responded in FACTOR F4/2016 as follows:

'The CAA understands the intent here is to define the area of ground over which the commander of an aircraft will be permitted to display that aircraft. This can be done in a number of ways. The CAA does not accept that it should specify information in the manner set out in the recommendation. The CAA has concluded that the FDD's risk assessment should be informed by and take account of both the manoeuvres to be flown and the area of ground over which they will be flown.

The CAA now requires pilots to confirm to the FDD well in advance of the display briefing that their air display conforms to the air display permission granted by the CAA. If the series of linked manoeuvres or the area of ground over which the aircraft will fly is outside the areas already risk assessed by the FDD, the FDD will be able to take this into account in their risk assessment and document it accordingly.

It remains the responsibility of the organisers of flying displays to follow this guidance and conduct risk assessments that are suitable and sufficient to manage the risks associated with the air displays that they are organising.'

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response to the Safety Recommendation is as follows:

> *'The risk assessment conducted by the FDD is required to be informed by and take account of both the manoeuvres intended to be flown and the area of ground over which they will be flown.*
>
> *The CAA has amended CAP 403 Appendix B "Certificate to be supplied to the event organiser by a pilot participating in a flying display", to specify the information that the commander of the aircraft intending to participate in a flying display must provide to an organiser in advance of a display, including the manoeuvres intended to be flown. Appendix B must be supplied in sufficient time to enable the event organiser to conduct a risk assessment for the display. The risk assessment (to be submitted with the application for a Permission) must also take account of the ground area over which the display will be performed, which in turn will enable the CAA to specify the boundaries of a flying display within which any permission applies.*
>
> *The CAA has introduced a requirement, in CAP 403 for any pilot intending to fly aerobatic manoeuvres to notify the FDD of the series of the linked manoeuvres that they intend to perform at least one day prior to a display. If the information is not provided, the FDD must not allow the pilot to fly in the display. This information, together with the prior notification of a defined area within which the permission applies, will support the implementation of an effective risk assessment.*
>
> *CAP 403 was amended in June 2016.Completed.'*

The AAIB has categorised the response to Safety Recommendation 2016-31 as 'Partially adequate – closed'.

> **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.

The CAA responded as follows:

> *'The CAA accepts this recommendation. The CAA now requires 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.*
>
> *As set out in the March 2016 edition of the CAA's guidance "Flying displays and special events: A guide to safety and administrative arrangements", all pilots participating in a flying display must supply the FDD of the air display with a*

certificate confirming that the display that they intend to perform complies with the conditions placed on the aircraft's Certificate of Airworthiness and Permit to Fly. A template for the certificate is at Appendix B of the guidance.'

The AAIB has categorised the response to Safety Recommendation 2016-035 as *'Adequate – closed'.*

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.

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response is as follows:

'The CAA has removed the general exemption to flight at minimum heights issued for civil air displays, air races and contests, outlined in Official Record Series 4-1124.

Display Permissions granted by CAA under Article 86 of the Air Navigation Order 2016 now specify the boundaries of a flying display within which the permission applies.'

The AAIB has categorised the response to Safety Recommendation 2016-036 as *'Adequate – closed'.*

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.

The CAA responded as follows:

'The CAA understands that this recommendation relates to members of the public attending a flying display.

The CAA accepts this recommendation.

The MAA has commissioned an independent study into crowd separation distances. This research is ongoing and should report in 2017. As the MAA research is ongoing, the CAA decided in its review of UK civil air displays that, as an interim measure, where current MAA crowd separation distances are higher it would align with them. The increased distances were announced in April this year in the final report of the CAA's Review of UK Civil Air Displays. The CAA will confirm crowd separation distances after the independent study commissioned by the MAA into crowd separation distances reports in 2017.'

The CAA subsequently updated its response to this and Safety Recommendation 2016-038 as shown below.

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.

FACTOR F4/2016, issued on 9 June 2016, recorded that the CAA did not accept this recommendation. Following discussions with the AAIB the CAA, FACTOR F4/2016 Issue 2 provided an updated, combined, response to Safety Recommendations 2016-037 and 2016-038, as follows:

'The CAA will conduct a review, within six months of publication by the MAA of a study by Frazer-Nash, to consider whether any changes are required to the minimum distance that display aircraft are to be separated from the public (primary and secondary crowds) to effectively minimise the risk of injury to the public in the event of an accident to the displaying aircraft. In the event that this study does not deliver a clear output or is terminated, for any reason, the CAA will consider what additional work will be needed to resolve this Recommendation. Subject to the findings of the study and the outcome of the review, the CAA shall make any necessary revisions to the application process for Permissions granted under Article 86 of the Air Navigation Order 2016.'

The AAIB categorised this response as *'Adequate – closed'.*

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.

The CAA responded as follows:

'The CAA does not accept this recommendation.

The CAA expects the organisers of flying displays and in collaboration with FDDs to identify and then mitigate or manage all the risks to the public arising from their air display. It is for the organiser of the display and the FDD to decide what course of action is necessary and how they will implement it. Furthermore the pilot is responsible for performing their display in accordance with the Permission granted under Article 162 of the Air Navigation Order and their own display authorisation.'

The AAIB has categorised the response to Safety Recommendation 2016-039 as *'Superseded – closed'.*

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.

The CAA responded as follows:

'The CAA does not accept this recommendation as it is impractical to achieve in the relatively small air display community and maintain a working display evaluation system.

The CAA believes that it is better to identify any potential conflicts of interest, such as personal or commercial connections, and manage them. In its Action Report of its Review of UK Civil Air Displays, published in January 2016, the CAA strengthened the display authorisation process by requiring, after the first two years, a pilot holding a display authorisation to be revalidated by a different DAE, selected by the CAA. The CAA believes this will reduce the risks of conflicts of interest.'

The AAIB has categorised the response to Safety Recommendation 2016-040 as *'Partially adequate – closed'.*

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.

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response is as follows:

'The CAA will review the list of different categories of aircraft relevant to pilot Display Authorisation renewal and assess the impact of operating differences between each category. The CAA will expand this work to include a study of the potential for inappropriate transfer of behaviours between aircraft types. The CAA will consider introducing any relevant findings into the ongoing training and assessment requirements for display pilots, including the requirements for Display Authorisation renewal.

The CAA will conclude this review and publish its findings by April 2018.'

The AAIB has categorised the response to Safety Recommendation 2016-041 as *'Adequate – closed'.*

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 CAA responded as follows:

'The CAA does not accept this recommendation.

The CAA is developing a positive reporting culture - a Just Culture – for the air display community. Within the air display sector the CAA believes that this is the most effective way to identify and address potential safety issues before they lead to accidents.

In support of this, from April this year the CAA required all event organisers and FDDs to submit, within seven days, a post-air display report to the CAA. This report must include what went well at the display, as well as information on any lapses or breaches from the required standards. Pilots must also report any aspect of their display that could have caused a significant safety risk. The CAA will record all this information. Key information will be shared with the civil air display community through briefings, the pre- and post-season seminars that the CAA jointly hosts with BADA[3] and the MAA, and the annual seminar that the CAA organises for DAEs.'

The AAIB has categorised the response to Safety Recommendation 2016-042 as *'Partially adequate – closed'.*

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.

The CAA responded as follows:

'The CAA accepts this recommendation.

In its final report of its Review of UK Civil Air Displays, published in April 2016, the CAA announced that where a stop is called because an FDD, or member of the Flight Control Committee, has reason to doubt the fitness or competence of a pilot that pilot will be subject to a provisional suspension of their display authorisation pending an investigation by the CAA of the circumstances leading

Footnote

[3] British Air Display Association.

to the stop being called. In its investigation, the CAA will determine whether the suspension of the display authorisation should be withdrawn or further regulatory enforcement action taken against the pilot concerned.'

The AAIB has categorised the response to Safety Recommendation 2016-043 as *'Adequate – closed'.*

Safety Recommendation 2016-044

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

Following the publication of FACTOR F4/2016 Issue 2, the CAA's response is as follows:

'The CAA will undertake a study to identify and publish meaningful safety indicators for civil display flying.

The CAA will conclude this study and publish safety indicators by September 2017.'

The AAIB has categorised the response to Safety Recommendation 2016-044 as '*Adequate – closed'.*

The following new Safety Recommendations are made in this report:

Safety Recommendation 2017-001

It is recommended that the Civil Aviation Authority amend CAP 403 to clarify the point at which an aerobatic manoeuvre is considered to have been entered and the minimum height at which any part of it may be flown.

Safety Recommendation 2017-002

It is recommended that the Civil Aviation Authority require pilots intending to conduct aerobatics at flying displays to be trained in performing relevant escape manoeuvres and require that their knowledge and ability to perform such manoeuvres should be assessed as part of the display authorisation process.

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.

Safety Recommendation 2017-004

It is recommended that the Civil Aviation Authority remind operators, whose activities are subject to the guidance published in Civil Aviation Publication 632, of the need to maintain detailed training records for pilots and check their compliance during inspections it carries out.

Safety Recommendation 2017-005

It is recommended that the Civil Aviation Authority specify that the flight demonstration requirement of a display authorisation evaluation, other than to assess formation following, cannot be satisfied by the pilot following another aircraft during the evaluation.

Safety Recommendation 2017-006

It is recommended that the Civil Aviation Authority undertake a study of error paths that lead to flying display accidents and integrate its findings into the human factors training it requires the holders of display authorisations to undertake.

Safety Recommendation 2017-007

It is recommended that the Civil Aviation Authority review the arrangements for safety regulation and oversight of intermediate and complex ex-military aircraft operated in accordance with Civil Aviation Publication 632, to ensure that they are consistent and appropriate.

Safety Recommendation 2017-008

It is recommended that the Civil Aviation Authority consider implementing the changes outlined in Health and Safety Laboratory report MSU/2016/13 'Review of the risk assessment sections of CAP 403'.

Safety Recommendation 2017-009

It is recommended that the Civil Aviation Authority require operators of aircraft used for flying displays to identify, and where practicable remove, any hazardous materials.

Safety Recommendation 2017-010

It is recommended that the Civil Aviation Authority prohibit the use of phenolic asbestos drop tanks on civil registered aircraft.

Safety Recommendation 2017-011

It is recommended that the Department for Transport commission, and report the findings of, an independent review of the governance of flying display activity in the United Kingdom, to determine the form of governance that will achieve the level of safety it requires.