ACCIDENT

Aircraft Type and Registration:	North American Rockwell OV-10B Bronco, G-BZGK
No & Type of Engines:	1 Garrett Airesearch T76-G-418 turboprop engine 1 Garrett Airesearch T76-G-419 turboprop engine
Year of Manufacture:	1971 (Serial no: 338-17)
Date & Time (UTC):	10 July 2012 at 1350 hrs
Location:	Cotswold (Kemble) Airport, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	4,096 hours (of which 179 were on type) Last 90 days - 41 hours Last 28 days - 18 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot was performing a display practice during which he attempted a barrel roll. Approaching the inverted position, at the top of the manoeuvre, the nose of the aircraft dropped below the horizon and the aircraft entered a steep descent. The pilot had reduced the rate of roll, thinking that it was too fast, but the aircraft continued to pitch through the vertical. The aircraft struck the ground in an approximately wings level, upright attitude with a high rate of descent. There was an immediate post-impact fire but the RFFS were on standby and reached the aircraft rapidly. The pilot was assisted from the aircraft having suffered serious injuries.

The investigation identified areas of concern in the granting of regulatory approvals and authorisations, and subsequent related audits. Four Safety Recommendations are made.

History of the flight

Previous flights

On 5 July 2012, the aircraft was flown from Kortrijk-Wevelgem International Airport (EBKT), Belgium to RAF Fairford (EGVA), Gloucestershire, where it was displayed at an airshow, as a static exhibit, on 7 and 8 July 2012. While at Fairford, the aircraft was refuelled.

On the morning of 9 July 2012, the aircraft departed RAF Fairford and flew to nearby Cotswold (Kemble) Airport (EGBP). The flight time was 5 minutes and the total engine running time was 19 minutes. On departure, the pilot recorded that the fuel in the internal tanks was indicating 1,760 lbs and that the centreline (external) drop tank was full (1,488 lbs). That afternoon the pilot flew the aircraft on two air-to-air photographic flights. The quality of the photographs was degraded and it was suspected that this was the result of fuel, in the form of a mist, being released from the centreline drop tank. A further flight was planned for the morning of 10 July 2012 but this was cancelled due to unfavourable atmospheric conditions.

Accident flight

On the afternoon of 10 July 2012 the pilot decided to carry out two display practices. He had not carried out a display practice for several months, so added 300 ft to his minimum authorised (base) height, for aerobatic manoeuvres, of 500 ft. He notified ATC of his intended practice by radio prior to departure. The RFFS were advised and were at 'Local Standby' status (fire appliance manned with the engine running) and, on this occasion, were in a position guarding the perimeter track that crosses the Runway 08 threshold.

The aircraft took off from Runway 26 and the pilot initiated his first manoeuvre. This was a steep climbing left turn, away from the display line. Further on in the sequence he commenced a barrel roll. This was entered on a westerly track, parallel to and south of Runway 26. The pilot recalled that the manoeuvre began with a positive pitch up into a climb, 45° nose-up, followed by a roll to the left. After the aircraft had rolled through 90°, he sensed that the roll rate was too high and reduced it. Witnesses observed that, as the aircraft approached the inverted position, the nose started to drop below the horizon and a steep nose-down attitude developed. The aircraft continued to pitch through the vertical until it was upright but in a nose-down attitude, with insufficient height to recover before striking the ground.

The pilot later recalled that, by the time he realised the aircraft was departing from the normal flight path for a barrel roll, he was in an upright, approximately 45° nose-down, wings level attitude. As he tried to pull the nose up to the horizon, the rudder pedal shaker activated, indicating he was approaching the stall. He continued pulling but eased the back pressure on the control column to avoid stalling. He also recalled turning through 20 to 30º, to head towards an area which was relatively free from obstructions.

The aircraft struck the ground in an approximately level, upright attitude with a high rate of descent. The fuel centreline drop tank disrupted on impact and a fire began immediately. The aircraft slid forwards along the surface and through a fence, before rotating about its right wing and travelling backwards across the runway in the direction of the ATC Tower.

The aircraft came to rest upright, with a significant fire burning aft of the cockpit. The RFFS and several bystanders were rapidly on the scene and the fire was suppressed. Meanwhile, the pilot released himself from his harness and tried to escape from the aircraft but, at first was trapped. Several people attempted to pull him out but were also unsuccessful. Eventually, the pilot freed himself and was assisted from the aircraft. He had suffered spinal injuries and burns and was flown to hospital by Air Ambulance.

Aircraft information

Aircraft description

The OV-10A aircraft was designed for and operated by the American military as a light, close support, ground observation and attack aircraft. It features a large, side access, multiple Perspex panel canopy over a tandem cockpit, with dual ejector seats. The aircraft is powered by two turboprop engines which are located under the wing, on each side of the fuselage. Twin tail booms extend continuously from the engine nacelles, with vertical tail fins and rudders on each boom. The tops of the vertical fins are joined by a large horizontal stabiliser and single, full length elevator. The tall, retractable main landing gear legs extend from bays in the tail booms, directly behind the engines. The nose landing gear leg is located in the nose cone forward of the cockpit (see Figure 1).

Figure 1

At the rear of the fuselage is a small load bay, accessed via the tail cone. During military operations, the tail cone can be replaced by a transparent one, or removed completely, for reconnaissance and parachuting missions. The high straight wing, located behind the cockpit, has five integral fuel tanks. A large capacity drop tank can also be fitted to a belly centreline hard point.

The stall warning system consists of a stall detector installed on the leading edge of the right wing and a pedal shaker on the right rudder pedal. During the most recent Permit to Fly renewal flight test, carried out in October 2010, it was noted that the stall warning activated at approximately 10 kt above the actual stall speed in the clean configuration. The Flight Manual for the aircraft indicates that, at a weight of 10,000 lbs, the stall speed in the clean configuration and power on is 70 kt IAS and with power off it is 84 kt IAS.

Aircraft history and configuration

A number of OV-10 aircraft were exported to the German Air Force for use as target-towing aircraft. Although effectively identical to the OV-10A, the export version was designated the OV-10B. Whilst the aircraft were owned by the German Air Force and used for military training, they were flown by civilian pilots and the ejector seats were disabled. As part of this process, the pilot's seat was modified. The twin shoulder straps of the harness clip onto a T-shaped bracket at the top of a steel cable which runs vertically up the forward face of the seat back, the other end of which is secured to the seat pan. The rear face of this bracket forms the jaws of a clamp, which fasten around a horizontal, solid plastic cylinder. This is secured by a 1/16 inch split pin through the clamp and cylinder. The plastic cylinder is moulded onto a nylon strap which is wound around an inertia reel located at the top of the seat back. A lever on the side of the seat pan either locks or releases the inertia reel.

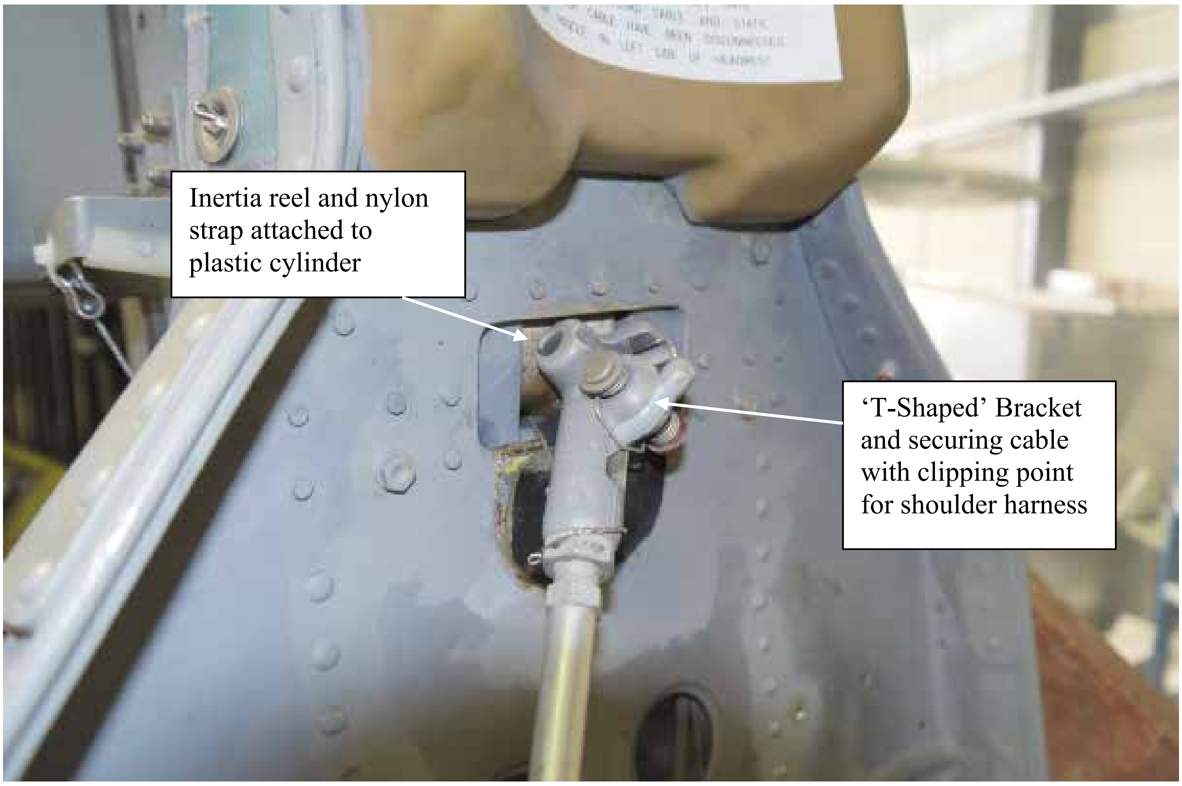

Figure 2
Seat shoulder harness attachment

Other role specific changes included the removal of the rear observer's seat from the cockpit and the installation of an aft-facing operator's seat in the load bay, for target towing.

After retirement from flying duties with the German Air Force, the aircraft were used as static airframes for battle damage repair training, before being sold off following a period of long-term storage. The pilot bought three of these aircraft for restoration. G-BZGK was the first to be restored to flying condition and was ferried to the United Kingdom in 2001. It then underwent extensive restoration and was issued with a Permit to Fly in 2007.

The aircraft was originally restored with a single pilot's seat in the cockpit, no role-specific equipment in the load bay and an opaque tail cone. The observer's seat in the cockpit had recently been replaced to facilitate carriage of a passenger. However, at the time of the accident the Organisational Control Manual (OCM) had not been updated to reflect this and, as such, passengers were not permitted.

Fuel on board

The Flight Manual states that the aircraft's fuel capacity is 1,677 lbs in the internal tanks and 1,488 lbs in the centreline drop tank, giving a total of 3,165 lbs. The pilot noted that, with full internal fuel tanks, the relevant gauge indicated 1,750 lbs on departure from Fairford. The operating times and the fuel states between leaving Kortrijk-Wevelgem International Airport and the time of the accident are shown at Table 1.

ROUTE/DATE	TAXI time/mins	FLIGHT time/mins	FUEL ON BOARD (lbs)	FUEL BURN (lbs)
EBKT-EGVA 5 July 2012	15	60	Start 1150 End 600	550
EGVA-EGBP 9 July 2012	14	5	Start 1750 End 1650 (Belly Full 1500)	100
EGBP-EGBP 9 July 2012	16	48	Start 1650 End 1250 (Belly Full 1500)	400
EGBP 10 July 2012	12	4	Start 1250 (Belly Full 1500)	100 (Estimated)

Table 1

Recorded flight and taxi times with fuel status

Consequently, on these flights the aircraft consumed 500 lb/hr to 550 lb/hr of fuel. From the known fuel quantities and flight times, it was estimated that the fuel load at the time of the accident was 2,650 lbs and that the aircraft weight was 10,700 lbs (4,853 kg). The Maximum Takeoff Weight (MTOW) for the aircraft is 12,500 lb (5,682 kg).

Airport information

There are a limited number of locations in the UK where pilots can practise flying displays at their normal display height. Cotswold Airport permits such display practices by pilots with a CAA Display Authorisation (DA). Display practices are normally to be carried out to the south of the runway, using the hard runway as the display line. All practices are required to be pre-booked with Aerodrome Operations. When an aircraft is carrying out a display practice the RFFS is brought to 'Local Standby'. A plan of the layout of the airport is at Figure 3.

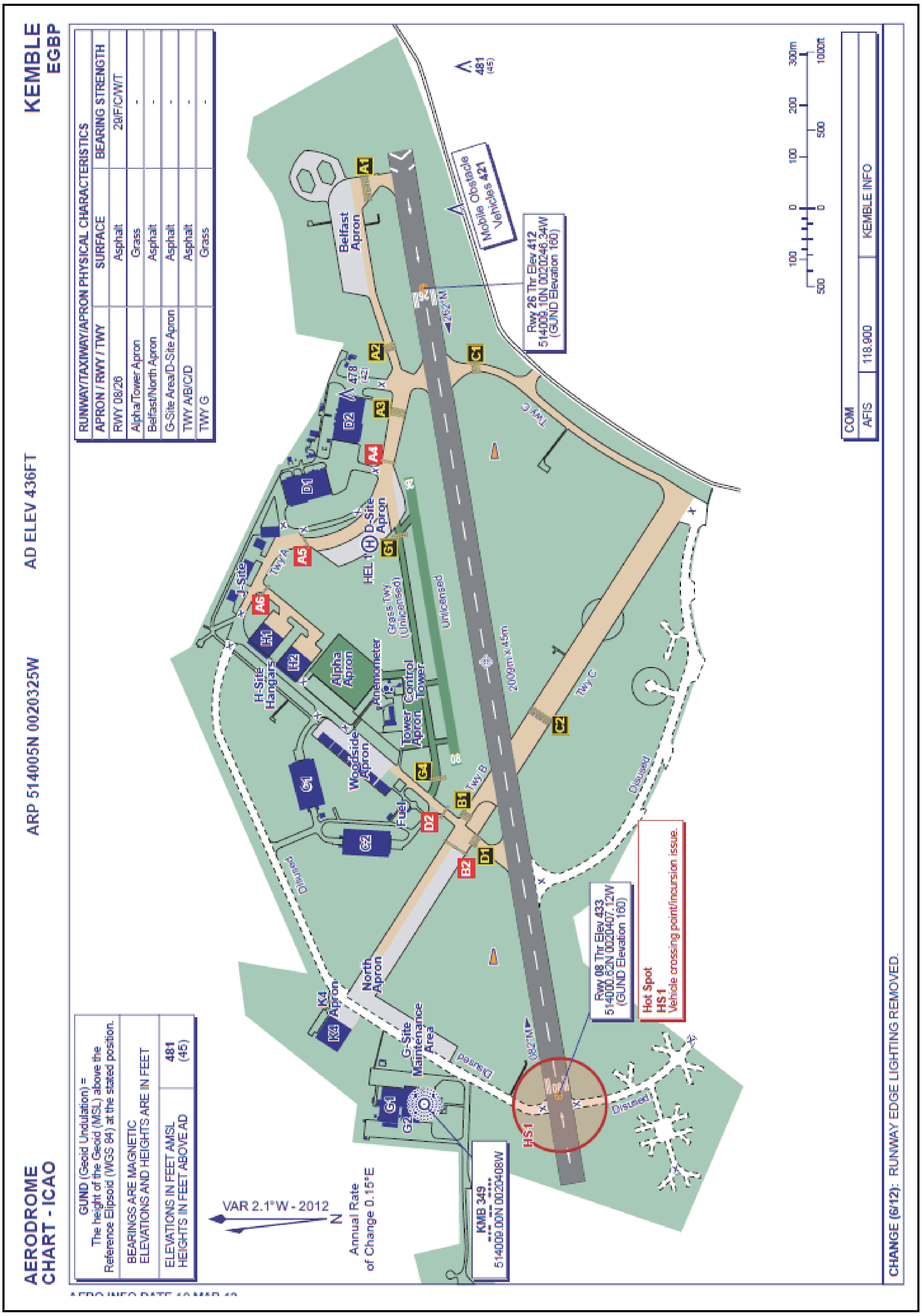

Figure 3

Aerodrome Chart from the UK AIP for Cotswold (Kemble) Airport

Accident site and wreckage

The initial impact marks were located on the grass area to the south of the runway, approximately in line with the ATC Tower and adjacent to the intersection between the runway and Taxiway C. The impact with the surface created large ground marks and there were a number of 'chop' marks where the rotating propeller blades of the left engine had contacted the ground. There was a significant amount of scorched grass around the initial point of contact, and soot and scorch marks extended through the adjacent section of boundary fence, which had been destroyed, on to the surface of Taxiway C. The ground marks continued for some 340 m, on a heading of 018°, across the runway to the location of the main wreckage, on grass, approximately 40 m to the southeast of the ATC Tower. Debris from the aircraft had been released, in a continuous trail, from the initial impact with the ground to the location of the main wreckage. A component from the rotating assembly of one of the propellers was found between the maintenance hangars to the northwest of the ATC Tower.

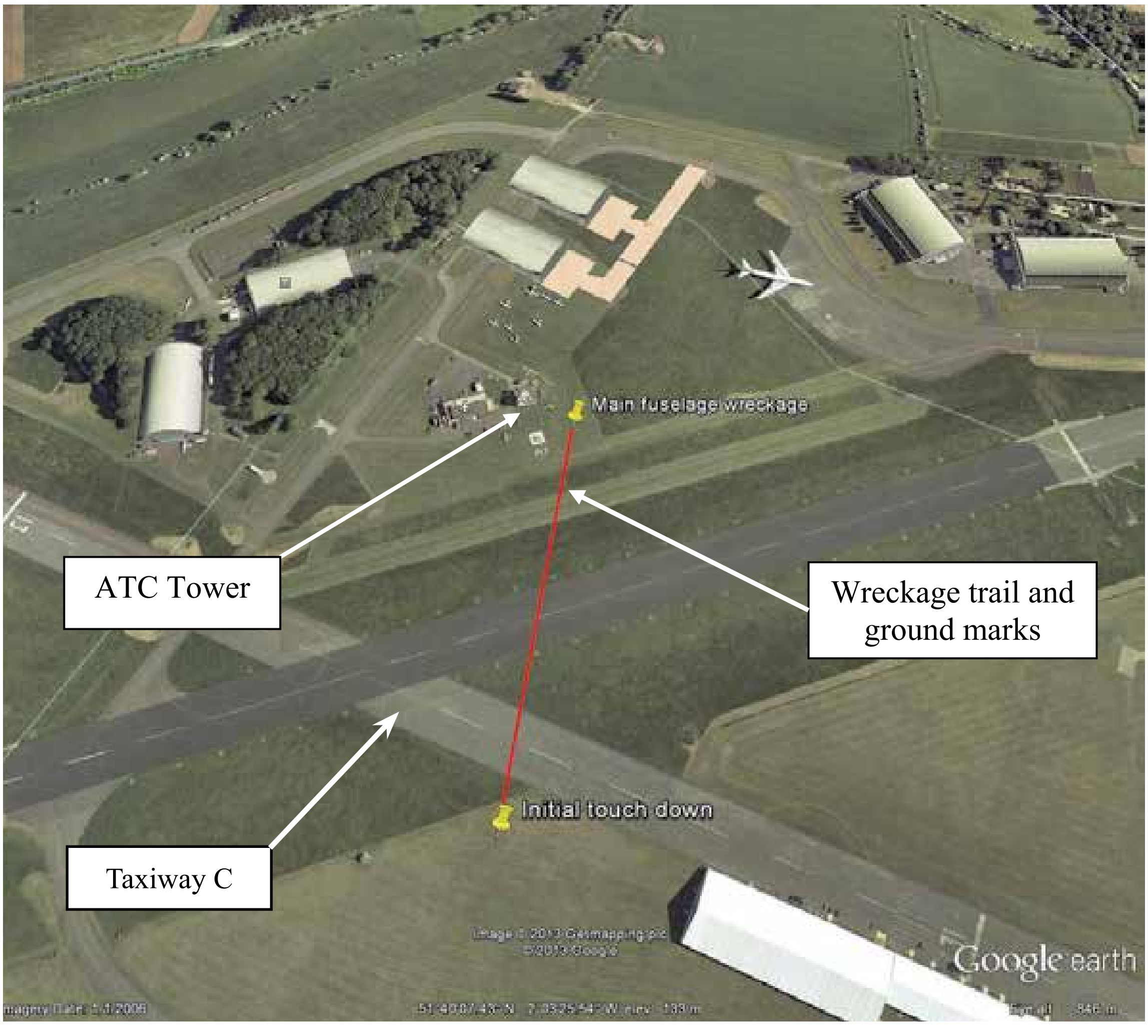

Figure 4

Accident site, looking north

The aircraft had been significantly damaged during the impact with the ground and the subsequent slide to its final position. The centreline-mounted drop tank, which was full of fuel, was destroyed and the fuel within it ignited. Various burnt components from the tank were scattered across the airfield. The right main landing gear leg had completely detached from the aircraft, as had the right engine and propeller blades. The left main landing gear leg was down and supporting the wing structure and left engine, which had rotated 90° vertically down from its normal orientation but remained attached by the service couplings. All but one of the propeller blades remained in the hub on the left engine but were significantly distorted, consistent with being under power at impact.

The right side of the wing was in contact with the ground. The right tail boom was intact but almost completely detached from the right engine nacelle and the horizontal stabiliser. The left tail boom remained attached but had fractured between the landing gear bay and the vertical fin, such that it leaned over at a 90° angle relative to the left engine nacelle. It was fully detached from the horizontal stabiliser. The entire fuselage had suffered significant fire damage, with the rear fuselage almost completely consumed. The wing had structurally detached from the fuselage and the five wing tanks contained a significant amount of fuel, which continued to leak from the aircraft after the fire had been extinguished. The forward fuselage, containing the two seats, remained intact but was severely damaged by the fire.

Wreckage inspection

The wreckage was inspected in situ and then in more detail after recovery to the AAIB's facilities. No pre-impact defect or damage which could have contributed to the accident was identified. This was supported by evidence from photographs of the aircraft taken immediately prior to impact and as it struck the ground.

The photographs of the aircraft during the initial impact showed that the pilot had not been restrained by the seat shoulder harness, causing him to be thrown forward and receive a head injury, despite wearing a helmet. Inspection of the pilot's seat identified that the plastic cylinder on the end of the inertia reel strap was intact and the strap had wound back onto the reel. However, the cylinder was no longer located within the clamp of the shoulder harness bracket. The plastic cylinder appeared to have pulled out sideways from the open end of the bracket clamp. Its retaining split pin was not present and there was no evidence that it had been in place at the time of the accident.

Maintenance review

A review of the maintenance records identified that the daily pre-flight inspection, required by the OCM and maintenance schedule, had not been signed off in the aircraft's Technical Log by the pilot during the days prior to the accident. With the exception of an unserviceable transponder, which was noted on his kneepad, the pilot stated he had not identified any defects and no additional maintenance had been carried out on the aircraft during this period. There was no record of fuel being released from the centreline drop tank, which had been identified in the photographic flights.

Pilot information

The pilot gained a Belgian Private Pilot's Licence (PPL) in 1999 and was issued with a UK JAR PPL in 2001. In 2003 he gained a Belgian Commercial Pilot's Licence (CPL) and in 2008 he was issued with a UK JAR CPL with a Shorts SC7 Skyvan type rating.

The pilot first flew G-BZGK in 2001 when he ferried the aircraft from Belgium to the UK. For ex-military types, where no civil type rating exists, a Civil Aviation Publication (CAP) 632 Aircraft Type Rating Exemption is required. Prior to the start of training on the type, a pilot is required to agree with the CAA a training syllabus appropriate to his or her level of experience. The CAA will then issue an exemption, specifying a period of training and the name of the person responsible for the conduct of that training. An initial short-term exemption was issued in 2001, for a ferry flight. A further exemption was issued in January 2008, when the pilot started flying G-BZGK regularly. Thereafter, annual exemptions were issued.

The pilot advised that he had received basic training in aerobatics in 2000, and additional training in aerobatics as part of his qualification for his Belgian CPL. In February 2009, he undertook a further course of aerobatic training in the United States, consisting of 7.5 flying hours in an Extra 300L aircraft.

The pilot was first granted a DA by the CAA in June 2010. It was issued for the OV-10B aircraft and was restricted to flypast displays, with a minimum height of 200 ft agl. In June 2011, following a DA evaluation, he was granted an upgrade to Standard Category aerobatics, restricted to aileron and barrel rolls only, with a minimum height of 500 ft agl. In July 2011, he completed a further evaluation, after which his DA was upgraded to allow him to fly as a member of a formation display. His most recent DA renewal was in April 2012, when his DA was upgraded again, to reduce the minimum height during a flypast to 100 ft agl.

The pilot's flying logbook recorded his display practices and aerobatics. The most recent practices were on 5 May 2012, when he recorded three display practice flights, each of ten minutes duration. The pilot planned to carry out two practice displays at Kemble and a further practice at a show venue on 27 July, prior to his scheduled display at the same location on 28 July. Recency requirements stipulate that three full display routines must be carried out in the 90-day period prior to a display. There was no evidence that any of these practices had been mentored by a Display Authorisation Evaluator (DAE) and there was no requirement that they should be.

The pilot stated that he always conducted the same display sequence. For the accident flight he had added a further 300 ft to his approved base height of 500 ft, for aerobatics, because he considered he was not sufficiently current.

Meteorological conditions

The meteorological observation recorded at Kemble at 1353 hrs was: surface wind from 280° at 9 kt, visibility greater than 10 km, few cloud at 900 ft, scattered cloud at 1,300 ft and QNH 1010 hPa. Photographs of the aircraft in flight, taken during the accident manoeuvre, showed clear sky conditions and good visibility. In CAP 632, the recommended meteorological minima for a solo aircraft carrying out a full aerobatic display, is a cloud ceiling of 1,000 ft and visibility 5 km.

An aftercast obtained from the Met Office estimated that, at 1350 hrs, the wind at 1,000 ft agl was from 300° to 320° at 15 kt and the wind at 2,000 ft agl was from 310° to 330° at 20 kt.

Recorded information

Introduction

Recorded information was contained in GPS equipment[1] recovered from the aircraft. The data included a track log of the accident flight, with aircraft GPS-derived position, track, altitude and groundspeed recorded. During the final manoeuvre, data points were recorded at an average rate of just greater than once every three seconds.

The GPS track log commenced at 1331 hrs, with the aircraft positioned on the taxiway at Holding Point B2. It ended at 1350:12 hrs, shortly before the aircraft struck the ground.

Interpretation

At 1345 hrs the aircraft commenced its takeoff run and, once airborne, performed a series of manoeuvres to the south of Runway 08/26.

The maximum recorded ground and calculated airspeed during the flight (based on an estimated wind at 1,000 ft of 310°/15 kt) was 195 kt (Figure 5 - Point A). At 1347:22 hrs, the aircraft was photographed[2] with the landing gear and flaps extended, following which the aircraft made a slow speed pass, parallel to Runway 26, at a height of about 200 ft agl. As the aircraft approached the end of Runway 26, the landing gear was retracted. A photograph taken about 40 seconds later showed that the flaps had also been retracted.

At 1349:50 hrs, the aircraft was positioned about 130 m to the south of the Runway 26 threshold, at a height of approximately 440 ft. Two seconds later, having established an almost parallel track with the runway, the aircraft's groundspeed was 146 kt (calculated airspeed 156 kt) (Figure 5 – Point B). The next data point was recorded six seconds later, by which time the aircraft had climbed to 700 ft agl and the groundspeed had reduced to 142 kt (calculated airspeed 154 kt). During the next seven seconds, the aircraft proceeded to alter track by nearly 35° to the left, whilst climbing to a height of about 1,240 ft agl and reducing to a groundspeed of 93 kt (calculated airspeed 90 kt). The aircraft then descended rapidly whilst also altering track towards Runway 08/26. The final data point was recorded at 1350:12 hrs, with the aircraft at a height of about 120 ft agl, on a track of 012° and at a recorded groundspeed of 164 kt. The aircraft struck the ground shortly afterwards.

Footnote

1 Garmin manufactured unit, model 495.

2 A witness positioned on the control tower balcony had taken a series of photographs of G-BZGK during the accident flight.

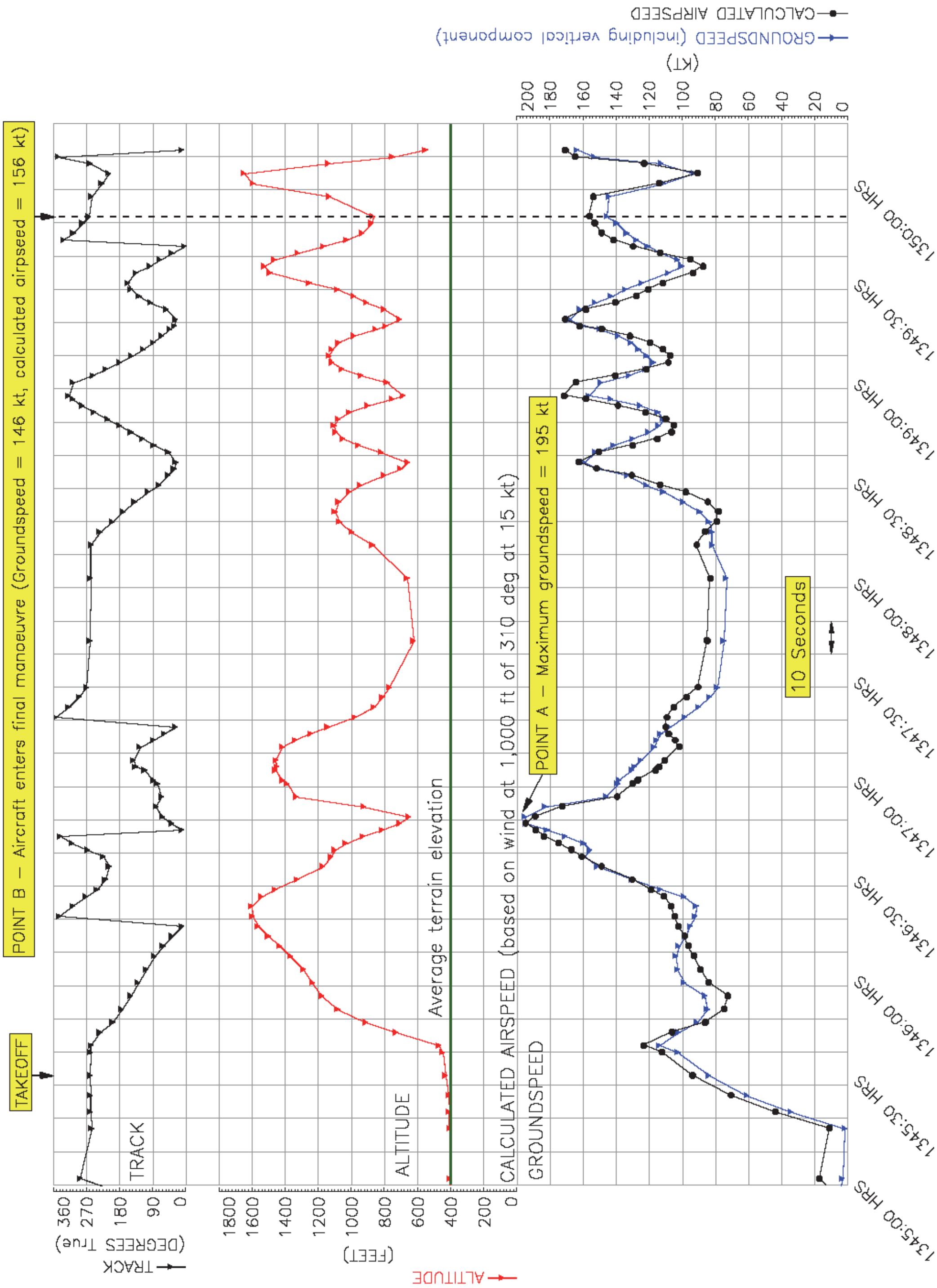

Figure 5

GPS track, altitude, groundspeed and calculated airspeed profile

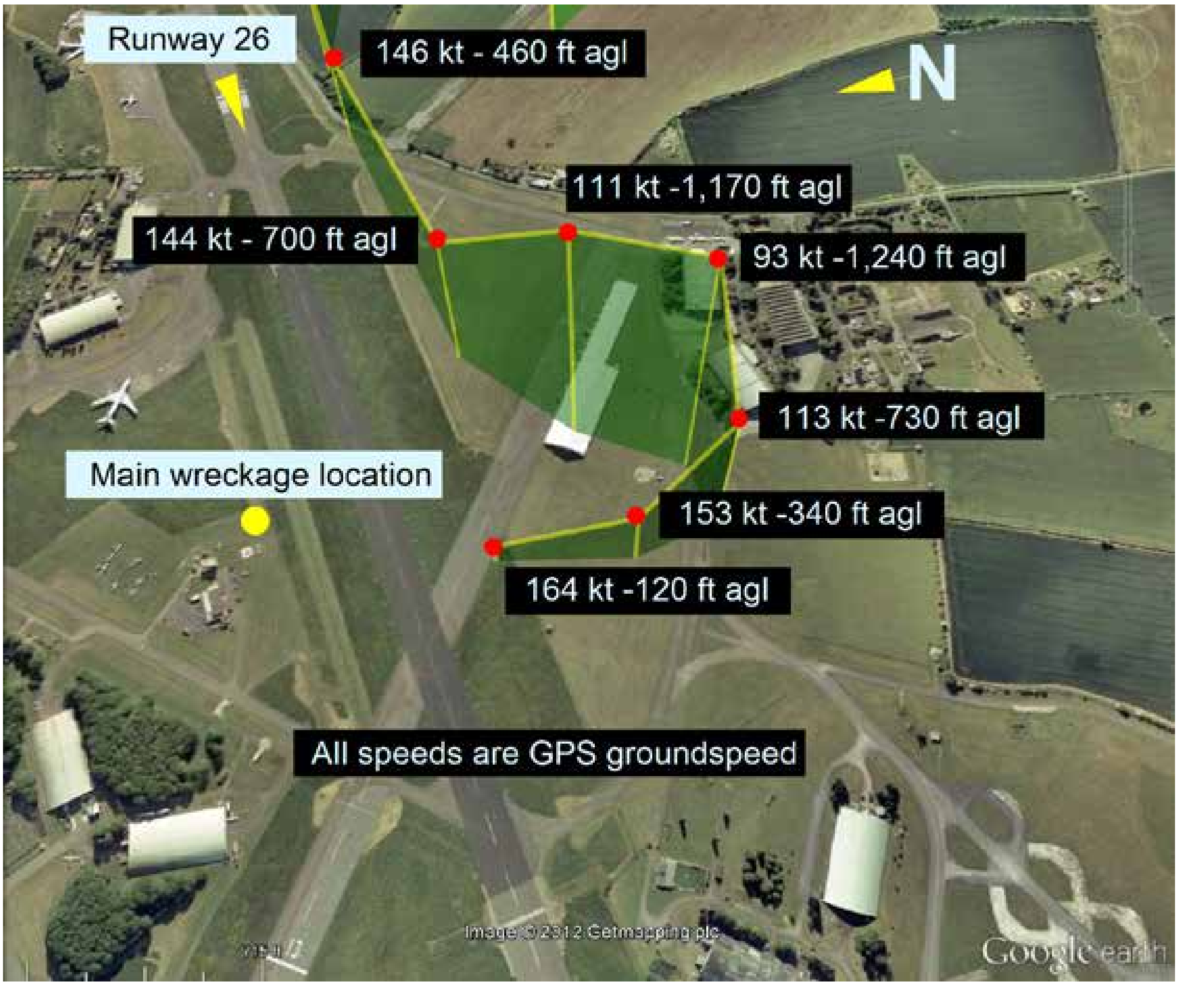

Figure 6

G-BZGK – Final manoeuvre

Organisational and management information

The operator owned three OV-10B Bronco aircraft listed on the UK register. The aircraft were being operated in accordance with CAP 632, Operation of 'Permit to Fly' Ex-Military Aircraft on the UK Register, a publication which specifies the operational requirements for the issue of a Permit to Fly. An operator is required to provide an OCM to demonstrate how it complies with the provisions of CAP 632. The operator may be an organisation or individual but a minimum operational and technical framework must be in place. In this case, the pilot was the Accountable Manager and the Chief Pilot.

In order for the aircraft to be operated at a flying display, a further publication, CAP 403, *Flying Displays and Special Events: A Guide to Safety and Administrative Arrangements,* provides information on the requirements to be met. The following text is included in the introduction:

> *'Air Displays and Aerial Special Events form a significant part of the UK leisure industry today and participation, together with their organisation and administration, needs careful consideration if the highest safety standards are to be achieved and maintained. This publication is intended as a code of practice and an indicator of best practice to provide guidance to ensure that the safety of both the participants and the spectators is not compromised.*
>
> *They (the standards quoted) should be treated as applying equally to practice for, as well as participation in, Air Displays and Special Events.'*

In an air display, or a practice, the minimum distance between the Display Line and the Crowd Line is related to the actual speed of the aircraft and the type of display. For an aircraft flying at a maximum speed of 200 kt, this is 100 metres for a flypast and 150 metres for aerobatics.

There are no specific minimum experience requirements before a pilot can apply for a DA but there are guidelines which suggest the pilot of a fixed wing aircraft should have at least 200 hours experience. For an initial DA, Form SRG 1301 is completed. This form includes comprehensive background information about a pilot's previous experience and preparedness for display flying, in addition to an evaluation of a demonstration flight. The evaluator completes a review of the applicant's documentation, plus previous aerobatic experience and training, if applicable, and relevant knowledge and display planning.

When a pilot seeks to renew or extend the privileges of his or her DA, Form SRG 1302 is used. This form requires the applicant to provide a record of displays and practices carried out and the evaluator to assess a demonstration flight. However, it does not include a review of documentation, knowledge and display planning.

A paragraph in CAP 403, concerning mentoring, was introduced in the 12th Edition, dated June 2012. It states:

> *'Part of the application process is a degree of mentoring. All initial DAs will be mentored by an appropriate DAE throughout their process of workup. It is highly recommended that the mentoring continues after the DA is initially issued.'*

There is no similar requirement for mentoring when a pilot seeks to extend the privileges of his or her DA.

Another publication, CAA leaflet, Doc 743 '*Civil Air Displays, a guide for pilots*', contains information for display pilots on all elements of planning and carrying out a flying display, and includes the following:

> *'It is important that you have constructive and critical comment during your display planning and workup from an experienced display pilot who is preferably a Display Authorisation Evaluator experienced on your type of aircraft. Choose someone with whom you have a good rapport, mutual trust and respect. Then heed the advice given.'*

Approvals for restoration, airworthiness control and maintenance of ex-military aircraft

Ex-military aircraft which are subsequently operated by private owners and placed on the UK register are required to gain an aircraft-specific Permit to Fly from the CAA, in order to comply with the Air Navigation Order. Granting of a Permit is subject to the owner or operator satisfactorily demonstrating that the aircraft has been restored and will be maintained to an appropriate standard by an approved organisation. As the Permit is issued and administered by the CAA, CAP 553, *BCAR Section A - Airworthiness Procedures where the CAA has Primary Responsibility for Type Approval of the Product,* is applicable. Chapter A8-20 of this document relates to approval of organisations responsible for the restoration, airworthiness control and maintenance of aeroplanes and rotorcraft of military origin (Group E4 and M5)[3].

The granting of A8-20 (E4/M5) approvals and subsequent oversight auditing is conducted within the CAA by the Survey department of the Safety Regulation Group (SRG)[4]. The internal procedure against which this work is carried out details the organisational requirements for applicants and the appropriate paperwork, including a company exposition, which must be submitted to demonstrate compliance. Initial assessment of the application is carried out centrally, against the submitted paperwork, prior to a confirmation visit and assessment by a surveyor from one of the regional offices. If the application is considered satisfactory, a further surveillance plan is created, typically scheduling an audit every 12 months. If the organisation is considered to be in compliance, the approvals are not time limited. The CAA advised that this process does not consider whether the applicant also operates the aircraft under CAP 632 and, as a consequence, no review of a related OCM takes place when assessing an A8-20 application.

Initial approval and continued surveillance against the requirements of CAP 632 is conducted by a separate Flight Operations department within SRG, now the SARG. The CAA confirmed that no coordinated assessments take place between the Flight Operations and Survey departments, either during initial approval or continued surveillance against CAP 632 and CAP 553 compliance.

Maintenance arrangements and approvals

The pilot had contracted a third party with the appropriate E4 and M5 approvals to conduct the restoration of G-BZGK and to provide ongoing maintenance and continuing airworthiness control. At the time of the accident, this organisation was listed in the OCM as being the sole provider of such services.

In 2011, the pilot applied for and was granted E4 and M5 approval for a maintenance company which was a subsidiary of his parent company, which operated the accident

Footnote

[3] E4 is the approval to undertake assessments and report to the CAA relating to the initial granting of a Permit to Fly. M5 is the approval to undertake assessments and make recommendations relating to the annual reissue of permits and to conduct and certify maintenance on aircraft of military origin.

[4] These department names were subsequently amended in a reorganisation of the CAA. The Safety Regulation Group became the Safety and Airspace Regulation Group (SARG).

aircraft. The company exposition, submitted as part of the approval process, listed the pilot as the nominated post holder for most of the senior roles, including Chief Executive, M5 coordinator, E4 signatory and Check Pilot. The pilot confirmed that the annual Permit inspection, due in November 2012, was likely to have been done by his company.

Although they had granted the appropriate approvals, the CAA considered that the pilot's subsidiary company and its approvals were dormant[5] at the time of the accident. As such, no audits had been scheduled or completed by the CAA. They advised that the original arrangement with the third party provider was considered to be still in force for the accident aircraft, as detailed in the operating company's OCM. This meant that any maintenance or modification of the aircraft had to be carried out under the third party supplier's approval and any deviations, such as operating with an unserviceable component, required their approval.

Other information

Survivability

The pilot was wearing a flying suit and gloves made of flame resistant material which, together with his helmet, undoubtedly contributed to his survival. He remained conscious following the accident and was able to free himself from his initial trapped position before being assisted from the aircraft.

The barrel roll

A barrel roll is an aerobatic manoeuvre in which the aircraft describes a corkscrew path, along the inside of an imaginary cylinder. Pitch and roll rates should be co-ordinated so that the wings reach the level inverted position before the nose falls through the horizon. If the roll is too slow the nose drops through the horizon before the wings are level inverted and, without corrective action from the pilot, the aircraft enters a spiral descent, with an associated increase in speed and considerable loss of height.

In a loop, the height gained and lost by an aircraft is predictable and repeatable, leading to height and speed 'gates' at the entry and highest points of the manoeuvre. If met, these gates provide a measure of assurance that, correctly performed, the manoeuvre can be completed successfully. However, in a barrel roll, the combination of roll with pitch means that the predictability and repeatability of the manoeuvre is less easy to achieve and that the height required is likely to be variable. Thus, it is not possible to establish similar height and speed 'gates' for the barrel roll.

If the attitude of an aircraft is unusual during a barrel roll, the recognised recovery technique, to minimise height loss, is to roll the aircraft wings level to the nearest horizon, then pitch to achieve level flight. In a nose-low, inverted attitude the quickest way of rolling to the nearest

Footnote

5 The term 'dormant' is not used by CAA procedures and there is no formal process or definition for categorising approvals in this way. Additionally there is no process for identifying when an approval is no longer 'dormant' and no formal requirement for a company to report to the CAA when an approval is actively being used or otherwise.

horizon may be to continue the roll at an increased rate or reverse the direction of roll. However, if instead the aircraft is flown through the vertical, towards the opposite horizon, the aircraft will develop an increasing nose-down attitude, the speed will increase and there may be insufficient height to recover to level flight. Additionally, the trajectory of the aircraft is likely to deviate from the display line.

There is no guidance in the OV-10B Flight Manual as to how a barrel roll should be carried out. However, a US Naval Aviation Manual included some limited information (see Table 2).

AEROBATIC MANEUVER PARAMETERS

MANEUVER	COND LEVER	RPM	ENTRY AIRSPEED	MINIMUM MANEUVER SPEED
AILERON	NORMAL FLIGHT	95 - 98%	150 - 200	—
WINGOVER			200	100 - 110
BARREL ROLL			200	100 - 110
LOOP			250	100 - 110

Table 2

Extract from US Naval Aviation Manual

Witnesses

Some of the witnesses, who were professional display pilots, commented that the roll rate appeared slow but that if the rolling manoeuvre had continued then the situation would probably have been recoverable. They observed that, in conjunction with the slow roll rate, there was an unusually rapid pitch down from the inverted attitude and that there was insufficient height for the aircraft to pull through the vertical.

Analysis

Conduct of the flight

The pilot was carrying out a display practice. The airport operator was notified, as was required, and the RFFS were on standby. The meteorological conditions were suitable and met the CAP 403 recommended minima for an aerobatic display to be carried out.

The centreline drop tank had recently been filled with fuel and was still full of fuel, an unusual configuration for performing a display. The extra weight may have affected the performance and feel of the aircraft but it does not appear to have been a predominant factor in the accident.

The documentation regarding recommended speeds and techniques for flying aerobatic manoeuvres in this aircraft type was limited but one reference suggested that a suitable entry airspeed for a barrel roll would be 200 kt. The actual entry airspeed was calculated to be 156 kt. Although the entry speed was lower than recommended, the pilot reported that he had intentionally reduced the roll rate, which would account for the observed slow rate of roll. However, the lower than recommended speed would have had an effect on the performance of the aircraft, especially with the unusual fuel load.

The pilot's display was one which he practised on a regular basis. Witnesses observed that the aircraft deviated from the intended barrel roll manoeuvre when it was in an inverted attitude and pitched down unusually rapidly. At this stage, they considered that a successful recovery could have been made. However, the aircraft continued to pitch down, with insufficient roll, and a steep nose-down attitude developed. The pilot recognised the problem after the aircraft had pulled through the vertical into an upright, nose down attitude, by which time, however, there was insufficient height to recover. An additional effect of continuing to pitch 'up', in the aircraft's normal axis, with insufficient roll, was to alter the trajectory of the aircraft, taking it towards and subsequently through the notional crowd line.

Display authorisation

The pilot met the recommended guidelines for minimum experience for the initial issue of a DA. The most recent editions of CAA publications CAP 403 and Doc 743 refer to the value of mentoring during the time that a pilot is working towards both gaining a DA and after initial issue. The pilot had demonstrated his flying display to a DAE as part of the evaluation and renewal process but there was no evidence that his display had been evaluated separately, or that there had been any mentoring, other than on those occasions. Thus, if a problem had developed with the way a particular manoeuvre or display was being conducted, it may not have been detected and an opportunity to address it may have been missed.

The pilot was initially issued with a DA for Flypast, with a minimum base height of 200 ft. When he applied to extend the DA privileges to aerobatic flying, the process was less rigorous than for an initial application. Form SRG 1302 is used for the evaluation of an application to extend DA privileges and does not require an assessment of previous aerobatic experience. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2014-001

It is recommended that the Civil Aviation Authority revise Civil Aviation Publication 403, *Flying Displays and Special Events: A Guide to Safety and Administrative Arrangements*, to ensure that the requirements in Form SRG 1301, *Display Pilot Authorisation Application*, for an initial application for a display authorisation, also apply to an application to extend the privileges of a display authorisation.

Secondly, there is no requirement for mentoring during the process to extend the privileges of a display authorisation, as required for an initial Display Authorisation. The accident pilot was the only person flying this aircraft regularly and was not part of a larger organisation. Consequently, the opportunity for mentoring may have been limited. Within a larger organisation there tends to be a natural and, in some cases, required element of oversight by other pilots. This suggests that the element of mentoring, which is recommended by the CAA, is particularly relevant where pilots are operating outside a larger organisational environment. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2014-002

It is recommended that the Civil Aviation Authority extend the requirement in Civil Aviation Publication 403, *Flying Displays and Special Events: A Guide to Safety and Administrative Arrangements*, for mentoring, as required during the application process for an initial Display Authorisation, to apply to the application process to extend those privileges.

Maintenance and operational approvals

Although not directly casual to the accident, a number of issues were identified during the investigation regarding airworthiness control and the operation of the aircraft. These highlighted potential safety management issues where a single individual is the nominated post holder for multiple roles, covering both the operational and maintenance sections of an organisation.

The pilot's subsidiary maintenance organisation had been granted the necessary maintenance and airworthiness approvals for the aircraft from the CAA, although these were not yet active. This process did not take into consideration the arrangements for the operation of the aircraft. A review of the OCM identified that a single individual had been granted approval to manage the operation and maintenance of the aircraft as Chief Pilot and Maintenance Coordinator.

The absence of the cross-checking and independent assessment that comes from separating aircraft operation and maintenance responsibilities can result in a valuable safety benefit being lost. Discussion with the CAA highlighted that such issues may not be detected during the initial CAA approval process for CAP 632 or CAP 553 (Chapter A8- 20) applications, where an organisation both operates and maintains an aircraft. This is particularly relevant if individual applications are not concurrent, as the processes are administered by separate departments within the CAA which do not consult with each other during the approval process. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2014-003

It is recommended that the Civil Aviation Authority revises its procedures for granting or amending approvals under Civil Aviation Publication 632 and Civil Aviation Publication 553, Chapter A8-20, to ensure consultation takes place between the Flight Operations and Airworthiness capability teams of the Safety and Airspace Regulation Group.

Once approvals have been granted under CAP 632 and CAP 553, the relevant organisation is subject to a routine ongoing CAA audit process, to ensure that the standards demonstrated in theory, to gain the approvals, are being maintained in practice. As with the initial approval process, audits against the two different CAP requirements are currently carried out separately and without consultation between the Survey and Flight Operations departments, despite there being a crossover in the subject matter being assessed. This has the potential for airworthiness concerns to be missed or underestimated in importance, as the operation (combined engineering and flight operations) is never assessed as a whole by an individual or team with the appropriate combination of skills and experience in both disciplines. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2014-004

It is recommended that the Civil Aviation Authority revises its procedures for auditing approvals which have been granted under Civil Aviation Publication 632 and Civil Aviation Publication 553, Chapter A8-20, to ensure that the audits completed by the Flight Operations and Airworthiness capability teams of the Safety and Airspace Regulation Group are conducted in a coordinated manner, so that all aspects of the operation and maintenance are adequately assessed.