

Bell P-63A-7BE, G-BTWR, 3 June 2001

AAIB Bulletin No: 4/2002	Ref: EW/C2001/6/4	Category: 1.2
Aircraft Type and Registration:	Bell P-63A-7BE, G-BTWR	
No & Type of Engines:	1 Allison V1710-117 piston engine	
Year of Manufacture:	1944	
Date & Time (UTC):	3 June 2001 at 1444 hrs	
Location:	Biggin Hill Airport, Kent	
Type of Flight:	Private (Display)	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew 1 Fatal	Passengers N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	43 years	
Commander's Flying Experience:	7,730 hrs (of which 13 were on type)	
	Last 90 days 143 hrs	
	Last 28 days 56 hrs	
Information Source:	AAIB Field Investigation	

The Bell P63A Kingcobra aircraft was being flown in an air display at Biggin Hill. The pilot displayed the aircraft successfully on the first day of the airshow but on the second day, at the top of a vertical manoeuvre, he appeared to lose control and the aircraft departed controlled flight before impacting the ground in a steep nose-down attitude.

History of the flight

On the second day of the airshow three American World War II fighter type aircraft were to perform a joint display. The plan was for the aircraft to fly together initially, with the Kingcobra designated to be third aircraft, whilst performing some manoeuvres. The Kingcobra would then break away and the first two aircraft would carry out a pre-planned routine together, consisting principally of low-level horizontal manoeuvres. The role of the Kingcobra was to fill in between these two aircraft with a display that included some vertical manoeuvres. This arrangement meant that unlike the first two aircraft, the Kingcobra was not flying a pre-planned sequence.

All three aircraft waited at the holding point for Runway 03 for 15 minutes before takeoff. After take-off the aircraft held to the west of the airport for three minutes prior to commencing their display. They then ran in together and each performed a loop followed by a half Cuban eight, following which the Kingcobra broke away from the other two as planned. One minute later, after performing a flypast along the display line at a measured speed of 220 kt and having passed opposite the other two aircraft, the Kingcobra was seen to pull up into a rolling, climbing manoeuvre. At the top of this manoeuvre, with the aircraft partially inverted, the pilot appeared to lose control and the aircraft entered an incipient spin. The pilot recovered the aircraft, having lost considerable height, and continued with his display. Next he flew past the crowd from left to right, carried out a wingover to the left and returned past the crowd from right to left at 190 to 195 kt. The aircraft then went out of view for some 20 seconds, in which time it was turned to the right through some 220°, before running in directly towards the crowd and pulling up into the first half of a loop. At the top of this manoeuvre, in the inverted position, full nose-up elevator was maintained and a substantial amount of right rudder was applied. The aircraft yawed to the right and then departed into an upright incipient spin. The nose dropped steeply, full nose-up elevator was maintained, and the rudder returned to neutral. The aircraft did not recover from the ensuing dive and impacted the ground in a nose down attitude at about 160 kt. There was an immediate fire that was quickly extinguished by the attending fire crew but the pilot had suffered fatal injuries in the impact.

Pilot experience

The pilot had originally been trained to fly whilst serving in the Royal Air Force (RAF). During his RAF service he completed a three year tour of duty as a member of the Red Arrows display team flying Hawk aircraft. After leaving the RAF he continued to fly professionally, initially with a display team flying a Pitts aircraft and latterly as an airline pilot. For the last three display seasons he had also flown a variety of historic aircraft on an occasional basis. He first flew the Kingcobra in April 1998 and had flown it in displays on at least 10 occasions since then. He was known to have enjoyed flying the aircraft.

The pilot held a current Display Authorisation (DA) for a Category C aircraft. The certificate of test had been renewed and was valid until September 2001. To maintain the validity of the DA the pilot was also required to carry out at least three display sequence practices, one in the same category of aircraft, in the 90 days preceding a display. During the required period the pilot had flown 30 minutes dual in a Harvard, 25 minutes of display practice in the Kingcobra on 1 June 2001 and the airshow display on 2 June. Relevant display practices were not recorded in the pilot's logbook but were recorded as having been carried out by the aircraft operator's organisation.

Pathology

No evidence was found of any pre-existing disease or medical condition that could have contributed to the accident. A post mortem toxicological examination did not reveal any factors which might have influenced the performance of the pilot. Special attention was given to the possibility of carbon monoxide poisoning but the levels of carboxyhaemoglobin in the medical samples were insufficient to have had any effects of an incapacitating nature. Shortly before the accident, the pilot was observed by several witnesses to have been in good spirits and looking forward to carrying out his display.

Aircraft performance

The maximum continuous operating limits for the aircraft engine as stated on the Permit to Fly were 2,500 RPM and 40 inches manifold pressure (MP). These were also the limits used for carrying out aerobatics. The takeoff limits were 3,000 RPM and 46 inches MP. The recommended entry speed for looping and other vertical manoeuvres was 250 kt.

The Centre of Gravity (CG) at the operating weight, including the pilot, was at the aircraft forward limit. Fuel load did not materially affect the CG position so the aircraft was normally operated at the forward CG limit.

Meteorology

The weather conditions were good for display flying except that both the surface and upper winds were towards the crowd. The surface wind was north-westerly at 10 to 12kt, visibility was greater than 10 km, cloud was broken at 1,500 feet and the air temperature was 13°C.

Video evidence

A large number of video recordings and still photographs were made available to the investigation. As a result it was possible to reconstruct most of the display sequence flown by the pilot. It was not possible to make any direct comparison with his display on the previous day because only limited film was available and the weather conditions were different.

The elapsed time from takeoff until the accident was seven minutes. One unsuccessful manoeuvre, which resulted in a departure from controlled flight, two minutes before the accident, was clearly observed and recorded on video film. The aircraft was quickly recovered and all the other manoeuvres until the final manoeuvre appeared to have been conducted normally but at slower speeds than might be expected.

Some sections of video allowed estimates of the aircraft's speed to be derived. Manoeuvre entry speeds were calculated so they could be compared with target entry speeds. These calculations showed that on the entry to the first loop, when all three aircraft were flying together, the speed of the Kingcobra was around 250 to 270 kt. Just before pulling up into the first manoeuvre from which a loss of control resulted, the speed was 210 to 230 kt. After this manoeuvre airspeed was not again measured to be above 200 kt. Later in the display, on the crowd flypast before the final manoeuvre, the speed was measured by two separate methods at 192 kt. The engine speed was also calculated at this point from recorded sound at 2,750 RPM.

During the final manoeuvre control surface positions could be determined which showed full up elevator throughout. When the aircraft was inverted over the top of the manoeuvre with the nose about 30° below the horizon, there was a large input of right rudder and the aircraft responded by yawing to the right. Once the aircraft had departed into the incipient spin, the rudder returned to neutral. There was some movement of the ailerons during the dive and the aircraft rolled to the right before impact.

Aircraft description

The Bell P-63C (*jpg 32kb*) Kingcobra was a single seat WW II fighter aircraft with tricycle landing gear and a laminar flow wing. It was powered by a 1,325 HP liquid-cooled piston engine which

drove a hydraulically controlled, four-blade, constant speed propeller. The propeller was driven through a reduction gearbox at a fixed ratio of the engine crankshaft speed. The governor in the propeller regulator assembly, mounted on the rear of the propeller hub, controlled the blade angle to maintain the selected propeller RPM. The propeller was 11 feet in diameter and had a pitch range between 20° (fine) and 55° (coarse). The engine was located behind the pilot with a drive shaft running forward connected to the propeller gearbox. The landing gear and flaps were electrically operated. The flying controls were conventional and manually operated. The elevators and ailerons were operated by control rods and the rudder via control cables. A 'bag' type fuel tank of 66 US gallons capacity was located in each outboard wing section. The aircraft had been refuelled to full tanks on the previous day.

Aircraft history

This aircraft was constructed in 1944. After acquisition by the operator in 1991, having flown a total of 1,085 hours, it was completely dismantled. The airframe and all the systems were overhauled and a zero-timed engine, gearbox and new propeller were fitted.

After the overhaul the aircraft first flew on 12 August 1994. Between August 1994 and January 2001 it had flown 73 hours. The most recent annual inspection for the Permit to Fly renewal had been carried out on 24 May 2001 following which the aircraft next flew on 1 June 2001. Between that flight and the accident flight the aircraft had completed two hours flying.

On-site wreckage examination

The aircraft had crashed in a confined area to the west of the runway just within the airfield boundary, in a steep nose down attitude and on a heading of around 076°. The pitot tube on the left wing was found embedded in the earth at an angle of 70°. The marks made on the ground by the wings indicated that the right wing had impacted first and there had been very little ground slide. The front section of the aircraft was buried in the ground to a depth of around one metre. The outer section of the left wing including the left fuel tank, together with the right fuel tank had become detached and were located approximately 13 metres from the main wreckage. There had been an impact fire around the fuel tanks which was extinguished by the Airport Fire Service. Both tanks still contained some fuel and there was evidence of fuel spillage on the vegetation nearby. The main wreckage was unburned apart from a small fire around the rear of the engine.

It was established that at impact the landing gear and flaps were retracted. The propeller blades showed some evidence of rotational scoring associated with high power but no tip damage. The blade pitch mechanism had broken and so no assessment could be made of propeller pitch angle from the site.

Detailed wreckage examination

The wreckage was recovered to the AAIB's facility at Farnborough for a detailed examination. There was no evidence of any mechanical failure within the engine. The propeller regulator and the blade pitch change mechanism were examined; the initial dismantling was performed with the assistance of the operator's maintenance organisation. This revealed no evidence of malfunction. The position of the regulator control lever indicated a position approximately midway between the fine and coarse positions. The angle of each blade was controlled hydraulically by means of a torque unit. The position of the piston within each unit was consistent with the position of the

regulator control lever and showed a similar angle for each blade. Therefore, the propeller appeared to have been operating within the governed pitch range.

The needle on the propeller RPM gauge had struck the face of the instrument at a reading of 2,800 RPM which was consistent with the audio analysis of the video evidence. The tail of the manifold pressure gauge needle had also struck the face of the instrument, indicating a reading at impact of around 48 inches; this would represent an engine power above the maximum continuous setting. The throttle quadrant had been crushed in the impact; the throttle lever was in a mid position, the propeller lever was close to the maximum RPM position and the mixture control was at the idle cut-off position. However, these levers could have moved as the fuselage collapsed after the impact and so their positions were unreliable indications of pre-impact settings. The mixture control on the carburettor was at auto-rich, the normal setting.

The extensive breakup of the airframe precluded an assessment of the possibility of a flying control restriction due, for example, to a loose article, but there was no evidence of any pre-impact disconnection.

Air display safety procedures

Guidance concerning the regulation and organisation of flying displays is contained in Civil Aviation Publication (CAP) 403. This document contains a recommendation that at large displays a Flying Display Committee should be utilised. It also states that at least one member of the committee should be positioned on the crowd line with direct communication to the Flying Display Director who holds the responsibility for control and modification of the flying display programme.

A Flying Display Committee was established at the airshow to monitor the display standards and ensure that the safety regulations were not infringed. A system was in place whereby a committee member could contact Air Traffic Control (ATC) and arrange for a display to be stopped if they considered safety was being compromised. Because the ATC tower was located on the opposite side of the runway from the crowd line, communication was to be by telephone or radio. On this occasion, during the Kingcobra's display, a committee member became concerned by the loss of control at the apex of the first rolling climbing manoeuvre. The committee member attempted to contact ATC five times by radio and the Display Director twice by telephone but he was unable to get an answer.

The high-speed display line was established west of Runway 03/21, 230 metres from the crowd line. The aircraft impacted the ground 100 metres further west of the display line. A plan of the aerodrome layout is shown at Figure 1(*jpg 125kb*).

Discussion

It is difficult to understand why the pilot, who was experienced and practised in the display environment, continued with his display after experiencing a departure from controlled flight during one of the manoeuvres. If there was a problem with the performance or handling of the aircraft then it seems unlikely that he would have continued the display without reviewing the problem. This was, however, a large public display and it is relevant to consider the extra psychological pressures this could have exerted. Nevertheless, the pilot had considerable experience of air show displays and his associates had had no reason to question either his ability or his judgement.

Because of the constant need to check the positions of the other two aircraft, as well as his own position with reference to the display line, and make adjustments accordingly, the display task was more difficult than a solo display. The intention was to carry out a flexible series of individual manoeuvres and it would have required a positive trigger, such as failure to achieve a target airspeed or minimum height, to cause him to stop it prematurely. The absence of a pre-planned and practised sequence of manoeuvres could have contributed to the pilot's task of assessing the aircraft's potential to complete the next intended manoeuvre, but it should not have had a bearing on his decision to continue the display after the first incipient spin.

Analysis of the aircraft speeds from video footage showed that the final manoeuvre was probably entered with insufficient speed for it to be completed successfully. The lack of speed was most likely evidence of a continuing loss of energy during the display, partially as a consequence of the earlier failed manoeuvre. The aircraft engine at one stage was running at a higher RPM than recommended which may have been an attempt to regain the energy and airspeed.

The rudder and ailerons could be seen to move during the final manoeuvre but the elevator remained fully up. This would have required positive back pressure on the control stick to be maintained, or a jam in the control system. There was no evidence of the pilot having a problem with the flight controls earlier in the flight so it is more likely that the stick was held in this position. The flight control inputs at the top of the final manoeuvre, in particular the rudder, were not consistent with a display manoeuvre or a recovery action. In fact, they were similar to the control positions used to effect deliberate entry into a spin and the aircraft entered an incipient spin. From consideration of the evidence and the experience of the pilot, it seems likely that an unknown factor affected the pilot's physical and/or mental performance during the display.

Communication difficulties across the airfield were responsible for the failure of the system established by the airshow organisers to interrupt the display when required. After the accident, the event organisers installed a direct telephone line between the Flying Display Committee on the crowd side of the runway and the Display Director in the ATC tower.