BAC 167 Strikemaster MK83, G-BXFX, 9 December 2000 at 1318 hrs

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Aircraft Type and Registration:	BAC 167 Strikemaster MK83, G-BXFX
No & Type of Engines:	1 Bristol Siddeley Viper 20 MK 535 turbojet engine
Year of Manufacture:	1970
Date & Time (UTC):	9 December 2000 at 1318 hrs
Location:	4 nm north-west of Louth, Lincolnshire
Type of Flight:	Private (Air Test)
Persons on Board:	Crew - 1 - Passengers - 1
Injuries:	Crew - Fatal - Passengers - Serious
Nature of Damage:	aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	3,283 hours (of which 84 were on type)
	Last 90 days - 5 hours
	Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

The pilot was to carry out a 'Permit to Fly' renewal air test on a company owned Strikemaster aircraft from Humberside airport. He was the Company Training Captain and, after leaving a career in the RAF, had been with the company for over 6 years carrying out air tests and display flying on Jet Provosts (JPs) and Strikemasters. One of the maintenance engineers, employed by the company, was given the opportunity that day to occupy the aircraft's right hand seat to act as 'observer' to assist the pilot through the air test schedule. The schedule called for, amongst other profiles the checking of the aircraft's spinning characteristics, both incipient and fully developed to the left and the right.

The engineer arrived at the airport at 1000 hrs and assisted the company's chief engineer to prepare the aircraft for its flight test. The aircraft was towed to the apron and refuelled with 1,011 litres of Jet A1 aviation turbine fuel filling the main and tips tanks to full, a capacity, estimated by the observer to be 2,700 lb. (The Flight Manual maximum fuel is stated as being 2,128 lb. in the internal wing tanks with 384 lb. in each tip tank making a total of 2,896 lb.). The pilot arrived at approximately 1130 hrs, and after reviewing the aircraft's paperwork, proceeded to give the observer a thorough briefing on the flight test and how he was to complete the air test schedule as the flight progressed. He also gave him a comprehensive briefing on the ejection seat, finishing with the warning that as there was a strong wind that day he should expect significant drift landing in a parachute should the need to eject arise. The pilot also checked that the observer was correctly dressed with thermal underwear, flying suit, flying jacket, boots, gloves and a correctly fitting helmet and oxygen mask.

At 1210 hrs both men walked to the aircraft and after a pre-flight 'walkround' check entered the cockpit. With the cockpit checks complete both the pilot and observer removed their ejection seat safety pins ensuring that all pins for both seats and the canopy ejection system had been removed and were correctly stowed. The aircraft taxied for departure, engine checks were carried out and, at 1240 hrs, the pilot carried out an uneventful take off and timed climb to FL350. As the aircraft climbed through FL230 it was transferred from Humberside approach control to the London Military frequency for control in the upper air (above FL245). The only unserviceability found with the aircraft during the climb was that the pressurisation system was not functioning. The aircraft reached FL350 at a time recorded on the schedule as being 28:15 minutes after take off but may have interrupted its climb whilst ATC climb clearance was sought.

At FL350 further engine checks were carried out and after 5 minutes at full power a fuel state of 2,200 lb. was recorded on the air test schedule by the observer. The aircraft was then flown into a high speed descent to FL150 at a maximum of Mach 0.75. At FL150 the air test schedule called for further checks some involving stalling in various configurations, inverted flight and spinning.

The schedule also called for the recording of the aircraft's fuel state prior to stalling. The actual figure, written in grease pencil on a plastic sleeve covering the schedule, was distorted and smudged but closely resembled the numbers 900. The observer recalled that this figure, written by him, was shorthand signifying that the fuel was balanced and that the contents of one wing was 900 lb. making the total fuel on board 1,800 lb.

With the stalling and inverted flight checks completed and before the spinning phase the pilot explained how the spinning check was to be conducted and checked with his observer that he was happy to continue with the test.

At 1314 hrs the pilot re-contacted Humberside Radar, was identified by the radar controller 9 miles south east of Humberside and offered a Radar Information Service (RIS). The controller suggested that if the pilot wished to carry out manoeuvres, his present position or one to the southwest in the Binbrook area would be satisfactory. The pilot replied that as he was in a turn to the right he would go back to the Binbrook area and operate from FL150 down to FL080.

Before carrying out the fully developed spins the pilot explained to the observer that initially he intended to carry out incipient spins to the left and right and added that Strikemaster aircraft on occasions were reluctant to spin. The observer reported that as the first incipient spin to the left was initiated the aircraft rapidly entered a fully developed spin. Moments later the pilot called out '100 and 3' (probably indicating that 3 turns of the spin were completed and the aircraft was passing FL100 with the altimeter was set to 1013 mb) followed immediately by an expletive. By now the aircraft was spinning rapidly. The observer noticed that the pilot was moving the control column repeatedly from the neutral position to the fully forward position. He did not know what rudder pedal movements were being made for he had ensured that his feet were on the floor clear of the pedals before the exercise commenced. The pilot warned the observer to prepare for a possible ejection then transmitted "HUMBERSIDE FOXTROT XRAY HAVE AN UNRECOVERABLE SPIN STAND BY". The Humberside controller, who had noticed earlier that the primary radar return from the aircraft was stationary, heard the pilot's transmission and immediately contacted the Distress and Diversion (D&D) cell at the London Air Traffic Control Centre (LATCC) to apprise them of the situation.

The observer continued to notice the pilot's control inputs remembering that at one stage the pilot was holding the control column fully to the right with full back stick applied. He then described the aircraft's nose as appearing to 'go beyond the vertical, returning through the vertical and oscillating in pitch'. The pilot then asked the observer for a reading from the altimeter. The observer found this impossible for his eyes were drawn to the spinning compass and artificial horizon. He replied that he could not read the instrument. The pilot immediately said 'get ready to eject'. The observer raised his arms to grip the upper ejection seat initiation handle and placed his feet on the rudder pedals, which by now were in the neutral position. He also remembered seeing 'the tinge of new green crops on a brown field through a thin haze layer of cloud below'. The pilot shouted 'EJECT! EJECT!' The observer pulled the upper ejection seat handle and as his parachute canopy deployed saw the aircraft wreckage close below him. The observer estimated that he was beneath his parachute for only 5 seconds before his feet hit the ground. Winded and unsure of his injuries he elected to lay stationary on his back until medical help arrived.

Seeing the radar return disappear from his screen the controller attempted to re-establish contact with the pilot. With no reply, the radar controller instructed the tower controller to telephone the emergency services and passed the aircraft's last known position. He also noted the weather at Humberside timed at 1320 hrs gave a surface wind of 200°/20kt, visibility greater than 10km, few clouds at 1,000 feet, scattered clouds at 1,500 feet with a temperature of +10°C and a QNH of 997 mb.

A pilot of a Cessna aircraft, also in the local area and on the radar frequency, offered his services. He was vectored by the controller to the aircraft's last known position to act as a communications link. At 1327:30 hrs a rescue helicopter checked in on the radar frequency and was informed by the controller, the aircraft's position, that there were 2 persons on board and that he believed it was equipped with ejection seats. By 1331 hrs the pilot of the Cessna reported that he was circling wreckage sighted on the ground and that he thought he could see one and possibly two parachutes close by.

Several witnesses in the local area saw the aircraft as it descended. One witness described the aircraft descending 'in a tight spiral several thousand feet up before the spiral became wide' with the aircraft acting 'like a leaf in the wind'. Another witness described the aircraft as 'cork screwing' with 'parts falling from the aircraft'. He saw 'one man eject at an estimated height of 250 feet'. After impact he attended the scene to find that one of the aircraft's occupants was close to the aircraft. He was still strapped to his ejector seat but had sustained fatal injuries. The other occupant was injured and lying on the ground close by still attached to his parachute. Whilst attending to the occupant close to the aircraft the witness noticed a small fire developing within the wreckage around the engine area. He retrieved a small fire extinguisher from within the damaged cockpit and with some difficulty extinguished the fire.

Engineering aspects

Aircraft history

The Strikemaster is a development of the Jet Provost Mk 5A training aircraft and is able to carry external stores, giving it a ground attack capability. G-BXFX was constructed in 1970 and entered service with the Kuwait Air Force in 1971. It was transferred to the Botswana Defence Force in 1988 having undergone extensive refurbishment by British Aerospace plc. In April 1997 it was acquired by the current owners who submitted it for issue, of a CAA Permit to Fly. The Permit was issued on 1 December 1997, at which time the aircraft had accumulated 2,305 flying hours and 3,107 landings. At the time of the accident the hours and landings were around 2,318 and 3,125 respectively, with the current Permit to Fly due to expire on 29 December 2000.

Apart from the removal of the master armament switch, few modifications were required for civilian registration. For example the pressurised cabin, oxygen system and ejection seats were retained, as were the under wing weapons pylons and the tip tanks.

On site examination

The aircraft had come to rest on a northerly heading in a level field approximately 400 feet amsl. There was no ground-slide, indicating zero forward speed. Marks made by the wing leading edges indicated that the aircraft had been rotating to the left at impact. The right hand tip tank had become detached at impact and thrown forwards, again indicating rotation to the left. Severe crushing damage on the underside of the nose together with structural failure of the fuselage aft of the cockpit indicated a nose down attitude at impact. The inboard weapon pylon on the right wing was found embedded in the earth at an angle of 20°. Thus the evidence was consistent with the aircraft having struck the ground whilst in a spin to the left, with a high descent rate and a 20° nose down attitude. A photograph of the wreckage is shown at Figure 1.

The observer had landed approximately 400 metres north-east of the aircraft impact area, with his seat being found 50 metres west of the main wreckage. The canopy was lying 80 metres to the east. The pilot's seat had landed on its back close to the aircraft and had made a deep impression in the ground. The parachute pack was still in position, although the drogue bullet, its associated lanyard and parachute had deployed. The stabilising parachute, which was attached to the drogue parachute, was partly pulled out of its stowage in the seat head-box. It therefore appeared that the system had been part way through its deployment sequence at the moment of ground impact. The close proximity of the seat to the aircraft suggested a reasonably flat aircraft attitude at the time the pilot ejected, since any extremes of pitch or roll would be expected to result in a degree of horizontal separation.

The front of the engine was exposed as a result of the breaking open of the fuselage aft of the cockpit. Many of the compressor blades had been bent against the direction of rotation, indicating the engine had been rotating at impact. There was evidence of a small fire having started around the collector tank, which was trapped beneath the engine, close to the combustion chamber area. This had been extinguished, with the aid of the cockpit fire extinguisher, by the witness who attended the aircraft shortly after the accident.

There was a strong smell of fuel and some fuel pooling in the ground beneath the wreckage. Both tip tanks had been ruptured during the impact, the left tank had remained attached to the wing. The other, as noted earlier, had become detached, and there was evidence of residual fuel having drained into the ground.

Subsequent detailed examination

(i) Airframe

The wreckage was recovered to the AAIB's facility at Farnborough for a detailed examination. During the recovery process, a spanner was found on the ground in the area beneath the mid to aft fuselage. Whilst this appeared to come from the aircraft, it was not possible to define its location or how it came to be in the aircraft, although it was thought that it was unlikely to have come from the cockpit area. Close examination of the spanner did not reveal any witness marks to indicate its interference with any part of the aircraft. A photograph of the item is shown at Figure 2.

The primary flying controls on this type of aircraft are conventional, manually operated, with the dual control columns connected to the control surfaces via cables, pulleys, push-rods and bellcranks. Some scope appeared to exist for a loose article, such as the spanner, to cause a control jam at the rear of the fuselage, where the elevator and rudder controls ran in close proximity. No witness marks were found on any of the components that might have suggested that such an event had occurred however. Elsewhere in the fuselage, the control runs were located alongside the engine and jet pipe and presented little opportunity for being jammed.

The examination of the flying controls revealed no evidence of a pre-impact failure or disconnect. The elevator trim was found in the approximate mid position. The rudder appeared to have been in the central position at impact. It was established that the flaps and landing gear were retracted.

(ii) Ejection seats

(a) Operation

The seat occupant initiates ejection either by pulling the seat-pan or face-screen handle. As he does so a sear is withdrawn from the ejection gun breech firing unit, initiating a one second delay, during which time the canopy is jettisoned clear of the cockpit area. After the 1 second delay the ejection gun cartridges are fired. The ejection seat ascends the gun guide rails; static rods on either side of the seat structure remove sears from the Drogue Gun and Time Release Unit, starting a time delay in both units.

As the seat clears the aircraft the 0.5 second delay in the Drogue Gun runs out, firing the Drogue Gun Bullet, which extracts the drogues to slow and stabilise the seat. 0.75 seconds later, and if the seat is below 5,000 metres altitude, the time delay in the Time Release Unit runs out releasing the scissor shackle allowing the drogues to extract the main carrying chute from its container and also releasing the seat harness locks to allow man/seat separation. Above 5,000 metres altitude the time delay in the Time Release Unit is interrupted until the seat has descended to below 5,000 metres, when the time delay is allowed to run and the normal sequence resumes. Thus the minimum time from the initiation of ejection to man/seat separation is 2.25 seconds

(b) Examination

Both Martin Baker KP B4 ejection seats were examined by the Centre of Aviation Medicine (CAM) at Henlow in Bedfordshire. Their report concluded that the observer's seat had operated normally, with ejection occurring within the survivable ejection envelope. The pilot had evidently ejected at a lower altitude and the report noted that if the aircraft descent rate had exceeded 80 ft/sec, which was equivalent to the end-of-gun velocity of the seat, there would have been no net upward velocity of the seat relative to the ground. This would have resulted in minimal seat separation from the aircraft.

Examination of the seat components indicated that they had been in a fully functional and well maintained condition prior to impact. There was no evidence of a malfunction in the pilot's seat and it was concluded that the low abandonment altitude resulted in ground impact before the seat sequence had run through to completion.

(iii) Personal safety equipment

CAM also examined the pilot's helmet. It had sustained damage to the left rear side. This damage was found to have been caused as a result of violent contact with the front of the head-box, which would have occurred when the seat impacted the ground on its back.

Pilots' notes

The pilot's notes for the BAC 167 Strikemaster contain a section relating to spinning. The relevant extract relating is reproduced below:

11 Spinning

(a) Limitations

(i) The clean aircraft or an aircraft with under-wing pylons or light series bomb carrier (no bombs) is cleared for erect spinning up to 4 turns. The tip tanks must be empty and the maximum internal fuel state must not exceed 1,600 lb. The difference between port and starboard contents must not exceed 100 lb. Deliberate inverted spinning and spinning with under-wing stores is prohibited.

(ii) The minimum recommended height for commencing a deliberate spin is 18,000 ft A.G.L.

(b) Spin entry

(i) Close the throttle and at the stall apply full rudder in the intended direction of spin and move the control column fully back.

(ii) The entry technique usually determines the character of the incipient stage of the spin but in general entry from a straight stall produces fairly consistent behaviour by the third turn.

(iii) Entry from manoeuvres or with the ailerons held in the pro-spin direction will in most cases result in oscillation at the incipient stage; however, application of approximately half out-spin aileron will damp out this oscillation.

(iv) Spins at high fuel state i.e.' 1,000 - 1,600 lb are usually quicker to stabilise and have a moderately high rate of rotation, particularly spins to port. At fuel states below 1,000 lb. the rate of rotation is usually lower, particularly in spins to starboard. Once the spin has stabilised, the I.A.S. remains fairly steady and little if any elevator buffet is present. An unstabilised spin will be indicated by strong elevator and rudder buffet and a continuously increasing I.A.S.

(c) Characteristics of the controls in the spin

In the stable spins, the elevator will be overbalanced and little if any effort is required to hold the control column hard back. In any spin the ailerons tend to float towards the direction of spin unless restrained: occasional buffet, tramping or snatching may affect all controls. Rudder forces are high for both holding the aircraft in the spin and for recovery.

(d) Spin recovery action

The first turn of an erect spin can be considered as incipient, and if recovery is required at this stage it can usually be achieved by moving the controls to the neutral position. If this action does not lead to a recovery or if the spin has been allowed to develop, carry out the following:

(i) Close the throttle

(ii) Apply and maintain full rudder to oppose the direction of yaw as observed visually and indicated by the turn needle.

(iii) Observe a 2 second pause.

(iv) Move the control column forwards to the 2/3rds forward position or until the spin stops. Ensure that the ailerons are neutral throughout.

(v) Centralize the rudder immediately the spin stops.

(vi) Level the wings and ease out of the dive.

(e) Spin recovery considerations

(i) It is important that the control column is in the correct position when the spin stops. Recovery with the control column held aft of neutral may lead to a further spin in the opposite direction; recovery with the contro1 column moved harshly beyond the 2/3rds forward point may lead to an inverted spin.

(ii) To ensure a clean recovery, the rudder should be centralised quickly once the spin has stopped.

(iii) As the control column is moved forward during recovery action, the rate of rotation will speed up before the spin stops. Elevator forces may be high requiring a strong push force.

(iv) The aircraft normally recovers within 3 turns. Up to 6,000 ft may be lost from the initiation of the recovery to the attainment of straight and level flight. Recovery time from any spin varies with the spin characteristics. Generally recovery from oscillatory or the incipient stage of a spin is rapid. Recovery from stable spins takes longer, especially at high fuel states, and pilots should be prepared to wait for the anti-spin controls to take effect.

Note: *The aforementioned actions and considerations are valid for all erect spins, including those inadvertently entered with the aircraft configuration outside the spinning limitations. {see Pt.2, Ch .1).*

(f) Mishandling the controls

(i) If the control column is forced forward whilst maintaining pro-spin rudder or forced forward without an adequate pause, then a highrotation spin with similar or steeper attitude can be induced.

(ii) If only partial rudder is used either during entry or during recovery, there will be a speed up in the rate of rotation and recovery may not be achieved until full corrective rudder is applied and maintained.

(g) Delayed spin recovery

If the aircraft has not recovered from the spin after recovery action has been maintained for four turns, it is probable that the controls have been mishandled. Carry out the following actions:

(i) Recheck the turn needle.

(ii) Ensure that full rudder to oppose the direction of yaw - as indicated by the turn needle - is applied and maintained throughout.

(iii) Move the control column fully forward, ensuring that the ailerons are neutral throughout.

(iv) Jettison stores (if applicable).

(v) Centralise the rudder immediately the spin stops, but not before.

(vi) Level the wings and ease out of the dive.

If recovery has not been achieved by 5,000 ft A.G.L. the aircraft must be abandoned.

(h) Inverted spinning

Note: *No inverted spinning trials have been carried out.*

(i) An inverted spin will be recognised by the presence of continuous negative 'g'.

(ii) The recommended action is to apply full rudder to oppose the spin direction, as shown by the turn needle and move the control column steadily to the neutral position.

Discussion

The aircraft's fuel state recorded prior to the earlier stalling exercises was 1,800 lb. With the aircraft burning approximately 20 lb. of fuel a minute the fuel state for the spinning phase of the air test would have been approximately 1,600 lb.; the maximum allowed for this exercise.

Prior to the spinning checks the crew had spent several minutes at FL 350 in an unpressurised environment. This could have produced some physiological effects associated with 'decompression sickness'. However, the observer suffered no ill effects and the pilot's evident lack of incapacitation from his performance at lower level make this condition unlikely.

The entry into the incipient spin to the left was carried out from FL150. This was 3,000 feet below the pilot's notes recommended height for entry into a deliberate spin. The pilot may have believed however that this was acceptable as only an incipient spin was being attempted with recovery action to be taken almost immediately. In the event the aircraft's behaviour was such that the incipient stage was not apparent.

The pilot appeared to accept that a fully developed spin had occurred and continued with the spin using it as one of the fully developed spins required for the air test. During the descent he called out the aircraft's passing flight level (FL100) and the number of turns (three) completed for the observer to note. It is not known whether the correct technique was used when it came time to attempt a recovery. The pilot's use of an expletive at the time suggests however that either he had used the correct technique and the aircraft was not responding as expected, the erect spin had changed to an inverted spin, or, for an unknown reason, he could not achieve the required control movement. If the spanner, which was found beneath the fuselage had caused a control jam the pilot would more than likely have committed to an early ejection. The fact that he did not and continued to move the control column suggests that he was attempting to affect a recovery. Alternatively, since the observer saw the pilot move the control column fully forward and, knowing from the advice given in pilots notes that this could induce a high rotational spin, it is possible that the pilot was obliged to do this in order free a control restriction. Although it seems unlikely that the spanner played any part in the events leading to the accident the possibility cannot be entirely discounted. The presence of loose articles, especially tools, is a well known hazard, particularly to aircraft that perform aerobatic manoeuvres.

While continuing to effect a recovery the pilot asked the observer for a reading from the altimeter. This must be considered unusual as the instrument is more directly in front of the pilot and would have been as easily read by him and would have been a part of his priority instrument scan. He was either therefore unable to read the instrument because of its speed of movement and needed a second opinion or he was concentrating so much on the recovery that he needed the observer's assistance for by now the aircraft may have transitioned into a more disorientating high rotational inverted spin. Evidence for this can be drawn from the observer's recollection of the aircraft's attitude oscillating close to and sometime beyond the vertical.

The pilot continued to attempt to recover from the spin as the altitude reduced and the time available for a successful ejection diminished. The altimeter's subscale was set to 1013mbs to indicate flight levels. With a sea level pressure of 997mbs the indications on the instrument exaggerated the height the aircraft was above the surface by some 880 feet. The pilot had already mentally prepared his observer for a possible ejection and eventually decided that this was the only course of action left. In line with his military training he therefore ordered the observer to eject first waiting for his successful separation from the aircraft before initiating his own ejection. The observer ejected just within the survivable ejection seat performance envelope. The aircraft by now was only a few hundred feet from the ground and well below the recommended minimum ejection height of 5,000 feet agl. There was therefore insufficient time remaining for the pilot to survive.

Figure 1. General view of aircraft wreckage

Figure 2. Spanner found in fuselage