**AAIB Bulletin No: 8/95** **Ref: EW/C95/3/2** **Category: 1.2**

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| **Aircraft Type and Registration:** | North American T-6 Harvard 2A Texan, G-TEAC |
| **No & Type of Engines:** | 1 Pratt & Whitney R1340-AN1 piston engine |
| **Year of Manufacture:** | 1943 |
| **Date & Time (UTC):** | 4 March 1995 at 1608 hrs |
| **Location:** | Woodham Walter, 3 nm west of Maldon, Essex |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - 1 Fatal Passengers - N/A<br>1 Serious |
| **Nature of Damage:** | Aircraft destroyed |
| **Commander's Licence:** | Private Pilot's Licence with display authorisation |
| **Commander's Age:** | 44 years |
| **Commander's Flying Experience:** | 1,310 hours<br>(of which 64 hours were on type since August 1993)<br>Last 90 days - 4 hours<br>Last 28 days - 4 hours |
| **Information Source:** | AAIB Field Investigation |

## Background

The aircraft was owned by the pilot who was one of the founder members of the Harvard Display Team and a co-Director of 'North Weald Flying Services' a company that specialises in operating vintage and World War II aircraft of all descriptions from the airfield at North Weald in Essex. Periodically the aircraft was based at RAF Swanton Morley in Norfolk, an airfield close to the pilot's residence. For the remainder of the time it was flown from the airfield at North Weald.

The pilot had started his flying career in 1968 with the University Air Squadron at Cambridge. During that time he was twice awarded trophies for his aerobatic excellence. Since then he had participated in approximately 138 public flying displays. At the time of the accident he held a Private Pilot's Licence (PPL) with a current medical certificate and current Civil Aviation Authority (CAA) Display Pilot Authorisation for Harvard aircraft. This was valid until July 1995 and permitted him to carryout flypasts (at a height not less than 50 feet agl) and Standard-level aerobatics (at heights of not less than 200 feet agl).

An instructor at the Empire Test Pilot's School at RAF Boscombe Down, Wiltshire, who is qualified on the Harvard and joined the Harvard Display team in 1989, had flown with the pilot on several occasions during formation and aerobatic manoeuvres. He described him as a pilot with "a great deal of natural ability, especially with respect to formation flying. He flew the aircraft in a very positive, controlled manner and his aerobatics were spirited and flown to the limits of the aircraft". This instructor had also flown the accident aircraft and stated that he could not recollect it having displayed any handling abnormalities.

The pilot's son was also a qualified pilot who had held a PPL since December 1989. He had flown a total of 260 hours of which 76 hours were on type. At the time of the accident he also held a current medical certificate and a CAA Display Pilot Authorisation for the Harvard permitting him to carryout flypasts (not lower than 200 feet agl) and formation flying only. His display authorisation was valid until June 1995.

**History of the flight**

On the day of the accident the pilot and his son had planned to fly their aircraft, G-TEAC ('AC'), in formation with another Harvard, G-BKCK ('CK') to practice manoeuvres designed to improve the finale to their forthcoming summer season of public displays. The pilot was to occupy the rear seat of the tandem seats fitted in 'AC'. The pilot of 'CK', a family friend, was to occupy the front seat of his aircraft with a passenger in the rear.

At approximately midday the pilot and his son met at the North Weald flying club with the pilot and passenger of 'CK'. Before the main aerobatic flight of the day the pilot of 'CK' and the son flew their aircraft solo on a brief formation flight in order to refresh their skills. The aircraft landed back at North Weald at 1430 hrs after a 25 minute flight that was carried out over the disused airfield of Willingale, 6 nm to the east of North Weald. After landing both aircraft were refuelled to full tanks. The Harvard has a total tank capacity of 80 imp gallons when refuelled in the tail down position. A fuel receipt for 'AC' showed that 178 litres (39.1 imp gallons) of fuel was uplifted.

The pilot of 'CK' and the son then joined the other members of the party and, over a light lunch, debriefed that flight and briefed for the forthcoming formation aerobatic sortie. The briefing for this flight was given by the pilot (father). The plan was for the son, occupying the front seat of 'AC' with his father seated in the rear, to lead the formation with the other aircraft, 'CK', practising station keeping in echelon. After that the intention was to practice the end of display finale which involved performing several 'Half Cuban' manoeuvres (5/8's of a loop pausing in an inverted 45° dive and

rolling erect before recovering to the horizontal). The pilot of 'AC' briefed the entry speed for the 'Half Cubans' as 180 mph (156 knots). The pilot of 'CK' has since stated that he was a little surprised at this as it was normal to enter the manoeuvre at 180 knots. He thought, however, that the reason for the discrepancy was due to the fact that the airspeed indicator (ASI) in 'AC' was calibrated in mph and not in knots and although this speed was slower than normal it was within acceptable limits.

The other co-director of the North Weald company stated that although he was not present at the pilots briefing he did speak with them and advised them to "operate well to the east of Chelmsford to avoid any noise nuisance to the built-up areas".

The aircraft departed North Weald Airfield at 1545 hrs and transited to the east, flying to the south of Chelmsford before turning to the north east and climbing to approximately 3,000 feet amsl. During the transit, the No 2 aircraft ('CK'), remained in formation with the leader ('AC') changing position as they carried out several gentle turns. The pilot of 'CK' then took up a position in line astern of 'AC' in preparation for the 'Half Cuban' manoeuvres. The passenger in 'CK' stated that throughout the flight he gained the impression that the son was flying 'AC' as it was his voice that he could hear on the radio, transmitting formation instructions.

By now the aircraft were north east of Danbury and to the west of Maldon, clear of controlled airspace but with the London Terminal Control Area 500 feet above them at an altitude of 3,500 feet amsl. Recorded radar information from the radar head at Debden in Essex was analysed and this confirmed the ground track of the formation showing the position of 'AC', at 1607 hrs, just prior to the accident.

Weather conditions in the area were excellent. Witnesses described them as being 'cool and bright with clear skies and calm winds'. An aftercast obtained from the Meteorological Office at Bracknell gave the synoptic situation at 1600 hrs as showing a southwesterly airstream covering the area with nil weather, visibility 30 km and no cloud. The wind at 3,000 feet was 250°/23 kt with a temperature of -4°C.

Both aircraft entered the first 'Half Cuban' manoeuvre and pulled up towards the top of the loop. The pilot of 'CK' reported that at this point, because of the slow speed, his controls became less effective and he had to release back pressure on the control column and unload the wings in order to avoid stalling the aircraft and flicking. This low 'g' condition affected the engine's fuel supply which is designed to operate under positive 'g' conditions only. The engine 'spluttered' and lost power. The pilot of 'CK' then radioed to the leader "No 2's out" (No 2 is out of position and clearing from the leader), rolled the aircraft wings level and throttled back in order to avoid an over speeding propeller.

This caused him to drop back behind the leader. Unable to follow him into the second 'Half Cuban' he carried out a gentle left turn to clear and restart his engine. As he turned he lost sight of the other aircraft as it pulled up towards the vertical for the second manoeuvre.

Several witnesses on the ground observed the progress of 'AC' as it entered the second 'Half Cuban'. One witness, positioned half a mile from the crash site, stated that the aircraft reached the vertical and then appeared to hang motionless momentarily with no engine noise. "It then slipped to the right about 10° to 20° and started to spin. It continued to spin slowly so that I could see progressively the upper and lower surfaces of the aircraft. At the last moment it pulled out of the dive in an upright position but hit the ground in a large fireball". Several witnesses described the aircraft as sliding tail first, rocking slightly, before it entered the spin. A witness, looking from a first floor window, across a field to the rear of a nearby public house, first saw the aircraft as it attempted to recover from the dive. He described the aircraft as flying level 20 feet above the ground, at a speed estimated by him to be 80 mph, with 45° of left bank and with power applied. "It then banked to the right and pulled up sharply to avoid trees at the edge of the field. Once over the trees it dropped like a stone hitting the ground with its wings level. Two seconds later there was a fireball".

As the pilot of 'CK' completed his clearing turn he looked back to see 'AC' and described it as being in a fully developed spin 300 feet below him and some half mile distant. He stated that the aircraft was spinning very fast in a 'nose low' attitude. The aircraft completed approximately nine turns in the spin and it was only after four turns that he realised that the spin was inverted. At the last moment he saw the aircraft recover from the spin but hit the ground in a 'wings level' attitude.

The pilot of 'CK' circled the crash site for several seconds after the impact before transmitting a "MAYDAY" message on the flying club discrete frequency of 123.52 MHz. Shocked by the events he gave the position of the accident as being "4 miles north east of Cambridge" (instead of Chelmsford). This message was received and passed to the club co-Director who alerted the emergency services and Cambridge Airfield. Although the club radio operator replied to 'CK' his transmission was not received. The pilot of 'CK' therefore changed frequency to the International Distress Frequency of 121.5 MHz and at 1610 hrs re-transmitted the "MAYDAY" message amending the position of the crash to "5 miles north east of Chelmsford". The crew of a commercial airliner monitoring the frequency heard the MAYDAY and relayed the information to the London Air Traffic Control Centre (LATCC). After circling the crash site for a further seven minutes the pilot of 'CK' returned to North Weald.

Many people witnessed the accident and telephoned for the emergency services. The Ambulance and Fire services arrived on the scene at 1628 hrs and administered first aid to the survivor.

At the time of the accident an RAF helicopter from No 22 Squadron, RAF Wattisham, was on a training flight refuelling at RAF Manston in Kent. On board were the Station Medical Officer and five specialist doctors including an anaesthetist and a trauma specialist. The helicopter was called to the

scene and on arrival deployed a winchman and two specialist doctors to assist. At 1633 hrs, because of the nature of the survivor's injuries, it was decided to call for the Helicopter Emergency Medical Service (HEMS) from London. The HEMS arrived on site at 1648 hrs, departed scene with the survivor at 1719 hrs arriving at the London Hospital, Whitechapel, at 1734 hrs.

**Medical and Pathology**

The pilot, in the rear seat of 'AC', suffered fatal injuries in the impact. A post-mortem examination revealed that he had received a severe head injury and the forces involved in the accident were such that no safety equipment could have prevented a fatal outcome. Furthermore there was no evidence of any pre-existing medical condition that would have influenced events.

The rear seat passenger of 'CK' stated that, whilst airborne, he saw the father in the rear of 'AC' wearing a white crash helmet. There was no sight of this helmet during the post-accident examination of the wreckage. The helmet was discovered by the police several days later near the accident site.

The son was thrown clear of the aircraft during the initial impact and survived although seriously injured.

**Wreckage examination**

The aircraft had crashed in a large, flat, ploughed field. The nature of the soil did not leave detailed impressions, but the initial impact marks were consistent with a shallow entry into the ground of the tailwheel, followed by deeper marks made by the propeller and the fuselage. The aircraft configuration had been: mainwheels and flaps up, and a bank angle of approximately 5° to the right. It was not possible to determine accurately the pitch angle or the speed, but the accident site evidence indicated that the flight path angle was a few degrees below the horizontal and that the aircraft speed had been reasonably high.

There had been two heavy impacts; the wings separated at the first impact and the engine detached at the second. The forward cockpit had been severely disrupted and had released the front seat occupant before folding back through 180 degrees to lie alongside the rear cockpit.

Both propeller blades showed stone damage and scoring consistent with hitting the ground at a high power. There was evidence along the wreckage trail of fuel fires associated with the wing fuel tanks. This was corroborated by aerial photographs and indicated that the fuel tanks had contained a

significant quantity of fuel. The flying controls were badly disrupted due to the impact, however examination of them revealed no evidence of any pre-impact failure.

In summary, no engineering evidence was found to indicate that a mechanical failure had contributed to the accident.

## Spinning

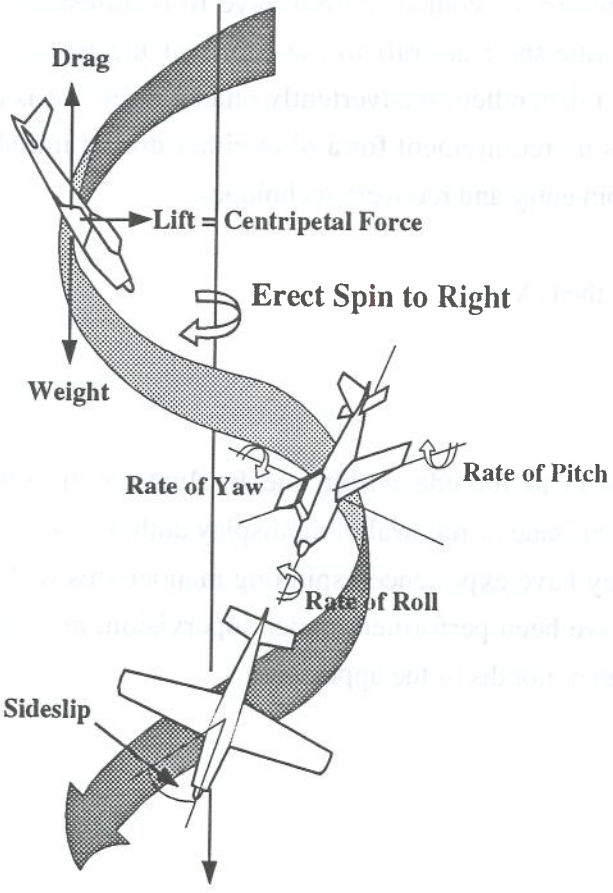
### Erect Spin

In an erect spin (see diagram) the aircraft describes a ballistic trajectory dependent on the entry manoeuvre. To the pilot this will appear unsteady and oscillatory initially until the aircraft settles down into a stable spin with a steady rate of descent and rotation about the spin axis. This occurs when aerodynamic forces, inertia forces and moments can achieve a state of equilibrium. The aircraft attitude will depend on its aerodynamic shape, the position of the controls and the distribution of mass throughout the aircraft. In an erect spin, say to the right, the aircraft is rolling right, pitching up and yawing right. Spin recovery is aimed first at stopping the yaw by applying opposite rudder to produce an anti-spin yawing moment and then moving the control column forward until the spin stops, maintaining the ailerons neutral.

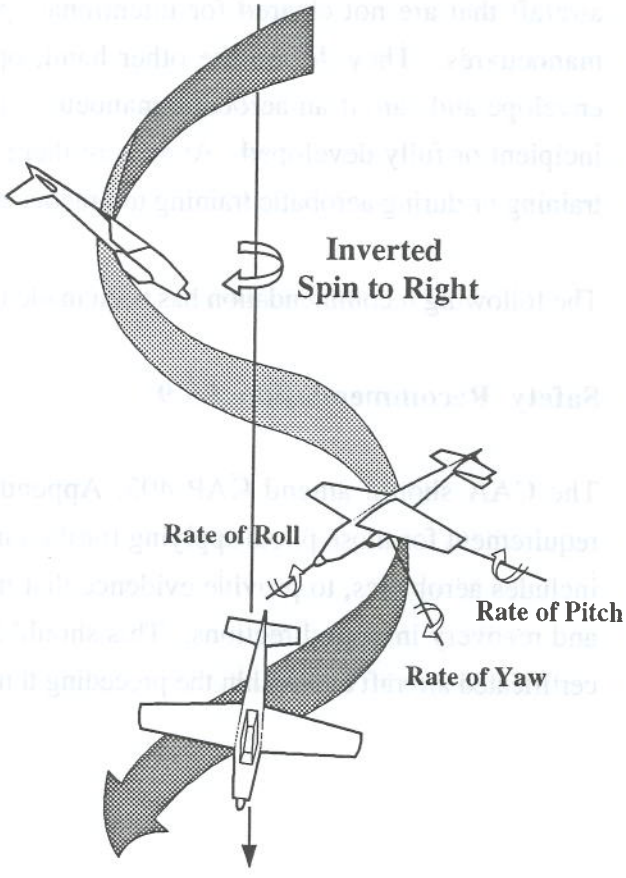
### Inverted Spin

An aircraft in an inverted spin to the right (see diagram) follows the same flight path as that in an erect spin except that the motion, relative to the pilot, is compounded by a pitching velocity in the nose-down sense, a rolling velocity to the right and a yawing velocity to the left. Thus roll and yaw are in opposite directions, a fact which affects the recovery actions. The inverted spin is fundamentally similar to the erect spin and the principles of moment balance are equally valid. The values of the aerodynamic moments, however, are unlikely to be the same since, in the inverted attitude, the shielding effect of the wing and tailplane may change markedly. The main difference will be caused by the change in relative positions of the fin and rudder and the tailplane. For example an aircraft with a low mounted tailplane will tend to have a flatter erect spin and recovery will be made more difficult due to shielding of the rudder. The same aircraft inverted will respond much better to recovery rudder since it is unshielded. The control deflections required for recovery are dictated by the direction of roll, pitch and yaw and the aircraft's mass distribution. In this case rudder is applied to oppose the yaw as indicated by the turn needle, and up elevator is selected. If the aircraft has more centreline weight than outboard weight then aileron is applied in the same direction as the observed roll.

## MOTION OF AN AIRCRAFT IN AN ERECT SPIN TO THE RIGHT




## MOTION OF AN AIRCRAFT IN AN INVERTED SPIN TO THE RIGHT




### Display Competency

Civil Aviation Publication CAP 403 sets out the safety and administrative procedures to be followed by the organisers and participants in flying displays held at civil locations within the United Kingdom.

Appendix G, entitled 'Display Competency', details the requirements and guidelines to be used by the CAA and Display Authorisation Evaluators for the issue or removal of a Display Authorisation. The guidelines include the inspection of documentation relating not only to the pilot's licence and his experience but also that relating to the aircraft. On the practical side pilots have to undergo an oral examination discussing amongst other things those relating to manoeuvre energy management and problems with stalls and spins whether intentional or inadvertent. A pilot also has to demonstrate aerobatic manoeuvres and be evaluated on particular aspects including; their precision and sequence; airspeed and height control; and the ability to handle emergencies during a display performance.

Display pilots authorised for intermediate and advanced aerobatic displays, who operate aircraft that are cleared for spinning and who include spins or flick manoeuvres in their display sequence, have to demonstrate these manoeuvres in order to be issued with a Display Authorisation. Pilots displaying aircraft that are not cleared for intentional spinning, of course, do not have to demonstrate these manoeuvres. They do, on the other hand, operate their aircraft to the limits of the performance envelope and can, if an aerobatic manoeuvre is mishandled, inadvertently enter a spin that is either incipient or fully developed. At present there is no requirement for a pilot either during initial PPL training or during aerobatic training to practice spin entry and recovery techniques.

The following recommendation has been made to the CAA:

**Safety Recommendation 95-9**

The CAA should amend CAP 403, Appendix G to include within the Evaluator's discretion a requirement for those pilots applying for the initial issue or renewal of an display authorisation, which includes aerobatics, to provide evidence that they have experienced spinning manoeuvres with entry and recovery in both directions. This should have been performed, under supervision, in a suitably certificated aircraft and within the preceding thirteen months of the application.