Cassutt Racer IIIM, G-BPVX

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Aircraft Type and Registration:	Cassutt Racer IIIM, G-BPVX
No & Type of Engines:	1 Continental C90-8F piston engine
Year of Manufacture:	1971
Date & Time (UTC):	3 July 1999 at 1629 hrs
Location:	Bembridge Airport, Isle of Wight
Type of Flight:	Private.
Persons on Board:	Crew - 1 - Passengers - None
Injuries:	Crew - 1 (Fatal) - Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	717 hours (of which 10 were on type)
	Last 90 days - 41 hours
	Last 28 days - 16 hours
Information Source:	AAIB Field Investigation

History of the flight

Preparation for the air race

On the day of the accident the pilot had flown from Lashenden in Kent to Bembridge on the Isle of Wight to take part in the Formula 1 air race qualification. This was in preparation for the competition which was to be held on the following day.

The previous evening the pilot had spent several hours preparing and checking his aircraft and had told friends that he was fully satisfied with it. At 0905 hrs the following morning the pilot made a short ten minute flight to check the compatibility of a new motorcycle crash helmet he had purchased in order to fully comply with the Formula Air Racing Association (FARA) race rules. Radios are not required during racing but provision had been made for a hand held VHF radio to be attached, using Velcro to the right hand side of the instrument panel. This was used in conjunction with a headset for the transit flight and arrival at Bembridge. Race control is exercised using pre-briefed flag signals.

Air racing qualification

On arrival at Bembridge the aircraft fuel tank was dipped with the contents confirmed as 2/3 full. Following lunch a full race briefing was held at which the Cassutt pilot was given an additional brief by the race organiser concerning his qualification requirements; this being his first Formula 1 race. The requirements were to take off without deviating more than 5 feet either side of the runway centreline, carry out 10 circuits of the race course of which 5 must be at full race speed and demonstrate an aileron roll to the left and right. The Cassutt was to be the last of four aircraft to undertake qualification.

At about 1555 hrs the Cassutt engine was started but the aircraft was held for some ten minutes due to departing traffic before closing down to await clearance for the qualification. At 1615 hrs the pilot restarted and taxied to the holding point of Runway 30. Race officials monitoring the pilot's take off considered it exemplary with no deviation despite the crosswind. His race circuits were all well flown with lap times coming down consistently and the aileron roll to the left was successfully carried out with only a minor deviation from heading on the exit from the manoeuvre.

The accident

The pilot made a wide right hand circuit to run in slightly south of the runway in order to carry out the roll to the right. A video taken by a spectator showed that the aircraft approached wings level at an estimated height of 500 feet agl and an air speed of 145 mph +/- 10 mph. The aircraft pitched 10° nose up and entered a roll to the right with the nose progressively dropping to 10° below the horizon at the inverted position. At this point witnesses state that the engine stopped although the propeller continued to rotate. The wings were levelled in the inverted position and a positive inverted bunt manoeuvre took place to 60° above the horizontal before the roll to the right continued to wings level. The nose initially dropped but then pitched up slightly, with the aircraft adopting a Dutch rolling motion before entering an incipient spin to the left through one rotation before impacting the grass area some 100 metres south of Runway 30.

The airfield fire crew, St John Ambulance personnel and an off duty paramedic, attended the scene immediately. The aircraft structure was severely disrupted but there was no fire. With fuel spilling from the ruptured fuel tank the fire crew deployed the necessary resources whilst medical personnel attempted to render assistance to the pilot, who had received fatal injuries. The police where at the scene and the local fire and ambulance responded rapidly. The airfield manager, who had witnessed the accident, initiated the airfield crash plan.

Description of the aircraft

The Cassutt Racer IIIM is a small single seat racing monoplane powered by a Continental C90-8F engine with a fixed pitch wooden propeller. The fuselage is constructed of tubular steel covered with fabric; the wings are of fabric covered wooden construction with full span ailerons but no flaps. There is no inverted flight fuel system, therefore negative G manoeuvres will cause engine fuel starvation.

G-BPVX was constructed in USA in 1971 and had flown a total of 162 hours by the time it was imported into UK in June 1989. Shortly after this it was granted a UK Permit to Fly. It was fitted with an exchange racing engine in September 1989, having flown a further 12 hours, and had

remained in that state since. The pilot bought it in April 1999 and he conducted the test flight for its current Permit. At the time of the accident the aircraft had flown a total of about 295 hours.

The aircraft type is light, fast and highly manoeuvrable with speeds in excess of 200 mph being achieved whilst racing. The 1G stall on this individual aircraft had been recorded during all permit renewal flight tests and had occurred consistently at between 56 and 58 mph, 'power off' with a natural buffet about 5 mph above stalling speed.

Examination of the accident site and aircraft

The aircraft had struck the ground when on a westerly heading, with its wings almost level and a pitch attitude of about 30° to 45° nose down. Although it had had a very high rate of descent, it had very little forward speed and the aircraft had bounced rearwards out of the impact crater. Inspection of the site showed that the aircraft had been intact before impact and later examination did not reveal any evidence of a pre-impact malfunction or failure of the structure or flying controls.

The canopy transparency was fragmented but all pieces were located in the immediate locality of the impact area and a reconstruction of the canopy did not reveal any evidence of a birdstrike on it. There was evidence of interference between the top of the pilot's helmet and one of the fasteners attaching the transparency to the top of its frame.

Ground marks at the point of impact and the condition of the propeller showed that it had been rotating at the moment of impact but it did not appear that the engine had been developing full power. Examination of the engine controls indicated that the mixture was in the 'Rich' setting, the throttle was advanced beyond the idle setting but not at 'full power' and 'Cold' air was selected.

Analysis

The pilot had some 514 hours experience in motor gliders and was the CFI of an RAF Air Experience Flight. He was issued with a PPL/A in 1992 and had logged 203 hours on a number of different aircraft types of which 165 hours were as pilot in command. Since buying the Cassutt Racer in February 1999 he had flown 11 hours in the aircraft in 20 flights. Witnesses described his approach to gaining experience on the Cassutt as incremental and responsible.

In July 1998 the pilot had been cleared by his flying club for basic aerobatics on the Stampe aircraft following a normal period of training. As recently as 19 June 1999 he had carried out spinning in the Stampe. None of this flying had included sustained negative G manoeuvres.

FARA Rules set out flying experience and aircraft operating requirements which were fully met. A description of the qualifying manoeuvres to be demonstrated has already been given. Although minimum heights are not stipulated for the carrying out aileron rolls, they were required to be conducted 'at a safe height and speed'. The Cassutt is flown on a Permit to Fly, issued by the Popular Flying Association on behalf of the CAA. It is not cleared for aerobatics. The one exception to this is that aileron rolls are permitted for air race qualification.

The CAA issued two exemptions to the air race organisers for the aircraft taking part. Rule 5(1)(e) and Rule 17(4) exemptions to permit low flying and overtaking on either side. A minimum height above the surface was set at 30 feet within pre-determined areas and outside minimum distances

from the crowd line. Although, under the ANO, air races are not classed as flying displays, air display crowd separation distances are applied to Rule 5 (1) exemptions issued for air racing.

With regard to the aileron roll manoeuvre a number of factors need to be considered. An experienced aerobatic pilot, who had flown the Cassutt in air races, was asked to comment on the video recording showing the flight path leading up to the accident. He concluded that whilst the entry into the manoeuvre had sufficient speed the pitch up was inadequate and was not allowed to stabilise before commencing the roll. The nose dropping below the horizon was to be expected when approaching the inverted position and would need correcting before continuing the roll. Fuel starvation due to the lack of inverted fuel system would also have occurred. The forward input into the controls to reposition the nose above the horizon was excessive and caused an outside bunt resulting in a negative G force calculated at -4.5G for 2 seconds. Given the rapid loss of airspeed and the increase of stalling speed which was due to the G loading, the inverted left wing appeared to stall resulting in the aircraft rolling to the right. When the aircraft achieved wings level the roll ceased and the nose dropped as if at the stall but this attitude was not sustained, the nose pitched up and the aircraft speed reduced until the left wing dropped and the aircraft entered an incipient spin.

Cockpit environment

Whilst the pilot was well protected by clothing and a helmet, the OAT was +18°C in sunshine. The ten minutes spent in the cramped cockpit while waiting to depart before closing down would have been hot and uncomfortable. The ten laps with the attendant concentration, heat and noise would also have imposed some degree of physical strain. Whilst this cannot be fully assessed it would have led to a degree of degradation in the pilot's performance.

Hand held VHF radio

The hand held VHF radio had Velcro attached to its rear upper half. The only matching Velcro in the cockpit was on the right side of the instrument panel. Running down the right side of the cockpit was the antenna lead, which when attached to the radio, allowed the radio to be mounted on the instrument panel. The antenna lead had broken close to the radio. Whilst none of the witnesses recalled seeing the radio on the instrument panel its presence in the cockpit was not necessary for the qualifying flight. If the radio was firmly attached to the Velcro it is unlikely to have detached during the inverted bunt. Static tests required a force of 8G to cause it to peel off the Velcro even with the additional weight of the radio battery assisting the process when the aircraft was inverted. If the radio was not properly secured or it was loose in the cockpit it would have posed a significant distraction or even hazard during the bunt or rolling manoeuvre. No witness marks or other evidence exists to show it was not restrained until the final impact when the whiplash effect caused it to be thrown from the cockpit landing on the grass to the left side of the aircraft fuselage.

Head clearance

The pilot was 6' 3" (1.92 metres) tall with the additional height of the crash helmet. It is not known under normal G conditions what clearance existed between the helmet and canopy. New tape had been placed over securing nuts inside the canopy above the pilot's head to prevent damage to the helmet. This, along with a photograph of a previous owner seated in the aircraft with known head clearance, indicated a very limited amount of head room. Whilst the lap seat belt was attached beneath the seat, without a negative G strap during inverted flight or negative G manoeuvre the pilot would have moved out of his seat to some degree towards the canopy. If his head had come into contact with the fibreglass cover the effect would have been to force his chin onto his chest

thereby severely limiting his ability to see out. This situation would only be rectified when positive G was restored. Witness marks on the helmet showed the top of the helmet to have rubbed against the fibreglass portion of the canopy. A deep fore and aft scratch suggests contact between a nut which holds the canopy Perspex to the fibreglass canopy roof. The nut was not found in the wreckage and may have been dislodged during the inverted manoeuvre. Whilst the canopy Perspex was intact at impact some disruption or cracking could have occurred when the pilot's head contacted the canopy during the inverted flight.

The inverted manoeuvre

The pilot, during his aerobatics training in the Stampe aircraft had practised taking corrective action when, during an aileron roll, the nose fell below the horizon. This was to level the wings in the inverted position and then apply a large amount of down elevator to raise the nose to the correct position above the horizon before continuing the roll. The club pilot who had instructed the Cassutt pilot in this technique had emphasised the positive forward movement needed in the Stampe to achieve this. Whilst negative G is experienced it is expected and manageable. The Cassutt in a similar situation requires much smaller control inputs in pitch to avoid excessive rates of pitch with the subsequent increased negative G loading. In order to achieve the bunt manoeuvre seen in the accident sequence a large sustained forward control movement would have been required similar to that used in the Stampe.

The effects of negative G

Whilst the pilot had some previous experience of the effects of negative G the degree and length of exposure would not have been of the combined magnitude of -4.5G for 2 seconds. The effect of such forces would have been to cause great discomfort particularly in the head and neck combined with a degree of disorientation. The Royal Air Force Institute of Health provided a summary of the effects of the negative and positive G forces experienced by the pilot. Tolerance of negative G is lower than positive G and even low levels of negative G can produce serious decrements of performance. Effects could include unpleasant feelings and blurring of vision - preceding 'red out'. Disturbance of heart rhythm is almost invariable with negative G and it is not uncommon for the heart to stop for 5 to 6 seconds when pushing -2.5G. This can cause loss of consciousness. Exposure for greater than 6 seconds will almost certainly cause unconsciousness. It is thought that the maximum tolerance to negative G is of the order of -4.5G for 5 seconds. However, this is the maximum tolerance and it is possible that individuals have a much lower tolerance. Another factor is that negative G reduces the tolerance to positive G. Rapid changes from negative to positive G are known as 'the push pull phenomenon'; this phenomenon is commonly accompanied by serious decrements in the pilot's ability to fly the aircraft, the change in vector causes a profound drop in blood pressure which may lead to unconsciousness. Given that the total time over which the pilot was exposed to negative G was 4.5 seconds followed by a positive pitch nose up which would have induced greater than +1G once the aircraft had rolled wings level following the inverted bunt, it is likely that the pilot was at this stage incapacitated and unable to control the aircraft.

Survivability

The pilot was wearing the previously mentioned crash helmet which was properly secured with a chin strap. The pilot wore denim trousers and a T shirt under a military specification Nomex flying suit. Over the flying suit was a military flying jacket and hand protection was afforded by leather flying gloves. There was a good level of protection against a survivable accident.

A four point harness was secured but had failed at the airframe attachment point due to the considerable deceleration force which had destroyed the cockpit structure. The rear of the engine had punctured the front of the aluminium fuel tank which had released the remaining fuel into the ground beneath the wreckage. The accident was not considered to be survivable.

Conclusions

It is most likely that a combination of the pilot's inability to exercise control due to his probable incapacitation; the aircraft's apparent instability following the particular manoeuvre; and low airspeed caused the aircraft to depart from controlled flight with an incipient spin to the left. In this accident at the manoeuvre was performed at a level where insufficient height remained for recovery.

Safety recommendations

It is recommended that:

Recommendation No 99-46

The CAA, when issuing exemptions to permit formula 1 air racing, should satisfy itself that the safety of persons on the ground is not compromised by the nature of an air racing event, including the design and limitations of the courses to be flown.

Recommendation No 99-47

There is a need to demonstrate aileron rolls at a representative height at which an upset due to wake turbulence might be encountered when racing. The CAA should invite the Formula Air Racing Association to consider whether pilots' abilities in such manoeuvres should be tested at altitude before being demonstrated for qualification at race level.