Hawker Hunter Mk 6A, G-BVVC

AAIB Bulletin No: 5/2004	**Ref: EW/C2003/06/07**	**Category: 1.1**
Aircraft Type and Registration:	Hawker Hunter Mk 6A, G-BVVC	
No & Type of Engines:	1 Rolls Royce Avon Mk 207 turbojet engine	
Year of Manufacture:	1956	
Date & Time (UTC):	1 June 2003 at 1410 hrs	
Location:	Borth, North Wales	
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:	Private Pilot's Licence	
Commander's Age:	44 years	
Commander's Flying Experience:	4,142 hours (of which 114 were on type)	
	Last 90 days - 38 hours	
	Last 28 days - 18 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft departed Blackpool for a display in Northern Ireland with the intention of returning to its home base at Exeter. It took off with one of the two electrical generators inoperative and at an indeterminate time during or shortly after the display, the second generator failed. The pilot did not notice the failure until he had initiated a climb to high altitude through extensive cloud. He continued to climb and reached visual conditions above the cloud. At altitude he decided to continue the flight to Exeter 'non-radio' and proceeded in accordance with his flight plan at FL220. On encountering some cirrus cloud over North Wales he decided to descend to FL180 so as to remain in visual flight conditions and throttled back the engine slightly. On reaching FL180 he advanced the throttle but the engine did not respond and attempts to relight it were unsuccessful. He adopted a glide towards Llanbedr Airfield but when he realised he would not reach it, he turned towards the nearest shoreline and ejected over a large river estuary. The pilot was injured during ejection and he landed heavily in shallow water. He was rescued by helicopter and the abandoned Hunter crashed into marshland near the estuary bank.

Factual Information

Background

The aircraft had been pre-positioned at Blackpool on the Monday before the accident in readiness for displays on the following Friday, Saturday and Sunday. During the flight to Blackpool one of the two generator warning lights was flickering. Minor troubleshooting was conducted on the ground at Blackpool and the aircraft flew one flight from and back to Blackpool on the Friday with no electrical problems. On the Saturday flight, one generator failed to come on line after engine start but the pilot decided to fly with just the one functioning generator. This generator failed during the recovery to Blackpool and the radio became unusable before the aircraft landed. After landing, the operator's engineer found that the two aircraft batteries had low terminal voltages and both were replaced. The aircraft was refuelled to full tanks.

History of the flight

The Sunday flight was to include a display at Portrush in Northern Ireland followed by a high altitude return to the aircraft's home base at Exeter. The weather at Blackpool was fine with bright sunshine and just a few cirrus clouds but, as the pilot was later to discover, the weather was much worse in the vicinity of Portrush. Before start preparations were carried out using external electrical power and the engine was started with both generator contact breakers deliberately tripped. After start-up the engineer accessed the avionics bay and reset both generators. He offered a 'thumbs up' sign to the pilot and received a 'thumbs up' signal from him. The engineer took this to be a sign that all was well whereas the pilot realised that one generator was still off-line. Since the aircraft had a recent history of this generator being somewhat temperamental, the other generator was apparently working and the weather was fine, the pilot decided to continue with the planned flight and no further attempt was made to reset the generator. After takeoff from Blackpool, he climbed to FL210 (approximately 21,000 feet altitude) for the transit to Portrush.

At Portrush the weather was overcast at about 1,500 feet and the visibility beneath cloud was poor in haze and showers. The pilot was compelled by the weather to do a relatively 'flat' display that lasted between four and five minutes. On leaving the Portrush area he noticed that the quality of radio communications had degraded significantly but he was able to hear RTF on the display frequency. These were the last successful radio communications. On climbing out through cloud the pilot attempted to contact Scottish Centre but heard nothing so, diagnosing a radio failure, he selected code 7600 on his transponder and continued the flight in accordance with his flight plan.

The aircraft penetrated significant cloud during the departure and climb to the flight-planned level of FL220. During the climb the pilot noticed that both generator failure warning lights were illuminated. Subsequently some of the electrically powered flight instruments failed due to lack of electrical power from the aircraft's batteries. The pilot continued the climb using the turn and slip which appeared still to be working and the aircraft broke out through the cloud tops on passing through FL160. On levelling at FL220 abeam Belfast, the pilot set course to cross overhead the Isle of Man VOR beacon towards central Wales in accordance with his flight planned route to Exeter.

In the cruise the pilot withdrew and actioned the flight reference card for double generator failure. At this time he was to the north of airways L70 and L975 which, broadly speaking, join Dublin to Liverpool and lie to the north of Wales. Next he reviewed his options for continuing or curtailing the flight and he decided to continue as per the flight plan and land at the aircraft's maintenance base at Exeter.

At FL220 the pilot was flying through thin cirrus clouds and he did not have a good view of the ground or the airspace ahead. When he was south of the airways and about 10 to 15 miles east of Lake Bala (Llyn Tegid), he decided to descend to FL180 so as to become VMC below the cirrus cloud. He throttled back slightly and descended. At this time the 230 gallon drop tanks were still about one third full so the pilot was confident that he had ample fuel to reach Exeter.

Upon reaching FL180 the pilot gently advanced the throttle but the engine did not produce more power. He was aware of 'bleed valve chatter' (a normal artefact of the Avon engine at moderate RPMs) and noticed that the engine RPM and Jet Pipe Temperature were reducing. Initially he attributed these indications to the loss of electrical power to the instruments because there were no obvious changes in engine noise or thrust. However, selection of full throttle produced no increases in noise, thrust or temperature and at that point he diagnosed engine failure. At FL180 he could see Lake Bala and he knew Wales well from the air, so he had no difficulty in turning towards the airfield at Llanbedr which was the nearest airfield suitable for a forced landing. He also tried relighting the engine but without success and he considered jettisoning the 230 gallon underwing tanks but, having no control or prediction as to where they might strike the ground, he decided not to jettison them in recognition of the risk to people and property. The pilot established the aircraft in a glide at 250 KIAS and the windmilling engine continued providing hydraulic power to the flight controls. Before long he realised that he had insufficient energy to reach Llanbedr and so an ejection became inevitable. He turned the aircraft slightly and headed towards the nearest area of water which was the River Dyfi estuary between Llanbedr and Aberystwyth. In preparation for the ejection he tightened the lower straps of the ejection seat harness and mentally reviewed the ejection procedure but he did not jettison the canopy or apply any aileron trim. Once the aircraft was over the Dyfi estuary and pointing away from habitation, he ejected at an altitude of 2,500 feet and a speed of 240 KIAS in straight and level flight.

Ejection conditions

The pilot was seated on the original PSP that contained a dinghy and other survival equipment. To eject he had a choice of using either the face-screen handle above him on the seat's headrest or the seat-pan handle on the front of the seat-pan between his legs; he chose to use the seat-pan handle. He made a determined effort to keep his elbows in and his head back throughout the ejection sequence.

Immediately after the ejection he was aware that he had suffered a back injury during the early part of the ejection sequence. After his parachute deployed, he saw the aircraft "nosing over at the apex of a steep climb". He then separated himself from the ejection seat at a fairly late stage during the descent by releasing the seat harness and prepared to land in the water of the river estuary. Unfortunately, where he landed the water was very shallow, being only about 6 inches deep, and it did not cushion his descent as he had hoped. After a heavy landing in the shallows he was dragged for a short distance before he could disconnect fully from the parachute harness.

Search and Rescue

After releasing his parachute, the pilot came to rest in shallow water on his right side. He was in great pain, unable to stand up, and although wearing a lifejacket, he was unable to inflate it. He could not move his legs in the normal manner so he positioned them by grabbing his external g-suit fabric with his hands and dragging his legs into position so that he could turn himself onto his back. He also removed his flying helmet and used it as a headrest to keep his face out of the water. He did not attempt to recover his survival pack since he was in no fit state to board the dinghy.

Several people nearby saw the pilot land in the water and set off to assist him. The first person to reach him did so through a combination of wading and swimming; he reached him after about 35 minutes and was followed shortly afterwards by another person who had waded from a different position on shore. Next to come to his aid was an RNLI inshore rescue boat but soon afterwards the pilot was winched into a Search and Rescue Helicopter which had been scrambled from RAF Valley on the Isle of Anglesey. He was flown directly to hospital in Swansea for emergency medical treatment.

Pilot's injuries

The pilot's spinal injuries were very serious and he was sedated for some days before undergoing an operation to repair his spine. He remained hospitalised for 6 weeks and is still unable to resume full flying duties.

Hunter Mk 6A flight controls

The aircraft is fitted with conventional ailerons and elevators that are hydraulically assisted and have a manual reversion capability. Manual operation can be selected deliberately by electrical switches in the cockpit. The rudder is also conventional but has no hydraulic assistance. Longitudinal trim is provided by an electrically operated variable incidence tailplane. The wing trailing edge flaps are electrically selected and hydraulically actuated; they have six intermediate positions between UP and DOWN (80°). If either hydraulic or electrical power is not available, the flaps can be deployed by an emergency air bottle which is discharged by a cable operated control. Once operated, the flaps deploy to the 80° position and cannot be retracted until the system is reset on the ground. Similar arrangements are provided for lowering the landing gear which is also electrically selected and hydraulically operated.

Hunter Mk 6A electrical system

Fundamentally the aircraft has a DC electrical generation and distribution system. It is fitted with two 6000-watt engine driven generators which charge two 24 volt, 25 ampere-hour batteries connected in parallel. The generators have a separate control panel in the avionics bay but no pilot-operated controls are fitted. A warning light for each generator, below the flight instruments panel, illuminates when its associated generator is not supplying power. Electrical services requiring 115 volt AC are supplied either by one of two rotary inverters (effectively a main and a standby) or by dedicated static inverters.

Normal electrical loads

One rotary inverter draws 7.5 amps and together the two booster pumps draw 35 amps; other services in use at the time require a minimum of 12 amps to which should be added the requirements of the radio, the transponder and the navigation aids. Consequently, until non-essential services are switched off, the load on the batteries is likely to be at least 60 amps.

Hunter Mk 6A fuel system

Fuel is carried in six internal tanks, one in each wing plus two front and two rear tanks in the centre fuselage. The tanks are of the flexible bag type. G-BVVC was also fitted with two 230 gallon capacity underwing tanks on the inboard pylons. The two rear tanks contain 411 lb fuel; the two front tanks contain 1,580 lb fuel and the two wing tanks contain 1,106 lb fuel giving an internal total of 3,097 lb. The 230 gallon underwing tanks increased the total fuel capacity to 6,731 lb.

Fuel is fed to the engine by a booster pump in each front tank. These electrically driven pumps charge fuel recuperators for negative g flight and feed the engine via a fuel proportioner through LP and HP cocks. In normal operation the booster pumps are switched on before engine start and remain on until after engine shut down. If both booster pumps fail, the negative g recuperators discharge and fuel balancing is impossible.

Fuel is transferred in the following order: from the rear tank to the front tank on the same side, then from the drop tank to the wing tank and from the wing tank to the front tank on the same side. Transfer is by air pressure from a tapping on the engine compressor and electrically motored valves control the changeover from rear to front tanks; this usually happens shortly after takeoff. The front tanks should be the last tanks to empty and each contains a float operated fuel level switch which illuminates an amber warning light when the tank contains less than about 650 lb fuel. These warning lights are mounted on the coaming to the left of the gunsight mounting point. Normally fuel transfer is entirely automatic but should the fuel transfer system malfunction, there are contents gauges, warning lights, 'dolls-eye' magnetic indicators and changeover switches that may be used to diagnose a fault and rectify fuel transfer. However, the two 650 lb warning lights are considered by experienced Hunter pilots to be the dominant indication of useable fuel status.

Accident site, impact parameters and wreckage recovery

The accident site was in an area of soft marsh animal grazing land that was bordered to the north by the Dyfi estuary. Because of its proximity to the sea the sub-surface water level at the accident site was tidal. The AAIB did not attend the accident site but from photographs taken by the operator's representative it could be assessed that the aircraft impacted the ground at high speed, in a nose down attitude of approximately 85° and yawed to the right by approximately 15°. Also from the photographs it could be seen that at the time of impact there was a substantial quantity of fuel onboard the aircraft. Using local contractors the operator recovered the wreckage. It was found during the initial phase of the recovery that the water table at high tide was 0.5 metres below the ground's surface and that as earth was removed, the wreckage sank further into the ground. Because of these ground conditions only the rear fuselage, empennage, wings and engine were recovered.

Wreckage examination

The wreckage was recovered to the operator's base at Exeter where the AAIB and a representative from the engine manufacturer carried out an examination. The examination revealed that very little of the aircraft and its systems forward of the engine's front casing had been recovered. The small amount of cockpit and aircraft system pieces recovered were severely broken-up and fragmented rendering them unidentifiable. None of the cockpit fuel system controls or indicators were recovered. None of the electrical fuel boost pumps, the fuel tank changeover valves, the negative g recuperators or the fuel proportioning valve were recovered. The engine core was intact but many of the accessories were missing including the accessory gearbox, the generators and the engine driven fuel pumps. Examination of the engine core indicated that there had been no pre-impact mechanical failure, fire or ingestion of a foreign object.

Fuel consumption

In G-BVVC's configuration, the climb from sea level near Portrush to FL220 feet would have consumed about 400 lb fuel and the aircraft would have travelled about 25 nm. In the cruise at FL220, the typical fuel consumption rate is 36 lb/min at an airspeed of 280 KIAS which equates to a TAS of approximately 380 kt.

Ejection seat

The aircraft type was fitted with a Type 2H or 3H ejection seat; the seats are similar in most respects and the following description applies to both types of seat. The ejection seat incorporates separate parachute and torso restraint harnesses, negative g restraint, leg restraint, emergency oxygen and a personal survival pack known as a PSP. This PSP fills the space within the seat-pan and forms the seat 'cushion' upon which the pilot sits. The ejection seat has an 80 ft/sec ejection gun but no rocket pack. When either firing handle is pulled the canopy is jettisoned by a pyrotechnic device; at the same time the trip lever of a time delay unit is operated. This unit withdraws the sear from the ejection gun after one second, firing the seat cartridge which ejects the seat. After ejection, at heights of 10,000 feet and below, a 'barostatic' time delay unit causes an automatic cycle to commence. After 1¼ seconds if the 'g stop' has not operated (a high speed safety feature which is unlikely to have operated at the speed of this ejection) the safety harness is automatically released by a cable running to the quick release fastener. The pilot is pulled free from the seat by a drogue parachute which then extracts the pilot's main parachute by means of a parachute withdrawal line. The seat itself is then unrestrained and free falls to the ground.

Ejection procedure

For a controlled ejection (ie an ejection with time to prepare and the aircraft still under control), the recommended speed is 250 KIAS and the pilot is advised to use the face-screen handle unless he has previously jettisoned the canopy, in which case he should use the seat-pan firing handle. In essence, the sequence between pulling either firing handle to being suspended below a fully deployed parachute should be fully automatic and, if the ejection is initiated at low to moderate speed below 10,000 feet, last no longer than about five seconds. However, should the automatic system malfunction, the pilot can pull a 'D ring' which disconnects the parachute from the parachute withdrawal line and also exposes the parachute rip cord 'D ring'. The pilot must then manually release the safety harness before pushing himself free of the seat and pulling the ripcord 'D ring' to deploy his parachute.

The Aircrew Manual contains a number of safety warnings in connection with the use of the ejection seat. Foremost amongst them are: *'The feet must be left on the rudder pedals when either firing handle is pulled; drawing the feet back may lead to injury' and 'If conditions necessitate using the seat-pan firing handle, it is essential to sit firmly in the seat and to press the head firmly against the headrest to minimise the risk of spinal injury on ejection'.*

Emergency drills

The pilot's flight reference cards were lost during the accident. However, the Aircrew Manual listed the actions required in the event of numerous malfunctions and emergencies and the flight reference cards were simply a précis of the text in the Manual that had been laid out in an itemised checklist format.

The Aircrew Manual states that if one generator fails, the other provides sufficient output for all electrical services provided engine RPM are kept above 4,000. The Manual listed three electrical services which should be switched off to limit the electrical load on the remaining generator but these were either not fitted to G-BVVC or not in use at the time.

Double generator failure is indicated by both generator warning lights illuminating and the inverter magnetic indicator ('dolls eye') changing from black to white, although the flight instruments continue to be powered by another inverter which draws power from the aircraft's batteries. The immediate actions are to switch off all non-essential electrics, including booster pumps, reduce to flight idling RPM and descend as for booster pump failure (if it occurs at high altitude), thereafter restricting RPM to a maximum of 7,200, and to trim load free. The subsequent actions are to *'land as soon as possible'*, select the turn and slip instrument electrical supply to emergency and ultimately to lower the landing gear and flaps using the emergency systems which are powered by compressed air from bottles discharged by cable operated controls.

When both generators fail, the normal electrical power demand is supplied by the batteries which, if fully charged, should supply power for between 20 and 30 minutes before exhaustion provided that non-essential electrical loads have been switched off. If not, the Aircrew Manual states *'with normal services running, the main batteries cannot be relied upon for more than about 10 minutes'. The consequences of depleting battery power are described as follows: 'Once the batteries are discharged, no electrical services can be operated, eg trim tab actuators, tailplane motors, electro-hydraulic selectors etc. In addition the fuel gauges and electrically operated flight instruments become inoperative. The fuel booster pumps cease operation which may entail reduction in altitude and RPM to ensure satisfactory engine running. No relight or fire extinguisher facilities are available when the batteries are fully discharged'.*

The implications of the booster pumps ceasing to operate are restrictions on altitude, engine RPM, fuel balancing and carefree engine handling. The absolute altitude limit with fuel in the drop tanks is 30,000 feet although the recommended maximum is 20,000 feet. Throttle movements should be kept to a minimum and engine RPM should be restricted to a maximum of 7,200. Negative g manoeuvres must be avoided, fuel balancing is impossible and the engine will not run when one 'side' is empty of fuel.

Analysis

Total electric failure

The aircraft had a recent history of electrical generation problems and the risk of double generator failure had been realised the day before but probably without completely exhausting battery power. For the accident flight, provided single generator failure was the only fault, the remaining generator should have been sufficient to supply all this aircraft's electrical needs and charge the batteries. Replacement batteries had been fitted before the flight and external power was available to support pre-start preparations so the aircraft should have had well-charged batteries and one functioning generator when it taxied.

The pilot did not notice the exact moment when the second generator failed in flight. Since the primary indication would have been an additional red warning light down near his knees, with no immediate loss of any electrical services, it is not surprising that he did not notice it immediately. At first, the only secondary indication of double generator failure would have been the changeover of a single 'dolls-eye' magnetic indicator from black to white. If at the time he was concentrating on instrument flying in cloud or carrying out his display beneath it, he was unlikely to notice that indication either. However, until he took action to shed non-essential electrical loads, particularly the booster pumps, the load on the batteries would have depleted them after about 10 minutes. The time to climb out to FL220 would have been about three to four minutes so the failure of the radios followed by some flight instruments during the climb suggests that the second generator failed during the display. Given the pressures, skills and concentration required to carry out a display, especially in restrictive weather conditions, it is not surprising that the pilot did not notice either warning until he had completed his display.

As the batteries discharged, any warning lights would have dimmed and once the batteries were depleted, there would have been no warning lights and no internal fuel gauging. It seems likely that battery power expired during the climb to high altitude or shortly afterwards so the load shedding carried out in the cruise would have had little beneficial effect.

Landing options

Once at altitude with few flight instruments, no internal fuel gauging, and no communications, the pilot was committed to landing at an airfield where good visual flight conditions prevailed, and preferably one that could be reached without penetrating controlled airspace. The extension of the Hunter's wing flaps creates a significant change in pitch trim so, depending on the tailplane position when the batteries expired, the inability to trim might mean that the pilot would be forced to land his aircraft 'flapless' and with no retardation from the electrically released brake parachute. Consequently, he would have needed at least 1,500 metres of hard surface to be confident of stopping on the runway. These constraints had to be set against the Aircrew Manual's advice to '*land as soon as possible'*. The aircraft was above cloud so the pilot's decision to continue in accordance with his flight plan towards central Wales, where the weather was much improved, was sensible. Photographs of the aircraft departing Blackpool showed that the weather there was fine and cloudless less than hour earlier so landing there might have been practicable. Also, since the pilot could see Lake Bala from FL180, a landing at nearby RAF Valley or at Llanbedr were potential options. However, the pilot decided that since he had plenty of fuel and the appropriate technical expertise to rectify the aircraft was at Exeter, he would continue at altitude and land there.

Engine flameout

The engine ran down at some time between throttling back to descend and advancing the throttle to level off at FL180. The immediate action of trying to relight the engine was bound to fail because there was no electricity to power the igniters. There were no mechanical failures evident within the engine which continued to 'windmill' and plenty of fuel on board the aircraft, so it seems highly probable that the flameout occurred through temporary fuel starvation.

Fuel starvation

With no booster pumps, fuel should still transfer from the front tanks to the engine through air pressure. The electrically motored fuel sequence valves would have been at the 'wing' transfer position when electrical power was lost so fuel from the drop tanks should still have transferred to the wing tanks and from them to the front tanks under the action of air pressure. There had been no reported problems with fuel transfer in recent flights and the pilot noticed that both drop tanks were about one third full over Wales (they have mechanical quantity indicators). Consequently, there is no reason to assume that the electrical failure was responsible for a fuel transfer failure. However, if fuel transfer from one or both 'side' groups of wing and drop tanks into the associated front tank stopped, the engine would have flamed out when one of the front tanks emptied. There would have been no amber light warning of low fuel contents in the front tank because of the total electrical failure.

Each front tank's capacity is 790 lb and it would have been supplying only half the engine's demand. If fuel transfer ceased when the electrical system failed, a maximum of 200 lb fuel from each tank would have been used in completing the climb and the remainder would have been consumed at about 18 lb per minute (half the engine consumption rate from each tank). This would have been sufficient for 32 minutes cruising at FL200. With a groundspeed of 380 kt (6.3nm/min), flameout through fuel exhaustion would not have happened until the aircraft was more than 200 nm from Portrush. The distance flown from Portrush to 15 nm east of Bala Lake was about 185 nm so this explanation for the flameout is plausible but unlikely.

Throttle handling

With no booster pump pressure and hence no recuperators, throttle handling must be gentle and maximum power is restricted because air pressure transfer alone cannot meet the engine's fuel requirements at full throttle, but the engine should still run if it is managed sensitively. Closing the throttle reduces the fuel demand so this action is probably less critical than opening the throttle which must be done slowly so that an uninterrupted fuel supply to the engine is maintained. The pilot stated that he opened the throttle slowly but this was the moment that he noticed the engine failed to respond. Consequently, throttle handling seems a likely explanation for the flameout but it may be that the engine was unusually sensitive to throttle advances under the prevailing conditions.

Forced landing

At a speed of 210 KIAS the Hunter glides about 2 nm for every 1,000 feet of height and when downwind, the pilot needs at least 2,500 feet height abeam the touchdown point in order to land near the runway threshold. The distance from a position 15 nm east of Bala Lake to Llanbedr is about 35 nm so from 18,000 feet the aircraft may have had just enough potential energy to reach Llanbedr, but probably not enough to land because the runway was aligned at right angles to the aircraft's approach track. Also, with fuel in the drop tanks the aircraft was still fairly heavy and the pilot opted to glide at 250 KIAS, thus reducing the aircraft's glide radio slightly but improving the chance of a relight, had there been any electrical power to achieve it, but there was none. For similar reasons, the drop tanks would probably not have separated if he had tried to jettison them because they are released by explosive ejector units initiated by an electrical pulse. An accumulation of these factors probably deprived the pilot of any realistic chance of reaching Llanbedr but it was well worth the attempt. When it was obvious to him that he could not achieve a forced landing, he sensibly and considerately decided to head for open water and eject, thereby minimising the risk to other people and property.

Ejection sequence

The pilot prepared for the ejection but chose to use the seat-pan handle rather than the face-screen handle. He may have done so instinctively because he was more familiar with seats that have just a seat-pan handle. Whether his injuries would have been less severe had he used the face-screen handle as recommended in the Aircrew Manual is impossible to determine but on this type of seat, a better ejection posture is achieved if the face-screen firing handle is used.

Unlike modern ejection seats which have rocket assistance, the range of ejection seats fitted to the Hunter had only the telescopic ejection gun with which to achieve ejection velocity. These seats are, therefore, of necessity somewhat harsher in operation than 'rocket seats'. The rate of acceleration has to be greater and so spinal injuries are more likely. Another factor which influences the probability of spinal injuries is the PSP upon which the pilot sits. The Mark 2H and 3H seats have a 'soft' PSP whereas modern seats generally have a more rigid fibreglass 'shell' covering and containing the pack which is contoured and forms the base of the seat. This rigid shell transfers the ejection impulse to the pilot's body more swiftly than the soft pack and so minimises the peak acceleration imparted into the pilot's spine.

The pilot saw his abandoned aircraft pitch up. This is not surprising given the likely change in centre of gravity position due to the lost weight of the seat and its pilot, and their relatively long moment arm from the centre of gravity. Moreover, the aircraft was out of trim in the nose-up sense when he ejected and so likely to behave erratically after he ejected for both reasons.

The ejection seat was recovered but not examined by the AAIB. It was, however, examined by a knowledgeable person. Apparently, all the automatic sequencing had operated and there were no obvious pre-impact defects. Pilot separation from the seat should have happened automatically but the most likely explanation for his retention was a stuck torso restraint harness. The pilot is attached to his parachute by one harness and held in the seat by a totally separate harness which should have been released by a cable connecting its fastener to the 'barostatic' time release unit. The unit must have operated to deploy the pilot's parachute so it is likely that the cable did not move the fastener sufficiently to release the harness. However, the pilot had only to operate the seat harness release mechanism with one hand in order to free himself from the seat.

The pilot's spinal injuries may have been aggravated by his heavy landing on the sandbank. Numerous people had seen him descending on his parachute and had reported the event to the emergency services, resulting in the scramble of the RAF rescue helicopter. Bystanders also made their way through the shallow water to assist the injured pilot. Had he descended into deep water or further out to sea, the outcome might have been different.

Conclusions

The accident was preceded by total electrical failure but caused by engine flameout. The engine probably flamed out because its fuel supply was delivered to the engine at abnormally low pressure and was temporarily interrupted when the throttle setting was changed. Without robust electrical power the engine could not be relit and the pilot was unable to reach a suitable airfield for a forced landing so he ejected. He received spinal injuries during the ejection and had to separate himself from the seat when the seat harness remained fastened after his parachute had inflated. His spinal injuries might have been less severe had he used the face-screen firing handle and not landed in very shallow water.

Recommendations

There were no formal safety recommendations arising from this accident but it does serve to remind operators of ex-military jet aircraft that safety is compromised if recurrent faults are allowed to persist. Moreover, pilots of such aircraft must bear in mind the likely consequences of accepting pre-take-off defects before undertaking a demanding flight.