S3/2002 - Sikorsky S76 (Modified), G-BJVX

AAIB Bulletin No:	**Ref: EW/C2002/07/04**	**Category: 2.2**
Aircraft Type and Registration:	Sikorsky S76A (Modified), G-BJVX	
Serial Number:	760100	
No & Type of Engines:	2 Turbomeca Arriel 1S turboshaft engines	
Year of Manufacture:	1980	
Date & Time (UTC):	16 July 2002 at 1944 hrs	
Location:	28 miles north-east of Cromer, Norfolk	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew -2	Passengers - 9
Injuries:	Crew -2 Fatal	Passengers - 8 Fatal, 1 Missing
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Airline Transport Pilots Licence	
Commander's Age:	42 years	
Commander's Flying Experience:	8,585 hours (of which more than 2300 were on type) Last 90 days - 135 hours Last 28 days - 35hours	
Information Source:	AAIB Inspectors Investigation	

History of the flight

The aircraft had been scheduled to complete five multi-sector flights from Norwich on the day of the accident. The first four flights were completed without incident and the aircraft departed Norwich Airport at 1731 hrs for the final scheduled flight, consisting of a series of sectors between installations in the 'Sole Pitt' and 'Leman' gas fields of the southern North Sea.

The first four sectors again went without incident and the aircraft departed on its penultimate planned sector between the gas production platform 'Clipper' and the drilling rig 'Global Santa Fe Monarch'. The purpose of this sector was to transfer one passenger between the two installations before returning the remaining eight passengers to Norwich.

The departure from the 'Clipper' was described as normal by the helideck crew and the aircraft climbed to 1,500 feet for the planned ten minute sector to the 'Global Santa Fe Monarch'. During the cruise, the crew spoke to Anglia Radar before establishing radio contact with the Monarch's radio operator. There was some confusion at first as the 'Monarch' had not been expecting any further flights that evening. However, the Monarch's helideck crew was quickly assembled and the aircraft commenced its approach.

With the aircraft at a height of about 320 feet on a south-easterly heading, workers on the drilling rig heard a loud bang. No witnesses were watching the aircraft at the time but some subsequently saw the aircraft dive steeply into the sea. One witness also described seeing the main rotor head with the blades attached falling into the sea after the remainder of the aircraft had impacted the surface.

Search and rescue

The alarm was raised by the radio operator on the 'Monarch' and the first response was from the rig standby vessel, 'Putford Achilles'. This vessel was holding station approximately 1.5 miles from the accident location and immediately launched its two fast rescue craft (FRC) to the observed area of wreckage. They arrived at the scene seven minutes after initial notification and recovered four bodies and some light debris. Shortly afterwards they were informed that there were 11 persons on board the aircraft and the search was continued resulting in the recovery of another body. Great Yarmouth Coastguard launched rescue helicopters and other vessels arrived on the scene that night but no survivors or further bodies were recovered from the surface search.

The floating wreckage indicated that the break-up of the helicopter was extensive and that the accident was not survivable. An underwater search for the six missing persons was commenced on 17 July. Five more bodies were recovered on 19 July. The underwater search for the one remaining body continued unabated but was eventually suspended on 23 July after the likely area had been thoroughly searched. A surface vessel search was maintained for two more days and an aerial search was continued until 30 July without success.

Wreckage location

Initial indications of the position of the helicopter's impact with the sea surface were misleading. On 18 July a combination of eye witness reports, sidescan sonar data from the vessel 'Geosearch', radar data from National Air Traffic Services and the signal from the Dukane sonar beacon fitted to the combined voice and flight data recorder were used to locate the debris field. It was first located by the vessel 'Kommandor Subsea's' remotely operated vehicle (ROV) on the morning of 19 July. The Diving Support Vessel 'Mayo' arrived on scene later that day and commenced the recovery of bodies and wreckage.

Wreckage recovery

Recovery operations were hampered by strong currents which constrained diving operations to periods of approximately three hours at each tide. More than 97% of the structure of the helicopter was recovered by divers working from the Diving Support Vessel 'Mayo'. The main debris field was approximately 300 metres long, 30 metres wide and some 40 metres below the sea surface.

During the evening of Saturday 20 July, the wreckage was transferred from the 'Mayo' to a smaller vessel and brought ashore at Great Yarmouth during the morning of Sunday 21 July. It was then transferred by road to the AAIB's facility near Aldershot, Hampshire where the vital components were examined by investigators from the AAIB, the National Transportation Safety Board (NTSB) of the USA, the Federal Aviation Administration (FAA) of the USA, the aircraft manufacturer and the operator.

Flight recorder information

G-BJVX was fitted with a combined voice and flight data recorder (CVFDR). An endless loop of Mylar tape was used to record five hours of data (in excess of 30 parameters) and one hour of audio (on three separate tracks). The CVFDR was retrieved from the sea bed and taken to the AAIB headquarters where the recording tape was removed from its crash protected enclosure. The tape was then cleaned, dried and the information thereon recovered.

The audio recordings revealed that the crew were not aware of any significant abnormality until the flight from the 'Clipper' platform to the 'Monarch' platform. About 4.5 minutes into this sector the crew discussed an increase in vibration. The non-handling pilot carried out a 'rotor track and balance' procedure. The increase in vibration did not cause the crew any immediate concern and the rotor track and balance procedure was carried out to enable the IHUMS (Integrated Health and Usage Monitoring System) to log main rotor track and balance data for subsequent analysis by the IHUMS ground station. Preliminary frequency spectrum analysis of the recorded audio information indicated an increase in the amplitude of frequencies associated with main rotor vibration towards the end of the recording. A more exhaustive analysis is in progress. The audio recording ends abruptly with three unusual, probably structure borne, sounds.

The recorded flight data did not show any anomalies during the five hour recording. The recording ends with data time histories showing the aircraft was in level flight at about 320 feet asl, travelling at a speed of 100 kt on a heading of 150° (M). The recorded data became corrupted about two seconds before the end of the recording. Work is continuing to decode the corrupted data and to analyse the recorded rotor track information to determine if any trends are evident from the time histories.

Wreckage analysis

Amongst the wreckage were two items of major significance. Firstly, three of the main rotor blades exhibited only superficial damage whereas the fourth was fractured at a position approximately 76.75 inches from the blade root. The missing outer blade section was not recovered from the main debris field. The second significant clue was the condition of the main rotor gearbox. The casing had fractured and there was visible evidence that the gearbox together with the rotor head had broken away from the fuselage mountings in flight.

The fractured blade was taken to QinetiQ's materials laboratories where the fracture surface was cleaned and prepared for microscopic analysis. Clear evidence of fatigue was present indicating that approximately half the circumference of the blade's titanium spar had failed in fatigue before the outer portion separated. Thus it was clear that the blade fracture had initiated the catastrophic event; the gearbox had separated from its fuselage mountings due to the severe imbalance created by the loss of the separated blade section.

Metallurgy

The metallurgical examination revealed two areas that contributed to the blade separation.

The fatigue initiation point of the blade's titanium spar was on the upper surface in the area of the inboard edge of the scarf joint between the two piece titanium leading edge erosion strip. Microscopic examination of the initiation point indicates that it had suffered intense thermal damage. The area has the appearance of and discolouration similar to an electrical 'spot weld'. There is no evidence of thermal damage to the surrounding composite materials, resins or paint.

During the metallurgical examination, evidence was found of an anomaly in the scarf joint between the two titanium leading edge erosion strips. The tip of the tang on the inboard end of the outboard erosion strip was bent and folded under the outboard end of the inboard erosion strip (Figure 1). This resulted in a doubling of the thickness of the erosion strip material in that area which in turn resulted in virtual contact between the erosion strip and the blade's titanium spar especially in the areas at either end of the tang's fold line. This anomaly had occurred during the blade's manufacturing process some 21 years prior to the accident.

The initiation point of the fatigue failure of the blade's spar was at the rear point of the tang's fold line.

Rotor blade history

This rotor blade was manufactured in March 1981. In 1999 when fitted to Sikorsky S76A G-BHBF it was damaged by a lightning strike (see AAIB Bulletin 3/2001). At that time the blade had accumulated 8,261 hours usage. The blade was returned to the manufacturer for assessment where, following inspection, it was repaired and returned to service. Neither the thermal damage to the spar nor the manufacturing anomaly were detected during this inspection. At the time of the accident, the blade had accumulated 9,661 hours usage. The airworthiness limitation life of the blade is 28,000 hours.

The AAIB and the helicopter's manufacturer are of the opinion that the electrical energy imparted by the lightning strike in 1999 exploited the anomaly that was built into the blade at manufacture and damaged the spar.

Safety action

On 24 July the aircraft manufacturer issued Alert Service Bulletin (ASB) 76-65-55. The purpose of this ASB was "To remove from service any main rotor blade identified as having been damaged by a lightning strike". A modified version of the ASB (76-65-55A) was issued the next day. The modifications related to the accomplishment instructions and did not alter the purpose of the original ASB. The modified ASB was subsequently mandated by Emergency Airworthiness Directive 2002--15-51 issued on 26 July by the Federal Aviation Administration.

Safety Recommendation No 2002-25

It has not yet been established whether the anomaly seen in the fractured blade went unnoticed or whether it was permitted by concession. If the anomaly was not detected during manufacture, there may be other blades where the anomaly is slightly different in nature and/or severity. The anomaly

now exposed on the fractured blade would have been hidden from view during routine in-service blade inspections. Conceivably there could be another damage mechanism such as abrasion or fretting between the titanium spar and the titanium erosion strip that might induce fatigue. Consequently, there may be other S-76 blades that have a similar hidden anomaly that may be relevant to the continued airworthiness of those blades. Therefore, on Friday 26th July it was recommended that:

The Federal Aviation Administration mandates appropriate action to ensure the continued airworthiness of Sikorsky S-76 main rotor blades which have either:

A two-piece leading edge titanium sheath (erosion strip).

or

Have suffered a lightning strike.

This safety recommendation was copied to the UK CAA.

Further Investigation

The Chief Inspector of Air Accidents has ordered an Inspector's Investigation into the circumstances of this accident under the provision of the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996.

Figure 1 Titanium leading edge erosion strip scarf joint (jpg 41kb)