products were ingested into the No2 engine oil cooler; this caused the rapid overheating and complete failure of the No2 engine reduction gearbox. The crew had experienced a loud bang which preceded the No1 engine failure and a fire developed, followed approximately 50 secs afterwards by the No2 engine failure. The subsequent investigation identified that the ac had suffered an uncontained FPT failure. The cause of this uncontained FPT incident on the No1 ECU was identified as an Oil Bobbin failure resulting in a Zone 59 Fire.

d. **Navy Lynx XZ255** (23 Apr 05). Lynx Mk3 XZ255 of 702 NAS was conducting a routine vibration check test flight when the Pilot heard a loud bang and the ac yawed to port. Exhibit 269 The Pilot observed that the No2 engine T6 was reading 800°C and FPT rpm (expressed as Nf) was running down through 50%. The engine was immediately shut down with the Fire Caption illuminated and audio warning sounding. Both the No1 and No2 engine bay extinguishers were fired into the No1 engine bay and the fire warning ceased. After reports by an accompanying ac of blackening of the fuselage aft of No2 engine exhaust, the ac landed in a field. Investigation showed that the No2 engine had suffered an uncontained failure of the 1st stage power turbine. The No2 ECU suffered from a Zone 59 fire as a result of the failure of the No9/No10 bearing oil feed bobbin. This resulted in the release of the 1st stage FPT blades.

1.4.32 The 4 previous incidents were similar to XZ210 in that they all involved an uncontained failure of the FPT assembly, either of the blades or the disc. The FPT overspeeds in XZ205 and XZ667 were deemed to have been due to a fault with the FCS and in the cases of XZ256 and XZ255, a Zone 59 fire from a mis-aligned oil feed bobbin. None of these causes had any relevance to XZ210.

1.4.33 **Yaw**. At the onset of accident sequence, the QHI and CM reported that the ac yawed approximately 10° before recovering heading. Witness 1 Witness 3 The catastrophic failure of the FPT drive arm would have resulted in an instant and complete loss of drive from the No2 engine. Annex G The Panel judged that the most likely explanation for the yaw was the ac torque reaction induced by the loss of the No2 engine.

1.4.34 **LP Fuel Pipe Damage**. Evidence in the No2 engine bay showed that when the 2nd stage FPT aerofoil sections exited the engine casing they impacted components in the vicinity with significant force. Annex G The No2 engine LP fuel supply pipe was severed midway along its rigid section directly in line with the FPT breakout cut, which led to fuel being pumped directly into the No2 engine bay.

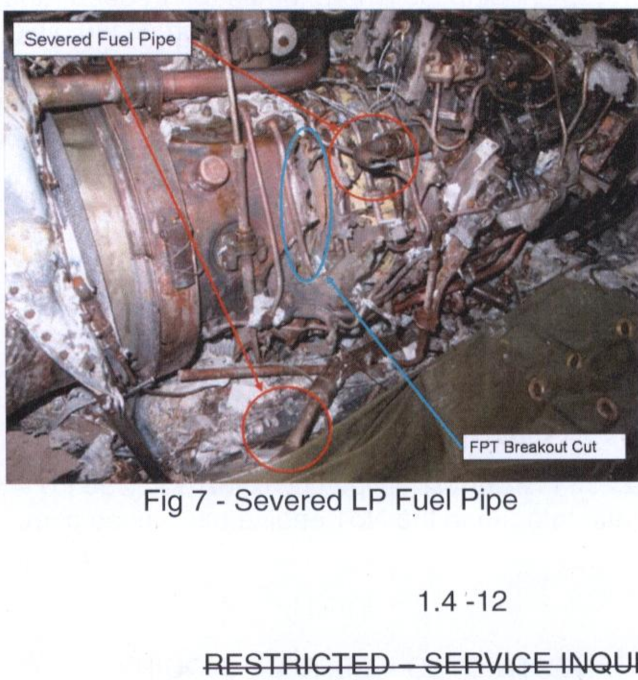

Fig 7 - Severed LP Fuel Pipe

1.4.35 The resultant effect of this fuel leak transformed the emergency in 2 ways:

a. **Smoke**. It was likely that the uncontained fuel from the severed pipe sprayed around the hot components and atomised. Engineering analysis concluded that the fuel would have mixed with the hot gases escaping from the Module 7 rupture (FPT inlet temperature was estimated to have been in the region of 400 to 450°C), causing the fuel to partially combust, thus generating large quantities of white/grey smoke. Annex G

b. **Fire**. Civilian witness evidence described the ac being on fire prior to landing; therefore, ignition was judged to have taken place at some point shortly after the FPT disintegration. The Panel considered three possible sources of ignition: Witness 13-19

a. Escaping gas stream heating the enclosed space of the engine bay.

b. 'Hot plate' ignition as fuel sprayed on to the hot surfaces of the Module 7.

c. Electrical spark from a damaged engine bay wiring loom.

The most likely of these was deemed to have been hot plate ignition due to the relatively large surface area presented by hot materials exacerbated by a heat soak rise in temperature on various FPT components as internal cooling gas flows suddenly stopped. This became a fuel fire fed by a continuous stream of fuel from the airframe fuel system via the ruptured pipe. The engine bay itself was not airtight but additional air was likely to have been introduced at this stage via holes which would have been made in the engine cowling by the FPT disintegration. The three elements of a fire were therefore present throughout; heat (ignition source), fuel and air. Annex G

1.4.36 The location of the LP Fuel Pipe in relation to the FPT was a function of ac design (**organisational influence**) which resulted in it being severed by the ejected aerofoil sections. The engineering investigation concluded that this transformed the whole nature of the emergency, which would otherwise have manifested itself as a single engine failure with hot gas leak. In the Panel's view, the crew would have been well placed to deal with an emergency of this nature based on their training and experience; however, the resultant fire and smoke significantly complicated the situation and ultimately led to the complete destruction of the ac. The Panel found that the severing of the No2 LP fuel pipe by the ejected aerofoil sections from the failed FPT which resulted in an engine fire/smoke was an **aggravating factor**. Annex G

1.4.37 **Other Lynx Accidents involving LP Fuel Pipe Damage**. The Panel considered other Lynx accidents which involved LP fuel pipe damage:

a. **Army Lynx XZ205** (14 Jul 82). In the XZ205 accident, the ac was evacuated due to fire around the engine and equipment bay. Once the uncontained detachment of the 2nd stage FPT blades occurred, the blades severed fuel lines and the fire resulted. The fire was extinguished within 4 mins and damage restricted to the engine and equipment bay. Exhibit 144

b. **Army Lynx XZ667** (10 Apr 94) In the XZ667 accident, the uncontained failure of the 2nd stage FPT (as a direct result of the FPT over-speed) breakout had cut through the main fuel pipe, which developed into a fire which eventually destroyed the ac. Exhibit 110

c. **Navy Lynx XZ256** (12 Jun 02). In the XZ256 accident, the overspeed lead to the 1st and 2nd stage blades being shed and the 1st stage FPT disc Exhibit 269 exited the engine. The release of the 1st stage FPT disc of the No1 ECU dislodged the LP fuel pipe from its location clip on the side of the engine case and resulted in the fracturing of the pipe at the FCU quick connect coupling. This caused a fuel leak and fire in the engine bay, which spread to the No2 engine causing it to fail and the ac to ditch.

1.4.38 The 3 previous accidents identified were similar to XZ210 in that they all experienced a fire after an FPT failure. The fires were all deemed to have resulted from damage to fuel supply lines. In XZ205 and XZ667, it was not known whether the damaged fuel line was the LP fuel pipe or the HP fuel pipe[4]. In XZ256, the fire was deemed to be as a result of damage to the LP fuel pipe; the subsequent inquiry was the only one to include any recommendation to alter the design of the LP fuel pipe.

1.4.39 **Smoke in the Cabin / Cockpit**. Within 5 secs of the start of this accident sequence, significant amounts of smoke started to enter the ac interior. The following timeline sets out the order of events: Exhibit 103

Time after Bang	Smoke Event
5 secs	CM observes large quantities of smoke entering cabin
11 secs (estimated)	Pilots lose all visual references
12 secs	QHI instructs crew to open windows and doors
17 secs (estimated)	CM opens cabin door
19 secs (estimated)	QHI regains sufficient visual references to avoid tree and make a safe landing

1.4.40 As a result of smoke in the cockpit, the Panel estimated that the pilots spent approximately 8 secs with no visual references. This meant that the pilots were not able to see the ac instrumentation at a crucial stage in the accident sequence which might have enabled them to diagnose the symptoms of the emergency and carry out the appropriate FRC drills. The Panel concluded that smoke in the cockpit had a significant effect on the crew's ability to deal with the engine failure and fire and was therefore an **aggravating factor**. Exhibit 103

1.4.41 **Smoke Routing into the Ac**. The CM reported that the smoke entered the cabin in the vicinity of the lower aft section of the starboard cabin door. The Panel considered the possible routes for smoke ingress: Witness 3

a. **Cabin Heating System**. At the rear of the cabin mounted on the floor against the aft bulkhead, were two cabin heating louvres which distributed a mix of engine air (from the HP compressor) and external air drawn in by an electrical fan. The external air intake was on the rear equipment bay fuselage skin on the left side of the ac. Early investigation focussed on whether the smoke had entered the ac interior from the engine bay via the cabin heating system. In order to explore this theory further, the XZ210 P3 tap off pipes, combining manifold and selector valve as a whole assembly was sent to 1710 NAS (MIG) for forensic examination. The investigation showed that the valve was closed, thus eliminating the ability for engine air, contaminated or otherwise, to enter the cabin heating system. Annex G

b. **Cold Air Intake**. The only other route directly into the cabin heating system was via the cabin fan inlet scoop mounted on the outside of the fuselage mid way up the left hand side of the equipment bay. For smoke to Annex G

[4] In XZ205 the fuel pipe damage is characterised as severed fuel lines and in XZ667 the damage is characterised as cut through the main fuel pipe.

enter this intake it would have had to have been drawn forward and around to the opposite side of the fuselage from the No2 engine at an ac speed of 120kts. This, coupled with the size and position of the intake, approximately 100 x 40mm, made it improbable that this was the route by which the significant quantities of smoke described entered the cabin. It is worthy of note that the Lynx was not commonly renowned for drawing its own engine exhaust fumes into the cabin or cockpit heating system, further supporting the implausibility of this scenario.

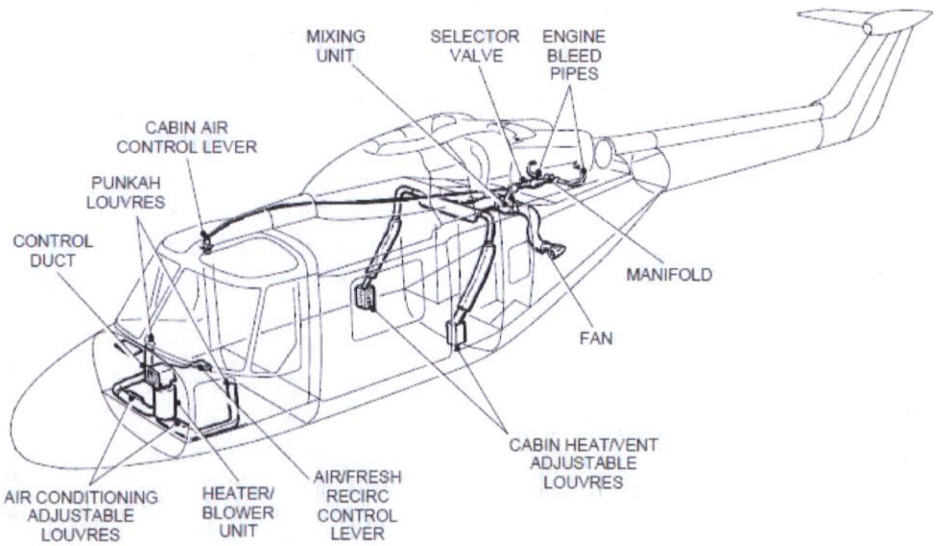

Fig 8 – Lynx Heating and Ventilation Systems

c. **Heating Duct**. The external air component of the heating system travelled along a wire coil re-enforced neoprene duct situated at the forward bulkhead of the equipment bay and was mixed with the engine air in the mixing unit. It was probable that smoke and burning fuel entered the equipment bay via the heatshield holes. Consideration was given to the duct material producing the smoke by smouldering or burning as a result of being in the vicinity of burning fuel or other material in the equipment bay. Annex G

d. **Gaps in Cabin Bulkhead**. There were two separate fuel tanks situated against the bulkhead between the cabin and the rear equipment bay. Between the 2 tanks was a void gap of about 300mm wide at the rear of which was the skin separating the cabin and equipment bay. There were several rows of relays mounted on plates or boards attached to the bulkhead. Also at the top was the heating trunk passing through the bulkhead from the mixer unit. These items were covered by an insulation system overlaid on the fuel tank surfaces and covering the void gap from floor to roof in the form of a quilted synthetic blanket attached to the ac structure at the top, bottom and sides by Velcro. This covering would have greatly slowed or even prevented a large inflow of smoke being carried into the cabin. Damage from the engine failure was restricted to a narrow area directly in line with the FPT discs. The rearwards position of the engines, in particular the plane of the FPT being approximately 1.5m aft of the cabin rear bulkhead, meant that it was highly improbable that shrapnel could have penetrated the cabin or cockpit areas thus presenting a potential route for smoke ingress. Annex G

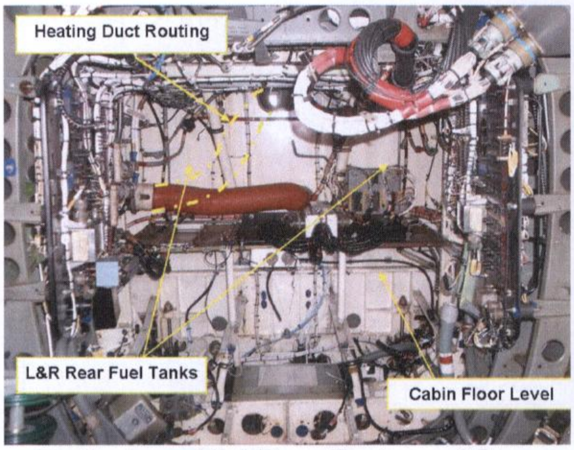

Fig 9 - Lynx Mk7 Rear Equipment Bay
(Avionics removed & heating duct disconnected)

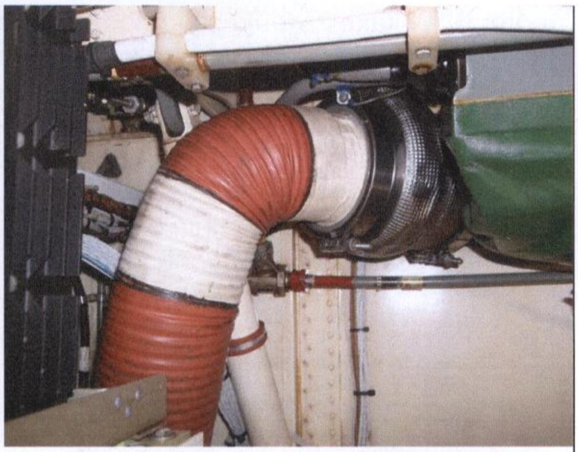

Fig 10 - Heating Duct Connected

e. **Gap in Cabin Door**. At the time of the accident, the crew estimated that the air speed was approximately 120kts with the ac in a slight descent. Although the cabin doors were shut at the time of the incident, the possibility that smoke entered via gaps between the doors and fuselage was considered. The rotor rotated in an anti-clockwise direction when viewed from the top and there was a possibility that rotor disc downdraught might have drawn smoke forward and down from its source even at this forward velocity. The cabin doors and associated fittings were destroyed by the ground fire; however, examination of a serviceable Lynx Mk7 showed that the aft edge and bottom of the left and right cabin doors have 12mm open gaps when shut, through which smoke could pass (see Fig 12). However, for this to happen the lower aft area of the cabin doors and therefore the ac fuselage would have to be surrounded by smoke and there would also have to be a negative pressure in the cabin. Annex G

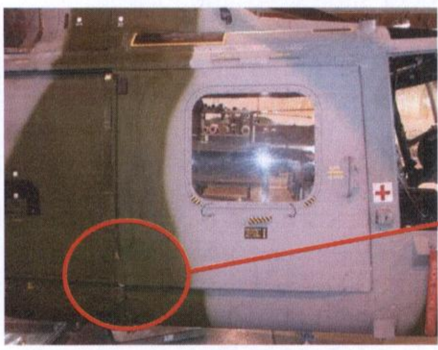

Fig 11 – Cabin Door

Fig 12 – Cabin Door Lower Edge

1.4.42 The technical investigation provided no conclusive evidence to determine which of these potential ingress routes the smoke had taken.

1.4.43 **Other Lynx Accidents involving Smoke in the Cockpit**. The Panel considered other Lynx accidents which involved similar large amounts of smoke ingressing the ac interior:

a. **Army Lynx XZ199** (18 May 99). On a transit between Dishforth and Odiham, after approx 50 mins into the flight, the crew noted that the No2 engine oil pressure gauge was 'flicking' between the GREEN/AMBER sectors. 5 mins later the No2 engine failed with a loud mechanical bang. The No2 engine was shut down, but a second bang was heard and the cabin immediately filled with black acrid smoke. The Handling Pilot lost all visual references and the ac cdr took control as he was able to get his head Exhibit 111 partially out of the window. The cause of the smoke was deemed to be as a result of a bolt ejected from the front of Module 1 on failure (first loud bang) and ignited (second bang) finely atomised hydraulic fluid, which was escaping from an hydraulic leak in the area under the main gearbox, and filled the cabin/cockpit with black acrid smoke. The ac was destroyed and only the ac cdr survived.

b. **Navy Lynx XZ256** (12 Jun 02). The sole survivor stated that some smoke was observed in the cabin soon after the bang occurred; however, there was no evidence to suggest that the level of smoke restricted the Pilot's visual references. The ac was at 400ft flying at 120kts when the FPT failed and despite using both fire bottles in the No1 engine bay the fire could not be extinguished. Exhibit 269

c. **Army Lynx XZ216** (20 Apr 09). During reversionary circuits at night, the crew of Lynx ac XZ216 observed smoke in the cockpit and trailing behind the ac during a downwind left turn, although there were no signs of fire. The crew elected to return to base, and as the ac came in to land, the smoke plume from the engine got worse and engulfed the ac just prior to touchdown. Examination of the engine at ERS identified that two 1st stage FPT blades had lost material from the shroud, subsequent investigation revealed the blades had failed due to creep following a significant over-temperature that had most likely occurred during an engine start. Increased out of balance forces from the loss of material from the 1st stage FPT blades resulted in the application of high vibratory forces to the main structural members supporting the FPT shaft and a loss of locking torque on the retention bolts securing the No11 Bearing Retainer. This resulted in a loss of sealing at the front of the No11 Bearing chamber and entrainment of the oil in the LP compressor sealing air supply, which subsequently burned in the gas path, producing the smoke witnessed. This smoke then either became entrained in the ambient air being drawn by the cabin air conditioning system or was blown into the ac via the open cabin windows or doors. The smoke which entered the cockpit during this incident was considered to have been due to recirculation from the engine exhaust entering through the open window and/or side door as the oil loss into the gas path occurred downstream of the cabin air off-take from the engine. Exhibit 268

1.4.44 Although the origin of the smoke differed in the cases of XZ199 and XZ216, the fact that the smoke was able to enter the ac cockpit/cabin area was similar to XZ210. The common feature was the lack of definitive explanation for the routing of the smoke into the cockpit. The fact remained that significant quantities of smoke entered the Lynx cabin and cockpit area very quickly and put the crews at an increased risk during an emergency situation. The Panel made the **observation** that, in spite of a number of accidents having been aggravated by smoke in the cockpit, the mechanism of smoke ingressing the Lynx ac interior was not understood fully.

1.4.45 **XZ210 Crew Actions to Ventilate Ac**. 12 secs after the initial bang the QHI instructed the crew to open windows and doors: Exhibit 103

a. **RHS Window**. Images taken of the ac after landing showed that the RHS cockpit window had been opened at some point. Although not part of his original statement, the QHI later recalled that after calling for the windows and doors to be opened, he swapped hands on the cyclic in order to open the RHS cockpit window and then re-adjusted his hands to take control as normal. This action apparently had little effect on the smoke filling the cockpit as the QHI reported that his visual references did not improve with the window open. Exhibit 227

Military Aviation Authority
MAA

b. **LHS Window**. The LHS Pilot recalled locating the port window latch but was unable to open the window. Despite his lack of success, he reported that he persisted in this activity. He made some association between this experience and the Helicopter Underwater Escape Trainer, a qualification for which he had required extensive remedial training in order to pass. The Panel considered that while this past experience may have added to the stress it was not necessarily the determining factor in his inability to open the cockpit window. It was judged that his relative inexperience, limited flying time in the LHS (routinely occupied by the ac cdr) and infrequent operation of the port cockpit window meant that he had not developed the required motor actions to operate the window instinctively. In addition, it was likely that the lack of references and extreme stress of the situation further exacerbated the issue. A typical response in a life-threatening scenario when the individual is highly stressed is to get stuck in a 'cognitive loop'. This is where the subject repeatedly executes the same motor outputs regardless of repeated failure. During this process the individual has limited capacity to think, decide or execute any other course of action and as a result, the behaviour is unconditionally repeated. Unfortunately, frustration exacerbates this process by increasing focus and limiting capacity even further. Witness 2 Exhibit 098 Annex A

c. **Cabin Door**. CVR audio evidence of the door being opened in flight was not conclusive; however, the Panel estimated that the door was probably opened approximately 12 secs after the CM first noticed smoke in the cabin area. The CM reported that once the door was open the smoke in the cabin and cockpit cleared within 2-3 secs. The Panel judged that this event was critical in terms of the eventual outcome as it enabled the QHI to avoid the tree and then effect a controlled landing. Exhibit 103 Witness 3

1.4.46 The CM opened the door just in time to clear the smoke from the cockpit sufficiently for the QHI to see the tree. The Panel considered whether the time taken to open the door once smoke entered the cabin area might have been reduced. At the start of the accident sequence, the CM was sitting in the middle seat of the starboard fore-aft bench. Having informed the pilots of smoke ingress, the CM then turned his attention to the cockpit area in an attempt to understand what might be happening; he recalled losing sight of the 2 pilots almost immediately. Faced with an emergency situation, the CM reported that his first instinct, based on his training, had been to ensure the door was shut, sit down and to strap into his seat. The Panel judged that his subsequent decision not to strap in was prompted, at least in part, by the QHI calling for windows and doors to be opened. From the middle seat, the CM reported not being able to reach the cabin door handle and so had to reposition forward to the front seat immediately behind the RHS Pilot; additionally, he reported that his actions were also the result of his desire to move away from the smoke. Although unable to see the door handle, he was able to locate and operate it by feel once he had repositioned to the forwardmost cabin seat, immediately behind the QHI. Witness 3

1.4.47 **Lynx FRC Drill – Smoke in Cabin/Cockpit**. The only reference to smoke in the Lynx FRCs was in the cockpit/cabin fire drill, where it listed opening the cabin doors (if possible) as a subsequent action[5]. In the Panel's view, this placed insufficient emphasis on the need to ventilate the cockpit area as soon as possible in order to minimise the risk that the pilots might lose visual references or suffer other detrimental physiological effects of smoke, limiting their ability to fly the ac and carry out diagnosis or remedial action. The Panel made the **observation** that opening the cabin door was Exhibit 275

[5] Actions which are taken to consolidate the situation once immediate danger to the ac has passed; FRCs must be consulted.

not listed in the Lynx AH Mk7 FRCs as an immediate action in the event of smoke in the ac cabin/cockpit.

1.4.48 **CM's Role in Clearing Smoke**. In the Panel's view, the presence of a CM in the cabin was a decisive factor in determining the survivability of this accident. While JHC direction set out a minimum Lynx crew of 2, local flying orders for 1 Regt AAC stated that: Exhibit 276 Exhibit 100

> *"Crews are to comprise, in role, an aircraft commander, a pilot and a rear crewman. Crewman may be omitted from the crew only where sub-unit commanders deem it appropriate."*

The Panel made the **observation** that this formal guidance on the requirement to man the ac cabin whenever possible had enhanced safety and was entirely appropriate. The Panel also noted that there was similar direction in the 9 Regt AAC Standing Orders. Exhibit 239

1.4.49 The Panel concluded that the CM's instinctive response, based on his training and influenced by Lynx FRC content (**organisational influences**), would not have been to open the door immediately and that this resulted in a slight delay before the smoke in the cockpit was cleared. While the action was taken sufficiently quickly for the QHI to effect a safe landing on this occasion, the Panel made the **observation** in other circumstances, even a small delay may impact on the outcome of another accident.

1.4.50 **Other Systems Damage**. It was clear that the high energy release of the 2nd stage FPT aerofoil sections produced shrapnel[6] which radiated outwards in all directions precisely in line with the position of the 2nd stage FPT disc. In so doing, they impacted anything in their narrow path, but may also have been deflected from their trajectory by more solid components. Examination of the remains of the wreckage showed that the aerofoil sections did significant but localised damage. Fortunately none of the shrapnel penetrated the engine bay heatshielding where it formed a tunnel between the No1 and No2 engines through which the tail rotor drive shaft passed. It was also important to note that none of the aerofoil sections entered the cabin and cockpit and the location and trajectory of the shrapnel did not present a direct risk to the crew. Annex G

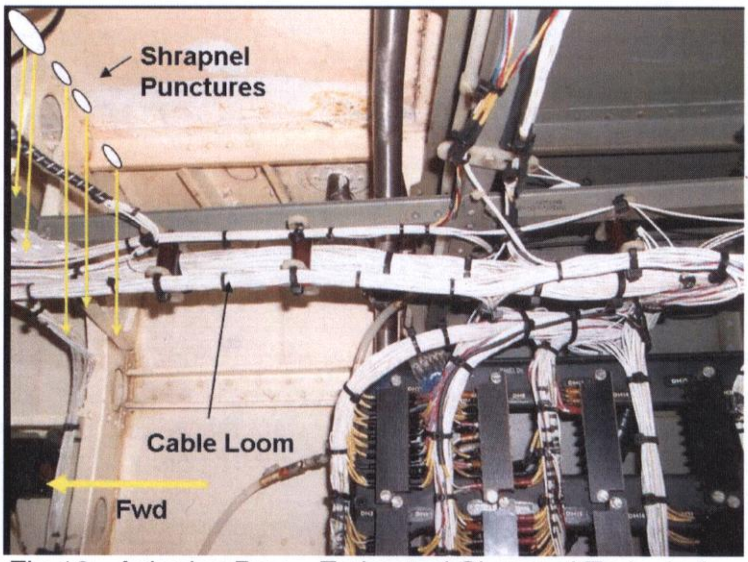

Fig 13 - Avionics Bay – Estimated Shrapnel Trajectories

[6] Shrapnel in this case and throughout this report is being used to describe high energy fragments of the FPT aerofoil sections and shrouds. It also describes material which may have broken off or been ejected as a result of being impacted by the FPT aerofoil sections or shrouds thus becoming secondary shrapnel.

1.4.51 In line with the FPT breakout hole on the engine bay floor there were a number of holes and splits in the heat-shield material. Directly beneath these holes, in the equipment bay, was a substantial wiring loom which ran longitudinally between fuselage frames, consisting of 25 wires which were the supply, return and earth cables for a number of engine and airframe sub-systems. Annex G

1.4.52 The engineering investigation concluded that the aerofoil sections may have caused disruption to this wiring loom. Although the fire damage was too great to establish which wires were damaged, AW conducted an analysis specifically considering the severing of some or all of the wires in this loom to understand the effect of losing one or more of these cables. In summary the potential losses fell into 2 categories: Annex G

a. **Failure without Indication**. Those systems which did not indicate a problem until the crew try to use the system, such as the anti-collision lights or the accessory drive actuator.

b. **Failure with indication**. Those systems which indicated to the pilot that something was at fault either by instrument needles or indicators decaying to zero or system status lights extinguishing. Examples in this category were the loss of the No2 engine torque indication or the loss of AFCS lanes. These failures are shown in the table below:

Exhibit 186

Electrical Systems contained within Upper Starboard Looms in the Rear Avionics Bay		
System	**Consequence**	**Caption/Indication**
Automatic Flight Control System (Lane 2)	Loss of Lane 2 AFCS	"AFCS" CWP Caption And Master Caution Pitch, Roll & Yaw Lane 2 lights extinguish on AFCS Controller
AFCS Computer Lane 2	Loss of Lane 2 AFCS	"AFCS" CWP Caption And Master Caution Pitch, Roll & Yaw Lane 2 lights extinguish on AFCS Controller
Lateral, Fore and Aft and Tail Servo Control Units Lane 2	Loss of Lane 2 AFCS	"AFCS" CWP Caption And Master Caution Pitch, Roll & Yaw Lane 2 lights extinguish on AFCS Controller
Computer Acceleration Control Unit Lane 2	Loss of Lane 2 Coll	Coll light extinguishes on AFCS controller
No2 Vertical Gyro and Co-Pilot Attitude Indicator	Loss of AC Supply	"OFF" Flag on Co-Pilot AI Pitch & Roll Lane 2 lights extinguish on AFCS Controller
No2 Engine Torque	Loss of DC Supply & Earth Return for Electronic Unit	Loss of Engine 2 Displayed Torque on both Torque Indicators
No2 Engine Oil Pressure	Loss of Transducer Earth Return	Incorrect Oil Pressure Indication
No2 DC Generation Voltage Regulator	Loss of Earth Return for Voltage Regulator & Loss of No2 DC Gen	"DC GEN" CWP Caption and Master Caution which will extinguish when the DC Supply is removed from DHNo2 and DHNo20 (see below)
DC Generation 2 Indication	Loss of DC Supply to Essential Bus Mag. Ind.	Cross Hatch displayed on MI – non powered state
DC Bus 2 Indication	Loss of DC Supply to General Bus Mag. Ind.	Cross Hatch displayed on MI – non powered state

1.4.53 In the absence of Flight Data Recorder (FDR) data or crew statements regarding actual failure indications in the cockpit, it was not possible to determine which systems, if any, had been damaged by the FPT burst. The fact that the ac responded to pilot control input indicated that the damage was not enough to compromise the inherent structural integrity and fly-ability of the ac. For similar reasons it was unlikely that shrapnel damaged or impinged on any of the vital flying control or transmission components. Annex G

1.4.54 **CWP indications /Audio warning**. None of the crew recalled specifically which CWP captions had been activated, but the 2 pilots[7] heard the Master Caution Audio Warning and the LHS Pilot cancelled the 'attention getter'. The consensus was that some red captions had been activated, predominantly in the top right section of the CWP. Witness 1 Witness 2

Fig 14 - Lynx Mk7 CWP Indications

1.4.55 The Panel considered the potential CWP caption indications that might have arisen following the mechanical failure based on the evidence from the engineering investigation: Exhibit 262

a. **FIRE**. The red FIRE caption would illuminate when the temperature in either engine bay reached a critical temperature as detected by the firewire loop; this could be caused by a hot gas leak or fire in the engine bay. The FIRE caption would activate the Master Caution audio and illuminate the respective fire button and ECL warning light. In this case, it was likely that the caption was activated immediately after the 2^{nd} stage FPT blade burst which allowed hot gas to escape. There was also the possibility that mechanical damage to the firewire from the FPT blade burst could have resulted in the activation of the caption. In addition, civilian witnesses on the ground reported having seen the ac on fire whilst airborne, which would have activated the caption. Based on the statement by the LHS Pilot, the No1 engine FIRE warning system (ECL fire button indication) also activated at some point during the accident sequence; the Panel judged that this occurred once the heat from the failed engine spread to the No1 engine bay. As the fire in the No2 engine had already illuminated the single FIRE caption, the subsequent activation of the No1 engine fire detection system would not have re-activated the Master Caution audio. Annex G Witness 13-19 Witness 2 Exhibit 264

b. **ENG 2 OIL PRESS**. The red ENG 2 OIL PRESS caption would activate when engine oil pressure fell to the level where the pressure gauge pointer moved into the red sector. In this case, the evidence suggested that damage to the oil scavenge system in the form of holes in the scavenge bowls associated with the No 9, No 10 and No 11 bearings resulted from the FPT burst damage; additionally, various oil supply and return pipes were dented and ruptured. It was therefore judged highly likely that oil pressure would have immediately dropped sufficiently to put the gauge into the red "danger zone", illuminating the CWP caption and activating the audio attention getter.[8] Annex G

c. **DC GEN**. The amber DC GEN caption would illuminate when the generator output fell below approximately 25 volts (off line) or if a busbar coupling contactor or battery contactor was de-energised. It would also

[7] On the Lynx AH Mk7, the CM intercom box does not relay CWP or rad alt audio attention getter.
[8] In the XZ667 (10 Apr 1994) accident, the Eng 1 Oil Pressure caption illuminated immediately after the loud explosion associated with the FPT failure.

have illuminated after the failure of No2 engine. In this case, it was possible that damage to the associated wire in the upper starboard loom within the avionics bay (as described in para 1.4.52 above) resulted in the activation of the caption. The No1 engine would have continued to drive the No1 DC starter/generator thereby maintaining the DC supply to the ac.

d. **FUEL PRESS**. The amber FUEL PRESS caption would illuminate when the pressure switches on the LP manifold indicated that the pressure in the system was less than 0.14 bar, which could be due to booster pump failure or fuel leak. In this case, the caption would have activated when the LP fuel pipe was cut by the 2nd stage FPT burst.

e. **CABIN HOT**. The amber CABIN HOT caption would activate when the temperature in the cabin air mixing unit was above 100°C, it may be caused by the fan failing to switch on automatically when HOT was selected in the cockpit. In this case, there was potential for the temperature sensor downstream of the mixing unit to have been activated due to fire within the avionics bay where the unit was located.

f. **AFCS**. An amber AFCS caption could indicate a variety of failures within the AFCS system. In this case, it was possible that the caption illuminated when damage occurred to the associated wire in the upper starboard loom within the avionics bay as described in para 1.4.52 above.

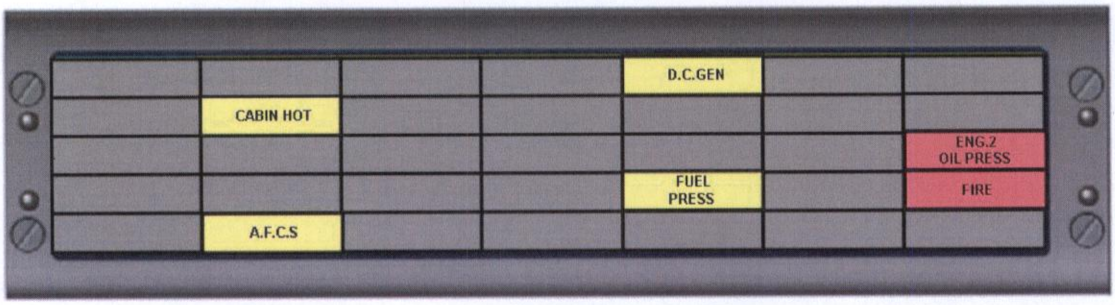

Fig 15 - XZ210 - Possible XZ210 CWP Caption Indications

1.4.56 There was no evidence to suggest that any other captions would have illuminated. While the lack of FDR removed the possibility of definitive conclusions regarding sequencing, the Panel judged that the red FIRE and ENG 2 OIL PRESS captions were likely to have activated almost immediately, triggering the Master Caution audio attention getter. The Panel found that the lack of CWP/rad alt audio warning to the CM intercom box was detrimental to the crew member's situational awareness and was an **other factor**.

Annex G

1.4.57 **FDR**. Following inquiries into the Lynx Mk8 XZ256 (HMS RICHMOND) and Lynx Mk7 XZ199 accidents, safety recommendations for the embodiment of FDR were made. Originally it was intended that this requirement would be met by the Lynx upgrade programme through the installation of a Health & Usage Monitoring System (HUMS), which would include CVR & FDR capabilities. The Lynx was one of a number of RW platforms included in plans for the embodiment of a Generic HUMS (GHUMS); however, this programme was cancelled in 2004. Following the cancellation of the GHUMS programme, the Lynx PT continued to pursue the development of a bespoke HUMS for Lynx ac. The introduction of a combined CVR/FDR was considered as part of PR07 under Option E07AL08SE; however, the requirement to fit FDR was cancelled subsequently as a PR08 savings measure. A 'do minimum' option was then pursued to fit a crash survivable CVR in order to meet the minimum requirements set out by the Civil Aviation Authority.

Exhibit 214