

1.4.202 The Panel considered potential reasons for the Crew Chief failing to act upon the 1710 NAS (MIG) recommendation to place XZ210's No2 engine on a reduced sampling regime. A number of human factors were identified concerning the Crew Chief that may have influenced his on-task performance and, specifically, his performance in monitoring the engine sampling:

Annex A

- a. **Workload.** It was acknowledged by the Wksp Management that the Crew Chief role was busy and demanding. As a result the Crew Chief reported that this workload affected his physical and mental wellbeing (sleeping patterns, ability to unwind after work and missed meals).
- b. **Distraction.** As a result of the high workload, the Crew Chief would often perform extra duties to maintain suitable levels of supervision on the line and in the Wksp.
- c. **Pressure.** The majority of pressure perceived by the Crew Chief was felt to be self-induced pressure to perform.
- d. **Performance.** As a result of foregoing issues, the Crew Chief felt under significant levels of stress; however, he reported this rarely resulted in on-task errors, although it often resulted in limited remaining capacity and longer task times.
- e. **Experience.** The Crew Chief, a Sgt, had been placed into a role which was established as a SSgt post. Although the Crew Chief was familiar with the Lynx, his most recent experience prior to being posted into 1 Regt AAC Wksp REME had been with the Apache, which did not require engine EFD sampling.
- f. **Expectation.** The Crew Chief reported that he had only received approximately 2 unsatisfactory EFD results in the 5 months preceding the accident. Due to this infrequent exposure to unsatisfactory sampling, the Crew Chief may have developed an expectation of satisfactory results.

1.4.203 The Panel concluded that the combination of the preceding issues resulted in an environment which impacted on the Crew Chief's ability to carry out his responsibilities as the focal point for the management of on-ac engineering tasks (EPC).

1.4.204 Notwithstanding the fact that the Crew Chief should have ensured that the whole EFD e-mail had been read, the Panel found that the format used by MIG, listing unsatisfactory results last, was an **organisational influence** which contributed to the breakdown of the process. The Panel made the **observation** that the conversion of EFD signal messages to email format may have played a part in important information being missed; however, the failure of the Wksp Crew Chief to open the email and/or scroll down the message to ensure that all the information had been viewed was found to have been an error by omission in the form of a **lapse**.

1.4.205 **Consequences of the Failure to Instigate Reduced Sampling.** It was considered possible that the elevated level of heat being generated by the micro-movement of the No10 bearing sealing flange was enough to reduce the efficiency of the lubricating oil and cause a slightly higher wear rate in the bearing but not enough to prevent the bearing from working correctly. This would have produced the small amounts of debris (M50 bearing material) detected by 1710 NAS (MIG). In the event of 3 successive abnormal EFD sample checks done under a reduced sampling regime, which displayed worsening characteristics, 1710 NAS (MIG) procedure would normally have been to reject the associated engine.

Annex G

Exhibit 177

1.4.206 In the latter stages of the failure sequence the heat generation was so enormous that lubrication and oil flow into the No10 bearing was prevented, thus the larger material produced as the No10 bearing was destroyed was not carried onto the No4 MDP (hence no worsening of the debris discovered and the remarkably clean condition of the No4 MDP after the accident). It was therefore concluded that the M50 detected during the routine sampling prior to the accident resulted from increased wear rate of the No10 bearing due to heat generated in the early stages of the silvaloy seal rub and that this would not have produced enough debris for 1710 NAS (MIG) to recommend immediate engine rejection.

1.4.207 **Summary of Findings (1 Regt AAC Wksp REME EFD Process Issues).** The Panel investigated the EFD process within 1 Regt AAC Wksp REME to ascertain why certain advice that 1710 NAS (MIG) had sent to the Wksp did not get actioned for XZ210. The Panel found 4 areas of concern:

- a. **Undue delay in the dispatch of samples.** On occasion, there was a significant delay between samples being taken and receipt by 1710 NAS (MIG) which was contrary to the direction in MAP 01 Chp 11.4. This was a **breached defence**.
- b. **Mishandling of signal traffic within 1 Regt AAC.** The system for handling EFD signal traffic was undermined by the lack of a formal process and associated training for those involved. There was little evidence of being able to trace and/or close the loop for the 'sample and result' traffic. This was an **organisational influence**.
- c. **Monitoring of EFD Samples/Results.** The failure to keep a record of EFD analysis signals was a **lapse** by Eng Con which hindered the ability to trace relevant EFD information.
- d. **Failure to Apply 1710 NAS (MIG) Advice to XZ210.** The format of the signals used by MIG was an **organisational influence** which contributed to the breakdown of the process. The failure of the Crew Chief to open the email and/or scroll down the message to ensure that all the information had been viewed was found to have been an error by omission in the form of a **lapse**.

1.4.208 The Panel concluded that the failure to action signals advising a reduced EFD sampling for XZ210 did not affect the outcome of this accident, as the subsequent failure mode of the No2 engine was such that the EFD sampling regime would not have identified the potential failure; however, the EFD process (**organisational influence**) within the Wksp was judged to have been flawed and had the potential to influence another accident, and was therefore deemed to have been an **other factor**.

Other EFD Issues

1.4.209 **Wire Brush Bristle Contamination.** In signal 2 of Fig 37 – XZ210 EFD Signal Traffic, it was noted that a small fragment of stainless steel wire was evident on MDP 5. The debris was "*not considered critical*" at the time; however, the post crash engineering investigation noted the presence of more small fragments of stainless steel wire within the ECU A63169 oil system. These fragments of wire were identified as broken bristles from small wire 'toothbrushes' (Fig 41) used for removing carbon deposits in engines during engine overhaul at ERS. In addition, the RR and 1710 NAS MIG investigation also discovered that this brush material was detected in other engines shortly after overhaul on the test bed and in service.



Fig 41 – Wire Brush

1.4.210 Whilst the investigation of ECU A63169 continued, there were concerns that serious damage resulting from interaction with foreign bodies such as wire fragments could not be discounted. Therefore an urgent safety recommendation was made to reduce the sampling to 5-hourly on any engine that was found to have such debris within the Gem ECU oil system and the Gem EA were to investigate where and how these wire brushes were used during Gem ECU overhaul and reassess their suitability for continued use.

1.4.211 Further research led to the conclusion that although the presence of brush wire was highly undesirable within the ECU oil system, its presence was coincidental and not related to the engine failure. Additionally, the PT addressed the usage of the wire brushes at ERS and RR. This resulted in the withdrawal of the recommendation to apply a 5-hourly MDP inspection regime if brush wire particles had been found, reverting back to normal sampling routines using the EFD safeguards already in place.

1.4.212 The presence of the wire bristle fragments was not considered a factor in the failure of the Module 7 in this case; however, the presence of any debris in the oil lubrication system of the ECU was undesirable and so the Panel found that the use of the wire brushes in the maintenance facilities was an **other factor**.

1.4.213 **REME EFD Training.** The training for EFD, which took place at Arborfield, covered how to take samples and the responsibilities of the supervisor in the process. Although actual methodology and practice of EFD sampling were satisfactory, the Panel made the **observation** that the most up-to-date EFD reporting and recording methods (as recommended in the MAP01 with respect to the WDMS) were not being taught as best practice. However, it was noted that the training was in the process of being updated to include the use of the WDMS as the default method of sample recording.

SUMMARY OF FINDINGS

Cause

1.4.214 The Panel found that the loosening of the retaining bolts on the No10 bearing flange which resulted in the failure of the FPT drive arm and subsequent FPT overspeed was the causal factor in this accident. (1.4.28)

Contributory Factors

1.4.215 The Panel did not identify any factors that made the accident more likely to happen.

Aggravating Factors

1.4.216 The Panel identified 5 factors that made the outcome of the accident worse:

- a. The severing of the No2 LP fuel pipe by the ejected aerofoil sections from the failed FPT which resulted in an engine fire/smoke. (1.4.36)
- b. Smoke in the cockpit had a significant effect on the crew's ability to deal with the engine failure and fire. (1.4.40)
- c. The CM not being strapped into his seat prior to landing meant that he was thrown forward sustaining an injury. (1.4.86)
- d. The Lynx was not fitted with energy attenuating cockpit seats which may have exacerbated injuries to the LHS Pilot. (1.4.88)
- e. Mod 0908 moved the location of the LP fuel pipe, but was not embodied. If the modification had been fitted to the starboard side of XZ210, the FPT failure would not have severed the LP fuel pipe and the emergency would, in all probability, have been confined to a single engine failure with a hot gas leak. (1.4.148)

Other Factors

1.4.217 The Panel identified 16 factors which were not direct factors in this accident but could cause, contribute to, or aggravate a future accident:

- a. Lack of QHI egress drill currency might have influenced the outcome of events, particularly with less experienced aircrew. (1.4.17)
- b. The lack of CWP/rad alt audio warning to the CM intercom box was detrimental to the crew member's situational awareness. (1.4.56)
- c. The decision not to carry out shutdown drills before egress. (1.4.77)
- d. The Lynx was not fitted with energy attenuating cabin seats which increased the potential for injury to the CM in the event of a heavy landing. (1.4.88)
- e. Lack of formal training on the Mk60 ACLP influenced the CM's ability to operate the emergency release mechanism. (1.4.100)
- f. The strop length would have allowed the CM to be thrown to a position where there was potential to be trapped beneath the ac in the event of rollover following an uncontrolled landing. (1.4.104)

- g. There was potential for the karabiner connecting the two strops to snag on an open seat harness which had the potential to hinder egress in an emergency. (1.4.108)
- h. When the Lynx strop assembly was adjusted to the shortest length, there was no single-thickness webbing accessible to enable the use of the Mk1 Aircrew Cutter in order to conduct an emergency cut-away. (1.4.109)
- i. The inhibition of inertia crash switch (Mod 0821) functionality may have affected the survivability for the aircrew had they been incapacitated. (1.4.152)
- j. Resultant symptoms of under manning within 1 Regt AAC Wksp REME had the potential to influence another accident. (1.4.162)
- k. 1 Regt AAC Wksp REME management were trying to maintain output but with manpower and experience limitations. The lack of suitably qualified and experienced personnel in key positions had an impact on workload and management effectiveness. (1.4.166)
- l. On occasions, there was a significant delay between EFD samples being taken at 1 Regt AAC Wksp REME and receipt by 1710 NAS (MIG) which was contrary to the direction in MAP 01 Chp 11.4. (1.4.192)
- m. The system for handling EFD signal traffic was undermined by the lack of a formal process and associated training for those involved. (1.4.196)
- n. There was no closed loop process relating to the dispatch and receipt of EFD samples and results within the 1 Regt AAC Wksp REME to enable supervisors to track progress. (1.4.200)
- o. The EFD process within 1 Regt AAC Wksp REME was judged to have been flawed and had the potential to influence another accident. (1.4.208)
- p. The use of wire brushes in the maintenance facilities introduced wire bristle fragments in the oil lubrication system of the ECU. (1.4.212)

Observations

1.4.218 The Panel made 28 observations:

- a. There was no staff check of log books on completion of the Lynx RTT Course to confirm that individuals had maintained / achieved the non-timetabled currencies by the end of the course. (1.4.15)
- b. Other JHC units used the STARS system to help record and monitor aircrew currency. (1.4.16)
- c. There was no formal egress drill syllabus for the Army Lynx. (1.4.18).
- d. 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. (1.4.44).
- e. Opening the cabin door was not listed in the Lynx AH Mk7 FRCs as an immediate action in the event of smoke in the ac cabin/cockpit. (1.4.47)
- f. Formal guidance on the requirement to man the ac cabin whenever possible had enhanced safety and was entirely appropriate. (1.4.48)
- g. Any delay in opening the cabin door may impact on the outcome of another accident where smoke in the cabin/cockpit was influential. (1.4.49)
- h. The absence of an FDR limited the Panel's ability to understand the full detail of the accident events relating to XZ210. (1.4.58)
- i. Simulated smoke in the cockpit emergencies were rarely, if ever, practised, either in the air or in the simulator. (1.4.65)
- j. Army Lynx crews did not routinely practice forced landing shutdown checks in either the simulator or 'live' ac, as described in RA2350. (1.4.76)
- k. The dual nature of the ECL start button, probably misled the LHS Pilot into believing that he had operated the No1 Fire Extinguisher. (1.4.80)
- l. If the CM had been secured in a cabin seat, there was a high probability that he would still have been able to operate the cabin door and then to tighten the straps before landing, thus avoiding the **(S40)** (1.4.89)
- m. The cabin floor attachment points were not specifically mentioned for use as a dispatch harness anchor point in the Ac Documentation Set. (1.4.105)
- n. Yoke mounted harnesses were in common use by CM in other JHC helicopters (Merlin Mk3/3A, Chinook and Puma), but all used roof mounted attachment points; the Lynx Mk7 RTS listed a suitable roof mounted anchor point above the port cabin door, but its use was not taught as part of the CM's course. (1.4.105)
- o. Guidance in the Safety Case relating to the Mk60 ACLP yoke mounted harness lacked coherence with the supporting Integration Report, regarding its suitability for use with floor attachment points. (1.4.107)
- p. The assessment of the LP fuel pipe modifications as a survivability improvement as opposed to a flight safety consideration contributed to the lower prioritisation given for embodiment. (1.4.129)
- q. The XZ210 accident occurred 9 ½ years after the HMS RICHMOND accident and 6 ½ years after the decision to re-route the LP fuel pipe. (1.4.129)

- r. The safety recommendation related to the LP fuel pipe issue arising from the XZ256 (HMS Richmond) Inquiry had not been transferred during a change in the RN PAAFU Log in Nov 06; this meant that there was no independent monitoring of progress of the modification embodiment programme. (1.4.138)
- s. The omission in Lx GM 638 of any direction to amend the associated technical documentation resulted in the LP fuel pipe modification not being carried out as part of the engine change process on XZ210 in Sep 11. (1.4.146)
- t. The over-burdening of Class 1 technicians to provide OJT for Class 3 technicians had exceeded what the unit establishment was meant to support. (1.4.164)
- u. Although 1 Regt AAC Wksp REME correctly identified, managed and highlighted the manning risk, there was some misunderstanding regarding its management by the Operating Authority which allowed the risk to endure. (1.4.177)
- v. Each service had a different procedure for recording EFD samples and results in the MF737. (1.4.184)
- w. Differing approaches to EFD process by the 3 services continued to endure due to the lack of a single joint EFD policy; other than cultural legacy there was no obvious reason why such differences existed. (1.4.185)
- x. The absence of any requirement to acknowledge EFD advice meant that 1710 NAS (MIG) were unaware whether recipients actually heeded their recommendations. (1.4.185)
- y. 1710 NAS (MIG) incorrectly assumed that all bearings were replaced automatically as part of the Gem Module 7 reconditioning process, when in fact the decision was condition-based. (1.4.189)
- z. Failure to keep a record of EFD analysis signals by Eng Con hindered the ability to trace relevant EFD information. (1.4.200)
- aa. The conversion of EFD signal messages to email format may have played a part in important information being missed. (1.4.204)
- bb. The most up-to-date EFD reporting and recording methods were not being taught as best practice at the REME training facility at Arborfield. (1.4.213)

Summary of Factors (Observations not included).



