PART 1.4 – ANALYSIS OF FACTORS & FINDINGS

Environmental conditions

Post-incident aspects

Organisational influences

Summary of findings

Introduction

1.4.1 The XZ936 Service Inquiry (SI) was convened on 10 Jun 14 to investigate the circumstances surrounding the incident involving a QinetiQ owned Gazelle HT3 at MoD Boscombe Down and to make recommendations in order to enhance Defence air safety. Whilst the main focus for the Panel centred on the Human Factors (HF) aspects of the incident, the Panel's Terms of Reference (ToRs) directed a broader investigation to include organisational influences.

1.4.2 The Panel had access to a wealth of physical and data evidence to examine which included the aircraft itself, the Accident Data Recorder (ADR), a Cockpit Voice Recorder (CVR) and Flight Test Instrumentation (FTI). In addition, the Panel had access to QinetiQ resources (independent of the investigation) that included the use of experienced Flight Test Engineers and ADR/CVR specialists.

1.4.3 Due to the nature and chronology of the incident, the Panel commenced the investigation with technical incident analysis before progressing on to the associated HF elements. This has led to the same subject areas being covered in multiple sections but analysed for differing and specific purposes.

Fig 1: XZ936 – MoD Boscombe Down Rwy 23 (Grass)

Methodology

1.4.4 **Incident Factors**

a. Once an incident factor had been determined it was then assigned to one of the following categories:

(1) **Cause**. The factor which led directly to the incident.

(2) **Contributory Factor**. A factor which made the incident more likely.

(3) **Aggravating Factor**. A factor which made the outcome worse.

(4) **Other Factor**. A factor which was none of the above but was noteworthy in that it may cause or contribute to future accidents.

1.4.5 **Observations**. An issue that was not relevant to the incident but worthy of consideration to promote better working practices.

1.4.6 **Available evidence**

a. The Panel had access to the following evidence:

(1) Interviews with the crew of XZ936.

(2) Formal statements from witnesses.

(3) ATC transcripts/audio.

(4) ADR/ CVR / FTI data of the sortie.

(5) Photography from various sources.

(6) Relevant orders, ToRs and documentation including flying logbooks, aircraft documentation, briefing materials and engineering documentation.

(7) XZ936 aircraft at the crash site/ hangar.

(8) Aircraft Technical Report by the Military Air Accident Investigation Branch (MilAAIB).

(9) Technical Report by 1710 Naval Air Squadron (NAS).

(10) HF Report provided by RAF Centre for Aviation Medicine (RAF CAM).

(11) All flight safety related material, including previous accident reports, ASIMS/E-Cassandra.

1.4.7 **Services**

a. The Panel was assisted by personnel from the following agencies:

(1) MilAAIB

(2) RAF Centre of Aviation Medicine (RAF CAM)

(3) 1710 NAS

(4) Joint Aircraft Recovery and Transportation Squadron (JARTS)

(5) QinetiQ

(6) MoD Boscombe Down

1.4.8 **Aspects considered by the Panel**

1.4.9 The Panel conducted the SI with a comprehensive set of ToRs (Part 1.2) and considered the following broad areas:

a. Determining the cause

b. Crew Resource Management

c. Crew preparation

d. Environmental conditions

e. Post-incident

f. Organisation

Determining the cause

Data available

1.4.10 XZ936 was fitted with Flight Test Instrumentation (FTI) to assist Empire Test Pilots' School (ETPS) test pilots and flight test engineers during routine post-flight analysis in addition to an ADR and CVR. This provided the Panel with large quantities of data covering a wide range of parameters from the incident sortie. However, the Panel was aware that even though the data available was superior to what would normally be available post-incident, it would not in itself answer all the questions or be able, for example, to determine what, or who, was making a particular control input (e.g. the origin of cyclic input be that left hand seat (LHS) or right hand seat (RHS)). During the initial 'coarse cut' analysis it became apparent that the flight period of interest was relatively short, starting from the 'check' phase of the final Engine Off Landing (EOL) to the blades striking the tail; a period of just under 10 seconds. Exhibit 20 Annex C

1.4.11 The FTI provided a far larger number of parameters than the ADR at a higher sampling rate (50hz compared to a typical 4hz (dependant on the parameter)). The CVR was a single channel recording from the two pilots' microphones. Unlike more modern CVR and ADR systems, there was no Annex C Exhibit 21 synchronising time signal or 'stamp' on the audio to align it with the ADR/FTI data streams, thus the data sets were time-aligned manually by QinetiQ ADR technicians. The alignment error between the merged data has been minimised and is likely less than 0.5 seconds. When reviewed in parallel the alignment appeared a good fit, reinforcing the Panel's confidence in it. Exhibit22

Recommended Engine Off Landing (EOL) technique

1.4.12 90 Kt, 200 ft Low Level Variable Flare (LLVF) EOL (Fig 2) consists of a flare to reduce speed to around 65 kts, whilst entering autorotation, then a further 'flare' at around 150 - 100 ft to reduce rate of descent (RoD) and forward speed, a 'check' to reduce RoD and forward speed further, followed by the levelling ('level') of the aircraft. An application of collective pitch is then used to 'cushion' through the landing. Once on the ground and when the aircraft has come to a stop, the collective can be lowered gently.

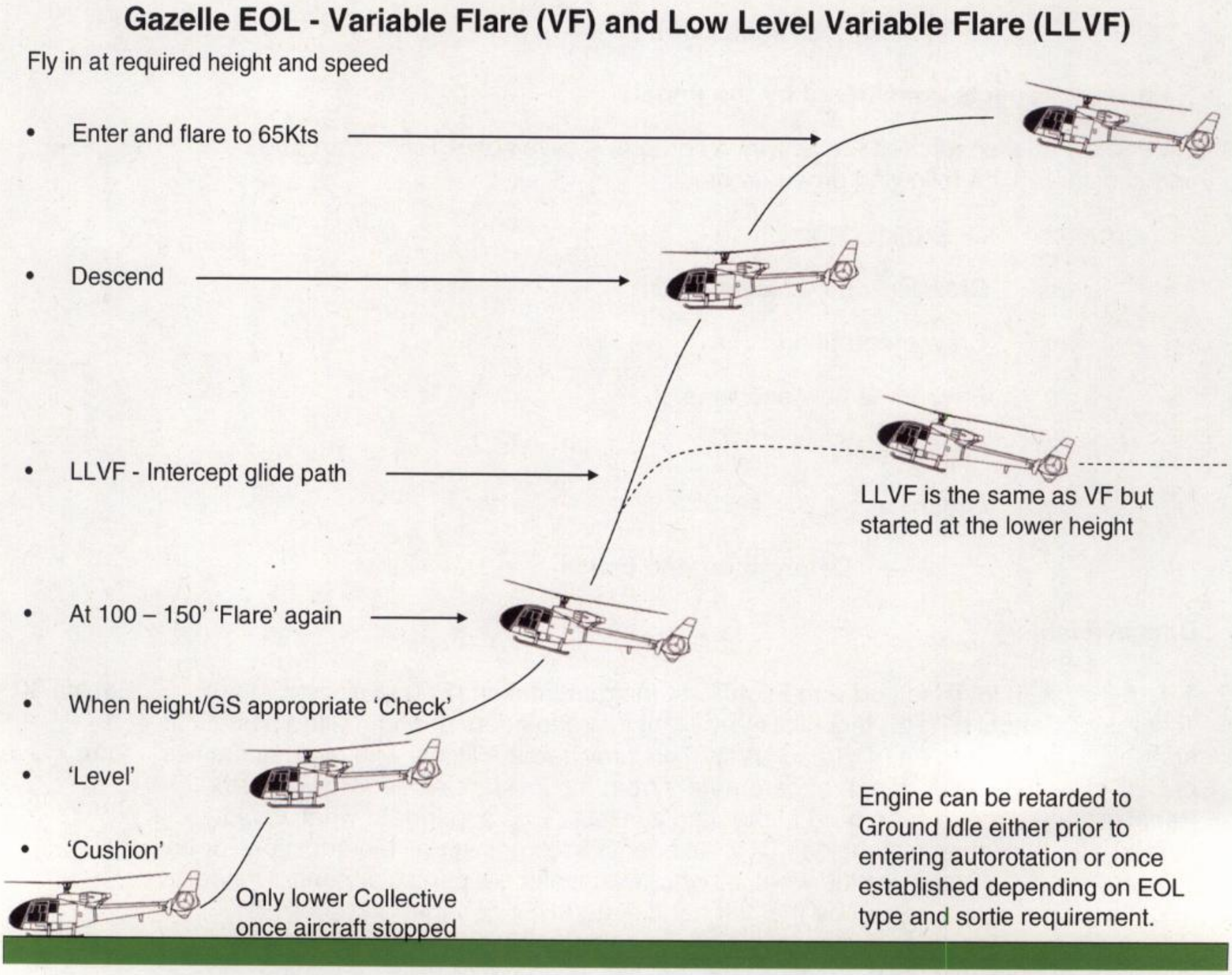

Fig 2 – Gazelle EOL VF and LL VF Profiles

Flare / Check / Level

1.4.13 The Panel compared the FTI data from the incident EOL with the previous successful and correctly flown EOL by the RHS pilot. It was only at the 'check' phase that significant differences became evident. On the incident EOL, the 'check' was applied higher. The greater height at the 'check' resulted in the aircraft being in a relatively low energy position from which very careful management was required of the remainder of the manoeuvre. Both crew stated they were cognisant of this and, although not ideal, the manoeuvre could, from this point, be brought to a successful conclusion. The crew had, individually, been in the same situation several times before and, furthermore, it is a well known student error which instructors are taught to prevent or resolve.

Annex C
Witness 1
Witness 2
Exhibit 10

Cushion to land

1.4.14 From this low energy situation, the crew were aware that they should not be tempted to raise the collective any further until the aircraft was nearer the ground as doing so would bleed energy from the rotor disc too early. The RHS pilot stated that he covered the collective in case the LHS pilot attempted to do so in response to any ground rush. However, the trace showed that the collective was 'bled in' from this point, before the rate of application increased to 'cushion', with full travel reached just prior to the aircraft touching the ground. With no remaining collective to further 'cushion' the landing the aircraft touched down firmly. As the high 'check' position required very careful management of the remainder of the manoeuvre and led to both pilots interacting with the controls the Panel concluded that the high 'check' was a **Contributory Factor**.

Witness 1
Witness 2
Annex C

1.4.15 The crew stated that they were both raising the collective in the final stages but they had differing recollections to the extent of the range used. The Panel considered whether the use of full collective travel prior to reaching the ground was contributory but assessed that the normal 'g' deceleration on touchdown was within the bounds of what could reasonably be expected during a successful EOL. EOLs with high 'g' touchdowns often crease the underside of the transportation joint or leave other evidence of a heavy landing, none of which was present on XZ936 post-incident.

Witness 1
Witness 2
Annex A

1.4.16 Full collective travel was reached fractionally before the aircraft touched the ground. Approximately 3 seconds later the Main Rotor Blades (MRBs) began to impact the tail section. The Panel conducted further analysis on the cause of the blade impacts.

Annex C

Blade impact with the tail

1.4.17 **Main Rotor Head (MRH) design**. The Gazelle has an articulated rotor head with three blades that are marked individually Red, Yellow and Blue for identification during maintenance activities. The blades are relatively flexible in the flapping plane and it is a consequence of the Gazelle's design that it is possible for blades to interact with the tail section of the aircraft in certain dynamic conditions (Fig 3). Examples include:

Exhibit 23
Exhibit 24

> (1) During start-up or shutdown when low rotor speed (Nr) means the blades have the ability to sail, usually due to extremes of wind or gusts.

Exhibit 25

(2) During EOLs where both conditions of low Nr and control positioning can lower the blade tip path, regardless of wind. Exhibit 26

The Panel found a further 7 recorded instances of the tail section being struck by MRBs during Gazelle EOLs since 1978. The Panel consider the design of the Gazelle, which allows possible interaction between the MRBs and tail, to be a **Contributory Factor**. Exhibit 26 Exhibit 27 Exhibit 28

Fig 3 – MRB ability to strike tail

1.4.18 **Impact event**. Analysis of the FTI and CVR from the final EOL indicated that 3 seconds after touchdown the tail was struck by the MRBs. This corresponded with a sudden drop in Nr and an abnormal sound on the CVR indicating the first in a series of five blade strikes. There were no further such sounds evident on the recording after the 5th strike. The first recorded impact was of relatively low audible amplitude; the magnitude and sound of the next three were larger than the first, whilst the 5th was the most severe. The time interval between the first four impacts was similar but there was a larger interval between the fourth and fifth. Analysis of the timings in conjunction with the Nr reveals that there were likely four consecutive blade passes that struck the tail, then two successive blades passed over without contact, before one of the blades struck the tail again. Further timing analysis of the audio of the five blade strikes shows that the tail was struck three times by one blade and only once each by the other two. Annex C Exhibit 14 Exhibit 22

1.4.19 **Physical damage**. The left lateral stabilizer was almost completely destroyed and could not be reconstructed from the debris. The right lateral Annex A stabilizer was found in several pieces that, when reconstructed, showed multiple marks suggesting progressively lower blade strikes (Fig 4). The lateral stabilizers sit higher than the main section of the tail boom and could therefore be struck in isolation by blades that do not fly low enough to strike the main tail section. These are a comparatively soft part of the aircraft structure that, whilst likely to make a sound when struck, are unlikely to significantly damage a blade. As the blades progressed lower, they were more likely to come into contact with rigid parts of the aircraft's structure such as the Tail Rotor Drive Shaft. On inspection of the MRBs, it was found that two of the blades had suffered only superficial damage with some paint scuffing and impact marks on the blade tips whilst the Red MRB had sustained far more significant damage. The two rigid hydraulic lines that run the length of the top surface of the Gazelle tail, one pressure and one return, were completely severed by the blade strikes during the incident sequence. The tail rotor control cables were also severed meaning no physical control linkage remained between the fenestron and the pedals. Exhibit 33

1.4.20 **Blade impact conclusion**. The Panel concluded that the Red MRB was the first to strike the tail followed by the other two blades. The Red MRB then struck the tail again sustaining damage which caused a change from its demanded flight path. This led to the blade striking the tail for the third and final time, lower, severing it from the fuselage. Exhibit 22 Annex A

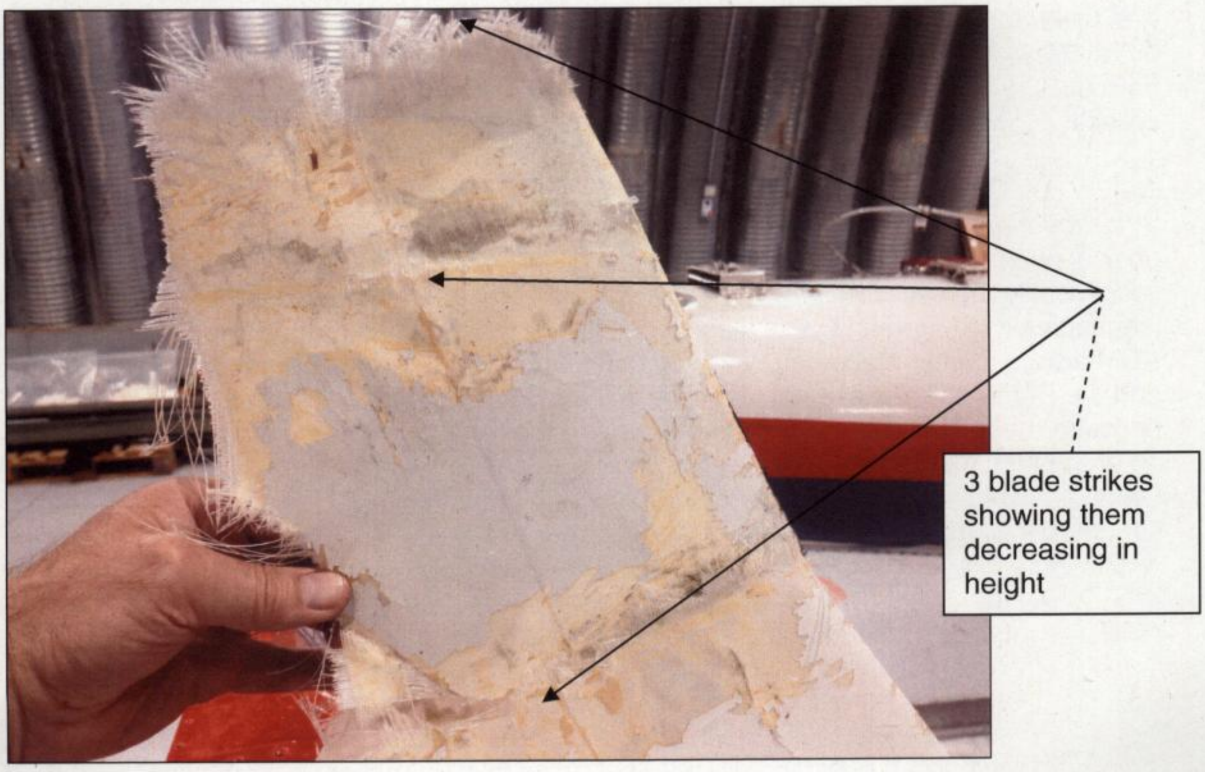

Fig 4 - Blade interaction with Lateral Stabilizer

Control positions

1.4.21 **Blade flight path**. The Panel looked to ascertain why the blades would fly so low to the tail as to impact it, looking initially at the flying control positions at the time of first impact as shown by the FTI. At the sudden drop in Nr the cyclic was against its aft stop, having been in that position for 1.76 seconds. Annex C

The cyclic was also displaced to the left which, in these conditions, would be expected to cause the tip plane path to be at its lowest position on the left side of the aircraft. In essence each blade would still be descending as it passed the tail. The collective lever reached the fully lowered position some 0.05 seconds before the drop in Nr; a blade would have been passing across the tail every 0.12 seconds.

1.4.22 **Collective position**. The collective lever changes the pitch angle of all MRBs by the same amount at the same time (i.e. collectively). The Aircrew Manual (ACM) gives advice on the use of the collective during the ground phase of an EOL: *'…if necessary control the length of the landing run progressively lowering the collective lever. Do not lower the lever fully until the aircraft has stopped and, then lower it gently to avoid stress to the airframe* ***and the risk of the blades striking the tail'***. AP3456 describes the touchdown technique for EOLs: '*At touchdown [Nr] will be low and coning angle high and therefore the lever should be* ***lowered smoothly so as to avoid the blades flexing and flapping down excessively***.' At touchdown the Nr was low (241 rpm[1]) and continued to reduce. During the incident manoeuvre the collective was initially lowered in small stages over 2.5 seconds from 101.9% to 75.4%. The rate of movement then changes from the relatively high position (75.4%) all the way to the minimum (0%) in approximately 0.5 seconds; a very fast rate, in excess of 135%/sec. In comparison, during the LHS pilot's previous EOL, the collective was lowered from 75% to 0% averaging 62.5%/sec, with a peak rate from 32% to 0% at 75.3%/sec. In the RHS pilot's previous EOL the collective was lowered from 66% to 0% at 98%/sec. The Panel concluded that the rate and scale of collective lowering during the landing phase was a **Contributory Factor**.

Exhibit 29
Exhibit 24
Exhibit 30
Annex C

1.4.23 **Cyclic position**. In regard to the aft cyclic demand, the ACM states '*After touchdown maintain the cyclic stick position…*'. Whilst there is no exact position with which this corresponds across all EOLs, if the manoeuvre is flown successfully the cyclic is likely to be in approximately the mid position both longitudinally and laterally; this was its position in the previous manoeuvre. The ACM advice implies that aircrew are to avoid large cyclic inputs post-touchdown and the Panel noted that a full aft cyclic selection would reduce the separation between the MRBs and the tail-boom by tilting the rotor disc aft. During the run-on of the final manoeuvre there were two excursions to the fully aft position, the second of which was maintained to the point of blade strike, and the Panel sought to investigate the reason these occurred.

Exhibit 24
Annex C
Exhibit 24
Exhibit 29
Annex C

a. The cyclic started its first movement to the aft stop shortly after touchdown when the aircraft had a high rate of pitch down motion. This motion was due to the aircraft arriving at the ground approximately 4 degrees above the skids level attitude, causing the skid heels to touch down first. It is plausible that the cyclic achieved its fully aft position as a result of an instinctive response by the LHS pilot to arrest this pitch down moment. This is supported by the fact that the cyclic stick moved forward shortly **after** the aircraft began to pitch up having achieved its maximum nose down. These control inputs appear to have been an attempt to counter the pitch oscillations. The Panel assessed the aircraft attitude on touchdown to be a **Contributory Factor**.

Annex C
Annex B
Annex C

[1] Power-off Nr limits 310-430 rpm.

b. The second aft cyclic movement did not share these characteristics. Here the cyclic began its movement to the aft stop very shortly **before** the nose of the aircraft had achieved its highest point. Whilst this could have been in anticipation of the nose dropping again and thus a continuing effort to dampen the oscillations, the cyclic was maintained fully aft whilst the aircraft completed further oscillations, albeit those of a reducing magnitude. This aft control input did not appear to be a response to the aircraft attitude. Annex C Annex B

c. During the same timeframe, the cyclic also migrated to the left. This combination of fully aft and left cyclic is an unusual and uncomfortable position for a pilot to hold in a Gazelle. The LHS pilot's recollections of this phase of the landing were that, on contact with the ground, the cyclic began to move significantly through almost the full envelope, and that the cyclic was moving his hand and not the other way around. He recalls his first impression being that the RHS pilot was moving the controls and verbalises the same on the CVR just after the incident. He stated that he was aware that the RHS pilot was following him through from earlier in the manoeuvre. Believing these to be RHS pilot inputs, the LHS pilot made no attempt to resist the cyclic movement. The RHS pilot, whilst recollecting his input to the collective lever during the cushion to land, had no recollection of the position of his right hand in relation to the cyclic during the incident. The Panel assessed that the aft cyclic position was a **Contributory Factor** irrespective of what caused it. Witness 1 Exhibit 14 Witness 1 Witness 2

1.4.24 **Combination of cyclic and collective inputs**. Whilst the collective and cyclic inputs individually made the incident more likely, the Panel concluded that the rapid lowering of the collective in *combination* with the aft cyclic positioning post-touchdown, resulted in the Main Rotor Blades striking the tail and therefore was the **cause** of the incident. Annex C Annex A

1.4.25 **Recommendation: Joint Helicopter Command and Air Warfare Centre DDH Gazelle should re-emphasise to all Gazelle crews the potential for Main Rotor Blade interaction with the tail and the importance of the related advice on the conduct of EOLs found in the Gazelle Aircrew Manual.**

1.4.26 **Recommendation: OC Handling Squadron should incorporate an explicit warning in the Gazelle Aircrew Manual that combinations of low Nr, low collective pitch and aft cyclic must be avoided as they present a high risk of a Main Rotor Blade strike on the tail.**

Other possible sources of cyclic input

1.4.27 **Investigation**. The Panel investigated other possible sources of cyclic input prior to the blade strike. They were as follows:

a. Trim system malfunction.

b. Stability Augmentation System (SAS) malfunction.

c. Hydraulic failure.

d. Pitch Control Rod (PCR) failure.

e. RHS pilot interaction with the controls.

1.4.28 **Trim system**. The Gazelle HT3 has a 'stick feel' that provides a Exhibit 31
spring force about a neutral datum that can itself be moved by operating the 'trim release' button on the cyclic. 'Stick Feel' was found selected to the 'on' position after the incident (Fig 5). Unlike the 'beeper trim' systems found on other aircraft, the system cannot be motored to a new trim position. As a result it does not have the ability to 'run away' so the Panel discounted trim runaway as a factor. When the cyclic is trimmed to a position, deviations from this position create a force towards the trimmed position but this force is easily overcome by a pilot. The Panel considered whether the crew had operated the trim system during the landing sequence, inadvertently trimming the cyclic to the fully aft position contributing to disorientation with respect to the cyclic position. Whilst the possibility of this contribution could not be completely discounted, the crew had stated that the aircraft was trimmed for the final time at 65 kts in the descent and Exhibit 14
the Panel could find no evidence to suggest otherwise.

1.4.29 **Stability Augmentation System (SAS)**. The HT3 is fitted with a Exhibit 31
SAS that when selected 'on' works via the control runs to smooth oscillations in
pitch, roll and yaw that are not induced by the pilot. During an actual EOL the Exhibit 24
SAS would drop out as it is fed by the Alternating Current (AC) electrical system Annex A
that is engine driven. As such the ACM mandates that practice EOLs should be
flown with the SAS 'off'. The SAS was found selected to the 'off' position after the Annex C
incident (Fig 5). Additionally, the SAS actuator positions were recorded by the FTI and the trace shows no active rate damping thus confirming the SAS as 'off'. As a consequence the Panel discounted SAS interaction as a factor in the incident.

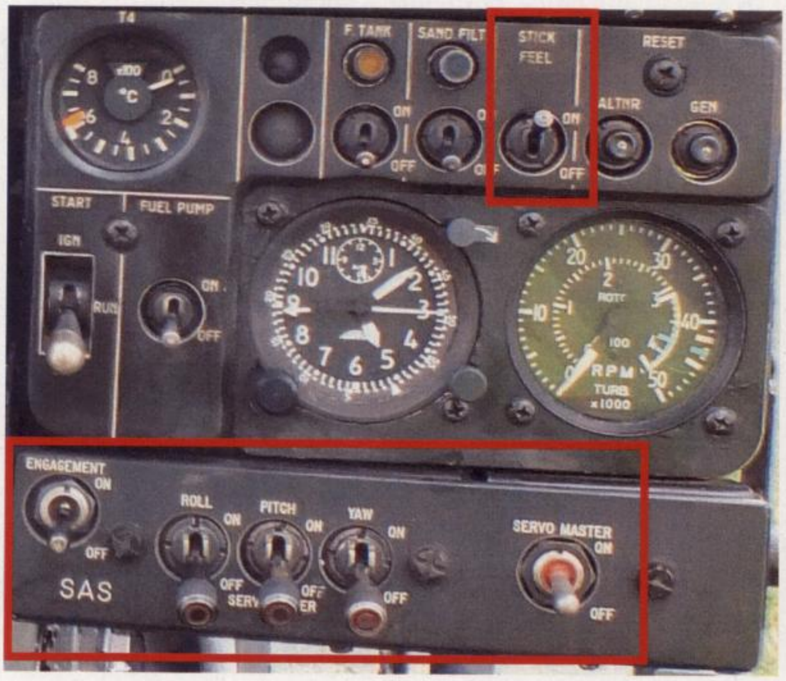

Fig 5 - Position of SAS and Stick Feel switches post-landing (XZ936)

1.4.30 **Hydraulic failure**. Helicopter flying control hydraulic systems are designed to shield the pilot from the feedback forces inherent in a helicopter and allow control loads to be lessened and easily overcome. The Gazelle hydraulic system is driven from the Main Rotor Gearbox (MRGB) and hydraulic power is available, even after an engine failure, as long as the blades are turning. Should the hydraulic pump fail, an accumulator provides sufficient reserve of hydraulic power to allow some assisted repositioning of the flying controls and control of aircraft attitude. When this reserve is exhausted or the system fails, the controls revert to manual and aerodynamic forces are fed back through the flying controls.

Exhibit 32
Exhibit 33
Exhibit 34
Exhibit 33

1.4.31 **Hydraulic lines**. The blade strikes severed the hydraulic lines at the tail, leading to a loss of hydraulic pressure. With no hydraulic pressure the aerodynamic forces, in conjunction with an out of balance blade set, are likely to have been considerable. The FTI trace after the blade strikes, which shows large and erratic changes in cyclic position, was entirely consistent with this.

Exhibit 33
Annex C

1.4.32 **Hydraulic failure sequence**. The Panel considered whether hydraulic failure could have occurred *before* the tail strike and produced feedback into the controls during the touchdown phase. Technical inspection of the hydraulic components revealed no additional defects beyond those assessed as a direct consequence of the incident. 'Power-on, hydraulics-out' flight is practised by Gazelle pilots and the control loads experienced are fully manageable in the speed range articulated in the ACM; including the speed range of this EOL. The same document describes the handling characteristics that would be present if the hydraulic system failed at high speed, high g or high altitude which can lead to heavier than normal feedback forces through both cyclic and collective. These three factors were not present in the incident sequence and the crew stated that nothing was abnormal about the forces through the collective lever, nor did they experience any additional force through the pedals.

Annex A
Exhibit 24
Witness 1
Witness 2

1.4.33 **Hydraulic feedback forces**. Although the rotors had comparatively low Nr and the aerodynamic forces would consequently have been lower, it is considered likely that any hydraulic pressure failure would still have shown on the FTI trace as a disturbance in the collective and/or pedal positions. Whilst the Panel could not find any evidence to support the theory of hydraulic failure preceding the blade strikes, they considered that any control forces thus caused could have been overcome by the crew. The Panel considers this controllability argument to hold for both a complete failure as discussed above or an under-pressure condition that, although unlikely given this system and scenario, is theoretically possible given a lower than normal Nr. The Panel concluded that hydraulic system failure was not a factor in the cyclic movement prior to the blade strikes.

Annex C

1.4.34 **Pitch Control Rod (PCR) failure**. The PCR failed at some point during the incident sequence. The Panel sought to determine whether the failure could have occurred prior to the blade strike. If a PCR fails, the pitch of its associated blade can no longer be controlled and its flight path will diverge from the other blades. This will produce significant out of balance forces that could feasibly overcome the hydraulics and feedback to the controls, thus driving their position beyond that demanded. To understand whether this could have occurred, the Panel, with assistance from the MilAAIB, sent the damaged PCR for expert analysis by 1710 NAS. This analysis determined that the PCR had failed in compression through overload. Further investigation was then

Annex A1

undertaken on the incident aircraft and the Panel noted the following:

a. The Pitch Change Horn (PCH) that connects to the Red PCR at its top end was significantly deformed upwards which would have required a large force (Fig 6). For the PCR to have failed in isolation and subsequently bent the PCH, it would require the broken upper portion of the PCR to make contact with a section of the rotor head and transfer force to the PCH. Had this occurred there would be witness marks on the PCR at the base of the broken upper portion. No such witness marks were present nor is there any obvious mechanism whereby the PCR could interact with the head in this way. Annex A

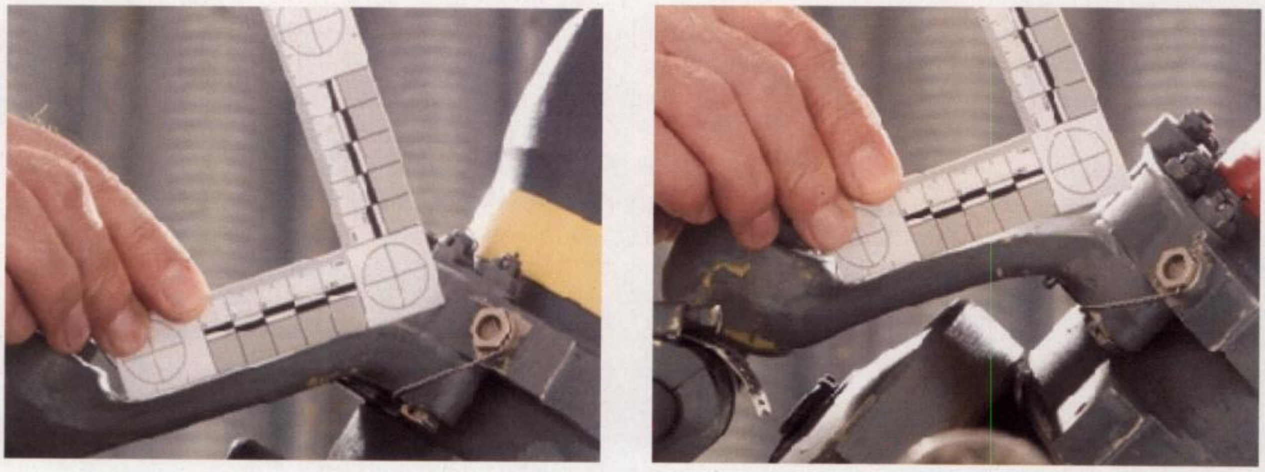

Fig 6 – An undistorted PCH and the distorted Red PCH

b. A force applied through the intact PCR and PCH together would create damage consistent with the pattern seen on both components.

c. Had the PCR failed in isolation prior to the blade strikes there would be significant evidence of it on the FTI trace through degradation of in-flight stability and an increase in vibration from out of balance forces. These characteristics were not present on the FTI trace until the blades struck the tail.

The Panel concluded that the PCR failure occurred as a result of the blade strike(s) against the tail and therefore was not a factor in the aft cyclic position prior to the strikes.

1.4.35 **Right Hand Seat Pilot interaction with the cyclic**. The RHS pilot does recall covering, and interacting with, the collective lever but has no recollection of any interaction with the cyclic during the incident sequence. The LHS pilot recalls becoming aware of the RHS pilot following through[2] on the cyclic. However, this would not necessarily have resulted in any RHS pilot input to the cyclic. In the absence of an FTI or ADR feed of pressures exerted on the controls by each seat occupant, or a cockpit video, the Panel probed other possible indications of RHS pilot interaction with the cyclic. Witness 2 Witness 1

[2] 'Following through'; a technique used by the non-handling pilot to have their hands/feet lightly touching the controls in this instance to allow rapid intervention if required to remedy a poor situation.

a. Very shortly after the MRB strikes, a voice can be heard on both the CVR and ATC recording that originated from the aircraft. This voice was identified as the RHS pilot. A Press to Transmit (PTT) selection from either seat will bar the other seat's ability to transmit on the same frequency so it is not possible for either pilot to depress one of their own PTTs and transmit the other pilot's voice. There are two PTTs which the RHS pilot can use to transmit. One is below the collective beyond the reach of a RHS pilot whilst holding the collective normally. This would require significant hand movement to action so the Panel considers it improbable that this PTT initiated the transmission. The other is a pressel on the front face of the RHS cyclic and is a two position switch normally depressed with the index finger. On the ATC audio, in the seconds leading up to the voice on the tape, there are a number of clicks and noises in addition to the voice. There are also a number of clicks on the CVR during the landing run. The Panel sought to ascertain what these noises were and whether the clicks on each recording were related.

Exhibit 14
Exhibit 22
Exhibit14

b. The CVR audio records noise from many sources and so it is more difficult to strip out specific sounds. In comparison, the ATC recording is limited solely to discrete transmissions on the Tower frequency. The two audio streams were aligned so that the two recordings of the voice were synchronised. When displayed visually (Fig 7) the two audio streams show that many of the clicks occur simultaneously on both recordings indicating that their source was 'on frequency'; audio analysis reveals that they are consistent with the pressing of a PTT. Whilst PTT depressions only show up as clicks on the CVR, they reveal more information on the ATC audio. In addition to the clicks, carrier wave transmissions with some audio overlain can be seen and heard even when nothing was said by the individual transmitting. Whilst the voice is heard towards the end of a longer transmission that starts immediately prior to the fifth and final blade strike, the sequence of PTT interactions begins earlier, approximately 1.25 seconds after touchdown.

Exhibit 13
Exhibit 22

CVR and ATC Audio.

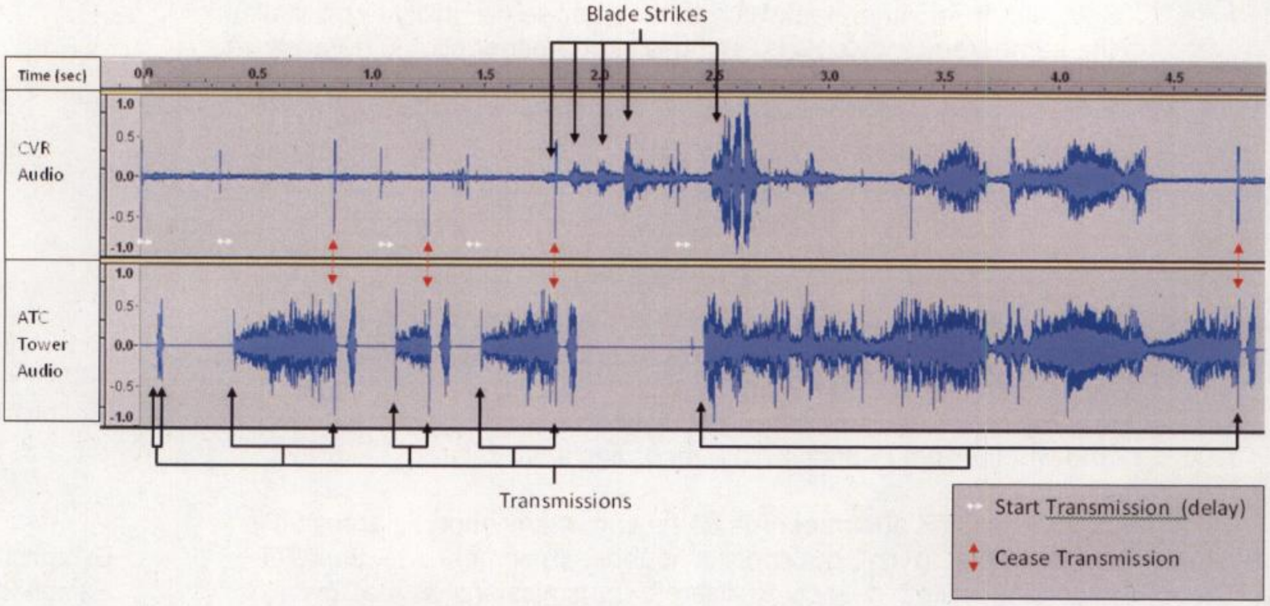

Fig 7 – CVR and ATC Audio

c. As there are multiple stations on the Tower frequency, the Panel sought to determine the source of the transmissions. Had the fragments of audio overlain on the carrier wave been from another source, they would be audible on the CVR in addition to the internal sounds and would sound external. Instead, only the clicks themselves are audible on the CVR and thus the Panel concluded that the source of the transmissions was XZ936. The Panel assessed that it is extremely unlikely that both seat occupants were independently interacting with their respective PTTs over such a short period of time. Furthermore, as the longest transmission in a five second sequence of transmissions could be sourced to the RHS, in all probability all of these unintended transmissions were RHS generated.

Exhibit 14
Exhibit 22

d. The above analysis strongly suggests that the RHS pilot's hand was interacting with the front face of the cyclic with sufficient force to depress the PTT from just after aircraft touchdown. In addition, the LHS pilot stated that the RHS pilot was following through on the controls from earlier in the manoeuvre. The Panel had insufficient evidence to establish that the RHS pilot definitely provided an input into the cyclic beyond the series of PTT selections. However, the very fact that the LHS pilot perceived that the RHS was making inputs led the Panel to conclude that there was confusion over which pilot had control of the aircraft during this phase of flight and this was assessed as a **Contributory Factor**.

Witness 1
Annex B

Crew Resource Management (CRM)

1.4.36 **Control of the aircraft**. It is apparent that both crew members believed that the other was in control of the aircraft post-touchdown; neither pilot took action to prevent the sequence of control movements that caused the blades to strike the tail and the timeframe in which this confusion could have been resolved was very short. Witness 1 Witness 2

1.4.37 **Collective and cyclic inputs**. Whilst it is possible for the Panel to comment on the likely source of the cyclic movement, the same cannot be said for the collective lever. Both pilots had their hand on their respective collective levers and both reported having raised the collective during the 'cushion' but it was not possible to determine who lowered it or why it was lowered at such a rate. Witness 1 Witness 2

1.4.38 **QHI intervention**. With the benefit of time, data and hindsight it is possible to suggest points at which intervention would have been appropriate. The RHS pilot stated that had a student generated a similar condition he would have intervened - a different recovery strategy was required over that from the normal 'check' height. As intervention would have been likely had a student generated the situation but didn't happen in this case, the Panel considered the crew composition further, noting that intervention was also cited as a feature of an EOL incident at RAF Shawbury in Jul 14. Witness 2 Exhibit 44

1.4.39 **Cockpit gradient**. The RHS pilot stated that he was less likely to have to intervene on an instructor/instructor EOL sortie than on an instructor/student sortie. In addition he stated that he thought the LHS pilot should have been able to successfully recover the manoeuvre. Both these statements are reflective of a degree of trust in the ability of the LHS pilot and are representative of a flat cockpit gradient. This trust was likely to have impacted the probability of the RHS pilot intervening as he perceived that the LHS pilot would successfully complete the manoeuvre. Therefore, the Panel concluded that the flat cockpit gradient was a **Contributory Factor**. Witness 2 Witness 2 Annex B

1.4.40 **Recommendation: Single Engine Rotary Wing DDHs that conduct Engine Off Landings (Commandant DHFS, AWC Chief Test Pilot and Commander ARF) should take steps to ensure that intervention protocols are briefed prior to any EOL instructional flight or currency flying and rigorously applied irrespective of the crew composition.**

Pre - flight preparation

1.4.41 **Crew composition**. It is assessed that the crew were of the correct composition for the sortie and were authorized to carry out the exercises they planned. Both crew members were acting in the course of their permitted duties. Exhibit 11 Exhibit 37 Exhibit 38 Exhibit 39 Exhibit 40

1.4.42 **Crew readiness**. The crew were fully trained and qualified for this sortie and were current in all disciplines (less EOL for the LHS pilot) required for the planned sortie. Exhibit 37 Exhibit 38 Exhibit 3

1.4.43 **Flying authorizations**. The crew had completed the required Aviation Task Risk Matrix (ATRM) which confirmed that, in accordance with ETPS orders, only 'Routine Auth' was required. The highest level of authorization that could be required is 'Exec Auth'; a power held by the Authorizer in this instance. Exhibit 8 Exhibit 10

1.4.44 **Code abbreviation**. The Panel reviewed the authorization codes for the sortie and how they were recorded versus the requirements of the MRPs. Under the 'Duty' section of the authorization sheet the sortie was detailed as 'TP' (circled) 'EOLS'. The circled characters refer to it being an ETPS sortie and 'EOLs' is an ETPS Flying Order Book (FOB) Duty Column Code. Such codes detail exercises and any associated minima. No further detail for the sortie was given in the 'Duty' section of the authorization sheet. Exhibit 11 Exhibit 10 Exhibit 41

1.4.45 **Minimum Separation Distance and Criteria (MSD/C)**. The MRP directs that when operating at or below 250' AGL/AMSL, an authorization should include either a MSD or a combination of MSC[3] and AGL can be used. A separation criterion is not present in the FOB height minima, only 'Ground' is stated. Exhibit 42

1.4.46 **Authorization codes**. The Panel noted a further deviation from the MRP requirement: auto-rotations and running landings were planned and flown during the sortie but neither was reflected explicitly in the authorization sheet although codes existed that included them. The ETPS FOB codes that could have been used in combination with 'EOLs' are code 'general handling' (GH) which includes Running Landings with 10' MSC and code 'Practice forced landings' (PFL) which includes autorotations to 10' AGL with the inference of 30' MSC. Exhibit 14 Exhibit 10 Exhibit 41

1.4.47 **Authorized profile**. The Authorizing Officer was entirely cognisant of the profile of the flight he was being asked to authorize, not only as a consequence of his familiarity with it, owing to his position on the Squadron, but also through the authorization process for this particular sortie. The Panel considers authorization for this sortie to have been appropriate (acknowledging the caveats above) and **not a factor**. The Panel made an **observation** that there was a lack of detail in the authorization sheet and the Duty Column Code 'EOL' was not compliant with the Military Regulatory Publications. Exhibit 10 Exhibit 42 Witness 8

1.4.48 **RECOMMENDATION: Chief Test Pilot should ensure that authorization sheets reflect all exercises to be flown and height / separation minima where required by Regulatory Article (RA) 2330(1).**

1.4.49 **Currency**. The Panel identified that there was ambiguity as to the EOL currency requirement. ETPS' computer based Currency Tracker calculated currency in line with the EOL requirements within the ETPS FOB; this was for 2 x Constant Attitude (CA) and 2 x Variable Flare (VF) within 90 days. LLVF EOL were also tracked in accordance with a FOB requirement. However, Air Warfare Centre Air Staff Orders (AWC ASOs), the higher level document, required 4 of each of the 2 types (8 total) in one part of the document and suggested 4 in total in another. Although AWC ASOs were only released on the day of the incident they were, on this subject, in line with the preceding orders, namely 2 Group ASOs. Hence, the ETPS FOB was more permissive than the most stringent Exhibit 10 Exhibit 7 Exhibit 3 Exhibit 43

[3] Minimum Separation Criteria -

requirement in the higher level document, requiring only half the number of EOLs to achieve currency.[4] Currencies are a defence and whilst in this instance the defence was not breached, the sortie could have been flown by an Aircraft Commander uncurrent in accordance with AWC ASOs but indicating 'green' on the ETPS tracker. The Panel considered the ambiguity in the AWC orders, and its interpretation in the ETPS FOB to be an **Other Factor**. Exhibit 3 Exhibit 7

1.4.50 **RECOMMENDATION: Chief Test Pilot should review the Air Warfare Centre and Empire Test Pilots School Flying Orders regarding Engine Off Landing (EOL) currency requirements and ensure amendment where necessary, to remove ambiguity and ensure harmonisation.**

1.4.51 **Aircrew supervision**. There is a tried and tested supervisory chain within the AWC, MoD Boscombe Down and ETPS. The level of supervision was correct for this type of exercise. The Panel did not consider supervision to be a factor in this incident. Exhibit 35

1.4.52 **Incident sortie details and planning**. The sortie profile was within the MoD Boscombe Down airfield thus not requiring a Centralized Aviation Data Service (CADS) entry. The Panel consider that the crew had appropriately planned the sortie and had identified and maintained awareness of the most significant variable (namely the wind). The Panel did not consider planning to be a factor in this incident. Witness 1 Witness 2 Witness 8

1.4.53 **Crew logbooks**. During the investigation the logbooks of the crew were examined and the Panel made the following **observations**:

a. Logbooks were not up-to-date. Exhibit 1 Exhibit 2 Exhibit 45

b. The crew had erroneously logged sorties during which they were under instruction as 'P1' which should instead have been recorded as 'dual'. Exhibit 1 Exhibit 2

The Panel noted that CTP has subsequently issued clear direction on compliance with this area.

Environmental conditions

1.4.54 The Panel checked data for the incident time period provided by Boscombe Met Office in addition to CVR recording of wind information passed by ATC. Whilst neither of these data sets reveal the wind strength and direction continuously throughout the manoeuvre, they do strongly suggest that there was the required 5kts headwind component. Despite the marginal nature of the winds, the Panel assessed the weather as appropriate for the sortie. Exhibit 6 Exhibit 46

1.4.55 In the absence of a ground speed feed to either the ADR or FTI, the best indicator that the aircraft contacted the ground with positive forward ground speed was the 12.1 metre run-on of the aircraft in addition to the crew's estimates of the run-on speed. The recorded Met wind and the run-on evidence indicated that the manoeuvre was flown in compliance with the requirement for 10 kts Annex A Exhibit 7 Exhibit 47 Witness 1 Witness 2

[4] The ETPS Currency Tracker (that tracks in accordance with the ETPS FOB) indicated that the LHS pilot was 'green', (i.e. current) for a type of EOL for which, in accordance with AWC ASOs, he was not. The RHS pilot and Aircraft Commander was shown as 'green' (i.e current) for all 3 of the tracked EOL types and had sufficient of each for him to be current under AWC ASOs.

through the disc, a limitation of which the crew were highly cognisant throughout. Exhibit 14

1.4.56 The wind limitations in force for Gazelle EOLs within AWC are broadly similar to those in force with Joint Helicopter Command (JHC) at Middle Wallop who also conduct Gazelle EOLs, e.g. 10 kts through the disc. More wind is generally considered better as it provides more translational lift, making the collective lever more effective when cushioning the landing. The Panel considered the suitability of the wind limitations and whether an increase or reduction of this limitation would be beneficial. The Panel concluded that there would be little benefit to reducing it as it would erode safety margins. Any increase would disproportionately affect the ability to carry out training within the AWC due to the reduced number of days per year where the wind would be of the required strength. This was supported by a study, albeit with a small data set, which showed that the risk of an incident remains broadly similar across a range of wind strengths. Exhibit 69 Exhibit 48

1.4.57 The Panel noted that there were relatively slack winds at the time of the incident and, whilst the manoeuvre was flown within the regulations for wind strength, the marginal conditions did reduce the margin for error. As such the Panel conclude that the wind strength was a **Contributory Factor** in the incident.

Suitability of Rwy 23/05 Grass for EOLs

1.4.58 AWC ASOs gives responsibility for ensuring the suitability of the landing area prior to commencement of EOLs to the Aircraft Commander. The CVR shows the crew did discuss the suitability of Rwy 23 Grass. The Aircraft Commander was also one of the Rotary Wing (RW) STANEVAL authorized inspecting officers who conducts routine inspections of all MoD Boscombe Down approved EOL areas. The Panel **observed** that whilst a MoD Boscombe Down Routine Order circulated to squadrons by Boscombe Operations stipulated that rotary wing aircraft should avoid the edges of the strip within 1 rotor span, this was in conflict with the Boscombe FOB which stated that rotary wing aircraft should use the full length of the EOL strip but only the middle third of the width. Rwy 23/05 Grass was assessed by the Panel as suitable for EOL training and **not a factor** in the incident. Exhibit 7 Exhibit 14 Exhibit 10 Exhibit 49

Post-incident aspects

Survival aspects

1.4.59 **Aircrew post-flight actions**. Whilst the aircraft was not shutdown in accordance with the Flight Reference Cards (FRC), the methodology employed was assessed as sound under the circumstances. The RHS pilot made an emergency call to ATC before shutting down the aircraft. Both crew vacated via their respective doors and no signs of fire were apparent. Witness 2 Exhibit 13

1.4.60 **Medical issues**. [redacted] The Panel found no evidence of any medical issues relevant to the incident. Exhibit 16

Personal Aircrew Equipment Assemblies (AEA)

1.4.61 The crew's verbal pre-EOL checks recorded on the CVR included a statement that their visors were in the up position and the LHS Pilot stated in interview that this was a requirement. The Panel could find no documentary evidence that this was a requirement and noted that the practice stemmed from perceived visual problems due the interaction of the visor's curved transparency and the Gazelle's heavily curved canopy. However, the Panel **observed** that this practice was contrary to the advice from both 22 Group and JHC, and the removal of a level of AEA protection may reduce safety due to the potential for facial injuries caused by debris from an aircraft accident or birdstrike. Witness 1 Exhibit 50 Exhibit 51

1.4.62 **Recommendation: Chief Test Pilot should review the hazard risks associated with the use/non-use of visors during Gazelle EOL training and promulgate direction or guidance accordingly**.

1.4.63 The crew wore Mk 61M Armour Capable Life Preservers (ACLP) fitted with McMurdo Fast Find location beacons. The Panel **observed** that, of the five ACLP available to ETPS Gazelle crews, only one had the paperwork in place such that in the event of a Fast Find[5] activation the specific jacket, and thus in turn the specific crew member and aircraft, could have been readily identified. If activated, the other four could only have been traced to MoD Boscombe Down, potentially delaying the Chain of Command's or Rescue Agencies' determination of aircraft type, number of POB and their details. Exhibit 52

1.4.64 **RECOMMENDATION: Chief Test Pilot should ensure that a robust system is in place to record which 406Mhz capable Survival Beacon has been issued to which specific user to enable rapid identification in the event of an incident or accident**.

Post Crash Management (PCM)

1.4.65 Information regarding the incident was slow to reach the Post Crash Management Incident Officer (PCMIO); he was flying at the time of the incident and so efforts made by Aerodrome Operations to contact him via his telephone extension were unsuccessful. Notwithstanding this, he did arrive on site within the requisite 3 hours. Exhibit 12 Annex D

1.4.66 The QinetiQ official photographer and Airfield Manager were on the site prior to the PCMIO or MilAAIB Investigators' arrival. Once the PCMIO was on scene PCM was well handled and the site was correctly supervised. He briefed the QinetiQ individuals and prevented any further encroachment within the crash site prior to the arrival of the MilAAIB. Although there were no adverse implications in this case, all personnel should be made aware of the implications of entering a crash site without prior permission of the investigating team unless in an emergency. Annex D Annex E Exhibit 53

1.4.67 The Panel **observed** that the latest Deputy Chief of Defence Staff Duty Officer (DCDSDO) Significant Occurrence informing protocol was not used, as required in the MoD Boscombe Down Emergency Response Plan. Annex D Exhibit 53 Annex E

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[5] Fast Find. 406MHz capable beacon with specific identity coding.

1.4.68 The support from external agencies was appropriate and there were no issues with the salvage operation. The Aircraft Recovery Officer (ARO) informed the Airfield Manager and the PCMIO of the requirements to complete a thorough 'Foreign Object Debris (FOD) Plod' post the aircraft removal and before the commencement of any Station flying. There was an assumption that all debris was contained in a small area around the aircraft but a few days later, during such a 'FOD Plod', a part of the aircraft was found on the other side of the runway. The Panel **observed** that the initial 'FOD Plod' was not extensive enough and the MoD Boscombe Down PCM procedures should be reviewed to ensure the area to be checked is wide enough to cover all eventualities. The Panel noted that MoD Boscombe Down is addressing this issue through the lessons identified in the PCMIO's Report. Annex F Annex D

Cost of damage to aircraft

1.4.69 The current estimated cost of bringing XZ936 back into service is £480K. This is subject to change but it serves as a reasonable estimate. The key point to note is that XZ936 is substantially more valuable to QinetiQ and the MoD than a standard Gazelle as it contains the FTI fit essential for its ETPS support role. Exhibit 71

Safety, Health and Environment (SHE)

1.4.70 There was minimal Man Made Mineral Fibres (MMMF) contamination of the site and only a minor fluid leak from the aircraft as a result of the incident. The environmental impact was therefore assessed as negligible. Due to the flight safety risks of removing the soil and leaving an uneven surface, the Institute of Naval Medicine advised in their report that spilled oil should be allowed to naturally attenuate. The Panel found no other SHE implications. Annex E Annex E1

Organisational influences

Rationale for EOL training

1.4.71 EOL training is a European Aviation Safety Agency (EASA) requirement for TPs and an intrinsic part of the ETPS Test Pilot Syllabus, having applicability throughout the Test and Evaluation (T&E) process. In addition to the EASA requirement, there are strong supporting arguments for retaining EOL training both in this environment and in the training arena for ab-initio students. This aims to give pilots the confidence and required techniques should an EOL be required either as a result of engine failure or the broader range of emergencies that dictate an EOL. The Panel is of the opinion that there would be a reduction in safety if EOL training were to be curtailed. Exhibit 54 Exhibit 55 Witness 10 Exhibit 56 Exhibit 48

Risk

1.4.72 **EOL risk**. The Panel investigated whether appropriate consideration had been given by the Duty Holder (DH) Chain to the risks associated with EOL training. Orders for the conduct of EOLs at MoD Boscombe Down are extensive and include amongst other things; wind limitations, crew currency and the requirement to conduct EOLs to specific and prepared areas. These are all aimed at achieving a safe outcome when practicing EOLs. The Panel considers them a suitable mitigation strategy for the safe conduct of EOLs. Exhibit 7 Exhibit 10 Exhibit 49

Exhibit 57

1.4.73 **Risk Register**. The Gazelle Platform Risk Register, managed by MoD Boscombe Down Air Safety Cell (ASC), did include an entry regarding EOLs focused on the potential for a heavy landing from mishandling the aircraft leading to damage (specifically the frangible fairing) and/or minor injury to crew. However, it did not refer to the extant mitigations inherent in the relevant AWC Orders.

1.4.74 **Mitigation**. Whilst the mitigations in place (but outside the Risk Register) were broadly in line with other users that conduct EOLs, namely 22 Group and JHC, no evidence within the ASC could be found of documentary evidence to support the Gazelle EOL Risk Register entry. Exhibit 57

1.4.75 **Documentation**. The MRP states that an *'ODH is required to make an argument that risks are ALARP[6]; justifying and recording how this is reached is an important and vital step in safety management'*. The Panel **observed** that better documentary evidence could be provided in support of the EOL risk mitigation strategy in order to conform to the regulatory requirement. Exhibit 7 Exhibit 49 Exhibit 10 Exhibit 58

1.4.76 **Air Safety Cell (ASC) risk burden**. T & E flying is performed under a specific and extensive risk management process designed to cater for the potentially hazardous nature of T&E flying, be that pre-Release-to-Service (RTS) or outside RTS flying. This process is much more extensive than that required by MAA RAs that cater for inside RTS flying. Looking beyond the Gazelle EOL specific case, the Panel noted that there were a considerable number of types operated within the ASC's Area of Responsibility (AoR) for routine flying. With a responsibility for a significant number of platforms, the ASC bear a significant risk management burden. Within MoD Boscombe Down ASC AoR, there are manning gaps and those in post lack the required training and are thus not fully compliant with the Suitably Qualified and Experienced Personnel (SQEP) requirements of the MRPs. Exhibit 58

1.4.77 **Conclusion on risk**. The Panel concluded that the risks associated with conduct of Gazelle EOL training had been fully considered by the DH and sufficient risk mitigation was in place through extant orders. However, the Panel **observed** that there was a lack of detail in the Risk Register itself and there were manning shortfalls within the ASC. Witness 5 Witness 7 Exhibit 58 Exhibit 59

1.4.78 **RECOMMENDATION**: **ACOS Manning should ensure that the MoD Boscombe Down Air Safety Cell has sufficient numbers of Suitably Qualified and Experienced Personnel**.

Aircraft suitability

1.4.79 The Gazelle is an 'in-service' aircraft and one of the few that truly disengages the engine from the drive train when the throttle is retarded from flight to ground idle. When the throttle is retarded in the Gazelle, the aircrew are fully committed to the manoeuvre (from the heights the majority of EOLs are practised) and, whilst this is realistic of an actual engine off scenario, this commitment is not the case in all aircraft. Aircrew performing EOLs in the Squirrel, for example, have the ability to reinstate the drive which could be seen to increase safety margins over the Gazelle. However the Squirrel does have the

[6] ALARP – As Low As Reasonably Practicable

disadvantage of providing some power to the rotor system when at ground idle, degrading the fidelity of the training manoeuvre. It is understood the CoC has directed that other platforms be investigated to see if a suitable compromise can be found. The subject is outside the TORs of this SI but, due to its fully committed nature, the Panel assess the continued use of Gazelle for EOL training as an **Other Factor**. Exhibit 48

Maintenance

1.4.80 **Aircraft maintenance history**. The Panel assessed the pre-flight technical history and concluded that aircraft maintenance activities were not a factor in the incident. One aspect that the Panel discussed concerned the Load Statement document which is prepared before the first flight of the day, details the weight of the aircraft and summarises the Limitations (LIMs) and Acceptable Deferred Faults (ADFs). The Load Statement is placed in the F700 once completed and is also sent to the crew electronically for planning purposes prior to the sortie. The document does contain the caveats that it is for guidance only and that aircrew are responsible for cross-checking it with the F700 but the LIMs and ADFs on this Load Statement were different from those recorded in the F700. For example, new entries had not been included and cleared entries had not been removed. The Panel **observed** that the LIMs and ADFs on the Load Statement document were not up to date and so degraded the document's suitability for planning purposes. Annex A Exhibit 60 Exhibit 61 Exhibit 62 Exhibit 63 Exhibit 9 Exhibit 74 Exhibit 75

1.4.81 **Aircraft serviceability**. The technical investigation included analysis of elements such as oil and fuel samples, serviceability and calibration checks on aircraft instrumentation, MRGB alignment checks and the MRBs strike patterns on the tail. This technical analysis concluded that there were no faults with the aircraft systems prior to the incident. As such the Panel assess that aircraft serviceability was **not a factor**. Annex A

1.4.82 **FTI calibration**. In order to eliminate any possible discrepancies between the FTI data and the actual position of the flying controls, the Panel analysed the connectivity between the controls and the FTI equipment. It was confirmed that the measurement of flying control movements was taken directly from instrumentation in the control runs and was not a calculation of movement from data collected at a remote point on the aircraft. The suite of FTI equipment was calibrated during depth maintenance in Oct 13 and post-incident checks of the flying controls FTI connections also confirmed that they were still in calibration. Therefore, the Panel confirmed that the integrity of the flying control FTI data was not compromised. Annex A Exhibit 64 Exhibit 65 Exhibit 66

1.4.83 **Non-Destructive Testing (NDT)**. NDT examination of XZ936 was requested by 1710NAS and was carried out by QinetiQ technicians; several areas of delamination were found on the Transmission Support Platform (TSP). NDT of the TSP is not a scheduled maintenance activity and maintenance documentation instructs 'examine' for that particular area of the aircraft. There was no evidence of any NDT examination of the TSP prior to the post-incident inspection. As the delamination damage was only discovered as a result of NDT following this particular incident, the Panel assesses that the possibility exists that some, or all, of the delamination may have been legacy damage and not as a result of this incident. The Gazelle Project Team (PT) have advised that maintenance activities previously scheduled at 800 hrs to examine the TSP will Annex G be directed at 100 hrs in a revision of the Topic 5 maintenance documentation. Whilst this Topic 5 revision will increase the frequency of examinations of the area, it will not necessarily result in NDT inspections of the TSP; therefore, the Panel assessed this as an **Other Factor** and recommends that the Gazelle PT review the requirement for specific NDT scheduled inspections given the delamination damage found during this inquiry. Exhibit 70

1.4.84 **RECOMMENDATION: The Gazelle Project Team should implement Non-Destructive Testing (NDT) inspections for the Transmission Deck of all Gazelle types at appropriate service intervals.**

1.4.85 **Mil Part 145 Maintenance Organisation**. The QinetiQ maintenance organisation complies with Gazelle RTS but also employs their own QinetiQ Aircraft Release (QARel) for QinetiQ specific activities outside the RTS, and for the embodiment of additional equipment on the aircraft. Maintenance activities comply with Air Publication (AP)101C maintenance documentation but QinetiQ Air Engineering Group documentation is also in use for detailing QinetiQ procedures such as aircraft engineering documentation and tool control. These QinetiQ procedures are similar to local engineering orders found on MoD units operating aircraft. The Panel **observed** that maintenance documentation still makes reference to Joint Air Publications (JAP) although these have been superseded by the Manual of Maintenance and Airworthiness Processes (MMAP). Similarly, since the update of the Aircraft Repair Manual[7] (ARM) in Dec 13, the Panel **observed** that references made in the Major Maintenance Schedule[8] regarding inspection of the TSP no longer correspond to the correct section in the ARM. Exhibit 67 Exhibit 68

1.4.86 **Regulation**. The QinetiQ maintenance organisation complies with MAP governance and has embedded within it the MAA Continuing Airworthiness Management Organisation (CAMO). Exhibit 67

1.4.87 **Hazard Log**. The Hazard Log (e-Cassandra) is managed by Defence Equipment and Support (DE&S), the Type Airworthiness Authority for the Gazelle, and details those controls put in place to mitigate identified hazards. This log is the foundation document for all DH functions when assessing Risk to Life and articulated via the RTS. The Log was reviewed by the Panel and there were 3 EOL controls referenced which support the following higher level entries pertaining to the hazard of losing an aircraft. This provides the rationale to carry out, and train for, EOLs. The relevant hazards are: Exhibit 56

a. Loss of Aircraft Hazard – Partial or total loss of engine power in flight.

b. Top level accident – Loss of aircraft due to insufficient lift.

[7] AP101C-0901/3-6A2

[8] AP101C-0901-5D

Summary of findings

1.4.88 **Cause**. The cause of the incident involving Gazelle XZ936 on 2 Jun 14 was the rapid lowering of the collective in combination with the aft cyclic position post-touchdown which resulted in the Main Rotor Blades striking the tail.

Contributory Factors

1.4.89 The Panel identified 8 Contributory Factors:

a. CF1 - The high 'check'.

b. CF2 - The possibility of interaction between the Main Rotor Blades and the tail.

c. CF3 - The rate and scale of collective lowering during the landing phase.

d. CF4 - The aircraft attitude on touchdown.

e. CF5 - The second aft cyclic selection.

f. CF6 - The confusion over which pilot had control of the aircraft.

g. CF7 - The flat cockpit gradient.

h. CF8 - The strength of the wind.

Aggravating Factors

1.4.90 The Panel found no Aggravating Factors.

Other Factors

1.4.91 The Panel identified 3 Other Factors:

a. OF1 - The ambiguity in the AWC Orders, and its interpretation in the ETPS Flying Order Book.

b. OF2 - The continued use of Gazelle for EOL training.

c. OF3 - That Non-Destructive Testing of the Transmission Support Platform is not mandated.

Observations

1.4.92 The Panel made 12 Observations:

a. OBS 1 – There was lack of detail in the authorization sheet and the Duty Column Code 'EOLs' was not MRP compliant.

b. OBS 2 - Crew logbooks were not up-to-date and there were deviations from MRP on the recording of First Pilot (P1) versus Dual.

c. OBS 3 – There was a discrepancy between a MoD Boscombe Down Routine Order and the Boscombe Flying Order Book regarding the useable area of Rwy 23/05 Grass for Engine Off Landings.

d. OBS 4 - The practice of having visors in the up position for EOLs was in contrast to the advice from 22 Group and Joint Helicopter Command.

e. OBS 5 - Of the five ACLP available to ETPS Gazelle crews, only one had the paperwork in place such that in the event of a Fast Find activation the specific jacket, and thus in turn the specific crew member and aircraft, could have been readily identified.

f. OBS 6 - The Deputy Chief of Defence Staff Duty Officer (DCDSDO) Significant Occurrence informing protocol was not used.

g. OBS 7 - That the initial 'FOD Plod' was not extensive enough and would need to be reviewed in the MoD Boscombe Down PCM procedures.

h. OBS 8 - Better documentary evidence could be provided in support of the EOL risk mitigation strategy in order to conform to the regulatory requirement.

i. OBS 9 - There was a lack of detail in the Risk Register and there were manning shortfalls within the Air Safety Cell.

j. OBS 10- LIMs and ADFs on the F700 Load Statement document, were not up to date.

k. OBS 11 - Maintenance documentation still makes reference to Joint Air Publications (JAP), although these have been superseded by the Manual of Maintenance and Airworthiness Processes (MMAP).

l. OBS 12 - References made in AP101C-0901-5D (Major Maintenance Schedule) regarding inspection of the Transmission Support Platform no longer correspond to the correct section in the updated AP101C-0901/3-6A2 (Aircraft Repair Manual (ARM)).

PART 1.5 – RECOMMENDATIONS

Recommendation		Analysis Reference
Introduction. The following recommendations are made in order to enhance Defence Air Safety:		
1.5.1	**ACOS Manning:**	
	a. Should ensure that the MoD Boscombe Down Air Safety Cell (ASC) has sufficient numbers of Suitably Qualified and Experienced Personnel.	1.4.78
1.5.2	**Chief Test Pilot:**	
	a. Should ensure that authorization sheets reflect all exercises to be flown and height / separation minima where required by Regulatory Article (RA) 2330(1).	1.4.48
	b. Should review the Air Warfare Centre and Empire Test Pilots' School Flying Orders regarding Engine Off Landing (EOL) currency requirements and ensure amendment where necessary, to remove ambiguity and ensure harmonisation.	1.4.50
	c. Should review the hazard risks associated with the use/non-use of visors during Gazelle EOL training and promulgate direction or guidance accordingly.	1.4.62
	d. Should ensure that a robust system is in place to record which 406Mhz capable Survival Beacons has been issued to which specific user to enable rapid identification in the event of an incident or accident.	1.4.64
1.5.3	**Joint Helicopter Command and Air Warfare Centre DDH Gazelle:**	
	a. Should re-emphasise to all Gazelle crews the potential for Main Rotor Blade interaction with the tail and the importance of the related advice on the conduct of EOLs found in the Gazelle Aircrew Manual.	1.4.25
1.5.4	**Commandant DHFS, AWC Chief Test Pilot and Commander ARF:**	
	a. Single Engine Rotary Wing DDHs that conduct Engine Off Landings should take steps to ensure that intervention protocols are briefed prior to any EOL instructional flight or currency flying and rigorously applied irrespective of the crew composition.	1.4.40
1.5.5	**Gazelle PT:**	
	a. Should implement Non-Destructive Testing (NDT) inspections for the Transmission Support Platform of all Gazelle types at appropriate service intervals.	1.4.84
1.5.6	**OC Handling Squadron:**	
	a. Should incorporate an explicit warning in the Gazelle Aircrew Manual that combinations of low Nr, low collective pitch and aft cyclic must be avoided as they present a high risk of a Main Rotor Blade strike on the tail.	1.4.26

PART 1.6 – CONVENING AUTHORITY COMMENTS

1. On 2 Jun 14, 2 Test Pilots (TPs) from the Empire Test Pilot's School (ETPS) were tasked to complete Engine Off Landings (EOLs) for pilot currency at Boscombe Down Airfield. This incident is an account of how 2 highly competent and professional TPs conducting a relatively routine training exercise can be quickly caught out by a known risk. The crew completed a number of EOLs without incident but on the final detail the helicopter landed on the rear of its skids, rocking backwards and forwards until the main rotors struck and severed the Fenestron tail assembly, completely detaching it from the tail boom. The pilots evacuated the aircraft without injury. The right hand seat pilot was a Qualified Helicopter Instructor and TP and was acting as the Aircraft Captain and Instructor. The left hand seat pilot was a Test Pilot Instructor regaining his EOL currency. It is assessed by the Service Inquiry Panel that this routine exercise with 2 very experienced pilots likely resulted in a 'flat cockpit gradient'[1] which manifested itself when things started to go wrong. The Panel completed a commendable inquiry in short order which confirmed the cause as 'a rapid lowering of the collective in combination with aft cyclic post touchdown'. As the aircraft was fully instrumented, the Panel had a wealth of data available to support their conclusions, together with the open and honest statements of the crew. As well as determining the cause, I asked the Panel to comment on the reason for practising EOLs as part of the ETPS course and whether this risk had been considered and mitigated by the Duty Holder (DH) community. I agree with the cause of this accident and support the recommendations made by the Panel. I also acknowledge that following this incident the ODH considered and subsequently confirmed the requirement for EOL training as part of the ETPS syllabus. Although I agree with his analysis and support the conclusions drawn, I recommend that this decision is ratified from a policy perspective by the Department for reasons which I will go on to explain.

2. The Service Inquiry Panel has made a number of comments on flight administration and post-incident handling but I will restrict the bulk of my comment to the practise of EOL training. Unfortunately, in common with most other Inquiries that I have looked at over the past 2 years, there were a number of disappointing flight administration and authorisation aspects to this incident. In particular, logbooks were out of date, some sortie durations had been logged as P1 and not dual, there were authorisation and minimum height anomalies and ambiguous currency requirements for EOLs. It is highly unlikely that any of this had any material bearing on the cause or outcome of this incident but it serves as another reminder to flying units to sort out their administration. The potential for blade contact with the rear fuselage is a known hazard on Gazelle under certain conditions, and the warnings are clearly stated in the Aircrew Manual. Indeed, it is well known to operators through bitter experience that mishandling of the cyclic and/or the collective during the latter stages of an EOL might result in blade contact with the stabiliser fins or, in extremis, the rear fuselage post touchdown. The Instructor had performed a correct demonstration of an EOL before getting the left hand seat pilot to do the same manoeuvre. This proceeded as per the demo until he initiated his 'check' too high, requiring very careful management of the remainder of the manoeuvre. This was controlled by a variety of collective and cyclic inputs by both pilots simultaneously as they attempted to recover from a situation which they both recognised was wrong. In his evidence to the Panel, the Instructor stated that he was less likely to intervene in this case than he would have with a normal student and clearly had a degree of trust that, given his

[1] Cockpit Gradient refers to the established, and/or perceived, command and decision-making power hierarchy in a crew. The desired situation is a gradient that recognises the captain's authority, but retains relationships and synergistic working.

experience, the pilot would be able to land the aircraft safely. Despite this, the data indicated that when the landing profile started to deviate from the norm, the instructor did make inputs to both the cyclic and collective, but without completing any positive intervention protocol. There is clearly a time that an instructor will guard the controls or even follow through on them, but at all stages the crew must be absolutely clear who has control of the aircraft, with changes to this being verbalised with the terminology 'You/I have control'. In this case both pilots thought the other had control of the aircraft in the final stages of the EOL and after the helicopter touched down.

3. The UK Military Gazelle has recorded over 1.1 million flying hours, during which time there have been only 4 recorded EOLs due to engine failure and a further 8 other failures or incidents where the EOL technique was used to recover the aircraft. However, over the same period 67 incidents (including 4 incurring CAT 4/5 damage) have occurred during EOL practise, although many of these were during ab-initio training. While the incident rate on the Gazelle fleet has reduced dramatically since it ceased being used to train student pilots, over the past 14 years there have been 17 EOL related incidents resulting in varying degrees of damage at Boscombe Down. This equates to one incident every 9 months. Following this particular incident, the ODH reviewed the requirement for EOL training within the ETPS syllabus and concluded that the Risk to Life posed is low when set against the requirement to train TPs to deal with an EOL. While I agree with the analysis undertaken in reaching this conclusion, the facts highlight that we are damaging aircraft at frequent intervals in doing so. I therefore recommend that DCDS Mil Cap confirms that Defence is content to bear the cost (in financial and equipment terms) associated with the delivery of the current ETPS EOL syllabus. He may also wish to consider, in conjunction with the relevant FLC, whether or not the Gazelle continues to represent the most appropriate platform to deliver this training. The Panel also identified a lack of detail in the Risk Register in relation to EOL training. In their view this issue was probably compounded by SQEP shortages in the Boscombe Down Air Safety Cell. These observations should be addressed by the ODH. Finally, a lesson from the past which has caught many out over the years – beware of flat cockpit gradients.

DG MAA