Defence
Safety
Authority

# Service Inquiry

## HERCULES C-130J Mk4 (ZH873) Heavy Landing Incident

25 August 2017

Defence Safety Authority

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# PART 1.1

## Covering Note & Glossary

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## PART 1.1 – COVERING NOTE

DSA/DAIB/17/020

31 Oct 18

DG DSA

**SERVICE INQUIRY INVESTIGATION INTO ACCIDENT INVOLVING AN RAF C130J ON OPERATIONS ON 25 AUG 17**

1. The Service Inquiry Panel assembled at MOD, on the 13 Sep 17 by order of the DG DSA for the purpose of investigating the accident involving C130J ZH873 on 25 Aug 17 and to make recommendations in order to prevent recurrence. The Panel has concluded its inquiries and submits the provisional report for the Convening Authority's consideration.

2. The following inquiry papers are enclosed:

| | |
|---|---|
| Part 1 REPORT<br>Part 1.1 Covering Note and Glossary<br>Part 1.2 Convening Orders & TORs<br>Part 1.3 Narrative of Events<br>Part 1.4 Findings<br>Part 1.5 Recommendations<br>Part 1.6 Convening Authority Comments | Part 2 RECORD OF PROCEEDINGS<br>Part 2.1 Diary of Events<br>Part 2.2 List of Witnesses<br>Part 2.3 Witnesses Statements<br>Part 2.4 List of Attendees<br>Part 2.5 List of Exhibits<br>Part 2.6 Exhibits<br>Part 2.7 List of Annexes<br>Part 2.8 Annexes<br>Part 2.9 Schedule of Matters Not Germane to the Inquiry<br>Part 2.10 Master Schedule |

PRESIDENT

[redacted]

Commander Royal Navy
President
ZH873 SI

MEMBERS

[redacted]

Flight Lieutenant
Operations Member
ZH873 SI

[redacted]

Captain
Engineering Member
ZH8743 SI

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## PART 1.1 - GLOSSARY

| | |
|---|---|
| AAR | Air to Air Refuelling |
| ACAWS | Advisory Caution and Warning System |
| Acft Cdr | Aircraft Commander |
| ACM | Air Crew Manual |
| ACNS(A&C) | Assistant Chief of the Naval Staff (Aviation, Amphibious Capability and Carriers) |
| ADH | Aviation Duty Holder |
| AE | Air Engineering |
| AEA | Aircrew Equipment Assemblies |
| AGE | Aircraft Ground Engineer |
| AGL | Above Ground Level |
| AI | Aircrew Instructor |
| AKR | RAF Akrotiri |
| ALOC | Air Line of Communication |
| AMASI | Air Mobility Air Staff Instructions |
| AMF | Air Mobility Force |
| AMFTD | Air Mobility Force Training Directive |
| AMPA | Aircraft Mission Planning Aide |
| AO | Air Officer |
| AOAM | Air Officer Air Mobility |
| AOC | Air Officer Commanding |
| AOR | Area of Responsibility |
| AP | Air Publication |
| ARM | Accident Route Matrix |
| ASAV | Air Safety Assurance Visit |
| ASIMS | Air Safety Information Management System |
| AS | Air Safety |
| ASO | Air Staff Orders |
| AST | Air Safety Team |
| ASSWG | Air System Safety Working Groups |
| AT | Air Transport |
| ATEC | Air Test Evaluation Centre |
| ATSB | Australian Transport Safety Bureau |
| Av | Aviation |
| BALCS | Body Armour Load Carriage System |
| BCRs | Basic Currency Requirements |
| BD | Boscombe Down |
| BFS | Before Flight Servicing |
| BME | Broader Middle East |
| BZN | RAF Brize Norton |
| CAE | Chief Aircraft Engineer |
| C2 | Command and Control |
| CAM | Centre of Aviation Medicine |
| CBR | California Bearing Ratio |
| CCP | Cursor Control Panel |
| CDM | Climb Dive Marker |
| Cdr(s) | Commander(s) |
| CEC | Combat Entry Checks |
| CLE | Clearances with Limited Evidence |
| Cmn | Crewman |
| CO | Commanding Officer |
| CofC | Chain of Command |

 

| | |
|---|---|
| CONOPS | Concept of Operations |
| CRM | Crew Resource Management |
| CRMI | CRM Instructor |
| CVR | Cockpit Voice Recorder |
| CWG | Capability Working Group |
| CQHFI | Civilian Qualified HF Instructors |
| DAC | Deputy Air Commander |
| DACOS | Deputy Assistant Chief of Staff |
| DAIB | Defence Accident Investigation Branch |
| DAS | Defensive Aids Suite |
| DASOR | Defence Aviation Safety Occurrence Report |
| DAT(I) | Defence Air Team (Iraq) |
| DDH | Delivery Duty Holder |
| DDM | Dispatch Deviation Manual |
| DEF-STAN | Defence Standard |
| Det | Detachment |
| Det Cdr | Detachment Commander |
| DFDR | Digital Flight Data Recorder |
| DG | Director General |
| DGC | Defence Geographic Centre |
| DH | Duty Holder |
| DHAN | Duty Holder Advice Note |
| DLoD | Defence Line of Development |
| DMS | Dynamic Mission Simulator |
| DMU | Digital Mapping Unit |
| DSA | Defence Safety Authority |
| DTADS | Data Transfer and Debrief System |
| EAW | Expeditionary Air Wing |
| EFT | Elementary Flying Training |
| EGI | Embedded Global Positioning System and Inertial Navigation Unit |
| EPC | Error Promoting Condition |
| ETPS | Empire Test Pilot School |
| EWH | Eye to Wheel Height |
| FDM | Flight Deck Monitoring |
| FDR | Flight Data Recorder |
| FE | Force Elements |
| FHQ | Force Headquarters |
| FI | Flying Instructor |
| FLC | Front Line Command |
| Flt | Flight |
| Flt Cdr | Flight Commander |
| Flt Ops | Flight Ops |
| FPA | Flight Patch Angle |
| FRC | Flight Reference Cards |
| FRMS | Fatigue Risk Management System |
| ft | Feet |
| FU | Formed Units |
| GASO | Group Air Staff Orders |
| Gp | Group |
| HDD | Head Down Display |
| Herc | Hercules |
| Herc Det Ops | Hercules Detachment Operations |

 

| | |
|---|---|
| HF | Human Factors |
| HFACS | Human Factors Analysis Classification System |
| HFF | Human Factors Facilitator |
| HFS | Human Factors Specialist |
| HPT | Hercules Project Team |
| HQ | Headquarters |
| hrs | Hours |
| HUD | Head Up Display |
| Hz | Hertz |
| IA | Individual Augmentees |
| IAS | Indicated Airspeed |
| IIT | Image Intensifier Tubes |
| IPCC | Intergovernmental Panel on Climate Change |
| IPD | Inter-Pupillary Distance |
| IPT | Integrated Project Team |
| IR | Infrared |
| IRED | Infrared Emitting Diode |
| JFIG | Joint Forces Intelligence Group |
| JOMOC | Joint Oceanographic and Meteorological Operations Centre |
| KTP | Key Transition Point |
| Kts | Knots |
| LM | Lockheed Martin |
| MA Release | Military Aircraft Release |
| MAA | Military Aviation Authority |
| [redacted] | [redacted] |
| MADS | Manual of Aerodrome Design and Safeguarding |
| MF | Mobility Force |
| MONIM | Met Office Night Illumination Model |
| MOS | Military Operating Standard |
| MPCM | Manual of Post Crash Management |
| MRP | Military Regulatory Publications |
| NATO | North Atlantic Treaty Organisation |
| NFU | Non-Formed Units |
| NOS | Natural Operating Surface |
| NSI | Non-Statutory Inquiry |
| NSO | Natural Surface Operations |
| NVG | Night Vision Goggles |
| OC | Officer Commanding |
| OCC | Operational Capability Certificate |
| OCU | Operational Conversion Unit |
| ODH | Operating Duty Holder |
| ODM | Operating Data Manual |
| OEA | Operational Events Analysis |
| OEC | Operational Emergency Clearance |
| OPCOM | Operational Command |
| OPCON | Operational Control |
| OPSEC | Operational Security |
| ORM | Operational Risk Matrix |
| OSSA | Operating Safety System Assessment |
| PCM | Post Crash Management |
| PCMP | Post Crash Management Plan |
| PDI | Pre-Deployment Interview |
| PDT | Pre-Deployment Training |


OFFICIAL SENSITIVE – SERVICE INQUIRY

| | |
|---|---|
| PF | Pilot Flying |
| PI | Preparatory Instructions |
| PNF | Pilot Non-Flying |
| QPI | Qualified Pilot Instructor |
| QQ | QinetiQ |
| QuART | Quarterly Aircrew Recurrent Training |
| RA | Regulatory Article |
| RADALT | Radar Altimeter |
| RAF | Royal Air Force |
| RAF CAM | Royal Air Force Centre of Aviation Medicine |
| RAFSC | RAF Safety Centre |
| Recce | Reconnaissance |
| RF | Radio Frequency |
| RODs | Record of Decisions |
| RoD | Rate of Descent |
| RPG | Rocket Propelled Grenades |
| RTS | Release to Service |
| RTSA | Release to Service Authority |
| SA | Situational Awareness |
| SAF | Small Arms Fire |
| SC | Secret Clearance |
| Secs | Seconds |
| SES | Survival Equipment Section |
| SHE | Safety, Health and Environment |
| SI | Service Inquiry |
| SMP | Safety Management Plan |
| SNCO | Senior Non-Commissioned Officer |
| SQEP | Suitably Qualified and Experienced Personnel |
| Sqn | Squadron |
| SS | Safety Statement |
| STANAG | Standardisation Agreement |
| STANEVAL | Standards and Evaluation |
| Strat | Strategic |
| SyO | Security Officer |
| T | Tons |
| Tac | Tactical |
| TACATC | Tactical Air Traffic Control |
| TACOM | Tactical Command |
| TACON | Tactical Control |
| TAS | True Airspeed |
| TATOM | Tactical Air Transport Operations Manual |
| TLZ | Tactical/Temporary Landing Zone |
| TP | Training Protocol |
| TRM | Team Resource Management |
| TTP | Tactics Training and Procedures |
| $V_{AT}$ | Velocity at Threshold |
| WSOp | Weapons System Operator |

# PART 1.2

## Convening Order & TORs

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Defence Safety Authority

# Service Inquiry Convening Order

13 Sep 17

SI President
SI Members

Hd Defence AIB
DSA MAA Legad

Copy to:

| | | |
|---|---|---|
| PS/SofS | DPSO/CDS | PSO/Comd JFC |
| MA/Min(AF) | MA/VCDS | MA/DES CofM Air |
| PS/Min(DP) | NA/CNS | PSO/AOC 2Gp |
| PS/Min(DPV) | MA/CGS | MA/DSF |
| PS/Perm Sec | PSO/CAS | Dir DDC |

**DSA DG/SI/06/17 – CONVENING ORDER FOR THE SERVICE INQUIRY INTO THE HERCULES C-130J Mk4 (ZH873) HEAVY LANDING INCIDENT [redacted] ON 25 AUG 17**

1. In accordance with Section 343 of Armed Forces Act 2006 and in accordance with JSP 832 – Guide to Service Inquiries (Issue 1.0 Oct 08), the Director General, Defence Safety Authority (DG DSA) has elected to convene a Service Inquiry (SI).

2. The purpose of this SI is to investigate the circumstances surrounding the incident and to make recommendations in order to prevent recurrence.

3. The SI Panel will formally convene at Ministry of Defence Main Building, Whitehall, London at 1100L on Wednesday 13 September 2017.

4. The SI Panel comprises:

| | |
|---|---|
| President: | **Commander** [redacted] |
| Members: | **Flight Lieutenant** [redacted] |
| | **Captain** [redacted] |

5. The legal advisor to the SI is **Wing Commander** [redacted] (DSA MAA LEGAD) and technical investigation/inquiry support is to be provided by the Defence Accident Investigation Branch (Defence AIB).

6. The SI is to investigate and report on the facts relating to the matters specified in its Terms of Reference (TOR) and otherwise to comply with those TOR (at Annex). It is to record all evidence and express opinions as directed in the TOR.

7. Attendance at the SI by advisors/observers is limited to the following:

**Head Defence AIB – Unrestricted Attendance.**

**Defence AIB investigators in their capacity as advisors to the SI Panel – Unrestricted Attendance.**

8. The SI Panel will work initially from the DAIB facilities at Farnborough. Permanent working accommodation, equipment and assistance suitable for the nature and duration of the SI will be requested by the SI President in due course.

9. Reasonable costs will be borne by DG DSA under UIN D0456A.

*Original Signed*

R F P Felton CBE
Lt Gen
DG DSA – Convening Authority

Annex:

A. Terms of Reference for the Service Inquiry into the Hercules (ZH 873) Heavy Landing [redacted] on 25 Aug 17.

**TERMS OF REFERENCE FOR THE SERVICE INQUIRY INTO THE HERCULES C-130J Mk4 (ZH873) HEAVY LANDING INCIDENT [redacted] ON 25 AUG 17**

1. As the nominated Inquiry Panel for the subject SI, you are to:

a. Investigate and, if possible, determine the cause of the occurrence, together with any contributory, aggravating and other factors and observations.

b. Examine what procedures, orders and instructions were applicable to the duty sortie, with a particular focus on the landing phase, whether they were appropriate and complied with and establish, investigate and assess any identified departures.

c. Establish the level of training, relevant competencies, qualifications and currency of the individuals involved in the activity.

d. Investigate the appropriateness of the crew constitution and the wider manning measures to include the roulement, arrival in theatre and handover arrangements.

e. Review the levels and extent of authority and supervision covering the duty sortie.

f. Identify if the levels of planning and preparation were commensurate with the activity's objectives.

g. Examine the governance of such operational tasking to include; assessing the process used to determine the requirement for sorties to this type of location and review the arrangements for approval by means of Operational Emergency Clearances.

h. Investigate and comment on relevant fatigue implications of individuals' activities prior to the matter under investigation.

i. Determine the status of any relevant equipment including serviceability status, defects or deficiencies.

j. Ascertain value of loss/damage to Service property/equipment.

k. Review whether the Post-Incident Management Arrangements including crew decisions and inspections were carried out correctly and were appropriate.

l. Assess any Health and Safety at Work and Environmental Protection implications in line with JSP 375 and JSP 418.

m. Determine and comment on any broader organisational and/or resource factors.

n. Report and make appropriate recommendations to DG DSA.

You are to ensure that any material provided to the Inquiry by the United States, or any other foreign state, is properly identified as such, and is marked and handled in accordance with MOD security guidance. This material continues to belong to those nations throughout the SI process. Before the SI report is released to a third party, authorisation should be sought from the relevant authorities in those nations to release, whether in full or redacted form, any of their material included in the SI report, or amongst the documents supporting it. You are not to make a judgement on the origin of any classified material. The relevant NATO European Policy or International Policy and Plans team should be informed early when dealing with any foreign state material.

2. The Terms of Reference above have been designed to be wide ranging in order to ensure that you have the freedom to investigate wherever the evidence leads. During the course of your investigations, should you identify a potential conflict of interest between the CA and the Inquiry, you are to pause work and take advice from your DSA Legal Advisor and DG DSA.

3. If at any stage the Panel discover something they perceive to be a continuing hazard presenting a risk to the safety of personnel or equipment, the President should alert DG DSA without delay; in order to initiate remedial actions immediately. Consideration should also be given to raising an Urgent Safety Advice note.

4. Very particular care will be necessary regarding the classification and handling of the evidence and reporting for this SI.

# PART 1.3

## Narrative of Events

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## TABLE OF CONTENTS – PART 1.3

## PART 1.3 – NARRATIVE OF EVENTS

All times Local.

### Synopsis

### Introduction

1.3.1. On 25 Aug 17, the crew of Hercules C130J[1] ZH873 was tasked to conduct a Exhibit 1
routine resupply mission in support of operations. At 2356 hours (hr), it impacted upward
sloping terrain short of the runway while conducting a Military Operating Standard (MOS) Exhibit 2
approach to a semi-prepared[2] Temporary Landing Zone (TLZ), at night on Night Vision
Goggles (NVG). The pilots initiated a go-around post the ground impact, and recovered the Witness 1
aircraft to a diversion airfield.

1.3.2. The aircraft, from No. 47 Squadron (47 Sqn) based at RAF Brize Norton (BZN),
formed part of the Hercules Detachment (Herc Det) of 903 Expeditionary Air Wing (EAW) at
RAF Akrotiri (AKR). The crew consisted of two pilots, two Weapon Systems Operator Exhibit 2
(Crewman) (WSOps 1 and 2), two Aircraft Ground Engineers (AGEs 1 and 2), two
signallers and a movements specialist. The two pilots, AGE 1 and WSOp 1 were located Exhibit 3
on the flight deck, with the remaining personnel located in the cargo compartment. The
Aircraft Commander (Acft Cdr) was the Pilot Flying (PF) and occupied the left-hand seat, Witness 1
whilst the co-pilot was the Pilot Non-Flying (PNF) sat in the right-hand seat.

1.3.3. The impact with the ground resulted in the crew being subjected to relatively Exhibit 363
moderate forces. Although these were subsequently determined as below the injury
thresholds for significant musculoskeletal or life threatening injuries, 2 crew members were
downgraded from flying duties for more than 2 months.

1.3.4. The damage to ZH873 was assessed as Category 5 (Component)[3]. Exhibit 4

### Pre-Accident Events

### Crew Composition

1.3.5. Both pilots of ZH873 were Hercules Flying Instructors. The PF was seconded from Witness 2
No. XXIV Sqn (XXIV Sqn) (the Hercules Operational Conversion Unit (OCU)) for this Witness 3
detachment; he had not flown on operations for more than 3 years and was not current for Witness 3
flying hours. His last live MOS landing to a Natural Surface TLZ (Natural Surface Exhibit 5
Operations (NSO)) had been in Apr 17; he had not flown to this TLZ prior to the accident. Witness 1
The PNF had been assigned to 47 Sqn in Sep 16 and had completed 20 NSO landings in Exhibit 6
the 7 months prior to the accident. He had been the PNF for a similar task to the same TLZ Witness 4

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[1] Here in after, the term Hercules is used to refer specifically to the Hercules C130J unless stated otherwise.

[2] A Semi-Prepared Natural surface has been graded to remove natural undulations and potentially compacted to increase firmness of the substrate.

[3] MAA 02 Master Glossary: The aircraft is beyond economic repair, or is surplus, but is recoverable for breakdown to components and spare parts.



 

in Dec 16.

1.3.6. Following their nomination, both pilots set about conducting the mandatory pre-deployment preparation which included several administrative tasks, a pre-deployment interview and a simulator serial designed to highlight some of the specific nuances of this detachment.

Exhibit 7
Exhibit 8
Exhibit 9

## Sortie Details and Preparation

1.3.7. Both pilots arrived at AKR on 22 Aug, and joined the other crew members who were already in theatre coming to the end of their deployment cycle. On arrival both pilots conducted a reading-in process and were given a handover from one of the off-going pilots.

Witness 4b
Witness 1h
Exhibit 10
Witness 1
Exhibit 11

1.3.8. They were informed by the Detachment Commander (Det Cdr) that their first tasking would be on 25 Aug. The sortie had been generated by the Tactical Command (TACOM) authority several weeks prior to the event, and was planned to be a routine logistics re-supply to a known location. On 20 Aug, the Det Cdr completed the Operational Risk Matrix (ORM) for the sortie and passed it up the Operational Chain of Command (CofC) to obtain necessary clearances and approvals.

Witness 1b
Witness 5
Witness 5

1.3.9. Final detailed planning for the sortie was conducted in the days prior the event. The pilots were cognisant that the task required use of an Operational Emergency Clearance (OEC), and focussed on creating a robust fuel plan to mitigate the potential of an over-weight landing at the TLZ. Two sources of information relating to the TLZ's layout were available; a report generated by RAF Tactical Air Traffic Control (TACATC), and the other created by the TLZ operator. The pilots were aware of discrepancies between the two documents, especially regarding runway slope; they decided to use the partner nation survey and assess which way the runway sloped when they arrived at the TLZ.

Witness 1
Witness 4b
Witness 5
Witness 4b
Witness 1
Exhibit 18
Exhibit 19
Exhibit 20
Witness 4

1.3.10. On 25 Aug, the PF and PNF awoke at 0900 hr and 0700 hr respectively, and both had a nap in the afternoon prior to reporting for duty at 1800 hr. After arriving at Herc Det Operations the PNF attended a meteorological briefing for the mission, but this didn't contain details of the weather or light levels at the TLZ. Concurrently, the rear-crew collected the equipment required for the sortie including personal weapons, NVG and Body Armour Load Carrying System (BALCS).

Witness 1
Witness 4
Witness 4c
Witness 1d
Exhibit 12
Witness 6

1.3.11. After collecting equipment and obtaining the meteorological details, the crew assembled at Herc Det Headquarters (HQ) for a crew brief. On completion, the rear-crew left Herc Det HQ to start preparing the aircraft, whilst the pilots stayed behind to complete mission planning and obtain authorisation[4] for their mission from the Det Cdr. The PF was authorised as the Acft Cdr, and an Out Brief was completed in accordance with the operational Flying Order Book. None of the crew used the Hoffman Test Box to check their NVG for serviceability and correct focus.

Witness 1
Exhibit 2
Witness 5
Exhibit 21

1.3.12. Subsequently, the pilots proceeded to their expected parking location of ZH873; however, this was incorrect, requiring them to relocate to the other end of the airfield. On

Witness 1
Witness 4b

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[4] MAA 02 Master Glossary: Approval given to an individual and recorded in an appropriate record.

their delayed arrival, at 2020 hr, they were informed by a crew member that the required take off time was 2050 hr, ten minutes earlier than expected.

Exhibit 2

## Sortie Execution

1.3.13. The aircraft checks and start-up were completed, and ZH873 departed AKR at 2054 hr. The departure, climb-out and transit towards the TLZ were flown without incident, although two technical failures occurred; a Head Down Display (HDD) failed, as did a switch on the Cursor Control Panel (CCP). The latter fault removed the ability to display a cursor in the Head Up Display (HUD), prevented them from using the Digital Mapping Unit (DMU) and required reversion to a pre-marked paper chart. The aircraft also developed a noticeable, but temporary, pitch phugoid (oscillation) estimated at 0.25 Hz.

Witness 1
Witness 4b
Witness 1
Witness 1 c
Exhibit 13
Exhibit 14

1.3.14. At approximately 2320 hr the crew completed Combat Entry Checks (CEC) in readiness for entering a non-permissive environment. This consisted of donning BALCS, flying helmets and NVGs, and reconfiguring the aircraft lighting to be NVG compatible internally and Infrared (IR) externally.

Witness 1
Witness 6
Exhibit 15

1.3.15. Immediately prior to descent the crew completed the LZ Pre-Assault Checks, and confirmed their landing performance having obtained the weather details at the TLZ. In the cargo bay, AGE 2 and WSOp 2 positioned themselves as door observers in the paratroop doors to ensure 360-degree lookout for hostile action from the ground, and to manually operate the Defensive Aids Suite (DAS) if required. Following completion of the checks, the aircraft began to depressurise; the aircraft's Advisory Caution and Warning System (ACAWS) activated, alerting the crew that the cabin altitude had exceeded 10,000 ft. A descent was initiated and the crew inhibited automatic deployment of the passenger oxygen system.

Exhibit 15
Witness 1
Exhibit 16
Exhibit 17

1.3.16. The TLZ was acquired visually by both pilots and the aircraft was descended, slowed and configured for landing by approximately 8-9nm. Final approach was established at approximately 3nm and the PF flew a 2.5° glideslope to an aiming point towards the front of a 500ft long IR marked touchdown box which indicated the start of the runway.

Witness 4
Witness 1

## Accident Events

1.3.17. The initial approach was largely uneventful, bar the PNF needing to prompt the PF twice that his approach speed was too fast, which he corrected to be within tolerance by approximately 50ft AGL. In the latter stages of the approach, as requested by the PF, the PNF provided a Radar Altimeter (RadAlt) talk down which the PF could use to judge his height above the ground. Although both pilots had visually acquired the TLZ with little difficulty due to the IR marked touchdown box, both found the final approach to be very dark with little visual acuity. The PF reported that at 50ft he couldn't see much in terms of ground definition and the PNF described the visual cues as very monochromatic.

Witness 4
Witness 1
Witness 1a
Witness 4
Witness 1a

1.3.18. As the PNF called 20 feet, both pilots recalled that the ground *'appeared to rise up at the aircraft'* and the aircraft made heavy contact with the ground at 2356 hr, approximately 400 ft short of the runway.

Witness 4
Witness 1
Exhibit 28
Exhibit 29

1.3.19. The impact caused both pilots' helmets to rotate forward, partially obscuring their vision, and misaligning their NVG's. The PF's NVG counterbalance weight detached from

Witness 1
Witness 4b

 

his helmet, further exacerbating the misalignment of his helmet. Other items stowed on the flight deck became detached, including a rifle that broke free from its stowage rack on the port side of the cockpit. In the cargo compartment, the door observers were thrown forward from their seats, which are not equipped with a restraining harness. The load was restrained; however, the starboard cargo locks became unlocked, and individual load items shifted within the confines of their pallets and covering cargo nets. Witness 4 Witness 6

1.3.20. Immediately following the impact the aircraft bounced, the PF initiated a go-around and following subsequent bounces the aircraft began to climb away. The impact had been sufficiently violent to cause the aircraft to veer left, initially climbing away on a heading approximately 20 degrees displaced from the runway centre line. Witness 1 Witness 4

## Post-Accident Events

1.3.21. Having regained stable flight in a climb, the crew recognised that the aircraft had exceeded its structural limitations and would require engineering assessment after landing. This precluded a return to the TLZ, so the mission was aborted and preparations commenced for a return to AKR. However, while in the climb, the PNF noted that the aircraft was not pressurising sufficiently; concurrently the crew in the cargo compartment reported a *'whooshing sound'* that was assessed potentially as air escaping through the fuselage adjacent to the port wing root. Following discussion between the crew, the decision was made to divert direct to the nearest suitable and secure location. Witness 1 Witness 4 Witness 6

1.3.22. At this point the crew informed Herc Det HQ via satellite phone about the incident and intent to divert. Herc Det HQ then informed the Det Cdr, 903 EAW watch keeper and the TACOM (within the Defence Advisory Team (Iraq) (DAT(I)) about ZH873's situation. Witness 5

1.3.23. The pilots agreed to switch responsibilities with the former PNF taking control of the aircraft for the landing at EIA. Witness 4 Witness 1

1.3.24. Prior to the approach at EIA, given concern that the landing gear may have sustained damage and fail to function properly, despite correct cockpit indications, AGE 1 viewed the landing gear through cabin inspection windows to ensure it was fully deployed. As a further precaution, crew in the cargo compartment held fire extinguishers in case of further system failures, damage or fire upon landing. Witness 7 Witness 1 Witness 4

1.3.25. The aircraft landed without further incident.

## Post-Crash Management

1.3.26. After landing, the pilots contacted the Det Cdr to provide an initial update. Concurrently the AGEs completed an inspection of the aircraft to ascertain what damage had been sustained. Witness 1 Witness 4 Witness 5 Exhibit 23

1.3.27. Damage was found in the form of rippling of the aircraft skin and pulled rivets. Given previous experience where similar effects had resulted in a Category 4[5] damage assessment, AGE 2 approached the DAT(I) Deputy Air Commander (DAC) for advice. Exhibit 24 Exhibit 362

[5] MAA 02 Master Glossary: The aircraft is repairable but it is considered to need special facilities or equipment not available on site. The repair would be carried out at a MOD facility or contractor's works.

Following further consultation between the DAC and Hercules Det Cdr it was decided as a prudent precaution to treat the hard landing as a potential accident and follow the relevant reporting guidelines in accordance with Military Aviation Authority (MAA) Regulatory Article (RA) 1410.

1.3.28. No formal Aircraft Post Crash Management (APCM) plan was activated, however, once an accident had been declared for reporting purposes, appropriate documentation was quarantined at DAT(I) by the Detachment Security Officer and at AKR by the Det Cdr. Exhibit 24

1.3.29. In order to preserve evidence and sanitise the aircraft, the AGEs removed all encrypted equipment as well as the Digital Flight Data Recorder (DFDR) and the Cockpit Voice Recorder (CVR). The aircraft was sealed and placed under continuous protection. Exhibit 24 Exhibit 25 Witness 7

1.3.30. All members of the crew were offered Role 1 medical facilities for any injuries; however, none required medical treatment at the time. Exhibit 24

1.3.31. The crew, and all items removed from the aircraft, were recovered to AKR on 27 Aug. Upon return, all of the crew reported to the AKR Medical Centre with back and neck injuries, and subsequently one member was hospitalised for further diagnosis. Witness 4

1.3.32. All crew members were offered Trauma and Incident Management support. Exhibit 24

## PART 1.4

## Analysis and Findings

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# TABLE OF CONTENTS – PART 1.4

# PART 1.4 – ANALYSIS AND FINDINGS

All times Local.

## Introduction

1.4.1. At 2054 hr, 25 Aug 17, Hercules C-130J[1] C Mk 4 ZH873 launched from RAF Akrotiri (AKR), Cyprus, to deliver cargo to a surveyed natural surface Temporary Landing Zone (TLZ[2]). Exhibit 2

1.4.2. The crew of ZH873 comprised 2 Pilots, 2 Weapon System Operators (Crewman) (WSOps), 2 Aircraft Ground Engineers (AGE), 2 Signallers and 1 'Mover' (colloquial term for logistics personnel). The Hercules Force utilises a crew composition of Pilot Flying (PF) and Pilot Non-Flying (PNF), where the PF flies the aircraft while the PNF operates the radios, navigates and offers support to the PF. Both pilots were qualified to act as PF or PNF and, as both were Flying Instructors (FIs), either could have been authorised as aircraft commander. Exhibit 2 Exhibit 3 Exhibit 5 Exhibit 6 Exhibit 26

1.4.3. Other than a failure of a Head Down Display screen (HDD), the Cursor Control Panel (CCP) and a temporary phugoid[3], the transit was uneventful; the TLZ was acquired visually and the aircraft was descended, slowed and configured for landing by approximately 8-9 nautical miles (nm) from the TLZ. The approach was commenced at 3 nm with the Aircraft Commander as the PF in the left-hand seat flying the aircraft; by 1.5 nm the aircraft was established on the extended centreline and 475 ft Above Ground Level (AGL). As the aircraft neared the final stages of the approach the PNF commenced calling the vertical height as indicated on the Radar Altimeter (Rad Alt). Both pilots stated in interview that, as the PNF called 20 ft, the ground appeared to rise up at the aircraft and the aircraft made heavy contact with the ground short of the Touchdown Box[4]. The crew believed that the aircraft had contacted the ground approximately 50 to 100 ft short of the Touchdown Box; however subsequent evidence indicated that the actual point of impact was on an upslope 400 ft short of the runway, some 100 ft short of the overrun. Exhibit 14 Witness 4b Witness 1 Witness 1 Witness 4 Exhibit 27 Exhibit 169 Exhibit 108

1.4.4. On impact, the aircraft bounced, and the PF commenced a Go-Around. Pilot testimony indicated that it began to climb away on a heading estimated to be 20° left of the runway centre. In so doing, it was assessed that ZH873 passed close to a berm/wall that runs parallel to the runway. Witness 1 Witness 4

1.4.5. Recognising they had experienced a hard landing[5] the crew aborted the mission and continued to climb away with the intent of returning to AKR. Subsequently, the PNF noted that the aircraft could not pressurise sufficiently; concurrently crew in the rear of the aircraft heard a whooshing sound that was assessed potentially as air escaping through the fuselage aft of the port wing root. This resulted in a decision to divert to the nearest suitable and secure location. Witness 4 Exhibit 30

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[1] The terms Hercules C-130J, Hercules and C-130J are used interchangeably throughout this report.

[2] A Temporary Airfield or Temporary Landing Zone (TLZ) is defined as a natural, semi-prepared or prefabricated strip with surface, slope, dimensions, load bearing capacity and clearance from obstruction sufficient to allow suitably trained crews to land and take-off aircraft safely in specified weather conditions. (MAA Manual of Aerodrome Design and Safeguarding Issue 8).

[3] Of or relating to a long-period oscillation in the longitudinal motion of an aircraft, rocket, or missile.

[4] A 500 ft long "box" indicating the start of the runway which is preceded by a 300ft overrun prepared to the same standard. At night, the box is marked by Infrared (IR) markers positioned at each corner.

[5] The PNF noted a 3.2g indication on his HUD; the limit is 2.5g. Subsequent analysis indicated that the actual impact had been 4.225g.

1.4.6. Prior to commencing the approach at the diversion airfield, the crew in the rear of the aircraft prepared themselves in case of further system failures, aircraft damage or fire upon landing. Additionally, given concern that the landing gear may have sustained damage at the TLZ, the rear crew confirmed its condition by viewing the undercarriage through inspection windows. The diversion and subsequent landing were achieved without further incident. Exhibit 362

## Methodology

### Accident Factors

1.4.7. Once an accident factor had been determined to have been present, the Panel considered its relation to the accident before assigning it to one of the following categories:

a. **Causal Factor.** 'Causal factors' are those factors which, in isolation or in combination with other causal factors and contextual details, led directly to the incident or accident. Therefore, if a causal factor was removed from the accident sequence, the accident would not have occurred.

b. **Contributory Factor.** 'Contributory factors' are those factors which made the accident more likely to happen. That is, they did not directly cause the accident. Therefore, if a contributory factor was removed from the accident sequence, the accident may still have occurred.

c. **Aggravating Factor.** 'Aggravating factors' are those factors which made the final outcome of the accident worse. However, aggravating factors do not cause or contribute to the accident. That is, in the absence of the aggravating factor, the accident would still have occurred.

d. **Other Factor.** 'Other factors' are those factors which, whilst shown to have been present played no part in the accident in question, but are noteworthy in that they could cause, contribute to or aggravate future accidents. Typically, other factors would provide the basis for additional recommendations or observations.

e. **Observation.** Observations are points or issues identified during the investigation that are worthy of note to improve working practices, but which do not relate to the accident being investigated and which could not contribute to or cause future accidents.

### Human Factors Modelling

1.4.8. The Panel exploited a bespoke Human Factors (HF) investigation approach which has been developed at the Royal Air Force Centre of Aviation Medicine (RAF CAM). Based on aviation psychology, HF literature and experience gained from undertaking in excess of 60 military air accident investigations, it utilises the Accident Route Matrix (ARM). The ARM is based on the systematic and validated Exhibit 359 framework of the Human Factors Analysis Classification System (HFACS)[6] which is grounded in James Reason's Swiss Cheese Model[7]. RAF CAM has adapted HFACS for use during accident investigations by analysing the type of HF issue, the time of effect, and the impact of that issue in the accident sequence.

1.4.9. The Panel drew further from Reason's work in its analysis of evidence across the following categories:

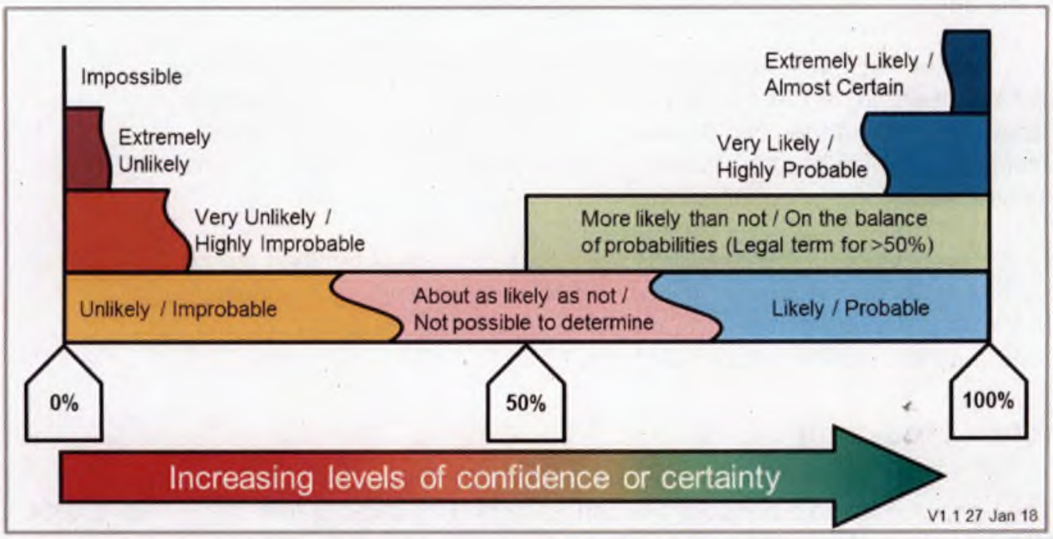
a. Error Promoting Condition (EPC). The psychological, physical/mental limitations and physiological factors that can influence human performance, ie capacity, fatigue, etc.

b. Organisational Influences. The broader (often indirect and latent) influences that a higher organisation brings to bear on those involved in an occurrence, and which are beyond those individuals' control in terms of resources, climate, etc.

c. Breached (or failed) Defences. Those rules, orders, practices and procedures designed to assure the safe operation of aircraft, which failed or were breached by those involved.

## Probabilistic Language

1.4.10. The terminology used in this Report (Figure 1) is based on terms published by the Intergovernmental Panel on Climate Change (IPCC) in their Guidance Note for Consistent Treatment of Uncertainties[8] as well as the Australian Transport Safety Bureau (ATSB) in their paper on Analysis, Causality and Proof in Safety Investigations[9].




[6] Weigmann, D.A. and Shappell, S.A. (2003). *A Human Error Approach to Aviation Accident Analysis*. Ashgate: Aldershot, UK.

[7] Reason, J. (1990). *Human Error*. Cambridge, UK: Cambridge University Press.

[8] https://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf

[9] https://www.atsb.gov.au/media/27767/ar2007053.pdf

**Figure 1 – Probabilistic Terminology**

## Available Evidence

1.4.11. The Panel had access to the following evidence:

a. Interviews.

b. Digital Flight Data Recorder (DFDR), Cockpit Voice Recorder (CVR) and Data Transfer and Debrief System (DTADS) data from ZH873.

c. Satellite and Light Detection and Ranging (LIDAR) Imagery.

d. Relevant orders.

e. All relevant publications including flying logbooks, aircraft documentation, sortie planning, briefing materials and engineering documentation.

f. Physical examination of ZH873.

g. Aircrew Equipment Assemblies (AEA), Night Vision Goggles (NVG) and Body Armour Load Carrying System (BALCS).

h. Defence Accident Investigation Branch (DAIB) Report.

i. RAF CAM Human Factors Report.

j. RAF CAM Accident Investigation Report.

k. 1710 Naval Air Squadron Examination of Paratroop Door Seats.

l. Hercules C-130J and A400M Atlas simulators at RAF Brize Norton.

m. Flight safety related material, including previous accident reports.

n. Air Test and Evaluation Centre (ATEC) Flight Physics Analysis.

o. Air Warfare Centre (AWC) Trial ILLUMINATOR.

p. QinetiQ IR Lights Report.

1.4.12. The Hercules is equipped with a Cockpit Voice Recorder (CVR). This is a 4-channel digital recorder that records audio from the cockpit area microphone and the pilot and co-pilot microphones. The 4th channel records the time stamp from the DFDR. Thirty minutes of recorded ICS microphone channel data is stored in memory before erasure and re-recording. Exhibit 357

1.4.13. Thus, although the CVR was serviceable and available, all data relating to the TLZ final approach and landing was overwritten during the aircraft's subsequent diversion. Additionally, the aircraft remained under electrical power on the ground while hard landing checks were completed by the AGEs, thereby overwriting the last Witness 6 Exhibit 362

30 minutes of flight. As a result, the only objective evidence available to the Panel regarding the pilots' actions during approach to and landing at the TLZ was that contained within the DFDR. The non-availability of the CVR evidence resulted in greater reliance on subjective evidence from witness statements to understand the accident's sequence of events.

1.4.14. Such subjective evidence is considered less reliable as it may be distorted due to stress (it is natural for stress to affect event processing and recall), hindsight bias (it is natural to perceive data differently with hindsight), and distortion/decay (it is natural for memories to become distorted or forgotten over time). Consideration was given during the analysis to the time since the accident at which the statement was made; and witness interviews and statements were evaluated in relation to the objective evidence with any discrepancies being explored further. Exhibit 359

## Services

1.4.15. The Panel was assisted by the following personnel and agencies:

a. DAIB.

b. RAF CAM.

c. Air Officer Commanding (AOC) No 2 Group (Gp), also the Operating Duty Holder (ODH).

d. Station Commander RAF Brize Norton (BZN), also the Delivery Duty Holder (DDH).

e. [redacted]

f. Air Mobility Force (AMF).

g. RAF Safety Centre (RAFSC).

h. Hercules Project Team (HPT).

i. QinetiQ (QQ) Boscombe Down (BD).

j. Defence Geographic Centre (DGC) and Joint Forces Intelligence Group (JFIG).

k. RAF Akrotiri (AKR).

l. 903 Expeditionary Air Wing (EAW).

m. Defence Advisory Team (Iraq) (DAT(I)).

n. 47 Squadron (Sqn).

o. XXIV Sqn.

p. United States Air Force Safety Centre.

q. Lockheed Martin (LM).

r. 1710 Naval Air Squadron.

s. QinetiQ Human Systems Technology, Farnborough.

## Factors Considered by the Panel

1.4.16. With respect to the accident, the Panel analysed the following key areas:

a. Flying Technique.

b. Training, Competence and Recency.

c. Regulations and Orders.

d. Planning and Preparation.

e. Authorisation and Supervision.

f. Human Factors (HF) and Crew Resource Management (CRM).

g. The Prevailing Environmental Conditions.

h. Aircraft Serviceability.

i. Aircraft Post-Crash Management.

j. Organisational and Systemic Factors.

k. Safety Management.

# Background

## Hercules Force

1.4.17. The Hercules is a component of the Air Mobility Force (AMF), which operates under the command of Air Officer Commanding (AOC) No 2 Group (2 Gp). Exhibit 32

1.4.18. The Hercules Force consists of 20 aircraft split between 2 squadrons (Sqn). Exhibit 33

a. No XXIV Sqn (XXIV Sqn) is the Air Mobility Operational Conversion Unit (OCU), responsible for the provision of training to aircrews flying the Hercules C-130J and A400M Atlas aircraft; in addition, XXIV Sqn's Maintenance Training School is responsible for training engineers to maintain the C-130J Hercules, A400M Atlas and C17 Globemaster aircraft.

b. No 47 Sqn (47 Sqn) is the operational Hercules sqn, delivering support to current and contingent operations.

## 47 Squadron

1.4.19. 47 Sqn is manned with 25 crews of varying competencies, described by the Officer Commanding (OC) against the following definitions: Exhibit 33

a. Tier 5: recent graduates of the OCU and able to support Strategic Air Transport (AT) tasks in permissive[10] environments.

b. Tier 4: capable of conducting Strategic AT in non-permissive[11] environments. Qualified to conduct tactical approaches whilst wearing Night Vision Goggles (NVG) and trained in the use of Infrared (IR) Defensive Aid Suite (DAS).

c. Tier 3: Tactical (Tac) AT capable: Tier 4 plus low level flying (day and night), operations to TLZs, operations to unpaved runways (Natural Surface Operations (NSO)), Tactical Formation Flying, Air to Air Refuelling (AAR), paratroop drops and aerial delivery of stores.

d. Tier 2: Tier 3 plus advanced parachute and boat drops.

e. Tier 1: Tier 2 plus use of Radio Frequency (RF) DAS.

1.4.20. At the time of the accident 47 Sqn was split into 2 Flights (Flt): Exhibit 33

a. A Flt: 15 crews, comprising Tiers 3 and 4.

b. F Flt: 10 crews, comprising Tiers 1 and 2.

## Hercules Detachment

1.4.21. The Hercules Detachment (Herc Det) at AKR provided an AT capability, comprising 3 aircraft, to support OP SHADER, Ministry of Defence [redacted] requirements and Broader Middle East (BME) tasking in the Arabian Gulf. The detachment consisted of approximately 40 support personnel and 3 flying crews. Of these crews, two were Tier 3 qualified and the third was a Tier 1 crew. The latter was specifically required for the task on 25 Aug 17. Witness 5f

1.4.22. Command and Control (C2) of the aircraft was split between two chain of commands dependent on aircraft tasking, as indicated in Table 1. Exhibit 22

[10] An environment in which friendly forces anticipate no obstructions to, or interference with, operations. NATO AAP-06
[11] An environment in which friendly forces anticipate obstructions to, or interference with, operations. NATO AAP-06

| | OP SHADER / BME | [redacted] Tasks |
|---|---|---|
| **Operational Command (OPCOM)** | Commander Joint Operations | [redacted][12] |
| **Operational Control (OPCON)** | Air Component Commander | [redacted] |
| **Tactical Command (TACOM)** | Commanding Officer 903 EAW | Defence Advisory Team (Iraq) Air Cdr |
| **Tactical Control (TACON)** | Herc Det Cdr | Herc Det Cdr |

**Table 1 - Operational Command Chain**

1.4.23. The mission undertaken by the crew of ZH873 on 25 Aug 17 was a [redacted] task.

## The Task

1.4.24. A requirement for an Air Line of Communication (ALOC) had been identified in Aug 16 to generate one resupply sortie every 4-6 weeks to an established, semi-prepared TLZ operated by a partner nation. Witness 8

1.4.25. The task was met initially by deploying a crew to AKR from the UK as and when mission requirements were identified. Due to the location of the TLZ, the threat assessment required that the crew should be Tier 1 qualified. Witness 8 Witness 9

1.4.26. By Feb 17, the resupply requirement had increased, necessitating up to 2 sorties per week. Air Command proposed a number of options, the result being that a Tier 1 crew was permanently positioned at AKR in support of the task, with the deployment roster managed by 47 Sqn F Flt. Witness 9 Exhibit 34 Exhibit 37 Witness 9

1.4.27. The capability deployed by AOC 2 Gp in support of [redacted] requirements was articulated in an Operational Capability Certificate (OCC). This declared a Force Element of 1 Hercules with crew and support personnel, and a defined number of flying hours per month, including the following roles and capabilities: Exhibit 22

a. Day and night AT for movement of passengers and freight, including Aero-Medical evacuation.

b. Day and night operations to TLZs, including NSO.

[12] OPCOM transferred from CJO to [redacted] two hours prior to take off until one hour after recovery to AKR.

1.4.28. The OCC also granted a standing dispensation for use of Military Operating Standards (MOS), as required for the mission on 25 Aug 17 (see paragraphs 1.4.444 *et seq*). Exhibit 22 Exhibit 39

1.4.29. The Panel determined that:

a. The capability outlined by the OCC met the requirement of the Operational Commander, and that this could be delivered by a correctly generated, trained and supervised Tier 1 crew.

b. The task was governed by appropriate and comprehensive orders. Exhibit 22 Exhibit 38 Exhibit 21

1.4.30. The Panel concluded that the task was **Not a Factor**.

## Crew Deployment Management

1.4.31. The deployment of Tier 1 crews was planned and managed by the 47 Sqn F Flt Pilot Leader who, supported by his deputy, was responsible for arranging the detachment, exercise and leave programmes of F Flt pilots. This included the task at AKR, 4 lines of National Standby tasking, and up to 12 exercises per annum. Witness 11 Witness 3 Witness 9

1.4.32. Following the requirement to deploy a Tier 1 crew permanently to AKR, detachments were planned to be between 6 and 8 weeks in duration. Additionally, the intent was to programme crews up to 12 months in advance, allowing them to plan other commitments around what had become an enduring requirement. Witness 5b Witness 11

1.4.33. In Apr 17, a series of exercises, other enduring task lines and loss of personnel meant the Deputy Pilot Leader had difficulty manning the Tier 1 deployment from within F Flt for a 10-day period in Aug 17. Through utilisation of the Hercules Force planning application he identified that the PF and PNF were the only Tier 1 qualified pilots available for deployment at that time. As the PF was from another squadron, the Deputy approached him regarding his availability to deploy to which he indicated that he was available and would benefit from the operational experience given that he hadn't deployed for over 3 years. Witness 3

1.4.34. The Pilot Leader and Deputy informed their Flt Cdr, and entered the PF onto the detachment programme. However, during interview neither could state whether this required formal approval from either XXIV or 47 Sqns, or who would be responsible for assuring the PF's currencies and competence. (See paragraph 1.4.509) Witness 3 Witness 11

1.4.35. Although both XXIV and 47 Sqn command chains were aware of the PF's inclusion onto the detachment roster, the Panel found no evidence that any formal consideration appeared to have been given to assess his suitability to undertake the task. The lack of dialogue between 47 and XXIV Squadrons at a higher level was a missed supervisory opportunity to assess the PF's recent flying experience and identify any training requirements that could arise from it. (see paragraphs 1.4.506 *et seq*). Exhibit 41 Exhibit 42

1.4.36. The Panel concluded that the Crew Deployment Management by the Pilot Leader and Deputy was **Not a Factor** in the accident.

## Crew Pre-Deployment Training

1.4.37. The Panel examined the Pre-Deployment Training (PDT) required for crews. Interview testimony consistently referred only to the Individual Readiness Training elements of the Preparatory Instructions (see paragraph 1.4.47 *et seq*) and a Pre-Deployment simulator serial. Witness 9 Exhibit 43 Exhibit 44

1.4.38. The PF and PNF conducted a Pre-Deployment simulator serial on 8 Aug 17, which lasted for 2 hours. Exhibit 45

1.4.39. No formal reference could be found mandating crews to undertake the PDT simulator serial. The requirement appeared to have been generated from within 47 Sqn during Autumn 16, initially as a specific mission rehearsal for the crews that were deploying on an ad hoc basis. However, the Panel noted that, in Dec 16, the ODH had required 2 Gp Standardisation and Evaluation Unit (STANEVAL) to review the Pre-Deployment Simulator Mission Rehearsal as part of a Duty Holder Advice Note (DHAN) Addendum that re-instigated an Operational Emergency Clearance (OEC) for heavier weight landings to TLZs (see paragraphs 1.4.427 et seq). Exhibit 9 Exhibit 46

1.4.40. No evidence could be found of any such review having formally taken place. However, the Panel was informed that the serial had been witnessed by a STANEVAL Hercules pilot and that his observations were incorporated into the design of the Pre-Deployment package. Exhibit 47 Exhibit 48

1.4.41. In Apr 17, the Flt Cdr F Flt Operations (Ops) sought to standardise the profile and emailed XXIV Sqn with specific serialised sortie content consisting of: Exhibit 9

a. Tactics, Techniques and Procedures (TTPs) relevant to this operational theatre.

b. Natural Surface Operations at increased all up masses (OEC 022).

c. Ferry Flight (specifically take-offs)[13].

1.4.42. Although performance data relating to Ferry Flight is contained within the Hercules Operating Data Manual (ODM), it is prohibited by the Hercules Release to Service (RTS), Aircrew Manual (ACM) and 2 Gp ASOs. Exhibit 49 Exhibit 50 Exhibit 51

1.4.43. The DDH indicated that contingency planning had identified a potential scenario wherein an aircraft with only 3 serviceable engines could be placed in operational danger at an in-theatre location, and the safest option could be to launch in that configuration. As a precaution, it was deemed prudent to have given crews simulated experience so that, were it to arise, the ODH would be better placed should he wish to consider approving such an option. The procedure taught was based on that used by the Italian Air Force, and verified by Exchange Officers. Exhibit 48

1.4.44. The Panel assessed that:

a. The tactical content of the Pre-Deployment simulator serial promulgated by 47 Sqn F Flt was appropriate as a Mission Rehearsal.

[13] Ferry Flight is that for which one engine/propeller combination is unserviceable at the beginning of the flight (take-off).

b. Inclusion of Ferry Flight was a prudent decision that had DH approval.

1.4.45. The Panel concluded that Pre-Deployment training was **Not a Factor;** however, see paragraph 1.4.562 *et seq* regarding the simulator's fidelity for TLZ/MOS/NSO training.

1.4.46. The Panel **Observed** that the Pre-Deployment Simulator Serial's informal promulgation meant that it would not be subject to periodic review or assurance.

## Pre-Deployment Administration

1.4.47. All personnel deploying to AKR are required to be prepared in accordance with: Exhibit 52 Exhibit 53 Exhibit 54 Exhibit 55 Exhibit 56 Exhibit 57 Exhibit 58 Exhibit 59

a. Leaflet 1511 to Air Publication (AP) 3392 Vol 2 (The Management of Personnel Nominated for Deployed Operations and Actions to be taken by Unit HR Staff).

b. AP 9012 (RAF Stress Management and Resilience Policy) Chapter 4 Annexes A, B and D.

c. HQ Air Command (HQ AIR) Preparatory Instructions (PI) for Op SHADER or [redacted] Operations.

d. 2 Gp Air Staff Order (ASO) 2305.100.5 (Pen Pictures).

1.4.48. The PI is generic in nature and covers the spectrum of Operational deployments from those involving Formed Units (FU) through smaller Non-Formed Units (NFU) down to Individual Augmentees (IAs). For example, AP 9012 Chapter 4 Annex B states: *'When small groups or detachments are deployed and do not constitute a FU or NFU deployment, a management plan for these individuals should be developed by the* [Parent Unit] *and should be based on the principles of this policy. This is particularly relevant in units where multiple short duration deployments are part of the standard deployment routine. ... Examples of these groups are single AT crews flying in and out of operational theatres.'*

1.4.49. The final element of the administration process is completion of a Pre-Deployment Interview (PDI), the purpose of which is to: Exhibit 57

a. *'Identify and assist in the management of any issues that, if left unresolved, may adversely affect the individual's or group's preparation for deployment.'*

b. *'Ensure that the individual is appropriately trained and equipped for their deployment.'*

1.4.50. Having been notified of a deployment, personnel were required to complete paperwork issued by the 47 Sqn Adjutant, prior to attending a PDI with a Flt Cdr. This had to be completed on every occasion an individual deployed, creating an administrative burden for the Adjutant, individuals and line managers. For example, between Jun 15 and May 16, one pilot completed this process on 4 separate occasions, requiring him to make repeated visits to multiple departments and sections spread across BZN. Exhibit 60 Exhibit 61 Exhibit 62

1.4.51. The PF stated that his PDI had been conducted by a 47 Sqn Flt Cdr; however, his interview pro forma had not been signed. The Flt Cdr in question stated in interview that he had discussed the task with the PF, but this had not been a PDI, which he told the PF would need to be completed by his own Flt Cdr in XXIV Sqn. Exhibit 7 Exhibit 8 Exhibit 63 Witness 9

1.4.52. Interviews conducted by the Panel indicated that there was no singular view as to who should conduct the PDIs for personnel "loaned" between squadrons. The 47 Sqn view was that this should be handled internally by XXIV Sqn, whereas the XXIV Sqn view was that, being a non-deployable squadron without an administrative process to manage deploying personnel, it would be better placed with 47 Sqn. Exhibit 64 Witness 9 Exhibit 65 Exhibit 66

1.4.53. The DDH stated that XXIV Sqn should be responsible for the administrative aspects of their deploying personnel; however, 47 Sqn should ensure that the individual was consciously brought into the supervisory chain given that they would be flying within a crew that is otherwise comprised of 47 Sqn personnel. Witness 10

1.4.54. The Panel noted that although the PNF's PDI pro forma had been signed by a Flt Cdr, it was otherwise blank. The Panel reviewed a sample of 47 Sqn Pre-Deployment paperwork. Folders of 12 personnel were examined, containing the supporting paperwork for 33 individual deployments. Of these, 7 had no record of a PDI. Exhibit 62

1.4.55. Additionally, 2 Gp ASOs required that, when requested by an external supervisory chain, *'pen pictures'* should be provided on changeover of crews to provide background information to the relevant Det Cdr and in-theatre flying supervisors. The Flying Order Book required that a *'Statement of Deployed Aircrew Capability'* (SDAC)[14] be sent prior to crews deploying. This was not completed for the PF or PNF, and is discussed further under Supervision at paras 1.4.506 *et seq*. Exhibit 21 Exhibit 69

1.4.56. The Panel assessed that the PF had not completed a PDI. However, given the wide-ranging content of the discussion he could have had reasonable belief that this had been satisfied by his meeting with the 47 Sqn Flt Cdr, despite the Flt Cdr's assertion that he had been clear to the contrary. Further, even had he completed a PDI within XXIV Sqn, the Panel concluded that it was almost certain that the PF would still have deployed without affecting the circumstances outlined in this Report.

1.4.57. The Panel concluded that Pre-Deployment Administration was **Not a Factor**.

1.4.58. The Panel **Observed** that:

a. The Pre-Deployment administrative burden in 47 Sqn could be reduced by incorporating guidance regarding multiple short duration deployments contained in AP 9012 Chapter 4 Annex B.

b. A Pre-Deployment Interview, were it to include discussion of recent flying practice, operational recency and BCRs relating to the expected operational task, could strengthen the supervisory process (See paragraph 1.4.506 et seq).

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[14] The Panel noted that terms *'pen picture'* and SDAC were interchangeable and widely understood.

c. A significant proportion of Pre-Deployment Interviews were not being completed or formally recorded by 47 Sqn.

## Flying Currency and Competence

### Regulations and Orders

1.4.59. The regulations for Currency and Competence are specified in Military Aviation Authority (MAA) Regulatory Articles (RA) 2102 (Aircrew Competence in Role) and 2103 (Currency and Continuation Training). Exhibit 71 Exhibit 72

1.4.60. RA 2102 requires the Aviation Duty Holder (ADH) chain to issue orders detailing the competence levels, in terms of flying experience, qualifications and skill sets for each Air System and role, required for the safe operation of UK Military Air Systems within their Area of Responsibility (AOR). It also requires that Certificates of Competence should be formally documented, and that Aircrew competence shall be periodically and independently assessed.

1.4.61. Within 2 Gp, Group Air Staff Orders (GASOs) contain the AOC's intent, direction and orders for the conduct of flying, whilst general operating, management and training procedures are outlined in the Air Mobility Air Staff Instructions (AMASIs) and AMF Training Directive (AMFTD). Exhibit 73 Exhibit 74

1.4.62. 2 Gp ASOs detail how competency is assured across the 2 Gp AOR through Standards Evaluation (STANEVAL) units. Specifically: Exhibit 75 Exhibit 76

a. HQ 2 Gp Air STANEVAL units are responsible for providing the Station and AMF Cdrs with assurance regarding all aspects of aircrew standardisation in accordance with GASOs, TTPs, SOPs, flying and operational output, and;

b. STANEVAL are to conduct formal checking (flying and simulator) of at least 10% of aircrew against orders and flying ability. Exhibit 77

1.4.63. Criteria for the initial award of competence to aircrew, their retention and subsequent currency requirements are laid out within the AMFTD. Exhibit 78 Exhibit 79

1.4.64. Having reviewed the relevant documentation, the Panel determined that 2 Gp and the Hercules Force had underlying orders appropriate to support the regulatory requirement.

1.4.65. The Panel concluded that the Orders relating to Currency and Competence were **Not a Factor**.

### Basic Currency Requirements

1.4.66. AMF aircrew Basic Currency Requirements (BCRs) are contained within the AMFTD. Exhibit 79

1.4.67. The Panel reviewed the BCRs relevant to the task undertaken by ZH873 and noted the Aircraft and Role Checks for the PF appeared to have expired (Table 2). Exhibit 5 Exhibit 6 Exhibit 80

| BCR | Frequency (Months) | Date Awarded |
|---|---|---|
| Aircraft Check | 12 | **18 Jun 15** |
| Role Check | 12 | **31 Jul 14** |
| Instructor Check | 12 | 4 Jul 17 |

**Table 2 – PF's BCRs**

Exhibit 81
Exhibit 78

1.4.68. Advice from STANEVAL highlighted that the AMFTD stated that, where an instructor check provides '*enough evidence to assess the competence of the Aircrew Instructor (AI) in role and aircraft handling, Sqn Cdrs may use this evidence in lieu of bespoke role and aircraft checks for the award of an* [Operating Category] *to that AI.*' Exhibit 86

1.4.69. The PF's most recent Instructor Check was completed on 4 Jul 17, although the original categorisation form could not be located. Conducted by a STANEVAL agent, the sortie report was brief, consisting of little more than a paragraph. OC XXIV Sqn was not assured that it contained sufficient evidence to re-award the PF's Operating Category, so discussed the sortie's content further with the STANEVAL assessor. Having been assured that the PF had performed to a '*Combat Ready (Above Average)*' standard in all regards, OC XXIV Sqn recalled paraphrasing the conversation into the relevant area of the form, and re-awarded the PF's Operating Category. Exhibit 83 Exhibit 84

1.4.70. The Panel determined that:

a. OC XXIV Sqn had taken appropriate action to assure himself that he could re-award the PF's Operating Category.

b. The PF was in date for his Aircraft and Role Checks.

c. All crew members were qualified and in date for their BCR requirements relevant for the task. However, see paragraphs 1.4.590 *et seq* for discussion specific to the Body Armour Load Carrying System (BALCS).

1.4.71. The Panel concluded that Basic Currency Requirements were **Not a Factor**.

## Flying Hours

1.4.72. The AMFTD mandates live flying hour requirements, on a rolling 3-monthly calendar basis as summarised in Table 3 below: Exhibit 78

| | Red | Amber | Green |
|---|---|---|---|
| All Hercules Aircrew (non-seat time for AIs/STANEVAL) | <36 | 36-48 | >48 |
| Seat time for Hercules AI & STANEVAL | <9 | 9-12 | >12 |

**Table 3 – Hercules Rolling 3 Monthly Live Flying Hour Requirements**

1.4.73. The AMFTD also states that: Exhibit 78

a. The requirement for live flying hours applied to all Hercules aircrew, irrespective of their role or the extent of their BCR completion.

b. AI and STANEVAL aircrew were to apply both sets of thresholds listed in Table 3.

1.4.74. Table 4 summarises the PF and PNF Flying hours, number of landings, MOS approaches and NSO sorties throughout 2017 up until their deployment to AKR. Exhibit 5 Exhibit 6

| Month | Total Hours | | Rolling 3 Month - Total | | Seat Hours | | Rolling 3 Month - Seat | | Landings | | MOS | | NSO | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PF | PNF | PF | PNF | PF | PNF | PF | PNF | PF | PNF | PF | PNF | PF | PNF |
| Jan | 9:40 | 28:40 | | | 1:10 | 21:40 | | | 4 | 18 | 0 | 0 | 0 | 0 |
| Feb | 10:05 | 29:00 | | | 6:20 | 17:30 | | | 2 | 10 | 0 | 4 | 0 | 0 |
| Mar | 8:50 | 45:00 | 28:35 | 102:40 | 4:50 | 19:30 | 12:20 | 58:40 | 4 | 6 | 0 | 0 | 0 | 0 |
| Apr | 13:10 | 17:50 | 32:05 | 91:50 | 4:30 | 9:50 | 15:40 | 46:50 | 8 | 3 | 0 | 0 | 2 | 1 |
| May | 13:20 | 28:20 | 35:20 | 91:10 | 5:40 | 8:40 | 15:00 | 38:00 | 1 | 5 | 0 | 0 | 0 | 2 |
| Jun | 1:40 | 25:40 | 28:10 | 71:50 | 1:40 | 17:20 | 11:50 | 35:50 | 1 | 4 | 0 | 0 | 0 | 4 |
| Jul | 9:10 | 46:20 | 24:10 | 100:20 | 5:30 | 32:40 | 12:50 | 58:40 | 2 | 23 | 1 | 1 | 0 | 13 |
| Aug | 17:15 | 10:30 | 28:05 | 73:30 | 7:35 | 10:30 | 14:45 | 60:30 | 11 | 3 | 0 | 0 | 0 | 0 |
| Total | 83:10 | 231:20 | | | 37:15 | 137:40 | | | 71 | 33 | 1 | 4 | 2 | 20 |

**Table 4 – Pilots' Flying Summary**

1.4.75. The Panel assessed that the PF was not current for flying hours as required by the AMFTD. Although he had achieved the "Seat" time minima for a "Green" assessment for the majority of the period, he had been "Red" for total hours throughout. However, it also considered that there was a degree of ambiguity in the Order, with a variety of potential interpretations being offered by individual Panel members. Further opinion regarding the applicability of the Live Flying Hours Requirements for Aircrew Instructors was sought:

a. 2 Gp STANEVAL stated that there was no need to achieve both criteria; '*Instructor/STANEVAL - A 'Green pilot needs 12 hrs seat time. If the Instructor is short of seat time, then they may still appear 'Green' if they have achieved 48hrs non-seat time.*' Exhibit 86

b. The DDH indicated that he assessed that an AI should achieve the non-seat time total, within which the seat time minima must be achieved. Witness 10

c. Naval Flying Standards Flight was approached for an independent view, and concluded that both lines should be achieved, ie an AI would need to amass 48 hr non-seat time **and** 12 hr seat time to remain green for flying hours currency. However, the response also indicated potential that the table could be interpreted as an '*either/or*' requirement. Exhibit 87

1.4.76. The Panel also noted that neither of the A400M Atlas, C-17 Globemaster or A330 Voyager fleets had mandated flying hour requirements. For A400M and C-17 the currency mandate is that a pilot must have completed a take-off and landing as PF in the aircraft within the previous 31 days. The A330 fleet is similar, except that the requirement is split across 2 periods, namely 31 and 90 days. Exhibit 88 Exhibit 89 Exhibit 90 Exhibit 91

1.4.77. When asked why this was the case, the AMFC indicated that the Hercules requirement reflected a period when aircraft availability had been reduced. This had Witness 17 resulted in a paucity of flying hours, thereby requiring a flying hours metric to be applied to gauge currency and recency from a supervisory/authorisation perspective. A similar example was offered within the A400M fleet, where OCU training had been suspended by the AMFC in order to ensure sufficient availability to meet the operational requirement and currency of Combat Ready aircrew. While recognising the requirement to maintain currency and competence, the Panel did not understand why such a metric would only be required during occasions of reduced aircraft availability.

1.4.78. Within the AMFTD, Training Protocol (TP) 717 states the following recovery actions are to be taken where minima are not achieved: Exhibit 78

a. Aircrew in the Red for hours required a Flt Cdr or Sqn Cdr review to determine whether sufficient mitigating circumstances existed to support continued flying (for example, recent simulator serials or a supervised airborne sortie with supporting documentation). In any other circumstance, completion of an appropriate recovery package was required before the individual could be permitted to fly unsupervised.

b. Individuals in the Red for 3 monthly rolling minima, required paperwork to be raised and retained within their training folder that outlined mitigating circumstances and, if appropriate, a recovery plan. Copies of the paperwork were to be submitted to STANEVAL, who were to monitor the number of non-compliances and advise the Stn Cdr accordingly.

1.4.79. TP717 required AMF HQ to report the following currency compliancy details on a quarterly basis; however, it did not specify to whom such reports were to be made: Exhibit 78

a. Crews at Red, Green or Amber for each competency and for flying hours.

b. Extensions for primary BCRs/competencies.

1.4.80. Both STANEVAL and AMF HQ were approached to determine the extent of such non-compliance across the Hercules Force:

a. STANEVAL stated that no such report had been received concerning any pilot since the issue of TP717 in Feb 17, although some drafts had been sighted on Squadrons. Information had been submitted to the Stn Cdr in Jan 17 regarding Hercules currency, but no specific report had been rendered since, as relevant comments would be included within annual assurance activity. Exhibit 86

Exhibit 92

b. The AMF HQ response was that no quarterly reporting had been completed, and the provenance of the requirement was uncertain.

Witness 10

1.4.81. The DDH confirmed that he had no such formal reporting passed to him by STANEVAL or AMF HQ. However, he indicated that he felt he maintained a good understanding of currency compliance via alternate means such as STANEVAL Assurance Visits, the Air Safety Cell and through direct engagement with squadron Commanding Officers. As an example, following a period of poor aircraft serviceability, bad weather and airfield work, he had met with OC 47 Sqn weekly in order to discuss in detail the squadron's currency and mitigations, including the management of Op SHADER deployments and RED / AMBER / GREEN risks.

1.4.82. The Panel reviewed the XXIV and 47 Sqn Pilot Currency 3 Month Currency Trackers for the period Mar-Aug 17. Recognising that further research would be required to assess individual circumstances, and limiting the analysis only to those personnel who had at least 6 months of data, the following observations were made:

a. On XXIV Sqn, 7 of 12 pilots were Red for total hours throughout the period and the remaining 5 had at least 3 such months. Only 2 were Green for Seat hours every month, while 3 were Red and/or Amber in both categories for at least 3 months. Exhibit 93

b. On 47 Sqn, only the total hours were recorded recognising that, unlike XXIV Sqn only the minority are instructors. 1 of 58 pilots was Red or Amber throughout, while 15 were either Red or Amber for 3 or more months; 25 were in the Green throughout. Exhibit 94

1.4.83. The Panel was concerned about the proportion of pilots on XXIV Sqn not achieving the mandated Live Flying Hours requirement. XXIV Sqn was asked how compliance with TP717 was assured, and what action was being taken to ensure that the OC, DDH and Force Cdr were aware of any associated risk. The response stated that STANEVAL were able to access the Sqn's Hours Tracker to periodically check on currencies, but that '*dipping below Green has always been commonplace, especially for crews that do not often fly lengthy route sorties.*' It further argued that STANEVAL accepted that the nature of an instructor's task meant that a more appropriate metric was '*seat time backed up by considerable time as an instructor in the simulator.*' Exhibit 94

1.4.84. The Panel recognised the potential difficulty of achieving the TP717 requirements for instructors, and that there was no facility within it to allow simulator hours to count towards the necessary totals. Nevertheless, it was apparent that the requirements for reporting compliancy shortfalls were not being followed across the Hercules Force, and that there appeared to be a lack of understanding across units, STANEVAL and the AMF HQ as to where this responsibility fell. This was redolent of a degree of complacency among all stakeholders, as further discussed at paragraphs 1.4.506 *et seq*.

1.4.85. The Panel determined that:

a. AMFTD TP717 is insufficiently clear regarding AI and STANEVAL Live Flying Hour requirements, with 3 different interpretations being given by competent and authoritative personnel.

b. Notwithstanding the variety of interpretations possible regarding AI Flying Hour Currency requirements as laid down in AMFTD TP717, the PF was not compliant with the 3 Monthly rolling requirements for Total Flying Hours when he undertook the sortie on 25 Aug 17, and had not been throughout 2017.

c. This non-compliance was widespread across the Hercules Force, particularly on XXIV Sqn, creating a potentially unquantified risk to Air Safety.

d. The procedures for reporting and quantifying flying hour and BCR currency non-compliance were not being adhered to, impacting subsequent risk identification and quantification.

e. The AMFTD did not specify to whom AMF HQ Quarterly Reports regarding non-compliance should be sent.

f. There was inconsistency regarding the mandating of Flying Hours currency requirements across the AMF fleets such that full compliance with RA 2103 might not be assured.

1.4.86. The Panel could not assess with any degree of certainty whether the PF's lack of currency directly contributed to the accident. However, it agreed that shortfalls in training and currency are likely to increase the risk of skill fade and make it difficult for personnel to build experience. Exhibit 359

1.4.87. The Panel concluded that non-compliance with TP717 currency requirements was an **Other Factor**.

**Recommendation:**

1.4.88. **The Air Mobility Force Commander should clarify:**

a. **AMFTD TP717 Live Flying Hour requirements to ensure there is no ambiguity in interpretation or meaning.**

b. **Currency Requirements across the Air Mobility Force to ensure their fitness for purpose.**

c. **Reporting requirements regarding AMF currency and BCRs, and ensure future compliance.**

1.4.89. The Panel **Observed** a lack of consistency in the logging of MOS/NSO landings in Aircrew Logbooks, for which there was no over-arching guidance within 2 Gp ASOs or AMASIs. As a consequence, it was difficult to accurately establish how many of these the PF and PNF had conducted. Exhibit 5 Exhibit 6

1.4.90. The Panel noted that, from late 2017, the Hercules Force began utilising the Squadron Training Achievement Recording System (STARS) to record the number and type of landings conducted by individual pilots. This should make such data more readily available to flying supervisors.

## Arrival in Theatre

## Acclimatisation and Fatigue

1.4.91. The PF and PNF arrived at RAF Akrotiri 3 days before the accident, and acclimatised themselves to the 2-hour time difference between the UK and Cyprus. Exhibit 359

1.4.92. Given the extended time period between the accident interviews with the crew, the evidence available to the Panel to assess the pilots' fatigue on the day of the accident was limited. However, both the PF and PNF described a high level of demands prior to the detachment, with the PF specifically highlighting extended Exhibit 44 Exhibit 359 working hours immediately prior to deploying, stating 12-hour days as being typical during the previous three weeks.

1.4.93. On the day of the accident the PF reported that he woke at 0900 hr and had a nap in the afternoon. The PNF stated that he woke at 0700 hr, and also had a 4-hr nap in the afternoon after taking Temazepam that had been prescribed to him. Tamazepam is authorised for prescription to aircrew for management of work and rest in operational circumstances, and is effective in inducing sleep without residual sequela or complications. Its short duration of activity prevents significant accumulation in the body, and extensive testing has failed to detect any deleterious effects on individuals or performance 6 hours after ingestion.

Exhibit 95
Exhibit 96
Exhibit 97
Exhibit 98
Exhibit 99

1.4.94. The crew reported for duty at 1800 hr. Although the accident took place at 2356 hr, which is towards the circadian low and could result in an increased risk of fatigue, RAF CAM indicated that the afternoon naps taken by the PF and PNF would have been an appropriate mitigation.

Exhibit 100
Exhibit 359

1.4.95. The Panel assessed that the PF and PNF had sufficient time to acclimatise post arriving at AKR, had not experienced difficulties sleeping since arrival, and showed no evidence of a sleep deficit.

1.4.96. The Panel concluded that Fatigue was **Not a Factor.**

## Crew Handover

1.4.97. Crew roulement was normally planned so that an entire crew (2 Pilots and 2 WSOps) deployed together. On this occasion the pilots of ZH873 deployed separately from their WSOps who were already in theatre.

Witness 9

1.4.98. Detachments were planned to include an overlap between outgoing and incoming crews. This allowed for acclimatisation as well as a handover period during which the incoming crew would read into orders and guidance specific to their task, be briefed by the outgoing crew and complete induction procedures. The "handover" between the 2 crews consisted of a verbal brief from one of the outgoing pilots, as well as written notes which were held within the crew's mission folder.

Exhibit 11
Exhibit 101
Exhibit 102

1.4.99. Although the PF stated that he couldn't remember specifics of the verbal brief, he stated that he had received a good handover which had included a lot of discussion about the TLZ. The written notes outlined the crew's battle rhythm as well as mission specific details such as radio frequencies and routeing. Despite the PF's comment regarding the thoroughness of the handover, the Panel noted that neither the verbal handover nor the written notes appear to have mentioned specific detail regarding the approach at the TLZ; however, the PF stated that he had been told informally about unusual Rad Alt readings in the undershoot of the runway. When interviewed, the outgoing pilot (who had flown into the TLZ 13 times) mentioned that he believed there was potential to land short at this TLZ, and although he couldn't explain why this was happening he had begun to aim further into the runway to mitigate the risk of landing short. This was not included in the handover with the PF, nor had it been reported.

Witness 13
Exhibit 103

1.4.100. Where possible, the Herc Det Cdr planned for the outgoing crew to 'screen' (fly with) the incoming crew on an operational sortie, but due to the operational tempo it was considered that no suitable tasking would be available before the remaining outgoing pilot departed.

Exhibit 362

1.4.101. The Panel considered that:

a. There was a sufficient period of time allocated for crew handover.

b. Although there was a lack of detail regarding the unusual Rad Alt readings or the outgoing pilot's perception of landing short at the TLZ, the handover *per se* was sufficiently robust.

c. The lack of screened sortie was a missed supervisory opportunity.

1.4.102. The Panel was unable to establish if more information regarding the unusual Rad Alt readings or the outgoing pilot's perception of landing short would have affected the PF's approach technique on the accident sortie. As is discussed in paragraphs 1.4.232 to 1.4.238 the slope immediately preceding the overrun was considered an **Aggravating Factor**, and the prescribed night MOS approach technique is not dependent on the construct beyond the overruns.

1.4.103. The Panel concluded that the crew handover was **Not a Factor**.

1.4.104. The lack of a screened sortie and its relevance to Supervision is discussed further at paragraphs 1.4.518 *et seq*; lack of reporting is discussed in paragraphs 1.4.617 *et seq*.

## Planning, Briefing and Authorisation

### Background

1.4.105. Following the increase in sortie requirement from Feb 17 (paragraph 1.4.26), tasking into the TLZ was notified to the Det Cdr several weeks before each mission was due to be flown. Exact load requirements would be confirmed closer to the date, prior to being detailed on the Herc Det's weekly flying programme published by the Det Cdr each Sunday. At the same time, the Det Cdr compiled an Operational Risk Matrix for the task, submitting it through the Operational Chain of Command (CofC) to obtain required clearances. Key to this mission were: Exhibit 40 Exhibit 105

a. NSO.

b. Use of OEC 001 - MOS.

c. Use of OEC 022 – Increased All-Up Mass for Landing.

1.4.106. Of these clearances, authority to grant NSO was held by the TACOM and MOS was authorised by the OCC. The ORM recorded that OEC 022 had a standing dispensation (see further discussion at paragraphs 1.4.427 *et seq)*. Exhibit 104 Exhibit 22

1.4.107. Thus, by the time of the pilots' arrival in AKR, task planning had already commenced, requiring them to read into theatre and mission orders prior to confirming the final details of the load and plan the actual flight. Both the PF and PNF considered that they had sufficient time to do this, concentrating on the more administrative tasks on 23 Aug before concentrating on the sortie on 24 Aug. Exhibit 101 Exhibit 102

 

## Temporary Landing Zone Planning

1.4.108. Much of the planning focus was spent studying the Temporary Landing Zone (TLZ). Information was drawn from:

a. The RAF Tactical Air Traffic Control (TACATC) survey of the TLZ, dated 02 Feb 17. Exhibit 106

b. The partner nation's survey, dated 03 Mar 17, and its associated Theatre Airfield Card (a summary of pertinent survey detail as approach and departure information). Exhibit 20

c. The Advanced Mission Planning Aid (AMPA), an electronic tool with the ability to display mapping and imagery.

1.4.109. The TLZ runway, illustrated in Figure 2, was constructed of crushed aggregate and gravel which had been graded to remove undulations, and was classed as *'Semi-Prepared'*. The runway was marked in the North Atlantic Treaty Organisation (NATO) Standard night configuration of 'Box plus Z'; a 500ft Touchdown Box, lit on each corner with an IR light, signifies the start of the runway and a flashing strobe ('Z' marker) denotes the end of it. Beyond each end of the runway are 300ft overruns prepared to the same standard as the runway itself, and are included to mitigate the risk of aircraft landing short of the runway. Exhibit 109 Exhibit 106

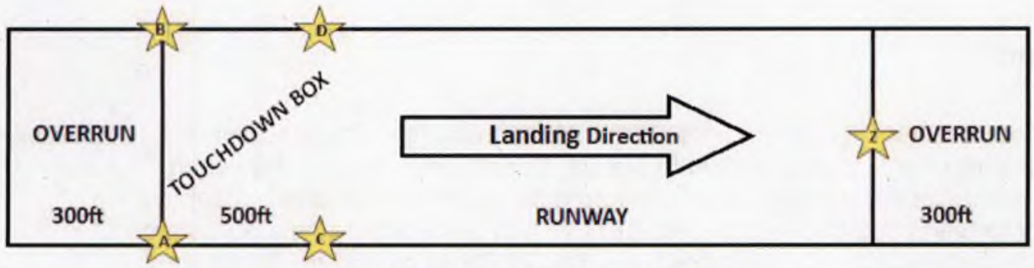


**Figure 2 – Box + Z Configuration**

1.4.110. The Box+Z configuration, despite being a NATO standard likely to be encountered by UK crews on operations, is not listed within either the Manual of Aerodrome Design and Safeguarding (MADS) or the Tactical Air Transport Operations Manual (TATOM). Further, it is not utilised during live or synthetic training serials, as these TLZs are marked by UK TACATC personnel. Exhibit 35 Exhibit 36 Exhibit 117

1.4.111. The AMPA terminals used by the Herc Det at AKR contained historic satellite images that pre-dated the TLZ's construction. The Herc Det Flight Operations team indicated that there was no process to issue regular updates to AMPA imagery. Exhibit 116

1.4.112. The crew mentioned that whilst planning they became aware of discrepancies between the two survey reports, specifically in regards to which way the runway sloped. The British survey stated that the runway sloped downwards (0.46% / 0.26°) whereas the partner nation survey indicated that it sloped upwards (0.6% / 0.34°). Despite this contradiction the crew elected to utilise the partner nation survey and confirm the direction of slope on arrival. The PF stated that this decision-making process caused him no particular concern as errors in such reports were not uncommon. The Panel noted that this discrepancy had been apparent to Herc Det crews for some time, but could find no evidence of it being reported. The Panel utilised satellite imagery to determine that the runway sloped up by 0.52% / 0.3°. Exhibit 110 Exhibit 111 Exhibit 101 Exhibit 113 Witness 1

1.4.113. Neither of the surveys available to the crew mentioned a significant upslope that immediately preceded the overrun (Illustrated in Figure 3). However, the PNF had sighted separately a previous edition of the partner nation's survey which contained a cross sectional diagram that clearly annotated it. As the PF was not in Herc Det Operations at this time, he had not seen this older survey. However, the PF had spoken to the outgoing pilot during their handover who had stated that there were unusual Rad Alt readings on the final approach. This was confirmed in interview where that pilot also stated that he had not reported this either in the Air Safety Information Management System (ASIMS) or internally within the Herc Det.

Exhibit 107
Exhibit 111
Exhibit 114

1.4.114. The previous edition of the partner nation's survey indicated that the slope preceding the overrun was 5% (2.86°). After the accident, the site operator indicated that it was 4.1°, while satellite imagery suggested that it was 3.9°. Given the variety of data, but the consistency of the latter two, the Panel utilised 4° for its subsequent analysis, as shown in Figure 3.

Exhibit 107
Exhibit 108
Exhibit 113

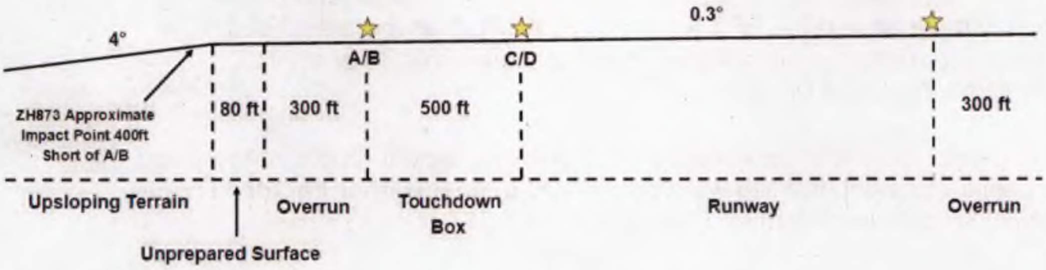


**Figure 3 – TLZ Slopes (Not to scale)**

1.4.115. The PF stated that the first time he became aware of the slope was post recovery to AKR following the accident where he subsequently sighted the older TLZ survey. The Panel considered that the unusual Rad Alt readings almost certainly related to the upslope preceding the runway; however, such a link had not been made. The PF had not mentioned such readings to the PNF before or during the sortie, and nor had the PNF mentioned what he had noted in the earlier survey.

Exhibit 114

1.4.116. During interview the Det Cdr stated that, following the accident, he became aware of the slope preceding the overrun when the PNF mentioned the older survey. This had been contained in a '*Det Cdr's File*' that he hadn't been using as it appeared to consist primarily of legacy material from when the task had first been established; he had been using more recent documentation – including the updated TLZ survey.

Exhibit 115

1.4.117. The UK and partner nation surveys also contained different threshold co-ordinates, but as the difference was small the crew considered it to be unimportant recognising that they would recover by a visual approach to the infrared (IR) lit runway. As such, they chose to use coordinates contained on the AMPA that had been utilised by previous crews.

Witness 1
Witness 4

1.4.118. The Panel assessed that:

a. Information regarding the upslope preceding the TLZ overrun was not readily available to the crew.

b. Up to date imagery in AMPA would have almost certainly enhanced the crew's situational awareness regarding the TLZ.

c. The non-inclusion of the 'Box +Z' configuration in MADS or TATOM, and the lack of synthetic or live training, did not allow crews to prepare correctly for Operations.

d. There had been a lack of formal reporting regarding:

(1) Unusual RadAlt indications on final approach to the TLZ.

(2) Discrepancies between TLZ surveys provided to crews.

e. A previous version of the survey remained available within the Det Cdr's file; however, it had not been rigorously perused by the Det Cdr who was utilising the more recent version and remained unaware of the additional information it contained. Witness 5

1.4.119. The Panel was unable to conclude to what degree information regarding the upslope may have altered the PF's approach to the TLZ, as the prescribed ACM technique is not dependent on the construct beyond the overrun. *Per se,* TLZ planning was **Not a Factor** in the accident.

1.4.120. However, discrepancies between TLZ surveys, lack of recent imagery and shortfalls in publications and training were considered to be an **Other Factor**. The lack of reporting is considered further at paragraphs 1.4.617 *et seq*.

**Recommendations:**

1.4.121. **D MAA should amend MADS to include the Box + Z configuration to ensure that UK military operators are aware of configurations likely to be encountered on NATO operations and exercises.**

1.4.122. **AMFC should;**

a. **Amend TATOM to include the Box + Z configuration.**

b. **Facilitate the Box + Z configuration during live and synthetic training to ensure crews are trained in scenarios likely to be encountered when deployed.**

c. **Ensure up to date mapping and imagery is procured and maintained for use by the AMF on all 2 Gp mission planning systems.**

## Meteorology and Illumination

1.4.123. The Panel noted the requirements of 2 Regulatory Articles (RA).

a. Aircraft Commanders are to ensure that an appropriate meteorological brief is obtained (RA 2115). Exhibit 118

b. Authorising Officers are to ensure that the Aircraft Commander has thoroughly planned his mission (RA 2306). Exhibit 119

1.4.124. At the time of the accident, illumination levels at the TLZ were approximately 2 Millilux (mLux); however, in interview, the crew stated they believed forecast illumination levels were between 5 to 8 mLux. The impact of the actual Exhibit 112 Exhibit 121 Exhibit 122 weather and light levels are further considered at paragraphs 1.4.181 and 1.4.241 respectively.

1.4.125. The UK Meteorological Office Night Illumination Model (MONIM) is the primary method used to provide forecast illumination, and has the capability to adjust its forecast based on factors such as cloud cover and cultural lighting; it was available to, and being used by, the forecasters at AKR. Due to the sensitivity surrounding the TLZ location, as well as a lack of knowledge of individual security clearances, details necessary to provide an accurate forecast were not passed to the Met Office. As such, the brief provided to the crew contained weather and illumination forecasts for an arbitrary location within the operating area, and included significant cultural illumination. The forecast illumination for this arbitrary location was 10-15 mLux. Exhibit 123 Exhibit 12 Exhibit 121

1.4.126. While recognising the requirement for Operational Security, the Panel considered that not disclosing the TLZ location denuded the crew, and authoriser, of the illumination and meteorological information to satisfy regulatory requirements fully. Additionally, while visiting 903 EAW, 10-14 Oct 17, the Panel established that the Senior Forecaster had a Developed Vetting security clearance and could have been given sufficient location information to enable the necessary briefing. Alternatively, the Detachment could have requested Joint Oceanographic and Meteorological Operations Centre (JOMOC) at PJHQ Northwood provide the necessary briefing. Exhibit 124

1.4.127. The Panel assessed that the meteorological brief was inadequate as it did not consider the weather or light levels at the TLZ. However, (as discussed at paragraphs 1.4.181 *et seq)* the weather at the TLZ was **Not a Factor**, and the light levels were within limits for the task (paragraph 1.4.241 *et seq*).

1.4.128. The Panel concluded that the lack of an appropriate meteorological brief was an **Other Factor**.

## Crew Briefing

1.4.129. Regarding crew briefing:

a. MAA RA 2305 states, *'Briefing of aircrew before flight, and subsequent de-briefing on completion of the sortie, is essential and should be conducted in a thorough and professional manner.'* Exhibit 125

b. 2 Gp ASOs state, *'The* [aircraft commander] *is responsible for the supervision and correct implementation of the flight/mission planning and crew briefing/debriefing.'* Exhibit 126

1.4.130. Prior to their mission, the crew mustered at Herc Det operations and attended a crew brief. During interviews the crew and Det Cdr stated that the primary focus of this brief was the intelligence picture specific to their theatre of operations. Exhibit 127

1.4.131. Despite having planned the mission and attended the crew brief, the PF stated that when he and the PNF arrived at the aircraft, one of the WSOps informed them that they needed to get airborne earlier than they intended. The PNF stated that this placed him under a degree of pressure, and that there was a rush to get airborne to ensure that they would not miss their allocated slot time at the TLZ. Exhibit 128 Witness 1

1.4.132. The crew stated that the source of this confusion was because the detachment flying programme was written using an estimated take-off time. After the Witness 1 rear crew's prompt, the PNF recalled that it was necessary to get airborne earlier in case of Air Traffic Control delays en route.

1.4.133. Compounding the requirement to get airborne earlier was confusion regarding the aircraft's parking location. A miscommunication at Herc Det operations meant the pilots initially drove to the wrong part of the airfield, a mistake which the PNF said deprived them of 25 minutes of preparation time at the aircraft. Witness 4b

1.4.134. As TLZ operations are a Tac AT discipline, TTPs are held within TATOM which states that it is to be used as a basis for the planning and execution of all Tac AT Operations and Exercises involving 2 Gp aircraft. It subsequently requires that all sorties, Exercises and Operations, including single aircraft missions should be briefed in accordance with the Tactical Flight Reference Cards (FRCs). Exhibit 129

1.4.135. The Tactical FRCs outline the content of initial, pilot and crew briefs. The Panel noted the extensiveness of these briefs and that the following points are included: Exhibit 130

a. Take-off Time.

b. Aircraft Status.

c. Routeing.

d. Ground Taxy Plan.

e. TIMENAV Management.

f. TLZ Time.

1.4.136. The Panel noted that both pilots seemed unaware of their required take-off time or the aircraft's parking location despite the FRCs containing a number of checks to clarify these points. When asked, the PF stated that he omitted using the FRC guide. Witness 1d

1.4.137. When asked whether crews would be expected to use the FRC briefing guides, STANEVAL stated that although it is not written down that they have to use it, STANEVAL would expect crews to conduct the FRC mission brief for these types of sortie. Witness 14

1.4.138. After the crew briefing, the rear-crew left to prepare the aircraft whilst the PF and PNF remained behind to conduct an Out-Brief with the Det Cdr and be authorised. The Panel noted the comprehensive nature of the Out-Brief pro forma which contained information specific to the sortie, including aircraft parking location, aircraft routeing, performance figures, communication planning and contingency planning. Additionally, the Out-Brief contained elements pertinent to all crew members, such as confirming the correct testing of NVGs; given that the rear crew had already departed to the aircraft, this could not be done. Witness 1 Exhibit 131 Witness 5

1.4.139. Throughout interviews the Panel noted that the mission (particularly the TLZ element) was considered relatively simple and routine by the pilots and authoriser, despite the recent arrival in theatre of the pilots. The Panel considered it probable that the focus of the Det Cdr and pilots had been on the higher tariff requirements of the sortie, particularly the threat scenario and requirement for a Tier 1 crew, to the detriment of more basic detail. Witness 5 Witness 1

1.4.140. The Panel determined that:

a. Despite attending a crew brief and an Out-Brief, neither pilot identified either the correct take off time or aircraft parking location.

b. It was highly probable that the crew brief, focussing primarily on the intelligence picture and tactical nature of the sortie, was insufficiently robust and omitted discussion of take-off time and aircraft location. This would have been less likely had the Tactical FRCs been used, in accordance with the TATOM requirement.

c. Although the Det Cdr stated that he spent more time conducting the Out-Brief given that it was the first sortie in theatre for both pilots on this detachment, it was more likely than not that it had not been sufficiently rigorous given their subsequent lack of awareness of aircraft location and take-off time. Witness 5

d. Only having the pilots present at the Out-Brief rendered it of limited utility and was a missed supervisory opportunity.

1.4.141. Notwithstanding the confusion regarding take-off time and aircraft parking location, which created time pressures on the pilots, ZH873 arrived at the TLZ early.

1.4.142. The Panel concluded that the lack of appropriate crew briefing was an **Other Factor.**

## Authorisation

1.4.143. On completion of the Out-Brief, the Det Cdr authorised the mission, with the PF as aircraft commander. Exhibit 2

1.4.144. The regulatory requirement for authorisation is laid out in RA 2306. This lists what are considered as the minimum duties of an Authorising Officer, which in summary are: Exhibit 119

a. Detail the Aircraft Commander.

b. Ensure that the Aircraft Commander is capable of carrying out his responsibilities as detailed.

c. Ensure that the Aircraft Commander has thoroughly planned his mission, alternate mission or duty.

d. Ensure that the crew members are qualified, in current flying practice, and capable of executing the tasked mission, alternate mission or duty as planned without undue hazard.

1.4.145. It further states that:

a. Authorising Officers should pay particular attention to Aircrew competency and qualifications.

b. The key role of the Authorising Officer is to be aware of the probability and impact of potential problems and to eliminate, reduce or control the hazards involved through risk management and implementation of suitable controls.

1.4.146. When asked how the aircraft commander role had been decided, interview testimony indicated that there had been a collaborative decision. It had been discussed by the pilots during planning, where they concurred it should be the PF given that: Witness 1d Witness 4c

a. Both were qualified and experienced Captains.

b. The PF was only programmed to be in theatre for 10 days, so this might have been his only opportunity to fly this mission.

1.4.147. This was subsequently discussed with, and agreed by, the authoriser. Additionally, there was a collective view that the PNF role was the more difficult task, particularly with regards to tactical requirements and radio management. Given the PNF's previous experience of the mission, it was considered that he would be best placed to conduct this element and be in a position to mentor the PF regarding the intricacies, rather than be distracted from flying the aircraft had the roles been reversed. This chimed with the initial internal investigation completed by the DDH following ZH873's accident, which stated, *'Operating as PNF in the C-130J is often a more demanding role, especially given a new mission environment in which to manage the aircraft'*. Witness 5d Exhibit 336

1.4.148. The Det Cdr was aware that the PF had not been on operations for a significant period of time, and that the PNF was the only one of the 2 who had been to this specific TLZ. However, he concurred with the rationale above, and assessed the choice of aircraft commander as '*even*'. Witness 5d

1.4.149. The Panel was not convinced about the logic of this argument, given that the Aircraft Commander is '*entirely responsible for the safety of the Air System, its occupants and equipment, both in the air and on the ground*'. As such, the PF was responsible for oversight of everything happening in the aircraft, rather than being able to concentrate solely on flying as had been implied. On being asked if the Aircraft Commander had to sit in the left-hand seat, the Det Cdr responded that he didn't have to, but the typical positioning other than in training would be the Captain in the left-hand seat and the co-pilot in the right. The Panel noted that AMASIs listed a qualification for Right Hand Seat Captain, which both pilots would have been eligible for as qualified Aircrew Instructors. Witness 5 Exhibit 118 Exhibit 321

1.4.150. The Det Cdr also acknowledged the potential for flat cockpit gradients in dual captain crews. However, he asserted that assigning the duties as he did would have allowed the PNF to assist the PF, and that he would be able to utilise his additional knowledge regarding the TLZ as they approached it. The Panel agreed that the PNF's prior knowledge of the TLZ, and his greater recent operational experience, would have afforded him greater capacity; however, it considered that this would probably have been better utilised as Aircraft Commander, regardless of PF/PNF duties. Witness 5

1.4.151. Regarding crew members being qualified, in current flying practice, and capable of executing the tasked mission, the Det Cdr indicated that he considered both pilots were current based on their BCRs and that their Pre-Det simulator sortie had appropriately prepared them for the mission of 25 Aug. He stated that he was not aware of the limited amount of flying undertaken recently by the PF. Witness 5 Witness 5d

1.4.152. The Panel assessed that the Authoriser believed he had made a considered judgement regarding his decision to authorise the PF as Aircraft Commander. However, in continuation of the conclusions drawn earlier (see paragraph 1.4.36) there did not appear to have been any analysis or discussion regarding the PF's recent NSO experience or his lack of recent flying on operations. The Panel considered that the Det Cdr would have been helped significantly in this regard by provision of a pen picture (SDAC), as required by 2 Gp ASOs and the Flying Order Book.

1.4.153. Additionally, the Panel opined that the decision regarding selection of Aircraft Commander was unduly influenced by the PF's reputation across the Force, which parallels the complacency observations regarding Supervision (see paragraph 1.4.510). The PF's desire to revalidate his credibility on Operations, particularly recognising his imminent assignment to [redacted], would have been achieved simply by the opportunity afforded him by this short duration detachment; it did not require him necessarily to undertake particular duties on this sortie.

1.4.154. The Panel also considered that authorising the PNF as Aircraft Commander would have offloaded the PF of the additional potential pressures and allowed him to concentrate on the task of flying the aircraft. Additionally, had the PNF been Aircraft Commander the Panel believed that, on the balance of probabilities, it would have encouraged more assertive behaviour during the approach (see paragraph 1.4.349).

1.4.155. Other than in training, the Hercules Force construct is generally predicated on crews constituted with Captains and Co-Pilots. As such, an authoriser might often consider the issue of nominating the Aircraft Commander as pre-ordained. It is also the norm that Captains fly in the left-hand seat, as this is the only seat from which the nose wheel can be steered[15]. This is particularly important during MOS landings, where use of nose wheel steering is required immediately after touching down. The Panel considered that these two factors create a circumstance that could result in the potential blurring of any division between PF and Aircraft Commander responsibilities, and where the allocation of Aircraft Commander could fall out almost as if by default.

1.4.156. Such potential to conflate the PF with the Aircraft Commander was apparent when the Det Cdr was asked whether the Aircraft Commander had to sit in the left-hand seat. He stated that he didn't have to if he was qualified to be captain in the right-hand seat. However, he added that it was '*best practice*' during NSO or MOS sorties that the PF was in the left-hand seat for landing given the almost immediate requirement to use nose wheel steering. Witness 5d

1.4.157. The Panel also noted that when the TLZ was first used in autumn 2016, the practice had been for pilots to be PNF during their first mission in order to provide an exposure without the pressure of flying the aircraft (see paragraph 1.4.519). As this procedure wasn't mandated, it wasn't applied to the sortie on the 25 Aug and resulted in the PF undertaking that duty, and being the Aircraft Commander, despite it being his first approach to the TLZ. Witness 11

1.4.158. While it was not possible to determine whether the accident would have happened were the PF and/or Aircraft Commander roles reversed, the Panel assessed that:

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[15] Used during ground taxiing, and at speeds during take-off and landing when the aircraft's rudder is unable to maintain directional control.

a. Nomination of the PF as Aircraft Commander exacerbated the issues of a flat cockpit gradient, setting circumstances for unassertive behaviour from the PNF.

b. Nomination of the PF as Aircraft Commander increased the pressure on him by making him '*entirely responsible for the safety of the Air System, its occupants and equipment, both in the air and on the ground*', which was quite the opposite of the Authoriser's (and PNF's) intent.

c. The normal construct of Captain and Co-Pilot detracted from sufficient attention being given to the roles and responsibilities of Aircraft Commander, as distinct from Pilot Flying.

d. As a Flying Instructor, the PNF was qualified to be Aircraft Commander in the right-hand seat.

1.4.159. The Panel concluded that the Authorisation process should have identified the risks inherent in the crew's composition and addressed them before flight, particularly the allocation of duties and nomination of Aircraft Commander. As such, Authorisation was considered a **Contributory Factor**.

**Recommendation:**

1.4.160. **D MAA should develop a Case Study, incorporating the Supervisory, Authorisation and Human Factors issues identified within this Report, to be used in Air Safety Training in order to promote awareness across the Defence Aviation Environment.**

## Aircraft Serviceability

1.4.161. ZH873 completed its Aircraft Deployment Preparation Schedule, including fitment of flight deck armour on 7 Jun 17 and arrived in theatre on 28 Jun 17.

Exhibit 132
Exhibit 133
Exhibit 134
Exhibit 135
Exhibit 136
Exhibit 137
Exhibit 138
Exhibit 139
Exhibit 140

1.4.162. The aircraft's technical logs (MOD Form (MF) 700), as well as its Military Airworthiness Certificate were examined by the Panel. From these the Panel assessed that the aircraft was serviceable with no known Faults or Limitations that would impact execution of the planned sortie.

1.4.163. The Panel concluded that at the commencement of the sortie on 25 Aug 17, ZH873 was serviceable and ready in all respects for tasking. Aircraft serviceability prior to the accident was **Not a Factor**.

1.4.164. Notwithstanding this conclusion, the Panel **Observed**:

a. ZH873 had a high number (55) of extant Acceptable Deferred Faults (ADF) extending back to 2013 (the second highest amount in the fleet, and 30% above the average). The vast majority of ZH873's ADFs had been deferred until depth maintenance; however, the Panel noted that some had not been rectified during the previous two depth cycles. Exhibit 141

b. ADFs deferred to Depth maintenance, with associated spares demands, had no review date in contravention of MOD Form 799/3. (Instructions for use of [ADFs]). Exhibit 142

c. On some occasions, ADFs deferred to depth were not supported by associated spares demands, in contravention of MOD Form 799/3. The Panel felt that this had potential to delay spare part supply during depth maintenance, resulting in ADFs not being rectified. Exhibit 142

## Transit to Temporary Landing Zone

### Cruise Malfunctions

1.4.165. The crew stated in interview that the aircraft suffered a number of faults whilst transiting to the TLZ. Having reviewed the aircraft's Data Transfer and Debrief System (DTADS), the Panel established that ZH873 suffered a failure of: Witness 1 Witness 4

a. 1 of its 4 Head Down Display (HDD) Units.

b. The Cursor Control Panel (CCP).

1.4.166. Failure of the HDD would have resulted in the crew having to rearrange information displayed on the remaining screens whilst failure of the CCP removed the crew's ability to select relevant charts on the Digital Mapping Unit (DMU). A loss of the CCP also removed the ability to display a map cursor inside the Head Up Display (HUD) which can be used as an aid to navigation. Exhibit 13 Exhibit 143

1.4.167. The Panel considered that although the loss of a HDD and Digital Mapping would have reduced the crew's Situational Awareness (SA), this would have been mitigated by use of paper charts, their previous experience flying in tactical airspace and the benign weather conditions en route.

1.4.168. As the PNF is responsible for navigation, the majority of the workload increase would have been felt by him, not the PF. Further, the crew stated that they located the TLZ with little difficulty.

1.4.169. The Crew also reported that a temporary phugoid was experienced during the transit. DFDR analysis confirmed an oscillation in pitch for approximately 6 minutes, correlating with the Automatic Flight Control System switching between Altitude Hold and Speed Hold. It was not possible to determine if this was the result of a system malfunction or an inadvertent selection by the crew; however, the phugoid did not reoccur during the sortie. Exhibit 145 Exhibit 14 Exhibit 358

1.4.170. The Panel assessed it as extremely unlikely that any of these malfunctions acted as a stressor to, or fatigued, the PF.

1.4.171. The Panel concluded that the malfunctions experienced en route were **Not a Factor** in the accident.

### Pre-Assault Checks – Inadvertent Depressurisation

1.4.172. The crew stated that the aircraft prematurely depressurised whilst en route to the TLZ. This followed completion of the LZ Pre-Assault Checks, which were conducted 10 minutes before landing, in accordance with the TATOM. When operating to semi-prepared or unprepared surfaces, the checks require isolation of the engine Nacelle Shut Off Valves to prevent potential dust and debris ingestion on Exhibit 146 Exhibit 147 Exhibit 148 landing. This removes engine bleed air from the pressurisation system causing the aircraft to start depressurising.

Exhibit 149

1.4.173. The checks were conducted at 11,000 ft as the aircraft was about to commence final descent. As such, the PNF believed sufficient time would exist to allow the aircraft to descend below 8,000 ft before the cabin altitude depressurised to that value. This is significant as RA 2309 and the FRCs require flight deck crew to don oxygen between 8,000 ft and 10,000 ft cabin altitude. However, the PNF had forgotten that cabin altitude had been re-set to 7,000 ft during the Combat Entry Checks in order to reduce the risk of explosive decompression should the aircraft be hit by small-arms fire.

Exhibit 151
Exhibit 150

Exhibit 149

1.4.174. The cabin altitude passed 10,000 ft before the descent actually commenced. This triggered a 'CAB ALT HIGH' alert on the aircraft's Advisory Caution and Warning System (ACAWS), following which the PF commenced an immediate descent to an altitude below 8,000 ft.

Exhibit 152

1.4.175. Although the Hercules DFDR doesn't monitor cabin altitude, it was likely that ZH873's cabin altitude exceeded 10,000 ft for approximately 30 seconds, and was above 8,000 ft for approximately 4 minutes.

1.4.176. RAF CAM assessed that this short duration exposure to a moderate altitude was unlikely to have generated a negative effect on cognitive performance in ZH873's crew members.

Exhibit 359
Exhibit 151
Exhibit 150

1.4.177. The crew was required to don oxygen following the 'CAB ALT HIGH' ACAWS alert in accordance with the FRCs and RA 2309. However, the Panel considered that the aircraft commander's decision to expedite the aircraft's descent rather than don oxygen was an airmanship consideration in accordance with the following proviso within MAA Regulations, *'The Regulations contained within the MRP do not absolve any person from using their best judgement to ensure the safety of Air Systems and personnel'.*

1.4.178. The Panel concluded that inadvertent depressurisation following the Pre-Assault Checks was **Not a Factor.**

1.4.179. The Panel **Observed** that TATOM guidance regarding timing of LZ Pre-Assault checks creates potential for a premature selection of the Engine Nacelle Shut Off Valves to occur, resulting in inadvertent depressurisation.

## Approach

### General

1.4.180. In the absence of any immediate technical malfunction causing the accident, the Panel focussed on other factors that could cause an aircraft to land short, in particular:

a. Weather.

b. Throttle Handling.

c. Speed.

d. Glide Slope.

e. Aiming Point.

f. Flare.

## Weather

1.4.181. The following meteorological effects were assessed as those most likely to cause an aircraft to suffer an undemanded, increased, rate of descent and land short of a runway: wind shear, turbulence, squalls, and microbursts. Table 5 records the weather conditions at the TLZ at the time of the accident:

| | |
|---|---|
| **Surface Wind** | 270/10 Kts |
| **2000 ft Wind** | 270/15 Kts |
| **Cloud Cover** | Nil |
| **Precipitation** | Nil |
| **Visibility** | 10 km or greater |
| **Surface Pressure** | 1006 Hpa |
| **Outside Air Temperature** | 30 Degrees Celsius |

Exhibit 112

**Table 5 – Weather at the TLZ, 25 Aug 17**

1.4.182. The Panel engaged with specialists from the Met Office to establish whether any localised weather effect could have affected ZH873. All evidence suggested that the meteorological conditions at the TLZ were not consistent with those required to produce weather phenomena that could have momentarily increased ZH873's rate of descent resulting in landing short. Exhibit 153

1.4.183. The Panel concluded that weather was **Not a Factor** in the accident.

## Throttle Handling

1.4.184. For a MOS approach the ACM states, *'Power reduction should be coordinated throughout the flare, aiming to achieve FLIGHT IDLE as the main wheels touch the ground'.* Exhibit 109

1.4.185. The TATOM and Aircrew Manual contain the following warnings, both cautioning large power reductions in the later stages of the approach.

> *'Warning: Power lever movements should be kept to a minimum during the final stages of the approach. A large power reduction <u>will</u> result in an early touch down.'* Exhibit 147

> *'CAUTION: Pilots should be aware that attempts to correct airspeed excesses in the final stages of the approach by reducing power can lead to the aircraft touching down heavier and earlier than expected. The effect might be especially significant in `hot and high' climatic conditions. Pilots should also avoid premature reduction of power if the aircraft appears high* Exhibit 109

*at a late stage in the approach. If the speed is greater than VAT+5 kts or the aircraft is high, overshoot should be considered.'*

1.4.186. These warnings are the result of a QinetiQ trial, which observed that reducing power to correct excess airspeed during the latter stages of an approach could result in an unexpected touchdown short of the runway. The QinetiQ report found that the most significant effect of reducing power was not a change in airspeed, but a change in the flight path angle due to less powered lift. Powered lift, also called 'blown lift', is generated by the increased air flowing over the wing behind the propeller. Exhibit 154

1.4.187. Given that a power reduction could result in an aircraft touching down early, and recognising that ZH873 was fast during its approach (see paragraph 1.4.193), the Panel investigated if the power lever movements of the PF were significant enough to reduce powered lift and cause the aircraft to land short.

1.4.188. The Air Test and Evaluation Centre (ATEC) stated that during the trial, final power reduction occurred typically 1 to 2 seconds prior to touch down for a normal MOS landing. Figure 4, a DFDR trace of ZH873's throttle position, airspeed and height, demonstrates the PF initiated final power reduction approximately 0.5 seconds before the aircraft impacted the ground. Therefore, compared to other MOS landings, the power reduction seen by ZH873 was actually later that would have been expected. Exhibit 155 Exhibit 156

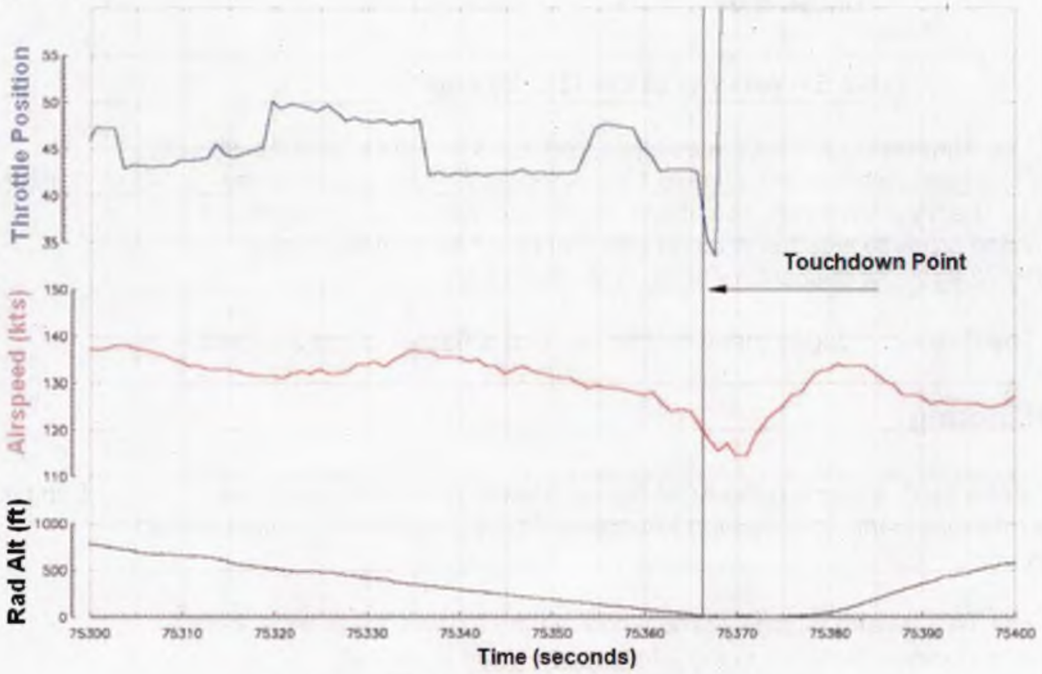


**Figure 4 – Throttle Position vs Airspeed**

1.4.189. The Panel determined that there was no evidence of an early and/or excessive power reduction leading to a high rate of descent at touchdown.

1.4.190. Notwithstanding this, the Panel queried why the PF closed the throttles later than had been apparent in the MOS trial sorties; this is further considered in paragraphs 1.4.224 *et seq.*

1.4.191. The Panel concluded that the PF's throttle handling was **Not a Factor**.

## Speed

1.4.192. The ACM MOS technique involves flying the approach at $V_{AT}$ +5kts reducing to $V_{AT}$ by 50 ft Above Ground Level (AGL). $V_{AT}$ is defined as the speed at which the aircraft should cross the runway threshold when landing, and for MOS approaches is 123% of the aircraft's stalling speed. Exhibit 157

1.4.193. Based on the aircraft's weight of 61.5 Tonnes, ZH873's $V_{AT}$ was correctly calculated by the crew as 121 kts, with a stalling speed of 98.37 kts. Table 6 records its Indicated Airspeed (IAS) at 50 ft intervals from 500 ft above ground level (agl), and demonstrates that it was consistently fast. Exhibit 160 Exhibit 161

| Height (ft agl) | Speed (Kts) | Difference from $V_{AT}$ |
|---|---|---|
| 500 | 131 | +10 |
| 450 | 132 | +11 |
| 400 | 134 | +13 |
| 350 | 137 | +16 |
| 300 | 135 | +14 |
| 250 | 133 | +12 |
| 200 | 132 | +11 |
| 150 | 130 | +9 |
| 100 | 128 | +7 |
| 50 | 124 | +3 |
| 0 | 121 | - |

**Table 6 – ZH873's Indicated Airspeed from 500 ft until impact**

1.4.194. Although ZH873's stalling speed was 98.37 kts, this could have been higher were a load factor (commonly referred to as g-force) applied to the aircraft; ie the higher the g-force, the higher the stalling speed. The increase is calculated by multiplying the stalling speed by the square root of the g-force applied. Analysis of ZH873's DFDR demonstrates that in the 30 seconds prior to impacting the ground, the maximum g-force experienced by the aircraft was 1.18 g. Therefore, the maximum stalling speed would have been $\sqrt{1.18} \times 98.37$, ie 106.85 kts. Exhibit 159 Exhibit 161

1.4.195. Given that ZH873's speed never dropped below 121 kts and that the aircraft's inbuilt stall protection equipment did not activate, the Panel assessed that the aircraft didn't stall prior to impacting the ground. Exhibit 161

1.4.196. The ACM states that, '*...provided $V_{AT}$ is achieved within 5 kts, the correct MOS technique is flown and the aircraft has touched down before the stop-go line, then sufficient landing ground run will be available.*' Although this was achieved, the speed profile throughout the approach was consistently and significantly above the prescribed limit. It was also the case that, due to the density altitude, the aircraft's groundspeed would have been up to 8 knots higher than the speed indicated to the pilot. Exhibit 162

1.4.197. The Panel assessed that it was more likely than not that the PF's need to control speed in the final stages of the approach, as prompted twice by the PNF, would have served as a distraction in the final stages when attempting to gain sufficient visual acuity to judge a flare and land. Additionally, he would have been approaching the TLZ at a higher groundspeed speed that he had been used to in his limited recent live MOS flying, reducing the time available both to decelerate and judge his flare. Witness 4

1.4.198. The Panel concluded that the speed of the aircraft at touchdown was **Not a Factor**; however, the PF's efforts to reduce it to $V_{AT}$ were an additional distraction.

## Glide Slope

1.4.199. The Hercules Aircrew Manual prescribes a 3° approach for MOS and, therefore, NSO approaches. Given witness testimony that the PF flew a 2.5° approach aiming at the front of the Touchdown Box, the Panel sought to establish whether this shallower approach could have resulted in ZH873 landing short. Exhibit 157

1.4.200. Particularly in large transport aircraft, pilots sit in a position significantly forward of, and well above, the main wheels. The Aiming Point selected by a pilot when landing is the position at which their eyes would touch down if carried to a logical conclusion; however, this is not physically possible because of their position in relation to the undercarriage, which will touch down below and behind them. This principle is widely referred to as "*Eye to Wheel Height*" and the Panel noted a comprehensive explanation of it, and its relevance to Glideslopes, in the Sentry E-3D Aircrew Manual, supplemented by a diagram (Figure 5). There is no such information in the Hercules Aircrew Manual. Exhibit 163

> *'On a visual approach at 2.5°, aiming 1000 feet from the threshold, the pilot's eye passes about 43 feet above the threshold. Because of the vertical distance between the pilot's eye level and the bottom of the mainwheels (about 23 feet in the E-3D under normal approach conditions) the mainwheels pass 20 feet above the threshold, and without flare would touch down only 470 feet up the runway. If the pilot flies a flatter, say 1.5° approach to the same aim point, the mainwheel touchdown point moves back to a point just five feet in from the threshold'.* Exhibit 163

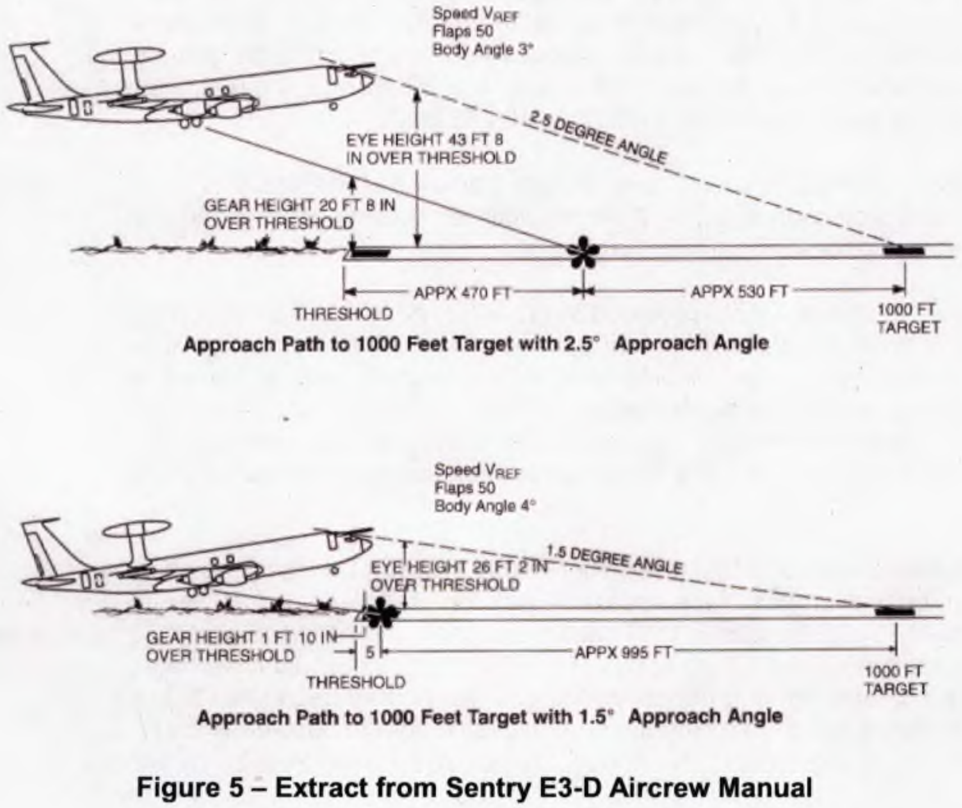


**Figure 5 – Extract from Sentry E3-D Aircrew Manual**

1.4.201. The landing position of the main undercarriage on any given approach can be calculated by trigonometry. If a pilot, positioned *h* ft above the main wheels, and *x* ft in front of them, flies a glide slope of $\alpha°$, then the distance, *d*, between the pilot and the Aiming Point at touch down is given by the formula $d = h / \tan(\alpha)$. The aircraft's actual touchdown point is $d + x$, as illustrated in Figure 6:

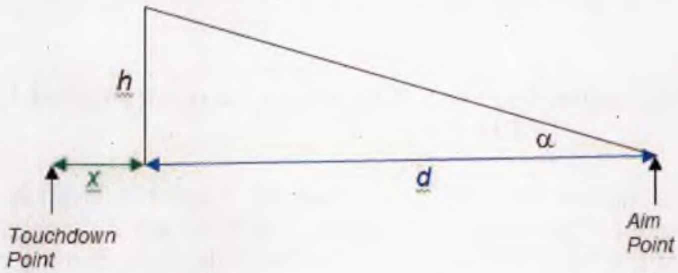


**Figure 6 – Trigonometric Illustration of Main Wheel Touchdown Point**

1.4.202. In the Hercules, the pilots sit 45.58 ft (*x*) in front of, and 11.83 ft (*h*) above, the main wheels. The distances that a Hercules' main undercarriage will touch down from the Aiming Point on 2.5° (*d1*) and 3° (*d2*) approaches can be evaluated as:

| | |
|---|---|
| *d1* = 11.83/tan(2.5°) + 45.58 | *d2* = 11.83/tan(3.0°) + 45.58 |
| = 270.95 + 45.58 | = 225.73 + 45.58 |
| = 316.53 ft | = 271.31 ft |

1.4.203. This is illustrated for a 2.5° approach in Figure 7 below:

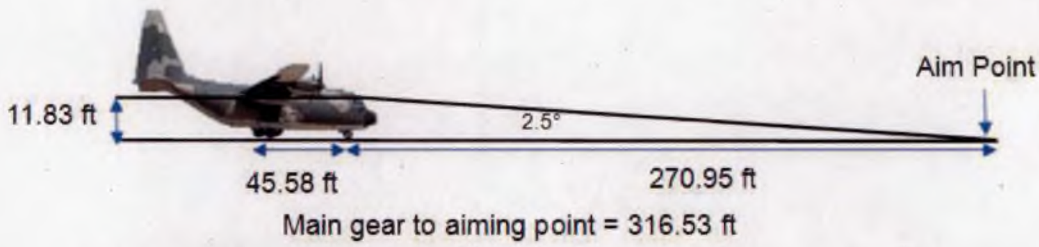


**Figure 7 - Hercules Main Wheel Touchdown Point – 2.5° Approach**

1.4.204. However, this analysis is based on the aircraft being in a horizontal attitude whereas the expectation on landing would be for a nose up attitude due to flaring of the aircraft. DFDR evidence indicated that ZH873 had a 1.5° nose up attitude at impact; this would increase the vertical displacement of the pilot from the main wheels to 13.82 ft, but decrease the horizontal distance to 45.56 ft. The net effect of this pitch is for the wheels to touch down 362.09 ft before the Aiming Point, as shown below in Figure 8. Exhibit 164

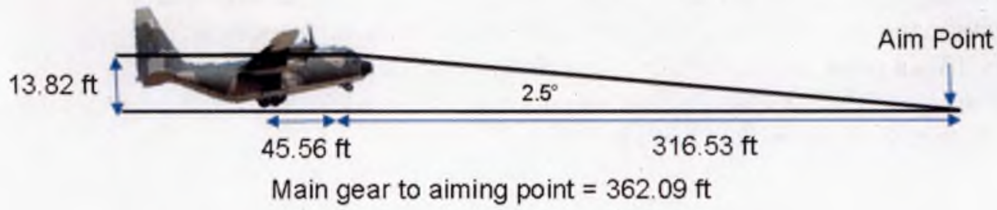


**Figure 8 - Main Wheel Touchdown Point – 2.5° Approach / Aircraft Pitched 1.5° Nose Up**

1.4.205. The Hercules is equipped with a HUD, an example of which is given in Figure 9, and includes a number of features which assist pilots flying an approach. The Reference Flight Path Angle Bar (FPA) is set to a desired glide slope and the aircraft is flown to a position where the FPA is aligned with the required Aiming Point on the ground. In simplistic terms, if the pilot then controls the aircraft to keep the Climb Dive Marker (CDM) positioned over the FPA, the aircraft will follow the desired glide slope towards the selected Aiming Point.

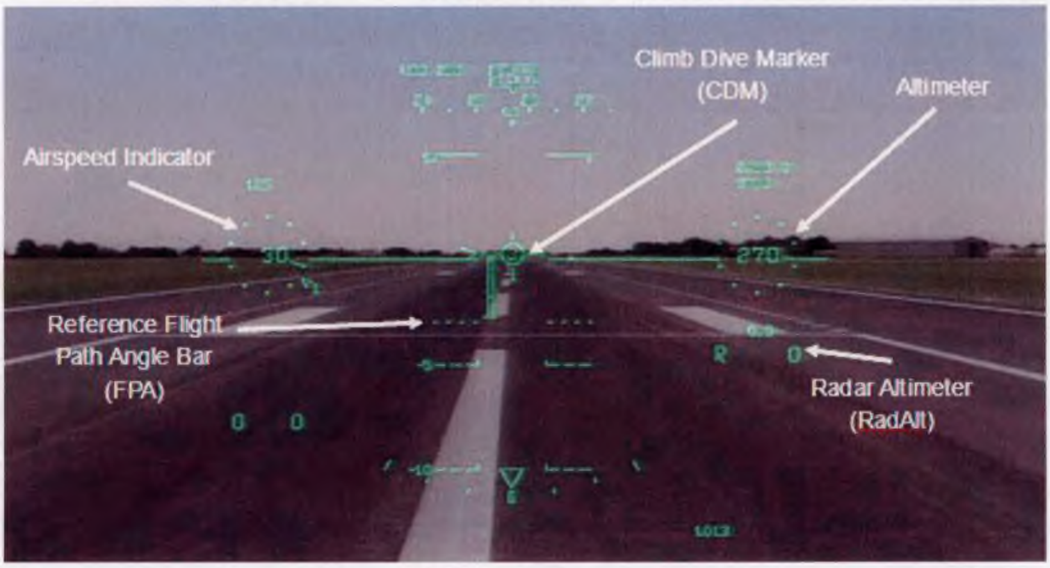


**Figure 9 – Hercules HUD**

1.4.206. The Panel sought to confirm the calculations above regarding main wheel touchdown points by performing a test within an aircraft. As shown in Figure 10 the FPA on an actual aircraft was aligned with a point on the ground and the distance from the main wheels measured.


OFFICIAL SENSITIVE

 

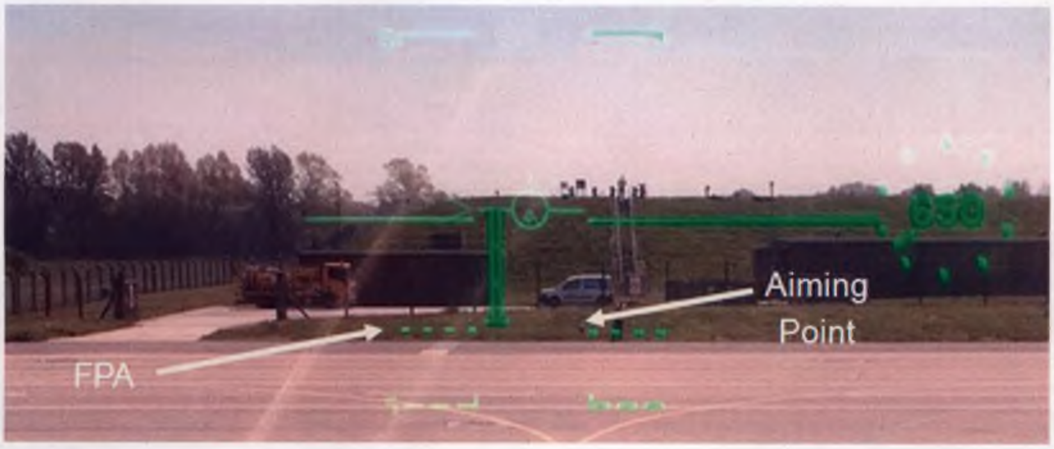


**Figure 10 – FPA Set to 3°**

1.4.207. Table 7 summarises the Panel's findings as well as the expected distance from an Aiming Point calculated by trigonometry.

| FPA (Glide Slope) | Expected Distance Trigonometry (Aircraft 0.23° Nose Up) | Measured Distance (Engineer's Wheel) | Percentage Error |
|---|---|---|---|
| 2.5° | 275 ft | 295 ft | 6.7% |
| 3.0° | 229 ft | 268 ft | 14.5% |
| 3.5° | 196 ft | 221 ft | 11.3% |
| 4.0° | 172 ft | 186 ft | 7.5% |

**Table 7 – Expected and Measured Eye to Wheel Height Distance**

1.4.208. The Panel noted the apparent differences between the expected and measured distances and attributed this to:

a. A potential error of 0.02° in the HUD due to alignment tolerances.

b. Difficulties accurately aligning the FPA with the marked point.

1.4.209. Notwithstanding this, the Panel were satisfied that the measured distances supported the Panel's calculations, with an average error of 10%.

1.4.210. Thus, in the absence of any other factor, from a 2.5° approach and a 1.5° pitch up attitude at landing, ZH873's theoretical touchdown point would have been 362 ft short of the selected Aiming Point. The crew testified that the PF was aiming at or just beyond the start of the Touchdown Box, and evidence states that the aircraft landed 400 ft short of it.

1.4.211. As to the actual glideslope flown, analysis was conducted by ATEC and DAIB. ATEC concluded that the average glideslope flown over the final 1.5nm of the approach was 2.5°, as stated by both pilots. The DAIB analysis suggested that the approach was as shallow as 2° for much of the approach, but recovered to 2.5° during the final 4 seconds before impact, as shown in Figure 11.

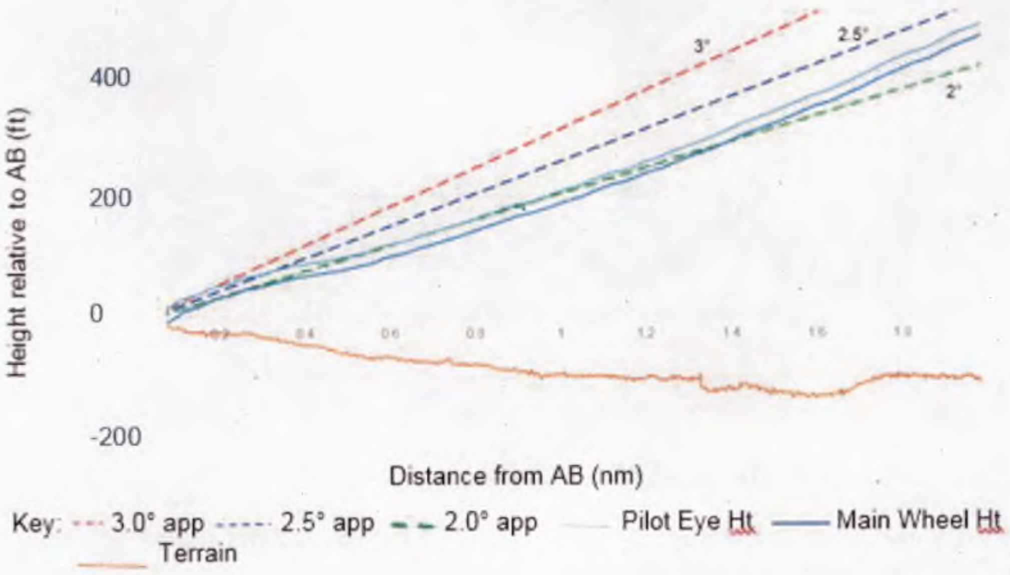


Exhibit 108

Exhibit 360
Exhibit 167

**Figure 11 – DAIB Analysis of ZH873's Approach Profile**

1.4.212. Investigation by the DAIB indicated a discrepancy between the HUD imagery displayed to the PF and PNF. Figures 12 and 13 show that the PF and PNF HUDs displayed the Horizon bar and FPA in different positions. Both photographs were taken with the aircraft in the same position, and the FPA set to 2.5°. This was assessed as a misalignment of the 2 Embedded Global Positioning System and Inertial Navigation System Units (EGIs) that provide data to position respective HUD symbology. Given the austere location of the aircraft, full forensic investigation of this potential fault, which could only be achieved with the units in situ, was not possible. The DAIB investigator estimated a potential error of 0.25°, but it could not be determined whether this was isolated to a single EGI/HUD, or a combination of individual errors within each of them. Exhibit 167

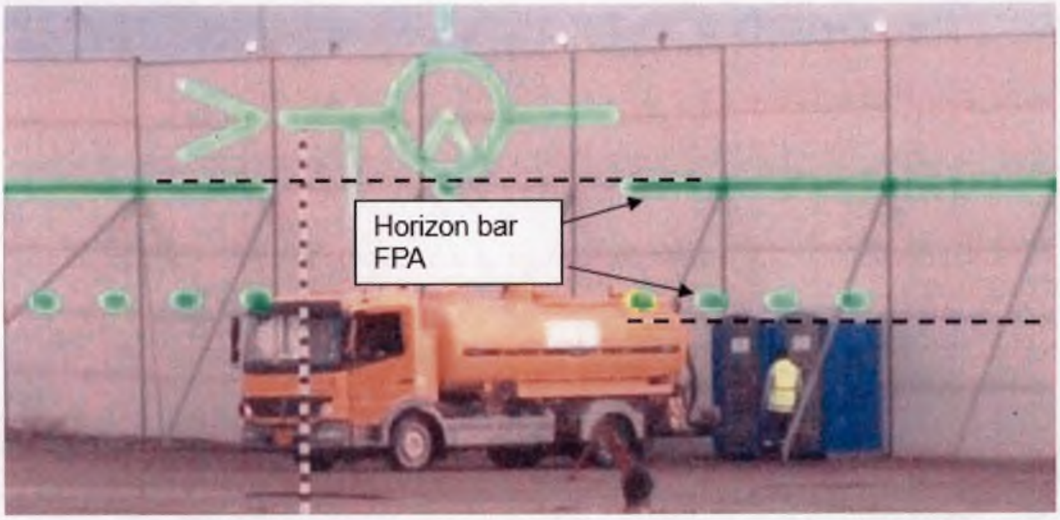


Exhibit 358

**Figure 12 – PF's HUD**

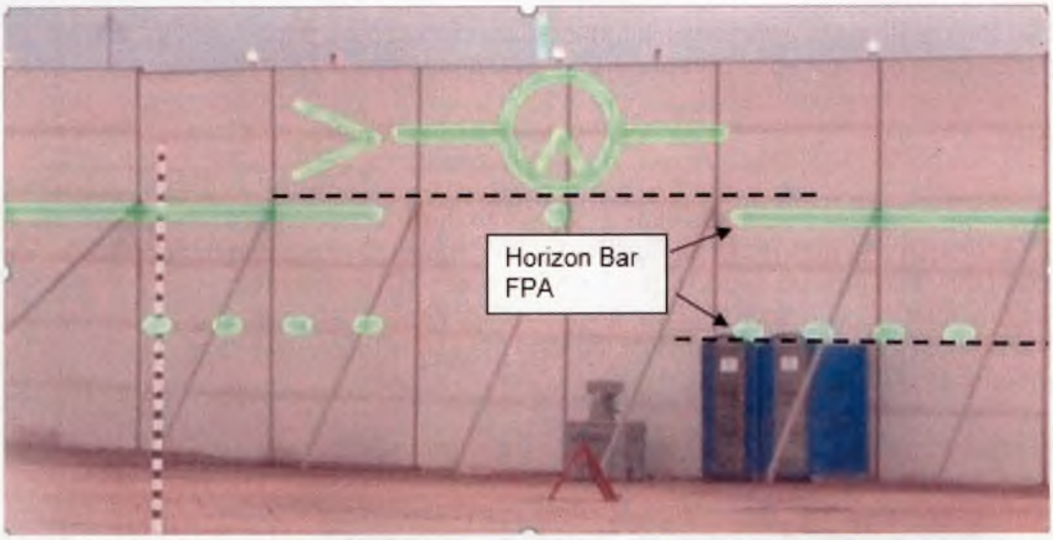


Exhibit 358

**Figure 13 – PNF's HUD**

1.4.213. Thus, during the approach, when the PF's CDM and FPA were aligned on his intended Aiming Point, it is likely that the PNF's display would have been different. The PNF would have seen the CDM aligned with the Aiming Point, but his FPA would have been displayed lower on his HUD. Were the PNF's display accurate, and the error contained solely to the PF's HUD, then this would result in the aircraft actually being flown on a shallower approach than intended, in this case as low as 2.25° based on the DAIB assessment. Neither pilot reported any such discrepancy; however, the Panel considered it highly probable that it was of a magnitude that would not be noticed easily in a dynamic cockpit environment. Nevertheless, were it the case that a 2.25° approach had been flown, then the theoretical touchdown point would have been 397.30 ft from the intended Aiming Point. Exhibit 358

1.4.214. The Panel determined that:

a. Despite the differences in the ATEC and DAIB analyses, it was highly probable that the glideslope flown by the PF was in the order of 2.5° in the latter phase of the approach, and almost certainly shallower than the prescribed 3°.

b. Although there was an apparent discrepancy in the pilots' HUD displays, it was not possible to determine with any confidence its magnitude, its significance to the PF's approach or its effect on the actual Touchdown Point. Exhibit 358

c. Had the PF flown a 3° approach it is very likely that ZH873 would have touched down closer to the runway, almost certainly onto the surface preceding the overrun. It is extremely likely that this would have resulted in less structural damage to the aircraft (see paragraph 1.4.232 et seq).

1.4.215. Based on the PF's intended aiming point and the calculated touchdown point, the Panel concluded that the glide slope was a **Contributory Factor**.

1.4.216. A recommendation regarding MOS approaches, including the glide slope is made at paragraph 1.4.479.

1.4.217. Eye to Wheel height awareness is further discussed at paragraph 1.4.570. HUD discrepancies are considered at paragraphs 1.4.580 *et seq.*

## Aiming Point

1.4.218. The Hercules ACM prescribes aiming 150 ft into the Touchdown Box when flying an MOS approach. As outlined in paragraph 1.4.205, the HUD has a number of features to assist this, and Figures 14 to 16 (screenshots taken in the Hercules simulator) illustrate how the FPA and CDM are positioned for three differing aiming points. For the purposes of clarity, the lights delineating the 500 ft Touchdown Box have been enhanced. Exhibit 109

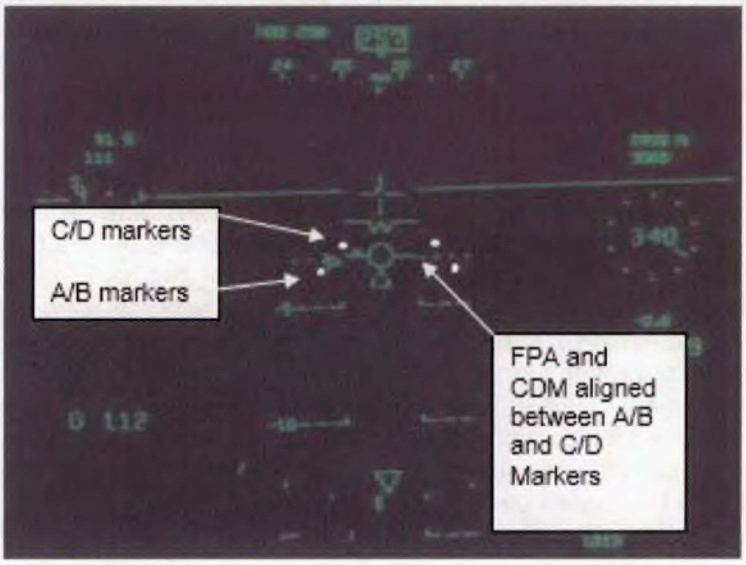


**Figure 14 – Aiming inside the Touchdown Box**

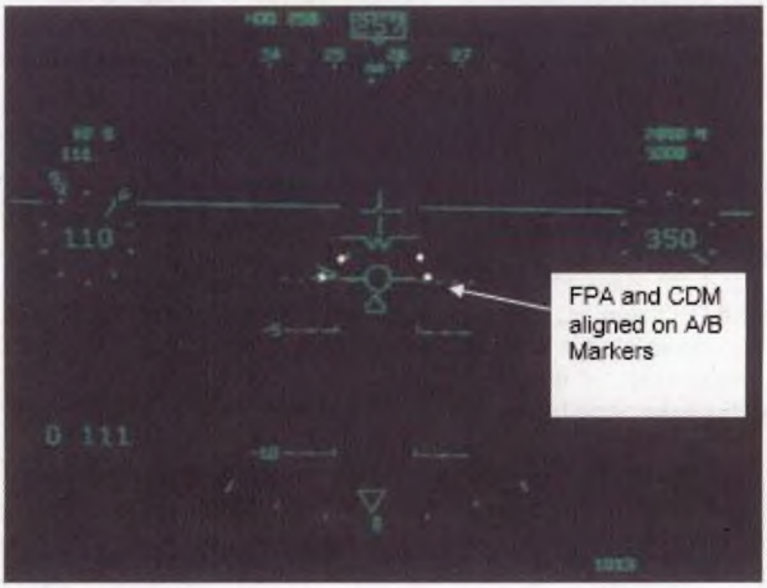


**Figure 15 –Aiming at the front of the Touchdown Box**

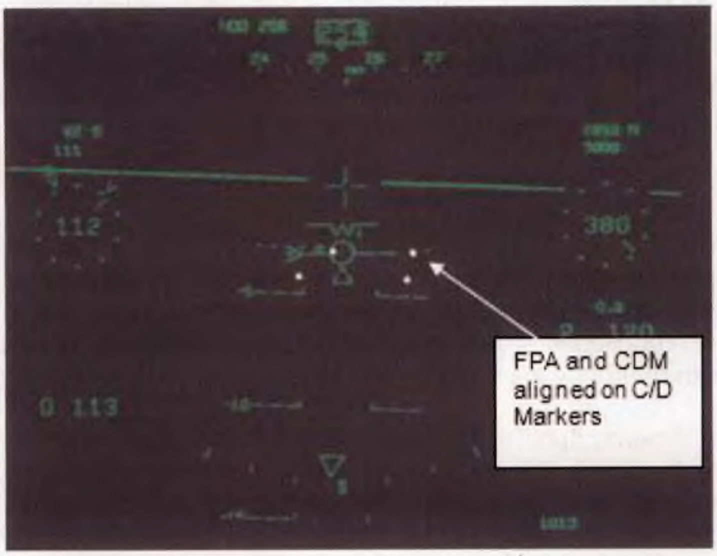


**Figure 16 – Aiming at the back of the Touchdown Box**

1.4.219. Testimony from both pilots, indicates that the handling pilot was aiming at the front of the Touchdown Box, which was not in accordance with the ACM. As is further discussed at paragraph 1.4.553, the PF indicated that his recent experience of lighter aircraft in the training environment was of a tendency for aircraft to 'float' and touch down towards the back of the Touchdown Box. His selection of an aiming point shorter than mandated reflected his desire to avoid missing the Touchdown Box or floating down the runway, and having to initiate a Go-Around.

Witness 1
Witness 1a
Witness 1e
Witness 4
Witness 4a
Witness 4d

1.4.220. The potential implications of aiming short are well described in the Sentry E-3D ACM. Figure 17 demonstrates how a Sentry could land 30 ft short of the runway when aiming 500 ft into it, rather than the prescribed 1000 ft. There is no such advice given within the Hercules Aircraft Document Set:

Exhibit 163

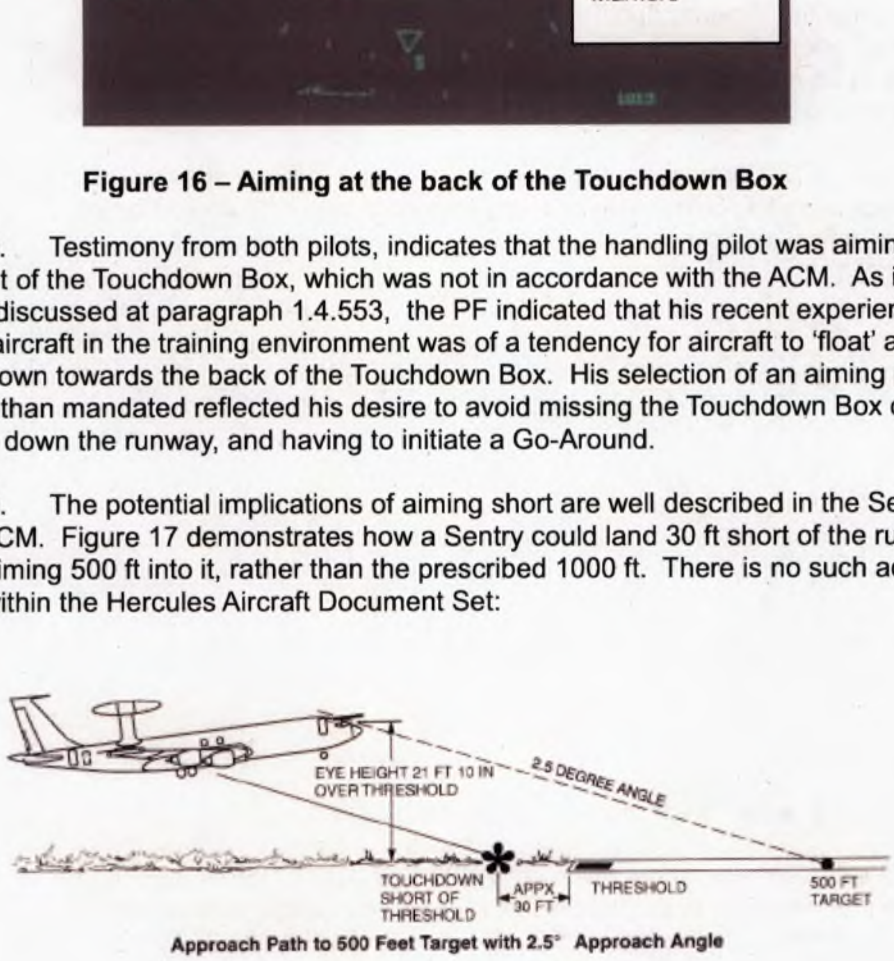


**Figure 17 – Landing Short when Aiming 500ft, instead of 1000ft, into a runway**

1.4.221. Had the PF aimed into the Touchdown Box, the Panel assessed it as almost certain that ZH873 would have landed 150 ft further forward than it did. At the very least this would have been beyond the 4° slope, and extremely likely to have been on the 300 ft of prepared overrun surface rather than 100 ft short of it. This would almost certainly have resulted in less structural damage to the aircraft (see paragraph 1.4.232 et seq).

1.4.222. The Panel concluded that the PF's selected Aiming Point, being at the front of the Touchdown Box, was a **Contributory Factor.**

1.4.223. A recommendation regarding MOS approaches, including the Aiming Point is made at paragraph 1.4.479.

## Flare

1.4.224. The flare in a fixed wing aircraft is the transition phase between the final approach and the touchdown on the runway. It involves a simultaneous increase in aircraft pitch attitude and a reduction in engine power/thrust, the combination of which results in a decrease in both rate of descent (RoD) and airspeed.

1.4.225. As highlighted in paragraph 1.4.200, a large aircraft can touch down significantly short of where the pilot is aiming because of Eye to Wheel height; however, this should be negated by the horizontal distance covered as an aircraft flares (flare distance), ie the mainwheels should touchdown closer to the Aiming Point.

1.4.226. Figure 18, a DFDR trace of ZH873's flare, shows a gradual nose up input (increase in elevator angle) approximately 5 seconds prior to impact, followed by an increased nose up deflection approximately 0.4 seconds before impact.

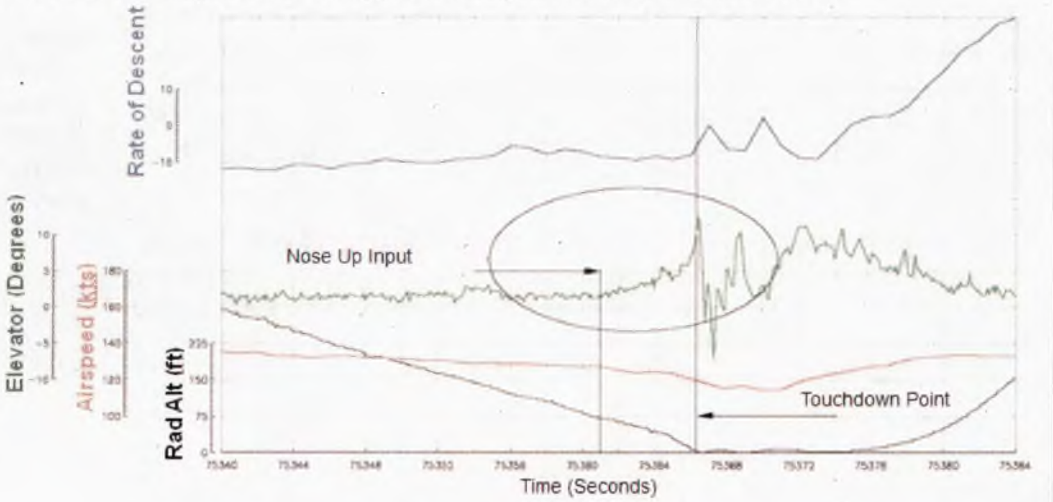


Exhibit 169

**Figure 18 – Increase in Elevator Angle**

1.4.227. ZH873's flare was compared with data gathered during NSO trials (Figure 19). In each case the initial part of the flare is very similar, ie at about 5 seconds prior to touchdown a gradual nose up elevator input is initiated. However, ZH873's trace shows that the final elevator deflection is later than the other 2 approaches, and ZH873 appears to have touched down before its flare was completed, ie the aircraft impacts the ground while the elevator input is still being increased. This would have affected the reduction in the rate of descent and achievement of the full flare distance expected.

Exhibit 169

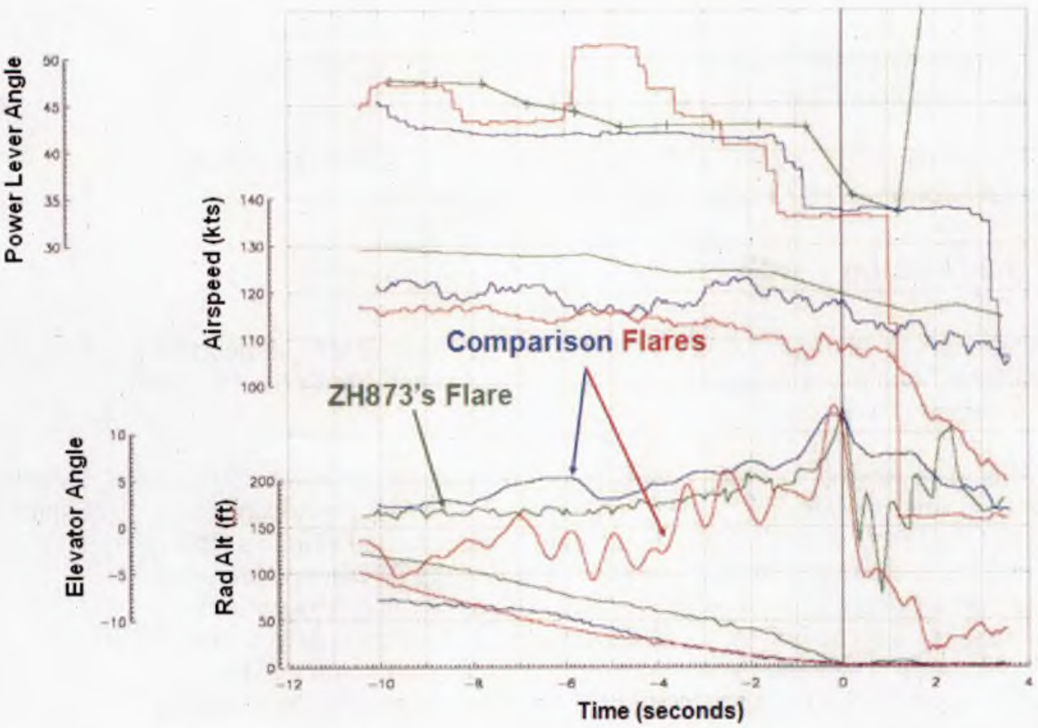


**Figure 19 - Flare Comparison – ZH873 and NSO Trial Data**

1.4.228. The Panel queried whether the differences in flare timing might have reflected aircraft weight; those used in the NSO trials' sorties, at 59 tonnes, were approximately 2.5 tonnes lighter than ZH873. In response ATEC confirmed that, by analysing other MOS landings, the amount of elevator input required to perform the required "check" of RoD is not significantly affected by All up Mass or Centre of Gravity. The magnitude of the final elevator input observed on ZH873 was similar to that seen during MOS landings at similar AUM during ATEC trials. Exhibit 169 Exhibit 170 Exhibit 171

1.4.229. Additionally, ATEC stated that, given the conditions at the time, ZH873's flare distance should have been 380 ft. It was not possible to determine how much, if any of this, was actually achieved from the late and incomplete flare. Exhibit 169

1.4.230. The Panel determined that:

a. ZH873 was flared late. This is reinforced by the apparent late power reduction as discussed in paragraph 1.4.188.

b. The flare was ineffective, resulting in:

(1) The aircraft's rate of descent not being reduced and;

(2) Insufficient horizontal distance being covered to achieve a landing within the Touchdown Box (see paragraphs 1.4.449 *et seq)*.

c. From the point at which the PF entered his final flare the aircraft's trajectory was not recoverable resulting in a ground impact 400 ft before the Touchdown Box, and onto a significant slope that was approximately 100 ft short of the prepared overrun surface.

d. Had the flare been initiated earlier and/or completed, it is highly probable that ZH873 would have landed up to 380 ft further into the TLZ, adjacent to the AB markers as intended.

1.4.231. The Panel concluded that an ineffective flare, being late and incomplete, was the **Causal Factor** of ZH873 landing short of the TLZ overrun.

## Why was the Landing Hard?

1.4.232. The analysis at paras 1.4.180 - 1.4.231 explains why ZH873 landed short of the TLZ surface, but does not explain why the landing was sufficiently hard to result in Category 5 damage.

1.4.233. At landing weights in excess of 58,970 kg (as was the case with ZH873), the Hercules RTS limits the landing rate of descent (RoD) to 5 feet per second (ft/s); below that weight the RoD limit is 9 ft/s. An accurate assessment of ZH873's RoD at impact was difficult to calculate due to low sampling rate of the DFDR, and known pressure errors which affect pitot-static instruments as the aircraft enters ground effect. Notwithstanding these issues, QinetiQ flight physicists were able to utilise ZH873's True Airspeed (TAS) and Flight Path Angle (FPA) to determine that the aircraft would have had a RoD of approximately 9 ft/s immediately prior to impacting the ground (Figure 20). Exhibit 368 Exhibit 169

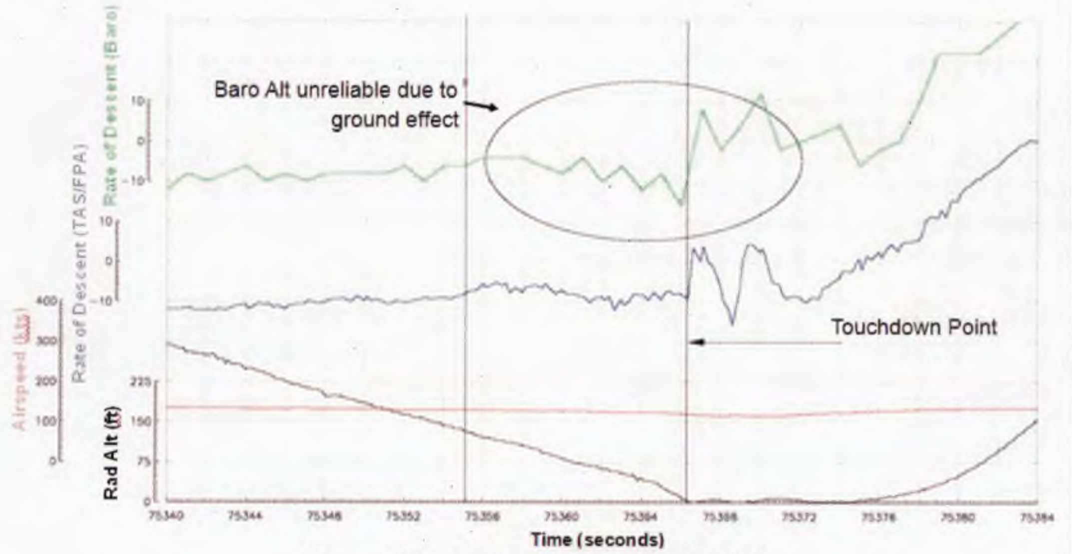


Exhibit 169

**Figure 20 – Rate of Descent Profile**

1.4.234. ATEC indicated that Lockheed Martin has increased the maximum AUM associated with the higher 9 ft/s RoD to 71,669 kg. This revision has not been incorporated by the Hercules Project Team (HPT), but the Panel noted the catastrophic damage suffered by ZH873 despite its RoD being only marginally in excess of a potentially revised limitation. Exhibit 169

1.4.235. Light Detection and Ranging (LIDAR) imagery of the TLZ, along with DFDR data, was used to produce a detailed model of the terrain under ZH873's approach. Figure 21 highlights the significance of the slope preceding the TLZ. Exhibit 172

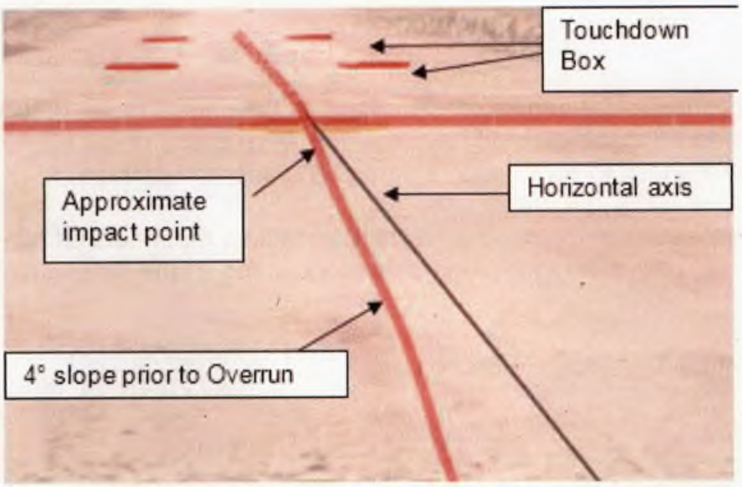


**Figure 21 – Slope Preceding Overrun**

1.4.236. Advice was sought regarding the implication of landing on up-sloping terrain, for which ATEC assessed the relative RoD across a variety of gradients (Table 8). This indicates that, had ZH873 touched down on the overrun or runway (with a slope of 0.3°) then the effective RoD would almost certainly have been in the order of 10.10 ft/s. However, the effect of landing on the 4° slope immediately prior was to increase this to 23.77 ft/s, in excess of 4 times the limit prescribed by the RTS, and more than twice that cleared by the Lockheed Martin. Exhibit 173

| Ground Speed | Actual Rate of Descent (RoD) | Slope | Slope | Relative RoD |
|---|---|---|---|---|
| (Kts) | (ft/s) | (%) | (deg) | (ft/s) |
| 125.0 | 9.00 | 0.00 | 0.00 | 9.00 |
| **125.0** | **9.00** | **0.52** | **0.30** | **10.10** |
| 125.0 | 9.00 | 2.00 | 1.15 | 13.22 |
| **125.0** | **9.00** | **7.00** | **4.00** | **23.77** |

**Table 8 – Impact on RoD of Sloping Surfaces**

1.4.237. The Panel determined that:

a. The Hard Landing was a result of impacting the 4° upslope that created a relative RoD of approximately 23.77 ft/s.

b. Had ZH873 impacted the TLZ overrun that had an upslope of 0.3°, it is extremely unlikely that it would have sustained the same level of damage, albeit that the RTS RoD limitation would almost certainly have been exceeded.

1.4.238. The Panel concluded that the upslope immediately preceding the TLZ Overrun was an **Aggravating Factor**.

## Situational Awareness

1.4.239. Having established a late and incomplete flare as the causal factor of the accident, the Panel considered that this could have resulted from a loss of, or insufficient, situational awareness to commence a flare at the appropriate time.

1.4.240. The Panel assessed the following as significant factors that could affect crew situational awareness, particularly with regards to conducting a safe flare at night using NVG:

a. Ambient Light / Visual References.

b. NVG Setup.

c. Aircraft Landing Lights.

d. Rad Alt.

e. Visual Illusions.

## Ambient Light / Visual References

1.4.241. Although NVG MOS approaches are conducted with extensive use of aids within the HUD, the Aircrew Manual states these should only be used until approximately 100 ft agl, after which the approach should be continued using visual cues only. It also states:

> *'During NVG landings a daytime technique should be used as judging the* [flare] *is not difficult especially when using the IR landing lights.'* Exhibit 109

1.4.242. The minimum light conditions for flight on NVG are contained in 2 Gp ASOs, which state: Exhibit 174

> *'**NVG Ops - Minimum Light Conditions**. NVG flying is not to take place when the forecast zero cloud light level is below 2 mLux or equivalent. This does not restrict approaches, landings and take-offs from lit TLZs where the required visual references are available.'*

1.4.243. In attempting to establish what constitutes a lit TLZ neither STANEVAL or TACATC could provide a reference, but stated that the minimum requirements would be IR markers denoting both the Touchdown Box and the end of the runway. Exhibit 175 Exhibit 176

1.4.244. Similarly, 2 Gp ASOs gave no definition as to what the required visual references were, for which STANEVAL referred the Panel to the Manual of Military Air Traffic Management (MMATM).

1.4.245. MMATM states that, '*All current approach procedures ultimately end with a visual approach when the required visual references are acquired or when a missed approach is begun.*' The required visual references are listed dependent on the type of approach flown; for example, to land from a non-precision approach, at least one of the following must be '*distinctly visible to and identifiable by the pilot.*' (as illustrated in Figure 22 below). Exhibit 177

a. Elements of the approach light system.

b. The threshold, or its markings, lights or identification lights.

c. The visual glide slope indicator(s).

d. The touchdown zone, zone markings or zone lights.

e. The runway edge lights.

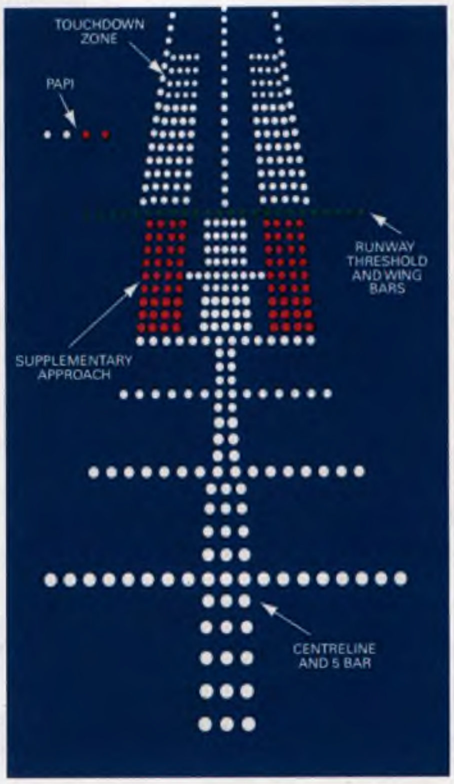


**Figure 22 – Approach and Runway Lighting Example**

1.4.246. The same criteria are re-produced in AMASIs. Exhibit 179

1.4.247. The Panel was of the opinion that the visual references in both MMATM and AMASIs were written for landings at conventionally lit runways, and are not relevant to *'Bare Minimum TLZ Markings'* (those lit with IR Lights only). The Panel questioned how a daytime technique, as required by the ACM, could be utilised in zero mLux with the only lighting available being IR markers. STANEVAL stated that in such circumstances *'the visual flare will be achieved by illumination from the landing lights'*. The only 2 Gp ASO order requiring landing or taxi lights to be switched on for NVG landings was within the C-17 section. Exhibit 36 Exhibit 175 Exhibit 180

1.4.248. The crew of ZH873 was conducting the approach with illumination levels of approximately 2 mLux. In their initial interviews with the Panel, the PF and PNF stated that light levels during the approach were expected to be between 4 and 8 mLux, based on the Meteorology Brief; however, they described the levels of visual acuity as low. Exhibit 112 Witness 1 Witness 4

1.4.249. The PF stated that, initially, his Aiming Point of the AB markers stood out really well. However, at approximately 50 ft, as he transitioned from focussing on Exhibit 182

HUD information to concentrate on visual cues from the runway, he had no ground definition and the picture was monochromatic. Rather than having granularity that helps judgement of height, such as undulations and gravel being highlighted by the IR lights, the touchdown area appeared like a '*floating box'*.

1.4.250. Other crew members had similar impressions, stating that it was very black with single spots of light, and that there was very little definition or visual acuity given the insufficient ambient light for definition to be gained through the goggles. Exhibit 183 Exhibit 184 Exhibit 185

1.4.251. The Panel also noted the PF's interview during the DAIB Triage investigation, 3 days after the accident, where he said that he could remember thinking (as the aircraft passed 50 ft) that he was finding it hard to judge his position, and that ground features could not be identified due to the monochromatic picture. In relating the Rad Alt calls from 50 ft he indicated that he thought that the ground impact occurred very soon after the 20 ft call and that he could not recall whether or not he had flared the aircraft. Exhibit 186

1.4.252. On balance, given the very low light levels and the overall impression of poor visual references on final approach, the Panel opined that the crew could see little more than the 5 IR markers delineating the runway, and very little else in the way of ground definition. This was particularly re-enforced by the PF stating that it appeared to be like a *'floating box'*.

1.4.253. The Panel assessed that:

a. The required visual references in MMATM relate only to landings from instrument approaches, and were not relevant to NVG approaches to TLZs.

b. 2 Gp ASOs lack clarity regarding required visual references for NVG MOS approaches.

c. The Hercules Force has insufficient advice regarding the use of landing lights in tactical scenarios (see Paragraphs 1.4.265 *et seq*).

d. The actual light levels were less than those expected by the pilots, reflecting the lack of a specific location brief (see paragraph 1.4.124).

e. The crew of ZH873 had insufficient visual references to judge a flare and make a safe landing. In such circumstances a Go-Around should be initiated.

1.4.254. The Panel concluded that low ambient light and poor visual cues were a **Contributory Factor**.

**Recommendation:**

1.4.255. **D MAA should revise MRP content specific to NVG operations, particularly consideration of minimum light levels in order to provide enhanced guidance for operations to *'Bare Minimum TLZ Markings'*.**

1.4.256. **AOC 2 Gp should establish the required visual references for Air Mobility Force aircraft conducting NVG approaches to TLZs.**

## Night Vision Goggle Setup

1.4.257. In order to facilitate visual flying at night in a tactical environment, military pilots utilise NVG. Although colloquially described as NVG, the equipment consists of 2 components:

> a. The overall assembly (NVG) including mounting bracket, battery compartment, adjusters and switches.
>
> b. Image Intensifier Tubes (IIT) that amplify light across the entire visible spectrum and into the near IR to produce an intensified image visible to the user through the eye-piece.

1.4.258. Correct set up of NVGs is considered as critical both to maximise their performance and to accommodate differences between each user's helmet brow position, facial anthropometry and sitting posture. The aim is to position the NVGs such that each eye is looking along the optical axis of each eye piece, and at the correct distance from the eye (eye relief) to allow the full field of view to be observed by the user as a single circular image. At the correct eye relief, it should still be possible to maintain a view of the cockpit instruments under the eye pieces. Once correctly positioned, it is then necessary to adjust the optical focus to provide a comfortable viewing distance (normally to infinity) for which the Hoffman 20/20 Test Box is recommended. Exhibit 187

1.4.259. Both pilots of ZH873 stated that they focussed and adjusted their NVGs, at the aircraft prior to departure and not via use of the Hoffman test box located within the Herc Det SES. The Panel also ascertained that, although crews routinely tested their NVG with a Hoffman test box when flying training serials in the UK, lack of such testing within the Herc Det was a cultural norm, contrary to requirements of the Mission Out-Brief. Exhibit 188 Witness 15 Exhibit 131

1.4.260. The PF and PNF's NVG assemblies were sent to RAF CAM for analysis, and were proved fully serviceable surpassing the minimum acceptable visual acuity and luminance range. However, the Panel considered that it would be impossible to prove exactly what setup the NVGs were in at the time of the accident. Exhibit 363

1.4.261. As the pilots had not utilised the Hoffman Box to setup their NVG, it was not possible to determine if they were focussed and adjusted to their optimum settings. Any incorrect adjustment would have degraded the pilots' visual acuity in already low light levels and resulted in reduced SA.

1.4.262. The Panel assessed that the PF and PNF's NVG assemblies were serviceable at the time of the accident, but had not been objectively tested using a Hoffman Box prior to flight. It was not possible to determine their set up at the time of the accident.

1.4.263. Given the lack of objective evidence the Panel concluded that NVG set-up, without the use of a Hoffman Box, was an **Other Factor**

1.4.264. NVG training and orders are further explored at paragraphs 1.4.534 *et seq*, and recommendations made at paragraphs 1.4.540, 1.4.541 and 1.4.551.

## Infrared Landing and Taxi Lights

1.4.265. The Hercules is equipped with the following external lights to illuminate the ground when landing (Figure 23): Exhibit 192

a. Landing Lights on each wing between the engines.

b. Main Landing Gear (MLG) taxi lights.

c. Wingtip Taxi Lights.

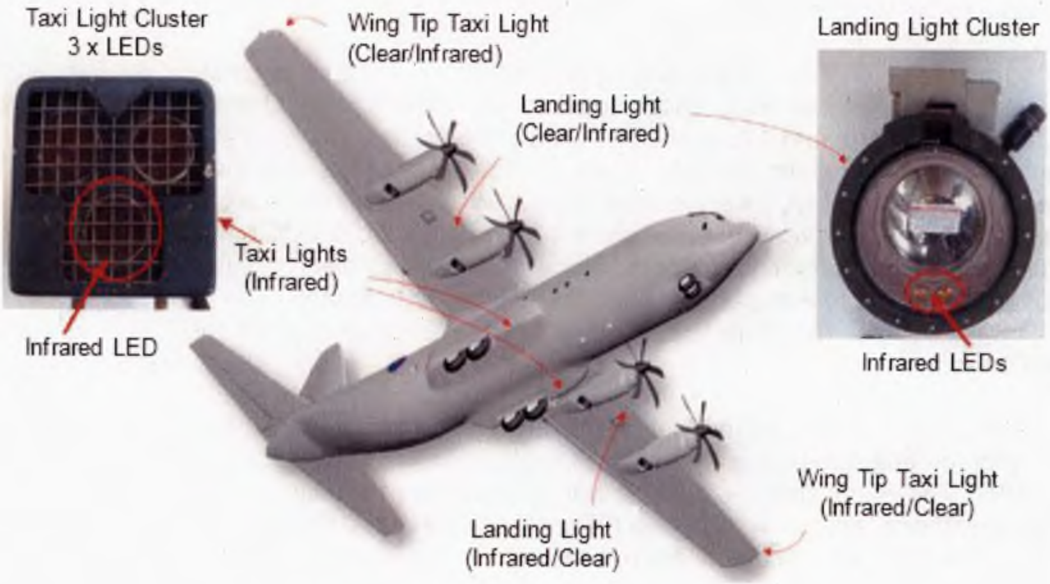


**Figure 23 – Hercules Landing and Taxi Lights**

1.4.266. These lights can be selected to either white light, for conventional landings, or 'covert' Infrared Emitting Diodes (IREDs) for use with NVGs. There are 2 IREDs within each Landing Light Cluster, and 3 within each Taxi Light cluster. As ZH873 was flying in a non-permissive environment, the crew elected to use covert external lighting as per Air Warfare Centre (AWC) tactical advice. Exhibit 181

1.4.267. The Aircrew Manual stated that: Exhibit 109

a. *'The IR landing lights provide an excellent source of ground illumination while performing NVG landings, and;*

b. *'Using the IR landing lights, NVG landings are more easily performed than non-NVG landings using conventional landing lights.*

c. *'During NVG landings a daytime technique should be used as judging the roundout is not difficult especially when using the IR landing lights.'*

1.4.268. Given the pilot testimony regarding poor visual acuity during the final stages of the approach, the Panel tasked the AWC to conduct a trial, examining a number of different lighting configurations in order to prove the veracity of the ACM assertions. Trial ILLUMINATOR concluded that: Exhibit 194

a. White wingtip taxi lights provided the best source of illumination for NVG approaches and landings to a natural surface at very low ambient light levels, with ground illumination rated as 'very good'.

b. With all external IR lights (landing, MLG taxi and wingtip taxi) selected, ground illumination was assessed as sufficient to enable an approach and landing to be performed safely, with the available ground illumination stated as 'good' to 'very good'.

c. MLG IR taxi lights alone provided sufficient lighting to make an approach and landing achievable, but lighting levels were only deemed to be 'adequate' to 'good'.

d. IR landing lights on their own provided marginal to adequate lighting and IR wingtip taxi lights on their own provided too little light to be effective.

e. MLG white taxi lights and (by prediction) white landings lights were deemed unsafe when used in conjunction with NVGs for the approach and landing phase.

1.4.269. The Report further stated, *'The covert landing lights on their own do not provide "an excellent source of ground illumination while performing NVG landings". However, using all external covert/IR lights, including landing, MLG taxi and wingtip taxi lights, illumination was assessed to be sufficient to perform an approach, flare and landing safely in low ambient light conditions (assuming there was adequate surface texture).'* Exhibit 194

1.4.270. The trial recommended that ACM advice be amended to read *'The Covert Infra-Red (IR) landing, taxi (main landing gear) and wingtip taxi lights used together provide an adequate source of ground illumination while performing NVG landings in low ambient light conditions (<10 mLux). The required visual references to achieve a safe landing are likely to be acquired at or below 100ft, providing there is sufficient surface texture.'* Exhibit 194

1.4.271. The TLZ surveys stated that the runway is constructed from a mixture of compacted dirt/rock and crushed aggregate. The panel noted the large number of aircraft movements that had occurred at the TLZ, the majority at night, and the lack of any reported concern regarding *'sufficient surface texture'* to consider that this requirement was met. This was re-enforced by the Panel's Hercules pilot member who flew the aircraft simulator to imagery of the TLZ location and noted that the TLZ as a whole stood out very well on NVG against its immediate surroundings. Exhibit 18 Exhibit 19 Exhibit 108

1.4.272. Based on the data gained during Trial ILLUMINATOR, the Panel considered that the advice within the Aircrew Manual was inaccurate and that the trial recommendations would provide enhanced guidance, resulting in reduced operating and operational risk. This was passed to the Hercules ODH as Urgent Safety Advice, 6 Apr 18. Exhibit 195 Exhibit 196

1.4.273. The Panel concluded that the advice regarding use of available lighting for NVG approaches was inaccurate, and this was a **Contributory Factor**.

**Recommendation**

1.4.274. **Hercules ODH should include the following Trial ILLUMINATOR recommendations within relevant documentation:**

a. **When operating in COVERT lighting mode, for both training and operational scenarios, in low ambient light conditions, all IR lights, including the landing lights, main landing gear taxi lights and wingtip taxi lights are to be used together.**

b. **The use of white wingtip taxi lights only may continue for initial NVG training and non-tactical scenarios.**

c. **White main landing gear taxi lights and landing lights are NOT to be used for NVG approaches.**

1.4.275. **Hercules ODH and HPTL should amend AP 101B-0704/5-15A1C Part 3, Chapter 4, Paras 33 to read:**

***"The Covert Infra-Red (IR) landing, taxi (main landing gear) and wingtip taxi lights used together provide an adequate source of ground illumination while performing NVG landings in low ambient light conditions (<10mlux). The required visual references to achieve a safe landing are likely to be acquired at or below 100ft, providing there is sufficient surface texture."***

1.4.276. Notwithstanding the conclusions of Trial ILLUMINATOR, given the testimony regarding insufficient visual acuity, the Panel sought to establish whether: Exhibit 183 Exhibit 182

a. All, or some, of the aircrafts landing and taxi lights were switched off, or;

b. All, or some, of the aircrafts landing and taxi lights were unserviceable.

1.4.277. Landing light switch positions are not recorded by the aircraft's DFDR or DTADS, and in interview neither pilot could categorically recall whether or not the landing lights had been switched on prior to landing. As stated at paragraph 1.4.12, CVR evidence was not available, thus denying the potential for verbal confirmation of a switch selection. The PNF, who would normally make the selection, believed he had done so but could not be sure. Exhibit 197

1.4.278. Ground testing of ZH873's external IR lighting system determined that 1 of 2 IREDs in the port landing light and 1 of 3 IREDs in the port MLG taxi light were serviceable. On the starboard side, both landing IREDs and 2 MLG IREDs were functioning. Thus, of the 10 IR IREDs within the external IR Taxi and Landing Lights, 40% were unserviceable. There is little evidence that the covert landing light system is prone to unserviceability. Information from the PT indicated that, on average, an aircraft was likely to suffer one IR landing light failure every 4 years and one IR taxi light assembly failure every 2 years. Exhibit 358 Exhibit 392 Exhibit 358

1.4.279. Specifically regarding ZH873, no fault or defect entries were found in the MOD Form 700 to indicate the lights were unserviceable prior to ZH873's Before Flight Servicing (BFS) on 25 Aug 17. The BFS requires the external lights to be '*operated*', and this was signed as being completed prior to ZH873's sortie. Exhibit 358 Exhibit 385 Exhibit 386 Exhibit 387

1.4.280. Three technicians, including one involved in the servicing of ZH873 prior to the accident, were interviewed to confirm their understanding of the requirements of the Servicing activity. They indicated that they would switch the lights on from the flight deck before conducting an external check of individual units. However, not all were aware that there is more than 1 IRED within any cluster, and it was apparent to the Panel that it was confirmation of light being emitted from a cluster that was being checked, rather than confirmation of output from all individual IREDs. Exhibit 388 Exhibit 389 Exhibit 390

1.4.281. The Flight Servicing Schedule does not require confirmation that all IREDs within each cluster are serviceable, which the Panel assessed as resulting in an Error Promoting Condition. Exhibit 385

1.4.282. Additionally, the IR Taxi and Landing lights are not subject to any scheduled maintenance. They are replaced 'on condition', ie when individual IREDs or complete clusters are known to have failed. There is no assessment of any through-life degradation of their output. Exhibit 391

1.4.283. The light units were sent to QinetiQ (QQ) for testing in order to:

a. Objectively quantify the amount of light produced by each unit;

b. Benchmark the performance of each unit against fully serviceable equivalents provided for comparison;

c. Assess the potential impact of the unserviceable diodes.

1.4.284. Table 9 shows that for a 30° arc, the radiant intensity of the starboard taxi light had degraded to 9.6% of the intensity of a brand-new reference light assembly with all 3 IREDs operating. For the port taxi light, with only 1 IRED functioning, radiant intensity degraded to 6% of the reference assembly. Exhibit 378

| | Radiant Intensity over 30° Ø circle mW/sr | Notes |
|---|---|---|
| Port Taxi Light (1 of 3 IREDs working) | 111 | Measured in condition received, surface contamination with dust and dirt. |
| Starboard Taxi Light (2 of 3 IREDs working) | 178 | Measured in condition received, surface contamination with dust and dirt. |
| New, unused Taxi Light All 3 IREDs working | 1861 | Measured in condition received, this was in manufacturer supplied sealed packaging and had not been opened prior to testing. |

**Table 9 – Summary of the Taxi Light Measurements**

1.4.285. Table 10 summarises the tests for the Landing Lights. The irradiance produced by the single IRED operating in the port assembly was 50.4% of the reference unit, while that from the starboard unit (both IREDs operating) was 94.8%. However, the minimum irradiance level required is 1200 μW/cm$^2$, hence the reference Exhibit 378 Exhibit 165 source provided from serviceable stock did not achieve the specified minimum performance.

| | Irradiance at 12 inches (305mm) µW/cm2 | Notes |
|---|---|---|
| Port Landing Light (1 of 2 IREDs working) | 523.6 | Measured in condition received, some minor surface contamination |
| Starboard Landing Light (2 of 2 IREDs working) | 985.2 | Measured in condition received, some minor surface contamination |
| Landing Light (from Service Bay) 2 of 2 IREDs working | 1039.1 | Measured in condition received, appeared to have been cleaned in a service bay but was not new. |

Exhibit 378

**Table 10 – Summary of the Landing Light Measurements**

1.4.286. QQ indicated that the IREDs were contaminated with dust and dirt, particularly the Taxi Light Clusters. Following the accident, ZH873 remained quarantined in the open environment for 5 months before the lights could be removed. The Panel assessed that the contamination was almost certainly due to such prolonged exposure to the elements, and that they would have been significantly cleaner prior to the accident. The greater levels of dust and debris on the Taxi Light units would be consistent with this assessment, given that they were in a vertical position, close to the ground and significantly prone to the elements. The Landing Lights, being stowed flush with the underside of the wing would almost certainly have gathered less dust and debris, as was observed by QQ. Exhibit 378

1.4.287. Once cleaned, a 29% increase in the Radiant Intensity was observed in the port Taxi Light, but this remained a 4-fold reduction compared to the new unit had all IREDs been operating at this reduced output during ZH873's approach. The Panel could not explain the significant reduction of ZH873's Taxi Light IREDs, but noted such potential degradation was apparent in both units. Importantly, it suggested that even had all the IREDs been serviceable before the hard landing, there would have been a significant reduction in their output. Exhibit 378

1.4.288. QQ provided a spreadsheet program to predict the expected irradiance intensity in front of an aircraft at differing heights, pitch angles and IRED serviceability; it makes no allowance for terrain, but assumes a flat earth in the area of interest. Figure 24 shows the prediction for an aircraft at 100 ft, on a 2.5° glide slope approach and pitched up at 1.5° with fully serviceable IR lights operating at full power output. This height is significant, as it is the point at which the ACM states the use of aids in the HUD should stop, and for the approach to be continued using visual cues only. Exhibit 378

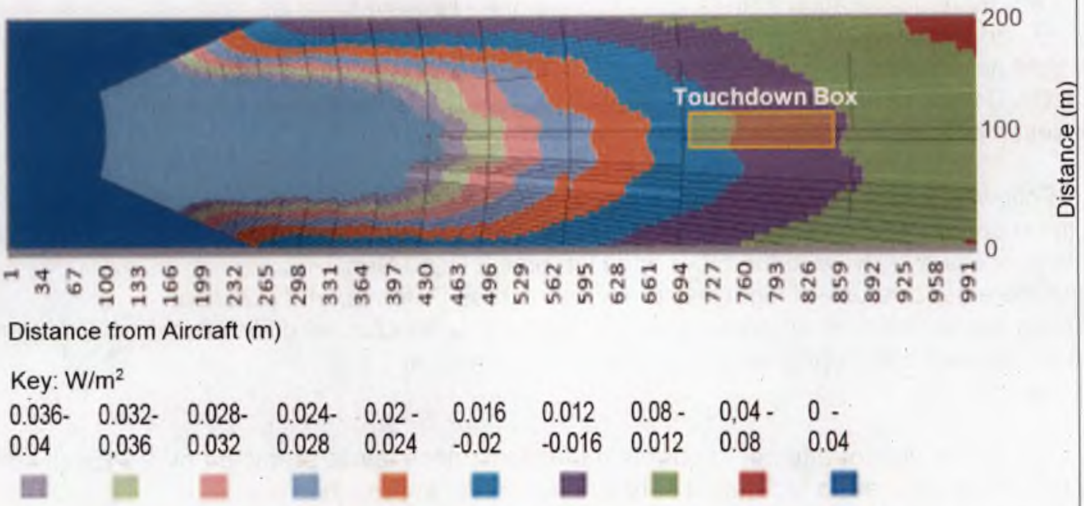


Exhibit 358

**Figure 24 – Illuminance Prediction, Aircraft 100 ft Above Runway with Fully Serviceable IR Lighting**

1.4.289. Figure 25 is also a prediction for the aircraft at 100 ft and 1.5º pitched up. However, it reflects both the 4 IREDs observed not to be operating and also the reduced power output measured by QQ in comparisons with serviceable units.

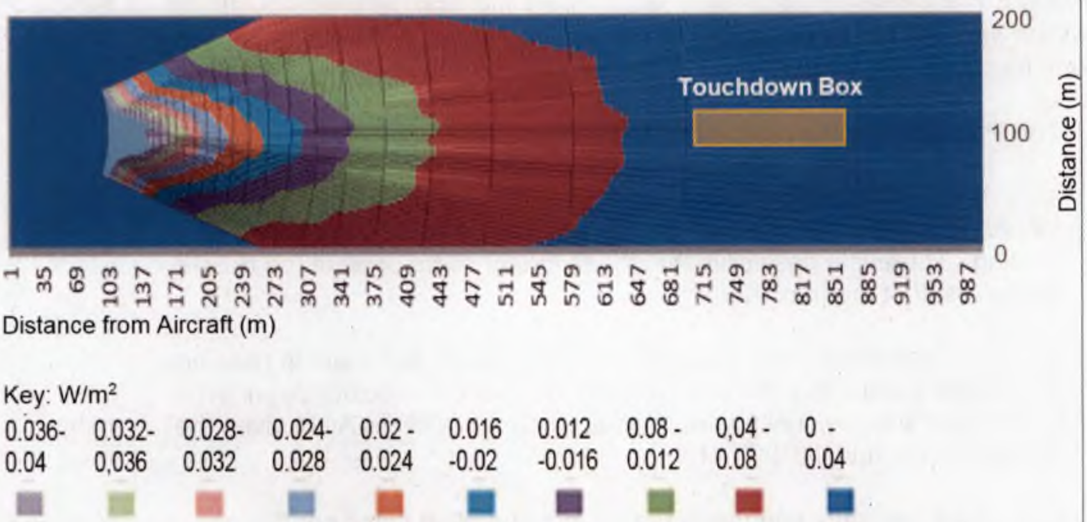


Exhibit 358

**Figure 25 – Illuminance Prediction, Aircraft 100 ft Above Runway, IR Lighting as removed from ZH873**

1.4.290. The predictions in Figure 25 show no IR illumination reaching the Touchdown Box, resulting in no enhancement of the natural light being offered to the crew. Light levels below 5 mLux result in a rapid decline in NVG Image Intensifier Tube image performance and sub-2 mLux light levels are insufficient for the NVGs to be effective. Under such circumstances additional illumination is required to produce a coherent picture in the NVGs, and would be expected to be provided by the IR

Exhibit 358

lights.

1.4.291. The QQ analysis confirmed the significance of the IR Taxi Lights reported by Trial ILLUMINATOR, indicating that the combination of landing and taxi lights provided 73.6% more illumination than landing lights alone. However, the issue of potential IRED degradation was not known at the time and so output intensity of the respective light assemblies from the Trial ILLUMINATOR aircraft was not measured. As a result, DAIB were unable to determine what irradiance levels were associated with the assessments of '*marginal, adequate, good and very good'*. Exhibit 378

1.4.292. Following initial analysis of the QQ Report by the Panel, DG DSA endorsed the recommendations at paragraphs 1.4.297 and 1.4.298. These were issued as Urgent Safety Advice to the ODH and Hercules PTL,10 Sep 18. Recognising the extensive use of night vision devices across Defence, and potential for similar risks across other environments and platforms, this was further distributed to Defence Equipment and Supply and the Defence Maritime, Land and Air Regulatory Authorities. Exhibit 394

1.4.293. The Panel did not attempt to correlate the illuminance levels predicted by QQ with a minimum required to facilitate a safe landing. NVG approaches are complex, and the visual picture experienced by a crew will be a combination of several factors including moon phase, cultural lighting and the surface texture in addition to IR light output. Ultimately, the decision whether to continue must remain with the pilot. However, given the complexities of the approach and landing, and the small margins for error associated with the relatively small overruns prior to the Touchdown Box, the Panel opined it essential that crews had clear and unambiguous guidance on which to base their decision-making process. A parallel was drawn with the Decision Altitude for Precision Approaches, which is defined as, '*A specified altitude or height in the precision approach or approach with vertical guidance at which a missed approach must be initiated if the required visual reference to continue the approach has not been established*'. Exhibit 358 Exhibit 255

1.4.294. The Panel determined that:

a. It was impossible to state whether ZH873's IR Landing and Taxi Lights were either switched on or fully serviceable for its approach and landing. There is a possibility that the failure of some or all of the IREDs was a result of the hard landing.

b. Had the lights been switched on, and in a fully serviceable condition, it is almost certain that the crew would have gained sufficient visual acuity to continue with a visual approach in accordance with the ACM given the results of Trial ILLUMINATOR.

c. Had the lights been selected on, but operating in the condition measured by QQ, then it is almost impossible that the crew would have had sufficient enhancement of the low ambient light to have been able to transition to visual cues from 100ft above the runway in accordance with the ACM.

d. Had the lights not been switched on, it is almost impossible that the crew would have had sufficient visual acuity to transition to a visual landing technique given the ambient light of approximately 2 mLux.

 

e. The 'on condition' replacement policy for IREDs does not allow for potential through-life degradation.

f. The Flight Servicing schedule is insufficiently clear with regards to ensuring that all IREDs are serviceable.

g. Both degradation through-life and operation with failed IREDs would result in an increased, but unknown, operating risk to the DH chain.

1.4.295. The lack of visual acuity reported by the crew of ZH873 as they approached the TLZ is consistent with either the IR Landing Lights not being switched on at all, or being switched on with the significantly reduced output as reported by QQ. In either case, the Panel assessed it as almost certain that the crew had insufficient visual acuity to judge the flare and conduct a landing.

1.4.296. The Panel concluded that insufficient ground illumination through the non-selection, unserviceability or degradation of the aircraft's external IR lighting was a **Contributory Factor.**

**Recommendation:**

1.4.297. **The Hercules ODH should assess any increased Operating Risk arising from degraded Infrared Landing and Taxi Lights, pending further advice from the Hercules PTL.**

1.4.298. **The Hercules PTL should:**

a. **Take urgent action to determine extent of unserviceable Infrared Emitting Diodes throughout the Hercules Fleet.**

b. **Establish the veracity of reduced Infrared Emitting Diode output reported by QinetiQ, and determine any effect on the Platform Safety Case.**

c. **Revise current Servicing and Maintenance Schedules to include the necessity to confirm individual IRED serviceability and allow for any effects of degradation.**

1.4.299. The Panel **Observed** that 47 Sqn had insufficient IR monocles to provide one for the Herc Det at Akrotiri. This resulted in the engineers drawing a set of NVGs from the SES, and were conducting Flight Servicing activity with incorrect equipment.

## Radar Altimeter

1.4.300. The Hercules is fitted with a Radar Altimeter (Rad Alt) that provides instantaneous height above the ground information. Despite its role in enhancing situational awareness, it is not to be used to initiate a flare during a MOS approach, as evidenced by the following:

a. The Hercules RTS states, '*WARNING: The Radar Altimeter is not to be used as a cue to initiate the landing flare during NVG landings.*' Exhibit 198

b. The ACM cautions that: Exhibit 199

(1) *'During NVG landings a daytime technique should be used as judging the* [flare] *is not difficult especially when using the IR landing lights. The RadAlt must not be used as a mechanistic cue to initiate the landing flare*', and:

(2) *'Use of the RadAlt to provide an Altitude call cannot be relied upon as a mechanistic cue to flare. Visual cues should be used to judge the flare by day.'*

c. *XXIV* Sqn training documentation states, '*Use of the RadAlt as a cue to flare can lead to HUD fixation and a heavy landing. Use visual cues from 50ft (If the terrain is suitable the PNF can give the PF a RadAlt countdown from 100ft).* Exhibit 168

1.4.301. Pilot testimony indicated that the XXIV Sqn provision for a countdown from 100ft was utilised to assist situational awareness regarding the rate of ground closure; crews would listen to the cadence of such calls were used, rather than to cue the flare *per se.* Exhibit 200

1.4.302. With reduced visual cues to judge altitude, the barometric altimeter and Rad Alt would have been the prime sources of altitude information (although the barometric altimeter would have displayed altitude above mean sea level rather than the ground). Interviews with the crew stated that during preparations for landing, the PF requested the PNF to provide Rad Alt calls of 50ft, 20ft and 10ft. The PF and PNF both reported a 50ft call being provided and that the aircraft impacted with the ground very shortly after the 20ft call. Witness 1 Exhibit 359 Witness 1a

1.4.303. The TLZ ZH873 was approaching is positioned at the top of gently rising terrain, and is preceded by a significant slope immediately before the overrun surface (paragraph 1.4.113); as such the Rad Alt readings would have been greater than the aircraft's actual height above the runway threshold. This is illustrated in Figure 26:

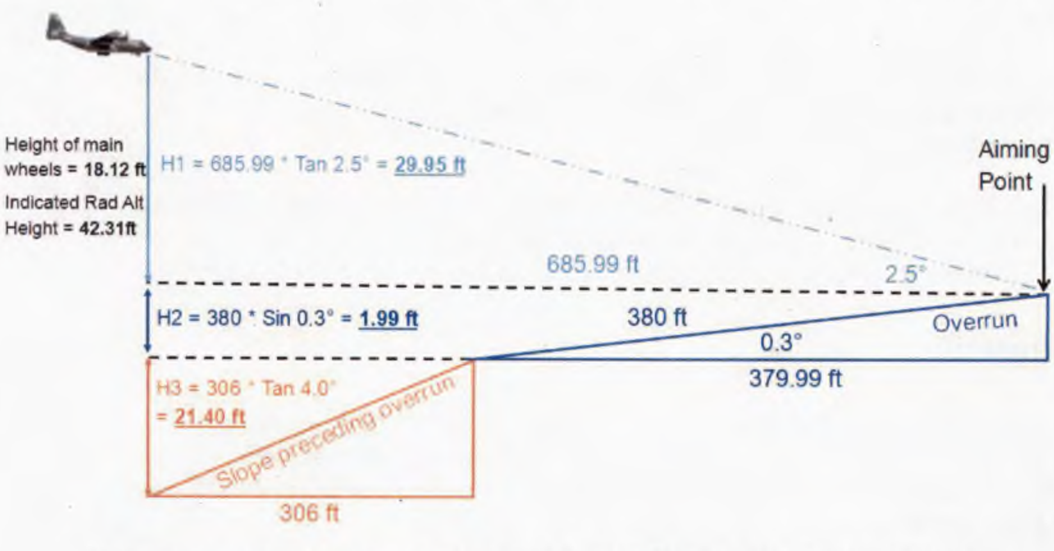


**Figure 26 – Rad Alt Height Reading as ZH873 Crossed Start of Slope (Not to scale)**

1.4.304. As ZH873 crossed the start of the slope prior to the runway, the pilot's eye would (theoretically) have been 29.95 ft above the Aiming Point (H1 in Figure 26). By extrapolation, using the Eye to Wheel Height of 11.83 ft, the main wheels, are 18.12 ft above the Aiming Point. However, because of the combined effect of the slope and the gradient of the overrun, the Rad Alt would have been indicating 42.31 ft.

1.4.305. As stated in paragraphs 1.4.113 – 1.4.115 the PF was unaware of the slope preceding the runway. Without such awareness, he is unlikely to have appreciated the effect it would have on Rad Alt readings being greater than his actual height above the runway threshold, thereby potentially giving him a false sense of security regarding his remaining time until landing. Had the aircraft actually been some 42 ft above the Aiming Point when it crossed the start of the upslope, then there would have been some 4.5 seconds before touching down, given a RoD of 9 ft/s (see paragraph 1.4.233). On this occasion, because of the effect of the slope, the aircraft was actually 18 ft above the Aiming Point and just 2 seconds from touchdown.

1.4.306. Additionally, the slope would have markedly affected the apparent rate of descent as indicated on the Rad Alt readings, thereby explaining the crew testimony that the ground rushed up at the aircraft.

1.4.307. In interview, when asked how pilots would judge a flare in zero mLux, the PF stated that they'd either have to rely on the lights providing sufficient visual acuity or have to use the Rad Alt by flaring mechanically at 10 ft. Exhibit 201

1.4.308. The Panel assessed that:

a. The rising terrain leading to the TLZ, and slope immediately preceding it, meant that Rad Alt indications were consistently greater than the vertical separation from the runway threshold.

b. The Warnings and Cautions in the ADS regarding use of the Rad Alt to aid flaring the aircraft are appropriate.

c. It is probable that the PF placed over-reliance on the Rad Alt as for his situational awareness information (paragraphs 1.4.241 et seq).

d. It is highly probable that the PF was relying on the 10 ft Rad Alt call to judge his flare given the lack of visual references.

1.4.309. The Panel concluded that the PF's reliance on Rad Alt information was a **Contributory Factor.**

1.4.310. A recommendation regarding MOS approaches, including use of the Rad Alt, is made at paragraph 1.4.479

1.4.311. The Panel **Observed** that, by not specifying what constitutes *'suitable terrain'*, the XXIV Sqn MOS training presentation might contravene ADS cautions and warnings regarding use of the Rad Alt as an aid to flaring the aircraft.

## Visual Illusions

1.4.312. Illusions occur when conditions modify the pilot's perception of the environment relative to his or her expectations, possibly resulting in spatial disorientation or landing errors (eg landing short). Visual approaches at night present a greater risk from illusions because of the reduction in available visual references. Exhibit 202

1.4.313. The Panel considered the following visual illusions as the most relevant to short landings:

a. Runway Width.

b. Runway Slope.

c. Sloping Terrain.

d. Autokinetic Illusion.

e. 'Black Hole' Illusion.

**Runway Width**

1.4.314. The width of a runway can lead to false perceptions regarding height above, and therefore, distance to the runway. This may cause pilots to fly higher or lower on their approach. Exhibit 203

1.4.315. The vast majority of the PF's recent experience had been landing on paved runways significantly wider than the TLZ; as an example, BZN has a runway width of 183ft, twice as wide as the TLZ. However, use of the FPA and CDM within the HUD (see paragraph 1.4.218) would minimise any tendency to fly higher or lower on the approach, and the Panel considered it unlikely that the PF would have been affected by this illusion. Witness 1d

**Runway Slope**

1.4.316. Runway slopes can also lead to visual illusions; upward sloping runways can result in pilots thinking they are higher, and lead to them flying a lower, flatter approach. Exhibit 203

1.4.317. Although the runway at the accident TLZ has an upslope, given that the pilot had very little visual definition other than the 5 IR lights the Panel considered it extremely unlikely to have induced spatial disorientation.

**Sloping Terrain**

1.4.318. A slope before the runway also has the potential to generate a visual illusion. Where a significant upslope precedes the runway, it is possible for pilots to assess that they are higher than they actually are causing them to fly a shallower approach to compensate. Exhibit 203

1.4.319. As previously discussed, the TLZ is positioned at the top of gently rising terrain and is preceded by a significant slope immediately before the runway. Although this slope had the potential to create a visual illusion, the Panel felt it was extremely unlikely to have affected the PF given that accurate glide path information was available from the HUD, and that he was unable to see it because of the poor visual acuity generally.

**Autokinetic Illusion**

1.4.320. Autokinetic illusion occurs when an individual fixates on a small, dim light for a period of 10 secs or more in a darkened environment, and can lead to the light to appear to move. Although RAF CAM assessed that there was no evidence indicating that autokinetic illusion actually occurred, the Panel assessed that the nature of the Exhibit 359 visual environment would be typical of a situation in which it might. If so, it would have increased any difficulty faced by the PF in maintaining his intended aim point.

1.4.321. Given the PF's comments regarding the box appearing to float in mid-air, and recognising that he had no visual reference other than the lights, the Panel considered it as likely as not that he was subject to a degree of autokinetic illusion. Witness 1a

**Black Hole Illusion**

1.4.322. The 'black hole' visual illusion can occur at night when a pilot is flying an approach over unlit featureless terrain to a lit runway. It can cause pilots to think they are higher than they actually are, causing them to fly a lower approach. Although the terrain surrounding the TLZ meets the requirements for black hole illusion, the Panel felt it unlikely to have affected the PF given the accurate glide slope information available in the HUD and because the TLZ is insufficiently lit to meet the typical scenario for the illusion to occur. Exhibit 204

**Illusion Summary**

1.4.323. The Panel determined that:

a. The PF experienced a degree of auto-kinetic illusion as evidenced by the description of the TLZ appearing as a floating box.

b. It is very likely that the HUD, FPA and CDM would have minimised any potential for the PF to have flown a high or low approach, mitigating the effects of runway slope and width, black hole illusion and sloping terrain.

1.4.324. The Panel was unable to determine to what extent any spatial disorientation contributed to the accident. While it did not consider it was as significant as the Glide Slope and Aiming Point, as outlined at paras 1.4.215 *et seq*, it would have been exacerbated by any lack of irradiance from the IR Landing and Taxi Lights, whether they were unserviceable or not switched on.

1.4.325. The Panel concluded that Visual Illusions were an **Other Factor.**

## Situational Awareness Summary

1.4.326. ZH873 landed short of the runway because of an ineffective flare that was late and incomplete. Although the aircraft's equipment, particularly the Head-up Display can assist pilots to locate and approach the TLZ (paragraph 1.4.205 *et seq*) the actual landing manoeuvre is not automated and requires sufficient references to judge the flare, which can only be achieved in low light conditions by use of landing lights and NVG. Prime to this requirement, particularly on dark nights with low ambient light, are the IR Landing and Taxi Lights. As discussed at paragraphs 1.4.278 *et seq*, it is almost certain that the lights were either not switched on or provided significantly reduced output due to unserviceability or degradation.

1.4.327. Night MOS approaches culminate with a visually judged landing. It is therefore essential that pilots have sufficient visual references to judge their flare and complete it safely. This re-enforces the necessity for clearly defined visual reference criteria, as recommended at paragraph 1.4.256.

1.4.328. Given the location and construct of this specific TLZ (paragraphs 1.4.109 – 1.4.113) the Rad Alt readings exceeded the vertical separation from the runway, significantly so in the most critical phase of the final approach. Notwithstanding the ADS warnings about not using the Rad Alt in a mechanistic way to judge the flare, the Panel concluded that XXIV Sqn teaching created the potential for this to be adopted, particularly in low light levels, as was indicated in interview. In the absence of sufficient visual acuity, the Panel considered it extremely likely that the PF placed over-reliance on the Rad Alt as his primary aid for height information, not recognising that this was significantly in excess of the vertical displacement of ZH873 from his Aiming Point.

1.4.329. The potential for visual illusions could not be ruled out. It was as likely as not that a degree of auto kinetic affected the PF, particularly given the low ambient light and lack of any visual references other that the IR Touchdown Box lights.

1.4.330. The Panel assessed that:

a. It was almost certain that the PF's reduced SA during the final approach led to a late and ineffective flare.

b. Most significantly this resulted from the lack of visual acuity gained from the IR Landing and Taxi Lights, which almost certainly led to a reliance on the Rad Alt information as a cue to judge the flare, in contravention of the ACM warning.

c. The tolerances for NVG MOS approaches are small, particularly recognising the Hercules EWH proximity to the 300 ft Overrun. When the aircraft is being aimed at the front of the Touchdown Box, and a flare is not successful, this will almost certainly result in a landing adjacent to the end of the Overrun (paragraphs 1.4.199 *et seq*).

1.4.331. The Panel concluded that lack of Situational Awareness was a **Contributory Factor**.

**Recommendation:**

1.4.332. Recommendations regarding Situational Awareness have been made at paragraphs 1.4.255, 1.4.256, 1.4.274, 1.4.275, 1.4.297, 1.4.298.

## Go-Around and Stabilised Approach Criteria

1.4.333. Immediately prior to landing, the PF could see little more than what he described as a '*floating box*' of the Touchdown Box IR lights, and the Panel concluded that he had insufficient visual references to judge a flare and that a Go-Around should have been initiated (paragraph 1.4.253).

1.4.334. When asked why he did not execute a Go-Around, the PF stated that by the time he considered it the aircraft had already impacted the ground. Witness 1

1.4.335. Occasions on which a Go-Around should be initiated during MOS approaches are listed within the Aircrew Manual, TATOM and XXIV Sqn Briefing material, as shown at Table 11:

| Document | Criteria | | | |
|---|---|---|---|---|
| **Aircrew Manual** | If at any time the aircraft deviates excessively from the final approach course or glide slope and the correct flight path cannot be safely re-established | If the aircraft is not in a position to land within the agreed touchdown speed parameters | If the aircraft is not in a position to land within the agreed touchdown point parameters | |
| **TATOM** | | | If the aircraft will overshoot the touchdown box (500ft beyond runway threshold) | If, on landing, the aircraft bounces and height cannot be judged |
| **XXIV Sqn Training Slide pack** | Not flying a stable approach by 100ft above ground level | Speed is not between Tactical $V_{AT}$ and Tactical $V_{AT}$ + 5 knots (kts) immediately prior to touchdown | Not on the ground by the nominated last touchdown point | If, on landing, the aircraft bounces and height cannot be judged |

Exhibit 109
Exhibit 147
Exhibit 148
Exhibit 168

**Table 11 – List of Go-Around Criteria**

1.4.336. Having examined the ACM, TATOM and XXIV Sqn documentation, the Panel determined that:

a. By failing to define terms such as '*excessively*' and '*not in a position to land*'; the ACM guidance could lead to subjective decision making regarding instigation of a Go-Around.

b. The criteria listed within TATOM failed to provide any guidance regarding when to Go-Around during an approach, concentrating solely on events post landing.

c. The XXIV Sqn guidance was the most comprehensive; however, it did not define what was meant by '*stable approach*' or '*immediately prior to touchdown.*' Further, the OCU instruction did not reflect higher level documentation.

d. There was no consideration of specific requirements for NVG approaches to an IR lit Touchdown Box.

1.4.337. Regarding stabilised approaches, AMASIs state that: *'all approaches shall be flown as stabilised, unless operational circumstances dictate that an approved tactical profile be used. A stabilised approach is an approach which is flown in a controlled and appropriate manner in terms of configuration, energy and control of the flight path from a pre-determined point or altitude/height down to a point 50 feet above the threshold or the point where the flare manoeuvre is initiated if higher… For approaches where the pilot has visual reference with the ground, stabilisation should* *be achieved not later than 300ft above airfield elevation. The approach should be considered to be fully stabilised when the* [aircraft] *is:* Exhibit 220

a. *Tracking on the required approach path and profile.*

b. *In the required landing configuration and attitude.*

c. *Flying with the required rate of descent (<1000'/min unless briefed) and speed (Vapp[16] +15/-5).*

d. *Flying with the appropriate thrust/power and trim.*

e. *All briefings and checklists complete.'*

1.4.338. As discussed at paragraphs 1.4.199 *et seq*, ZH873's approach to the TLZ was shallower than the 3° required by the ACM. This could contravene the AMASI requirement for, '*Tracking on the required approach path and profile*.' However, AMASIs allow a concession from the criteria for operational circumstances where an '*approved tactical profile'* is flown. The Panel assessed that MOS approaches constitute such a profile, being governed by an OEC, listed within the Tactical Operations section of the ACM and specifically trained for within the Hercules Force.

1.4.339. Although the AMASI requirement regarding stabilised approaches does not necessarily apply to MOS approaches, the Panel opined that there is a sound safety factor for them to do so in the absence of criteria specific to these profiles.

1.4.340. Following the accident, the DDH issued a Duty Holder Operating Instruction (DHOI), which specified the following:

*'<u>APPROACH GATES:</u>*

*For MOS approaches, the following criteria must be satisfied not later than 100 feet agl, and should be confirmed by the PF on intercom otherwise a Go-Around should be initiated.*

*a. The approach is stable, on glideslope and centreline as shown by the CDM and GFPM.* Exhibit 221
*b. The speed is between Vat and Vat +5 kts.*
*c. The aim point is within the prescribed landing box.*
*d. The HUD acceleration cue is proximate to the CDM, indicating positive blown lift.'*

1.4.341. The Panel determined that:

a. The guidance available to Hercules crews regarding MOS Go-Around criteria is vague and inconsistent.

b. MOS approaches constitute an approved tactical profile, for which the AMASI stabilised approach criteria might be taken not to apply.

c. The PF's approach met all extant stipulated MOS Go-Around and Stabilised Approach criteria.

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[16] Approach Speed

d. The DHOI, while addressing some of these shortcomings, does not define what is meant by a MOS stable approach.

e. A consistent set of orders regarding visual references and Go-Around criteria would provide enhanced guidance to aircrew.

f. Lack of such orders may result in an Error Promoting Condition where pilots continue with an approach when a Go-Around would be more appropriate.

1.4.342. Given the ambiguity outlined above the Panel concluded that a lack of clearly defined Go-Around and Stabilised Approach criteria were **Contributory Factors.**

**Recommendation:**

1.4.343. **The Hercules ODH should provide specific Go-Around and Stabilised Approach criteria for MOS approaches.**

## Human Factors

## Cockpit Gradient and Crew Resource Management

1.4.344. Both pilots were Flying Instructors and therefore qualified to be authorised as Aircraft Commander. A potential consequence of similarly experienced personnel being crewed together is a flat cockpit gradient; this can impact effective Crew Resource Management (CRM) as they are less likely to raise concerns because of an expectation or belief that the other crew member will perform a task successfully. Such expectation may be conscious or unconscious. Exhibit 6 Exhibit 7 Exhibit 359

1.4.345. The lack of CVR data hampered the Panel's ability to make a thorough assessment of the crew communications and CRM on-board prior to the accident, leading to a reliance on crew interviews for evidence (see paragraph 1.4.13).

1.4.346. The Det Cdr, PF and PNF all stated that they were aware of the risk of a flat cockpit gradient; but believed that it would not prevent them from utilising sound CRM techniques during the flight. Witness 5 Witness 4c Witness 1h

1.4.347. On approaching the TLZ, the PNF asked the PF several times whether he was visual with the runway. The PF responded that he was, but the PNF did not hear this so '*talked*' the PF onto the location of the TLZ, ensuring that the landing site had been acquired. The PF confirmed again that he was visual with the TLZ, although both the PF and PNF commented that the response was short or curt. It was considered that this was very likely to be indicative of the pressure experienced by the PF, as discussed at paragraphs 1.4.352 *et seq.* Witness 4

1.4.348. The PNF stated that despite assessing that the PF was not utilising the correct TLZ Aiming Point, he did not raise a concern about the Aiming Point as he had confidence in the abilities and experience of the PF. He added that he could have been more strident at the time, and that he may have been more likely to intervene had he been flying with a less experienced Captain. Witness 4b

1.4.349. The Panel assessed that a flat cockpit gradient existed between the pilots and that it was very likely that this negatively affected CRM. Most significant was the lack of assertive behaviour from the PNF regarding the Aiming Point on final approach. Had this been challenged and the Aiming Point moved further into the Touchdown Box, then it is highly probable that the aircraft would not have landed short of the TLZ overrun. The Panel also noted that the heavy landing involving Hercules ZH870 at the same location, 29 Aug 16, had a dual captain crew. Although the investigation report did not conclude that a flat cockpit gradient or CRM contributed to that accident, the Panel considered that the increased potential for flat cockpit gradients to lead to less assertive behaviour within crews requires constant address. Exhibit 222

1.4.350. The Panel concluded that sub-optimal CRM, and a subsequent lack of assertive behaviour, was a **Contributory Factor**.

**Recommendation:**

1.4.351. **D MAA should develop a Case Study, incorporating the Supervisory, Authorisation and Human Factors issues identified within this Report, to be used in Air Safety Training in order to promote awareness across the Defence Aviation Environment.**

## Pressure to Perform

1.4.352. RAF CAM identified 3 sources of potential pressure pertinent to ZH873's sortie: Exhibit 359

a. The PF and PNF arrived at the aircraft later than intended, and then had to prepare for an earlier take-off (paragraphs 1.4.133 *et seq*). Limited time can impose pressure, resulting in errors in task completion, or to tasks perceived as less important not being completed. Exhibit 359

b. During the transit to the TLZ the crew experienced a number of aircraft system malfunctions, described at paragraphs 1.4.165 *et seq.* which the PNF described as a stressor. Witness 4

c. The PF stated that he was anxious to visually acquire the TLZ as soon as possible, and avoid a hard landing as had been experienced in a previous incident at the same TLZ. Exhibit 359

1.4.353. The PF also indicated that he felt a degree of self-induced pressure, stemming from several factors: Witness 1b

a. Having been a Tier 1 instructor for the past 3 years, and now having to deliver it for real.

b. His lack of recent familiarity with Operations.

c. Maintaining his credibility prior to joining [redacted].

d. Ensuring he got the aircraft into the Touchdown Box, and avoiding landing long which would necessitate a mandatory Go-Around.

1.4.354. When asked how demanding the end customer was, the Det Cdr stated that the detachment had a good working relationship with them and although the cargo was important, enough redundancy existed within the ALOC that it wasn't essential that this task was achieved on this day. The Panel noted that, in his direction to the crew on the Operational Risk Matrix, the Det Cdr wrote, *'Safe passage* Exhibit 40 *remains top priority. Do not let Op Pressure affect good airmanship and sound judgement'.*

1.4.355. The Det Cdr stated, with hindsight, that despite his direction that safety was paramount, it was probable that the PF remained under pressure to prove himself given that he was only on a short detachment and that he had been selected for [redacted]. Witness 5

1.4.356. The Panel determined that:

a. Despite the time pressures apparent prior to take-off and the malfunctions experienced during the transit, ZH873 arrived in the vicinity of the TLZ in good time and its location was acquired without difficulty. Thus, it was extremely unlikely that either of these would have been influencing the PF's performance during the approach and landing.

b. Notwithstanding direction from the Det Cdr that there was no Operational pressure or imperative for the mission, the PF remained affected by self-induced pressure.

c. It was very likely that the PF felt a need to prove himself, given his short time in Theatre, lack of recent Operational experience and selection for [redacted].

d. It was highly probable that self-induced pressure arising from the PF's desire to succeed and a task-focussed mentality resulted in him continuing to fly the approach despite having insufficient visual references to judge his flare and land the aircraft.

e. The PF's nomination as Aircraft Commander exacerbated any pressure on him, self-imposed or otherwise.

1.4.357. The Panel concluded that pressure on the PF was a **Contributory Factor.**

**Recommendation:**

1.4.358. **D MAA should develop a Case Study, incorporating the Supervisory, Authorisation and Human Factors issues identified within this Report, to be used in Air Safety Training in order to promote awareness across the Defence Aviation Environment.**

## Post-Accident

### Inability to Pressurise the Aircraft

1.4.359. Following the hard landing, and having regained stable flight in a climb, the PNF noted that the aircraft would not pressurise sufficiently, leading to the decision to divert. Concurrently crew in the rear of the aircraft reported a '*whooshing sound'* that was assessed potentially as air escaping through the fuselage aft of the port wing root. Witness 4

1.4.360. While conducting on-aircraft investigative activity, the DAIB were unable to determine the cause of the whooshing noise. There were no obvious signs of holes, implied by the inability to pressurise the aircraft, in the cargo hold particularly around Exhibit 358 the wing roots. Because of the aircraft's austere location and the limited C130J maintenance facilities at the diversion airfield, there was no equipment available to pressurize the aircraft to determine where fuselage integrity may have been compromised. The investigation team was forced to rely on visual inspections after removing panels.

1.4.361. The Panel agreed with the DAIB conclusion that it was as likely as not that the whooshing sounds were caused by turbulent air from the separated edges of the skin panels on the upper surfaces of the fuselage and wing roots. Exhibit 358

1.4.362. It was not possible to determine the reason that the crew could not pressurise the aircraft sufficiently post the hard landing, but the Panel considered it probable that is was a direct result of the damage resulting from the 4.225g impact. Exhibit 4 Exhibit 252 Exhibit 253

1.4.363. The inability to pressurise the aircraft during the diversion was **Not a Factor.**

## Survivability

1.4.364. Aircrew Equipment Assemblies (AEA), Flight Deck Seats, Flight Deck Weapon Stowage and Flight Deck Armour Panels were sent to the Accident Investigation and Human Factors (AIHF) department at RAF CAM for analysis. Exhibit 363

1.4.365. The most significant observations of the AIHF report concerned the unrestrained seating for Door Observers. The Door Observer on the starboard side was seated with his knees facing to the rear, but was sitting twisted looking to the left through the cabin door window and holding on to a locally made fabric lashing tied to a hard point to the rear of the right-hand doorframe. The seat occupant experienced a back injury during the impact and subsequently required medical treatment. This is discussed further at paragraphs 1.4.480 *et seq*.

1.4.366. The heavy impact with the ground resulted in the crew being subjected to relatively moderate forces. Although these were below the injury thresholds for significant musculoskeletal or life threatening injuries, 2 crew members were downgraded from flying duties for in excess of 2 months.

### Aircrew Flying Helmets

1.4.367. All crew members were issued with Mk 4B/4L helmets, for which the maintenance and checking of fit periodicities are contained in DAP 108A-006-2 (N/A/R)1 (Survival Equipment and Aircrew Equipment Assemblies Support Authority General Orders). This mandates a maintenance periodicity of 30 weeks for Mk 4B/4L Helmets, with a check of fit to be carried out every 15 weeks. Exhibit 226

1.4.368. DAP 108F-0214-1(Aircrew Helmet Mk4B/4L General and Technical Information) contains the specific detail regarding the helmet used by the crew, including the process for initial fitting, which is completed by a check of fit. Exhibit 228

1.4.369. The only reference the Panel could find regarding subsequent checks of fit was a footnote to the final paragraph, which stated:

> *'NOTE*
> *A check of helmet fit and readjustment is to be carried out on issue and following scheduled maintenance together with the oxygen mask or NBC AR5, if*

*applicable, by an AUTHORISED PERSON iaw DAP 108B-0001-1, Chap 2 to confirm overall firmness of fit and function.'*

1.4.370. However, Chapter 2 of DAP 108B-0001-1 has been removed and the user is referred to DAP 108A, the Support Authority General Orders for which the relevant paragraph states: Exhibit 229 Exhibit 226

*'At the 15 and 30 week periodicities, all Aircrew Protective Helmets, together with oxygen masks and/or NVGs (including FPVs/CBWs), where worn/fitted are to be given a "Check of Fit" to the wearer [authorised personnel]. Aircrew who would normally wear Corrective Flying Spectacles (and Aircrew Respirator Spectacles (ARS) when NVG flying) are to be requested to wear them during the check to ensure there is no interaction with the [Face Protection Visor] or visual restriction. Where forward or rearward rotation or general looseness is apparent then a complete refit is necessary.'*

1.4.371. The PF's most recent check of fit was completed on the 17 Jul 17 and the PNF's was completed on the 01 Aug 17, so both were in date at the time of the accident. Exhibit 227

1.4.372. The helmets worn by all members of the crew were undamaged and none had been subjected to significant impacts with cockpit structures. However, during a subsequent check of fitment, the PF only achieved a satisfactory helmet fit without NVG fitted. With NVG fitted, slight circular or fore and aft movements caused the helmet to rotate forward resulting in the NVG optics falling below his eyes. This was consistent with the observations that his helmet rotated significantly during the impact at the TLZ (paragraph 1.3.19). Exhibit 363

1.4.373. BZN Survival Equipment Section (SES) was contacted to confirm Check of Fit procedures, and stated that Checks of Fit were completed with NVG attached only during initial fitment of a new helmet for NVG qualified aircrew, or for personnel about to commence NVG training. The Panel considered this to be highly consistent with the RAF CAM observation that the PF only achieved a satisfactory helmet fit without NVG fitted. Exhibit 230

1.4.374. The Panel considered that:

a. Both pilots' helmets were in date for their check of fit.

b. Documentation regarding "Check of Fit", having no categoric check of fit guidance, is incoherent.

c. Lack of inclusion of NVG during checks of fit excludes a significant factor that could exacerbate helmet movement when subjected to significant rotational movements.

1.4.375. Lack of clear guidance regarding Checks of Fit was considered an **Other Factor** in that incorrectly fitted helmets could cause, contribute to or aggravate future accidents.

**Recommendation:**

1.4.376. **The Aircraft Commodities Project Team Leader should amend aircrew helmet support and maintenance documentation to ensure coherency and clarity of guidance.**

1.4.377. **The Hercules DDH Chief Aircraft Engineer (CAE) should assure the DDH that DAP 108A-006-2 (N/A/R)1 and DAP 108F-0214-1 are being complied with at BZN.**

**Flight Deck Armour and Weapon Stowage**

1.4.378. The Flight Deck Armour (FDA) and Weapon Stowage are installed as a complete system (MOD/HECJ/1057 & MOD/HERCJ/1073); all off aircraft maintenance is completed by Marshall Aerospace and Defence Group at BZN in accordance with DAP101B-0704_5-5A3 and DAP101B-0704_5-5F. It consists of ballistic armour protection panels fitted around the Flight Deck (including the floor and pilot seats) (Figure 27) and stowage for aircrew weapons (Figure 28). Both elements require extensive use of hook and loop fasteners for security of attachment and functionality. Exhibit 231 Exhibit 232

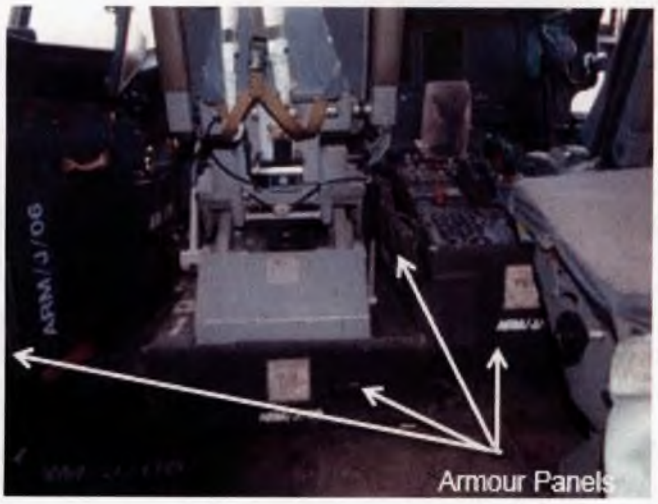


**Figure 27 – Flight Deck Armour**

**Figure 28 - Weapon Stowage**

1.4.379. At procurement, the manufacturer recommended that the life cycle of the hook and loop fastening be set at 200 cycles (1 cycle defined as attachment and removal of a panel). However, the life cycle was set at 3 years. The Panel noted that Exhibit 233 Exhibit 234 the majority of panels were rarely disturbed while installed on the aircraft, and as such a 3-year life cycle would be appropriate. However, certain items, particularly the Weapon Stowage and Circuit Breaker Panels, would be frequently used, with a high probability that the 200 cycles would be exceeded within 3 years.

1.4.380. The FDA was installed in ZH873 on 4 Jun 17, as part of the deployment preparation. Once fitted to the aircraft, it is subject to scheduled inspection to *'ensure secure'* and *'look for damage'* during Before, After and Turn Around Flight Servicing. This requires the fasteners be cleaned to remove any dirt; additionally, where its serviceability is doubted, it should be tested to ensure a minimum hold force of 35 lbs. This strength test had been incorporated following a number of Defence Air Safety Occurrence Reports (DASORs) commenting on poor fastener adhesiveness; however, the Panel **Observed** that first line engineers believed that it was only undertaken by the BZN Role bay.

Exhibit 235
Exhibit 236
Exhibit 237
Exhibit 238
Exhibit 239
Exhibit 240
Exhibit 241

1.4.381. During the hard landing:

a. Circuit Breaker Armour Panels located beside the pilots' seats partially detached, obstructing the escape pathway to be taken in an emergency evacuation - Figure 29.

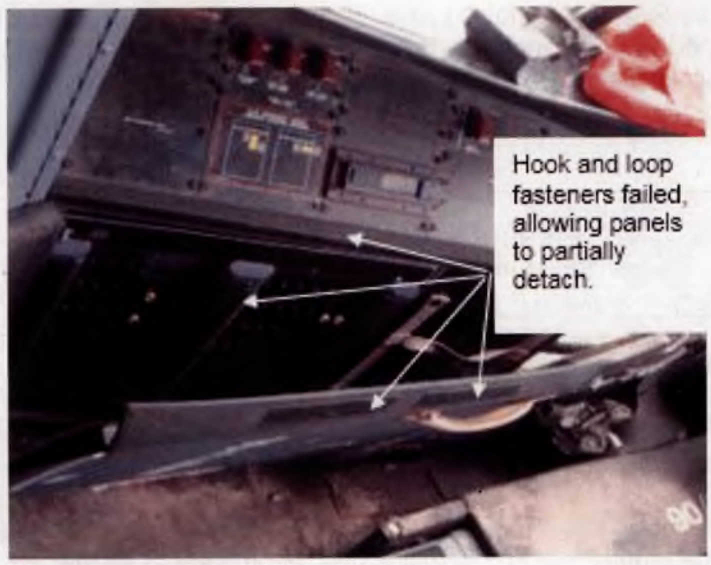


**Figure 29 - Circuit Breaker Armour Panel partially detached.**

b. One weapon became dislodged from its stowage as the hook and loop retaining strap failed, resulting in further obstruction of the emergency egress pathway (Figure 30). This is subject to the same testing and servicing regime as the armour panels.


**Figure 30 - Weapon Stowage Hook and Loop retaining strap fastener failed**

1.4.382. Examination by RAF CAM showed ZH873's hook and loop fasteners were contaminated and ingrained with dirt and dust; in load testing, the Weapon Stowage retaining straps and co-pilot's Circuit Breaker Armour Panel failed to achieve the minimum shear force required (which should be in excess of 35 lbs), as shown in Table 12. Exhibit 363

| PANEL | SHEAR FORCE (lb) |
|---|---|
| Co-pilot Circuit Breaker Panel (RHS) | 10-15 |
| Individual Co-pilot Weapon Stowage Brackets (x2) | 15 |
| Individual Pilot Weapon Stowage Bracket | 15 |

**Table 12 – Shear Force required to open hook and loop fasteners**

1.4.383. The Panel considered it highly probable that this was a result of the higher cycle of usage of these components, combined with the environmental contamination.

1.4.384. Such degradation of hook and loop fasteners associated with FDA had been reported by a Service Inquiry in 2007, resulting in a recommendation that its fitment and attachment methods be reviewed by the HPT. This recommendation was recorded as closed in Jan 08, with the statement, *'Fitment and attachment methods for flight deck armour have been reviewed and found to be suitable'* in the RAF "Yellow Book" that tracked such recommendations before the establishment of the MAA and DSA. Exhibit 355 Exhibit 356

1.4.385. The Panel noted that the co-pilot's Circuit Breaker Panel was restrained by use of a fabric strap (Figure 31) a local practice that was in common adoption to circumvent problems with hook and loop adhesiveness. While this minimised the obstruction potentially caused by a detached panel, it created a snagging hazard in the egress pathway. Exhibit 242

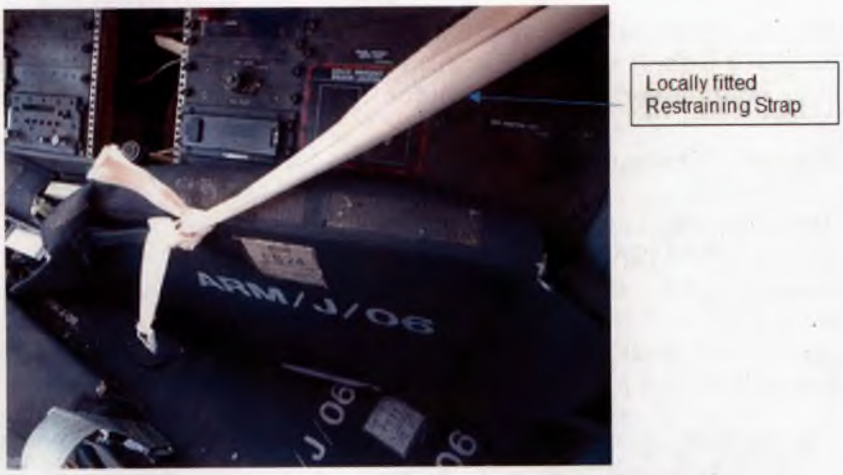


**Figure 31 – Detached Circuit Breaker Panel retained by locally attached strap**

1.4.386. The Panel determined that:

a. The hook and loop fasteners on the Circuit Breaker Panels and Weapon Stowage were unserviceable as a result of frequent use and dirt ingrained into the fabric.

b. This should have been identified during routine maintenance, and either rectified through cleaning and testing, or replacement parts demanded.

c. The 3-year life cycle is unsuitable for particular components of MOD/HECJ/1057 & MOD/HERCJ/1073 elements because of the requirement to frequently disturb the hook and loop fastener.

d. The common practice of utilising locally placed securing straps suggested that either:

(1) Relevant maintenance/servicing schedules were not being adhered to, or;

(2) The retaining mechanism is unfit for purpose.

e. The addition of locally placed restraining straps created a potential snagging hazard to personnel having to evacuate the flight deck in an emergency.

1.4.387. The Panel concluded that the unserviceable components of the Flight Deck Armour and the use of Locally Placed Retaining Straps were **Other Factors**.

**Recommendation**

1.4.388. **Hercules DDH CAE should ensure compliance with on-aircraft Servicing and Maintenance Schedules for Flight Deck Armour and Weapon Stowage.**

1.4.389. **HPT Leader should revise the servicing schedule for MOD/HECJ/1057 & MOD/HERCJ/1073 Circuit Breaker Panels and Weapon Stowage in order to ensure effective maintenance periodicities for higher frequency use areas.**

**Flight Deck Weapon Stowage Compatibility**

1.4.390. The Panel also noted that the flight deck weapon stowage was not compatible with the L85A2 (SA80) Theatre Entry Standard (TES) rifle carried by the crew, having been designed for the L85A1 (SA80), that has a different hand guard. As can be seen in Figure 32, the upper securing assembly is located particularly close to the trigger guard, and is extremely tight on the modified hand guard (Quad Rail with Down Grip) making it difficult to insert the weapon.

Exhibit 370

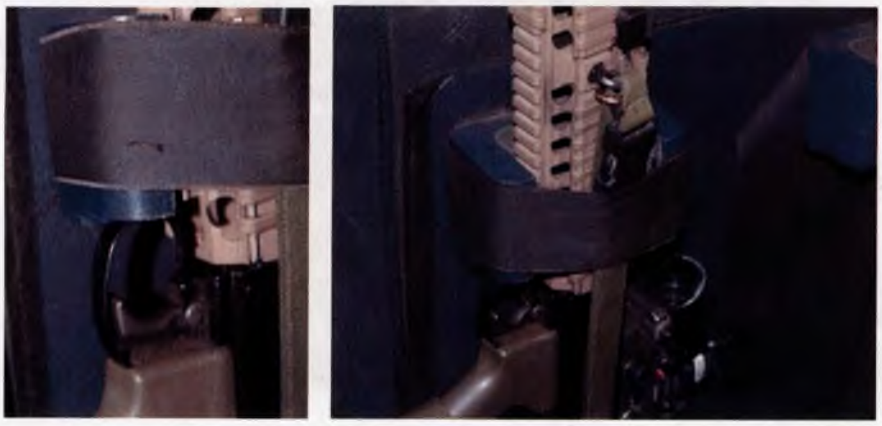

**Figure 32 - Tightness of Fit to Trigger Guard and Hand Guard Rail**

1.4.391. Although a Panel member was able to fit a weapon into the stowage, this was only achieved by placing significant upward and outward pressure on the upper securing assembly. As a consequence, the tendency is for the rifle to be only partially placed into the stowage, as indicated in Figure 33; not only did this reduce its security, it exacerbated the tendency of the weapon's weight to pull the top of the stowage away from the armour panel behind it.

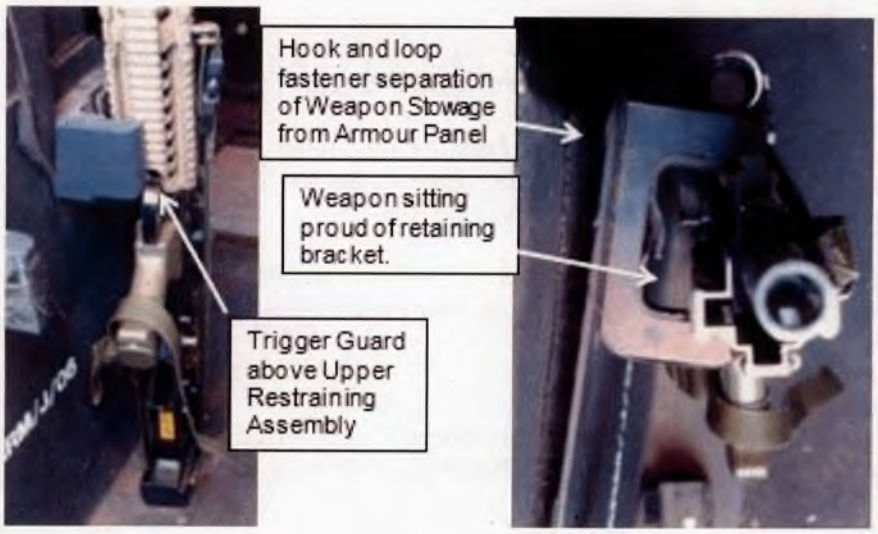


**Figure 33 - Partially Secured Rifle**

1.4.392. This was in contrast to the stowage used in the rear cabin (Figure 32), which has a different securing arrangement without the issues identified above.

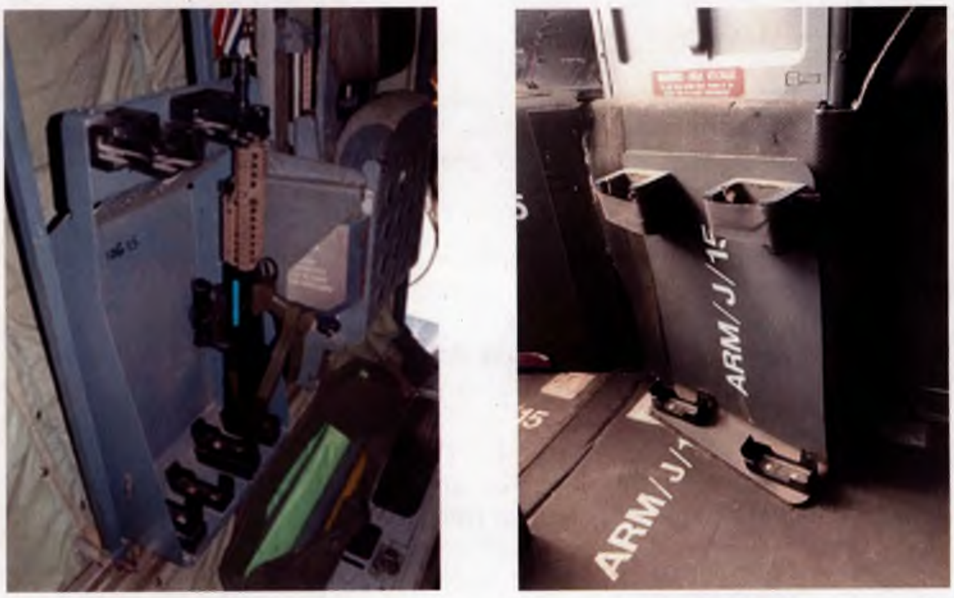

**Figure 32 - Comparison of Weapon Stowage**

1.4.393. The Panel determined that the Weapon Stowage utilised on the flight deck, being designed for the L85A1/A2 (SA80), is incompatible with the L85A2 (SA80) Theatre Entry Standard rifle.

1.4.394. The Flight Deck Weapon Stowage was concluded to be an **Other Factor**, in that it poses a risk of loose articles from insufficiently restrained weapons.

**Recommendation**

1.4.395. **HPT Leader should provide a Hercules flight deck Weapon Stowage compatible with the L85A2 SA80 Theatre Entry Standard Rifle.**

1.4.396. **The Hercules ODH should establish the extant risk of loose articles arising from the current flight deck Weapon Stowage, and ensure that any Risk to Life is mitigated and managed appropriately.**

## Aircraft Post Crash Management

1.4.397. Aircraft Post Crash Management (APCM) action was co-ordinated by the Deputy Air Commander (DAC). Initially, the extent of the damage was not clear; however, subsequent inspection by the crew suggested it was similar to that sustained in a previous hard landing that had resulted in a Category 4 assessment. In compliance with RA 1410, Occurrence Reporting, and MAA02, the DAC reported the event as an accident. Exhibit 24

1.4.398. The following activities were undertaken:

a. Aircraft documentation was quarantined at the diversion airfield by the Security Officer and at AKR by the Hercules Det Cdr.

b. Immediate witness accounts were written by the crew. These were held by the DAC and passed to the DAIB Triage Investigator.

c. The aircraft itself was quarantined with RAF Police Security Seals and 24-hour Force Protection.

d. Role 1 medical facilities were made available to the crew, with no significant injuries identified at that time. The following morning several of the crew reported back injuries; a full injury assessment was carried out on return to Akrotiri that day. Witness 4

1.4.399. The Panel noted that there were several APCM Plans that could apply to Hercules operating out of AKR, dependent on their task at the time:

a. RAF Akrotiri Crash Support and Major Incident Plan (CSMIP) for an accident at AKR or within Western Sovereign Base Area. Exhibit 243

b. Op BALDWIN: 903 EAW's APCM Plan which detailed how 903 would react to assisting the CSMIP for accidents local to AKR, or respond to accidents beyond the AKR Area of Responsibility. Exhibit 244

c. DAT(I) APCM Plan: for aircraft operating in support DAT(I). Exhibit 193

d. 903 EAG APCM Plan: for aircraft accidents within the Op SHADER Joint Operating Area. Exhibit 245

e. Op LANDAWAY: for aircraft operating in support of Op SHADER needing to land at diversion airfields across the wider Middle East. Specifically, it detailed the procedures to be invoked in order to recover 903 EAW or DAT-I UK aircraft after an unplanned diversion. Exhibit 247

1.4.400. The Panel considered the plans to be consistent and coherent.

1.4.401. Notwithstanding the decision to report the occurrence as a potential accident, no formal APCM plan was enacted. Having concluded that the aircraft had recovered safely, the DAC elected to consult the DAT(I) PCM plan as a source of useful contacts and "handrail" rather than activate it formally. Exhibit 24

1.4.402. Given the circumstances of the occurrence, whereby the aircraft had recovered to a secure location with unknown damage, the Panel felt that the decision of the DAC to report it as an accident, and to ensure that documentation and the aircraft were quarantined, was well considered and correct. However, that no formal APCM Plan was activated did not ensure that a co-ordinated response, with a single point of contact ensuring the relevant actions were taken. Op LANDAWAY catered specifically for the scenario encountered by ZH873, even listing the diversion airport as one likely to be used; it was also mentioned within the DAT(I) APCM plan as a specific consideration for Hercules aircraft that had landed at a secure, prepared airfield. Activation of LANDAWAY would also have enabled formal activation of 903 EAW resources that could have both off loaded the requirements from, and provided advice to, DAT(I). Exhibit 247 Exhibit 193

1.4.403. The APCM Report compiled by DAT(I) following the accident concluded:

a. *'For incidents not involving injury, MAA 02 defines aircraft accidents in terms of aircraft damage category. This is unhelpful in the initial stages, as an assessment of Category 4 or 5 damage was not made until nearly 4* *weeks post-incident. The definition of MAA 02 be amended or further guidance be provided as to when incidents should be reported iaw accident of serious incident criteria.'*

b. *'The reporting requirements of RA 1410 and PJHQ SOP 3004 are considerable and not readily achievable for small HQs who are simultaneously dealing with an accident/serious incident. There is a risk that these reporting requirements detract from actually dealing with the incident. Consideration be given to rationalising reporting requirements for aircraft accidents/serious incidents between RA1410 and SOP3004.'*

c. *'Mandatory reports were in non-editable PDF format. This wasted valuable time exporting them to a format that could be disseminated as required by RA 1410. All report formats should be available in a suitable word processing format which allows simple filling, saving and distribution. These should be clearly hyperlinked in RAs.'*

1.4.404. The Panel understood the concern regarding accident definitions, but did not agree that this would necessarily be rectified by amendment; there will always be occasions wherein specialist advice needs to be sought following an aviation occurrence. Where this concerns the boundary between aircraft incidents and accidents, then the worst-case scenario should be assumed until proven otherwise, or until the appropriate risk holder authorises any alternative. The DAC and Det Cdr's actions were therefore correct and appropriate given the circumstances they faced.

1.4.405. RA 1410 requires an Initial Report following an aircraft accident to be submitted to the MOD Deputy Chief of Defence Staff Duty Officer (DCDSDO) or the Permanent Joint HQ Duty Ops Controller (PJHQ DOC) depending on the occurrence location. SOP 3004 is the PJHQ Standard Operating Procedure for Incident Reporting; it is required following incidents in operational theatres, including aircraft accidents, but contains more information than required in the Initial Report. The Panel recognised that this could result in a burdensome requirement on reporting units. However, the differing functions of each justified the individual reporting chains, and any attempt to remove the Initial Report requirements from SOP 3004 would probably create more complexity in completion and result in greater potential for error.

Exhibit 248
Exhibit 249

1.4.406. The comments regarding reports in PDF format were noted. However, a series of links to editable PDF forms for the majority of mandatory reports was found on the ASIMS homepage. Of note, the Initial Report, which has to be submitted within 1 hour of an accident, is only contained within the RA itself, and in an un-editable format. The Panel assessed that provision of links to all Air Safety reports in an editable format from a single access point would significantly assist provision of timely, accurate information. Additionally, the Panel noted a degree of duplication between the Initial Report and Significant Occurrence Notification.

Exhibit 250
Exhibit 248
Exhibit 251

1.4.407. The Panel concluded that APCM was **Not a Factor**. However, it assessed that its process would be enhanced by improved access to reporting templates, and by removing duplication of information.

**Recommendation**

1.4.408. **D MAA should:**

a. **Provide links from the ASIMS home page to editable documentation for all Air Safety reports.**

b. **Amalgamate the Serious Occurrence Notification and Aircraft Accident Initial Report into a single pro forma, with an Annex for accident specific data.**

## Organisation / Systemic Factors

### Air Safety Management – Safety Statements and Operational Emergency Clearances

1.4.409. The sortie required use of two Operational Emergency Clearances (OECs), OEC 001 Military Operating Standards (MOS) and OEC 022 (Increased All Up Mass for Landing).

1.4.410. Operational Emergency Clearances are utilised to clear the use of equipment, systems or operating modes that do not satisfy the project safety standards for a Release to Service, but can be included with special conditions attached. Exhibit 255

1.4.411. They are governed by RA 1330 and should: Exhibit 257

a. Be identified when the Air System will be operating outside its declared safety target.

b. Be authorized by the Release to Service Authority (RTSA).

c. Only be enabled at Operating Duty Holder (ODH) level for a given activity and defined period.

1.4.412. On implementation of an OEC, the ODH should:

a. Update the Safety Statement for the Air System and record their judgement that the benefits of operating the Air System outweigh any increased Risk to Life (RtL).

b. Declare in the Safety Statement to which Operation the OEC applies.

1.4.413. Safety Statements are outlined in RA 1205(3), which states that they should include: Exhibit 258

a. A formal declaration by the ODH that all RtL are currently and foreseeably at least Tolerable and As Low As Reasonably Practicable (ALARP).

b. Any supplementary information outlining any significant issues and concerns that the ODH might have with any element of the Air System Safety Case, or the management of any RtL.

c. A note of any RtL that have been escalated, together with any subsequent decision/action taken by the SDH.

1.4.414. Safety Statements should be reviewed:

a. At least annually.

b. Prior to implementing any significant change in an Air System in any Defence Lines of Development (DLoDs) (eg major capability upgrade, change in usage or operational context).

c. Following any other change judged by an ODH to impact on the validity of the Safety Statement.

d. As a formal element of ODH succession activities, to ensure the incoming ODH is personally content with the level of RtL being carried and the effectiveness of any extant mitigation measures, leading to the incoming ODH issuing his own Safety Statement on taking post.

1.4.415. The Panel wished to understand the process for management of OECs and production of Safety Statements within 2 Gp, and researched associated documentation.

1.4.416. The RAF Safety Management Policy (SMP), Air Publication (AP) 8000: Exhibit 259

a. Describes how safety is managed across the RAF and outlines how the Chief of the Air Staff (CAS) ensures that his responsibilities as the SDH are met across the RAF. Exhibit 260

b. Requires that the RTS is maintained by the RTSA, details the operating parameters of the aircraft and includes any Operational Emergency Clearances (OEC) and Clearances with Limited Evidence (CLE).

c. Requires that each platform has an up to date Safety Case, highlighting that a Safety Statement is a formal declaration by the ODH that, based on its Safety Case, all identified RtL associated with a specific air system are at least tolerable and ALARP. Exhibit 261

d. Outlines the governance for Air System Safety Working Groups (ASSWGs): platform specific meetings chaired by the ODH, held at least bi-annually and attended by the DDH and DDH-level representatives from DH-facing organizations. It is the primary forum for managing and transferring RtL at the ODH/DDH interface. The ASSWG aims to evaluate the airworthiness, operation and maintenance of the platform across all 8 DLoDs and provides the ODH the opportunity to review the platform Safety Statement and, formally declare that all RtL associated with a specific air system are at least tolerable and ALARP. Exhibit 262

1.4.417. The 2 Gp ASMP, extant on 25 Aug 17, mandated the discussion of OECs at ASSWGs, on completion of which the ODH would issue the Safety Statement. It required detailed minutes of the ASSWG and the resulting Safety Statement, as *'auditable documents'*, to be submitted to the SDH. A generic Safety Statement was included in the ASMP for this purpose. These requirements remained extant following revision of the ASMP. Exhibit 263 Exhibit 264 Exhibit 265 Exhibit 266

1.4.418. 2 Gp ASSWGs are run to a set agenda, guided by a comprehensive set of briefing slides. On completion, a Record of Decisions (RODs) is produced, and an audio recording is kept.

1.4.419. At the Nov 16 ASSWG, the briefing slides included all extant OECs and the Delegated RTSA (DRTSA) stated, *'the only point worthy of note is the introduction of OEC022 which increases AUM on landing.'* In response to a question from the ODH regarding the future intent for this OEC, the DRTSA indicated an intent that this clearance would be translated into a Clearance with Limited Evidence (CLE). However, neither this, nor any other OEC was referred to in the RODs. Exhibit 267

1.4.420. The Nov 17 ASSWG was similarly supported by briefing slides, and the RODs recorded that the ODH was briefed on all extant OECs and CLEs. The audio recording confirms this, but the Panel noted that neither the ODH's direction for additional detail regarding 2 particular OECs, or his requirement for greater clarity regarding who had authority to approve them (recognising his personal accountability), was recorded in the RODs. Exhibit 268 Exhibit 365 Exhibit 369

1.4.421. The Panel requested 2 Gp HQ provide a copy of the Hercules Safety Statement extant at the time of ZH873's accident; it could not be located. Asked about this in interview, the ODH stated that a Safety Statement following the Nov 17 ASSWG, his first in post, was in the course of production, but that he had a copy of the 2015 version. Neither the 2015 nor 2017 versions included mention of OECs, and a new Safety Statement had not been issued on supersession of the ODH. Exhibit 269 Exhibit 270 Exhibit 271 Exhibit 272 Exhibit 257

1.4.422. As a comparison, the Panel examined how Safety Statements are managed on a platform type within another ODH area, namely Typhoon and 1 Gp. This established a similar set of organisational arrangements within 1 Gp's ASMP, and that this had resulted in the production of a comprehensive Safety Statement. Exhibit 273 Exhibit 274 Exhibit 275

1.4.423. The Panel determined that:

a. Hercules Safety Statements had not been issued annually.

b. A Safety Statement had not been issued on supersession of the ODH.

c. Safety Statements did not record Operational Emergency Clearances.

d. ASSWG RODs were incomplete and did not meet the remit of providing detailed minutes to the SDH.

1.4.424. As such, the Hercules ASSWG was non-compliant with MAA RA 1330, AP8000 and the 2 Gp ASMP.

1.4.425. The Panel concluded that non-compliance with RA 1205(3), RA 1330 and AP8000 regarding Safety Statements and Operational Emergency Clearances for Hercules was an **Other Factor**.

**Recommendation:**

1.4.426. **AOC 2 Gp should ensure that the 2 Gp ASMP and its associated Risk Management processes are compliant with RAs 1205, 1330 and AP 8000.**

## Operational Emergency Clearance 022 – Increased All Up Mass at Landing Weights for Operational Necessity

1.4.427. OEC 022 (Increased AUM at Landing Weights for Operational Necessity), was introduced into the RTS in Oct 16 as ANA4-16. It followed extensive work by the DH chain, contained in Duty Holder Advice Note (DHAN) – High Mass Landings dated 14 Oct 16. This argued that a clearance to allow aircraft to operate using MOS at 62,500kg rather than the RTS limit of 58,970kg would lower Operating Risk by reducing the number of sorties necessary to meet the operational resupply requirement (paragraphs 1.4.24 *et seq*). It also concluded that OEC 022 did not result in any increased RtL. Exhibit 276 Exhibit 277

1.4.428. In parallel, the DRTSA had authorised the OEC prior to conducting a formal hazard transfer to the ODH. Exhibit 278

1.4.429. The ODH concluded that platform airworthiness had been properly considered with appropriate RTSA engagement and directed that the DDH could manage the additional capability *'when operational necessity requires it, though this is planned to be OEC, not routine activity, and I wish to be informed when the facility has been used.'* He also required that he be updated regarding its usage at the ASSWG planned for Nov 16. However, following the convening of a Non-Statutory Inquiry into an overweight landing of Hercules ZH870, 29 Aug 16, the ODH withdrew his support for the OEC. Exhibit 277 Exhibit 279

1.4.430. On 2 Dec 16, by means of an Addendum to the DHAN, the DDH recommended that the OEC be re-instigated. Drawing from the accident of 29 Aug 16, it proposed a series of additional barriers to further mitigate risk which included use of Pinnacle NVG, Pre-Deployment simulator training at increased weights and revised MOS and NSO BCR requirements. The Addendum concluded that as long as its recommendations were implemented, and given the PT assessment that 62,500 kg was well within the design limits for the aircraft, then: Exhibit 46

a. No additional RtL would result from the OEC implementation, and;

b. Fewer sorties at the higher AUM would provide a better balance of risk compared to operating more sorties at the reduced weight of 58.97T.

1.4.431. It also asserted that use of the OEC would require ODH approval, rather than management at the DDH level which had been approved within the Oct 16 DHAN.

1.4.432. The ODH approved the Addendum on 6 Dec 16, stating that he was content that there was a sound case to authorise an increased AUM for a single mission on 7 Dec. However, he added that additional consideration would be required before approvals for subsequent sorties. This DHAN Addendum remained in force throughout 2017, without alteration. Exhibit 280

1.4.433. The Panel noted that the ORM pertaining to ZH873's sortie indicated that OEC 022 had a standing dispensation. As this contravened the DHAN Addendum, the Panel sought to understand how this had been approved. Exhibit 281 Exhibit 40

1.4.434. On 31 Dec 16, the Herc Det Cdr requested approval via the command chain to use OEC 022 for a mission on 5 Jan, which was copied to the DDH. On 3 Jan 17, the DDH replied to the Det Cdr that he had discussed the requirement with the ODH who was content that, having re-approved of the OEC in the DH Addendum, there was a general permission that it could be planned for future tasks. This was subject, however, to the stipulations in that Addendum being adhered and the DDH being notified so that he could take a view and make the ODH aware. Exhibit 246

1.4.435. In interview, the DDH indicated that this approval process was further modified in Jan 17. Thereafter, where planning identified a requirement for OEC 022, it would be communicated to 2 Gp who were effectively managing whether the ODH was happy for it to go ahead, and that he (the DDH) would let the ODH know if he had an objection to it being used. As such, control of the OEC had been executed by email correspondence. Witness 10

1.4.436. This was consistent with evidence from the ODH Senior Operator stating that, following issue of the DHAN Addendum, the ODH's position evolved such that, from 3 Jan 17, he wanted to be '*aware of when OEC 022 was being used (on each occasion) but did not feel the need to specifically approve it on a sortie per sortie basis.*' Exhibit 246

1.4.437. On 24 Apr 17, the Herc Det Cdr requested HQ 2 Gp confirmation of a standing dispensation for "MOS Procedures < 62,500Kg". The Senior Operator responded that use of MOS had been granted as a standing dispensation for this TLZ, which would be recorded in the next iteration of the Operational Capability Certificate (OCC). He indicated by email to the Det Cdr that there would be '*no need to ask for subsequent* [Operation Name] *sorties to this location from now on*' but required that HQ 2 Gp were always informed of such missions in order '*to demonstrate assurance to AOC 2 Gp*'. On 26 Apr, the [redacted] Deputy Air Cdr, also included in the email distribution, acknowledged this, stating '*Thank you for approving a standing dispensation for use of MOS PROCEDURES < 62,500kg (OEC022)*'. Exhibit 282

1.4.438. The relevant OCC was updated in May 17. Although it specified that AOC 2 Gp had approved a standing dispensation for Hercules crews to utilise MOS for operations to the TLZ, it made no mention of OEC 022. Exhibit 22

1.4.439. The Panel noted that 2 Gp ASOs states, '*Authority to operate to MOS does not necessarily include the use of overload weights or military fuel reserves, both of which must be authorized separately.*' Exhibit 284

1.4.440. The Panel determined that:

a. The management of OEC 022 had not been in accordance with either the relevant regulation or the DHAN Addendum that had authorised its use specifically for a single sortie in Dec 16.

b. Despite the clear direction contained within the Addendum, thereafter it became increasingly vague as to the level of approval required for its use.

c. By Apr 17, an incorrect, but inadvertent, cross-referral of a standing dispensation for MOS with a weight of 62,500kg created a false impression that OEC 022 had a similar dispensation.

1.4.441. Whilst the management and implementation of OEC 022 did not contribute to ZH873's accident, it was concluded to be an **Other Factor**.

**Recommendation**

1.4.442. **AOC 2 Gp should ensure that a robust mechanism for approving use of OECs is clearly articulated in appropriate documentation**.

1.4.443. The Panel noted that, subsequent to ZH873's accident, the ODH had instigated a series of measures to improve management of OECs by 2 Gp including Exhibit 285 his clear requirement that OEC 022 could only be used following his express approval.

## Operational Emergency Clearance 001 – Military Operating Standard

1.4.444. MAA 02 defines 3 Operating Standards – Normal, Reduced and Military: Exhibit 255

a. Normal Operating Standard (NOS): generally similar to civil aviation standards, the standard normally used, and is always presented in the ODM. It requires no special flight authorization.

b. Reduced Operating Standard (ROS): an order of magnitude greater risk than NOS. Use is governed though an OEC when the military necessity justifies a reduction of the safety margins.

c. Military Operating Standard (MOS): an order of magnitude greater risk than ROS. Use is governed through an OEC when the military necessity justifies a reduction of the safety margins.

1.4.445. The Panel sought further advice regarding the risk levels associated with MOS:

a. The MAA responded that NOS, ROS and MOS do not appear in the MRPs. As such, there is no need for their retention within MAA02[17], and would be removed at the next issue. Exhibit 286

b. Where Aviation Duty Holders determine a requirement for an activity that does not meet project safety standards then it should be captured appropriately, eg through an OEC (see paragraph 1.4.410). Exhibit 286

c. The PT indicated that the level of risk associated with MOS would be $1 \times 10^{-4}$ flying hours, being *'2 orders of magnitude'* greater than the NOS safety target of $1 \times 10^{-6}$. Exhibit 287

1.4.446. However, Air Test Evaluation Centre (ATEC) trials worked to a standard specification that required the risk of a MOS short landing to be no greater than 1 in 1000. This was based on a paper, *'Aeroplane Performance – Military Operating Standards'*, dated 9 Jan 89, intended to standardise MOS across Defence. It proposed that: Exhibit 288

'[There should be] *sufficient margins to allow for the inevitable variation of engine performance standard, wind, temperature and piloting techniques, etc, which will occur in Service use, to ensure that the probability of the published MOS performance not being achieved is not greater than about 1 in 1000 take-offs or landings.'* Exhibit 289

1.4.447. No further reference as to whether this proposal was accepted into Defence aviation regulations was found.

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[17] MAA02 is a glossary of terms used only within the Military Aviation Regulatory Publications.

1.4.448. MOS was incorporated within the Hercules Release to Service in Jan 99, having been previously utilised by the C130K from Apr 90, and is recorded as OEC 001. Exhibit 290 Exhibit 291

1.4.449. Hercules MOS techniques have developed from recommendations arising from a series of trials conducted by the ATEC at Boscombe Down. The following discussion focuses particularly on trial conclusions regarding the required Aiming Point necessary to satisfy MOS touchdown dispersion criteria.

1.4.450. The first trial in 2002 concluded there was significant probability of touching down short of the runway if the start of the Touchdown Box was used as an initial approach aim point. It recommended that the initial approach aim point must not be positioned less than 150 ft beyond the beginning of the runway and this was incorporated in the Aircrew Manual. Exhibit 215

1.4.451. The Report also considered it desirable that the location of the initial approach aim point was clearly marked on the runway to *'ensure the minimum undershoot criteria of 150ft has been accounted for'*. However, the Panel could find no evidence of this being taken forward.

1.4.452. Specific NSO trials were first conducted in 2003 and utilised the same runway and Touchdown Box layout as the previous MOS trial; however, the Aiming Point was changed to 50 ft inside the Touchdown Box. This meant that the requirement for it to be at least 150 ft beyond the start of the runway was satisfied, providing that the Touchdown Box was preceded by at least 100 ft of usable runway surface. Exhibit 292

1.4.453. A significant difference from the earlier MOS trial was that the mean touchdown point during these trials was found to be adjacent to the Aiming Point, rather than 109 ft beyond it. Exhibit 292

1.4.454. The Report noted that the MOS trials had been conducted to a non- length limited, paved runway, whereas the NSO trials were conducted to shorter field-length limiting TLZs. The Panel agreed with the Report's conclusions that: Exhibit 292

a. The earlier touchdown point was a result of pilots focusing more intently on getting the aircraft on the ground as soon as possible given the shorter landing ground run available, and;

b. This would be more representative of operational MOS conditions.

1.4.455. The NSO Trial indicated that its "*small sample size does not support rigorous statistical analysis*"; however, it stated that: Exhibit 292

a. *'.. with the aim point in its current location (ie 50 ft beyond the start of the touchdown box), by estimation the probability of the aircraft touching down in the undershoot is 1 in 25.'*

b. *'By simply relocating the aim point 100 ft further forward, to a position 150 ft beyond the start of the touchdown box, the probability of touching down short of the runway is reduced to approximately 1 in 600. While this does not meet the MOS criteria of 1 in 1000 landings, relocation of the aim point significantly reduces the likelihood of landing in the undershoot.'*

c. *'Standard Operating Procedures dictate that for training purposes a 300 ft undershoot should be added to the beginning of the strip. Whilst this in itself does not eliminate the risk of touching down outside of the runway, the consequences of landing short of the touchdown point will be benign. More significantly Service experience indicates that approximately 90% of all MOS landings are under training conditions, thus only 10% of landings actually carry the risk of 1 in 600. Therefore, it is estimated that the overall risk of landing short of the actual runway is significantly less than the 1 in 1000 MOS criteria.'*

1.4.456. The Panel found these statements confusing and noted that the assertion, '*with the aim point in its current location (ie 50 ft beyond the start of the touchdown box)'* was at odds with the Aircrew Manual aiming rule of *'a minimum of 150ft beyond the start of the runway'*, as recommended by the previous MOS Trial. This confusion was compounded by use of the word "undershoot", for which no formal definition could be found in MADS or the MAA Glossary. Following subsequent clarification from ATEC, the Panel was able to correlate Trials Report terminology with that as laid down in the MADS (Table 13): Exhibit 288

| **Trial Term** | **MADS equivalent** |
|---|---|
| Undershoot | Overrun |
| Runway | All of the prepared surface, including overruns |
| Touching down in the undershoot | Landing on the overrun |
| Touching down short of the runway | Landing before the overrun surface (as was the case with ZH873) |

**Table 13 – Trials Terminology and MADS Equivalent**

1.4.457. The Panel was also concerned that the required probability of 1 in 1000 had not been rigorously proven, for which ATEC stated (bold emphasis added by Panel):

*'As it states in the Final NSO report, the small sample size **did not support rigorous statistical analysis** and so **a statistically based confidence level could not be determined** from the data set. Based on the observed touchdown dispersion relative to the aim point, **engineering judgement** was used to estimate that by moving the aim point to 150ft the probability of touching down short of the runway is reduced to approximately 1 in 600 (based on a 100ft undershoot). It was acknowledged in the report that this did not meet the "acceptable level" for MOS criteria of 1 in 1000 landings. However, the report states that based on service experience at the time that only 10% of MOS landings were known to be conducted with a 100ft undershoot. **Therefore, the overall fleet risk (based on 90% of landings being conducted with a 300ft undershoot) was estimated to be less than 1 in 1000**.'* Exhibit 292

1.4.458. The NSO Report recommended that, as an Essential Safety Condition, the Aiming Point for MOS and NSO *'must be 150ft beyond the start of the touchdown box.'* However, the accompanying *'Proposed changes to Aircrew Manual'* made no reference to this revision. The Panel considered that this seemingly subtle change to aiming beyond the start of the Touchdown Box rather than the start of the Runway was a significant change; however, the Aircrew Manual retained the original advice of aiming a minimum of 150 ft beyond the start of the runway.

1.4.459. Further analysis of MOS handling techniques took place during a trial in 2010 where it was asserted that the RAF had adopted a technique of aiming at the start of the Touchdown Box. The Panel could find no evidence supporting this claim, which is inconsistent with the technique prescribed within the Hercules ACM and the TATOM. Exhibit 293

1.4.460. The latest trial to include MOS handling techniques was conducted in 2013. Known as '*Milestone 2*', it was part of a series of trials designed to expand the landing mass limits for the Hercules fleet: Exhibit 219

a. Milestone 1 had consolidated all previous ATEC reporting with respect to heavy mass operations.

b. Milestone 2 sought to provide advice regarding an expansion of the landing mass limits to paved surfaces.

c. Milestone 3 was intended to apply the expanded paved surface landing mass limits to Natural Surface Operations. Milestone 3 was never undertaken.

1.4.461. Milestone 2 also utilised an Aiming Point at the start of the Touchdown Box, incorrectly stating that this was the standard MOS technique. ATEC stated that this resulted from discussions with RAF Hercules operators at the time of the trials, but could not produce any correspondence in support of such a belief. Exhibit 219 Exhibit 288

1.4.462. Although it focussed on an Aiming Point at the start of the Touchdown Box, Milestone 2 also assessed an Aiming Point Estimated as 150ft into the Touchdown Box for occasions when the '*runway location dictated that a suitable 300ft undershoot could not be designated*'. The report recommended that the following warning be included within the Aircrew Manual: Exhibit 219

*'WARNING: When using a 500ft touchdown box with an unmarked, visually assessed aim point, the possibility of undershooting[18] or needing to Go-Around is elevated. Such approaches should therefore only be conducted in cases of operational necessity.'*

1.4.463. Despite the Hercules ACM continuing to prescribe an unmarked, visually assessed Aiming Point for all MOS approaches, this warning (which was consistent with the 2002 recommendation to clearly mark the aim point) was not placed in the ACM.

1.4.464. The Panel sought to establish why this warning had not been incorporated into the Aircrew Manual. No definitive evidence could be located, the HPT response stated that: Exhibit 287 Exhibit 288

[18] Landing on the Overrun

a. The Aircrew Manual includes a warning about touching down short and to consider overshooting if a MOS approach is high or fast.

b. MOS must be authorised at ODH level because of the higher level of risk associated with it.

c. None of the recommendations from the Milestone 2 Report have been included in the ADS because the additional capability underpinned by it, namely increasing the maximum all up weight of the Hercules when operating to paved runways, was never introduced.

1.4.465. Notwithstanding that the Milestone series of trials were delayed, the Panel noted that this was the second trial providing a warning regarding use of an unmarked Aiming Point.

1.4.466. As well as the discrepancies regarding aiming points used by ATEC against those contained within the ADS, the Panel also noted that latter trials utilised a 2.5° glideslope rather than 3°. Asked why this was and what it meant for the validity of recommendations, ATEC responded: Exhibit 288

a. The belief that the RAF used a 2.5° glideslope stemmed from a meeting between with the IPT, RTSA, STANEVAL, Handling Squadron and the Hercules OEU in May 2004.

b. The touchdown dispersion dataset for 2.5° landings was consistent with the 3° dataset from previous trials. Recommendations were made by ATEC to support amendment to the ADS to provide a correction for landing distance for 2.5° approaches.

1.4.467. The Panel determined that:

a. The Aiming Point prescribed in the Aircrew Manual had not changed since the original trial in 2002, referring to the start of the runway vice Touchdown Box, despite changes recommended by subsequent trials.

b. The MOS trials were confusing in their use of terminology, particularly the terms undershoot and runway.

c. The use during trials of aiming points and glideslope that were inconsistent with those within the ADS and being used by the Hercules Force suggested a lack of effective communication between relevant stakeholders.

d. There was potential that the ODH did not understand the risk associated with MOS/NSO given:

(1) The lack of inclusion of a warning regarding use of a marked Aiming Point, and;

(2) The *'small sample size and lack of rigorous statistical analysis'* underlying the NSO Trial recommendations.

1.4.468. The Panel concluded that incoherent management of OEC 001, in particular the associated MOS/NSO Trials and their subsequent inclusion within the ADS, was an **Other Factor.**

1.4.469. The Panel **Observed** that:

a. Although the ACM handling advice for NVG NSO utilised the day MOS technique (which relied on visual cues to initiate the flare), no formal trials of NVG NSO had been carried out. Exhibit 297

b. The technique used by the pilot of ZH873, namely aiming at the front of the Touchdown Box on a 2.5° Glideslope, was the same as that used during the more recent Air Test and Evaluation Centre trials.

**Recommendation:**

1.4.470. **AOC 2 Gp should:**

a. **Confirm that the operating risk associated with MOS and NSO is understood and recorded as part of the Hercules Air System Safety Case.**

b. **Determine whether empirical evidence would support better quantification of the risk associated with OEC 001 and support its elevation to a CLE or full inclusion within the RTS.**

1.4.471. **HPT Leader should review all associated Trials Reports in order to ensure all safety recommendations emanating from Trials Reports have been sentenced with an auditable record of decisions.**

## Documentary Disparity

1.4.472. Handling advice for MOS approaches is contained within a number of documents issued to Hercules Crews, as summarised in Table 14.

| Parameter | Aircrew Manual | TATOM | XXIV Sqn Training Slides |
|---|---|---|---|
| **Speed** | $V_{AT}$ [19] +5 Kts reducing to $V_{AT}$ by 50ft | VTL from 250ft | $V_{AT}$ from 500ft |
| **Aiming Point** | 150ft Beyond Start of Runway | 100ft Inside 500ft Touch down box | 150ft Beyond Start of Runway |
| **Approach Path** | 3° | 2. 5° | 2. 5° |
| **Head Up Display** | Use HUD until approx. 100ft | N/A | Use HUD until approx. 50ft then visual cues |
| **Rad Alt** | *"Use of the RadAlt to provide an Altitude call cannot be relied upon as a mechanistic cue to flare. Visual cues should be used to judge the flare by day. "* | N/A | *"Use of the RadAlt as a cue to flare can lead to HUD fixation and a heavy landing. Use visual cues from 50ft (If the terrain is suitable the PNF can give the PF a RadAlt countdown from 100ft)"* |

Exhibit 359
Exhibit 109
Exhibit 147
Exhibit 168

**Table 14 – Differences in Handling advice offered to Hercules pilots.**

1.4.473. It is apparent that each document prescribes a different technique or limitation. The presence of such contradictions is likely to have led to uncertainty regarding the correct parameters to use and to a perception that there was flexibility in the parameters to use during an approach. Exhibit 359

1.4.474. Although it was established that the ACM advice takes primacy, the TATOM asserted that its handling advice was mandatory for all crews. Exhibit 205

1.4.475. Instruction on XXIV Sqn was not consistent with either the ACM or TATOM. Exhibit 206 Exhibit 207

1.4.476. The Panel determined that:

a. It is almost certain that differences regarding handling techniques in relevant documentation had generated a perception of flexibility in how an MOS approach should be flown.

b. It is highly likely that crews were confused as to which document took primacy in regards to handling advice.

c. Training delivered on XXIV Sqn was incorrect.

[19] $V_{AT}$ is the speed a pilot aims to cross the runway threshold when landing.

1.4.477. The lack of consistency in these references, alongside other documentary discrepancies, was identified soon after convening the SI, and led to the issue of Urgent Safety Advice to the ODH by the Panel regarding clarification of documentary precedence. This was followed by ODH direction that the Aircrew Manual should be regarded as the prime reference for handling procedures. Exhibit 208 Exhibit 209

1.4.478. The Panel concluded that the disparity in handling advice issued across the Hercules Force documentation was a **Contributory Factor.**

**Recommendation:**

1.4.479. **AOC 2 Gp should:**

a. **Mandate that all crews apply the standard MOS approach as laid down in the ADS.**

b. **Take urgent action to resolve the documentary discrepancies regarding MOS handling advice.**

c. **Conduct a wider review of the ADS and supporting publications (particularly the TATOM), ensuring consistency and clarity of primacy.**

## Door Observers and Management of Risk to Life

1.4.480. During the Combat Entry Checks en route to the TLZ, AGE2 and WSOp (Cmn) 2 positioned themselves at the port and starboard paragraph-doors respectively as Door Observers. [redacted]. The Panel sought advice from the AWC as to when the concept was established; a definitive answer could not be found, but the earliest recommendation dated from 2007. Exhibit 298 Exhibit 299 Witness 6

1.4.481. MAA RA 2130 requires that all aircraft occupants shall be suitably restrained in all phases of flight and, for take-off and landing, that they should be seated and restrained using a seat harness. Exhibit 300

1.4.482. Door observers sit on a stool with two fold down legs fabricated of aluminium (Figure 35). This was not designed to be used for take-off or landing and has no form of restraint attached; crews had resorted to attaching fabric tape to the aircraft as 'grab handles' and developed a system of [redacted] to help restrain themselves during take-off and landing (Figures 36 and 37).

 

[redacted]

Figure 35 – [redacted]

Figure 36 - Locally Manufactured Hand Strop

[redacted]

Figure 37 – Door Observer utilising Hand Strop [redacted]

1.4.483. At the time of the accident, Door Observer employment was governed by a DDH Addendum published on 25 Apr 14 following a Duty Holder Board to discuss the associated risk, 6 Feb 14. This acknowledged that the practice of utilising Door Observers during take-off and landing was in conflict with regulation, and that injury to unrestrained crew members could affect operational capability. The DDH approved their continued use, but requested that the AMF HQ provide options for a permanent

Exhibit 302
Exhibit 301

restraint system to the PT as a potential future mitigation. The risk was recorded on the Platform Safety Risk Register (PSRR) as *'C-130 20: Injury to Door Flight Observer'*.

1.4.484. The AMF HQ raised a Statement of Requirement (SOR) in Mar 14, recommending that in order to reduce RtL and/or mission failure, a suitable crash-worthy door observer seat be sourced and trialled at the earliest opportunity. As an interim solution, use of a suitable restraint system alongside the extant seat should be investigated. However, it is not clear to whom it was submitted as no HPT addressee was identified. Exhibit 303

1.4.485. During the 3½ years between the raising of the SOR and the accident, the Panel could find little evidence as to the progress of this requirement, the following being noted in the BZN Duty Holder MOSS area:

a. In 2015, following a requested update, the PT indicated that the seat restraint remained *'below the line with no plans for moving* [above the line] *at the moment'*. Exhibit 304

b. In 2016, the BZN Air Safety Officer conducted a review of the PSSR risk. This stated that, *'the C-130J PT has considered the matter and it formed part of the Delivery Confidence Matrix but was currently unfunded. Until the replacement programme detailing equipment priorities is produced it will continued to be monitored by the ASC. Other programmes have taken priority in the preceding months (Brake failure, TCAS v SATCOM etc).'* Exhibit 305

c. In 2017, immediately following the accident to ZH873, the PT was requested to provide another update. The response stated, *'The only reference to previous work we have carried out on the para door seat was under LM-1 Task 232 back in 2008. Essentially the seats were strengthened as they were prone to cracking. However, I must point out that the seats were never designed or cleared for use during take-off and landing, only during flight, and do not have any restraints.'* Exhibit 306

1.4.486. Asked in interview about the status of a technical solution, the DDH indicated that he was not aware of any in the near future due to time and cost, and that its progress sat with AMF HQ Cap Dev. Witness 10

1.4.487. The AMFC informed the Panel that, following submission of the SOR, the 2 Gp Cap Dev individual running with the task had departed on maternity leave; it was no longer on her task tracker when she returned and she did not recall asking for an update. The submission of the SOR alone was insufficient authority to initiate any work by the PT, which would have necessitated an Initial Look Request to establish Very Rough Order of Magnitude cost figures to be provided back to the budget holder. As such, there was no further activity conducted regarding progression of either a temporary or permanent technical solution. Exhibit 307

1.4.488. In its Initial Report, the Panel raised its concern regarding the risk posed to Door Observers during take-off and landing with no means of restraint, making an Urgent Safety Recommendation that it should be reviewed. The Panel noted that a DDH Operating Instruction was issued stating: Exhibit 361 Exhibit 299

 

a. *'When employed, Door Observers are to be seated and fully restrained for take-off and landing unless in the opinion of the Captain, exceptional operational or safety considerations override the risk of injury.*

b. *'Timing of the release of Door Observers to perform their duties is at the discretion of the Captain and must be briefed clearly to the crew prior to approach/departure.*

c. *'This DHOI will be followed by a DHAN with further details.'*

1.4.489. Ownership and management of Risk to Life (RtL) is regulated by RA 1210, which states that: Exhibit 308

a. Aviation Duty Holders are legally accountable for ensuring that RtL is both Tolerable and ALARP.

b. A risk can be said to be reduced to a level that is ALARP when the sacrifice of further reduction is grossly disproportionate to the decrease in risk that would be achieved. An ALARP argument must balance the sacrifice (in time, money or trouble) of possible further risk reduction measures against their expected safety benefit (incremental reduction in risk exposure). Once a risk has been reduced to ALARP, the ADH must balance the residual risk against the expected benefit to determine whether the risk is Tolerable.

1.4.490. Since 2016, 2 Gp had been in the process of transferring from a Platform Safety Risk Register (PSRR) to a system based on Bowtie analysis. Bowtie models are visual risk tools which display the causal factors (threats) and outcomes (consequences) for a specific risk (top event). They highlight the controls in place (barriers) to prevent the risk from materialising, and can help understand what could cause those controls to fail; it is a risk management tool included in MAA training and widely used in civil aviation. Exhibit 309 Exhibit 310 Exhibit 311 Exhibit 366

1.4.491. Although there had previously been a PSRR entry for the risk of injury to Door Observers, the Panel could not find a corresponding Bowtie where Door Observers were identified as a top event. This was confirmed by the Air Safety Cell at BZN, which indicated that Door Observers were only considered as a barrier in 2 other Bowties, namely "Attempted Engagement by the Enemy" and "Aircraft Operating in the Threat Band" as shown in Figures 38 and 39 below. Exhibit 312

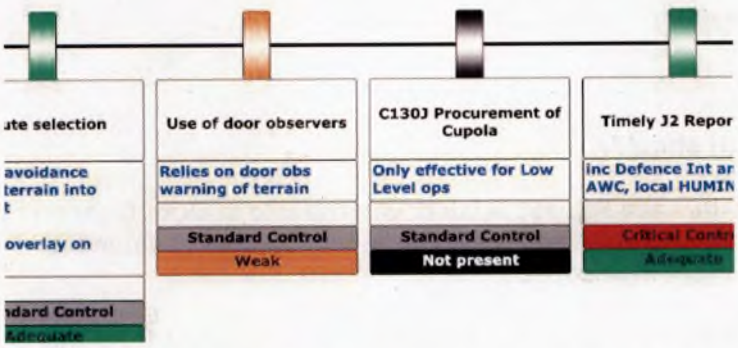


Exhibit 314

**Figure 38 – Bowtie Extract: Operating in Threat Band**

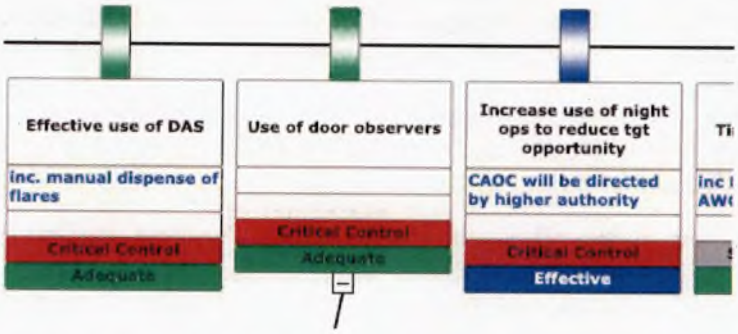


Exhibit 313

**Figure 39 – Bowtie Extract: Enemy Engagement**

1.4.492. The Panel determined:

a. There was a credible risk to life associated with Door Observer employment, particularly noting the injuries suffered by AGE2 that resulted in him being unfit to fly until 5 Oct 17, approximately 7 weeks after the accident. Exhibit 363

b. There had been a lack of effective management of this potential RtL that had apparently been extant since 2007.

c. Notwithstanding the DHOI issued following ZH873's accident, it was apparent that there remained the possibility for personnel to be unrestrained during landing in certain operational circumstances.

d. Over a period of 4 years following issue of the DDH Addendum, there was no activity regarding a potential technical solution; the DDH was thus denied the information necessary to make an ALARP argument based on the requirements of RA1210.

e. The shift from a PSRR to Bowtie had focused on risks likely to lead to loss of an aircraft, such as runway excursions, low flying and enemy engagement; this resulted in a credible RtL no longer being managed as a specific risk in itself.

1.4.493. The Panel concluded that, having led directly to the injury of the seat occupant, the use of a non-crashworthy seat without restraint for Para Door Observers was an **Aggravating Factor**.

**Recommendation:**

1.4.494. **Hercules DDH should:**

a. **Ensure that the RtL associated with the use of Door Observers is ALARP and Tolerable, and founded on an objective, evidenced ALARP argument in accordance with RA1210.**

b. **Identify all Risks to Life not transferred to Bowties from the PSRR in order to ensure they have been appropriately sentenced and remain under a robust risk management regime.**

1.4.495. The Panel **Observed** that there was no Bowtie for TLZ Operations, despite it being listed as one of 2 Gp's 'Top 5 Total Safety Risks' (Figure 40). The only Bowtie referring to TLZs was one entitled '*Unauthorised Obstruction on the TLZ.*'

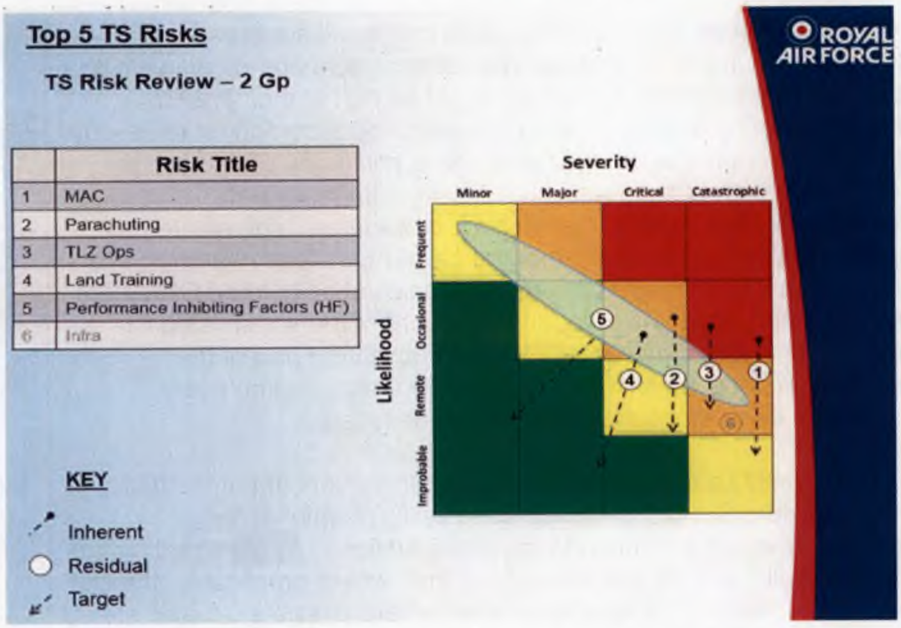


**Figure 40 – 2 Gp Top Total Safety Risk Review**[20]

## Supervision – Orders

1.4.496. Supervision of UK military flying is governed by RA 2305 which requires Duty Holders to appoint officers to supervise the flying operations for which they are responsible and promulgate appropriate orders detailing their duties. Exhibit 125

1.4.497. In the Foreword to 2 Gp ASOs, the AOC stated that, being primarily concerned with the control and supervision of flying, these orders referred to the Full Command chain rather than the Air Safety (AS) Duty Holder Chain. Exhibit 316

1.4.498. This is reflected in 2 Gp ASO 2305 which requires: Exhibit 126

a. All flying undertaken by 2 Gp aircraft to be under the continuous control of a designated AOA in accordance with RA 2305. This may be HQ AIR, HQ 2 Gp, the parent station or the authority specified in an Operation Order or another directive.

b. Station Commanders to ensure that crews are qualified and experienced to undertake operational missions.

c. When requested, pen pictures for all crew members are to be provided to an external supervisory Chain of Command on arrival/changeover of crews to provide background information to the relevant Det Cdr and in-theatre flying supervisors.

[20] HQ 2 Gp Air Safety MOSS Page, accessed 05 Jun 18.

d. Aircraft Commanders to be responsible for the supervision and correct implementation of the flight/mission planning and crew briefing/debriefing.

e. Operational Risk Matrix (ORM). As a tool to aid supervisors in exercising appropriate oversight, aircraft commanders are to complete a flight/task specific operating risk assessment as part of their pre-Flt planning and briefing activity. The details are to be recorded for review by the sqn supervisor prior to authorization. As a minimum, details are to include: individual crew members' currency / competency and qualifications; the flight/task/sortie/mission; consideration of fatigue and fatigue inducing factors; the airframe and passengers/load; weather; and, threat/operational factors as appropriate. Copies of completed ORMs are to be retained and stored as an auditable record of the supervision / authorisation process. Since the ORM is a constituent part of the authorisation process, an ORM should be fully completed on every occasion when an authorisation is amended or initiated.

1.4.499. The OCC for ZH873's task stated the supervisory oversight of the task would be provided by the Herc Det Cdr supporting the DAT(I) Regional Air Commander. The Det Cdr would also provide specialist advice to [redacted] regarding the planning and execution of all Hercules operations and that, where practicable, the Det Cdr should supervise all sorties, including authorisation where possible. It also stated that the Operational Commander could seek operational risk advice at any time from the 2 Gp Operational [sic] Risk Holders, namely the ODH or AM Force Cdr. Exhibit 22

1.4.500. The mission undertaken by ZH873 was subject to a specific Concept of Operation (CONOP). The CONOP outlined the procedures to be used by AT aircraft conducting sorties to the specific TLZ, including the route, communications, diplomatic clearance and contingency planning. It also specified that the CONOP was to be used in conjunction with the relevant Flying Order Book. Exhibit 38

1.4.501. The Flying Order Book required that: Exhibit 21

a. Statements of Deployed Aircrew Capability (SDAC) should be issued prior to deployment.

b. Particular consideration of the operational necessity should be given when tasking a Hercules into a TLZ with low forecast light levels.

1.4.502. The Panel noted that neither 2 Gp ASOs nor the Flying Order Book stated to whom pen pictures or SDACs should be sent, nor was there any guidance as to what factors should be included. In comparison, the Joint Helicopter Command provides clear direction regarding Statements of Deploying Aircrew Capability (SDAC) content via a Command Instruction, and the Royal Navy publish similar guidance within Naval Aviation Orders. Exhibit 67 Exhibit 68

1.4.503. The Panel assessed that there was a regime of underlying regulation and mission specific orders that was broadly robust.

1.4.504. However, the Panel concluded that Supervisory Governance, particularly the lack of direction regarding Statement of Deploying Aircrew Capability and pen picture content or distribution, was an **Other Factor.**

**Recommendation**

1.4.505. **AOC 2 Gp should revise the 2 Gp ASO requirements for pen pictures, specifically including:**

a. **A minimum set of factors to be included;**

b. **A supervisory assessment of recent flying experience and BCRs in relation to the expected task;**

c. **Guidance as to subsequent distribution within the Operational Command chain.**

## Supervision – Crew Selection and Deployment

1.4.506. In considering the selection of the 2 pilots for deployment the Panel established that both were suitably qualified in respect of their Operating Category, and Basic Currency Requirements. However, the Panel could find no evidence of any individual or organisation relating the BCR minima as laid down in the AMFTD to the task expected in the operational environment, and thereby determining an appropriate training requirement prior to deployment.

1.4.507. For example, although the PF was a current Tier 1 Flying Instructor, he had not undertaken any operational deployments over the previous 3 years; in this time his experience of TLZ and NSO flying had been minimal. Apart from the necessity to be qualified to operate the Hercules RF Defensive Aids Suite, and hence the necessity for a Tier 1 qualified crew, the prime requirement of the mission was to conduct a logistical re-supply to a TLZ at night, essentially a Tier 3 skill. However, throughout the whole of 2017, the PF had only conducted 1 MOS and 2 NSO landings. While this kept him current from a pure BCR perspective, the Panel was concerned that this had been in the more benign training environment, in lighter aircraft and, particularly for the NSO serials, to a familiar TLZ. Witness 1b

1.4.508. Following ZH873's accident, the Panel noted that the ODH directed that aircrew who had not deployed on operations for more than 6 months should be exposed to '*lower tariff*' missions before conducting live NVG MOS tasks. Where this was not possible, then DDH approval would be required. Exhibit 367

1.4.509. The Panel could find no evidence of any formal approval regarding the deployment of the PF from XXIV Squadron. Although all key personnel were aware of the intent and the fact that he appeared on the detachment programme, there had been no discussion between the units confirming command approval. Following the PF's own confirmation of his availability and desire to deploy, the decision had been left at the F Flt Pilot Ldr level. While the solution was a pragmatic and advantageous one, the lack of any formal inter-squadron liaison resulted in a missed opportunity to discuss any currency/training requirements, or to confirm ownership of the subsequent Pre-Deployment administrative process. Witness 2 Witness 12 Witness 9 Witness 11

1.4.510. The Panel considered that there had been complacency regarding the currencies and competencies of the PF, with consistent commentary indicating that: Witness 12 Witness 9

a. Although the PF hadn't been on this task previously; both he and his background would have been known to the Detachment Commander in theatre.

b. Both on paper and in reality, the PF was a very experienced operator and probably one of the most qualified pilots. Unsurprisingly, he was the top nominee for the [redacted] position.

1.4.511. This was re-enforced by the PF's Aircrew Categorisation and Form 2020G Aircrew Insert Slip Reports where he was consistently assessed as Combat Ready (Above Average) and commented on as being '*one of the best C-130J operators*.' Exhibit 317

1.4.512. Although the Pre-Deployment simulator serial included NVG NSO landing and take-off serials, it also required the crew to rehearse procedures in a Radio Frequency (RF) contested environment in order that it represented a realistic Mission Rehearsal. While pragmatic, the sortie content was designed around a 47 Sqn crew wherein the pilots had recency in each of these skills; it did not consider the specific needs of an individual pilot such as one being loaned from the OCU. As a Tier 1 FI on XXIV Sqn, and as a lead figure for the introduction of RF DAS to the platform, a large amount of the PF's recent experience had been focused on this discipline. Given the PF's relative lack of NSO experience, the Panel considered it might have been more appropriate to concentrate on NSO work in the simulator (or to have conducted live serials). Exhibit 9 Exhibit 317

1.4.513. In planning the deployment programme, no consideration had been given to environmental conditions such as moon phase during crew changeover periods. Thus, the mission on 25 Aug 17, the first sortie for the PF and PNF post arrival in theatre, was on a night of very low mLux illumination, with a first quarter moon having set just prior to the ZH873 accident. Exhibit 296

1.4.514. The Panel noted the Flying Order Book requirement that *'particular consideration'* of the operational necessity should be given when tasking a Hercules into a TLZ with low forecast light levels. The Panel considered that the PF's minimal recent flying experience into a TLZ, his lack of recent experience on operations and the dark ambient lighting would have merited such attention across the planning, supervisory and authorisation levels. Exhibit 21

1.4.515. Following the accident, the ODH directed that pilots should not conduct MOS approaches to in theatre TLZs for the first time in light levels of less than 10 mLux. Where operational necessity precluded such an option, then DDH approval would be required. Exhibit 367

1.4.516. Despite the 2 Gp ASO and FOB requirements for pen pictures and SDACs, they were not being produced for Hercules crews deploying to AKR. Testimony consistently included justifications that SDACs were not necessary because the Hercules community is small and that as the Det Cdr in theatre '*knows the guys intimately, there wasn't really a requirement to… send them a pen picture'*. The Panel opined, however, that SDACs or pen pictures should not just be provided to the Det Cdr, but also to the Operational Command Chain where there would not be such intimate knowledge of deploying personnel. Not to do so denudes the ability to exercise supervisory oversight by the Operational Command Chain responsible for delivering the mission. This was particularly relevant for this mission given the dislocation of TACOM from AKR. Witness 10 Witness 12 Exhibit 322 Exhibit 21

1.4.517. Additionally, the Panel assessed that the Det Cdr had a significant workload to address, being responsible for 3 diverse areas of tasking. As the sole supervisor (and authoriser) within AKR for the Tier 1 task, he was extremely busy with these tasks alone; while not unmanageable, provision of succinct summaries by SDAC or pen picture would have aided his situational awareness and supervisory oversight significantly.

1.4.518. The DAIB Triage Report mentioned that it was normal practice for the handover procedures for pilots to include a mentored operational sortie. Asked why this had not happened for this particular crew, the Det Cdr indicated:

a. Mentored sorties usually occurred on other tasking which did not require a WSOp to occupy the 3rd seat on the flight deck. There was no such tasking during this crew's handover period. Exhibit 320

b. For the sortie on 25 Aug 17, which did require a WSOps Cmn, the 3rd pilot would not be able to be seated with a view of instruments and beyond the aircraft. The only alternative for him to be able to see sufficiently to provide advice on the approach would be stand behind one of the pilots, contrary to regulation.

c. The assessment at the time was that the least risk option was not to include a 3rd pilot on the sortie as the additional risks were greater than the potential benefits.

1.4.519. The Panel understood this rationale, and opined that it would not be feasible to provide mentored sorties in every scenario. However, it was advised of a different methodology used at the onset of the task in Dec 16. The first sortie was conducted by a double captain crew, from which the non-flying pilot became the PF for the 2nd task with a different PNF who became the PF for the 3rd mission. This process was repeated, allowing pilots to gain experience of the route and communications, as well as exposure to the TLZ, prior to flying it themselves. Such a serial could have been achieved prior to the out-going pilot's departure, and was considered an appropriate option to better enhance the crew's awareness, particularly recognising the lack of operational recency of the PF and that the PNF's only experience on this mission had been some 10 months previously. Witness 11

1.4.520. It was noted that, since the accident, the ODH had directed that OC 47 Sqn should ensure that at least one pilot on the detachment had conducted this task previously. However, it recognised that this might not be possible where a crew was constructed on a pilot and co-pilot composition.

1.4.521. The Panel determined that, despite a supervisory system that met the regulatory intent, the manner in which it was utilised did not ensure that the defensive barriers designed to prevent an aircraft accident were sufficiently strong. Rather it resulted in:

a. A pilot with very little recent operational experience, who had not achieved the mandated flying hours currency for a significant period, and who was at the bare minima regarding the necessary BCRs executing an operational task as both PF and Aircraft Commander.

b. A systemic reliance being placed on the PF's extensive experience, employment as a Tactical FI on the OCU, nomination as the next [redacted] and his wide reputation as a one of the most experienced Hercules tactical flying instructors and Tier 1 pilots, rather than an objective analysis of his currency, recency and competence.

c. Failure to provide a pen picture or SDAC (as required by 2 Gp ASOs and the relevant Flying Order Book) to the Det Cdr or Operational Command chain. This could have significantly enhanced awareness by summarising aircrew currency and recency, and highlighting any relevant shortfalls or supervisory considerations.

d. A missed supervisory opportunity in not providing a screened sortie with the out-going pilot.

1.4.522. Additionally, the Panel noted that the ODH had taken steps following the accident to address many of the concerns identified during this inquiry, via an ODH Adjustment Plan, dated 07 Sep 17. However, the Panel considered that, where appropriate, these should be recorded formally in relevant documentation to ensure their permanent capture and long term utility. Exhibit 367

1.4.523. The Panel concluded that Flying Supervision throughout the crew's selection and deployment was a **Contributory Factor.**

**Recommendation:**

1.4.524. **AOC 2 Gp should ensure direction given in the ODH Adjustment Plan regarding aircrew recency on operations and minimum light levels for live MOS approaches are recorded in appropriate Orders to ensure long term utility.**

1.4.525. **D MAA should develop a Case Study, incorporating the Supervisory, Authorisation and Human Factors issues identified within this Report, to be used in Air Safety Training in order to promote awareness across the Defence Aviation Environment.**

## Operational Risk Matrix

1.4.526. 2 Gp ASOs mandate supervisors and aircraft commanders to complete a specific Operating Risk Matrix during sortie planning and briefing. It requires squadron commanders to develop a system which can be tailored to meet the needs of their squadron; as a minimum, this should include currency, competency and qualifications, the task, fatigue considerations and operational factors. Exhibit 322

1.4.527. The Hercules ORM contained 5 discrete areas: Mission, Enemy, Environment, Crew and Time. These areas were further broken down into sub factors, each of which required a '*Low, Moderate or High'* Assessment at both the planning and authorisation stages. On completion, each of the 5 areas were given an overall rating of '*Low, Moderate or High'* prior to a similar assessment being made for the sortie as a whole. Subject to that final scoring, the sortie would require approval as listed in Table 15: Exhibit 40

| Risk Assessment | Level of Approval/Authorisation |
|---|---|
| Low | Det Cdr |
| Moderate | Det Cdr / Regional Air Cdr |
| High | [redacted] Air Cdr |

**Table 15 – Mission Risk Approval Levels**

1.4.528. The Hercules Det Cdr scored the mission's overall assessment as Moderate, for which he had the authority to authorise the sortie. However, the Panel noted that there was no guidance as to how the scores within and across each of the discrete areas should be aggregated to assess the overall level of risk of the mission, and determine at what level authorisation should be granted.

1.4.529. Although the ORM was compliant with 2 Gp ASOs, a review by the RAF CAM Accident Investigation identified a number of shortfalls in how fatigue and other crew-related risks were captured. Such shortfalls resulted in the potential for considerable subjectivity in assessment, thereby limiting the ability of the ORM to accurately capture and manage sortie risk. Exhibit 359

1.4.530. The Hercules ORM was compared against that for the Shadow R1, which utilised a similar scoring system of '*Low, Moderate, High, Severe'*. However, this was supplemented by numerical grading, the outcome of which mandated at what level a mission should be both authorised and approved. While the Hercules ORM required that the [redacted] Air Cdr should approve High Risk sorties, it was not apparent when this threshold would be reached, given the lack of objective guidance in the ORM risk assessment. Exhibit 21

1.4.531. The Panel assessed that:

a. The Hercules ORM generated considerable potential for subjectivity, and had limited ability to accurately capture and manage sortie risk.

b. The GASO requirement for squadron commanders to develop systems appropriate to their squadron needs was pragmatic at an individual platform level, but would benefit from enhanced guidance regarding objective scoring.

1.4.532. The Panel concluded that the subjective nature of the 2 Gp Operational Risk Matrix was an **Other Factor.**

**Recommendation:**

1.4.533. **AOC 2 Gp should revise 2 Gp ASOs regarding the ORM to enable greater objectivity when assessing risk and determining relevant approval levels.**

## Night Vision Goggle Training and Orders

### NVG Training

1.4.534. The Panel was made aware of a QinetiQ study conducted as part of a MOD Capability Theatre Airspace Capability (CAP TA[21]) review of aircrew night vision capability. The Report, *'Optimisation of NVG Training and Maintenance for Aircrew and Survival Equipment Fitters'*, published in March 2012, highlighted concerns with NVG knowledge, training and set up procedures. It made 45 recommendations covering aircrew and maintainer training, maintenance and documentation. Exhibit 323

1.4.535. When asked to confirm whether the report had been accepted, and what recommendations had been taken forward, Air Cap Del AE SO2 responded that the relevant NVG Capability Working Group (CWG) had been resurrected in Mar 17 having *'not sat for some time, due to manning resource issues.'* At that meeting, Front Line Commands (FLCs) were tasked to '*provide a progress summary to track response to the recommendations in the 2012 QQ Report*'. However, the NVG CWG had not sat again (as at 20 Sep 18) due to further resourcing issues. Exhibit 324

[21] Now Air Cap Dev / Del Air Enablers

1.4.536. Additionally, the Panel noted that there was no representation at the meeting from RAF CAM or the Air Commodities Project Team, both of whom would be significant stakeholders in implementation of the recommendations.

1.4.537. The Panel was concerned given the number of recommendations made by the Report, some of which had direct relevance to the ZH873 accident, and that no discernible evidence could be found regarding their acceptance or implementation. Although an article summarising the report's conclusions regarding the importance of correct user settings had been published in Air Clues, this represented little more than an information bulletin to promote awareness. Exhibit 187

1.4.538. The Panel assessed that the recommendations from this study regarding NVG training and maintenance:

a. Had not been robustly considered for implementation by relevant stakeholders.

b. Should be considered for formal inclusion within relevant training programmes to ensure the lessons are embedded successfully within military aviation.

1.4.539. Lack of detailed consideration of the '*Optimisation of NVG Training and Maintenance for Aircrew and Survival Equipment Fitters'* Report dated Mar 12 across Defence was concluded by the Panel as an **Other Factor.**

**Recommendation:**

1.4.540. **DACOS Air Cap Dev should re-invigorate the NVG Capability Working Group in order to ensure responses from pertinent stakeholders regarding recommendations made in the 2012 '*Optimisation of NVG Training and Maintenance for Aircrew and Survival Equipment Fitters'* Report are recorded formally.**

1.4.541. **DACOS Av Med should incorporate pertinent aspects of the 2012 '*Optimisation of NVG Training and Maintenance for Aircrew and Survival Equipment Fitters*' within Night Vision Goggle training conducted at RAF CAM**.

**NVG Orders**

1.4.542. As discussed at paragraphs 1.4.257 *et seq* the pilots' NVGs had not been set up and focussed objectively by use of the Hoffman Box.

1.4.543. No specific RA covering NVD use was found within the MAA 2000 Series, *'Flying Regulations,'*, the only relevant reference was within RA 2330 – *'Low Flying'*. Exhibit 325
This requires Aviation Duty Holders to specify in Orders additional criteria to be applied for Low Flying at Night, including equipment serviceability, and minimum safe operating light levels and environmental conditions pertinent to night vision systems being used.

1.4.544. 2 Gp ASOs have no specific chapter concerning NVGs, however the Exhibit 174
majority of Order 2G2309, *'Flight Procedures'* is concerned with NVG use. Order 2G2309.100 – *'NVG Operations General'* states that NVG flying is more demanding than standard operations and requires specific authorisation and close supervision, highlighting factors such as crew qualifications, currency, weather and light conditions for particular attention. It requires aircrew to have attended the Night Operations

 

Familiarisation Course at RAF CAM prior to commencing NVG flying training, and that authorising officers should either be NVG qualified or have undertaken the same course *'where possible'*. Thereafter there are sections relating to the C17 and Hercules individually.

1.4.545. Order 2309.110 for the C-17 is comprehensive, listing weather and crosswind limitations, minimum crew requirements, required lighting, runway dimensions and equipment serviceability requirements. Exhibit 174

1.4.546. By contrast, the Hercules section at Order 2G2309.115 covers flight planning, aircraft navigational lighting and a requirement for a 3rd crew member on the flight deck to enhance look out. There are no weather limitations or equipment serviceability requirements. Exhibit 174

1.4.547. There was no 2 Gp ASO requirement mandating the use of the Hoffman Box to objectively set up and focus NVGs. The Panel also noted that, although 2G2309.100.3 stated that *'approaches, landings and take-offs from lit TLZs* [are permissible] *where the required visual references are available* ', there was no guidance as to what visual references were required (for which a recommendation was made at paragraph 1.4.256).

1.4.548. By way of comparison, other ODH orders regarding NVDs were examined:

a. Naval Aviation Orders contain a specific NVD order covering Aircraft Requirements; Training, Qualification and Currency; Operations; and Low Level Flying. Exhibit 190

b. The Joint Helicopter Command (JHC) Flying Order Book has a similar order, covering Qualification and Training; Operations; Restrictions; Recce Requirements and NVD Setup. Exhibit 191

c. 1 Gp ASO details requirements for Electro-Optical (EO) Night Flying, including, EO Training Requirement; Supervision; Currency; Low-Level Minima; and Equipment Serviceability. Exhibit 189

d. All of the above included use of the Hoffman Box to objectively test and focus NVGs.

1.4.549. The Panel determined that 2 Gp Orders regarding NVG were non-compliant with RA 2330 in not:

a. Specifying NVG weather minima or equipment serviceability requirements for the Hercules, or;

b. Requiring use of the Hoffman Box to objectively set up and focus NVGs across the AMF.

1.4.550. The lack of compliant orders regarding NVG use was concluded to be an **Other Factor.**

**Recommendation:**

1.4.551. **AOC 2 Gp should revise 2 Gp ASOs regarding use of NVGs to ensure compliance with RA 2330 and to mandate use of the Hoffman Box to objectively test and focus NVGs.**

 

1.4.552. The Panel **Observed** that there was no currency associated with the NVG Training Course at RAF CAM.

## Natural Surface Operations/Temporary Landing Zone Training

1.4.553. During the Panel's investigation, a common concern raised regarding TLZ/NSO training was its unrepresentative nature. Crews stated that the natural surface TLZ's utilised in the training environment were too short to land at aircraft weights typically encountered on operations, and that lighter aircraft handled differently. As such, a significant proportion of training approaches required a Go-Around because the aircraft was going to touchdown beyond the Touchdown Box. Witness 4d Witness 16

1.4.554. The PF re-enforced such concerns, saying that his experience was of a tendency for aircraft to *'float'* and touch down towards the back of the box during training. When asked why he chose an aiming point shorter than required he stated that he wanted to avoid missing the Touchdown Box or floating down the strip, and having to initiate a Go-Around. When asked why he didn't inform the PF that he was aiming shorter than prescribed, the PNF asserted that the aim was not short, but within the Touchdown Box; while he wasn't aiming one third of the way in, he was aiming '*within the contract*', ie the Alpha Bravo to the Charlie Delta. Witness 1

1.4.555. There are 4 Natural Surface TLZ's available to the Hercules Force for training in the UK; Deptford Down on Salisbury Plain, Pembrey and Pendine Sands in South Wales and Saunton Sands in Devon. Deptford Down, a grass TLZ, is approximately 3600ft long, whilst the latter are beaches at least 5000ft in length. Exhibit 327 Exhibit 328 Exhibit 329 Exhibit 330 Exhibit 331

1.4.556. Beach TLZ's, although longer and able to facilitate heavier landings, are tidal dependent; this can result in particularly short NVG opportunities in the summer. Further, firmness of the substrate can lead to sorties being cancelled at late notice or the length of runway available being shortened. Beach TLZs incur significant aircraft recovery overheads in post sortie engineering requirements. Exhibit 332

1.4.557. Deptford Down can be rendered unusable by prolonged periods of rain, which degrades the firmness of the runway. It is also relatively short, limiting the weight of aircraft to circa 52,000kg. Exhibit 333

1.4.558. Issues with UK TLZ/NSO training have been long recognised by the Hercules Force, for which a risk had been extant on the Hercules Platform Safety Risk Register. In 2011 a User Requirement Document was raised by 2 Gp for an all-weather NSO TLZ, with an In-Service Date of 30 Sep 14. Its Statement of Requirement highlighted the following: Exhibit 334 Exhibit 335

a. A need to conduct operationally essential training prior to operational deployments against a lack of reliable, suitable all-weather training facilities.

b. A 2008 National Audit Office (NAO) Report recommendation that an all-weather NSO TLZ would increase aircraft availability and make maximum use of limited Tac AT training assets.

c. A purpose-built TLZ would provide enduring savings of circa £300k per year to Defence, as well as reducing the increased risk of bird strikes associated with beach TLZs.

 

1.4.559. The URD concluded that failure to implement an all-weather NSO TLZ would result in a continued burden to C-130J training (and A400M subsequently) due to limited aircraft availability, engineering overheads and additional flying hours.

1.4.560. An Assessment Study Report, completed in Nov 12, recommended that such a facility be located at Keevil airfield, Wiltshire. However, no such facility has yet been constructed.

1.4.561. The DHAN Addendum supporting OEC 022 (see paragraphs 1.4.427 *et seq*) concluded that '*Beach TLZs provide a poor replication of conditions and factors associated with operations. A representative training TLZ with enablers would increase ability to train and rehearse for operations*'. Exhibit 277

1.4.562. TLZ operations can also be practised in the Dynamic Mission Simulator (DMS). Immediately following ZH873's accident the DDH published a Duty Holder Advisory Note which commented on the realism of this synthetic training. It stated that the fidelity of the DMS during the landing flare is unassessed, and might provide poor quality or negative training regarding throttle handling. It was therefore possible that, in the DMS, crews might not appreciate that they had mishandled an approach, particularly given an observation that DMS training focused on the parameters of a good approach rather than identifying a poor one. This was consistent with the Panel's experience, while conducting a simulated MOS/NSO serial, that the DMS had no ability to determine the aircraft's point of landing was actually within the Touchdown Box, on the prepared overrun that precedes it or even further short. Exhibit 367

1.4.563. Approval of Flight Simulator Training Devices (FSTD) is regulated by RA 2375 which states, '*When assessing the fidelity of a FSTD, the following considerations, as a minimum, are applicable:* Exhibit 337

a. *Handling characteristics throughout the flight envelope.*

b. *Performance characteristics throughout the flight envelope.*

c. *Mission realism.*

d. *Accuracy of cockpit layout.*

e. *Realistic systems architecture (eg software menus etc).*

f. *Representative visuals with sufficient acuity.*'

'*Fidelity Assessments will normally be made by a current and qualified Test Pilot assisted by Qualified Aircrew Instructors (Qualified AI) who are current and qualified on type.*'

1.4.564. Within 2 Gp, the conduct of FSTD approval is contained within AMASIs, including a procedure and scoring protocol to be used. The most recent assessment of the Hercules DMS was conducted by a STANEVAL pilot on 19 Sep 17. It concluded, '*The Flight Simulator has met the requirements applicable to Flight Simulations in accordance with RA 2375*', and scored it as '*Level 3 (Fair)* [sic]'[22]. This meant that '*minimum crew compensation was required for desired performance*'; there Exhibit 338 Exhibit 339 Exhibit 340

[22] This is a typographical error within the report. It should read Level 1 (Fair) which is equivalent to SARS Level 3.

were some '*mildly unpleasant deficiencies*' but that the simulator was assessed as having '*very high levels of fidelity and coherence*'.

1.4.565. The Panel noted the potential contradiction between this assessment and the observations regarding potential negative training in the DMS at paragraph 1.4.562.

1.4.566. The Panel determined that:

a. Current UK NSO TLZ's are heavily dependent on favourable environmental conditions, making it difficult to schedule training.

b. Deptford Down's relatively short length means crews are constrained to training at unrepresentative aircraft weights.

c. The Hercules DMS does not provide sufficiently representative TLZ training, particularly regarding throttle handling, the flare, and identification of a poor approach.

d. Provision of a bespoke NSO TLZ for training would reduce Air Safety risk, reduce operating costs and increase overall aircraft availability.

1.4.567. The Panel concluded that non-representative NSO/TLZ training was an **Other Factor.**

**Recommendations:**

1.4.568. **AOC 2 Gp should:**

a. **Pursue construction of an 'all-weather' NSO TLZ of suitable length in order to allow the Air Mobility Force to plan NSO training sorties consistently and for crews to train at weights representative of those required on Operations.**

b. **Review the fidelity of the Hercules DMS for MOS approaches, specifically regarding flare and throttle handling, in order to facilitate representative training.**

1.4.569. The Panel **Observed** that AMASIs require FSTDs to be assessed by a '*service aircrew wherever possible. They are to be experienced and current on type, ideally from the appropriate STANEVAL.*' This is seemingly inconsistent with RA 2375 which states '*Fidelity Assessments will normally be made by a current and qualified Test Pilot assisted by Qualified Aircrew Instructors.*'.

## Eye to Wheel Height Awareness

1.4.570. As noted at paragraph 1.4.200 *et* seq, in large transport aircraft, pilots sit in a position significantly forward of, and well above, the main wheels. This can result in the aircraft landing short of an aiming point, particularly if there is no flare.

1.4.571. Following an investigation in which lack of Eye to Wheel Height (EWH) awareness was considered significant, the Canadian Transport Safety Board noted a general lack of availability regarding EWH information. As a consequence, it Exhibit 211 recommended that manufacturers make EWH information readily available to pilots of aircraft exceeding 12,500lbs.

1.4.572. Although the Panel noted that manufacturers of some large aircraft publish tables containing EWH data, such information is not readily available to Hercules aircrew. Neither its significance nor the measurements necessary to calculate its effect are mentioned in any document within the Hercules ADS. Exhibit 210

1.4.573. Furthermore, the Panel established that EWH is not taught to RAF pilots. It is not a part of either the Elementary Flying Training (EFT) or Multi Engine Pilot Training (MEPT) syllabi within 22 Group. Although it is discussed during some conversion to type training (such as the Sentry E3D), STANEVAL and XXIV Sqn stated that it does not form part of Hercules specific training. Witness 14 Exhibit 212 Exhibit 213 Witness 16

1.4.574. Although the Hercules ADS contains no reference to EWH, other large aircraft within the RAF inventory do have information regarding its significance. The Panel drew heavily on information contained within the Sentry E3-D Aircrew Manual and also found information within the C-17 Pilots' Manual. Exhibit 163 Exhibit 214

1.4.575. The Panel determined that:

a. The Hercules Aircraft Document Set contains no reference regarding EWH.

b. Hercules Pilots are not taught about EWH during conversion to type.

c. RAF pilots receive no instruction regarding EWH during Elementary Flying Training or Multi Engine Pilot Training.

d. Without having had formal EWH instruction and relating it to the very short overrun surface at a TLZ, it was very likely that the PF was insufficiently aware of any related risk of not aiming at the prescribed point.

1.4.576. The Panel concluded that lack of EWH awareness was a **Contributory Factor.**

**Recommendation:**

1.4.577. **DE&S Director Air Support should ensure the C130, C17, Sentinel, BAE 146, A400M, Voyager, RC135W, E3-D Sentry and P-8A Aircraft Document Sets contain Eye to Wheel Height (EWH) information in order that pilots of large aircraft understand the significance EWH can have on their touchdown point.**

1.4.578. **AOC 22 Gp should ensure that EWH, particularly its significance to landing short, is incorporated into Multi Engine Pilot Training.**

1.4.579. **The AMF and ISTAR Force Commanders should ensure Implementation of formal EWH instruction during conversion to type training to ensure that crews are aware of the potential risks of landing short in large aircraft.**

## Head Up Display Discrepancies

| | |
|---|---|
| 1.4.580. As discussed at paragraph 1.4.212, ZH873 had a discrepancy in the HUD information presented to the 2 pilots. During interview, the PF stated that he had experience of HUDs being misaligned by up to 1°, which had resulted in pilots having different Flight Path Angle Bar (FPA) indications. | Exhibit 358 |
| 1.4.581. A search of ASIMS revealed no previous DASORs regarding HUD misalignment, although the Panel noted one submitted by the PF during the course of this inquiry. | Exhibit 377 |
| 1.4.582. During preparatory work prior to the Panel's engineering investigation of ZH873, a HUD misalignment was also found on a Hercules ZH867 at RAF Brize Norton. A further 2 aircraft were checked but these showed no such misalignment. | Exhibit 358 |
| 1.4.583. HUD errors can be generated as a result of either misalignment of the projector generating the image or the Embedded Global Positioning System and Inertial Navigation Unit (EGI) systems. It was the latter that was discovered in ZH873 following the accident. | Exhibit 358 |
| 1.4.584. The Hercules PT indicated that there was no procedure for checking HUD projector calibration; displays are fitted and bore sighted[23] during aircraft assembly and never re-calibrated, although minor adjustments can be made on the unit itself. | Exhibit 358 |
| 1.4.585. EGI misalignment issues had been a known problem within the fleet, although ZH873 was not one of the aircraft identified. These issues were a result of the EGI mounting trays being removed during maintenance without a calibration procedure for subsequent refitting. | Exhibit 165<br>Exhibit 379 |
| 1.4.586. Following the errors found in ZH867 and ZH873, as well as the DASOR submitted by the PF, the Panel noted that the PT has issued 2 Routine Technical Instructions to gather fleet-wide data on EGI and projector discrepancies. Additionally, the DDH has issued orders requiring crews to cross check HUD symbology, and actions to be taken if discrepancies are identified. This includes testing by STANEVAL or 206 Sqn where possible, and specific direction that a MOS approach is to be terminated if a crew deem that the aiming point or glideslope cannot be safely monitored. Additionally, the PT has placed a task with the manufacturer to provide a procedure for confirming HUD alignment, and correcting errors so identified. | Exhibit 381<br>Exhibit 380<br>Exhibit 382<br>Exhibit 384<br>Exhibit 377 |
| 1.4.587. The Panel determined that there were potential inaccuracies in critical information being displayed to Hercules pilots. Appropriate action has been taken to:<br><br>a. Determine the extent of the problem, and establish any risk arising from it.<br><br>b. Ensure pilots are able to identify any errors before flight, and actions to be taken where discrepancies are established.<br><br>c. Establish a procedure to accurately align the HUDs. | |
| 1.4.588. HUD Discrepancies across the Hercules Fleet were concluded to be an **Other Factor.** | |

[23] Bore sighting: A process for ensuring sensors are aligned/zeroed with the aircraft rotational axes and a set external calibration point.

**Recommendation**

1.4.589. **The Hercules PT Leader should establish a maintenance procedure for checking and correcting HUD alignment.**

## Body Armour Load Carrying System

1.4.590. Hercules crews flying in non-permissive environments are required to don BALCS. BALCS, as shown in Figure 41, provides ballistic protection and was being worn by all of ZH873's crew members prior to the accident.

**Figure 41 – BALCS**

1.4.591. BALCS Assessment and Integration trials for the Hercules were conducted by RAF CAM in 2013. The assessment was conducted using an aircraft on the ground and did not involve airborne or simulated flying serials. Exhibit 341

1.4.592. Regarding pilot interaction, the RAF CAM assessment concluded that there were no adverse interactions or comfort issues for normal activities in any of the flight deck crew positions. Individuals were able to adjust and operate flight controls, flight instruments, emergency warning panels, communications and navigation equipment on the side, centre and overhead panels, with negligible restriction in movement. BALCS did not affect the wearer's vision of the internal or external environment. Exhibit 341

1.4.593. The Report noted that a minor restriction in full rearwards movement of control column could be encountered by larger pilots due to the configuration of the pockets. However, given the customizable nature of BALCS, this could be eliminated by moving pockets from the front to the sides of the assembly. Exhibit 341

1.4.594. Regarding the cargo bay, the Report commented that the secure and body conforming nature of the armour would result in minimal restriction in movement over and around various cargo loads, considering '*the limited movement of the Loadmaster during take-off and landing'*. Exhibit 341

1.4.595. The Hercules RTS requires pre-flight integration checks and emergency escape drills to be carried out by all crew prior to their first flight wearing BALCS. TP717 requires that Aircraft Evacuation Drills will be practised wearing BALCS and SE from the strapped in position. Exhibit 85 Exhibit 78

1.4.596. The PF stated that the first time he had handled an aircraft whilst wearing BALCS was during the accident sortie. Although the PF had been fitted for BALCS prior to his deployment, this process didn't involve using the equipment in an aircraft; he had not completed either of the RTS or TP717 requirements to complete integration checks and Evacuation Drills in BALCs. Witness 1a Witness 1d

1.4.597. Both the PF and PNF described BALCS as bulky and uncomfortable to wear, and that it altered their normal sitting position. Compounding this, both pilots commented that the flight deck armour also negatively affected their seating position. Additionally, one of the WSOps commented that in his experience BALCS made it difficult to move around the cargo bay in a fully loaded aircraft. Witness 1d Witness 4 Witness 20

1.4.598. A review of ASIMS (Jan 14-Dec 17) highlighted 10 DASOR reports regarding BALCS, none of which highlighted issues with comfort or seating positions of pilots. However, one highlighted a concern regarding moving around the back of the cargo bay to an appropriate seat for landing because of, among other reasons, the '*load configuration.*' Exhibit 342

1.4.599. Notwithstanding the above, the Panel considered that the abnormal sitting position resulting from BALCs and flight deck armour could serve as a distraction, particularly on first use, as was the case with the PF. An appropriate mitigation would be to train with it, particularly BALCS, but this was not a requirement prior to the accident sortie. Post the accident, the ODH issued a directive for crews to conduct pre-deployment simulator training in representative survival equipment; however, this is of relatively short duration and does not prepare rear crew for their tasks in a loaded cargo bay. Exhibit 367

1.4.600. The Panel determined that:

a. The combination of BALCS and Flight Deck Armour placed the PF into an abnormal sitting position that he had not experienced previously, potentially leading to distraction.

b. Notwithstanding the requirements to conduct individual integration checks and Evacuation drills in BALCS, there was insufficient training being conducted to prepare personnel for operating the aircraft in BALCS.

1.4.601. The lack of training in BALCS was concluded to be an **Other Factor**.

**Recommendation:**

1.4.602. **The Hercules ODH should revise the requirement for Pre-Deployment Training in BALCS to ensure that it is of sufficient duration and covers all appropriate personnel.**

1.4.603. The Panel **Observed** that:

a. The BALCS assessment and integration trials for the Hercules, particularly the lack of a loaded cargo bay, were not conducted under representative conditions. Exhibit 341

b. The PF had not completed his Evacuation Drills in Body Armour Load Carrying System (BALCS) as required by TP717, and evidence gathered suggested the potential for wider non-compliance. Witness 1d Witness 5

c. TP717 does not require BALCS to be worn in Evacuation Drills for WSOp Cmn, despite them occupying the 3rd seat on the flight deck. Exhibit 78

d. TP717 does not require any form of evacuation drill for Aircraft Ground Engineers. Exhibit 78

## Hercules Force Operational Tempo/Resource

1.4.604. Throughout its investigation, the Panel often heard that the Hercules Force was continuing to deliver a high operational output despite a reduction in both personnel and aircraft. Pilots described it as typical to be away for 4 months of every year, and when not deployed additional duties required a large amount of their time to staff.

1.4.605. The Strategic Defence and Security Review, 2015 (SDSR15), extended the Hercules Out of Service Date (OSD) from 2022 until 2035, albeit that the number of aircraft would reduce. A staged drawdown was planned, as highlighted at Figure 42. Exhibit 371

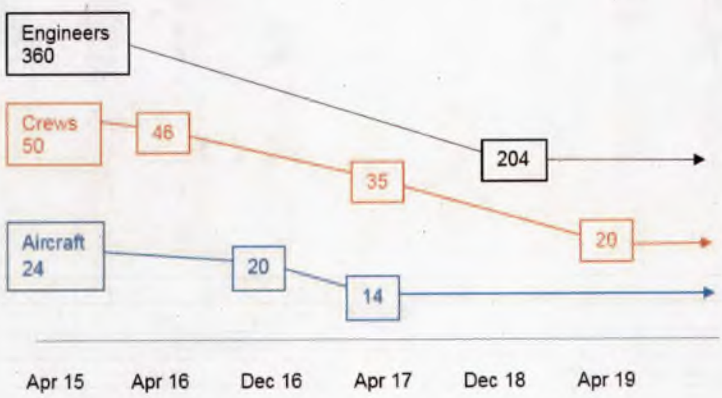


**Figure 42 – Hercules Equipment and Personnel Staged Drawdown**

1.4.606. This plan was based on a number of assumptions, one being that the A400M would absorb certain task lines, in particular the Falkland Islands from Nov 16, and the Broader Middle East, from Jun 17. Delays in that programme required the Hercules Force to maintain these tasks until Mar 18 and Nov 17 respectively, although the drawdown in personnel and airframes had already commenced and was not halted or reversed.

1.4.607. In Jan 17, 47 Sqn was required to service 14 task lines, however 5 were not resourced with aircraft, and had to be taken at risk against other tasks. By Dec 16, the tasking requirement had reduced to 12 lines, but 5 lines remained un-resourced with aircraft given the continuing fleet drawdown. Exhibit 371

1.4.608. Exacerbating the problem faced by 47 Sqn were both the planned drawdown and gapping of engineering personnel. Thus, while the number of engineer positions reduced during 2017 by 60, this was aggravated by approximately 20% of Mechanical Engineer and 40% of Avionics Engineer positions being gapped. 47 Sqn's engineering management team's view was that this was akin to having resource to Exhibit 372 support 14 aircraft and 20 crews whilst the Force retained 19 aircraft and 37 crews.

1.4.609. The PF stated that in the 3 weeks prior to his deployment he was exceptionally busy, describing '*12 hour working days*' as *'typical'*. He said that a large amount of this related to non-flying duties such as rewriting the TATOM, and that, with hindsight, more of his capacity should have been devoted to preparing for his impending operational detachment. Witness 1

1.4.610. Hercules Force Op Tempo and Resource, specifically as it affects 47 Sqn was discussed at length at the 2017 Hercules ASSWG. Utilising Figure 43, OC 47 Sqn articulated concerns that, during the year preceding the accident, planned manpower changes had resulted in a reduction of crews by 25% and air engineers from 354 personnel to 295. There had also been a reduction in the usable fleet by 7 aircraft, primarily resulting from the planned withdrawal of 4 Mk 5 aircraft and 2 accidents. However, the amount of tasking set to the Sqn remained broadly constant. Exhibit 343 Exhibit 344

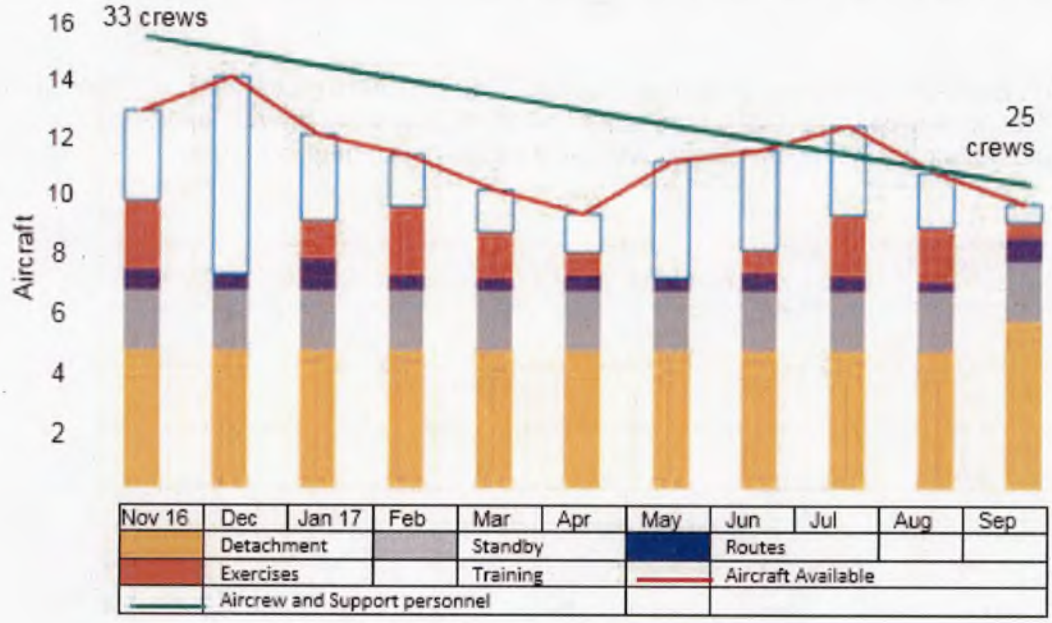


**Figure 43 – 47 Sqn Task and Resource**

1.4.611. The impact of this was presented to the ODH as 2-fold:

a. Fewer people and aircraft were available to deliver the same output. However, with the continued decline in crew numbers, the pull of commitments and exercises meant that there was very little margin left in this area, particularly when factoring in leave and professional courses, etc. Exhibit 343 Exhibit 344

b. Continuation training suffered, being the only variable under Sqn control.

1.4.612. The ODH accepted the argument and voiced his opinion that continuing along the projected path would erode both safety and capability. He highlighted a concern that, without action, a '*Can-do attitude*' would result in an accident that could have been foreseen. In an attempt to get more forward looking, he gave clear direction that training should be a priority that is properly considered. He also required a better understanding of the optimum blend of aircraft, aircrew and Exhibit 343 Exhibit 344 engineering personnel such that he could make appropriate arguments when discussing resource based decisions with Air Command.

1.4.613. In order to give such priority, squadron training requirements are now included within the AMF Programme as a dedicated bid, rather than having to rely on utilisation of aircraft not required elsewhere. This allows the Force Cdr to identify periods where aircraft availability will be insufficient to meet the planned requirement, allowing for alternative planning or prioritisation decisions to be implemented as necessary. This is bearing success, with 47 Sqn indicating that a significant benefit has been seen, particularly in flying hours and training. Exhibit 345

1.4.614. Further to the ODH's concern regarding resource requirements, concerns persist regarding the ability of the Hercules Force to sustain Defence requirements into the future. These have been highlighted in a number of submissions by OC 47 Sqn and AMF Capability Development, asserting that the resourced position of 20 crews will be insufficient to deliver a sustainable force beyond 2019. An Option supporting an uplift to 28 crews, plus the requisite increase in annual flying hours and engineering support has been submitted for the planning round of Annual Budget Cycle (ABC) 19. Exhibit 373 Exhibit 374 Exhibit 375 Exhibit 376 Exhibit 393

1.4.615. The Panel determined that:

a. Prior to the accident, the Hercules Force Operational Tempo had remained broadly constant despite a reduction in resource.

b. This had resulted in an increased workload for personnel, particularly engineers in sustaining the number of aircraft required.

c. Although it was noted that the PF had been particularly busy prior to deploying, and agreeing that it is important that crews are able to focus properly on preparing for operational deployments, the Panel was unable to assess to what degree this might have affected the PF's performance.

d. Despite improvements resulting from task reduction and improved programming, concerns remain at unit and Force Level regarding the resourced position for the Hercules Force beyond 2019.

1.4.616. The Operational Tempo and additional workload generated by the drawdown of the Hercules Force was concluded to be an **Other Factor**.

## Air Safety Reporting and Management

1.4.617. During the investigation, the Panel identified a potential poor reporting culture within the Herc Det. Examples where reports had not been made included:

a. Unusual Rad Alt readings during approach to the TLZ. Exhibit 110

b. Aiming further into the Touchdown Box because of a perception of landing short at the TLZ. Witness 13

c. Previous experience of landing short during a training sortie. Witness 4d

d. The PNF being aware of an earlier TLZ survey highlighting the slope preceding the overrun (see paragraph 1.4.113). Witness 4c

e. Concerns regarding BALCs, specifically mobility issues in loaded cargo bays for WSOps. Witness 20

1.4.618. The investigation into the overweight landing of Hercules ZH870 at the same TLZ, 29 Aug 16, contained a specific section regarding reporting culture, concluding, *'The crew of ZH870 were experienced and familiar with incident reporting in ASIMS. However, the captain in particular expressed concerns about the distribution of DASORs, believing them to be open source* [and a risk to OPSEC] *…. Evidence has also shown that there may still be reticence in some cases to report for fear of repercussions …. Interviews conducted during the inquiry also highlighted concerns about ORG outcomes, which may act as a deterrent to open reporting. Finally, there is also scepticism about the benefits of reporting, as there is often no feedback or transparent action taken as a result'.* Exhibit 347

1.4.619. As Convening Authority for a Service Inquiry regarding carriage of dangerous goods in a Hercules, Jun 17, AOC 2 Gp concluded, '*The poor reporting and questioning culture identified is directly preventing learning, but more significantly is an indication of the lack of trust of personnel in the command and safety environments.'* Exhibit 348

1.4.620. The Panel requested data from the RAF Safety Centre (RAFSC) regarding reporting rates of DASORs across the Hercules Force, Air Mobility Force and wider RAF, as highlighted in Table 16. Exhibit 349

| | Totals | | | Rate per 10,000 flying hours | | |
|---|---|---|---|---|---|---|
| | All DASORs | Haz Obs | Incidents | All DASORs | Haz Obs | Incidents |
| Herc Dets OOA | 465 | 28% | 72% | 172 | 48 | 124 |
| Herc Force Total | 1139 | 34% | 66% | 177 | 60 | 117 |
| C17 | 747 | 53% | 47% | 187 | 99 | 88 |
| A400 | 217 | 59% | 41% | 218 | 129 | 89 |
| RAF Total | 43005 | 41% | 59% | - | - | - |

**Table 16 – Flight Safety Reporting Totals and Rates 1 Jan 13 – 31 Dec 17**

1.4.621. The Panel noted that the percentage of Hazard Observation (Haz Obs) reports from the Hercules Force, particularly for Out of Area (OOA) deployments was significantly lower than that of the C17 and A400 Forces, and the RAF generally. Haz Obs are proactive in nature, providing information on a situation or circumstance where the potential for an incident to occur in the future was identified, unlike reactive Incident Reports that are submitted after an event has actually occurred. The Manual of Air Safety considers such reporting as essential if the MOD's Air Safety Management System (ASMS) is to become truly effective in anticipating hazard and risk. Such a low reporting rate within the Air Safety Information Management System (ASIMS) is suggestive of a potential unwillingness to report. Of the 5 examples identified at paragraph 1.4.617, 4 would have been consistent with a Haz Obs submission to highlight a possible Air Safety issue. Exhibit 350 Exhibit 255

1.4.622. Notwithstanding the deduction (Table 16) that the Hercules Force appeared to have a lower reporting rate, the Panel sought further detail from the RAFSC in order to consider whether there were any differences in reporting rates from units deployed to Operations more generally (Table 17).

| Aircraft Type | Unit / Location | Totals (%) | | Rate per 10k flying hours | |
|---|---|---|---|---|---|
| | | Haz Obs | Accidents / Incidents | Haz Obs | Accidents / Incidents |
| Hercules | Operations | 28 | 72 | 48 | 123 |
| | Non-Deployed | 34 | 66 | 134 | 307 |
| A400M | Operations | 55 | 45 | 122 | 99 |
| | Non-Deployed | 65 | 35 | 254 | 137 |
| Typhoon | Operations | 40 | 60 | 75 | 113 |
| | Non-Deployed | 35 | 65 | 198 | 269 |
| Tornado | Operations | 53 | 47 | 156 | 138 |
| | Non-Deployed | 68 | 32 | 777 | 365 |

**Table 17 – Flight Safety Reporting Rates: Deployed/Non-Deployed Comparison**

1.4.623. Table 17 highlights that, with the exception of the Typhoon Force, the percentage of Haz Obs submitted on Operations is lower. More importantly, and without exception, it further suggests that DASOR reporting of any format, normalised to a rate of reports submitted per 10,000 flying hours, is significantly reduced on Operations.

1.4.624. Regarding low reporting rates identified within the deployed elements of the Hercules Force specifically, it was apparent to the Panel that Operational Security (OPSEC) remained a factor, particularly for aircrew. Although pilots had spoken of unusual Rad Alt readings (see paragraph 1.4.99) and the PNF was aware of a previous TLZ survey showing the significant slope, this had not been reported in ASIMS; nor had it been recorded locally within the Herc Det to ensure such information was retained for crews with no prior experience of the TLZ. The Panel acknowledge that no other UK fixed wing operator was using this TLZ, and that its location was of a classified nature. However, a functioning ASMS ensures information is passed to all who have a need to know, enables risk based decisions and to retain corporate memory. Without any reports, the ODH, as operating risk owner, was deprived of information regarding the discrepancies identified, and so was not in a position to identify any increased risk or require action from relevant parties such as the operational command chain.

1.4.625. A review was conducted of OOA Hercules DASORs, Jan 13-Dec 17, and the following points noted: Exhibit 351

a. 69 reports were submitted, an average of 1 per month.

b. Initials were frequently utilised, rather than provision of a full name.

c. 78% did not include the sortie authoriser and/or aircraft commander details.

d. It was common to list a BZN phone extension as the contact details, rather than a local contact number or official email address.

1.4.626. Safety reports will often require clarification from report originators to assist subsequent investigation or activity, and requires the ability to make such contact. Notwithstanding the difficulties of deployed operations, or sensitivities regarding OPSEC, the lack of complete or relevant information was considered a potential indication of a lack of an engaged safety culture.

1.4.627. During interviews, concerns were raised to the Panel regarding lack of action when reports were submitted. 3 specific DASORs were highlighted, 2 of which had been raised by the PF. Witness 1c Exhibit 352 Exhibit 353 Exhibit 354

1.4.628. In Feb 14, a DASOR highlighted that TATOM Issue 2.6 stated that TLZ MOS approaches should be flown at 2.5° using an aim point of 100ft into the LZ, which was in direct contradiction to the Aircrew Manual and ODM. It also asserted that TLZ Surveys conducted by TACATC were based on 3 degree approaches (as was confirmed by OC TACATC) and that 2.5 degree approaches could result in in increased risk of collision with obstacles on the approach. Exhibit 352

1.4.629. The DASOR was managed by a Local Investigation, which relied exclusively on input from various commentators including XXIV Sqn, TACATC, STANEVAL and Handling Squadron. Comments were wide and varied, including diverse opinions about the background of the different glide slopes and recommendations from various MOS trials, some of which were ill-informed. This continued for several months until, in May 15, BZN Flight Safety stated that a DASOR review meeting had concluded that '*all UK C-130J TLZ work is conducted using UK generated TATSID data and therefore will use only 2.5° approach* [sic]. *Awaiting comment to confirm relevant amendments are made to aircrew publications before closure.*' No recommendations were formally assigned to any addressees regarding required amendment action and the DASOR remained open. Exhibit 352

1.4.630. In May 2015, the DASOR originator placed a comment raising his frustration regarding lack of activity following his report. This was followed in Nov 15 by the manager of the Hercules ODM at Handling Squadron who provided authoritative comment regarding trials recommendations. He corrected previous assertions regarding aircraft stability on 3° approaches, quoting the trial conclusion that '*Aircraft handling during MOS landings flown visually using a 3° glide slope was SATISFACTORY.*' He also indicated that a QinetiQ trial had not actually recommended a 2.5° glide slope, but that it had conducted technical work on that approach, which could be incorporated within the ADS subject to appropriate stakeholder endorsement. He supported the originator's assertion that the aircraft should be flown to the Aircrew Manual guidance as that was the technique reflected in the ODM. Exhibit 352

1.4.631. The DASOR remained open before being picked up by XXIV Sqn Unit Flight Safety Officer (UFSO) in Apr 16. He concluded that '*we find ourselves going around in circles*', suggesting that consideration of the issue re-commence, focussing on amending the ADS to prescribe a 2.5° glide slope as '*the general consensus from the front line was that that is what they wanted to keep*'. Thereafter activity on the report stopped until 26 May 17 when the Occurrence Manager wrote, '*This DASOR has now been open for over 3 years with no activity in the past 12 months. Crews are now mandated to fly 3 degree MOS approaches and the current teaching on XXIV Sqn is consistent with this technique. Whilst background work continues into the merits of 2.5 degree approaches and may lead to a change of policy in the future (dependant on any relevant trials work), this DASOR is ready for DDH review and closure.*' Exhibit 352

1.4.632. The Panel noted that:



 

a. The only record of any investigation into this DASOR was in the comments attached to it. No formal consolidation of these appears to have been made.

b. The investigation section of the DASOR was annotated: "*See 'comments trail for investigation. Following advice from C-130 STANEVAL, decision made to close the DASOR.'* No record of this advice was apparent.

c. The DDH review section was completed by BZN FS Assurance, with the comment, '*FS Assurance for DDH. No further action required, report closed.'*

d. The Findings section stated that use of a 2.5° glide slope had become standard practice, but that the policy had now changed to mandate 3° approaches.

e. There was no use made of the ASIMS recommendations facility, whereby personnel could have been assigned auditable actions to ensure that all relevant requirements associated with such a policy change, for example alterations to necessary training.

f. The DASOR was not formally raised to the DDH, who indicated he had not had sight of it during interview. Witness 10

1.4.633. In Jun 16, the PF raised a DASOR suggesting that the TATOM posed a flight safety risk, as it was in a poor state of amendment and contained out-dated procedures. It highlighted that the post responsible for updating TATOM had been disestablished and that crews were operating in accordance with unpublished procedures, with risk being held at an inappropriate level. Exhibit 353

1.4.634. Again, the Report was managed by means of a local investigation, with the only record consisting of comments attached to the DASOR. This included input from the PT stating that the Safety Argument for the C-130J, and therefore the DH Safety Case, relied on the aircraft being operated by correctly trained crews, following fit-for-purpose SOPs and procedures. AMF HQ commented that the TATOM Editor post had been taken as a saving during FHQ re-organisation, but that an individual had been identified to update the publication in the near term. No recommendation was raised assigning that action, thereby preventing a means to track it through to conclusion. The DASOR was closed on 20 Feb 17, with a statement of assurance for the DDH that no further action was required.

1.4.635. However, on 01 Feb 17, the PF raised another DASOR again highlighting issues regarding the state of TATOM. AMF HQ was asked to provide comment regarding the update intentions outlined previously; the response indicated that *'2 Gp was considering the most efficient way forward, and that a further update would be provided at the end of March.'* However, it was not until October that TATOM was confirmed as an AMF HQ controlled publication. Exhibit 354

1.4.636. The 2 Gp Air Safety Management Plan requires DDHs to form a DASOR Occurrence Review Group (ORG), the purpose of which is to, '*to review all DASORs that concern DDH level RtL … For risk assessments at ODH level, or where the ODH should be made aware of the safety issue, the DASOR is to be transferred to the ODH*'.

1.4.637. In the 3½ years preceding ZH873's accident, 3 DASORs had been submitted outlining concerns regarding discrepancies between the Aircraft Document Set and the TATOM, all of which have pertinence to this Service Inquiry. Throughout this time, despite raising concerns that the aircraft was being operated outside its Release to Service and concerning publications owned by the ODH, none of the reports were elevated within ASIMS to the ODH, as might have been expected in accordance with the ASMP.

1.4.638. While accepting that formal amendment to documents can take a significant period of time, nevertheless, the Panel considered that more immediate direction, particularly given the specific issues highlighted in the DASOR of 2014, could have been provided in the interim to clarify the procedures to be followed or the hierarchy of documentation.

1.4.639. The Panel also considered that this might have been more effectively managed by better utilisation of ASIMS functionality, particularly assigning time-bounded recommendations that could be tracked in an auditable manner. As an example, despite the DASOR Occurrence Manager stating that the policy had changed to 3 degree approaches, the training on XXIV Sqn continued using a 2.5° approach.

1.4.640. The Panel determined that:

a. There is a poor reporting culture within the deployed elements of the Hercules Force, based on a combination of OPSEC considerations, fear of reprisal and lack of visible action when reports are submitted.

b. More generally, there appears to be a lower rate of Air Safety reporting from operational locations across the RAF.

c. Management of 3 DASORs with direct consequence to ZH873's accident had:

(1) Been protracted and inefficient.

(2) Failed to prevent continued operation of the aircraft beyond the ADS.

(3) Not been raised formally to appropriate DH ownership.

(4) Not utilised full ASIMS functionality, particularly assigning action recommendations to assist subsequent audit and assurance.

1.4.641. Air Safety Management and Reporting, particularly a lack of effective management of the DASORs highlighting documentary inconsistencies and aircraft being operated beyond the ADS, was concluded to be a **Contributory Factor**.

**Recommendation**

1.4.642. **Hercules DDH should revise his Air Safety Management System to assure compliance with the 2 Gp ASMP and ensure that DASORs resulting in ODH level risk are formally elevated within ASIMS for subsequent risk management activity.**

1.4.643. **Hercules DDH should provide guidance on:**

a. **Appropriate methods of reporting from operationally sensitive locations in order to capture Air Safety risks without compromise to Operational Security.**

b. **Utilisation of the Recommendations function within ASIMS to generate an auditable record of actions taken in addressing investigation findings.**

1.4.644. **The Inspector of Flight Safety, Royal Air Force Safety Centre, should investigate the lower rate of Air Safety reporting identified from Operational locations and advise the SDH accordingly.**

## Assurance

1.4.645. RA 1200, Defence Air Safety Management, requires all organisations within Defence aviation to establish and maintain an effective Air Safety Management System (ASMS). It lists 16 auditable facets that an ASMS should contain, broken down across 4 areas: Exhibit 350

a. Safety Policy and Objectives.

b. Safety Risk Management.

c. Safety Assurance.

d. Safety Promotion.

1.4.646. Assurance activity is conducted at 3 levels, as defined in MAA 02: 1st Party (Internal), 2nd Party (External) and 3rd Party (Independent). Exhibit 255

1.4.647. The Panel sought to determine how Air Safety (AS) assurance is governed across the Hercules Force, BZN, 2 Gp and EAWs, and what activity had taken place in the two years prior to ZH873's accident.

1.4.648. The RAF Safety Management Plan (AP 8000) requires Duty Holders to assure themselves that aviation activities within their Area of Responsibility (AoR) are conducted safely. This was to be achieved through a variety of activities, including visits, safety meetings, risk register analysis, review of occurrence reports and assessment of the effectiveness of recommendations. Exhibit 395

1.4.649. Specifically with respect to AS assurance visits, AP 8000 stated that the primary aim was to '*determine the extent to which an organization is adhering to a structured SMS and to RAF safety policy; and where organizations are operating aircraft they are doing so in accordance with the Aircraft Document Set*.' Exhibit 395

1.4.650. The MAA conducted a 3rd Party audit in Jun 15, assessing the efficacy of both the 2 Gp and BZN ASMS through examination of Air Safety governance and assurance mechanisms at the ODH and DDH levels. It concluded that this was '*largely positive with no immediate or concerning AS risks*', and recommended that the next ODH audit would take place after 2 years, or prior to the ODH handover if sooner. However, it also noted that although 1st and 2nd party assurance '*was taking place* …[it] *was not undertaken as part of a holistic assurance plan*.' Exhibit 399

1.4.651. As recommended in the 2015 report, the subsequent MAA audit took place in 2017. The focus was HQ 2 Gp and RAF Northolt, with AMF HQ, BZN and the Hercules squadrons being considered out of scope. No immediate or critical RtL issues were identified. Exhibit 400

1.4.652. A 2nd Party Air Safety Assurance Visit (ASAV) was conducted to 903 EAW by the RAFSC in Jan 17. This included the Herc Det and resulted in a '*Full Assurance*' assessment.[24] Exhibit 423 Exhibit 420

1.4.653. The 2 Gp ASMP Section 3 outlined how its AS assurance would be conducted, including: Exhibit 396

a. Formal ASAVs to Main and Deployed Operating Bases. These would be combined where appropriate with other visits, eg RAFSC or the Command External Quality Assurance team.

b. Attendance at sub-ordinate level AS meetings.

c. Review of risk registers and Bowties.

d. Review of trend analysis at DDH and ODH levels, including Gp-wide DASOR analysis.

1.4.654. The 2 Gp Air Safety Team (AST) conducted an ASAV to BZN in Mar 16, concluding with an overall ASMS Grading of Full Assurance Exhibit 401

1.4.655. A specific requirement of this visit had been to review '*perceived normalisation of behaviours within the C130J Force.*' The report observed that 47 Sqn Flt Cdrs had '*identified and questioned norms that had developed across the C130J fleet as a result of years of continuous operational work and an engrained 'can-do'* attitude. However, no detail was offered as to the extent of these norms, their potential risk to AS or what actions had been put in place as mitigation.

1.4.656. It was observed that the main focus of concern among Hercules Sqn Executives regarded aircraft and sqn documentation (including the ACM and TATOM) which were '*suggested to have diverged from what was actually taught and flown by aircrew'* (sic). The report recommended a review of SOPs, the ACM and TATOM should be completed in co-ordination with the PT, OC Ops, 2 Gp STANEVAL and the C130 Force, but did not assign a lead responsibility for the requirement.

1.4.657. The Panel noted the similarity of this recommendation with the concerns highlighted in the three DASORs discussed at paragraphs 1.4.627 *et seq*. However, although the first one pre-dated the ASAV, no cross referral was made. In addition, it considered that this recommendation arose from an observation that suggested the Hercules was not being operated in accordance with the ADS, a key assurance requirement of AP 8000 (paragraph 1.4.649). The Executive Summary of the report commented that a number of areas were highlighted, '*mainly related to assurance of the Aircraft Document Set*', but did not emphasis the potential that aircraft were being operated beyond it.

[24] The scale of assessments being No Assurance, Limited Assurance, Substantial Assurance, Full Assurance, Developed Assurance and Excelling Assurance.

1.4.658. The recommendation was transferred to the 2 Gp Assurance Recommendation Tracker (ART). Following publication of the Non-Statutory Inquiry (NSI), dated 29 May 17, into an overweight landing of Hercules ZH870 at the same TLZ on 29 Aug 16, which included similar recommendations to amend GASOs, TATOM and the AMFTD, the ASAV recommendation was closed, being cross referred to the NSI.

Exhibit 402
Exhibit 415
Exhibit 422
Exhibit 402

1.4.659. A re-issue of TATOM was published in Sep 17. Although this addressed the NSI recommendation regarding stabilised approach criteria (paragraphs 1.4.337 - 1.4.343), those regarding 'Box + Z' configurations remained in draft, awaiting prior amendment to MADS (paragraphs 1.4.110 to 1.4.122). Despite the re-issue, it was noted that TATOM still referred to JSP552, a publication superseded following the introduction of MAA Regulatory Publications from Aug 11.

Exhibit 422
Exhibit 425

1.4.660. While researching Assurance activities, the Panel was made aware of AOC 2 Gp's direction for a thorough review of 2 Gp aviation documentation. This was led by the ODH Senior Operator, resulting in a proposal for a wholesale re-structuring of GASOs, AMASIs and the TATOM into an '*Ops Manual*', as outlined in Figure 44:

Witness 19
Exhibit 418
Exhibit 419

| Part A (Orders) | Part B (Procedures) | Part C (Airfield Information) | Part D (Training) |
|---|---|---|---|
| Future GASOs (to include all safety-related and supervision orders) | Future AM SOPs (incorporating platform/role specific elements of TATOM) | Stn FOBs/DAMs/Airfield Directories | Future AM Training Policy (Training Directive) |

| Accountable (Owner) | | | |
|---|---|---|---|
| ODH | ODH | DDH | ODH |

| Responsible (Delegated authority) | | | |
|---|---|---|---|
| SO to ODH | DDH | OC Ops Wg<br>SO1 Current Ops | AM FC (TRA)<br>DDH (TDAs) |

| Author | | | |
|---|---|---|---|
| 2 Gp AS Reg | STANEVAL<br>Fg Sqns | Ops Wg staff<br>AM FHQ staff | AM FHQ staff<br>Fg Sqns |

**Figure 44 – Future Structure, Ownership and Accountability: 2 Gp Ops Manual**

1.4.661. This has been endorsed by AOC 2 Gp, with a projected completion between Apr-Sep 19 recognising the scale of the task and need for resource. The Panel considered it highly probable that this would address the recommendations made in the ASAV, the NSI and relevant areas within this Inquiry.

1.4.662. The 2 Gp ASMP outlined an additional assurance mechanism entitled Operating Safety System Assessments (OSSAs). Backed by a comprehensive Concept of Operations (CONOPS), OSSAs were designed to augment 2 Gp ASMS assurance activity through '*direct in-flight observation*', the intent being to (*inter alia*):

Exhibit 396
Exhibit 408

a. Identify positive or drifting attitudes or abnormal deviation trends.

b. Highlight potential risks to 2 Gp output.

c. Promote and support 2 Gp ASMPs, safety strategies and action plans.

1.4.663. The CONOPS stressed that an OSSA was not a STANEVAL check; comments were intended to '*assess safety hazards, discuss operating issues and promote safety hazard reporting.*' In addition to recording observations regarding

Exhibit 408

SMS culture and operating norms, it would focus on '*2 Gp SMS areas of interest*', which included Loose Article Management, 'Can Do' Attitudes and Norms.

1.4.664. The Panel considered the OSSA was an example of a good practice to enhance AS assurance activity. It also noted that the 2 Gp '*areas of interest*' mirrored concerns raised by Hercules Executives (paragraph 1.4.656) and in this report (paragraphs 1.4.396 and 1.4.479). However, 2 Gp AST stated that OSSAs were very much an aspirational activity, in part due to manning shortages within the AST, and were not intended to take place at deployed locations. Of the two OSSAs that had been conducted, neither involved the Hercules Force. Exhibit 409

1.4.665. Requirements for 1st Party Assurance were set out in the BZN ASMP, which was assessed by the Panel as consistent with the 2 Gp ASMP. Annual ASAVs were conducted by BZN AS staff to both XXIV and 47 Sqns during 2016 and 2017, all concluding with a '*Full Assurance*' assessment. Exhibit 397 Exhibit 404 Exhibit 405 Exhibit 406 Exhibit 407

1.4.666. The Executive Summary for 47 Sqn's 2017 Report stated that the visit '*highlighted the task versus resource imbalance and personnel felt they were not being listened to by higher command levels. Personnel, especially in the engineering cadre, felt a serious accident/incident was likely and this was the only time a thorough review of tasking would take place.*' Although no recommendation was made regarding this observation, the Panel considered it as consistent with the ODH concerns regarding '*can-do*' attitudes and the submissions of ABC Options to ensure longer term sustainability (see paragraphs 1.4.607 - 1.4.614). Exhibit 420 Exhibit 405

1.4.667. In addition to pure AS assurance activity outlined above, 2 Gp STANEVAL was responsible for providing 1st Party Assurance to the DDH regarding all aspects of aircrew standardisation in accordance with GASOs and TTPs, and 2nd and 3rd Party Assurance to the ODH and SDH respectively. To discharge this function, STANEVAL was tasked to conduct, *inter alia*, Exhibit 398

a. Formal checks of a minimum of 10% of aircrew.

b. Annual inspections of flying units. These would be supported by 2 Gp Air Safety to carry out a '*more forensic*' analysis of supervisory systems.

c. A '*Mock Service Inquiry*' at each flying squadron annually to examine in detail the '*preparedness of a crew selected at random for flying.*' Among other specified aspects, this would look at whether the crew was correctly trained and sufficiently experienced for the flight, the documentation relating to it and whether all orders pertinent to the flight were complied with.

1.4.668. The 2 Gp ASOs also required STANEVAL to carry out, '*when practical*', occasional air checks on '*special flights*' including, but not limited to, VIP and SF tasks. The purpose of such checks was '*not to role check an individual but to observe the operation of an individual and the crew to ensure that the attendant pressures to accomplish the task do not jeopardise flight safety*'.

1.4.669. Reports of the annual STANEVAL visits to 47 and XXIV Sqns during 2016 and 2017 were reviewed. Each was based on a generally standardised format covering personnel flying documentation, flying logbooks, aircrew publications, authorisation, flying currency and flying supervision. The Panel noted that only 47 Sqn's reports contained a paragraph entitled, '*Flying Standards and Supervision*', Exhibit 411 Exhibit 412 Exhibit 413 Exhibit 414 however this appeared to summarise the Sqn's task and organisation, rather than observations regarding standards and supervision *per se*.

1.4.670. All of the reports resulted in a positive conclusion, ranging from assessments of '*very good*' to '*high average*', although none contained a formal list of recommendations to be taken forward.

1.4.671. Both the 2017 reports commented on flying currency shortfalls. That for 47 Sqn noted that '*some individuals*' had lacked currency during the year, and that subsequent paperwork required by the Training Directive had not been raised. The XXIV Sqn report commented that Aircrew Instructor (AI) seat time was '*mainly being achieved*', and that '*many AIs struggled to maintain green total flying hours'* currency'. Although such observations mirror the Panel's concerns raised at paragraphs 1.4.72 to 1.4.87, neither report included comment regarding: Exhibit 412 Exhibit 79 Exhibit 414

a. The extent of such non-compliance.

b. Any underlying causes.

c. Consequent risk to AS, or mitigations put in place to address it.

d. Recommendations to address the observations.

1.4.672. A STANEVAL visit was conducted to the Herc Det 903 EAW, in Apr 17, with specific focus on Op SHADER and BME tasking, and operational support given to crews. No particular concerns were highlighted. Exhibit 426

1.4.673. Across each of the STANEVAL reports reviewed, the Panel considered them to be rather broad-brush and shallow in extent, commenting on what should happen rather than assessing what might actually be happening during normal day to day activity. As an example, in the Apr 17 visit to 903 EAW, there was no comment regarding normalised behaviour or can-do attitudes, which had been a specific 2 Gp area of concern and mentioned in the 2016 ASAV report (paragraphs 1.4.655, 1.4.656 and 1.4.663).

1.4.674. Ten '*Special Flight'* checks were conducted by STANEVAL between May 15 and Apr 18, but none involved the Herc Det at AKR. Given the nature of this task (paragraphs 1.4.22 to 1.4.29), the extensive work conducted by the DH chain in consideration of OEC 022 (paragraphs 1.4.427 *et seq*) and the accidents of Aug 16 and Aug 17, the Panel opined that this would have been an appropriate means of increased assurance to both the DH and operational command chains.

1.4.675. The Panel considered that:

a. The system to assure Air Safety for Hercules squadrons, BZN and 2 Gp at 1st, 2nd and 3rd Party levels is regulatory compliant and comprehensive.

b. Despite a specific objective to review potential normalisation of behaviour within the Hercules Force, and confirming this was an issue identified by 47 Sqn Executives, the 2 Gp ASAV report of Mar 16 made no assessment of the extent of such behaviour or recommendation to address it. As such, it did not allow the DH chain to assess any potential risk to AS.

c. The recommendation arising from the Mar 16 ASAV regarding documentary discrepancies mirrored the concerns raised in ASIMS (paragraphs 1.4.627 *et seq*). However, no link was made to the corresponding DASORs, and no progress was made to close it until similar recommendations were made in the ZH870 NSI.

d. The lack of such connection to DASORs, or of comment within STANEVAL reports regarding normalised behaviour or aircraft being operated beyond the ADS resonated with the MAA observation that assurance was not being undertaken as part of a '*holistic plan*'.

e. The AP8000 requirement to assure the DH chain that organisations operating aircraft were doing so in '*in accordance with the Aircraft Document Set*' was not being met.

f. There had been several triggers that might have prompted consideration of an OSSA or '*Special Flight*' check of the Herc Det. These included the 2016 ASAV report concerns regarding an engrained '*can*-do' attitude, ZH870's heavy landing, 29 Aug 16 or the nature of this specific task itself. Although the Panel could not determine whether either would have prevented ZH873's accident, it was considered probable that similar conclusions would have been made to those in this report regarding non-compliance with NVG Hoffman Box testing, failures of Flight Deck Armour, issues with BALCs and lack of Air Safety reporting.

g. Not conducting such assurance activity, even following ZH873's accident and with the benefit of hindsight, was a missed opportunity.

1.4.676. The Panel **Observed** that

a. BZN 1st Party ASAV Reports did not include comment regarding compliance with previous visit recommendations.

b. 2 Gp STANEVAL Formal Staff Visit Reports did not quantify the extent of observations made, or comment on the potential risk associated with them.

c. 2 Gp STANEVAL Formal Staff Visit Reports did not contain a consolidated list of recommendations.

d. The Reports raised following 2 Group STANEVAL Formal Staff Visits and 1st and 2nd Party Air Safety Assurance Visits did not assign Recommendation Owners or required completion dates.

e. STANEVAL do not meet the requirements for a 3rd Party assurance agent as laid down in MAA02 or AP8000. Exhibit 255 Exhibit 395

1.4.677. Despite extensive AS assurance activity and associated recommendations with direct relevance to ZH873, suggesting the Hercules was being operated beyond the ADS, an apparent lack of cross-referral between these assurance activities meant that the readily identified shortcoming were not addressed in a timely fashion and, as such, Air Safety Assurance at all levels was considered to be a **Contributory Factor.**

## Cost to Defence

1.4.678. Initial assessment of ZH873 following the accident by 71(R) Sqn recommended a categorisation of Cat 4 (Works)[25]. However, following further work, including analysis of data from ZH873's Data Transfer and Diagnostic System, the Design Organisation concluded that significant Design Limit Loads had been exceeded across much of the airframe, all of which was consistent with the visible evidence contained within the 71(R) Sqn report. This led to the Type Airworthiness Authority (TAA) concluding that '*the aircraft has significantly exceeded its Design Limits and ... there will be resulting widespread damage to its primary structure. The TAA assesses therefore that the aircraft is beyond economic repair and recommends that AOC 2 Gp should agree that ZH873 is categorised as Cat 5 (Comp)*'. Exhibit 252 Exhibit 253 Exhibit 4

1.4.679. The value of ZH873 was assessed as £17.5M. However, this was offset by the recovery of components from the airframe prior to its final disposal, as shown in Table 18 below. Exhibit 254

| | |
|---|---|
| Loss Hercules C-130J C Mk 4 (ZH873 current estimated value) | £17.5M |
| Cost saving from RTP activity | £5.5M |
| Total Cost to defence | **£12M** |

**Table 18 – Cost to Defence**

## Summary of Findings

1.4.680. The Panel concluded that the accident was caused by a late, incomplete and ineffective flare resulting in a landing short of the TLZ runway.

1.4.681. The Panel assessed that this was due to a lack of situational awareness resulting in an inability to judge the flare timing in order to achieve a safe landing on the runway surface.

1.4.682. The lack of situational awareness was compounded by a variety of interlinked factors, including IR Landing Light operation or serviceability, CRM, handling technique, light levels, Rad Alt readings and potential visual illusions.

1.4.683. **Causal Factors.** The Panel identified one Causal Factor of the accident (ie that which led directly to the accident): an ineffective flare, being late and incomplete. 1.4.231

1.4.684. **Contributory Factors.** The Panel identified 15 Contributory Factors to the accident (ie those which made the accident more likely to happen):

a. Authorisation. 1.4.159

[25] The aircraft is repairable but it is considered to need special facilities or equipment not available on site. The repair will be carried out at a contractor's works. (MAA02 – Master Glossary).

| | |
|---|---|
| b. Glide Slope. | 1.4.215 |
| c. Aiming Point. | 1.4.222 |
| d. Low Ambient Light and Poor Visual Cues. | 1.4.254 |
| e. Inaccurate advice regarding use of available lighting for NVG approaches. | 1.4.273 |
| f. Insufficient ground illumination through the non-selection, unserviceability or degradation of the aircraft's external IR lighting. | 1.4.296 |
| g. The Pilot's Reliance on Rad Alt Information. | 1.4.309 |
| h. Lack of Situational Awareness. | 1.4.331 |
| i. Lack of Clearly Defined Go-Around and Stabilised Approach Criteria. | 1.4.342 |
| j. Sub-Optimal Crew Resource Management and a Lack of Assertive Behaviour. | 1.4.350 |
| k. Pressure on the Pilot. | 1.4.357 |
| l. Disparity in Handling Advice issued across the Hercules Force documentation. | 1.4.478 |
| m. Flying Supervision throughout the Crew's Selection and Deployment. | 1.4.523 |
| n. Lack of Eye to Wheel Height Awareness. | 1.4.576 |
| o. Air Safety Management and Reporting, particularly a lack of Effective Management of DASORs. | 1.4.641 |

1.4.685. **Aggravating Factors.** The Panel identified 2 Aggravating Factors to the accident (ie those which made the outcome accident worse):

| | |
|---|---|
| a. The Upslope immediately preceding the Temporary Landing Zone Overrun. | 1.4.238 |
| b. Use of a Non-Crashworthy Seat without Restraint for Para Door Observers. | 1.4.493 |

1.4.686. **Other Factors.** The Panel identified 20 Other Factors to the accident (ie those which were not a factor in the accident, but noteworthy in that they may cause, contribute to or aggravate future accidents):

| | |
|---|---|
| a. Non-compliance with Training Protocol 717 currency requirements. | 1.4.87 |
| b. Discrepancies between TLZ Surveys, lack of recent imagery, and shortfalls in publications and training. | 1.4.103 |
| c. Lack of an appropriate Meteorological Brief. | 1.4.128 |

d. Lack of an appropriate Crew Briefing. 1.4.142

e. Night Vision Goggle set-up, without the use of a Hoffman Box. 1.4.263

f. Visual Illusions. 1.4.325

g. Lack of Clear Guidance regarding Aircrew Helmet Checks of Fit. 1.4.375

h. Unserviceable Components of the Flight Deck Armour and the use of locally placed Retaining Straps. 1.4.387

i. The Flight Deck Weapon Stowage. 1.4.394

j. Management of Safety Statements and Operational Emergency Clearances. 1.4.425

k. Management and Implementation of Operational Emergency Clearance 022. 1.4.441

l. Incoherent management of Operational Emergency Clearance 001, in particular the associated Military Operating Standard and Natural Surface Operations trials and their subsequent inclusion within the Aircraft Document Set. 1.4.468

m. Supervisory Governance, particularly the lack of direction regarding Statement of Deploying Aircrew Capability and Pen Picture content or distribution. 1.4.504

n. The subjective nature of the Hercules Operational Risk Matrix. 1.4.532

o. Lack of detailed consideration of the '*Optimisation of NVG Training and Maintenance for Aircrew and Survival Equipment Fitters*' across Defence. 1.4.539

p. Lack of compliant Orders regarding Night Vision Goggles use. 1.4.550

q. Non-Representative Natural Surface and Temporary Landing Zone training. 1.4.567

r. HUD Discrepancies across the Hercules Fleet. 1.4.588

s. Lack of Training in Body Armour Load Carrying System. 1.4.601

t. Operational Tempo and the additional workload generated by the drawdown of the Hercules Force. 1.4.616

1.4.687. **Observations.** The Panel made 25 Observations (ie issues that were not relevant to the accident but worthy of consideration to promote better working practices).

a. The Pre-Deployment Simulator Serial's informal promulgation meant that it would not be subject to periodic review or assurance. 1.4.46

 

| | |
|---|---|
| b. The Pre-Deployment administrative burden in 47 Sqn could be reduced by incorporating guidance regarding multiple short duration deployments contained in AP 9012 Chapter 4 Annex B. | 1.4.58.a |
| c. A Pre-Deployment Interview, were it to include discussion of recent flying practice, Operational Recency and Basic Currency Requirements relating to the expected Operational Task, could strengthen the Supervisory Process. | 1.4.58.b |
| d. A significant proportion of Pre-Deployment Interviews were not being completed or formally recorded in 47 Sqn. | 1.4.58.c |
| e. A lack of consistency in the logging of Military Operating Standard and Natural Surface landings in Aircrew Logbooks, for which there was no over-arching guidance within 2 Group Air Staff Orders or Air Mobility Air Staff Instructions. | 1.4.89 |
| f. ZH873 had a high number of extant Acceptable Deferred Faults extending back to 2013 (the second highest in the fleet, and 30% above the average). The vast majority of ZH873's ADFs had been deferred until depth maintenance, but some had not been rectified after two such depth cycles. | 1.4.164.a |
| g. Acceptable Deferred Faults deferred to Depth maintenance, with associated spares demands, had no review date in contravention of MOD Form 799/3. | 1.4.164.b |
| h. On some occasions, Acceptable Deferred Faults deferred to depth were not supported by associated spares demands, in contravention of MOD Form 799/3. | 1.4.164.c |
| i. The Tactical Air Transport Operations Manual guidance regarding timing of Landing Zone Pre-Assault checks creates potential for a premature selection of the Engine Nacelle Shut Off Valves to occur, resulting in inadvertent depressurisation. | 1.4.179 |
| j. 47 Squadron had insufficient Infrared Monocles to provide one for the Hercules Detachment at RAF Akrotiri. This resulted in the engineers drawing a set of Night Vision Goggles from the Safety Equipment Section, and conducting Flight Servicing activity with incorrect equipment. | 1.4.299 |
| k. By not specifying what constitutes "suitable terrain", the XXIV Squadron Military Operating Standard training presentation might contravene Aircraft Document Set cautions and warnings regarding use of the Radar Altimeter as an aid to flaring the aircraft. | 1.4.311 |
| l. 47 Sqn Engineers believed that strength testing of the Armour Panels and Weapon Stowage Racks hook and loop fasteners was only undertaken by the Brize Norton Role Bay. | 1.4.380 |
| m. The Aircrew Manual handling advice for Night Vision Goggle Natural Surface Operations utilised the day Military Operating Standard technique which relied on visual cues to initiate the flare. Natural Surface Operations at night were approved only with Night Vision Goggles, but there was no trials evidence to support this technique. | 1.4.469.a |

| | |
|---|---|
| n. The technique used by the pilot of ZH873, namely aiming at the front of the Touchdown Box on a 2.5° Glideslope, was the same as that used during the more recent Air Test and Evaluation Centre trials. | 1.4.469.b |
| o. There was no 2 Group Bowtie for Temporary Landing Zone Operations. | 1.4.495 |
| p. There was no currency associated with the Night Vision Goggle Course at RAF Centre of Aviation Medicine. | 1.4.552 |
| q. Air Mobility Air Staff Instructions require Flight Simulator Training Devices to be assessed by '*service aircrew wherever possible. They are to be experienced and current on type, ideally from the appropriate STANEVAL.*' This is seemingly inconsistent with Regulatory Article 2375 which states '*Fidelity Assessments will normally be made by a current and qualified Test Pilot assisted by Qualified Aircrew Instructors*'. | 1.4.569 |
| r. The Body Armour Load Carrying System Assessment and Integration trials for the Hercules were not conducted under representative conditions, particularly regarding the lack of a loaded cargo bay. | 1.4.603.a |
| s. The Pilot had not completed his Evacuation Drills in the Body Armour Load Carrying System as required by Training Protocol 717, and evidence gathered suggested the potential for wider non-compliance. | 1.4.603.b |
| t. Training Protocol 717 does not require Body Armour Load Carrying System to be worn in Evacuation Drills for Weapons System Operator Crewmen, despite them occupying the 3rd seat on the flight deck. | 1.4.603.c |
| u. Training Protocol 717 does not require any form of Evacuation Drill for Aircraft Ground Engineers. | 1.4.603.d |
| v. RAF Brize Norton 1st Party Air Safety Assurance Visit Reports did not include comment regarding compliance with previous visit recommendations. | 1.4.676.a |
| w. 2 Group STANEVAL Formal Staff Visit Reports for Hercules Squadrons did not quantify the extent of observations made, or comment on the potential risk associated with them. | 1.4.676.b |
| x. 2 Group STANEVAL Formal Staff Visit Reports for Hercules Squadrons did not contain a consolidated list of recommendations. | 1.4.676.c |
| y. The Reports raised following 2 Group STANEVAL Formal Staff Visits and 1st and 2nd Party Air Safety Assurance Visits did not assign Recommendation Owners or required completion dates. | 1.4.676.d |

1.4.688. **Accident Factor Summary.** The Causal, Contributory and Aggravating Factors concluded by the Panel are summarised in Figure 45.

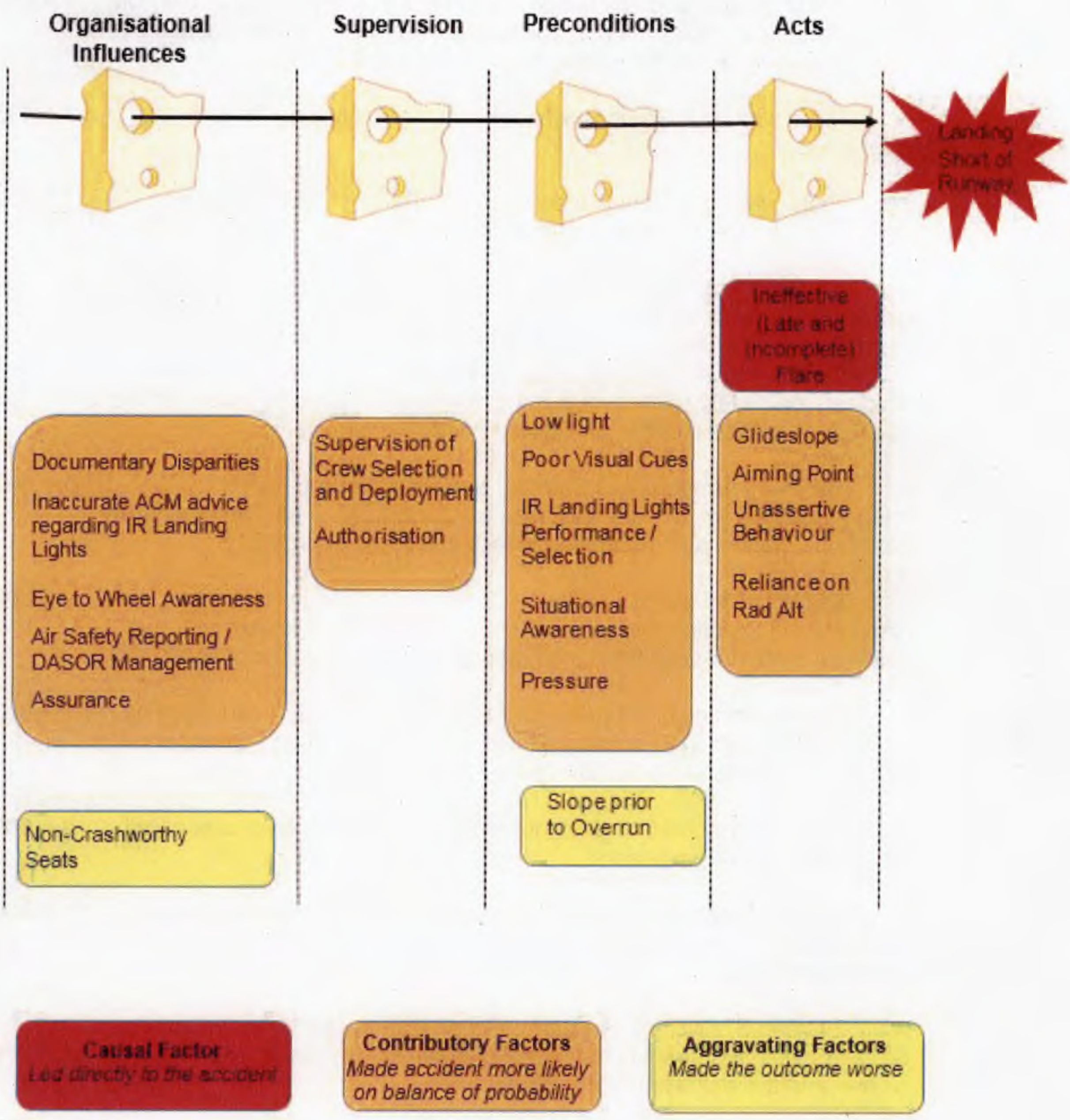


**Figure 45 – Causal, Contributory and Aggravating Factors**

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# PART 1.5

## Recommendations

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## PART 1.5 – RECOMMENDATIONS

1.5.1. **Introduction**. The following recommendations are made in order to enhance Defence Air Safety.

1.5.2. **Director Military Aviation Authority should:**

a. Amend MADS to include the Box + Z configuration to ensure that UK military operators are aware of North Atlantic Treaty Organisation configurations likely to be encountered Operations and Exercises. 1.4.121

b. Develop a Case Study, incorporating the Supervisory, Authorisation and Human Factors issues identified within this Report, to be used in Air Safety Training in order to promote awareness across the Defence Aviation Environment. 1.4.160 1.4.351 1.4.358 1.4.525

c. Revise Military Regulatory Publications' content specific to Night Vision Goggle operations, particularly consideration of minimum light levels in order to provide enhanced guidance for operations to 'Bare Minimum Temporary Landing Zone' Markings. 1.4.255

d. Provide links from the Air Safety Information Management System home page to editable documentation for all Air Safety reports. 1.4.408.a

e. Amalgamate the Serious Occurrence Notification and Aircraft Accident Initial Report into a single pro forma, with an Annex for accident specific data. 1.4.408.b

1.5.3. **Director Air Support should:**

Ensure the C130J, C17, Sentinel, BAE 146, A400M, Voyager, RC135W, E3-D Sentry and P-8A Aircraft Document Sets contain Eye to Wheel Height (EWH) information in order that pilots of large aircraft understand the significance EWH can have on their touchdown point. 1.4.577

1.5.4. **Air Officer Commanding 2 Group / Hercules Operating Duty Holder should:**

a. Establish the necessary visual references required for Air Mobility Force aircraft conducting NVG approaches to TLZs. 1.4.256

b. Include the following Trial ILLUMINATOR recommendations for inclusion within relevant documentation: 1.4.274

(1) When operating in COVERT lighting mode, for both training and operational scenarios, in low ambient light conditions, all Infrared lights, including the landing lights, main landing gear taxi lights and wingtip taxi lights are to be used together.

(2) The use of white wingtip taxi lights only may continue for initial Night Vision Goggle training and non-tactical scenarios.

(3) White main landing gear taxi lights and landing lights are NOT to be used for Night Vision Goggle approaches.

c. Amend AP 101B-0704/5-15A1C Part 3, Chapter 4, Paragraphs 33 to read, *'The Covert Infra-Red (IR) landing, taxi (main landing gear) and wingtip taxi lights used together provide an adequate source of ground illumination while performing NVG landings in low ambient light conditions (<10mlux). The required visual references to achieve a safe landing are likely to be acquired at or below 100 ft, providing there is sufficient surface texture.'* 1.4.275

d. Assess any increased Operating Risk arising from degraded Infrared Landing and Taxi Lights, pending further advice from the Hercules Project Team Leader. 1.4.297

e. Provide specific Go-Around and Stabilised Approach criteria for Military Operating Standard approaches 1.4.343

f. Establish the extant risk of loose articles arising from the current flight deck Weapon Stowage, and ensure that any Risk to Life is mitigated and managed appropriately. 1.4.396

g. Ensure that the 2 Group Air Safety Management Plan and its associated Risk Management processes are compliant with Regulatory Articles 1205, 1330 and AP 8000. 1.4.426

h. Ensure that a robust mechanism for approving use of OECs is clearly articulated in appropriate documentation. 1.4.442

i. Confirm that the Operating Risk associated with Military Operating Standard and Natural Surface Operations is understood and recorded as part of the Hercules Air System Safety Case. 1.4.470.a

j. Determine whether empirical evidence would support better quantification of the risk associated with Operational Emergency Clearance 001, and support its elevation to a Clearance of Limited Evidence or full inclusion within the Release to Service. 1.4.470.b

k. Mandate that all crews apply the standard Military Operating Standard approach as laid down in the Aircraft Document Set. 1.4.479.a

l. Take urgent action to resolve the documentary discrepancies regarding Military Operating Standard handling advice. 1.4.479.b

m. Conduct a wider review of the Aircraft Document Set and supporting publications (particularly the Tactical Air Transport Operations Manual), ensuring consistency and clarity of primacy. 1.4.479.c

n. Revise the 2 Gp Air Staff Orders' requirements for Pen Pictures, specifically including: 1.4.505

(1) A minimum set of factors to be included;

(2) A supervisory assessment of recent flying experience and Basic Currency Requirements in relation to the expected task;

(3) Guidance as to subsequent distribution within the Operational Command chain

o. Ensure direction given in the Operating Duty Holder Adjustment Plan, dated 07 Sep 17, regarding aircrew recency on operations and minimum light levels for live Military Operating Standard approaches are recorded in appropriate orders to ensure long term utility. 1.4.524

p. Revise 2 Group Air Standing Orders regarding the Operational Risk Matrix to enable greater objectivity when assessing risk and determining relevant approval levels. 1.4.533

q. Revise 2 Group Air Standing Orders regarding use of Night Vision Goggles to ensure compliance with Regulatory Article 2330, and to mandate use of the Hoffman Box to objectively test and focus Night Vision Goggles. 1.4.551

r. Pursue construction of an 'all-weather' Natural Surface Temporary Landing Zone of suitable length to allow the Air Mobility Force to plan Natural Surface Operations training sorties consistently and for crews to train at weights representative of those required on Operations. 1.4.568.a

s. Review the fidelity of the Hercules Dynamic Mission Simulator for Military Operating Standard approaches, specifically regarding flare and throttle handling, in order to facilitate representative training. 1.4.568.b

t. Revise the requirement for Pre-Deployment Training in Body Armour Load Carrying System to ensure that it is of sufficient duration and covers all appropriate personnel. 1.4.602

1.5.5. **Air Officer Commanding 22 Group should:**

Ensure that Eye to Wheel Height, particularly its significance to landing short, is incorporated into Multi Engine Pilot Training. 1.4.578

1.5.6. **The Air Mobility Force Commander should:**

a. Clarify Air Mobility Force Training Directive Training Protocol 717 (Live Flying Hour requirements) to ensure there is no ambiguity in interpretation or meaning. 1.4.88.a

b. Clarify Currency Requirements across the Air Mobility Force to ensure their fitness for purpose. 1.4.88.b

c. Clarify reporting requirements regarding Air Mobility Force currency and Basic Currency Requirements, and ensure future compliance. 1.4.88.c

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| | d. Amend TATOM to include the 'Box + Z' configuration. | 1.4.122.a |
| | e. Facilitate the 'Box + Z' configuration during live and synthetic training to ensure crews are trained in scenarios likely to be encountered when deployed. | 1.4.122.b |
| | f. Ensure up to date mapping and imagery is procured and maintained for the Air Mobility Force for all 2 Group Mission Planning Systems. | 1.4.122.c |
| | g. Ensure implementation of formal Eye to Wheel Height instruction during conversion to type training to ensure that crews are aware of the potential risks of landing short in large aircraft. | 1.4.579 |
| 1.5.7. | **The ISTAR Force Commander should:** | |
| | Ensure implementation of formal Eye to Wheel Height instruction during conversion to type training to ensure that crews are aware of the potential risks of landing short in large aircraft. | 1.4.579 |
| 1.5.8. | **The Hercules Delivery Duty Holder should:** | |
| | a. Ensure that the Risk to Life associated with the use of Door Observers is Tolerable and ALARP, and founded on an objective ALARP argument in accordance with Regulatory Article 1210. | 1.4.494.a |
| | b. Identify all Risks to Life not transferred to Bowties from the Platform Safety Risk Register in order to ensure that they have been appropriately sentenced and remain under a robust risk management regime | 1.4.494.b |
| | c. Revise his Air Safety Management System to assure compliance with the 2 Group Air Safety Management System Plan and ensure that Defence Air Safety Occurrence Reports resulting in Operating Duty Holder level risk are formally elevated within the Air Safety Information Management System for subsequent risk management activity. | 1.4.642 |
| | d. Provide guidance on: | 1.4.643 |
| | (1) Appropriate methods of reporting from operationally sensitive locations in order to capture Air Safety risks without compromise to operational security. | |
| | (2) Utilisation of the Recommendations function within the Air Safety Information Management System to generate an auditable record of actions taken in addressing investigation findings. | |
| 1.5.9. | **Inspector of Flight Safety, Royal Air Force Safety Centre, should** | |
| | Investigate the Lower Rate of Air Safety Reporting identified from Operational Locations and advise the SDH accordingly. | 1.4.644 |
| 1.5.10. | **Deputy Assistant Chief of Staff, Air Capability Development should:** | |

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| Re-invigorate the NVG Capability Working Group in order to ensure responses from pertinent stakeholders regarding recommendations made in the 2012 'Optimisation of NVG Training and Maintenance for Aircrew and Survival Equipment Fitters' Report are recorded formally. | 1.4.540 |

1.5.11. **Defence Equipment and Support, Hercules Team Leader should:**

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|---|---|
| a. Amend AP 101B-0704/5-15A1C Part 3, Chapter 4, paragraphs 33 to read, *'The Covert Infra-Red (IR) landing, taxi (main landing gear) and wingtip taxi lights used together provide an adequate source of ground illumination while performing NVG landings in low ambient light conditions (<10mlux). The required visual references to achieve a safe landing are likely to be acquired at or below 100 ft, providing there is sufficient surface texture.'* | 1.4.275 |
| b. Take urgent action to determine extent of unserviceable Infrared Emitting Diodes throughout the Hercules Fleet. | 1.4.298.a |
| c. Establish the veracity of reduced Infrared Emitting Diode output reported by QinetiQ, and determine any effect on the Platform Safety Case. | 1.4.298.b |
| d. Revise current Servicing and Maintenance Schedules to include the necessity to confirm individual Infrared Emitting Diode serviceability and allow for any effects of degradation | 1.4.298.c |
| e. Revise the servicing schedule for MOD/HECJ/1057 & MOD/HERCJ/1073, specifically for the Circuit Breaker Panels and Weapon Stowage in order to ensure effective maintenance periodicities for higher frequency use areas. | 1.4.389 |
| f. Provide a Hercules Flight Deck Weapon Stowage compatible with the L85A2 SA80 Theatre Entry Standard Rifle. | 1.4.395 |
| g. Review all associated Trials Reports in order to ensure all safety recommendations emanating from Trials Reports have been sentenced with an auditable record of decisions. | 1.4.471 |
| h. Establish a procedure for checking, and correcting, Head Up Display alignment. | 1.4.589 |

1.5.12. **Deputy Assistant Chief of Staff, Aviation Medicine should:**

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| Incorporate pertinent aspects of the 2012 'Optimisation of NVG Training and Maintenance for Aircrew and Survival Equipment Fitters' within Night Vision Goggle training conducted at the Royal Air Force Centre of Aviation Medicine. | 1.4.541 |

1.5.13. **Defence Equipment and Support, Aircraft Commodities Project Team Leader should:**

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| Amend aircrew helmet support and maintenance documentation to ensure coherency and clarity of guidance. | 1.4.376 |

1.5.14. **Hercules Delivery Duty Holder, Chief Aircraft Engineer should:**

a. Assure the Delivery Duty Holder that DAP 108A-006-2 (N/A/R)1 and DAP 108F-0214-1 are being complied with at RAF Brize Norton. 1.4.377

b. Ensure compliance with on aircraft maintenance and servicing for Flight Deck Armour and Weapon Stowage. 1.4.388

## PART 1.6

## Convening Authority Comments

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## PART 1.6 – CONVENING AUTHORITY COMMENTS

1.6.1. On 25 Aug 17 ZH873[1] suffered Category 5 (Component)[2] damage during a routine night resupply mission with the crew on Night Vision Goggles (NVG). The aircraft experienced a hard landing[3], whilst conducting a Military Operating Standard (MOS) approach to a semi-prepared Temporary Landing Zone (TLZ). A go-around was initiated and the aircraft successfully recovered to a diversion airfield. Although ZH873 was effectively 'written-off' by the impact of the hard landing, thankfully only relatively minor injuries were sustained by some of the nine persons on board.

1.6.2. ZH873 came from 47 Squadron's Hercules Detachment, forward based as part of 903 Expeditionary Air Wing (EAW), at RAF Akrotiri in Cyprus[4]. Its task on 25 Aug 17 was in support of operations and governed by appropriate and comprehensive orders. As a planned operational necessity, ZH873's landing weight was in excess of its normal Release to Service (RTS) All Up Mass (AUM) limits for MOS landings[5]. This weight was, however, compliant with an Operational Emergency Clearance (OEC).

1.6.3. I am grateful to the Service Inquiry (SI) President and his Panel for their very comprehensive Report. It is thorough in its consideration and analysis of the considerable evidence gathered and has met fully the Terms of Reference (TOR) I set. I agree with the findings of the Report and with the recommendations it makes. If implemented fully, I'm confident the recommendations will help prevent a recurrence of a similar accident. The Report will be of interest beyond the Hercules community and those in 2 Gp. Its findings are relevant to those involved in the planning and conduct of aviation operations and especially those responsible as commanders, supervisors, authorisers and Duty Holders (DH).

1.6.4. The accident was caused by a late, incomplete and ineffective flare resulting in a landing short of the TLZ runway. The inability to judge the timing of the flare and achieve a safe landing was due to a lack of Situational Awareness (SA) amongst the crew. A variety of inter-linked factors[6] compounded this lack of SA and made the accident more likely. An upslope just prior to the 'touchdown' area of the TLZ exacerbated the impact of the landing and damage caused. I will restrict my comments to the SI's more pertinent findings where shortfalls resulted in ZH873's mission on 25 Aug 17 not being best set up for success. In this I will consider the TLZ, operating safely in low ambient light levels and the technique used during the approach. I'll then comment on authorisation, crew composition and broader findings concerning air safety management before summarising.

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[1] ZH873 is the military registration of the C130J Hercules involved in the accident. Throughout this Section 1.6, the registration will be used.

[2] From the MAA's Master Glossary – Category 5 (Component). The aircraft is beyond economic repair, or is surplus, but is recoverable for breakdown to components and spare parts.

[3] Analysis assessed the impact as 4.225g against a limit of 2.5g.

[4] The Hercules Force comprises two squadrons. XXIV Squadron is the Hercules Operational Conversion Unit (OCU) and 47 Squadron holds crews at Readiness for operations.

[5] The RTS limit for MOS landings is 58,970kgs. Operational Emergency Clearance (OEC) 022 permitted landing up to 62,500kgs.

[6] These factors included Infra-Red Landing Light serviceability and operation, Crew Resource Management (CRM), handling technique, light levels, Radar Altimeter (RADALT) readings and potential visual illusions.

## The TLZ – Opportunities Missed

1.6.5. The task conducted by ZH873 on 25 Aug 17 was considered routine in that resupply flights had been flown to the TLZ every 4-6 weeks between Aug 16 and Feb 17. From Feb 17, the requirement had increased with up to 2 x resupply flights per week. The TLZ was classed as 'semi-prepared' and marked using the NATO standard night configuration (Box + Z). Despite it being a NATO standard and likely to be used frequently by UK crews, the configuration was not listed in either the Manual of Aerodrome Design and Safeguarding (MADS) or the Tactical Air Transport Operations Manual (TATOM). Furthermore, the Box + Z configuration was not used during live or simulated training.

1.6.6. The Detachment's Advanced Mission Planning Aid (AMPA) displays mapping and imagery and is used extensively for planning. The AMPA in use for this mission contained images that pre-dated the TLZ's construction, with no process to provide regular updates evident. Discrepancies existed regarding TLZ survey data, specifically on its slope, with no mention of a significant upslope immediately prior to the landing point[7]. Crews that had flown to the same TLZ previously had experienced unusual Rad Alt readings on the final approach, but this had not been reported through either the Air Safety Information Management System (ASIMS) or to the Detachment Commander. It was not possible for the SI to conclude how any additional information might have altered ZH873's approach to the TLZ, but opportunities to improve familiarity with the TLZ were missed.

## Operating Safely in Low Ambient Light Levels

1.6.7. The crew's ability to acquire sufficient visual cues in the low ambient light level conditions faced on 25 Aug 17 was fundamental to the conduct of a safe landing. The TLZ did not represent a conventionally lit runway, but had the 'bare minimum TLZ markings'. It was dark as ZH873 conducted its approach to the TLZ. The crew expected light levels between 4-8 mLux as per the Meteorological Brief, but actual levels at the TLZ were closer to 2 mLux, as the Brief failed specifically to consider weather and light levels at the TLZ[8]. This meant the crew could see little more than the 5 x fixed Infra Red (IR) markers delineating the runway. Insufficient ground definition made it difficult for the Pilot Flying (PF) to judge his position and therefore when to flare.

1.6.8. NVG MOS approaches are conducted with the extensive use of aids provided within the aircraft's Head Up Display (HUD). The Aircrew Manual (ACM) states these should only be used until approximately 100 ft above ground level (agl) after which the approach should be continued using visual cues only. Indeed, there is an expectation in governing documentation that all approach procedures should ultimately end with a visual approach. However, the SI found inconsistencies in relevance and clarity in this documentation. Both the Manual of Military Air Traffic Management (MMATM) and Air Mobility Air Staff Instructions (AMASI) were found not to be relevant to NVG operations to TLZs[9]. Furthermore, 2 Gp Air Staff Orders (ASO) lacked clarity in defining required visual references for NVG MOS approaches.

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[7] Between the RAF Tactical Air Traffic Control (TACATC) survey conducted on 2 Feb 17 and a partner nation survey conducted on 3 Mar 17. The former stated the runway sloped upwards, the latter stated the opposite.

[8] The Meteorological Brief received by the crew was considered inappropriate as it failed to consider the weather, including light levels at the TLZ, although these levels were within limits for the task.

[9] The Manual of Military Air Traffic Management (MMATM) states: 'All current approach procedures ultimately end with a visual approach when the required visual references are acquired or when a missed approach is begun'. The MMATM continues to describe what constitutes 'required visual reference', but these were found to be pertinent to landings from instrument approaches to conventionally lit runways, and not relevant to NVG operations to TLZs. Air Mobility Air Staff Instructions (AMASI) contained the same criteria.

1.6.9. The crew were wearing NVG to facilitate visual flying at night in a tactical environment. To maximise their performance, the NVG must be correctly fitted to the user and the optical focus adjusted to provide a comfortable viewing distance. To achieve the latter a Hoffman 20/20 Box is used. Although the Hercules Detachment had a Hoffman Box, the crew of ZH873 elected not to use it. Whilst both pilots' NVG were found to be fully serviceable, it was not possible to determine if they were focussed and adjusted to achieve optimum performance. Any incorrect adjustment would have degraded the pilots' visual acuity and reduced their SA. Furthermore, although the Hoffman Box was routinely used during training serials in the UK, not doing so prior to deployed operational sorties appeared to have been established as a cultural norm.

1.6.10. The aircraft has lighting to assist crews during landing, especially during low ambient light conditions. These lights can be selected to 'white-light' for conventional landings or 'covert' Infra Red Emitting Diodes (IRED) for use with NVG. As ZH873 was flying in a non-permissive environment, the crew elected to use covert external lighting. Pilot witness testimony regarding poor visual acuity during the final approach, prompted the SI Panel to task the conduct of a trial. This trial was to assess the effectiveness of different lighting configurations and whether these provided the levels of illumination stated in the Aircrew Manual (ACM). The Air Warfare Centre (AWC) conducted Trial ILLUMINATOR. The Trial's findings contradicted ACM advice and compelled DG DSA to issue Urgent Safety Advice during the conduct of the SI[10]. The incorrect advice given by the ACM made the accident more likely.

1.6.11. Notwithstanding the findings of Trial ILLUMINATOR, the SI further investigated if the covert lights had been switched on and whether they were fully serviceable. Landing light switch positions are neither recorded by the aircraft's Digital Flight Data Recorder (DFDR) nor Data Transfer and Debrief System (DTADS) and any Cockpit Voice Recorder (CVR) evidence on confirmation of switch selection would have been over-written[11]. In interview neither pilot could categorically recall whether the landing lights had been switched on prior to landing.

1.6.12. Ground testing of ZH 873's external IR lighting system determined that 40% of external IR Taxi and Landing lights were unserviceable[12]. Furthermore, the Flight Servicing Schedule does not require confirmation that all IREDs within each cluster are serviceable, with technicians more focused on whether lights worked and not on how well they worked. ZH873's light units were sent to QinetiQ (QQ) to test their output. This found not only that 60% of the IREDs were not working, but that the output of those that did illuminate had degraded below that of the manufacturer's specification. Had the lights been switched on and operating in the condition measured by QQ, then it would almost have been impossible for the crew to transition to visual cues from 100 ft above the runway in accordance with the ACM. In summary, there would have been insufficient ground illumination to achieve the required visual cues, owing to the non-selection, unserviceability or degradation of the aircraft's external covert IR lighting system. This made the accident more likely.

1.6.13. ZH873 was fitted with a Radar Altimeter (Rad Alt), which provides instantaneous 'height above ground' information. It assists with SA during an approach but is not to be used to initiate a flare during a MOS approach[13]. During the approach to the TLZ on 25 Aug 17, the PF requested

[10] The Urgent Safety Advice (20180910-DSA URGENT SAFETY ADVICE_C130J-OS) recommended ACM advice be amended as the Trial had confirmed the Covert landing lights on their own would not provide sufficient illumination and needed the use of all covert lights.

[11] The CVR was serviceable however, it only records and stores 30 minutes of data before erasing and re-recording. All data from the TLZ approach and landing had been over-written.

[12] This included 1 of the 2 IREDs in the Port landing light and 1 of 3 IREDs in the Port Main Landing Gear (MLG) taxi light, and on the Starboard side, 1 IRED in the MLG taxi light was unserviceable.

[13] In accordance with the Hercules Release To Service, the ACM and XXIV Squadron training documentation.

the Pilot Non Flying (PNF) to provide Rad Alt calls at 50 ft, 20 ft and 10 ft. Both recall a 50 ft call and that the aircraft impacted the ground very shortly after the 20 ft call. Had the crew been aware of the rising terrain leading to the TLZ and the slope immediately preceding it, they might have realised the Rad Alt indications would be greater than their actual vertical separation from the TLZ threshold. It is probable the PF placed an over-reliance on the Rad Alt for his SA, and highly probable that the PF was relying on the 10 ft Rad Alt call to judge his flare, given the lack of visual references. This reliance on the Rad Alt made the accident more likely.

**Selecting the Correct Aiming Point**

1.6.14. The Hercules ACM prescribes aiming 150 ft into the touchdown box when flying a MOS approach. The pilot is assisted in assessing this by features provided in the HUD[14]. However, on ZH873's approach to the TLZ, the PF elected to aim at the front of the touchdown box. This reflected the PF's recent experience of flying lighter aircraft in the training environment, where he described a tendency for the aircraft to 'float' and touchdown towards the back of the Touchdown Box. By aiming shorter he sought to prevent missing the Touchdown Box and having to initiate a 'Go Around'. The SI found that had the PF aimed into the Touchdown Box in accordance with the ACM, then it's almost certain ZH873 would have landed further forward than it did and on the prepared overrun surface. This would almost certainly have resulted in less structural damage to the aircraft. The PF's selected aiming point made the accident more likely.

**Authorisation**

1.6.15. The regulatory requirement for authorisation is laid out in MAA RA 2306. The primary tasks of an Authorising Officer are to detail the Aircraft Commander, ensure they are capable of carrying out their responsibilities as detailed and that crew members are qualified, in current flying practice and capable of executing the tasked mission[15].

1.6.16. **Experience**. Both pilots in ZH 873 were very experienced with a total of some 13,000 flying hours between them. Both were graded as Combat Ready (Above Average), were qualified Aircraft Commanders and Flying Instructors. The PF had deployed as a volunteer from the OCU. He had not been on operations for over 3 years, had conducted only 3 x MOS approaches in the previous 8 months (2 to a natural surface), but none had been with a heavy aircraft. He had no prior experience of the specific TLZ. The PF's deployment was for only 10 x days. This contrasts to the PNF who had extensive operational experience and recency. He had flown 24 x MOS approaches in the previous 8 months (20 to a natural surface). He was fully current throughout the year with circa 3 x times the total hours and circa 4 x the 'seat' hours compared to the PF. He had also flown to the specific TLZ before as PNF.

1.6.17. **Currency**. 2Gp and the Hercules Force's underlying orders for flying were found appropriate and met MAA Regulations. Whilst basic flying currency requirements were not found to be a factor, the PF was not compliant with the 3 month rolling requirement for Total Flying Hours when he undertook the sortie on 25 Aug 17 and had not been throughout the year. This non-compliance was widespread across the Hercules Force and particularly within XXIV Squadron. No assessment with any degree of certainty could be made on whether this lack of currency contributed directly to the accident. However, shortfalls in currency are likely to increase the risk of skill fade and make building experience more difficult.

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[14] These features include the Flight Path Angle (FPA) and the Climb Dive Marker (CDM).

[15] This is not the complete requirement as laid down in RA 2306.

1.6.18. In authorising ZH873's flight on 25 Aug 17, the Authorising Officer detailed the PF as the Aircraft Commander. This judgement appeared to lack full consideration of the PF's recent operational and NSO experience and was made without reference to the PF's SDAC[16], which had not been completed as required by 2 Gp Air Staff Orders and the Flying Order Book. The Authorisation process thus did not identify risks inherent to the crew's composition, particularly in allocating duties and nominating the aircraft commander. This also adversely affected Crew Resource Management (CRM)[17]. Despite a lack of CVR data, witness testimony supported an assessment of a flat cockpit gradient and a lack of assertive behaviour[18]. Shortfalls in both Authorisation and CRM made the accident more likely.

**Air Safety Management**

1.6.19. The sortie required the use of 2 x Operational Emergency Clearances (OEC)[19]. The use of OECs is governed by RA 1330. Their implementation by the 2* Operating Duty Holder (ODH) requires a declaration in (and update to) the platform's Safety Statement in accordance with RA 1205(3). These and other processes fall within Air Publication (AP) 8000 – The RAF Safety Management Policy. The SI found shortfalls against policy. Of significance, the ODH chaired Hercules Air System Safety Working Group (ASSWG) was non-compliant with RA 1330, AP 8000 and the 2Gp Air Safety Management Plan (ASMP)[20].

1.6.20. Although these shortfalls did not contribute directly to the accident, documentary disparities and inconsistencies in the handling advice issued to the Hercules Force for MOS approaches were judged to have made the accident more likely. Handling advice given in the ACM, TATOM and in XXIV Squadron training slides all differed. Aside from the training delivered on XXIV Squadron being found to be incorrect, these disparities could lead to a wider perception of flexibility in how an MOS approach should be flown.

**Summary**

1.6.21. This SI has been particularly thorough in its analysis in determining what happened and why[21]. The Hercules Force is rightly held in high regard, owing to its consistency in meeting a significant operational demand with recorded success. Yet the majority of the SI's findings concern areas where shortfalls could quickly erode the operational 'edge' and excellence that separates success from failure. Arguably this was the case for ZH873 with two vastly experienced pilots ultimately being placed in a position of attempting to land without being able to see the landing site. Perhaps an example of how factors can conspire to negate even the most basic 'Airmanship' principles.

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[16] The Statement of Deployed Aircrew Capability (SDAC) includes a pen-picture of the pilot describing his qualifications, currency, ability and competencies.

[17] Effective Crew Resource Management (CRM) is better achieved when the selection of cockpit crew results in an appropriate gradient in terms of rank, experience, ability and personality. A 'flat' cockpit gradient can impact effective CRM as pilots are less likely to challenge actions or raise concerns, owing to an expectation that the other crew member will perform a task successfully.

[18] For example, the PNF, despite noticing the PF was utilising the incorrect TLZ aiming point, did not raise a concern. The PNF stated he may have been more likely to intervene had he been flying with a less experienced Captain.

[19] OECs are used to clear the use of equipment, systems or operating modes that do not satisfy the project safety standards for a Release to Service, but can be included with special conditions attached. For the sortie OECs 001 (MOS) and 022 (increased all up mass for landing) were required.

[20] This included Hercules Safety Statements not being issued annually, Safety Statements not recording OECs and incomplete ASSWG Records of Decisions.

[21] Aside from the Causal Factor, it has identified 16 x Contributory and 20 x Other Factors. It also makes 25 x Observations.

1.6.22. I highlight Governance as the most pressing concern and in this the standards of leadership, supervision and assurance demonstrated by both the operational chain of command and Duty Holders. This could easily be regarded as complacency, reflecting an attitude endemic in a small force, where 'everyone knew each other'. The evidence just from the selection, preparation and deployment of the PF supports this. The evidence also suggests a 'normalisation of ineffective practices'. Both are indications of a weakening Safety Culture and should be of concern. Notwithstanding, the energy and focus shown by the ODH during the conduct of this SI, gives me confidence its findings and recommendations will be given the appropriate priority.

**Lieutenant General Richard Felton CBE**
**Director General, Defence Safety Authority and Convening Authority**