deployed AESOs. The system appears to work very well but for some slight overlap regarding the delineation of responsibilities between the PAE in theatre and the SO1 AEO BARO. The PAE has been given level K for the H450 and, according to the JHC Command Instruction (CI), responsibility for ensuring that engineering governance is maintained for Tactical UAS and Mini UAS in theatre.

Witness 19
Exhibit 79
Witness 33

1.4.160. **H450 GTOLS Re-implementation. (S26)**

. The DDH issued a comprehensive set of instructions to be carried out by 57 Bty before they could **(S26)** in Sept 11. The final instruction to the BC 57 Bty, was to:

Exhibit 36
Exhibit 82
Witness 17

"Ensure 32 Regt RA Operating Standards Cell (OSC) provide the DDH with assurance that the procedures are carried out correctly."

Exhibit 82

This instruction was later superseded by a command from the DDH removing the explicit requirement for external assurance of the safe use of GTOLS:

Witness 32, 33, 34

"Principle is that TH IUAS Bty is fully qualified and competent to commence GTOLS launch and recovery without external assistance; recognised they are not current. However Comd wants assurance that no 'novel' issues or incorrect practices have arisen with the enforced EP role in predominantly a GTOLS process; this is the specific role of the OSC. Hence 57 Bty need to complete all preparation prior to OSC arrival, and <u>can</u> hold until OSC attendance if such issues/practices have arisen, or <u>continue</u> and demonstrate correct confidence and competence to OSC. Th IUAS Bty dry drills and work up should flush this out well before."

Exhibit 82

Despite a **(S26)** , 57 Bty were still technically current in GTOLS and there was an impetus to get the GTOLS procedures running again. Both 1 Arty Bde staff and the DDH's SO acknowledge that they applied pressure to 57 Bty to **(S26)** because 57 Bty needed to be current in GTOLS in order to qualify 10 Bty during the forthcoming ThQ process. Once the Panel arrived in theatre, it quickly became apparent that errors had been made with the GTOLS approach. Therefore, immediate safety advice was issued to the DDH to reinstate the requirement for the OSC to oversee the **(S26)** .

Witness 32, 33, 34
Exhibit 148

1.4.161. **NSI Recommendations.** Recommendations from previous NSIs and a BOI were captured by 1 Arty Bde through the Issues and Risk Register. More recently, a Post Aircraft Accident Follow Up (PAAFU) spreadsheet has been created to manage these recommendations. There is evidence to suggest that previous NSI recommendations have been recorded and actioned, but the Panel discovered there were occasions where a recommendation would reappear again as part of another inquiry, suggesting a lack of action.

Exhibit 83
Witness 32, 33, 34

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1.4.162. **Human Factors - RAF CAM Report.** The RAF CAM HF report was received and read by HQ 1 Arty Bde, but not captured on the Issues and Risk Register, nor any specific action taken on the recommendations. There was a general awareness of HF among the organisation and there were qualified personnel acting as HF facilitators; however there was no evidence to suggest any particular significance was placed on the findings of the RAF CAM report by HQ 1 Arty Bde. The following are a selection of the most significant recommendations taken from the RAF CAM HF report: Exhibit 16 Witness 32, 33, 34

a. H450 training should be reviewed to ensure crews are provided with sufficient skills and knowledge prior to deployment to effectively operate the H450. This training should include sufficient airmanship training so they can effectively manage both the mission and the mission preparation. Exhibit 16

b. H450 crews should be provided with sufficient consolidation time to process and practise all required skills.

c. IP training should be reviewed to ensure crews are provided with sufficient human factors knowledge and skills prior to deployment to effectively operate the H450. This training should at least include information on distributed situation awareness, distraction, scan biases, fixation, visual illusions and how to manage workload and control human error.

d. IP simulator hours should be officially and independently logged.

e. IPs should be provided with guidance on the emergencies and handling activities to achieve within the designated 10 hours in the simulator.

f. The role of the Mission Commander should be reviewed to ascertain if it is achievable to increase mission supervisory responsibilities to improve flight safety.

g. Training and experience for the UAS-c role should be reviewed. Training for this role should at least include aircrew / airmanship leadership training.

h. Crews should perform regular debriefs to improve flight safety by catching unknown operating norms or errors and improving performance accordingly. Debrief sessions should regularly include the review of mission tapes.

i. Crews should be briefed on the use of and functionality of GTOLs prior to **(S26)** *. This is to minimise the risk of inappropriate and/or untimely recovery inputs as a result of lack of trust and system understanding.*

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1.4.163. The recommendations above are echoed by the findings and recommendations of this SI. Most significantly, the RAF CAM HF report provided a summary of the identified faults and probable impact on future incidents which, as it is of significance in demonstrating the accident route matrix, is reproduced here: Exhibit 16

SUMMARY AND PROBABLE IMPACT ON FUTURE INCIDENTS

The majority of the factors raised in this report concern an insufficient aviation infrastructure for the H450, i.e. most factors were at the organisational level. Although many factors have been raised concerning training, there was no evidence to suggest unsafe supervision. In fact to the contrary, the supervisory chain had attempted to mitigate some of the safety factors by implementing procedures and practices that were achievable within their current resources. Although most factors were favourable at the local level, again it is recommended this study is conducted outside the 100 day wind period and preferably towards the end of a tour for a more representative operating picture. Exhibit 16

The identified factors may influence the likelihood a H450 crew would enter a hazardous scenario and the likelihood that crew may fail to recover from that scenario, should these factors not be addressed. A summary of the factors raised are provided in Figure 15. Exhibit 16

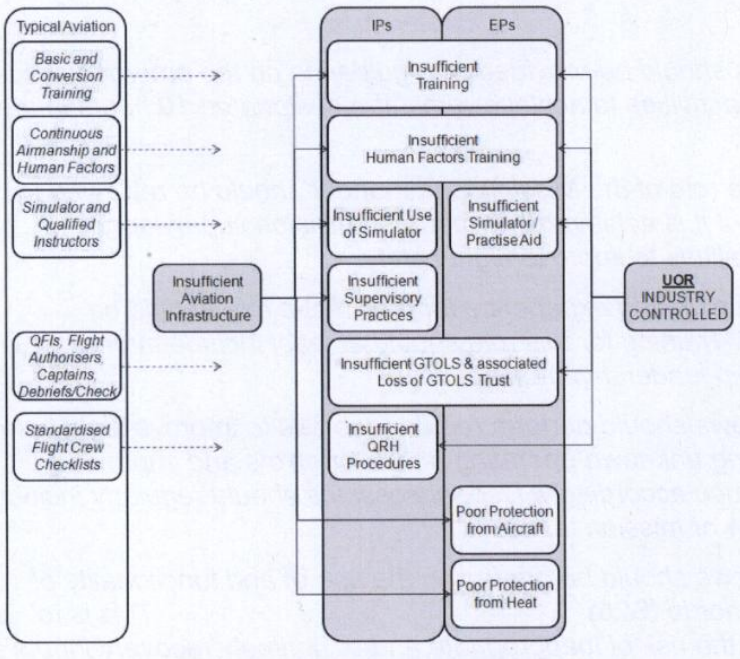

Figure 15 - Summary of identified factors

These factors have been highlighted on RAF CAM's Accident Route Matrix in Figure 16 to illustrate a potential route to another H450 incident or accident. Exhibit 16

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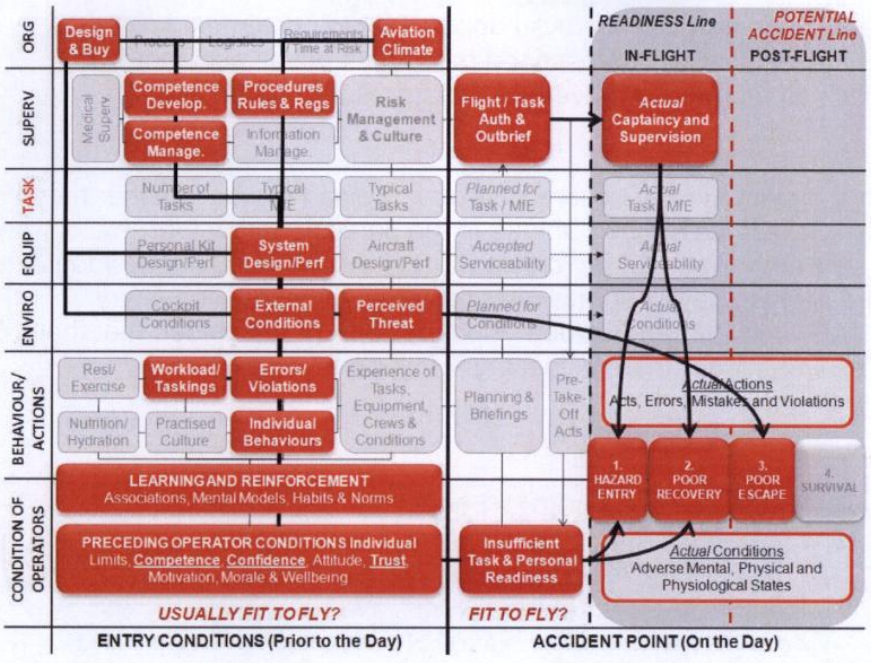

Figure 16 - Identified factors on the Accident Route Matrix - showing <u>potential</u> accident route in Jun 11

1.4.164. From the potential accident route matrix above, identified by RAF CAM in Jun 11, 4 months before ZK515's accident, it can be seen in the Accident Point (on the day) section that the identified factors were very close to predicting what happened in this accident. In this respect, the predicted accident factors can be matched against the entry conditions for ZK515's accident:

Exhibit 16

Level	Factor	Identified as Potential Hazard in June 11	Contributor to ZK515 SI in Oct 11
Organisation	Insufficient aviation infrastructure	✓	✓
	Insufficient training content	✓	✓
	Insufficient airmanship training	✓	✓
	Insufficient captaincy selection and training	✓	✓
	Insufficient GTOLS training	✓	✓
	Insufficient ATC integration to training	✓	✓
	Insufficient human factors training	✓	✓
	Insufficient training continuity	✓	✓
	Insufficient consolidation	✓	✓
Supervision	Insufficient task supervision (see captaincy training)	✓	✓
	Insufficient competency checks by non-Instructors	✓	✓
Task	Remote control, visual monitoring workload	✓	✓
Equipment	Lack of trust in GTOLS due to poor training / NSIs	✓	✓
Environment	Operational pressures, H450 low priority for ATC	✓	✓
Operator	Insufficient task readiness due to above factors	✓	✓
	Insufficient GTOLS operating confidence	✓	✓

Table 2 – Entry Conditions for ZK515's accident
(Reproduced from exhibit 7)

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Therefore, the Panel observed that a crucial opportunity to implement key actions that could have prevented or lessened the impact of this accident was missed due to a lack of importance placed on the Jun 11 RAF CAM Human Factors report.

1.4.165. Another aspect the Panel considered regarding HF was whether the accident on 2 Oct 11 would have been unique to the particular crew that operated ZK515, or whether any 57 Bty crews were at the same risk of accident and therefore were likely to have had a similar outcome given identical entry conditions. The RAF CAM Aircraft Accident report for ZK515 concluded that the general level of risk was higher than necessary for all 57 Bty crews, as presented in Table 3 below: Exhibit 7

Key Risk Factor	PRIOR TO THE ACCIDENT DAY THE PROBABLE RISK FOR *ALL* CREWS WAS:		Reason
	Expected Level of Risk	Higher Than Necessary Risk	
Hazard Entry		Yes	All Entry Conditions, leading to insufficient task readiness and potentially insufficient personal readiness for the SO. + Lack of sufficient mitigation for an unexpected GTOLS landing.
Poor Recovery		Yes	

Table 3 – General risk from entire Bty
(Reproduced from exhibit 7)

1.4.166. Linked to the analysis above was the evaluation conducted by RAF CAM into the assessment of risk carried for the crew of ZK515 to ascertain whether the specific crew were at risk of this accident before they even took off. It was concluded that there were no on-the-day variables that made the crew of ZK515 at any greater risk than any other crew that had not prepared for a GTOLS landing and had an in-flight emergency, shown in Table 4: Exhibit 7

Key Risk Factor	ON THE ACCIDENT DAY THE PROBABLE RISK FOR THE CREW OF ZK515 WAS:		Reason
	Expected Level of Risk	Higher Than Necessary Risk	
Hazard Entry	Yes		Contributors were inherent to most crews, not specific to ZK515.
Poor Recovery	Yes		

Table 4 – On-the-day risk for the crew of ZK515
(Reproduced from exhibit 7)

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1.4.167. **Training Assurance.** RA TDT are the TRA and are responsible for providing external assurance of the training provided in accordance with the Defence Systems Approach to Training (DSAT) process. As H450 is a UOR and was only intended to be in service for 2 years, there was originally no requirement for a Training Needs Analysis (TNA). However, whilst the UOR continues to be extended, now in its sixth year, there is a growing need to conduct a proper job analysis[83] to ensure the training provided accurately reflects the current requirement. Although it may be too late to make a difference while H450 remains in service, the importance of training that is fit for purpose should not be underestimated. RA TDT have been carrying out external validation (Exval) on all of the courses within their area of responsibility and they have been monitoring the pilot training in **(S26)** . The responsibilities within the H450 training pipeline have become fragmented over time, with various different training agencies taking responsibility for different elements due to manpower constraints. For example, GTT is the organisation responsible for delivering collective training, but has been tasked to review the UAS Level 3 course. The Panel believes that the UAS Level 3 course is part of the RA Career Employment Group (CEG) training pipeline and not just for the UOR. As such, the Level 3 course will become part of the Watchkeeper training package and therefore should be subject to a proper Job analysis with TOs formulated by RA TDT.

Witness 32, 33, 34

Exhibit 84

Exhibits 85, 86 87, 88, 90

Exhibit 84

Witness 32, 34

1.4.168. Notwithstanding TDT's responsibility towards individual courses, the DDH has overall responsibility to ensure the training pipeline delivers personnel suitably trained, qualified, competent and current to carry out their assigned task. With extremely limited opportunities for continuation training, the training pipeline delivers an output that is "just enough just in time"; the DDH organisation accepts that the entire training pipeline for H450 is truncated as a result of the operational requirement. The DDH organisation acknowledges that there is a risk in terms of limited training and experience when the pilots reach the front line and agrees there is a competency dip for new pilots between their training in **(S26)** and when they deploy, which can be up to a number of months. Notwithstanding such acknowledgements, these risks are not yet contained within their risk register.

Exhibit 84 Witness 32,33,34

Witness 32,33,34

1.4.169. **Organisational Structure.** A complete UAV Battery deploys as a formed sub unit every 6 months, requiring a considerable amount of preparation and training for both ab initio and qualified plots. This training is carried out over a relatively short period with little time for consolidation prior to deployment. The training pipeline is shown again below:

[83] Job Analysis is a systematic exploration, study and recording of the responsibilities, duties, skills, accountabilities, work environment and ability requirements of a specific job in order to derive an effective training solution.

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(S26)

Figure 17 - Training pipeline for a H450 pilot

1.4.170. The requirement to maintain flying currency for a large pool of H450 pilots with no live flying in the UK and only one simulator is extremely difficult; the system is flawed as pilots on the Bty most recently returned from Theatre are not maintaining the 1 Arty Bde FOB currency requirements. Once promoted past Sgt, a H450 pilot would not expect to be employed in this role again, so flying experience is mainly limited to Bdr and LBdr. The Panel believes that consideration should be given to modernising the structure of a UAS Regt to contain a smaller, centralised pool of UAS operators with a larger rank range and within a specialised aviation Career Employment Group (CEG). This approach would focus the operational experience within the Regt and decrease the training burden which at present is inefficient; roulemont of a Bty every 6 months is not an efficient or intrinsically safe way to conduct flying operations. Figure 18 below shows that over the last 5 years, the majority of incidents are concentrated either side of the Bty changeover period 'Relief-in-Place' (RIP), when the outgoing Bty is likely to be suffering from skill fade and the new Bty is inexperienced. The Panel believes a UAS Regt should comprise of more typical aviation squadron structure consisting of a pool of pilots who can rotate through for shorter periods (for example 2-3 months) to maintain the pool of experience and currency in theatre. This would avoid the lengthy ThQ process every 6 months and prevent skill fade between tours. The transport and subsistence savings from continuous refresher training in **(S26)** is also thought to be worthy of investigation.

Exhibit 73,74

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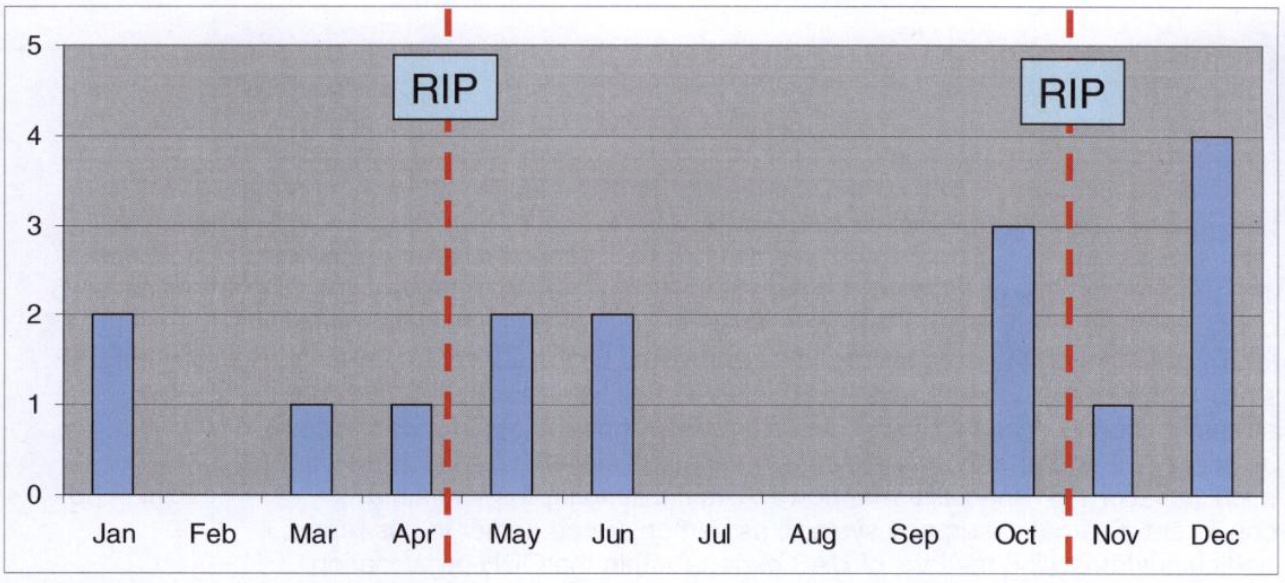

Figure 18 - Graph showing when H450 incidents have occurred over the last 5 years

1.4.171. **Mission Commander.** As highlighted earlier in the report, the MxC role is currently little more than a communications position responsible for obtaining airspace clearances and general liaison. The individual holds the rank of Sgt yet does not have to be qualified as a H450 pilot and has no command or supervisory function within the GCS, despite being the most senior member of the crew. Furthermore, the MxC does not wear a headset whilst in the GCS, resulting in limited SA. If the MxC was required to have previous experience as a UAS-c and was able to maintain currency as a UAS-c, not only would this experience be invaluable during high workload situations and emergencies, but the crew would also be able to rotate rest periods, creating an efficient and more effective crew. Using the MxC in this way would retain and grow experience within the UAS Regts and would be another benefit of implementing a RA aviation CEG. Two previous NSIs and a HF report concluded that the MxC role required extensive updating in order to reflect a more supervisory function. However, the Panel understands that this work has only just been begun.

Witness 11, 32

Witness 30, 34

Exhibit 16

Witness 34

Exhibit 16

"Although the ZK518 NSI went on to recommend that improvements could be made to on-task supervision by increasing the supervisory responsibilities of the Mission Commander, this must only be implemented with clear lines of responsibility and clear piloting experience pre-requisites for the Mission Commander role (not all Mission Commanders were previous IPs). Many accidents have occurred due to the 'I thought it was ok as he never said anything' assumption scenario; a scenario driven by confused lines of authority."

Exhibit 16

Furthermore, the title 'Mission Commander' is potentially confusing and does not adequately reflect the division of responsibility between the MxC and the UAS-c. The Panel believes 'Mission Controller' would be a more appropriate title, reflecting the division of command and control between the GCS crewmembers, akin to that used by the US Army.

1.4.172. **OSC.** The OSC are currently part of 32 Regiment RA chain of command. The Panel believes that the OSC provide a vital function as part of the safe assurance of UAS flying on behalf of the DDH. Consequently, the

Witness 27,28

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Panel believes that the OSC should work directly for the DDH, via the DDH's UAS SO.

Organisational Culture

1.4.173. During the course of the SI, the Panel has observed a number of factors regarding organisational culture. Whilst there is limited evidence to support the following findings, the Panel feels there is merit in inclusion as they help add context to the overall findings of the SI.

1.4.174. The size of the Army UAS community is very limited and consequently a small number of individuals tend to rotate around the specialist jobs, particularly with some officers and specialists such as instructor qualified staff. Conversely, since there is no RA officer specific aviation CEG, career stream officers can move between aviation and other RA jobs, further limiting development and retention of experience within this small community. With such limitations on specialist manpower, it is challenging to maintain a consistent external assurance system, as demonstrated earlier in this report, particularly regarding the lack of UAS experts within the ODH organisation. Moreover, a previous BOI recommended greater involvement with the wider UAS and air community. The Panel has found limited evidence that this is in place and strongly supports greater interaction with other UAS communities. Witness 32 Exhibit 83 Exhibit 43

1.4.175. As with any robust military hierarchical structure, the officers and soldiers within the Regt are highly motivated and focused. They are passionate about the roles they perform and take their position within Army aviation very seriously.

Watchkeeper

1.4.176. Watchkeeper is to be introduced as core equipment, thus in some areas it will be noticeably different to H450.[84] Although not tasked to consider Watchkeeper, the Panel believes there is a real danger of the key H450 SI findings highlighted in this report transferring to Watchkeeper. For example, external assurance and governance, UAS operator selection, simulation and currency, captaincy, airmanship, and some CEG elements of training may be as relevant to Watchkeeper as they are for H450. Therefore, the Panel observes that there is now an opportunity to map the factors and risks identified in this SI across to the Watchkeeper programme to ensure real, tangible progress is made within RA UAS aviation. Witness 32

[84] For example, the Watchkeeper training solution was subject to a TNA, though this was conducted in 2006, and the training facility will be based in the UK.

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TOR M – SECURITY OF PERSONNEL, EQUIPMENT OR INFORMATION

Assess whether the security of personnel, equipment or information was compromised and if so to what degree

1.4.177. No compromise of security has been reported or discovered during the SI.

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TOR N – LOSS OR DAMAGE TO SERVICE OR CIVILIAN PROPERTY

Ascertain value of loss/damage to the service and/or extent(and, if readily available, the value) of loss/damage to civilian property

1.4.178. **Service.** The UA is Category 5, non repairable. The cost of a replacement H450 UA is **(S43)**; financial liability between the MoD and Contractor has yet to be established by the UAS PT. The damage to the concrete of the aircraft dispersal where the UA crashed and the tear to the canvas on the aircraft shelter was assessed as negligible by Sqn Ldr Ops at 903 EAW in consultation with the USAF. Exhibit 149

1.4.179. **Civilian.** Nil.

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TOR O – SAFETY, HEALTH AND ENVIRONMENTAL PROTECTION IMPLICATIONS

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

1.4.180. An initial risk assessment was carried out by the MilAAIB, coordinated with the UAS PT, which identified that Beryllium, used within the H450 Payload, was the only significant hazard. The RAF CAM aircraft hazard data sheet set does not include H450 and such hazard data would have been useful prior to attending the crash site. Exhibit 2

1.4.181. Following return of the UA to the UK, the Institute of Naval Medicine (INM) carried out a risk assessment after a smell of ammonia was emanating from the airframe. The INM Risk Assessment highlighted that no significant risks were apparent. The smell was likely to be from damaged circuit boards or fragmentation of the composites following the accident. Exhibit 2 Exhibit 111

1.4.182. The Lithium Emergency Battery (EB) presented a fire risk after the accident. Normally, once the UA has landed the EB would switch itself off after being in a 'ground state' for 5 minutes. In the case of this accident, this did not happen as the UA pitot probe was ripped off when it collided with the hangar, causing the UA central computer to continue reading an airspeed of 50 knots. The EB can become over discharged once in this state and can heat up over a period of hours and potentially vent or explode. The Theatre UAS Battery was unaware of this risk until they were advised by the DA via the BARO. Exhibit 68

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