c. Despite a perceived pressure to land, there was nothing necessitating an immediate landing. Other options existed, for example, waiting for a possible break in the weather, but these were not explored.

1.4.1.48. **Conclusion**. The Panel concluded that pursuing landing attempts with cloud at the CP was a decision which made the accident more likely and was therefore a **contributory factor**. The Panel further concluded that it was the crew's expectation of being able to make a safe landing during the allocated recovery period and in the prevailing conditions that drove the decision to pursue landing attempts with cloud at the CP.

Selection of Alt Dev Override

1.4.1.49. The *Alt Dev* override could be used to prevent the UA aborting a landing due to a ground proximity being detected by the laser altimeters on the approach. The Panel found that *Alt Dev* override was used on the first 2 landing attempts in accordance with the FRCs, as low visibility was correctly anticipated at the CP.

1.4.1.50. VMSC data showed that the laser altimeters returned a reading of less than 1m due to cloud at the CP. An ATOL *Alt Dev* fault message was recorded on the first approach, so the *Alt Dev* override prevented the UA aborting. The laser altimeter reading, however, caused the VMSC to open a *Ground Touch identification window* leading to the *Land Status Time Out* messages observed when the UA did not progress to the *Free-roll* stage within 2.8 seconds.

1.4.1.51. The selection of *Alt Dev* override prevented a ground proximity abort, but allowed a *Ground Touch Identification Window* to open on the first 2 approaches. Further protection measures, however, aborted these approaches at the end of the *Ground Touch identification Window*. On the 3rd approach MO overrode these further protection measures and the UA proceeded to crash. Therefore, the Panel concluded that the selection of *Alt Dev* override was not a contributory or causal factor.

1.4.1.52. The Panel considered whether the selection of *Alt Dev* override and the opening of the *Ground Touch identification window* put the UA in a hazardous situation and should be classified as an other factor. Whilst the Panel could not discount the possibility that the UA could erroneously sense *Ground Touch* and latch WOW1 within 2.8 seconds, they assessed that unless MO was also selected, a Land Status Timeout abort would be initiated.

1.4.1.53. In conclusion, the Panel found that whilst the selection of *Alt Dev* override allowed a *Ground Touch identification window* to be opened erroneously, exposing the susceptibility of the VMSC software to erroneous laser altimeter readings, a suitable protection measure existed in the abort which followed the *Land Status Timeout* (i.e. the closing of the *Ground Touch identification window*). The Panel assessed that the selection of *Alt Dev* override was **not a factor**.

Selection of Master Override (MO)

1.4.1.54. **Effect of MO**. MO is an emergency function, which overrides all ATOL automatic aborts, although it is still possible for the crew to initiate a manual ATOL abort with MO selected. The purpose and function of MO is described in more detail in the System Description in Part 1.2. Because MO

overrides all automatic aborts, the final approach was not aborted for the *Ground Touch identification timeout*, which happened to have occurred whilst the UA was experiencing *Air Jump*[17]. Therefore, as previously described in Table 3, having already sensed *Ground Touch* and *Air Jump*, the UA proceeded to return from *Air Jump* and declare itself to be *On-ground.* The UA continued to fly for almost one minute passing the *final approach point*, the *underrun* and the *semi-flare* point. At the *underrun* point, a *laser altimeter difference*[18] was recorded, which would also have aborted the landing had it not been overridden by MO. In order to categorise the effect of MO as an accident factor, the Panel considered the following:

a. With MO selected, abort conditions are displayed to the crew and the crew are able to manually abort the approach at any point if required. The crew could have manually aborted the landing until the *Semi-flare* point was reached. Therefore, the crash was not inevitable after the system had declared *On-ground* shortly after the CP.

b. The UA can be landed successfully with MO selected, but with a higher risk of exceeding one or more if its landing parameters and therefore, a higher risk of incident.

c. As MO only prevents the UA from aborting if an abort condition arises, arguably, any incident involving MO would originate from the cause of the abort condition, rather than the lack of an automatic (or manual) abort.

d. If the UA had continued to abort due to cloud at the CP, it would have been appropriate to select MO as a last resort to ensure that the UA had the best chance of continuing to come down on the runway, should it have had insufficient fuel to guarantee completing another circuit. Therefore, whilst it is true to say that the accident would not have happened on the 3rd approach had it not been for the selection of MO, had the weather conditions not improved, an accident may still have occurred.

The Panel concluded that the use of MO did not cause the accident, but failed to prevent it in the same way that the absence of a manual abort action being taken after seeing the *LAND STATUS TIMEOUT* and *Air Jump* messages failed to prevent it. Selecting MO made the accident more likely and therefore was a **contributory factor**. The factors leading to the Selection of MO are discussed in the following paragraphs.

1.4.1.55. **Crew gradient**. The HF report noted the significant difference in experience between the Captain and both the Pilot and Payload Operator. It explained how this gradient may cause the less experienced crew members to defer decision making and limit their influence on decisions. One of the objectives of the sortie was to provide captaincy experience to the Pilot and the

Exhibit 44
Exhibit 42
Exhibit 43

[17] *Ground Touch identification timeout* occurs 2.8s after the *Ground Touch identification window* is opened. Within this time window the UA had sensed *Ground Touch* and *Air Jump*.

[18] The IETP Document Code WATCHKEEP0MK1-AAA-C00-00-00-0000-442A states that *ATOLS Laser Altimeters Diff* means '*A difference of over 20cm between the Laser Altimeters measurements or there is a measurement difference of over 5% between the Laser Altimeter measurements and the aircraft's actual altitude'. Unless overridden, this condition would be expected to cause an ATOL abort.*

Captain reported allowing the crew to handle faults, only offering guidance on occasion. By the recovery phase, however, analysis of the CVR audio showed that the Captain had fully taken charge and was directing the course of action. However, the Pilot did question the Captain during the final approach which influenced his decision to speak with the AO. The Panel found that:

a. During the recovery phase the crew were presented with an unusual and potentially hazardous situation that they had not previously encountered. It was reasonable for the Captain to take charge as he did.

b. The crew, whilst respecting that the Captain had the final call on all decisions, still felt able to ask questions and offer suggestions.

The Panel concluded that crew gradient was **not a factor**.

1.4.1.56. **HF hazard entry**. The Panel considered the factors that influenced the decision to use MO in the 'hazard entry' conditions described in the HF report:

a. **UA aborting at the CP**. The UA had aborted twice shortly after declaring the CP. Analysis of the CVR revealed that the Captain explained to the crew that there was no specific override for the *LAND STATUS TIMEOUT*. He concluded that the only thing that they could do to get beyond that point in the approach was to select MO. The Panel inferred that the Captain believed selection of MO to be the only option at that point in time. Exhibit 44 Exhibit 42 Exhibit 43

b. **Override design**. The Panel noted and considered that: Exhibit 28 Exhibit 44

(1) Individual overrides were necessary to land the UA safely in some conditions and, where the crew fully understood the cause of the ATOL termination, they could be used safely.

(2) Some abort conditions could not be individually overridden. The reason for this is that some conditions, if overridden, could present a greater hazard to the UA. The Panel considered it reasonable that some conditions should not have an individual override.

(3) There may be some scenarios where to abort a landing and go around could present a greater risk to life than to continue to attempt to land. MO was designed to allow the UA to continue to attempt to land by overriding all abort conditions. The Panel found it appropriate that an MO function was provided.

The Panel concluded that whilst there is a risk that crews may regard the use of MO as a progressive step to landing when individual overrides are not available, the design of the overrides was reasonable.

c. **FRC guidance.** The crew's FRCs for an ATOL abort on landing are at Annex A Figure 1. The Panel found that an 'extended Exhibit 47

ATOLS recovery'[19] as referred to in the FRCs, was not available and had not been pre-planned at BDN, as it would have taken the UA outside of its cleared airspace. The crew selected MO after 2 failed attempts with an individual override (*Alt Dev*) selected. In accordance with the FRCs, the Electro-Optic Payload (EOP) and observer were used to monitor the approach as far as possible. The Captain briefed that he would leave MO selected and if he called 'Abort' the crew were to immediately follow his instructions and he would explain why afterwards. The Panel concluded that the crew followed FRC guidance in their decision to use MO.

Witness 15
Exhibit 48
Exhibit 42
Exhibit 43
Witness 9

d. **Understanding of the UA system.** The Captain identified the *LAND STATUS TIMEOUT* as '*effectively the ground proximity identification timeout*'. The Panel found (paragraph 1.4.1.50) that the selection of the *Alt Dev* override prevented a ground proximity abort and that the *LAND STATUS TIMEOUT* signified the end of the *Ground Touch* identification window and not the end of a *ground proximity* condition. The Panel concluded that the meaning of *LAND STATUS TIMEOUT* was not fully understood by the crew. Further analysis on the information available in the ADS for crews to understand and deal with emergency and unusual situations is covered in Section 1.4.2.

Exhibit 44
Exhibit 42
Exhibit 43

e. **Experience of MO use.** The Captain reported previously using MO successfully. He also reported that his understanding of the WK031 accident was that a *Ground Touch identification window* had opened 20m above the ground when MO was applied and a gust of wind had caused the UA to sense *Ground Touch*. The Panel concluded that the Captain's mental model of the situation, and the absence of gusty conditions, led him to believe that he could land the UA safely, in the circumstances, with MO selected.

Exhibit 44
Witness 1

f. **Desire to land.** The HF report concluded that the crew's focus was to land rather than explore other options. The Panel found (paragraph 1.4.1.48) that this was borne out of an expectation to make a safe recovery in the prevailing conditions.

Exhibit 44

g. **CRM.** The HF report explained how the expectation of being able to make a safe landing, coupled with the crew gradient, led the crew into a situation where they only made limited use of resources to increase their understanding of the situation or explore alternative options. After the first landing attempt failed, the Captain briefed the crew that if the second landing attempt failed, they would have no other option than to use MO. He briefed this again after the second failed landing attempt, hence offering them a solution to the *LAND STATUS TIMEOUT* (sub-paragraph a.). Because an experienced operator (the Captain) had offered them a solution, it was unlikely that the Pilot and Payload Operator would explore alternatives. Nevertheless, the Pilot suggested calling in the AO, which the Captain agreed to. When the AO arrived the Captain told him,

Exhibit 44
Exhibit 42
Exhibit 43

'Land Status Timeout at the connect waypoint so we are

[19] A long straight in recovery to provide a smoother and more predicable approach.

having to override it', '….. just thought I'd let you know.'

The language used implied that the Captain was informing the AO rather than seeking to engage in discussion. The brief discussion that ensued demonstrated to the Panel a limited consideration for the effects that this course of action may have or any alternative courses of action.

h. **Perception of the weather.** As previously described (paragraph 1.4.1.47.b), the crew were not expecting an improvement in the weather.

1.4.1.57. **Conclusion**. The Panel found that MO had inhibited the protection measures that would otherwise have resulted in the final landing attempt being aborted by the system (paragraph 1.4.1.27.b). As only manual aborts were possible from this point onwards, the Panel found that the selection of MO made the accident more likely and therefore concluded that the decision making process that led to the selection of MO was a **contributory factor**. As stated previously, the decision to use MO was within FRC guidance. However, the use of MO was predicated on the decision to continue to attempt to land with cloud at the CP. As other options existed (paragraph 1.4.1.47.c) the Panel believe that the decision to use MO was premature given the warning about the potential loss of the UA within the FRCs and in the context of the revised procedures introduced following the loss of WK031.

The crew's understanding of landing logic and cautions seen.

1.4.1.58. As previously described, MO inhibits all ATOL aborts; however, all abort codes, cautions, warnings and advisories continue to be displayed to the crew. Following the selection of MO the crew reported seeing the following messages displayed:

Witness 1
Witness 3
Witness 4

a. Land status timeout (listed as an ATOL *Ground Touch* identification timeout).

b. Jump.

1.4.1.59. The Panel considered the following:

a. Land Status Timeout is designed to occur 2.8 s after a *Ground Touch identification window* is opened if the UA does not progress to *Free roll.*

b. Jump was an indication that a *Ground Touch* had occurred (paragraph 1.4.1.54).

c. These indications would only normally be seen very close to the ground after the UR point and were not expected immediately after the CP.

d. There was limited information on the meaning of these indications in the ADS (Section 1.4.2).

1.4.1.60. The Panel found that:

a. The messages observed by the crew at the CP indicated the

hazard.

b. The crew could not have been expected to have been able to identify the hazard due to the paucity of information relating to the recovery phase in the ADS, which is discussed further in Section 1.4.2.

Accident sequence

1.4.1.61. **Accident sequence**. To ensure that all causal and contributory factors were analysed within the context of the accident sequence the Panel produced the diagram at Figure 8. It can be seen that the accident chain contains human decisions, software logic and pre-programmed events. The Panel considered the reasons why each event occurred and labelled it as an 'input' to the event. Design safety measures and human interventions that could have broken the accident chain were also considered.

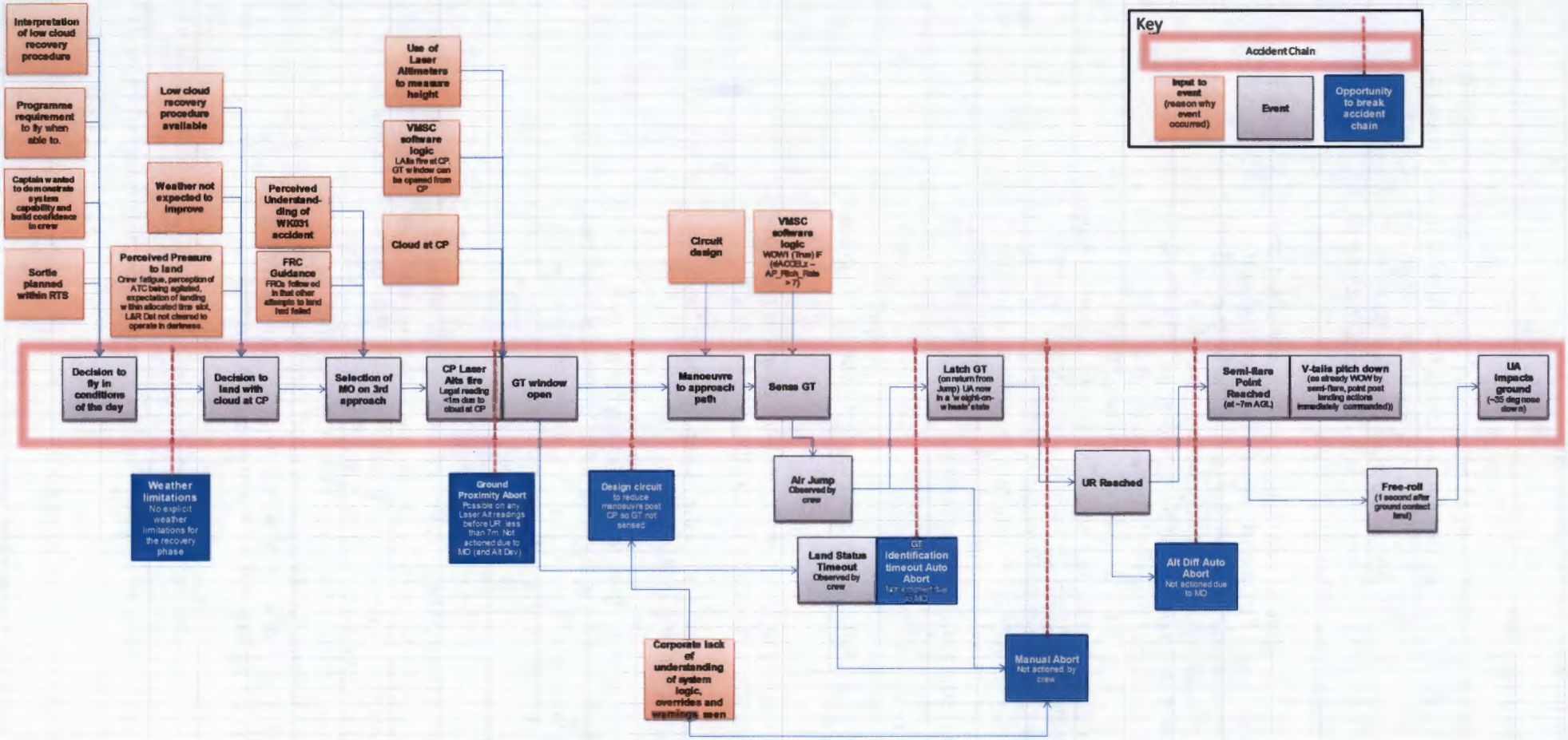

Figure 8 – Accident sequence

Other factors and observations

External Air Temp 1 and 2 sensor fail

1.4.1.62. Early in the sortie the crew experienced an 'external air temp 1 and 2 fail' caution indicating that External Air Temperature readings from both Met Sensors had failed. The crew consulted their FRCs, and a warning stated that crew were to avoid icing conditions and '*Land as soon as practicable*'. The crew assessed that they were clear of icing conditions and elected to continue with the planned sortie. The caution cleared on recovery. Witness 3 Witness 1 Exhibit 47

1.4.1.63. The Panel considered whether this failure had had any effect on the eventual accident, to what extent FRCs had been followed and what the risks were to safety. The Panel could find no evidence that the failure had in any way contributed to the accident. The FRC contained a procedure for calculating the icing risk based on an estimated air temperature. The Panel concurred with the crews' assessment that the UA was not at risk of encountering icing conditions. The Panel asked the crew what their understanding of 'land as soon as practicable' was. The crew's understanding of this differed from the training they had received and the *Notes to Users* in the FRCs, which defined *Land As Soon as Practicable* to be '*Recover to base and land*'. The crew believed that they could continue to achieve the sortie objectives provided they understood the failure and the environment that they were operating in and assessed it to be safe to do so. Witness 3 Witness 1 Witness 15

1.4.1.64. The Panel found that:

a. The External Air Temp 1 and 2 fail caution seen by the crew was **not a factor**.

b. Based on the Met forecast and the crew's assessment that they were in clear air, icing was not a credible risk to the UA.

c. The crew elected to continue the sortie, but could have requested an earlier landing at BDN.

1.4.1.65. The Panel concluded that although the UA was not put in a dangerous situation by continuing with the sortie, it would be normal practice to recover to base and land, given the FRC wording. The implications of non-adherence to FRCs is considered from Paragraph 1.4.1.70.

Crew actions after 1st Abort

1.4.1.66. Shortly after the first aborted approach, the crew re-commanded *LAND* to ensure that the original *LAND* command had been received and in an attempt to get the UA to recommence the landing profile. Instead, the UA re-initiated the landing sequence and turned west towards the beginning of the recovery sequence[20]. Analysis of the CVR showed that the crew had not anticipated this manoeuvre and immediately pressed abort, whereupon the UA flew back to the runway and towards the Go Around Point. The unanticipated manoeuvre was described in Paragraph 1.4.1.24 and shown in Figure 1. Witness 1 Exhibit 42 Exhibit 43

[20] The Panel believe that this manoeuvre was in accordance with the UA's system logic and therefore can be regarded as the 'correct' manoeuvre given the operator input.

1.4.1.67. The L&R Det and a recently qualified WK pilot believed they heard the UA overfly their location at Fire Site 2 on its first approach, rather than down the centre of the runway. Although they could not actually see the UA through the fog, they were sufficiently concerned to move the vehicles and personnel further away from the runway after the AO briefed them that they were going to use MO and it was definitely going to land. Witness 9

1.4.1.68. The guidance in the FRCs for an aborted landing is shown at Paragraph 1.4.1.56.c. The guidance on the implications of an automatic ATOL abort was: Witness 15

> ***Implications***
> *ATOL terminated due Fault / Inaccuracy of one or more ATOL components*
> *GO AROUND / FREEROLL will be performed according to termination logic*

During interview the Thales UK Senior WK instructor explained that pilots were taught to look at the cause of the abort and understand it. He explained that the FRCs should be followed and that the selection of any override was predicated on understanding the cause of the abort and the implications of using the override.

1.4.1.69. The Panel found that the crew did not allow the automatic *go around* to be performed, instead choosing to re-command *LAND* which was not in accordance with the FRCs. In the opinion of the Panel it was unlikely that the crew understood the cause of the abort as they were not anticipating the *LAND STATUS TIMEOUT* message at the CP. The Panel, therefore, concluded that the selection of *LAND* was an action not detailed in the FRCs, carried out at a safety critical point in the flight (on the approach), during a situation that the crew did not fully understand and had not witnessed before in the simulator. The action caused the UA to perform an unexpected manoeuvre at low level. The Panel found that although the manoeuvre performed by the UA took the crew by surprise, in the event, the situation was quickly rectified and did not present a hazard to the UA or contribute to the accident. Further analysis on the issue of adherence to FRC guidance is given under its own heading below.

Adherence to FRC guidance

1.4.1.70. The crew deviated from FRC guidance on two occasions as described in the paragraphs above. Whilst these actions did not contribute to the accident or in the event cause a flight safety hazard, the following paragraphs consider the wider implications of non-adherence to FRC guidance.

1.4.1.71. **Regulation.** The 1 ISR Bde WK Boscombe Down SOP stated that '*all WK emergency procedures will be conducted in accordance with the FRC/FLRC. The commanders do not have authority to override those procedures unless to do so would prevent Risk to Life as expressed in the JHC and DDH FOB forward.*' The FRC 'Notes to Users' stated '*The application of sound judgement and good airmanship applies at all times and is paramount. Any deviation from the prescribed procedures or drills should be fully justifiable and users are strongly advised to record this justification to aid any* Exhibit 5 Exhibit 47

subsequent inquiry or investigation.'

1.4.1.72. **Risk analysis**. The Panel found that the crew understood the issues of inadvertently flying in icing conditions associated with the External Air Temperature sensor failures. They had consciously considered these risks in accordance with the FRC procedure and assessed them to be negligible. Whilst they deviated from the guidance they applied judgement in their decision to continue with the sortie. The Panel believe it unlikely that the crew had fully considered the implications of re-commanding *LAND* after the first abort and assert that the UA's manoeuvre took them by surprise.

1.4.1.73. **Authority**. Deviation from the FRCs was not justified by a clear Risk to Life issue or obvious operational imperative. The crew did not consult with the AO or Flying Supervisor and no authority was given.

1.4.1.74. **Conclusion**. The Panel concluded that there was a limited adherence to FRC guidance, which resulted in unnecessary additional risk being held at an operator level. In the opinion of the Panel, the 2 instances where the crew did not follow FRC guidance were poorly judged and could be defined as a situational rule breaking violation according to the DA FAiR model[21]. The Panel concluded that unjustified deviation from FRC guidance was noteworthy in that it may cause or contribute to further accidents and therefore identified it as an **other factor**.

1.4.1.75. **Recommendation. The Panel recommends that the DDH should ensure that WK operators should, by default, follow FRC guidance and only deviate from the prescribed procedures and drills by exception.**

Flight data and audio recording

1.4.1.76. **Flight Data Recorder (FDR)**. The Panel **observed** that WK did not have a crashworthy FDR capability. The Panel noted that the flight parameters required for analysis of the accident were recorded by the VMSC and that UTacS were able to download the VMSC and present the data relatively easily for analysis. However, some data recorded by the VMSC was only recovered from the second download attempt by UTacS after missing segments of continuously recorded data were seen during analysis. The fact that all data was eventually downloaded suggested that the issue was with the download solution, which UTacS were employing, rather than because of any damage to the VMSC caused as a result of the accident.

Exhibit 17

1.4.1.77. **GCS playback capability**. The Panel **observed** that the WK system does not have a GCS playback capability to assist with crew debriefing or the investigation of faults, accidents or incidents. Consequently, it was not possible for the Panel to confirm what cautions and warnings were seen during the flight. The Defence AIB investigators had to rely on GFCC logs to corroborate the crew's recollection of the warnings and cautions displayed and messages received and sent to the UA. The GFCC logs downloaded from the GCS were in the format of a large 'hex dump' and had to be processed by UTacS to turn them into a headed CSV file for analysis. The 'patch' software used by UTacS corrupted the data on the first attempt to 'decode' it such that

Exhibit 17
Exhibit 49

[21] MAA Manual of Air Safety Chapter 3 Annex C.

during analysis, the investigators found that reported events did not align with events recorded in the data. The second attempt by UTacS to produce a GFCC log for analysis produced more credible results.

1.4.1.78. **CVR.** The Panel **observed** that a number of the expected CVR files were either missing or corrupt. The corrupt files were recovered by QinetiQ. Despite recovering the corrupt files the missing files equated to approximately 3 hours of the sortie not being recorded against individual channels. The Area_Mic recorded continuously, but speech for the most part was inaudible. The Panel accept that the CVR solution would have been satisfactory, had it not failed to record for some of the time. Exhibit 17

1.4.1.79. **Recommendation. The Panel recommend that Head Unmanned Air Systems Team:**

a. **Provide a reliable flight data and CVR audio recording and download solution, for the purpose of assisting accident and incident investigations.**

b. **Provide a GCS playback capability to assist with crew debriefing or the investigation of accidents and incidents.**

Comparison with WK031 SI Findings

1.4.1.80. **Introduction**. At 1113 hrs on 16 Oct 14, a WK UA, WK031, operated by a civilian crew from UTacS Ltd, was involved in an accident while making an approach to land at West Wales Airport (WWA), Aberporth. After reaching the semi-flare point, the UA pitched rapidly nose down and impacted the ground, damaging the UA beyond economic repair. A SI Panel was convened on 22 Oct 14 to investigate the accident. This section of the report summarises the findings of the WK031 SI and compares and contrasts them with the WK006 accident. Exhibit 50

1.4.1.81. **WK031 Accident**. The events leading up to the loss of WK031 were as follows: Exhibit 50

a. As WK031 entered the Air Traffic Zone for WWA, ATC informed the crew the surface wind was 210°/10 kts and that a thunderstorm level warning 'moderate' was in force, reinforcing an earlier report that the crew had received about deteriorating weather conditions.

b. The crew initially selected the Alt Difference Override because of concerns about laser altimeter performance over a wet runway and concerns that it would automatically abort the approach if it detected a height discrepancy.

c. The crew then selected MO to ensure that the UA did not abort the approach, resulting in it overshooting into deteriorating weather conditions.

d. Following the selection of MO the CP was reached and ATOLS radar lock was achieved and continued its approach.

e. Past the UR point at approximately 17s to impact, the laser altimeter 2 reading was disqualified by the system. With MO selected and laser altimeter 2 disqualified, the system logic opened up a *Ground Touch identification* window 20m above the ground and disqualified both laser altimeters.

f. WoW1 logic registered a *Ground Touch* followed by an *Air Jump*. On return from *Air Jump*, WoW1 logic latched to *On-ground*.

g. The WOW1 *on-ground* input was used by the VMSC to trigger ground contact. As soon as the UA passed the semi-flare point it pitched nose down and impacted the runway.

1.4.1.82. **WK031 Cause**. The WK031 SI Panel found that the '*sequencing of the landing logic within the Vehicle Management System Computer functioned as designed but not as intended. The VMSC commanded the post landing actions (V-Tail pitch down) whilst the UAV was still airborne, after recognising a false Ground Touch*'. Exhibit 50

1.4.1.83. **Technical comparison.** Figure 9 shows a subset of the recorded VMSC data for the final 8 seconds of both flights. WK031 was pitching up and down in response to a gust of wind, which caused the UA to sense a *Ground Touch*. This is further corroborated by the motion of the V-tails which suggested it may have been correcting for gusty conditions. As also shown in Exhibit 50 Exhibit 51

Figure 9, WK031 briefly experienced an *Air Jump* before incorrectly declaring Weight-on-Wheels *On Ground*. In comparison WK006 sensed a *Ground Touch* and erroneously declared itself to be Weight-on-Wheels almost a minute earlier at the CP. From the semi-flare point, the descent profiles look almost identical. Both UAs pitched down rapidly once *Ground Contact* was declared, despite being airborne.

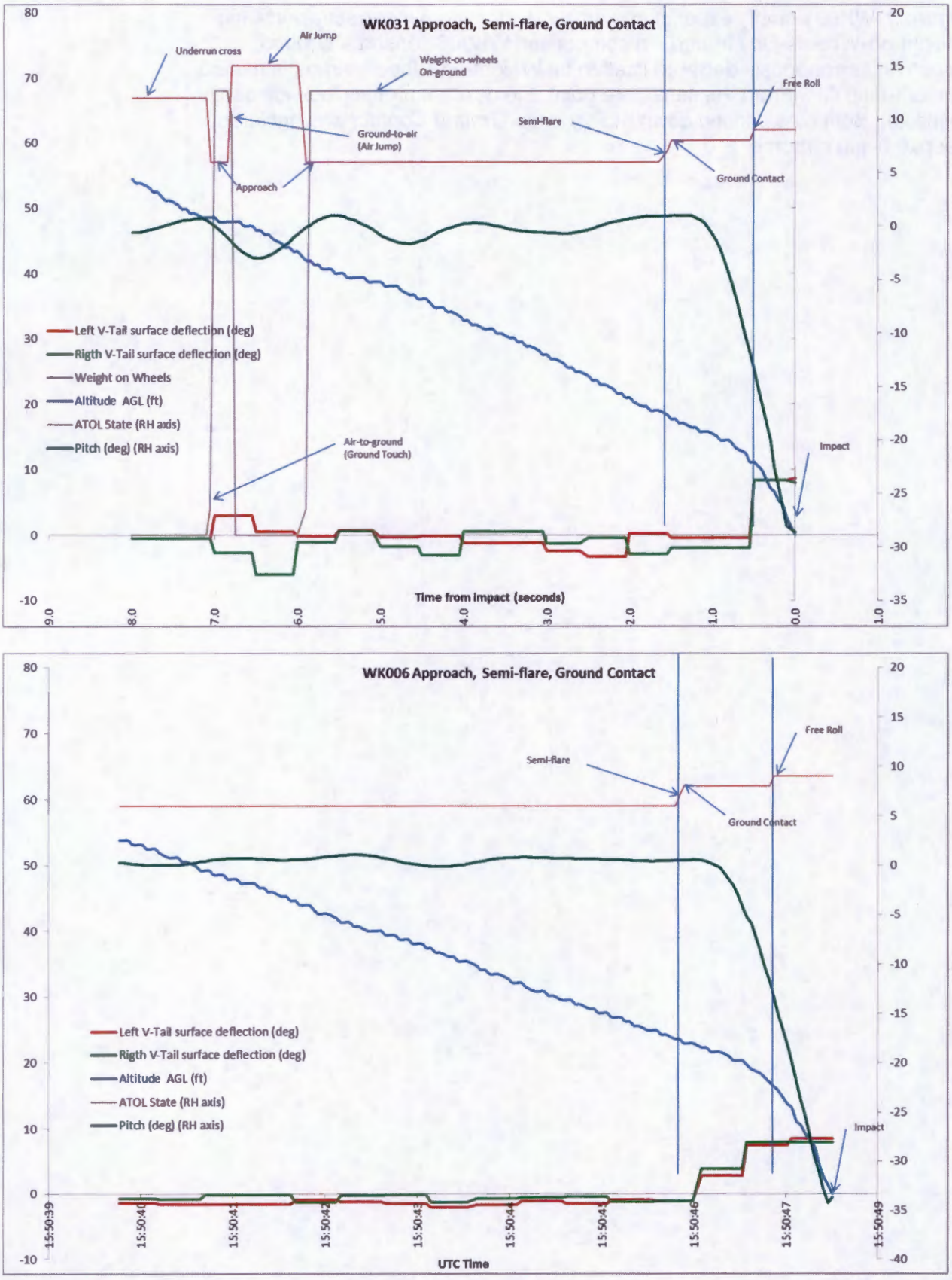

Figure 9 – Comparison of final 8 seconds of flight

1.4.1.84. **Similarities**. The Panel noted the following similarities between the two accidents: Exhibit 50

a. Both UAs were using the same WOW1 landing logic, responding to pitch rate and acceleration inputs, to erroneously sense a *Ground Touch.*

b. Both UAs had MO selected. This made the UAs continue with landings that they would otherwise have automatically aborted.

c. Both UAs sensed *Ground Touch*, *Air jump* and then latched WoW1 whilst still airborne.

d. Both UAs commanded post landing actions (V-tails pitching the nose down) whilst still airborne.

1.4.1.85. **Key differences**. The Panel considered:

a. **Opening the Ground Touch identification window.** Following the selection of MO, WK031 opened a *Ground Touch identification window* at 20m AGL. Conversely WK006 opened a 'regular 1m AGL' *Ground Touch identification window* at 360ft AGL. In WK031, both laser altimeters were disqualified whereas in WK006 both laser altimeters gave 'legal' but erroneous readings. Exhibit 50

b. **Sensing Ground Touch.** WK031 sensed a *Ground Touch* as a result of the difference between pitch rate and acceleration induced by a gust of wind. WK006 sensed a *Ground Touch* as a result of pitch rate and acceleration difference caused by a valid and normal manoeuvre at the CP.

c. **Timing of events.** WK031 sensed and latched *Ground Touch* well past the UR and flew for only a few seconds with WOW1 *On-ground*. WK006 sensed and latched a *Ground Touch* within seconds of reaching the CP and flew for nearly a minute with the WOW1 *On ground.*

d. **Handling of the UA.** MO was selected on the first approach by the crew of WK031 in an attempt to land due to deteriorating weather. Following the WK031 crash, changes to the FRCs and IETP were made in an attempt to restrict the number of occasions when MO would be used and use it as a last resort. During the WK006 recovery, MO was used on the third attempt to land, after the 2 previous attempts to land with *Alt Dev* override, had failed.

1.4.1.86. **Conclusion**. Both crashes were a result of the VMSC commanding post landing actions whilst the UA was airborne. The hazard that led to this situation was the VMSC software logic's susceptibility to sense and latch a false *Ground Touch*. The hazard entry conditions were, however, different; the *Ground Touch identification window* was opened using different logic and the *Ground Touch* was triggered by a VMSC commanded manoeuvre in the case of WK006, rather than a gust of wind in the case of WK031. The fact that different and unforeseen technical entry conditions exposed the systems vulnerability to falsely sense a *Ground Touch*, demonstrated that mitigating the known hazard entry conditions alone was insufficient to prevent reoccurrence, as other hazard entry conditions existed. The Panel therefore

believe the operation of WK with the flawed VMSC logic carries, at present, an undefined safety risk, unless it can be demonstrated that there are no other conditions that exist that could lead to a false *Ground Touch* being sensed. The Panel has not been able to gain a sufficiently full and detailed understanding of the VMSC landing logic and the flight control system to comment further on the likelihood of other hazard entry conditions existing.

1.4.1.87. **Recommendations. The Panel recommend that the Head of the Unmanned Air Systems Team should:**

a. **Obtain a full and detailed functional description of the Flight Control System and all Vehicle Management System Computer logic and include this information in the Aircraft Document Set in sufficient detail to assist aircrew in dealing with unusual or emergency situations.**

b. **Commission a thorough review of the system logic to determine all circumstances in which a *Ground Touch* could be senses by the aircraft whilst it is airborne.**

Summary

1.4.1.88. The Panel established that due to cloud at the Connect Point, the laser altimeters read less than 1m, which caused the VMSC to open a *Ground Touch identification window* at approximately 360 ft above ground level. Following a manoeuvre at the CP, the VMSC erroneously sensed a *Ground Touch* and *Air Jump* and then declared that the UA was on the ground. Approximately a minute later, once the aircraft had reached the *semi-flare* point, 22 ft above the ground, all logic conditions were satisfied for the VMSC to command post landing actions. The VMSC commanded pitch down and the aircraft impacted the runway approximately 35 degrees nose down. The decision to fly in the forecast conditions and specifically to pursue landing attempts in fog was a contributory factor. The selection of MO overrode all safety measures that would otherwise have automatically aborted the landing and hence made the accident more likely and was therefore also a contributory factor. The Panel found that the selection of MO was in accordance with the crew's FRCs, but premature given that the options to hold and seek further advice or see if an improvement in visibility was likely both existed. Both the WK006 and WK031 crashes were a result of the VMSC sensing a *Ground Touch* and subsequently commanding post landing actions whilst still airborne, but the entry conditions which caused the *Ground Touch identification window* to open were different.

SECTION 1.4.2 – POLICIES, ORDERS AND INSTRUCTIONS

TOR2: Examine the policies orders and instructions that were applicable and whether they are appropriate and were complied with to include:

a. The level of awareness and application of the information contained within the Safety Advice issued by the DG MAA on 10 Feb 15.

b. The environmental limitations for the operation of the system, with specific reference to the recovery and landing phase regarding precipitation and visibility.

c. The Aircraft Document Set to ensure sufficient information is available to crews to deal with emergency/unusual situations.

Introduction

1.4.2.1. This Section considers the policies, orders and instructions that were applicable at the time of the accident, whether they were appropriate and whether they were complied with. The Section first considers the issues surrounding the level of awareness and application of the Safety Advice issued by the DG MAA on 10 Feb 15 in response to the on-going investigation into the loss of WK031 at WWA on 16 Oct 14. It then goes on to describe the Panel's findings regarding the environmental limitations for the operation of the system and the information available to crews in the Aircraft Document Set (ADS).

Applicable policy, orders and instructions

1.4.2.2. **MAA RA 1015 – Type Airworthiness Authority (TAA) – Airworthiness Responsibilities**. RA 1015 stated that *'the TAA shall be responsible for the Type Airworthiness[22] of an air system throughout its life from development to disposal'*. Under Type Airworthiness Management, listed in Guidance Material (GM) 1015(1), the following TAA responsibilities, relevant to this section, are stated: Exhibit 52

a. *'The completeness and accuracy of the Approved Data, including all elements of the Aircraft Document Set (ADS) and the upkeep of the Type'.*

b. *'Developing, maintaining and enhancing a Safety Management System, compliant with the Operating Centre Director (OCD) approval project airworthiness strategy, which will contribute to the Operating Duty Holder's (ODH's) Air System Safety Case for each type'.*

c. *'Ensuring that appropriate action is taken in response to airworthiness issues including, but not limited to, the issuing of Technical Instructions, and recommending to the OCD the stoppage of, or major restriction to, of flying'.*

d. *'Collecting, investigating and analysing reports of and*

[22] MA002 defined airworthiness as 'the ability of an aircraft or other airborne equipment or system to be operated in flight and on the ground without significant hazard to aircrew, ground crew, passengers or to third parties; it is a technical attribute of materiel throughout its lifecycle'.

information related to, failures, malfunctions, defects or other occurrences to confirm that the type design remains airworthy'.

e. *'Informing the type designer, other operators and the MAA of the outcome of any investigation into a significant airworthiness occurrence'.*

f. *'The provision of modifications necessitated by in-service experience or as requested by the DHs for safety, operational, or economic reasons'.*

1.4.2.3. **MAA RA 1220 (4) – Project Team Airworthiness and Safety: Independent Evaluation and Audit**. RA 1220 (4) stated that *'the TAA or Commodity PTL shall ensure that the Equipment Safety Assessment and Project Safety Management System (SMS) is subject to independent evaluation and audit'*[23]. It stated that the Equipment Safety Assessment and Project SMS should be subjected to independent evaluation and audit consisting of *'Independent analysis of the data evidence supporting the Equipment Safety Assessment, by an Independent Technical Evaluator (ITE)'.* Exhibit 53

1.4.2.4. **MAA RA 1013 – DE&S Air Systems Operating Centre Director (OCD) – Provision of Airworthy and Safe Systems**. RA 1013 stated that *'in ensuring the provision of safe and airworthy air systems the OCD should: Assess and, if content, approve any decision to reject significant airworthiness advice from an appointed competent design or maintenance organization, or an appointed independent advisor.'* Exhibit 54

1.4.2.5. **WK Safety Assessment Report V 4.0**. The WK Safety Assessment Report (SAR) stated the requirement for the WK Safety Assessment to be independently assessed. It stated that the ISA has no executive authority and the Project team accepts full responsibility for safety. The Project Team may overrule an ISA's recommendations but in *'such cases a robust justification for the decision should be recorded'.* Exhibit 55

1.4.2.6. **MAA RA5202 – Military Flight Test Permit (MFTP)**. WK031 was operated by Thales UK under a MFTP. RA5202 provided the regulation for the MFTP. RA 5202 detailed that the authorisation of flights *'shall be conducted using a MFTP if all of the following conditions exist: Where the design standard is not reflected in an extant RtS or flying outside the service environment, ie outside the recognised and agreed flight envelope'.* The TAA authorised the initial WK MFTP and its subsequent amendments, which enabled Thales UK to undertake test and evaluation sorties at West Wales Airport (WWA). The Guidance Material stated that *'following an occurrence, the Applicant or the TAA may withdraw the MFTP'.* Therefore, the TAA had 'direct control' over WK flying at WWA as is illustrated in Figure 10. Exhibit 56 Exhibit 57

1.4.2.7. **Release to Service (RtS)**. WK006 was flown under an RtS, over which the TAA did not have 'direct control'. The TAA compiled engineering certification evidence to support the introduction of WK RtS and its subsequent amendments. The TAA also provided airworthiness and maintenance advice to WK Aviation Duty Holders (ADHs), who were responsible for the safe operation of WK within their AoR and the Capability Directorate Combat Support (CDCS), Exhibit 58

[23] Independence is one of the four airworthiness pillars, described earlier in RA 1220.

who were responsible for the delivery of the WK capability. As shown in the above diagram, the TAA had no direct control over Army WK operations. The TAA provided SQEP advice to the RTSA, WK ADHs and CDCS.

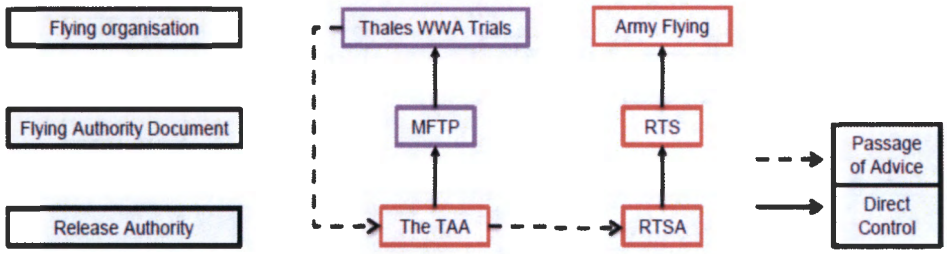

Figure 10 – Overview of TAA control of WK flying

Safety Advice

1.4.2.8. Following the WK031 accident, the WK031 SI President raised the following Safety Advice to DG MAA, who subsequently issued it:

'The Panel recommends that the DES UAS TAA ensures that the VMSC landing mode software logic when MO is selected is corrected to prevent a Ground Touch and Free Roll command being activated whilst the Aerial Vehicle is still airborne'.

In considering the level of awareness and application of the Safety Advice, the WK006 SI Panel found it necessary to consider the actions taken following the WK031 crash as it became clear to the Panel that they shaped opinion and influenced the direction of travel following the issue of the Safety Advice. Therefore, the next group heading analyses the actions taken following the loss of WK031 to provide context for the actions taken following the Safety Advice. An overview of the documents reviewed by the Panel, prior to and after the issue of the Safety Advice, is shown in Figure 11.

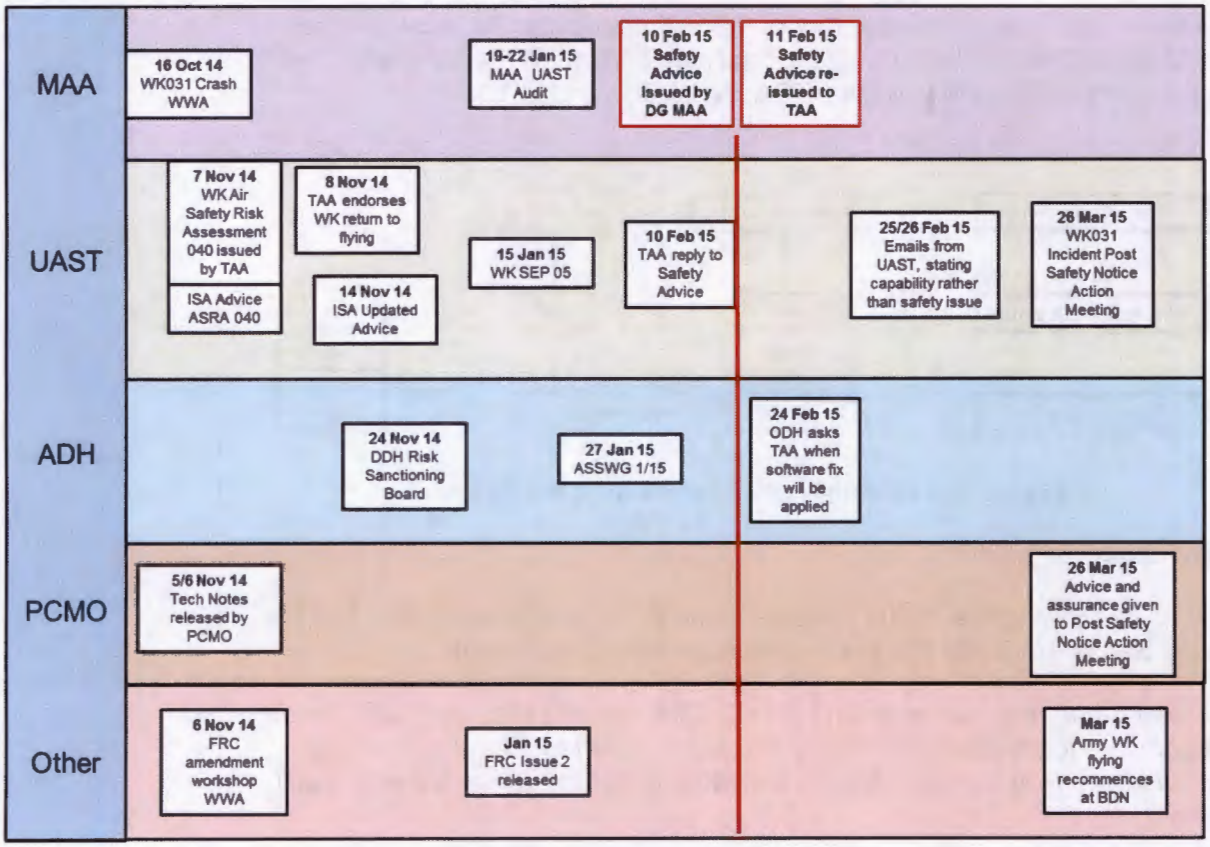

Figure 11 - Chronological Overview of the document trail analysed by Panel

Actions following the loss of WK031

Design Approved Organization Scheme (DAOS)[24] Organisations Technical (Tech) Notes – 5/6 Nov 14

1.4.2.9. **ESL Flight 395 Analysis Report**[25]. Approximately 3 weeks after the loss of WK031, ESL released a report detailing their findings and recommendations. The report determined that a *Ground Touch identification Window* (described as '*ground detection logic*') was opened at 20m AGL and that a gust of wind then caused the first *Ground Touch* (described as a *'ground contact state'*) due to a momentary increase in pitch. The UA was reported to have continued in Landing flight mode until the Free Roll point, where it pitched down at approximately 5m AGL having satisfied all VMSC logic to put traction on the nose wheel by commanding a V-tail nose-down deflection. The Executive summary to the document first made the point that '*Automatic landing with "master override" commanded; in this mode all automatic terminations in the Landing process are overridden'*. It concluded the Executive summary with, '*all observed VMSC behaviour is per the design as captured in the VMSC FRS'*. Extensive reference was made to the VMSC FRS, which is understood to be the Functional Requirements Specification for the VMSC. A small subset of the FRS was provided in the document.

Exhibit 34

[24] DAOS provides an independent assessment of the competence of defence contractors and service organisations involved in the design of aircraft systems, associated equipment and airborne explosive ordnance and armament equipment.

[25] ESL Flight 395 Analysis Report version 5, dated 5 Nov 14 (released 6 Nov 14)

1.4.2.10. **Thales UK Tech Note: Safety Analysis of Flight UK395 Initial Findings**[26]. Thales UK also provided an overview of their investigation and associated findings. The Thales UK report agreed with the findings of the ESL report and also included a Safety Assessment of the incident and proposed additional advice restricting the use of MO to when there was no other option and a small set of specific emergencies. The summary stated that: Exhibit 59

a. The system had performed as designed.

b. There were not any credible conditions under which the system would initiate a pitch-down manoeuvre before it had reached the Underrun point.

c. There were not any credible conditions under which the system would initiate a pitch-down to free-roll when it was more than 7m plus any altitude errors[27] above the ground and therefore it would always be over the runway surface were this to happen.

d. There was not an increased Risk to Life associated with the use of MO[28].

e. MO use did increase the risk of aircraft loss and that crews should be made aware of that fact.

1.4.2.11. **Analysis of DAOS Organisations' Tech Notes**. Whilst it was not the intention of the Panel to 'mark the homework' of the two DAOS organisations, in accepting that these two technical documents played a significant role in shaping the subsequent course of action taken by the UAST, it was necessary for the Panel to consider both their accuracy and emphasis. The Panel considered:

a. That the reports explained why the *Ground Touch identification window* had opened at 20m AGL.

b. That ESL had credibly demonstrated how they had resolved the local wind conditions based on recorded VMSC data and how a gust had caused a sudden pitch rate leading to an erroneous *Ground Touch*.

c. Whilst the pitch down manoeuvre was commanded before the UA declared *Free Roll* (seemingly contrary to the ESL analysis), the Tech Notes identified the cause of the accident.

d. That the UA behaved as described in the VMSC FRS, however the Panel believed it was unlikely that the UA would have been intentionally designed to be capable of sensing a *Ground Touch* whilst still airborne and that this was a design flaw.

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[26] Thales Technical Note, Reference 701-120592 Issue 2, dated 6 Nov 14.

[27] The document assessed that with a large GPS altitude error of 3-sigma, the highest that the pitch down manoeuvre could be initiated was 22m, which equated to a worst case distance of 420m from the Touch Down Point (TDP). This was assessed to be well inside the underrun point, which is a minimum of 600m from the TDP.

[28] The document based this on the safety case assumption T85, that the landing strip would be clear of personnel and that any reoccurrence would always be over the runway landing surface.

e. That the Thales UK safety assessment that was based on the assumption that the landing site would always be clear of personnel (the validity of which is considered later) was reasonable.

f. That whilst the WK031 accident sequence was accurately described, no other potential hazard entry conditions were considered and only a limited subset of the FRS was provided to enable any independent technical evaluation.

g. That both reports put emphasis on the use of MO and that the Thales UK advice centred on restricting the use of MO, emphasising the increased risk of aircraft loss and stressing that crews should be made aware of the additional risk.

1.4.2.12. **Conclusion of DAOS Organisations' Tech Notes**. The Panel established that the Tech notes were accurate and that both Thales UK and ESL seemingly had a good understanding of the cause of the accident. The Panel concluded that emphasis was put on the use of MO, describing the hazard entry conditions and stressing that the UA 'behaved as designed' rather than giving any indication that there was an inherent design flaw in the system. Consequently, recommendations centred on reducing the use of MO, rather than any requirement to modify the VMSC to correct a design flaw.

Recommendation to return to flying, WK Air Safety Risk Assessment (ASRA) 040 and Independent Safety Advice – 7/8 Nov 14.

1.4.2.13. **ASRA 040**. Following the release of the DAOS organisation Technical Notes, the UAST released ASRA 040, titled '*Use of Master Override*'. It stated that the UAST's focus had been on assessing the primary cause of the '*heavy landing*' and reassessing any emergent RtL implications. The purpose of the ASRA was stated to be, to allow the TAA to make a decision on resuming WK trials flying under the MFTP and to underpin a recommendation to the DDH that in-service WK operation remained safe. The document, stated that it was based on the '*full gambit*' of WK expertise, including the DAOS organisations' Tech Notes and endorsed the recommencement of WK flying operations, based on revised emergency procedures. The Panel noted the following points from the ASRA: Exhibit 60 Exhibit 61

a. **Executive Summary**. A summary was provided at the beginning of the document, which reported that:

(1) The UA behaved as designed and that the root cause of the accident was the UA's susceptibility to incorrectly sense that it has landed when MO has been selected in conjunction with a laser altimeter error.

(2) Prohibiting the use of MO was neither appropriate nor practicable and hence the immediate actions would revolve around providing improved advice to the DDH regarding its use and revised emergency procedures in the FRCs.

(3) Changes to the MO logic would almost certainly require modifications to the WK flight critical software and thus would be only likely to occur within ES2 timescales.

(4) The TAA '*...had sufficient understanding of the accident sequence to establish that any reoccurrence of a heavy*

landing whilst using MO would be restricted to the confines of the cleared landing area. Consequently the RtL created by this activity remained the same as detailed in the WK Equipment Safety Assessment and remained Tolerable and ALARP'.

b. **Safety Impact Assessment**. A Safety Impact Assessment was provided. It stated that the Thales UK technical submission had confirmed that:

(1) No VMSC 'ground contact' detection logic is activated until the UA has passed the defined 'Under-run Point.

(2) The ground detection window is not opened until the UA is at 20m AGL (GPS/STOLS height) when in MO and when an altimeter fault has been declared.

(3) The VMSC-declared 'Semi-flare' height (which is a necessary condition for the initiation of the post-free roll pitch down manoeuvre) cannot be declared above 7m (GPS/ATOLS height).

It made the case that in the worst case the UA could impact at a distance of 420m before the nominal touch down point. It concluded that a premature pitch down manoeuvre would always result in the UA impacting the ground '*...within the runway lateral bounds and within the runway zone that is clear of personnel for landing (as defined in WK Planning Assumption T85, which was 'owned' by the DDH)'*. Consequently, the ASRA stated that there was no increased RtL from an occurrence of that nature. It did, however, state that *'the use of MO, in conjunction with a laser altimeter fault, does however, increase the probability of the loss of the UA. This is considered to be a capability issue rather than a RtL issue'.*

c. **Immediate Actions**. Immediate actions centred around providing the DDH with improved advice on the implications of using MO and, if required, revised emergency procedures in the FRCs. It noted that the DDH had already tasked a review to confirm that the use of MO remained appropriately described and that amendments to the FRCs and IETP had been identified.

d. **Longer-Term Actions**. In the longer term, the ASRA stated that the SI into the loss of WK031 would be likely to investigate the *'appropriateness of the MO logic'* and that the UAST would work with Thales, ESL and the SI to consider potential changes to emergency procedures, VMS detection parameters and controlling logic.

e. **Mitigation Strategy**. The document described the mitigation strategy, which centred on ensuring that procedures referring to the use of MO were appropriate and that operators were better informed. It stated that the use of MO remained subject to real-time crew assessment as to whether the RtL posed by a missed approach and go-around was greater than that of a heavy landing within the cleared area.

f. **Independent Assessment**. The document stated that the

Independent Safety Adviser[29] (ISA) provided an endorsement of the ASRA conclusion for the return to flight and that the extant RtL assessment was unchanged. The endorsement was subject to the proviso that the ADS was updated and Operators were trained on the correct use of overrides. The ISA report recommended that further work was conducted in order to ensure that MO does not affect phases of flight other than landing.

g. **Required Actions**. Four proposed mitigations, shown at Figure 12, concluded the ASRA. At the time of issue, an update to the ADS and improved DH Advice, in the form of an Engineering Advice Note (EAAN), was to be issued.

Ser (a)	Proposed Mitigation (b)	Progress (c)	
1.	**Establish Technical Elements of Accident Sequence.** Downloaded flight data to be analysed to establish likely accident sequence and confirm that UAS behaved as designed.	Elbit and Thales have analysed the flight data downloaded from WK031's VMSC and GCS09 GFCC. Their analysis and findings are at [Ref A] and [Ref B] respectively.	Closed
2.	**ADS Review.** FRCs [Ref D] and IETP to be reviewed for appropriate use of Master Override.	• Workshop at WWA on 6 Nov 14.	Closed
3	**ADS Update.** Identified amendments to FRCs and IETP applied.	• Required amendments to be raised as AILs, ANAs or up-issues as appropriate. •	Ongoing
4.	**Improved DH Advice.** DDH to be provided with improved advice on operation and implications of Master Override usage.	• EAAN to be issued.	Ongoing

Figure 12 – Summary of Required Actions, ASRA040

1.4.2.14. **ISA's initial response to ASRA 040 – 7 Nov 14**[30]. The UAST asked their ISA to review ASRA040 prior to its release by the TAA. The ISA conducted an overnight review of the ASRA and Tech Notes and replied with his initial findings the following day, but stating that he would make a more considered reported within 7 days. The Panel noted: Exhibit 62

a. The ISA concurred with the consensus regarding the functional root-cause of the accident sequence, accrediting it to the use of MO and errors in the laser Altimeter. He suggested that the weather conditions might also have been a contributory factor and should not be discounted until the investigation had concluded.

b. The ISA reported that '*…some aspects of the argument have not been presented well, specifically that of the potential for the accident sequence to have occurred between the CP and the UR'.*

c. The ISA stated that *'focus is given to the incident itself, using the ASRA as a repository for the UAST's assessment of the incident rather than presenting a substantiated Safety Assessment for the*

[29] Def Stan 00 56 Annex A defines the ISA: An individual or team, from an independent organisation, that undertakes audits and other assessment activities to provide assurance that safety activities comply with planned arrangements, are implemented effectively and are suitable to achieve objectives; and whether related outputs are correct, valid and fit for purpose.

[30] RPS/RFA9060/UAST/EC1/005

use of all Overrides'.

d. The ISA accepted that the UAST was not required to produce a '*forensic analysis*' of flight data to support return to flight. However, he wrote '*naturally there is a degree of understanding necessary, required to inform the decision making of the TAA'.* He continued '*…It is imperative to understand what would make operations safe by bounding the use of Overrides and by ensuring that the UK understanding of these models is to such a degree that the implications of their use is fully understood'.*

e. In the ISA's opinion, the ASRA should have presented *'…an evidence based argument for the safe use of all overrides, which, it is believed, would probably only be able to support use of MO in extremis, not because of the potential to cause harm, but due to the increased likelihood of Cat 4/5 damage owing to the peculiarities of the design implementation'.*

f. The ISA was surprised that the previous use of MO had not been considered in the ASRA and wrote *'…the question arises, regarding the extensive use of Master Override and whether this has masked other issues within the system that might have the potential to expose other hazardous states which should be considered at this juncture'.*

g. The ISA wrote that '*it would appear that the Programme is once again feeling false pressure to draw conclusions in a hasty manner'.*

h. The ISA wrote that *'Prior to a return to flight, the UAS team should seek appropriate independent technical evaluation if the core competencies are not available within the team to draw the conclusions made'.* The TAA did not consider ITE necessary as the underpinning documents had been reviewed by software subject matter experts within the UAST.

i. The ISA endorsed the ASRA conclusion for WK return to flight, on the proviso that*:*

> (1) *'Thales demonstrate understanding of all the overrides, how they are implemented, when they are to be used and what the potential consequences are as a result of their use; this should form the basis of a Risk Assessment'.*
>
> (2) *'The ADS is updated and Operators are trained on the correct use of overrides'.*
>
> (3) *'Thales present an argument to prove that any such accident sequence could not occur until the UA has passed the underrun'.*

The 2nd proviso was recorded in the ASRA, and the 1st and 3rd actioned separately with Thales UK, after a return to flying had been endorsed.

j. The ISA also stated (not necessarily proceeding a return to

flight) that *'as a follow-up, further work should be done to:*

(1) *Enhance the UK understanding of all Overrides and a Risk Assessment made.*

(2) *Determine whether the extensive use of MO has masked the potential for other hazardous states to occur'.*

1.4.2.15. **TAA email endorsing a return to flying - 8 Nov 14**. Writing to the Head of the UAST, the DDH and the AM(MF), the TAA endorsed a return to flying. The email stated: Exhibit 61

a. That the UA behaved as designed and that the cause of the accident was the susceptibility of WK to incorrectly sense that it had landed when MO was selected, in conjunction with a laser altimeter error or fault.

b. Whilst this increases the probability of a heavy landing, when MO is selected over individual overrides, if the landing site is setup in accordance with the IETP, any such incident would occur over the runway, thus no greater Risk to Life than already assessed in the Safety Case was presented.

c. That whilst the TAA was content for WK to return to flying, he recommended that the AM(MF) and DDH ensured that their crews were fully briefed on the implications of using MO and had instigated the revised procedures prior to recommencing WK ops.

d. Work would continue (in conjunction with the SI) to understand what action could be taken to alter the WK MO system logic such that the chances of it creating a loss of an Air Vehicle was reduced.

1.4.2.16. **Analysis of the UAST recommendation to return to flying**. The Panel considered:

a. The use of the term '*heavy landing'* was, in the Panel's opinion, surprising given the damage that was known to have occurred to WK031 and the acceptance that a rapid pitch down manoeuvre could be initiated from 7m AGL (or 22m in the worst case).

b. The ASRA drew heavily on the Tech Notes and accurately described the cause of the WK031 accident. Having determined that it was not possible to modifying the VMSC software in the short term, mitigation, to reduce the risk of re-occurrence, focussed on reducing the use of MO through better advice and procedures.

c. The Panel could not find where the Thales UK Technical submission confirmed that, '*no VMSC 'ground contact' detection logic is activated until the UA has passed the defined 'Under-run Point'*. This statement is now understood to the Panel to be incorrect[31]. The Panel believe that the ASRA was reasonable in its

[31] WK006 was assessed to have sensed a false *Ground Touch* after the CP long before the UR point. Although the statement in the ASRA was incorrect the assessment was still valid as the pitch down manoeuvre was assessed as being triggered after the semi-flare point, approximately 7m above the runway and after the UR point.

'worst case' assessment that the UA could pitch down up to 420m from the nominal touch down point, but questioned whether there was sufficient detail in the Safety Case Assumption T85 to make an assessment on the RtL.

d. All actions stated in the ASRA were completed, with the exception of the issue of an Engineering Authority Advice Note (EAAN), which was overtaken by events when additional advice was provided by the UAST to the DDH on the use of MO through the various safety forums.

e. The ISA was given unfettered access to the information contained within ASRA 040, but only 24 hours to comment on it. Whilst he did not request additional time, the ISA did note that the programme appeared to be feeling '*false pressure*'.

f. The ISA's endorsement of return to flying was made with proviso's, only one of which was captured by the ASRA. The opportunity, prior to a return to flight, to get Thales UK to demonstrate a full understanding of all overrides and present a safety argument that any such accident sequence could not occur before the UR point, was lost. The UAST did not receive this information from Thales UK until 26 Mar 15.

g. Like the Tech Notes, the ASRA focussed on the WK031 accident in isolation and in the ISA's opinion the case for the accident sequence occurring between the CP and the UR was not well made. The Panel accepted that the UA behaved as described by the FRS, but considered whether this would be more accurately described as a design flaw, rather than reiterating the manufacturers statement *'the UA behaved as designed'*. The Panel also looked at it from the point of view that the UA behaved as designed and therefore exactly as could have been expected in the situation, but noted that neither Thales UK, UTacS, nor the UAST had a detailed knowledge of the FRS for the VMSC at the time.

h. Despite the heavy reliance on the DAOS organisation Tech Notes and the ISA's suggestion, ITE was not considered to be necessary. The requirement for ITE is further considered in the report.

i. In noting '*...the UA's susceptibility to incorrectly sense that it has landed'* and the potential for a future modification, the UAST acknowledged a design flaw in the system logic.

j. The TAA made the increased risk to capability clear to the AM(MF) and DDH and recommended that they briefed their crews on the implications of using MO and instigated the revised emergency procedures **prior** to a return to flying.

1.4.2.17. **Conclusion of the UAST recommendation to return to flying**. In ASRA 040, the UAST acknowledged a design flaw in the system logic; however, as with the Tech Notes, emphasis was focussed on the use of MO. Whilst the Panel believe that focussing on the use of MO, as a hazard entry condition, was reasonable, in the context of the ASRA, it may have detracted from a full assessment of the hazard itself (the UA's susceptibility to sense that it had landed whilst still airborne), hence other possible accident sequences

associated with the hazard were not considered. Furthermore, the ASRA risked misinforming the target audience that a re-occurrence would only be possible when MO was selected and there was a specific laser altimeter fault resulting in differences being detected between the 2 laser altimeters. The ISA's advice was not fully recorded in the ASRA or acted upon before the release of the ISA endorsing a return to flying. This lead the Panel to form the opinion that programme pressures may have reduced the effectiveness of the ISA's advice. Despite this, the UAST's advice regarding the use of MO was clear.

The ISA's view[32] – 14 Nov 14

1.4.2.18. **ISA Safety Management Concerns – 14 Nov 14**. Writing to the UAS TAA a week later when the ISA had more time to consider the issues fully, the ISA stated that in his opinion, '*…the operation of WK should be considered as untenable at present and as the theatre operational imperative has gone, time should be taken for UAST and other Duty Holders to take stock of the Safety Management Arrangements*'. The ISA was concerned that there appeared to be a fragmented approach between the Training DLoD and Equipment DLoD, to such an extent that they could not be relied upon to ensure that flight safety could be maintained. The ISA stated '*…that the aforementioned is supported by the fact that SMAs are teetering on the point of needing re-assurance as the Safety Assessment, MRI and associated design safety have all evolved with significant deltas since the initial Release to Service without in-depth Independent Assessment (the ISA believes that the same could be said for the DDH Bow-ties)*'. The ISA raised further flight safety concerns '*when one considers the recent Flight 395[33] incident at WWA, the GCS quality issues, the potential for issues in quality to be endemic across all equipment (not just the GCS), the issues regarding the version of IETP, ISPEC development and the possibility that the Training DLoD Assurance Statement could be withdrawn based on the current divergence*'. The ISA concluded by recommending: Exhibit 63

a. *'Time should be taken for UAST to take stock and resolve the issues that currently prevent ISPECs being produced from the latest ADS'.*

b. *'Bring the Training on line at a later date in accordance with revised validated material'.*

c. *'Resolve the equipment related issues whilst re-assessing the potential implications from the WK Flight 395 incident'.* Witness 16

The ISA confirmed that he did not receive a response to his letter.

1.4.2.19. **Analysis of ISA Concerns**. The ISA recommended that WK flying should be suspended for a combination of reasons, one of which was the WK031 crash at WWA. Whilst the Panel accepts that elements of the ISA's concerns lay outside DE&S, problems highlighted with the ADS and equipment issues, underpinning the ISA's argument, lay in the domain of the UAST. The Panel noted that the WK SAR stated that if a Project Team overrules an ISA's Exhibit 64 Exhibit 65 Witness 16

[32] Letter from the ISA to the UAST, 'An Erosion of Confidence in the Assured Flying Safety' Reference: RPS/RFA9060/WK/EC1/007 dated 14 Nov 14.

[33] Flight 395 was the flight involving the crash of WK031 at WWA in Oct 14.

recommendation, '*...a robust justification for the decision should be recorded'*. RA1013 also stated that the DE&S Operating Centre Director should '*approve any decision to reject significant airworthiness advice' from an 'appointed independent advisor'*. The DE&S Safety and Environmental Handbook provided the framework with which to do this; '*Where the ISA and PT cannot come to an agreement on any substantive issue, it must be escalated ... to the OC Director'*. The Panel considered whether in maintaining the position that WK should continue flying, the UAST did, in effect, reject the ISA's advice to suspend flying. The TAA explained that he did not believe that the UAST rejected the ISA's advice but confirmed that Director of Combat Air (DCA), as the Operating Centre Director, was fully aware of the situation. The TAA added that, at the time, he had become concerned that the UAST did not have a robust and auditable process for handling ISA advice and had since introduced a system to allow better tracking of such advice. The UAST's engagement with the ISA in the round is further considered in Paragraph 1.4.2.51.

1.4.2.20. **Conclusion on ISA Concerns**. The ISA expressed concern in a number of areas. The cumulative effect of these concerns was that the ISA believed that the continued operation of WK untenable. The UAST stated that at the time of the ISA advice, they did not have a good system for recording and handling ISA advice. Consequently, the Panel found it difficult to assess to what extent it had been considered, but concluded that the ISA's concern did not significantly alter the direction of travel within the UAST, initiated by the Tech Notes and the ASRA. The Panel concluded that there should be a robust and auditable system for recording safety and airworthiness advice.

1.4.2.21. **Recommendation. The Panel recommend that Head Unmanned Air Systems Team ensures a robust and auditable system is used for recording the consideration, sentencing and actioning of safety and airworthiness advice. The system should be capable of providing feedback to the originator to ensure that the intent of any such advice has been understood.**

DDH Risk Sanctioning Board, 24 Nov 14

1.4.2.22. The DDH held a Risk Sanctioning Board to identify the risks in returning WK to military flying. The Board reviewed the WK 'Top Line Event's, found in the WK Risk Register and listed 10 items which needed to be addressed before the DDH was content for WK flying to recommence at BDN. One of these mitigations was that the DDH requested that the TAA provide a summary of and comment upon the letter produced by the ISA that had articulated their independent view of the WK capability Risk to Life and the on-going capability delivery process. In Jan 15, a further meeting was held at Upavon, where the UAS TAA briefed 1ISR Bde personnel, on his understanding of the WK031 accident and again recommended that a return to flying was justifiable.

Exhibit 66
Witness 14

1.4.2.23. **Analysis of Risk Sanctioning Board**. The Panel found that the Board demonstrated itself to be an effective means of ensuring that the DDH had all the information required to fully consider aviation risks and where required request further information. The minutes provided a simple but effective audit trail of what had been considered and recorded decisions.

WK Safety and Environmental Panel (SEP) #05, 15 Jan 15.

1.4.2.24. The incident involving WK031 was discussed at the SEP in Jan 15,

Exhibit 67

chaired by the UAS TAA, and attended by the DDH, amongst others. The Panel considered the following points from the minutes of the meeting relating to the WK031 crash and actions taken as a result.

a. The UAST were awaiting the WK031 SI interim and final reports.

b. The UAST had written to Thales UK seeking assurance that the use of MO in other phases of flight did not have associated and, as of yet, unidentified safety impacts. Thales UK stated that they intended to deliver a presentation by then end of Jan 15 to all relevant stakeholders, answering the UAST's question, and to help understand how MO should be used going forward.

c. Tighter procedural mitigations in the FRCs on the use of MO were now in place.

d. A software fix to the underlying problem was expected for ES2.

e. The ISA raised the matter of his report 'Erosion in Confidence of the Assurance of Flight Safety'. The ISA was aware that many actions had been undertaken by the TAA and the DDH to address the issues, but remained concerned that the organisations were not in place or were too thin to provide sufficient WK safety assurance and that he continued to wait for a response to EC1/007[34].

1.4.2.25. **Analysis of SEP #05**. The Panel noted that the meeting was attended by all key individuals and that a quorate declaration was made as such by the TAA. The minutes were detailed and the meeting appeared to be an effective way of recording the status of the many issues that the SEP was dealing with at the time. Of note, no actions were taken as a result of the ISA's report. The Panel believe that this was a missed opportunity to ensure and record the fact that all ISA advice was being considered at an appropriate level.

MAA Audit of the UAST, 19 – 22 Jan 15

1.4.2.26. The MAA conducted a routine audit of the UAST in Jan 15, with the objective of evaluating the adequacy and effectiveness of the Air Safety Management Systems (ASMS). The criteria for the audit were based on MRP requirements for airworthiness, safety and, where applicable, environmental related topics. The MAA audit report raised the following issues: Exhibit 68

a. In the context of their Air Safety Culture (ASC), the management team had a good understanding of the supporting principles and showed a clear understanding of its importance to their business.

b. The audit team formed the opinion that the UAST approached their business from knowing that they were safe rather than questioning how safe they were. The opinion was supported by the audits finding that the management board did not assess their ASC in any way nor discuss their ASC at any formal meetings. The audit team did not dispute the 'we are safe' position taken by the UAST

[34] In this report, this is referred to as the Updated ISA Safety Advice, issued 14 Nov 14.

but suggested that an 'are we safe' approach may have led to a more questioning and learning culture, that could lead to continued improvements in the UAST ASC and SMS.

c. That the UAST had found it difficult to recruit permanent SQEP personnel and as a result there were a number of tasks in support of key SMS activity that had not been progressed in the last 6 months.

1.4.2.27. The Panel agreed that whilst the findings of the MAA Audit were not directly relevant to the SI, they supported the Panel's findings regarding the UAST reliance on the DAOS Tech Notes and the rigour in the production of the ASRA. The Panel noted that the MAA found a competent management team with a positive ASC. The Panel then considered whether the UAST had been questioning enough of the DAOS organisation Tech Notes on the WK031 incident and whether any failure to sufficiently challenge the DAOS organisations was an ASC issue or simply down to a limited availability of SQEP in key areas. The Panel considered the timescale in which ASRA040 had been produced and its reliance on the DAOS Tech Notes, noting that the ASRA was not revisited in depth following the ISA advice and that the source documents (specifically the FRS for the VMSC) used to produce the Tech Notes were not requested by the UAST.

1.4.2.28. The Panel believe that had ASRA 040 been revisited more thoroughly in line with the ISA's advice, the UAST would have had to be more questioning of the DAOS organisations. This may have shifted focus away from the use of MO onto the design flaw in the system and opened the door for considering other possible accident sequences associated with sensing a false *Ground Touch*. This would have required an in depth technical examination of the VMSC FRS by the UAST, in conjunction with the DAOS organisations, but would have better informed the debate about whether an urgent safety modification to the system was required.

WK Air System Safety Working Group (ASSWG) - 27 Jan 15

1.4.2.29. The TAA updated the ASSWG and the ODH on progress with equipment issued and any changes to the Equipment Safety Case and the Hazard Log since the previous ASSWG. The minutes stated that the TAA informed the ODH that the SI into the WK031 crash had revealed that the UAV had operated exactly as it was designed to do, but not as expected. The emergency procedures around the use of MO had been revised and work was being done to reduce the probability of a repeat situation. This would involve software changes which would not be completed before ES2. The TAA further noted that the SI Panel would be issuing a Safety Notice before 31 Jan 15, but it was not anticipated to contain anything that had not already been discussed. Exhibit 69

1.4.2.30. **Analysis**. The comments recorded in the ASSWG minutes show that the TAA was expecting the safety advice but did not believe that it would contain anything that he was not already aware of.

Actions following the issue of the Safety Advice

1.4.2.31. The following paragraphs consider the response to the Safety Advice, against the backdrop of the on-going investigations into the loss of WK031.

TAA response to the Safety Advice, 10 Feb 15

1.4.2.32. The Safety Advice was initially issued on 10 Feb 15 with the recommendation to correct the VMSC landing logic apportioned to the AM(MF). The TAA identified that any changes to the VMSC software would require a modification and hence were a type design issue and accordingly assumed responsibility for the action. The Safety Advice was updated and released the following day with the recommendation now against the TAA rather than the AM(MF). Exhibit 70

1.4.2.33. The TAA wrote to the Head of the Unmanned Systems Team and others, and stated: Exhibit 70

a. The findings detailed in the SA were entirely in line with the UAST's conclusions.

b. Therefore, his recommendation for WK to recommence flying with the revised procedures made in Nov 14 still stood.

c. He was content that the UA behaved as designed and that the cause of the incident was the susceptibility of WK to incorrectly sense that it had landed when MO was selected in conjunction with a laser altimeter fault.

d. He acknowledged the increased probability of heavy landings. He also stated there was no increased Risk to Life than already assessed in the Safety Case.

The TAA added that, the runs that the SI team did in the hybrid lab when they were able to repeatedly replicate WK031's accident sequence provided further confidence in the integrity (ie repeatability) of the VMSC software, and hence the UAST understanding of the MO logic sequence. The TAA further added that discussions concerning modifications to the VMSC software were underway and that any modifications would be part of the ES2 software changes.

1.4.2.34. **Analysis**. The TAA was correct to take responsibility for the recommendation in the Safety Advice as it was indeed a type design issue. The issue of the Safety Advice did not cause the TAA to change his position regarding the cause of the accident or the associated risks. The initial findings of the Panel articulated in the Safety Advice provided him with further confidence of his understanding of the MO logic. He highlighted the increased capability risk, and stated that discussions regarding software changes to the VMSC, as part of ES2, were already underway.

UAST advice to the ODH & SRO, 25 and 26 Feb 15

1.4.2.35. **TAA Response**. The ODH wrote to the TAA, enquiring when a software/firmware fix would be applied to WK to address the logic in the VMSC and whether it would be in advance of ES2. The TAA stated that: Exhibit 71

a. A modification to the VMSC could be made before ES2, but

would have a detrimental impact on ES2 timelines. Once agreed, the testing and certification of the software modification would take between 6 and 9 months.

b. A hardware modification to fit radar altimeters in place of the laser altimeters could potentially be completed sooner, but that course of action had not yet been fully investigated by the UAST.

c. As the Risk to Life impact of the MO issue was negligible, it was a capability issue rather than a safety issue and the 'do nothing' option and accept potential WK losses, although it felt intrinsically wrong, would need to be fully analysed.

d. A modification would require additional funding and therefore any course of action (including 'Tolerate') would need to be agreed by the Capability Integration Working Group (CIWG).

e. A panel of suitably qualified and experienced personnel was being arranged to consider courses of action in more detail, following which a paper would be produced by the UAST, which would suggest various courses of action including rational for changes, time and cost implications, which would be sent to the ODH for his consideration, before going to the CIWG.

1.4.2.36. **UAST Dep Hd comments**. The UAST Dep Hd provided the following advice on the next steps to the SRO's staff for the WK programme to consider the options available, including any potential modifications, against other priorities: Exhibit 72

a. The UAST, with support from the Thales UK and the DH chain, would consider the technical options available.

b. If the ODH was to claim this as a safety modification (the UAST Dep Hd, cross referring to the TAA's advice to the ODH, stated that he did not believe it was a safety issue), the ODH would need to prioritise this requirement in the Requirements Working Group against other ODH priorities for WK.

c. That is was '*principally a capability rather than a safety issue*' and that the risk of recurrence was already lower given the changes in how MO was now being used by the Thales UK Flight Operations Organisation, and '*even when selected a repeat of this incident would have to involve a repeat of the particular climatic circumstances that occurred on the day*' of the WK031 accident.

d. The WK031 SI had not completed its work and the options analysis was immature. Therefore, the UAST did not feel that they were in a position to form a view on the preferred course of action. The Dep Hd suggested that the priorities were as follows:

(1) Get the Army flying.

(2) Deliver ES2 & Def Stan 970 compliance, noting that if ES2 was delayed for any software or hardware modifications that Thales may try and recover considerable sums of money from second order impacts.

(3) Deliver Narrow Band Data Link (NBDL) by Jan 16 to prevent a cease of flying

(4) Deliver the Emergency Procedures Trainer.

(5) Develop WK future support contract to provide an improved service.

(6) Explore options for updating training courseware for IETP drops.

(7) Improve the Part Task Trainer and competence of instruction, particularly for maintainers.

e. The email closed with a strong recommendation to let UAS team explore from a technical perspective the potential options available but without commitment, and allow that work to be staffed through the Requirements Working Group.

1.4.2.37. **Analysis**. The Panel noted that the UAST were considering alternative COAs to a software modification based on the assessed unchanged Risk to Life and perceived low probability of re-occurrence. The Panel noted that the UAST appeared not to consider the risk to capability as a safety issue, which seemed to be at odds with the MAA001 definition of safety, stated as '*Air Safety is the freedom from unacceptable risk of injury to persons, or damage, throughout the life cycle of military Air Systems*'. The UAST's belief that the chances of re-occurrence being negligible may have been a result of the Tech Notes and the ASRA failing to consider other possible accident sequences associated with the UA's susceptibility to sense *Ground Touch* whilst still airborne.

WK031 Incident Post Safety Notice Action Mtg, 26 Mar 15

1.4.2.38. A SQEP mtg, chaired by the UAS TAA, was held on 26 Mar 15 to discuss the possible courses of action in response to the Safety Advice recommendation following the WK031 accident. It was stated that no firm decision would be made on the basis of the meeting, or any commitment on funding. Exhibit 73

1.4.2.39. The UAST had requested that Thales UK provide them with formal advice that: Exhibit 73

a. They have a full understanding of the use of all overrides, including MO, when they are to be used, and what the potential consequences are as a result of their use.

b. Owing to the greater than expected use of MO, there are no masked, previously unidentified, system design shortfalls that could lead to hazardous situations that individual overrides could not overcome alone.

c. They can argue that the use of MO does not lead to the potential for an un-assessed hazard that could occur before the UA has passed the under run.

Thales UK gave a presentation during the meeting, which they considered to

have answered the above.

1.4.2.40. The Panel noted that: Exhibit 73 Witness 10

a. Thales UK suggested 4 design improvements that could be considered:

(1) Addition of a radio altimeter.

(2) Stopping the permanent disqualification of a laser altimeter.

(3) Reducing or removing the *Ground Touch identification window* opening at 20m when MO is selected.

(4) Reintroduce a physical WoW.

b. Thales UK also suggested the *'do nothing more than already done'* option, noting the procedural mitigations implemented.

c. Thales UK was tasked to examine design improvement actions and report back by end of Apr 15 (action 2.2).

d. Thales UK stated that no software changes could now be included in the ES2 software testing.

1.4.2.41. The UAS TAA closed the mtg by stating '*that nothing had been discussed to indicate that the overarching logic and integrity of the software had been brought into question.'* Exhibit 73

1.4.2.42. **Analysis**. The Panel considered:

a. That the Thales UK presentation, if accepted by the UAST, would have satisfied the ISA's provisos for a return to flying (Paragraph 1.4.2.14).

b. The aim of the meeting was to discuss possible courses of action in response to the Safety Advice, however, modifying the VMSC software was only discussed in two of the 5 possible design improvements considered. Thales UK confirmed that the window of opportunity[35] to include changes in the ES2 software testing had closed and none of the options had been fully evaluated technically or in terms of cost benefit.

c. Whether the 2 VMSC software modifications suggested would have prevented the WK006 accident. They would not have as the entry conditions for WK006 to sense a false *Ground Touch* did not require the *Ground Touch identification window* to open up to 20m (the laser altimeters read less than 1 metre) and neither laser altimeter was disqualified.

1.4.2.43. **Conclusion**. The Panel concluded that Thales UK was focused on

[35] In Apr 15, it is understood that the planning and contractual assumption for the completion of ES2 Final Qualification and Testing and Technical Field Trials was Dec 15.

preventing a re-occurrence of the WK031 accident rather than fixing the VMSC flaw that allowed a false *Ground Touch* to be sensed. Having reviewed the available evidence, the Panel formed the opinion that Thales UK were not planning a software modification at the time.

Thales Tech Note: WK031 Incident – Potential Modifications, 17 Jun 15

1.4.2.44. As tasked at the Post Safety Notice Action meeting, Thales UK produced a Tech Note which assessed the probability of aircraft loss against different potential modifications. It considered 2 potential aircraft loss cases: Exhibit 74

a. **Case 1**. The case of WK031: (MO selected) AND (laser altimeter failure after the UR) AND (erroneous *Ground Touch* detection whilst airborne)

b. **Case 2**. A second hypothetical case: (MO selected) AND (no ATOLS altitude available) AND (laser altimeter failure) AND (GPS altitude error > 5m).

The number of flights per incident was estimated for both cases, both at the time of the WK031 incident, following the mitigations introduced following ASRA 040 and with a series of potential modifications. A qualitative assessment of the 'pros and cons' of each modification was made. The Tech Note carried the disclaimer that the results were based on very small samples and therefore were unlikely to be statistically significant. The report estimated that the '*do nothing*' option would result in a reoccurrence of the WK031 incident every 5200 WK flights. The report made no recommendations, stating that it was produced to inform further discussions.

1.4.2.45. **Analysis**. The Panel accept that whilst the quantitative assessments made in the report were unlikely to be statistically significant, it showed that there was a risk of a reoccurrence which could be significantly reduced with a suitable modification to software or hardware. The Panel noted that, whilst Thales UK did not foresee the WK006 accident, they did attempt to consider another accident scenario based on MO and laser altimeter failure after the UR rather than focussing on the WK031 accident.

1.4.2.46. **Conclusion**. The Panel concluded that the Tech Note was written to inform and generate further debate and potentially could have been a good starting point for deciding on a course of action had there been a follow up to the Post Safety Advice Action Meeting. The Panel believe that a known design flaw, even when procedurally mitigated, likely to result in an aircraft loss once every 5200 flights, should have warranted urgent safety action.

WK031 SI

1.4.2.47. Around the time of the Thales UK Potential Modifications Tech Note the UAST were expecting to have sight of the outcome of the WK031 SI recommendations. The TAA reported in interview '*being stuck*' waiting for sight of the WK031 SI report before assessing any further decisions. He was concerned that this report might give a different perspective and that decision might need to be changed after they had potentially embarked on an expensive course of action. The TAA explained that he had voiced his concerns in a number of conversations with the ODH about the issue. The Panel asked the TAA if he had replied to the DG MAA's Safety Advice. The TAA had already explained that he had articulated that the risk was to capability and not to life, and further explained that he had spoken with DCA and they had agreed that Witness 10

ultimately it was an ODH and SRO issue. The TAA therefore used the ASSWG to decide what to do. He kept the WK031 Panel informed of the actions and therefore, did not see an obvious need to reply.

1.4.2.48. **Analysis**. The Panel noted the UAST's expectations of the WK031 SI Panel and considered to what extent Panel Presidents, the Def AIB or indeed the Convening Authorities should be responsible for updating Project Teams, Duty Holders and other affected organisations on the progress of SIs. The Panel, accepted that there were complicated issues at play and that a simple fix to implement the Safety Advice was not within the gift of the TAA alone. It appeared to the Panel that after Jun 15 progress in enacting the Safety Advice had largely stalled, with the UAST awaiting outcome of the WK031 SI and Thales UK awaiting further direction from the UAST.

1.4.2.49. **Conclusion**. The Panel concluded that to maintain independence and avoid feeling any pressure to draw hasty conclusions, SI Panels should not be responsible for updating or providing inputs into such organisations and that questions should be referred back to the Convening Authority. The Panel **observed** that there was no stated requirement to formally respond to the Safety Advice, thereby resulting in the DG DSA (formally DG MAA) and the wider DSA organisation remaining unsighted as to the decisions and course of action resulting from the Safety Advice. The Panel believe that this could undermine the purpose, benefit and accountability in issuing safety advice.

1.4.2.50. **Recommendation. The Panel recommends that Director General, Defence Safety Authority should consider stating a requirement for the recipient to respond within a given timescale to Safety Advice issued.**

Further analysis

1.4.2.51. **RtL**. The Panel accepted the UAST's analysis that any reoccurrence would be over the landing site, but wanted to ensure that the RtL assessment was correct in practice. The Panel considered:

Witness 5
Exhibit 75
Exhibit 76
Exhibit 77

a. Safety Case Assumption T85, owned by the DDH, describes the responsibility for ensuring that the strip is clear. It stated that '*standard practice is to have an Observer – part of the WK L/R team to ensure the strip is clear*'. The Panel established that it is not routine practice to have observers during recovery and that they are only stipulated to be present when an override is selected.

b. The IETP defined a safety zone around the landing site, which was a perpendicular distance 40 metres from the runway centreline, and 60 metres beyond the ends of both runways.

c. The BDN SOPs stated that the '*WK L&R hold point for a 17W recovery is HOTEL loop*'. The Panel was unable to find a clear written definition of *Hotel loop* but noted its position to be adjacent to the landing strip between the underrun and the defined runway start, as shown in Figure 13.

d. The Bty stated there were no laid down rules about safety distances when operating around the runway for L and R crews and Observers and that they relied on individuals' judgement to determine safe distance from the UA. The Bty stated that they could not find any clear direct orders or training material which stipulated a

safety distance.

e. On 2 Nov 15, 3 visitors were observing WK operations and were in the vicinity of the runway when WK006 crashed. The AO stated that he escorted the visitors to 'Fireside 2' (shown in Figure 13) to observe the landing, which was approximately 50 metres closer to the touchdown point than the point taken to be *Hotel Loop* (the documented holding point for personnel during L&R operations).

f. Debris from the WK006 crash made it as far as the lateral bounds of the tarmac strip onto the grass area adjacent.

The Panel could not determine with confidence that personnel on the airfield would always be at a safe distance to avoid risk of injury in any reoccurrence of the WK006 or WK031 accidents. The Panel **observed** that the ADS did not clearly specify the areas personnel had to remain clear of during WK launch and recovery operations. The Panel also **observed** that the Safety Case assumption T85 may not have been valid regarding the use of observers.

1.4.2.52. **Recommendation. The Panel recommend that the Delivery Duty Holder reviews the assumption T85 made in the Safety Case to ensure that it remains valid.**

1.4.2.53. **Recommendation. The Panel recommends that Head Unmanned Air Systems Team ensures sufficient detail is included in the Aircraft Document Set to allow the Delivery Duty Holder to define appropriate safety distances for WK Launch and Recovery operations.**

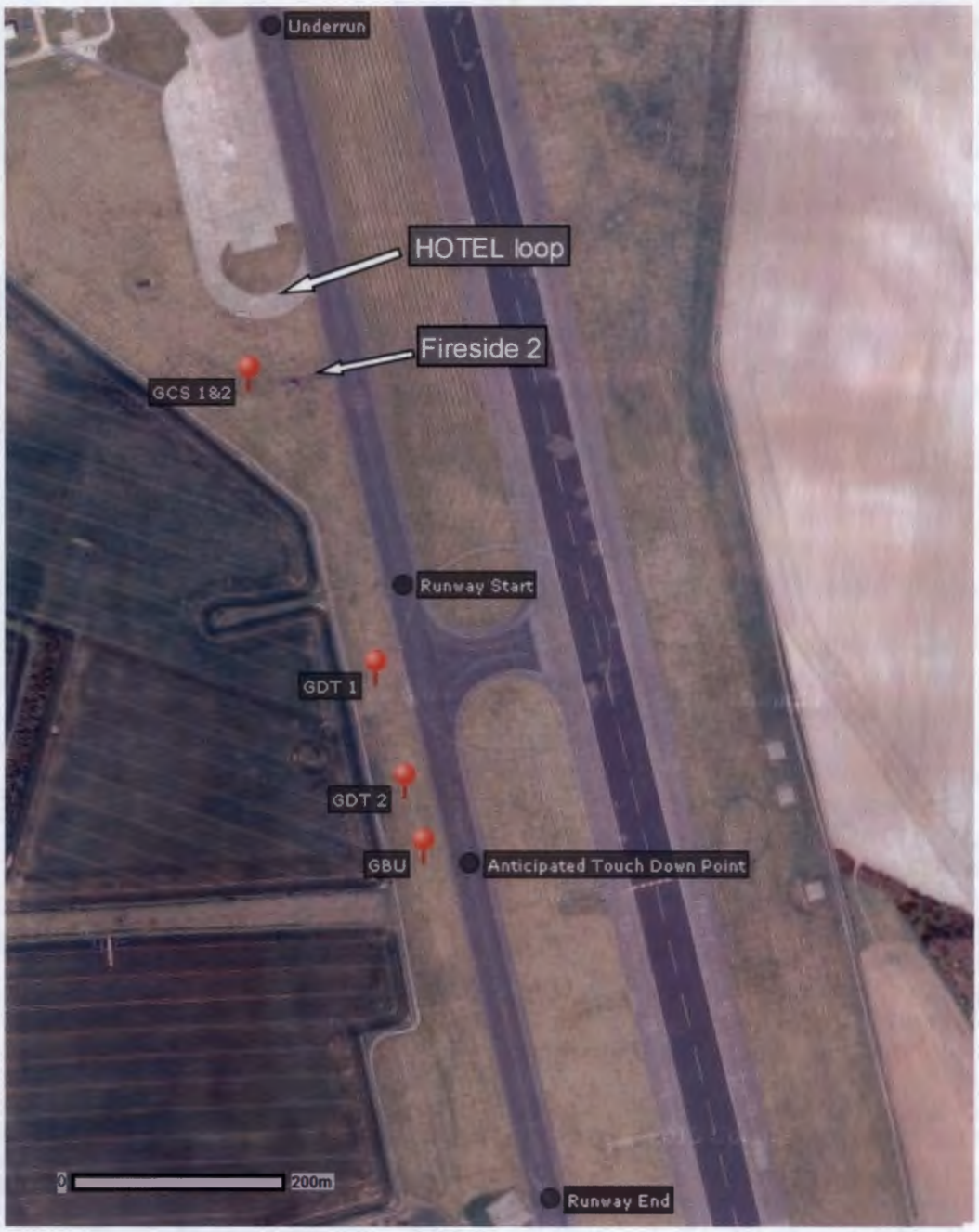

Figure 13 - Overview of Fireside 2 and Hotel Loop

1.4.2.54. **ISA Engagement**. The Panel established from the evidence that, at the time of the WK006 accident, the ISA had been on contract continuously since Sep 14 and had initially been actively involved in providing independent advice to the UAST. The Panel, however, ascertained that, due to overspending against the ISA contract, from around mid-Jan 15, until May 15, the ISA was not actively involved in providing independent advice to the UAST. The Panel could find no evidence of any ISA reports on WK over this period and noted his absence from the post safety notice action meeting in Mar 15. The DE&S Safety and Environmental Handbook stated that the Project Team should provide the ISA with unfettered access to appropriate information, underpinning the Regulation contained within RA 1220, and laid down in Def Stan 00-56. The Panel **observed** that, despite the ISA remaining on contract, the UAST was functioning without an active ISA for a 3 month period of the WK programme.

Witness 16
Exhibit 78
Exhibit 65
Exhibit 133

1.4.2.55. **Recommendation. The Panel recommends that the Head of Unmanned Air Systems' Team should ensure that the Project Team receives uninterrupted independent safety advice, to satisfy the requirements in Def Stand 00-56, RA1220 and the DE&S Safety and Environmental Handbook.**

1.4.2.56. **Independent Technical Evaluation**. Following the crash of WK031, ASRA 040 sought to establish whether the use of MO altered the RtL position and assessment previously made in the WK Equipment Safety Assessment[36]. The Panel believe that as an event had occurred, which had forced a re-evaluation of elements of the WK Equipment Safety Assessment, independent analysis of the data underpinning that re-evaluation was required[37]. The DE&S Environmental and Safety Handbook stated that 'care must be taken to ensure that there is no possibility of an organization assessing its own design and/or Safety Assessment/case'. On 6 Nov 15, the UAST stated that they would be sending a draft of the ASRA to the ITE for review. However, the Panel established that the UAST did not request ITE of the ASRA and had no record of ITE having been conducted on the technical documents from ESL and Thales UK, which underpinned their technical position in the ASRA. The UAST stated that, in their opinion, there was no requirement for ITE to be conducted on the ASRA because it was an internally generated document 'that provided a summary of an issue and its safety implications/risk assessment' and that the technical documents were reviewed by two subject matter experts within the UAST[38]. The Panel noted that, within RA1220, it was permissible for personnel from within the team with the required level of competence and experience to conduct ITE. The Panel believe that, similarly to ISA advice, any ITE conducted should be recorded and to avoid any risk of the organisation assessing its own safety assessment, that it may be prudent to seek external ITE when assessing technical information underpinning safety assessments.

Exhibit 79
Exhibit 65
Exhibit 64
Exhibit 134

1.4.2.57. **Recommendation. The Panel recommends that Head Unmanned Air Systems Team should ensure that the Project Team obtain and record independent technical evaluation when assessing technical information underpinning their Safety Assessment/Case.**

1.4.2.58. **Level of technical understanding**. The Panel found no evidence to suggest that the UA did not behave as designed, but believe that a design flaw was uncovered following the loss of WK031. The Panel questioned whether the UAST had sufficient information to be able to understand the wider implications of the design flaw uncovered by the WK031 accident. It did not appear that the UAST had requested any further details of the landing logic and neither the UAST nor Thales UK held a copy of the Functional Requirements Specification for the VMS, which was referred to in the manufacturer's assessment of the WK031 accident. An email from a member of the UAST, written at the time of the ASRA, expressed concern about the UAST being led in a direction by Thales UK, an optimism bias at a senior level within the UAST and agreed with the ISA's view that the team were focussing too narrowly on the crash scenario rather than considering the wider implications on the use of overrides. The Panel believe that the UAST may not have been questioning

Exhibit 79
Exhibit 68

[36] The Executive Summary of ASRA040 stated 'Consequently, the RtL created by this activity remains the same as detailed in the WK Equipment Safety Assessment and remains Tolerable and ALARP.

[37] The requirement for Independent analysis is laid down in RA1220(4).

[38] Including a software specialist employed through Contingent Labour (also known as Manpower Substitution).

enough about the UA's behaviour and its effects on safety. This belief is supported by a finding in the MAA Audit in Jan 15.

1.4.2.59. **ISA debrief on WK**. The UAST ISA was replaced in Mar 16. The outgoing ISA produced a report for the UAST which stated the following; Exhibit 78

'The UK remains limited in knowledge regarding the intricacies of the Watchkeeper design and the integration of 'additional features' that differentiate Watchkeeper from its lineage of predecessors. It is perceived that credit is given to 'modes' and associated algorithms taken from other platforms, however, the rationale for the logical and ordered integration into Watchkeeper is not clearly understood by the UK and when 'tested', questions inevitably arise that remain unanswered. Before any significant changes to the Watchkeeper design are considered to address issues regarding the landing capability of the air-vehicle, [the ISA] believes it is imperative that the UK demonstrates a comprehensive understanding of the logic, rationale for the logic and ordering or sequences steps prior to any intervention and corrective action'.

The Panel accept that the outgoing ISA's debrief on WK was written after the WK006 accident, but have chosen to include it having confirmed that he was referring to opinions drawn following the WK031 accident. In carrying out the technical investigation associated with the SI, the Panel found that many of their questions about the landing logic and functioning of the UA had to be referred to ESL by Thales UK and UTacS (an example of a relatively straightforward question being referred and taking over 3-months to be answered by the UA manufacturer is described in Section 1.4.3). Information was seldom volunteered by ESL and responses to specific questions, staffed through a 'Technical Question (TQ)' process, appeared to be stiflingly slow. The Panel believe that this may be the root cause of the limited UK knowledge observed by the ISA.

Conclusions regarding the Safety Advice

1.4.2.60. The Panel were tasked with examining applicable policies, orders and instructions, whether they were appropriate and complied with to include (amongst other things) the level of awareness and application of the Safety Advice issued by DG MAA. The Panel found that the Safety Advice was expected by the UAST, who took ownership of the action within it and led much of the subsequent activity; however, the safety advice itself did not significantly alter the direction of travel.

1.4.2.61. The awareness of the risks associated with the use of MO were documented and articulated by the UAST. With the UAST's advice these risks were considered by the DDH, ODH and SRO through various safety forums and there was a broad acceptance of a risk to capability, but not a risk to life. This coupled with, what proved in hindsight, to be a limited UK understanding of the system functioning during the landing phase, led to the conclusion that the risks had been acceptably mitigated with better procedures and increased awareness alone. This was prior to the issuing of the SA, which the Panel found, did not materially alter the assessments already made. The Panel found, however, that the ASRA was produced under time pressure and focussed only on the WK031 accident sequence and not any wider implications of the issues uncovered, as highlighted by the ISA. The Panel believe that the initial intent of the UAST and the ISA's suggestion to obtain ITE advice would have been wise in the

circumstances. Additionally, the Panel believe that all of the ISA provisos, in supporting the return to flight recommendation, could have been addressed, prior to the return to flight to ensure a better understanding of the system.

1.4.2.62. The UAST formed the opinion that an immediate safety modification was not required as they considered that the Risk to Life remained unchanged and described the issue as a capability issue, not a safety issue. The risk to capability was articulated to the ODH and SRO, although the risk was not quantified until Thales UK produced their 'Tech Note*: WK031 Incident Potential Modifications*'; it was implied by the UAST that the risk of reoccurrence was very low. The Panel believe that in the absence of a detailed understanding, the UAST could have been more questioning of the DAOS organisations and allowed an optimism bias to form, possibly in the face of programme pressures. If one considers this with the HF findings described in Section 1.4.1, regarding the selection of MO, it would seem that this optimism bias percolated as far as the Captain of WK006, who having been involved in many of the post WK031 discussions concerning the use of MO, also believed that a repeat of the WK031 accident, even with MO selected, would require a repeat of the same meteorological conditions. Therefore, the limited understanding within the UK of the technical issues concerning the recovery of WK was a **contributory factor**, which the recommendation made in 1.4.1.87 should address.

Environmental Limitations and ADS

1.4.2.63. The remainder of this Section will examine the policies, orders and instructions contained within the WK Release to Service (RtS) Issue 1 AL4, WK Interactive Electronic Technical Publication (IETP) Version 7.1 and the WK Flight Reference Cards (FRCs), issue 2 dated Jan 15. Specifically it will assess whether they provided sufficient information to crews to deal with emergency and unusual situations and the environmental limitations within them at the time of the accident.

WK Aircraft Document Set (ADS)

1.4.2.64. RA1310 defined the regulation relating to the ADS. The rationale behind the regulation was that the ADS 'contain the documents that have prime airworthiness function for each aircraft type. It is essential that detail from the Release to Service is carried forward into supporting aircrew and engineering publications'. RA1310 stated that *'the RtS is the master airworthiness reference in the ADS'*. RA1310 GM stated that *'the Aircrew Manual and FRCs support the RtS by describing and translating to the operational circumstances and aircrew needs the statements given in the Safety Case'*. At the time of the accident, RA1310 also stated that the ADS should contain the following documents: Exhibit 80

a. RtS.

b. Aircrew Publications, including Aircrew Manual.

c. Operating Data Manual (ODM).

MOD Army Release to Service (RtS) Issue 1 AL4, dated Jun 15

1.4.2.65. The initial WK RtS was completed on 28 Feb 14 and was at AL4 on 2 Nov 15. The Panel focused their analysis onto 2 subject areas; Witness 1 Witness 2 Witness 3 Witness 4 Exhibit 81 Exhibit 80

a. **Environmental Limitations**. The Panel was told repeatedly in interview with WK operators that there were no weather limits in the RtS relating to the recovery phase. The broader weather limits appear to be almost an exact 'copy' from the IETP. The RtS did not contain any specific weather limits, relating to cloud and visibility during the recovery phase. This is discussed in greater detail later in this section.

b. **ATOL limitations**. WK is a 'first of type', in delivering an autonomous landing capability. However, the only reference to the ATOL is in Section A – Description. There is no reference to ATOL in Section B – Design or Handling Limitations, or Section C – System Limitations and Constraints. The Panel were surprised that the RtS, the master airworthiness document within the ADS (as described by RA1310), contained no limitations or direction to operators relating to ATOL. For example, WK is a deployable capability; the RtS provides no direction, reference or limitations on how crews are to construct the circuit profile when arriving at a new location. The Panel believes that the inclusion of ATOL would be in keeping with the guidance in RA1300 as to what is 'content appropriate to the RtS'. The Panel believes that information on ATOL would be relevant to the target audience (the system operators) as it would help define the safety envelope of the Air

System. The Panel **observed** that the lack of information in the RtS relating to ATOL requirements, could detract from an operator's appreciation of significant limitations and therefore capabilities.

1.4.2.66. **Recommendation. The Panel recommends that the Head of the Unmanned Air Systems Team should submit a Release to Service recommendation to the Release to Service Branch (Army) to include explicit ATOL procedures and limitations, including recovery set-up and operation, in the WK Release to Service.**

Operating Data Manual (ODM)

1.4.2.67. The Panel **observed** that there was no ODM for WK, which, at the time of the accident[39], was a requirement listed in RA1310. A MAA Audit of the UAST in Jan 15 stated that the UAST were unable to present an ODM for WK. It stated *'the lack of a validated ODM calls into question the reliability of the performance data used for planning purposes and operation of UAST platforms'*. The Panel acknowledge that the mandated requirement for an ODM has been removed from RA1310, however agreed with the MAA recommendation as some of the data presented in other documents did not have a clear source document. Despite a high level of automation in the WK system the Panel believe that the data provided in an ODM would aid understanding of the aircraft's performance, which could assist crews in dealing with unusual or emergency situation or planning for novel activities. The Panel views that the efforts in introducing an ODM should focus on ensuring that build standard ES2 has an ODM at its introduction to military service, hence improving the ADS information as the WK community grows and enhances its capability. Exhibit 80 Exhibit 68

1.4.2.68. **Recommendation. The Panel recommends that the Head of the Unmanned Air Systems Team should consider introducing a WK Operating Data Manual.**

WK Interactive Electronic Technical Publication (IETP) Version 7.1

1.4.2.69. The IETP is an electronic suite of documents sponsored by the UAST and produced by Thales UK, which includes system descriptions, illustrated parts catalogues, operating, handling, routine servicing and maintenance procedures. IETP Version 7.1 was extant at the time of the accident and was hosted on TrilogiView and available to operators and maintainers on ToughBook Windows XP laptops. The week following the accident, the IETP was uplifted to Issue 8.0. The Panel focussed their analysis onto 2 aspects of the IETP: Exhibit 44 Exhibit 69

a. **The usability of IETP**. In addition to being a technical publication, the IETP was intended to fulfil the role of an aircrew manual. During interview, operators told the Panel it was difficult to quickly access information within the IETP because it was not intuitive to use. The IETP was only accessible on the ToughBook laptops, which were not taken into the GCS and were limited in number, which restricted individual study. The WK006 HF report

[39] At the time of writing, the mandated requirement for an ODM had been removed from RA1310.

stated '*The difficulties described with accessing and using the IETP could limit the crew's knowledge of WK as information may not be found or the time taken to find information may also put personnel off using the IETP altogether*'. The Panel **observed** that the IETP did not provide a suitable platform to act as an Aircrew Manual.

b. **Content of IETP**. At the time of the accident, the Panel **observed** that there was insufficient information within IETP v7.1 relating to the landing phase; the IETP provided the procedures on how to land the UA, but provided operators with no detail on the various landing logics, circuit set up and all possible logic states. For example, one of the crew reported seeing *Air Jump* displayed during the recovery but did not know what it meant. Although the warning was contained in the FRC, there was no amplification in the FRCs of what this meant, and a search of the IETP revealed that the IETP did not contain any reference or explanation of this caution.

1.4.2.70. **Recommendation. The Panel recommends that the Head of the Unmanned Air Systems Team should:**

a. **Introduce an Aircrew Manual for WK, which is readily accessible to crews, both in the Ground Control Station and for self-study.**

b. **Ensure that there is sufficient information in the Aircrew Manual to enable operators to deal with emergency/unusual situations.**

WK Flight Reference Cards (FRCs) Issue 2, dated 2 Jan 15.

1.4.2.71. The Panel **observed** inconsistencies within the FRCs and between the WK FRCs and the IETP.

a. **Pre Landing Checks**. The FRCs offered conflicting guidance to that found in the IETP concerning when to select and deselect *Alt Dev* override. This is covered more detail later in this section.

b. **Override labelling**. Annex A Figure 2 shows the ATOL Termination Codes listed on card E78 of the WK FRCs. At the time of the accident, it was found that the individual overrides for ATOL terminations *Envelope Vertical* and *Envelope Ground Proximity* were the wrong way around; ie, for the *Envelope Ground Proximity*, the *Alt Dev* was to be used as opposed to the *Ground Proximity* override and vice versa. An explanation of this was not included in IETP 7.1. The WK006 HF report stated that the override that had to be applied to each abort was therefore counterintuitive. The issues in labelling were known amongst WK crews and described in the 'Known Issues and Workarounds' document. The Panel believe that there remains a risk that an error will be made as a result of incorrect labelling. The Panel also assessed that there could be risk of selecting the incorrect override once the labelling has been corrected.

c. **Card E78 – ATOL Termination Codes**. There was a discrepancy between the warning the crew received on the AVDC

in the GCS, and what was listed in the FRCs and IETP. During the recovery of WK006, the AVDC displayed a *'Land Status Timeout'* warning to the crew. There is no reference to this in the FRCs or IETP. The Panel has subsequently established that this warning was actually the *Ground Touch identification window timeout*. The WK006 HF report stated the following; '*Operators did not know the meaning of land status timeout and Ground Touch identification timeout if this message was displayed outside the normal touchdown area. Land Status Timeout was referred to as Ground Touch identification Timeout within WK documentation. Although a technical definition was given, there was no detail of what Land Status Timeout might mean if it was displayed outside of the normal touchdown area (i.e. a significant distance from the ground). These mental models and understanding of how the UA operated would set expectations regarding how the system would respond in particular conditions and would be likely to influence decision making regarding the use of overrides'*.

1.4.2.72. The validation process involved in the FRCs had been raised by the ISA at the ODH's ASSWG in Jan 15. The correct validation process would have been for the User Authenticator in AAvn Stds to validate the FRCs produced by the Handling Squadron. However, it was acknowleged to be difficult due to the limited availability of WK SQEP within AAvn Stds. An individual, heavily relied upon throughout the programme, had reviewed the FRCs on behalf of Cap CS, and in the absence of SQEP, Thales UK Head of Flying had been asked to conduct the verification exercise. The Panel **observed** that the limited availability of SQEP in AAvn Stds, and the reliance on Thales UK could have reduced the effectiveness of the verification and assurance process for the FRCs. The Panel noted that although the UAST is responsible for the ADS, which includes the FRCs, RA1310 stated that it is the ODH who should be responsible for appointing a User Authenticator for reviewing aircrew publications. Exhibit 69

1.4.2.73. **Recommendation. The Panel recommends that the Head of the Unmanned Air Systems Team should ensure that the Aircraft Document Set and all training material reflects the exact wording of all warnings, cautions and advisories that could be seen by WK operators.**

1.4.2.74. **Recommendation. The Panel recommends that the Operating Duty Holder should ensure that WK Flight Reference Cards are reviewed by Suitably Qualified and Experienced Personnel who are independent of Thales UK and have in-service military experience of operating WK.**

Environmental Limitations within the ADS

RtS

1.4.2.75. **RtS – WK UAS Issue 1 AL4**. The RtS contained environmental limitations covering snow, rain, dust, volcanic ash, hail, icing and lightning. The RtS did not contain any specific environmental limitations concerning precipitation, cloud or visibility, during the recovery and landing phase. Exhibit 4

WK IETP Version 7.1

1.4.2.76. **IETP – General Description**. The IETP stated that WK *'is an all-weather aircraft'*. Environmental limitations were present in 2 discrete sections Exhibit 82

of the publication, as shown below.

1.4.2.77. **IETP – Technical Data**. This information was contained within the Descriptive section of the WK System Information data set. UAV environmental limitations were listed, including limits concerning wind, maximum rainfall, temperature and turbulence. Also covered were limits for thunderstorms, snow, icing and hail. This section of the IETP did not contain any information or limitations regarding cloud or precipitation on recovery. Exhibit 83

1.4.2.78. **IETP - Use in special environments; Low Cloud**. This data set was contained within the procedural section of the WK system information data set. It stated the following: Exhibit 84

*During **normal flight conditions** the connect point should be clear of cloud, with adequate visibility to provide a clear view of the runway. There may be occasions when the UAV is to be recovered while the connect point is in cloud. **It is recommended that the minimum cloud base for recovery is higher than the downwind leg and therefore higher than the connect point**. Occasionally the weather will deteriorate to worse than forecast and there could be some cloud at or below the connect point. If the weather does deteriorate the UAV will most probably auto abort if it detects cloud at the connect point. If this happens, the GCS crew must perform the procedure for UAV recovery in low cloud conditions*[40].

1.4.2.79. **IETP – Low Cloud Recovery Procedure**. This is contained within the GCS Normal operation procedures (crew). It stated that if the UA auto aborts in cloud at the connect point, 'proceed as follows for the next circuit'. Crews are then to select ATOL override *Alt Dev* during the downwind leg before reaching the connect point. The IETP low cloud procedure did not state a requirement to deselect the *Alt Dev* override prior to the underrun point. If landing was still unsuccessful, the procedure directed crews to consider the use of MO. Exhibit 85

WK FRCs

1.4.2.80. There were 4 separate elements of WK aircrew publications, produced by the Handling Sqn at BDN; Normal/Emergency Procedures, Known Problems and Work-Arounds, Enhanced Image Analyst procedures and Flight Line procedures. Limitations, including environmental limitations for the UA and ground equipment were contained in the Normal/Emergency Procedures, which was at Issue 2 at the time of the accident. Exhibit 47

1.4.2.81. The WK FRCs did not contain any environmental limitations concerning precipitation, cloud or visibility, during the recovery and landing phase. A copy of the FRC Environmental Limitations is provided at Figure 3 in Annex A.

1.4.2.82. The Pre-Landing Checks, shown in Figure 4 at Annex A, stated that if the CP was in cloud, to select the ATOL *Alt Dev* Override to ON prior to the first approach. The FRCs then direct the crew to deselect *Alt Dev* prior to the Underrun Point (not replicated in the IETP). Exhibit 47

[40] WK IETP 7.1. AAA-C00-00-00-0000-885A-A

Analysis – Environmental Limitations

RtS, IETP and FRCs

1.4.2.83. The RtS, IETP and FRCs did not contain any specific, clearly defined weather limits concerning cloud or precipitation during the recovery phase. Furthermore, the IETP stated that WK *'is an all-weather aircraft'*, which is not true and could have led personnel to have confidence beyond the real world capabilities of the UA.

1.4.2.84. The Panel were told by members of the crew that a low cloud recovery procedure was contained within the IETP, as has been reproduced above. None of the personnel interviewed by the Panel made any reference to the IETP special environments section, where it stated that 'the connect point should be clear of cloud'. Whilst this guidance was contained within the IETP, it was not contained within the Technical Data section, where the other environmental limitations were listed and could be missed by personnel when assessing the platform's weather limitations. Irrespective of the location of the guidance, the Panel believes that the information is insufficiently clear and directional, and could read very much as advice, for example the IETP did not define 'normal flight conditions'. Critically, this 'advice' was not reflected in the RtS. The Panel established that every other weather limit stated in the IETP had been incorporated in the RtS. The RtS contained no limitations or cautions about cloud or visibility during recovery. Witness 1 Witness 3 Witness 4 Witness 5

1.4.2.85. The IETP stated that due to changing weather, occasionally the UA may need to be recovered with cloud at or below the CP and directs crews 'to perform the procedure for UAV recovery in low cloud conditions'. During interview, the Panel established that personnel were aware of the procedure, and viewed it as further justification to launch WK006 as an official procedure existed to deal with such a situation. The Panel believe that the wording of this section, when combined with no formal limitations, led to the normalisation of a low cloud procedure, where crews believed they could routinely conduct flights when cloud was expected at or below the CP. This was a **contributory factor**. Witness 5

1.4.2.86. The direction in the FRCs and the IETP regarding the low cloud procedure was conflicting. Within the FRCs, crews were directed to 'pre-emptively' select *Alt Dev* prior to the CP, if it is in cloud, and then deselect *Alt Dev* prior to the Underrun. This information was contained within the pre landing checks and is not a stand-alone checklist. The IETP stated that crews should only select *Alt Dev* if the UA has conducted an approach and Auto Aborted. Additionally, it did not state the requirement to deselect *Alt Dev* prior to the Underrun in the IETP. Therefore, the Panel noted some inconsistency between the FRCs and the IETP, in relation to the low cloud recovery procedure. Exhibit 47

WK Operations at West Wales Airport (WWA)

1.4.2.87. **Overview**. The Design Organisation conducted test and development flights at WWA concurrently to Army operations at BDN. Test flights were conducted under a Military Flight Test Permit (MFTP). An approved MFTP is a requirement before flight tests may be undertaken[41]. In

[41] RA5202 details when a MFTP is required. This includes in the absence of a Valid Certificate of Usage and when the design standard is not reflected in an extant RtS or flying outside the service environment.

this instance Thales UK, the Applicant, applied for a MFTP, which was approved by the UAS TAA.

1.4.2.88. **Technical Note 701-518134 Issue 1, 5 Sep 13.** Thales UK issued a Technical Note, which highlighted that if there was cloud at the Connect Point, it is likely that the UA would automatically abort the landing, which had been experienced in flight trials. It stated that a Low Cloud Procedure had been developed and documented in the IETP. It stated that no safety risk had been identified related to the issue and that it *was 'not proposed to recommend any specific RtS content related to this issue'.* Exhibit 86

1.4.2.89. **Hot Poop.** Thales UK released a Hot Poop titled 'Limitation: Min Weather Conditions for Flight' in Sep 13. This document was updated and re-issued in Sep 14 and again in Aug 15. The Panel established that the Hot Poop was in force at WWA at the time of the accident of WK006. Although unrelated to the landing logic issues previously described in this report and initially pre-dating the loss of WK031, the Hot Poop stated that the general weather limitations which should be observed for WK operations at WWA were 'no significant cloud below 700ft AGL' and 'horizontal visibility – 3.7km'. It stated that the Design Organisation Safety Review Board has granted approval for data gathering flights in lower weather conditions (200ft cloud base and 800 metres visibility). It stated that if operators wish to fly to these lower weather conditions, they were to consult with the DA or Accountable Manager (Military Flying) prior to flight. Exhibit 87 Exhibit 88

1.4.2.90. **MAA RA 5202 – Military Flight Test Permit (MFTP).** RA 5202 provides the regulation and procedures for the issue of an MFTP. It stated the following, at 5202(2) Para 15**:** *'If at any time after an MFTP has been issued, the Applicant [Thales UK] becomes aware of evidence that necessitates a restriction on existing limitations, the Applicant should immediately advise the TAA'.* It continued, *'where the restriction may affect other operators of similar Military Air Systems, the Applicant should also make arrangements for them to be informed via the appropriate regulatory authorities'.* Exhibit 56

1.4.2.91. **Analysis of Thales UK Hot Poop**. The Panel established that Thales UK had weather limits in place at WWA for 2 years prior to the WK006 accident. The weather conditions on 2 Nov 15 at BDN, both prior to and during the flight of WK006, were well below the required weather minima listed for WK operation in the Hot Poop. The Panel reviewed the MFTP and sought advice from the MAA, who confirmed that the WWA Hot Poop constituted a restriction on the existing limitations within the MFTP and that the TAA should have been advised immediately. The UAST confirmed to the Panel that the TAA and the UAS Engineer team were **not** aware of the contents of the Hot Poop Weather Limitation, prior to the WK006 accident. The Panel could also find no evidence that Thales UK, as the MFTP holder, had formally informed the Army of the contents. Exhibit 89 Witness 5

Conclusions

1.4.2.92. The Panel concluded that:

a. Personnel involved in the operation of WK006 did comply with the environmental policies, orders and instructions, which were in force at the time of the accident.

b. IETP 7.1 contained a paucity of information about the landing regime and did not provide operators with sufficient information to

deal with the landing of WK006 and contributed towards a limited understanding by the crew of the landing logic and messages displayed to the crew during the recovery of WK006. The paucity of information relating to the landing phase within the ADS was, therefore, a **contributory factor**.

c. The absence of environmental limitations relating to cloud and visibility during the recovery/landing phase in the RtS was a **contributory factor**.

d. Since 2013, Thales UK had been aware of system limitations regarding cloud at/beneath the CP and had limited the operating envelope of WK when operating from WWA under the MFTP. In failing to communicate this increased limitation to the TAA, the opportunity to introduce similar weather limits at BDN was missed. The UAS TAA was not informed of the weather restriction in place at WWA. The Panel considered this to be a **contributory factor**.

e. The guidance in the FRCs and IETP relating to the low cloud procedure was inconsistent across the 2 documents. The Panel **observed** that the inconsistent procedures within the ADS could confuse operators and undermine the safe operation of the platform.

1.4.2.93. **Recommendations.** The recommendations made in Paragraph 1.4.1.87 should help to address the paucity of information in the ADS. **The Panel further recommends that the Head Unmanned Air Systems Team should:**

a. **Ensure that weather limitations, relating to cloud and visibility during the recovery phase are introduced into the Release to Service and Military Flight Test Permit and that these limitations reflect the actual capability of the system. These limitations should be underpinned by comprehensive test and evaluation evidence.**

b. **Ensure that WK crews have unambiguous advice about operating WK should cloud develop at or below the Connect Point.**

c. **Establish regular communication between Thales UK, the Unmanned Air Systems Team and the Army WK Organisation to ensure that pertinent safety information concerning the operation of WK is passed between organisations.**

d. **Remove all references from the Aircraft Document Set and training material to WK being an 'all weather system'.**

SECTION 1.4.3 – SERVICEABILITY OF THE UNMANNED AIR SYSTEM

TOR 3: Establish the state of serviceability of the aircraft and relevant equipment.

Introduction

1.4.3.1. This Section considers the state of serviceability of the Unmanned Air System (UAS) immediately prior to the accident. The UAS includes the Unmanned Aircraft (UA), GCS and all ancillary Ground System (GS) equipment required to operate the UA. An overview of the WK UAS is at Part 1.2. This Section draws extensively from the Defence AIB Technical Report into the loss of WK006, which in turn draws from the 1710 NAS report and specialist manufacturers' component testing reports.

1.4.3.2. Following the accident, equipment and associated maintenance documentation were quarantined for examination and testing as follows: Exhibit 17

a. **WK006 UA wreckage**. Fuel and oil samples were taken by Defence AIB investigators and sent to 1710 NAS for analysis. The Vehicle Management System Computer (VMSC) was removed, tested for damage and downloaded at the UTacS facility. The laser altimeters and GPS/INS units were also removed and tested at their respective manufacturer's facilities. The accident site and the location of the wreckage was marked and recorded by JARTS and the UA was moved into a quarantined hangar for subsequent inspection and categorisation by 1710 NAS.

b. **Ground Control Station (GCS).** The GCS used to control WK006 was examined by the investigators with the assistance of Thales UK technicians and the Ground Flight Control Computer (GFCC) logs and the CVR were downloaded onto digital media. The GCS was then quarantined until the Panel were satisfied that all data had been downloaded and converted successfully.

c. **ATOLS ground system set-up.** The ATOLS system, ATOL01, as set-up for use at the time of the accident, including the Ground Radar Unit (GRU), Ground Beacon Unit (GBU) and all associated cabling was impounded. It was inspected and tested for serviceability by the Defence AIB with the assistance of REME technicians from 74 Bty.

d. **Ground Data Terminal (GDT).** The GDTs (GDT01 and GDT02) and all associated cabling were impounded, inspected and tested for serviceability by the Defence AIB with the assistance of REME technicians from 74 Bty.

e. **Portable Aircraft Test Equipment (PATE)**. The PATE laptop, PAT04, used on WK006 prior to the accident was impounded by the Defence AIB investigators. It was inspected and tested for serviceability by the investigators with the assistance of REME technicians from 74 Bty.

f. **Documentation**. All associated F700s were impounded and inspected by the Defence AIB investigators. Copies of the deferred maintenance logs were printed out. Copies of the most recent Military Airworthiness Review Certificates and Physical Aircraft

Audits of these system elements were taken for inspection by the Defence AIB along with the Record of Engineering Authorisations for technicians that had worked on the UA or had signed for elements in the F700s.

Continuing airworthiness documentation

1.4.3.3. **Aircraft history**. At launch, the WK006 airframe and engine had flown 81:57 hrs and 131:51 hrs respectively.

1.4.3.4. **Maintenance documentation**. The Defence AIB conducted a review on behalf of the Panel of the maintenance documentation described above and noted the following anomalies: Exhibit 17

a. The fuel state on the F705 for WK006 signed for by the Captain was blank. The pilot therefore could not have cross checked his fuel state as recorded in the F700 with the fuel state reported in the GCS.

b. The Acceptable Deferred Faults logs were missing the names of the individuals making the deferment. The deferments were cross-checked with the F700 and the names recorded in the F700 were crossed checked with the Record of Engineering Authorisations and it was found that all individuals deferring maintenance were correctly authorised to do so.

c. The engine running time had been corrected by REME engineers. This was found to be an arithmetical correction to ensure the accuracy of total engine running time. The recorded hours were credible and no further investigation was deemed to be necessary.

d. The software log was blank. This was understood to be because all software used in LRUs within the UA was standardised at the time of manufacture and should any future modifications be carried out then the part number would be prescribed with a suitable denoting reference (-1, -2 and so on).

1.4.3.5. **Military Airworthiness Review Certificate (MARC)**. The Panel found that WK006, GDT01, GDT02 and WB08 each had a valid MARC at the time of the accident. The WK Arrestor system, ATOLS and PATE were removed from the requirement to have a Military Airworthiness Review by the Continuing Airworthiness Management Organisation on 29 Jun 15 following a review of this requirement for ground elements of the system. Exhibit 90 Exhibit 91 Exhibit 92 Exhibit 15 Exhibit 93.

1.4.3.6. **Physical Aircraft Audit**. The Panel reviewed the most recent Physical Aircraft Audits. These audits were up to date and the paperwork had been completed and signed off correctly. The Panel found no evidence of any major defects having been reported that could have led or contributed to the loss of WK006. Exhibit 94 Exhibit 95 Exhibit 96 Exhibit 97 Exhibit 98 Exhibit 99

1.4.3.7. **Conclusion**. The Panel concluded that continuing airworthiness documentation was not a factor. Notwithstanding the minor anomalies noted by the Defence AIB investigators, the Panel found that maintenance documentation was, overall, of an acceptable standard.

Operation, maintenance and handling of the UA

1.4.3.8. The Panel considered how the UAS had been operated, maintained and handled in order to identify any factors that may have affected its serviceability.

1.4.3.9. **Handling**. Analysis of the VMSC data and GFCC logs showed that on 2 Nov 15 the UA had:

a. Operated within prescribed environmental condition limitations.

b. Operated within its design envelope and stayed within its segregated airspace.

c. Notwithstanding the last 2s of flight, not performed any 'out-of-limits' manoeuvres.

1.4.3.10. **Mass and centre of gravity**. The Defence AIB confirmed that the UA's weight and balance had been calculated correctly. The UA was below its Maximum All Up Mass limit. The UA was in-date of its biannual physical weight check. Exhibit 17

1.4.3.11. **Fuel**. The fuel state at take-off was 79.1 kg with approximately 45 kg remaining at the time of the accident. 1710 NAS confirmed that the fuel was of the correct type (Avgas), that the parameters measured (density and total water) were within expected 'in-service' ranges and that there was no evidence of contamination. Exhibit 17 Exhibit 100

1.4.3.12. **Oil**. The UA took off with 10.1 kg of oil. The Defence AIB found no evidence of oil starvation. 1710 NAS confirmed that the oil was of the correct type and grade (Mobil Pegasus 1). An oil sample taken from the main oil tank contained a large amount of environmental material[42], microbiological contamination and elevated water content (2100 ppm). A second oil sample taken from downstream of the internal filter was not significantly degraded or adulterated and water content was within the expected range. The Panel, therefore, concluded that oil contamination did not affect the serviceability of the UA. The Defence AIB Technical Report stated that the presence of debris, water and microbiological contamination indicated that standards of cleanliness and diligence during Flight Servicing were not satisfactory. The Panel noted that it was possible that water had entered the main oil tank after the accident and that the microbiological growth may have been encouraged by the presence of water over a period of time. Exhibit 17 Exhibit 100

1.4.3.13. **Conclusion**. The panel found that operation, maintenance and handling of the UA did not affect the serviceability of the UAS. The Panel **observed** that the presence of environmental material in the main oil tank was most likely to be a result of poor maintenance practices.

1.4.3.14. **Recommendation. The Panel recommend that the Delivery Duty Holder Chief Air Engineer ensures that appropriate maintenance practices are adopted to ensure the risk of oil contamination is**

[42] Reported to be plant leaves, insects and general dirt

minimised.

UAS physical examination

1.4.3.15. The Panel considered whether the serviceability of the UA could have been affected in flight. The Panel considered the following factors:

a. **Mid-air collision**. At the time of the accident, the UA was operating within segregated airspace under ATC control. There had been only one other aircraft movement at BDN on the 2 Nov 15 hours earlier. VMSC recorded GPS positional information shows that at no time during the sortie did the UA leave its cleared segregated airspace. The Panel therefore ruled out the possibility that at any time during the sortie, the UA had been involved in a mid-air collision. Exhibit 29 Exhibit 30

b. **Bird strike**. There was no evidence of a bird strike found during the Defence AIB examination of the wreckage. Exhibit 17 Exhibit 27

c. **Control restriction**. The Defence AIB found no evidence of a control restriction. Exhibit 17

d. **Un-commanded GCS input**. The Panel found no evidence in the GFCC logs to suggest that the UA received or executed any un-commanded inputs from the GCS. Exhibit 16

e. **Environmental conditions (other than cloud at the CP)**. Noting that a gust of wind was reported to have played a part in the loss of WK031, the Panel considered whether other environmental conditions could have played a part in the loss of WK006. The Panel, however, found no evidence to suggest that any other environmental factors or meteorological conditions adversely affected the operation of the UA or influenced the outcome. Exhibit 22 Exhibit 23 Exhibit 50

1.4.3.16. The Panel considered the UAS as a whole and looked for evidence of any unserviceability arising prior to the crash in each of the following areas:

a. Aircrew equipment.

b. Fuel, lubrication and cooling systems.

c. Electrical systems.

d. UA fuel system.

e. UA propulsion system including the engine and transmission.

f. UA Undercarriage.

g. UA structural components.

h. Flying control system.

i. Air Vehicle Data Computer.

j. GFCC.

k. VMSC.

l. Communications systems and datalinks

m. Navigation systems and sensors.

From the physical inspections of the wreckage and impounded systems by the Defence AIB and 1710 NAS and a review of the fault logs, the Panel were unable to find any evidence of any significant faults arising with the above that would have affected the serviceability of the UA. The VMSC, elements of the ATOLS system, INS/GPS units and laser altimeters were removed and subject to further testing under the supervision of the Defence AIB as described in the following paragraphs.

1.4.3.17. **VMSC**. The VMSC was found to be physically intact. It was connected to a pre-production aircraft at UTacS, which was connected to a PATE and its non-volatile memory downloaded. The initial data download revealed 'gaps' in what should have been continuous streams of data. A second download was carried out in which 'gaps' in the data appeared, but in different places. From the 2 downloads, the Defence AIB and the Panel were able to recover all expected data. The Panel concluded that the VMSC had recorded flight data continuously and that the issues with recovering the data were most likely to be with the download process and not a result of a fault in the VMSC itself. The Panel made an observation about the data recording solution in Section 1.4.1. Exhibit 17

1.4.3.18. **GPS Data Recorded by the VMSC**. The GPS height data was observed by the Defence AIB and the Panel to have 'frozen' each time the UA passed the CP. The Panel noted that an explanation provided to the WK031 SI Panel was that the GPS data had frozen as the system had selected ATOLS for the landing. In the case of WK006, the UA was in GTOLS mode and yet the GPS was still 'frozen' from the CP, which was contrary to the previous explanation. Confirmation was sought on 13 Feb 16 from ESL, who confirmed on 2 Jun 16 that this information was not recorded by the VMSC during take-off and landing and that the behaviour was in accordance with the telemetry plan. Whilst there were no serviceability issues with the GPS, the Panel believe that this demonstrated an incomplete understanding of the system within the UK Industry and the MOD. It also highlighted difficulties in obtaining answers to technical questions from the ESL. This further highlighted a compounding issue of well-meaning engineers being prepared to offer plausible but not assured answers to try and 'fit the facts', substantiating the Panel's belief that the UAST need to be more questioning of DAOS organisations (Section 1.4.2 Paragraph 1.4.2.28). Exhibit 36

1.4.3.19. **ATOLS**. ATOLS was reported to be unserviceable throughout the recovery and at the time of the accident. As discussed in Section 1.4.1, the Panel does not believe this contributed to the accident. ATOLS was reported to be working at take-off, however, the Panel were not able to determine the exact time ATOLS became unserviceable or the exact cause of the unserviceability. The fibre optic cable that connected the GBU/GRU to the GCS was found to be damaged by what looked like the bite marks of a small mammal. A functional test by Defence AIB Investigators, however, confirmed that the cable was functioning correctly and the Panel therefore concluded that the bite marks were unlikely to be the cause of the unserviceability. During interview, a senior member of the L&R Det stated that moisture gathering on the cable connections was a known problem and that he had tried to clean Witness 9

them, but moisture was re-gathering before he could connect the cable back together. It is likely therefore that moisture ingress was the cause of the ATOLs unserviceability. The Panel confirmed with UTacS that wiping with non-approved materials or blowing out the ends of the connectors was not a recommended practice. The Panel **observed** that:

a. The ATOLS fibre optic cable was reported to suffer poor serviceability due to its susceptibility to being damaged by wildlife and tendency to gather moisture in the connectors.

b. The L&R Det did not have fibre optic connector cleaning kits.

1.4.3.20. **Recommendation. The Panel recommend that Head Unmanned Air Systems Team should:**

a. **Review the design and use of the Automatic Take-Off Landing System fibre-optic cable to ensure its reliability in service.**

b. **Provides fibre optic cable cleaning kits and appropriate training to ground crews.**

1.4.3.21. **Effect of ATOLS unserviceability**. The Panel found that had ATOLS been serviceable, it would not have affected the outcome, but may have affected the height at which semi-flare was declared (which by design is 7m) The Panel observed that the GTOLS landing profile flown by the UA prior to impact was accurate to within one metre, based on the VMSC recorded GPS position at impact and the JARTS land survey of the first witness mark on the ground. The Panel, therefore, found that the unserviceability of ATOLS was **not a factor**.

1.4.3.22. **INS/GPS**. The two Rockwell Collins Athena GS-411 INS/GPS were found to be intact and correctly connected. They were removed and tested at Rockwell Collins using their proprietary test and calibration equipment for newly manufactured units. Both units passed with the exception of the z-axis angular rate (yaw rate) accuracy. This parameter was required to be accurate to 0.15 deg/s, but they were accurate to 0.2797 and 0.2029 deg/s. The Defence AIB, in consultation with the manufacturer, concluded that this slight drift did not make the unit unserviceable as the test for a newly manufactured unit was necessarily more stringent. The Panel noted that the z-axis angular rate measurement was not used to sense *Ground Touch* and therefore the accuracy of this parameter would not have affected the outcome. The Panel found that the serviceability of the INS/GPS units was **not a factor**.

1.4.3.23. **Laser altimeters**. As previously described, the Panel identified the use of the laser altimeter readings at the CP to be a causal factor, however, the VMSC data confirmed that both laser altimeters were functioning and giving valid (but erroneous) readings prior to the crash. It was therefore important to ascertain that the laser altimeters themselves were serviceable and functioning as designed. The laser altimeters were removed by the Defence AIB and under their supervision tested by the manufacturer Noptel of Finland. The series of tests conducted by Noptel confirmed to the satisfaction of the Defence AIB that both units were serviceable. The Panel found that the state of serviceability of the laser altimeters was **not a factor**.

Exhibit 17

Conclusion

1.4.3.24. The Panel considered the state of serviceability of the UAS, both from a physical perspective and from a continuing airworthiness documentation perspective and found that, with the exception of ATOLS, the UAS was serviceable immediately prior to the accident. The Panel made two observations about the ATOLS system (Paragraph 1.4.3.19) and observed that microbiological contamination was present in the UA's main oil tank (Paragraph 1.4.3.13). Notwithstanding these observations, the Panel found that the state of serviceability of the UAS was **not a factor**.

SECTION 1.4.4 – LEVEL OF TRAINING, COMPETENCIES, QUALIFICATIONS AND CURRENCY, AUTHORISATION AND SUPERVISION

TOR4: Establish the level of training, relevant competencies, qualifications and currency of the individuals involved in the activity and its authorisation and supervision.

Documentation and record keeping

1.4.4.1. The Panel reviewed the following documentation, which was impounded as part of the Aircraft Post Crash Management (APCM) process:

a. Battery Authorisation (Auth) Sheets from 2 Nov 15.

b. Crew and Authorising Officer (AO) logbook.

c. Pilot and Payload Operator Training Record Folder (TRF) and Flying Record Folder (FRF).[43]

1.4.4.2. As it became apparent that further information would be needed to ascertain the currency of the personnel involved in the accident, the following additional documentation was reviewed:

a. Captain's Trg Record.

b. Previous 90 calendar day Auth Sheets.

c. Sortie Brief documents from previous 90 calendar days.

d. Excel spread sheet 'Currency tracker'.

1.4.4.3. The Panel was unable to fully ascertain the currency of all personnel involved in the flight from the documentation alone and conducted further interviews with the Captain and the Flying Supervisor[44]. This Section therefore describes the documentation and records analysed before addressing the level of training, relevant competencies, qualifications and currency of the individuals involved in the activity and its authorisation and supervision.

Auth sheets

1.4.4.4. **Regulation - MAA Regulatory Article (RA) 2401 – Documents and Records**. RA 2401(5) stated that *'Aviation Duty Holders and AM(MF) shall ensure that accurate and detailed records of flight authorisations are maintained'.* Exhibit 101

1.4.4.5. **Orders - 1 ISR Bde FOB**. The 1ISR Bde FOB contained the Auth Sheet template which personnel were directed to use to capture flight authorisations and flying records , shown at Figure 14. The FOB also stated that the AO was to, as a minimum; Exhibit 5

[43] The Trg Record of the Captain was not gathered in by the Battery and the Defence AIB. The Panel requested the document on 17 Nov 15 and received it on 18 Nov 15.

[44] Telephone interview on 2 Dec 15.

a. *'Define the duties of each member of aircrew in the Flight Authorisation Record before flight'.*

b. *'Accurately state the nature of the planned duty or exercise'.*

c. *Ensure that all aspects of the authorisation are recorded in sufficient detail in an appropriate authorisation record'.*

1.4.4.6. **Recording of crew position/duty**. The aircraft Captain (column c) and the names of the crew (column d) were recorded on the Auth Sheets, however, the Auth Sheet in use did not provide a simple way of recording which crew position an individual occupied during a sortie. Personnel also did not routinely annotate an individual's operating position (pilot or payload operator) on the Auth Sheets. WK Pilots had to achieve minimum currency requirements from both the pilot and payload operator position. The Auth Sheet in use did not provide a suitable template to record, in sufficient detail, flight records and crew position during a sortie, or part thereof and therefore did not satisfy the Order listed in the 1ISR Bde FOB (Para 1.4.4.5). Exhibit 102 Exhibit 103

1.4.4.7. **Recording of 'Mission Cycles'**. A Mission Cycle[45] is a fundamental currency requirement laid down in the 1ISR Bde FOB. The Auth Sheet was not designed to capture this information, nor did personnel regularly 'hand annotate' this in the comments section (column s) The Panel was, therefore, unable to establish from the Auth sheets alone, how many Mission Cycles an individual had completed. Exhibit 102 Exhibit 103

1.4.4.8. **Recording of Simulator Flying**. It is common practice among flying units to record simulator flying on Auth Sheets, to ensure there is a formal record that the training has taken place. Personnel did not centrally record simulator flying on the Auth Sheets, or by any other method. Exhibit 102 Exhibit 103

1.4.4.9. **Previous 90 days Auth Sheets**. The Panel discovered that during one sortie, 5 personnel were annotated on the Auth Sheet for the entire duration of the flight. As there are not 5 operating positions in the GCS, the Panel was unable to accurately allocate hours flown to individuals or which crew position they had occupied. The Panel noted that in other sorties, some Captains had provided amplification, such as specifying which position an individual had operated from and for how long. However, this was the exception and the Panel was unable to find any direction on how Auth Sheets were required to be completed. The panel **observed** that the previous 90 days of Auth Sheets did not provide a comprehensive and accurate record of WK flying. Exhibit 103

1.4.4.10. **Recommendation. The Panel recommends that the Delivery Duty Holder should:**

a. **Provide WK flying units with bespoke Authorisation Sheets suitable for accurately recording WK flying, including the key elements required for currency.**

b. **Provide direction to WK flying units on how they are to**

[45] A Mission Cycle is defined in the 1ISR FOB to include: Brief, Msn Plan, Entity creation, Msn upload, Start up/taxi/take off, Conduct msn, Plan recovery, Land, Shutdown, De-brief.

formally record simulator training.

c. **Issue direction to WK flying units on how WK Auth Sheets are to be completed, to ensure compliance with RA2401 and ensure all relevant WK flying activity is accurately recorded.**

TUAS AUTHORIZATION RECORD
(REVISED 09 APR 2014)
FLIGHT AUTHORIZATION AND FLYING HOURS

_____ LOCATION : _____

UNIT: _____ DATE FROM: _____ TO: _____

ACTION BEFORE FLIGHT											ACTION AFTER FLIGHT									
DATE	C/S TAIL NO OCS	NAME OF UAS COMD	NAMES OF CREW	LRDC	ETD (HOTO)	ETR (HOTO)	FLIGHT NUMBER NATURE & DETAILS OF DUTY	CURRENCY EMERGENCY PROCEDURE PRACTICED	INITIALS OF AUTHORISING OFFICER	INITIALS OF PILOT IN COMD	ACTUAL TAKEOFF OR HOTO TIME	ACTUAL HOTO OR LANDING TIME	DAY HRS DUAL	NIGHT HRS DUAL	TOTAL	TAKEOFF / LANDING TYPE TKO	TAKEOFF / LANDING TYPE LD	REMARKS AO'S COMMENTS	UAS CAPTAIN INITIALS	FLYING HOURS RUNNING TOTAL
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)
									TOTALS											TOTAL

SHEET____ OF _____ SEEN BY UASS-C/BTY COMD_____

2306-8

Figure 14 – TUAS Auth Sheet

Logbooks

1.4.4.11. **Regulation - MAA RA 2401 – Documents and Records.** RA2401 (3) stated that '*accurate and detailed records of flying times* shall *be maintained by personnel who are required to fly regularly in the course of their duties*'. Under the Acceptable Means of Compliance (AMC), RA 2401 (3) stated that '*Flying logbooks should be completed in accordance with promulgated instructions and the guidance below, which* should *be amplified by Aviation Duty Holder and AM(MF) Orders when deemed necessary*'. Under Guidance Material, the RA stated that logbooks '*are a comprehensive record of flying and must be completed meticulously in order to provide an accurate record of all flights undertaken. Individuals will remain responsible for the accuracy of all entries in their flying logbooks*'. Exhibit 101

1.4.4.12. **Orders - 1ISR Bde FOB**. Order U401(2) of the 1ISR Bde FOB provided amplification to crews, mandated under RA 2401. Aircrew were directed to use Army Book 646 Army Air Systems UAS Aircrew Logbook to record their flying details. A Certificate of Qualification on Type (CQT) and their revalidation following lapse were to be recorded in section one of their logbook, and Certificates of Competence in Role were to be recorded in Section 2. As WK was deemed dual control by the ODH, the FOB stated that *'...WK crews are to log the full duration of all missions in the UAS 1st pilot column in their logbook'*. Finally, the 1ISR Bde FOB stated that aircrew were to present their logbooks to their CO, or delegated commander, for monthly and annual inspection. Exhibit 5

1.4.4.13. **Completion of logbooks**. The Panel reviewed the 4 logbooks of the crew and AO. In the view of the Panel, although some logbooks had been completed to a higher standard than others, none of them had been completed meticulously. For example, monthly summaries had not been completed, or had been completed but not signed off. Only 2 individuals had the WK CQT annotation in Section 1 of their logbook. One individual had an 'LCR' competency entered into his logbook, which was not awarded at the time of the accident. Annual Summaries were either missing or incomplete from the 2 logbooks which should have contained them, and there were no Periodic Summaries, following the completion of Conversion to Type Training, for the Pilot and PO. The Panel noted the findings of an Army Aviation Standards (AAvn Stds) Visit to the WK training facility in Apr 15, which stated that the maintenance of logbooks was unsatisfactory. At the time of the WK006 crash, the Panel **observed** that the logbooks reviewed failed to comply with RA 2401 and the 1 ISR Bde FOB. Exhibit 8
Exhibit 10
Exhibit 12
Exhibit 14
Exhibit 103

1.4.4.14. **Logbook design and completion.** WK pilots had to maintain currency in both operating positions; Army Book 646 did not allow for the recording of time spent in the Payload Position. Additionally, in directing that WK crews were to log the full duration of all missions in the 1st Pilot column, the Panel believe that this led to inaccurate record keeping as it contributed to a situation where payload hours were not recorded. The majority of logbook entries reviewed by the panel did not record whether a mission cycle had been achieved during a sortie. The Panel **observed** that Army Book 646 did not capture all WK flying data, including information relating to specific currency items.

1.4.4.15. **Recommendation. The Panel recommends that the Delivery Duty Holder should:**

a. Ensure that WK crews and supervisors receive detailed direction and guidance to accurately complete a flying logbook

b. Provide a logbook that is suitably designed to record all WK flying activity, including essential currency requirements.

Training Records

1.4.4.16. **Regulation - MAA Regulatory Article (RA) 2401 – Documents and Records**. RA 2401 (7) stated that *'Aviation Duty Holders and AM(MF) shall maintain training records for all aircrew'*. Under AMC, it stated that '*training records should be maintained by the supervisory chain that record all relevant training currencies and qualifications as required by the MRP 2000 series Regulatory Articles. An auditable record, normally referred to as the 'training folder', should be kept for at least the period of the current aircrew flying appointment or where appropriate, retained for the subsequent appointments'*. Exhibit 101

1.4.4.17. **Orders - JHC FOB**. The JHC FOB stated that DDH's are to maintain training records for all aircrew (J2401.130). Order J2401.135.1 covered the AAC Flying Records Folder. '*The purpose of the AAC Flying Record Folder is to provide a consolidated record of an individual's flying ability, experience, qualifications, special skills and occurrences. This provides continuity in the supervision of the professional aviation standards of aircrew'*. Exhibit 104

1.4.4.18. **AAvn Stds Guidance**. AAvn Stds directed that 2 documents, a Flying Record Folder (FRF) and a Training Record Folder (TRF) were to be maintained by aircrew in order to satisfy the requirements of RA 2401 and JHC J2041.130. The FRF would provide a consolidated record of an individual's overall flying experience and formed part of the audit trail. The TRF was designed to record all training conducted at unit level not otherwise recorded in the FRF. Detailed instructions for the maintenance of both documents were provided by AAvn Stds and were at the front of the TRFs/FRFs the Panel reviewed. Exhibit 6

1.4.4.19. **TRFs**. The Panel reviewed 4 TRFs as part of their investigation and only found 2 to be compliant with the guidance issued by AAvn Stds. One TRF contained a significant number of unnecessary, irrelevant and old documents, some of which did not relate to the individual concerned. A further TRF equivalent was maintained by the AO, a civilian contractor flying on 43 Bty and therefore subject to the Regulations contained within the MAA Regulatory Publications. Whilst this particular TRF contained a reasonable overview of the individuals flying record, the Panel noted that he maintained a 'training record card' which was a document produced by UTacS and did not have any guidance for completion, nor did it technically fall under the remit of the AAvn Stds guidance. The Panel believe that the AO's Training Record Card was designed to capture all training completed, and therefore represented an amalgamation of the Army TRF and FRF. The Panel noted that AAvn Stds had stated, following their visit to the Bty in Apr 15, that proof of training was difficult to follow as there was no record of training in the TRFs. The Panel believes that the standard of TRFs had improved little since Apr 15. Exhibit 6 Exhibit 7 Exhibit 9 Exhibit 13 Exhibit 105

1.4.4.20. **FRFs**. In accordance with RA2401, a FRF was required for each Military crew member. During their investigation, the Panel only found 2 partially completed FRFs, which were scant on detail, for example providing no

details on previous Army Aviation experience. The Panel could find no evidence that a FRF existed for the other member of the crew.

1.4.4.21. **Access to training records**. The Panel established that the TRF/FRFs were not held centrally by 43 Bty. The instructors held onto their own flying records, which were stored either off-site or elsewhere at BDN. The Panel established that due to TRF/FRFs being stored at different locations, the AO of the day and the Flying Supervisor did not have ready access to the documents. The Panel felt that this led to a reduction in the level of supervision of flying on the Bty. Witness 1

1.4.4.22. **Conclusion – Training Records**. The Panel **observed** that the Bty did not maintain training records to the required standard and did not follow the guidance issued by AAvn Stds. The Panel believe that this adversely affected the continuity of supervision of personnel.

1.4.4.23. **Recommendation. The Panel recommends that the WK Delivery Duty Holder should ensure that:**

a. **Subordinate units maintain flying records in accordance with extant direction, thereby satisfying the Regulatory requirements within RA 2401.**

b. **Aircrew, supervisors and those in support functions, receive appropriate training to ensure their aviation records are maintained to the required standard.**

c. **Aircrew flying records are readily accessible to the supervisory chain during flying operations.**

d. **Guidance is issued to civilian contractors flying on Army WK units on how they are to record their flying history, qualifications and competencies, in order for the supervisory chain to have the suitable oversight.**

43 Bty Currency Tracker

1.4.4.24. **Overview**. Due to a delay with the introduction of Squadron Training Achievement Recording System (STARS), the Bty used a locally produced Excel spread sheet. This was created by a civilian instructor flying from BDN and was designed principally to track his and other Instructor's currency, consisting of live and synthetic flying, mission cycles and emergency training. Exhibit 106 Witness 15 Exhibit 107

1.4.4.25. **43 Bty Currency Tracker**. Although designed for individual use, the Bty had adopted the Bty tracker to track details of all personnel. The Tracker was not controlled by the supervisory chain and some of the data input did not appear to have been checked and verified for accuracy. The Panel established numerous discrepancies between the Tracker, logbooks and authorisations sheets, leading to a confused record of flying activity. Additionally, in the 1 ISR Bde WK BDN SOP, there was no reference or requirement in the post mission in-brief checklist to record details in the Currency Tracker. The Panel believe that this further reduced the possibility that the Tracker would be completed to the requisite standard. In summary, the Panel recognised the laudable attempt by its creator to provide a bespoke WK currency tracker; however, the Tracker was not controlled to the required standard, nor integrated into Bty procedures. The Panel therefore **observed** Witness 15 Exhibit 108

that the Bty did not have a reliable method for capturing individuals' currencies and providing an overview to the supervisory chain. Consequently, it was difficult to reliably establish whether an individual was current.

1.4.4.26. **Recommendation. The Delivery Duty Holder should ensure that subordinate units are provided with a robust system to track currency information, such as Squadron Training Achievement Recording System (STARS).**

Watchkeeper Pilot Training

1.4.4.27. **Overview**. At the time of the WK006 accident, the WK pilot training pipeline was in its infancy. The Captain of WK006 and the sortie AO were viewed as 'first on type' by the previous DDH and as such had undertaken a non-formalised conversion route from Hermes 450 to WK. The Pilot and Payload Operator were both recent graduates of the WK Development Course' having completed the course in Oct 15. They had been selected, due to rank and experience, to be fast-tracked to becoming WK Captains and Instructors, and assist in delivering Course 1, early in 2016. Exhibit 13 Exhibit 9 Witness 1,2,3,4,5,12

1.4.4.28. **Development Course overview**. The WK Development Course, designed to take approximately 29 weeks, consisted of 5 Modules, which included various Ground school packages, an Airmanship Development Flying Module and Conversion To Type training. Figure 15 provides a graphical overview of the course.

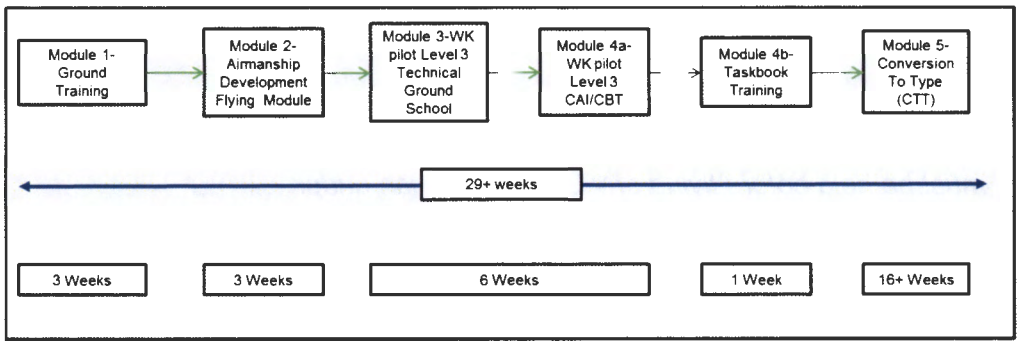

Exhibit 109

Figure 15 – Dev Course Overview

1.4.4.29. **WK Development course length**. The Panel established that the Pilot and Payload Operator had been on the WK Development Course between Jun 14 and Oct 15, a period of approximately 74 weeks. The Panel established that the Pilot and Payload Operator had completed all of these modules, with the exception of the first theoretical based ground school module. Additionally, the Payload Operator had received a dispensation from the DDH to defer his attendance on the Airmanship Development Flying Module until after he had finished the WK Development Course. The delays on the WK Development Course were principally caused by the operational deployment of WK, a lower flying rate when operating from BDN and pauses in flying due to equipment related issues. Despite the lengthy period of time taken to complete the training, the Panel could find no evidence to suggest that this had affected the quality of their training. Witness 12 Exhibit 12 Exhibit 10

1.4.4.30. **WK Development course delivery**. The Panel established that Thales UK subcontracted provision of the Technical Ground School instruction Witness 15 Exhibit 69

to a third party. The Panel found that these Instructors were not qualified on type and were not UAS SQEP and therefore relied heavily upon the Instructional Specification of the instruction material.

1.4.4.31. **Conclusion – WK Pilot Trg**. The Panel established that the WK Pilot trg was not a contributory factor. However, the Panel **observed** that the use of non SQEP ground-school instructors, who were not qualified on WK, did not represent best practice.

1.4.4.32. **Recommendation. The Panel recommends that the Chief Instructor Unmanned Air systems, the Royal School of Artillery should ensure that ground school Instructors are suitably qualified and experienced to deliver WK Level 3 Training.**

Qualifications

Certificate of Qualification on Type (CQT)

1.4.4.33. **Regulation - MAA RA 2101 Aircrew Qualifications**. RA 2101 stated '*To fly, or operate, a UK Military Aircraft, aircrew shall be qualified*'. It stated that Aviation Duty Holders should promulgate in Orders the criteria for the award, or recognition of aircrew qualifications. The RA also stated that in order to fly, or operate, UK Military registered aircraft, aircrew should be qualified; relevant to WK, operators should be in possession of, or have previously been awarded a UK military or AM(MF) approved Remotely Piloted Air System (RPAS) pilot/operator qualification. Exhibit 110

1.4.4.34. **Policy**. The 1ISR Bde Trg Directive, dated 15 Oct 14, provided the DDH directed framework for the WK pilot qualification: Exhibit 111

a. '*The WK 1st Pilot CQT is awarded to personnel on completion of initial WK pilot training on type. It is the certificate of qualification that enables trained pilots to comply with Flying Orders J2101 and U2101 and must be held before flying any UAS, other than under proper instruction'.*

b. '*The CQT is awarded on the completion of the conversion to type (CTT) module of the RA Crewman 2000 Gnr IUAS L3 (WK) course'.*

c. '*The CQT is to be entered into Section 1 of the pilot's logbook by the Course Officer'*

1.4.4.35. **CQT course**. The Panel established that at the time of the accident, the RA Crewman 2000 Gnr IUAS L3 (WK) course had not been formally stood up. CQT training was conducted at the WK Training School (Simulators and ground school) Larkhill, and at BDN, and the course was titled RSA F-P Branch WZ40 WK Pilot L3 (Dev) course. Whilst the Panel was content that this training was acknowledged as providing the CQT qualification, they noted that the course promulgated as the CQT course in the 1ISR Bde Trg Directive did not exist at the time of the accident. Exhibit 11

1.4.4.36. **WK006 CQT**. The CQT status of the crew was:

a. **Captain**. The Captain had not completed the RA crewman 2000 Gnr IUAS course or the current Conversion to Type trg. However the Captain had been awarded Watchkeeper CQT, due to Exhibit 8 Exhibit 9

a DDH Dispensation, on the 'basis of experience flying other aircraft types, flying WK under Thales UK MFTP, and as '*first in class*' pilots to fly WK under RtS'[46]. The CQT was entered into Section 1 of the Captain's logbook. The Panel was therefore satisfied that the Captain was Qualified on Type.

b. **Pilot**. The Pilot had a Sortie Report Form in his TRF, detailing the successful completion of his Final Handling Test (FHT) in Oct 15. However, there was no entry in Section 1 of the Pilots logbook, recording the award of the CQT qualification, as directed in the 1ISR Bde Trg Directive. The Panel sought confirmation from the RSA that the Pilot had successfully completed the CQT course. This was received in Jan 16. The Panel was therefore satisfied that the Pilot held a valid CQT at the time of the accident and was, therefore, Qualified on Type. Exhibit 10 Exhibit 7 Exhibit 112 Exhibit 11

c. **PO**. The PO did not have a Sortie Report Form in his TRF from his FHT, or a WK CQT entry in Section 1 of his logbook. The Auth Sheets from 14 Oct 15 show that the PO conducted a FHT, but there is no comment on whether the PO had successfully passed the sortie. The Panel was told in interview, and later received confirmation from RSA Inval, that the PO had successfully completed the CQT course. The Panel was therefore satisfied that the Payload Operator held a valid CQT at the time of the accident and was, therefore, Qualified on Type. Exhibit 12 Exhibit 6 Exhibit 112 Exhibit 11

d. **Authorising Officer (AO)**. Although the AO was not defined on the Auth Sheets as a member of the crew on 2 Nov 15, the 1ISR Bde Pers Directive mandated that he was required to be a current WK Captain and Pilot, and therefore by extension hold a CQT. The Authoriser had not completed the RA crewman 2000 Gnr IUAS course or the current Conversion to Type trg. However, in May 14 he had been awarded CQT on the basis *'of his experience flying other aircraft types, flying WK under Thales UK, and as 'first in class' pilots to fly WK under the RtS'*. At the time of the accident, the Authoriser had the '*Pilot/Cmd*' qualification annotated in his logbook. Although the Panel could not find any reference to this in the 1ISR Bde Trg Directive, following consultation with the Senior Operator, the Panel was satisfied that the AO held a valid CQT at the time of the accident and was, therefore, Qualified on Type. Exhibit 113 Exhibit 14 Exhibit 13

1.4.4.37. **Summary – CQT status**. Although the Panel is satisfied that all of the aircrew involved in operation of WK006 held a valid CQT and were therefore Qualified on Type, the Panel **observed** that the audit trail to support this was poor, resulting in it being difficult for Supervisors, on the basis of written evidence, to ascertain an individual's CQT status.

1.4.4.38. **Recommendation. The Panel recommends that the Delivery Duty Holder should ensure that Certificate of Qualification on Type qualifications are accurately recorded in logbooks following successful completion of the prescribed training course, as directed in 1ISR Bde**

[46] Letter from Commander 1 ISR Brigade, dated 25 Apr 14.

Flying Order Book U2041(2). The certificate should also be recorded on a Form 3 and placed in a Flying Record Folder.

WK Certificates of Competence (C of C) in Role

Limited Combat Ready (LCR)

1.4.4.39. **Policy**. The 1 ISR Bde Trg Directive, dated 15 Oct 14, stated that *'The Watchkeeper Limited Combat Ready Pilot C of C is awarded to qualified WK pilots by the CO following completion of the Conversion to Role phase of the WK L3 WK Pilot/Payload Operator course and demonstration of competence in this role. WK LCR Pilot C of C competences are taught and tested during the Conversion to Role (CTR) phase of the RA L3 UAS Pilot/Payload Operator (WK) training course'.* Exhibit 111

1.4.4.40. **Analysis**. The Panel established that none of the crew or the Authoriser held this competency on 2 Nov 15 as the Conversion to Role training was still under development and therefore the LCR C of C was not awarded at the time of the accident. The Panel was informed that this was because 1ISR Bde was focussing its efforts on increasing the number of trained Pilots; tactical training (which included LCR/CR training) would be developed in the future. Exhibit 7 Exhibit 10 Exhibit 12 Exhibit 6 Exhibit 14 Exhibit 13 Exhibit 8 Exhibit 9 Exhibit 114 Exhibit 115

Captain

1.4.4.41. **Policy**. The 1 ISR Bde Trg Directive stated that *'the Watchkeeper Captain C of C is awarded to qualified WK pilots by the CO following a period of continuation training and demonstration of competence in this role'. It stated that the WK Captain C of C is to be entered by the CO into Section 2 of the pilot's logbook*[47]. It continued; *'The C of C is awarded to qualified WK pilots who satisfy the experience and competence requirements:* Exhibit 111

a. *Current WK UAS Pilot with 400hrs total Tactical UAS Pilot experience (may aggregate H450 and WK).*

b. *WK LCR Pilot Certificate of Competence.*

c. *Assessment of Competence in Captaincy Role assessment recorded on a Form 3'.*

1.4.4.42. **Analysis of Policy**. WK LCR is listed as one of 3 experience and competency requirements in order to become qualified as a WK Captain. As previously discussed, the Panel **Observed** that this competency was not awarded at the time of the accident. The Panel does not believe that this affected the selection, training or ability of the Captain

1.4.4.43. **Recommendation. The Panel recommends that the Delivery Duty Holder review the experience and competence requirements necessary to become WK Captains, pending the availability of the LCR competency.**

[47] The 1 ISR Trg Directive stated that all revalidations are to be entered in Section 2 of the logbook by the assessor.

1.4.4.44. **Audit trail.** According to his logbook, the Aircraft Captain was initially awarded the WK Captain C of C in Apr 15 and had a revalidation entry dated 7 May 15. Both of these entries had been signed by the DDH. The Panel has been unable to find any supporting evidence for these entries, as the Captain did not appear to have a FRF and his TRF did not contain a Form 3 'Assessment of Competency in Captaincy Role'. As highlighted in the above policy paragraph, the 1 ISR Bde Trg Directive stated that one of the requirements to become a UA Captain was to demonstrate competency in that role and to have it recorded on a Form 3. Exhibit 8 Exhibit 116

Competent to Instruct (C to I)

1.4.4.45. **Regulation - MAA RA 2125 – Aircrew Instructor (AI) Training.** RA2125 provides the Regulation for Aircrew Instructor Training. It stated that '*Personnel selected for flying instructional duties shall receive appropriate training and attain the instructional standards required to facilitate the provision of high quality instruction for all aircrew disciplines'*. The following excerpts from RA2125 were of interest to the Panel: Exhibit 117

a. *'AI Training should take place at a recognized training unit which itself should be subject to formal independent assessment at intervals not exceeding 2 years'. (2125(1) AMC Para 2)'*

b. *'Any AI who is empowered through Orders to award a CQT should have been assessed in the air and on the ground as competent to do so by a CFS Examiner or Agent'. (2125(1) AMC Para 3).*

c. *'Pre-Operational Conversion Unit (OCU) flying instruction leading to the award of the appropriate UK military flying badge should only be delivered by AIs who have successfully completed training at a CFS-approved instructor training unit. (2125(1) AMC Para 4)'.*

d. *'To assure competence, all AIs, irrespective of qualification level, should undertake an instructional competence check on an annual basis*[48]*. This check should be conducted by an independent assessor*[49] *and should include, as a minimum, the following areas:*

(1) *Ability to impart skill and knowledge, utilizing effective analysis and debriefing.*

(2) *Proficiency in flying or airborne operating skills, and knowledge of the aircraft on which tested.*

(3) *Standardization of current training practice.*

(4) *Knowledge of subjects allied to flying (2125(1)AMC*

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[48] Emphasis added by the Panel

[49] Independent Assessor is defined in the JHC FOB as 'An A Category QHI/Level 2/3 QHTI qualified on type, not in the same immediate flying Sub-unit, exceptionally a Sqn Cdr nominated B1 QHI qualified on type, approved by the DDH, not in the same immediate flying sub unit. A Sub-Unit is defined as a Flying Squadron. For Sub-Units with an OCF, OCF QHI/QHCIs are considered sufficiently independent to conduct ICCs on individuals on the same Sub-Unit.

Para 9)'.

1.4.4.46. **Policy – JHC FOB**. The JHC FOB defined Aircrew Instructors. It stated '*to be graded Competent to Instruct, an Aircrew Instructor must have completed a Central Flying School (CFS) validated Fixed Wing or helicopter course, as appropriate, and have been categorised to at least B1*[50]*. Thereafter, a Qualified Aircrew Instructor may be assessed as C to I during a period while he gains experience after converting to a new type of aircraft'.* Exhibit 104

1.4.4.47. **Policy – 1ISR Bde FOB**. The 1ISR Bde FOB stated that '*Personnel selected for UAS Instructional Duties are to hold a valid JHC AAvn Stds Endorsement of Competence to Instruct in their logbooks'.* Exhibit 5

1.4.4.48. **Policy – 1ISR Bde Pers Directive**. The 1ISR Bde Pers Directive stated that the pre-requisites for aircrew to be selected to become C to I included to be current on type, and hold the Captain and LCR Certificates of Competency. Exhibit 113

1.4.4.49. **Captain C to I qualification**. The Captain had a 'C to I' qualification annotated in his logbook, dated May 15. The Panel then sought confirmation, from an associated Form 3, that the C to I assessment met the Assurance direction within Regulation 2125(1), reproduced at Paragraph 1.4.4.45. The Panel was unable to find a completed Form 3 relating to this C to I assessment. Following an interview with AAvn Stds, the Panel received the completed Form 3 for the Captain's C to I assessment, which the Panel **observed** was completed after the loss of WK006. The C to I assessment was signed off by AAvn Stds, which were directed by JHC to be the Independent Assessor. However, the Panel established in interview with AAvn Stds, that as no one from AAvn Stds was a qualified WK Pilot, they were unable to conduct the Assessment by themselves and had to rely on the small cadre of WK Instructors. The Panel **observed** that the C to I assessment conducted on the Captain was not independent, as mandated in RA2125. Witness 11 Exhibit 8 Exhibit 9 Exhibit 13 Exhibit 14

1.4.4.50. **Recommendation. The Panel recommends that the Operating Duty Holder ensures that Army Aviation Standards has Suitably Qualified and Experienced Personnel to act Independent Assessors for WK training assurance purposes, as stipulated in the JHC Flying Order Book and mandated in RA2125.**

1.4.4.51. **Recommendation. The Panel recommends that the Delivery Duty Holder should ensure that Instructor assessments are formally recorded at the time of the assessment and a suitable audit trail maintained in the Flying Record Folder, to provide Supervisory oversight and ensure compliance with RA2125.**

1.4.4.52. **C to I terminology in 1ISR Bde FOB**. The JHC FOB definition of C to I is found at Paragraph 1.4.4.46. The Panel established that the Captain had not completed a CFS validated aircrew instructor course and had never been categorised as a B1 Instructor. The Panel **observed** that the terminology in the 1ISR FOB, calling all WK Instructors 'C to I', was misleading and did not comply with higher guidance from JHC, which termed the WK Instructor Witness 1

[50] CFS define a B1 as a Capable Instructor and have at least 120 hours instructional flying.

Qualification as a '*Remotely Piloted Air Systems Instructor.*

1.4.4.53. **Recommendation. The Panel recommends that the Delivery Duty Holder aligns the terminology used in the 1ISR Flying Order Book to describing WK Instructors to the definition found in the JHC Flying Order Book.**

1.4.4.54. **LCR prerequisite**. The 1ISR Bde Aviation Pers Directive stated that individuals were to be WK LCR in order to be considered as WK Instructors. As previously discussed, the LCR qualification did not exist at the time of the accident., therefore as observed in Paragraph 1.4.4.42, this was not achievable. Exhibit 113 Exhibit 13 Exhibit 9

1.4.4.55. **Waiver against RA2125(1) Para 4**. A waiver had been approved by the MAA against RA2125(1) Para 4, granting dispensation for individuals who had not completed training at a CFS approved instructor training unit, to award an appropriate flying badge. In granting the waiver, the MAA stipulated that '*All RSA RPAS Army Instructors undergo periodic assessment by the CFS Exam Wing*'. The Panel found no evidence of this periodic assessment. Exhibit 118 Exhibit 119

1.4.4.56. **Compliance with RA2125**. The Panel **observed** that the WK instructors had not received AI Training at a 'recognized training unit'. The Panel **observed** that WK instructors at the time of the accident, who awarded CQT to the Pilot and PO of WK006, had not been assessed as competent to do so by CFS.

1.4.4.57. **Recommendation. The Panel recommends that the Duty Delivery Holder ensures that WK Instructor Training adheres to the Regulations stipulated in RA 2125, or seeks a waiver or an additional Acceptable Means of Compliance.**

Currency

Overview

1.4.4.58. **Regulation – MAA RA2103 – Currency and Continuation Trg**. RA2103 stated that '*Aviation Duty Holders shall specify in Orders the currency minima, by type and role, for the safe operation of aircraft by aircrew within their Area of Responsibility*'. RA2103 stated that '*all aircrew employed in flying appointments should maintain flying currency*'.

1.4.4.59. **Policy**. The Currency Requirements for WK aircrew was detailed in the 1 ISR Bde FOB, U2103 (1) and a summary of the currency requirements is provided at Figure 16. In order for an individual to be deemed WK 'current', they had to meet the currency minima in 3 separate areas – live flying, simulator flying and simulator emergency training. The 1ISR Bde Trg Directive mandated that Regiments and Units were to conduct 6 monthly Air Safety Training Days and all personnel were expected to attend. Exhibit 5

1.4.4.60. **Pilot and PO**. 1ISR Bde policy at the time of the accident was that following the award of CQT, individuals would subsequently fly dedicated sorties to ensure they met the currency minima laid down in the 1ISR Bde FOB. As the sortie on 2 Nov 15 was the first post CTT flight for the Pilot and PO, the aim of the sortie was to 'build' their currency. Therefore, this section of the report will not comment on the currency of the Pilot and PO. Exhibit 115

WK Pilot Currency Requirements – 1 ISR Flying Order Book.		
Live Flying (rolling 3 month period)	**Simulator Flying (rolling 3 month period)**	**Simulator Emergency Trg**
A minimum of 10hrs flying A minimum of 3 sorties, each consisting of a full mission cycle[51] Of these 3 mission cycles, aircrew must fly at least one sortie from the Pilot seat and one sortie from the Payload seat Instructors may include up to 50% of their required minimum pilot currency whilst instructing flying duties on type	A minimum of 10hrs 'hands on' flying. A minimum of 3 sorties each consisting of a full mission cycle[52] Of these 3 mission cycles, aircrew must fly at least one from the Pilot seat, and one from the Payload seat Instructors may include 5hrs instructional delivery in the sim to reduce their 'hands on' currency requirement to 5hrs	Detailed breakdown of emergencies to be covered. Divided into Critical and Rotational emergency training. Completion of emergencies is to be recorded in the pilot's training folder

Figure 16 – Overview of WK Pilot Currency Requirements Exhibit 5

Live Flying Currency

1.4.4.61. **Aircraft Captain**. The Aircraft Captain had flown a total of 32hrs, 28 minutes in the 3 months prior to the accident. Due to the record keeping described previously, the Panel has been unable to establish how many hours 'hands on flying' and how many mission cycles the Aircraft Captain had completed. The Panel has therefore been unable to ascertain the live flying currency of the Captain. Exhibit 103 Exhibit 8 Exhibit 107

1.4.4.62. **AO**. The AO had flown a total of 41hrs 23 minutes in the 3 months prior to the accident. The Panel was able to establish that the AO had satisfied both the mission cycle and 'hands on flying' currency requirement[53]. The Panel has established that the AO was live flying current on 2 Nov 15. Exhibit 103 Exhibit 14 Exhibit 107

1.4.4.63. **Instructor live flying currency**. The Panel **observed** that the reduced 'hands-on' live flying hours requirement of Instructors was not best practice. WK is accepted as being a challenging system to operate, and as such, in the opinion of the Panel, a baseline currency should exist for all personnel, especially during the growth of the WK programme.

1.4.4.64. **Recommendation. The Panel recommends that the Delivery Duty Holder should review the reduced 'hands on' live flying requirement for WK Instructors.**

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[51] To include: Brief, Msn Plan, Entity creation, Msn upload, Start up/taxi/take off, Conduct msn, Plan recovery, Land, Shutdown, De-brief.

[52] To include: Brief, Msn Plan, Entity creation, Msn upload, Conduct msn, Plan recovery, Land, Shutdown, De-brief. Start-up/Taxi/Take-off has been omitted as the synthetic trainers are not currently capable of effectively simulating this environment.

[53] The AO had recorded more thorough detailed records of sorties in both the Auth sheets and his logbook.

Simulator Flying Currency

1.4.4.65. **Aircraft Captain**. The Captain's logbook stated that he had completed 21hrs 25 minutes[54] of synthetic flying in the 3 months prior to the accident. The logbook did not provide a record of what event the Captain was undertaking in the sim, or which position he was operating from. The Panel has not found any other formal record of these simulator sorties and as such is unable to establish how much 'hands on flying' the Captain had achieved, and whether he achieved any full mission cycles. The Panel was unable to ascertain the overall synthetic flying currency of the Captain. Exhibit 103 Exhibit 8 Exhibit 107

1.4.4.66. **AO**. The AO's logbook stated that he had completed 15hrs 30 minutes of synthetic flying in the 3 months prior to the accident; the AO had annotated the entries with his role and/or position during the simulator exercise, which aided the Panel in assessing whether the AO had met the hours requirements for synthetic currency. Although the Panel has not found any other record of these simulator sorties, the Panel believe that the AO had achieved the hours and 'hands on' synthetic flying currency requirements. As there was no record of whether a Mission Cycle had been recorded, the Panel was unable to ascertain the overall synthetic flying currency of the AO. Exhibit 103 Exhibit 14 Exhibit 107

1.4.4.67. **Instructor simulator flying currency**. The Panel **observed** that the reduced 'hands on' simulator flying hours requirement for Instructors was not best practice.

1.4.4.68. **Recommendation. The Panel recommends that the Delivery Duty Holder should review the reduced 'hands on' simulator flying requirement for WK Instructors.**

Simulator Emergency Training

1.4.4.69. **Captain and AO**. The Panel was unable to find any evidence that the Captain and AO had completed the mandated simulator emergency training. There was no record of recent simulator emergency training in the Captain and AO's TRF. The Panel established that there was no robust system in place to conduct the training or record that it had been accomplished. The Panel does not believe that the Captain and AO were current in simulator emergency training. Witness 1

Collective Training

1.4.4.70. **1ISR Bde Policy**. The 1ISR Bde Trg Directive stated that 47 Regt RA, was to conduct a minimum of a full day's Unit collective training every six months. All personnel were expected to attend the training days, which covered Air Safety, Human Factors (HF) and Met. The Trg Directive also stated that UAS Btys were to conduct '*at least one day's air safety, HF and met training programmed to fall between 6-monthly Unit Air Safety days (such that every 3 months there is either a unit or sub-unit collective training day)*'. Units were also directed to programme 'Crew Room Discussions'. The 1ISR Bde Trg Directive stated that participation of the above directed air safety was to be recorded in training record folders for Pilots. Exhibit 111

[54] The Panel established from interview that the Captain had operated the simulator 'solo' for 9hrs and 55 minutes. The logbook figure for the Captain includes this time.

1.4.4.71. **Analysis**. The Panel established that some individuals believed that the intent of these training days was met through the daily Met brief and other planning and flying activities which occurred during the course of a flying day. Recommendation 1.5.29 from the Hermes 450 SI was the '*Comd 1 Arty Bde, in conjunction with JHC Flt Safety, should introduce a formal system, where airmanship experiences and important lessons from real events are passed between H450 pilots, AOs and System Commanders, within an environment conducive to collective improvement and air safety*'. The Panel **observed** that there was no record that the Captain and AO had attended a Unit or Bty Air Safety training day, or crew room discussion. In the opinion of the Panel, WK collective training remained essential, especially in the context of the 'immature' but rapidly expanding WK capability.

Witness 1,

Exhibit 120

1.4.4.72. **Recommendation. The Panel recommends that the Delivery Duty Holder should ensure that units conduct mandated Air Safety Training days.**

Summary of Currency Findings

1.4.4.73. A summary of the Panel's findings relating to currency is shown at Figure 17. It highlights that the Panel were unable to ascertain the live flying currency of the Captain and the simulator flying currency of both the Captain and AO. Furthermore, the Panel does not believe that the Captain and AO had completed the prescribed emergency training, nor attended collective training. The Panel, therefore, established that the Captain and AO did not meet all the currency requirements stated in the 1ISR Bde FOB. Whilst the Panel found no evidence to suggest that this caused, contributed to or aggravated the accident, the currency status of the Captain and the AO, and its corollary for Air Safety, was an **Other factor**.

1.4.4.74. **Recommendation. The Panel recommends that the Delivery Duty Holder should introduce a robust governance structure to ensure WK pilot currency, both live and synthetic, is accurately recorded, tracked, maintained and assured.**

Regulation	Certification of Qualification on Type (CQT)		Competence in Role					Compent to Instruct		Current on Type					Medical	Air Safety Training
	1ISR Trg Directive: Trg 301(3). Watchkeeper 1st P is awarded on completion of initial WK pilot training on type. It is the certificate of qual that enables trained pilots to comply with Flying Orders J2101 and U2101 and must be held before flying any UAS, other than under proper instruction		1ISR Trg Directive: Trg 302(1). LCR is awarded to qualified WK pilots by the CO following completion of the Conversion to Role phase of the WK L3 WK Pilot/Payload operator course and demonstration of competence in this role.			1ISR Trg Directive: Trg 302(8). Awarded to Pilots who are current WK UAS Pilot, WK LCR Certificate of Competence, Assessment of Competence in Captaincy Role assessment recorded on a Form 3. 12 month validity period				Live Flying		Sim Flying			MAA MRP RA2135 JHC FOB J2135 1ISR FOB U2135	1 ISR UAS Trg Directive.
	CQT	CQT Doc in Logbook	LCR	LCR in section 2 of logbook (U2102 (2) Para 5a/b	LCR in training record (U2102 (2) Para 5b	Captain	Captain in Logbook	C to I	C to I in Logbook	Hours Minima	Mission Cycles	Hours Minima	Mission Cycles	Emerg Trg	Medical	Regiment and Bty Training Days
CAPTAIN																
PILOT																
PAYLOAD																
AO																

Decode

Unable to ascertain	
Complies with Reg	
Does not comply with Policy	
Not relevant/ not assessed	

Figure 17 – Overview of Panel's findings relating to Section 1.4.4

Authorisation

1.4.4.75. **Regulation – MAA RA2306**. RA2306 listed the regulation relating to the authorisation of UK Military Aircraft and within AMC, provided a list of minimum duties required to be completed by an AO. Included in that list was the following; '*Ensure that the crew or formation members are qualified, in current flying practice, and capable of executing the tasked mission, alternate mission or duty as planned without undue hazard*'. Further guidance stated the following under the title, 'Aircrew Capability'; '*AOs should pay particular attention to aircrew competency and qualifications…*' Exhibit 117

1.4.4.76. **Policy**. The 1ISR Bde Pers Directive provided direction on eligibility requirements for an AO; further guidance was provided in the 1ISR Bde Trg Directive. The Commanding Officer of 47 Regt RA issued a Flight Authorisation Policy, dated 25 Sep 15. He provided a list of individuals with delegated powers of authorisation and provided direction on what he expected from them. Exhibit 121 Exhibit 113 Exhibit 111

1.4.4.77. **AO selection and qualification.** The Panel was satisfied that the AO met the majority of the pre-selection criteria in the 1ISR Bde Pers directive, with the exception that the Panel could find no evidence that the AO had attended the mandatory RA AO Briefing day, which was a post ZK515 SI requirement[55]. The AO's TRF contained a letter of delegation from the DDH, empowering the AO to authorize WK sorties; additionally, the AO was listed on the letter from the CO, 47 Regt RA, which again confirmed his status as a WK authorizer. The Panel was satisfied that the AO was qualified to act as the sortie AO. Exhibit 13

1.4.4.78. **Pre-flight Authorisation procedure**. Due to systemic failings concerning record keeping and documentation, the Panel does not believe that the AO would have been able to satisfy RA2306, in ensuring crew members were in current flying practice. The Panel also believes that not having a dedicated Auth desk (discussed further in Section 1.4.5) may have reduced the opportunity of the AO to properly fulfil his duties.

1.4.4.79. **AO role during flight**. The key role of the AO, stated in RA2306 '*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*'. The AO was one of the most experienced UK WK operators and had experience in selecting MO to land the UA. Having been actively involved in flying post the crash of WK031, the Panel believe he would have been aware of the emphasis placed on using MO as a 'last resort'. The AO was called to the GCS by the Captain. In the AO's opinion, the Captain had already decided on the course of action in selecting MO and the UA was already in the recovery phase. The AO believed that the Captain's plan was to de-select MO or Abort the UA at the Semi-flare. The Panel determined that the Captain always intended to leave MO selected. The Panel believe that the AO did not exert enough control over the situation, did not fully understand the Captain's intended course of action, and deferred to Exhibit 117 Witness 5 Witness 5

[55] This requirement was footnoted with the following; 'this is a temporary post-ZK515 SI requirement and will endure until the manned aviator attachment to CDCS ceases'.