1.4.5.11. **Continuation Training.** All military pilots are required to carry out CT[25] to ensure that core individual flying skills are maintained. The RAFAT DD stated that pilots should carry out "a minimum of 12 CT sorties per year" in order to maintain proficiency in General Handling (GH) and IF, and that these sorties were "to be spread as evenly as possible over the year". TGOs contained a Hawk TMk1 currency table for CT currency; the order stated that "RAFAT pilots should use the same currency regime [as other Hawk users] (with the exception of serials 11-16)[26]". Witness 28 Exhibit 18 Exhibit 49 Exhibit 52 Exhibit 53 Exhibit 114

CT and instrument approaches were often logged during transit sorties which were claimed by pilots in the authorization sheets and log books. The Panel noted that on some of these sorties the flight time was insufficient to carry out all of the activity claimed. Additionally, IF hours and instrument approaches were claimed when the meteorological records made actual flight in cloud unlikely and ATC logs showed no evidence of approaches having been made. It is the view of the Panel that these practices, which were used to give the impression of currency, were not recent phenomena and that they were widespread within the RAFAT. Although the authorization sheets were signed by the aircraft captain after each sortie, the details were often completed by a single individual who was tasked with ensuring that the pilots remained current. It is the Panel's view that this may have been designed to reduce the burden on the individual to track and maintain currency; however, in practice it may have made individual pilots more likely to accept the collective practice of claiming for approaches, CT and IF hours that they had not flown. The Panel concluded that the false recording of CT, IF and instrument approaches resulted in many of the RAFAT pilots, including the accident Pilot, failing to meet the required minima to maintain handling currency and instrument ratings; and that this was **an other factor**. Exhibit 8 Exhibit 52 Exhibit 53 Exhibit 54 Exhibit 55

ENGINEER TRAINING AND STANDARDS

1.4.5.12. **Background.** RA 4150 states that 'all personnel who maintain aircraft and associated equipment **shall** be trained and assessed as competent to do so' and that the associated training '**shall** comply with the DSAT Quality Standard[27]'. On a typical RAF Sqn an induction package is completed by all newly arrived personnel to provide an overview of the relevant platform. This training is then followed by a formal Q course, which teaches an individual how to maintain that particular aircraft. Once the Q course has been completed, the individual will undergo On-The-Job-Training (OJT) assisted by supervisors who are Suitably Qualified and Experienced Personnel (SQEP), before a formal assessment is made in order to award an authorization to maintain. After completing a set of pre-defined tasks and gaining sufficient experience, typically 12 months, they receive the 'X' annotation for that platform,[28] identifying them as an experienced type-qualified aircraft technician. The 'X' annotation is not transferable between platforms and is valid for 5 years once the individual no longer maintains the aircraft type. Witness 23 Witness 55 Exhibit 56 Exhibit 57

1.4.5.13. **RAFAT Engineer Training.** The RAFAT was the only Hawk user in the UK that utilized RAF personnel to maintain its aircraft and carried out maintenance up to and including minor star servicing[29]. BAE Systems were contracted by the MOD to maintain the majority of Witness 22 Witness 26 Witness 41

[25] Continuation Training - General Handling activities such as circuits, Practice Forced Landings (PFL) and stalls.

[26] Serials 11-16 were weapon delivery profiles therefore not relevant.

[27] Defence Systems Approach to Training (DSAT) – A defence standard outlining the process for identifying training need, formulating appropriate courses and then subsequently evaluating the content.

[28] X annotation - The X annotation is followed by a 3 digit number which identifies the aircraft type to which the individual is qualified to maintain and has gained the requisite experience.

[29] Minor star servicing – A comprehensive level of Hawk servicing completed every 1200 flying hours or 6 years.

the other UK Hawk fleets, delivered through a sub-contract to Babcock, who utilized their own technician training organization at RAF Valley. The RAFAT conducted in-house training at RAF Scampton, the training policy and procedures were outlined in AESOs and the assessment as to when SQEP status was awarded to military engineers was the responsibility of the associated level K engineer,[30] which in the case of RAFAT, was the SEngO. The Panel found the following: Witness 44 Exhibit 44

a. **RAFAT Line Training Course.** A short line training course was run for all engineering personnel to qualify individuals in Hawk flight servicing and line operation[31]. This course, run by the Quality, Engineering Standards and Training (QUEST) cell, was the only formal training that RAFAT engineers undertook at RAF Scampton. The training was contained within AESOs; however, it was not DSAT compliant as there was no auditable scoping exercise, needs analysis, training design or subsequent external validation. Additionally, there was no formal review process to ensure that the training remained current. Witness 14 Witness 22 Exhibit 44

b. **Qualification to Maintain.** There was no formal Q course to qualify RAFAT engineers to maintain the Hawk aircraft. A five-week training course was conducted at RAF Valley to train Babcock engineering personnel, as was a Hawk managers course. Neither of these were utilized by the RAFAT, the judgement being that they were not appropriate for military engineers. The view from within the RAFAT appeared to be that the Babcock training was not appropriate for RAF personnel due to differing entry standards. Witness 22 Witness 26 Witness 45

The Hawk T Mk1 Support Policy Statement (AP 101B-4401-2(R)1) stated that there was no requirement for pre-employment training for either engineering officers or airmen prior to employment on the RAFAT; the Hawk Support Authority (HSA) were unsure as to why this was the case. In light of this document and the lack of an existing Q course, the RAFAT utilized OJT in an attempt to meet the training gap. Co-ordinated by trade managers, the OJT was conducted by experienced Sgts and Cpls; the Panel noted that in many cases they did not hold an OJT instructor qualification[32]. Although a SQEP tracking matrix had been introduced, there was no evidence of a formal auditable assessment process. This resulted in a situation whereby RAFAT engineers were maintaining Hawk aircraft without any recognised DSAT compliant training. Witness 22 Witness 26 Exhibit 58 Exhibit 98 Exhibit 109

1.4.5.14. **Armourer Training.** The Hawk T Mk1 utilized by the RAFAT has no weapons capability; however, the ejection seat and some other systems necessitated armourers to support their operation. On a typical RAF fast jet station, a centralized 'weapon load training cell' exists with its own dedicated aircraft and trained instructors. The cell delivers armourer equipment specific training (including ejection seats), whilst also providing independent examiners to conduct armourer re-authorization checks. RAFAT armourers did not have access to any such training or support organization independent from the Sqn, and were reliant upon OJT delivered by individuals who were themselves not formally trained. A number of the 6 RAFAT armourers had no recent experience of ejection seat equipped aircraft. One individual had not worked on ejection seats or received any external ejection seat training since undergoing basic training at RAF Cosford some 6 years earlier. Witness 9 Witness 10 Witness 11 Witness 38 Witness 51 Witness 52 Witness 55

[30] Level K Air Engineer Officer (AEO) – This is the highest level of engineering authorization and is held by the Senior Air Engineer Officer on a Unit. All engineering authorizations flow from this individual who holds responsibility for the engineering practices and standards within his unit.

[31] Line operation training – This course was expected to provide the requisite skills to conduct flight servicing and line operations (ground crew see-off and recovery) for the Hawk aircraft.

[32] On The Job Training (OJT) - RAF Training policy stated that OJT must be delivered by either qualified instructors or those that have received training to the standard of the On the Job Training Instructor Training (OJTIT) course.

1.4.5.15. **Signatory Malpractice.** RA 4300 (Certification of Aircraft Documentation) states that " In the interest of flight safety and airworthiness integrity, there is a chain of individual responsibility for maintenance work carried out within the Military Air Environment (MAE)" and that "an individual's certification affirms that the equipment is operationally ready and that operators may entrust their lives to it...the importance of correct recording and certification cannot be over-emphasized and all personnel are reminded that it is a serious offence to certify a maintenance record without first ensuring its accuracy." In addition RA 4602 (Aircrew Assisted Escape Systems (AAES) – Maintenance, Vital and Independent Checks) defines mandated checks on all maintenance activity on AAES due to the criticality of correct function when operated. MAP Chap 13.1.2. defines the 3 levels of check required once AAES work has been completed; a maintenance check for correct assembly, locking and function; a vital check for the correct assembly, routeing, locking and function and finally an independent check covering final visual confirmation that all locking, routeing and installation processes have been carried out correctly. Each level of check is to be carried out in accordance with the relevant maintenance procedure and by a technician who is appropriately authorized by the associated level J or level K engineer. The maintenance activity can be carried out by any suitably authorized technician, however, the maintenance and vital checks can only be carried out and signed for by a Level D supervisor and the independent checks can only be carried out and signed for by a Level E supervisor not previously involved in the task. Whenever maintenance activity is required a Maintenance Work Order (MWO) is raised. Whoever carries out the maintenance activity signs as the 'Tradesman', the Level D supervisor who carries out the maintenance and vital checks signs as the 'Supervisor', the Level E supervisor who carries out the independent checks signs below both the 'Tradesman' and the 'Supervisor'.

Witness 9
Witness 10
Witness 16
Exhibit 37
Exhibit 95
Exhibit 99
Exhibit 100

The Panel found evidence that the RAFAT almost exclusively raised a single pre-printed MWO for RTI 59D which did not separate the maintenance activity between the front and rear seat. However, when RAFAT armourers carried out RTI 59D, the work on each aircraft would generally be carried out by 2 armourers; one would carry out the maintenance activity on the front seat and the other on the rear. They would then check each others work (each carrying out maintenance and vital checks) and a third armourer, who had not been involved prior, would then carry out the independent checks. Therefore, one of the 2 armourers would sign as 'Tradesman' for both seats, when in reality he had only worked on one; conversely, the other armourer would sign as 'Supervisor' for both seats despite having only carried out maintenance and vital checks on one of the seats[33]. The last RTI 59D carried out on XX177 on the 24 Oct 11 was conducted in this manner, but one of the 2 armourers was found not to be a Level D supervisor. Therefore, the Panel could not determine which armourer carried out the maintenance activity on which seat and noted that the maintenance and vital checks for one of the seats was carried out by an unqualified and unauthorized individual. Although this signatory and supervisory practice was a significant deviation from RA 4300 and the MAP, the assembly of the drogue and scissor shackle was found to be in accordance with RTI 59D, DEF STAN 00-970 and general engineering principles and therefore did not contribute to the accident. However, the Panel concluded that the severity and frequency of this signatory and supervisory malpractice on the RAFAT was indicative of training and assurance shortfalls, compounded by a lack of adequate supervision and was **an other factor.**

1.4.5.16. **RAFAT Engineering Training and Standards Summary.** It is the view of the Panel that the majority of the findings regarding engineer training were not new and had been developed over time. Additionally, as discussed later in this section, SEngO RAFAT had recognised some of the training gaps and had made an attempt to raise them through the

[33] Of note, self supervision was not employed on the RAFAT.

command chain. The Panel concluded that the lack of an RAF Hawk Q course, combined with the absence of formal tracking, assessment and assurance of OJT, resulted in an engineering organization on the RAFAT that did not contain sufficient SQEP engineering personnel to maintain Hawk aircraft, an issue categorized as the top Risk-to-Life (RtL) in the standalone RAFAT engineering risk register and discussed further at 1.4.5.26. Whilst the line training course prepared engineers to carry out flight servicing on the Hawk, the course was not DSAT compliant and there was evidence that some of the flight servicing and line procedures taught were contrary to the authorized aircraft document set. Consequently, the content and quality of the flight servicing, including the ejection seat, that was carried out on XX177 between 4 and 8 Nov 11 was unclear. The Panel concluded that the absence of formal, DSAT compliant RAF engineer training for the Hawk aircraft meant that RAFAT engineers were less likely to identify an SFH in an unsafe condition and that this was therefore **a contributory factor**.

RAFAT OPERATING TIMELINE

1.4.5.17. **Output Focus.** It is the Panel's view that the RAFAT focused on a primary output: the provision of a nine-aircraft formation aerobatic display or flypast, designed to impress as a visual spectacle, and choreographed to split-second timings. While this is entirely reasonable, the Panel also noted that it had a tendency to become all-consuming, and that the unique role of the RAFAT had over time given rise to the development of RAFAT-specific procedures and working practices which deviated from those of mainstream RAF Sqns, other Hawk users and the aircraft document set. The intent of these deviations appeared to be primarily driven around a desire to improve 'efficiency', motivated by the perception that the high tempo of tasking during the summer season warranted it. The Panel noted that RAFAT tasking had been reduced for the 2011 season, which was driven by AOC 22 (Trg) Gp, to prevent overflying the RAFAT flying hour allocation which had taken place in previous seasons (in the order of 20%). In order to achieve this, OC RAFAT had attempted to regionalise displays to reduce transit sorties, enabling the incorporation of some minor changes, most notably an increase in the turn-round time afforded to the engineers and the addition of 5 minutes to the pilot brief to take-off timeline. However, it is the view of the Panel that a significant number of deviant 'norms' were still extant, which are described in this Section and that the legitimacy of these RAFAT bespoke procedures was reinforced by the continued acceptance of these deviations by the supervisory chain.

Witness 19
Witness 20
Witness 23
Witness 24
Witness 28
Witness 42
Witness 56
Exhibit 18

1.4.5.18. **Procedural Drift.** In the process of analysing the RAFAT timeline, the Panel considered the potential for procedural drift. According to Dekker (2006),[34] a mismatch between laid down procedures and practice almost always exists. This mismatch can grow over time, increasing the gap between how a system was designed, or imagined, and how it actually works. This is called procedural drift: the slow incremental departure from initial written guidance on how to operate a system. Factors that lie behind procedural drift are:

a. Rules that are, or perceived to be, overly designed and that might appear practically difficult to implement.

b. Emphasis on local efficiency pushes operational people to achieve and prioritise one goal or a limited set of goals. Such goals are typically easy to measure, whereas it is much more challenging to articulate how safety is eroded.

c. Past successes are taken as a guarantee of future safety and each operational success achieved, at incremental distances from the original rules, can be established as the new 'norm'.

[34] The Field Guide to Understanding Human Error, Sidney Dekker, Ashgate (2006)

d. Departure from the original rules becomes routine, and when viewed from inside a unit, violations become compliant behaviour.

1.4.5.19. **Brief, Start-Up, Taxi, Take-Off (SUTTO) Timeline.** During the winter and spring work-up the RAFAT flew multiple practice sorties in a day, usually of 30 minutes' duration. When compared to other Hawk users, the Panel noted that the RAFAT had developed a bespoke brief to take-off timeline. The standard time allocated by OC RAFAT from start of brief to airborne was 35 minutes in the winter, some times reducing to 30 minutes in the summer when briefing 'on the wing'[35]. The **35 minutes** broadly broke down into the following timings: **14 minute** allocation for the sortie brief; **8 minutes** to dress, sign the MOD F700[36], walk to the aircraft, carry out initial cockpit checks, rear seat checks, aircraft external checks, ejection seat checks, strap-in and pre start checks; **3 minutes** to check-in, engine start, carry out after-start checks and be ready to taxi; **10 minutes** to taxi (Rwy 22 at RAF Scampton), line up and take-off as a nine ship formation. As a comparator, other non-training Hawk users normally brief at least 1 hour prior to take-off and allocate a minimum of 30 minutes from end of brief to take-off, compared to 21 minutes for RAFAT. The standard RAFAT timeline analysed further below:

Witness 2
Witness 6
Witness 8
Witness 21
Witness 27
Exhibit 18
Exhibit 21
Exhibit 96

a. **Brief/Outbrief.** The RAFAT sortie brief was relatively short in duration (circa 14 minutes); however, the sortie content tended to be repetitive due to the nature of the flying and the Panel considered it comprehensive for the display. Although not mandated, an 'out-brief' is used by all other fast jet operators as an opportunity for a last check prior to walking for an aircraft and is usually done at the authorizer's desk, after the main brief and often once dressed for flying. The RAFAT did not conduct a dedicated out-brief, in part due to a belief that the number of pilots made it logistically challenging. The Panel noted that a standard 4 ship of Tornados involved a comparable number of crew and still retained an out-brief. Additionally, there was a belief that the areas normally covered within an out-brief were routinely included in the main brief. The Panel found that the mandated briefing items in the RAFAT Display Directive (DD) omitted a number of items, such as flying currency, survival drill currency, fatigue, whether the pilots were dressed to survive and instrument rating restrictions. A check of correct authorization is normally an integral part of out-briefs; however, the RAFAT block filled the authorization sheets for each day and signed for all the sorties prior to the first brief in the morning. Although there are times where the pre-signing of auth sheets for a period of time may be entirely appropriate, it is the view of the Panel that this method of completing the authorization sheets on a regular basis, combined with the lack of an out-brief, led to assumptions over currency and fitness to fly being made many hours before flight. It is the Panel's view that by not conducting an out-brief, and by 'block' signing the authorization sheets in advance, widely used pilot preparedness supervisory safeguards were not being employed.

Witness 2
Witness 3
Witness 6
Witness 8
Exhibit 18

b. **Dress.** Prior to flying, fast jet pilots are required to 'don' Aircrew Equipment Assemblies (AEA) and ensure that they are 'dressed to survive' the expected conditions in the event of an ejection during the sortie. The items concerned

Witness 2
Witness 3
Witness 6

[35] Briefing on the wing - during the Display Season it was common for sortie briefs to take place at the aircraft on the Pan.

[36] MOD F700 – this document contains the engineering maintenance and servicing history, modification state, fuel state and aircraft limitations of each individual aircraft.

[37] DAP108A-0006-2(N/A/R)1 - Support Authority General Orders for Survival Equipment and Aircrew Equipment Assemblies and is a joint document produced by the Aircraft Escape Systems Project Team PT (AES PT)).

[38] CBRN – Chemical Biological Radiological and Nuclear.

depend on the aircraft type, role employed, weather conditions and terrain (mountains, desert, jungle, arctic, sea etc.). For the RAFAT, the aircraft type and role was consistent, therefore the variables were the weather and to a degree the environment. The RAFAT briefed in flying coveralls ('flying suits') and afterwards donned the following as a minimum: Anti-G trousers, leg restraint garters, life preserver, helmet with oxygen mask and gloves. Weather and terrain might necessitate an immersion suit when flying over water for long periods or cold weather flying clothing when the weather necessitated it. Witness 8 Exhibit 10 Annex E

The normal RAFAT timeline allowed approximately 30 seconds to walk from the briefing room on the first floor, to the ground floor and then 30 seconds to don the requisite AEA and ensure they were dressed to survive. Whilst one minute was perceived as adequate by the RAFAT pilots, it is the view of the Panel that it was insufficient to allow an adequate pre-flight check as to the serviceability of the AEA and ensure its correct fitment. Should a problem have been discovered, it is the Panel's view that the time available would not have allowed adequate analysis, without compressing the timeline further, or delaying the take-off. As an example, on the day of the accident, the plan was to fly to and operate over North Wales. The November weather should have necessitated the wearing of a cold weather flying jacket to give better thermal insulation in the event of an ejection over North Wales. The Pilot searched briefly for his jacket, could not find it and elected to go without. Of note, one of the items omitted from the mandated briefing items in the RAFAT DD, that might have been part of an out-brief, was whether all crews were 'dressed to survive'. In the event, on the accident sortie an unplanned pause in the timeline was instigated by the maintainers at this point in order that the MOD F700 paperwork was completed. It is the Panel's view that the allocation of less than one minute to don the appropriate AEA, check its serviceability, correct fitment and be dressed to survive was insufficient.

It is expected practice for pilots to wear 'long johns' and a long sleeve aircrew jersey underneath their flying coveralls. The two layers of clothing provide thermal insulation for the pilot and protection from MDC splatter burns during an ejection. Additionally, the Panel noted that one of the recommendations from SI XX233/XX253 was that RAFAT pilots should conform to this; the exception, laid down in the RAFAT DD, was that in the summer the long sleeve jersey could be relaxed to a T-shirt to prevent thermal stress. On the day of the accident, the Pilot was wearing a Red Arrows short sleeve T-shirt and consequently sustained MDC splatter burns which were mainly confined to the lower parts of the upper arms and forearms which were only covered by one layer of fabric. The RAFAT appeared to have not implemented the specific recommendation regarding the wearing of long sleeve jerseys. The Panel **observed** that guidance regarding minimum clothing requirements provided by different ODHs, flying similar aircraft types, differed. Exhibit 39 Exhibit 113

In the course of the Panel's investigations into AEA, fitment and servicing, the following was noted, which, while not factors in the accident, are included as **observations**: Exhibit 40 Exhibit 41 Exhibit 48 Exhibit 49 Exhibit 50

i. **Immersion Suits.** The Royal Navy and Army mandate the use of immersion suits for flights which are predominantly over water when the sea temperature is below 15˚C. The Royal Air Force do not mandate their use until the sea temperature is below 10˚C.

ii. **Servicing of AEA.** DAP108A-0006-2(N/A/R)1[37] states that Before Flight Servicing of non CBRN[38] AEA equipment is "the responsibility of the

user and are to be carried out by the user in the aircraft". DAP 108A-0006-5F(N) lays down the BF and AF inspections of SE and AEA for the Royal Navy. There is no equivalent document for the RAF or Army. In effect, there is a document that lays down the requirement for aircrew to carry out the BF on their own equipment, but there is no document that explains what that entails for the RAF or the Army.

c. **Checking and Signing of the Form 700.** By signing in the F700 the pilot is accepting responsibility for the aircraft and that the pilot understands its configuration, servicing history and limitations. Prior to acceptance of the aircraft, it is therefore conventional for the pilot to read the relevant sections of the F700 and, where necessary, discuss the contents with the engineers; this affords the pilot the opportunity to gain the requisite knowledge of the aircraft. Additionally, it is the view of the Panel that this actively demonstrates to the engineers that their paperwork and thoroughness will be scrutinised. The timeline allowed approximately one minute for all nine pilots to flow through the line office and sign the F700s. Pilot names, dates and times were pre annotated on the servicing certificate by the engineers to expedite the process further. There was little opportunity afforded to accurately check the state and limitations of the aircraft and discuss its contents with the engineers without halting the flow of proceedings and delaying the take-off. When the pilots were questioned as to whether they would omit this on previous sqns, the answer was almost exclusively "no" and when asked whether they had ever found anomalies with F700 paperwork in the past, the answer was generally "yes". There appeared to be a collective belief that any potential shortfalls associated with this approach to the F700 on the RAFAT were covered by the engineering brief delivered by JEngO during the morning sqn brief and that RAFAT pilots flew the same aircraft and therefore knew its history. The Panel explored this approach and examined the following:

Witness 6
Witness 7
Witness 8
Witness 26
Witness 28
Exhibit 42
Exhibit 45

i. The depth that each aircraft was discussed in the morning brief is not known; however, it is the Panel's view that the JEngO would not have had time to brief up to 10 aircraft in sufficient depth nor provide the assurance for successive sorties that aircraft servicing and paperwork had been completed. It relied on the pilot being informed of any changes rather than proactively checking, leading to the situation where the emphasis was shifted towards the engineers to check the F700 which had the potential to create a perception that it was no longer the responsibility of the pilot.

ii. The perception that each pilot flew the same aircraft on a regular basis was not completely unfounded, as this was often the case for considerable periods during the display season; however, some routine maintenance and flight servicing would have been carried out between sorties. Additionally, flying the same aircraft in the summer was by no means guaranteed and was certainly not the case during the winter, when the same approach to the F700 was employed by the RAFAT.

It is the Panel's view that the time allocated to the inspection and signing of the F700 was insufficient and decreased the likelihood of understanding safety critical limitations or identifying potentially safety critical anomalies.

d. **"Walk-Round" Checks, Pre-Start Checks and Engine Start.** All other Hawk users in the UK carry out checks of the flying controls to ascertain the correct operation of aileron, tail-plane and rudder. These are carried out independently of each other and are observed by ground-crew to confirm correct

Witness 3
Witness 6
Witness 7
Witness 8

operation, taking in the order of 30 seconds to complete. The genesis for these checks is a recommendation in BoI XX164[39]. RAFAT pilots carried out a combined 'full and free' check, taking approximately 5 seconds, but omitted to carry out ground-crew monitored checks of the individual flying controls. The perception of the majority of the pilots was that the 'full and free' checks were monitored for correct operation by the ground-crew and that a 'thumbs up' was positive confirmation. However, AESOs state that "this check is to ensure that the tail plane, rudder and ailerons have operated and is **not** a confirmation of correct movement; **correct movement is the responsibility of the pilot**"; this was supported by witness evidence from ground-crew. The abbreviated control checks and confusion over responsibilities between pilots and engineers did not provide positive confirmation of correct flying control operation of RAFAT aircraft prior to flight.

Exhibit 43
Exhibit 44
Annex C

The RAFAT standard timeline allowed approximately 6 minutes on completion of signing out the aircraft to walk the 100yds to the aircraft, carry out initial cockpit checks, rear seat checks, aircraft external checks, ejection seat checks, strap-in and pre-start checks. During the accident sortie, the necessity for the groundcrew to complete MOD F700 paperwork caused a pause in the timeline prior to the aircrew signing for the aircraft. However, the timeline from aircrew signature to check in, including external checks, internal checks and a mobile telephone call, was broadly comparable to the 'normal' timeline. The standard RAFAT timeline allowed 3 minutes from check-in (prior to engine start), to be engine running, ready to taxi. This compares to 5 minutes which is used by other Hawk users. Of note, during MITL testing when the 'test' pilot was tasked to conduct his cockpit checks, including the ejection seat, in a time comparable to the RAFAT timeline, he failed to spot the SFH in an unsafe condition on several occasions. When the 'test' pilot carried out the same checks, but at his 'normal speed', he discovered the SFH in an unsafe condition[40]. It is the view of the Panel that the time allocated by the RAFAT in their standard timeline to carry out this activity was insufficient and was only achievable by changes to normal Hawk operations outlined later in this Section. Whilst the actual workload and pressure experienced by the Pilot on that day will never be definitively known, it is the view of the Panel that the compressed nature of the checks, including those for the ejection seat, increased the likelihood that the Pilot would not discover the SFH in an unsafe condition.

1.4.5.20. **RAFAT Timeline Summary.** It is the view of the Panel that the short timeline had evolved over the years, was symptomatic of procedural drift and had evolved to mitigate a challenging display programme. The compressed operating timeline appeared to have been accepted by the command chain as the solution, rather than seeking to address the cause, and past success underpinned a perception of future safety. A realistic appraisal of alternative courses of action appeared to have been set aside in favour of timesaving measures which included the removal of some safety critical activity. The view from inside the Team was that the timeline felt normal and that an outsider would "have to fly with us to understand". Many of the deviations adopted by the RAFAT, when looked at in isolation, appeared to be relatively minor. However, there is little evidence of any assessment of the potential cumulative impact of the changes incorporated by the RAFAT and there appeared to be no reason for the application of these deviations other than to save time. The 'best case'

[39]BoI XX164 – This BoI investigated a fatal accident at RAF Valley that occurred in 1996 involving XX164; it was found that the ailerons on this Hawk aircraft were not reconnected following maintenance, which led to the introduction of ground crew monitored flying control checks for 'correct' operation.

[40] Up until this first detection of an unsafe condition, the 'test' pilot had been unaware of any possibility that an SFH could be in an unsafe position with the pin inserted.

timeline of 35 minutes from brief to airborne was roughly half the time allocated by other Hawk users. The timeline was squeezed to such an extent that safety critical activity was not being carried out and safety margins had been significantly reduced. When questioned as to what would happen if F700 paperwork was not correct, SE was unserviceable or a minor fault was discovered during external checks, the view from RAFAT pilots was that anyone could say 'stop' at any time and that there was 'no pressure'. Nevertheless the compression of the timeline created a situation whereby safety critical activity was being habitually compromised. There are examples whereby RAFAT personnel rightly halted the process during the timeline which resulted in a delay to check-in. However, it is the Panel's view that the RAFAT prided itself to such a degree on meeting its display times to the second that the fear of not being ready at 'check-in' may have resulted in a reluctance to halt proceedings or question bespoke procedures. The RAFAT timeline is likely to have affected the thoroughness of the Pilot's checks, made the movement of the SFH on 4 Nov 11 more likely, and the probability of the Pilot detecting the SFH in an unsafe condition on 8 Nov 11 less likely. The Panel therefore concluded that the RAFAT timeline was **a contributory factor**.

RAFAT DISPLAY DIRECTIVE AND SOPs

1.4.5.21. **Background.** At the time of the accident the overarching documents governing military aviation were the Military Regulatory Publications (MRP) which had come into use as of 01 Aug 11. The RAFAT Display Directive (DD), extant until Spring 12, dated 19 May 11, referenced the Military Aviation Regulatory Document Set (MARDS) and was complementary to 22 Training Group Orders (TGOs). The RAFAT DD comprised 4 parts; extracts from Part 2 and Part 3 are discussed below:

1.4.5.22. **Part 2 of the RAFAT DD – Authority to Display.** This covered details of the PDA for the RAFAT and was issued under the signature of AOC 22 (Trg) Gp who was the Aircraft Operating Authority (AOA). It contained caveats attached to the PDA and exemptions to orders, regulations and the aircraft document set. Exhibit 18 Exhibit 46 Exhibit 47

In the covering letter to Part 2, under the heading of "Exemption to Orders, Regulations and the Document Set" it stated that "deviations from extant policy must be approved by the AOA". The reference quoted (JSP 550.R335.000.3[41]) stated that "formation teams may operate and practice to differing limitations and minima when the AOA considers it essential to the display…to be approved, in writing, by the MAA". JSP 550.R335.000.3 applied only to displays and practices and should not have been used as authority for changes to orders, regulations or the document set.

RA 2401 states that "all aircraft checks **shall**[42] be completed in accordance with the relevant aircrew manual/pilot's notes and associated FRCs". Changes to Technical Information (TI) and the aircraft document set are covered in RA 2401, RA 4353 and the MAP. The Acceptable Means of Compliance (AMC) in RA 2401 states that "aircrew who observe a deficiency, omission or inaccuracy [in aircrew publications] **should**[43] raise a MOD F765X and submit it in accordance with the instructions for use printed on the form". Temporary alterations to the FRCs can be authorized by aviation Duty Holders and commanders, however "such alterations **should** be forwarded to handling sqn for confirmation and approval before being incorporated as permanent amendments[44]". RA 4353 (Amendment to TI) states

[41] JSP 550.R335.000.3 – This JSP was superseded by RA 2335; the text contained within remains the same.

[42] **Shall** is the executive verb used in regulation to state that the regulated person has no choice but to do what is stated in the regulation.

[43] **Should** is the permissive verb used in the AMC to allow a Regulated Entity the opportunity to consider alternative approaches in meeting the regulation; noting that any alternative approach must be approved by the MAA.

[44] Of note, Hawk FRCs state that comments and suggestions should be forwarded using a MOD F765X to the Hawk CFS Agent, 208 Sqn, for forwarding to OC Handling Sqn.

that "all personnel working in the Military Air Environment (MAE) **shall** report any unsatisfactory feature, error or omission [or when it is considered that there is a better way of undertaking a task than that described] within TI when identified" and refers to the MAP for the AMC: Chap 8.2 of the MAP states that "all amendment proposals and subsequent actions **must** be recorded using the MOD F765". Of note, there are different variants of MOD F765; MOD F765X applies to "aircrew publications and flight test schedules".

Part 2 of the RAFAT DD contained a table of the following deviations from 22(Trg) Gp TGOs and the aircraft document set:

a. **Ground-Crew External Checks.** JSP 550 D305.130 stated that "AOAs are to specify, by aircraft type, which member of the aircrew or maintenance personnel is responsible for conducting the external aircraft checks as laid down in the FRCs". It is the Panel's view that the intent behind this statement was to allow for the allocation of responsibility between crew members on multi-crew aircraft, such as C-130, AWACS etc, not to delegate external checks to ground-crew. The dispensation in the RAFAT DD table referred to "a limited number of RAFAT ground-crew [who] may be trained and authorized to carry out aircraft external checks". However, the RAFAT DD later used the term "walk-round checks" when referring to checks carried out by ground-crew; 'walk-round checks' is a term that does not exist in the FRCs, it is a colloquial term that is sometimes used in place of external checks. The composition of these 'walk-round' checks was laid down in AESOs: the Panel noted that the external checks laid down in the FRCs contained 4 lines of general guidance and only 6 specific checks. However, the 'walk-round checks' listed in AESOs, to be conducted by RAFAT engineers, numbered some 70 specific checks and incorporated the majority of the solo/rear seat flight checks, initial checks-front cockpit, external checks, ejection seat checks and internal checks-front cockpit. The majority of these checks were non delegable to engineers without a change to the document set. Exhibit 18 Exhibit 28 Exhibit 44 Exhibit 47

b. **Turnbacks.** The dispensation stated that "Pending amendment of the Hawk Aircrew Manual (AM) to remove the prohibition on turnbacks to the reciprocal runway, all RAFAT pilots, Comdt CFS, Wg Cdr RAFAT and HQ CFS Advanced Examiners (Hawk) are authorized to practise turnbacks to the reciprocal of the take-off runway". The Panel noted that this still featured as a 'deviation' in the RAFAT DD dated May 11; however, the amendment to the Hawk AM was no longer pending, having been issued three years' earlier in May 08. Exhibit 18 Exhibit 27

c. **VHF Radio Check.** The dispensation stated that "Pending FRC amendment action, RAFAT may dispense with the VHF radio check and conduct the pre-start checks in the sequence given in the RAFAT DD, provided that all check list items are completed". The Hawk FRCs state that the VHF radio should be tested prior to engine start. The RAFAT omitted a VHF check "unless a Team member suspects a problem", therefore the full serviceability state of the VHF radio could not be ascertained. During normal operations this was unlikely to be an issue; however, unforeseen circumstances such as poor weather could cause the RAFAT to use an untested VHF radio. Additionally, the RAFAT direction in the event of a UHF transmitter failure for the leader or UHF receiver failure for wingmen during the display was to use the standby UHF or VHF radio. Exhibit 18 Exhibit 28

1.4.5.23. **Part 3 of the RAFAT DD – SOPs.** Part 3 of the DD covered RAFAT specific SOPs for pilots and was issued under the signature of OC RAFAT. The covering letter stated that OC RAFAT was responsible for ensuring that "any deviation from higher-level orders and regulations referred to in the SOPs has been correctly authorized by the relevant authority". Exhibit 18 Exhibit 105

The Panel found that although the RAFAT DD stated that the start sequence only "differs slightly from the standard Hawk ac", in actuality there were a significant number of changes to the procedures being employed by both RAFAT aircrew and engineers. The changes which relate specifically to the accident are discussed below:

a. **Flight Servicing.** RAFAT AESOs directed that ground-crew leave the Seat Pan Actuator (seat height) in the present position during servicing, despite clear instruction in the Flight Servicing Manual to "motor to the upper limit" and to "ensure the cockpit floor is clean and dry". The Panel could find no reason for this intentional omission other than to save time for the pilots when strapping-in. It is the view of the Panel that the probability of RAFAT engineers and the Pilot identifying the SFH in an unsafe position would have been increased had the procedure laid down in the Flight Servicing Manual been adhered to. If the seat in XX177 had been raised to its full extent, a better view with a greater front aspect of the SFH would have been afforded, thereby increasing the probability of detecting it in an unsafe condition. Exhibit 30 Exhibit 44

b. **Start Sequence.** Hawk FRCs instruct that the canopy is closed and that the MDC and SFH safety pins are removed and stowed prior to engine start[45]. Other Hawk users carry out a positive check between ground-crew and pilot that the MDC and SFH safety pins have been moved to the correct position prior to engine start. The Panel found that the RAFAT winter and summer routines involved using the noise of the GTS ignition to 'warn' the ground-crew of engine start; the ground-crew would then move under the aircraft while the pilots closed the canopy. The pilot would then 'remove and stow' the SFH and MDC safety pins, making the seat 'live', without obtaining a positive check from the ground-crew. Additionally, the Panel noted that by intentionally sequencing events that resulted in ground-crew being under the aircraft during engine start, the opportunity for prompt fire detection and suppression during start was significantly reduced. Witness 2 Witness 3 Witness 7 Witness 8 Witness 28 Exhibit 28

The routine of combining engine start, canopy closing and moving SFH and MDC pins increased the cockpit activity and may have made cognitive failure more likely. An assumption of safety unless informed otherwise, rather than a positive acknowledgement of pin movement, may have contributed to the delayed reminder and movement of the safety pins during the accident sortie. As outlined in Section 1.4.2, the late detection of 'un-travelled' pins, and the subsequent hurried removal of the SFH pin just prior to the accident, most likely moved the SFH from Position 2 to Position 3.

1.4.5.24. **Display Directive and SOPs Summary.** Changes to TIs (including aircrew publications and the flight test schedule) **must** be proposed and the subsequent actions recorded using MOD F765 variants. The RAFAT DD, AESOs and RAFAT specific SOPs deviated from orders, TIs and the document set, applicable to both operators and engineers. The Panel found no evidence of any F765/F765X submissions, despite these significant deviations, some of which related to safety critical checks and procedures. It is the view of the Panel that the introduction of these changes was not a recent event and that, in the words of the RAFAT DD, had "evolved over many years of ops". The perception of the Team was that this way of operating had been handed down as best practice and that it represented "the safest way of working…having stood the test of time", despite there being no evidence of any risk assessments. There was a collective rationalization by both pilots and engineers and acceptance of these 'norms' because of the perception that the 'unique' nature of the unit justified different ways of working. It is the view of the Panel that the unauthorized changes to Exhibit 108

[45] The main engine start sequence is initiated by ignition of the Gas Turbine Starter (GTS).

the Hawk aircraft document set without any apparent risk assessment resulted in the omission or inappropriate delegation of safety critical activity, with an associated risk to air safety. The Panel concluded the following:

a. The incorrectly authorized deviation from the Flight Servicing Schedule, regarding seat height, reduced the likelihood of detecting the SFH in an unsafe condition and was therefore **a contributory factor.**

b. The incorrectly authorized change of procedure to start the GTS prior to closing the canopy and moving the safety pins, combined with the lack of a positive pins check, increased cockpit activity which may have distracted the Pilot, making movement of the SFH to position 3 more likely and was **a contributory factor.**

c. The regulation and acceptable means of compliance for the amendment of TI (including aircrew publications and flight test schedules) is clear, unambiguous and laid down in RA 4353 and the MAP and uses the term 'must' when referring to the use of MOD F765 variants by all personnel working within the Military Air Environment (MAE). However, the amendment by aviation Duty Holders and Commanders of aircrew specific documentation is also laid down in RA 2401 but uses the term 'should' when referring to AMC and the use of MOD F765 variants. The Panel **observed** that the acceptable means of compliance relating specifically to aircrew documentation was not coherent between the two RAs.

RISK MANAGEMENT

1.4.5.25. **Risk Management Introduction.** Aviation Duty Holders are legally accountable for the safe operation of systems within their area of responsibility and for ensuring RtL are reduced to at least Tolerable and ALARP[46]. Risk management is an essential element of an effective Air Safety Management System (ASMS). Relevant MAA Regulatory Articles introduced 1 Aug 11 and their preceding instructions state that aviation Duty Holders shall use a standardised risk register, MOD aviation hazard risk matrix, and referral/escalation protocols in managing RtL in a coherent and consistent manner. At the DDH level, primary attention must be applied to mitigating single risks, whilst the ODH focus must be on reducing the aggregated RtL by monitoring safety trends across their AOR. A single unified risk register must be owned by the ODH, cover all platforms operated by the ODH within his AOR, must consider pan Defence Lines of Development (DLOD) elements and must have a suitably senior and empowered Risk Register Manager (RRM). Each risk must have a unique identifier, risk owner, risk manager and assessment of risk level, both before and post mitigation. Exhibit 59 Exhibit 65

1.4.5.26. **ODH Risk Management.** The absence of a 22 (Trg) Gp unified risk register was identified in the MAA audit conducted in Mar 11, was highlighted as being non-compliant and a Corrective Action Requirement (CAR) was raised. At the time of the accident there was evidence that progress had been made to rectify this; however, the ODH risk register remained a collection of individual aircraft type registers and the Hawk T Mk1 was further separated within 22 (Trg) Gp between 4 FTS risk register, the RAFAT Display Directive and SEngO RAFAT's risk register. The ODH held regular Air Safety Steering Group (ASSG) and Air System Safety Working Group (ASSWG) meetings to manage risk, attended by relevant Witness 56 Witness 57 Exhibit 66 Exhibit 67

[46] Risk Management - The goal of risk management is to show that safety risks can be tolerated and are at levels that are As Low As Reasonably Practicable (ALARP). A risk can be said to be ALARP when the cost of further reduction is "grossly disproportionate" to the benefits of the risk reduction.
[47] The Panel could find no record of exactly when, during the week of 24 Oct 11, this VTC took place.

stakeholders. The absence of a unified risk register during ASSGs may have hindered the ODH in understanding the totality of the RtL he was holding across his AOR.

AOC 22 (Trg) Gp had been in post since 14 Oct 11, having completed a 5 day handover. A face-to-face meeting between the outgoing and incoming AOCs took place on 10 Oct 11 to discuss training outputs, structures and some aspects of RtL. The following day the incoming AOC visited HQ DFT in Bristol for an induction into MFTS and RAFAT operations. RA 1210(2), issued 01 Aug 11, states that "as the risk owners, the DH shall always remain accountable for RtL within their AOR". On 13 Oct 11 the outgoing AOC wrote a letter to DFT directing him to maintain the effectiveness of the 22 (Trg) Gp ASMS until the incoming ODH had received and accepted his Letter of Delegation (LoD) from the SDH, but stressed that "this was not a delegation of responsibility" for RtL. The incoming AOC received his LoD from the SDH on 20 Oct 11, which he formally accepted the next day. The understanding of the outgoing ODH was that he had retained accountability for RtL until 21 Oct 11 (when the incoming ODH accepted his LoD). Having reviewed the risk register and RAFAT DD, the incoming ODH conducted a VTC briefing with DFT, his Senior Operator (SO) and Chief Air Engineer (CAE), which took place at some point during the week of 24 Oct 11[47]. During this meeting the AOC requested that the risks contained within the RAFAT DD be transferred to the 22 (Trg) Gp risk register and "formally accepted the risks to be held [by the ODH] from DFT". The understanding of the incoming ODH was that he did not formally accept the RtL until this VTC during the week of 24 Oct 11 and that he did so from DFT. When interviewed, DFT was unsure who had been holding RtL between 14 Oct 11 and the VTC; stating that it was either DFT, the ODH SO or the outgoing AOC. DFT had been nominated as 'deputy' ODH in accordance with the RAF SDH Directive dated 1 Aug 11. Although he was an experienced officer with significant corporate knowledge of 22 (Trg) Gp risks, he was neither formally appointed as a DH by the SDH, as required by regulations, nor endorsed by the MAA and was not, therefore, authorized to hold RtL. Moreover, the Air Safety Regulator does not recognise or accept the term "Deputy" Duty Holder. The Panel could find no clear audit trail with which to understand fully the handover of 22 (Trg) Gp RtL and had to rely predominantly on individual's recollection of events. It therefore remains unclear to the Panel who was responsible and accountable for 22 (Trg) Gp RtL during this handover period and in particular for the 3 to 7 days between 21 Oct 11 and the VTC during the week of 24 Oct 11.

Witness 56
Witness 57
Witness 58
Exhibit 65
Exhibit 68
Exhibit 112

1.4.5.27. **RAFAT DDH Risk Management.** At the DDH level, risk management within the DH construct is primarily concerned with mitigating single risks. In order that a DH understands the RtL within his AOR, there is a requirement to establish a robust ASMS and his own DH governance construct, based around a regular battle rhythm of air safety management meetings, advised by his SO and CAE. Contrary to regulations, the DDH had not formally nominated a CAE or SO and there was some confusion over who was his CAE. The DDH and 22 (Trg) Gp staff (including SO1 CAM) understood SO1 CAM to be the DDH CAE; however, SEngO RAFAT believed that he was the CAE, which was supported by the RAFAT DD. In part 4, under the signature of Comdt CFS, covering the concept of operations and risk assessment it stated: "**Duty Holder and supervisory chain**. Working to the Operational Duty Holder, AOC 22 (Trg) Gp, Comdt CFS is the Delivery Duty Holder for RAFAT, with Wg Cdr RAFAT as his Senior Operator and SEngO RAFAT his Chief Engineer".

Witness 22
Witness 24
Witness 34
Exhibit 18
Exhibit 65

The Panel found no evidence of any formal meetings between the DDH and his CAE or SO to discuss RAFAT RtL and there was no unified risk register. There were 2 separate registers utilized by the RAFAT; the engineering risk register was produced by SEngO whilst a separate risk register, which dealt with operating risk, was compiled by Wg Cdr RAFAT. There was no record of any discussions having taken place to assess operating and engineering risks together, despite the many local changes to procedures employed by the RAFAT. No structured forum existed to sentence and then, if required, formally elevate risks. The RAFAT 'engineering' risk register was copied to the DDH, Wg Cdr RAFAT, OC RAFAT and 22 (Trg) Gp SO1 CAM by SEngO RAFAT on an informal basis, although there was no

Witness 21
Witness 22
Witness 24
Witness 34
Exhibit 69

evidence of any formal acceptance. As an example of the potential for incoherence, the RAFAT engineering risk register stated that the top risk was related to manning experience and represented a RtL. Of note, the mitigation put forward in the risk register, updated 14 Oct 11, was the "introduction of a Q course or properly sponsored training package". The DDH was aware that SEngO had concerns regarding engineering experience levels; however, he was not aware that SEngO had raised it as a RtL and appeared content that SEngO was managing it.

1.4.5.28. **Risk Management Summary.** It is the view of the Panel that the absence of a 22 (Trg) Gp unified risk register made the understanding, and subsequent mitigation, of RtL across the ODH's AoR more difficult. The uncertainty surrounding responsibility and accountability for 22 (Trg) Gp RtL during the handover of ODH undermined the fundamental rationale behind RA1020; "that clearly defined roles and responsibilities are required so that legally accountable individuals can effectively carry out their duties in mitigating and making judgements on Air Safety risk". At the RAFAT DDH level the absence of an extant ASMP, any formal meetings to discuss RtL, separate engineering and operating risk registers and confusion over where DDH CAE responsibility lay, created an environment where RtL was not proactively and effectively managed. The risk management processes within 22 (Trg) Gp, and more specifically within the RAFAT, permitted many of the unconventional operating procedures and engineer training shortfalls that had evolved over time to continue without identification, risk assessment and subsequent mitigation; this made the dislodgement of the SFH to an unsafe condition more likely, and lowered the probability of its subsequent detection and hence was **a contributory factor.**

FLIGHT SAFETY

1.4.5.29. **Flight Safety.** A flight safety culture should be just, inclusive, supported up and down the command chain and across all aspects of aviation, and forms an essential part of any ASMS. In pursuing the aim of Flight Safety, the effectiveness of a good safety culture depends on individuals at all levels integrating hazard identification and occurrence prevention into every activity, and being accountable for complying with appropriate safety standards. The RAFAT was included in the RAF Cranwell flight safety organization, which was a legacy arrangement from when the unit was RAF Cranwell based. Red 10 was the UFSO, OC RAFAT was responsible for the "Maintenance of the highest standards of safety" and Wg Cdr RAFAT was "specifically responsible for flight safety at RAF Scampton".

Witness 27
Witness 21
Exhibit 64
Exhibit 70
Exhibit 101
Exhibit 102

Unit Safety Management Group (USMG) meetings were held at RAF Scampton, chaired by SATCO and attended by representatives from the Station. The USMG was found to be the only formal flight safety forum held at RAF Scampton. The Panel noted that, without exception, every set of minutes for these quarterly meetings included apologies for Red 10 and the RAFAT engineering representative. There is no evidence of any member of RAFAT ever attending this meeting since the earliest record (Jun 08). RAFAT attendance at the Cranwell Flight Safety Committee meetings (held 3 times a year) was less than 50% over the preceding 3 years. The limiting factor of geographic separation[48] and the availability of RAFAT personnel during the display season was recognised by the Panel; however, there was no evidence of any mitigation put in place, such as RAFAT flight safety meetings, nor was it ever formally raised as a risk or issue.

Witness 50
Exhibit 71
Exhibit 72

1.4.5.30. **Flight Safety Summary.** The Panel found there to be an open reporting culture within the RAFAT and a considerable amount of work had been done to mitigate flying display risks following SI XX233/XX253. However, there appeared to be a belief amongst the senior supervisors and pilots that the primary 'dangers' for the Team lay solely in display flying and

[48] The distance between RAF Cranwell and RAF Scampton being 36 miles by road.

that they were content to focus their flight safety activity accordingly. This prioritization, exacerbated by the geographic separation from RAF Cranwell's flight safety organization, led to a situation where some flight safety activity was omitted. It is the view of the Panel that the absence of comprehensive RAFAT flight safety oversight at the time of the accident reflected a culture that was focussed almost exclusively on display flying and that this situation was compounded by the absence of any effective external scrutiny. The Panel concluded that the absence of traditional flight safety oversight reduced the opportunity to question, and potentially address, some of the deviations to Hawk procedures, making dislodgement of the SFH to an unsafe condition more likely and reducing the subsequent probability of its detection, and was therefore **a contributory factor**.

ASSURANCE

1.4.5.31. **22 (Trg) Gp Structure.** RAFAT sat within 22 (Trg) Gp; the AOC was the ODH and AOA for all flying activity within the Group, and Comdt CFS was the DDH. TGOs stated that "Director of Flying Training (DFT) is responsible for all flying within the Group". However, TGOs also stated that for RAFAT flying "Comdt CFS is directly responsible to AOC (22) Trg Gp for RAFAT display flying, special events and flypasts including the selection, supervision and training of crews." Additionally, they stated that "Comdt CFS **shall** promulgate a RAFAT Display Directive and SOP which **shall** be approved annually by AOC 22 (Trg) Gp". Like all DDHs, Comdt CFS as the RAFAT DDH, was specifically and directly responsible to the ODH for managing RtL. However, the direct command line from the AOC in parallel, presumably originally intended to distinguish supervision of the RAFAT's unique operations from normal 22 (Trg) Gp flying training activity, appeared to have the unintended effect of excluding DFT and his specialist staff, thus hindering their ability to provide broader assurance of RAFAT consistent with that of the Gp's wider activity to the AOC.

Witness 24
Witness 27
Witness 28
Exhibit 49

1.4.5.32. **AOC Assurance.** It is normal for AOCs to utilize Annual Formal Inspections (AFIs) and Formal Staff Visits (FSVs) as part of their assurance process. Within 22 (Trg) Gp, FSVs of flying Stations and Units were carried out by DFT's staff and involved a general check of flight publications, log books, unit flight safety and training documentation. Inspections by the 22(Trg) Gp flight safety organization were also carried out, and all of these reports were used to inform the AOC's AFI report. The Panel found little evidence of routine formal assurance of RAFAT activities prior to spring 2011 when an inaugural AFI and FSV were conducted in response to a recommendation from the XX233 & XX253 RAFAT SI. The scope of that FSV report indicated that the visit had covered operations, engineering and admin support procedures, as well as flight safety and training. The report stated that the "RAFAT has an excellent attitude to flight safety"; this assessment appears to have been based on "an impression of the individuals [pilots] that we spoke to" and by observing a sortie brief and de-brief. The staff who carried out the FSV stated that they thought a 22 (Trg) Gp flight safety audit of the RAFAT had been recently completed; however, the Panel found no evidence of any flight safety audit having ever been carried out by either 22 (Trg) Gp or 1 Gp[49]. The positive picture of flight safety and the state of publications and pilot log books appears to be contrary to the findings in this Section. It is the Panel's view that the FSV may not have provided the AOC with an accurate picture of the RAFAT upon which to base his AFI report.

Witness 35
Witness 36
Witness 56
Witness 57
Exhibit 39
Exhibit 60
Exhibit 61

During the collation of documentary evidence for Part 2 of this SI Report, evidence came to

Exhibit 116

[49] RAF Scampton was a 1 Gp Station.

[50] Continuing Airworthiness Monitoring Organization (CAMO) – In the forward environment, the CAMO is part of the DH's assurance system for the standards and practices of work carried out on Forward units. For Depth, the CAMO should agree the work package content and assure its satisfactory completion.

[51] Part of the Quality Audit (QA) system that consists of both internal audits (IQA) and external audits (EQA) to assess the performance of a unit against the procedures it employs.

light of a "RAFAT Independent Review" carried out in late 2007, which was conducted on the direction of the then AOC 22 (Trg) Gp and reported on 24 Jan 08. The remit of the Review was to examine RAFAT operating procedures, SOPs and planning procedures through consideration of the RAFAT DD, RAFAT AESOs, and the balance of tasking against resource. Although this evidence does not materially affect the findings of the Panel, a number of the Review's findings exhibit significant similarities to those of this and other recent SIs involving RAFAT. Notable amongst the Review's recommendations were several designed to ensure that identified discrepancies between RAFAT SOPs, TGOs and the ADS were subject to risk assessments and, where appropriate, formal amendment action. The then Comdt CFS' response to the Review accepted some of the recommendations but, on grounds of the proximity of the 2008 display season, sought approval to continue with extant RAFAT procedures, including "groundcrew conducting ejection seat checks and removing MDC pins" and to only conduct formal risk assessments for future changes. In the absence of any evidence to the contrary, the Panel must assume that such approval was given prior to 2008 Public Display Approval and are unsighted on any follow-up action that may have been taken thereafter.

1.4.5.33. **Comdt CFS Assurance.** Comdt CFS exercised control of the RAFAT from RAF Cranwell and was their DDH. The primary role of CFS is to develop and maintain the highest possible standards of pure flying and flying instruction throughout the RAF. Comdt CFS and his staff regularly flew with the RAFAT and were aware that they did not carry out their checks in accordance with the FRCs and appeared content with this approach. Comdt CFS stated that "over time I think they have developed a set of routines which are absolutely fine from where I sit", indicating a normative acceptance of different standards for the RAFAT compared to other military flying units. Continued support by CFS for this longstanding divergence from the FRCs appeared to be an acceptance of the RAFAT's logic for these changes, justified under the umbrella of their 'unique' role and reinforced by success.

Witness 24
Witness 42

The preceding decade saw increased use of civilian contractors throughout the Armed Forces, this was particularly prevalent within 22 (Trg) Gp which had many aircraft types and a high percentage of contracted maintenance. Following a CAR from the MAA audit of 22 (Trg) Gp in Mar 11, and driven by a paucity of Crown Servant engineers within the Group, the ODH's CAE proposed that DDHs utilise HQ 22(Trg) Gp SO1 CAM as their CAE, to ensure that a Crown Servant fulfilled this role IAW RA 1023(1). This resulted in SO1 CAM assuming CAE responsibility for 12 aircraft types on behalf of 6 DDHs in addition to his CAMO[50] responsibilities, and led to a situation where his role could only be reactive within the DH construct. Although some 22 (Trg) Gp CAMO staff had contact with RAFAT prior to the accident, the DDH CAE had not visited the RAFAT or RAF Scampton. The Panel found little evidence of proactive engineering assurance of RAFAT, with the exception of a single Internal Quality Audit (IQA)[51] conducted by RAF Waddington personnel dated 10 Feb 11. The IQA highlighted the lack of formal training and absence of any formalised review/amendment procedure. The Panel found no evidence of any External Quality Audits (EQA), engineering assurance visits or visibility of the IQA by the DDH or 22 (Trg) Gp personnel.

Witness 45
Witness 34
Exhibit 63
Exhibit 66
Exhibit 103
Exhibit 104

1.4.5.34. **Unit Level Assurance.** The Panel noted that OC RAFAT was perceived to be the Formation Leader rather than an 'OC'. Senior supervisors and the command chain routinely referred to OC RAFAT as either the "Team Leader" or "Red 1"[52]. There appeared to be little recognition from OC RAFAT or other 'operators' within the supervisory chain, up to and including Comdt CFS, of command responsibility for engineers or matters pertaining to anything other than flying. Notwithstanding, OC RAFAT's TORs clearly stated that he was responsible to Comdt CFS, through Wg Cdr RAFAT, for the maintenance of engineering

Witness 8
Witness 21
Witness 23
Witness 24
Witness 28
Witness 57
Exhibit 64

[52] AOC 22 (Trg) Gp referred to him as 'Team Leader' exclusively throughout his Annual Formal Inspection report.

standards on RAFAT. In interview, all three individuals indicated that they thought engineering was the responsibility of SEngO and that as pilots they were not in a position to understand, or take responsibility for the command and supervision of the unit as a whole. As an example, all 3 declared themselves satisfied that the engineering training on the RAFAT was of a high standard, although none of them knew how it was conducted, by whom, or what standards should apply. Yet, the Panel noted that many of the unique RAFAT changes to normal Hawk operations that had been approved by the command chain involved delegating responsibility to the engineers, relying on their competency. The complexity of the display, with its inherent risks, focused the command chain and OC RAFAT almost exclusively on its preparation and execution.

Witness 22
Witness 34
Witness 34
Witness 45
Witness 55

On a typical RAF station, OC Eng is an experienced SQEP Wg Cdr aviation engineer with MAP Level K and QR 640 authority, and is the CAE to the DDH. Detached from the pressures of directly supporting daily tasking, his role is to mentor the unit SEngOs whilst providing independent assurance to the command chain and DDH that engineering standards are being maintained. This construct did not exist at RAF Scampton, a 1 Gp station with no flying units other than the RAFAT, which was itself accommodated as a 'lodger unit', and where there was no appointment of an OC Eng; therefore, SEngO RAFAT was granted MAP Level K and QR 640 authority. This authority had been awarded by appointment, with no apparent formal assessment or boarding process to ascertain suitability. Therefore SEngO was able to make significant engineering decisions, which in a normal construct would have been referred to an OC Eng. In effect, a level of external scrutiny and assurance, detached from the pressures of supporting RAFAT tasking, was absent and SEngO held conflicting roles of both delivery and assurance, which was exacerbated by the workload and remote location of the DDH CAE[53].

1.4.5.35. **Assurance Summary.** It is clear to the Panel that many of the divergent procedures and RAFAT specific unauthorized changes to the aircraft document set were not recent events and that they had evolved unchecked over many years. The lack of external formal visits by 22 (Trg) Gp staff, exacerbated by a bespoke command chain, combined with an institutional willingness to disapply standards expected elsewhere, hindered an accurate and objective appraisal of ways of working, standards, supervision and risks. The operating focus amongst senior supervisors, the unrealistic workload of the DDH CAE and the conflict of interest between assurance and delivery of the MAP Level K, QR640 engineer responsible for RAFAT, resulted in a reactive system of engineering assurance that failed to scrutinize training and practices effectively. The Panel concluded that the lack of robust external and internal assurance of the RAFAT allowed unconventional operating procedures and engineering training shortfalls to develop over time, whereby the dislodgement of the SFH to an unsafe condition was more likely, while the subsequent probability of its detection was reduced, and that this was therefore **a contributory factor.**

[53] The DDH CAE (SO1 CAM) was based in Bristol.

SECTION 1.4.6 - POST CRASH MANAGEMENT

1.4.6.1. **Post Crash Management.** The Panel considered the following aspects of Post Crash Management (PCM): Witness 24 Witness 48 Exhibit 17 Annex A

a. **Crash and Disaster (C&D) Contingency Plan.** RAF Scampton did not have its own C&D Plan; instead, actions at Scampton were included in an annex to the RAF Cranwell Plan. As such, RAF Cranwell held APCM responsibilities for any accident involving a military aircraft within the RAF Scampton Military Air Traffic Zone (MATZ), although it was recognised that the latter retained responsibility for the initial response to any disaster occurring within its boundary. At 11:44hrs on 8 Nov 11, the Duty Ops Controller at RAF Cranwell reacted to news from RAF Scampton that there had been an incident involving RAFAT Hawk XX177. A short time after, the Cranwell Crisis Management Centre (CMC) was stood up, a PCM Incident Officer (PCMIO) was nominated and personnel for a Guard Force identified. At Scampton the Crash Suite in ATC was prepared for use once the initial response by the emergency services was completed.

b. **PCM Action.** The accident occurred on the aircraft hard-standing outside of the RAFAT Sqn buildings. As a consequence, the initial PCM action was conducted quickly and efficiently by Wg Cdr RAFAT, R10 and the Sqn XO backed up by the RAFAT eng, admin and support staff. The PCM action and decision making process was later augmented by the arrival at the RAFAT Hangar of the RAF Scampton Acting Stn Cdr and Comdt CFS. Meanwhile, an effective cordon had been established to preserve evidence, digital media of the accident was captured and the civilian Police had arrived to take up primacy of the post-accident investigations. Whilst the Panel found the PCM action carried out to have been largely effective and correct, the following **observations** were made:

i. **Crash and Disaster Plan.** As part of the C&D Plan a response matrix outlined the duties of nominated personnel, including that of an RAF Scampton Incident Officer (IO) who would be Wg Cdr RAFAT, SATCO or a nominated CMC Controller. The Panel found no evidence that an Incident Officer had been formally established and the prepared Crash Suite for the IO and his support staff went unused. Instead, the accident response was conducted from the RAFAT Hangar by the personnel above, and was conducted in a similar way to the accident response for XX179, in that they largely based their response on the experience gained from the handling of previous RAFAT accidents. Whilst this response was effective, the Panel believe that the establishment of an IO and use of the crash suite could have prompted a more complete response and included the use of the C&D Plan checklists. Evidence that that this had not been completed included: PIDAT (Post Incident and Drug and Alcohol Testing) had not been considered by Comdt CFS or the Acting Stn Cdr. When questioned about the injuries incurred during the accident the Acting Stn Cdr had no awareness that 2 RAFAT ground-crew personnel had been hurt during the accident.

ii. **PCM Debrief.** Whilst the Panel found that some individual sections, like ATC, had completed their own PCM debrief to learn from the PCM action conducted, there was no evidence that this had been completed at Stn level.

iii. **PCM Training.** The Panel could find no evidence of the conduct of

any recent PCM training exercises at RAF Scampton, with the exception of a Table Top exercise conducted in preparation for a Families Day that was to be held in Aug 11, but was subsequently cancelled due to the previous accident to XX179.

SUMMARY OF FINDINGS

1.4.7.1. **Cause**. The Panel concluded that **the cause** of the accident was an inadvertent ejection following the application of a force to the SFH in Position 3; 20 degrees down from the horizontal plane and 30 degrees right from SFH housing centre line. 1.4.2.9.

1.4.7.2. **Contributory Factors**. The Panel identified 17 contributory factors to the accident.

a. The lack of wider knowledge regarding the SFH in an unsafe condition.	1.4.2.7
b. Incorrect routing of the right hand crotch strap.	1.4.2.13.
c. The ability to incorrectly insert the safety pin through the SFH alone.	1.4.2.15.
d. The difficulty in identifying the SFH in an unsafe condition.	1.4.2.20
e. The practice of inserting the SFH safety pin without visual reference.	1.4.2.22.
f. The late and expeditious removal of the safety pin.	1.4.2.23.
g. The ability to initiate ejection in a manner different to the design intent.	1.4.2.26.d.
h. Self medication.	1.4.2.28.a.
i. Pilot distraction.	1.4.2.29.
j. The RAFAT pilot selection process.	1.4.5.7.
k. The absence of formal, DSAT compliant RAF engineer training for RAFAT engineers.	1.4.5.16.
l. The RAFAT brief to takeoff timeline.	1.4.5.20.
m. The incorrectly authorized deviation from the Flight Servicing Schedule, regarding the raising of the ejection seat.	1.4.5.24.a.
n. The incorrectly authorized change of procedure to start the GTS prior to closing the canopy and move the safety pins, combined with the lack of a positive pins check.	1.4.5.24.b.
o. The risk management processes within 22 (Trg) Gp, and more specifically within the RAFAT.	1.4.5.28.
p. The absence of traditional flight safety oversight.	1.4.5.30.
q. The lack of robust external and internal assurance of the RAFAT.	1.4.5.35.

1.4.7.3. **Aggravating Factors**. The Panel identified 4 aggravating factors to the accident.

a. The extant publications and guidance for fitment of the drogue and scissor shackle.	1.4.3.12.
b. Poor communication between DE&S, Industry and the User and the lack of a robust system of tracking amendments, including warnings.	1.4.4.2.
c. The dimensions of the drogue shackle components, when combined with the extant guidance on fitment.	1.4.4.3.

1.4.7.4. **Other Factors**. The Panel identified 6 other factors to the accident.

a. Components in circulation that were outside of design specification.	1.4.3.7.c.
b. The general shortfall in auditable recording of airworthiness decisions within DE&S.	1.4.4.7.
c. Absence of accurate and relevant RAFAT pilot training records.	1.4.5.8.
d. The practice of 'sharing' simulator slots and inaccurate logging of simulator practices by RAFAT pilots.	1.4.5.10.
e. The false recording of CT, IF and instrument approaches by RAFAT pilots.	1.4.5.11.
f. RAFAT engineer signatory and supervisory malpractice.	1.4.5.15.

1.4.7.5. **Observations**. The Panel made 13 observations.

a. The ejection seat fitted to XX177 had no method of warning the pilot or engineers of a potentially unsafe condition, or the positioning of the pins, other than a visual inspection.	1.4.2.16.
b. There are a number of differences in guidance and procedures between Hawk FRCs and the aircrew manual regarding emergency ground egress.	1.4.2.21.a.
c. Tucano procedures mirror those employed by the Hawk TMk1 despite not being fitted with a 'zero/zero' seat.	1.4.2.21.b
d. The criteria for Sqn command selection and the emphasis placed on pre-command training varied significantly between the three Services, all of which exercise aviation command from OF3 to OF6 level.	1.4.5.4.
e. The guidance regarding minimum clothing requirements provided by different ODHs, flying similar aircraft types, differed.	1.4.5.19.b.
f. The Royal Navy and Army mandate the use of immersion suits for flights which are predominantly over water when the sea temperature is below 15°C. The Royal Air Force do not mandate their use until the sea temperature is below 10°C.	1.4.5.19.b.
g. There is a document that lays down the requirement for aircrew to	1.4.5.19.b.

carry out the BF on their own AEA, but there is no document that explains what that servicing entails for the RAF or the Army.	
h. The AMC relating to the amendment of aircrew documentation is not coherent between RA 4353 and RA 4201.	1.4.5.24.c.
i. Not all aspects of the RAFAT crash and disaster plan were adhered to.	1.4.6.1.b.i.
j. No station level PCM debrief was carried out at RAF Scampton.	1.4.6.1.b.ii.
k. Limited exposure to PCM training carried out at RAF Scampton and the RAFAT.	1.4.6.1.b.iii.

~~RESTRICTED – SERVICE INQUIRY~~