SURVIVABILITY CONSIDERATIONS

1.4.67. **Ejection Modelling**. RAF CAM modelled the XX179's flight profile to ascertain if an ejection would have been successful at or immediately before ground impact and, if not, the last point in the accident sequence at which a successful ejection may have been likely. The results of RAF CAM modelling suggested that the last point at which any ejection was likely to have been successful was at break +10.5 seconds. This was immediately prior to the transmitted warnings and approximately 4 seconds before ground impact. Annex A

1.4.68. **Aircraft Aerodynamic Modelling**. BAE Systems', 6DOF modelling was used to replicate XX179's flight path to ascertain if the aircraft was theoretically recoverable at the point which the pilot appeared to take recovery action. The results of this modelling indicated that recovery was possible with a maximum theoretical ground clearance being approximately 130 ft. It was noted that the biggest single factor in effecting a successful recovery was to roll the wings level as quickly as possible and that had the accident pilot applied full left aileron (as opposed to half) he may have recovered the aircraft. To attempt to qualify these theoretical results the Panel conducted an assessment using the Hawk T Mk1 simulator at RAF Valley and 5 QFIs who had a broadly similar background to the accident pilot. The result of this testing broadly agreed with the modelling albeit the ground clearance margins were significantly less than the modelling data suggested. Annex G Exhibit 44

1.4.69. **Discussion on Recovery and Ejection Modelling**. Set against theoretical modelling evidence, the Panel noted that pilots who had experienced G-LOC described being in a confused state during the recovery. Specifically, the pilot from the 2005 incident (discussed at para 1.4.49.) believed he was incapable of making an ejection decision. Such witness accounts are consistent with RAF CAM observation of subjects who succumb to G impairment during centrifuge training. The Panel concluded that: Exhibit 36 Witness 30

a. The aircraft was aerodynamically recoverable at the time recovery action was apparently initiated.

b. The accident pilot's recovery actions, and any ejection considerations, were likely to have been hampered by reduced cognitive ability.

c. Any attempt to eject during the recovery profile would likely have resulted in fatal injury.

RISK MANAGEMENT

1.4.70. **Generic Risk Management Procedures**. Risk management is an essential element of an effective Aviation Safety Management System (ASMS) and people should only be exposed to risk of harm where some defined benefit is expected and the risks are adequately controlled. In Defence Aviation terms, Aviation Duty Holders (DH)s are legally accountable for the safe operation of systems in their area of responsibility (AoR) and for ensuring that Risks to Life (RtL) are reduced to at least TOLERABLE and As Low as Reasonably Practicable (ALARP). Although DHs can delegate the management of risks to other suitably qualified and experienced individuals, they shall always remain accountable for RtL within their AoR. Superior DHs shall ensure a consistent approach to risk management, particularly if lower level DHs have similar responsibilities, eg similar aircraft types within their AoRs. A single, unified Risk Register for all RtL within their AoR should be maintained and held by Operational Duty Holders (ODHs). This register should include both type-specific risks and pan-DLoD elements. Those DHs who were responsible for RAFAT operations were the Delivery Duty Holder (DDH), Comdt CFS, and the Operational Duty Holder (ODH), AOC 22(Trg) Gp.

Exhibit 83
Exhibit 86
Exhibit 51
Witness 34

1.4.71. **22 (Trg) Gp HQ Risk Management**. To ascertain the collective risks held by 22(Trg) Gp, the Panel attempted to access their unified Risk Register via the Gp's intranet site. However, there did not appear to be a single source document but rather a series of hyperlinks to individual risk registers for each flying unit within the Gp. In attempting to determine if this was an administrative error, the Panel formally requested a copy of the Gp's unified Risk Register, via 22(Trg) Gp staff, but were referred back to the Gp's website. The Panel noted that the absence of a 22(Trg) Gp unified Risk Register was highlighted by MAA auditors in Mar 11 and a formal Corrective Action Requirement (CAR) had been raised. However, within 22(Trg) Gp there did not appear to be any structured plan to resolve this regulatory non-compliance and no apparent progress had been made. The situation was not helped by the Wg Cdr Air Safety Manager position within 22 (Trg) Gp being temporarily vacant, with the Sqn Ldr Flight Safety Officer straddling both AoRs. With respect to the Risk Registers that were presented, these often comprised multiple spreadsheets, making it difficult to gain a broad perspective of what risks were actually being held. Additionally there appeared to be some duplication of risks and, in some instances, an apparent misunderstanding of the risk management process itself.

Exhibit 54
Exhibit 55
Witness 45
Witness 46

1.4.72. **RAFAT Risk Management**. With respect to the RAFAT's Risk Register, there were referrals to operating risk which had no RtL at all. For example, hazards such as "No flying phase declared" were identified, with the consequence being aircraft may have to divert. This was indicative of personnel not truly understanding the risk management process and, if not kept in check, could result in an unwieldy document that may foster a dismissive approach to risk management. In addition to the formal RAFAT Risk Register, there appeared to have been 2 other risk assessment documents that stood in isolation. One was specific to engineering risks and the other display risks. The former document was a "best effort" and well intended but often failed to identify the true RtL and none of the risks had been transferred to the main Risk Register. The latter document, mandated after a previous RAFAT accident, had 2 significant flaws. First, it grouped some hazards together into homogenous lists, making the risk management strategies difficult to isolate and manage. Second, like the engineering risk assessment, the risks were not transferred to the RAFAT Risk Register. This had particular relevance because all of the risks identified were assessed as MEDIUM and, as such, the DDH did not have the authority to hold at his level. Consequently, although the ODH accepted the overall display risk as MEDIUM, within the Public Display Approval, evidence indicated that there were some risks which the ODH was unaware the team were carrying; such as engineering risks and the risk of G-LOC. With respect to formal training, the drafter of the RAFAT Risk Register

Exhibit 45
Exhibit 46
Exhibit 47
Exhibit 14
Witness 48
Witness 13-2
Witness 20-2
Witness 47
Witness 11-2
Witness 13-2
Exhibit 86
Exhibit 50
Exhibit 51
Exhibit 18

had attended a one day workshop in Mar 11, after the register had been completed. The DDH did not receive formal Duty Holder specific training until Jun 11. The Panel noted that the timing, and possibly the level, of formal risk management training could have contributed to some of the more esoteric errors observed. However, the Risk Management advice contained within JSP 551 V3, 22(Trg) Gp Air Safety Management Plan (ASMP) and the MRP was clear, and the fundamental failures within the risk management processes should have been obvious to anyone familiar with these documents.

1.4.73. **G-LOC Risk Management**. Within 22 (Trg) Gp both RAF Valley and the RAFAT operate the Hawk T Mk1. The RAF Valley Risk Register had indentified the potential of G-LOC and highlighted risk protection measures of regular anti-G suit checks, G awareness training and annual medicals with additional proposals of improvement to AEA and centrifuge training. The RAFAT Risk Register had also identified the risk of G-LOC and offered proposed mitigation of wearing anti-G suits, receiving G awareness training at RAF CAM and controlling manoeuvre entry speeds to limit the maximum instantaneous G. The Panel **observed** that attempting to mitigate G-LOC solely by speed could be operationally limiting and a better risk management measure would have been to assess all manoeuvres for their G-LOC potential and provide mitigation to minimize the risks associated with each. Notwithstanding this, collectively both Risk Registers had identified several G-mitigation strategies; however there was no apparent cross feed of ideas. The primary process to facilitate such interaction was the Hawk T Mk1 Safety and Environmental Panel (SEP), held at RAF Valley, which was a new initiative with its inaugural meeting taking place on 26 May 11. This took place as the RAFAT were returning to the UK following their pre-season work up training in Cyprus, hence no RAFAT representation was at the meeting. Notwithstanding this potentially missed opportunity, the risk mitigation measures that were identified by the RAFAT were not actively managed. This may have been detected if there was an active review of the Risk Registers but there did not appear to be any formal self-assurance process in place. Further evidence of inadequate internal ensurance/assurance procedures was identified by pilots neglecting to sign for an updated RTS, the 2011 SOPs and the 2011 DD. The Panel noted that the RAFAT DDH had not implemented a RAFAT ASMP which should have formalised the units Risk Management and ensurance/assurance procedures.

Exhibit 48
Exhibit 46
Witness 1-3
Exhibit 49
Witness 13-2
Exhibit 101

1.4.74 The impact of the RAFAT's omission to manage their own Risk Mitigation procedures was assessed by the Panel. Of the 3 mitigations offered, the first 2 were already governed by extant procedures/regulation in that all fast jet aircrew wear anti-G trousers and receive G awareness refresher training at RAF CAM. This left the omission to impose max entry speeds for manoeuvres. During the course of the investigation, the Panel interviewed the extant OC RAFAT, and 2 previous incumbents of the post, and specifically asked them to recall break procedures. Over the years it appeared that the norm was somewhere between 330-360 KIAS, depending upon the type of break. However it was noted that, currently, breaks were sometimes flown at up to 400 KIAS and may have been flown at up to 420KIAS in the past. The accident break speed of 384 KIAS was within the spectrum of what the RAFAT reported as acceptable. Therefore, the Panel considered that *if* the RAFAT had mandated a max entry speed for the manoeuvre, it would likely have been greater than the speed flown on the day.

Witness 1-1
Witness 33
Witness 37

1.4.75. **Summary of Risk Management Anomalies.** A summary of the Panel's risk management findings are as follows:

a. 22(Trg) Gp did not possess a single unified Risk Register. MAA auditors had highlighted 22(Trg) Gp's non-compliance with extant regulation in Mar 11; however, no apparent progress had been made.

b. The RAFAT had 3 separate Risk Registers/Assessments. Of these 3 documents only one was passed up to 22(Trg) Gp resulting in the ODH being unaware of several MEDIUM level risks being held by the RAFAT including engineering risks and the risk of G-LOC.

c. Some personnel had been actively involved in Risk Management prior to receiving formal training which may explain some of the more esoteric process errors. However, the Risk Management advice contained within the 22(Trg) Gp ASMP and MRP was relatively clear and the fundamental failures within the risk management processes should have been apparent to anyone familiar with these documents.

d. The RAFAT assurance procedures were inadequate. This may have been captured if an effective ASMP had been devised and implemented.

e. While the RAFAT's omission to implement their own G-LOC risk management was unsatisfactory, it was assessed that the mitigation measure that had been suggested would, in isolation, have been unlikely to prevent this particular accident. The Panel **observed** that attempting to mitigate G-LOC solely by speed could be operationally limiting and a better risk management measure would have been to assess all manoeuvres for their G-LOC potential and provide mitigation to minimize the risks associated with each.

Collectively, the Panel concluded that the shortcomings observed in the 22(Trg) Gp and RAFAT Risk Management Process, when combined, were a **contributory factor**. Inadequate assurance procedures, within and of the RAFAT, was also considered a **contributory factor**.

OCCURRENCE AND FAULT REPORTING

1.4.76. **Reporting Overview**. As stated in the Nimrod Review Report, '*the fostering of a strong and effective Safety Culture is vital to reducing accidents*'. A reporting culture which fosters an organisational climate where people readily report problems, errors and near misses is the corner stone to an effective Safety Culture. MOD policy is well established with RA 1410 and RA 4307, detailing Occurrence Reporting and Fault Reporting, providing clear guidance for front line commands. Exhibit 87 Exhibit 93

1.4.77. **Occurrence Reporting Observations**. MAA rationale states that '*the aim of Air Safety is to maximise operational capability by reducing those risks inherent in military aviation to at least Tolerable and ALARP. Occurrence reporting is a fundamental element of that aim*'. Taking the approach detailed in the Nimrod Review the following questions, when raised against the backdrop of previous incidents, reinforce the importance of occurrence reporting across military aviation:

a. **Were there any previous incidents which highlighted the risk of G-LOC/A-LOC?** The Panel's investigation highlighted a significant near miss in 2005 and identified previous cases of G-LOC/A-LOC which had been reported locally but not through the formal notification channels. If we compare the numbers who had experienced G-LOC, taken from the 2004 G-LOC survey report, with the number of G-LOC occurrences reported post 2000 we get an imbalance of 454:12. While the former figure may span a career and the latter is a 10 year snapshot, the comparison indicated that instances of G-induced impairment may have gone unreported. The 'Heinrich's Triangle' relationship between low-level deviations and accidents indicates that ratios of 600:1 are typical. Exhibit 38 Exhibit 35 Witness 32 Exhibit 36 Exhibit 32

b. **What was the response to those previous incidents?** Two of the quoted incidents investigated by the Panel were dealt with by local commanders and apparently not reported up the chain of command. In the case of the third, an HF Open Report was written such that lessons could be shared. Witness 32 Witness 35 Witness 36 Witness 38

c. **Were opportunities missed?** The previous three incidents were dealt with as one-off occurrences with little further thought being given to potential organisational/cultural issues, risks or wider implications. It also appears that the pilots were not subject to medical investigation nor were the aircraft subject to engineering investigation. Exhibit 35 Witness 35 Witness 36 Witness 38

d. **Were lessons learned?** As 2 of the 3 incidents investigated were dealt with at local or station level, limited corporate lessons were learned. Additionally, of the one incident that was reported, little corporate knowledge remained. Indeed, of those interviewed only the personnel that had been at the station in question at the time had any knowledge of the event. It is also worthy of note that following the reported incident, the G-LOC occurrence rate rose 8 fold over the next 3 years. This broadly equated to a tour length and the Panel speculated that any lessons learned were not enduring. Overall, with greater corporate knowledge, it would have been expected that the risks of G-LOC/A-LOC could have been captured and adequate mitigation implemented. Witness 7 Exhibit 35 Exhibit 36

1.4.78. **Risks Identified by the Hawk T Mk1 Support Authority**. Engineering fault reporting, as with occurrence reporting, is fundamental to the safety culture. A narrative fault report is raised using the MOD Form 760 series of forms when a fault on a piece of equipment warrants further investigation. In certain situations, especially if more information is required following a fault or series of faults, a mandatory reporting process may be initiated by the Support Authority (SA). Technical issues raised through occurrence and fault reports are assessed by the Defence Equipment and Support (DE&S) Hawk T Mk1 SA who identify technical trends and make risk assessment decisions. The Hawk T Mk1 SA had formally captured a hazard of 'anti-G trousers loss of functionality' on the SA risk register. This originated from a single failure of the connection between the G-suit bladder and the inflation hose which occurred in 2005; it should be noted that the G trousers in this accident were not affected by this failure. The SA's hazard of 'anti-G trousers loss of functionality' was closed on 3 Aug 11, with a mitigated factor cited as 'post-flight servicing checks'. There were no other anti-G system risks formally held by the Hawk T Mk1 SA.

Exhibit 58

1.4.79. **Anti-G System Fault Reporting.** As previously highlighted in para 1.4.34, the RAFAT had experienced 19 AGV faults over a 17 month period, see table 4; however, none of these had been subject to formal fault or occurrence reporting. The Panel noted that the RAFAT were working from a mandatory fault reporting instruction dated Mar 05, whereas the latest version had been updated in Apr 11. Although this was indicative of an inadequate assurance process, the anti-G system had not been included as a mandatory fault reporting item on the Mar 05 instruction or subsequent 2 amendments due to the long standing nature of the issue. When looking beyond the boundaries of RAFAT engineering, the wider Hawk community had experienced 51 occurrences (which included the RAFAT) of anti-G trousers being slow, or failing to inflate or deflate, over a 9 month period. Like the RAFAT instances, none of these occurrences had been subject to formal fault or occurrence reporting. The Hawk T Mk1 SA were aware of the ongoing anti-G system issue, but the associated hazard of an anti-G system failure had not been captured on the SA's risk register. Figure 15a provides an example of a RAFAT Hawk T Mk1 AGV that had been affected by corrosion. Evidence provided to the Panel suggested AGV failures had been an issue with the Hawk T Mk1 since the 1980s.

Witness 20-1
Exhibit 61
Exhibit 62
Exhibit 63
Exhibit 64
Exhibit 65
Exhibit 104
Exhibit 37
Exhibit 58

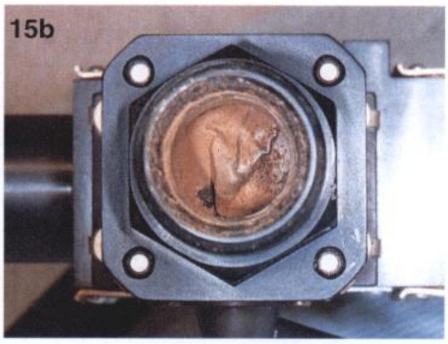
Table 4 – Summary of RAFAT unreported anti-g valve failures over a 17 month period

Date (a)	Tail Number (b)	Fault (c)	Action (d)
02 Jun 10	XX306	Anti-G test at idle pants do not inflate. Airborne ok	Valve replaced
20 Jun 10	XX266	Anti-G valve sticky	Valve replaced
16 Jul 10	XX322	Anti-G failed	Valve replaced
19 Jul 10	XX322	Anti-G valve inoperable	Valve replaced
18 Aug 10	XX322	Anti-G valve works intermittently	Valve replaced
29 Aug 10	XX306	Anti-G valve works intermittently	Valve replaced
22 Nov 10	XX308	Anti-G test pressure weak and slow to inflate	Valve replaced
10 Jan 11	XX266	Anti-G valve stuck down	Valve replaced
26 Jan 11	XX308	Anti-G test stuck on	Valve replaced
15 Mar 11	XX319	Anti-G valve slow to operate	Valve replaced
30 Mar 11	XX308	Anti-G giving full inflation	Valve replaced
04 Apr 11	XX242	Anti-G valve sticky – slow to operate	Valve replaced
08 Apr 11	XX227	Anti-G valve stays fully inflated	Valve replaced
08 Apr 11	XX322	Anti-G valve fully on half of flight	Valve replaced
21 Jul 11	XX322	Anti-G full on when not under 'g'	Valve replaced
06 Aug 11	XX308	Anti-G valve u/s	Valve replaced
21 Oct 11	XX266	Anti-G seized on	Valve replaced
28 Oct 11	XX264	Anti-G valve late to inflate	Valve replaced
28 Oct 11	XX266	Anti-G fails to deflate	Valve replaced

1.4.80. **Panel's Assessment of the AGV Hazard**. The 2005 anti-G trouser occurrence had been captured on the Hawk T Mk1 SA's risk register. The Panel assessed that the frequent anti-G system failures, which resulted in the same hazard of '*anti-G trousers loss of functionality*', should have been captured on the SA's risk register and highlighted to the Duty Holder chain for consideration. At the time of the accident there was no formal direction or guidance issued to the front line units operating the Hawk T Mk1 with regard to the engineering issue, operational risk or suggested mitigation.

1.4.81 During the final writing phase of this inquiry, an occurrence report was raised on 1 Mar 12 following an anti-G valve failure on a 4g run in and break to land; the anti-G system failed to inflate the pilot's anti-G trousers. The occurrence report highlighted that no engineering fault report had been raised for this incident and the conical filter was found to have collapsed with evidence of corrosion present. This incident reinforces the requirement for proactive and diligent fault and occurrence reporting with the aim of preventing subsequent accidents or near misses. Figure 15b illustrates a separate case of a collapsed AGV inlet filter caused by corrosion on the inlet filter. Exhibit 66

Figure 15 – Examples of Hawk T Mk1 AGVs with corrosion on the inlet and conical inlet filter (15a) and a collapsed filter caused by corrosion particles collected on the inlet filter (15b). Exhibit 59 Exhibit 60



1.4.82. **Conclusions on Occurrence and Fault Reporting.** The Panel concluded that:

a. When comparing G-LOC survey data with occurrence reporting it was likely that, at least some, G-impairment incidents had not been formally reported.

b. Some historical instances appear to have been reported to the chain of command but handled at a local level.

c. There was an apparent tendency for aircrew not to engage with medical SMEs post G-induced impairment incidents.

d. Corporate knowledge of reported incidents was lacking.

e. Anti-G system failures were not included on the SA's mandatory fault reporting list. Notwithstanding this, the frequency and nature of AGV failures should have been formally raised via extant fault and occurrence reporting procedures.

f. Frequent anti-G system failures had not been captured as a formal hazard on the Hawk T Mk1 SA's risk register or raised to Duty Holders for consideration.

g. No formal direction or guidance has been issued on the anti-G system failures.

Overall, inadequate occurrence and fault reporting was considered to be a **contributory factor** in this accident.

GENERIC RAFAT OPERATIONS, PROCESSES AND STRUCTURE

1.4.83. **Low flying over congested areas**. During the inquiry, a civilian eye witness commented that the RAFAT appeared to fly very low over Bournemouth. Of the 2 aircraft equipped with video equipment, only one had to reposition overland during the display sequence, and this aircraft's video was cross checked with ADR data and ordnance survey mapping. The results indicated that the aircraft had been operated between an estimated 200ft to 300ft MSD for a 40 second period (it should be noted that the Hawk T Mk1 is not fitted with a Radar Altimeter and therefore aircraft height is visually assessed by the pilot). The Panel interviewed the pilot who believed he was cleared to 300ft MSD while repositioning and this was consistent with Part 1 of the RAFAT DD. However, RA 2335 stated that flight over Congested Areas (CA) should only occur below 2000ft when conducting official flypasts. For such events, flight to 1000ft MSD can be authorised, although the RAFAT have dispensation to permit such flypasts at 500ft MSD provided they comply with specific risk mitigation measures. When the RAFAT supervisory chain were asked what height they would expect an aircraft to be repositioning over a CA responses were inconsistent, and the societal risks associated with such manoeuvring had not been fully considered. It was suggested that all locations that may require RAFAT operations, over a CA, would be cleared through a pre-season survey by HQ P&SS. The Panel **observed** that HQ P&SS has been disbanded for many years and that the pre-season survey procedures, referred to in Part 1 of the RAFAT DD, did not clarify who was responsible for initiating any request. On contacting HQ P&SS's successor organisation, it transpired that they were not familiar with the survey categorisation system discussed in the RAFAT DD nor had they any record of a survey being completed for the 2011, or indeed any other, Bournemouth Air Festival. In attempting to précis extant regulatory MSDs, the RAFAT DD had not considered repositioning over a CA. Additionally, the RAFAT DD appeared to refer to outdated processes and it appeared to have been an assumption that pre-season surveys would be conducted by other organisations. The Panel noted that the 2011 RAFAT DD descriptions of the pre-season survey process, and the minimum heights to be used when re-positioning, were identical to the 2008 RAFAT DD. The Panel concluded that:

Exhibit 1
Witness 25
Exhibit 100
Exhibit 16
Exhibit 89
Exhibit 53
Witness 1-4
Witness 8-2

a. At least one RAFAT aircraft was in contravention of extant Regulations governing flight over CAs.

b. In attempting to summarise extant regulation the RAFAT DD had not considered repositioning over a CA and mandated a single MSD for all repositioning.

c. The pilot was attempting to fly at 300ft MSD, which the RAFAT DD stated was his minima for repositioning, and he was not deliberately breaching extant regulation.

d. There was a perception that, at least some, RAFAT pilots were using MSDs as a target height as opposed to an absolute minima.

e. With the exception of permitting flypasts to 500ft MSD, no other Regulatory Waiver had been approved to authorise flight over CAs.

f. The risks associated with 300ft MSD manoeuvring over CAs had not been formally considered.

g. The initiation procedure for pre-season surveys, for those displays that may operate over a CA, was not clear and referred to a long since disbanded organisation.

h. There was an overreliance that surveys would have been, or had been, conducted by other organisations and no formal assurance process was in place to cross-check.

i. In transferring some wording from previous versions of the RAFAT DD incorrect assumptions were made that processes remained valid.

j. Overall, the RAFAT's approach to low flying over a congested area was considered an **other factor**.

1.4.84. **RAFAT Chain of Command**. The Panel observed that although Wg Cdr RAFAT was the DDH's Senior Operator (responsible for self-regulation and internal assurance of operating procedures, standards and Flight Safety – MRP RA 1020), and Senior Supervisor at Scampton, he was not directly in the RAFAT Chain of Command; with OC RAFAT reporting directly to the DDH and running the Sqn on a daily basis. Additionally, the Panel also noted that the extant OC RAFAT was a recently promoted Sqn Ldr who had no previous experience of command and whose staff experience was also limited. Interviews with previous OC RAFATs, one of whom subsequently commanded a front line Sqn, considered their RAFAT command as the most challenging appointment they had held. Unlike other flying Sqns, OC RAFAT has to fly on almost every trainees' work up sorties and every transit, flypast and display through the entire display season. The Panel **observed** that the chain of command peculiar to the RAFAT appeared to have some inherent weaknesses. In its current construct, the position of OC RAFAT may not be suited to a newly promoted Sqn Ldr with little previous experience of command and no staff background.

Exhibit 26
Witness 1-2
Witness 11-2

1.4.85. **Workload**. While the operational tasking process was broadly understood, the detail was not defined in any single document. It appeared that tasking was confirmed in late Jan each year, with OC RAFAT having an opportunity to comment and ultimately decline events. However, the summer season tasking was generally accepted as demanding and it was not uncommon for single rest days to be allocated between deployments. During the investigation it became apparent that there had been instances of pilots reporting for work during "days off" to prepare for the next detachment. This practice was known to at least some in the supervisory chain who were not enforcing rest days, although it was noted that 22(Trg) Gp Orders did not mandate the number of consecutive days personnel could work for. The Panel also noted that, over the years, the display length had increased by approximately 5 minutes and in FY09/10 the RAFAT had over-flown their funded hours by a margin of 287 hrs. The DDH had taken measures to rectify the over-fly and by FY10/11 this figure had reduced to an under fly of 330hrs such that the task was within the formal RAFAT engineering capacity which was based on a manpower liability to support 2620 hrs. The FY11/12 tasking was on line to be within the 2620 funded hours. However, from a engineering supervisory perspective the task still required the Senior Engineering Officer (SEngO) to be on the road for 80% of the summer season, the Junior Engineering Officer (JEngO) for 100% and the Flight Sergeants for 50% of the time. Para 1.4.9 has already discussed omissions to procedures that may have arisen from a well-intended, but perhaps over ambitious, PR programme. The Panel accepted that PR is a fundamental aspect of RAFAT operations; however, this must be carefully controlled to ensure it does not distract the RAFAT from their flying task. During the 2011 season the RAFAT PR team was undermanned and this placed additional burden on those filling the gaps. The combination of heavy tasking, increased display lengths and ambitious turnaround times collectively exposed the RAFAT to increased risk. The Panel concluded that:

Exhibit 27
Exhibit 28
Witness 1-3
Witness 37
Witness 38
Witness 48
Witness 20-2
Exhibit 109
Exhibit 47

a. Crew rest days were being not being taken by at least some of the team.

b. 22(Trg) Gp Orders did not mandate the maximum number of consecutive duty days in any one cycle.

c. From FY 10/11, the RAFAT were flying within their funded hours but this still resulted in the RAFAT engineering supervisory chain of command being fragmented for significant periods.

d. In a brief snapshot there was one unrealistic PR event programmed which may have resulted in crews rushing post-flight procedures. Furthermore the RAFAT PR team was undermanned during the 2011 season.

e. Overall, the RAFAT workload was an **other factor**.

1.4.86. **Engineering SQEP and Authorisations**. In the process of the Inquiry the Panel observed the following:

a. **Engineering SQEP**. The RAFAT was the only RAF unit where service personnel maintained the Hawk T Mk1, and there was no Hawk specific pre-employment training for individuals posted into RAFAT. Additionally, newly arrived engineers received very limited in-house training prior to being granted engineering authorisations. The RAFAT were not blind to these issues, with the RAFAT engineering Risk Register declaring that the unit had an '*inability to assure that sufficient RAFAT engineers are SQEP*'. As discussed in para 1.4.72, the engineering RR was not incorporated into the Main RAFAT RR and it was evident that the ODH was unaware he was carrying any engineering risk on the unit. The Panel assesses the inability of RAFAT to ensure that sufficient engineers were SQEP as an **other factor**.

Exhibit 47
Witness 20-1

b. **Engineering Authorisations**. On a typical RAF station, the Officer Commanding Forward Support Wing (normally a Wg Cdr) generally holds the MAP-01 level K engineering authorisation. This level of authority would be exercised over the respective flying Squadrons with the Squadron SEngOs (normally Sqn Ldrs) holding the MAP-01 level J authorisation. Within RAFAT, the SEngO, as a Sqn Ldr, holds the MAP-01 level K and JEngO (Flt Lt), as his subordinate, holds the level J authorisation. The authorisation of SEngO as a level K was sanctioned by 22(Trg) Gp in accordance with AP100B-01 (Order 1.1 Annex E). The introduction of competency based authorisation as opposed to appointment linked authorisation was being reviewed by 22 (Trg) Gp (**Observation**).

Witness 19
Witness 20-1
Witness 47
Exhibit 68
Exhibit 85
Exhibit 97
Exhibit 94

c. **Conflict Between Flight Servicing and Level K/J Authorisations**. The record of engineering authorities confirmed that both the SEngO and JEngO were authorised to conduct flight servicing as well as being authorised to undertake the duties of a flight servicing coordinator. JEngO, in particular would routinely deploy with Red 1 and service the aircraft on a daily basis. In the opinion of the Panel, a level K or J engineer routinely conducting hands on engineering flight servicing has the potential to blur the impartiality of engineering managerial decision making (**Observation**).

Witness 19
Witness 20-2

d. **Delineation of Engineering Responsibilities**. Evidence suggested that the JEngO ran the day-to-day engineering while SEngO looked after longer term planning. This was reflected in the sample of the records of engineering competencies, with all approval signatures in the reviewed documents being signed by the JEngO. The Panel noted, especially when

Witness 19
Witness 20-2

linked to the RAFAT risk of the '*inability to assure that sufficient RAFAT engineers are SQEP*', that this practice created the potential for authorisations to be awarded or engineering management decisions to be made without SEngO's knowledge (**Observation**).

1.4.87. **Engineering SQEP and Authorisations Conclusions**. The Panel concluded that collectively the RAFAT Engineering SQEP and authorisation process was an **other factor**.

1.4.88. **Servicing Error, Independent Checks and Aircraft Physical Surveys**. The analysis of the aircraft wreckage identified that XX179's left aileron PFCU had been incorrectly assembled with a washer missing from under a securing nut. While this had no bearing on the accident, this servicing error should have been identified during the post-maintenance independent inspection. With this risk control measure breached, the error may have been identified through a regime of invasive physical aircraft surveys. However, RAFAT aircraft surveys were non-invasive, focusing primarily on the aircraft's outer structure as indicated at Table 5. Further investigation revealed that the RAFAT were non-compliant with a Hawk T Mk1 SA instruction which detailed an invasive regime of Hawk T Mk1 surveys. It was noted that the RAFAT are due to come under the airworthiness review certificate system of externally conducted annual aircraft and documentation audit inspections; however, this was not in place at the time of the accident. The Panel assessed that the RAFAT's post-maintenance independent inspections, from this single sample size, and the RAFAT's non-compliant process of aircraft surveys was unsatisfactory and was an **other factor**.

Witness 20-2
Annex D
Exhibit 52
Exhibit 65
Exhibit 69
Exhibit 70
Exhibit 71
Exhibit 72
Exhibit 73
Exhibit 95
Exhibit 98
Exhibit 99

Table 5 – Summary of previous 3 aircraft physical surveys conducted on XX179

Survey Completed (a)	Date (b)	Number of Observations Made (c)	Remarks (d)
Aircraft Physical Survey XX179	May 2011	Nil	No observations, XX179 assessed as satisfactory throughout
Aircraft Physical Survey XX179	Jun 2011	1	1 x paint and restore comment
Aircraft Physical Survey XX179	Jul 2011	7	6 x paint and restore comments 1 x restore surface finish

1.4.89. **RAFAT Quality Management System**. During the course of the Inquiry the Panel observed deficiencies in the following areas; the aircraft physical surveys, the aircraft documentation and out of date instructions. The Panel concluded that:

a. The RAFAT quality management system, which included the engineering documentation, aircraft physical surveys and independent post-maintenance inspections, was inadequate.

b. Overall, the RAFAT quality management system was assessed to be an **other factor**.

POST CRASH MANAGEMENT

1.4.90. **Aircraft Post Crash Management Background**. The post crash management procedures appear to have been conducted in accordance with the Manual of Post Crash Management (MPCM) which defines Post Crash Management (PCM) '*as those activities carried out at an aircraft accident site which encompass the preservation of evidence, Health and Safety precautions, Corporate Communication and those activities undertaken to restore the accident site to a satisfactory condition. PCM does not encompass activation of emergency services nor accident investigation*'. The **following Observations** are made regarding those procedures. Exhibit 17 Exhibit 110

a. **Electronic Document Sets**. The Panel noted that although all paper documentation was impounded at the time of the accident, many regulations, policy documents, ASMPs, risk registers etc are now kept electronically on the defence intranet. Although these could be recovered later, if there had been a change to the document it would be more problematic to source the version applicable at the time of the accident. Additionally, due to the intense nature and the frequent travel during the first weeks of the Inquiry, the Panel did not always have access to IT. The Panel observed that it would have been advantageous to have digital copies of all the relevant post crash electronic documents.

b. **Panel Training**. Although the Panel received excellent assistance from the MilAAIB, no members of the Panel had any previous training in the SI process. This placed the Panel on the "back foot" for the first few weeks of the Inquiry and, with hindsight, certain aspects of the investigation could have been undertaken more efficiently. Although this had no relevance to the output of the Inquiry, it did delay some aspects. The Panel **observed** that pre-training for the SI Panel would have been beneficial.

c. **Other Agencies**. At the outset of the Inquiry the Panel noted that there were limited formal memorandums of understanding detailing what was expected, during the investigation, from other MOD agencies or industry. This provided some blurring of responsibilities as it was not readily apparent where boundaries and responsibilities started and stopped. This took some time to resolve and resulted in some nugatory effort. The Panel observed that some form of written guidance to explain what agencies were involved in the SI process, their TORs, and how they interacted with each other would have been useful.

d. **Emergency Services**. Although the initial emergency services response is not formally classified as PCM, the BIA PCM report noted difficulty in locating the crash site, due to its rural location, despite having several helicopters over the area providing a "talk on". Once at the site, the noise of the helicopters led to difficulty with communications on the ground. The Panel **observed** that the inability to locate the rural crash scene could have led to this issue being an aggravating factor (**potential aggravating factor**). Exhibit 81 Exhibit 82

e. **JARTS Aircraft Recovery**. The JARTS team were reliant on a local farmer to provide lift capability to move the larger parts of the aircraft onto the flatbed transportation. JARTS do have a MOU with local military units to provide Army recovery vehicles for the purpose of lift and recovery tasks. The Panel **observed** that the reliance on a local farmer to provide suitable lift capability for aircraft recovery, when an extant MOU was in place to provide Army recovery vehicles, was non-optimal. Annex P Exhibit 31

1.4.91. **Crash Site Restoration**. XX179 crashed on private land in the vicinity of Throop, Bournemouth. The resultant contamination was restricted to a relatively small area, which was predominantly in the field to the east of the River Stour. The access to the site was well controlled and adequate measures were implemented to protect against the occupational hazards associated with an aviation crash site. The nature of the soil helped to contain the aviation fuel leaked from the aircraft and the Defence Infrastructure Organisation was satisfied that all of the contaminated soil was removed from the site. A survey of the river was conducted and no obvious contamination found. Annex E

SUMMARY OF FINDINGS

1.4.92. **Cause**. The Panel found that the most likely cause of the accident to XX179 was G-induced impairment (A-LOC) of the pilot leading to flight into terrain. 1.4.53

1.4.93. **Contributory Factors**. The Panel identified 8 contributory factors to the accident. They also identified 1 factor that was probably contributory to the accident and 7 factors that were possibly contributory to the accident.

a. **Contributory Factors**.

(1) The combination of break manoeuvre speed and technique resulting in rapid G onset rate to high G for a sustained period. 1.4.63

(2) The absence of clearly defined SOPs for the break. 1.4.63

(3) The 500 ft circuit height resulting in insufficient altitude to recover. 1.4.66

(4) The cultural attitude to G resulting in a false sense of security. 1.4.55

(5) Inadequate occurrence and fault reporting. 1.4.82

(6) Conventional 5 bladder anti-G trouser design no longer offers aircrew the best possible protection against G impairment. 1.4.59

(7) Inadequate Risk Management within 22(Trg) Gp and the RAFAT. 1.4.75

(8) Inadequate assurance procedures within and of the RAFAT. 1.4.75

b. **Probable Contributory Factors**.

(1) An ineffective AGSM. 1.4.57

c. **Possible Contributory Factors**.

(1) Reduction in the effectiveness of the pilot's anti-G trousers, due to the thigh zips not being fully closed. 1.4.39

(2) Inadequate G awareness. 1.4.56

(3) The failure to deliver an updated centrifuge trg facility, which may have resulted in inadequate centrifuge trg. 1.4.58

(4) Dehydration resulting in decreased G tolerance. 1.4.60

(5) Acute cervical pain resulting in a distraction from performing an effective AGSM. 1.4.60

(6) Fatigue resulting in decreased G tolerance. 1.4.60

(7) Absence of a 'hot' call that may have acted as a mental prompt to ensure that an appropriate AGSM was applied from the outset of the break. 1.4.63

1.4.94. **Aggravating Factors**. The Panel identified 1 factor which, although not causal or contributory to this accident, could make the outcome of a future accident worse:

a. An initial inability to locate the rural crash scene. 1.4.90

1.4.95. **Other Factors**. The Panel identified 7 factors that, whilst not causal or contributory in this accident, may cause or contribute to a future accident:

a. The serviceability of the Hawk T Mk1 anti-G system. 1.4.34

b. RAFAT over-reliance on "word of mouth" SOPs. 1.4.63

c. The RAFAT's approach to low flying over a congested area. 1.4.83

d. The RAFAT's workload. 1.4.85

e. The RAFAT engineering SQEP and authorisation process, including the ability of RAFAT to ensure that sufficient engineering personnel were SQEP. 1.4.86

f. The RAFAT non-compliant process of aircraft surveys and a RAFAT post-maintenance independent inspection. 1.4.88

g. The RAFAT quality management system. 1.4.89

1.4.96. **Observations**. The Panel made 20 Observations:

a. The formal record of training had ceased when the team arrived in Cyprus for pre-2011 season work up. 1.4.7

b. The pre-season survey procedures, referred to in Part 1 of the RAFAT DD, were outdated and did not clarify who was responsible for initiating any request. 1.4.83

c. The chain of command peculiar to the RAFAT appeared to have some inherent weaknesses. 1.4.84

d. The introduction of competency based authorisation, as opposed to appointment linked authorisation, was being reviewed by 22 (Trg) Gp. 1.4.86

e. The authorisation of the level K and J holders to conduct flight servicing and the duties of a flight servicing coordinator has the potential to blur the impartiality of engineering management decisions. 1.4.86

f. JEngO ran the day-to-day engineering, including the routine authorisation of engineers' competencies, while SEngO looked after longer term planning. This had the potential to leave SEngO unsighted on important engineering decisions. 1.4.86

g. Although no component life or maintenance scheduling discrepancies were identified, some engineering documentation anomalies were observed. 1.4.42

h. The pilot had sought private medical treatment for cervical pain and had self medicated on the day of the accident. 1.4.60

i. The audio evidence from in-cockpit video was invaluable in assessing when pilots commenced straining during manoeuvre. A voice recording from XX179 would have significantly assisted this investigation. 1.4.55

j. Although a 100ft MSD break to land had been commonplace for many years, these were not formally approved within the PDA. 1.4.64

k. The DDH's authorization of breaks below 300ft MSD for display flying was in contravention of RA 2335. 1.4.64

l. The Regulatory Waiver request did not capture all risks associated with display flying in a 700ft cloud base nor did it identify the frequency with which the dispensation was expected to be exercised. 1.4.65

m. The current practice of conducting display recoveries in a 700ft cloud base was not covered by an extant Regulatory Waiver. 1.4.65

n. The Regulatory Waivers approved for the RAFAT did not have an explicit validity period in the text. 1.4.65

o. Guidance on aviation medicine continuation training was not given in order 2135 to TGOs. 1.4.56

p. Some minor discrepancies, with respect to the AGSM, existed between SME advice given to the Panel during the SI process and the advice within AP3456, 6-1-1-3. 1.4.56

q. Anti-G system failures were not included on the SA's mandatory fault reporting list. Notwithstanding this, the frequency and nature of AGV failures should have been formally raised via extant fault and occurrence reporting procedures. 1.4.82

r. The reliance on a local farmer to provide suitable lift capability for aircraft recovery, when an extant MOU was in place to provide Army recovery vehicles, was non-optimal. 1.4.90

s. It would have been advantageous for the Panel to have digital copies of all the relevant post crash electronic documents. 1.4.90

t. Pre-training for the SI Panel would have been beneficial. 1.4.90