

Part 1.4 Findings

1. **Introduction.** The Panel was extremely fortunate to have access to a significant amount of evidence. This enabled an accurate account of events leading up to and immediately after the accident, to be pieced together relatively easily. As a result, the Panel was able to concentrate its efforts on a detailed analysis of the actions taken by each pilot at key stages of the OBR prior to the collision. The Panel also took into consideration Human Factors (HF), aircraft integrity, RAFAT training strategy, supervision and direction by the relevant Orders and Instructions.

2. **Available Evidence.** To assist the Panel in their deliberations the following evidence was utilised:

a. **Witness Statements.** Written statements from RAFAT personnel present at the scene of the accident were presented to the Panel on arrival.

b. **Video and Photographs.** Videos taken by RAFAT and local nationals, which included footage of the accident from crowd centre and the Northern end of the runway, were available for analysis. Furthermore, photographs taken immediately before and after the mid-air collision proved to be invaluable in determining the impact points between the 2 aircraft.

c. **Expert Witnesses.** Former Synchro pilots provided expert comment on the intricacies of the OBR.

d. **Accident Data Recorders.** Both Accident Data Recorders (ADR) produced meaningful data. However, the lack of an ADR audio track and Press To Transmit (PTT) parameter on the ADR caused difficulties when accurately Synchronising the video with the associated Radio Transmission (RT) recording and ADR data.

e. **Global Positioning Systems Data.** The Global Positioning Systems (GPS) from both aircraft were recovered; however, the information gained proved to be of limited value. Due to the fact that XX253's GPS was set to the lowest sample rate (recorded every 30 secs), the data was not as complete as first hoped. Moreover, the time taken to recover XX233's GPS and damage to the memory module power supply incurred during impact meant that no data was recovered.

f. **RAFAT Documentation.** Because RAFAT deployed with the minimum documentation necessary, not all information was available to the Panel on arrival. Furthermore, the task of collating the required engineering documentation was complicated by the fact that it was split across a number of units.

g. **HF Report.** Guidance from the HF psychologist proved to be extremely useful in determining contributory factors; however, no immediate support was available as the only accident investigation psychologist employed at the Royal Air Force Centre of Aviation Medicine (RAFCAM) was on leave at the time of the accident.

h. **XX253 and XX233.** Due to the Quick Reaction Alert (QRA) commitment at HAF Kastelli, it was imperative that the airfield reopened as quickly as possible. As a result, some of the debris had to be removed before the Joint Aircraft Recovery and Transportation Sqn (JARTS) had the opportunity to map it; however, members of RAFAT photographed and recorded the GPS position of all the pieces of debris before disturbing anything. This action ensured that it was possible to complete a full plot of the wreckage. XX253 was quarantined immediately after the accident and was available for inspection by the Panel as required.

3. **Services.** To assist the Panel in their deliberations the following services were utilised:

- a. RAFCAM.
- b. QinetiQ – RAF Boscombe Down.
- c. HAF Kastelli Base Commander.
- d. JARTS.
- e. Air Accident Investigation Branch (AAIB) Senior Inspector of Air Accidents (Engineering).
- f. AS SIA1 (now AS SIA/Engineering Investigator).
- g. Defence Attaché staff in Greece.
- h. Hawk Support Authority (SA).
- i. 71 Squadron.

FACTORS CONSIDERED BY THE PANEL

4. The Panel considered the following factors:

- a. Aircraft Selection.
- b. Aircraft System Integrity (Pre & Post Collision).

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- c. Aircraft Escape Systems.
- d. Search and Rescue.
- e. Environmental Aspects.
- f. Sortie Brief and Authorisation.
- g. Opposition Barrel Roll – Theoretical.
- h. Opposition Barrel Roll - Accident Sortie.
- i. Human Factors.
- j. Detachment Planning and Preparation.
- k. Selection and Suitability of Personnel.
- l. Synchro Training.
- m. Currency and Competency of Aircrew.
- n. Display Supervision.
- o. Risk Assessment.
- p. Orders and Instructions.
- q. Post Crash Management.

DISCUSSION OF FACTORS

5. **Aircraft Selection.** RAFAT aircraft should normally be fitted with an engine that has been upgraded to improve acceleration (Mk 15102). Whenever an aircraft is flown that is not fitted with a modified engine, its use is limited to positions 1, 2, 3 and 6 (provided no Synchro manoeuvres are carried out). Both XX233 and XX253 were fitted with upgraded engines and had been used for Synchro flying on a regular basis without incident. A review of engineering documentation highlighted a number of minor errors in the F700s, but did not identify any underlying issues or reasons why XX233 or XX253 should be not used as Synchro aircraft. The Panel concluded that both aircraft were suitable for use by the Synchro Pair.

Exhibit 8

Annex G
Exhibit 11
Annex H

6. **Aircraft System Integrity.** The Panel considered the possibility that the individual or combined failure of an aircraft component during the execution of the OBR may have been a factor. However, neither pilot reported any abnormalities with their aircraft prior to the collision and this was supported by analysis of the ADR traces. In addition, the Panel considered the following:

Witness 4&5

a. **Radio Failure.** Analysis of the ADR trace does not provide confirmation of radio serviceability; therefore, the Panel considered the possibility that radio failure during the OBR may have contributed to the accident. The video footage of the accident sortie taken by the RAFAT includes all RT calls made during the sortie. Whilst the manner in which RT calls were made by Red 6 was considered to be unorthodox and, in some cases unclear when listened to at normal speed, both pilots stated that all calls were clearly heard and understood. Radio failure was not considered to be a factor.

Exhibit 3

Witness 4&5

Witness 4&5

b. **Control Restriction.** Whilst both pilots stated that the aircraft flying controls felt normal, consideration was given to the possibility that a loose article may have caused a flying control restriction during a critical stage of the OBR for the following reasons:

(1) Shortly after the accident, the Defence Attaché informed the Panel that a Greek national had seen a 'c-shaped' spanner in the vicinity of XX253 after Red 7 diverted to HAF Heraklion. Following a review of the tool control system, a 100% physical tool check, which included a check of spanner serial numbers against toolkits and a telephone conversation with the Greek National concerned, the Panel dismissed the possibility of a loose tool as a factor.

Witness 11
Exhibit
12&13

(2) On 22 Apr 10, RAFAT aircraft XX306 suffered a flying control restriction during Synchro training at RAF Scampton. The subsequent F765B action found that the control restriction had been caused by a loose pannier hook fouling between the tail plane control rod and the surrounding structure. Following a review of the F765B findings and confirmation from RAFAT that all items associated with the panniers in use in Crete were accounted for, the Panel dismissed this as a possible factor.

Exhibit 14

Exhibit 15

7. **Aircraft System Integrity (Post Collision).**

a. **XX233.** As a result of the collision, XX233's windscreen and canopy shattered and a vortex generator on the starboard wing was sheared off. Analysis by the AAIB suggests that the aircraft was still in a 'flyable condition' after the collision. However, due to the low height, downward vector and disorientation caused by the windscreen and canopy smashing, the pilot elected to eject. Had the pilot had sufficient time to assess the condition of the aircraft following the collision, it is possible that the aircraft could have been landed safely. The

Annex C

Witness 5

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Panel considered the height at which this manoeuvre was performed to be an aggravating factor.

b. **XX253.** XX253 lost the tip of its fin and incurred significant damage to the rudder, which almost caused it to detach in flight and left it unusable. There was also damage to the starboard tip of the tailplane. Despite the damage, the pilot was able to maintain control, climb away from the ground and divert to HAF Heraklion. Annex C
Witness 4

8. **Aircraft Escape Systems.** Analysis by RAFCAM found nothing to suggest that the ejection sequence had not operated correctly. The angle of bank and rate of descent of the aircraft at the time of the ejection was within the safe ejection envelope for the Martin Baker Mk 10B ejection seat. As a result, efforts were concentrated on determining the possible reasons for the injuries incurred by Red 6 during the ejection. Annex A

a. **Dislocated Shoulder.** Red 6 initiated ejection with his right hand whilst his left hand remained on the throttle, rather than with both hands on the ejection handle. As a result, he sustained damage to his left shoulder caused by arm flail from exposure to the windblast as the seat left the aircraft. The Mk 10B ejection seat installed in the Hawk aircraft is not fitted with Arm Restraint Lines (ARL) and it is highly likely that had they been fitted, the severity of injuries incurred would have been reduced. The Panel considered Red 6's hand position at the time of ejection and absence of ARLs to be aggravating factors. Annex A

b. There are a limited number of occasions when injuries have been shown to occur during the windblast phase of the sequence, but typically for these types of injuries the mechanism is not usually It is, therefore, unlikely the injuries were caused from windblast flail. Furthermore, injuries are unlikely if the restraint line systems function correctly and in this ejection there was no evidence to suggest otherwise. The most likely explanation is that Red 6 suffered a , which was brought about by a minor rotational acceleration generated by an off-centred head impact during the windblast phase of the ejection. This was probably exacerbated by poor posture on ejection. As a result, he was unable to prepare himself for the parachute landing and was most probably when he impacted the ground. The Panel concluded that Red 6's posture on ejection was an aggravating factor. Annex A

c. Red 6 sustained significant Whilst Annex A

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would be expected in this case, they are not typically seen on the as the flying clothing and undergarments are usually sufficient to protect the skin. Detailed examination of the clothing showed that tiny particles of MDC lead splatter had penetrated between the weave of the cloth, thereby coming into contact with the underlying skin

These types of tend to occur if the pilot is only wearing 2 layers of clothing rather than 3. On this occasion the pilot was only wearing a flying suit and a RAFAT t-shirt; as such, the Panel considered the number of layers worn by the pilot to be an aggravating factor.

Exhibit 16
Annex A

d. The pilot had

Annex A

It is likely that these windscreen and canopy transparency during the mid-air collision. RAFAT pilots tend to wear short sleeved Red Arrows logoed t-shirts under their flying coveralls, which means that the distal upper arm (below the level of the sleeve) and forearms are covered by only one layer of fabric. On this occasion occurred below the level of his t-shirt's sleeve; accordingly, the Panel concluded that this may have been an aggravating factor.

9. **Search and Rescue.** HAF rescue crews and RAFAT personnel were swiftly on the scene of the crash to attend to the pilot. Red 6 was placed on a spinal immobilisation board and a rigid neck collar was fitted to his cervical spine. Although a Search and Rescue (SAR) helicopter had landed at the site, he was transferred into a road ambulance. He was then taken to the civilian hospital at Heraklion. Red 6 described the journey, which took 45 mins, as being particularly uncomfortable due to the winding mountainous route. By the time he arrived at the hospital his left leg was also causing him pain. The decision to use the ambulance rather than the helicopter was taken by the HAF Kastelli Base Cdr. It was based on the fact that the helicopter could not land at the hospital and a further transfer would be required. RAFAT had not discussed the issue of SAR cover with the HAF prior to the accident; accordingly, decisions were being made in the heat of the moment. It has not been possible to positively determine which mode of transport would have been more comfortable for the pilot.

Witness 2

Witness 5

Witness 2

Witness 12

10. **Environmental Aspects.** The following aspects were considered by the Panel:

a. **Topography.** The proximity of high ground surrounding the base was considered by a number of RAFAT personnel and display axis were chosen to avoid the highest mountains. Accordingly, the high ground only affected crowd rear arrivals and the Goose manoeuvre; it had no impact on the OBR. This was confirmed by familiarisation sorties flown on the first day of the detachment.

Witness
1,3&4

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- b. **Weather factors.** Weather factors were benign with no extremes of temperature, wind, cloud, visibility or precipitation. However, the presence of small amounts of cumulus cloud for the second half of the display necessitated Red 6 changing to a Flat display. This is not an unusual event for the Team and the Panel considered that the decision to change to a Flat display had no bearing on the accident. Exhibit 3
Witness 5
- c. **Sun Position.** Neither pilot commented that the sun position was in any way distracting during the display. In late Mar the sun would be on a bearing of 207.2 degs with an elevation angle of 52.8 degs. Although this could mean Red 7 was looking towards the sun through Red 6, the elevation angle should preclude any obscuration. As Red 6 was flying away from the sun his picture of Red 7 shouldn't have been affected. Witness 4&5
Exhibit 17
- d. **Airfield Elevation.** Although the airfield is elevated (c1200ft amsl), both Synchro pilots had recent experience of operating at higher altitude display sites following their trip to Jordan in the 2009 season. The affect of altitude on aircraft performance at Kastelli had been considered and was judged to be insignificant; this was confirmed by the familiarisation sorties flown on the first day of the detachment. Witness 1&6
Witness 1&5
- e. **Areas of Population.** HAF Kastelli is surrounded by a number of small communities. This includes Kastelli town which is situated just outside the base boundary beyond the runway 02 threshold. In order to minimise impact on this community, a third datum was chosen, which was used for the accident sortie. This datum still provided good ground features for both Red 6 and Red 7. Exhibit 18
Witness 5
Witness 4&5
Exhibit 19

The Panel found no evidence that any of the aforementioned environmental aspects were a factor in this accident.

11. **Sortie Brief and Authorisation.** The sortie was briefed in accordance with the RAFAT DD & SOPs. Prior to the main brief, Red 6 and Red 7 covered lessons learnt from previous sorties, datum to be used and associated ground features for Synchro manoeuvres. In the main sortie brief relevant changes from the preceding two sorties and safety procedures for various emergencies were covered. As such, the Panel did not consider the style or content of the brief to be a factor. The sortie was correctly authorised by Red 1 in accordance with RAFAT DD & SOPs. Exhibit 8
Witness 4&5
Witness 1
Exhibit 4&8
12. **Opposition Barrel Roll - Theoretical.** The OBR was an established manoeuvre and to date had not been the subject of any other known accidents. Video footage from differing angles along with discussions with expert witnesses enabled the Panel to gain a better Exhibit 3
Witness

understanding of the OBR. Specifically, the Panel considered how the OBR should be executed, the escape options available and events that occurred during the accident sortie.

1&13

a. **OBR Execution.** The OBR is flown by Red 6 and Red 7 in the second half of the display. It involves both aircraft descending towards their respective Cross Points. These are geographical features, 12000 ft apart, along the display line and not the point at which the aircraft cross in front of the crowd. Prior to reaching the Cross Points both aircraft turn towards each other and roll out on their predetermined line, whilst descending to 100 ft agl, 330 kts airbrake out (See Fig 1). Lines are chosen to guarantee a minimum of 100 ft lateral separation. The aircraft continue down their line until the first pilot reaches a second geographical point at which they call, 'Threshold'. The geographical features used for the 'Threshold' calls are 6000 ft apart and should be easily identifiable to the pilots. Providing the second pilot is visual with the first aircraft, on parameters and happy to commit to the manoeuvre, he will respond with a second 'Threshold' call. This call may not necessarily relate to his geographical feature. This is done to allow the pilots to commence the manoeuvre as expeditiously as possible. The second 'Threshold' call confirms that both pilots are happy to commence the next stage of the manoeuvre. The next action is initiated on a 'Roll go' call from Red 6. The timing of this call is judged purely on a visual picture based on Red 6's previous experience of flying the manoeuvre. On the 'R' of the roll, Red 6 changes smoke colour to blue and Red 7 to red. On the 'G' of go, both pilots drop their right wing and pull. On dropping the right wing, the pilots start a turn and should apply about 4g to allow the aircraft to cross flight-paths as they swap to the opposite line. This should only take a fraction of a second and almost immediately afterwards the turn is reversed to commence the barrel roll part of the manoeuvre. The two aircraft are then aiming to cross at the centre point of the crowd line, 'Datum'. The two individual aircraft flight paths are corrected in such a manner to allow this cross to happen approximately half way up the first stage of the barrel roll. Once the cross has happened each aircraft will continue their own barrel roll and fly away from each other.

Witness 4&5

Exhibit 19

Witness
1,4&5

Witness
1,5&13

Witness 4&5

Witness
4,5&13

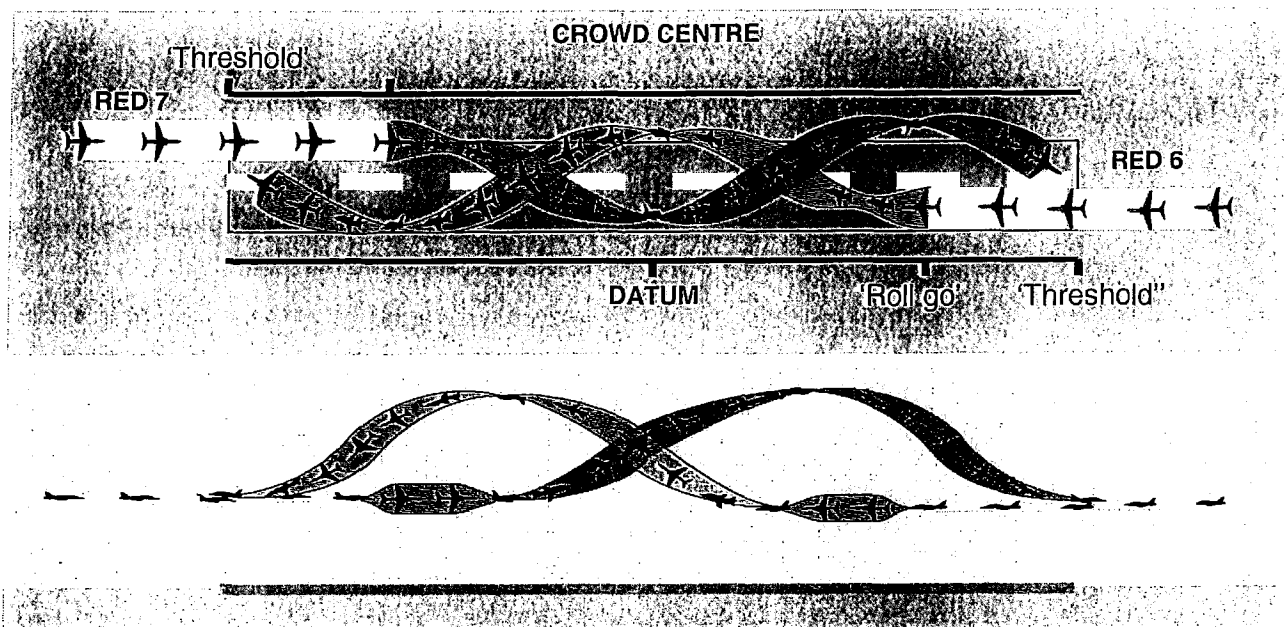


Fig 1 OBR Execution

b. **Escape Manoeuvres.** During their first season, RAFAT pilots undergo escape manoeuvre training prior to flying in formations in excess of 5 aircraft. From this point onwards, pilots only receive briefings on escape manoeuvres; however, the procedures remain extant. In addition, the Synchro leader briefs specific escape manoeuvres which are only relevant to them. For the OBR the following escape manoeuvre options are available:

Exhibit 8

Witness 1&5

(1) **Up to Threshold Point.** If either pilot is unhappy with the initial set up then they simply do not call 'Threshold'. This results in both aircraft flying down their individual lines.

Witness
1,4,5&13

(2) **'Threshold' to 'Roll Go'.** Once both 'Threshold' calls are made the next call should be 'Roll go' from Red 6. If Red 6 is unhappy with the picture, he will not make the 'Roll go' call and both aircraft will fly straight down their own line. If Red 7 encounters a problem or is not happy prior to the 'Roll go' call, then he has the option to escape on-crowd.

(3) **'Roll Go' Onwards.** Once Red 6 calls 'Roll go' but prior to the aircraft dropping their right wing, if either pilot is unhappy, they still have the option to escape on or off crowd as appropriate. Once both aircraft have dropped their wing, committing to the manoeuvre is the safest option. Effectively, a collision has been created which remains until the aircraft have crossed flight-paths. In the event of an RT failure, Red 6 specifically briefs that his entry to the manoeuvre also initiates Red 7's manoeuvre.

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(4) **Deconfliction.** It is routinely briefed by Synchro Lead that Red 7 is responsible for avoiding Red 6, whilst Red 6 is to remain predictable; however, the Panel found no documentary evidence to corroborate this fact.

(5) **'Fly it Through'.** The term 'Fly it through' is used to highlight an emergency with an individual's aircraft to the rest of the formation. This term is not generally used to break off a manoeuvre due to a poor set up.

13. **Opposition Barrel Roll - Accident Sortie.** In order to understand the events leading to the accident, the Panel used comparative analysis of the OBR from previous sorties. Exhibit 3&21

a. It is evident that Red 7 flew beyond his Cross Point and subsequently had to adjust to the correct line. Red 7 then reached his geographical threshold point first but did not call 'Threshold'. On reaching his geographical point, Red 6 made his 'Threshold' call, which prompted Red 7 to respond. This confirmed that both pilots were happy to continue. As Red 6 made the first 'Threshold' call, he should have had a minimum of 6000 ft separation from Red 7. However, Red 7 was 611 ft inside threshold and Red 6 was 219 ft inside his point at the time of the first 'Threshold' call. This gave a total aircraft separation of 5270 ft compared to 6932 ft on a previous sortie. Exhibit 20
Witness 4
Witness 5
Exhibit 21

b. Believing he had the required time and separation, Red 6 briefly checked his position with regard to datum to assess where the aircraft would cross. On looking back towards Red 7, he noticed that the aircraft seemed closer than normal. Despite this, Red 6 still felt there was sufficient distance to complete the manoeuvre. The cadence of the 'Roll go' call was noticeably quicker. This equated to a time of 2.7 secs from the first threshold call to the G in 'Roll go', compared with the average of 3.5 secs. Despite the quicker call, the aircraft were still 977 ft closer together than on the previous practice sortie at the same point. Accordingly, there was insufficient separation to execute the manoeuvre whilst maintaining a Minimum Separation Distance (MSD) of 100 ft. Witness 5
Exhibit 3
Exhibit 21
Exhibit 22

c. On the 'Roll go', Red 6 committed to the manoeuvre. Despite seeing an unfamiliar picture, Red 7 did not elect to escape on-crowd as he did not want to lose visual with Red 6. Instead, following a noticeable delay (1.7 secs compared to an average of 0.9 secs), he dropped his right wing to commence the turn, but did not apply sufficient positive g to cross flight paths. Additionally, he did not change the colour of his smoke. Believing there was insufficient distance to cross flight paths, Red 7 attempted to avoid Red 6 by flying beneath him. In the moments immediately prior to impact, attempting to avoid a collision, Red 6 Witness 5
Exhibit 3
Witness 4
Exhibit 21
Exhibit 3
Witness 4
Witness 5

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also backed off slightly on his pull. Due to the accuracy of available data and number of variables involved, it was not possible to positively determine whether the aircraft would have collided had Red 7 fully committed to the manoeuvre.

Exhibit 22

d. The aircraft came into contact with each other at 2 separate points. XX253's right hand tailplane dragged lightly across XX233's outboard upper wing surface, while at the same time the top of XX253's fin struck the right hand side of XX233's windscreen, breaking off a piece of the frame. Red 6 saw his windscreen shatter; given the aircraft's downward vector and proximity of the ground, he elected to eject. Red 7 flew his aircraft away from the ground before assessing the damage and recovering to HAF Heraklion.

Exhibit 23
Annex C

Witness 5

Witness 4

e. The Panel noted that the average time between the 'Threshold' and 'Roll go' calls had increased by approx 1.5 secs between 2008 and 2010. If nothing else where changed, this would compact the manoeuvre and lead to the aircraft crossing earlier in the barrel roll. Although an element of individual technique has to be accepted, the Panel considered the increase in delay may have been caused by Red 6's practice of looking towards datum prior to calling 'Roll go'.

Exhibit 21

Witness 5

14. The Panel concluded that the following were causal factors:

a. The reduced distance between the aircraft at the 'Roll go' call.

b. Red 7's decision not to escape on-crowd after the 'Roll go' call.

15. In addition, the Panel considered the following to be contributory factors:

a. The reduced separation between the aircraft at the first 'Threshold' call.

b. Red 6 averting his attention to datum

c. Increased time between 'Threshold' and 'Roll go' calls from 2008 to 2010 season.

16. Other manoeuvres flown by the Team were reviewed and it was noted that the OBR had similar characteristics to the Gypo Pass. However, in the Gypo Pass there is no requirement to cross flight-paths prior to commencing the barrel roll. The Panel concluded the requirement to cross flight paths during the OBR was a contributory factor.

Witness 1

Exhibit 3

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17. **Human Factors.** In considering HF, the Panel consulted the RAFCAM Aviation Behavioural Psychologist. The Panel concentrated their inquiries in the following areas:

- a. **Physiological Fitness.** Although this was the 3rd trip of the day, this work rate is normal for the Team. Both pilots stated that they were well rested and feeling fine prior to the sortie. Post Incident Drug and Alcohol Testing (PIDAT) was not invoked. However, witness statements corroborated the fact that neither pilot had consumed a significant amount of alcohol in the preceding 24 hours. The Panel found no reason to suggest that physiological fitness was a factor. Witness 4&5
Witness 1&2
Witness 3&6
- b. **Fatigue.** Despite having the work up delayed due to poor weather following the Christmas break, the Team were on schedule as they approached Ex SPRINGHAWK. The deployment had been relatively uneventful and the previous display practices had all been executed safely. Neither pilot showed signs of fatigue. Witness
1,3&5
- c. **Focus and Motivation.** To be selected for the Team, pilots have to demonstrate above normal levels of focus and motivation. Both pilots had remained motivated throughout the work up period and were keen to get on with the season. They had only just arrived in Crete and neither pilot reported having any personal issues affecting their focus. Witness 1
Witness 4&5
- d. **Complacency.** Given that this was the start of the season, the Panel considered that it was unlikely that either Synchro pilot had become complacent. There was no evidence to suggest complacency was a factor.
- e. **Confusion.** The Panel considered the possibility that the change in datum for this particular sortie may have resulted in a misidentification of features for either pilot. Both pilots confirmed that they were happy with the changes and were able to positively identify their features. The Panel did not consider that either pilot was confused about their specific ground features during the accident sortie. Exhibit 19
Witness 4&5
- f. **Distractions.** The requirement for Red 7 to correct his line after flying through his cross point may have momentarily distracted him, which may have contributed to him passing through his threshold point without making the associated RT call. The Panel considered this may have been a contributory factor. Annex I
- g. **Effect of Conditioning.** The nature of RAFAT flying is such that the Team rely on repetitive training. As a result, pilots become used to standard cadence and timings. Whilst this is essential in some phases of the display, the Panel felt this may Witness 5

potentially have a negative impact on visually assessed manoeuvres. Following analysis of timings, the Panel considered that Red 6 may have subconsciously become used to a standard timing between the 'Threshold' and 'Roll go' calls. This may have incorrectly led him to assume he had time to glance away from Red 7 before making the 'Roll go' call. Additionally, previous practice would have conditioned him to believe that when he makes the first 'Threshold' call, Red 7 should be at least 6000 ft away, which was not the case on the accident sortie. As a result, the Panel concluded that the effect of conditioning may have been a contributory factor.

Exhibit 21

Annex I

h. **Workload/Stress.** It is likely Red 7 experienced an increase in workload due to the requirement to correct to his line. Given that the aircraft were closer together than usual, it is also likely that both pilots experienced a very high visual workload as the manoeuvre progressed. Accordingly, the Panel considered that Red 6 and Red 7 experienced an increased level of stress as the visual picture was not as expected and this may have affected their decision making process.

Annex I

i. **Decision Making.** Both Red 6 and Red 7 were unfamiliar with the visual picture, which meant they had to engage in time-consuming decision making processes. Prior to the roll, both pilots understood the available escape manoeuvre options and felt these were achievable, if required. However, they lacked the knowledge to determine if the presented visual cues met the escape criterion. The Panel considered that this may have been a contributory factor.

Annex I

j. **Natural Human Reaction.** The Panel considered the following:

(1) **Doubt.** The delay in Red 7's reaction to the 'Roll go' call suggests that he had some concerns over their separation prior to dropping his wing. Furthermore, his apparent reluctance to commit to the manoeuvre on dropping the wing supports the fact that he was unsure of his ability to cross flight paths.

Witness 4
Exhibit 3

(2) **Survival Instinct.** As the two aircraft got closer, Red 7's natural survival instincts took over. Throughout his work up training, Red 7 had been briefed to avoid Red 6 and, in his mind, the best way to avoid Red 6 was to bunt and fly beneath him. Red 6 committed to the manoeuvre and, on seeing Red 7's wing drop, falsely believed Red 7 had also committed. However, in the final moments, Red 6 realised that Red 7's aircraft was on a collision course. Once again, natural instinct took over and Red 6 also bunted to avoid collision. Despite months of training, both

Witness 4
Annex I

Witness 5

Annex I

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pilots reacted instinctively rather than conditionally to this unfamiliar situation.

The Panel concluded that Natural Human Reaction was a contributory factor in this accident.

18. **Detachment Planning and Preparation.** The aim of Ex SPRINGHAWK was to continue the work up at a 'fair weather' location prior to PDA. The Panel considered the following:

Exhibit 1

a. **Base Selection.** HAF Kastelli was offered as a location for the first phase of Ex SPRINGHAWK after a request to return to the base used for the 2009 season work up was declined by HAF. Heraklion and Souda Bay were also rejected as they were also used as civilian airports. Although RAFAT had no previous experience of HAF Kastelli, an on-site recce confirmed that it would be an ideal location. Minimal aircraft movements meant that the RAFAT would almost have sole use of the airfield. The surrounding area was not densely populated and no obstructions were evident on the airfield. The only possible issue was the presence of high ground to the East and North-West of the airfield. The Panel concluded that for the purposes of Ex SPRINGHAWK, the selection of HAF Kastelli was well considered and appropriate.

Witness 6

b. **Deployment.** Following a down-day, 10 RAFAT aircraft departed RAF Scampton for Crete on 21 Mar 10. The route to Crete involved a refuel stop in Lyons, France and an overnight stop at Bari, Italy. Except for poor weather when departing RAF Scampton and a minor delay caused by a loose article in Italy, the transit went smoothly and all aircraft arrived at HAF Kastelli on schedule. The Panel concluded that the deployment to Crete was not a contributory factor.

Witness 3

c. **Flying Programme.** The detachment flying programme was similar in tempo and sortie length to that routinely flown at RAF Scampton. The Panel believed that there was sufficient time to fully brief and debrief sorties and that this did not result in any undue pressure on the pilots. The detachment flying programme was not considered to be a factor.

Witness 1&3

Witness 4&5

19. **Selection and Suitability of Personnel.** The selection process for RAFAT is very extensive and strict criteria are applied to the entry application. The selection of Red 7 is carried out after individuals have been with the Team for a full season and is made by the previous Red 7, now Red 6. The selection of Red 7 was well received by the Team and no supervisory concerns were raised. The Panel considered the pilots' previous experience and comments raised in their F5000s. Based on the evidence presented, the Panel concluded that the selection and suitability of personnel was not a factor in this accident.

Exhibit 8

Witness
1,3&6
Witness
1,2&6
Annex B

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20. **Synchro Training.** The Panel reviewed the training of the Synchro Pair and looked at the following:

- | | |
|---|--|
| a. Training Strategy. Training had been conducted throughout the winter season in accordance with RAFAT DD & SOPs, which included set criteria for Red 7's individual work down. To coincide with the main formation timeline, the Synchro work up plan had been agreed between Red 1 and Red 6. Red 7's work up was monitored primarily by Red 6, aided by Reds 1, 10 and 11. Red 6 used his experience gained during the previous season to train Red 7. The Panel considered that this training strategy relied heavily on Red 6 and his interpretation. Moreover, this strategy may result in subtle changes to manoeuvres over time, which may not be identified by the supervisory staff. | Exhibit 8

Exhibit 24
Witness 5
Exhibit 7
Witness 1&5 |
| b. Training Supervision. For Synchro work up, there were 4 levels of supervision: Synchro lead, OC RAFAT, Wg Cdr RAFAT (or Red 10) and Commandant CFS. However, of the current supervisors, only Red 1 had previous RAFAT experience. According to log book extracts, Red 1 had only flown with Red 6 once and Red 7 once during the work-up phase. Whilst additional sorties were flown with the other supervisors, the Panel felt that it may have been more difficult for them to identify subtle changes in technique. That said, observations on safety issues were routinely made by the supervisory chain and accepted by the Team. Despite this apparent depth of supervision, the Panel considered that the process could be made more robust if either Red 10 or Wg Cdr RAFAT had previous RAFAT, or other display experience. As a result, the Panel concluded that the amount of previous RAFAT experience in the supervisory chain may have been a contributory factor. | Exhibit 8

Exhibit 6&7

Witness 3 |
| c. Training Documentation. To aid with the training of Red 7 the following were available: | |
| (1) RAFAT DD & SOPs. | Exhibit 8 |
| (2) E-mail handover to Red 6 from previous Red 6. | Exhibit 25 |
| (3) Written training plan for Synchro by Red 6. | Exhibit 26 |
| (4) Hand drawn diagrams of the manoeuvres with details of RT, smoke and escape options. | Exhibit 27 |
| (5) Power point presentation from Red 6 to Red 7. | Exhibit 28 |
| (6) White board briefing aide-memoire in Synchro office. | Exhibit 29 |

Exhibit 27

Although the list of documents detailed above would appear extensive, the Panel had a number of concerns regarding quality, control and consistency. The hand drawn diagrams had been passed down through the years and had not been updated when changes had been introduced. This was evident for the OBR as the diagrams indicated that smoke colour changes were made on the 'Threshold' call instead of the 'Roll go' call as stated on the current smoke plan. Some of the above documents were not readily available to the Panel and the training admin folder had not been updated since 2008. The Panel also discovered a page missing from the 2010 Gypo work down signature list. Although the Panel concluded that this was not a contributory factor in the accident, improvements could be made to the quality and control of training documentation.

Exhibit 30

Exhibit 8

d. **Escape Manoeuvres.** RAFAT DD & SOPs detail some generic escape manoeuvres; however, most of these relate to the 9-ship formations and little guidance is given to specific Synchro or Gypo manoeuvres. These are routinely briefed by Red 6; however, the Panel considered these manoeuvres should be formally documented as this would reduce the chances of misinterpretation.

Witness 5

e. **Simulator Training.** In the moments preceding the accident both pilots were confronted with a scenario for which they had no previous exposure and, as such, no experience on which to base a response. At present, the Team only use the Hawk simulator facility for emergency handling. Following a practical session in the simulator with a previous Synchro pilot, the Panel concluded that greater benefit could be gained if the simulator was also used to give pilots exposure to situations that cannot be safely recreated in the air.

Witness 1&2

21. **Currency and Competency of Aircrew.** The Panel reviewed the training, competency and qualifications of the personnel involved. The Panel found that both pilots were competent to undertake the task and had flown 3 full displays plus a familiarisation sortie in the preceding 2 days. On closer inspection some anomalies were found with regard to Continuation Training (CT) currency; however, the Panel considered that none of these anomalies affected the accident sortie.

Exhibit 4

22. **Display Supervision.** Joint Service Publication (JSP) 550 P335 outlines the requirement for display flying, principally from the display organiser's perspective. Training Group Orders (TGOs) expand on this and provide greater detail with regard to display work up supervision. However, TGO 335.003 exempts RAFAT from this order; instead the responsibility is passed to Commandant, Central Flying School (CFS) and documented in the RAFAT DD & SOPs. On the day of the accident, Wg Cdr RAFAT was on the ground acting as the display supervisor. As

Exhibit 31

Exhibit 8

Witness 2

Exhibit 8&32

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such, the Panel noted that the display was correctly supervised. The Panel also noted that despite his supervisory role, Red 10 is not included in the list of approved supervisors detailed in RAFAT DD & SOPs para 1 or in his Terms of Reference (TOR).

23. **Risk Assessment.** Whilst the RAFAT DD & SOPs contains a Risk Register, it does not cover the specific risks associated with each manoeuvre. When a new manoeuvre is introduced to the display it is staffed via the relevant channels and authorised by Commandant CFS. The Panel considered that had a periodic risk assessment been carried out on all manoeuvres, there was a possibility that risks could have been identified and further mitigation put in place, or at least, the extant risks formally highlighted to the Team and supervisors. The lack of a specific risk assessment for the OBR may have been a contributory factor.

Exhibit 8

Witness 5

24. **Orders and Instructions.** The Panel found several minor discrepancies in RAFAT and HQ 22 Gp documentation:

a. **Recording of Amendments.** The paper copy of TGOs used by RAFAT on Ex SPRINGHAWK wasn't updated to Version 8 dated Feb 10. Team members stated that they had read the change but this wasn't reflected in the detached signature sheets. The Panel found that the Team had not signed for the latest amendment (AL1) to the Hawk T1 Release to Service (RTS). The letter detailing the amendment was held in the same folder but the amendment itself had not been incorporated.

Exhibit
31&33

b. **TGO 120 - Continuation Training.** RAF DD & SOP stipulate a minimum currency requirement for CT for RAFAT. In accordance with TGO 120.100.3, Red 7 had not flown sufficient time in cloud nor had he completed the number of instrument approaches required to maintain his green rating. As a result, he was technically downgraded to a white rating, which could have led to him having different diversion and approach criteria. Whilst this was not considered a factor, the Panel were concerned that the pressure on training hrs and the need to be ready for Ex SPRINGHAWK may have put a strain on the number and/or length of CT sorties flown. The Panel considered that closer supervision of 6-monthly IF hours would be beneficial.

Exhibit 8

Exhibit 7

c. **TGO 305 – Supervisory Checks.** TGO 305 stipulates that ATTU and non-ATTU pilots are required to undergo a number of mandatory supervisory checks; however, there is no specific reference to cover RAFAT. Whilst the risk and associated mitigation has been included within the RAFAT DD & SOPs Risk Register, the Panel considered that TGOs should be amended to cover RAFAT.

Exhibit 31

d. **TGO 401 – Logging Instrument Flying Hours** The Panel noted an anomaly with the Instrument Flying (IF) hrs as all

Exhibit 4&31

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9 pilots had claimed long periods of actual IF during the 3 transit sorties whilst en-route to Kastelli. In accordance with TGO D401.105.2 sub para a.4, only the formation leader can claim IF hrs. Following discussion with Red 11, this appears to have been a 'one off' and the Team have been reappraised of these requirements. The Panel considered that the requirements stipulated in TGOs were reasonable.

e. **Hawk T1 Flight Reference Cards – LSHC.** A LSHC drill is included in the 4 FTS 3225 and Red 7 used his previous experience to carry out the drill. However, the LSHC does not appear in the Hawk T1 Flight Reference Cards (FRCs). The Panel considered that the LSHC should be added to the Hawk T1 FRCs.

Exhibit 34

f. **Engineering Standing Orders Part 2 Order 3 – Tool Control.** The detachment tool controls did not reflect authorised procedures. Furthermore, in order to reduce the time taken to prepare aircraft for the next sortie, engineering personnel conducting walk-rounds signed for tool checks before carrying them out. There was no evidence to suggest that tool control lapses had occurred as a result of these deviations.

Exhibit 12
Witness 12
Witness
7,8&11

Unlike other sqns, RAFAT are currently not subjected to a Formal Staff Visit (FSV). If they had been, the Panel felt that many of the discrepancies highlighted during the inquiry would have been identified.

25. **Post Crash Management.** The Panel considered the following aspects of Post Crash Management (PCM):

a. **PCM Plan.** The RAFAT PCM Plan is contained in the RAF Cranwell Crash and Disaster Plan. It details the actions to be taken by RAF Scampton personnel in the event of a crash or aircraft accident at, or within sight of, RAF Scampton airfield, within normal working hours. It does not provide guidance on the actions to be taken in the event of an accident whilst detached in the UK or overseas and was not available to RAFAT personnel at the scene of the accident. Following their arrival in Crete, RAFAT engineers had discussed the actions to be taken in the event of an emergency landing; however, the division of responsibilities between RAFAT and the host nation following an accident had not been discussed. Moreover, no documented procedure was produced to cover any aircraft emergency whilst deployed to Crete.

Exhibit 35

Witness 12

b. **PCM Training.** With effect from Feb 10, TGO 305 states that Station Flight Safety Officers (SFSO) are to complete PCM training by May 11. Red 10 was the nominated SFSO for RAF Scampton; however, he hadn't yet completed this course. Whilst Engineering Officer Foundation Training includes 2 periods on

Exhibit 31

Witness 3

PCM, there is no mandated requirement for sqn engineering managers to complete the PCM Incident Officers Course (PCMIOC). No key RAFAT personnel, operational or engineering, deployed on the detachment had completed the PCMIOC.

Exhibit 36

c. **PIDAT.** Following the accident the decision to invoke PIDAT was not considered by any of the detachment supervisors. JSP 835 states that the PIDAT regime only covers incidents occurring on the UK mainland and in home waters. As such, there was no requirement to invoke PIDAT in this case. Although this had no bearing on this accident, the Panel felt that the inability to invoke PIDAT whilst overseas may hamper future inquiries.

Witness 1&2

Exhibit 37

26. The Panel considered that the immediate actions taken by RAFAT after the accident were appropriate; however, a PCM checklist available to the nominated incident officer may have highlighted areas that would otherwise have been missed. Furthermore, the Panel concluded that the absence of a locally agreed PCM plan and trained personnel made the management of the incident more difficult.

SUMMARY OF CAUSES AND FACTORS

27. **Cause.** The mid-air collision between XX233 and XX253 occurred because the MSD requirements were not maintained during the execution of the OBR manoeuvre as detailed in RAFAT DD & SOPs. This was the direct result of:

Para 13b

a. The reduced distance between the aircraft at the 'Roll go' call.

Para 14a

b. Red 7's decision not to escape on-crowd after the 'Roll go' call.

Para 14b

28. **Contributory Factors.**

a. The reduced separation between aircraft at the first 'Threshold' call.

Para 15a

b. Red 6 averting his attention to datum.

Para 15b

c. Increased time between 'Threshold' and 'Roll go' calls from 2008 to 2010 season.

Para 15c

d. The requirement to cross flight paths during the OBR.

Para 16

e. Natural human reaction.

Para 17j

29. **Factors that may have been Contributory.**

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- a. Distraction of Red 7 as he flew through his cross point. Para 17f
 - b. The effect of conditioning on both pilots. Para 17g
 - c. The decision making process for both pilots. Para 17i
 - d. The lack of knowledge to determine if the presented visual cues met the escape criterion. Pare 17j
 - e. The amount of previous RAFAT experience in the supervisory chain. Para 20b
 - f. The lack of a specific risk assessment for the OBR. Para 23
30. **Aggravating Factors.**
- a. The height at which the OBR is performed. Para 7a
 - b. The pilots hand position at the time of ejection. Para 8a
 - c. The absence of ARLs on the Hawk T 1. Para 8a
 - d. Red 6's posture on ejection. Para 8b
 - e. The number of layers worn by the pilot. Para 8c
31. **Factors that may have been Aggravating.**
- a. The type of layer (RAFAT t-shirt) worn by Red 6. Para 8d

OBSERVATIONS

32. The Panel observed that:
- a. There is no audio track or PTT parameter on the ADR. Para 2d
 - b. The manufacturer's default setting on the Hawk GPS sample rate is not set to the optimum value for post-crash analysis. Para 2e
 - c. Failure to apply power to the volatile memory store in the GPS prevented the recovery of data. Para 2e
 - d. Actions taken by RAFAT personnel to photograph and log the position of wreckage prior to the debris being cleared from the runway were commendable. Para 2h
 - e. The Form 700s contained a number of minor errors; however, they were otherwise well maintained. Para 5

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- f. The overall quality and control of the training documentation was inadequate. Para 20c
- g. The training folder contained anomalies and omissions. Para 20c
- h. Specific escape manoeuvres are not clearly documented for the Synchro Pair. Para 20d
- i. RAFAT only uses the Hawk T1 simulator for emergency training; they do not use it to practice escape manoeuvres. Para 20e
- j. Red 10 is not included in the list of approved supervisors detailed in RAFAT DD & SOPs para 1 or in his TORs. Para 22
- k. The detached copies of TGOs and RTS were not at the correct amendment state. Para 24a
- l. Red 7 had not completed all the necessary CT to maintain his green rating. Para 24b
- m. RAFAT are not included in the list of supervisory checks detailed in TGO 305. Para 24c
- n. The Team had incorrectly logged IF hours for all aircraft when flying in close formation. Para 24d
- o. The LSHC is not included in Hawk T1 FRCs. Para 24e
- p. The detached tool control procedures did not reflect the procedures stipulated in Engineering Standing Orders. Para 24f
- q. RAFAT is not subject to a FSV. Para 24
- r. There was no PCM plan available to detached personnel. Para 25a
- s. No detached RAFAT personnel had completed the PCMIOC. Para 25b
- t. The requirement to invoke PIDAT was not considered by the RAFAT supervisory chain. Para 25c
- u. Current PIDAT procedures are only applicable to UK and home waters. There is no agreed procedure for overseas detachments. Para 25c
33. **Support to SI.** The panel had the following observations regarding support to the SI:
- a. **Availability of HF Psychologist.** There is only one HF Para 2g

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Psychologist employed on Accident Investigation at RAFCAM. Due to annual leave, for the first week of the SI the Panel had no HF support.

b. **IT.** The standard of issued IT was very poor. The initial Service laptop had no internet or intranet capability and the password wasn't accepted. As a result, the Panel had to rely on the single laptop provided for SIA1 for the first 10 days. On returning to the UK a replacement laptop was provided; however, this also had no internet or intranet capability. The lack of connectivity hampered progress as it meant that no email facility was available when detached and files had to be transferred by disc, which proved to be very time consuming and problematic.

c. **Mobile Phone.** Only one Service mobile was issued which made communication extremely difficult in Crete as the Panel were often separated between the crash site and the working office. Consideration should be given to allocating at least 2 Service mobiles.