ROYAL AIR FORCE
PROCEEDINGS OF A BOARD OF INQUIRY
INTO AN AIRCRAFT ACCIDENT

PART 1

DETAILS OF THE BOARD

Assembled on 3 Sep 06 at Headquarters No 2 Group

By order of the AIR OFFICER COMMANING No 2 GROUP

To inquire into an accident involving NIMROD MR2 XV230 on 2 SEP 06.

1. Composition of the Board.

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<thead>
<tr>
<th>Duty</th>
<th>Rank, Name, Service No &amp; Decoration</th>
<th>Branch</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>President</td>
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<td>GD</td>
<td>DCDC</td>
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<td>Members</td>
<td>WSO(ENG)</td>
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<td>RAF KINLOSS</td>
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2. Full Terms of Reference.

a. Investigate the circumstances of the accident to Nimrod MR2 XV230 near Kandahar, Afghanistan on 2 Sep 06.

b. Determine the cause or causes of the accident and examine related factors.

c. Ascertain the degree of injury suffered by persons both Service and civilian.

d. Ascertain if Service personnel involved were on duty.

e. Ascertain if all relevant orders and instructions were complied with.

f. Ascertain if aircrew escape and survival facilities were fully utilised and functioned correctly.
g. Ascertained extent of damage to aircraft, public property and civilian property.

h. Assess any human factors.

i. Investigate the loss of all classified material carried on or in the aircraft at the time of the accident.

j. Determine whether the age of the Nimrod MR2 fleet was a contributory factor.

k. Determine whether operational pressure was a contributory factor.

l. Make appropriate recommendations.
PART 2

CONCLUSIONS OF THE BOARD

NARRATIVE OF EVENTS

(All times ZULU. Afghanistan Local Time = ZULU + 4 1/2 hrs. All times are from source documents.
Correlation of identical events on the Kandahar ATC transcript, the aircraft mission tape (transcript version 12) and the C2 agency transcript indicates that while the latter 2 usually agree within seconds, the former is approximately 48 seconds divergent. Thus the C2 Agency’s times have been taken as the master and a correction applied to other times where possible. The times quoted in the AAIB report and the QinetiQ combustion study differ in some areas by a few seconds from those contained in this report; the differences are the result of independent interpretation of source data and are not significant.)

(Exhibits 2 and 10 are classified SECRET. To allow the main report to remain at RESTRICTED-STAFF these exhibits are held separately.)

INTRODUCTION

1. On 2 Sep 06, No 120 Sqn Crew 3, supplemented by 2
Witness 4
was tasked with the support of NATO and Afghani forces
engaged in Operation MEDUSA in Southern Afghanistan. Allocated
Nimrod MR2 XV230, the crew departed at 0913 hrs.
Although the initial stages of the mission appear to have gone according to
plan, at 1111:33 hrs, approximately 90 seconds after receiving 22 000 lbs
of fuel from a Tristar tanker, the crew experienced almost simultaneous
bomb bay fire and elevator bay smoke/hydraulic mist warnings; smoke
was observed in the cabin, coming from both elevator and aileron bays, and
shortly afterwards the aircraft depressurised. The crew commenced
evacuation drills and at 1114:10 hrs transmitted a MAYDAY, heading for
Kandahar airfield. The Nimrod was subsequently observed by a Harrier
GR7 pilot, at 1116:54 hrs, in an apparently controlled descent, with flames
emitting from the starboard wing root and the starboard aft fuselage.
Shortly thereafter several members of A Sqn Royal Canadian Dragoons
(RCD) observed the aircraft as it passed to the south of their position; the
fire appeared to them to be on the port side of the aircraft. At 1117:39 hrs
the Harrier GR7 pilot reported that the aircraft had exploded, at what he
believed to be 3000 ft agl, and he observed wreckage striking the ground.
The RCD also witnessed the explosion, although they reported it as being
at a lower altitude. A Scene of Action Commander was established over
the crash site and a Combat SAR team was deployed. However, there were
no survivors. Shortly after the crash, the RCD unit, subsequently
supplemented by members of 34 Sqn RAF Regt from Kandahar airfield,
secured the area. The crash site was in an area of known Taliban activity
and proximate to Operation MEDUSA combat operations: it was

| Exhibit 1 |
| Witness 27/ |
| Exhibit 82a-c |
| Witnesses |
| 37&38/ |
| Exhibits 9&73 |
| Exhibit 2 |
| Exhibit 3 |
| Exhibit 4 |
anticipated that the area could only be held for a limited period of time. Thus, initial priorities were the recovery of the crew’s bodies, personal effects, classified documentation and equipment. The Canadian unit was withdrawn the following day and, in an increasingly unstable situation, the remaining RAF Regt personnel were withdrawn shortly thereafter.

CREW BACKGROUND

2. Crew 3 had arrived at Deployed Operational Base (DOB) from the UK on 21 Aug 06 and had flown 3 sorties since their arrival, the last being on 27 Aug 06. The crew had achieved combat ready (CR) status on 1 Aug 06, after a work-up period following the appointment of the CR (Advanced) Flt Lt Squires as Captain. Exhibit 5

Witness 4

Full details of the crew are contained at Annex B.

AIRCRAFT BACKGROUND

3. Nimrod MR2 XV230 deployed to theatre on 3 Aug 06. In the previous 2 years it had received a Major maintenance between 24 Sep 04 and 23 May 05 (at 17,954 flying hours (fg hrs)), a Primary maintenance between 21 Nov 05 and 24 Mar 06 (at 18,445 fg hrs) and was the first Nimrod MR2 to undergo Equalised 1 maintenance between 18 May and 26 Jul 06 (at 18,568 fg hrs); under the previous maintenance regime, replaced by Equalised maintenance, XV230 would have been due a Minor maintenance at 18,854 fg hrs. Examination of the aircraft’s documentation revealed that no significant faults were found during the Major or in the period up to the aircraft’s loss. Although a number of fuel leaks were identified during the Primary maintenance, lengthening the Primary, these were confined to the wing areas and were successfully repaired (see para 39d).

Compiled from maintenance documentation held by the Board

Witnesses 7-18

The ground crew servicing XV230 in theatre reported that it had been a particularly serviceable aircraft. The complete technical details of XV230 are recorded at Annex C.

Annex C

PRE-CRASH EVENTS

4. Previous 24 Hours. The crew had no specific duties during the 24 hours prior to the incident and none booked themselves off DOB during this period. Aircrew accommodation was in air-conditioned single rooms and the standard of food provided by civilian contractors is described as excellent. There is no evidence to suggest that the crew were

Witness 4
other than adequately rested for their mission.

5. **Mission Preparation.** The pre-flight brief was issued to the crew by the briefing officer, , on the morning of 2 Sep 06 and, in accordance with standard practice, they briefed themselves prior to collecting their equipment and walking to the aircraft. Flt Lt Squires self authorised the mission. No difficulties were encountered as the crew prepared the aircraft for flight and they departed at 0913 hrs, only 3 minutes later than originally planned. This scale of delay is not unusual and was probably caused by the need to conform to air traffic departure timings at the combined military/ civil airport.

6. **Pre-Incident Events.** The reconstruction of events prior to the incident is based on information from the Digital Acquisition and Recording Unit (DARU) – the aircraft’s accident data recorder, the aircraft’s mission tape and the testimony of the Tristar crew who refuelled XV230 immediately prior to the incident. Crew intercom and positional information was extracted from the mission tape, which was recovered from the crash site in a badly damaged state; the DARU does not record cockpit voice, audio or positional information. The evidence from the mission tape covers the period 1000 hrs to 1115:43 hrs, but the damage sustained in the crash rendered some areas of data irrecoverable, despite extensive restoration. Nothing abnormal was reported by Crew 3 in the transit prior to rendezvous with a Tristar tanker for Air-to-Air Refuelling (AAR) at 1100 hrs, on a northerly track. Although the recovered tape does not cover the entire transit, it is assumed that, had the crew detected a significant abnormality, they would have returned to . The rendezvous was completed successfully and Flt Lt Squires made contact with the tanker’s refuelling hose on his third attempt. The Tristar crew noticed nothing unusual during the refuelling process, which commenced at 1103:53 hrs and lasted for approximately 6 minutes, during which time XV230 received some 22 000 lbs of fuel. The Nimrod crew noted 2 occurrences during this period, which were recorded on the mission tape from crew intercom. At 1109:23 hrs, the air engineer commented that the Supplementary Conditioning Pack (SCP) had shut down unexpectedly; the possible significance of this is discussed at paras 27, 38 and 42c. Shortly afterwards, at 1109:33 hrs, as AAR approached its completion, the flight deck crew appear to discuss an unexpectedly low fuel input to one of the fuel tanks; the fact does not appear of great concern to the crew, but the conversation is incomplete and it has proved impossible to determine the complete context (the occurrence is discussed further at Annex N).

7. **Incident Events.** At approximately 1110 hrs, XV230 withdrew from the tanker and moved to echelon right, climbing to Flight Level (FL) 220 and preparing to turn right (east), towards the operational area. Shortly after this manoeuvre began, at 1111:33 hrs, the crew experienced almost simultaneous bomb bay fire and elevator bay smoke warnings (relevant Nimrod warning systems are discussed at Annex D). The captain reacted initially to the bomb bay fire warning, requesting the manning of the bomb
bay periscope (although there is no subsequent evidence of any report from this position). However, the following 50 seconds of mission tape contains a continuous and, at times, overlapping, series of reports, which indicate the ingress of smoke into the cabin from both elevator and aileron bays, culminating in the rapid depressurisation of the cabin. After ensuring that everybody was on oxygen, the crew conducted the Aileron Bay Underfloor Warning Drill, although this was interrupted by the temporary loss of the air engineer’s intercom. A report, by the operator at 1113:45 hrs, of flames coming from the rear of the engines on the starboard side was followed at 1114:01 hrs by an initial report of fire in the aileron bay (the fire may well have been alight prior to this, as it would take a finite time for the nominated crew member to don portable oxygen and use the observation scope to examine the aileron bay). The captain initiated a descent to Kandahar airfield and a MAYDAY was transmitted on the C2 frequency. The previous turn towards the aircraft’s operational area had headed the aircraft towards Kandahar and the navigators inserted a steer for the airfield; the captain’s descent point was correct for an approach to Kandahar’s Runway 23. The C2 agency handed XV230 to Kandahar Approach, who passed the airfield’s details to the aircraft. At 1115:30 hrs, with flames still visible in the aileron bay, the second of 2 bursts of extinguisher was fired. The mission tape ends at 1115:43 hrs, with a report of more smoke emitting from the aileron bay. The final transmission from the aircraft to Kandahar Approach was at 1116:34 hrs, when the co-pilot acknowledged the airfield QNH (the airfield altimeter pressure setting). Thus, it can be surmised that, at this time, the crew still believed the aircraft to be under control and were intending to land at Kandahar airfield.

CRASH AND POST CRASH EVENTS

8. Crash Events. At 1116:54 hrs, the pilot of a Harrier GR7, engaged on operations at the west of Kandahar airfield, observed XV230 in what appeared to be a controlled descent beneath him (DARU analysis shows that XV230 was at FL 120 at this time). Flames were apparent over the rear half of the starboard wing, close to the fuselage and reaching out to the No 4 engine nacelle; the fire did not appear to originate in the engines. These flames ended at the rear crew door and a second source of flame was apparent from the rear starboard fuselage, extending over the starboard tail plane some 10 metres behind the aircraft. No fire was apparent, to the GR7 pilot, on the port side of the aircraft. The GR7 pilot maintained visual contact with XV230, as he ensured that Kandahar airfield was aware of the emergency, before observing what appeared to be a single, large fuel/airburst explosion at an apparent 3000 ft above ground level (agl); the time was 1117:39 hrs. Shortly after the GR7 pilot’s initial sighting of XV230, members of A Sqn RCD observed the Nimrod, as it passed to the south of their position, apparently in a controlled descent, with the port wing slightly below the horizontal. The RCD witnesses’ testimony agrees to a large extent with that of the GR7 pilot, with 2 exceptions. The RCD witnesses placed the fire on the port wing of the Nimrod, although in other respects the fire they observed was similar to
that seen by the GR7 pilot. One RCD witness also reported a rapid increase in the fire’s strength as the aircraft disappeared from sight on the horizon (and very shortly before it crashed). 

Exhibit 10

suggest that the aircraft impacted the ground at 1117:51 hrs. Subsequent analysis of the crash site suggests that, at a height of approximately 700 ft, the aircraft broke into at least 4 large sections (fuselage, starboard wing, port wing and tail section) and struck the ground at high speed, with a low angle of incidence. Several large hay ricks at the crash site were ignited, but these were the only significant areas of prolonged combustion on the ground. The crash site, at 3131:54 N and 06534:07 E, was approximately 14 nm west of Kandahar airfield, some 400 metres north-west of the village of Farhellah. Despite being extremely short of fuel, the GR7 pilot transmitted an accurate position of the crash to the controlling agency before departing the area.

Exhibit 11/1

Exhibit 12a

Witness 27

Exhibit 82a-e

Exhibit 8

9. Post-Crash Events. With the departure of the GR7, the C2 agency appointed the leader of a pair of USN F18s as Scene of Action Commander. A USAF Predator UAV was also used to provide visual imagery of the site. Furthermore, US Army helicopters were employed to actively discourage local nationals from entering the crash area. At 1207 hrs a Combat SAR team arrived by helicopter and confirmed that there were no survivors. The was reinforced by the arrival of A Sqn RCD at 1257 hrs, who had been tasked to secure the area. The crash site lay in a depression, surrounded by higher land containing housing and, as such, was not easily defensible. Nonetheless, the RCD prevented the ingress of any local nationals and recorded video footage of the scene shortly after their arrival. The Canadians were joined at 1430 hrs by a 22 man patrol from 34 Sqn RAF Regt accompanied by with previous RAF service as an engineering officer, all based at Kandahar.

Exhibit 2

Exhibit 13

Exhibit 3

Witness 37

Exhibits 4&14

904 EAW, at Kandahar, had expended considerable effort in attempting to obtain descriptions of any hazardous materials, weapons carried and the location of the DARU within the Nimrod; although he experienced difficulty in obtaining this information, the data he garnered was passed to the on-scene team. The priorities of the combined force were the recovery of the crew’s bodies, personal effects and classified equipment and data.

Witness 3

Exhibits 4&14

the personnel of 34 Sqn RAF Regt, assisted by those Canadians not actually guarding the site, conducted a number of searches of the wreckage, under the direction of their respective commanding officers.

. After recovery the crew’s bodies were placed in a central location, surrounded by the Canadians’ vehicles, where they would not be disturbed. As night fell the coalition force assumed a defensive position which ensured that the site’s integrity was maintained. At first light the following morning the search was resumed and the force was joined by 904 EAW and 34 Sqn, accompanied by a combat camera team, which was used to provide aerial photography of the crash site prior to departing for another task. 904 EAW conducted some on-site photography of elements of the wreckage. In view of the limited nature of evidence.
available, the photographic record proved invaluable. The Board noted that the air-to-ground photographs provided by the combat camera team were of a particularly high resolution and thus suitable for detailed analysis. Later that morning the crew’s bodies, accompanied by 34 Sqn RAF Regt and 904 EAW, were flown, in a United States Army Chinook helicopter, to Kandahar, where they were placed in the mortuary for storage until repatriation could be arranged. Shortly afterwards, 34 Sqn RCD was retasked to support other coalition units engaging the Taliban, at which point several hundred local nationals, including Taliban elements, began to enter the site. The remaining RAF Regt personnel formed a defensive position in an irrigation ditch crossing the site and, in view of the rapidly deteriorating situation, were withdrawn by air at 0910 hrs, some 21 hours after the initial arrival of ground forces. The security situation, combined with the probability that potential helicopter landing sites had been mined by the Taliban, has prevented any return to the crash site. Subsequent reconnaissance of the site revealed that the majority of the aircraft wreckage was removed within a short period of time, probably by local nationals.

10. The Board concludes that:

   a. The flight was properly authorised. Exhibit 6

   b. The flight was adequately briefed. Witness 6

   c. The crew were competent to undertake the flight. Witness 4/ Exhibit 5

   d. The aircraft was declared serviceable for flight. Witnesses 7-18/ Exhibit 15

   e. The weather was suitable for the flight. Exhibit 16/ Witness 6

DEGREE OF INJURY

11. The Board finds that:

   a. **Service Personnel.** All 14 Service personnel aboard Nimrod XV230 died instantaneously at the time of the crash. Exhibit 17

   b. **Civilian Personnel.** There were no injuries to civilian personnel. Witness 3

WHETHER SERVICE PERSONNEL WERE ON DUTY

12. All Service personnel were on duty at the time of the incident. Exhibit 6
AIRCRAFT ESCAPE FACILITIES AND SURVIVAL ASPECTS

13. The accident was not survivable and all personnel would have been killed instantaneously at the time of the crash. The Nimrod has no airborne escape system. Despite exhaustive investigations with MOD and civilian organizations, the Board has been unable to find any evidence of investigations into the utility of parachute escape from the Nimrod. However, no other aircraft in the RAF’s multi-engine fleet routinely carries parachutes for crew escape; all rely on the multiple redundancy of systems available in any large aircraft and the ability to divert. Nonetheless, the Board was of the opinion that, even had parachutes been available to Crew 3, all evidence indicates that, until approximately 90 seconds before the crash, the crew believed that they were going to be able to reach Kandahar airfield; thereafter it is unlikely that parachutes could have been employed successfully.

DAMAGE TO AIRCRAFT, PUBLIC AND CIVILIAN PROPERTY


15. Public Property. Public property to the value of £6,585,626.99 was lost as a result of the crash. Exhibit 18

16. Civilian Property. The winter animal feed for nearby villages was incinerated during the crash and there was possibly some fuel contamination of the ground. The Civilian Secretariat Lashkar Gah has confirmed that he has been advised of the damage to civilian property caused by the crash and is the party responsible for settling any claims. Witness 3 Exhibit 19

LOSS OF, OR DAMAGE TO, CLASSIFIED MATERIAL

17. The high impact velocity of the crash destroyed most electronic components, although the lack of a widespread and sustained fire led to the partial survival of a number of documents and maps. Personnel at the crash site attempted to recover as much classified material as possible. The material not recovered and action taken following its loss is described at Exhibits 21 and 22. Exhibits 21 & 22
INTRODUCTION

18. The Board was unable to conduct an on-site analysis of the wreckage and crash area, due to the high threat level. A continuing high threat level and the fact that the majority of the aircraft wreckage has been removed by local nationals has precluded any later attempt by the Board to visit the site. Therefore, the Board’s determination of the likely causes of the crash has relied for primary evidence principally upon analysis of the DARU, recovered mission tape, ATC recordings, imagery taken at the crash site and the minimal equipment recovered, coupled with witness testimony. As the Board was unable to examine the wreckage to determine a point and mode of failure, available evidence was used initially to determine the most likely point of the fire’s initiation; this was an essential prerequisite to considering the factors that might have caused that fire. Thereafter, the Board examined the probable means by which fuel, a means of ignition and oxygen could have been brought together in a viable manner to create the fire which eventually caused the loss of Nimrod XV230 and its crew. While the Board’s primary investigation was focused on the cause of the fire which precipitated XV230’s crash, it was also conscious of the fact that, until 1117:39 hrs, when the GR7 pilot reported the aircraft exploding, XV230 appeared, to external observers, to be in a controlled, albeit emergency, descent to Kandahar airfield. It can also be assumed that at 1116:34 hrs, when the co-pilot acknowledged the Kandahar airfield pressure setting the crew believed that the aircraft was still in control and that they would reach the airfield. Nonetheless, at a time between the co-pilot’s final transmission and the observed explosion, the Board calculated that the aircraft departed from its previous controlled descent into Kandahar; both rate of descent and airspeed increased markedly prior to the aircraft breaking-up. The Board felt that the sequence of events immediately prior to the crash at 1117:51 hrs also merited close examination.

AVAILABLE EVIDENCE

19. The following evidence was available to the Board:

a. **DARU Data.** The DARU, which is crash-protected, records aircraft pitch, altitude, accelerations, indicated airspeed, heading, control positions and also engine parameters - but not intercom or aircraft position. The DARU was badly damaged in the crash, although the recording unit was recovered intact; with specialist assistance from QinetiQ, it was possible to recover the data. However, recording ceased abruptly at approximately 1116 hrs, shortly before the crash, probably as a result of power failure. Power supplies to the DARU route along the starboard side of the fuselage, inside the pressure hull, and these were probably destroyed by the fire.
b. **Mission Tape.** The mission tape records Central Tactical System data, including aircraft position and intercom and its primary purpose is post-flight analysis of a sortie. Although the unit is not crash-protected, a section of mission tape covering the period 1000 hrs to 1115: 43 hrs survived, albeit extensively damaged. The tape was dispatched to QinetiQ for data recovery. Despite extensive specialist restoration, sections of data were irrecoverable.

\[Exhibit\ 1\]

\[Exhibit\ 2\ and\ 8\]

\[Exhibit\ 27\]

c. **ATC Recordings.** The Board was able to obtain transcripts of the ATC radio transmissions on both C2 and Kandahar ATC networks, together with a recording of the ATC transmissions. The C2 agency radar is not video taped and the video from Kandahar ATC was destroyed when staff attempted to remove it from the recorder unit in which it had become stuck. This did not restrict the investigation significantly as aircraft position information was available to the Board from the mission tape.

d. **Photographs.** A number of photographs were taken by 904 EAW and a UK combat camera team on 3 Sep 06. The photographs consist of general views of the crash site and photographs of specific sections of wreckage. Photographs were limited by the fact that the camera team was subsequently deployed to another task and 904 EAW's camera battery failed. Some of these photographs are compiled within Exhibit 11; the remainder have been archived in the Board's records. A video of the area taken by the Canadian unit shortly after their arrival, while extremely useful as an overall survey of the area gave no additional detail. Similarly, a video provided by the US Predator UAV simply confirmed the fact that the observed fires correlated with the burning ricks of villager's winter feed, but no other information. After analysis, the Canadian and Predator material was archived with the Board's material.

\[Exhibit\ 10\]

\[Exhibit\ 11\]

e. **Recovered Equipment.** Although it was impossible to recover large elements of wreckage, the recovery team was briefed to collect all material that might be classified. Thus a large number of relatively small items of principally electrical equipment were returned to Kandahar and subsequently to the UK. This material was identified by the Nimrod Aircraft Engineering Development and Investigation Team and subsequently analysed by the RN Flight Safety and Accident Investigation Centre.

\[Exhibit\ 28\]

f. **Witness Statements.** Extensive witness statements were recorded from DO3 personnel; the crews of aircraft which had observed XV230 during its flight; Kandahar C2 and ATC radar operators, and personnel who had participated in the recovery. A number of written statements were obtained from those personnel the Board was unable to interview, due to ongoing operations.
g. **Records of Previous Boards of Inquiry.** The Board also examined the records of Boards of Inquiry relating to accidents involving Nimrods XV257 and XW666; the record of the Unit Inquiry into an incident aboard Nimrod XV227 and records of extensive fuel leak rectification on Nimrod XV249 were also examined. Summaries are contained at Annex E.

**EXPERT ADVICE**

20. To assist the Board in their deliberations, the following individuals and agencies were consulted:

a. Nimrod specialist advice:
   
   (1) **Sqn Ldr (Fg (P))** (Reconstruction of final flight in Nimrod simulator).
   
   (2) **Flt Lt (120 Sqn) (Fg (WSO))** (Assistance with interpretation of mission tape).
   
   (3) **Chf Tech (Eng Tech A/P)** (Identification of recovered and photographed equipment).
   
   (4) **Chf Tech (Eng Tech P)**. (Specialist advice on fuel system).

b. Department for Transport, Air Accidents Investigation Branch (AAIB): and (Accident Investigation and Report).

c. Centre for Aviation Medicine: (Pathology Report).

d. BAE Systems: (Air Accident Investigation Specialist) and (Support from aircraft designer).

e. QinetiQ: and (Combustion Analysis study); and (Fluid Analysis); (Mission Tape and DARU Analysis).

f. Human Factors Investigations Limited: (Examination of GR7 eye-witness testimony).

g. Defence Science and Technology Laboratory: and (Analysis and...
modelling of SAM engagement criteria).

h. Maritime Data Analysis Group: Sqn Ldr and team (Mission tape transcription).

i. Air Warfare Centre: Wg Cdr (Analysis of SAM engagement probability).

j. 

k. RN Flight Safety Accident and Investigation Team: Lt Cdr, Lt and CPO. (Initial analysis of recovered equipment and production of Accident Report).

l. Accident Recovery Officer: WO and Jnr Tech

m. Photographic support was provided by a deployed Combat Camera Team and Ground Photographic Section, RAF Kinloss.

n. Hydraulic Analysis Ltd: (Production of model of No 1 fuel tank).

o. Eaton Aerospace Ltd: and (Analysis of fuel seal condition).


q. Air Refuelling and Communications Integrated Project Team, DLO RAF Wyton.

r. Nimrod Aircraft Engineering and Development Investigation Team (Identification of recovered avionic and electrical equipment and temperature trials).

s. Nimrod Software Team: Chf Tech (Analysis of mission tape position data).

t. Fg Off (Assistance in analysis of engineering records of XV230).

LOCATION OF FIRE

21. Evidence Indicating the Seat of the Fire. The evidence surrounding the ignition of the primary fire observed in XV230 is, at times, ambiguous and fragmentary. However, the Board used the following data to determine the most probable area in which the fire ignited:
a. Mission tape at 1111:33 hrs: report of a bomb bay fire warning, either coincident with, or closely followed by, an elevator bay warning.

b. Mission tape at 1111:33 hrs – 1112:26 hrs: an interlinked and, at times, overlapping series of reports from the crew of smoke entering the cabin from elevator and aileron bays.

c. Mission tape at 1112:26 hrs: a report that the aircraft had depressurised.

d. Mission tape at 1113:45 hrs: a report from the operator of flames coming from the rear of the engines on the starboard wing.

e. Report by Harrier GR7 pilot at 1116:54 hrs of XV230 descending with flames originating from the starboard wing root and starboard fuselage.

f. Testimony from 3 members of A Sqn RCD who observed approximately the final 40 seconds of XV230’s flight. The Canadians reported a fire in many respects similar to that of the GR7 pilot, but on the port side of the aircraft.

g. Photograph of the AV287 carrier used to hold the Apparatus Sea Rescue (ASR) in the bomb bay, showing no smoke or flame damage. The ASR is a combination of a single inflatable dinghy and 2 survival equipment packs, fitted to Station 4, at the mid-position of the bomb bay.

h. Photograph of 3 x No 4 Mk1 fusing units, recovered from the crash site, which had been fitted to the ASR’s AV287 carrier. None of these items display smoke or fire damage.

i. Photograph of the starboard rear bulkhead of the bomb bay showing probable scorching to the top third, but no warping due to heat.

j. Photograph of the starboard tail plane with paint discolouration caused by heat and flame.

k. Description of rear hinged fairing with no fire damage, although evidence of molten metal having dropped onto it.

l. Mission tape at 1109:23 hrs. A remark from the air engineer as the Supplementary Conditioning Pack (SCP) trips-off, causing a pressure change within the cabin.

m. Photographs taken of the interior of the aircraft tail section following the crash and smoke damage to the recovered sonar
location beacon show clear evidence of internal burning in the compartments aft of the pressure hull. However, the fire was of short duration and was probably ignited as a consequence of the principal fire further forward in the aircraft. It was not the initial scene of combustion.

22. Resolution of Contradictory Evidence. The principal area of contradictory evidence that the Board had to resolve was the fact that the GR7 pilot reported a fire on the starboard wing and fuselage, with no fire on the port wing, while the RCD reported a fire on the port wing. From correlation of witness positions and XV230’s assessed track the Board concluded that the Canadians had observed the Nimrod shortly after the GR7 pilot. The Board thus determined to examine the detailed evidence for the 2 fires.

a. The Starboard Fire. The GR7 pilot was some ft above XV230 and had a good plan view of the Nimrod as he passed from its port to starboard side. The relative size of the Nimrod to the witness is shown at Exhibit 74a. The evidence for a starboard fire is substantiated by the comment made by the operator and by evidence of scorching on the starboard tail plane. Thus the Board concluded that there was a fire on the starboard side of the aircraft.

b. The Port Fire. The GR7 pilot stated that there was no fire on the port side of the aircraft. However, it is possible that the fire started after he placed himself on the starboard side of XV230, or that it was so small as he passed behind the aircraft that he did not see it. Nonetheless, at this point a fire had been burning on the aircraft for approximately 5 minutes and so the port fire must have ignited after the starboard fire and, by implication, have been ignited by it. Evidence from the mission tape suggests that R1 was in the port beam window during refuelling and he would probably have returned there following depressurisation, as his oxygen mask would have been at this position. Although far from conclusive, it might have been expected that, had he returned, he would have commented on any fire on the aircraft’s port side. The Canadian witnesses were initially some 2-3 km from XV230, which was approximately 8000 ft above them; it descended from right to left across their position. The initial view reported was of a side elevation. The Board reconstructed the possible view of the aircraft held by the Canadians as it passed their position. Both the aspect of the aircraft and its relative size could have led the Canadians to conclude that the aircraft was banking to the left and that the large, luminous starboard fire was on the port side. Independent analysis by the AAIB confirmed that this could have occurred. Although the aircraft’s aspect to the Canadians improved as it travelled from them, its relative size would have decreased and as the fire increased in intensity, it may have continued to appear to originate on the closest wing. Nonetheless, at least one of the Canadians had...
seen XV230 for some 40 seconds and the statements they made were considered and cogent. QinetiQ investigated the potential means by which a fire could pass to the port side of the aircraft.

c. **Transfer of Fire from Starboard to Port.** The only means by which the fire could have reached the port wing at the time noted by the Canadian witnesses was by crossing the fuselage through the cabin, aileron bay, or bomb bay. Recovered components and the pathology reports indicate that the fire is unlikely to have entered the crew cabin. If the fire in the aileron bay had had the strength to breach its port side, it would appear likely that it would have also breached the cabin floor and entered the cabin. The condition of the ASR carrier and bomb bay bulkhead indicate that there was no substantial fire in the bomb bay and that it was thus unlikely that the bomb bay served as the transmission path for the fire. QinetiQ studies were unable to determine a likely means by which the fire could transfer from the starboard to port side of the aircraft.

It is impossible to discount completely the existence of a fire on the port side of XV230. However, if there was one, it was undoubtedly subsidiary to the main fire and caused by it.

23. **Probable Seat of Fire.** From the evidence the Board considered that the fire might have initiated in one of 4 locations.

   a. The bomb bay.

   b. The No 3 engine.

   c. The starboard Rib 1 landing.

   d. The dry bay forward of the starboard No 7 fuel tank (known henceforth as No 7 tank dry bay).

24. **Bomb bay.** The undamaged state of the ASR’s AV287 carrier and its associated fusing units militates against a fire in the forward bomb bay; in particular it means that the ASR (the only store in the bomb bay) could not have been the fire source. Although the fire could have originated in the rear of the bomb bay the Board has been unable to find a likely ignition source within this area. Furthermore, the photograph of the bomb bay’s rear bulkhead exhibits no evidence that it endured a sustained fire. Thus, the bomb bay was ruled out as the likely seat of the fire.

25. **No 3 Engine.** As the GR7 pilot and the operator reported flames close to the starboard engines, the Board considered the possibility of the fire having ignited in the No 3 engine bay. However, crew intercom makes no reference to any engine associated fire warnings and the DARU shows no significant fault with the engines up to the time that the DARU stops recording, about 2 minutes before impact. Both Nos 3 and 4 engines
indicate slightly lower HP RPMs than the other engines; however, No 3 exhibited the same characteristics on a previous flight and a similar, much less pronounced, trait on No 4 was noted, but not considered to be of significance. Moreover, titanium panels separate the No 3 engine bay from the Rib 1 area and from the No 7 fuel tank and wing rear spar attachment point area. Thus, initiation of a fire within the No 3 engine is most unlikely to have produced the observed warnings.

26. **Rib 1 Landing.** As neither the bomb bay nor the No 3 engine appeared to be the likely seat of fire, the Board considered areas at their shared boundaries. Within these criteria a possible location of the fire’s origin is the Rib 1 landing, which forms a triangular space between the titanium firewall of No 3 engine bay and the No 1 fuel tank in the centre fuselage, between the main plane front and rear spars. It is immediately forward of the starboard No 7 tank dry bay, but separated from it by a bulkhead at the main plane rear spar. The location of this area is such that a fire burning within it could exit to atmosphere from ventilation holes on the underside of the wing at the rear of the landing. However, an overheat sensor, positioned at the outlet of the Rib 1 landing, should have activated a Centre Section Overheat Light on the air engineer’s panel in the event of fire. There is no mention of such a warning on the intercom and, given that the warning light is immediately below the AAR switch panel, its illumination is unlikely to have gone unnoticed. Initiation of the almost simultaneous bomb bay and elevator bay warnings in the early stages of a fire in this location, without having first set off the Centre Section Overheat warning, is improbable. Although this warning could have been recorded on a damaged section of mission tape, if it had occurred, the air engineer would probably have mentioned it when the subsequent alarms initiated. Therefore, the Board consider the Rib 1 landing a possible, but unlikely, location for the origin of the fire.

27. **No 7 Tank Dry Bay.** Immediately in front of the No 7 fuel tank front face, and adjacent to the aileron bay, the No 7 tank dry bay houses the wing rear spar-to-fuselage attachment points, a number of fuel system components, a crossfeed air pipe containing hot engine bleed air and the tail anti-ice duct (see Annex G). The bomb bay’s firewire runs in close proximity to an opening between this dry bay and the bomb bay. Furthermore, the electrical feeds to the SCP Pressure Reducing and Shut Off Valve (PRSOV) run close to the bomb bay firewire in this area and the loss of the SCP could have been occasioned by the early stages of a fire melting the electrical insulation and causing a short. Another possibility is that leaking fuel disrupted the airflow through the SCP pre-cooler, instigating a shut down. However, the SCP has been known to stall in the turbulent airflow experienced behind a tanker, such that the loss of the SCP could be a simple coincidence. Nonetheless, a fire igniting in the dry bay could initiate the simultaneous warnings received. A fire in this position would also burn quickly through wing panels to provide the flames noted by both and GR7 reports. The fact that the mission tape intercom recording contains no evidence of the aileron bay warning being activated, despite that bay being on fire, remains an anomaly. Such evidence may
have been lost in one of the damaged sections of the tape or the aileron bay sensor could have been unserviceable or less sensitive than that in the elevator bay. Equally, the warning could have initiated but simply not been mentioned in view of the plethora of other warnings and smoke entering the rear cabin. The lack of a Centre Section Overheat warning could also be explained in this manner or following heat damage to the wiring.

28. **Conclusion.** From the evidence, the Board considers that the most likely origin for the ignition and initial seat of the fire is an area forward of the No 7 fuel tank on the starboard side – the starboard No 7 tank dry bay. This location has numerous fuel pipes running through it in addition to the crossfeed air pipe. It thus contains all the elements necessary to be the origin and the sustainment point of a fire.

29. **QinetiQ Combustion Study.** In view of the lack of firm evidence and to provide authoritative substantiation of the Board’s initial work, a study was commissioned with QinetiQ to investigate the possible causes and subsequent expansion of the fire. While acknowledging the paucity of quantitative data the study was able to confirm that the Board’s selection of the seat of fire was viable and that the fire’s subsequent spread could be correlated with other evidence as to its size and location. Moreover, the study also eliminated the other potential locations of fire considered by the Board.