

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

PART 1

DETAILS OF THE BOARD

Assembled on 4 SEP 95 at RAF KINLOSS.

By order of the AIR OFFICER COMMANDING NO. 18 GROUP.

To inquire into an accident involving NIMROD MR2 XV239
on 2 SEP 95.

1. Composition of the Board.

Duty	Rank, Name, Service No & Decorations	Branch	Unit
President	Redacted S.40 - Wg Cdr A	GD/P	HQSTC
Members	Redacted S.40 - Sqn Ldr B	GD/P	RAF KINLOSS
	Redacted S.40 - Sqn Ldr C	GD/P	RAF KINLOSS
	Redacted S.40 - Sqn Ldr D	ENG	RAF KINLOSS
	Redacted S.40 - Flt Lt E	GD (ENG)	RAF KINLOSS
In Attendance (QR 1261)	Redacted S.40 - Sqn Ldr F	GD/P	18 GROUP
	Redacted S.40 - Sqn Ldr G	GD/P	MOD IFS (RAF)
	Redacted S.40 - Sgt H	PERS ADMIN	MOD IFS (RAF)
	Redacted S.40 - Mr I	SALMO	DMS (N)
	Redacted S.40 - Mr J	SALMO	DMS (N)
	Redacted S.40 - Dr K	PATHOLOGIST	IPTM HALTON

2. Full Terms of Reference.

- a. Investigate the circumstances of the accident to NIMROD MR2 XV 239 on 2 SEP 95.
- 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 the aircraft escape and survival facilities were utilised and functioned correctly.

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- g. Ascertain the extent and value of loss or damage to aircraft, public property and civilian property.
- h. Assess any human failings.
- j Investigate the loss of all classified material carried in or on the aircraft at the time of the accident.
- k. Make appropriate recommendations.

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PART 2: CONCLUSIONS OF THE BOARD

NARRATIVE OF EVENTS

All times Local.

INTRODUCTION

1. On 2 Sep 95, seven aircrew of 120 Sqn Crew 9 were tasked to fly an air display at the Canadian International Airshow (CIAS) on the Toronto lakeshore of Lake Ontario. The aircraft, Nimrod MR Mk 2, XV239, departed Toronto's Pearson International Airport (PIA), at 1501 hrs and proceeded to the airshow holding point prior to commencing the display at 1524 hrs. The display sequence appeared normal until the final dumb-bell turn when, during the left turn back towards the display line, the aircraft stalled and crashed into the Lake at 1527:26 hrs.

Witness 1
Exhibit 1

Witness 2

Witness 1 & 9

Annex E

CREW BACKGROUND

2. The following personnel formed the crew of XV239:

a. Flt Lt D M GILBERT - Crew Captain. Although he had remained current on type during his previous tour in Ops Wg, RAF Kinloss, Flt Lt GILBERT

Exhibit 2,3 &
Witness 11

Redacted S.44

This was GILBERT's first display season, and he was ratified as a display pilot by AOC 18 Gp on 3 May 95.

Annex F

b. Flt Lt G H HOOPER - Crew Co-Pilot. Flt Lt HOOPER

Exhibit 4,5 &
Witness 11

Redacted S.44

and this was his first display season.

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c. Sgt G S MOXHAM - Crew Air Engineer. Sgt MOXHAM [REDACTED] Exhibit 6,7 & Witness 11

[REDACTED] Redacted S.44

[REDACTED] This was his first display season.

d. Flt Lt N BROOKS - Crew Navigator. Flt Lt BROOKS [REDACTED] Exhibit 8

[REDACTED] Redacted S.44

e. Flt Lt B WORTHINGTON - Crew AEO. Flt Lt WORTHINGTON [REDACTED] Exhibit 9

[REDACTED] Redacted S.44

f. Sgt R L WILLIAMS - Crew AEOp(R). Sgt WILLIAMS [REDACTED] Exhibit 10

[REDACTED] Redacted S.44

g. Sgt C BARNETT - Crew AEOp(S). Sgt BARNETT [REDACTED] Exhibit 11

[REDACTED] Redacted S.44

DETACHMENT ITINERARY

3. 120 Sqn Crew 9, captained by Flt Lt GILBERT, together with support personnel, departed RAF Kinloss on 23 Aug 95 for a detachment to Canada which would involve flying displays at CFB Shearwater, Nova Scotia, and the CIAS at Toronto. Exhibit 1 & Witness 1

S.40 - Sqn Ldr L [REDACTED] the crew's first navigator was the Detachment Commander and was authorised by the Stn Cdr in accordance with 18 Gp ASOs, to authorise Flt Lt GILBERT's display flying. The crew flew two short media demonstration sorties from CFB Shearwater on 25 Aug 95, which was followed by a display practise over the airfield. Flt Lt GILBERT flew 2 displays before departing Shearwater for Toronto on 30 Aug. The crew flew a media demonstration sortie over Lake Ontario and Niagara Falls on 31 Aug, during which the CIAS display area was clearly visible, but was not Witness 1 & Annex G

Witness 8

Witness 1

Witness 1 & 8

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overflowed. Flt Lt GILBERT did not conduct a display practise over the display area. The crew were planned to fly displays at the CIAS on 2, 3 and 4 Sep before returning to Kinloss on 5 Sep 95.

Witness 1
Annex H

AIRCRAFT TECHNICAL HISTORY

4. Nimrod MR Mk2 XV239 returned to RAF service on 5 Apr 95, following a Major Servicing at the Nimrod Major Servicing Unit, RAF Kinloss, and had subsequently completed 250 flying hrs prior to the accident. Following the accident, the aircraft's F700 was recovered damaged but complete and, therefore, all relevant aircraft documentation was available for scrutiny by the Board. Apart from several minor transcription and recording errors, all current F700 documentation was found to be in order. XV239 underwent a standard detachment preparation commencing on 22 Aug 95 which included a series of Out Of Phase Servicing (OOPS) tasks. In addition, a starboard rear outer mainwheel tyre was found to be worn to limits and was replaced. On 23 Aug 95 a Limitations Log entry, for the starboard No 7 fuel tank under-reading by 800lb, was cancelled but subsequently re-entered in the Limitations Log. In addition, a Searchwater radar receiver was replaced as a result of a built-in test failure. The following maintenance activities were carried out on XV239 following deployment from Kinloss:

Annex I

Annex J &
Exhibit 12

a. Maintenance at CFB Shearwater. Prior to the first media flight at Shearwater on 25 Aug 95, a Blue hydraulic system indication problem occurred during engine start which was cleared by a routine Blue system indication bleed. This problem is not uncommon in Nimrod operations and, although it involves the hydraulic supply to the primary flying control system, the fault is confined to the pressure indication system. The corrective Maintenance Procedure (MP) for this particular malfunction is further explained at Annex K. Following the media flights and practice display an OOPS code B5 was carried out, to empty the radome pitot drain traps, and a flight requirement was raised for OOPS code L1 which detailed a rated power take-off which was carried out on the next sortie. On start-up for the first public display at Shearwater on 26 Aug, the Blue hydraulic system indication problem

Exhibit 12

Annex K

Exhibit 12

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recurred and was again cured by a Blue system indication bleed. During the display, the aircraft fatigue meter registered a count of 2.35G. This amounts to an overstress of .35G over the aircraft's normal G limit, and the count occurred during the final pull-up manoeuvre. During this manoeuvre the pilot would be aiming for a target 2 G and, in other than smooth air conditions, it is not unusual for a single count of this magnitude to be recorded. This occurrence necessitated excess G checks to be carried out on the airframe and these were completed in accordance with the prescribed MP, with no damage found. An OOPS code C6 was also carried to check the security of the pilots' Terminal Approach Procedure holder. A Blue system indication bleed was again required during engine start prior to the second display at Shearwater on 27 Aug; the aircraft was serviceable on landing from this sortie. All routine flight servicing at Shearwater were carried out in accordance with the appropriate Flight Servicing Schedules.

Witness 2 & 6

Exhibit 12

b. Maintenance at Toronto. Following the transit flight to Toronto on 30 Aug, the starboard landing lamp was replaced, as were two bonded seals in the Red hydraulic system thermal relief valve. Following the Media flight on 31 Aug, a full After Flight servicing was carried out. On 1 Sep 95, an OOPS code B05 was carried out, to empty the radome pitot drain traps, and an OOPS code C5 was raised detailing the flight requirement for the aircraft to be taxied through the wash post-flight. Thereafter, no further maintenance activity took place until the day of the accident.

Exhibit 12

Witness 2

Exhibit 12

CREW PREVIOUS 24 HRS

5. On the morning of 1 Sep the flight deck crew and some members the rear crew participated in a live interview for a local TV station. Following the interview, all the crew members returned to their accommodation at the Regal Constellation Hotel which was some 10 minutes' drive from PIA. At approximately 1230 hrs, the crew, with the exception of Flt Lt GILBERT, left the Hotel for pre-arranged visits to local children's hospitals and Cheshire Homes. As a result of the early

Witness 1

Witness 1 & 9

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start for the TV interview, and because he was flying the next day, Flt Lt GILBERT had sought permission from the Detachment Commander to remain at the Hotel and rest. The crew returned to the Hotel later that evening where some of them met up with Flt Lt GILBERT in the Airshow Hospitality Bar. Flt Lts GILBERT and HOOPER joined S.40 - Sqn Ldr L in the Hotel bar at 2000 hrs and, together with Flt Lt BROOKS, proceeded to a restaurant opposite the Hotel for dinner after which they moved to an adjacent bar. During this period, Flt Lts GILBERT and HOOPER consumed no more than 3 small glasses of beer. S.40 - Sqn Ldr L and Flt Lt GILBERT returned to the Hotel at approximately 2245 hrs. Flt Lts HOOPER and BROOKS told S.40 - Sqn Ldr L that they would return to the Hotel once they had finished their drinks. Sgt MOXHAM retired at 2304 hrs. The flight deck crew, navigator and Detachment Commander attended the Display Briefing at 0830 hrs on 2 Sep 95, following which Flt Lts GILBERT and HOOPER ate a proper breakfast in a local coffee shop before returning to the Hotel, where Flt Lt GILBERT returned to his room to rest. The crew left the Hotel at 1300 hrs and proceeded to PIA.

Witness 1

Witness 8 & 9

Witness 1

Annex L

Witness 1, 10 & 13

Witness 1 & 10

Witness 10

PRE-ACCIDENT EVENTS

6. The Board's investigations into the pre-accident and accident events were aided by the availability of the aircraft accident data recorder, the Data Acquisition Recorder Unit (DARU). In addition, some recordings of crew intercom prior to the accident were available on Central Tactical System (CTS) tapes.

7. Aircraft Preparation. A Before Flight servicing and a Dispatch Check were carried out at 1230 hrs on 2 Sep 95, with no other maintenance activity required prior to crew-in.

Witness 2
Exhibit 12

8. Crew Briefing. The Airshow Briefing, given by the airshow organizers, in the Regal Constellation Hotel on 2 Sep 95 was detailed and comprehensive, covering meteorology, timings, display lines and features, and emergency and safety procedures. Following this briefing, and having been briefed by Flt Lt GILBERT on his intentions, the Detachment Commander authorized the flight. Flt Lt GILBERT conducted a crew briefing in the galley area of the aircraft prior to engine start, during which he briefed the beam

Witness 1 & 13

Witness 1

Witness 10

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look-outs on the visual cues for the display area and the minimum operating height during the display.

Witness 10

9. Pre-Start. The crew arrived at the aircraft, carried out their pre-flight checks and started engines at 1420 hrs.

Witness 2

10. Start-up, Taxi and Take-off. Following the start of No 3 engine, there was no indication of Blue hydraulic system pressure. Having seen this fault on repeated start-ups since leaving Kinloss, S.40-Sgt M anticipated the requirement for an indication system bleed and detailed tradesmen to standby with the requisite tools to complete the task. Supervised by S.40-Sgt M the airframe mechanic, S.40-SAC N with S.40-Cpl O as safety man, successfully completed a bleed of the system in the Hydraulic Bay in accordance with the MP. After confirming with the Air Engineer that the system was serviceable, S.40-SAC N then wire locked the hydraulic unions and secured the Hydraulic Bay. S.40-Cpl O placed the tools in the TEAC video cassette stowage at the recorder station, and this was confirmed by S.40-SAC N prior to leaving the aircraft. The aircraft start was completed at approximately 1440 hrs, and the aircraft took off at 1501 hrs.

Witness 2

Witness 6 & 7

Witness 2

Witness 6 & 7

Witness 2

11. Pre-Accident Airborne Events. Following an uneventful departure from PIA, the aircraft joined the display hold, some 10 nm east of the display datum, at 5000 ft. Once established in the holding pattern the crew carried out their pre-display checks, and as was usual for this crew, these checks were comprehensive and carried out in a competent manner. Having descended to 1000ft in the holding pattern, the aircraft departed the hold at 1520 hrs and commenced the display on time at 1524 hrs.

Annex M

Annex N

Annex M
Witness 1

ACCIDENT EVENTS

12. Weather conditions in the display area were excellent, with a 10 kt on-crowd wind. The run-in points to the display line, and a fire boat marking the display datum, should have been clearly visible. The aircraft arrived at the display datum on time, and commenced the standard Nimrod display sequence, completing the initial two orbits uneventfully. In setting up for the first dumb-bell turn Flt Lt GILBERT offset by 60

Witness 1
Annex O
Annex P

Witness 1

Annex Q, R & S

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deg from the display line, rather than the 70 deg recommended in 18 GP ASOs. The reduced offset, combined with the tightening wind resulted in a fairly tight turn back to the display line for the slow fly-past. Following the slow fly-past at 140 kts with undercarriage down and flap at 40 deg, full power was applied and the ac turned right into the second dumb-bell. The landing gear was retracted and the flaps selected to 20 deg. The aircraft was rolled wings level approximately 75 deg from the display line. When steady on the new heading, which was almost directly into wind, and with the airspeed increased to 175 kts, the aircraft was initially pitched up to +11 deg, followed by a further pitch up to +24 deg. Engine power was decreased to almost flight idle as the aircraft passed 950ft. The combination of low thrust and the high nose attitude resulted in the IAS reducing rapidly to the very low value of 122 kts as the aircraft continued to climb to 1400ft. The aircraft then turned left back towards the display line, initially at a bank angle of approximately 70 deg (bank angle is not recorded on the DARU). As the bank reduced to about 45 deg, the nose was lowered to 5 deg below the horizon with the aircraft trimmed into the turn. The trim was set at 5 divisions nose up, equating to some 10 deg of up elevator. Video evidence indicated the presence of some sideslip. The airspeed increased to 136 kts, accompanied by an increase in G to 1.6G, and the combination of G and low IAS caused the aircraft to stall. As the aircraft stalled, the left wing dropped to about 85 deg left bank, and the nose pitched down, eventually reaching 18 deg below the horizon. Full right aileron and full power were applied and, as the power increased, the elevator up-angle reduced momentarily from +13 deg to +10 deg, but then increased rapidly towards maximum up deflection of +20 deg, where it remained until just before impact, when it reduced to +17 deg. Both DARU and video evidence show that the aircraft hit the water 9 seconds after the stall, in a near wings level attitude, with the nose approximately 10 deg below the horizon, the engines operating at full power and the flaps set to 20 deg. There were no survivors.

Annex Q, R & S

Annex R

Annex T

Annex P & U

Annex V

Annex P

Annex R & T

Annex P, R, T, U

13. The Board concludes that:

- a. The flight was properly authorized.

Witness 1 &
Exhibit 1

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- b. The flight was adequately briefed. Witness 1
- c. The crew was competent to undertake the flight. Witness 1
- d. The aircraft was serviceable to undertake the flight. Exhibit 12
- e. The weather was suitable for the flight. Witness 1,13, Annex P & O

DEGREE OF INJURY

14. The Board finds that:

- a. All Service personnel on board Nimrod MR Mk2 XV239 at the time of the accident sustained fatal injuries. Annex X
- b. No civilian personnel were injured.

WHETHER SERVICE PERSONNEL WERE ON DUTY

15. All Service personnel on board Nimrod MR Mk 2 XV239 were on duty at the time of the accident. Witness 11 & Exhibit 1

AIRCRAFT ESCAPE FACILITIES

16. The impact forces to which the crew of Nimrod MR Mk2 XV239 were exposed during the crash were not survivable, and the probability of survival would not have been improved by any practical crashworthy design or additional aircraft escape facilities. Annex Y & P

DAMAGE TO AIRCRAFT, PUBLIC AND CIVILIAN PROPERTY

17. Aircraft. Nimrod MR Mk 2 XV239 suffered Category 5 (scrap) damage. Annex Z

18. Public Property. Apart from the aircraft and its inventory, there was no damage to public property other than to the Fly Away Pack (FAP), clothing issues and specialist equipment carried on board the aircraft, the loss of which is assessed to be valued at £688,315.27. Annex AA

19. Civilian Property. There have been no claims for damage to civilian property and none are expected.

LOSS OF, DAMAGE TO, CLASSIFIED MATERIAL

20. The crew's holdings of classified material were recovered, and have been destroyed in accordance with AP 3086. The KG84C encoder unit was returned to RAF Kinloss for subsequent refurbishment. The crew deployed with 10 reels of one inch wide Memorex 897 magnetic tape for use in the aircraft's CTS recorder. Each tape is approximately 9100 feet in length. Ten reels of the type used in the Nimrod CTS recorder were subsequently recovered from the crash site, all suffering varying degrees of damage, which made it impossible to positively identify the serial numbers on all the tapes. All the magnetic tape was accounted for with the exception of fragments, totalling approximately forty feet in length, of the tape which was in the CTS recorder at the time of impact. The Board considered that this portion of CTS tape posed no security risk and were satisfied that all classified material had now been reconciled.

Annex AB

AIRCRAFT SALVAGE OPERATION

21. The initial survey of the crash site was carried out by a Canadian Forces Fleet Diving Unit, using a Remotely Operated Vehicle (ROV) equipped with a video camera. However, the main salvage operation was conducted by The Directorate of Marine Services (Navy) (DMS(N)). The extent of the main wreckage area was determined initially using sonar side-scanning techniques, with individual pieces of wreckage identified by video camera linked to the salvage barge. Once the area was scanned and the wreckage plotted, divers began a systematic recovery of the debris. Individual pieces of wreckage were identified and significant items photographed prior to being transferred to hangar facilities at CFB Toronto by the Aircraft Recovery and Transportation Flt (AR & TF), RAF St Athan.

Annex AC

DIAGNOSIS OF CAUSES

INTRODUCTION

22. Initial examination of video, photographic and DARU evidence, together with eye witness statements, suggested that a mechanical failure had not occurred. Therefore the Board concentrated on the aerodynamic and aircraft

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handling aspects of the accident and the performance of the flight deck crew.

AVAILABLE EVIDENCE

23. To assist the Board in its deliberations, evidence was obtained from the following principal sources:

a. The DARU was recovered and transported to the Air Accident Investigation Branch (AAIB), DRA Farnborough, for analysis. The DARU provided accurate data for engine RPMs, normal acceleration, heading, IAS, altitude, pitch, aileron and elevator control surface positions, and flap settings. However, the DARU does not provide data on rudder position, bank angle or any flying control inputs. Furthermore, the DARU does not have a cockpit voice recording (CVR) facility.

Annex Q, R & T

b. The CTS recorder has the facility to record, inter alia, both crew and tactical intercom; however, this system is not crash-proof. Although part of the CTS tape in use at the time of the accident was recovered, detailed analysis revealed no useful information relating to the final manoeuvre. The absence of this information obstructed the Board's investigation.

Annex N & Q

c. Video recordings, photographs and eye witness statements.

Annex P & AD

d. Directorate of Marine Services (Navy): S.40 - Mr J [redacted] and S.40 - Mr I [redacted] - Salvage and Mooring Officers (Aircraft Recovery).

Annex AC

e. Nimrod engineering specialist advice:

(1) S.40 - ChfTech P [redacted] (Nimrod Line Sqn (South)) (Eng Tech A).

(2) S.40 - ChfTech Q [redacted] (Nimrod Line Sqn (North)) (Eng Tech P).

(3) S.40 - ChfTech R [redacted] (Nimrod AEDIT) (A Eng Tech).

f. Department of Transport, AAIB: Redacted S.40 Ms S [redacted] (DARU data analysis); S.40 - Mr T [redacted] (AAIB Inspector) (Accident Investigation and

Annex Q & V

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Report).

- g. ASW Acoustic Data & ACINT Centre (ADAC): **S.40 - Sqn Ldr U** and **S.40 - MAEOp V** (CTS analysis). Annex AE
- h. Metropolitan Toronto Police: **Redacted S.40 - SSgt W** (Post-crash investigation). Annex P
- i. DTEO Boscombe Down: **S.40 - Wg Cdr X** (Specialist handling advice). **S.40 - Mr Y** (Specialist aerodynamic advice). Annex W
- j. Joint Air Reconnaissance Intelligence Centre (JARIC), Reconnaissance Support Development Cell (RSDC): **S.40 - Sqn Ldr Z**, **S.40 - Flt Lt AA** and **S.40 - WO AB** (Video and photographic analysis). Annex U
- k. RAF Institute of Pathology and Tropical Medicine: **S.40 - Dr K** (Pathology and toxicology reports). Annex X & AO
- l. RAF School of Aviation Medicine: **S.40 - Mr AC** (Human Factors), **S.40 - Wg Cdr AD** (Aircrew Survival Aspects). Annex AF
Annex Y
- m. Transport Canada: **S.40 - Mr AE** (Radar trace and RT transcripts). Annex E & M
- n. British Aerospace (Chadderton): **S.40 - Mr AF** and **[Redacted]** (Aerodynamic and Systems Aspects). Annex S
- o. RAF Aircraft Recovery and Transportation Flight (RAF AR & T Flt): **S.40 - Flt Lt AM** (Aircraft Recovery/Transport). Annex Z
- p. The Board made extensive use of the Nimrod Dynamic Simulator (NDS) to reproduce the second dumb-bell manoeuvre. Annex AG
- q. For completeness, the Board reviewed a previous stalling incident, involving Nimrod MR Mk2 XV246 on 31 Mar 90. This incident resulted from a mishandled recovery from an unaccelerated, fully developed clean stall. The Board therefore considered that it was not relevant to this accident.

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FACTORS CONSIDERED BY THE BOARD

24. The Board considered the following factors

that may have had a bearing on the accident:

- a. Selection of Nimrod Display Flight Deck Crews.
- b. Training of Nimrod Display Flight Deck Crews.
- c. Supervision of Display Flying.
- d. The Nimrod Display Sequence.
- e. Competence of the Flight Deck Crew.
- f. Fitness of the Flight Deck Crew.
- g. Planning and Briefing.
- h. Weather.
- i. Birdstrike.
- j. Structural/Technical Failure.
- k. Crew Incapacitation.
- l. Change in Aircraft Centre of Gravity.
- m. Distraction.
- n. Disorientation.
- o. Stalling.
- p. Handling.

DISCUSSION OF FACTORS

25. Selection of Nimrod Display Flight Deck Crews. The Board found that the selection process for the 120 Sqn Display Flight Deck Crew had been carried out in accordance with 18 Gp ASOs. The Sqn Cdr's nominations were forwarded to the Stn Cdr who, whilst content with the nominations, in turn, passed the nominations to S.40 - Wg Cdr AJ OC Ops Wg and the senior display supervisor, for his comments. S.40 - Wg Cdr AJ OC 201 Sqn, acting on behalf of the Stn Cdr forwarded the

Witness 11,15
& Exhibit 13

Witness 5

Exhibit 13

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nominations, together with the flight deck crew's F5000 series, to HQ 18 Gp for consideration and approval by the AOC. The Board was satisfied that the selection procedure was sound, providing sufficient checks and balances up to the highest level in the command chain. Therefore, it considered that the procedure for the selection of Nimrod display flight deck crews was not a factor in the accident.

Exhibit 13

26. Training of Nimrod Display Flight Deck Crews.

The training of Nimrod Display Flight Deck Crews is detailed in 18 Gp ASOs; however, the Board noted that there is no approved formal training syllabus. Prior to ratification by the AOC, training is to continue until a satisfactory standard is achieved, with the display practises supervised by the Stn Cdr or a supervisor nominated by him. Having been approved by AOC 18 Gp, Flt Lt GILBERT and S.40-Flt Lt AH, the 201 Sqn Display pilot, began work-up training on 3 Apr 95, under the auspice of S.40-Sqn Ldr AL, Chief Flying Instructor and CFS Agent on the NOCU, and an experienced Nimrod display pilot. The training involved one sortie which was preceded by a pre-flight discussion on theory and technique. The sortie included a stalling sequence for both pilots, followed by a demonstration display at 1000 ft, during which the second dumb-bell turn was demonstrated using a target speed of 150 kts with power left on until the aircraft's nose dropped below the horizon. Subsequently during this sortie, S.40-Sqn Ldr AL supervised both flight deck crews each flying a display sequence at 1000 ft, followed by 2 display sequences at 500 ft. These practices were also supervised from the ground by S.40-Wg Cdr AL. Flt Lt GILBERT then flew 13 practise display sequences and one display sequence in the NDS, which included an emergency drill during the display, prior to ratification by AOC 18 Gp on 3 May. Thereafter, in addition to 12 actual displays, Flt Lt GILBERT conducted 9 practise display sequences and one sequence in the NDS prior to his detachment to Canada. The Board considered that during the work-up training the pre-flight discussion covering theory and technique, was appropriate, although it did not cover important aerodynamic factors, such as manoeuvre stall, in any great detail. Given Flt Lt GILBERT's level of experience, S.40-Sqn Ldr AL assumed that he understood the theory. The Board determined that Flt Lt GILBERT was aware of the

Annex AH &
Witness 14

Annex F

Witness 14

Witness 5

Witness 12
Exhibit 14

Annex AI, AJ &
Exhibit 14

Witness 14

relationship between G and stalling speed. However, the Board contend that when displaying a large aircraft, especially at low speeds, a full understanding of the practicalities of manoeuvre stall is essential. Accordingly, the Board considered that the training of Nimrod display flight deck crews was a contributory factor in this accident.

Annex AK

27. Supervision of Display Flying. Part 1 to HQ 18 Gp ASOs, Order 2103, states that display pilots are to fly at least one supervised practice every 30 days, and are to have flown a practice or actual display within the 8 days prior to a display. The Board determined that the supervision of Flt Lt GILBERT's display flying was carried out in accordance with 18 Gp ASOs. The supervisor, who is nominated by the Stn Cdr and invariably a wg cdr pilot, observes practise display sequences from the ground, and looks for correct and safe manoeuvring, and visual impact. In the event of more than one practice display being flown per sortie, which may also involve more than one display flight deck crew, debrief points are passed by RT from the supervisor to the display crew. Following each display practice sortie a face-to-face debrief between supervisor and display crew is carried out on the ground. Whilst Flt Lt GILBERT's initial display practices were a little ragged, S.40 - Wg Cdr AI assessed that they were flown in a safe and gentle manner. Furthermore, the display supervisor's sortie records indicated that, because he flew wider dumb-bell turns, with a later turn back to the display line, GILBERT's sequence was consistently some 20-30 seconds longer than the other two display pilots. Whilst GILBERT was conscious of this fact, he was reassured by S.40 - Wg Cdr AI that timing was not important, and that it would improve with experience. The Board noted that, following the initial demonstration and practice displays, Nimrod Display Pilots are not required to be supervised in the air. As a result, they develop their own technique throughout the display season, making it almost impossible for a supervisor on the ground to detect any minor variation in the laid down height minima and speed limits. Accordingly, the Board considered that supervision of flying displays was a contributory factor in this accident.

Annex AH

Exhibit 14

Witness 4 & 5

Witness 5

Annex AH

28. The Nimrod Display Sequence. The Board

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reviewed the advice contained within 18 Gp ASOs pertaining to the Nimrod Display Sequence, and also considered the consequences of the use of the signal pistol during the display sequence.

- a. 18 Gp ASO Advice. The standard Nimrod display sequence is contained at Appendix 3 to Annex B to Ch 21 Order 2103, and Annex C to Ch 21, Order 2103 of Part 1 to 18 Gp ASOs. The Board determined that, as a result of amendment action, the standard Nimrod Display Sequence was removed from 18 Gp ASOs in 1984. Hitherto, a minimum speed of 180 kts was stipulated for the second dumb-bell turn. A subsequent amendment to 18 Gp ASOs in 1991 re-introduced advice on the standard display, but did not stipulate a minimum speed for the second dumb-bell turn. Consequently, although a maximum height of 1000 ft is stipulated for the manoeuvre, speeds during the manoeuvre are left to the discretion of the pilot. During the period 1984-1991, individual sqn display pilots forwarded their display sequence to HQ 18 Gp for approval by the AOC. Whilst the Board was unable to determine why the current ASO did not stipulate a minimum speed for the manoeuvre, it considered the previous advice on minimum speed to be appropriate for that part of the display sequence. The Board considered that, had the ASO stipulated a minimum speed of 180 kts, Flt Lt GILBERT would not have been seduced into flying the manoeuvre at an airspeed almost 60 kts slower. Whilst the Board acknowledged that the technique which **S.40 - Sqn Ldr AL** had demonstrated for flying the manoeuvre was inherently safe, it concluded that a minimum speed of 180 kts would significantly increase the margin above manoeuvre stall speed without being overly prescriptive on the use of power. Accordingly, the Board concluded that the lack of ASO direction on the minimum speed at which the second dumb-bell manoeuvre is to be flown was a contributory factor in this accident.
- b. Use of the Signal Pistol. The Board obtained anecdotal evidence to suggest that crews flying at the CIAS are encouraged to use pyrotechnics to enhance the visual impact

Annex AH

Annex AL

Annex AH

Annex AL

Witness 14

of their displays, and noted that Flt Lt GILBERT's crew fired Verey cartridges during both dumb-bell manoeuvres. Whilst this is contrary to the advice in 18 Gp ASOs, the Board considered that the use of the Signal Pistol to fire Verey cartridges, other than at the top of the final pull-up and wing-over, did not constitute a hazard. However, the use of the signal pistol at these points in the display sequence requires the Air Engineer to be engaged in firing and re-loading procedures when he would otherwise be monitoring the operation of the aircraft's systems and services, as well as the aircraft's speed and attitude. In addition, the Air Engineer would not be fully secured in his seat throughout the firing and re-loading procedure, during a period of continuous manoeuvring. Accordingly, the Board considered that the use of the signal pistol during the dumb-bell turns was an Other Factor.

Witness 1

Annex AH

Annex V & AM

29. Competence of the Flight Deck Crew.

Redacted S.32

Witness 11
Exhibit 2 & 3

Witness 11

The flight deck crew's handling of emergencies during display practises in the NDS was very professional, as was their performance during monthly NDS training sorties. These events also indicated that the flight deck crew were very competent and effective in working together under pressure, displaying a good level of crew co-operation. Whilst the Board noted Flt Lt GILBERT's exaggerated description of the display sequence during media interviews in Toronto, it concluded that this was only intended to generate interest in the airshow, and the Nimrod display in particular, and the Board did not consider this to

Witness 12

Annex AN

RESTRICTED - STAFF

be a statement of intent or a show of bravado. The Board concur AVM SQUIRE's assessment that, whilst Flt Lt GILBERT was unwise in the words that he used during his interviews with the media, the manner in which he put the message across was entirely consistent with his normal, cool professionalism. Accordingly the Board concluded that Flt Lt GILBERT's competence as a display pilot and the competence of the other members of the flight deck crew was not a factor in the accident.

Witness 13

30. Fitness of the Flight Deck Crew. The flight deck crew of XV239 were fit and well rested on the day of the accident. During the 24 hours prior to the accident, the flight deck crew had consumed only modest amounts of alcohol, and the Detachment Commander was content that they were not suffering any after effects. Pathological evidence indicated that they had not taken drugs and were free of toxic substances, although there was clear evidence of self medication by several of the aircrew. The Board noted that Flt Lt GILBERT was in possession of the non-prescription drug Terfenadine, an antihistamine used to combat the effects of allergies. Whilst earlier members of this drug class had marked sedative side-effects, Terfenadine is stated to have a low incidence of such effects. The Board determined that Flt Lt GILBERT was prescribed Terfenadine by the RAF Kinloss Medical Staffs and that he had suffered no side-effects. The Board therefore concluded that the fitness of the flight deck crew was not a factor in this accident. However, the Board noted a need for further attempts to educate all aircrew of the dangers inherent in self medication.

Witness 1 & 10

Witness 1

Annex X & AO

Annex X

Annex AP

31. Planning and Briefing. Following the comprehensive CIAS display briefing Flt Lt GILBERT provided the Detachment Commander with a detailed briefing on his intentions. Content that the crew were competent to undertake the sortie, that the weather conditions were suitable and the Airshow organisation was sound, the Detachment Commander authorised the sortie. Flt Lt GILBERT also conducted a sortie brief in the galley area of the aircraft before engine start, during which he briefed the beam look-outs on the visual cues for the display area and the minimum operating height for the display. Accordingly, the Board concluded that planning and briefing for the sortie was not a factor.

Witness 1

Exhibit 15

Witness 1 &

Exhibit 1

Witness 10

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32. Weather. There were no meteorological warnings in force at the time of the accident. The weather was CAVOK, with a 10 kt on-crowd wind with no turbulence. The captain of the Canadian CP-140A, ARCTURUS display aircraft, which displayed some 24 minutes before the Nimrod, assessed the weather conditions to be excellent and there was no appreciable change in the weather conditions before the Nimrod commenced its display. Accordingly, the Board do not consider weather to be a factor in this accident.

Annex O, P &
Witness 13

Annex AQ

Witness 1

33. Birdstrike. Although the Airshow Director issued a 'bird precautionary' warning to all the airshow participants on their arrival at the display area, and there is video evidence of some bird activity along the Lakeshore, the CP-140A pilot reported no bird activity in the vicinity of the display area. Likewise, the Detachment Commander viewing the display from the shore had not seen any bird activity and was not aware of any bird activity that would have affected the display. However, due to the condition of the recovered wreckage, it was impossible to determine positively that the aircraft had not suffered a birdstrike. Therefore, the Board concluded that a birdstrike could have been a contributory factor in the accident.

Annex P & AQ

Witness 1

34. Structural/Technical Failure. The Board determined that fuel contamination was not a factor in the accident. Furthermore, video and photographic evidence, together with the AAIB investigator's report, indicate that the aircraft had not suffered a structural failure. However, the Board were unable to discount the possibility of a transient technical failure that may have caused a temporary control restriction or undemanded control input which may have led to a temporary loss of control of the aircraft. Consequently, the Board considered that a transient technical failure could have been a contributory factor in the accident, and is further discussed in paragraph 37d.

Annex AR
Annex P, V & AD

35. Crew Incapacitation. There was no pathological evidence to suggest that any flight deck crew member suffered any incapacitation immediately prior to the accident. Furthermore, both pilots suffered damage to their hands compatible with 'control stick' injuries. Although not conclusive evidence, this suggested

Annex X

to the Board that both pilots had their hands on the controls immediately prior to impact. This accords with both DARU and video evidence which indicates that the aircraft appeared to be under control until the point of impact. Accordingly, the Board did not consider crew incapacitation to be a factor in this accident.

Annex X
Annex P, R & T

Annex P, R & T

36. Change of Aircraft Centre of Gravity. The Board considered the possibility of a control problem resulting from a change in aircraft centre of gravity (C of G). On this occasion the aircraft was flown with the FAP fitted in the ordnance area to the rear of the fuselage, forward of the starboard sonobuoy launchers. The FAP was properly secured prior to take off, and the resultant centre of gravity of the aircraft was firmly in the mid-range for all stages of flight. In order to produce a significant change in aircraft stability, the FAP would have had to move suddenly fully aft. Both the magnitude and direction of the forces applied during the display would have been insufficient to cause such a movement of the FAP. Furthermore, the DARU elevator position trace shows no sudden corrective action as would be expected to compensate for a C of G change. Accordingly, the Board did not consider that this was a factor.

Witness 2

Annex R

37. Distraction. The Board considered the part that distraction could have played in the accident and divided its investigations into 4 areas: radio communications, other aircraft, a cockpit incident and an aircraft systems failure.

a. Radio Communications. The level of radio communications traffic was light and consisted of routine transmissions between the aircraft and the display controllers. The last transmissions from the aircraft to the display controller were made by the navigator, Flt Lt BROOKS, informing the controller that the aircraft was setting up for its final pass. These transmissions covered the period from the firing of the Verey cartridge at the top of the dumb-bell manoeuvre to just prior to the point at which the aircraft stalled. The Board considered that the display controller, in repeating the transmission for confirmation, would not have distracted Flt Lt GILBERT, who would have been monitoring the appropriate radio. The

Annex E

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Board concluded that radio communications did not cause a distraction and was therefore not a factor.

b. Other Aircraft. As Flt Lt GILBERT executed the second dumb-bell manoeuvre the nearest aircraft, the next act on the Display Programme, a formation comprising a B-25 and 2 P-51 aircraft, were some 6 miles to the east. The Board considered that, even if the aircraft were visible to the crew, they would not have given them cause for concern, and considered that distraction by other aircraft was not a factor in this accident.

Annex AS

c. Cockpit Incident. The Board considered the part which firing and reloading the signal pistol may have played in distracting the flight deck crew. When the Signal Pistol was located at the crash site, it was in the normal 'broken' position, had a live cartridge loaded, but was separated from its mounting in the cockpit roof. The Signal Pistol was fired as the ac reached the top of the second dumb-bell turn and the deployment of the pyrotechnic appeared normal. The pistol was subsequently reloaded with the live cartridge and this procedure would have taken an experienced operator approximately 7 sec. However, it is possible to reload the pistol whilst it is out of its mounting. To reload it in this manner, and subsequently insert it into its mounting, takes approximately 18 sec. The AAIB investigation considered 2 possibilities that, either, vibration and impact forces had caused the Signal Pistol to become unlocked and vibrate loose, or, it was being supported in the partially inserted position at the time of the accident. The Board could determine no reasonable circumstance whereby the Air Engineer would deliberately operate the Signal Pistol in the partially inserted position. The Board therefore considered the possibility that another crew member was operating the Signal Pistol; however, there is no evidence to suggest that anyone other than the pilots and Air Engineer were on the Flight Deck at the time of the accident. Consequently, given that the AAIB report could not discount the possibility that the Signal Pistol became detached from its

Annex AT

Witness 1

Annex P

Annex AM

Annex V

mounting due to impact forces, the Board consider it more likely that the Signal Pistol had been operated in the normal manner. Therefore, whilst the Board had previously considered that operating the Signal Pistol during the display sequence would divert the Air Engineer's attention from his normal monitoring duties it did not consider that, in this instance, the operation of the Signal Pistol constituted a cockpit incident which would have distracted Flt Lt GILBERT, and was therefore not a factor.

Annex V

d. Aircraft System or Instrument Failure.

A system or instrument failure could have provided a potential distraction to the flight deck crew. Whilst the AAIB investigation concluded that all relevant aircraft systems and instruments were operating normally at the point of impact, the possibility of the flight deck crew being distracted by a minor, transient, systems failure or instrument malfunction during the pull up into the dumb-bell manoeuvre or prior to the aircraft stalling, could not be dismissed. Therefore, the Board concluded that distraction by a system or instrument malfunction could have been a contributory factor in the accident.

Annex V

38. Disorientation. The weather on the day of the accident was excellent, with unlimited visibility, a well defined horizon, a small amount cloud and no turbulence. The on-shore wind produced a light chop which gave texture to the lake surface. During the second half of the second dumb-bell turn the Toronto skyline would have provided Flt Lt GILBERT with detailed visual cues. The fire boat at the display datum, together with the white display line marker buoys, would also have been clearly visible during the later half of the dumb-bell manoeuvre. Accordingly, the Board considered that disorientation was not a factor in this accident.

Witness 1 & 13
Annex O & P

Annex AU

39. Stalling. Having determined from video and DARU evidence that the aircraft stalled, the Board examined the following factors:

a. Stall Warning System. The Nimrod MR stall warning system is a pressure operated

Annex AV

system, which senses and compares the differential between calibrated under-wing vent and pitot pressures. The system is not factored for rate of change of G. The warning consists of a red indicator light on each pilot's instrument panel, and a mechanical shaker system fitted to both control columns. However, these indications also provide a warning of a G loading in excess of 2.05G, sensed independently of the stall warning system. In practice, at a normal aircraft weight for stall training, below 10,000 ft and with 20 deg of flap set, the system provides a margin of between 6 and 9 kts warning to the stall. These values apply to an aircraft in balanced flight. The presence of any sideslip will increase the stalling speed, although the stall warning system may not provide a corresponding increase in the stall warning speed, thereby decreasing the speed margin between the warning and the stall. Furthermore, if increasing G is applied, the time between the warning and the stall is also reduced, due to the increased rate of approach to the stall. The Board considered it unlikely that, even as a B-Category pilot and ACO, Flt Lt GILBERT would have been aware of these limitations in the stall warning system. Following analysis of the DARU data, the Board assessed that Flt Lt GILBERT received approximately 2 seconds of stall warning prior to the stall. In this time frame, Flt Lt GILBERT had to determine whether the stick shakers were providing a warning of an approach to the aerodynamic stall or a warning that the aircraft had exceeded 2.05G. Given, the reaction time to the warning, and the time taken for Flt Lt GILBERT to assimilate the information, the Board considered it likely that the aircraft stalled before Flt Lt GILBERT could take the necessary recovery action. Furthermore, the Board assessed that, in certain areas of the Nimrod's flight envelope, the dual-purpose nature of the warning system could lead to a delay in taking the necessary recovery action. Accordingly, the Board considered that the Nimrod stall warning system was a contributory factor in this accident.

Annex R, T & W

b. Stall Training. Stall recovery is taught during basic conversion to the

Annex AW

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aircraft and during refresher flying on the NOCU. The Board determined that Flt Lt GILBERT's training records covering the period of his refresher training on the NOCU had been destroyed. Therefore, in the absence of any comment in GILBERT's F5201C report raised on completion of his refresher course, the Board concluded that he had completed the relevant stalling training. The conversion syllabus covers a fully developed clean stall, stalling in the approach configuration recovering at the onset of stall warning and stalling in the turn. A simulator exercise is followed by a syllabus air exercise covering the approach to the stall, symptoms of the stall, and stall recovery techniques. A fully developed clean stall and recovery is demonstrated by a QFI. The student pilot then practises a clean stall, recovering at the onset of stall warning. Stalling in the approach configuration and in a turn are also practised, again recovering at the stall warning. Subsequently, recovery from the fully developed stall is only practised in the NDS to fulfil Basic Training Requirements. The technique for a clean stall is to approach the stall in balanced, 1G flight, at a speed reduction of 1 kt per second which provides between 6 and 9 seconds warning to the stall. Upon recognising the stall, the pilot initiates recovery action by moving the control column forward until stall buffet ceases, simultaneously applying full power. During initial work-up training, Nimrod display pilots are required to recover from a fully developed clean stall. For the majority of Nimrod pilots, this is the first time that they would have flown this manoeuvre in the aircraft. Flt Lt GILBERT flew such a manoeuvre with **S.40 - Sqn Ldr AL** but was required to fly a second clean stall and recovery, as he had recovered somewhat prematurely from the first stall. The Board noted that there is no requirement for a Nimrod display pilot to practice stalling in a turn as part of his work up training. It concluded therefore that Flt Lt GILBERT, in common with the majority of Nimrod pilots, was unfamiliar with the stalling characteristics of the Nimrod when stalling in a turn. Accordingly, the Board considered

Annex AW

Exhibit 3

Annex AW

Annex AX

Annex AV

Witness 14

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that stall training was a contributory factor in this accident.

c. Aircrew Manual Advice. The Board considered the advice contained in AP 101B-0503-15C, Aircrew Manual - Flying, Book 3 (ACM Bk 3) concerning stall warning speeds. The ACM Bk 3 advice on stalling suggests that, when operating below 10,000 ft with 20 deg flap selected, the stall warning system provides 10 to 12 kts of warning to the stall, but that this could be as low as 6 kts with wing tip pods fitted to the aircraft (wing tip pods are now a fleet-wide fit on both the Nimrod R Mk 1 and the MR Mk 2). However, when stalling in a turn, the ACM Bk 3 suggests that the margin between the on-set of stall warning and the stall varies between 15 and 26 kts. The Board determined that this information pertained only to an unpodded Nimrod, and is therefore incorrect. In addition, the graphical data contained within the ACM Bk 3 provides yet another source of stall and stall warning speeds which differ from the speeds stated in the preceding text. Furthermore, the Board noted that the text covering Stalling and Stalling for Crew Training makes no reference to the graphical information. The Board therefore concluded that the presence of several sets of conflicting stall warning speeds is confusing and misleading. Accordingly, the Board considered that the ACM Bk 3 advice regarding stall warning speeds could have been a contributory factor in this accident.

Annex AV

Annex AY

Annex AV

40. Handling. In determining why flying technique may have resulted in the aircraft stalling during the second dumb-bell manoeuvre, the Board examined the DARU information for two of the previous displays at Shearwater and CTS tape data from several of Flt Lt GILBERT's previous displays. During his initial display training Flt Lt GILBERT had been shown this manoeuvre at a target speed of 150 kts, and with power maintained until the nose dropped to the horizon in the turn. However, during the run-in to a display practise at Kinloss on 3 Aug 95, CTS tape transcripts show Flt Lt GILBERT to express concern about having too much energy during a dumb-bell manoeuvre. He

Annex R & T

Witness 14

Annex AZ

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concluded that reducing airspeed by a reduction in power during the pitch up into the dumb-bell was the best method of controlling this energy. Again, during an air display at Sunderland, on 6 Aug 95, Flt Lt GILBERT experienced difficulty in manoeuvring the aircraft onto the display line in the latter half of the second dumb-bell. The stick shakers operated, most probably as a result of applied G rather than aerodynamic stall and, as the G was reduced, the aircraft flew through the display line, albeit only slightly. This incident attracted comment not only from one of the crew members on board the aircraft, but also from a crew member who observed the display from the ground. Subsequently, during displays at Shearwater, Flt Lt GILBERT flew the second dumb-bell manoeuvre at a speed as low as 138 kts, having reduced power to almost flight idle whilst still in the climb. The consequence of using this technique was to leave little margin between airspeed and the manoeuvre stall speed. During the final display, he flew the second dumb-bell using this technique. Despite much deliberation, the Board could not determine why, on this occasion, the airspeed was allowed to reduce to 122 kts, although it could not rule out the possibility that the flight deck were distracted by a transient system or instrument failure or the aircraft had suffered a temporary technical failure. Furthermore, the AAIB report confirms that Flt Lt GILBERT had trimmed the aircraft to approximately this speed. The Board considered that this was an instinctive action, borne out of experience. Subsequently, the rising airspeed increased the effectiveness of the trimmed elevator position, causing the turn to tighten and the G to increase. The aircraft stalled and the left wing dropped with the DARU data showing that the G was maintained at 1.6G. The absence of a positive 'G-break' indicated that the aircraft probably unstalled almost immediately. However, although full control was regained, the aircraft attitude and height were such that the aircraft was unrecoverable. The Board therefore deduced that the low airspeed at which Flt Lt GILBERT flew this manoeuvre, exacerbated by the trimmed elevator setting, resulted in the aircraft stalling at a height from which it could not be recovered, thus causing it to crash into Lake Ontario.

Annex AZ

Witness 9

Annex BA

Annex V

Annex T

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SUMMARY OF CAUSES AND FACTORS

41. Cause. There were a number of potential causes for this accident; however, the Board concluded that the cause of the accident was that the aircraft stalled at a height from which recovery was impossible.

42. Contributory Factors. The Board found that the following factors could have contributed to the accident.

- a. Training of Nimrod Display Flight Deck Crews.
- b. Supervision of Nimrod Display Flying.
- c. 18 Gp ASO Advice.
- d. Birdstrike.
- e. Technical Failure.
- f. Distraction.
- g. Stall Warning System.
- h. Stall Training.
- i. ACM Bk 3 Advice.

43. Aggravating Factors. The Board found no factors that could have aggravated the final outcome.

44. Other Factor. The Board found that Use of the Signal Pistol was the only Other Factor which could have had a bearing on the findings.

RELEVANT ORDERS AND INSTRUCTIONS

45. The Board determined that all relevant orders and instructions were complied with, with the exception of Order 2103 to Part 1 of HQ 18 Gp ASO in that Flt Lt GILBERT did not fly the standard Nimrod display sequence.

CONSIDERATION OF HUMAN FAILINGS

46. Whilst the Board considered that the absence of on-board supervision and an approved formal

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training syllabus for Nimrod display pilots were contributory factors in the accident, they found that supervision was carried out in accordance with extant 18 Gp ASOs, and that the training regime was based on accepted practice exercised over a number of years. Accordingly, the Board found that no blame should be attached to those individuals involved in the supervision and training of Nimrod display crews. The Board therefore concentrated on the performance of the flight deck crew.

47. Flt Lt GILBERT. As the aircraft captain, Flt Lt GILBERT was responsible for the planning, briefing and execution of the flying display. Given that he attended the comprehensive Airshow briefing, had conducted his own crew briefing prior to engine start and had satisfied the Detachment Commander that the sortie was properly planned, the Board concluded that Flt Lt GILBERT had fulfilled these duties in a satisfactory manner. As to the Display, the CIAS at Toronto was the largest event at which Flt Lt GILBERT had displayed. The comprehensive and highly professional Airshow briefings, the public relations activities and the media attention may have put greater pressures on GILBERT than those which he would have experienced during his display season. The Board noted that Flt Lt GILBERT was aware of these pressures, and had taken measures to minimize them. Moreover, heavy emphasis during the display briefing on not infringing the display line may have resulted in added pressure on GILBERT during the display. Turning to his flying technique, as the display season progressed, the flight deck crew became familiar with seeing a low airspeed during the second dumb-bell manoeuvre. Other than comments from 2 crew members regarding Flt Lt GILBERT's handling of the second dumb-bell manoeuvre during the second display at Sunderland, the Board could find no evidence to suggest that any member of the crew had expressed concern at Flt Lt GILBERT's technique for flying the dumb-bell manoeuvre. Consequently, the Board concluded that, in the absence of any subsequent critical comment, Flt Lt GILBERT was content that this was a safe manoeuvre. The Board also concluded that elements of Flt Lt GILBERT's initial display training were inadequate, leaving him with no appreciation of the limitations of the stall warning system with regard to manoeuvre stall.

Exhibit 1

Witness 1, 10 & 13

Witness 1 & 13
Witness 13

Witness 9

Witness 14

His display work-up stall training would have led him to expect a far longer warning time to the stall, which, combined with his previous experience of stalling would have been misleading at best. Furthermore, the incorrect and confusing advice on stall warning speeds, provided in the ACM Bk3, would have misled him even further. The Board therefore concluded that Flt Lt GILBERT did not have the knowledge to fully appreciate that, at the time of the incident, the aircraft's stall warning system gave him only 2 seconds warning to the stall. The Board assessed this to be insufficient time to carry out recovery action. The Board considered that Flt Lt GILBERT had not acted in a reckless manner in the deliberate way in which he had developed his display sequence. Whilst his actions were pre-meditated and carried out with the apparent acquiescence of his crew, the Board further considered that he had acted without the benefit of adequate training, and without the full knowledge of the potential consequences of his actions. In addition, without the irrefutable evidence of a CVR and modern generation ADR, the Board was unable to discount the possibility that Flt Lt GILBERT was distracted by a transient aircraft systems or instrument failure, or that the aircraft had suffered a transient control restriction at a critical point during the final manoeuvre. However, in flying the dumb-bell manoeuvre at such a slow speed, Flt Lt GILBERT had developed an inappropriate modification to his display sequence, which left little room for error. The current guidance contained in AP 3207 is that only in cases in which there is absolutely no doubt whatsoever should deceased aircrew be found negligent. In this instance, the Board could not positively determine the sequence of events which led to the accident. Furthermore, no evidence was discovered which even hinted at undisciplined or reckless flying. Consequently, the Board considered that Flt Lt GILBERT had made an honest mistake and concluded that he had made an Error of Judgement. The Board recommend that he be absolved from blame in accordance with QR1270(2).

Annex AF & AV

48. Flt Lt Hooper. Flt Lt HOOPER had a responsibility as the co-pilot on the display crew for ensuring that the aircraft was safely configured during each part of the display sequence. He also had a responsibility to monitor

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Flt Lt GILBERT's flying of the sequence and to assist in the orientation and positioning of the aircraft. He would also be responsible for monitoring aircraft speed, height and attitude throughout the display. As the non-handling pilot HOOPER's time would be shared between looking out of the cockpit to assist with positioning, and looking in to monitor speed and configuration. The Board had no evidence to suggest that Flt Lt HOOPER had not advised Flt Lt GILBERT of the very low airspeed at the top of the second dumb-bell manoeuvre. However, the Board considered that in light of the low speeds at which Flt Lt GILBERT had successfully flown the dumb-bell turns during the previous displays at Shearwater, Flt Lt HOOPER would not have expressed any concern, particularly as he would have been aware of the increasing airspeed as the aircraft's nose was lowered below the horizon. The Board further considered that Flt Lt HOOPER had not been trained to recognize the dangers inherent in this manoeuvre, and it is unlikely, therefore, that Flt Lt HOOPER would have had reason to doubt the actions of his experienced captain. The Board concluded that there were no human failings attributable to Flt Lt HOOPER.

Annex AF

49. Sgt Moxham. As the Air Engineer, Sgt MOXHAM had a responsibility for the safe operation of the aircraft's systems, as well as to assist the co-pilot in monitoring aircraft speed, height and attitude. However, the Board considered that, during the final dumb-bell turn, Sgt MOXHAM's attentions were concentrated, in the main, on firing and reloading the Signal Pistol. The Board also considered that Sgt MOXHAM had not received the appropriate training to recognise the inherent dangers of flying the dumb-bell turn at low speeds and concluded that there were no human failings with respect to Sgt MOXHAM.

Annex P

RELEVANCE OF PREVIOUS SERVICE HISTORY

50. The Board examined Flt Lt GILBERT's Service history; nothing of relevance was uncovered. Copies of the last entries on his F5200 are reproduced as Exhibit 3.

Exhibit 3

RECOMMENDATIONS

51. The Board recommends that:

- a. Provision is made for intercom, bank

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angle, Global Positioning System position and time code to be recorded on a suitable crash proof recorder. A similar recommendation was made by the BOI into the accident involving Nimrod R Mk1 XW666 on 16 May 95.

b. The Nimrod display sequence should be reviewed and should include a minimum speed of 180 kts during the second dumb-bell turn.

c. An angle of attack device, with an integral stall warning system which takes into account rates of approach to the stall, is fitted to the Nimrod R MK1 and MR Mk 2.

d. The 2.05G detector fitted to the Nimrod R Mk1 and MR Mk 2 aircraft should be modified to provide a suitable discrete audio warning and should be disconnected from the Stall Warning Lights and Stick Shakers.

e. The ACM Book 3 advice on stalling is reviewed and up-dated, to provide accurate and unequivocal advice on stall and stall warning speeds.

f. A formal training syllabus is developed for Nimrod display crews. The syllabus should include theoretical and practical instruction on stalling characteristics.

g. The supervision of Nimrod display crews is reviewed to include an element of airborne supervision, both before and after ratification.

h. A review is carried out of theoretical and practical stall training for all Nimrod aircrew.

OBSERVATIONS

52. The Board observes that:

a. Medical reports recommend that further attempts are made to educate all aircrew of the dangers inherent in self-medication.

b. Use of the Signal Pistol during air displays may distract the Air Engineer from his primary duties. Therefore, the Board recommends that this practise should cease.

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ACKNOWLEDGEMENTS

53. The Board would like to thank those individuals and agencies detailed at paragraph 23 for their assistance in compiling this report.

President	Redacted S.40 - Wg Cdr A	Wg Cdr
Members	Redacted S.40 - Sqn Ldr B	Sqn Ldr
	Redacted S.40 - Sqn Ldr C	Sqn Ldr
	Redacted S.40 - Flt Lt E	Flt Lt

Date 14 Feb 96

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PART 3

REMARKS BY STATION COMMANDER

INTRODUCTION

1. The Board has carried out a detailed and thorough investigation into the circumstances surrounding the accident involving Nimrod MR2P, XV239. Despite the lack of comprehensive evidence, in particular the absence of voice recordings from a cockpit voice recorder or modern ADR, the Board has met its terms of reference and established the most likely cause of the accident. Furthermore, the Board has provided logical and well considered advice and recommendations for the future.

2. Nimrod Display History. Before reviewing the Board's findings, it is appropriate to consider briefly the Nimrod's display history. The Nimrod has been involved in the display circuit for more than 20 years and, throughout this period, the display sequence has remained largely unchanged. There is little doubt that the Nimrod is a popular combat aircraft at displays, particularly overseas, and in recent times has replaced the Vulcan as the agile "heavy". The number of display pilots selected for each season has varied, but has generally been 3 or 4, with each pilot conducting around 15 displays per season. In addition, each pilot has flown approximately 20 work-up and in-season practices during a display season. Therefore, well over 2000 Nimrod flying displays have been successfully conducted. While the specific display sequence was removed from 18 Gp ASOs over the period from 1984 to 1991, the restrictions imposed on the aircraft by its size and flight envelope have always resulted in a sequence which closely mirrors that detailed in the current ASO. Accordingly, it is reasonable to conclude that the display sequence is well proven and safe when flown correctly.

SELECTION OF NIMROD DISPLAY FLIGHT DECK CREWS

3. Adequacy of Selection Procedure. I support the Board's conclusion that the selection of the display flight deck crews for the 1995 season was carried out in accordance with current 18 Gp ASOs. However, the selection process is rarely easy, particularly given the current decline in crew experience levels, the effect of postings and squadron workload. These factors led to changes to the initial 206 Sqn flight deck crew combination, with the inclusion of S.40 - Sqn Ldr AM as display pilot. In addition, the NOCU crew nomination, with S.40 - Sqn Ldr AL as display pilot, was withdrawn. This latter decision was taken because S.40 Sqn Ldr AL had a particularly heavy workload, but more importantly, it was felt that a third consecutive season as display pilot might have led S.40 - Sqn Ldr AL to become

3 - 1

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overconfident. These changes typify the rigorous scrutiny that is undertaken and serve to illustrate that crew compositions are considered carefully at every level of the command chain. I agree with the Board's finding that the crew selection procedure was not a factor in this accident.

4. **Adequacy of Crew Experience.** Like many previous Nimrod display pilots, Flt Lt GILBERT held an 18 Gp B category (an above average standard) and was also an authorised checking officer (ACO), an appointment similar to a sqn QFI. Moreover, he was a qualified fighter affiliation pilot and, in this role, would have flown the aircraft using evasion manoeuvres in a flight regime just as demanding as the flight profile in the standard Nimrod display. However, whilst Flt Lt GILBERT's ability as a Nimrod pilot was not in doubt, he had no previous experience of display flying and, more importantly, had little experience of stalling the aircraft outside the simulator. What stalling experience he did have would certainly not have included stalling the aircraft in the turn or in the 20 flap configuration. Notwithstanding his limited stalling experience, I consider that Flt Lt GILBERT was adequately experienced to enter training as a display pilot. Whilst Flt Lt HOOPER and Sgt MOXHAM were relatively inexperienced when compared with their counterparts over the last 4 display seasons, the Board highlighted that they were by no means the least experienced aircrew to have been selected. Indeed, Sgt MOXHAM was an experienced and highly capable glider pilot and CFI, whilst Flt Lt HOOPER was an above average co-pilot who had also flown as an authorised rear-crew member on the 120 Sqn display crew for the 1994 season. Another major consideration was that the flight deck crew were known to work well together as a team. The combination of all these factors led me to conclude that the 120 Sqn flight deck crew had sufficient overall experience to be nominated for display duties.

5. **Minimum Experience Levels Required for Display Flying.** The Board discussed whether minimum levels of experience should be considered in the selection process. I support the view that stipulation of minimum experience levels (flying hours) would be overly restrictive and could remove any flexibility for stn and sqn cdrs to select display crews from already established teams on the basis of their proven ability as aircrew and their ability to work together. Although not discussed by the Board, I also consider that it is unnecessary to stipulate that both pilots should be filling designated first pilot appointments. All Nimrod pilots are trained to first pilot standard on the NOCU course and, once again, this stipulation would mean that an already constituted flight deck crew, with proven ability to work together, could not be nominated for display duties. In sum, it is ability as much as experience that counts and I support the Board's finding that the individual and collective experience of

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the 120 Sqn flight deck crew was not a factor in this accident.

6. **Minimum Required Crew for Display Flying.** The Nimrod minimum crew has been questioned on a number of occasions and it has always been concluded that 7 is a sensible and practical minimum. Even assuming the aircraft can return to base and land quickly, a cabin fire or underfloor emergency, if allowed to go unchecked, could result in a rapid build-up of smoke or fumes in the fuselage. Moreover, with the limited visibility offered by the Nimrod, the extra lookout and positional information afforded by 2 beam lookouts can be invaluable during displays. Taking these factors together, I agree that there should be no change to the minimum crew requirement.

TRAINING OF NIMROD DISPLAY FLIGHT DECK CREWS

7. **Absence of Syllabus of Training.** The Board highlighted that no syllabus of training for display flying exists and, with hindsight, I agree that this was a factor in the accident. Such a syllabus should be implemented and should be wide-ranging, covering topics such as stalling and aerodynamic theory.

8. **Airborne Training.** Flt Lt GILBERT was flying his 40th airborne display routine of the 1995 season (26 practices and 14 displays) and was, thus, well familiar with the display sequence. However, despite the existence of a well practised training regime which included discussion on display flying theory and technique, and the opportunity to carry out a supervised stall in the clean configuration, the Board correctly identified that the dangers associated with manoeuvre stall may not have been adequately understood by Flt Lt GILBERT and his crew.

9. **Simulator Training.** Under existing arrangements, display crews rehearse in the Nimrod Dynamic Simulator (NDS) and additional serials are made available if required. Flt Lt GILBERT had flown 2 NDS serials prior to deploying to Toronto, both of which included a serious simulated emergency during the second dumb-bell manoeuvre; these emergencies were handled well by the crew. Since the principles and recognition of manoeuvre stall could easily be taught and demonstrated in the NDS, I consider that additional NDS sorties should be flown as part of an enhanced training package.

10. **Techniques Taught.** S.40 - Sqn Ldr AL was an experienced display pilot and the technique he taught for flying the second dumb-bell manoeuvre with a target speed of 150 kts was inherently safe, allowing sufficient safety margin between target airspeed and the manoeuvre stall speed. However, while Flt Lt GILBERT had clearly used a similar technique during his early displays, he may have been seduced into reducing the target speed to negate a perceived

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excess of energy at the top of the dumb-bell climb. In doing so, he would have reduced the safety margin to a critical level. Alternatively, Flt Lt GILBERT could have been aiming for a target speed of 150 kts and had, perhaps, not retained sufficient flying accuracy on the day. In any event, had the target speed for the dumb-bell been 180 kts, as stipulated in the 18 Gp ASO which was removed in 1984, it is almost certain that the aircraft would not have stalled.

11. **Overall Adequacy of the Training System.** As had become standard practice, all the 1995 season display pilots were trained and supervised during their initial displays by an experienced display pilot. Historically, this positive handover of skills, combined with the experience levels of the nominated pilots and the strict and regular regime of practice and currency displays, led to a formal training syllabus being considered as unnecessary. With hindsight, it is now clear that display flying techniques can evolve over the season and specific checks are not in place to eradicate dangerous deviations from the initial methods taught. Moreover, while it is impossible to cover all eventualities, Nimrod pilots are currently not required to cover theory relating to problem areas, such as stalling, which may be experienced during display flying. Stalling was clearly the cause of this accident, but a relatively routine aircraft emergency, or perhaps a control restriction during a critical moment of a manoeuvre, could be just as serious. Thus, while I agree that stalling should be comprehensively covered during display work-up, it should be covered as part of a comprehensive aircraft handling package. The NDS is an excellent training facility and I consider that mandatory simulator exercises should be included as part of the work-up and continuation training schedule. These sessions should be overseen by a display supervisor who would act as "mentor" during the season, and should include all of the major aircraft handling emergencies (stalling, flying control failures, engine failures etc). In addition, a review of the aerodynamic theory involved with display flying should be covered before training commences. All of the above should be covered by a formal training syllabus. In sum, I agree that overall training was inadequate and was a factor in the accident.

SUPERVISION OF DISPLAY FLYING

12. **Adequacy of Supervision.** Within the current regulations, I am satisfied that Flt Lt GILBERT'S display flying was overseen by appropriately qualified and experienced supervisors who had been correctly briefed. However, while I agree that increased supervisory checks are necessary as a result of the accident, I have some concerns about the Board's recommendation that airborne supervision should be introduced. Airborne supervision might

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place an extra burden on a display pilot and, more importantly, this supervision could not be conducted satisfactorily from the co-pilots seat, since any display co-pilot is always fully occupied in a supporting role. Moreover, use of the 3rd pilot's jump-seat inhibits the flight engineer's movement and, arguably, would be an unwise practice during display manoeuvres. Thus, while airborne supervision may have identified the development of an unsafe flying technique, this could equally have been identified by supervised practices in the NDS and the use of Central Tactical System (CTS) tape strips to examine parametric data. I consider that the use of the NDS and CTS tape strips should become a routine part of the monitoring and debrief system during a display pilot's work-up and in-season training.

13. Awareness of Supervisory Team. All members of the supervisory team had a good rapport with the 1995 display pilots and I am confident that Flt Lt GILBERT, in particular, would have felt able to approach the supervisory team. The Board highlighted that Flt Lt GILBERT had expressed no concerns to his supervisors and it was not until early August, following a display practice at Kinloss and a subsequent display at Sunderland, where he flew slightly through the display line, that he developed his slow speed technique for the second dumb-bell manoeuvre first used at CFB Shearwater later in the month. Flt Lt GILBERT was already in Canada by this stage and, accordingly, as the supervisors were not aware of any problems experienced by Flt Lt GILBERT, I agree that the supervisory team were not at fault.

14. Use of Non-pilots in the Supervisory Chain. The Board did not specifically address whether it was appropriate to use navigators in the display flying supervisory chain. I do not consider this to be a factor, since the normal supervisory chain includes navigator or, indeed, AEO flt cdrs, sqn cdrs and stn cdrs as full authorising officers and supervisors. For obvious reasons, the supervision of display work-up and continuation training is always undertaken by a suitably qualified senior pilot. It would, of course, be possible to delegate all display supervision and authorisation to a senior pilot, but, eventually, this would cut-across the Stn Cdr's absolute responsibility for all aspects of flying supervision and authorisation. S.40 - Sqn Ldr L was a flt cdr with full authorising powers and was also the normal first navigator on Flt Lt GILBERT's crew; thus, he knew the crew extremely well and was a suitable choice to command the detachment. The Board did not mention that S.40 - Sqn Ldr L had also flown as a display crew navigator during a previous tour on 206 Sqn and had also flown 3 displays as navigator with Flt Lt GILBERT; thus, he was well familiar with the display routine. Moreover, during Flt Lt GILBERT's last practice at Kinloss, S.40 Sqn Ldr L viewed the display with OC 206 Sqn and was briefed on

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the specific areas of the display to monitor closely. Therefore, although he was a navigator, **S.40 - Sqn Ldr L** was familiar with the display sequence and was aware of the possible pitfalls in flying the display. The current 18 Gp ASO allows a Nimrod display pilot to self-authorise when flying an overseas display, but this is rarely done. The practice of always including a flt cdr as an authoriser on overseas displays was implemented at Kinloss to ensure that another safety check was in place and, more importantly, to ensure that the display pilot was not pressurised by display organisers; in this way the display pilot is left free to concentrate on the flying aspects. I recommend that the 18 Gp ASO is regularised to reflect the requirement for a flt cdr or sqn cdr to supervise and authorise overseas displays.

THE NIMROD DISPLAY SEQUENCE

15. **Aircraft Configuration.** The Board established that the aircraft's C of G was well within limits for the display and that removal of the FAP would have had a negligible effect on the stalling speed. I support the view that all extraneous equipment should be removed from the aircraft before display flying.

16. **Adequacy of 18 Gp ASO and Other Documents.** While 18 Gp ASOs stipulate that 1000 ft is the maximum height for the dumb-bell turns, I agree that Flt Lt GILBERT's climb to 1400 ft was insignificant on this occasion. However, it is arguable that, had he levelled at 1000 ft, the aircraft's speed would have been higher. While this may be true, it is likely that Flt Lt GILBERT had planned to fly the turn at slow speed and would probably have throttled back earlier in an attempt to achieve his target speed. Therefore, I am content that the height reached was not a factor. Conversely, had 180 kts been stipulated as a target speed, I believe that Flt Lt GILBERT would have flown to this speed and it is most unlikely that the aircraft would have stalled. Therefore, the absence of a target speed in 18 Gp ASO's must be seen as a factor in the accident. With hindsight, this was an omission, but I do not support the Board's view that blame should rest solely with the 18 Gp Air Staff. This was undoubtedly an organizational fault and the responsibility should be shared at all levels from HQ 18 Gp down to the individual display pilots involved over many years. Finally, I support the view that the Aircrew Manual Book 3 guidance on stall warning speeds is confusing and misleading and should be improved.

FLIGHT DECK CREW COMPETENCY

17. **Crew Competency.** Flt Lt GILBERT's record speaks for itself; as a B category, ACO and fighter affiliation qualified pilot, there could have been few sqn line pilots at Kinloss better qualified to enter training as a display pilot. His co-

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pilot, while relatively inexperienced on the Nimrod, had a high degree of airmanship, crew co-operation and handling ability and was recognised as one of the best co-pilots on 120 Sqn; moreover, he and Flt Lt GILBERT worked well as a team. Similarly, Sgt MOXHAM was a good air engineer who also worked well with his pilot team; he was also an experienced and highly capable glider pilot and chief instructor. While the co-pilot and air engineer were relatively inexperienced on the Nimrod, they were nearing the end of a full display season and had considerable display experience to draw upon. In sum, the handling pilot was well above the average and, with a fighter affiliation and ACO qualification, he was knowledgeable and well qualified in those areas requiring pure piloting and airmanship skills. I am satisfied that all 3 members of the flight deck crew were competent to undertake display duties.

18. **Planning and Briefing.** Flt Lt GILBERT and his authorising officer attended the CIAS main brief and were satisfied that the airshow organisation was sound. Flt Lt GILBERT then briefed his authorising officer on the actual display procedure and satisfied the latter that his intentions and planning for the display on the day in question were sound. In addition, Flt Lt GILBERT briefed his crew on his intentions for that particular display, including visual references and crew duties. Moreover, the subsequent ground radar track indicated that Flt Lt GILBERT had made due allowance for the slight component of on-crowd wind and it is, therefore, likely that wind corrections had also been carefully briefed. In locations with limited crew briefing facilities, it is not unusual for crew briefings to be carried out in the aircraft galley area before flight. The galley area is the only area in the aircraft where the crew can gather around a table with sufficient room to display maps and other briefing material. Briefings conducted in this manner are no less professional than those conducted in normal briefing facilities. Moreover, the flight engineer is invariably preparing the aircraft for flight during the main briefings and an on-aircraft brief is the only sure method of bringing the complete crew together in relative quiet, and with all the necessary briefing details, before commencing a display. I am content that the sortie was well briefed and correctly authorised, and that each crew member was fully aware of his responsibilities.

STRUCTURAL/TECHNICAL FAILURE AND DISTRACTION

19. **Structural/Technical Failure.** While there is no evidence to suggest that a structural or technical failure contributed to the accident, such a failure, or indeed a transient technical failure, cannot be positively ruled out. Similarly, the aircraft may have suffered a birdstrike at a critical stage which was undetected by the photographic or technical evidence.

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20. **Distraction.** Flt Lt GILBERT was nearing the end of a full display season and it is unlikely that a minor distraction would have led to the low speed at the top of the dumb-bell; however, in the absence of any cockpit voice recordings, I agree that the possibility of distraction by a system or instrument malfunction cannot be completely ruled out.

AIRCRAFT HANDLING AND TECHNIQUE

21. **Relevance of On-Crowd Wind Vector.** Flt Lt GILBERT had dealt satisfactorily with on-crowd wind components of up to 20 kts during his display work-up training. The ground radar plot at Toronto indicated that he had made due allowance for the small on-crowd wind at Toronto (approx 10 kts) and I agree that the wind was not a factor in this accident.

22. **Use of Signal Pistol.** I support the Board's view that the signal pistol was probably operated by the flight engineer in the normal manner. However, while 18 Gp ASOs do not prohibit the use of the signal pistol during the dumb-bell manoeuvres, such use is not part of the recognised display sequence. Moreover, repeated use of the pistol requires the air engineer to unstrap temporarily from his seat to carry out a reload. While this in itself is not a problem, it would distract the engineer from his primary duty of monitoring system indications and acting as an extra pair of eyes. Moreover, had the engineer dropped a live cartridge during the reload process, it could have caused a distraction at a critical stage. There is no evidence to suggest that this occurred; hence, I agree that the operation of the signal pistol was probably not, in itself, a factor.

23. **Handling and Technique.** Having allowed the aircraft speed to fall to 122 kts during the dumb-bell turn, it is not surprising that Flt Lt GILBERT instinctively trimmed the aircraft to relieve the control loads. Indeed, trimming into all turns is standard practice on the Nimrod. Given the exaggerated nose up trim setting, the onset of G as the speed increased would have been more rapid than he was used to and possibly would have led him to believe initially that the stick shakers were operating as a result of the G switch and not manoeuvre stall. Moreover, the trim setting would have reduced the pull required to achieve the desired turn rate and, given a normal pull force on the control column, may have further exacerbated the rate at which the G increased. Therefore, a combination of the high nose up trim, and even a small nose up control movement, would have induced a stall. While there is little that can be done to prevent such trimming, and a higher target speed would have negated the effect, I agree that the trim position was an additional contributory factor.

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24. **Post-Stall Recovery Action.** The standard stall recovery on the Nimrod requires the aircraft nose to be lowered sufficiently to ensure that the wings are unstalled and to stop the stall warning, and a simultaneous application of full power. I agree that the evidence shows that the correct recovery action was taken almost instantly; however, insufficient height remained to recover from the nose and wing drop and an impact with the surface was inevitable.

CONSIDERATION OF HUMAN FAILINGS

25. **Supervisory Chain.** The display crews for the 1995 season were selected, supervised, trained, authorised and briefed in accordance with current 18 Gp ASOs. The primary pilot display supervisor and his nominated deputy had both previously flown and supervised display work-ups. Although with hindsight, both might have considered viewing display practices in the NDS, neither considered airborne supervision as an option as this was not recognised practice. The supervisors had been fully briefed on their responsibilities and had carried out their duties methodically and conscientiously. Similarly, **S.40 - Sqn Ldr L** was fully briefed on the display sequence and carried out his supervisory duties in strict accordance with regulations and my own directive. The personal briefing given to the selected display crews by the AOC 18 Gp was a mark of the importance in which the whole supervisory chain regarded display flying and I support the Board's finding that no blame should be attached to the supervisory chain.

26. **HQ 18 Gp Staff.** The Board found that HQ 18 Gp staff over many years had failed in their responsibilities. Firstly, they failed to provide sufficient guidance on the training required for display flying and, secondly, they failed to provide an adequate training syllabus. Finally, the Board found that the 18 Gp staff had failed to amend 18 Gp ASOs to include a target speed for the second dumb-bell manoeuvre. While all these failings have been rightly identified, I do not agree that the responsibility was HQ 18 Gp's alone. These failures result from an organizational fault and must be shouldered by everyone involved in the process over many years of Nimrod display flying.

27. **Flt Lt GILBERT.** As he commenced the Toronto display, Flt Lt GILBERT was in current display practice and had the benefit of almost a full season of display flying behind him. While the DARU data taken from the 2 displays flown at CFB Shearwater shows that he had previously flown the second dumb-bell manoeuvre at slow speed, he would have had no specific warning that he was placing the aircraft close to the edge of its manoeuvre envelope. Therefore, the possibility of a sudden departure from controlled flight, which he ultimately experienced, would have been far from

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his mind. Nevertheless, Flt Lt GILBERT took every precaution to ensure he produced a safe and competent display. He was well rested, had briefed his crew carefully and comprehensively on their duties, and had satisfied his authoriser that he was competent and capable of conducting the display. However, in flying the aircraft slowly during the second dumb-bell manoeuvre without applied power he had, unknowingly, degraded his safety margins to a dangerous, and in this case, fatal degree. Given his thoroughly professional overall approach, it is likely that Flt Lt GILBERT had considered the implications of the speed change and had judged that, with 20 flap selected, his safety margins were adequate. Therefore, I support the Board's view that Flt Lt GILBERT was not negligent, but made an error of judgement.

28. **Remaining Flight Deck Crew Members.** The co-pilot was in a good position to monitor aircraft handling during the display and may have become familiar with seeing a low speed during the second dumb-bell turn. Therefore, assuming he had noticed the airspeed decay to 122 kts, it could have been some time before he thought to make a verbal warning. Given the rapidity with which the incident developed, it is highly unlikely that any such warning would have been effective. The engineer or navigator could also have warned the pilot of his excessively low airspeed and, indeed, may well have done so; however, given the engineer's involvement with the signal pistol and the navigator's limited attitude reference, such a warning would have been unlikely. Overall, therefore, I support the view that there are no human failings attributable to the remaining crew members.

SCHOOL OF AVIATION MEDICINE (SAM) REPORT

29. The School of Aviation Medicine (SAM) Aircraft Accident Investigation Report 14/95 (Annex Y to the BOI Report) arrived too late to be included with the main body of the Part 2. In the SAM Report I note that the quick release fastener (QRF), as fitted to the first pilot's restraint harness, did not comply with the specification for restraint harnesses and QRFs laid down in Def Stan 00-970. The harness and QRF as fitted to the new IPECO pilot's seat on the Nimrod are being replaced under the direction of SM60(RAF). Accordingly, SM60(RAF) should be tasked to investigate the provision of restraint harnesses and QRFs which conform to the requirements of Def Stan 00-970.

RECOMMENDATIONS

30. I have the following comments regarding the Board's recommendations:

- a. **Accident Recorder.** The Nimrod is likely to remain in

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service until 2006; hence, I support the recommendation to provide a modern accident recorder for the aircraft.

b. Display Sequence. The display sequence has been reviewed at Station level and recommendations, including a minimum airspeed of 180 kts for the second dumb-bell manoeuvre, have been sent to HQ 18 Gp.

c. Stall Warning System. While an improved stall warning system, incorporating rate of approach to the stall, would be beneficial during displays, its use during routine flying operations would be limited. Moreover, given the suggested amendments to the display sequence, it is extremely unlikely that a stall could cause a future display accident. I support a relatively inexpensive modification to de-couple the 2.05 G switch from the normal stall warning (and replace it with an audio warning), but an extensive modification to the stall warning system is probably inappropriate and unnecessary.

d. Aircrew Manual Book 3. I support the recommendation that a thorough review of the stalling advice offered in the Aircrew Manual Book 3 should be undertaken.

e. Training. I support the recommendation that a formal training syllabus for display flying should be implemented and that the training package should include theoretical and practical instruction on stalling techniques. However, the training package should also include advice on dealing with all major emergencies and failures that could occur during the display sequence and these should be practised in the NDS.

f. On-Board Supervision. I do not wholly support the recommendation calling for the inclusion of an element of on-board supervision. Increased use of the NDS to check display technique, and use of the CTS strip as a diagnostic tool, would, in my opinion, be a safer and less problematic method of ensuring consistency of technique during the season.

g. Review of Stalling Training. While I support the need for a review of stalling training, particularly with regard to display flying, it should be noted that current NOCU training undertaken by pilots is based on scenarios which might be encountered during routine flying operations. This requirement remains valid and, given the high fatigue penalty involved in stalling practice, a review is unlikely to justify the need for major change. However, stalling in the simulator, while not entirely realistic, could

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certainly be made more rigorous.

h. **Trimming During Displays.** I support the recommendation that Nimrod display pilots are warned of the dangers of trimming to low speeds during the display. However, a practical method of applying a restriction would be difficult. Moreover, providing the target speed during the second dumb-bell is 180 kts, any instinctive trimming carried out would not be a problem.

j. **Extraneous Equipment.** I support the recommendation that all extraneous equipment should be removed from the aircraft prior to display flying.

k. **Minimum Crew.** I support the recommendation that there should be no change to the minimum crew requirement.

l. **Use of Signal Pistol.** Provided the signal pistol is loaded before commencing the display sequence and only fired once during the final pull up manoeuvre, its operation is a safe and sensible part of the overall display sequence. 18 Gp ASOs should be amended to prohibit firing of the signal pistol at any other stage of the display.

ADDITIONAL RECOMMENDATIONS

31. I offer the following additional recommendations for consideration:

a. **Supervision of Overseas Displays.** The current 18 Gp ASO dealing with authorization (Annex A to Chapter 4 Order 0401) should be amended to prevent captains self-authorising overseas displays.

b. **Quick Release Fastener (QRF) Modification.** Restraint harnesses and QRFs fitted to the cockpit crew seats should conform to Def Stan 00-970.

CONCLUSION

32. This has been a difficult Inquiry, but I consider that the Board has completed a thorough and painstaking investigation into the fatal accident involving Nimrod XV239 at the Toronto International Airshow on 2 Sep 95.

33. Although the training methods and supervision practices for display flying have been used successfully over many years, the Board has identified weaknesses in these areas along with

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shortfalls in the aircraft stall warning system and confusing Aircrew Manual advice on stalling. Moreover, the absence of a cockpit voice recorder or modern ADR on the Nimrod means that the full circumstances behind the tragedy will never be known. Therefore, I support the finding that Flt Lt GILBERT made an error of judgement in allowing the airspeed to decay to 122 kts during the second dumb-bell manoeuvre. It is clear from the evidence gathered that the crew performed in a professional manner throughout, but failed to appreciate the late development of a major flaw in their display technique. The Board has made recommendations which, if implemented, would allow the Nimrod to be returned safely to the display circuit.

Redacted S.40 -
Gp Capt AN

28 Mar 96

Part 4**REMARKS OF AIR OFFICER COMMANDING**

1. Given the available weight of evidence, I agree that the aircraft was serviceable to undertake the flight and believe that we are able to reconstruct the events that led up to this tragic accident; however, without the irrefutable evidence of a modern ADR or CVR, any absolute conclusions drawn from the last few seconds of XV239 would be unsafe. I am therefore forced to agree with the Board's findings that Flt Lt GILBERT made an Error of Judgement in developing an inappropriate modification to his display sequence. It was this Error of Judgement which ultimately led to him flying the dumb-bell manoeuvre at a very low speed that left no margin for error and subsequently led to the stall and departure from controlled flight. Accordingly, I also agree with the Board that the cause of the accident was as the result of the aircraft stalling at a height from which, as flown, it was impossible to recover; although it is possible that, had Flt Lt GILBERT taken timely and appropriate stall recovery action at the first signs of stall warning, the accident may never have happened. I will return to this later.

2. I am conscious that, in reviewing this Board of Inquiry there have been over 2000 successful Nimrod flying displays during the past 20 years and thus it is entirely reasonable to conclude that the practices that have evolved have been seen as acceptable and logical at all levels; indeed, it was the benign nature of the display that was so dangerously seductive. Therefore, while I agree with many of the conclusions made by the Board, I disagree with their findings with regard to the adequacy of the selection process and, closely allied to this, the experience levels of those aircrew employed on displays. Further, I consider that the stall recovery action was a significant contributory factor in the accident.

HANDLING AND TECHNIQUE

3. Before discussing the handling aspects of the accident and examining the technique used, it is important that we review the evidence available on the final fateful seconds of the flight and establish an accurate sequence of events.

4. **Sequence of Events.** The aircraft had flown an unremarkable, initial portion of the display sequence. At the point of entry into the second dumb-bell manoeuvre the aircraft was turned onto a heading some 75 deg off the display line and pitched up in 2 stages to a maximum of 24 deg, as the aircraft passed 950ft the power was reduced to a setting just above flight idle on all 4 engines. At this point the IAS began to decay very rapidly below the assumed (and taught) target speed of 150 kts. At 1000ft the aircraft rolled into a port

turn with the IAS continuing to decrease to 122 kts (at which speed it stabilised for 5 secs) while the ac elevator was trimmed to the 10 deg nose up position (a trim position that equates approximately to 122 kts). As the nose of the aircraft dropped through the horizon and the speed began to increase, a further 3 deg nose up pitch was applied to the elevator just before the predicted stall warning point. With the application of elevator, and despite the moderate increase in IAS, the subsequent increase in G loading led to the predicted and actual stall point some 2.5 secs after the stall warning should have occurred. The aircraft then departed controlled flight and the aircraft nose and port wing dropped rapidly. At the point of stall it is apparent that full opposite aileron and full power were applied, although there is **no** forward movement of the elevator for a further 2 secs, and even then the movement appears to be consistent with relaxation to the trimmed position rather than a positive unloading. At this point the aircraft has radically departed from controlled flight and it is reasonable to assume that the subsequent application of maximum up elevator is an instinctive reaction to the proximity of the water. The evidence from both the DARU trace and video shows a progressive increase in both nose down pitch and roll angle until, it is assumed, with increasing airspeed the wing unstalled and an element of control was regained. At this point the DARU predicted stall speed and actual IAS can be seen to be convincingly divergent and the aircraft pitch and roll attitude is starting to improve; moreover, the video evidence supports the DARU indications. Therefore, I am convinced that the aircraft remained stalled until some 3-4 secs before impact.

5. **Handling Aspects.** Having established that the aircraft stalled and failed to recover at the time postulated by the Board, further examination of the stall recovery action was required. My major concern was the apparent lack of an early positive attempt to carry out the full stall recovery actions. The Board has established that Flt Lt GILBERT should have received stall warning indications at time 218.5 secs (on the DARU trace) and the initial point of stall was at 221 secs (9 secs before impact). However, while full power and full opposite aileron were applied at the point of the stall, it is a further 2 secs before any release of elevator back pressure is evident. Beyond this point I accept that the situation was irrecoverable. The absence of other information is significant but, most importantly, I find it hard to comprehend the crew's apparent lack of appreciation of their deteriorating situation or the delayed reaction by the handling pilot. Thus, while the possibility that an undetected problem with the stall warning sensors cannot be discounted (AAIB evidence only suggests that the 2 independent warning indicators were serviceable prior to impact), I believe that a further and significant contributory factor was that, for whatever reasons, the pilot failed to carry out appropriate and timely stall recovery action, when stall warning from both stick shakers and stall warning lights should have alerted him some 2.5 secs before the stall.

6. **Trimming.** Trimming is an instinctive and necessary technique for all Nimrod pilots during manoeuvres, and in this situation the extreme position of the elevator would have made recovery action more difficult but not impossible. Therefore, I agree with the Board that it was a contributory factor and I endorse the Board's recommendation that future Nimrod Display pilots are warned of the inherent dangers of trimming to low speeds during the display sequence.

7. **Technique.** The Board has established that Flt Lt GILBERT and his flight deck crew had discussed their perceived problem with the second dumb-bell between their first and second display at Sunderland. The problem was quantified as excess energy at the top of the manoeuvre which was ascribed as the major reason for a display line violation during the first display. The captain's solution was to reduce the energy level and the other members of the flight deck crew did not contradict the suggestion of an early reduction in power. It is evident that at no stage did the crew highlight their problem or discuss their proposed solution with anyone in a supervisory position. The first evidence that the crew had modified their display sequence is found in the DARU information from the second display at Shearwater, where an early reduction in power is apparent. This trend was continued at the third Shearwater display and finally, with fatal consequences, at the CIAS display at Toronto, where this early reduction in power was accompanied by a marked increase in pitch. The table at fig 1 details the data stripped from the DARU at the relevant airshows and emphasises the step change that occurred at Toronto.

	SHEARWATER DISPLAY 2	SHEARWATER DISPLAY 3	TORONTO CIAS
MAX ALT (ft)	1600	1425	1450
PWR OFF ALT (ft)	1250	1100	950
MIN IAS (kts)	138	138	122
MIN RPM (%)	78	77	77
MAX PITCH (Deg)	21	20	24
MAX 'G' BELOW 140 kts	1.25	1.4	1.6

Fig 1

The technique the crew had developed was clearly flawed in a number of areas. A high nose attitude and low power setting would inevitably lead to a rapidly decaying IAS; subsequent aerodynamic loading, either through pilot input or as a result of the trim position, would result in the aircraft being placed on, or close to, the stall boundary. In this specific case, the aircraft slowed to a

minimum of 122 kts (3 kts below the GASO stated absolute minimum speed for display of VAT + 5 (calculated at 125 kts), 16 kts slower than previous displays and 28 kts slower than the technique taught, and was then aerodynamically loaded with disastrous consequences.

8. **Nimrod Display Sequence.** The certified Nimrod display sequence is, in effect, a series of flypasts linked by representative operational manoeuvres. Flown correctly it is not an especially demanding exercise and well within the aircraft limits and flight envelope; however, display flying brings with it its own unique pressures which test the mettle of aircrew involved. However, examination of the extant GASO reveals 2 elements of poor advice in the second dumb-bell manoeuvre recommended technique. Firstly, although the technique demonstrated to Flt Lt GILBERT was inherently safe, the lack of a minimum speed or gate is most certainly a contributory factor in this accident. Secondly, the reference to applying full power momentarily at the beginning of the dumb-bell is misleading. The lack of a minimum IAS for this manoeuvre and the reference to momentary application in power may have seduced Flt Lt GILBERT into developing his flawed technique; the GASO sequence has been withdrawn pending complete review.

SELECTION AND EXPERIENCE OF NIMROD FLIGHT DECK DISPLAY CREWS

9. I agree with the Board that the selection procedure for display crews was carried out in a thoroughly professional and conscientious manner although it is self evident that the final judgement on crew suitability was flawed. Up to and including the 1995 display season, it had been the norm to select a crew from each and every operational sqn in order to meet the large number of display commitments, whilst the display crews maintained their operational currency. The emphasis was placed on recommending, albeit implicitly, a constituted crew that was seen to be both capable and harmonious. Against these criteria, I agree with the assessment that Flt Lt GILBERT and his crew were suitable candidates for selection. However, the demands and pressures of display flying are significantly greater than routine operational flying and the calibre and experience of the display aircrew must be assessed against a wholly different, and more stringent, criteria. Whilst Sqn constituted crews represent a cross-section of experience within the sqn and are carefully balanced, to limit the display selection field by taking a constituted crew from every sqn was wrong. Therefore, I conclude that the crew selection procedure was a factor in the accident and disagree with the Board.

10. Inextricably linked to the selection procedure is the experience levels of the Nimrod display flight deck crews, and, in reviewing the composition of this particular flight deck, one is struck by the presence of 2 first tourists in this

vital area. I agree with the Board that display crews must be selected on their proven ability as aircrew but this must be balanced with experience. Annex BE to the reconvened Board details the experience levels of those crews nominated for display duties from 1991 through to the present day. However, further investigation by my staff has revealed that the table does not reflect the changes ordered by the then AOC 18 Gp to 5 of the 19 crews, and in each case a more experienced crew member was substituted. Thus, although no rules were laid down, it is apparent that experience was considered an important factor in the past and that Flt Lt GILBERT's flight deck crew were cumulatively one of the least experienced crews to have displayed the Nimrod.

11. I firmly believe that a more experienced co-pilot or air engineer would have at the very least questioned the modification in display technique and would, almost certainly, have demanded corrective action at a stage which could have prevented the accident - conversely, the co-pilot and engineer may have done so but because of their inexperience it is possible that the captain did not give due weight to their warnings. Thus, I conclude that individual and collective experience did affect the outcome of this accident and was, therefore, a factor.

TRAINING

12. **Pre-Season Training.** I agree that the training Flt Lt GILBERT and his crew received was, with hindsight, inadequate. Whilst a supervised work-up programme was carried out, the lack of a prescribed, formalised syllabus of both air and ground training, allowed GILBERT and his crew to embark on their display season without a solid base on which to develop safely their technique; more formalised training may have prevented the inappropriate modification to the flying of the second dumb-bell. I have instituted a review of pre-season display training, to provide a mandatory syllabus which will be contained in my GASOs.

13. **Stall Training.** While I believe additional stall training is necessary before commencing a display season, I am convinced that the regime into which the aircraft entered prior to this accident would be familiar to any RAF pilot. All Service pilots undergo extensive stalling training at BFT/AFT and should, thus, glean a healthy respect for, and an appreciation of, stalling. I accept that the pilots in this accident would have had no exposure to fully developed manoeuvre stalls in the Nimrod because they are never carried out due to the unpredictability of the handling characteristics in such a large aircraft and the significant impact on the aircraft fatigue life. Yet, all Nimrod pilots undergo a comprehensive syllabus of unaccelerated stalls on their conversion or refresher courses on the NOCU. Furthermore, all current Nimrod pilots are required to undergo mandatory stall refresher training every 6 months in the dynamic simulator. Therefore, while there is clearly the need for a formalised

Syllabus for display pilots, I believe there is already in place a robust training regime which caters for the routine operation of the Nimrod, and that front line pilots are aware of the symptoms and warnings of an imminent stall and that they are practised in the correct recovery technique.

SUPERVISION

14. The supervision of Flt Lt GILBERT during the work up, ratification and execution of his display duties was meticulous and consistent with the procedures developed within the Gp over a number of years. Furthermore, all elements of supervision have been shown to have conformed with extant regulations. However, with hindsight, the Board has rightly identified that supervision was a factor. The introduction of a mentor into the supervisory chain, who would train and monitor progress at all phases of the season, in the air and on the ground, is a necessary and practical improvement. An on-board supervisor could safely carry out his duties from the flight deck jump seat in its rear position, without interfering with the Air Engineer's primary monitoring duty. The seat is a recognised crash position with access to oxygen and intercom and is regularly utilised by the QFIs on the NOCU during conversion sorties. Moreover, this Inquiry has revealed that the ground observer is unable to identify anything other than blatant errors of technique; thus, I agree with the Board that on-board supervision should be introduced and that this should be supported by video debriefing, CTS tape strips and supervised NDS sorties. However, from available evidence it must be noted that Flt Lt GILBERT developed his modified technique at a late stage in the display season when he was overseas and, therefore, away from the normal supervisory chain. Consequently, even these measures may not have prevented this accident.

15. The presence of non-pilots in the supervisory chain was not a factor in this accident. At all stages in the display flying process the non-pilot supervisors sought counsel from suitably qualified senior pilots, allocated them an appropriate level of delegated responsibility and provided firm guidance. The issue of overseas authorization is clearly addressed in STCASIs and I see no merit in revising this procedure. However, I strongly support the Stn Cdr's policy of sending a suitably qualified fit cdr on overseas display deployments with the primary role as detachment commander and protecting the display crew captain from inappropriate external pressure.

OTHER FACTORS

16. The Board has examined a number of other possible factors which may have affected the outcome of this accident, including:

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- a. **Competence.** Within the narrow confines of the IFS definition of competence there is no doubt that the crew were competent to undertake the sortie. However, I will return later in my remarks to the competence of the crews' actions that led to the accident.
- b. **Fitness.** I accept that the crew were fit to undertake the flight. However, I am concerned that there is evidence of self-medication by a number of the crew although specialist medical evidence has established that it was not a factor. It is therefore appropriate for all RAF aircrew to be reminded of the legitimacy and hazards associated with self-medication.
- c. **Planning, Briefing, Weather, Incapacitation, Disorientation and Distraction.** The crew prepared meticulously for the sortie and conducted a thorough brief in a logical manner and at a sensible place. The weather was almost ideal and the presence of a 10 kt on-crowd wind component was not beyond the demonstrated capability of Flt Lt GILBERT. The Board states that all pathological and video evidence shows that both pilots were making control inputs up until the point of impact and I am content to support their assertion that incapacitation is an unlikely factor in this accident. The investigation into the possibility of either disorientation or distraction being factors is thorough, and I endorse the Board's finding that except for a possible system or instrument failure, that they were not contributory factors.
- d. **Extraneous Equipment.** The presence of a well secured FAP on the aircraft is irrelevant to the eventual outcome. However, I fully support the recommendation for removal of all extraneous equipment prior to displaying the aircraft.
- e. **Stall Warning System.** The dual-purpose nature of the warning provided by the stick-shaker and red indicator lights on the pilot's instrument panels could be confusing in certain flight regimes of the aircraft particularly during the display sequence; although, to ascertain why the warning has operated should require only brief reference to relevant flight instruments. However, I am convinced that the stall warning and the G warning systems should be decoupled so that in the event of stick-shaker activation there can be no ambiguity as to the cause and recovery action taken instantly. I note that embodiment of Modification 1028 to provide a discrete audio excess 'g' warning could commence in mid 1997, achieving fleet embodiment by mid 1998. On the question of a more advanced stall warning system, I note the BAe task to establish the feasibility of installing a new system, but I support the Stn Cdr's comments that an extensive additional warning system is unnecessary and, I believe, too expensive considering the remaining in-Service life of the aircraft.

- f. **Aircrew Manual Advice.** The advice contained in AP 101B-0503-15C, the Aircrew Manual - Flying, Book 3 (ACM Bk 3) has been proven, by the Board, to contain inaccurate and outdated advice on stall warning speeds. However, I must emphasise that the stall recovery actions detailed in the text are valid and provide unequivocal direction. To address the existing flaws in the ACM Bk 3, I have instituted a review of relevant advice and procedures. RAF Handling Sqn expect to incorporate the changes in an amendment scheduled for publication by early Jun 96.
- g. **Use of the Signal Pistol.** I concur with the Board's finding that the use of the Signal Pistol at an unauthorised point of the display was another factor. The visual impact of the Verey is minimal and certainly does not justify the distracting effect it has on the Engineer's primary duty of monitoring aircraft systems and performance. Moreover, its use leaves the Air Engineer unsecured in a low level manoeuvring environment. Therefore, use of the Signal Pistol will be suspended as part of future Nimrod displays.
- h. **Pilot's QRF.** The conclusion at Annex Y that the Nimrod pilot's seat is fitted with a QRF which does not conform to Def Stan requirements is disturbing. I fully support the Stn Cdr's recommendation that SM60(RAF) be tasked with providing restraint harnesses and QRFs which conform to the appropriate Def Stan requirements, and I am pleased to note that modification action is well advanced with embodiment likely to commence in Sep 96 with a fleet embodiment timescale of about 7 months.
- j. **DARU.** The Board recommended that the data currently recorded by the DARU be extended to include greater detail and, in particular, a voice track. I believe that augmenting the data recorded by the DARU and embodying a CVR would assist investigations into any future accident or incident, and I note that work currently underway could result in modification work commencing in late 1997 with fleet embodiment completed by the end of 1998. Equally, I accept the Board's view that the GPS position could be an important parameter in any future inquiry and believe that, despite the incompatibility of the GPS data protocol with the current DARU, the Support Authority should continue to investigate the possibility of recording this data.
- k. **Birdstrike, Technical or Structural Failure.** In the absence of evidence to the contrary, it is impossible to discount the possibility of either birdstrike, technical or structural failure as a contributory factor in this accident. It is this uncertainty, however unlikely, which mitigates my conclusion in the assessment of human failings.

HUMAN FAILINGS

17. **Flt Lt GILBERT.** There can be little doubt that the changes Flt Lt GILBERT made to his display sequence were premeditated and made without reference to his supervisors. Further, although he appears to have first made the changes to the second dumb-bell at Shearwater, DARU evidence shows that the changes were significantly exaggerated at Toronto. It is also clear that, up to the point of departure from controlled flight, Flt Lt GILBERT did have the opportunity to recover the situation. The weight of evidence clearly suggests that Flt Lt GILBERT mishandled the aircraft. However, without irrefutable evidence, I cannot discount the possibility that he was misled or distracted by a transient aircraft system or instrument failure. Furthermore, the incorrect and confusing advice on stall warning speeds provided in the ACM Bk 3 and the lack of a minimum speed quoted for this manoeuvre in GASOs cannot be ignored. Therefore, I am forced to conclude, albeit with some reservation, that the only safe verdict is that he made an Error of Judgement.

18. **Flt Lt HOOPER.** Flt Lt HOOPER was responsible for ensuring that the aircraft was correctly configured for each element of the display and, further, was responsible for the monitoring of height, attitude and speed. Evidence shows that he accepted the modification to the display; however, his training and experience may not have alerted him to the inherent dangers of such a course of action. Most importantly, however is the fact that there is no evidence to suggest that Flt Lt HOOPER did not meticulously carry out his duties and warn the captain of the developing situation and, consequently, I believe that there can be no human failings attributed to him.

19. **Sgt MOXHAM.** Sgt MOXHAM was responsible for the safe operation of the aircraft's systems as well as monitoring the aircraft's height, attitude and speed. I agree with the Board that, at the critical moment, Sgt MOXHAM's attention was probably concentrated on the operation and reloading of the signal pistol but in the absence of any evidence to the contrary, it cannot be shown that he did not warn the captain of the developing situation and, therefore, I believe that there can be no human failings attributed to him.

20. **Supervisory Chain.** I agree with the Board's and Stn Cdr's findings that the display crews for the 1995 season were selected, supervised, trained, authorised and briefed entirely in accordance with GASOs. Within these extant statutes, these actions were carried out meticulously. It is only with the benefit of hindsight that we can now identify the faults that lay within that system of supervision and, therefore, I believe that there can be no blame attached to any individual despite the obvious corporate failure.

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21. **HQ 18 Gp Staff.** The absence of a formalised training syllabus, guidance on the training required and the lack of a target speed provided within GAS0s were correctly identified as failures by the Board. However, I agree with the Stn Cdr that these failures should not be solely ascribed to the HQ 18 Gp Staff but shared by everyone involved in the process over many years of Nimrod display flying. Although I believe that no human failings can be attributed to individual staff, it is a salutary reminder of the corporate responsibility of the command chain.

ACTIONS

22. Given the demanding nature of the many diverse roles carried out by the Nimrod force, their flight safety record is indeed a commendable one. However, this accident has served as a lesson to us all and highlighted the need to carry out a thorough scrutiny of all aspects of Nimrod display flying. Specifically the following actions are in hand:

a. I have tasked my staff with reviewing the Nimrod display sequence, developing a formalised and comprehensive display training programme, reviewing the selection and supervision processes and carrying out a detailed study into stall training in Nimrod aircraft. The results from these studies will be incorporated into future GAS0s and will be supplemented with direction on the removal of extraneous equipment, along with advice on the inherent dangers of trimming to low speeds during display sequences.

b. I am advised that RAF Handling Sqn have completed a draft revision to the ACM Bk 3 advice on stalling and associated speeds. Once this has been scrutinised and verified it will be incorporated in an amendment due in Jun 96.

23. Of the remaining recommendations made by the Board, I strongly endorse the modification to de-couple the stall/'g' warning system, the requirement for improvements to the DARU, modification to the pilots' seat harness and QRF in line with Def Stan requirements and the issuing of a warning to all aircrew on the legitimacy and hazards associated with self-medication. However, I believe that the costs associated with the introduction of an AoA device will outweigh its utility.

CONCLUSION

24. I believe that the Board has correctly identified the cause of this accident in that the aircraft stalled at a height from which recovery was impossible. Although the weight of evidence suggests a degree of culpability, in that Flt Lt GILBERT mishandled the aircraft such that it stalled at a critical phase of flight, the lack of absolute and conclusive evidence, and the other mitigating factors, drive my assessment that he made an Error of Judgement. Therefore, I am content that a safe verdict has been found and that the actions that will follow from the lessons learned will allow a complete reappraisal of display rules, crew selection, training and supervision. In addition to the pilot mishandling, the seeds of this accident can be found in many different areas and it should be a cautionary lesson to all who are involved in displays, however remote, that the integrity of such flying is only as good as the weakest link in the chain.



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3 Jun 96

PART 5 - REMARKS BY AIR OFFICER COMMANDING-IN-CHIEF

1. Flt Lt Gilbert ignored the briefings he was given by **S.40 - Wg Cdr AI** and **S.40 - Sqn Ldr L** that the stick-shaker was not necessary during the dumb-bell manoeuvre and that he should maintain a minimum speed of 150 knots until the nose of his aircraft dropped below the horizon. He ignored these specifics without consultation with either **Wg Cdr AI** or **Sqn Ldr L** and, it would appear, without investigation of alternative techniques through practice at a safe height. The low energy manoeuvre Gilbert opted to fly, reaching 122 kts at the apex of the dumb-bell, was one which demanded skill and finesse in controlling angle of attack [that he plainly neither appreciated nor possessed]. As a result, he stalled his aircraft at a height from which he could not possibly recover. Inevitably, he crashed and seven lives were lost.
2. In committing this error of judgement, Gilbert broke two of the cardinal rules associated with display flying and he almost certainly broke a third: he ignored his briefing; he did not refer his adjustments to those supervisors more experienced than himself and there is no evidence to suggest that he first rehearsed a new manoeuvre at a safe height. Whilst these omissions reveal his naivety in terms of the special demands of display flying, the boundary between a finding of error of judgement and one of negligence is still wafer thin. Yet despite all these considerations which, in the light of this accident, show Kinloss' glowing assessments of Gilbert's attributes and abilities to have been flawed, the Board of Inquiry still concludes that 'Flt Lt Gilbert's competence as a display pilot and the competence of other members of the flight deck crew was not a factor in the accident'.
3. Having drawn a patently absurd conclusion, the Board of Inquiry continues its illogical and muddled journey through a series of irrelevant considerations which lead to its opinions that, somehow, Group Air Staff bear a supervisory responsibility, that a written (GASO) target speed of 180 kts would have pre-empted Gilbert's mishandling, that there were no human failings attributable to the display supervisors (having first concluded that supervision was a contributory factor) and that this accident came about through a corporate error of judgement. Not once does the Board even allude to the possibility that Gilbert's abilities as pilot, captain and officer could have been exaggerated and, in being exaggerated, attracted misplaced confidence on the part of his supervisors. Rather, they give undue weight to fatuous suggestions that the crew might somehow have been distracted at the critical moment by a transitory instrument or systems failure. Exactly how or why such a problem, even if it had occurred, would have been beyond the crew to accommodate, the Board does not debate. This omission effectively encapsulates the protective shield which surrounds their deliberations - deliberations which fall well short of logical and objective analysis. I therefore looked to the Station Commander for a more robust and penetrating interpretation of events and judgement of the crew, yet his comments continue to blur the basic issues. Specifically, in his paragraph 12 the Station Commander notes that an unsafe technique could have been identified in the NDS or via the CTS, and considers their use should be routine. What he does not do is explain why such aids have thus far been ignored, given that they would have provided the opportunity to ensure Gilbert

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complied with the discipline of adhering to briefed speeds and techniques. Rather, the Station Commander refers on several occasions to hindsight. But it is foresight, not hindsight, which is the essence of effective supervision. It therefore follows that I do not agree with the Station Commander that 'supervisors.... carried out their duties methodically and conscientiously'. What the supervisors did was follow GASOs by rote, nothing more. Moreover, when the Nimrod allows effective airborne supervision, I am deeply disappointed that so little was done to analyse Gilbert's performance in the air.

4. GASOs comprise the formal medium through which a Group Commander makes his wishes known. They are signed off 'for the AOC'. They do not convey air staff executive responsibility, simply because air staff bear no such responsibility. Air Staff support the executive, which in this instance is the AOC. He, in turn, delegates certain responsibilities to his command chain. I do not accept any finding of 'corporate responsibility' regarding supervision. Supervision is a command function and any interpretation to the contrary is a matter of the gravest concern.

5. Finally regarding the Station Commander's comments, his conclusion that Gilbert 'took every precaution to ensure he produced a safe and competent display' persists in ignoring the facts of Gilbert's inadequacies and draws me back to the Station Commander's first sentence in his paragraph 17: 'Flight Lieutenant Gilbert's record speaks for itself'. This comment reveals the Station Commander's inability, or refusal, to open his mind to the prospect of Kinloss' assessment processes being flawed and I am relieved to read that the AOC draws this same conclusion. Even then, the AOC is of the view that supervision was 'meticulous and consistent with the procedures developed within the Group over a number of years'. My perception of these procedures is that they were pedestrian, blinkered and complacent. Comfortable in the Nimrod's past record, the supervisory chain lacked vigour. It showed no anticipation and, after the event, reveals only guarded self-criticism.

6. I have discussed my views with the Group Commander. He, in turn, will interview the Station Commander and convey to him my interpretation of the errors and shortcomings revealed by this Board of Inquiry.

7. Finally, I have instituted a complete review of Nimrod display flying; this will address, inter alia, the underlying rationale, the number and nature of displays, crew selection and supervisory procedures. Pending the outcome of this review, all Nimrod display activity has been halted. I have also directed Command staffs to conduct a wider study of stall and manoeuvre stall training to ensure that the aircraft handling lessons implicit in this accident are disseminated across the relevant aircraft fleets.



AOCinC STC

19 Jun 96