

PART 1.3 NARRATIVE OF EVENTS

All times Zulu.

Glossary of abbreviations provided at the end of Part 1.3.

BACKGROUND

1. On Thur 27 Jan 11, CACTUS 2 was part of a pairs Operational Conversion Unit (OCU) Long Course Simulated Attack Profile (SAP) sortie. The staff pilot and aircraft (ac) captain occupied the front seat and the student Weapon Systems Officer (WSO) occupied the rear seat. After departing RAF Lossiemouth at 1348, the aircraft (ac) proceeded to Tain Air Weapons Range (AWR) where it dropped a single 14Kg practice bomb, after which it continued at medium level to simulate a Paveway IV TIALD attack. On completion of this attack, the ac descended to low level for the remainder of the sortie. At 1435:46 the crew reported hearing a loud machine-gun-like noise emanating from the right-hand side of the ac. The pilot of ZG792 diagnosed this as an engine surge. He immediately brought both throttles back to idle whilst maintaining less than 10 units alpha. The NH appeared to be decreasing, in response to the throttles being brought back to idle, but the right NH continued to decrease below a level usually expected when selecting idle. At this time the pilot noticed that he had REHEAT and R OIL P captions and informed his WSO that he was shutting down the right engine. Just as he completed this action the crew received a L FIRE caption, with confirmatory signs of fire. The crew attempted to divert to Stornoway, but with the left engine losing thrust and ac control becoming increasingly difficult, the pilot initiated command ejection at 1443:14. Both crew were rescued by Coastguard helicopter and transferred to hospital, where their injuries were assessed as minor.

Witness 1, Part 1, Pg 1
Witness 1, Part 2, Pg 1
Witness 1, Part 3, Pg 3
Witness 2, Part 1, Pg 1,2
Witness 2, Part 2, Pg 1
Witness 2, Part 3, Pg 3,4

Exhibit 1

2. **Ac History.** ZG792 is a Tornado GR4 under the Aircraft Operating Authority (AOA) of AOC 1 Group. At the time of the accident, it was based at RAF Lossiemouth on XV(R) Sqn, the Tornado OCU. At the initial sortie launch time, the aircraft had flown 5240:10 flying hours (fg hrs) and was 124:45 fg hrs away from its next scheduled 'depth' maintenance (due to be a Minor servicing, conducted every 825 flying hours). The left engine had been fitted to ZG792 for 43:50 fg hrs. The right engine had been fitted to ZG792 for 392:15 fg hrs.

Exhibit 2

Exhibit 4

Exhibit 3

3. Crew Background

a. A review of the pilot's RAF Form 5200 and logbook found that he had completed flying training to an overall average standard in 1999. He was role disposed to the GR4 OCU where he was assessed as 'satis in most respects'. Following a front-line tour he was posted as a Qualified Flying Instructor (QFI) to RAF Valley, where he was assessed as above average, gaining his A2 instructor category. Returning to the GR4 in 2006 he conducted a further front-line tour, being assessed as above average, before being posted to XV(R) Sqn. His last 5200 and logbook assessments reported him as above average, including laudatory comments from his OC over his performance as a role demo pilot during 2010. At the time of the accident he had accumulated 2936 hours which included 1512 hours

Exhibit 5

Witness 20, Pg 1

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on the GR4. He had flown 7 hours in the past 30 days and 100 hours in the past 6 months.

b. The WSO was a student on the GR4 OCU Long Course. He had flown 346 hours total, of which 64 had been on the GR4. A review of his RAF Form 5200 and logbook found that he had finished flying training in 2010 to an overall above average standard, and was posted to the GR4 OCU where he had been for 6 months prior to the accident. He had 9 course syllabus sorties remaining. Although he commented that he had found the course demanding he was, according to his Sqn Cdr, on track to finish.

Exhibit 5

Witness 20, Pg 2

4. Preceding Events.

a. The pilot had recently returned to the Sqn following (S40)

Witness 1, Part 1, Pg 6

. On his first sortie back, on the Tuesday, the pilot made an error whilst selecting a new time-on-target (TOT). This resulted in a potential conflict over the target. On Wednesday the pilot was programmed to fly twice, but after the first sortie he vomited by the side of the ac and so went home. He did not consume any alcohol in the 24hrs prior to the accident. He returned to work on the day of the accident well rested and feeling fit to fly. He was programmed to give a PCON (Pilot Conversion) phase brief in the morning, which meant that he missed the start of the sortie plan. Just after leaving the PCON brief and entering the sortie plan, the pilot was informed by a Sqn Qualified Weapons Instructor (QWI) that he would be required to recount the previous day's TOT incident in front of the Sqn that Friday. In his HF interview the pilot stated that he was frustrated by this as he felt that his Flt Cdr, a personal friend, should have told him in person.

Witness 1, Part 3, Pg 2

Witness 20, Pg 5

Witness 1, Part 3, Pg 3

Annex A

b. The WSO had been on the Sqn for approximately 6 months and had 9 sorties to complete before finishing the OCU Long Course. Although he commented that he had found the course challenging, he was progressing well and was on track to finish. On the day before the accident the WSO was formally interviewed by his Sqn Cdr over a non-related incident. Although this was expected, in his HF interview the WSO commented on his frustrations at the time the RAF had taken to action the disciplinary findings. On the evening before the accident he had eaten dinner in the Officers' Mess where he lived, before watching a film. He was in bed by 2230 and asleep by 2300. He did not consume any alcohol in the 24hrs leading up to the accident. On the day of the accident he reported for duty at 0900.

Witness 2, Part 3, Pg 1

Witness 2, Part 3, Pg 2,3.
Annex A

Witness 2, Part 3, Pg 2

6. **Sortie Plan, Brief and Outbrief.** The accident pilot was unable to attend the start of the plan due to a previous programming commitment, but joined it shortly afterwards. The plan was supervised primarily by the senior authoriser in the formation (the staff WSO of CACTUS 1). In his informal interview with the Panel the student WSO stated that he was being worked hard, but he didn't go into the brief feeling anymore stressed than he would usually have felt; however, in his HF interview the WSO stated that he had

Witness 1, Part 1, Pg 6

Annex A

felt rushed during the plan and had forgotten most of it by the time the formation took off. The plan was briefed by the student pilot of CACTUS 1, and the student WSO of CACTUS 2. The crew were out-briefed as a formation by the XV(R) Duty Auth, with another formation in attendance as well, prior to changing into their Aircrew Equipment Assembly (AEA).

Witness 2, Part 3, Pg 3
Witness 21, Pg 1

7. **Sortie Pre-Accident Events.** The crew walked for the ac with adequate time to prepare for an on time departure. During his initial checks on the ac, the pilot noticed that the left pitch feel gauge was indicating approximately 100 bar, as opposed to the 60 bar he would normally expect. He called for assistance from a trade specialist, who then advised him that the abnormal indication was not a cause for concern and was residual pressure from the previous sortie. The rest of the start-up and taxi was uneventful. The sortie commenced with a 20-second stream takeoff at 1348. The max dry engine performance check figures were within acceptable limits compared to the placard figures from the F701A. The 2 aircraft remaining in trail for the subsequent Tain departure and entry into Tain AWR. A 30° dive attack was carried out using a single 14Kg practice bomb followed by a medium-level transit to the south-west. A medium-level Paveway IV SAP was carried out prior to entering low level in the Firth of Lorn. The formation then routed north towards another target to the south of Skye. This was a split Op 5° profile, simulating 1000lb retard weapons. The pilot reported that he had a number of ECST captions throughout the sortie, but that he had been able to reset these by selecting the alternate range on the cabin heat control. Other than this, he had no concerns about the serviceability of the ac. He had to transmit a call of 'Give me one' (a request for the lead ac to reduce power) during one formation rejoin, but thought that this was probably down to throttle mishandling by the lead pilot rather than a lack of thrust in his own ac. The student pilot in the lead ac was unable to successfully prosecute the SAP and, after a discussion with his instructor WSO, elected to manoeuvre the formation for a re-attack. The lead called a 90° battle turn to the left as the formation coasted out near the airfield at Plockton. Shortly after rolling out from the turn on a westerly heading, with CACTUS 2 on the northern side of the formation, the crew of ZG792 heard the machine-gun sound that marked the start of the accident sequence.

Witness 1, Part 1, Pg 3

Witness 11, Pg 1-3

Exhibit 1
Exhibit 3

Witness 1, Part 1, Pg 6

Witness 3, Pg 2

ACCIDENT SEQUENCE

8. **Time References.** T0:00 is defined as the start of the incident, marked by the pilot retarding the throttles in response to the machine-gun-like surge. All other times are expressed in minutes and seconds with respect to this datum, which occurred at 1435:46. This time was calculated by comparing a reference radio transmission from ZG792 with the GPS-derived system time shown on the VRS tape of another GR4 operating in the vicinity of the crash. A break down of the timings is provided at the end of section 1.3.

9. **Accident Reconstruction Validity.** The Replacement-Accident Data Recorder (R-ADR) has 75 channels of recorded data. This does not provide space to capture every possible desired parameter. Only certain CWP captions are recorded (or, in some cases, can be inferred from the recorded data) and there are numerous cockpit switch selections, such as the LP cock position and fire button activation, which are not captured. The CVR does capture the 'lyre bird' audio alarm, indicating a red CWP caption, thus

Exhibit 1

RESTRICTED—SERVICE INQUIRY

enabling red captions mentioned by the crew but not directly captured by the R-ADR to be linked to a specific time. The sample rate for each channel varies, but is as low as 1Hz in many cases, meaning that a fire caption, for example, could flicker on and off but not register on the R-ADR. This means that any recreation of the accident events, in particular the CWP captions, may contain errors.

10. **ECS Faults.** On several occasions prior to the accident sequence, the pilot had observed ECST captions, indicating a temperature error in the Environmental Control System (ECS). He had been able to rectify the fault on every occasion by selecting the alternate range on the temperature control. At the start of the accident sequence, the pilot reported that an ECST caption was present, a situation he was again trying to remedy, although the cockpit air flow was adequate and the system gave him no cause for concern.

Witness 1, Part 1, Pg 6

11. **Initial Symptoms.** The first symptom of an engine fault was a loud machine-gun noise from the right side of the ac. The WSO described this as being exactly like that he had experienced during hot strafe passes. The pilot, suspecting a surge, instinctively brought both throttles to idle and looked in at his engine instruments and CWP. As well as the previous ECST caption, he also saw a REHEAT caption on the CWP and that the right nozzle area indicator indicated Emergency Nozzle Close (ENC).

Witness 2, Part 3, Pg 6

Witness 1, Part 1, Pg 1

12. **Mechanical Failure Diagnosis.** At T0:13, the pilot concluded that he had a right engine fault and advanced the left throttle to max dry. He turned north, remaining over the sea, and entered a gentle climb, eventually reaching approximately 6000ft and 290KCAS by T5:00. At T0:16, with the right NH at 36.7%, the 'lyre bird' alarm went off and the pilot commented that he had a R OIL P caption. After a brief discussion of the various symptoms, he confirmed that he had a right mechanical failure and, at T0:38 selected the right throttle to HP Shut.

Exhibit 1

Exhibit 6

13. **L FIRE Caption.** Whilst dealing with the right mechanical failure, the pilot was interrupted by the appearance of a L FIRE caption. This prompted him to diagnose a rear fuselage fire, in response to which he selected the Air System Master to Emergency Ram Air (ERA). He also closed the right LP cock and discharged the fire extinguisher bottle into both engine bays by pressing both fire buttons simultaneously. The exact order of this sequence could not be positively determined.

Exhibit 1

Exhibit 6

14. **Visual Inspection From CACTUS 1.** The crew of CACTUS 1 elected to follow CACTUS 2 throughout the emergency, remaining on the right-hand side at a distance of around 1-2nm. Both crew members reported seeing a smoke trail from the aircraft, along with a bright orange glow from the left engine nozzle area. The presence of the glow prompted the instructor WSO of CACTUS 1 to ask, at T0:51, if CACTUS 2 was using reheat. At T1:00, the pilot of CACTUS 2 asked if there were any signs of fire, to which the WSO of CACTUS 1 replied "*Affirm...you have smoke and flames from the rear of the aircraft*". The WSO of CACTUS 2 was able to observe the rear of the aircraft using his mirrors and saw smoke emanating from the right side of the rear of the aircraft. The pilot concluded that the right side of the rear fuselage and possibly engine was on fire.

Witness 3

Witness 4

Exhibit 6

Witness 2, Part 2, Pg 1

Witness 1, Part 2, Pg 1

15. Emergency Radio Transmissions. After hearing of the initial problem, the instructor WSO in CACTUS 1 conducted all of the formation's radio transmissions to Scottish Centre on Guard UHF. After declaring a 'Mayday', he discussed the possible use of Stornoway as a diversion with Scottish Centre, and also requested that the Stornoway Coastguard SAR helicopter be ready to rescue the crew in the event of an ejection. Throughout the emergency sequence the WSO of CACTUS 1 divided his time between talking to his student pilot on intercom, the pilot of CACTUS 2 on the formation chat frequency and Scottish Centre on UHF Guard.

Exhibit 6

Witness 4, Pg 9

16. Other Fault Indications. As the emergency progressed, the crew were subjected to multiple 'lyre bird' audio warnings and witnessed numerous CWP captions, both intermittent and constant. These included CABIN, FUEL, L and R THROT, L and R OIL T, L and R FUEL T, GEN, R FIRE, and both L and R VIB captions.

Witness 1, Part 3, Appendix I.

17. Ejection Preparation. Believing the situation to be critical, the pilot ensured his navigator was suitably prepared and informed CACTUS 1 to standby for a premeditated ejection at T2:10. CACTUS 1 relayed this information to Scottish Centre.

Exhibit 6

18. Control Failures. At T2:50 the Command and Stability Augmentation System (CSAS) incurred several failures and the tailerons entered mechanical mode. The pilot did not directly observe which specific failures had occurred, but observed CSAS (both red and amber captions) and PFCS captions and felt the control quality degrade.

Exhibit 1
Witness 1, Part 2, Pg 2

19. Relight Attempt. The pilot then discussed his symptoms with the crew of CACTUS 1 as well as his WSO. He asked to be guided towards Stornoway, although he acknowledged that it was unlikely that he would be able to make it that far. He ensured once again that his WSO was ready for ejection and warned him this would be via the pilot's ejection handle. At T3:38 the pilot decided to attempt to relight the right engine. He moved the right throttle to idle and selected the engine start switch to RIGHT. There was no response from the engine, apart from the appearance of a R TBT caption, and the green START light did not illuminate. At no stage during the sequence did the pilot indicate that he had re-opened the right LP cock.

Exhibit 6

Witness 1, Part 3, Pg 10-11

20. Left Engine Control. After further discussion with his WSO and the crew of CACTUS 1 about the nature of the external symptoms, the pilot briefly exercised the left throttle and observed that he had no control over the left engine.

Witness 1, Part 1, Pg 2

21. CACTUS 1 Observations of Left Engine. At T4:54 the pilot of CACTUS 1 noticed that the glowing from the left engine appeared to have ceased. This was relayed to CACTUS 2 by his WSO. On hearing this, the pilot decided to remain with the aircraft to see if a recovery to Stornoway would be possible.

Exhibit 6

22. Loss of Left Engine Thrust. At T6:01 the pilot noticed his left NH gauge fluctuate, although the thrust output felt constant. This was followed at T6:20 by a perceived loss of thrust and deceleration.

Witness 1, Part 1, Pg 2
Exhibit 6

23. **Ejection Decision.** In the latter stages of the emergency, the pilot became aware that he had to apply more and more right control column input to correct a tendency for the aircraft to roll to the left. Believing that a total loss of control was imminent, he warned the WSO and initiated command ejection at T7:28 at 6250'AMSL and 238KCAS. The ejection process was entirely normal. During the descent the crew carried out their post-ejection drills, including the inflation of their LSJs and were well placed for their water entry. During the descent both crew descended through a layer of cloud, which they described as unsettling, but otherwise unremarkable. During the descent both pilot and WSO reported that the PSP, which had automatically lowered after ejection, caused a significant pendulous motion upon the parachute descent. Upon landing in the water, both PSPs automatically deployed their respective life rafts and the crew boarded with relative ease in calm seas. Once in their life rafts both crew commented that they initially experienced difficulty in untangling themselves and their equipment from the parachute canopy lines, but were eventually able to carry out their post life raft entry drills. Both crew activated their Fastfind PLBs and prepared their pyrotechnic flares for use. The pilot removed his helmet and placed the aircrew survival hood on before using his helmet to bail out the water from the life raft. Due to the advanced notice that the formation had had with regards to a potential ejection, CACTUS 1 had already requested the SAR helicopter for Stornoway be launched prior to the ejection and as such it was on task very quickly. The crew spent approximately 20 minutes in their life rafts before being winched into a Coastguard helicopter. Although a double strop was not available, the Coastguard winchman used the lifting beackets on the crews LSJ, combined with a strop placed around the knees to achieve the same result and minimize the possible impacts of thermal shock which may have been experienced if a vertical lift had been attempted.

Exhibit 1
Exhibit 6

Annex B

Witness 1, Part 3, Pg 15-16

Witness 2, Part 3, Pg 14

Exhibit 6

24. **Post-ejection Care.** The crew were initially transferred to Raigmore hospital, Inverness. Unsure of how to deal with ejectees, the Raigmore registrar discussed the necessary arrangements and precautions that needed to be considered with the RAF Lossiemouth SMO. Both crew were supine and in stiff neck collars with head blocks taped to the trolley at two points. The RAF Lossiemouth SMO arrived at the hospital shortly after the crew were admitted and was able to speak to them first hand. A detailed account of the SMO's findings is contained at Annex C. The SMO was able to examine both the pilot and the WSO and had no reason to believe that they were under the influence of drugs or alcohol, and as such PIDAT was not initiated. The crew were transferred to the Aeromed team at 2210 and placed on a C130 for the flight down to Queen Elizabeth Hospital (QEH), Birmingham, for specialist treatment. Of note, prior to being discharged from QEH there was significant confusion as to how the crew would be transferred back to RAF Lossiemouth. The WSO was collected from the hospital by family members; however the pilot seemed unsure of his return plans. As such, the Panel made arrangements for him to spend the night with them at the RAF Cottesmore Officers' Mess, prior to sharing a ride back to RAF Lossiemouth on the HS125 that had been tasked to transport the Panel.

Annex C

AIRCREW ESCAPE AND SURVIVAL FACILITIES AND AIRCREW EQUIPMENT ASSEMBLIES (AEA)

25. **Personal AEA.** Both aircrew were wearing standard Mk10c helmets and wearing Mk20 immersion suits. The pilot was wearing a non issue blue 'Polar Bears' bunny suit under his immersion suit, and the WSO wore a standard issue flying suit. Both aircrew wore standard green flying roll necks, although both were wearing non standard 'long johns'. All pieces of AEA appeared to have withstood the ejection process

Annex B, Pg A-1

26. **Mk 41 Life Jacket.** Both aircrew were wearing the standard Mk41 lifejacket. After ejecting the crew inflated their LSJs in accordance with post ejection drills. Both crew reported that the inflated lifejacket significantly impeded their ability to look around and down, and that as such an assessment of the exact landing location was difficult. Under the LSJ both crew wore a standard green Combat Survival Waistcoat (CSW) which housed the Fastfind Beacons.

Annex B

27. **ZQ Mk1 Personal Survival Packs and SS Mk15 Single man life rafts.** After ejection both PSPs auto detached from the seat and were hanging on the PSP lowering lines as expected. Upon contact with the water, both MK15 life rafts automatically inflated and remained so throughout the recovery procedure.

Annex B

28. **Fast find locator beacons.** Both pilot and WSO manually operated their Fastfind Location Beacons housed in their respective CSWs. The operation and performance of the Fastfind was thoroughly investigated by the Panel, and its detailed findings can be found at Annex G.

Annex B, G

DEGREE OF INJURY

29. The panel found that:

a. (S40)

Annex B, Pg 8

b. (S40)

Annex B, Pg 8

c. **Civilian Personnel.** There were no injuries to civilians.

DAMAGE TO AC, PUBLIC AND CIVILIAN PROPERTY

30. Damage to ac, public and civilian property was assessed as follows:

a. **Ac.** An initial damage assessment report was carried out by MAAIB. ZG792 has been classed as Cat 5 (SCRAP) by the Panel.

Annex D

RESTRICTED — SERVICE INQUIRY

b. **Environmental.** The Panel received a number of requests for information as to any environmental impact caused by the crash. Air Cmd sent a MinSub draft for the Panel to comment. MAAIB have staffed these requests having taken advice from the Institute of Medicine, MOD Abbey Wood and The Maritime and Coastguard Agency. All assess the environmental impacts as low. Prior to the wreckage recovery procedure, a full site survey was carried out to map the extent of the debris field. On completion of the recovery, a second survey was conducted and no further obvious signs of wreckage could be identified.

Annex D, Pg 5

c. **Civilian.** There was no recorded damage to civilian property.

d. **Costs.** The Net Book Value for ZG792 is £13,094,000.

Exhibit 7

LOSS OF, OR DAMAGE TO, CLASSIFIED MATERIAL

31. (S26)

a. (S26)

b. (S26)

AC RECOVERY

32. **Recovery from the crash site.** Following ejection the ac entered a nose down descent and rolled to the right. It impacted the sea at 384KCAS in a diving attitude of 27 degrees with 11 degrees of right bank at (S26)

Exhibit 1

. Investigations into the accident were initially delayed by the significant difficulties encountered in salvaging ZG792. HMS Blythe, a RN Sandown class minesweeper exercising in the area, was able to provide assistance in pinpointing the aircraft wreckage. Initially, the rocky sea bed made it difficult for a clear sonar picture to pinpoint the wreckage. Once this was achieved, poor weather off the west coast delayed salvage operations. Salvage was finally commenced by CSALMO on 15 Feb and lasted for four days. The ac suffered considerable break-up during impact (see Figure 1), and eventually came to rest at a depth of (S26). Notwithstanding, the salvage vessel docked in Invergordon with approximately 70% of the ac on 19 Feb.

Annex D, Pg 4

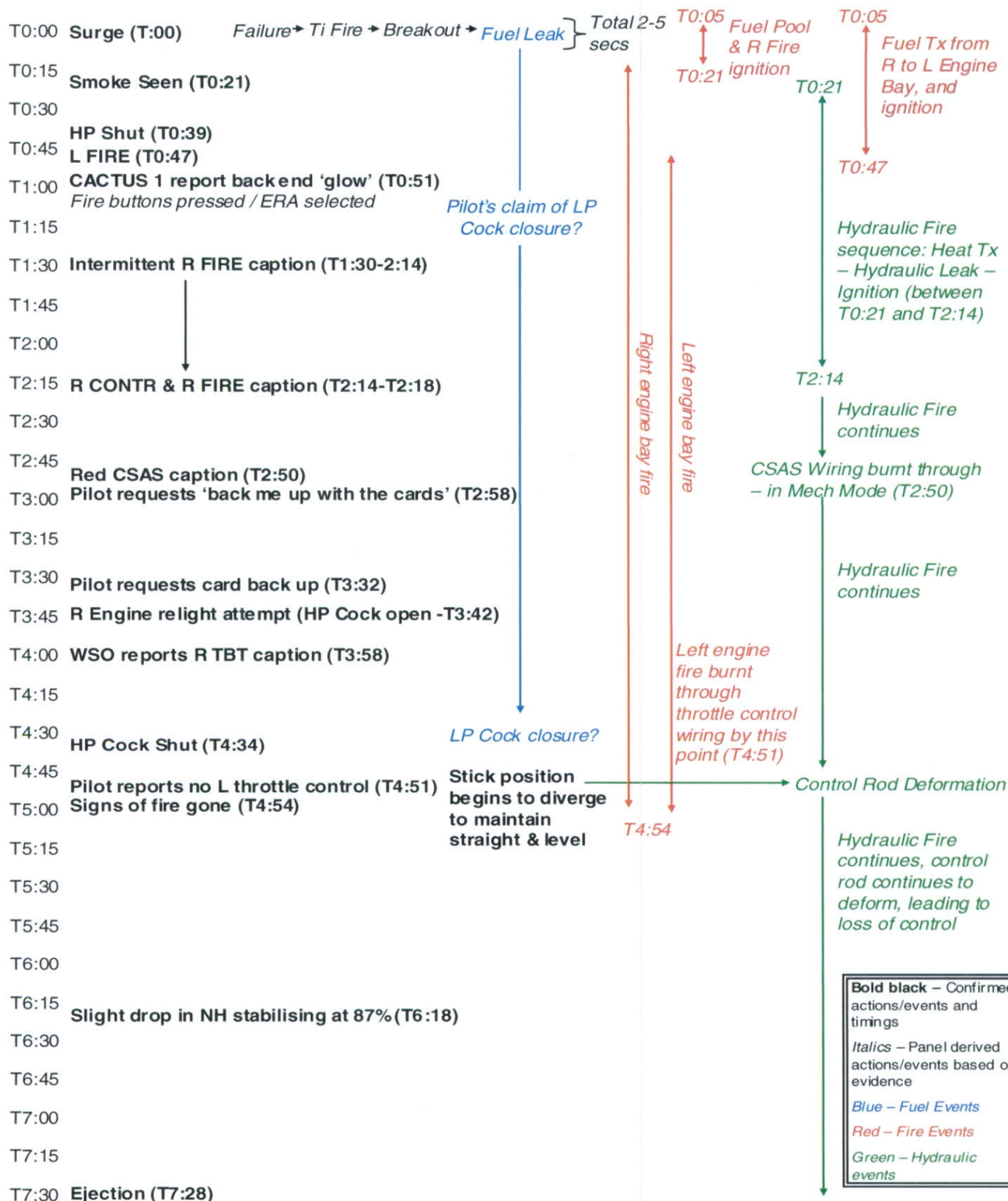


Figure 1 - One of two ISO containers housing the recovered parts of ZG792.

33. **Recovery to RNFSAIC.** The remaining wreckage was transported in ISO containers, by road, from Invergordon to RNFSAIC at RNAS Yeovilton. The wreckage has remained in the RNFSAIC hanger.

Annex D, Pg 4

ZG792 Timeline of Events



GLOSSARY

ac	Aircraft
AEA	Aircrew Equipment Assembly
AOA	Aircraft Operating Authority
AWR	Air Weapons Range
CSALMO	Chief of Salvage and Mooring Office
CSAS	Command and Stability Augmentation System
CSW	Combat Survival Waistcoat
CVR	Cockpit Voice Recorder
CWP	Centralised Warning Panel
ENC	Emergency Nozzle Close
ERA	Emergency Ram Air
fg hrs	Flying Hours
Flt Cdr	Flight Commander
HF	Human Factors
HP	High Pressure
KCAS	Knots Calibrated Air Speed
LP	Low Pressure
LSJ	Life Support Jacket
MAAIB	Military Air Accident Investigation Branch
MOD	Ministry of Defence
NH	High Pressure Compressor Speed
OCU	Operational Conversion Unit
PCON	Pilot Conversion
PIDAT	Post Incident Drug and Alcohol Testing
PLB	Personal Locator Beacon
R-ADR	Replacement Accident Data Recorder
RAF	Royal Air Force
SAP	Simulated Attack Profile
SMO	Senior Medical Officer
TDM	Transportable Data Module
TIALD	Thermal Imaging Airborne Laser Designator
Tor PT	Tornado Project Team
TOT	Time on Target
UHF	Ultra High Frequency
WSO	Weapon Systems Officer