

[REDACTED]

## PART 1.3. - NARRATIVE OF EVENTS

(All times LOCAL).

1. **Introduction.** ZE982, as callsign BLACKSMITH 1, was the lead of a pair of Tornado F3 ac flying a routine trg sortie from RAF LEUCHARS. The sortie aim was to conduct medium and low-level intercepts for part of an E3D AWACS sqn acceptance check for a weapons controller. The sortie conduct included Quick Reaction Alert (QRA) intercept profiles followed by a low-level navigation exercise. Prior to the sortie brief the crew were informed that the AWACS would be late on task. The original airborne time was achieved with the low-level navigation exercise re-planned prior to the AWACS on-task. Both F3 ac, in Configuration 3, took off at 1128 hrs from RAF LEUCHARS, flowed west at 3000ft and entered low-level to the west of PERTH. At 1142 hrs, during the navigation through a series of valleys to the west of TARBET, BLACKSMITH 2 (in trail) rounded a ridge in a left-hand turn and witnessed a fireball in the expected vicinity of ZE982. BLACKSMITH 2 took immediate recovery action in a westerly direction to avoid the rising fireball. ZE982 had struck the north slope of GLEN KINGLAS at 1198ft Above Mean Sea Level. The ac impacted civilian owned open hillside and was destroyed. Both crew members were killed.

Witness 14  
Exhibit 70

2. **The F3 Fce.** Since Apr 08, the F3 Fce had reduced from 3 sqns and an Operational Conversion Unit (OCU) on 2 stns, to 2 sqns on a single stn. As a result of the decision to reduce the F3 to a QRA only Fce by Oct 08, the accident Sqn was to disband. The Sqn was in its last 2 days of operating from its own HQ. Sqn personnel were to combine the week following the accident on its sister Sqn to support the Combined Qualified Weapons Instructor Course (CQWI) whilst disbandment activities were carried out.

### 3. Personnel Background.

a. The Pilot joined the RAF in 2004. At the time of the accident he was a front-line sqn pilot with 180 hrs on type. He had graduated from the Tornado F3 Operational Trg Establishment (OTE) in Sep 08 before becoming a Front-Line (FL) pilot on the same sqn. He completed his Combat Ready (CR) work-up in Apr 09, 3 months prior to the accident and was assessed, on completing the OTE, as Proficient in the air.

Exhibit 9,10

b. The Navigator joined the RAF in 1989 and following trg converted to the Tornado F3. In 5 flying tours he had flown 2930 hrs on type. He had completed 8 years consecutive flying and was assessed as Above Average in his last assessment. He held all the supervisory qualifications available in his rank.

Exhibit 12,13

4. **AC Background.** On the morning of 2 Jul 09, ZE982 was in Configuration 3, as described in the Tornado F3 Release to Service (RTS), comprising 2 x 2250 litre under-wing tanks, 2 x wing pylons. In addition, for the trg role, 1 x Rangeless Autonomous Information Debriefing System (RAIDS) pod (attached to a LAU-7A launcher on the starboard outer stub pylon) and 1 x Acquisition Trg Missile (ATM) (attached to a LAU-7A launcher on the port outer stub pylon) were fitted. This ac configuration is referred to using its NATO identifier of 'Lima' fit. The ac was declared fully serviceable by the groundcrew before being released for flight.

Exhibit 62

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a. **Airframe.** Prior to the accident flight, ZE982 had flown a total of 4101:45 hrs and 25:10 hrs had been flown since its last Primary maintenance. This was carried out within AC Maintenance Flight (AMF) at RAF LEUCHARS during Mar/Apr 09.

b. **Engines.** Rolls-Royce RB199 Mk 104 Engines were fitted to ZE982. The right hand engine (Serial No 7187) was last reconditioned on 1 Jun 07 by Tornado Propulsion Flight, RAF MARHAM; installed in ZE982 on 14 Jun 07 and had run 282:35 hours prior to the accident flight. The left hand engine (Serial No 7175) was last reconditioned on 11 Feb 08, by Tornado Propulsion Flight, RAF MARHAM; installed in ZE982 on 1 Mar 08 and had run 163:50 hours prior to the accident flight.

Exhibit 16

5. **Crew Accident Lead-in.** The Panel examined the events leading up to the accident:

a. **Pilot.** The Pilot last flew 3 days prior to the accident on a Defensive Counter Air mission as part of a work-up sortie to enable support to CQWI the following week. On 1 Jul 09, the day before the accident, the Pilot was at work carrying out secondary duties. He played golf late in the afternoon before arriving in the Officers' Mess bar at around 1915 hrs. He bought a glass of lemonade for himself and 3 bottled beers (330ml Corona) to take to dinner so as not to arrive empty handed. He left a short time later to drive round to a colleague's house for dinner. Nothing untoward about his behaviour was noted; it was reported that he was his usual jovial self. The Pilot had 1 beer and 1 lemonade as he was driving and left at approximately 2200 hrs, returning to the Officers' Mess. On returning to the Mess he had 1 lemonade before leaving the bar at approximately 2300 hrs. The Pilot had breakfast the next morning at approximately 0745 hrs before arriving at work at approximately 0815 hrs. It was reported that he appeared to be fully rested. Toxicology showed no alcohol in the Pilot's blood. Alcohol was found in the Pilot's urine and is discussed in Part 1.4 (para 41). It should be noted that the pilot was not under the influence of alcohol and the Panel concluded that the reported alcohol in the Pilot's urine was not a factor in the accident. Additionally, the sortie authorising officer spent approximately 1 hr in close company with the Pilot before authorising him.

Witness 5,6,7,9

Exhibit 65

Witness 4

Exhibit 7

b. **Navigator.** 48 hours prior to the accident, the Navigator was on QRA but did not fly. This was followed by QRA stand-down from mid-morning the day prior to the accident. He played golf in the afternoon and had dinner in the evening with his family before retiring to bed at approximately 2300 hrs. No alcohol was consumed. The Navigator had breakfast at 0745 hrs and then went to work. It was reported that there was nothing untoward about his behaviour and he appeared to be fully rested.

Witness 8

Exhibit 7

Witness 4

6. **Pre-Flight Briefings.** Prior to the Sqn Met and Ops brief, the crew of ZE982, as lead, had a short meeting to decide on the plan for the sortie. The trg to be conducted was a workup for an AWACS controller. BLACKSMITH were to act as target ac and interceptor for low and slow target profiles. Following this, a low-level free navigation exercise was to be conducted flowing in a westerly direction towards the Isle of TIREE. The Sqn Met and Ops brief was conducted at 0915 hrs by the Sqn Duty Authoriser. Both Pilot and Navigator of ZE982 were reported to be in good spirits. During this period, the Authoriser was informed that

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the AWACS would be delayed by 30 minutes; this information was passed to BLACKSMITH. It was decided, within formation, that the initial take-off time would not be altered and the low-level navigation exercise would be conducted first, to reduce ac weight prior to the low-level visual intercepts. Following the met brief, the Pilot performed a mini-brief to the rest of the formation on sortie overview, timeline and formation planning tasks. The main sortie brief was conducted by the Pilot. The brief was comprehensive and included a discussion on minimum speeds at various wing sweeps. It also included advice on Lima fit and low speed handling. The low-level exercise was to be free-navigation with the general flow west towards TIRRE, prior to the low-level intercepts. Notice to Airman (NOTAM) Z8222 (a helicopter operating with an under-slung load) was discussed as well as all pertinent area information for the sortie. It was reported that at out-brief the lead Crew's behaviour seemed normal and upbeat. All members of the Formation replied that they were fit to fly when asked as part of the out-brief, and were authorised by the Navigator.

Exhibit 14  
Witness 1,2,4

Exhibit 42

7. **Pre-Accident Events.** The 2 crews walked together for their ac. Initial crew-in was normal. On right engine start, ZE982 had to abort the start due to an over temperature. Actions were carried out in accordance with the Flight Reference Cards (FRCs) and a second attempt to start the engine was successfully carried out. In addition, ZE982 carried out a routine Command Stability Augmentation System (CSAS) functional test successfully. BLACKSMITH 2 had an intermittent main radio problem which required trade assistance. This problem could not be fully solved but the crew of BLACKSMITH 2 were content to continue, using their secondary radio if required. BLACKSMITH taxied as a pair and took-off at 1127hrs.

Witness 2  
Exhibit 63

8. **Airborne Sequence.** The sequence of airborne events is summarised below:

Exhibit 63  
Witness 1,2

a. After take-off, BLACKSMITH turned onto a westerly heading and climbed to 3000ft. They maintained 2800 - 3100ft for 5 minutes, at an airspeed of 342 - 376 kCAS. The Formation routed south of PERTH before descending to low-level in the STRATHALLEN area. They maintained low-level with a Minimum Separation Distance (MSD) of 250ft at 390 - 424 kCAS. On approaching NOTAM Z8222, BLACKSMITH 2 reminded the Crew of ZE982 of the avoidance area on the radio and this was acknowledged; the Crew had already factored the NOTAM into their routing. BLACKSMITH then turned south and routed down LOCH LOMOND before turning west at TARBET to follow the A83, via the viewpoint at REST AND BE THANKFUL and into GLEN KINGLAS. As ZE982 flew south along LOCH LOMOND, the wing sweep was moved to 27.9 degrees (130 sec prior to R-ADR End Of Data (EOD)) and the Pilot remarked "wings 25.... it will get 'windey'[twisty]". As ZE982 turned into the series of valleys at TARBET, Manoeuvre (MVR) flap and slat was selected<sup>1</sup>. The Ground Proximity Warning System (GPWS) audio warning sounded for 2 secs which was acknowledged by the Pilot with a "400 check, happy" and there was a coincident change in ac flightpath. As BLACKSMITH routed northwest along the valley, BLACKSMITH 2 closed to 'weaponeer' on ZE982 before dropping back. This generated the Radar Homing Warning Receiver (RHWR) audio warning within ZE982's cockpit which had persisted at regular intervals throughout the flight. As ZE982 approached the saddle at REST AND BE THANKFUL the Navigator made

Exhibit 14

Exhibit 67,68

<sup>1</sup> MVR when selected with the wings in the 25° will give 11° slat and 6°57' flap.

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a "Check height 270" [radar-altimeter] call which was acknowledged by the Pilot.

b. At 22 secs to EOD, the ac commenced a right turn and the GPWS audio sounded 4 secs later. The warning lasted for 6 secs without acknowledgement from the crew. The airspeed was 366 kCAS, which then decreased until EOD.

c. As ZE982 crested the saddle at REST AND BE THANKFUL, the Pilot retarded the throttles slightly from max-dry at 352 kCAS (16.5 secs to EOD).

d. The right bank angle reached 85° for 2 secs before reducing. At 15 secs to EOD, the turn was reversed going through wings level at a rate of 62°/sec at 12 secs to EOD. At 11.5 secs to EOD, max dry power was selected on both engines. SPILS<sup>2</sup> became active as the ADD increased through 12.3ADD<sup>3</sup>. As the ac crested the ridge and entered the final left turn the GPWS audio warning sounded (7 secs to EOD) and remained on without verbal acknowledgement from the crew. The Navigator gave a warning to the Pilot of high ground ahead concurrent with the GPWS audio starting.

e. At 5.2 secs to EOD, 16% left rudder pedal was applied which dropped the nose of the ac and induced a 256ft height loss over the final 5 secs, reducing the available turning room.

f. At 5 secs to EOD, a maximum left bank angle of 96° was achieved. The aft Control Column (CC) movement paused for 2.5 secs with an incidence of 19ADD (Normal Operating limit of ADD). At 4.7 secs to EOD, a large right CC input of 2/3 full travel was applied and the left bank started to reduce.

g. At 3.7 secs to EOD, right CC deflection started to reduce; bank angle was 76° left with a roll rate of 22°/sec to the right.

h. At 3.2 secs to EOD, the aft pitch CC movement resumed and reached a maximum deflection of -24° after 1.5 secs (-30° is fully back). The incidence exceeded 19ADD and continued to increase to the maximum recordable R-ADR value of 25ADD.

i. A left bank angle of 53 - 59° was maintained for approximately 3 secs until EOD.

j. At 2.4 secs to EOD, the throttles were moved from 29° to 43.5° (left) and 42° (right), ie from max dry to beyond max reheat and maintained to EOD. This was concurrent with the Navigator verbally warning the Pilot of the ground. Both nozzles began to open shortly afterwards in response to the throttle selection.

<sup>2</sup> Spin Prevention and Incidence Limiting System (SPILS) provides progressive control demand cancel signals to the Command and Stability Augmentation System (CSAS) to reduce control authority in roll and yaw at high Angles of Attack to prevent ac departure from controlled flight.

<sup>3</sup> Airstream Direction Detector displaying Angle of Attack (AoA) post the Air Data Computer as displayed in the Head Up display (HUD).

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k. The last reliable flight data was approximately 0.75 secs to EOD, with the following values:

Airspeed	294 kCAS
Radalt	59ft
Pressure altitude	1024ft
Left ADD	25 units (max recordable on ADR)
Bank angle	-53° (left wing down)
Roll rate	25°/sec (rolling right)
Pitch attitude	7° (nose up)
Pitch rate	-3°/sec (nose up)
Pitch stick	-24° aft (full back CC -30°)
Roll stick	-10° right (full travel -30°)
Heading	261° (True)
Wingsweep	27.5° (± 1.5°)
Both throttles	Beyond Max Reheat
Both nozzles	intermediate between dry and Combat Power
Left Nh	95.8%
Right Nh	96.5%
SPILS	Active

l. From the RAIDS pod (+/- 5% error), the max g reached was 3.3g at 8 secs to EOD, which was beyond NO limits but within NE limits<sup>4</sup>, and remained at around 3g for approximately 4 secs. Over the last 9 secs of flight, the average g was 2.833g. To maintain this g, airspeed was sacrificed and ADD increased significantly. As ADD passed 15 units, airspeed reduced with a corresponding reduction in available g.

Exhibit 62

m. The flight duration was 14 minutes 40 seconds.

n. There were no CSAS, hydraulic system failure indications or engine fire warnings on the R-ADR data.

o. The control surfaces moved in the correct sense for the R-ADR-recorded control inputs and throughout the flight the ac responded in the correct sense.

p. The Panel concluded that the main impact occurred at

<sup>4</sup> Ac Operating Limits. The F3 RTS defines ac operating limits including airspeed, g, AoA [ADD]. These limits are further defined as:

Normal Operating (NO) Limits. These values may be reached as often as the pilot task requires, without undue risk and may be exceeded occasionally by a small margin without untoward consequences. The pilot should not deliberately plan to exceed the quoted NO limits, unless specially authorised through 1GASO.

Never Exceed (NE) Limits. These values represent the full Design Flight Envelope or the highest figure for which all aspects have been investigated in ground and flight-testing. Operating beyond NO, and up to NE limits, reduces margin for error and increases the likelihood of exceeding NE limits, the consequences of which are either hazardous or unknown.

approximately 0.75 secs to EOD.

9. **Impact and Break Up.** The impact and break up sequence is summarised below:

Exhibit 3,69

a. The initial impact point was N 56 14 58 W 004 52 15 (D M S) 222228.378 N710035.602 (National Grid), 1198ft AMSL on the north slope of GLEN KINGLAS, SCOTLAND. The Glen is approximately 37 miles north-north west of Glasgow and runs east-west. The A83 road and RIVER KINGLAS run along its floor and the Glen has steep sides with numerous burns running down the hillside in ravines. Figure 1 shows the direction of approach from the south-east with the crash site circled.

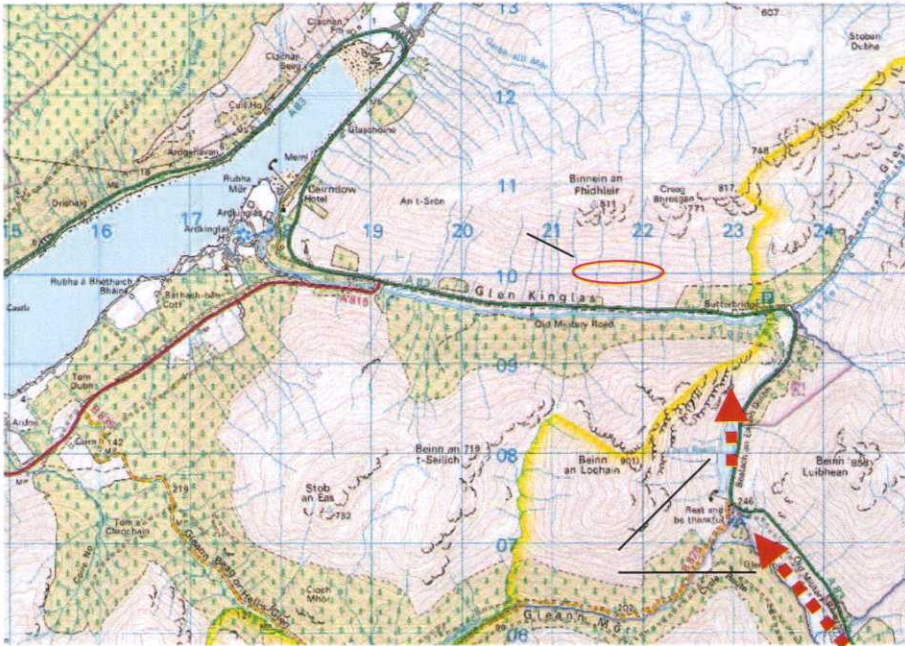


Figure 1  
Accident Location

b. The ac initially impacted a slight rise in the hill side with what was likely to be a fin of the left 2250L fuel tank (Figure 2). On the west side of a subsequent hollow was the main impact (Figure 3).



Figure 2  
Initial Impact Point



Figure 3  
Main Impact Point (with ac overlay)

c. There was a large fireball on impact and the engines, wing-box and cockpit had sufficient momentum to continue in the direction of travel. The

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other parts of the airframe fragmented and only the fin assembly and right taileron were found substantially complete.

d. The forward fuselage appears to have tumbled and, at some stage, there was a substantial impact to the left hand side of the cockpit. The Crew appears to have been initially protected within the cockpit but were separated from it later in the break up sequence. The cockpit parts of the aircraft came to rest against the side of a ravine close to the end of the wreckage trail and were severely disrupted.

e. The centre wing-box assembly was detached from both the fuselage and the remainder of the wing structure. The assembly probably struck more than one crest before reaching the end of the wreckage trail. Due to its weight and the gradient of the slope the assembly then slid down the hillside before coming to rest on the side of a ravine.

f. The engines were disrupted at the main impact point and parts from the rear of both engines were identified in the vicinity. Both engines lost blades early in the break-up sequence due to distortion of the casings caused by the impact. Both engines had struck the ground at least once after the main impact before coming to rest.

#### POST ACCIDENT ACTIONS

10. **Airborne.** BLACKSMITH 2 carried out an immediate escape manoeuvre following the observation of the fireball and then commenced a climbing turn-back over the site. BLACKSMITH 2 assumed On Scene Commander (OSC); Scottish Military vectored 2 x GR4 ac to the scene and they carried out imaging runs over the site to look for survivors. A Strathclyde Police helicopter arrived on-scene, coincident with the GR4s, and separation was coordinated by BLACKSMITH 2. The Police helicopter established a cordon around the site and persuaded a civilian witness, who was climbing the hill from the A83 to give assistance, to move back to the road. The Police helicopter placed an Observer on to the site to attend to the Crew. A SAR Sea-King arrived on-scene and liaised with the Police helicopter before placing a crewman onto the site. A USAF MC 130 replaced BLACKSMITH 2 as OSC and the F3 recovered to RAF LEUCHARS, landing at 1241hrs.

Witness 1

Witness 12

Witness 13

Exhibit 42

11. **RAF LEUCHARS.** The Stn was executing an EAW Level Trg event at the time of the accident. The accident was initially reported to Stn Ops by BLACKDOG (Control and Reporting Centre - SCAMPTON) approximately 10 mins after the accident; Stn ATC were informed by Scottish Military D&D 2 mins later. The Stn stood up the Emergency Control Centre (ECC) 15 minutes after the accident and the Stn Incident Officer deployed to the accident site 1hr 20mins after the accident. Following confirmation of death from MOD the Stn began Kin-Forming.