Defence
Safety
Authority

Service Inquiry

CHALLENGER 2 Incident at Castlemartin Ranges, Pembrokeshire

14 Jun 17

Defence Safety
Authority

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PART 1.1

Covering Note & Glossary

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PART 1.1 – COVERING NOTE

DSA/SI/05/17/RTR CR2 CMR

16 May 18

DG DSA

SERVICE INQUIRY INVESTIGATION INTO THE ACCIDENT INVOLVING A CHALLENGER 2 AT CASTLEMARTIN RANGES, PEMBROKESHIRE ON 14 JUN 17

1. The Service Inquiry Panel assembled at Ministry of Defence Main Building on the 27 Jun 17 by order of the DG DSA for the purpose of investigating the accident involving CHALLENGER 2 ERM DS39AA on 14 Jun 17 and to make recommendations in order to prevent recurrence. The Panel has concluded its inquiries and submits the finalised report for the Convening Authority's consideration.

2. The following inquiry papers are enclosed:

Part 1 REPORT	Part 2 RECORD OF PROCEEDINGS
Part 1.1 Covering Note and Glossary	Part 2.1 Diary of Events
Part 1.2 Convening Orders & TORs	Part 2.2 List of Witnesses
Part 1.3 Narrative of Events	Part 2.3 Witness Statements
Part 1.4 Findings	Part 2.4 List of Attendees
Part 1.5 Recommendations	Part 2.5 List of Exhibits
Part 1.6 Convening Authority Comments	Part 2.6 Exhibits
	Part 2.7 List of Annexes
	Part 2.8 Annexes
	Part 2.9 Schedule of Matters Not Germane to the Inquiry
	Part 2.10 Master Schedule

PRESIDENT

[Signature]

[redacted]
Commander Royal Navy
President
RTR CR2 CMR SI

MEMBERS

[Signature]

[redacted]
Major King's Royal Hussars
Army Member
RTR CR2 CMR SI

[Signature]

[redacted]
Warrant Officer Royal Air Force
Royal Air Force Member
RTR CR2 CMR SI

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PART 1.1 – GLOSSARY

Serial (a)	Acronym / Abbreviation (b)	Explanation (c)
1	2IC	Second in Command
2	ACT	Annual Crew Test A mandatory live firing exercise for all trained tank crews. Successful completion is the licence for crewmen to progress on to more advanced LFXs and operations on CR2. Also referred to as LFX8.
3	ACTO	Attractive to Criminal and Terrorist Organisations
4	AESP	Army Equipment Support Publication
5	AFV	Armoured Fighting Vehicle
6	AFVTTS	Armoured Fighting Vehicle Technical Training School Gunnery Wing is based at Lulworth, Dorset
7	AIG	Assistant Instructor Gunnery
8	ALARP	As Low As Reasonably Practicable
9	AOSP	Army Operational Shooting Policy
10	APFSDS	Armour Piercing Fin Stabilised Discarding Sabot The 120mm operational KE anti-armour round. Simulated by the DS-T round during training. Also referred to as a Fin round.
11	ANR	Active Noise Reduction (headset)
12	AT	Ammunition Technician
13	ATL	Automatic Tube Loader Located in the rear of the Breech Ring and provides the means of automatically loading a TVE into the TVE chamber at the rear of the BVA. A magazine containing up to 10 TVEs is retained in a recess in the casing of the ATL. When the gun recoils and returns to the run out position, the ATL loads the next TVE. The TVE for the first round fired has to be loaded by the Loader operating the ATL.
14	ATDU	Armoured Trials and Development Unit Based at Bovington Camp, Dorset.
15	ATA	Annual Troop Assessment Tests the crew's ability to operate as part of a Troop of tanks (up to 4 CR2).
16	AV	Armoured Vehicle
17	AVSO	Armoured Vehicle Standing Orders
18	BATUS	British Army Training Unit Suffield, Canada
19	BVA	Bolt Vent Axial Part of the CR2 Main Armament breech, which, together with the obturator pad and shim, forms the gas tight seal at the rear of the gun when it fires.
20	BVA Assembly	The BVA Assembly is the BVA, Obturator Pad, Shim and Thrust Housing.
21	Capt	Captain
22	CE	Chemical Energy Describes a projectile designed to create damage by its High Explosive content. Eg the 120mm HESH round.
23	CIM	Classroom Instructional Model
24	CMR	Castlemartin Ranges. Merrion Camp, Pembrokeshire, Wales.
25	CMT	Combat Medical Technician A specialist military trade within the Royal Army Medical Corps capable of assisting with the management of surgical, medical and psychiatric casualties from the onset of the condition until the casualty is admitted to a hospital offering specialist care.
26	CO	Commanding Officer
27	CoC	Chain of Command
28	Cpl	Corporal

Serial (a)	Acronym / Abbreviation (b)	Explanation (c)
29	CP DS-T	Charge Propelling Discarding Sabot – Training L18A1 Used to fire DS-T rounds from the main armament. Approximately 700mm long, it is a solid, orange, cylindrical case made of combustible nitrocellulose which contains a bundle of propellant sticks. It has a flat bottom, where the igniter is located in a silk bag, and a cup shaped cap at the top, which fits over the rear of the projectile when loaded in the gun. Sometimes referred to as a "bag charge".
30	CP SH	Charge Propelling Squash Head L3A2 Used to fire HESH, Smoke and SH-P rounds from the Main Armament. Approximately 700mm long, it is a cloth bag, D shaped in cross section, filled with a bundle of propellant sticks. The igniter pad (red) filled with gunpowder is at one end and a cloth lifting strap is at the other. Sometimes referred to as a "bag charge".
31	CR2	CHALLENGER 2 Main Battle Tank in use within the Royal Armoured Corp of the British Army since 1998.
32	C/S	Call Sign
33	DAIB	Defence Accident Investigation Branch
34	DIO	Defence Infrastructure Organisation
35	DS-T	Discarding Sabot – Training L29A1 120mm gun projectile. Training variant of the APFSDS round.
36	DTSO	Deputy Training Safety Officer WO2 on CMR staff. Part of the team responsible for the day to day delivery of a safe training environment and ranges for authorised users and the supervision of live fire and all-arms manoeuvre training
37	ECBA	Enhanced Combat Body Armour
38	ERM	Equipment Registration Mark Military Vehicle Registration Number.
39	FCC	Fire Control Computer
40	FMX	Fire and Manoeuvre Exercise
41	FNA	Firing Needle Assembly Part of the CR2 Main Armament Breach which holds the rear of the TVE and provides it with the firing pulse. The FNA is located in the lower breech block, held in place by the Thrust Housing.
42	GPMG	General Purpose Machine Gun 7.62mm calibre machine gun that can be mounted on the loader's cupola on top of the CR2's turret.
43	HESH	High Explosive Squash Head The operational High Explosive CE round. Simulated by the inert SH-P round during training.
44	HOTO	Hand Over / Take Over
45	JSP 440	Joint Service Publication 440 The Defence Manual of Security, Resilience and Business Continuity.
46	KE	Kinetic Energy Describes a projectile designed to create damage by hitting the target. It does not contain explosives. E.g. the 120mm APFSDS round.
47	L30A1 Gun	120mm calibre rifled tank gun fitted to the CR2 as the Main Armament.
48	L94A1 Chain Gun	7.62mm calibre chain gun fitted to CR2 as the Secondary Armament, mounted co-axially to the Main Armament.
49	LCpl	Lance Corporal
50	LDT	Loader Drills Trainer The LDT is a life size mock-up of the tank turret in which loaders are trained and practice the drills required to operate the Main and Secondary Armament.
51	Lt	Lieutenant
52	Lt Col	Lieutenant Colonel

Serial (a)	Acronym / Abbreviation (b)	Explanation (c)
53	LFME	Live Firing Monitoring Equipment System fitted to CR2 which allows gunnery staff to monitor live what the gunner and commander are looking at through their sights and hear what the crew are saying to each other on the intercom. This enables the quality of gunnery to be assessed and the LFX to be debriefed to crews on completion.
54	LFX	Live Firing Exercise
55	Maj	Major
56	MBT	Main Battle Tank
57	MG	Machine Gun
58	MTP	Multi Terrain Pattern
59	ODH	Operating Duty Holder The ODH is accountable for mitigating the risk to life to ALARP and to a level that is tolerable for those involved in the activity and anyone affected by it, including the public.
60	PAM 21	Pamphlet Number 21, Training Regulations for Armoured Fighting Vehicles, Infantry Weapon Systems and Pyrotechnics, dated Apr 17.
61	PCS	Personal Clothing System
62	PGTE	Precision Gunnery Training Equipment
63	PPE	Personal Protective Equipment
64	PTT	Part Task Trainer Simulator for the CR2 gunner's station, used to develop and practice gunnery skills. Part of the PGTE.
65	RASP	Range Action Safety Plan
66	RCO	Range Conducting Officer The RCO is responsible for the safe conduct of the firing, following the plan in accordance with the RASP. PAM 21 states the RCO should be qualified and competent with the weapons being used.
67	RDA	Range Danger Area
68	REME	Royal Electrical and Mechanical Engineers
69	RGSS	Regimental Gunnery Staff Sergeant
70	RIG	Regimental Instructor Gunnery
71	RL	Royal Lancers
72	RTR	Royal Tank Regiment Armoured unit, based at Tidworth, equipped with CR2. Part of 1 Armoured Infantry Brigade and 3 (UK) Division. Comprises of 6 Squadrons, AJAX, BADGER, CYCLOPS, DREADNOUGHT, EGYPT and FALCON.
73	SASC	Small Arms School Corps
74	SECR	Safety and Environmental Case Report
75	Sgt	Sergeant
76	SSgt	Staff Sergeant
77	SH-P	Squash Head – Practice L32A6 Inert 120mm gun projectile, ballistically matched to the operational High Explosive Squash Head round. Used for training
78	SPC	System Performance Check Live Firing Exercise, mandatory for each CR2, to confirm the vehicle preparation in order to continue with objective training. Checks alignment of CR2 armament and sights. Also referred to as LFX3.
79	Sqn	Squadron Armoured sub unit consisting of 18 CR2.
80	STSO	Senior Training Safety Officer Maj on CMR staff. Responsible for the day to day delivery of a safe training environment.
81	TFP	Test Firing Procedure Alignment procedure for CR2 if it fails two consecutive SPCs.

Serial (a)	Acronym / Abbreviation (b)	Explanation (c)
82	TGT	Turret Gunnery Trainer A simulator that brings together the gunner and commander and enables advanced gunnery techniques to be taught and practised. It is used to conduct the Threshold Test. Part of the PGTE.
83	Tpr	Trooper Armoured unit rank equivalent to a Private.
84	TSM	Training Safety Manger
85	TVE	Tube Vent Electric L4A2 Initiating charge for the 120mm L30A1 gun (CR2 Main Armament). Electrically initiated. A brass tube, 13mm in diameter, 10cm in length. Similar in appearance to a 0.5" blank cartridge.
86	TVEDU	Tube Vent Electric Display Unit Indicates that a TVE has been loaded to the Main Armament and that the Firing Circuit is operating.
87	WHT	Weapon Handling Test For CR2 the WHT is conducted in the LDT.
88	WCS	Weapon Control System
89	WO1	Warrant Officer First Class
90	WO2	Warrant Officer Second Class
91	WOME	Weapons Ordnance Munitions and Explosives

PART 1.2

Convening Order and Terms of Reference

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Defence Safety Authority

Service Inquiry Convening Order

27 Jun 17

SI President	Hd Defence AIB
SI Members	DSA Legad

Copy to:

PS/SofS	DPSO/CDS	PSO/Comd JFC
MA/Min(AF)	MA/VCDS	MA/DCGS
PS/Min(DP)	NA/CNS	MA/CFA
PS/Min(DVP)	MA/CGS	PS/GOC 3UK Div
PS/Perm Sec	PSO/CAS	EA/Dir DDC

DSA DG/SI/05/17 – CONVENING ORDER FOR THE SERVICE INQUIRY INTO THE CHALLENGER 2 INCIDENT AT CASTLEMARTIN RANGES, PEMBROKESHIRE ON 14 JUN 17.

1. In accordance with Section 343 of Armed Forces Act 2006 and in accordance with JSP 832 – Guide to Service Inquiries (Issue 1.0 Oct 08), the Director General, Defence Safety Authority (DG DSA) has elected to convene a Service Inquiry (SI).

2. The purpose of this SI is to investigate the circumstances surrounding the incident and to make recommendations in order to prevent recurrence.

3. The SI Panel will formally convene at Ministry of Defence Main Building, Whitehall, London at 1530L on Tue 27 June 2017.

4. The SI Panel comprises:

President: **Commander [redacted] RN**

Members: **Major [redacted] KRH**
Warrant Officer [redacted] RAF

5. The legal advisor to the SI is [redacted] and technical investigation/inquiry support is to be provided by the Defence Accident Investigation Branch (Defence AIB).

6. The SI is to investigate and report on the facts relating to the matters specified in its Terms of Reference (TOR) and otherwise to comply with those TOR (at Annex). It is to record all evidence and express opinions as directed in the TOR.

7. Attendance at the SI by advisors/observers is limited to the following:

Head Defence AIB – Unrestricted Attendance.

Defence AIB investigators in their capacity as advisors to the SI Panel – Unrestricted Attendance.

8. The SI Panel will work initially from the DAIB facilities at Farnborough. Permanent working accommodation, equipment and assistance suitable for the nature and duration of the SI will be requested by the SI President in due course.

9. Reasonable costs will be borne by DG DSA under UIN D0456A.

Original Signed

R F P Felton CBE
Lt Gen
DG DSA – Convening Authority

Annex:

A. Terms of Reference for the Service Inquiry into the Challenger 2 Incident at Castlemartin Ranges, Pembrokeshire on 14 Jun 17.

Annex A To
DSA DG/SI/05/17 Convening Order
Dated 27 Jun 17

TERMS OF REFERENCE FOR THE SERVICE INQUIRY INTO THE CHALLENGER 2 INCIDENT AT CASTLEMARTIN RANGES, PEMBROKESHIRE ON 14 JUN 17.

1. As the nominated Inquiry Panel for the subject SI, you are to:

   a. Investigate and, if possible, determine the cause of the occurrence, together with any contributory, aggravating and other factors and observations.

   b. Investigate whether the issued Personal Protection Equipment that was worn by the Crew was appropriate, sufficient and fit for purpose.

   c. Examine the procedures and processes for firing and the stowage of ammunition in Challenger 2 and whether they were complied with.

   d. Determine the status of any relevant equipment including serviceability status, defects or deficiencies.

   e. Examine what procedures, orders and instructions were applicable to the Live Firing Exercise and whether they were complied with.

   f. Review the supervision across each level of authority to include the roles and responsibilities across the respective Chains of Command.

   g. Establish the level of training, relevant competencies, qualifications and currency of the individuals involved in the activity.

   h. Identify if the levels of planning and preparation were commensurate with the activity's objectives.

   i. Assess any Health and Safety at Work and Environmental Protection implications in line with JSP 375 and JSP 418.

   j. Determine and comment on any broader organisational and/or resource factors.

   k. Report and make appropriate recommendations to DG DSA.

2. The Terms of Reference above have been designed to be wide ranging in order to ensure that you have the freedom to investigate wherever the evidence leads. During the course of your investigations, should you identify a potential conflict of interest between the CA and the Inquiry, you are to pause work and take advice from your DSA Legal Advisor and DG DSA.

3. If at any stage the Panel discover something they perceive to be a continuing hazard presenting a risk to the safety of personnel or equipment, the President should alert DG DSA without delay; in order to initiate remedial actions immediately. Consideration should also be given to raising an Urgent Safety Advice note.

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PART 1.3

Narrative of Events

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TABLE OF CONTENTS – PART 1.3

LIST OF FIGURES – PART 1.3

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PART 1.3 – NARRATIVE OF EVENTS

All times local (BST, Zulu plus 1 hour).

Synopsis

1.3.1. Between 2-16 Jun 17, BADGER Squadron (Sqn) of the Royal Tank Regiment (RTR) was conducting a CHALLENGER 2 (CR2) live firing exercise at Castlemartin Ranges (CMR), Merrion Camp, Pembrokeshire. On 14 Jun 17 at 1525, CR2, Equipment Registration Mark (ERM) DS39AA suffered an internal explosion whilst conducting a Live Fire Exercise (LFX) on Range 4. All 4 crew members were injured and were subsequently transferred to hospital, where 2, the Commander and Loader/Operator, later died. Exhibit 1 Exhibit 11

Background

Castlemartin Ranges

1.3.2. CMR is located in Pembrokeshire, Wales, and covers 2400 hectares of land. It provides live firing ranges for Armoured Fighting Vehicles. It consists of accommodation and support facilities (Merrion Camp) and a mixture of firing ranges. Ranges 2 and 4 are routinely used to conduct CR2 120mm Main Armament live firing practices. Each Range has a control point (those for Ranges 2 and 4 are located in Control Towers) under the overall control of the Warren Tower, which provides command and control for the entire site. Warren Tower is 1.3km from Range 4, but both the Range 4 Control Tower and the location of the accident are visible from Warren Tower. The layout of CMR and Range 4 is shown in Figure 1.3.1 and Figure 1.3.2.

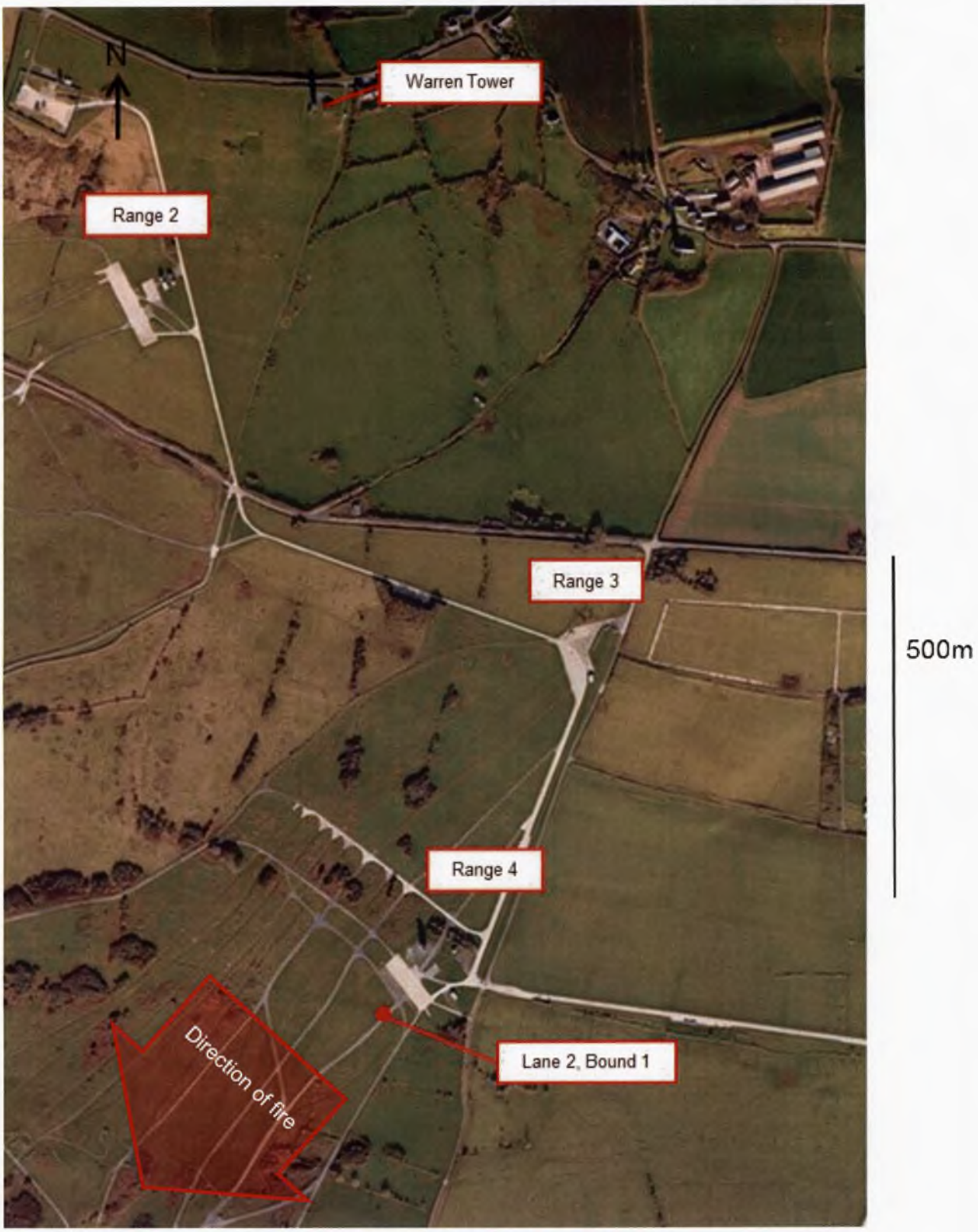

Figure 1.3.1: Aerial View of Castlemartin Ranges

Figure 1.3.2: Aerial View of Range 4

Pre-Accident Events

Background

1.3.3. Between 2-16 Jun 17, BADGER Sqn RTR was scheduled to conduct a CR2 live firing range package at CMR. The primary aim of the range period was for BADGER Sqn to progress through the LFX syllabus and pass Annual Crew Tests (ACT) prior to deploying to the British Army Training Unit – Suffield (BATUS) in Aug 17. All the firing took place on Ranges 2 and 4 under the overall control of Warren Tower.

Exhibit 2
Exhibit 11

1.3.4. On 14 Jun 17 Badger Sqn was using Ranges 4 and 6. Range 6 was being used to conduct first aid training for crews and no firing was taking place. Live firing was taking place on Range 4, predominately to complete outstanding ACTs. The weather was dry with sunny spells and the visibility was good. The Range was open for live firing from 0900 until 1630, with last round to be fired down range no later than 1600.

Exhibit 2
Exhibit 3
Exhibit 11

1.3.5. All the ACTs were completed by 1300. The intention was then to complete Test Firing Procedures (TFPs) on 2 CR2s which had previously failed 2 System Performance Checks (SPC or LFX3). The first CR2 was brought up to the firing point on Range 4 to start its TFP, but a further fault was discovered and it was unable to continue with the serial. The second CR2 was also unserviceable at this point.

Exhibit 3
Witness 1
Witness 3
Witness 12

1.3.6. With all other activity for that day completed, at approximately 1430, the Range Conducting Officer (RCO) on Range 4 decided to commence a series of 4 "Experience Shoots". These "Experience Shoots" involved unqualified personnel sitting in the Gunner's position in the CR2. These shoots were not formally defined LFXs, but a simple demonstration of the CR2's armament, where each run would consist of firing 2 main armament rounds (one Squash Head Practice (SH-P) and one Discarding Sabot Training (DS-T)), plus a number of 7.62mm rounds fired from the coaxial mounted Chain Gun. Firings would take place from a static tank at static targets on Range 4. CR2 ERM DS39AA was selected for the shoots, as it had proven to be an accurate, reliable firing tank throughout the range package.

Exhibit 1
Witness 1
Witness 2
Witness 11
Witness 16

Crew Composition

Figure 1.3.3: Crew Positions in a CHALLENGER 2

1.3.7. At the time of the accident, the Crew of the CR2 was made up of the following personnel:

Witness 1
Witness 2
Witness 3
Exhibit 13

a. **Tank Commander**. Corporal (Cpl) Darren Neilson, BADGER Sqn RTR, (hereafter referred to as the Commander) was a CR2 Tank Commander[1] and a Regimental Instructor Gunnery[2] (RIG).

b. **Loader/Operator**. Cpl Matthew Hatfield, BADGER Sqn RTR, (hereafter referred to as the Loader) was also a CR2 Tank Commander and a RIG.

c. **Driver**. The Driver was a member of BADGER Sqn, a qualified CR2 Driver, who was also qualified as a CR2 Gunner.

d. **Gunner**. The guest Gunner was a member of the Small Arms School

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[1] CR2 Tank Commanders are also qualified as Gunners and Loader/Operators.

[2] A Regimental Instructor Gunnery (RIG) is a Non Commissioned Officer, Corporal or above, who is selected and trained to instruct gunnery and gun drills within the unit, as well as their regimental duties, usually as tank commanders.

Corps (SASC) based at CMR and not a qualified CR2 crewman. He was in the tank to better understand the demands of conducting live firing in a CR2 at CMR.

The Commander and Loader were selected for the shoot in advance as the most appropriate members of BADGER Sqn to demonstrate the capabilities of the CR2. The Driver was selected by the Commander just prior to the shoot.

Vehicle History

1.3.8. CR2 ERM DS39AA had been in the RTR inventory since 8 Jan 15, originally belonging to AJAX Sqn. It was transferred to BADGER Sqn on 30 Mar 17. In this time it suffered from no significant serviceability or maintenance issues. On joining BADGER Sqn, the vehicle was assigned to a Troop Sergeant and his Crew (Call Sign 30B), and they remained responsible for it during the range package at CMR. It was transported by road to CMR, with the Squadron's other vehicles (including 8 other CR2s). It was up to date for all maintenance.

Witness 8
Exhibit 4

Previous 24 hours

1.3.9. The CR2 had been used throughout the range package and had proven to be a reliable, accurate firing unit. On the morning of 14 Jun 17, the vehicle was presented at First Parade and the normal pre-firing checks were completed[3]. The vehicle was then used by the Troop Sergeant's Crew to successfully complete their ACT, finishing at approximately 1300. During this Live Firing Exercise (LFX), 18 main armament rounds (6 x DS-T, 12 x SH-P) and approximately 600 7.62mm rounds were fired, with no reported defects or misfires.

Witness 1
Witness 8
Exhibit 7

Experience Shoot Details and Preparation

1.3.10. The accident occurred during an Experience Shoot designed to demonstrate the process of firing a CR2. Four people were invited to sit in the Gunner's position for a series of shoots. Each would fire 2 main armament rounds (one Squash Head Practice (SH-P) and one Discarding Sabot Training (DS-T)), plus a number of 7.62mm rounds from the coaxial chain gun.

Witness 1
Witness 3
Witness 4
Witness 11

[3] The pre-firing checks are discussed in more detail in Part 1.4

1.3.11. The Sqn Sergeant Major supervised the following ammunition being placed into the tank for the LFX: Witness 12

Serial	Nature	Quantity
1	120mm TK DS Practice, L29A1, Discarding Sabot Training (DS-T)	4
2	Charge, Propelling, 120mm, TK DS, L18A1	4
3	120mm TK Squash Head Practice, L32A6 (SH-P)	4
4	Charge, Propelling, 120mm TK Practice SH, L3A2	4
5	7.62mm Ball, 1B1T Linked L44A1/L45/A1	400
6	Tube Vent Electric 13mm L4A2	9

Table 1.3.1: Ammunition Loaded for LFX

The tank was parked adjacent to the Ammunition Point preparation area to the East of the Range 4 control tower and the ammunition was passed up to the Loader who placed it inside the turret.

1.3.12. The targets selected for this shoot were 3 static, hard targets (tank hulks) situated at a range of approximately 1000m on Range 4, chosen as they were clearly visible. Witness 1

Conduct of the Experience Shoot

1.3.13. The guest Gunner and the crew mounted the vehicle on the hard standing on Range 4 at approximately 1500. The driver's hatch was closed (as required during live firing) and the turret hatches were both open. They proceeded onto Range 4 Lane 2 and drove approximately 30m down the lane to the firing position at Bound 1[4]. The Commander spoke to the Range 4 Tower by radio and requested permission from the Range Conducting Officer to go to action. Permission was given. The orange, flashing indicator beacon on the rear of the turret was switched on, indicating that the tank was at action (ready to fire). Witness 1 Witness 11

[4] The "Bounds" are designated points marked along the firing lanes.

Incident Events

Figure 1.3.4: The Post Incident View from Range 4 Control Tower showing CR2 ERM DS39AA (circled in red) on Lane 2 Bound 1

1.3.14. At approximately 1525 white smoke was seen coming from the open turret hatches, accompanied by a loud hissing noise. Very shortly after this, the Commander was seen attempting to rapidly leave the turret from the Commander's hatch (right hand side). When his waist was level with the top of his hatch, an explosion occurred which threw him approximately 5m into the air and he landed on the grass 6m to the right of the vehicle. Immediately after this explosion, 2 large, violent jets of flame were seen coming from both turret hatches for approximately 5 to 8 seconds. The Training Safety Manger (TSM) in Range 4 Control Tower called "Stop, Stop, Stop" on the radio link to Warren Tower. Witness 1 Witness 11

1.3.15. The RCO attempted to raise the tank by radio [1526] but no response was heard. Witness 5 Witness 1

Post-Incident Events

1.3.16. At 1526, the Duty Range Officer in Warren Tower, having received the "Stop, Stop, Stop" order and witnessed the explosion and fire, called the Emergency Services (999) and requested at least 2 air ambulances. The entire range complex was then instructed to cease firing, clear guns and report when clear (Ranges 6, 7, 9, and 10 were allocated to small arms firing that day).

Witness 1
Witness 5
Exhibit 6
Exhibit 12

1.3.17. After a pause of approximately 4 minutes [1530] to allow the flames to recede and reduce the risk of injury to personnel from any further explosion, the on-range BULLDOG[5] Ambulance went forward with the Sqn Medic and 2 supporting staff onboard (Responders[6] 1 and 2). They drove directly to where the Commander had landed to the right of the tank. Due to fears of a further explosion, he was placed on a stretcher, loaded into the BULLDOG and transferred to Range 4, Lane 3, 80m away from the tank.

Witness 11
Witness 15
Witness 16
Exhibit 5

1.3.18. After the Commander was unloaded from the BULLDOG, the Second Sqn Medic arrived having been driven over from Range 6, 1.6km away, where he had been teaching First Aid. He assessed the casualty and initiated Cardiopulmonary Resuscitation (CPR). The Commander continued to receive CPR from unit members, later assisted by civilian paramedics.

Witness 9
Witness 11

1.3.19. The first civilian paramedics arrived on scene at 1540 and were escorted forward, initially providing support to the team administering CPR to the Commander in Lane 3.

Witness 1
Witness 11

1.3.20. At 1540 unit members approached the tank which was still smoking heavily. Responder 1 then called for Fire Extinguishers and moved around to the front of the vehicle with Responder 2 and attempted to communicate with the Driver by banging on the hatch. No response was heard, and a sledge hammer and crowbar were requested in order to conduct the emergency hatch opening procedure.

Witness 17
Witness 19

1.3.21. Responder 1 then climbed on top of the tank and discharged into the turret 2 fire extinguishers that were brought forward and passed up to him by Responder 3 [1545]. Responders 4 and 5 and the Sqn Medic then joined him on top of the turret and assessed the condition of the Loader and Gunner. The decision was made to extract both using a track rope. This is the standard means of extracting injured personnel from a CR2 and is routinely practised.

Witness 7
Witness 15
Witness 18
Witness 19

1.3.22. Responder 2 received the sledge hammer and crow bar and initiated the emergency release mechanism on the driver's hatch, by striking the release lugs with the hammer. This failed to release the hatch and he then placed the crow bar under the hatch lip and attempted to prise it open. This also failed, even when Responder 3 joined him and they both placed their full weight on the bar. They made the decision that the fastest way to get to the Driver was through the turret. Responder 3 then mounted the tank and joined the team on top of the turret.

Witness 16
Witness 17

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[5] A BULLDOG is a lightly armoured, tracked troop carrier.

[6] Responders 1-5 were all members of BADGER Sqn RTR.

1.3.23. The Loader was found to the rear of the left hand side of the turret, behind the rear edge of the Loader's Guard. He had visible serious injuries and appeared unconscious but breathing. Responder 1 then climbed down into the Commander's position to better view the casualty. Responder 3 climbed into the loader's position and together they released the Loader's Guard (allowing it to move forward), passed a track rope under his arms and guided the Loader out of the turret. He was transferred directly to a stretcher [1555] that had been brought forward and placed on top of the turret and moved to the ground at the rear of the tank to receive medical support from the Unit Medic and civilian paramedics.

Witness11
Witness 15
Witness 17

1.3.24. The Gunner was discovered in his seat, unconscious but breathing, with his head leaning forward to the right by the side of the gunner's sight. He had visible serious injuries. Due to the confined nature of the turret and the damage it had sustained, getting access to the Gunner was difficult and Responder 3 elevated the gun manually to give better access. Responder 4 entered the turret and between them they managed to pass a track rope around the Gunner and guide him out through the Commander's hatch [1601] where he was transferred directly to a stretcher on top of the tank and moved to the rear of the vehicle to receive treatment.

Witness 17
Witness 18

1.3.25. Whilst the turret crew were being extracted, work continued on opening the driver's hatch. With the arrival of the Local Area Fire Brigade, specialist hydraulic rescue tools (the "Jaws of Life") were brought forward. Responder 3 returned to the tank and disengaged the turret traverse gearbox. This allowed the barrel of the main armament to be pushed over the left hand side of the tank, giving better access to the driver's hatch. Two crowbars were then inserted into the edge of the hatch and used to create a small opening and the Fire Brigade then opened the hatch using their specialist equipment. The Driver was discovered unconscious, breathing, with visible minor injuries. He was extracted and moved to a stretcher to receive treatment at the rear of the tank.

Witness 17

1.3.26. By 1608 all the casualties had been extracted from the tank and were receiving treatment from paramedics and unit members on stretchers to the rear of the vehicle. When Responder 4 left the turret following the extraction of the Gunner, the turret was moved back into arcs (to ensure it was pointing in a safe direction) and he gave instructions that no one else was to enter the tank. The tank was left undisturbed until the arrival of the investigating Ammunition Technician (AT) the following morning.

Exhibit 5
Exhibit 9
Witness 18

Witness 1
Witness 2
Exhibit 5
Exhibit 12

Serial	Time	Activity
1	1500	Experience Crew mount DS39AA on hard standing at top of Range 4.
2	1525	Accident occurs.
3	1526	RCO in Range 4 Control attempts to raise DS39AA by radio.
4	1530-1532	BULLDOG Ambulance goes forward. Casualty moved to Range 4 Lane 3.
5	1540	Unit members mount DS39AA. First civilian paramedics arrive at scene.
6	1545	Two BCF fire extinguishers discharged into turret.
7	1545-1550	Initial unsuccessful attempt to open Driver's Hatch.
8	1548	First Ambulance arrived at Range 4
9	1550	First Fire Engine and Second Ambulance arrived at Range 4
10	1627	First air ambulance lands at CMR Range 4 hard-standing
11	1550-1555	Loader extracted from DS39AA and transferred to rear of vehicle on a stretcher.
12	1553	Police and second Fire and Rescue team arrive at Range 4

13	1555-1601	Gunner extracted from DS39AA and transferred to rear of vehicle on a stretcher.
14	1555-1608	Driver extracted from tank using specialist equipment provided by Fire Brigade.
15	1608	Loader, Gunner and Driver receiving first aid treatment at rear of DS39AA.
16	1632	Second air ambulance lands at CMR Range 4 hard-standing
17	1651	Third air ambulance lands at CMR Range 4 hard-standing
18	1725	The Loader was transferred to hospital by air ambulance (Lift 1)
19	1755	The Gunner was transferred to hospital by air ambulance (Lift 2)
20	1802	The Commander was transferred to hospital by air ambulance (Lift 3)
21	1803	The Driver was transferred to hospital by road ambulance

Table 1.3.2: Timetable of Key Events

Injuries Sustained

1.3.27. **Tank Commander**. Fatality. The Commander was halfway out of the commander's hatch when the explosion threw him approximately 5m into air and he landed 6m to the right of the tank. He was transferred to hospital by air ambulance, where he died of multiple fractures and burn injuries commensurate with being blown clear of the vehicle by the explosion. Witness 1 Witness 14 Exhibit 8

1.3.28. **Loader/Operator**. Fatality. The Loader was found to the rear of the loader's position, leaning forward onto the loader's guard, which was in the unbroken position (closed). He was transferred to hospital by air ambulance where he later died of his injuries. The cause of death was recorded as burns. Witness 1 Witness 20 Exhibit 8

1.3.29. **Gunner**. Serious Injuries. The Gunner was found unconscious having suffered serious burns. He was transferred to hospital by air ambulance. Witness 1 Witness 20

1.3.30. **Driver**. Minor injuries. The Driver was discovered unconscious and was transferred to hospital by road ambulance, where he received treatment for burns. Witness 19 Witness 20

Post-Incident Management

1.3.31. An investigation team from the Defence Accident Investigation Branch (DAIB), consisting of 2 Operations Investigators and 2 Engineer Investigators arrived at CMR at 2300 on 14 Jun 17. On 15 Jun 17 they conducted an initial triage investigation consisting of witness interviews and an inspection of the vehicle. Exhibit 1

1.3.32. On the morning of 15 Jun 17 the investigating AT was the first person to enter the tank (via the turret) in order to ensure explosive safety. Once made safe, he left the vehicle and the DAIB Investigators made their initial inspection. Exhibit 9

Salvage Operations

1.3.33. CR2 ERM DS39AA was recovered by road to the Armoured Trials and Development Unit (ATDU) at Bovington on 19 Jun 17. On 3-5 Jul 17 it was subject to a detailed examination by Dyfed Powys Police, supported by the DAIB. The SI panel, the Vehicle Project Team and the Health and Safety Executive (HSE) were present, together with supporting staff from the Armour Centre at Lulworth. Exhibit 10

PART 1.4

Analysis and Findings

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TABLE OF CONTENTS – PART 1.4

LIST OF FIGURES – PART 1.4

LIST OF TABLES – PART 1.4

PART 1.4 – ANALYSIS AND FINDINGS

All times local (BST, Zulu plus 1 hour).

Overview

1.4.1. From 2 to 16 Jun 17, BADGER Squadron (Sqn) Royal Tank Regiment (RTR) was conducting a CHALLENGER 2 (CR2) Main Battle Tank (MBT) Live Firing Exercise (LFX) at Castlemartin Ranges (CMR), Merrion Camp, Pembrokeshire. On 14 Jun 17 at 1525, CR2, Equipment Registration Mark (ERM) DS39AA suffered an internal explosion[1] and fire whilst conducting a LFX on Range 4. All 4 crew members were injured and were subsequently transferred to hospital, where 2, the Commander and the Loader/Operator, later died.

Exhibit 2
Exhibit 11
Exhibit 37

1.4.2. The report is split into the following sections:

a. An introduction to the CR2 and its Main Armament to provide the necessary background information required to understand the accident.

b. A chronological review of the period leading up to the accident, including the planning and preparation for the Range Package.

c. The accident itself and an analysis of the 2 principal events.

d. The immediate actions in response to the accident.

e. The Personal Protective Equipment (PPE) worn by the personnel involved.

f. A review of organisation and resources at CMR.

1.4.3. The Panel has drawn conclusions and made recommendations throughout the report, but a summary of Accident Factors is included at the end of Part 1.4 and a summary of Recommendations is in Part 1.5.

Methodology

Accident Factors

1.4.4. Once an Accident Factor had been determined, it was assigned to one of the following categories:

a. **Causal Factor**. An event which, in isolation or in combination with other factors and contextual details, led directly to the accident.

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[1] The term explosion used throughout this document is defined as *the sudden expansion of gases into a volume much greater than their initial one, accompanied by noise and violent mechanical effects*. Bailey A and Murray S G ((1989) Explosives, Propellants and Pyrotechnics. Brassey's, London

b. **Contributory Factor**. A factor which made the accident more likely.

c. **Aggravating Factor**. A factor that made the outcome worse.

d. **Other Factor**. A factor which was none of the above, but was noteworthy in that it may cause or contribute to future accidents.

e. **Observations**. An issue that was not relevant to the accident but worthy of consideration to promote better working practices.

Human Factors

1.4.5. The Panel has used the 'Swiss Cheese Model'[2] of accident analysis to assess evidence across the following categories:

a. **Unsafe Acts**. Fact-based non-judgemental statements aimed purely at categorising potentially unsafe acts of an individual (or team), whether intentional or unintentional; the aim being to clearly identify specific error types so that a correct assessment can be made of human performance issues relating to cited Accident Factors. They are grouped as:

(1) **Unintentional Acts**:

(a) **Slips**. Error by commission; where a well-practiced skill, requiring little cognition, is carried out incorrectly.

(b) **Lapses**. Error by omission; where a well-practiced skill, requiring little cognition, is not carried out.

(2) **Intentional Acts**:

(a) **Mistakes**. Deficiencies in judgement and/or failing to formulate the right plan based on flawed knowledge and/or incorrect comprehension of rules.

(b) **Violations**. Deliberate and conscious departures from established rules/procedures, although often with no intent to cause harm.

b. **Error Promoting Condition (EPC)**. The psychological, physical/mental limitations and physiological factors that can influence human performance, ie capacity, fatigue, etc.

c. **Organisational Influences**. The broader (often indirect and latent) influences that a higher organisation brings to bear on those involved in an occurrence, and which are beyond those individuals' control in terms of resources, climate, etc.

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[2] Reason J (1990) Human Error. Cambridge: University Press, Cambridge.

d. **Breached (or failed) Defences**. Those rules, orders, practices and procedures designed to assure the safe operation of the vehicle, which failed or were breached by those involved.

1.4.6. Due to the nature of this accident, Human Factors are essential to understanding why it occurred and the work of Professor Sidney Dekker[3] has been used to analyse what happened on 14 Jun 17. The Panel has avoided using hindsight to state what the Tank Crew **should** have done and focussed on explaining **why** the Crew did what they did. In doing so, the Panel has made recommendations that put in place control measures which should prevent this accident reoccurring.

Probabilistic Language

1.4.7. The probability terminology detailed below in Figure 1.4.1 clarifies the terms used in this report to communicate uncertainty within the report. It is based on terms published by the Intergovernmental Panel on Climate Change (IPCC) in their Guidance Note for Consistent Treatment of Uncertainties[4] as well as the Australian Transport Safety Bureau (ATSB) in their paper on Analysis, Causality and Proof in Safety Investigations[5].

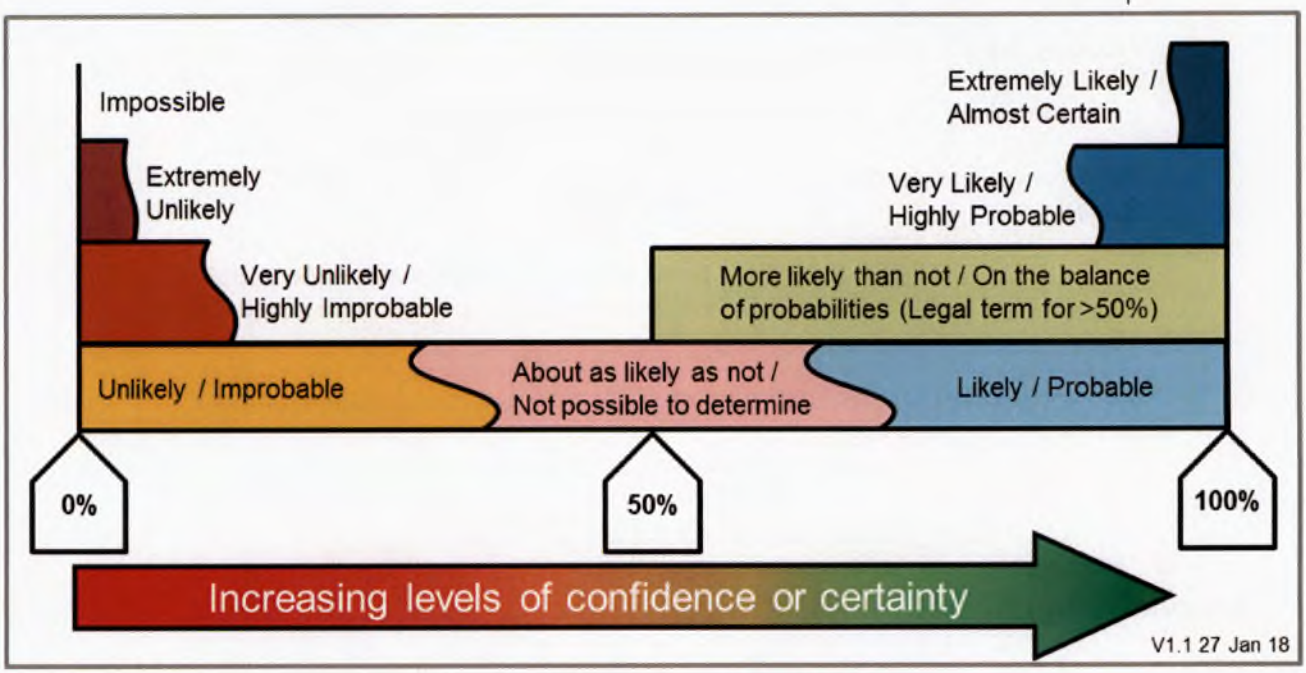


Figure 1.4.1: Probabilistic Terminology

[3] Dekker S (2006), The Field Guide to Understanding Human Error. Ashgate Publishing Limited.

[4] https://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf.

[5] https://www.atsb.gov.au/media/27767/ar2007053.pdf.

Available Evidence

1.4.8. The Panel had access to the following evidence:

a. Written statements from members of the RTR and CMR staff.

b. Range Action Safety Plans (RASPs) and Range Orders.

c. Photography from Defence Accident Investigation Branch (DAIB) Investigators and Dyfed Powys Police.

d. A written Technical Investigation Report from DAIB Investigators.

e. A written Munitions Accident/Near Miss Report from the investigating Ammunition Technician (AT).

f. A written Human Factors Report from an Army Personnel Strategy Occupational Psychologist.

g. Documentation and instruction from Assistant Instructor Gunnery (AIG) staff from the Armoured Fighting Vehicle Technical Training School (AFVTTS) Gunnery Wing at the Armour Centre.

h. Pathology Reports.

i. Army Equipment Support Publication (AESP) 2350-P-102 (CR2 MBT) Series.

j. CHALLENGER 2 Safety and Environmental Case Report, Issue 7, date 8 Aug 16 and L30A1 Safety and Environmental Case Report, Issue 2 dated 7 Mar 16.

k. CR2 MBT ERM DS39AA and its associated Gun Documentation Folder.

l. A number of other CR2s as reference tanks.

m. L30A1 Gun Classroom Instructional Model (CIM).

Interviews Conducted

1.4.9. Formal interviews were conducted with the following personnel:

a. Members of the RTR and attached arms who were present at CMR on 14 Jun 17.

b. Service and civilian staff at CMR.

c. AIG staff from the Armoured Fighting Vehicle Technical Training School (AFVTTS) Gunnery Wing at the Armour Centre.

d. Defence Equipment and Support CR2 Project Team.

Services

1.4.10. The Panel was assisted by the following agencies and organisations:

a. DAIB.

b. AFVTTS Gunnery Wing at the Armour Centre.

c. Army Personnel Strategy – Occupational Psychology.

d. Armoured Trials and Development Unit (ATDU).

e. The King's Royal Hussars.

f. Ammunition Technical Support Group.

g. Dyfed-Powys Police.

h. Training Technology Enhanced Learning Group at the Armour Centre.

Factors Considered

1.4.11. With respect to the accident, the Panel analysed the following key areas:

a. The relevance and impact of individual acts.

b. The planning and preparation leading up to the event.

c. Tank design, particularly the design and functioning of the Main Armament.

d. The prevailing conditions at the time of the event.

e. Regulations, instructions and orders.

f. Levels of authority and supervision.

g. Vehicle serviceability.

h. Incident response.

i. Personal Protective Equipment (PPE).

j. Organisation and resources.

k. Safety management and culture.

Introduction

1.4.12. This introduction provides background information on CR2 and its Main Armament. This will provide the reader with an understanding of the CR2 and be a source of reference for the technical points discussed in this report.

The CHALLENGER 2 Tank

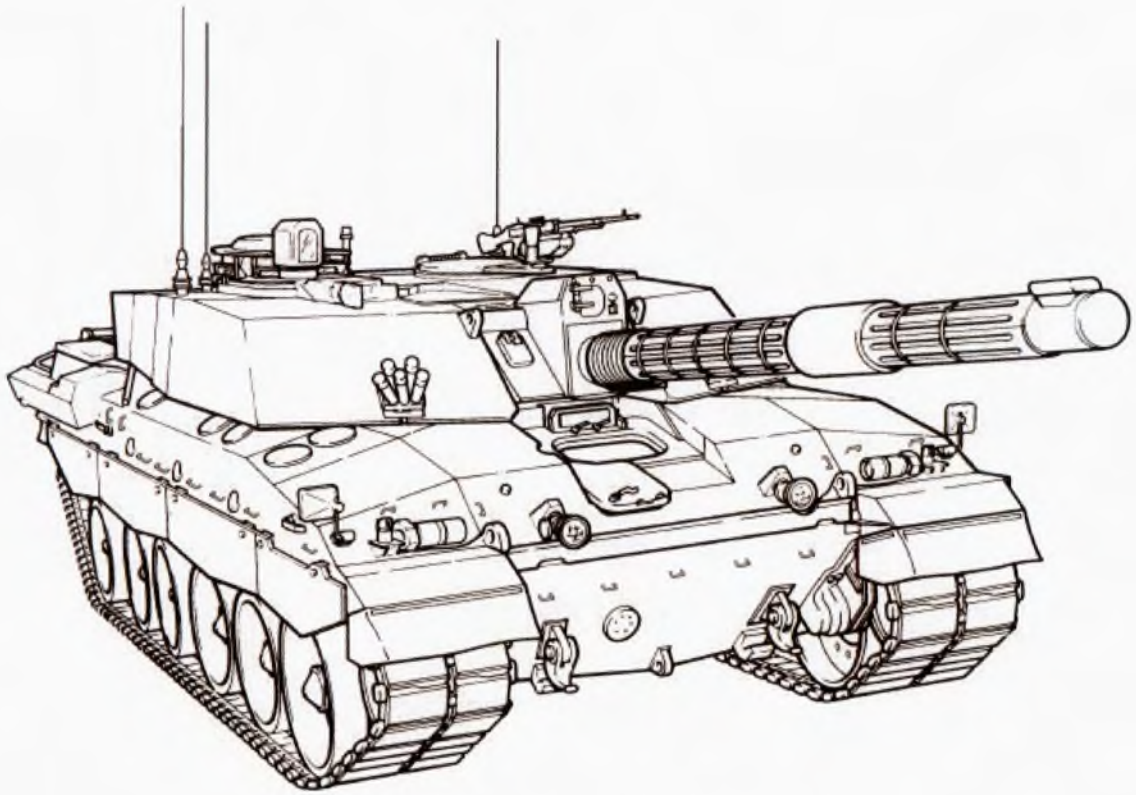


Figure 1.4.2: CHALLENGER 2 Main Battle Tank

1.4.13. **CR2**. The CR2 (Figure 1.4.2) is the Main Battle Tank used by the Royal Armoured Corps of the British Army since 1998. It is currently operated by the RTR, the King's Royal Hussars, the Queen's Royal Hussars and the Royal Wessex Yeomanry. It is a fully tracked, armoured fighting vehicle, operated by a crew of 4 and equipped with a stabilised 120 mm L30A1 gun mounted in a traversable turret as its main armament. The secondary armament comprises a 7.62 mm L94A1 Chain Gun mounted co-axially to the main armament and a 7.62 mm General Purpose Machine Gun (GPMG) mounted on the loader's cupola[6] (on top of the turret). Exhibit 36

[6] This weapon was not fitted on the vehicle involved in this accident.

1.4.14. **Tank Crew**. The crew of 4 (Figure 1.4.3) is made up of: Exhibit 36

a. **Commander**. The commander sits on the right hand side of the fighting compartment, just below the commander's hatch and is in overall charge of the vehicle. The commander has overall responsibility for the safety of the vehicle and its crew while individual crewmen are responsible for using the correct safety procedures in their crew position.

b. **Loader/Operator**. The loader stands in the left hand side of the fighting compartment. His primary task is loading the main and secondary armament and he is also the radio operator.

c. **Gunner**. The gunner sits directly in front of the commander, with his head adjacent to the commander's knees. His task is to work with the commander, identifying and engaging targets.

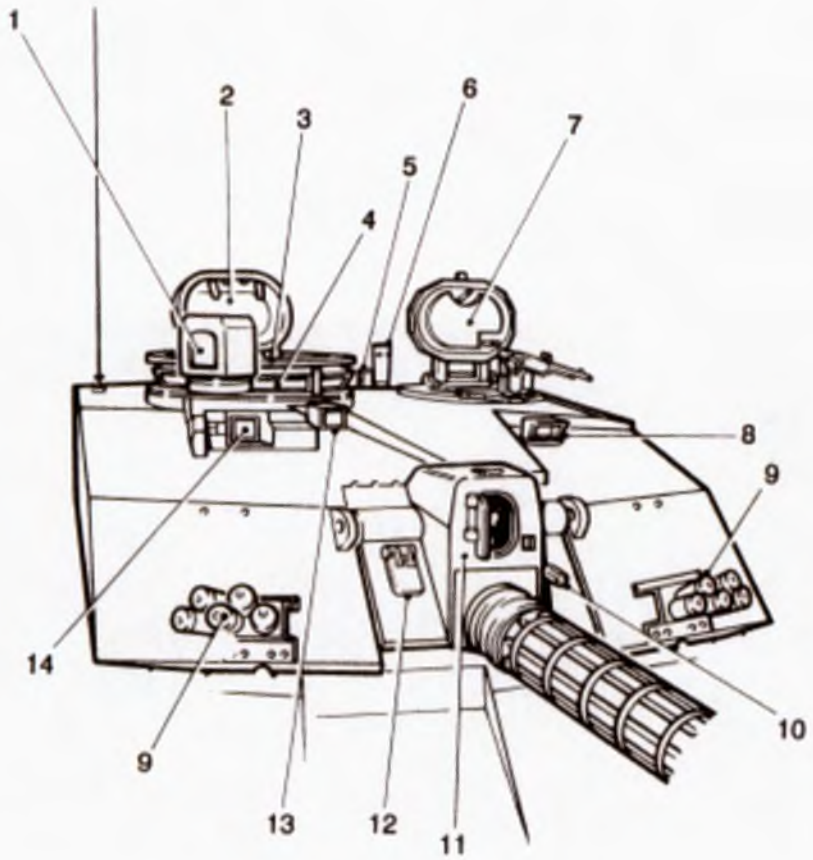
d. **Driver**. The driver sits in a semi-reclined position in the hull of the tank, forward of the fighting compartment. He has his own hatch which must be closed when the vehicle is firing.

Figure 1.4.3: Crew Positions in a CHALLENGER 2

1.4.15. **The Fighting Compartment**. The Fighting Compartment is the centre compartment of the vehicle and extends the whole width of the hull; it is separated from the power pack compartment by a transverse bulkhead and the driver's compartment by a partial bulkhead. The compartment is enclosed by the turret and the turret turntable, which is located on and supported by, rollers on the hull floor. The Fighting Compartment also houses projectile, charge and ammunition stowage. Exhibit 36

1.4.16. **Turret**. The armoured turret provides the housing for the main and secondary armament, sights, gun control equipment, radio sets, ammunition and seats for the commander, loader and gunner. It is capable of all round traverse, either manually or under power. The main gun is mounted on trunnions which allow it to be elevated and depressed from the horizontal, either manually or under power. The turret roof is fitted with 2 hatches for crew access, one for the loader, the other for use by the gunner and commander.

Exhibit 36



1	Commander's Primary Sight	8	Loader's Periscope
2	Commander's Hatch	9	Smoke Grenade Dischargers
3	Commander's Vision Cupola	10	Chain Gun
4	Commander's Unity Vision Periscopes	11	Armoured Barbette
5	Flashing Beacon	12	Gunner's Auxiliary Sight Flap
6	Meteorological Sensor	13	Gunner's Unity Vision Periscope
7	Loader's Hatch and Machine Gun Mount	14	Gunner's Primary Sight

Figure 1.4.4: The CHALLENGER 2 Turret

1.4.17. **Main Armament**. The L30A1 is a 120 mm rifled tank gun[7]. It fires 3 part ammunition made up of a projectile, a Propelling Charge and the Tube Vent Electric

Exhibit 35
Exhibit 36

[7] The L30A1 gun is an evolution of the existing L11 gun fitted to CHIEFTAIN and CHALLENGER 1. It was designed by the Royal Armament Research and Design Establishment (RARDE) and manufactured by Royal Ordnance plc.

(TVE), which is used to initiate the Propelling Charge. The projectile and the Propelling Charge are manually loaded by the Loader and the TVE is automatically loaded from a 10 round magazine by the Automatic Tube Loader (ATL) fitted to the rear of the gun. The loader has to operate the ATL manually to load the TVE for the first round to be fired, but subsequent rounds are automatically loaded. The operation of the Main Armament is discussed in more detail at Paragraph 1.4.21.

1.4.18. **Training Ammunition**. During live firing training, CR2 fires 2 types of main armament ammunition: Exhibit 36

a. **Squash Head – Practice (SH-P) L32A6**. (Figure 1.4.5) SH-P is ballistically matched to the operational High Explosive Squash Head (HESH[8]) round but has an inert filling. It is fired with the Charge Propelling Squash Head (CP SH) L3A2. CP SH is used to fire HESH, Smoke and SH-P rounds. It is a cloth bag, D shaped in cross section, filled with a bundle of propellant sticks. The igniter pad (red) filled with gunpowder is at one end and a cloth lifting strap is at the other. The D shaped cross section allows 2 charges to be stored in each location in the armoured charge bins.

Figure 1.4.5: Squash Head Practice L32A6 and Charge Propelling – Squash Head L3A2

Exhibit 36

b. **Discarding Sabot – Training (DS-T) L29A1**. (Figure 1.4.6) DS-T simulates the Armour Piercing Fin Stabilised Discarding Sabot (APFSDS[9]) round but with a much reduced safety range. It is fired with the Charge

[8] The HESH round is used against buildings, bunkers and non-armoured targets.

[9] The APFSDS round is used against armoured targets.

Propelling Discarding Sabot – Training (CP DS-T) L18A1. CP DS-T is only used with DS-T ammunition. It is a solid, cylindrical case made of combustible nitrocellulose which contains a bundle of propellant sticks. It has a flat bottom, where the igniter is located in a silk bag, and a cup shaped cap at the top, which fits over the rear of the projectile when loaded in the gun. Only one charge can be stored in each location in the charge bins.

Only these types of training ammunition were in use by the RTR for the LFXs at CMR during the Range Package.

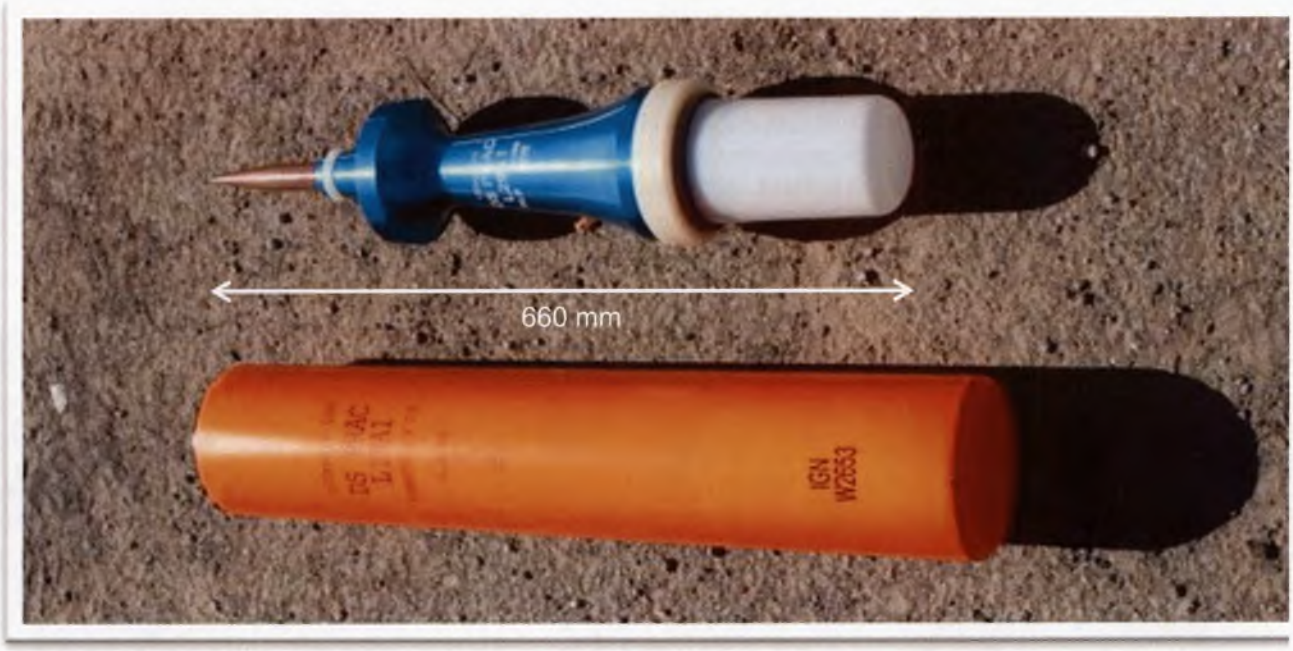


Figure 1.4.6: Discarding Sabot – Training L29A1 and Charge Propelling Discarding Sabot – Training L18A1

1.4.19. **Tube Vent Electric (TVE) L4A2**. (Figure 1.4.7) The TVE is used to ignite the main Propelling Charge. Once all the safety interlocks on the gun have been complete, the Gunner or Commander will press their gun firing switch, which results in the Firing Circuit electrically initiating the TVE. The TVE consists of a closed brass tube containing a gunpowder mixture and resembles a blank small arms cartridge, 13 mm in diameter, 65 mm in length. Exhibit 36

Figure 1.4.7: Tube Vent Electric L4A2

1.4.20. **Secondary Armament**. The co-axially mounted Chain Gun and the cupola mounted GPMG both fire belted 7.62 mm rounds. The ammunition is supplied in 200 round belts. When used in the Chain Gun, these belts are joined together and placed in the Ready Rounds Container, a dedicated ammunition bin, which can hold up to 1400 Exhibit 36

rounds.

The L30A1 Gun

1.4.21. The Main Armament and its Breech are central to this inquiry. This section of the report is designed to act as a source of reference. The key features and components of the L30A1 Gun (Figure 1.4.8 and Figure 1.4.9) which will be discussed are: Exhibit 36

a. the Breech Ring (3);

b. the Breech Blocks (Upper and Lower) (4);

c. the Bolt Vent Axial (BVA) Assembly, made up of the BVA, Obturator, Shim and Thrust Housing;

d. the Firing Needle Assembly (FNA);

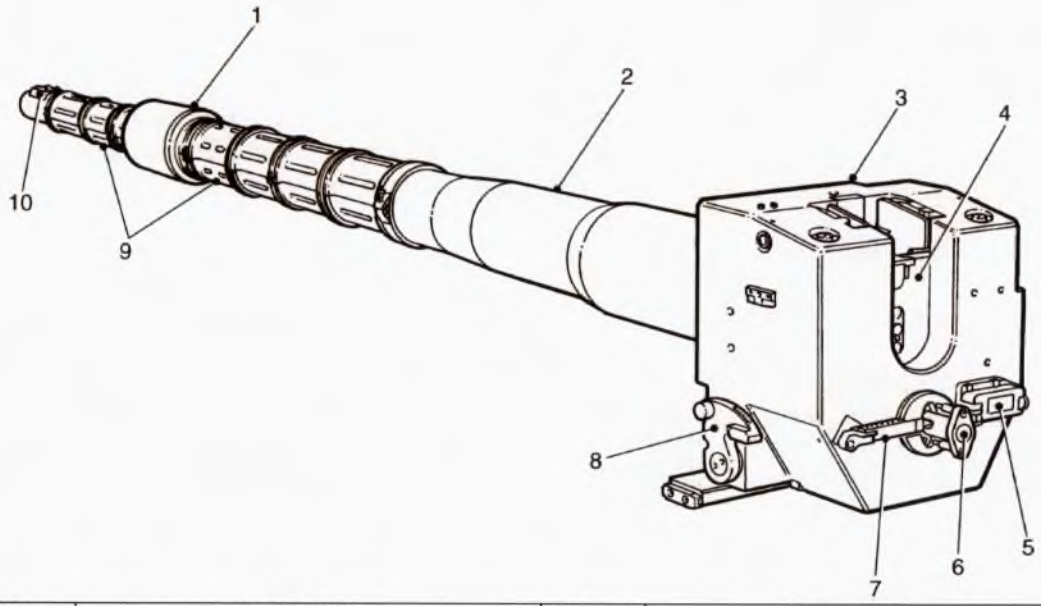
e. the Automatic Tube Loader (ATL) (6);

f. the Loading Tray;

g. the Loader's Guard;

h. the TVE Display Unit (TVEDU);

i. and the Firing Circuit.



Serial	Description	Serial	Description
1	Fume Extractor	6	Automatic Tube Loader (ATL)
2	Barrel Assembly	7	ATL Magazine
3	Breech Ring Assembly	8	Actuating Shaft
4	Breech Block Assembly	9	Thermal Sleeves
5	Release Mechanism Electrical (RME)	10	Muzzle Reference System Upstand

Figure 1.4.8: L30A1 Gun General Arrangement

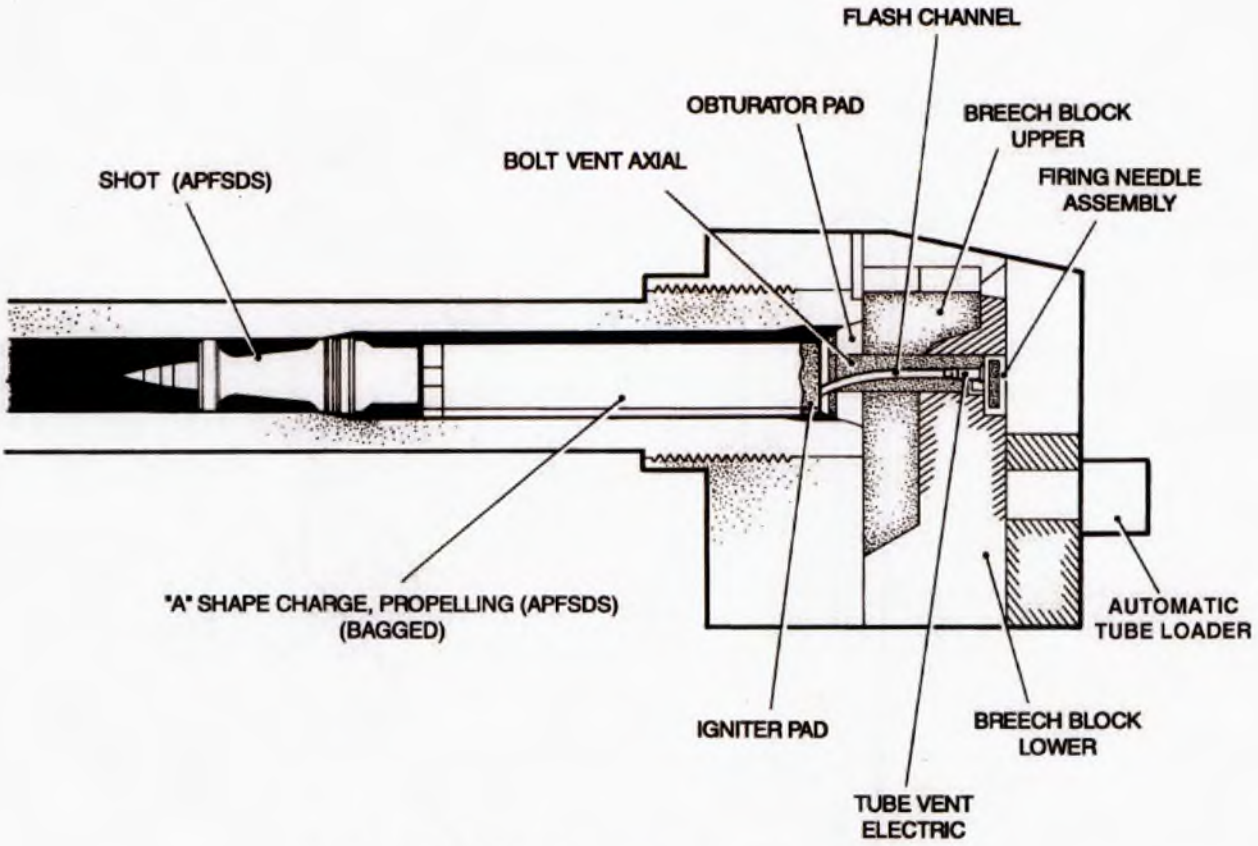


Figure 1.4.9: L30A1 Gun Major Breech Components

1.4.22. **The Breech Ring**. The Breech Ring is rectangular in shape and houses the 2 piece Breech Block Assembly and breech actuating mechanism. It is secured to the barrel by interrupted threads and a locking key and connects the gun to the recoil system. A cutaway portion in the lower part of the Breech Ring houses the Automatic Tube Loader (ATL) and magazine.

Exhibit 13

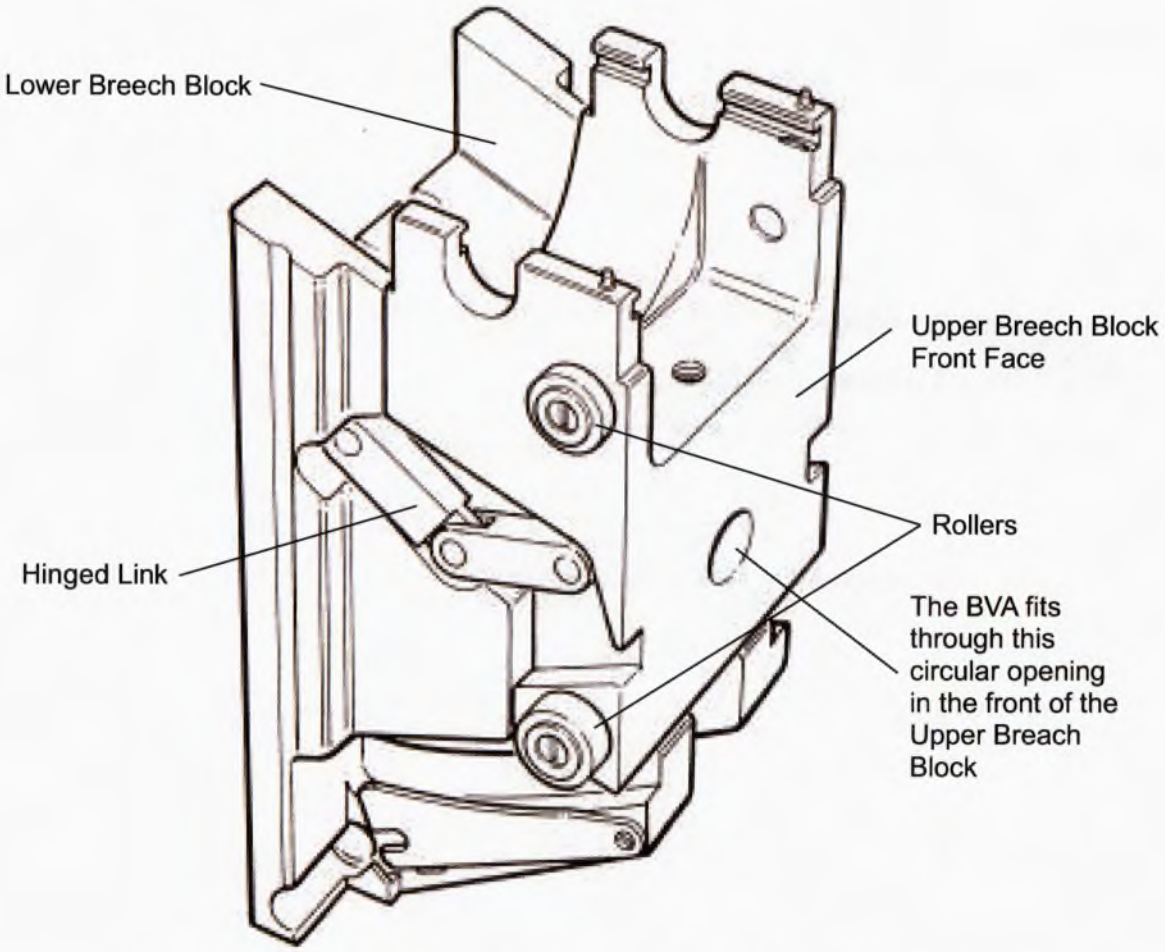


Figure 1.4.10: The Breech Blocks in the Closed Position

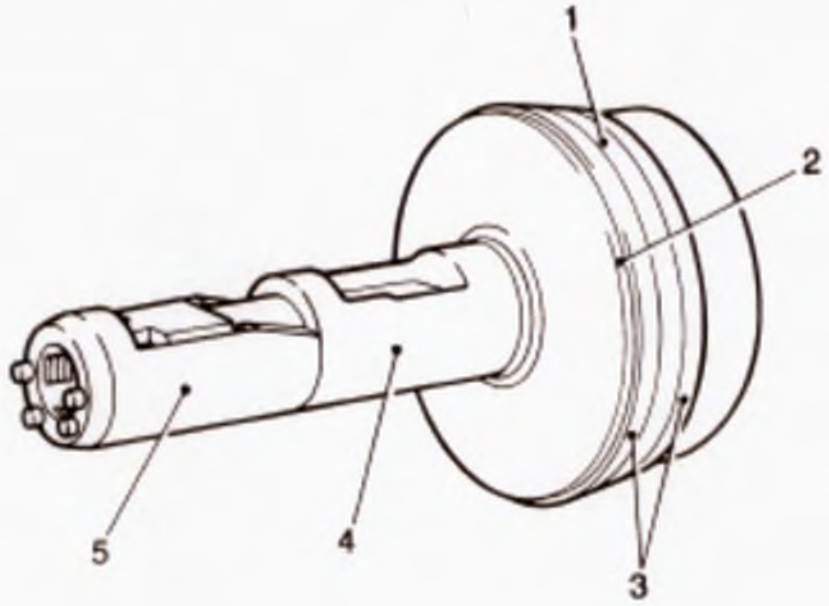
1.4.23. **Breech Block Assembly**. The Breech Block Assembly (Figure 1.4.10) consists of the Upper and Lower Breech Blocks, which are rectangular in shape and are connected by 2 hinged links. The FNA and BVA assembly fit into these blocks as described below: Exhibit 36

a. **Upper Breech Block**. The Upper Breech Block is machined to accept the BVA, the Loading Tray and the 4 rollers (one top and bottom each side). It is also machined each side to permit the attachment of the hinged links that join the 2 Breech Blocks together. When the breech is opened, the Upper Breech Block is positioned to sit and lock on top of the Lower Breech Block. When the breech is closed, the Upper Breech Block is positioned and locked in front of the Lower Breech Block.

b. **Lower Breech Block**. The Lower Breech Block is stepped and shaped to receive the Upper Breech Block in either the open or closed position. It is bored and prepared to accept the Thrust Housing (Figure 1.4.11) and the FNA (Figure 1.4.13).

1.4.24. **The Bolt Vent Axial (BVA) Assembly**. As shown in Figure 1.4.11, the BVA Assembly is made up of the: Exhibit 36

a. **BVA**. The BVA is a steel forging shaped to form a spindle and a mushroom head (Figure 1.4.12). The BVA is retained in the Upper Breech Block by a socket headed screw. The BVA carries the Obturator Pad, and Shim around the spindle section. It has a narrow tube (the flash channel) leading from the TVE chamber at the rear which channels the hot gases from the TVE (Figure 1.4.13) onto the igniter pad on the Propelling Charge loaded into the main chamber of the gun.

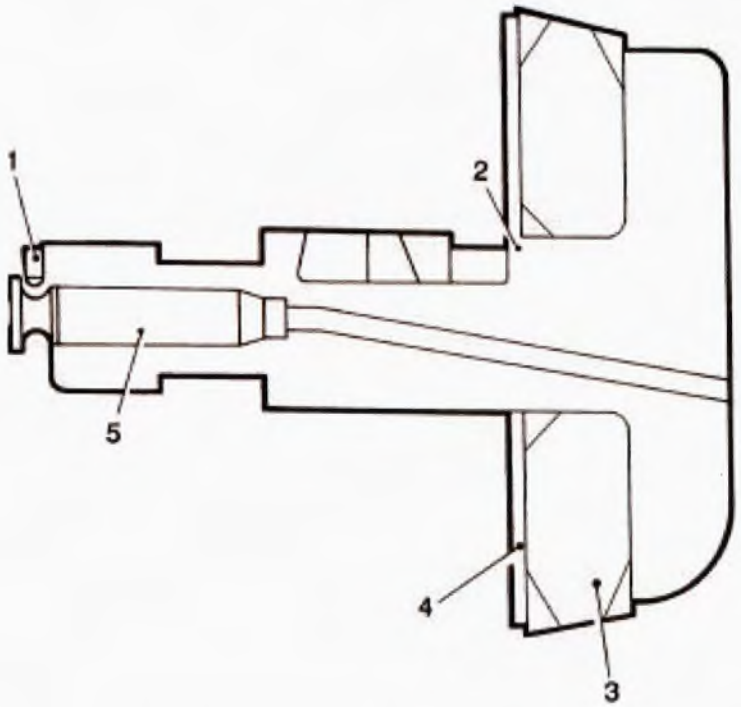


1	Obturator Pad
2	Shim
3	Scarf Rings (physically bonded to the Obturator)
4	BVA
5	Thrust Housing

Figure 1.4.11: The Bolt Vent Axial Assembly

b. **Obturator Pad and Shim**. The Obturator comprises a ring shaped reinforced neoprene pad. The Shim plate is fitted to ensure the pad is held in close contact with the obturator cone seating in the barrel when the breech is closed. A variety of thicknesses of Shim are available and the correct one is selected when the Obturator Pad and BVA are first fitted to the gun. Exhibit 36

c. **Thrust Housing**. The Thrust Housing is a separate section of the BVA Assembly which is housed in the Lower Breech Block. It holds the FNA in place (by means of an interrupted buttress thread, see Figure 1.4.13) and when the breech closes it slides upwards on to the BVA, fitting the FNA onto the rear of the TVE.



1	TVE retaining ball
2	BVA
3	Obturator Pad
4	Shim
5	TVE Chamber

Figure 1.4.12: Bolt Vent Axial Cross Section

1.4.25. **Firing Needle Assembly (FNA).** (Figure 1.4.13) The FNA is located in the lower breech block, held in place by the Thrust Housing. When the breech is closed, the FNA makes an electrical contact with the loaded TVE. The firing circuit to the FNA is only completed when the breech is fully closed. Exhibit 36

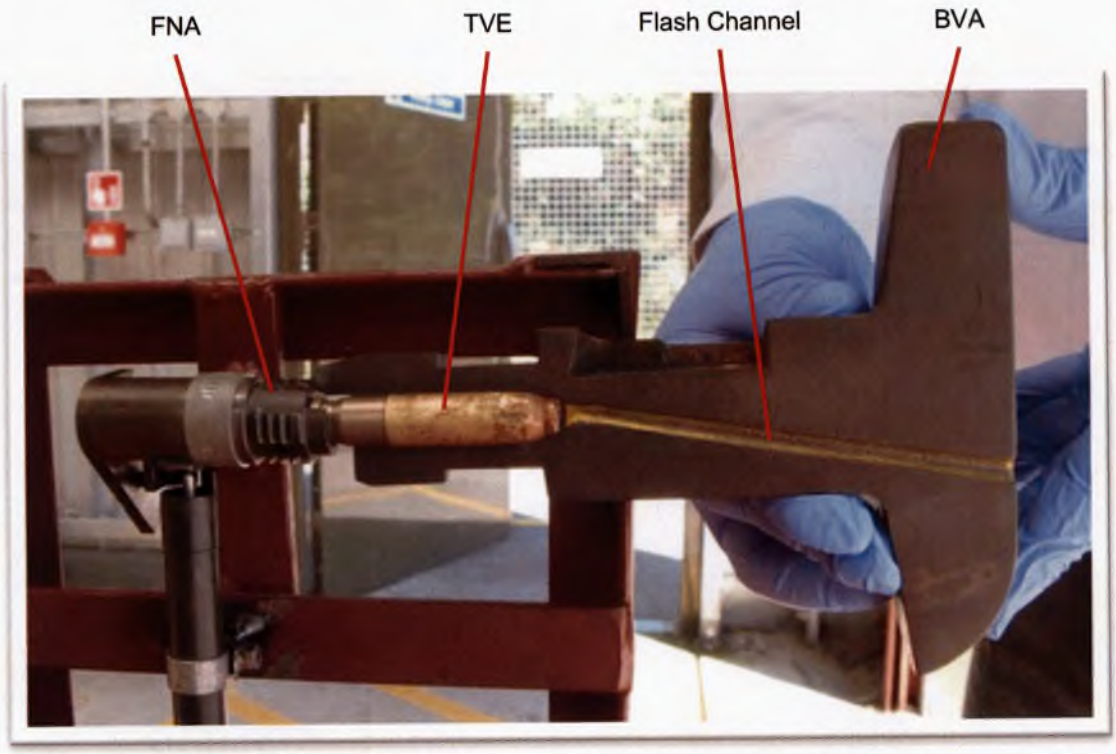
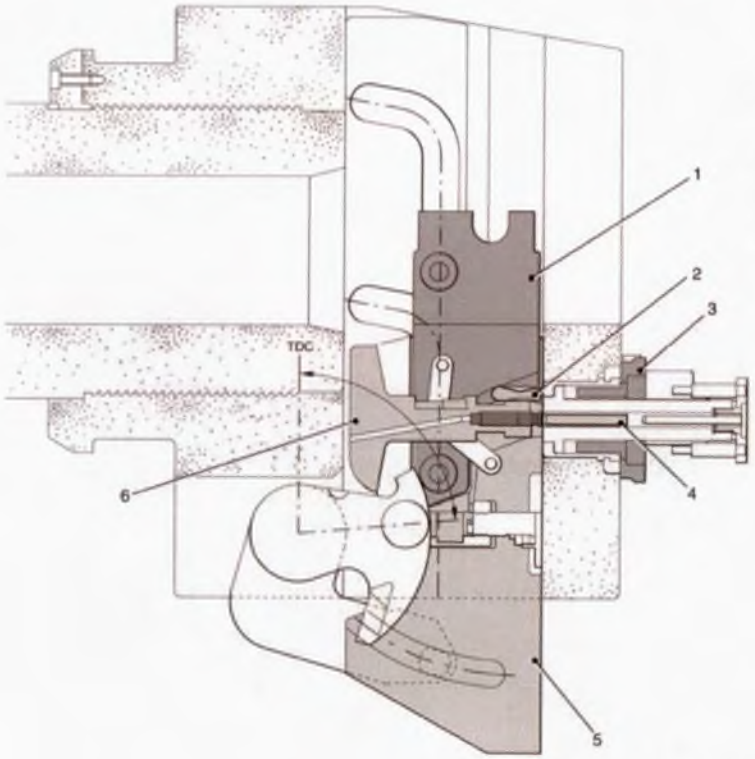


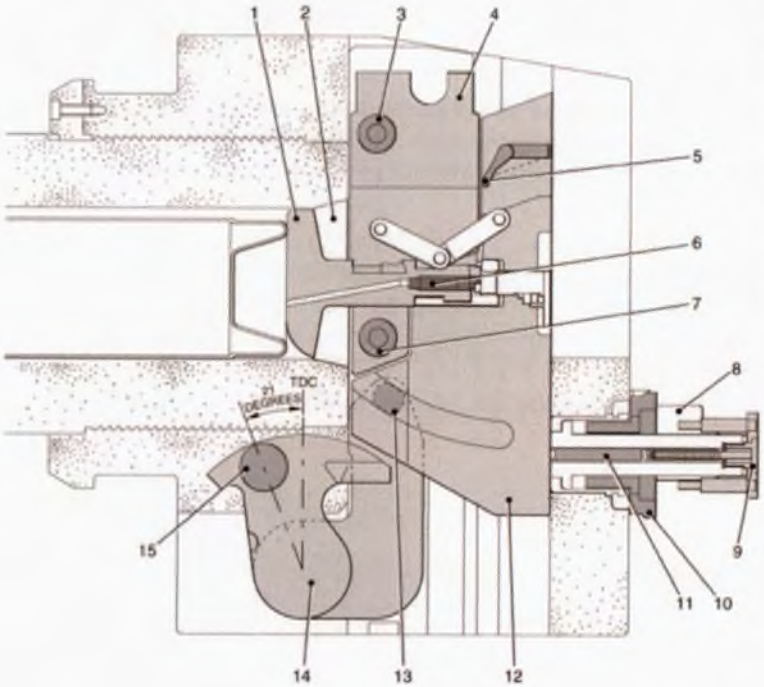
Figure 1.4.13: Cross Section of a Bolt Vent Axial Showing the Firing Needle Assembly The FNA is fitted to the TVE which is aligned with the Flash Channel (note the Thrust Housing, Obturator Pad and Shim are not present in this model)

1.4.26. **Automatic Tube Loader (ATL).** The ATL (Figure 1.4.15, Serial 9) is located in the rear of the Breech Ring and provides the means of automatically loading a TVE into the TVE chamber at the rear of the BVA. A magazine containing up to 10 TVEs is retained in a recess in the casing of the ATL. When the gun recoils and the recoil system returns it to its original, fully forward position (the run out position), the ATL loads the next TVE. The TVE for the first round fired has to be loaded by the Loader operating the ATL. Exhibit 36



1	Upper Breech Block
2	Extractor
3	Weight assembly
4	Rammer
5	Lower Breech Block
6	BVA

Figure 1.4.14: Breech Fully Open



1	BVA
2	Obturator
3	Upper Roller
4	Upper Breech Block
5	Extractor
6	TVE
7	Lower Roller
8	Release Mechanism Electrical
9	Automatic Tube Loader (ATL)
10	Weight Assembly
11	Rammer
12	Lower Breech Block
13	Sliding Block
14	Actuating Shaft
15	Cam Follower

Figure 1.4.15: Breech Fully Closed

1.4.27. **The Loading Tray**. (Figure 1.4.16) The Loading Tray is a metal trough that sits on top of the Upper Breech Block. When the breech is open, it aligns with the bore of the gun to provide a smooth platform onto which the Loader places the projectile and Propelling Charge. Each is pushed in turn into the chamber[10]. It has 2 spring loaded Charge Retaining Catches fitted to its forward edge which prevent the projectile or Propelling Charge from sliding back out of the chamber.

Exhibit 36

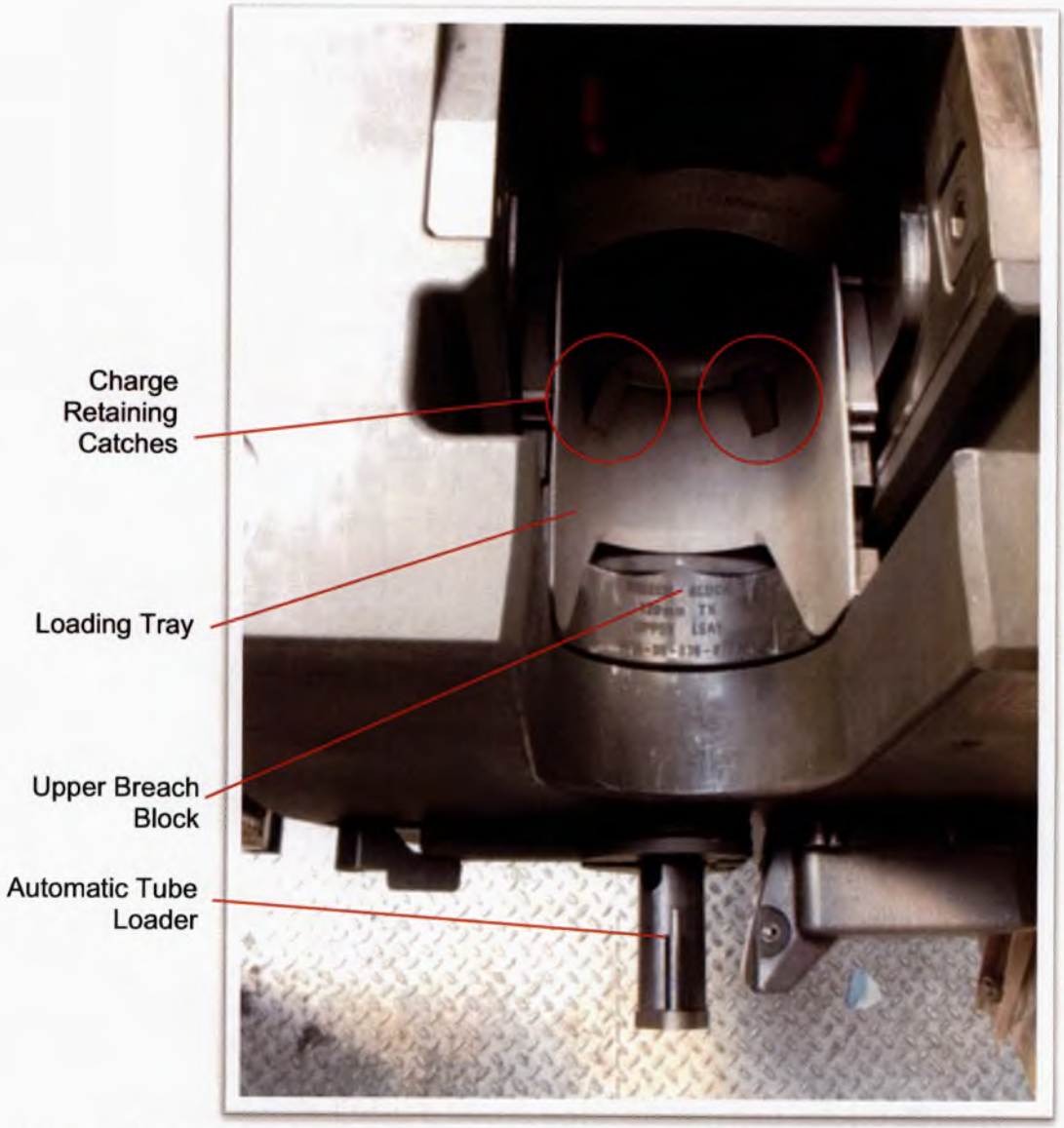


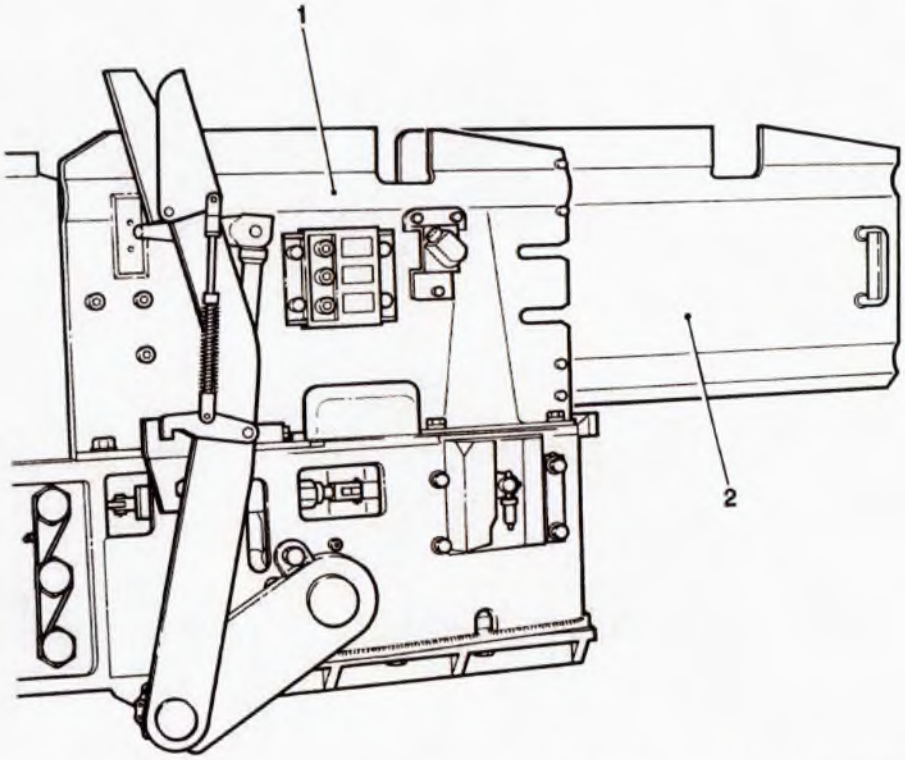
Figure 1.4.16: The Loading Tray Fitted to the Upper Breech Block with the Breech Open

[10] The chamber of the gun is the cylindrical cavity directly in front of Breech. It has a slightly larger diameter than the main section of the barrel and holds the Propelling Charge.

1.4.28. **The Loader's Guard**. The Loader's Guard protects the loader from the recoil of the gun when it is fired. It is made up of 2 sections: the Fixed Guard and the Sliding Guard (Figure 1.4.17). Exhibit 36

a. **The Fixed Guard**. The Fixed Guard is fitted onto the left hand side of the gun and forms the mounting for the Sliding Guard. The TVE Display Unit (TVEDU) is mounted in the centre of the Fixed Guard. An interlock switch secured to the Fixed Guard forms part of the gun Firing Circuits.

b. **The Sliding Guard**. The Sliding Guard moves backwards from behind the Fixed Guard to the "made" position (fully rearward). It is "made" by the Loader when he has finished his loading drill and is ready for the Gunner/Commander to fire the gun, as making the guard completes the Firing Circuit.



1	Fixed Guard	2	Sliding Guard in the Fully Rearward or "Made" Position

Figure 1.4.17: The Loader's Guard

1.4.29. **The TVE Display Unit (TVEDU)**. The TVEDU (Figure 1.4.18) is fitted to the Fixed Guard and provides the loader with an indication that a TVE has been loaded. This is achieved by the TVEDU carrying out a TVE loaded test and a Firing Circuit test, and providing a lamp indication of each result: Exhibit 36

a. **LOADED - GREEN indicator**. With the gun loaded and the Loader's Sliding Guard made, the green indicator illuminates to confirm a TVE is loaded in the BVA and the Firing Circuit is complete. The indicator remains illuminated for 10 seconds after the Loader's Sliding Guard is made. **The gun is ready to fire**.

b. **NOT LOADED - RED warning lamp**. With the gun loaded and the Loader's Sliding Guard made, the red warning lamp illuminates if there is no TVE loaded in the BVA or a failure has occurred in the Breech Ring components of the Firing Circuit. The warning lamp remains illuminated for 10 seconds after the Loader's Sliding Guard is made. **The gun will not fire**.

c. **FIRING CIRCUIT - AMBER indicator**. With the gun loaded and the Loader's Sliding Guard made, the amber indicator illuminates when any gun firing switch is operated. When the amber indicator is illuminated the green indicator and red warning lamp are suppressed. **Illuminates as the gun fires**.

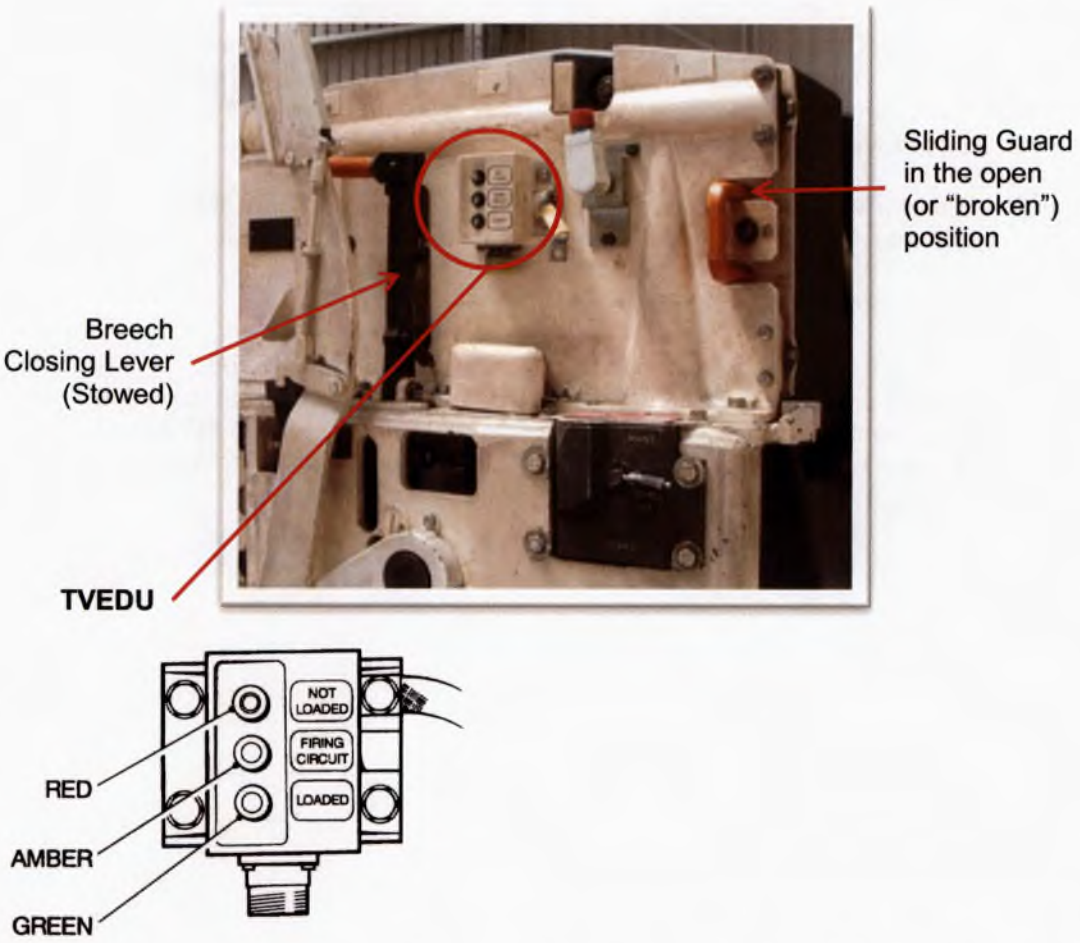


Figure 1.4.18: The Fixed Guard, Showing the Loader's Controls with inset Diagram of the Tube Vent Electric Display Unit

1.4.30. **Firing Circuit**[11]. The L30A1 gun is fired electrically – a firing pulse is sent to the TVE by the Firing Circuit. For the Firing Circuit to operate a number of events must occur:

a. **Fire Control Computer (FCC)**. The FCC checks on a number of variables before permitting the Firing Switches to become live. The primary check is for coincidence – is the gun aiming at the same position as the selected sight?[12]

b. **Safety Switches**. Each member of the crew has a safety switch. If any of these are pressed the Firing Circuit is interrupted and the turret and gun cannot move under power.

c. **Breech Closed**. There are a series of mechanical interlocks in the breech mechanism. Unless the breech is completely closed the electrical circuit to the FNA is not completed (the final motion in closing the breech allows the firing needle to move forward and contact the TVE).

d. **Loader's Guard**. The final firing circuit safety interlock is a switch that is closed by moving the Loaders Sliding Guard to the "made" position (fully rearward). This action also initiates the TVEDU check of the Firing Circuits, as explained in Paragraph 1.4.29.

e. **Firing Switches**. The gun is fired by either the Gunner or the Commander pressing their Firing Switch. These switches are located on their respective control handles (the Gunner's Control Handle is shown at Figure 1.4.19), each physically protected by a guard. The associated Gripswitch must also be depressed before the Gun Firing Switch will operate.

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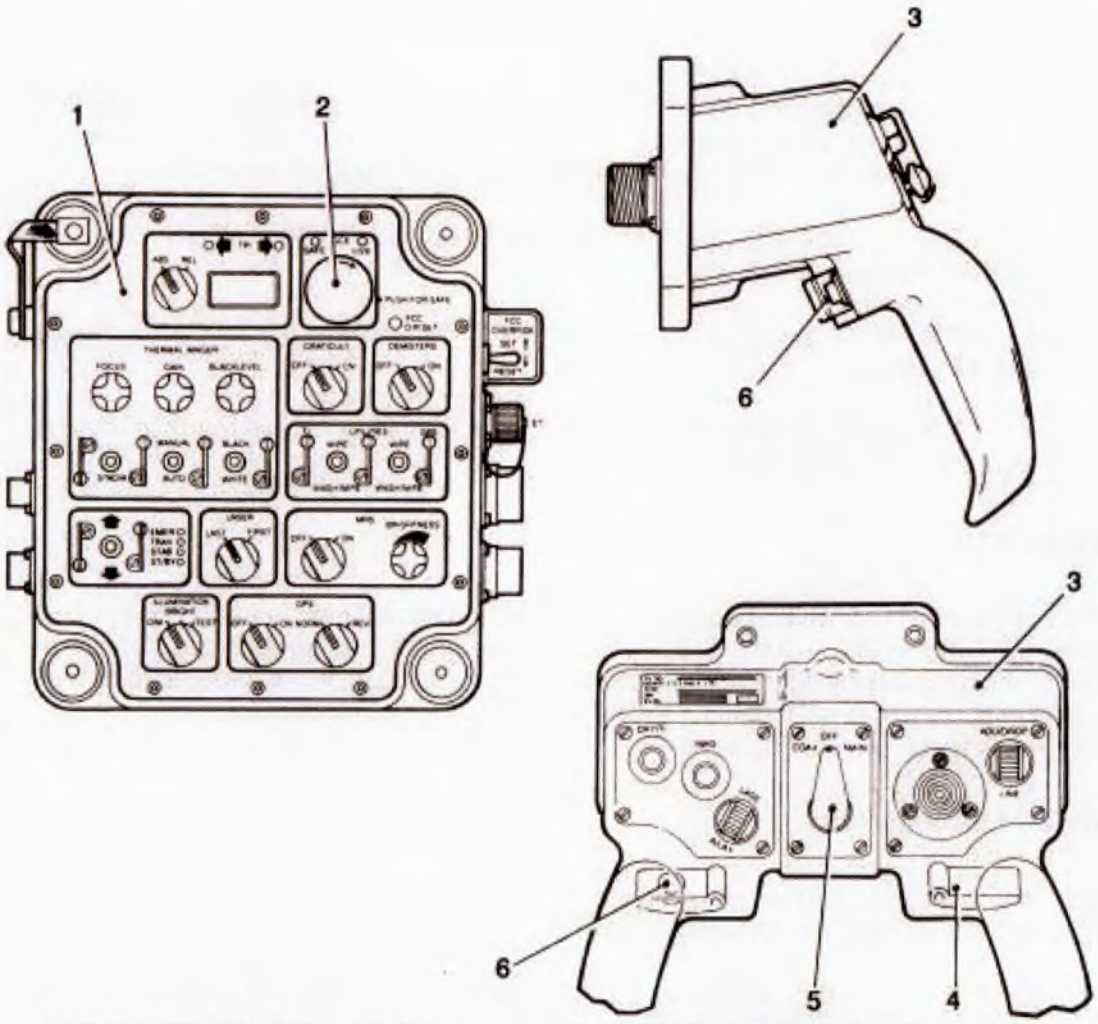
[11] There are 2 Firing Circuits within CR2, Normal and Emergency. Only the Normal Circuit is described here as the Panel has confirmed that Emergency mode was not used in the accident.

[12] The CR2 has 3 electronic sights which can be selected; the Gunner's primary Sight; the Commander's Primary Sight; and the Thermal Imaging Sight.



1	Gunner's Control Panel	4	Gunner's Gripswitch
2	FCC Override Switch (Safety Switch)	5	Armament Selector Switch
3	Gunner's Control Handles	6	Gun Firing Switch

Figure 1.4.19: Gunner's Controls

Planning and Preparation: Jan – May 17

1.4.31. This section of the report considers the actions of the RTR prior to arriving at CMR on 2 Jun 17. It analyses the levels of planning and preparation undertaken and considers these against the objectives of the Range Package. In particular it will consider:

a. The aims and objectives of the Range Package: were they clearly stated, promulgated and appropriate?

b. The planning process: what was the requirement, was this followed and was it fit for purpose?

c. The preparations for the Range Package, including the pre-requisite training: were they completed and appropriate?

Background

1.4.32. From Jan 17, BADGER Sqn was preparing for a deployment in Aug 17 to the British Army Training Unit – Suffield (BATUS), Canada, where they would act as opposition forces for the units deploying as part of the operational training cycle. In order to facilitate this, all crews needed to be in date for their Annual Crew Tests (ACTs), which are Live Firing Exercises (LFXs), conducted at CMR on this occasion. Witness 2

Aims and Objectives

1.4.33. The stated aim for the deployment of BADGER Sqn RTR to CMR to conduct live firing, from 2-16 Jun 17. The Objectives were: Exhibit 14

a. To ensure that all CR2 crews pass their ACT and achieve a minimum First Time Pass Rate of 90% or higher;

b. To test and qualify all variant crews[13] to level 4 pass at ACT;

c. To conduct all firing and associated activity in a safe and professional manner.

1.4.34. The ACT is an important training milestone and is the key mandatory element in the progressive nature of LFXs. Success in the ACT is the benchmark of a crew's competence and safety and allows crews to progress onto later, more advanced LFXs, combined arms LFXs and operations. The progression of LFXs is discussed further at Paragraph 1.4.54. The intention was to have 19 crews qualified by the completion of the Range Package (16 from BADGER Sqn and 3 from DREADNAUGHT Sqn). This is routine activity for a tank Sqn, a normal number of crews to take to a Range Package and the Panel assess that the activity was achievable in the timescales. Exhibit 15

[13] Variant Crews refers to the crews of vehicles other than the CR2, attached to a Sqn, for example CHALLENGER Armoured Repair and Recovery Vehicle, BULLDOG, Combat Vehicle Reconnaissance (Tracked) and PANTHER.

1.4.35. The majority of BADGER Sqn had been to CMR to conduct Live Firing on previous occasions, although the natural progression up through positions of responsibility meant that some soldiers were now employed in roles in which they had no previous live firing experience[14]. As such, there was considerable experience throughout the Sqn. — Witness 11

1.4.36. The aims and objectives were promulgated in the Administrative Instruction, dated 29 Apr 17, which was given a full distribution across the Sqn. All the witnesses interviewed knew why they were going to CMR, what was required of them collectively, and what their individual responsibilities were for the Range Package. — Exhibit 14

1.4.37. The Panel concluded that the aims and objectives of the Range Package were appropriate, clearly stated, promulgated and understood, and were **not an Accident Factor**.

Planning

1.4.38. The requirements for planning a Range Package are detailed in Pamphlet 21[15] (PAM 21) but the key steps are: — Exhibit 41

a. **Allocate Key Staff Appointments**. The key staff for the Range Package were appointed and their names and responsibilities were promulgated in the Administrative Instruction on 29 Apr 17. — Exhibit 14

b. **Confirm Resources and Facilities**. The vehicles required and preparation, mission maintenance and transport requirements were booked. Again the details were promulgated in the Administrative Instruction. — Exhibit 14, Witness 35

c. **Conduct a Range Recce**. The Recce was successfully conducted by the Range Conducting Officer (RCO) and a support team of 5 on 16 May 17. — Witness 1, Witness 35

d. **Produce Range Action and Safety Plan (RASP)**. The RASP was produced from a standard template provided by the Range Staff. It was modified by BADGER Sqn and returned to the Range Staff for endorsement. CMR Staff confirmed that the RASP produced by BADGER Sqn was of a good standard. — Exhibit 2, Witness 1, Witness 35

e. **Produce Range Danger Area (RDA) Trace and Sketch Maps**. There was no requirement to produce the RDA Trace from scratch. CMR is routinely used by CR2 units and danger areas are well established. All documentation required to support this planning activity is provided by CMR Staff as part of their requirement to provide a safe place to conduct training. — Exhibit 33

1.4.39. This Range Package was routine activity for BADGER Sqn. Armoured Sqns conduct Range Packages approximately once per year and CMR is well understood by the units. The key planning steps were conducted and the appropriate outcomes, as detailed above, were recorded in the Administrative Order and RASP. The Panel has reviewed the — Witness 11, Exhibit 2, Exhibit 14

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[14] Most tank soldiers start as drivers and subsequently move to become gunners, loaders and finally commanders.

[15] PAM 21. Pamphlet Number 21, Training Regulations for Armoured Fighting Vehicles, Infantry Weapon Systems and Pyrotechnics, dated Apr 17.

documentation and questioned witnesses regarding the content. The members of BADGER Sqn spoken to were aware of the contents of the RASP and Administrative Orders.

1.4.40. The written staffwork was reviewed by the Panel and compared to the requirements laid down in PAM 21 and no significant discrepancies were found. Exhibit 2 Exhibit 14 Exhibit 41

1.4.41. The Panel concluded that planning for the Range Package was commensurate with the objectives and in accordance with the regulations, and was **not an Accident Factor**.

Preparation – Material State

1.4.42. BADGER Sqn's previous Range Package was in Nov 16 and, whilst successful in terms of qualifying crews, they had suffered from technical problems that had impacted upon vehicle availability. To overcome this, the Sqn had worked hard in the earlier part of the year to improve and maintain their gunnery skills in the simulators, allowing time in the immediate run up to the Range Package to focus on the material state of their CR2s. This approach appeared to work. In interview, several members of the Sqn stated that the Range Package progressed more smoothly than in Nov 16. The members of the engineering support team were pleased with the equipment availability achieved. Witness 2 Witness 32 Witness 34

1.4.43. The Panel concluded that:

a. BADGER Sqn had taken their experiences in Nov 16 into account when preparing for the Range Package and, as such, were in a good material state when they arrived at CMR in Jun 17.

b. Material state preparation was **not an Accident Factor**.

Preparation – Training

1.4.44. There is an incremental and progressive build-up of training conducted in the Precision Gunnery Training Equipment (PGTE) simulators that must be completed prior to live firing. The progression includes: Exhibit 15 Witness 27

a. **Loader Drill Trainer (LDT)**. The LDT is a life size mock-up of the tank turret in which loaders are trained and practise the drills required to operate the Main and Secondary Armament. It includes simulations for misfires and other firing drills. The training culminates in the Weapon Handling Test.

b. **Weapon Handling Test (WHT)**. Conducted in the LDT, the WHT is compulsory for all loaders and commanders, regardless of rank, and must be passed within the 6 weeks prior to a live firing period. It tests the loader's ability to operate the weapon systems in an effective and safe manner, including the drills required to detect and deal with emergencies and faults. The WHTs are conducted by the Sqn's Regimental Instructors Gunnery[16] (RIGs), but 15% of personnel are

[16] A Regimental Instructor Gunnery (RIG) is a Non Commissioned Officer, Corporal or above, who is selected and trained to instruct gunnery and gun drills within the unit, as well as their regimental duties, usually as tank commanders. For range

re-tested by the AIGs from the Armour Centre to provide assurance that personnel are at the required standard.

c. **Part Task Trainer (PTT).** Synthetic training for the gunner and commander is conducted in the Part Task Trainer, which simulates the CR2 Gunner's Station. This facility is used to develop and practice gunnery skills.

d. **Turret Gunnery Trainer (TGT).** This simulator brings together the gunner and commander and enables advanced gunnery techniques to be taught and practised. It is used to conduct the Threshold Test.

e. **Threshold Test.** The Threshold Test is a full synthetic ACT and an Annual Troop Assessment (ATA)[17], conducted in the TGT. It tests their ability to identify and engage targets, safely and effectively, and proves their competency prior to a live firing period. Achieving a pass at the Threshold Test is mandatory for all gunners and commanders and must be completed no more than 3 months before a live firing period.

1.4.45. All tank commanders must be qualified as a loader and a gunner. This makes them competent to supervise their crew in the turret. Most non-commissioned tank commanders are also qualified as tank drivers, but this is not mandated. Exhibit 15

1.4.46. The training records of the Sqn were reviewed by the Panel[18] and all members of BADGER Sqn had successfully completed the mandated training and tests within the required timelines. The 15% WHT assurance retests were successfully completed. The training records of those directly involved in the Accident were printed out and have been referenced as evidence. Witness 1 Witness 2 Exhibit 22 Exhibit 27

1.4.47. The Panel concluded that the training in preparation for the Range Package was completed correctly, was commensurate with the aims and objectives and was **not an Accident Factor**.

Overall Conclusion

1.4.48. The Panel concluded that BADGER Sqn arrived at CMR on 2 Jun 17 with all planning completed, well prepared materially and with all mandated pre-live firing training and testing successfully completed.

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packages they are augmented by Assistant Instructors Gunnery (AIGs) who instruct across the Armoured Corps, normally as a full time job.

[17] The ATA tests the crew's ability to operate as part of a Troop of tanks (up to 4 CR2).

[18] The training test results for the WHT and the Threshold Test are held electronically within simulators at Tidworth and Donnington.

Range Package: 2-16 Jun 17

Castlemartin Ranges

1.4.49. All BADGER Sqn CR2 firings took place on CMR Ranges 2 and 4 under the overall control of Warren Tower (See Figure 1.4.20).

Exhibit 2
Exhibit 11
Exhibit 37

Figure 1.4.20: Aerial View of Castlemartin Ranges

1.4.50. A total of 9 CR2 were transported to CMR by road, plus a number of supporting vehicles, on 31 May 17.

Exhibit 14

Range Conducting Officer (RCO)

1.4.51. The RCO is responsible for the safe conduct of the firing, following the plan in accordance with the RASP. PAM 21 states the RCO should be qualified and competent with the weapons being used. Exhibit 41

1.4.52. The RCO for this Range Serial was the Second in Command (2IC) of BADGER Sqn. He joined the Army in Sep 13 and commissioned into RTR in Aug 14. He successfully completed his 6 month Troop Leaders' course from Sep 14 to Feb 15 which gave him the requisite qualifications to be an RCO for a CR2 Range Package (AFV (C) (08) and AFV (E) (08)[19]). In his current role as the 2IC of BADGER Sqn, and his previous role as a Troop Leader, he commanded a CR2. He passed his ACT during the Range Package and had completed all the prerequisite training. Exhibit 23 Witness 1

1.4.53. The Panel concluded that the RCO was suitably qualified and experienced to conduct his duties and he was current and competent on the CR2. These were **not Accident Factors**.

Live Firing Exercise Progression

1.4.54. Live firing is conducted as a progression of numbered LFXs, the aim of which is to provide a flexible and progressive series of practices to bring crews to the level required to pass their ACT (LFX8). All vehicles are required to complete LFX3. Trained crews start at LFX4 and work their way up to LFX8[20]. This is summarised in Table 1.4.1. Exhibit 15

LFX Number (a)	LFX Title (b)	Purpose (c)
3	System Performance Check (SPC)	Confirms vehicle and crew preparation in order to continue with objective training. Mandatory for each vehicle.
4	Fire Manoeuvre Exercise (FMX) KE / CE / MG	Practice tank crews in engaging with Main and Secondary Armament, static and moving using primary and secondary sighting systems. Instructor directed.
5	Fire and Manoeuvre Exercise (FMX)	Practice tank crews in freedom of manoeuvre and introduce lateral engagements.
6	Single Vehicle Training FMX	Practice tank crew's operational engagement procedures.
7	Single Vehicle Night FMX	Allows crews to gain experience working at night using thermal imager sighting systems
8	ACT	To test the standard of a tank crew in operational engagement procedures during an exercise that is set within the context of the contemporary operating environment. Mandatory for all crews.

Table 1.4.1: CHALLENGER 2 Live Firing Exercises

[19] The full definitions of these qualification categories and what the holder is qualified to conduct are in PAM 21.

[20] LFX 1 and 2 use the Live Firing Crew Training System (LFCTS) which fires a 12.7 mm round to simulate the Main Armament. It is used as a transition from synthetic to full bore firing. Its use is not mandated and is not routinely used by Units conducting Range Packages at CMR.

1.4.55. **Live Fire Monitoring Equipment (LFME).** To enable the standard of gunnery to be assessed and inform crews of whether they have passed each LFX, LFME is fitted to CR2s during Range Packages[21]. The system enables gunnery staff (RIGs and AIGs) to monitor live what the gunner and commander are looking at through their sights, including the info-graphics of the status of the armament, and hear what the crew are saying to each other on the intercom. The instructors sit in a trailer, located at the rear of the range (see Figure 1.4.21), and instruct and assess the LFXs as they progress. The range targetry is monitored via remotely operated cameras placed adjacent to the trailer. The video and audio is recorded to enable the crew to be debriefed after their LFXs. Crews are not mandated to use LFME once they have passed their ACT. Exhibit 15

1.4.56. By the end of Tuesday 13 Jun 17, all crews had successfully completed LFXs 4-7 and, with the exception of 3 crews, all had passed their ACTs. Witness 1

1.4.57. The Panel concluded that the LFX Progression was followed and the crews were on track to achieve the stated aims of the Range Package.

The Day of the Accident: 14 Jun 17

Preparations

1.4.58. On 14 Jun 17, BADGER Sqn was using Ranges 4 and 6. Range 6 was being used to conduct first aid training for crews and no firing was taking place. Live firing was taking place on Range 4 (Figure 1.4.21), with the priority being completion of 3 outstanding ACTs. The weather was dry with sunny spells and the visibility was good. The Range was open for live firing from 0900 until 1630, with last round to be fired down range no later than 1600[22]. Exhibit 2 Exhibit 3 Exhibit 11 Exhibit 37

[21] LFME is not permanently fitted to the vehicle. A number of electronics boxes, cables and aerials are fitted by the crew, supported by a contractor, for the duration of the Range Package.

[22] The last round fired is always 30 minutes before the range is closed to allow for a misfire drill, which includes a 30 minute wait period.

Figure 1.4.21: Aerial View of Range 4

1.4.59. At 0800 on 14 Jun 17, BADGER Sqn conducted their First Parade. All personnel, including attached Royal Electrical and Mechanical Engineers (REME) staff, were paraded on the hard standing at Range 4 and all vehicle checks were completed. In terms of the Main Armament, these checks included[23]: Witness 12 Exhibit 20

a. **Main Armament Prove the Gun**. The Prove the Gun drill is conducted by the tank crew to confirm the state of the weapon and check for ammunition. It must be completed before working on the Main Armament.

b. **Passing the Gauge Plug Bore**. Passing the Gauge Plug Bore is conducted by the unit armourers; it involves pulling a cylindrical steel gauge of a precise diameter down the gun barrel to check for damage or blockages.

[23] This list only summarises the key checks performed on the Main Armament. The full list of checks performed by the crew and the REME support element is significantly longer. The complete list of maintenance is contained in AESP 2350-P-102-601, Tank Combat, 120 mm Gun CHALLENGER 2, Maintenance Schedule, which was, on 14 Jun 17, at Amendment State 21, dated Apr 17.

c. **Check the breech closing action and lubricate if necessary**. Checking the breech closing action is conducted by the tank crew to confirm the breech mechanism is operating correctly, with any faults reported to the REME.

d. **Check the operation of the ATL and the associated Release Mechanism Electrical**. The operation of the ATL is conducted by the tank crew to confirm the ATL and Release Mechanism are operating correctly, with any faults reported to the REME.

e. **Test the operation of the Firing Circuits in Normal and Emergency modes**. The Firing Circuits are checked by the tank crew to confirm they are operating correctly, with any faults reported to the REME.

1.4.60. DS39AA was assigned to tank crew Call Sign (C/S) 30B. C/S 30B and the Unit Armourers stated that they completed these checks and no faults were reported. Witness 8 Witness 9 Witness 11

1.4.61. The Panel concluded that the Main Armament checks on DS39AA were conducted correctly during First Parade by Crew C/S 30B and the Unit Armourers.

Ordnance Management

1.4.62. All the major items of the Main Armament (commonly referred to as Ordnance), including the BVA and the Obturator Pad, are lifed items and it is important to ensure that the correct number of rounds is recorded for each serial numbered item. The number of rounds fired is recorded in the Gun Documents, unique to each tank, identified by ERM. Maintaining these records reduces the likelihood of a major gun components failing during live firing. Witness 12 Exhibit 18 Exhibit 34

1.4.63. The Gun Documents for DS39AA show that as of 12 Jun 17 the Gun Barrel, Breech Ring and Upper and Lower Breech Blocks had thousands of rounds of life remaining[24]. The BVA had 140 rounds of life remaining and the Obturator 122 rounds. The tank fired a further 45 rounds on 13 Jun 17 and 18 rounds on 14 Jun 17. Taking these rounds into account, at the start of the Experience Shoot, the BVA had 77 rounds of life remaining and the Obturator 59 rounds. Exhibit 34

1.4.64. The Main Armament is also subject to a routine Examination of Ordnance[25], conducted by Armourers after a specified number of rounds fired. The Gun Documents for DS39AA show that as of 12 Jun 17, 86 rounds were permitted to be fired before the next scheduled examination. Allowing for the 63 rounds fired on 13-14 Jun 17, at the start of the Experience Shoot there were 23 rounds remaining until the scheduled examination. Exhibit 34

[24] The Gun Barrel had 3713 rounds remaining. The Breech Ring, the Upper Breech Block and the Lower Breech Block had 12708 rounds remaining.

[25] The Examination of Ordnance is a detailed examination of the Main Armament as a whole and is recorded in the Gun Documents; in order to arrive at a reliable conclusion as to its condition and probable remaining life during which satisfactory functioning, accuracy and safety can be expected. It entails the use of specialist tools and gauges to measure, test, take impressions and non-destructive tests where necessary.

1.4.65. The Panel concluded that:

a. All of the lifed items of Ordnance within the Main Armament of DS39AA were within their authorised life for firing and this was **not an Accident Factor**.

b. The Main Armament of DS39AA was operating within its authorised limits for its Examination of Ordnance and this was **not an Accident Factor**.

Previous Live Firing Exercise

1.4.66. C/S 30B was programmed to use the tank that day to conduct their repeat ACT. Tank allocation and the day's programme were written on a white board outside the crew shelter, which was controlled by the Squadron Sergeant Major (SSM). The plan could change at short notice, due to a vehicle breakdown for example, but on the morning of 14 Jun 17, C/S 30B's ACT was identified on the white board as the third LFX of the day. Witness 1 Witness 8

1.4.67. C/S 30B started their ACT at approximately 1200 and successfully completed it at approximately 1240, firing 18 main armament rounds (6 x DS-T, 12 x SH-P) and approximately 600 7.62 mm rounds, with no defects or misfires[26]. On completion of the LFX, the tank returned to the hard standing at the top of Range 4 and the whole crew attended a debrief at the LFME Trailer. Witness 8

1.4.68. The Panel concluded that at 1240 on 14 Jun 17 DS39AA was functioning correctly and firing accurately.

Post-Firing Cleaning

1.4.69. C/S 30B's Commander and Gunner had other duties to complete and had to leave CMR shortly after completing the ACT debrief. The crew believed that the ACT was the last activity planned for DS39AA that day: C/S 30B's Loader stated that he checked the white board that morning and the only activity indicated for DS39AA was their ACT. As DS39AA was allocated to them as a crew, they decided to conduct post-firing cleaning on the Main and Secondary Armament. This is a standard drill which any loader and gunner would be expected to conduct unsupervised. Witness 8 Witness 9

1.4.70. For the Main Armament, post-firing cleaning involves the removal of several components including the Loading Tray[27], FNA and BVA Assembly. Unlike the FNA and the Loading Tray, which can simply be wiped clean with a rag, the BVA Assembly is directly exposed to the combustion products from firing and is therefore often removed from the vehicle and taken to an appropriate area for cleaning. Exhibit 14

1.4.71. The Loader of C/S 30B stated that he completed the following actions: Witness 9 Witness 10

a. He removed the Loading Tray from the Upper Breech Block and hung it on the projectile racking at the rear of the turret.

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[26] The Panel has reviewed the LFME recording and confirmed that the tank was firing correctly and accurately.

[27] For access to the BVA Retaining Screw.

b. He removed the FNA from the rear of the Lower Breech Block. He wiped it clean and stated he placed it in the Ration Stowage Box (Figure 1.4.22, Item 13).

c. He removed the BVA Assembly from the gun and transferred it to the Crew Shelter on Range 4[28], where its components were cleaned by a number of personnel who were waiting there.

d. He left the breech in the open position, with the Loading Tray off.

1.4.72. The Chain Gun was also cleaned by Sqn members at the crew shelter. Once cleaned, it was taken to the first floor of the Range 4 Control Tower where it was marked with the ERM (written on green tape) and stored with other Chain Guns and General Purpose Machine Guns. It was BADGER Sqn's policy to keep all small arms here, under guard overnight, until they were refitted at First Parade the following morning. Witness 9

1.4.73. The Panel concluded that the stripping and cleaning of the Main and Secondary Armament by C/S 30B was routine and an entirely expected activity when the vehicle is not anticipated to fire again that day.

Stowing the BVA

1.4.74. Once a BVA Assembly has been cleaned, and prior to refitting it to a gun, it is accepted custom and good practice in CR2 units to have it inspected by a qualified armourer, although this is not mandated. This is to check for any sign of damage to the Obturator Pad. It is also an opportunity to ensure that the correct BVA Assembly is fitted to each tank, by cross-checking the serial numbers with the Gun Documents. This provides assurance that the correct number of rounds fired is recorded against the life of the BVA Assembly. Witness 9 Witness 12

1.4.75. During this Range Package the 2 Unit Armourers based themselves in a van parked at the base of Range 4's Control Tower, ready to respond to any emergent defects. On 14 Jun 17, when the soldiers had finished cleaning the BVA Assembly from DS39AA, neither Armourer was on the range; they had driven to the REME Compound to collect spare bolts. The Armourers are not required to be on the Range at all times when firing is taking place and had a VHF radio with them to enable the Control Tower to call them if they were needed. Witness 12

1.4.76. On completion of cleaning the BVA Assembly, and in the absence of the Armourers on the Range, C/S 30B Loader gave the BVA Assembly to Trooper A, who had helped clean it, and told him to return it to DS39AA and place it in the Ration Stowage Box, situated to the rear of the Loader's Station (Figure 1.4.22, Item 13). When interviewed by the Panel, C/S 30B Loader stated that this is where he normally placed the BVA when not fitted to the gun, to prevent it from being dropped or damaged and he indicated that, in his opinion, this was common practice. Witness 9 Witness 14

[28] The Crew Shelter is a low, barn like structure with seating inside and is used by soldiers waiting to conduct firings or not employed on other duties around the range.

1.4.77. Trooper A took the Assembly to the tank and opened the Ration Stowage Box. Inside he found a white rag, a communications headset lead with a piece of orange mine tape, but stated that there was no FNA in the box. He removed these articles, placed the BVA Assembly into the box, replaced the rag, lead and tape, and closed the box lid. He then returned to the crew shelter, where he spoke to C/S 30B Loader and confirmed that he had placed the BVA Assembly in the Ration Stowage Box. Whilst in the tank, he noticed seeing an FNA in the Kidney Tray[29]: the Panel believe this very likely to have been the spare FNA (each tank carries 2) as it was found there by the DAIB Investigating Officers on 15 Jun 17. Witness 9 Witness 14

1.4.78. C/S 30B's Loader had other duties to attend to that afternoon and stated he would have refitted the BVA Assembly during First Parade on 15 Jun 17, when the Armourers would have been available to check it whilst they were conducting the gauge plug bore check (see Paragraph 1.4.59.b). Witness 14

1.4.79. The Panel concluded that:

a. C/S 30B's Loader did not refit the BVA Assembly because he did not expect DS39AA to fire again that day and the armourers were not available when the BVA Assembly had been cleaned.

b. Had C/S 30B known that their vehicle was to be used again, they almost certainly would have not stripped the armament for cleaning: it did not require cleaning before firing again having only fired 18 Main Armament rounds and it would require cleaning again after any subsequent shoot.

c. Not informing Crew C/S 30B that DS39AA would be fired again that day is assessed as a **Contributory Factor** as it resulted in the tank being left without the BVA Assembly fitted.

[29] The Kidney Tray is on the left hand side of the gun at the forward end of the loader's station. It is used to store tools and spare parts.

1	Drinking water tank	9	Loader's guard
2	NBC control box	10	Loader's seat rail
3	Loader's Control Panel	11	Projectile stowage
4	Loader's hatch	12	Loader's seat (removed for Range Periods)
5	Vehicle User Data Terminal (VUDT)	**13**	**Ration Stowage Box**
6	TVE round stowage	14	Power distribution box
7	User Control Device (UCD)	15	TVE shield
8	Oil can stowage		

Figure 1.4.22: Loader's Station, Turret Left Hand Wall Indicating Location of Ration Stowage Box (13)

State of the Main Armament

1.4.80. The Panel concluded at that the previous crew dismantled and cleaned the breech of the Main Armament and left it with the BVA Assembly in the Ration Stowage Box, the FNA and Loading Tray removed and the Breech open.

1.4.81. The Panel has not been able to establish where the FNA subsequently used to fire the gun was located inside the tank when the Experience Shoot Crew mounted the vehicle. It could have been in the Ration Stowage Box, refitted to the Lower Breech Block, or elsewhere in the vicinity of the Loader's station. Each option is considered below:

a. **Ration Stowage Box**. C/S 30B's Loader stated that he placed the FNA in the Ration Stowage Box after wiping it clean. If this was the case, it is likely that Trooper A would have seen it when he returned the BVA Assembly to the Tank. It is extremely likely that the Experience Shoot Loader would have found the BVA Assembly when looking for the FNA in the drills discussed later in the report. The Panel concluded that C/S 30B Loader was mistaken in his statement that he placed it in the Ration Stowage Box. — Witness 9

b. **Refitted to Breech**. It is very unlikely that C/S 30B's Loader refitted the FNA to the Lower Breech Block before leaving the tank. To do so he would have had to close the breech and then refit it, knowing that there was no Thrust Housing to fit it to and that he would have to remove it and reopen the breech in order to refit the BVA Assembly, which he expected to do after cleaning. The Panel concluded that the FNA was not refitted to the Lower Breech Block, although it is not impossible.

c. **Elsewhere in the Vicinity of the Loader's Station**. By discounting the possibility of the FNA being placed in the Ration Stowage Box or refitted to the Lower Breech Block, the Panel concluded that the FNA was probably placed somewhere convenient around the Loader's Station, possibly in or near the Kidney Tray with the spare FNA, but most likely on one of the flat surfaces around the rear of the turret.

The Accident: 14 Jun 17, 1500-1525

Background

1.4.82. All 3 planned ACTs for 14 Jun 17 were successfully completed by 1300. The RCO's intention was then to complete Test Firing Procedures (TFPs) on 2 CR2s which had previously failed 2 System Performance Checks (SPC or LFX3, see Table 1.4.1)[30]. The first CR2 was brought up to the firing point on Range 4 to start its TFP, but a fault was discovered and it was unable to continue with the serial. The second CR2 was also declared unserviceable at this point. — Exhibit 3, Witness 1, Witness 3, Witness 12

1.4.83. The only other activities still outstanding for the Range Package was the Brigade Study Day, planned for 15 Jun 17, and 4 Experience Shoots. The aim of the Brigade Study Day was to learn to become more lethal at range. This was to be achieved by improving — Witness 1, Witness 2

[30] SPC and TFP are firing accuracy checks used to align the gunnery sights to the Main and Secondary Armament. A TFP involves firing approximately 8 DS-T Main Armament rounds.

understanding of combined arms integration and would culminate in the Brigade Staff witnessing[31] CR2 night firing on Range 4. The Experience Shoots were seen as a useful rehearsal of this activity, and the same RTR personnel would conduct both firings.

1.4.84. The Commanding Officer (CO), RCO, SSM, Regimental Gunnery Staff Sergeant (RGSS) and the 3 Sqn RIGs were aware of the plan to conduct the 4 Experience Shoots during the Range Package. These were to be conducted on an opportunity basis and no fixed timeslot had been agreed, noting that they were not going to be conducted whilst there were higher priority tasks waiting to be executed. As discretionary activity, it was anticipated that they would occur late in the Range Package, probably on the morning of 15 Jun 17. Witness 1 Witness 2 Witness 3 Witness 11 Witness 28

1.4.85. The CO visited the Range 4 Control Tower at approximately 1230. Anticipating the imminent completion of the day's scheduled activity, and realising he had an available time slot, the RCO informed the CO of his intention to conduct the Experience Shoots that afternoon. The CO approved this plan[32]. On cancellation of the 2 TFPs and with all other activity for that day completed, at approximately 1430, the RCO decided to conduct 4 Experience Shoots. DS39AA was selected for the Experience Shoots as it had been used that morning and had proven to be a reliable, accurate firing tank throughout the Range Package. Exhibit 1 Witness 1 Witness 2 Witness 9 Witness 11

Experience Shoots

1.4.86. Experience Shoots are not formally defined LFXs, but are a recognised practice across the Royal Armoured Corps of demonstrating the tank's weapon systems. They involve an unqualified person (guest) sitting in the gunner's position, under the supervision of a qualified commander with a qualified loader and driver in the vehicle. The guest does not fulfil the roles and responsibilities of the gunner and the shoot does not qualify the guest to conduct further firing. Witness 11 Witness 16

1.4.87. On this occasion, the Sqn Staff decided that each of the 4 serials would consist of firing 2 main armament rounds, one SH-P and one DS-T, plus approximately 100 rounds of 7.62 mm ammunition from the coaxial Chain Gun. The plan was for the guests to be allowed to fire the armament under supervision. The shoots were very simple in format: the tank would be driven to the firing location at Range 4, Lane 2, Bound 1[33] and halt; and the firing would take place from a stationary tank firing at fixed targets[34]. Witness 1 Witness 11

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[31] The Panel understand that the Brigade Commander would have had the opportunity to sit in the gunner's position for the firing.

[32] During interview, the CO stated that in his initial interpretation of the conversation, he thought the Guest Gunner was going to be in a tank for the TFP. He conceded that in hindsight he realised the RCO was talking about an Experience Shoot, but the outcome was the same, an unqualified guest would be in a firing tank.

[33] The Bounds are designated points on the firing lanes. They are numbered and are normally marked with a concrete post. They are reference points for the crews when conducting LFXs. At CMR Range 4, Bound 1 is the first point down range at which a tank can fire.

[34] The targets to be used were the "hards", stripped tank hulks located approximately 1000m down the range, easy to see and hit.

1.4.88. The nominated guest gunners[35] were a Warrant Officer from the CMR range staff; a Royal Electrical and Mechanical Engineer (REME) Captain attached to the RTR; a REME Corporal (Cpl) attached to the RTR Light Aid Detachment; and an RTR Captain, the Regimental Operations Officer[36]. Although agreed several weeks in advance, there was no formal programme for when they would be conducted and were not mentioned in any of the written planning material. Witness 1

1.4.89. The Experience Shoot was simple, clearly defined, supervised appropriately and could have been conducted safely. Conducting an Experience Shoot did not make the accident more likely to occur; the accident could have occurred if any crew had conducted any form of shoot on that tank. The key issue was the state of the Main Armament at the start of the shoot.

1.4.90. There are other scenarios that could have occurred at short notice on 14 Jun 17 that the members of BADGER Sqn, particularly the RIGs, could have reasonably been asked to conduct that involved firing from DS39AA. For example, the RIGs could have been asked to conduct an additional training shoot for a gunner who was struggling. Range planning has to be adaptable and reactive. Equipment breakdowns may necessitate changing vehicle at short notice.

1.4.91. The Panel concluded that

a. The Experience Shoots were simple, well understood serials, and that although they were not specifically scheduled, the personnel conducting them were aware of the shoots and what they were required to do.

b. Conducting an Experience Shoot was **not an Accident Factor**. The Accident Factor was conducting **any** shoot **without** knowing the state of the Main Armament. This is discussed further in Paragraphs 1.4.102 to 1.4.105.

Crew Selection

1.4.92. With all ACTs complete, any crew from BADGER Sqn was capable of conducting an Experience Shoot, but the command team chose 2 of the Sqn's 3 RIGs to act as commander and loader, considering them to be the most appropriate personnel to supervise the guest gunners and demonstrate the capabilities of a CR2 in a safe manner. The 3 Sqn RIGs knew of the plan to conduct the Experience Shoots as they were involved in the preparations for the Range Package and that 2 of them would form the crew. The Driver was selected by the Commander just prior to the shoot, as a qualified and reliable driver. Witness 1 Witness 4 Witness 11

1.4.93. The Panel concluded that selecting 2 RIGs to conduct the Experience Shoot was a sensible and appropriate course of action. This was **not an Accident Factor**.

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[35] Witnesses stated that offering an individual an Experience Shoot was seen as a way of saying thank you to them for providing the Unit with support in the run up to and during the Range Package.

[36] Although a trained tank soldier and member of the RTR, he was not in date for his CR2 training (WHT etc.) as the Operations Officer is part of the headquarters element and does not have his own CR2.

Crew Experience, Qualification, Training, Competence and Currency

1.4.94. **The Tank Commander**. Cpl Darren Neilson joined the Army on 12 Feb 04 and had spent a significant portion of his Army career working on CR2, filling all 4 crew positions. His primary task in BADGER Sqn was the Commander of CR2 C/S 12 but he was also a RIG. He had completed all the required training in the run up to the Range Package. During the Range Package he had completed LFXs 3 to 8 and he and his crew achieved a Level 5 Pass (75-84% of targets hit) in their ACT. A summary of his career and key competencies is shown in Table 1.4.2: Exhibit 22

Serial	Competency	Date
1	CR2 Driver	17 Sep 04
2	CR2 Gunner	04 Mar 05
3	CR2 Loader/Operator	04 Mar 05
4	CR2 Regimental Instructor Gunnery	07 Jul 11
5	Substantive Promotion to Cpl	02 Oct 12
6	CR2 Commander	02 Aug 13
7	CR2 Weapon Handing Test (most recent)	11 May 17
8	PGTE Threshold Test	11 May 17

Table 1.4.2: Tank Commander's Career Summary

1.4.95. **The Loader**. Cpl Matthew Hatfield joined the Army on 29 Aug 06. He had recently transferred from the Queens Royal Hussars (another CR2 equipped regiment) to the RTR in order to remain in the Tidworth area. He too had spent a significant portion of his career in CR2 and had filled all 4 crew positions. In BADGER Sqn he was employed as the Commander of CR2 C/S 33 and was a RIG. He had completed all the required training in the run up to the Range Package. During the Range Package he had completed LFXs 3 to 8 and he and his crew achieved a Level 5 Pass (75-84% of targets hit) in their ACT. A summary of his career and key competencies is shown in Table 1.4.3: Exhibit 22

Serial	Competency	Date
1	CR2 Driver	30 Oct 07
2	CR2 Gunner	12 Dec 09
3	CR2 Loader/Operator	27 Apr 10
4	Substantive Promotion to Cpl	20 Mar 14
5	CR2 Commander	27 Feb 15
6	CR2 Regimental Instructor Gunnery	08 Jan 16
7	CR2 Weapon Handing Test (most recent)	09 May 17
8	PGTE Threshold Test	11 May 17

Table 1.4.3: Loader's Career Summary

1.4.96. **The Driver**. The Driver joined the RTR on 17 Apr 10 as a qualified CR2 Driver and subsequently qualified as a CR2 Gunner. After a period away from the regiment on other duties he returned to RTR in Oct 16 and was employed as a CR2 driver. He had little input into the Experience Shoot; he drove the vehicle approximately 30m to Lane 2 Bound 1 and the tank remained stationary from there on. A summary of his key competencies is shown in Table 1.4.4: Witness 4

Serial	Competency	Date
1	CR2 Driver	9 Dec 09
2	CR2 Gunner	19 Oct 10

Table 1.4.4: Driver's Career Summary

1.4.97. **The Guest Gunner**. The first of the 4 nominated Guest Gunners was a member of Small Arms School Corps (SASC) employed as the Deputy Training Safety Officer (DTSO), based at CMR and not a qualified CR2 crewman. He had no CR2 related competencies but was very familiar with the construct of the range. The DTSO is required to have a comprehensive understanding of the needs of the range users and must provide the appropriate advice and guidance so that the users achieve optimum safe training benefit. As such the Guest Gunner strongly believed that conducting the Experience Shoot would improve his ability to conduct his duties. Witness 3 Witness 5 Witness 34 Exhibit 39

1.4.98. **Conclusions**. The Panel concluded that:

a. The Commander, Loader and Driver were suitably qualified, experienced, trained, competent and current for their roles and the Experience Shoots were something they could reasonably be expected to conduct in a safe and competent manner.

b. The qualification, experience, training, competency and currency of the Commander, Loader and Driver were **not Accident Factors**.

c. The Guest Gunner conducted the Experience Shoot voluntarily, with the view that it would assist him in the conduct of his duties, but he was not qualified to be in the tank.

Permission for a Non-qualified Person to be in the Tank

1.4.99. As stated above, the Guest Gunner was not a qualified CR2 crewman. PAM 21 states that all exercising troops are to have the competency to handle, operate and fire the weapons, ammunition, pyrotechnics and vehicles they will use during the exercise, or they must have dispensation granted by the Operating Duty Holder (ODH)[37]. This is a written authorisation at 2* level[38] to permit a person, equipment, place or practice that does not meet the criteria of the Safe System of Training. No application was made to the ODH for dispensation for any of the guest gunners to conduct an Experience Shoot. The minimum crew required to operate a CR2 is 3, and this was in place in the form of a qualified commander, loader and driver. As discussed in Paragraph 1.4.92, the risk of having a non-qualified person in the tank (non-compliance with a safe system of training) was mitigated by using 2 highly qualified soldiers as the Commander and Loader (RIGs); nonetheless, there was no ODH authorisation of the task[39]. Witness 2 Exhibit 41

1.4.100. In the lead up to BADGER Sqn's Range Package, the Guest Gunner had routine interaction with the RGSS in helping to prepare for the firing serials. During this period he requested the opportunity to conduct an Experience Shoot and was told that it would be possible if there was time and ammunition available toward the end of the Package. The Guest Gunner also informed his own chain of command of his desire to conduct a CR2 firing. The Senior Training Safety Officer (STSO[40]) at CMR stated that on the several Witness 3 Witness 34 Exhibit 9

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[37] The ODH for RTR at the time of the Accident was the General Officer Commanding 3rd (UK) Division.

[38] 2* (2 Star) level is Major General or equivalent (Rear Admiral, Air Vice Marshal).

[39] No application was made to the ODH to put the Brigade Commander in a firing tank during the Brigade Study day on 15 Jun 17.

[40] The current STSO is a tank soldier who has been a CR2 Commander.

occasions he and the DTSO discussed the matter, he clearly informed the DTSO that he was not qualified as a CR2 gunner and that, in his opinion, this type of activity does not occur anymore. The STSO did not order the DTSO not to take part in the shoot and the DTSO continued to arrange the shoot with BADGER Sqn.

1.4.101. The Panel concluded that:

a. The minimum manning level for the CR2 was in place and this was **not an Accident Factor**.

b. The RTR had sufficient notice to make an application to the ODH for a non-qualified person to be in the tank.

c. The RTR not applying for permission from the ODH for the Guest Gunner to be in the Tank for the Experience Shoot, and the consequential lack of ODH oversight of the risk, did not cause the accident or make it more likely to occur. However, this is a mandated action and part of the Safe System of Training. As such it is assessed as an **Other Factor**.

Hand Over / Take Over (HOTO) Routine

1.4.102. When a crew is required to take over a tank from another crew on ranges, they are expected to conduct a HOTO. There is no written routine stipulated for the conduct of a HOTO. The soldiers interviewed were aware of the expectation and indicated that it was fairly obvious what had to be covered: each oncoming crewman would speak to his opposite number and explain the state of his equipment and how well it was working. Key equipment like the laser (specifically handing over the laser key) and the state of the armament and ammunition would always be covered. Although not stated, it is the Panel's opinion that it is the responsibility of the oncoming crew to seek a HOTO as opposed to the off-going crew to deliver one, because the off-going crew may not be aware of the requirement to use the vehicle again, and it is in the interest of the oncoming crew to understand the state of the vehicle.

Witness 2
Witness 10

1.4.103. No HOTO took place between Crew C/S 30B and the Experience Shoot Crew. When the Experience Shoot Crew were told the Experience Shoot was taking place, C/S 30B Commander and Gunner were away from the range, changing a minibus tyre in Carmarthen. C/S 30B Loader is an Advanced Signaller and was on the range working on communication equipment. He spoke briefly to the Experience Shoot Commander in the period after C/S 30B's ACT and before the Experience Shoot, but only to discuss the whereabouts of communication equipment. They did not discuss the material state of DS39AA and it is unlikely that the Experience Shoot Commander knew at that stage which tank he would be using.

Witness 9

1.4.104. The only other way of ensuring that the Main Armament is in a safe known state is to conduct a drill that positively identifies that all the safety critical components are present. This is considered in depth in the Analysis of the Crew Actions and Drills in paragraphs 1.4.136 to 1.4.171.

Exhibit 15

1.4.105. The Panel concluded that:

a. The Experience Shoot Crew would not have been aware of the material state of DS39AA when they mounted the vehicle at 1500.

b. Had a HOTO occurred, the removal of the BVA from the Main Armament would almost certainly have been mentioned.

c. The absence of a HOTO between C/S 30B and the Experience Shoot Crew was assessed to be a **Contributory Factor**. Not conducting a HOTO did not directly cause the accident to happen, because the Experience Shoot Crew may have realised themselves that the BVA was not fitted, but it made the accident more likely to occur.

Recommendation

1.4.106. Head of Capability Ground Manoeuvre should establish a formal Handover / Takeover (HOTO) regime in order to ensure that tanks are in a safe and known state prior to firing.

Experience Shoot and Accident

1.4.107. The Guest Gunner and the crew mounted the vehicle on the hard standing on Range 4 at approximately 1500. The Commander and the Driver mounted the vehicle first and were joined a few minutes later by the Guest Gunner and the Loader. The Driver's Hatch was confirmed closed (as required during live firing) and the turret hatches were both left open throughout the Experience Shoot[41]. Witness 11

1.4.108. The ammunition in Table 1.4.5 was loaded into the tank. It was passed up to the Loader by Sqn Staff, but no external witnesses saw where the Loader stowed the ammunition inside the turret. Witness 11

Serial	Nature	Quantity
1	120 mm TK DS Practice, L29A1, Discarding Sabot Training (**DS-T**)	4
2	Charge, Propelling, 120 mm, TK DS, L18A1 (**CP DS-T**)	4
3	120 mm TK Squash Head Practice, L32A6 (**SH-P**)	4
4	Charge, Propelling, 120 mm TK Practice SH, L3A2 (**CP SH**)	4
5	7.62 mm Ball, 1B1T Linked L44A1/L45A1	400
6	Tube Vent Electric 13 mm L4A2 (**TVE**)	9[42]

Table 1.4.5: Ammunition Loaded for Experience Shoot

1.4.109. The tank was driven onto Range 4, Lane 2 and drove approximately 30m down the track to the firing position at Bound 1. The Commander spoke to the Range 4 Control Tower by radio and requested permission from the RCO to go to action. Permission was given. Witness 1

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[41] Unless a stated requirement of the Live Firing Exercise, the position of the Turret Hatches is at the Commander's discretion.

[42] The post-accident physical evidence does not align with 9 TVEs being issued. This is discussed in the analysis at Paragraph 1.4.128.

Figure 1.4.23: The Post-Incident View from Range 4 Control Tower showing CR2 ERM DS39AA (circled in red) on Lane 2 Bound 1

1.4.110. Witnesses described what happened next as follows: Witness 1, Witness 5, Witness 16

a. The tank went to action as indicated by the orange, flashing beacon on the rear of the turret.

b. After a pause of several minutes, the gun started to move in a manner that indicated that the Gunner and the Commander was acquiring a target.

c. A loud hissing noise was heard and white smoke was seen coming out of the hatches, lasting for several seconds.

d. Very shortly after the start of the hissing noise, the Commander was seen rapidly attempting to leave the turret from the Commander's hatch.

e. When his waist was level with the top of his hatch, an explosion occurred which threw him approximately 5m into the air and he landed on the grass 6m to the right of the vehicle. The explosion was described by several witnesses as loud but different from the normal noise of a tank firing. Eye witnesses also stated that the Main Armament did not appear to recoil.

f. Immediately after this explosion, 2 large, violent jets of flame were seen coming from both hatches, lasting approximately 5 to 8 seconds.

Post-Accident Investigation

1.4.111. There are no witness accounts of what occurred inside the tank at the time of the accident. The Driver has no memory of the accident. He would have been unable to see anything occurring inside the Fighting Compartment and could not remember anything after leaving the hard-standing at the top of Range 4. Specifically, he had no memory of what was said over the vehicle's intercom[43]. The Gunner was not a trained CR2 operator and remembered having a safety brief. He also recalled pressing the gun firing switch, but could not add any detail. Consequently, the Panel identified the accident sequence based on the physical evidence; external witness testimony; scenario testing on reference models and tanks; and what they believe were the most likely actions of the crew, centred on the drills tank crews are taught to follow. Witness 3 Witness 4

1.4.112. LFME was not required for the Experience Shoot and, although fitted to DS39AA, was not switched on. The Fire Control Computer (FCC) is an integral part of the Weapon Control System (WCS) and conducts numerous functions. Of relevance, it records and maintains a Fault Log and an Engagement Log, where it records button presses and selections. These logs were interrogated as part of the investigation, but the time stamp was corrupted, preventing proper analysis of the records. However it did indicate that there were no faults with the WCS and that the Gunner was likely to have been the Gun Director and therefore pressed the firing switch, supporting the Gunner's statement. There were no other means of recording what occurred in the turret during the accident sequence. Exhibit 15

1.4.113. The Panel concluded that:

a. The Gunner pressed the firing switch.

And observed that:

b. Onboard recording would be beneficial to any future post-incident investigations (**Observation**).

c. Onboard recording could provide safety assurance, by producing evidence showing that tank crews are following gunnery drills and safety routines correctly (**Observation**).

Recommendation

1.4.114. Head of Capability Ground Manoeuvre should consider providing an on tank recording facility in order to provide assurance that tank crews are following safety drills correctly and to aid any post-incident investigation.

Physical Evidence

1.4.115. The physical investigations on CR2 ERM DS39AA initially took place at CMR from 15-16 Jun 17. The tank was subsequently sealed by Dyfed-Powys Police and moved by

[43] To overcome engine and weapon noise, tank crews communicate via an intercom system that is integrated into their hearing protection and helmet. This is recorded when LFME is running.

the Army to ATDU at Bovington Camp on 19 Jun 17, where a joint forensic examination (lead by the Police, supported by the DAIB) took place on 3-5 Jul 17.

1.4.116. It was apparent on viewing the Fighting Compartment through the turret hatches, that the inside of the tank had been subject to a violent fire. There was scorching and charring throughout the compartment; insulation on electrical cables was heavily charred; the plastic covers on the 3 DS-T rounds in the projectile racking at the rear of turret had melted; a set of Enhanced Combat Body Armour (ECBA) was found on the Loader's footplate which was badly burnt on the upper surface. The forensic examination indicated that the likely seat of the fire was on the turret floor in the Loader's station (left hand side of the turret). All the charge stowage bins had their lids closed and their insides showed no sign of fire damage. Exhibit 9 Exhibit 10

1.4.117. The following ammunition was found in the tank: Exhibit 9

a. Three DS-T Rounds in the upper rear projectile racking. The protective plastic covers on the rear of the rounds had melted. See Figure 1.4.24.

b. Three SH-P Rounds in the lower rear projectile racking. The rounds were scorched but the tracer components on the rear of the rounds had not functioned. See Figure 1.4.24.

c. One DS-T Round on the floor of the turret on the Loader's Foot Plate. The white cap on the rear of the round had melted and fused with a set of ECBA that it was resting on. See Figure 1.4.25.

d. Three Charge Propelling DS-T in the Ready Charge Bins[44]. These charges showed no evidence of fire damage, were removed from the tank and assessed as serviceable. See Figure 1.4.26.

e. Beneath the ECBA on the Loader's Foot Plate was a belt of approximately 650 rounds of 7.62 mm ammunition, some of which had been initiated by the fire[45]. Empty cartridge cases and ball and tracer rounds were found throughout the crew compartment.

f. A further belt of 200 7.62 mm rounds was found loaded to the Coaxial Chain Gun[46].

g. One vent tube magazine fitted to the ATL containing 6 unfired TVEs, which were assessed as serviceable.

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[44] The Ready Charge Bins are located on the left hand side of the turret, just forward of the Loader's position. They hold up to 4 CP DS-T or 8 CP SH-P.

[45] Commonly referred to as having "cooked off", it occurs when the ammunition functions as a result of the ambient temperature exceeding the ignition temperature of the propellant. Commonly the cartridge case will have distorted or ruptured and the bullet may be projected, although with far less velocity than from a rifle.

[46] 400 rounds of 7.62 mm ammunition were provided for the Experience Shoot. The additional 450 rounds found in the tank were left over from previous shoots.

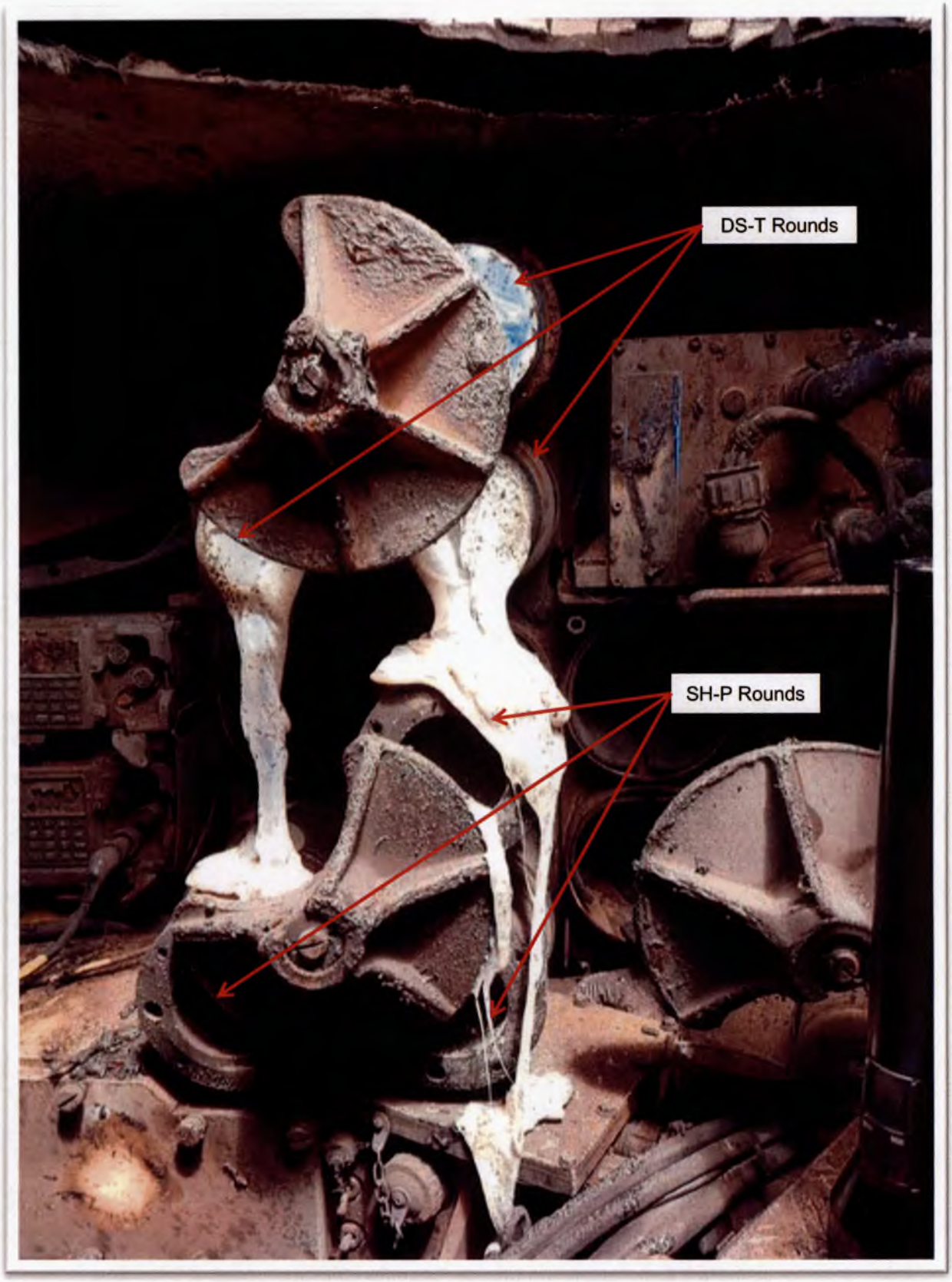

Figure 1.4.24: Projectiles in Racking

Figure 1.4.25: Discarding Sabot – Training Round on Tank Floor (circled in red) the ECBA has been removed

Figure 1.4.26: Remaining Charge Propelling Discarding Sabot – Training Left Photo: in the Charge Bin. Right Photo: as Recovered from the Tank

1.4.118. Initial examination of the Main Armament revealed: Exhibit 1 Exhibit 10 Exhibit 16

a. The bore and the chamber of the gun were clear, with no projectile or charge present.

b. All weapon user interfaces were set to the positions expected for a vehicle "at action" (ready to fire).

c. There had been a significant amount of damage to the breech mechanism. The Upper Breech Block was found to have been blown clear of the Breech Ring. It had struck the roof of the turret and was found embedded in the projectile racking at the rear of the turret. See Figure 1.4.27 and Figure 1.4.28.

d. The remains of the Loading Tray were found in several pieces scattered across the turret floor.

e. The BVA Assembly and the FNA could not initially be found.

1.4.119. The Firing Circuits in the tank were proved and were found to be working correctly and the TVEDU was operating as designed. Exhibit 10

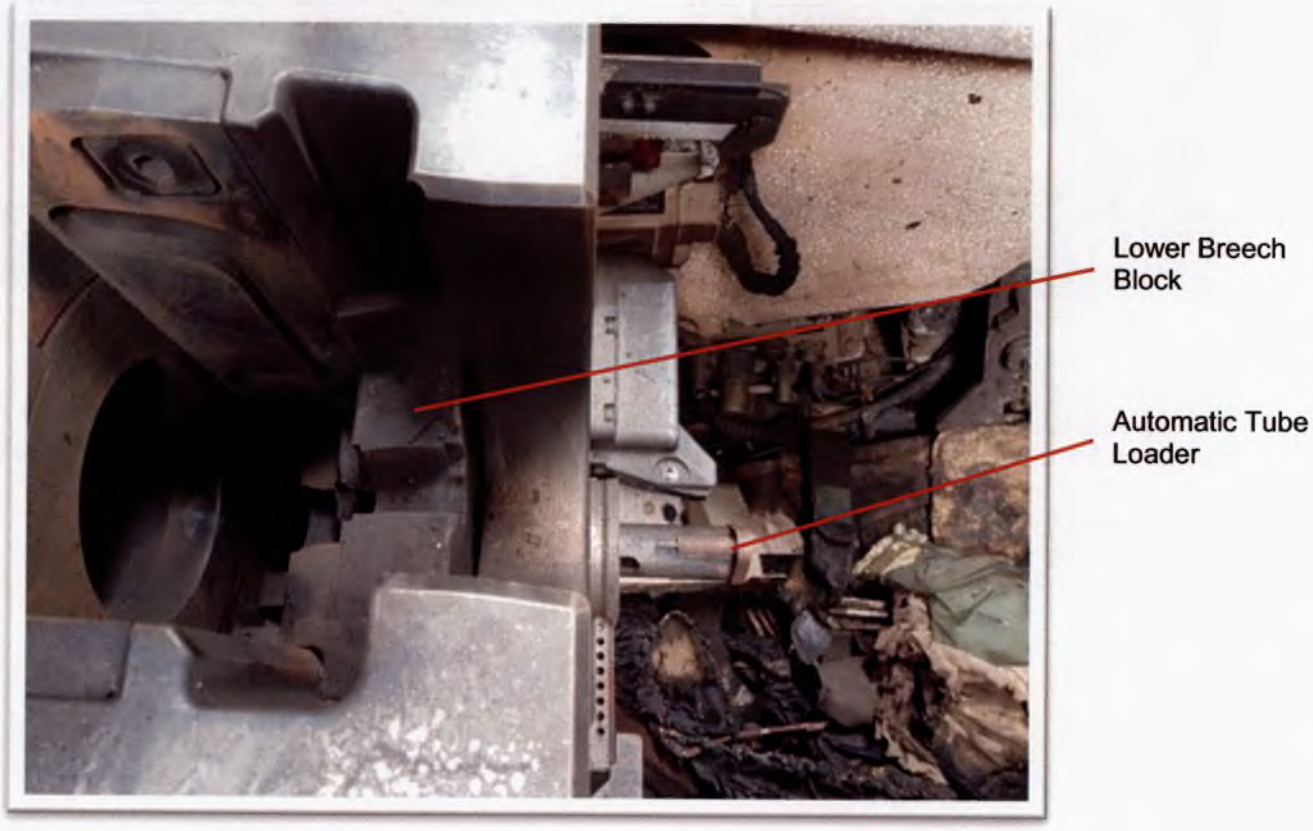

Figure 1.4.27: Damaged Breech Ring with Upper Breech Block Missing

Figure 1.4.28: Upper Breech Block (circled in red) in the Projectile Racking

1.4.120. A detailed examination of the tank's interior revealed that the BVA Assembly was in the Ration Stowage Box to the rear of the Loader's compartment (Figure 1.4.22). The Obturator Pad and Shim were fitted to the BVA and the Thrust Housing was under it. They were covered by a mobile phone[47], some orange mine tape, 2 electrical leads, a pink pencil and a white rag (Figure 1.4.29 and Figure 1.4.30).

Exhibit 1
Exhibit 10

[47] The presence of the mobile phone in the Ration Stowage is discussed further in Paragraph 1.4.138.

Figure 1.4.29: Contents of Ration Stowage Box as Discovered

Figure 1.4.30: Ration Stowage Box with Phone, Tape, Leads, Pencil and Rag Removed

1.4.121. The serial numbers of the BVA and Obturator Pad discovered in the Rations Stowage Box matched those recorded in the DS39AA Gun Documentation Folder and only one BVA had been issued to this tank. No other BVA Assembly was found on the tank post-accident. | Exhibit 1 Exhibit 10

1.4.122. One FNA and a BVA Retaining Screw were found in the Kidney Tray. Each tank normally carries 2 FNAs: one fitted and one spare. | Exhibit 1

1.4.123. During the subsequent forensic investigation the following was discovered: | Exhibit 10

a. An FNA was found located in the rear left hand corner of the fighting compartment with a fired TVE fitted to the face;

b. An unfired TVE was found located within the cables, forward of the rotary base junction on the floor of the turret.

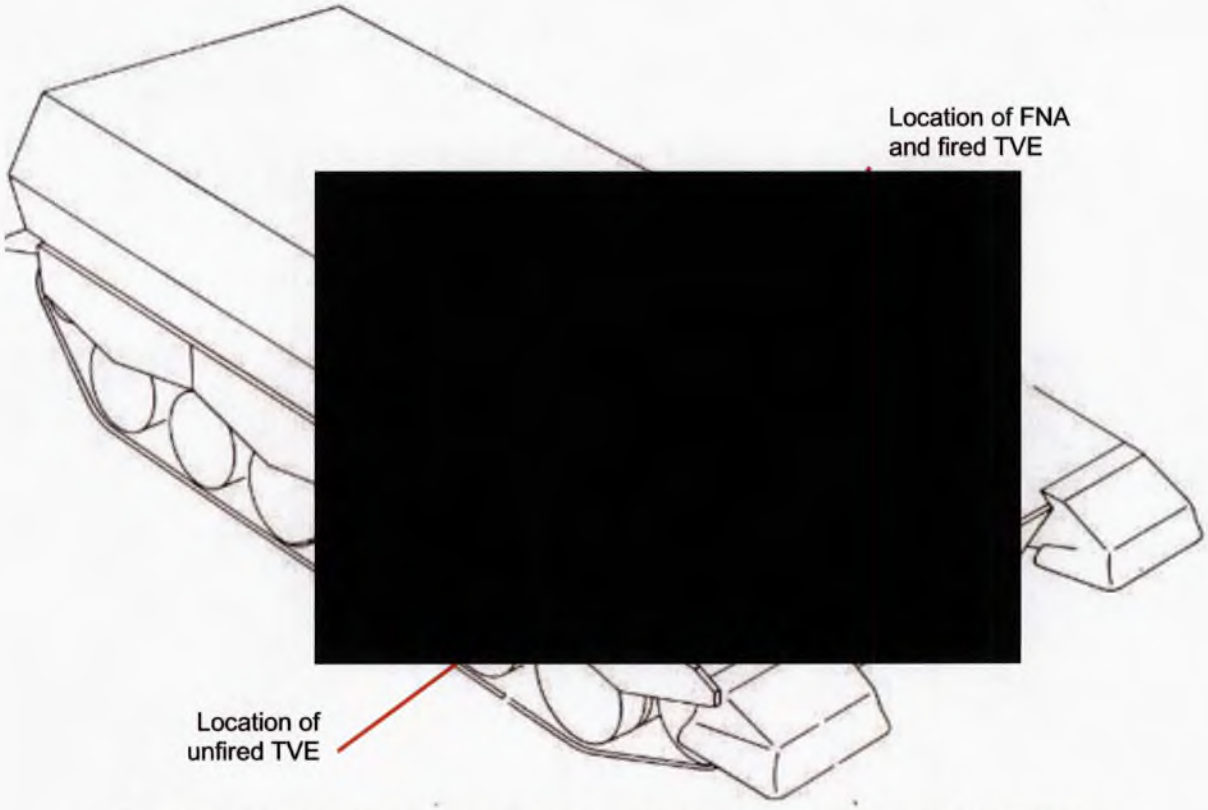

Figure 1.4.31: Location of Firing Needle Assembly and Unfired Tube Vent Electric

Analysis of the Physical Evidence

The Bolt Vent Axial Assembly

1.4.124. The BVA Assembly had been removed by the previous crew (C/S 30B), cleaned and placed in the Ration Stowage Box. It was recovered from this position in a clean state on 16 Jun 17. The serial number of this BVA matched the Gun Documents for DS39AA and no other BVA was found in the tank during the forensic examination. Witness 9 Witness 10

1.4.125. The Panel concluded that the BVA Assembly was not fitted to the Main Armament of DS39AA at the time of the accident.

Ammunition

1.4.126. Seven projectiles were recovered from the tank, 3 SH-P and 4 DS-T. Therefore the missing eighth projectile, a SH-P, almost certainly was loaded into the gun as the first round to be fired, with the appropriate Propelling Charge, a CP SH, in the gun chamber. The amount of energy required to cause the catastrophic breech failure, resulting in the Upper Breech Block detaching from the Breech Ring and the lower Breech Block is significant. The Panel opined that this could only come from the ignition of this Propelling Charge in the chamber. The bore of the gun was found to be clear and therefore the SH-P must have been fired from the gun[48] with a much reduced muzzle velocity. This is consistent with the witness statements of a different noise being heard (compared to a normal firing) and the lack of recoil observed[49]. Exhibit 9 Witness 11 Witness 17 Witness 19

1.4.127. The Panel concluded that a SH-P round was fired from Main Armament without the BVA fitted.

1.4.128. Six unfired TVEs were recovered from the tank in the TVE magazine fitted to the ATL. Two further TVEs were recovered from the floor of the turret; one unfired; one fired and still attached to an FNA. A witness stated that, during the ammunition transfer to the tank, he confirmed that the Loader had a spare TVE, indicating that 9 TVEs were provided. This spare should have been stored in a separate TVE magazine, which would normally be stowed in the TVE magazine rack on the left hand side of the turret. No evidence of a spare TVE was found, although 2 empty magazines were found in the magazine rack. Exhibit 9 Exhibit 10

1.4.129. The Panel were unable to confirm the existence of the ninth TVE and were unable to determine the reason for the discrepancy, however, this was **not an Accident Factor**.

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[48] Although considered, no attempt was made to find the fired SH-P round. This was primarily because, in order to preserve evidence, the tank was not declared "safe" until the morning of 15 Jun 17 and the range in front of it remained a danger area. The round would have been very difficult to find and, had a round been found, it would have been impossible to prove it was the round fired, as they are not uniquely serial numbered.

[49] The first personnel into the tank post-accident reported that the Loader's Sliding Guard was still made: the Sliding Guard is normally returned to the fully open (or "broken") position by the recoil of the gun.

The Firing Needle Assembly

1.4.130. The FNA and attached TVE found on the floor of the turret (Figure 1.4.31) are shown in Figure 1.4.32. Detailed examination revealed that: Exhibit 10

a. The witness marks from the firing needle on the primer cup indicated that the TVE had been fired using the Firing Circuit of the Main Armament;

b. The TVE was found to be bulged throughout its length, indicating that it was fired whilst not correctly chambered within the BVA;

c. The lack of damage to the interrupted threads on the FNA assembly indicates that it was not secured within the thrust housing at the time of ejection from the Breech Block.

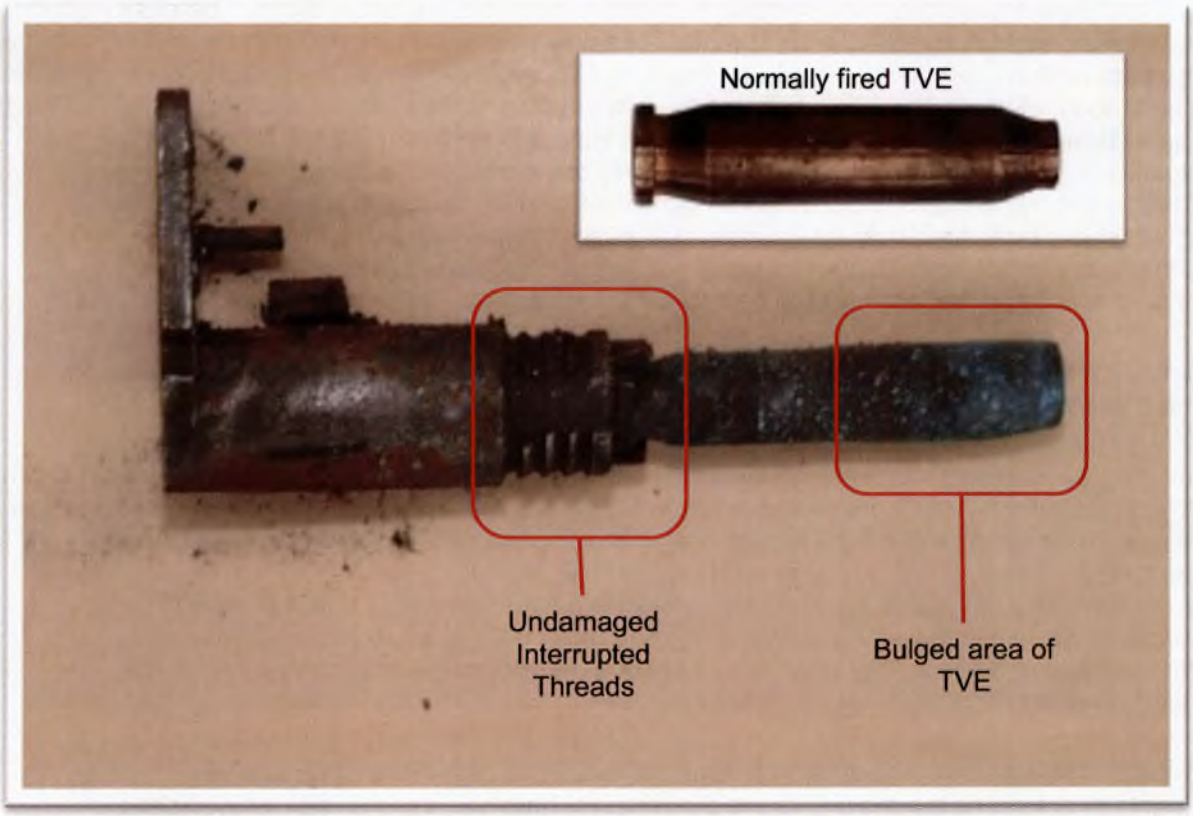

Figure 1.4.32: Recovered Firing Needle Assembly with Attached Tube Vent Electric Inset: Normally Fired TVE for Reference

1.4.131. As previously stated in Paragraph 1.4.111, the Gunner remembers pressing the Firing Switch and the Firing Circuits in the tank were proved to be operating correctly after the accident. Witness 3

1.4.132. The Panel concluded that:

a. The TVE attached to the FNA was initiated by the Firing Circuit in response to the Gunner pressing his Firing Switch.

b. The TVE firing had occurred without the FNA being attached to the Thrust Housing.

Reference Model Testing

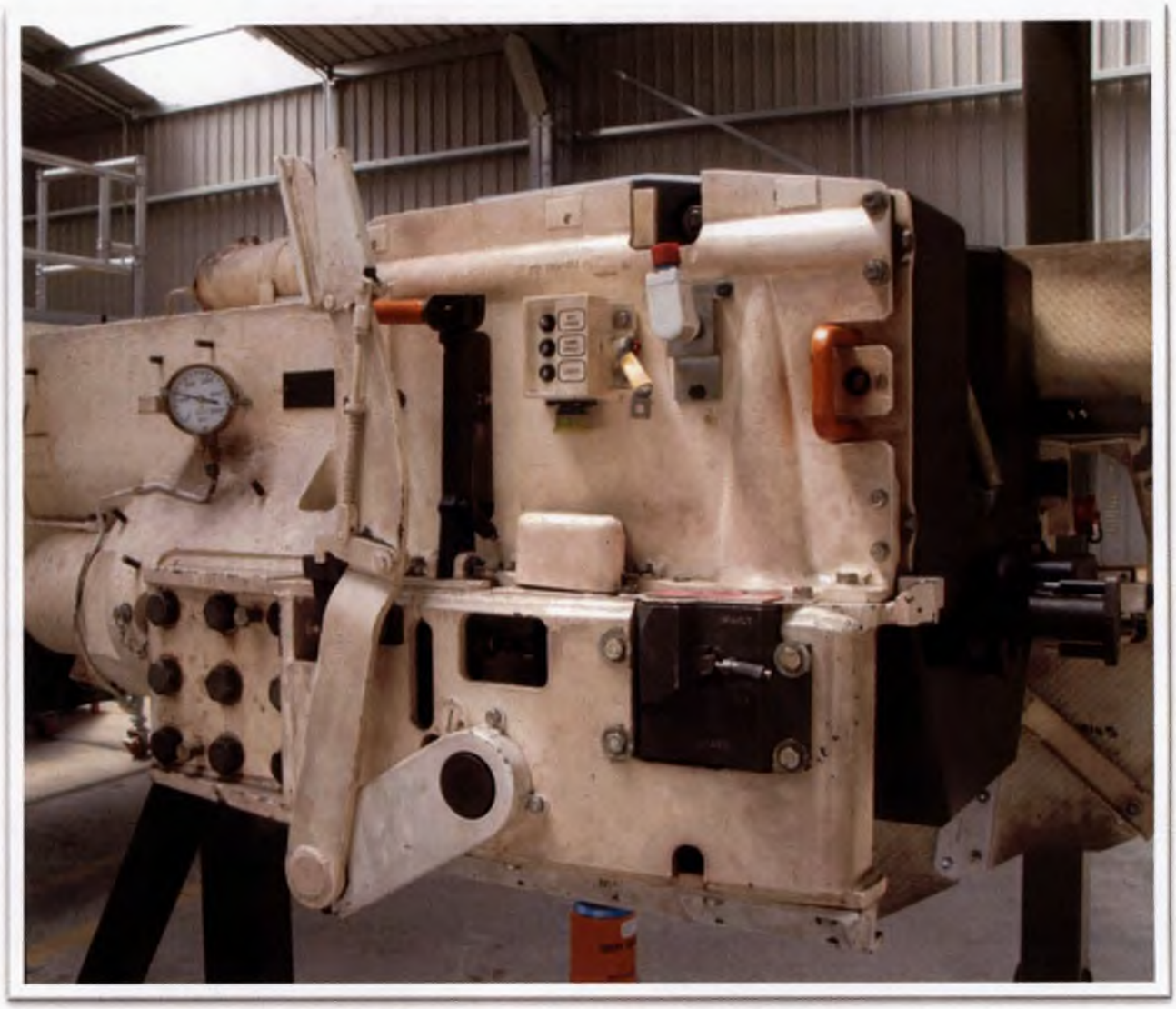

Figure 1.4.33: Classroom Instructional Model L30A1

1.4.133. In light of this conclusion, reference models were tested to discover how it was possible to complete the Firing Circuit and therefore fire the gun with the BVA Assembly removed. The BVA Assembly was removed from the Breech of a Classroom Instructional Model (CIM) of the Main Armament (Figure 1.4.33) and the following tests completed. Exhibit 10

a. **Loading with the ATL.** When a TVE was rammed using the ATL, as would occur in normal operation, the TVE was propelled through the BVA aperture in the Upper Breech Block and onto the floor on the other side (see Figure 1.4.34). This was to be expected, as the TVE chamber is located in the rear of the BVA. When the breech was closed, there was no TVE for the FNA to mate with and therefore the Firing Circuit was not completed. This was

indicated by the TVEDU displaying "NOT LOADED" with a red warning light (see Paragraph 1.4.29). The post-accident discovery of an unfired TVE on the floor of the turret indicates that the Loader very likely attempted to ram a TVE into the BVA using the ATL.

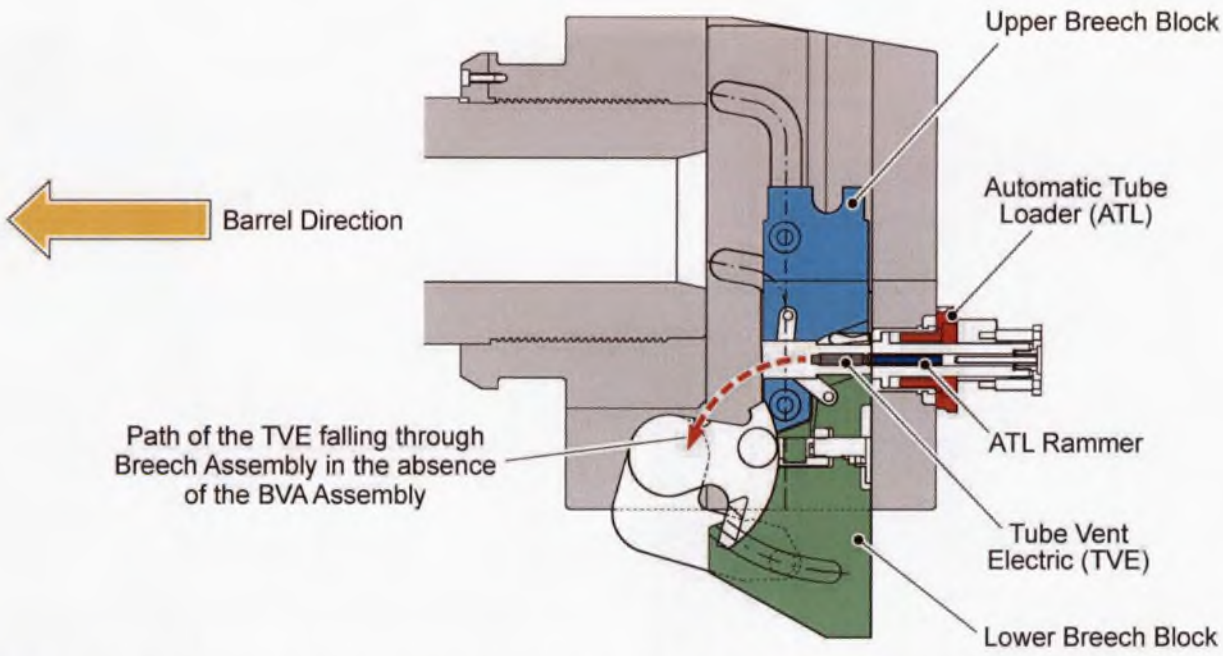

Figure 1.4.34: Loading a Tube Vent Electric with the Automatic Tube Loader with the Bolt Vent Axial Missing[50]

b. **Hand Loading with the FNA**. When conducting live firing and the TVEDU indicates RED "NOT LOADED", the Loader will conduct a drill in which the FNA is hand loaded with a TVE and reinserted into the Lower Breech Block (see Figure 1.4.35). This "Red Drill" was conducted in full on the CIM and, once the Loader's Guard was closed, the TVEDU displayed "LOADED" with a green light, indicating that the Firing Circuit was complete, despite the BVA Assembly not being fitted. This shows that the body of the BVA is not part of the Firing Circuit; the FNA provides both connection points to the TVE and is in direct contact with the Lower Breech Block, even without being locked into the Thrust Housing, thus completing the return path for the firing signal.

Both these actions were successfully repeated on a CR2 that had been provided as a reference vehicle.

[50] Diagram provided by BAE Systems and used with permission.

Figure 1.4.35: Hand Loading a Firing Needle Assembly with a Tube Vent Electric Fitted

1.4.134. Hand loading the FNA with a TVE fitted was the only method that the Panel and their supporting subject matter experts could establish that completed the Firing Circuit with the BVA Assembly missing. Witness 27

1.4.135. The Panel concluded that the Loader initially attempted to load a TVE with the ATL in the normal manner and subsequently hand loaded a TVE on the FNA as part of the Red Drill which is considered in Paragraphs 1.4.162 to 1.4.167.

Analysis of Crew Actions and Drills

1.4.136. The Panel then reviewed the actions and drills that the Experience Shoot Crew would be expected to follow to determine the series of events that led to hand loading the FNA with a TVE, and why the crew were not aware of the absence of the BVA Assembly. Exhibit 36

Actions on Mounting the Vehicle

1.4.137. The Commander was the first person to enter the Fighting Compartment when the Experience Shoot Crew mounted the vehicle at approximately 1500. He was joined shortly after by the Loader and the Gunner. A mobile phone was discovered in the Witness 3 Witness 11

Ration Stowage Box (Figure 1.4.30) which was later shown to belong to the Loader[51]. When the Loader mounted the tank he would likely have taken his mobile phone and placed it in the Ration Stowage Box to prevent it being damaged whilst he conducted the Experience Shoot. The Panel was told that the Ration Stowage Box is routinely used to store personal items. When he placed it in the Box he almost certainly did so in a manner which precluded observing the BVA Assembly, which was partially obscured by a rag and electrical leads.

1.4.138. PAM 21 states that mobile phones or other personal electrical devices are not to be switched on within 5m of any electrically initiated weapon system or ammunition point. CR2 is an electrically initiated weapon system and the TVE is an Electro Explosive Device (EED). When found, the mobile phone had a discharged battery, although the Panel cannot confirm that it was switched on when the Loader mounted the tank. However, the Panel believe that, on the balance of probability, the phone was switched on when stowed in the Ration Stowage Box. The presence of active mobile phones in tanks during the period of 2-14 Jun 17 was confirmed by other witnesses. Exhibit 41

1.4.139. The Panel concluded that:

a. The Loader placed his mobile phone in the Ration Stowage Box without noticing the BVA Assembly.

b. The Loader took his phone into the turret in contravention of PAM 21, although in this particular accident this was **not an Accident Factor**.

c. The practice of taking functioning mobile phones into CR2 is a common occurrence. This is an intentional, unsafe act in violation of the rules and is assessed as an **Other Factor**.

Recommendation

1.4.140. The General Officer Commanding 3rd (United Kingdom) Division and Director Land Warfare should put in place a suitable assurance regime to ensure that mobile phones or other personal electrical devices are not taken within 5 metres of Armoured Fighting Vehicles (AFVs) with loaded electrically initiated weapon systems, or ammunition points, in order to comply with extant regulations and reduce the risk of accidents.

State of the Main Armament

1.4.141. As described in Paragraphs 1.4.77 to 1.4.80 the Panel believes that the Main Armament was found by the Experience Shoot Crew in the following state:

a. **Loading Tray not fitted**. The previous Loader stated he left it hanging on the projectile racking. The Loading Tray must be removed to gain access to the retaining screw that must be removed to allow the removal of the BVA Assembly.

[51] Investigation conducted by Dyfed-Powys Police.

b. **Breech Open**. The previous Loader stated he left the breech open. The breech has to be open to allow the BVA Assembly to be removed and subsequently refitted. It is normal for a tank that has been firing to have the breech left open to allow air to circulate and cool the gun.

c. **FNA not fitted**. The previous Loader stated he removed the FNA. The FNA must be removed to remove the BVA Assembly. The Panel believes that the FNA was most likely to have been left on one of the flat surfaces at the rear of the Turret (Paragraph 1.4.81).

The Loading Tray

1.4.142. The Loading Tray was found in several pieces scattered across the turret floor, commensurate with having been fitted to the top of the Upper Breech Block during the breech explosion. The previous Loader stated that he had removed it and not refitted it. Exhibit 10 Witness 9

1.4.143. It is not possible to determine who refitted the Loading Tray, or when. It is possible that the previous Loader was mistaken and refitted the Loading Tray before leaving the tank, but this is unlikely as he would have had to remove it again before refitting the BVA Assembly[52]. The Experience Shoot Commander may have refitted it when he was alone in the turret prior to the rest of the Experience Shoot Crew mounting the vehicle. The Experience Shoot Loader may have refitted it prior to conducting the Prove the Gun Drill (details below in Paragraph 1.4.147). The Loading Tray was almost certainly refitted to the breech before the Main Armament was loaded, as the it assists in the smooth loading of the ammunition into the gun and it would be unusual to load the gun without it fitted, but not impossible.

1.4.144. As can be seen in Figure 1.4.36, when the Loading Tray is not fitted to the Upper Breech Block and the Breech is open, it is possible to see the top of the BVA and Obturator Pad. Importantly, once the Loading Tray is fitted, it is not possible to see either.

1.4.145. The Panel noted that it was considerably easier to refit the Loading Tray when the breech was closed. If the Loader refitted the Loading Tray, it is very likely that he closed the breech to do so. If he did this, then he would have noticed that the FNA was not fitted[53], as it is not possible to reopen the breech without either fitting the FNA or manually depressing the FNA Retaining Plunger. The Loader would have almost certainly refitted the FNA at this stage, prior to reopening the breech. Fitting the FNA is discussed further in Paragraphs 1.4.150 to 1.4.152 and in Annex A.

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[52] When he removed the BVA Assembly for cleaning, C/S 30B's Loader intended to refit it on completion.

[53] The Loader may have noticed the unfitted FNA before this and closed the breech to refit it, with the same result.

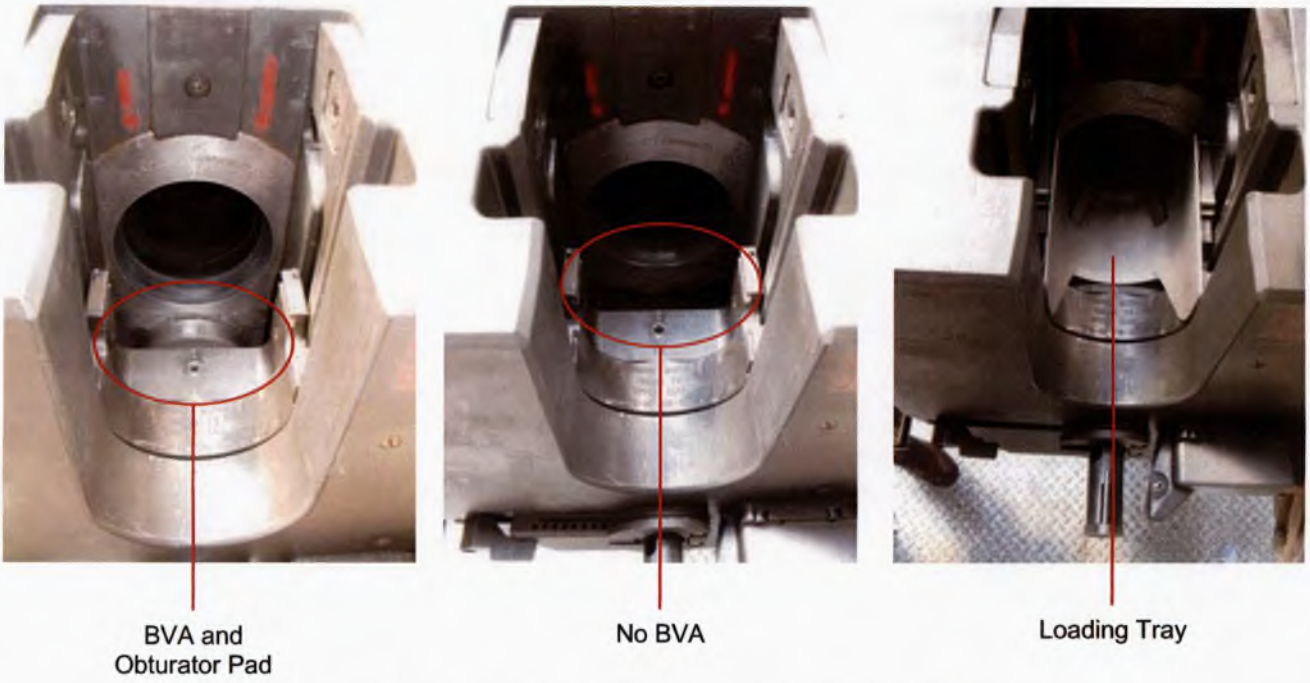


Figure 1.4.36: View of the Gun Breech[54] (Breech Open)
Left: BVA Assembly Fitted (Circled), Loading Tray Not Fitted
Centre: BVA Assembly Not Fitted, Loading Tray Not Fitted
Right: Loading Tray Fitted

1.4.146. The Panel concluded that:

a. The Loading Tray was refitted before the gun was fired. It was not possible to determine by whom.

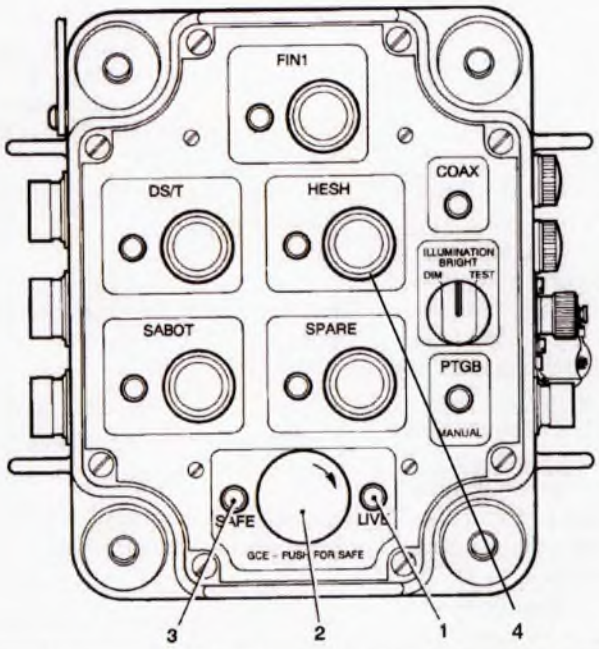
b. Neither the Loader nor Commander noticed that the BVA Assembly was not present prior to the Loading Tray being refitted. Once the Loading Tray was fitted, they would have been unable to see the BVA Assembly was missing.

Prove the Gun

1.4.147. "Prove the Gun" is a drill conducted by the Loader prior to commencing work on the gun, to ascertain the state of the armament, *specifically to ensure that it is clear of any ammunition*. The Panel cannot be sure that this drill was conducted, but, based on evidence presented, demonstration and explanation, believe that on the balance of probability, this drill was conducted shortly after the Crew mounted the tank. The key points of this drill[55] are listed in Table 1.4.6 below: a summary of the principle steps of the drill are listed in Column (b) and the details of subsequent actions that occurred in DS39AA are listed in Column (c). Exhibit 36

[54] These photographs were taken on a CIM Gun in a well-lit room. The view is less clear in the tank turret.

[55] This is a brief overview of the drill conducted. Steps which are not relevant to the accident sequence have been omitted, but the full drill is listed in AESP 2350-P-102-201, Amendment 31 dated Apr 17.



1	Safety Switch Live Indicator (Red)
2	Loader's Safety Switch
3	Safety Switch Safe Indicator (Green)
4	Nature Selection Switch – HESH

Figure 1.4.37: Loader's Control Panel
The location of the Loader's Control Panel is shown in Figure 1.4.22, Item 3

Exhibit 36

Serial (a)	Drill (b)	Probable Actions in Accident Tank (c)
1	Set the Loader's Safety Switch to SAFE.	The green LED on the Loader's Control Panel (LCP) would have illuminated. Figure 1.4.37, Item 3.
2	Remove and stow the vent tube magazine if fitted (to the ATL).	There was almost certainly no magazine fitted to the ATL at this stage, so no action would have been required.
3	Remove the Firing Needle Assembly (FNA) using the 4 mm Allen key on the Combination Tool (Figure 1.4.39).	This can only be done with the Breech Closed. If, as the Panel believe, the Breech was open when the Experience Shoot Crew mounted the tank, the Loader would have closed the Breech at this point. After closing the Breech, the Loader would have realised there was no FNA fitted[56].
4	Remove the vent tube from the FNA (if applicable) by depressing the contact holder and sliding the tube out of the FNA, then re-stow the vent tube in the magazine.	With no FNA fitted, there would be no requirement to check for the presence of a TVE. In the unlikely event of the FNA being fitted, it is extremely unlikely that a TVE would have been fitted to it. The FNA must be removed to remove the BVA for cleaning and the TVE would have been removed at that stage.

[56] The FNA may have been refitted if the Loader closed the breech to refit the Loading Tray as discussed in Paragraph 1.4.145.

5	Refit the FNA.	With no FNA in the Lower Breech Block, the Loader would have had to search for it. The Panel believe he most likely found it on one of the flat surfaces around the rear of the turret[57]. The action of fitting the FNA is discussed further in Paragraph 1.4.150.
6	Open the Breech with the Breech Mechanism Lever.	This drill would have almost certainly proceeded without incident.
7	Look through the bore from the chamber end to confirm that the bore and chamber are clear of any ammunition by looking from the 12 o'clock at the chamber end to 6 o'clock at the muzzle.	The bore and chamber were almost certainly clear.
8	Remove the ATL and check that it is clear.	The ATL was almost certainly clear.
9	Carry out a physical check of the TVE chamber in the rear of the BVA by running the fingers down the face of the BVA.	The action of checking the TVE Chamber is discussed further in Paragraph 1.4.153.
10	Refit the ATL and operate the release catch to allow the ATL Weight to go forward.	This drill would have almost certainly proceeded without incident.
11	Set the Loader's Safety Switch to Live.	The Loader would have checked the red LED on the Loader's Control Panel was illuminated.

Table 1.4.6: Main Armament Prove the Gun Drill

1.4.148. In the Prove the Gun drill detailed above, there are 2 opportunities for a loader to notice that the BVA Assembly is not fitted:

a. When refitting/fitting the FNA (Table 1.4.6, Serial 5).

b. When checking for a TVE in the TVE Chamber at the rear of the BVA (Table 1.4.6, Serial 9).

These 2 opportunities are discussed below.

1.4.149. The drill in Table 1.4.6 assumes that the breech is closed at the start. Discussions with subject matter experts at AFVTTS have revealed that if the breech is open at the start an alternative version of the drill can be conducted by moving directly from Serial 2 to Serial 7. This achieves the same results and does not require the breech to be closed and then opened again. If the TVE Chamber in the rear of the BVA is clear of ammunition, then the FNA cannot pick up a TVE when the breech is closed. This alternative drill has been added to the AESP post the accident date.

[57] He did not use the spare FNA as this was found in the Kidney Tray during the post-accident inspection.

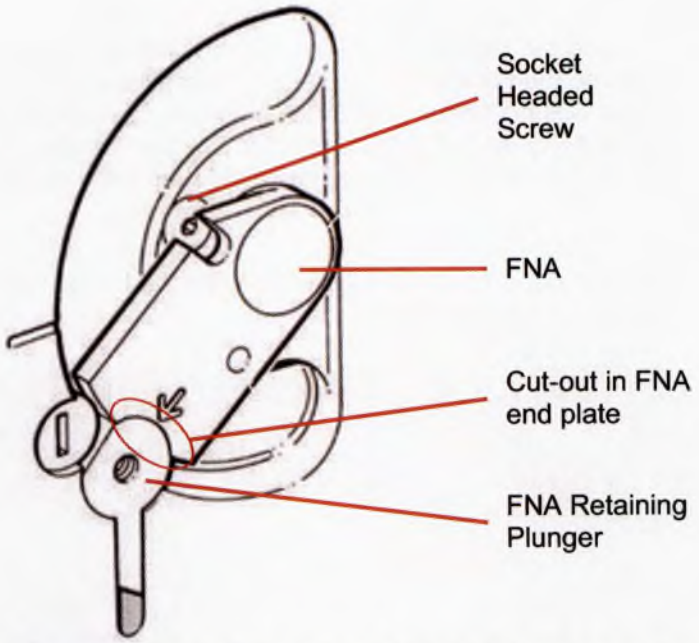


Figure 1.4.38: The Firing Needle Assembly Fitted to the Lower Breech Block

Fitting the FNA

1.4.150. The detailed instructions for fitting the FNA are as follows (see Figure 1.4.38): Exhibit 36

a. Insert the FNA fully forward into its housing in the Lower Breech Block.

b. Using the 4 mm Allen key on the combination tool, push in on the FNA Retaining Plunger[58] and rotate the FNA anti-clockwise until the cut-out in the FNA end plate is aligned over the FNA Retaining Plunger.

c. Release the FNA Retaining Plunger ensuring that it protrudes through the cut-out in the FNA end plate.

d. Using the 4mm Allen key rotate the axial (socket headed) screw anti-clockwise until it contacts the FNA end plate, do not over-tighten.

With the BVA fitted to the gun, the FNA is retained in the Lower Breech Block by the interrupted threads engaging in the Thrust Housing. To fit the FNA, it is inserted into the rear of the Lower Breech Block and rotated 45° anticlockwise, engaging the interrupted threads. Loaders are then taught to wind the socket headed screw back (anticlockwise) using the 4mm allen key on the end of the Combination Tool (Figure 1.4.39), until it just takes up any slack and stops the rear of the FNA from moving. As the socket headed screw is rotated anticlockwise it contacts the FNA end plate. With no Thrust Housing inside the Lower Breech Block to retain the FNA it is possible to keep winding the screw until the FNA starts to noticeably protrude from the rear of the Lower Breech Block and eventually the axial screw will come out of its socket.

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[58] The FNA Retaining Plunger is also referred to as the Safety Interlock Plunger.

1.4.151. When the Panel observed this drill being conducted on a CIM and in reference tanks, it was found that holding the Combination Tool with the back of the left hand flush against the FNA (holding it into the Lower Breech Block) it was relatively easy to turn the screw without realising there was no Thrust Housing in place, as the FNA is quite a tight fit. The dimensions of the tool require 2 hands to maintain any degree of control and, as such, all personnel witnessed conducting this drill placed their left hand on the FNA in this manner.

1.4.152. The Panel concluded that a loader can fit an FNA into the Lower Breech Block without realising that a BVA Assembly is absent.

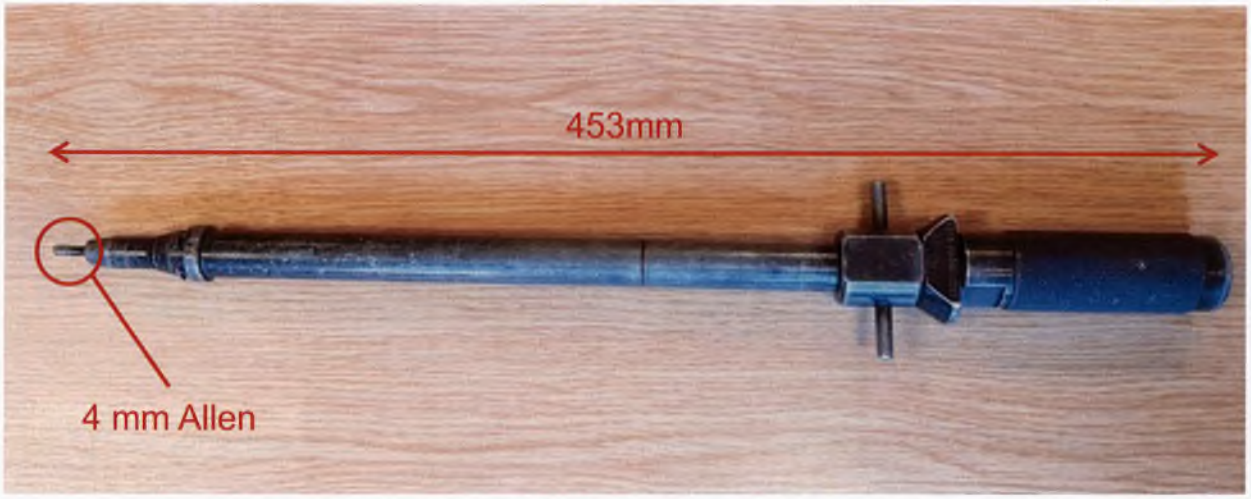


Figure 1.4.39: Combination Tool

Checking the Tube Vent Electric Chamber

1.4.153. Once the ATL has been removed, the drill instructs the loader to "carry out a physical check of the vent tube chamber in the rear of the BVA by running the fingers down the face of the BVA" but warns the loader "Do NOT place finger inside the Vent Tube Chamber". This drill is conducted to ensure that no ammunition (ie a TVE) is present; it is not conducted to check for the presence of a BVA. However, it is possible to check that no TVE is present without touching the BVA as the TVE protrudes approximately 9 mm from the rear of the BVA and the rear of a TVE in the chamber is relatively easy to see when the ATL is removed. If this drill is hurried or carried out without particular attention, then the Panel believe that the absence of the BVA is even more likely to go unnoticed. Exhibit 36

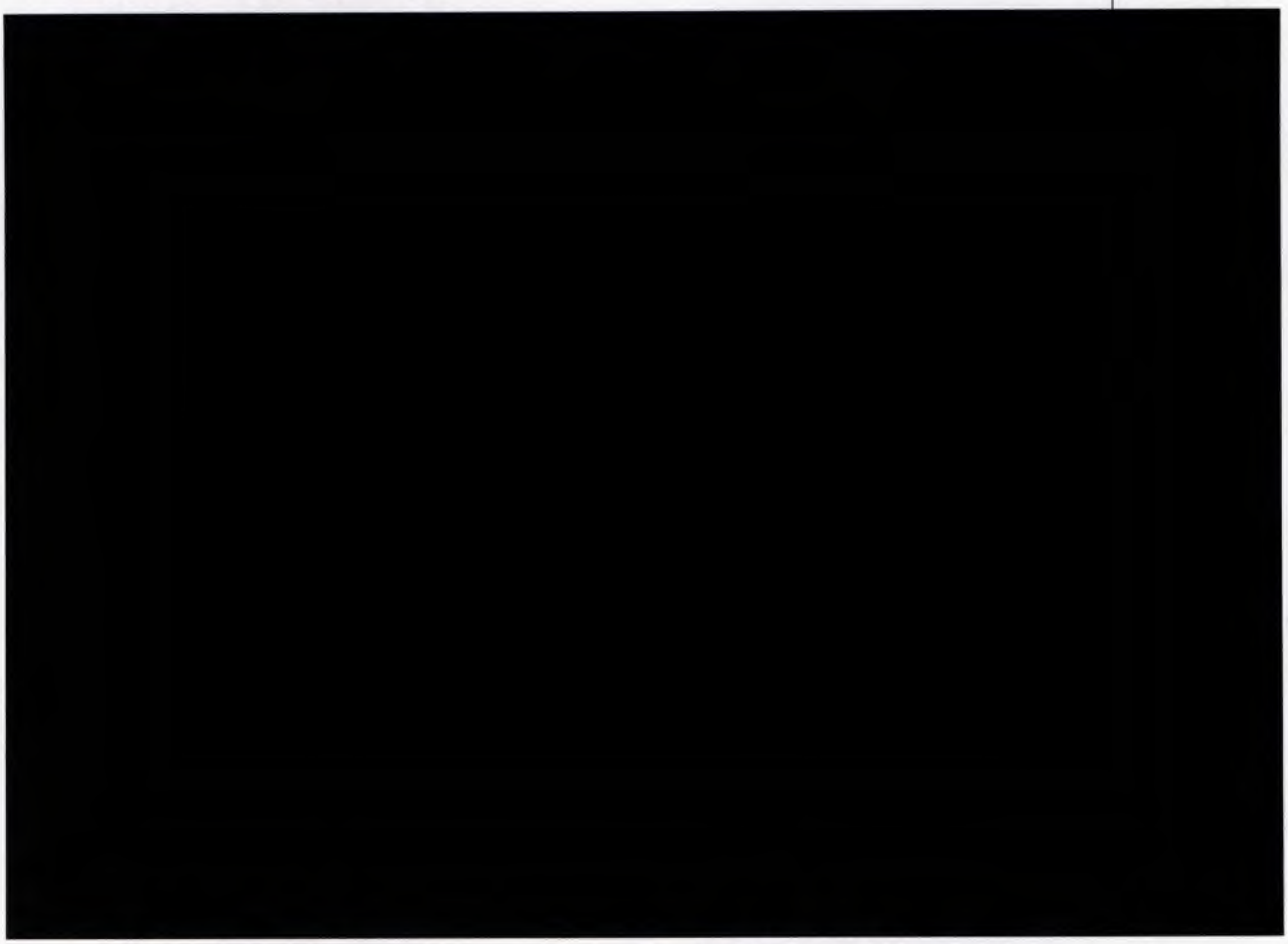
1.4.154. The Panel concluded that it is possible to confirm that there is no TVE in the TVE Chamber without noticing that the BVA is missing.

Summary

1.4.155. The Panel has witnessed the Prove the Gun drill detailed in the AESPs and taught to tank crews, conducted by subject matter experts both in the Armour Centre and in a front line unit, with the BVA Assembly fitted and not fitted. It was apparent from the drills witnessed that it was feasible to conduct the Prove the Gun drill without noticing the absence of a BVA.

1.4.156. The Panel concluded that the Loader probably conducted the Prove the Gun drill and did so without noticing the BVA Assembly was not fitted. It is possible that he did not conduct the Prove the Gun drill. If he did not fit the FNA when he refitted the Loading Tray and did not conduct the Prove the Gun drill, the FNA was very likely not fitted as he went into the Loading Drill. The accident sequence without the Prove the Gun drill has been analysed and the steps required to cause the accident can still be achieved. The details of this analysis are at Annex A.

Loading the Main Armament



1	Loading Tray	5	DS-T Projectile
2	ATL	6	Loader's Control Panel
3	Charge Bin	7	Loader's Hatch
4	Projectiles (SH-P) in Racking		

Figure 1.4.40: Loading the Main Armament

1.4.157. With the gun in the load position (angled slightly upwards), the breech open and all other drills complete, on receipt of the order "Action Load HESH" the Loader would have carried out the Main Armament Loading drill (see Figure 1.4.40), the key points of which are listed in Table 1.4.7 below. A summary of the principle steps of the drill[59] are

Exhibit 36

[59] This is a brief overview of the drill conducted. Steps which are not relevant to the accident sequence have been omitted, but the full drill is listed in AESP 2350-P-102-201, Amendment 31 dated Apr 17.

listed in Column (b) and the details of the actions that are likely to have occurred in DS39AA are listed in Column (c).

Serial (a)	Drill (b)	Probable Actions in Accident Tank (c)
1	Set the Loader's Safety Switch to SAFE.	The green LED on the Loader's Control Panel would have illuminated. Figure 1.4.37, Item 3.
2	Select the nature of ammunition on the Loader's Control Panel.	The Loader would have selected HESH. Figure 1.4.37, Item 4.
3	Open the breech (not required as breech already open) and check the bore and chamber are clear.	This is also checked as part of "Proving the Gun". The Loader would have reported either "Bore Clear" and proceeded, or "Bore Foul" and then cleared the obstruction. The bore was almost certainly clear.
4	Fit the vent tube magazine into its housing (on the ATL) ensuring the magazine retaining catch is fully engaged.	The Loader would have taken his TVE Magazine of 8 TVEs (probably stowed in the magazine rack on the left hand turret wall) and fitted it in to ATL. The magazine was recovered from this position after the accident.
5	Pull the ATL weight fully to the rear, release the weight by operating the plunger on the Release Mechanism Electrical to ram a TVE into TVE Chamber in the BVA. Visually check the weight has gone fully forward.	As described in Paragraph 1.4.133.a, with no BVA fitted, the rammed TVE would have fallen onto the turret floor, almost certainly unnoticed by the Loader.
6	Place the required projectile on the Loading Tray and push it forward into the Chamber until it passes the charge retaining catches on the Loading Tray.	The Loader would have selected a SH-P projectile and loaded it into the chamber. This was very likely stowed on the projectile racking at the rear of the tank, where the remaining 3 SH-P were found after the accident (Figure 1.4.24).
7	Open a charge bin, remove the correct charge, close and secure the charge bin lid.	Loader would have selected a CP SH. The Panel believe that the 4 CP SH were not stowed in a charge bin. This is discussed further in Paragraph 1.4.205.
8	Place the Propelling Charge onto the Loading Tray and vigorously push the charge forward into the Chamber with the fist of the right hand until it is forward of the charge retaining catches.	The CP SH would have been loaded into the Chamber.
9	Close the breech with the Breech Closing Lever and stow the Breech Closing Lever handle.	The Breech Closing Lever was found in the correct stowed position.
10	Set the Loader's Safety Switch to Live.	The Loader would have checked the red LED on the Loader's Control Panel was illuminated and reported "Loaded".

Table 1.4.7: Main Armament Loading Drill

1.4.158. The only opportunity in the Main Armament Loading Drill for the Crew to realise that the BVA Assembly was not fitted, would have been when the TVE fell onto the turret floor in Table 1.4.7 Serial 5. With the engine running and wearing hearing protection, they would almost certainly not have noticed this; if they had, they would very likely have investigated why and probably realised that the BVA Assembly was not fitted. The unfired TVE found on the turret floor supports this hypothesis (Paragraph 1.4.123.b). If the Loader did not conduct the Prove the Gun drill and fit the FNA to the Lower Breech Block drill, it is unlikely that he would have noticed the FNA was not fitted whilst conducting the Loading Drill, as the FNA is not visible until the Breech is closed (Table 1.4.7 Serial 9). Exhibit 10

1.4.159. The Panel concluded that:

a. The Loader conducted the Loading Drill described above, resulting in a SH-P and CP SH being loaded into the Main Armament.

b. The Loader rammed a TVE with the ATL, the TVE fell out of the other side of the Lower Breech Block, but neither he nor the rest of the Crew noticed it falling onto the turret floor.

Firing the Main Armament

1.4.160. Once the Commander and Guest Gunner were content with the selected target, the Commander would have given a fire order (for example "HESH Tank, stop loading, load DS-T"[60]), at which point the Loader would start his Action on Receipt of a Fire Order drill, detailed in Table 1.4.8. Again, a summary of the principle steps of the drill[61] are listed in Column (b) and the details of the actions that are likely to have occurred in DS39AA are listed in Column (c). Exhibit 36

Serial (a)	Drill (b)	Probable Actions in Accident Tank (c)
1	Select the next projectile to be fired (the ready round).	The next round was a DS-T, which the Loader probably removed from the rear projectile racking, where the remaining 3 DS-T rounds were discovered. Loaders are taught to hold the ready round in the crook of their right arm.
2	Close the Loader's Sliding Guard (move it rearward to the "made" position).	Loaders are trained to make the guard with the heel of their left hand.
3	Check the TVEDU for a Green LOADED indication (The LED will only illuminate for approximately 10 seconds).	On this occasion, with the BVA Assembly not fitted and no TVE present on the FNA, the Firing Circuit would have been incomplete and the TVEDU would have indicated Red NOT LOADED. The Loader would have reported "Red" to inform the crew, stopped this drill and commenced the Red Drill.

[60] This tells the Loader that the loaded HESH round will be fired at a tank target, to stop loading HESH and that the next round (the ready round) will be a DS-T.

[61] This is a brief overview of the drill conducted. Steps which are not relevant to the accident sequence have been omitted, but the full drill is listed in AESP 2350-P-102-201, Amendment 31 dated Apr 17.

4	Check the correct ammunition LED on the LCP and check the loader's safety switch LIVE LED is illuminated.	Not conducted at this point.
5	Report "Loaded"	Not conducted at this point.

Table 1.4.8: Action on Receipt of a Fire Order Drill

1.4.161. The Panel concluded that the Loader saw the Red NOT LOADED indication on the TVEDU, reported "Red" and commenced the Red Drill. The Commander would have almost certainly been aware of the situation. Exhibit 36

Red Drill

1.4.162. The TVEDU displaying Red NOT LOADED, indicates one of the following faults has occurred: Exhibit 36

a. No TVE has been loaded.

b. The loaded TVE is faulty.

c. The Breech Firing Circuit is faulty.

d. The Breech is not fully closed (jammed Breech).

The Red Drill is designed to discover which of these faults has occurred and get the tank firing again. The drill detailed in Table 1.4.9 is the only drill taught to loaders to rectify a TVEDU Red. Conducting it is a relatively common occurrence and one that is routinely tested in the WHT. Again, a summary of the principle steps of the drill[62] are listed in Column (b) and the details of the actions that are likely to have occurred in DS39AA are listed in Column (c).

Serial (a)	Drill (b)	Probable Actions in Accident Tank (c)
1	Reported "Red" informing the crew that a malfunction had occurred.	The Commander would have been aware of the problem and understood the delay.
2	Set the loader's safety switch to SAFE.	The green LED on the Loader's Control Panel would have illuminated.
3	Restow the ready round.	The Loader would probably have returned the DS-T round to the projectile racking where it was originally stowed.
4	Open the Loader's Sliding Guard.	

Exhibit 36

[62] This is a brief overview of the drill conducted. Steps which are not relevant to the accident sequence have been omitted, but the full drill is listed in AESP 2350-P-102-201, Amendment 31 dated Apr 17.

5	Check the breech is fully closed by ensuring that all of the FNA retaining plunger can be seen above the loading platform.	There is no evidence to suggest that the breech did not close and the Panel believe that the FNA retaining plunger would have been fully visible. It is possible, that if the Prove the Gun Drill was not completed, that there was no FNA fitted to the gun at this time. The Loader would now be aware of this.
6	Remove the FNA and check there is a TVE present.	On removing the FNA, the Loader would have found no TVE.
7	If no TVE is present, proceed as follows:	
8	Report "No Vent Tube".	The Commander would have been aware of the cause of the TVEDU Red indication.
9	Fit a vent tube into the FNA and refit the FNA.	The physical evidence suggests that the Loader had placed all his TVEs in a single magazine which was fitted to the ATL (Table 1.4.7 Serial 4), as 6 unused TVEs were recovered from this magazine post-accident. The Panel believe that he removed the magazine from the ATL, took the top round out and fitted it to the FNA. He would then have refitted the FNA in the manner described in Paragraph 1.4.150 and shown in Figure 1.4.35.
10	Change the TVE magazine.	The Loader only had one loaded TVE magazine and would have had to refit it to the ATL. He probably did this before he refitted the FNA.
11	Select the appropriate projectile.	The Loader would have redrawn the DS-T round (the ready round) from the projectile racking at the rear of the turret and held it in the crook of his right arm. The Panel believe this is the round that was recovered from the floor of the turret after the accident (Figure 1.4.25).
12	Close the loader's firing guard and visually check the TVEDU.	With the TVE fitted to the FNA, the Firing Circuit would be complete and the TVEDU would now display Green LOADED.
13	Visually check the correct ammunition LED is illuminated and set the loader's safety switch to LIVE and report "Loaded".	The Loader's Control Panel HESH LED and the red LED Safety Switch Live indicator would have both been illuminated. This takes the Main Armament to the same condition as Table 1.4.8, Serial 5, with the gun loaded and ready to fire. The Loader would have reported "Loaded".

Table 1.4.9: Tube Vent Electric Display Unit Red Drill

1.4.163. The most common cause for a Red Drill is no TVE has been loaded. This can be because the TVE magazine is empty (rounds expended), but at the start of a shoot, this is very likely because the Loader has forgotten to manually operate the ATL (Table 1.4.7, Serial 5). Subject matter experts stated that this is a common occurrence. Having just loaded the TVE Magazine and not fired, the Loader would have known that the magazine was not empty. Witness 27

1.4.164. The Panel concluded that when the Loader observed that no TVE was fitted to the FNA, he assumed that he had forgotten to operate the ATL and conducted the Red Drill without questioning the state of the gun.

1.4.165. In conducting this Red Drill the Loader had one further opportunity to notice that the BVA Assembly was missing: whilst refitting the FNA to the Lower Breech Block (Table Witness 27 Exhibit 36

1.4.9, Serial 9). However, as described in Paragraph 1.4.150, it is entirely possible to conduct this action without realising that the Thrust Housing is not present.

1.4.166. As mentioned in Table 1.4.9, Serial 5, it is possible that if the Prove the Gun drill was not completed before going to action, the FNA may not have been fitted until this point in the Red Drill. If this was the case, the Loader would have had to search for the FNA at this point. On finding it, he would have then fitted a TVE to it and hand loaded it into the rear of the Lower Breech Block. Whilst this would have worked and created the accident scenario, the Panel believe this would probably have caused the Loader concern over the state of the Main Armament. Specifically, as he had very likely operated the ATL, and in doing so thought he had rammed a TVE into the TVE Chamber in the rear of the BVA, he should not have been able to hand load a further TVE into the same chamber. Witness27

1.4.167. The Panel concluded that:

a. The FNA was fitted into the Lower Breech Block prior to Red Drill, further supporting the premise that the Loader had fitted it whilst conducting the Prove the Gun drill earlier.

b. The Loader conducted the Red Drill without noticing that the BVA Assembly was not fitted.

Why did the Experience Crew not Notice that the Bolt Vent Axial Assembly was Missing?

1.4.168. Whilst it is impossible to know what thoughts or decision making processes took place during the Experience Shoot, it is very likely that the mental model held by the Loader was that the BVA Assembly was fitted. This may have been influenced by the following: Exhibit 42

a. Having seen DS39AA fully operational in the morning the assumption was made that the tank was in the same operational state.

b. Not seeing the BVA Assembly anywhere in the turret or on the first floor of the control tower[63].

1.4.169. The Panel concluded that the Experience Shoot Loader and Commander did not even consider the fact that the BVA Assembly was missing. Whilst the drills they conducted offered some opportunity to notice the BVA was missing, the drills did not require them to check for the presence of the BVA. The drills were designed to achieve different outcomes, particularly Prove the Gun, which is a safety check designed to find unexpended ammunition.

1.4.170. The overall conclusion drawn by the Panel is that it is possible to conduct the Prove the Gun, Load the Gun and the drill associated with a Fire Order without noticing

[63] The other accepted place to store unfitted BVA Assemblies was the first floor of the Range 4 Control tower, together with the Chain Guns. The Loader almost certainly collected the Chain Gun from this location before fitting it to DS39AA on mounting the tank for the Experience Shoot.

that the BVA Assembly was missing. This was assessed as a **Contributory Factor**.

Recommendation

1.4.171. Head of Capability Ground Manoeuvre should put in place a drill or process that ensures that all safety critical components of the L30A1 gun are fitted prior to firing, in order to prevent the gun from being fired in an unsafe state.

The Breech Explosion

1.4.172. On completion of the Red Drill, all indications within the tank would show the Loader and the Commander that the Main Armament was ready in all respects to be fired. The Commander, having almost certainly confirmed the sight was on the target, instructed the Gunner to press his firing switch. The Firing Circuit would then have initiated the TVE, igniting the gun powder charge within. The Panel then analysed why the breech exploded.

Witness 3
Exhibit 36
Witness 22

Propelling Charge Ignition

1.4.173. In its normal mode of operation, the hot products of combustion from the gun powder charge in the TVE would pass down the Flash Channel in the BVA and ignite the Igniter Pad at the rear of the CP SH (see Figure 1.4.41). With no BVA fitted there was approximately a 12cm gap between the front of the TVE and the Igniter Pad, but even without the concentrating effect of the Flash Channel, the hot gases and particles were sufficient to ignite the pad, initiating the explosive train within the Propelling Charge and igniting the Main Charge.

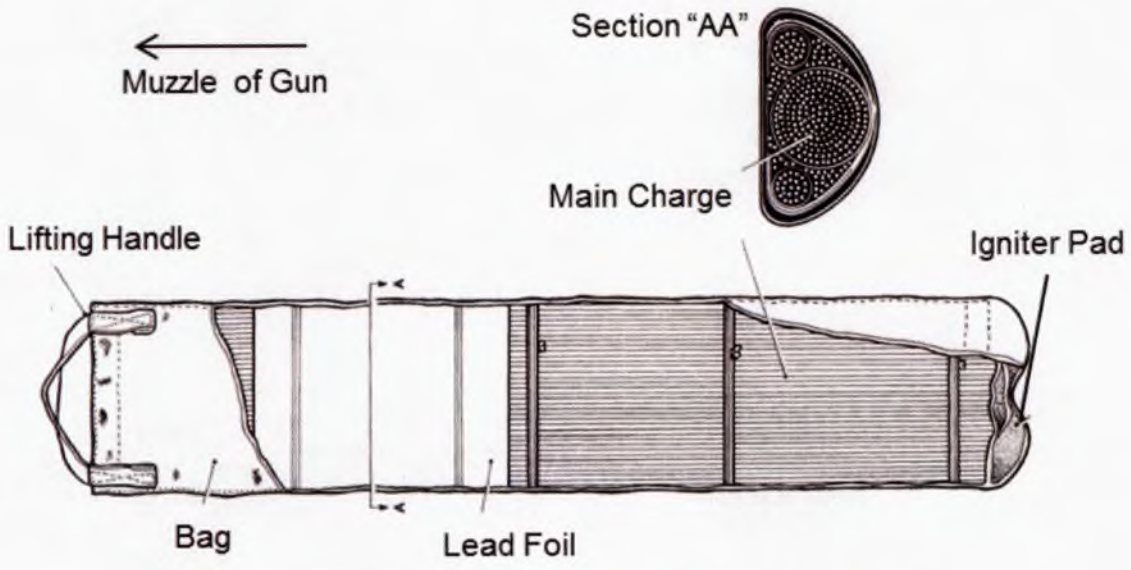


Figure 1.4.41: Detail of Charge Propelling – Squash Head L3A2

1.4.174. The Panel concluded that the TVE ignited the CP SH in the Chamber.

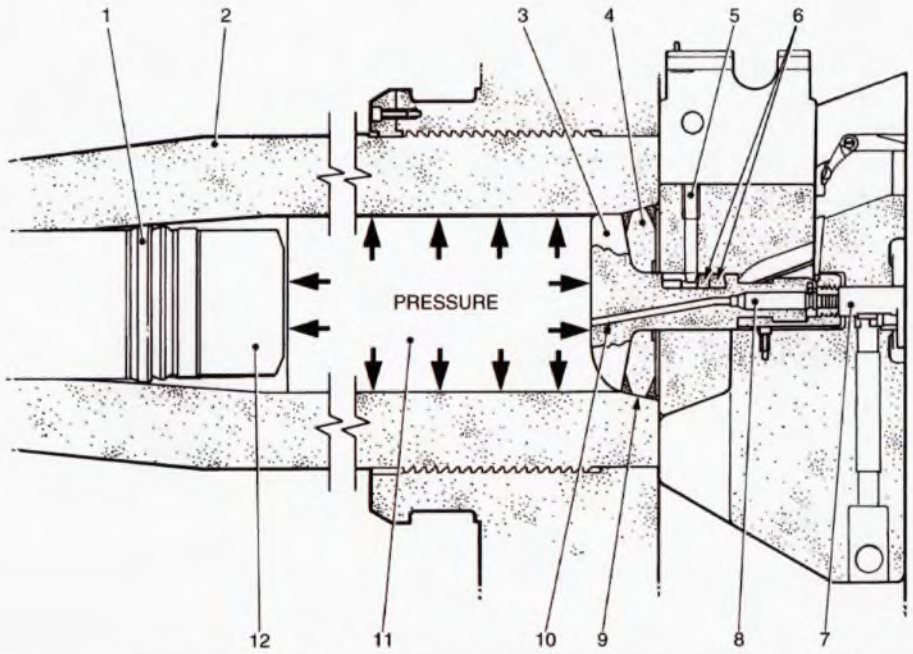
The Process of Obturation

Exhibit 36

1.4.175. Obturation is the formation of a gas tight seal within a gun which allows the extremely high pressure gases[64] created by burning the Propelling Charge in the **chamber** to accelerate the **projectile** out of the **barrel**:

a. Forward obturation is achieved by the **driving band** on the **projectile** engaging in the rifling in the gun **barrel**.

b. Rearward obturation in the L30A1 gun is achieved by the components in the breech, principally the **BVA** and **Obturator Pad**, all held in place by the Upper and Lower Breech Blocks. As the charge burns, the pressure builds on the front face of the BVA, forcing it rearward and compressing the Obturator Pad against the Upper Breech Block. This forces the Obturator Pad radially outwards to create a gas proof seal between the Obturator Pad and the **Cone Shaped Seating** at the rear of the barrel chamber. Gas pressure is transmitted rearwards via the BVA **Flash Channel** to the brass **TVE Case**. This expands the case hard against the TVE chamber wall creating a gas proof seal, completing rearward obturation. All the components in bold are shown in Figure 1.4.42.



1	**Driving band**	7	FNA
2	**Barrel**	8	**TVE Case**
3	**BVA**	9	**Cone Shaped Seating**
4	**Obturator pad**	10	**Flash Channel**
5	Retaining screw	11	**Chamber**
6	Metal buffer and synthetic rubber	12	**Projectile**

Figure 1.4.42: Obturation in the Main Armament

[64] In the L30A1 Gun, this pressure is in the order of 30 tons per square inch.

1.4.176. The burn rate of a propelling explosive is proportional to the pressure: the higher the pressure, the faster it burns. In the case of a charge in the gun chamber, fired normally with full obturation in place, the charge would be consumed in thousandths of a second, rapidly accelerating the projectile down the barrel.

1.4.177. During the accident, with limited rearward obturation, much of the hot gas produced by the Propelling Charge would have escaped through the breech. With no Thrust Housing to hold the FNA into the Lower Breech Block, the FNA, with the TVE attached, was probably ejected into the Turret at this stage, allowing the gasses a direct route out of the chamber as well as leaking through the gap left by the missing BVA Assembly.

1.4.178. The Panel concluded that the loud hissing noise and white smoke heard and observed by witnesses were caused by the propellant gases escaping from the rear of the gun (Paragraph 1.4.110.c).

Explosion

1.4.179. As more propellant burnt and the flame front moved further into the Main Charge, the pressure in the chamber would have continued to rise, further increasing the burn rate to the point where the charge exploded. In normal operation, the BVA and the Thrust Housing lock the Upper and Lower Breech Blocks together and direct the load of firing axially rearwards onto the Breech Ring. With no BVA fitted, the structural integrity of the Breech was severely compromised. This resulted in the catastrophic material failure of the Breech, where the Upper Breech Block detached from the Breech Assembly. At the same time, the projectile was expelled from the muzzle. The hot, high pressure gasses from the exploding breech would have flooded the inside of the Fighting Compartment.

Exhibit 28

1.4.180. The Panel concluded that the breech explosion was caused by the Main Armament being fired without the BVA Assembly fitted and that this was a **Causal Factor**.

Main Armament Breech Design

1.4.181. The accident demonstrated and the investigations proved that it is possible to fire the L30A1 Gun with the BVA missing. The gun does not work in its normal manner, as the ATL does not load a TVE; however, if the Red Drill is followed and the TVE is hand loaded on the FNA, the TVE can be initiated by the Firing Circuit and will ignite the Propelling Charge. It is the Panel's opinion that the Firing Circuit should not complete (shown by the TVEDU as green "Loaded" indication) with the BVA missing. As a design principle, no gun should be able to fire with a safety critical part missing: it should fail safe.

Exhibit 10
Exhibit 36
Witness 24
Witness 25
Witness 26
Witness 27

1.4.182. The current Design Authority (DA) have made the Panel aware of a report[65] authored by RARDE (the original designer of the L30A1 Gun) which contains the following passage:

Exhibit 36

[65] RARDE Report (GR1) (6/84), The Design and Development of the Gun 120 mm Tk XL30E, dated May 84.

> "*The vent axial assembly (see Annex A-3) consisting of a vent bolt containing a tube chamber and flash hole, together with its thrust housing, obturator and associated adjusting shim, is easily removed from the gun for servicing.* ***This provides a fail safe condition since the ignition tube cannot be loaded if the bolt which carries the obturator is inadvertently omitted.***" (emphasis added)

This report was written in 1984, 3 years before the design freeze in 1987 and 14 years before the gun entered service. It is unlikely that the details of the loader's drill would have been finalised at the time that the report was written[66]. The report indicates that the original design intent was for the breech to fail safe in the absence of the BVA, however that intent was subsequently able to be overridden by the Red Drill described in Paragraph 1.4.162, where the TVE is hand loaded on and held in place by the FNA and the firing circuit is completed, indicated by a TVEDU Green.

1.4.183. The Panel concluded that:

a. The Red Drill effectively overrode the fail-safe design intent of the original gun designers.

b. The combination of the design of the L30A1 Gun and the Red Drill, that allows it to be fired without the BVA Assembly in place, was a **Causal Factor**.

c. This is a latent hazard within the design of the breech and this accident could have occurred at any time in the CR2's service history.

Recommendation

1.4.184. The Land Equipment Vehicle Support Team Leader should provide a mechanism that prevents the L30A1 gun firing when the Bolt Vent Axial (BVA) assembly is not fitted, in order to physically prevent the gun firing in an unsafe state.

Hazard Identification

1.4.185. The Safety and Environmental Case Reports (SECRs) for the tank and the gun do not identify firing the Main Armament without the BVA Assembly fitted as a hazard. Consequently there were no warnings in the AESPs. There is no credible accident listed and no mitigation either in design or drill to reduce the risk of this happening. The reasons stated in the AESP for a TVEDU Red did not include the absence of the BVA. Exhibit 17 Exhibit 18

1.4.186. Prior to the accident on 14 Jun 17, no one in the CR2 Project Team was aware that the Firing Circuit could be completed with the BVA Assembly not fitted to the gun, and no related accidents have occurred before. Witness 30

1.4.187. Inquiries with the DA have not provided a definitive answer to the question "**Was the DA ever aware that the 120mm L30A1 Gun can be operated and fired with the BVA absent?**". In response the DA stated that in their opinion, to fire the gun with both Exhibit 32

[66] The First Edition of AESP 2350-P-102-201, which contains all the loader's drills, is dated Apr 98.

the BVA and Obturator not fitted[67] would require:

a. *A failure to follow relevant MoD pre-firing system drill; and*

b. *The design features I have referred to* (namely the ATL ejecting the TVE onto the floor of the tank as shown in Figure 1.4.34) *which prevent the gun from being fired, being manually overridden.*

Neither statement confirms whether the DA was aware, prior to the Accident that it knew that it was possible to operate and fire the L30A1 Gun with the BVA Assembly absent.

1.4.188. The Panel agrees that the pre-firing system drill may not have been correctly conducted. However, in the Panel's opinion, despite the original design intent, the ejection of the TVE by the ATL in the absence of the BVA is not a *recognised* design safety feature; it is simply what happens when the ATL is operated in the absence of the BVA. If it was a *recognised* feature, it would have an associated warning included in AESP 2350-P-102-201, for example "If the ATL is operated and the TVE falls out of the breech, then the BVA is not fitted. Stop and fit the BVA." It would be evident in the SECR and would have been taken into account in the drill actions associated with a TVEDU Red indication, preventing the Red Drill from manually overriding the feature. Exhibit 36

1.4.189. The DA stated that it was not known "*if the possibility of performing a "Red Drill" in the event that the Bolt Vent Axial and Obturator Pad were not fitted, and the Thrust Housing Assembly was not fitted and without the Firing Needle Assembly properly attached, and without adhering to the applicable Operating Procedures and System Drills was ever considered during the design, development, acceptance and subsequent safety management activities of the L30A1 Gun by RARDE, Royal Ordnance plc, MOD's Ordnance Board or* the DA." This too does not definitively answer the question.

1.4.190. The DA was subsequently asked if it was aware of the possibility of conducting a 'Red Drill" in the circumstances outlined in their reply (above). The DA reiterated that they participated in a review of the gun safety case to enable the issue of a Certificate of Safety Ordnance Munitions and Explosives, together with representatives from many related MOD teams[68] and an independent safety auditor. As part of this review it was never suggested that there was any in-service experience of the combination of events that occurred on 14 Jun 17. It is the DA's opinion that this scenario could only arise if the applicable operating procedures and system drills were not being followed. As the safety case assumes that all drills are followed, the DA stated that "*the combination of events which is understood occurred, did not represent a credible hazard at the time the safety review was being undertaken*". Exhibit 32

[67] It is not possible to fit the BVA into the Breech without the Obturator Pad fitted to it. There is a mechanical interlock (the Spring Stop Lever) on the side of the Thrust Housing that prevents the BVA being pulled into the Upper Breech Block without the Obturator Pad being present.

[68] This included representatives from Defence Equipment and Support technical, project and safety specialists; AFVTTS; Capability Directorate Combat (now Head of Capability Ground Manoeuvre) Training Development Team; the Armour Centre; Army Headquarters and the Defence Ordnance Safety Group.

1.4.191. Interviews conducted with subject matter experts employed at AFVTTS stated that they were not aware that the gun could be fired with the BVA Assembly missing. They also opined that it was very unlikely that anyone else within the Royal Armoured Corps would be aware that the gun could fire without the BVA fitted as this was not a scenario that was considered during training. Witness 27 Witness 35

1.4.192. The Panel obtained evidence from one witness who stated that he had identified that the firing circuits could be completed in the absence of the BVA. Some years previously, he stated that he and a colleague had been experimenting with the breech mechanism when they made the discovery. He stated that he did not conclude that the weapon could be fired without the BVA, merely that the firing circuits could be completed, and he told no one of their discovery. Witness 37

1.4.193. The Panel concluded that the accident sequence of firing the Main Armament without the BVA Assembly fitted was not recognised as a credible hazard prior to 14 Jun 17 and this is assessed to be a **Contributory Factor**.

Recommendation

1.4.194. The Land Equipment Vehicle Support Team Leader should amend the CHALLENGER 2 Safety and Environmental Case Report (SECR) to recognise the hazard of firing the gun without the BVA Assembly fitted, in order to demonstrate that the Risk to Life is tolerable and As Low As Reasonably Practicable (ALARP).

Other Gun Systems

1.4.195. The Panel reviewed all gun systems in service in the British Military. The only other system which achieves rearward obturation using an obturating breech[69] is the 155 mm L31 gun fitted to the AS90 Self Propelled Gun. In this weapon system, there is no equivalent Red Drill, and manual loading can only be achieved by inserting the primer (equivalent to the TVE) directly into the chamber on the L31 BVA. If the BVA is not fitted this is physically impossible. Exhibit 29 Exhibit

1.4.196. The Panel concluded that this nature of accident cannot occur in other in-service gun systems.

[69] All other guns in service achieve rearward obturation using a shell case.

The Turret Fire

Location of the Fire

1.4.197. Witness statements describe a violent fire occurring immediately after the explosion. The witnesses commented on the ferocity of the fire, with some recounting it as columns of flame, roaring out of the turret hatches like 2 jet engines, lasting 5 to 8 seconds. Inspection of the inside of the tank showed that the fire damage was worst on the left hand side of the Turret and the seat of the fire appeared to be on the turret floor in the Loader's Station.

Witness 1
Witness 5
Witness 11
Exhibit 9
Exhibit 10

1.4.198. The Panel concluded that a violent fire occurred in the Fighting Compartment and that the seat of the fire was on the turret floor in the Loader's Station.

Source of the Fire

1.4.199. Eight Propelling Charges were loaded into the tank at the start of the serial: 4 CP DS-T and 4 CP SH (Table 1.4.5), sufficient to conduct 4 Experience Shoots. Three undamaged CP DS-T were recovered from the Ready Charge Bin in the tank. With one CP SH consumed in the breech explosion, it was not possible to account for 4 charges, (one CP DS-T and 3 CP SH).

Exhibit 9
Exhibit 27

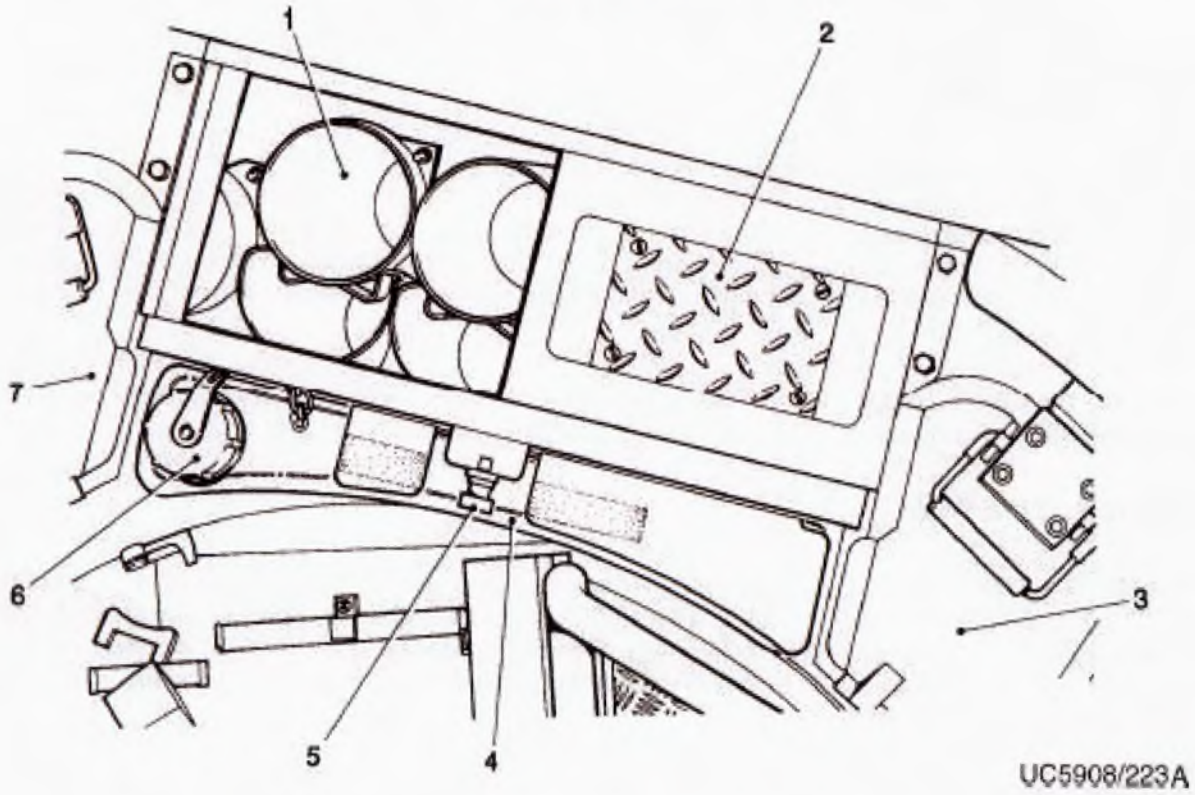
1.4.200. Propelling Charges are designed to burn very quickly to produce large amounts of very hot gas (in the region of 2500-3000°C). The Panel conducted a trial where one CP DS-T and 3 CP SH were ignited in a controlled manner in order to understand the magnitude of the event. Despite the charges being less contained and the source of ignition being smaller, the resultant fire was considerable and, had it occurred in the turret of a CR2, the flames would have been clearly visible venting from the turret hatches.

1.4.201. The Panel concluded that the 4 unaccounted for Propelling Charges were the fuel consumed in the turret fire and the source of the jets of flame seen by witnesses.

Stowage of Propelling Charges in CHALLENGER 2

1.4.202. The armoured charge bins in CR2 are located low down around the Fighting Compartment. The majority of them are fixed to the hull of the tank and do not rotate with the turret. As such, they are not accessible at all times: the orientation of the turret occasionally prevents access. They have sliding or lifting lids which must be closed after use, to protect the charges and prevent the lids from snagging on wiring or other fittings. Figure 1.4.43 shows the Rear Charge Bin, Centre Compartment, which has sliding lids.

Exhibit 15
Exhibit 36



1	Charge containers	5	Locking mechanism
2	Sliding top plate	6	Drinking water reservoir cap
3	Side charge bin	7	Side charge bin
4	Drinking water reservoir		

Figure 1.4.43: Rear Charge Bin, Centre Compartment

1.4.203. Figure 1.4.44 (below) shows the Ready Charge Bin which is fitted in the front left of the turret, forward of the loader's position. This stowage moves with the turret and is accessible irrespective of the position of the tank's hull.

1.4.204. It is mandated that all Propelling Charges are to be stowed in charge bins with the lids closed at all times, except when being handled[70]. This practice is taught and reinforced throughout tank soldiers' careers. The drills are tested during the WHT; neglecting to follow the correct drill, including forgetting to close the charge bin lid, results in the failure of the WHT, retraining and full retest.

Exhibit 36
Witness 22
Witness 29

[70] Typically for being placed into or taken off the tank, re-stowing around the tank as ammunition is used, or loaded into the Main Armament.

Figure 1.4.44: The Ready Charge Bin in a Reference Tank
Each of the 4 stowages can hold one CP DS-T or 2 CP SH

Location of Propelling Charges during the Accident

1.4.205. Whilst there are no witness statements detailing where the Loader stowed the ammunition detailed in Table 1.4.5, based on the physical evidence, the Panel believe that when the Squadron Sergeant Major passed the charges and projectiles to him. He stowed them as follows: Witness 11 Exhibit 9

a. It is very likely that he stowed all 4 CP DS-T in the Ready Charge Bin, filling it. Three undamaged CP DS-T were found here after the accident (Figure 1.4.26).

b. He probably leant the 4 CP SH against the outside of the Ready Charge Bin or placed them under the gun adjacent to his feet, at the location of the seat of the fire. One of these Propelling Charges was loaded as the first round and the other 3 were consumed in the fire.

c. He very likely stowed all 8 projectiles in the projectile racking at the rear of the turret: 6 of them were discovered here after the accident (Figure 1.4.24).

d. The TVEs were passed up to the Loader in their metal stowage tin[71]. He almost certainly transferred them into a TVE Magazine which he subsequently loaded into the ATL, where it was recovered from after the accident.

1.4.206. At some point before the breech explosion, the Loader very likely removed one of the CP DS-T from the ready charge bin and placed it on the turret floor adjacent to his feet, near to the CP-SH, in preparation for the second shot of the Experience Shoot. It is possible that he did not stow this charge in the Ready Charge Bin at all and that it was on the floor throughout.

Exhibit 10
Exhibit 16

Figure 1.4.45: Post-Accident View of the Ready Charge Bin

1.4.207. Post-accident inspection of the charge bins in the Fighting Compartment showed that all were intact, functional, had their lids closed and were free from fire damage. The 3 CP DS-T recovered from the Ready Charge Bin (Figure 1.4.26) were not affected by either the breech explosion or the fire. Figure 1.4.45 clearly shows the fire damage on the outside of the Ready Charge Bin.

Exhibit 9
Witness 24
Witness 25

[71] TVEs are supplied in metal tins of up to 14.

1.4.208. The Panel concluded that:

a. The 4 charges consumed in the fire were not stowed in the charge bins.

b. Had they been stored in the charge bins, the 4 charges would almost certainly not have caught fire.

Source of Ignition

1.4.209. As stated in Paragraph 1.4.179, as the breech exploded, the inside of the Fighting Compartment would have been flooded with very hot gas from the combustion of the CP SH in the Gun Chamber. The orange outside case of the CP DS-T is made of nitrocellulose, which is designed to be consumed entirely when the charge is ignited. The nitrocellulose case has an ignition temperature of 164°C. The CP DS-T would have been ignited by the hot gases coming from the Breech Explosion, which would have subsequently ignited the 3 CP SH[72]. No evidence was found of another source of ignition and the fire occurred immediately after the Breech Explosion.

1.4.210. The Panel concluded that the 4 Propelling Charges were ignited by the hot gases escaping from the breech explosion.

Nature of the Fire

1.4.211. Propelling Charges are designed to burn very quickly to produce large amounts of very hot gas. To achieve this, a fuel is reacted with an oxidiser. The chemicals in the Propelling Charges[73] used in CR2 combine the fuel and the oxidiser on the same molecule (they do not use atmospheric oxygen). When they are ignited, due to the energy released in the reaction and the inseparable nature of the fuel and oxygen, it is not possible to extinguish them.

1.4.212. The Panel concluded that once the Propelling Charges were ignited, the Crew would have been unable to extinguish them.

1.4.213. The inside fittings of the Fighting Compartment and designed to be non-flammable / fire retardant. On inspection, little of the tank's fittings appeared to have actually burnt away; they were heavily charred, but many of the cables were still functional when tested post-accident.

1.4.214. The Panel concluded that the internal fittings of the Fighting Compartment did not exacerbate the turret fire and were **not an Aggravating Factor**.

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[72] The CP SH may have been ignited directly by the Breech Explosion.

[73] The Propelling Charges used in the 120 mm L31A1 gun are Triple Based, consisting primarily of nitrocellulose, nitroguanidine and nitroglycerin.

Why were the 4 Propelling Charges not stowed in the Charge Bins?

1.4.215. The Panel interviewed in excess of 30 personnel either involved directly with the accident and its aftermath, the conduct of live firing from armoured fighting vehicles or the wider support and maintenance of CR2, both serving Service Personnel and supporting civilian staff. All knew of the requirement to stow Propelling Charges in charge bins. All serving members of BADGER Sqn employed as commanders and loaders during this Range Package had successfully completed the WHT (Paragraph 1.4.44.b): leaving charges out of charge bins or failing to close charge bin lids during a WHT results in a failure, retraining and retest. As RIGs, the Experience Shoot Commander and Loader were responsible for conducting WHTs in BADGER Sqn. Witness 21 Witness 22 Witness 27 Witness 29 Witness 31 Witness 36

1.4.216. The Panel concluded that all personnel involved in the Range Package from 2-16 Jun 17 were aware of the requirement to stow Propelling Charges in charge bins.

1.4.217. Within a tank crew, the Commander is responsible for the overall safety of the vehicle and for ensuring that all drills are correctly completed. The individual crew members are responsible for using the correct safety procedures in their crew position. The Propelling Charges are relatively large in the tight confines of the Fighting Compartment and the Panel are almost certain that the Commander would have noticed that the 4 Propelling Charges were not stowed in the charge bins. Exhibit 15

1.4.218. The Panel concluded that both the Loader and Commander were aware that Propelling Charges had been left out during the Experience Shoot.

1.4.219. The Accident Loader and Commander were both tank commanders with their own crews. The Panel interviewed the loaders from their respective crews; both stated that they had deliberately left multiple (up to 6) Propelling Charges out of the charge bins in their tanks during LFXs in this Range Package, including their ACTs, with the full knowledge and approval of their commanders. Other crews also admitted to leaving Propelling Charges out during LFXs. Witness 21 Witness 22

1.4.220. The Panel concluded that:

a. Both the Loader and Commander had left Propelling Charges out of charge bins during the Range Package.

b. Leaving Propelling Charges out of charge bins was not an isolated event and may be indicative of a wider issue in the Royal Armoured Corps[74].

1.4.221. The single reason given for the practice of having un-stowed Propelling Charges in the Fighting Compartment was speed of firing. The loaders prepare the next 2 or 3 shots prior to starting an engagement by getting the Propelling Charges out of the bins and stowing them around their position in the Turret (the Panel were told of a variety of positions where charges could be stowed). The Panel were told that this practice was particularly useful during 3 round SH-P engagements. In the structured LFXs conducted on ranges, Army shooting policy requires 3 SH-P rounds to be fired at a single target, Witness 12 Witness 21 Witness 22 Witness 29 Witness 31 Witness 33

[74] There was insufficient evidence to prove that leaving Propelling Charges out was widespread, either within the RTR or the wider Armoured Corps, but this may be the case.

within a set time period. This skill is tested on numerous occasions during LFXs 4-7 and during the ACT (LFX8), where on 4 occasions the crew is required to fire 3 SH-P in 45 seconds. Some of the loaders interviewed stated that, in their opinion, this standard was difficult to achieve without leaving Propelling Charges out of the charge bins. However, other loaders and commanders made clear statements about passing their ACTs with the charges correctly stowed throughout.

1.4.222. The Panel concluded that Propelling Charges are removed from charge bins in advance of being required in order to reduce the time to reload the Main Armament.

1.4.223. As explained in Paragraph 1.4.87, the Experience Shoot was a very simple shoot. Witness statements made it clear that the RCO and RIGs were under no pressure to complete the Experience Shoots that day; completing them that day was a bonus, and any shoots not completed that afternoon could have been rescheduled for the following morning. The shoots were entirely discretionary activity that they were not under pressure from the Chain of Command to achieve. During the Experience Shoot the Panel could not identify any reason to leave the 3 CP SH out of the charge bins; none of the charges were required until after the Guest Gunner changed over. The CP DS-T was required for the next shot, but there was no pressure to fire quickly. Witness 1 Witness 31

1.4.224. The Panel concluded that there was no benefit from leaving Propelling Charges out of the charge bins during the Experience Shoot.

Army Shooting Policy

1.4.225. A detailed review of the actual (as opposed to perceived) requirements for the 3 SH-P engagement reveals that rapid reloading, whilst important, it is not the critical factor. The 3 SH-P engagement is fired from a stationary tank at a static target[75]. The crews have a 15 second exposure time on the target – they are required to locate, identify, lay the gun and fire a single SH-P round at the target in this time period. If they fail to do this, the target may remain visible and the shoot may continue, but the score will not count. The round fired in this initial 15 seconds is loaded before the timing starts. If they achieve this first round, they then get 15 seconds per round for 2 further SH-P at the same, stationary target, which the gun is already pointing at. Loading the Main Armament in 15 seconds is not particularly demanding for a trained loader, and loading it quicker does not give the Gunner or Commander longer to conduct their own drills. Exhibit 15

1.4.226. During interviews with instructors at the AFVTTS Gunnery Wing, the Panel was told that speed of loading is not the critical path in achieving the 3 round engagements within the time limit. The first round is already loaded before the timed period starts and the gun can be reloaded in approximately 7 seconds[76]. By far the most time consuming activity is locating the target and laying the gun onto it. They also stated that the speed advantage gained from the use of muscle memory developed by drawing the charges from the same location in the charge bins for every shot far outweighed not having to open and close charge bins. The assessed LFXs are divided into discrete engagements, between which crews are instructed to check and restow their ammunition. After each Witness 27 Witness 29 Witness 31

[75] The target is not visible all the time, it lies flat, out of sight, and pops up on command from the Control Tower, but it does not move when exposed.

[76] The Panel witnessed these drills completed in this timescale in the LDT. The simulated loading in the TGT takes 7 seconds.

engagement, the order "check stowage and report when ready" is given by the instructors over the radio[77]. The restow is not timed and the LFX does not recommence until the crew reports that it is ready.

1.4.227. The Panel concluded that there is no requirement to have Propelling Charges out of charge bins whilst conducting live firing training. The timescales are demanding but the training progression is incremental and the crews have ample time to reorganise their ammunition load without taking unnecessary or inappropriate risk. Current Army Operational Shooting Policy was assessed as **not an Accident Factor**.

Why? – Human Factors

1.4.228. Leaving Propelling Charges out of their stowages may well have become a habit for the Loader and Commander. This "normalisation of deviance"[78] is a well-documented phenomenon which explains the gradual process where deviation away from a set process or procedure occurs, often because it bestows a gain of time, cost, or material to the individual or organisation. Whilst such deviation may have the potential to increase risk, the failure of these risks to materialise encourages the deviation to continue. In searching for examples of adverse consequences, the Panel has been unable to find any recorded instances of Propelling Charges catching fire in CR2 during training. The use of charge bins is not merely a safety regime; the correct stowage of charges also enables operational capability by protecting the charges from enemy fire, improving survivability. During a peace time Range Package there is clearly no threat of enemy action, again reducing the perception of adverse consequences. The tank soldiers the Panel spoke to, gave the impression that they thought CR2 was a safe platform, specifically in terms of operating the weapons systems.

Exhibit 17
Exhibit 18
Exhibit 42

1.4.229. It is inconceivable that the Loader and Commander set out to cause harm. When operating CR2 they had what they perceived to be conflicting priorities, namely speed and efficiency (firing quickly) versus safety (keeping Propelling Charges in charge bins). The Panel believe that the Commander and Loader (and probably other personnel across the Royal Armoured Corps) had come to the view that stowing Propelling Charges correctly was burdensome and unnecessary. They had become so accustomed to this practice, that they continued it, even when there was no requirement to fire quickly.

1.4.230. The Panel concluded that the 4 Propelling Charges were not stowed in the charge bins during the Experience Shoot as a deliberate act (as opposed to a slip, lapse or mistake).

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[77] This restow would typically involve replenishing the Ready Charge bin with propelling charges taken from less accessible charge bins, and reorganising the projectiles so that the projectile racks to the rear of the loader's position contain the correct rounds for the next engagement. This is also a useful opportunity to reload the ATL.

[78] Vaughan D (1996), The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA, Chicago: University of Chicago Press.

Overall Conclusion

1.4.231. The overall conclusions drawn by the Panel are that:

a. The fire was caused by the hot gases escaping from the Breech Explosion igniting 4 Propelling Charges which were left out of the charge bins during the Experience Shoot and this is assessed to be an **Aggravating Factor**.

b. The practice of leaving Propelling Charges out of charge bins had become routine for the Experience Shoot Loader and Commander and this is assessed to be a **Contributory Factor**.

Recommendation

1.4.232. The General Officer Commanding the 3rd (United Kingdom) Division and the Director Land Warfare should put in place a suitable assurance regime to ensure that Propelling Charges are correctly stowed, in order to reduce the risk of fire inside the CHALLENGER 2 turret.

Other Potential Accident Factors

Guest Gunner

1.4.233. During the Experience Shoot the Guest Gunner was supervised throughout. He was given a safety brief on mounting the vehicle and brief familiarisation training by the Commander. Through his routine duties, he was aware of the general capabilities of the CR2 weapon systems and the safety rules of firing at CMR. During the Shoot, he moved the turret and gun under supervision and pressed the gun firing switch when instructed to do so by the Commander. He had no experience of firing a CR2 and limited understanding of the conduct of the drills conducted by the Loader. That and his physical position in the tank made it extremely unlikely that he would have been able to notice that the BVA Assembly was missing, or that a TVE fell on the floor when the ATL was operated. However, it is the Panel's opinion that it is extremely unlikely that a trained Gunner would have noticed. Witness 3

1.4.234. The Guest Gunner stated that he did not notice that the Propelling Charges were out of their charge bins. With the charges stowed on the floor, under the gun, it is unlikely that a trained gunner would have noticed them either. Witness 3

1.4.235. The Panel concluded that the presence of the Guest Gunner during the shoot was **not an Accident Factor**.

Fatigue

1.4.236. Range packages are busy periods for personnel and the culmination of months of preparations. The soldiers are required to conduct sentry duties, but none of the Experience Shoot Crew conducted this duty on the night of 13-14 Jun 17. All RTR soldiers are required to double march when moving around the range. Food is available throughout the day. The 3 RIGs (including the Experience Shoot Commander and Loader) were required to supervise all the LFXs from the LFME Trailer, but they were Witness 1 Witness 11

assisted in this task by 2 AIGs and with only 3 LFXs to conduct that day, the workload was relatively light. There was no night firing on the evening of 13 Jun 17.

1.4.237. The Panel concluded that there was no evidence to suggest that fatigue caused a detrimental effect on the performance of the Experience Crew and therefore this was **not an Accident Factor**.

Weather

1.4.238. On 14 Jun 17 the weather was fine with light cloud and approximately 20°C, with good visibility. The inside of the tank would not have been excessively warm and the crew decided to keep the turret hatches open. Witness 1 Witness 11

1.4.239. The Panel concluded that the weather did not have a detrimental effect on the conduct of the Experience Shoot and therefore was **not an Accident Factor**.

Time Pressure

1.4.240. There was no time pressure on conducting the Experience shoot: the plan was for each guest gunner to fire 2 main armament rounds and approximately 100 rounds from the Chain Gun. A fully trained crew can fire this in less than a minute. With a start time of 1500, there were 15 minutes per person available before the last round to be fired at 1600. Even allowing for a comprehensive safety brief for each guest Gunner, there was sufficient time to achieve the serial. Failure to achieve all 4 shoots came with no penalty; they could have been conducted the following morning, or simply cancelled. Witness 1 Witness 31

1.4.241. The Panel concluded that time pressure was **not an Accident Factor**.

Stress

1.4.242. There is no evidence to suggest that members of the Experience Shoot Crew were under any undue stress. Interviews with their chain of command suggest that whilst their private lives were busy there was no evidence that this had any detrimental effect on their performance at work. Witness 1 Witness 2 Witness 28

1.4.243. The Panel concluded that stress was **not an Accident Factor**.

Post-Accident: 1525-1900

Summary of Events

1.4.244. Table 1.4.10 shows a summary of the post-accident events, full details of which are in Part 1.3 of this report.

Serial	Time[79]	Event
1	1525	DS39AA turret explosion and fire. Training Safety Manger in Range 4 Control Tower calls "Stop, Stop, and Stop".
2	1526	RCO in Range 4 Control attempts to raise DS39AA by radio. Duty Range Officer in Warren Tower contacts emergency services, requesting at least 2 air ambulances and halts all live firing on CMR.
3	1530-1532	BULLDOG Ambulance manned and takes Unit Medic forward to Commander to right of DS39AA. Casualty moved to Range 4 Lane 3.
4	1532	Second medic arrives at Range 4 and conducts triage on Commander. CPR initiated.
5	1540	Unit Medic and unit members mount DS39AA and attempt to contact driver. Call for BCF fire extinguishers to be brought forward. First civilian paramedics arrive at scene and provide support to Second Medic treating the Commander on Lane 3.
6	1545	Two BCF fire extinguishers discharged into turret. Unit Medic assesses casualties in tank. Decision made to extract Loader and Gunner with track rope.
7	1548	First Ambulance arrives at Range 4.
8	1545-1550	Initial unsuccessful attempt to open Driver's Hatch.
9	1550	Second Ambulance and first Fire Engine arrives at Range 4.
10	1550-1555	Loader extracted from DS39AA and transferred to rear of vehicle on a stretcher.
11	1553	Police and second Fire and Rescue team arrive at Range 4
12	1555-1601	Gunner extracted from DS39AA and transferred to rear of vehicle on a stretcher.
13	1555-1608	Driver extracted from tank using specialist equipment provided by Fire Brigade.
14	1608	Loader, Gunner and Driver receiving first aid treatment at rear of DS39AA.
15	1627	First Air Ambulance arrives at Range 4 hard standing.
16	1632	Second Air Ambulance arrives at Range 4 hard standing. (Departs for fuel at 1650 and returns 1713.)
17	1651	Third Air Ambulance arrives at Range 4 hard standing.
18	1725	First Air Ambulance departs with Loader.
19	1755	Second Air Ambulance departs with Gunner.
20	1802	Third Air Ambulance departs with Commander.
21	1803	Driver transferred to hospital by road Ambulance.

Witness 2
Witness 34
Exhibit 5
Exhibit 12

Table 1.4.10: Summary of Post-Accident Events

Initial Response

1.4.245. The CMR Staff followed an Accident Immediate Action Memoir which was permanently accessible in both Warren Tower and the Range 4 Control Tower. This provided a clear and concise plan which was common to both areas and was followed. The Immediate Action detailed in the RASP was also available to both towers: this plan was coherent with the Memoir. The team in Warren Tower immediately halted all other live firing across CMR, reducing the risk of a coincident accident, and immediately contacted the emergency services, clearly indicating the need for Air Ambulance response, and thus minimising the call out time.

Exhibit 2
Exhibit 12
Exhibit 21

[79] The timings in this table are approximate and are based on a combination of the timings taken from the logs taken in the Range 4 Control Tower and in Warren Tower. Where the timings disagree, the time from Warren Tower has been used.

1.4.246. There was a 15 minute pause between the explosion and unit members mounting the vehicle (Table 1.4.10, Serials 1 and 5). During this period, flames and smoke continued to vent from the turret hatches of the tank. Senior members of the Sqn were very concerned about further ammunition exploding and kept as many personnel as possible away from the vicinity of the incident. They were content to let the armoured BULLDOG ambulance go forward and used it to screen the Commander and the first aid team whilst they conducted their initial assessment. They moved the casualty and the first aiders away from the burning vehicle as soon as possible to the relative safety of Lane 3. When questioned, some unit members stated that because of the ferocity of the fire, they were convinced that no one could have survived the incident. As such, the priority of those in charge was to prevent further injury from the very real threat of DS39AA exploding. The injuries sustained by the Loader, Gunner and Driver were caused primarily by the Propelling Charge fire and, in the opinion of the Panel, the pause of 15 minutes was very unlikely to have made them worse.

Witness 9
Witness 11
Witness 15
Witness 16
Witness 17
Witness 19
Witness 31
Exhibit 5
Exhibit 12

1.4.247. The Panel concluded that:

a. The immediate response of the range staff in closing the range and calling for emergency assistance was timely and appropriate and was **not an Accident Factor**.

b. The initial response of BADGER Sqn and the delay to mounting the vehicle was appropriate and was **not an Accident Factor**.

Emergency Services Response

1.4.248. The first paramedic arrived 14 minutes after the alarm was raised and a significant medical and recue capability was available at Range within 30 minutes. Because of its remote, rural location, Units training at CMR are required to provide their own first aid cover; as such the NHS response time of 8 minutes for paramedic attendance is not applicable. Considering that CMR is a 15 minute drive from the nearest town of Pembroke, a 21 minute drive from the nearest Fire Station at Pembroke Dock and a 40 minute drive to the nearest Accident and Emergency department at Withybush General Hospital, it is the Panel's opinion that the response time achieved was excellent[80].

Exhibit 5
Exhibit 12

1.4.249. In terms of equipment provided, the Emergency Services were able to assist the Unit Medic by providing a defibrillator to assist the CPR response to the Commander and the provision of specialist hydraulic spreading tools was essential to opening the Driver's Hatch to extract the Driver.

Witness 6
Witness 7
Witness 15

1.4.250. Three Air Ambulances were dispatched to CMR and all 3 arrived before the medical teams on the ground were ready to load the casualties. There was sufficient time for the second Air Ambulance to refuel before conducting a longer transit to hospital.

Witness 1
Witness 34
Exhibit 5
Exhibit 12

1.4.251. The Panel concluded that the response of the Emergency Services was both timely and appropriate and was **not an Accident Factor**.

[80] Travel times are approximate and taken from Google Maps.

Fire Fighting

1.4.252. When the unit members mounted the tank at 1540 (Table 1.4.10, Serial 5) the smoke in the turret was so dense that they could not see either casualty, and small fires appeared to be still burning within the Fighting Compartment. They decided to bring forward 2 fire extinguishers (taken from other tanks on the hard standing at Range 4) and discharge them into the turret. Witness 15

1.4.253. Two bromochlorodifluoromethane (BCF) Halon 1211, vaporising liquid type, portable fire extinguisher are carried on CR2 and are provided to fight fires inside the tank[81]. The operating instructions for the vehicle warns of an asphyxiation hazard if the extinguishers have been used inside the vehicle, and personnel must not re-enter until all fumes have dispersed. However, with both turret hatches open, the concentration of oxygen within the Fighting Compartment was unlikely to drop to a level that would present a risk of asphyxiation to the Loader, Gunner or Driver. BCF 1211 is a low toxicity compound and is routinely used for fire fighting in confined spaces such as aircraft and tanks. With the very real threat of further ammunition explosions, dealing with the small fires still smouldering within the turret was, in the Panel's opinion, the correct priority for the First Responders. The 5 minute pause between activating the extinguishers and entering the turret (Table 1.4.10, Serials 6 and 10) would have reduced the risk to the Responders by allowing fumes to disperse. Exhibit 36 Witness 15

1.4.254. The Panel concluded that:

a. The fire fighting actions of the First Responders were appropriate and very unlikely to have caused further injury to the 3 remaining crew members, or significant risk to themselves.

b. Their actions were **not an Accident Factor**.

Casualty Extraction from the Fighting Compartment

1.4.255. The First Responders decided to extract the Loader and Gunner using a track rope (Figure 1.4.46) in the standard, practised routine. A track rope was brought forward in a timely manner, from another CR2 on the hard standing at Range 4. Witness 15

1.4.256. Extracting casualties from armoured fighting vehicles is a well-established procedure, detailed in the AESP (Figure 1.4.47) and trained both at the Armour Centre and on Units. BADGER Sqn had practised the drill in preparation for their Range Package which meant the drill was well executed on the day. The accident itself presented unique problems, namely the position of and injuries to the Loader, and the difficulty of access to the Gunner. The First Responders had access to extra equipment (trauma shears) to enable them to overcome these issues and the extraction was successful conducted. Witness 11 Witness 15 Witness 16 Witness 17 Witness 18 Witness 19 Exhibit 36

[81] There is a separate fixed fire fighting system fitted to the Power Pack Compartment.

Figure 1.4.46: CHALLENGER 2 Track Rope and Carabiner

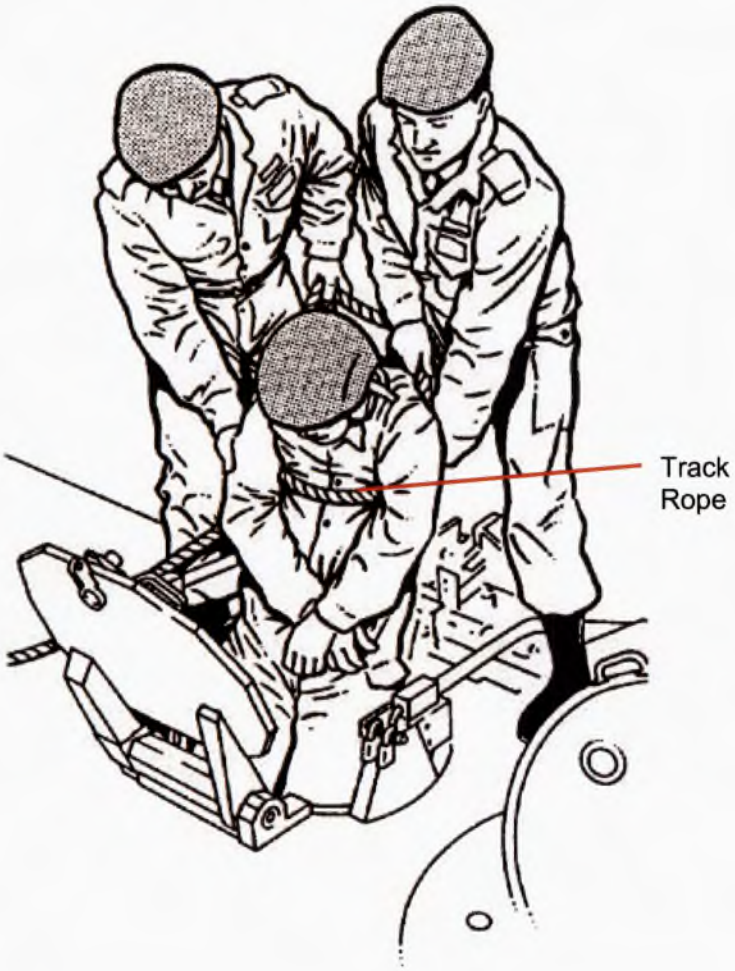


Figure 1.4.47: Casualty Extraction from the Loader's Hatch

1.4.257. The Panel concluded that:

a. All equipment required by the responders to access the casualties and extract them from the tank was readily available, thus availability of rescue equipment was **not an Accident Factor**.

b. The casualties were extracted from the Fighting Compartment as quickly as could be reasonably expected, taking into account the severity of their injuries. Delay in extraction was **not an Accident Factor**.

c. The methods for casualty extraction from the Fighting Compartment are documented, well trained and appeared fit for purpose. They were **not an Accident Factor.**

Casualty Extraction form the Driver's Compartment

1.4.258. When the first responders reached the front of the tank, they attempted to gain access to the Driver. After attempts to communicate with him failed, they initiated the release mechanism designed to allow the locked hatch[82] to be opened from outside the tank. In witness statement they described hitting the release lug on the hatch with a sledge hammer, but this failed to open the hatch. Witness 15 Witness 16 Witness 17

1.4.259. The prescribed drill to open the hatch in an emergency is detailed in the AESP and shown in Figure 1.4.48: Exhibit 36

a. Turn the locking clamp to clear the hatch (6) by striking it with a hammer or turning it with a suitable lever.

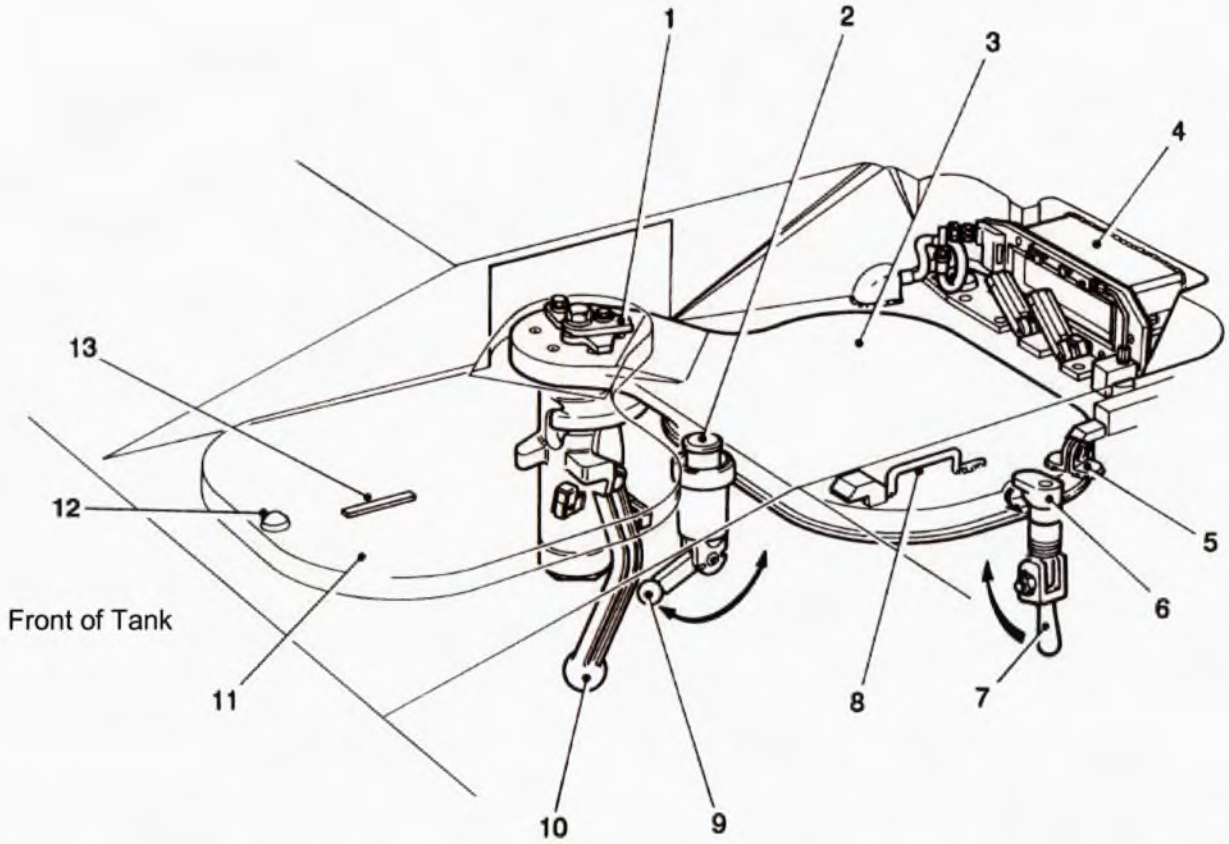
b. Strike the protruding arm of the emergency release lug (1) toward the right hand side of the vehicle to shear the internal shear pin.

c. The hatch should now rise sharply to clear the access recess and can now be pulled open using the handle (8).

d. If the hatch does not rise clear, a crowbar can be used to lift it.

1.4.260. The first responders clearly remember striking the emergency release lug (Figure 1.4.48, Item 1) but do not remember turning the locking clamp (Item 6). Post-accident inspection of the release mechanism has revealed that the sheer pin in the emergency release lug had been sheered. Whilst the locking clamp was found to be free to move, it had no witness marks on it to show it had been struck. Witness 15 Witness 16 Exhibit 24 Exhibit 25 Exhibit 36

[82] The Driver's Hatch must be locked closed from the inside during live firing.



1	Emergency release lug	8	Handle
2	Safety stop	9	Safety Stop operating lever
3	Driver's hatch (closed)	10	Operating handle
4	Driver's periscope hood	11	Driver's hatch (open)
5	Padlock lugs	12	Locating peg (on glacis plate)
6	Locking clamp	13	Finger bar
7	Locking clamp handle		

Figure 1.4.48: CHALLENGER 2 Driver's Hatch

1.4.261. As part of the investigation, 5 Driver's Hatches on reference tanks were opened using the emergency opening procedure, all without incident. Whilst this in itself does not disprove that the emergency release on DS39AA was faulty, it is evidence that indicates that there is not a wider problem.

Exhibit 26
Exhibit 36

1.4.262. The Panel concluded that:

a. The Driver's Hatch did not open because the rescuers did not move the locking clamp out of the way. This oversight is arguably understandable in the circumstances. They were working under extreme pressure next to a tank which they believed had a risk of imminently exploding.

b. The Driver's Hatch emergency opening procedure was not an Accident Factor on 14 Jun 17 because of the rapid presence on scene of the hydraulic spreading equipment and the short delay in extracting the Driver had no impact on his medical condition. However, in other circumstances, the inability to quickly rescue a Driver from a tank could have severe implications. As such, this is assessed as an **Other Factor**.

Recommendation

1.4.263. Head of Capability Ground Manoeuvre should direct that the drill to open the CHALLENGER 2 Driver's Hatch in an emergency is regularly practised in order to reduce the risk of any delay in accessing the driver following an incident.

First Aid and Medical

1.4.264. During the Range Package, BADGER Sqn was accompanied by 2 Combat Medical Technicians[83] (CMT) each of whom had a medical module (back pack) giving them the capacity to treat 4 very seriously injured personnel. In interview the lead Unit Medic (the first medic onto the tank) confirmed that sufficient equipment was in place to deliver the appropriate first aid care. This first aid was later augmented by NHS paramedics and medical staff from both ground and air ambulances. It is testament to their skill that both fatally injured soldiers left the range alive. Witness 6 Witness 7

1.4.265. It is the Panel's opinion that the casualties received appropriate and timely first aid from well trained and prepared staff (both Service and civilian) and the use of helicopters allowed them to be transferred to hospital quickly and efficiently, especially considering the remoteness of their location.

1.4.266. The Panel concluded that:

a. The medical equipment available to the Unit Medics was sufficient to deal with all the casualties and was **not an Accident Factor**.

b. The first aid and onward medical care given to the casualties was timely and appropriate, and was **not an Accident Factor**.

c. The casualties transport to hospital was timely and efficient, and was **not an Accident Factor**.

[83] The Panel has checked both were in date for all their mandated qualifications.

Injuries Sustained

1.4.267. Having studied the pathology reports, interviewed the personnel involved in delivering first aid, the Driver and the Gunner, and reviewed the physical evidence, the Panel has concluded that: Witness 6 Witness 7 Witness 11 Exhibit 8 Exhibit 31

a. The Commander received fatal injuries as a consequence of the breech explosion ejecting him from the turret and his subsequent impact with the ground.

b. The Loader, Gunner and Driver were rendered unconscious by the overpressure from the breech explosion.

c. The injuries sustained by the Loader, Gunner and Driver were all burn related. They were not struck by fragments or other parts of the exploding breech.

d. The Loader sustained fatal injuries from exposure to the Propelling Charge fire.

e. The Gunner was severely injured by the Propelling Charge fire.

f. The Driver suffered minor injuries from the Propelling Charge fire.

Personal Protective Equipment

1.4.268. This section of the report investigates whether the issued Personal Protective Equipment (PPE) that was worn by the Crew was appropriate, sufficient and fit for purpose.

Mandated Levels of PPE

1.4.269. The mandated level of PPE in CR2 is stated in the following publications:

a. **Army Operational Shooting Policy** (AOSP) Volume 4 directs tank crews: Exhibit 15

(1) To dress in accordance with Armoured Vehicle Standing Orders (AVSOs) dated 2015.

(2) To wear issue boots when operating Armoured Vehicles (AVs).

(3) To wear ECBA while conducting live firing.

b. **AVSOs** instruct personnel: Exhibit 38

(1) To wear issued ear protection in the close vicinity of an Armoured Vehicle with running engines or weapon systems that are in use.

(2) To wear eye protection when travelling in an AV in the head-up position.

(3) To refer to AESPs for the appropriate level of PPE required to conduct maintenance.

(4) To wear issued boots when operating AVs.

Exhibit 41

c. **PAM 21** directs that during training exercises:

(1) Sleeves need to be rolled down in the turret.

(2) Service issued hearing protection or Active Noise Reduction (ANR) headsets are to be worn.

Hearing Protection

1.4.270. All members of the Royal Armoured Corps are provided with hearing protection for use in AVs. The standard issue for personnel in the CR2 is the ANR headset, which combines in-tank communication (microphone and speaker) with suitable noise reduction. It is normally worn clipped into the Crewguard helmet, but can be used on its own, or with other types of protective headgear.

1.4.271. All the personnel in BADGER Sqn on ranges from 2-16 Jun 17 were equipped with the ANR headset when in the tank. Personnel outside tanks were provided with the standard Peltor headset and the Chain of Command ensured that they were worn when firing was underway. Witnesses state that the Experience Shoot Crew were all wearing ANR headset during the accident.

Witness 3
Witness 4

1.4.272. The Panel concluded that hearing protection was issued and worn and therefore was **not an Accident Factor**.

Eye Protection

1.4.273. Protective eyewear is provided to all soldiers on an individual basis. It is required to be worn when operating an AV in the head up position.

1.4.274. During the accident, eye protection was not required as none of the crew were operating in the head-up position.

1.4.275. The Panel concluded that eye protection was not required and was **not an Accident Factor**.

Protective Headgear

1.4.276. The Crewguard Helmet is provided to all tank crews for use in CR2. It is designed to protect the wearer from impact with the internal structure of the vehicle. It is not designed to provide ballistic protection.

1.4.277. During the Experience Shoot, all 4 Crew members were wearing a Crewguard helmet with the ANR headset incorporated.

1.4.278. The Panel concluded that protective headgear was available and worn and was therefore **not an Accident Factor**.

Ballistic Protection

1.4.279. ECBA is provided for all tank crews and is required to be worn whilst in a manoeuvring tank and at all time during live firing. ECBA provides protection from small arms fire and fragmentation when the crewman is exposed or dismounted. It also provides protection to the wearer from impact injuries when travelling inside the tank, especially cross-country during FMXs[84]. The Loader, who is not seated during an FMX, is particularly vulnerable to these injuries.

Exhibit 15
Exhibit 38

1.4.280. The Experience Shoot Crew members were all wearing ECBA when they mounted the tank[85]. The evidence shows that the Loader removed his ECBA before the accident; it was discovered on the floor of the turret with burn damage on the upper side. He probably removed it for comfort, although the weather was not particularly warm on the day in question, and also knowing that the tank would be stationary for the shoot. The ECBA would have provided the Loader with a degree of protection from the fire and its covering is fire retardant. However, in the opinion of the Panel, the intensity of the fire (as discussed in Paragraph 1.4.199) was such that no pragmatic PPE solution would have provided significant protection to a crew member enveloped in a Propelling Charge fire.

Witness 3
Witness 4
Witness 6
Witness 11
Witness 31

1.4.281. The Panel concluded that:

a. Mandated ballistic protection was provided and worn by the Commander, Gunner and Driver.

b. The Loader was in contravention of regulations by removing his ECBA during the Experience Shoot, but the intensity of the fire was such that the ECBA would have provided limited protection. Removal of ECBA is therefore assessed as an **Other Factor**.

Clothing

1.4.282. All soldiers are issued with the Multi Terrain Pattern (MTP) Personal Clothing System (PCS) and, for the majority of units, this is the standard uniform worn day to day, on ranges, on exercise and on operations. Tank soldiers can be issued an MTP Tank Suit, an all-in-one suit made of the same material as PCS. These are routinely worn on exercise instead of PCS. Members of the RTR are issued with Black Coveralls[86]. These are only worn by members of the RTR for historical reasons[87]. The RTR routinely wear their black coveralls as their day to day uniform and on ranges, but not on exercise or

Exhibit 43

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[84] LFXs 4-8 are defined as FMXs.

[85] The Gunner borrowed a set of ECBA from a member of BADGER Sqn prior to mounting the tank.

[86] Coveralls, Men's Black Army Pattern.

[87] The wearing of black coveralls is a custom reserved to the RTR. It stems from the Royal Review held at Aldershot in the presence of King George V in 1935, on which occasion black coveralls were worn on parade by all ranks of the Royal Tank Corps.

operations. Every other armoured unit is issued with Green Coveralls, made of the same material, which are routinely worn when working on or around vehicles to protect their normal uniforms. They are not worn on ranges, exercise or operations. MTP PCS, MTP Tank Suits, Black Coveralls and Green Coveralls are not treated with a fire retardant.

1.4.283. The Panel can find no authoritative document which states what clothing should be worn in an AV, although PAM 21 states that sleeves must be rolled down. The Administrative Instruction produced by BADGER Sqn for the Range Package instructs unit members to wear their Black Coveralls. Exhibit 14 Exhibit 15 Exhibit 41

1.4.284. The Black Coveralls worn uniquely by the RTR are 35% cotton, 65% polyester whereas standard PCS is 75% cotton, 25% polyester. Whilst neither is treated with a fire retardant, the higher cotton content of PCS should provide the wearer with more protection from both flash and fire. Exhibit 43

1.4.285. The Commander, Loader and Driver were wearing black coveralls. The Gunner was wearing MTP PCS, with the associated wind proof smock.

1.4.286. The Panel concluded that:

a. The Experience Shoot Crew wore the clothing system they were instructed to wear.

b. There is no coherent, mandated clothing directive for crews in AVs.

Footwear

1.4.287. All soldiers are issued with boots. They are required to be worn when operating an AV.

1.4.288. All personnel involved were wearing issued boots during the accident.

1.4.289. The Panel concluded that issued footwear was worn as required and was **not an Accident Factor**.

Safety and Environmental Case Report (SECR)

1.4.290. The SECR contains 2 identified accident scenarios that are pertinent to the accident on 14 Jun 17, namely injuries from using Weapons, Ordnance Munitions and Explosives (WOME) (Accident A14) and injuries sustained in a fire on the platform (Accident A17). Detailed mitigation for both these accident scenarios is listed and enables the risks identified to be assessed as ALARP and tolerable. However no standard of PPE is stated within the mitigation. The Panel believes this to be an oversight and that the risks cannot be considered ALARP until the required level of personal protection is defined. There are 168 recorded fires in the SECR (all classified as Near Misses) and, as such, there is clearly a credible risk of fire. Exhibit 17

1.4.291. The Panel concluded that the CR2 SECR is not complete until the required level of PPE is defined within the mitigation for accidents involving WOME or fire on the platform. This is assessed as an **Other Factor**.

Overall Conclusions

1.4.292. The Panel's overall conclusions are that:

a. The Experience Shoot Crew was provided with all mandatory PPE, although there is no mandated clothing standard.

b. A significant amount of testing would have to be conducted to have sufficient evidence to determine if the available PPE, particularly clothing, was truly fit for purpose. This is beyond the scope of the Service Inquiry. However, the Panel do have concerns over the suitability of the black coveralls worn by the RTR and the lack fire of protection in general.

Recommendations

1.4.293. The Head of Capability Ground Manoeuvre should review the Personal Protective Equipment that should be worn by Armoured Vehicle crews, and then implement the findings, in order to ensure that the risks to personnel are tolerable and As Low As Reasonably Practicable (ALARP).

Organisation and Resources

1.4.294. This section of the report looks to determine and comment on any broader organisational and/or resource factors, particularly at CMR.

Castlemartin Range Organisation

1.4.295. Merrion Camp provides a Defence Land Range Support Complex, along with a licensed area to store ammunition as part of the overall Safe System of Training. This system allows range users to train to meet their operational roles, whilst reducing any associated risks to ALARP. Additionally, CMR provides a secure location for arms and associated ancillaries considered Attractive to Criminal and Terrorist Organisations (ACTO[88]); this location meets the requirements of the security regulations[89].

Ammunition Point Licensing

1.4.296. The Ammunition Point on Range 4 has no explosive licence. This precludes it being used for storage of ammunition overnight. This requirement is clearly stated in CMR Standing Orders. It came to the Panel's attention that BADGER Sqn were routinely storing ammunition overnight on the Ammunition Point on Range 4, either on the ground, or in the Support Vehicle. The Panel was informed of other units conducting the same practice.

Witness 5
Witness 16

[88] A specified category of armament or ammunition store that requires extra security and accounting protection.

[89] JSP 440 – The Defence Manual of Security, Resilience and Business Continuity.

1.4.297. The Panel concluded that the practice of storing ammunition overnight at CMR Range 4 was contrary to Explosives Regulations, and this is an **Other Factor**.

Recommendation

1.4.298. The Defence Infrastructure Organisation Head of Service Delivery Training should ensure that explosives regulations at Castlemartin Ranges are adhered to, in order to comply with the explosives licence and reduce the risk of accidents.

Small Arms Stowage

1.4.299. Small Arms and ammunition, in the form of 7.62 mm ammunition, General Purpose Machine Guns and Chain Guns, are ACTO articles and require secure storage. CMR provides units with a dedicated armoury to meet this need. The Panel was told that units regularly store Chain Guns on the first floor of the Control Tower and maintain an overnight guard. JSP 440 states that this practice is only to take place when there is no suitable armoury facility available. The presence on the range of small arms ammunition on the Ammunition Point is also in contravention of JSP 440 which states that individuals should not have unsupervised access to both small arms and ammunition, other than required in the performance of their duties. Witness 9 Witness 16

1.4.300. The Panel concluded that the practice of storing ACTO weapons and ammunition overnight at CMR Range 4 was contrary to security regulations, and this is an **Other Factor**.

Recommendation

1.4.301. The Defence Infrastructure Organisation Head of Service Delivery Training should ensure that regulations regarding the storage of small arms and ammunition are adhered to by units using Castlemartin Range in order to comply with security policy and to reduce the risk of accidents.

Wider Safety Observations

1.4.302. Whilst conducting this SI, the Panel considered the wider context of the Safety Culture[90] displayed by the individuals and organisations involved. In doing so, it is important to realise that Safety Culture is a large and complex issue, and the Panel accepts that this accident investigation only provides a snapshot of a much wider pattern of behaviour. Exhibit 42

[90] Safety Culture is the attitude, beliefs, perceptions and values that employees share in relation to safety in the workplace.

Exhibit 42

1.4.303. During the investigation, the Panel noted a number of departures from required safety rules, ranging from more minor issues such as taking mobile phones into tanks, to the very serious matter of leaving Propelling Charges out of charge bins during live firing, although it is clear that there was never any intent to cause harm. There is evidence to suggest that some of these departures may have become habitual or normalised, and indicates a degree of complacency with regard to safety.

1.4.304. The Panel's greatest area of concern was the issue of not stowing Propelling Charges correctly, where there is a significant Risk to Life (RtL). The rule breaking appeared to be driven by a shared value of speed of loading over safety procedures, and it is particularly concerning to see this practise conducted by RIGs, whose tasks include oversight of gun drills and weapon handling tests. The more senior levels of management within the Unit either tolerated the practice or were unaware. Either way, this signified an inappropriate level of assurance oversight by the chain of command.

1.4.305. The Panel concluded that there was evidence of complacency with regard to safety instructions which led to inappropriate risk taking, especially the incorrect stowage of Propelling Charges. This is assessed to be a **Contributory Factor**. The implementation of the Recommendation at Paragraph 1.4.232 should address this Accident Factor.

1.4.306. Effective leadership is a key ingredient to promoting an effective Safety Culture. All leaders, irrespective of rank, must encourage an environment where even the most junior members of their team can challenge behaviour they believe compromises safety. This can be difficult in disciplined, hierarchical organisations, but is achievable especially when more senior leaders encourage a "questioning, just and reporting culture"[91].

1.4.307. The Service Inquiry has identified lessons and made recommendations which, if implemented, should prevent a reoccurrence of this specific accident scenario. However, if wider safety improvements are to be made, the accident must be viewed in the broader context of the risks of conducting complex military activity and there must be a commitment from all ranks to seek continuous improvement.

[91] A *just culture* is one where a person of any rank or experience can raise an issue without fear of recrimination. This is best achieved by encouraging an atmosphere of trust in which people are encouraged, even rewarded, for providing essential safety-related information.

Summary of Factors

Causal Factors

1.4.308. The following are assessed to be Causal Factors, in that they were events which, in isolation or in combination with other factors and contextual details, led directly to the accident:

a. The breech explosion was caused by the Main Armament being fired without the BVA Assembly fitted.	1.4.180
b. The current design of the L30A1 Gun, that allows it to be fired without the BVA Assembly in place.	1.4.183

Contributory Factors

1.4.309. The following are assessed to be Contributory Factors, in that they made the accident more likely to occur:

a. Not informing Crew C/S 30B that DS39AA would be fired again that day.	1.4.79.c
b. The absence of a HOTO between C/S 30B and the Experience Shoot Crew.	1.4.105
c. It is possible to conduct the Prove the Gun, Load the Gun and the drill associated with a Fire Order without noticing that the BVA Assembly was missing.	1.4.170
d. The accident sequence of firing the Main Armament without the BVA Assembly fitted was not recognised as a credible hazard prior to 14 Jun 17.	1.4.193
e. The practice of leaving Propelling Charges out of charge bins had become routine for the Experience shoot Loader and Commander.	1.4.231.b
f. There was evidence of complacency with regard to safety instruction which led to inappropriate risk taking within the Sqn, especially the incorrect stowage of Propelling Charges.	1.4.305

Aggravating Factor

1.4.310. The following is assessed to be an Aggravating Factor, in that it made the outcome worse:

a. Four Propelling Charges were left out of the charge bins during the Experience Shoot.	1.4.231.a

Other Factors

1.4.311. The following are assessed to be Other Factors, in that they were none of the above, but were noteworthy in that they may cause or contribute to future accidents:

a. The RTR not applying for permission from the ODH for the Guest Gunner to be in the Tank for the Experience Shoot, and the consequential lack of ODH oversight of the risk.	1.4.101.c
b. The practice of taking functioning mobile phones into CR2 is a common occurrence. This is an intentional, unsafe act in violation of the rules.	1.4.139.c
c. The driver's hatch emergency opening procedure.	1.4.262.b
d. The Loader was in contravention of regulations by removing his ECBA during the Experience Shoot.	1.4.281.b
e. The CR2 SECR is not complete until the level of required PPE is defined within the mitigation for accidents involving WOME or fire on the platform.	1.4.291
f. The practice of storing ammunition overnight at CMR Range 4 was contrary to explosives regulations.	1.4.297
g. The practice of storing ACTO weapons and ammunition overnight at CMR Range 4 was contrary to security regulations.	1.4.300

Observations

1.4.312. The following are assessed to be Observations, in that they were issues that were not relevant to the accident but worthy of consideration to promote better working practices:

a. Onboard recording would be beneficial to any future post-incident investigations.	1.4.113.b
b. Onboard recording could provide safety assurance, by producing evidence showing that tank crews are following gunnery drills and safety routines correctly.	1.4.113.c

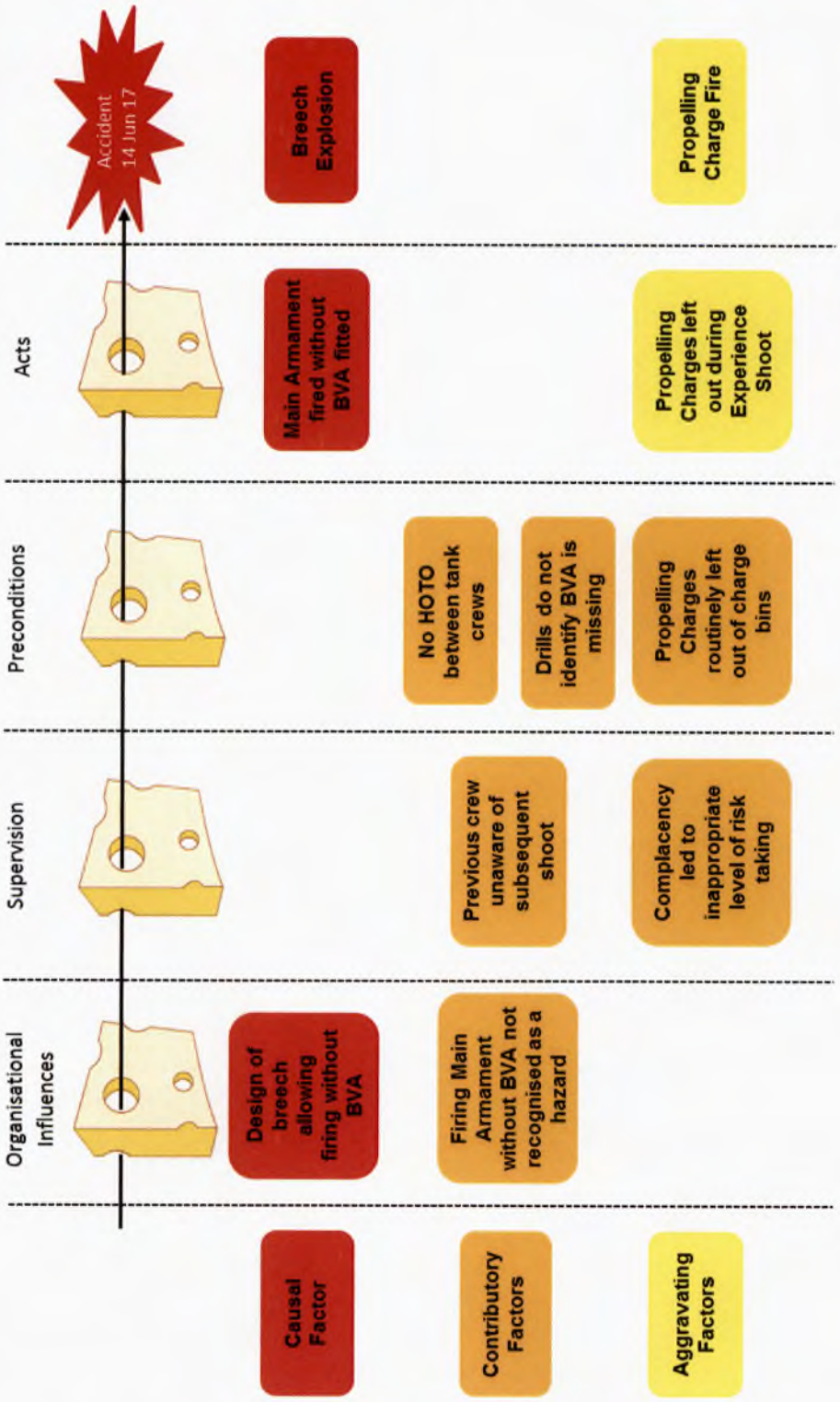

Figure 1.4.49: "Swiss Cheese"[92] Representation of the Accident Factors

[92] The original source for the Swiss Cheese illustration is: "Swiss Cheese" Model – James Reason, 1990. The book reference is: Reason, J. (1990) Human Error. Cambridge: University Press, Cambridge

Annex A to
DSA/SI/05/17/RTR CR2 CMR
Part 1.4

Analysis of the State of Gun

Introduction

1. This analysis looks at the possible states of the main armament that the Experience Shoot crew could have found on mounting the tank at 1500 on 14 Jun 17. Each of these states is analysed to assess whether it is possible to create the accident sequence.

Facts

2. The following statements are accepted as fact based on the physical evidence found after the Accident, and described and analysed in Paragraphs 1.4.115 to 1.4.135 of the Part 1.4:

a. The Gun was fired with a SH-P and a CP SH loaded in the chamber. Four SH-P were provided and only 3 SH-P were discovered post-accident.

b. The Loading Tray was fitted when the gun fired. The Loading Tray was found in several pieces scattered across the turret floor, commensurate with having been fitted to the top of the Upper Breech Block during the breech explosion.

c. The FNA was fitted to the lower breech with a TVE attached to its front face when the gun fired. The FNA was recovered from the tank with a fired TVE still attached.

d. The BVA Assembly was not fitted to the main armament when the gun fired. The BVA was found in the Ration Stowage Box.

Assumptions

3. In this analysis it has been assumed that the Prove the Gun drill was not completed. Prove the Gun is considered in detail in Table 1.4.6 and the Panel has drawn conclusions based on its completion. This analysis looks in detail at the sequence of events that would have to occur if the Prove the Gun drill was not conducted. If the Experience Shoot Loader did not conduct the Prove the Gun drill, he would have gone straight into the Load the Gun (Table 1.4.7) which starts with the order "Action Load HESH".

4. The previous crew stated that the Main Armament was left with the FNA removed, the Breech open and the Loading Tray not fitted. However, this analysis looks at all combinations of these variables.

5. When preparing to fire a CR2 for the Experience Shoot, the Loader had other tasks he had to complete. These included fitting and loading the 7.62 mm Chain Gun. These drills are not detailed in this analysis, but the reader must be aware that a considerable amount of work is required and may have distracted the Loader from the Main Armament drills listed below.

Definitions

6. The following definitions are used in the following paragraphs to describe what happened.

a. **Must** – required outcome not physically possible without taking this action/being in this state.

b. **Cannot** – physically impossible.

c. **Should** – required by the drill or normal taught practice.

d. **Might** – possible but not likely.

Operation of the Breech

7. The following statements describe how the L30A1 gun breech components and movements interact: Exhibit 36

a. To open the Breech (with the Breech Mechanism Lever):

(1) FNA **must** be fitted; or

(2) Without the FNA fitted, the loader **must** press FNA Retaining Plunger manually.

The Breech **cannot** be opened without doing one or other.

b. To load the gun:

(1) Breech **must** be open.

(2) Loading tray **should** be on.

c. If the breech is open, the loader **cannot** see whether the FNA is fitted or not. When the breech is closed the loader **might** notice whether the FNA is fitted or not.

d. To remove the BVA Assembly for cleaning:

(1) The Loading Tray **must** be removed.

(2) The FNA **must** be removed.

(3) The breech **must** be open when the BVA Assembly is removed from the gun.

e. On completion of removing the BVA Assembly, the Loading Tray and FNA **might** be refitted and the breech **might** be closed, noting that the Loading Tray and FNA **must** be removed and the breech **must** be open to refit the BVA Assembly.

f. If Loading Tray is fitted, the crew **cannot** see the BVA Assembly. If the Loading Tray is not fitted the crew **might** notice the BVA not being fitted.

g. If the ATL is operated when the BVA is not fitted, the TVE will fall out of the breech onto the floor of the turret.

h. To fire the gun without the BVA:

(1) The gun **must** be loaded (charge and projectile in the chamber and the breech closed).

(2) The Loader **must** have completed the Red Drill (the TVE **must** be hand loaded with the FNA). This is the only way to get a TVEDU Green.

(3) The Loader's Sliding Guard **must** be "made".

8. Whatever the starting state of the gun and its components, the final state of Loading Tray fitted, FNA fitted with TVE hand loaded and breech closed **must** have been achieved.

9. The different accident sequences are listed in Table 1.4.A.1 below. The 8 different start positions (Scenarios A – H) are detailed across the columns, and the outline drill actions are listed down the rows[93]. Scenario A is the state of the Main Armament as described by Crew C/S 30B's Loader as how he left the weapon.

10. In Scenarios E – H the breech is closed in the starting position, and must be opened before the order "Action Load HESH" can be conducted. If the Loading Tray was not fitted (Scenarios E and G) the loader would immediately notice and almost certainly fit it, before opening the breech.

[93] The drill steps listed down the rows are an abbreviated version of the drill explained in Table 1.4.7, Table 1.4.8 and Table 1.4.9, and full documented in AESP 2350-P-102-201, Amendment 31 dated Apr 17.

	Scenario A	B	C	D	E	F	G	H
Breech	Open				Closed			
FNA	Not Fitted		Fitted		Not Fitted		Fitted	
Loading Tray	Not Fitted	Fitted	Not Fitted	Fitted	Not Fitted	Fitted	Not Fitted	Fitted
Step 1	"ACTION LOAD HESH"		"ACTION LOAD HESH"		Notice no Loading Tray. Fit Loading Tray		Notice no Loading Tray. Fit Loading Tray	
2	Notice no Loading Tray. Fit Loading Tray		Notice no Loading Tray. Fit Loading Tray		Open Breech – cannot because FNA not fitted. Locate and fit FNA.		Open breech	
3					"ACTION LOAD HESH"		"ACTION LOAD HESH"	
4	Load TVE with ATL		Load TVE with ATL		Load TVE with ATL		Load TVE with ATL	
5	TVE falls on floor (did not notice)		TVE falls on floor (did not notice)		TVE falls on floor (did not notice)		TVE falls on floor (did not notice)	
6	Load SH-P		Load SH-P		Load SH-P		Load SH-P	
7	Load CP SH		Load CP SH		Load CP SH		Load CP SH	
8	Close breech		Close breech		Close breech		Close breech	
9	Might notice FNA missing. Locate and fit FNA with TVE on.							
10	"LOADED"		"LOADED"		"LOADED"		"LOADED"	
11	Wait while Commander briefs Gunner and acquires target							
12	FIRE ORDER "HESH TANK"		FIRE ORDER "HESH TANK"		FIRE ORDER "HESH TANK"		FIRE ORDER "HESH TANK"	
13	Make Guard		Make Guard		Make Guard		Make Guard	
14	TVEDU – Red		TVEDU – Red		TVEDU – Red		TVEDU – Red	
15	"RED"		"RED"		"RED"		"RED"	
16	Break Guard		Break Guard		Break Guard		Break Guard	
17	Notice FNA not fitted. Locate FNA		Remove FNA – no TVE		Remove FNA – no TVE		Remove FNA – no TVE	
18	Load TVE to FNA		Load TVE to FNA		Load TVE to FNA		Load TVE to FNA	
19	Fit FNA to Breech		Fit FNA to Breech		Fit FNA to Breech		Fit FNA to Breech	
20	Make Guard		Make Guard		Make Guard		Make Guard	
21	TVEDU Green		TVEDU Green		TVEDU Green		TVEDU Green	
22	"LOADED"		"LOADED"		"LOADED"		"LOADED"	

Text in red indicates drill actions that are not expected at the stage of the drill at which they occur.

Table 1.4.A.1: Starting State Scenarios

Analysis

11. The absence of the Loading Tray (Scenarios A, C, E and G) is immediately apparent to a loader as he looks at rear of the Main Armament. If the Loading Tray was left hanging on the projectile racking at the rear of the turret (as stated by C/S 30B's Loader), in clear view of the oncoming Experience Shoot Crew, then it is the Panel's opinion that the Experience Shoot Loader would have fitted the Loading Tray as his first action. In doing so he would have obscured the BVA Assembly from sight. This is the same action as would be taken if the Prove the Gun Drill was completed (Paragraph 1.4.146.a).

12. Scenarios G and H involve the least unexpected drill and provide the least opportunity for the Experience Shoot Crew to notice that the BVA Assembly is missing. However these start positions, particularly Scenario H, are the furthest from the statement given by C/S 30B Loader. When he removed the BVA Assembly for cleaning, C/S 30B Loader expected to refit it on completion and so refitting the Loading Tray, closing the breech and then refitting the FNA make little sense. These actions would have required reversing to conduct the fitting of the BVA and the previous loader knew that there was no Thrust Housing for the FNA to engage with.

13. Scenarios E and F afford the loader with an early indication that the FNA is not fitted but again require the off going Loader to close the breech before leaving the vehicle. As described above, this action would have had to be reversed before refitting the BVA. Additionally, it is common practice to leave the breech open after firing to allow air to circulate and cool the gun.

14. Scenarios C and D are unlikely to occur. To get to this position, the previous loader would have had to close the breech, fit the FNA (knowing there was no Thrust Housing for it to engage with) and then reopen the breech, all actions that would have required reversing before refitting the BVA Assembly.

15. Scenarios A and B, Step 9 is particularly unusual. If the BVA is fitted and a TVE has been rammed into the TVE Chamber at the rear of the BVA, it is not possible to fit the FNA either with a TVE fitted to its face or not. The FNA can only be fitted at this point if the loader has forgotten to operate the ATL or if the BVA is missing. It is the Panel's opinion that Step 9 was very unlikely to have occurred.

16. Scenario A is the most likely to have occurred. It is the condition that C/S 30B's Loader stated he left the gun in, and it is the most logical position. It is the state of the gun on completion of removing the BVA Assembly and the state the gun is required to be in when you start to refit the BVA Assembly. However, if Step 9 is dismissed as very unlikely, then the absence of the FNA is not realised until the Loader starts the Red Drill (Table 1.4.9). It is the Panel's opinion that this would have given a strong indication to the Accident Loader that there were issues with the state of the gun.

Conclusions

17. The Panel concluded that:

a. It is possible to fire the gun without the BVA Assembly fitted irrespective of the starting state of the Loading Tray, FNA and breech.

b. Of all the 8 scenarios, Scenario A was the most likely to have occurred.

c. The Experience Crew Loader completed the Prove the Gun drill before conducting the Loading Drill, and in doing so, fitted the Loading Tray and FNA.

PART 1.5

Recommendations

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PART 1.5 – RECOMMENDATIONS

1.5.1. **Introduction**. The following recommendations are made in order to enhance Defence Safety:

1.5.2. **The General Officer Commanding the 3rd (United Kingdom) Division:**

a. Put in place a suitable assurance regime to ensure that mobile phones or other personal electrical devices are not taken within 5 metres of Armoured Fighting Vehicles (AFVs) with loaded electrically initiated weapon systems, or ammunition points, in order to comply with extant regulations and reduce the risk of accidents. 1.4.140

b. Put in place a suitable assurance regime to ensure that Propelling Charges are correctly stowed, in order to reduce the risk of fire inside the CHALLENGER 2 turret. 1.4.232

1.5.3. **The Director Land Warfare should:**

a. Put in place a suitable assurance regime to ensure that mobile phones or other personal electrical devices are not taken within 5 metres of Armoured Fighting Vehicles (AFVs) with loaded electrically initiated weapon systems, or ammunition points, in order to comply with extant regulations and reduce the risk of accidents. 1.4.140

b. Put in place a suitable assurance regime to ensure that Propelling Charges are correctly stowed, in order to reduce the risk of fire inside the CHALLENGER 2 turret. 1.4.232

1.5.4. **The Head of Capability Ground Manoeuvre should:**

a. Consider providing an on tank recording facility in order to provide assurance that tank crews are following safety drills correctly and to aid any post-incident investigation. 1.4.114

b. Put in place a drill or process that ensures that all safety critical components of the L30A1 gun are fitted prior to firing, in order to prevent the gun from being fired in an unsafe state. 1.4.171

c. Establish a formal Handover / Takeover (HOTO) regime in order to ensure that tanks are in a safe and known state prior to firing. 1.4.106

d. Direct that the drill to open all CHALLENGER Variants' Driver's Hatches in an emergency is regularly practised in order to reduce the risk of any delay in accessing the driver following an incident. 1.4.263

e. Review the Personal Protective Equipment that should be worn by Armoured Vehicle crews, and then implement the findings, in order to ensure that the risks to personnel are tolerable and As Low As Reasonably Practicable (ALARP). 1.4.293

1.5.5. **The Land Equipment Vehicle Support Team Leader should:**

a. Provide a physical mechanism that prevents the L30A1 gun firing when the Bolt Vent Axial (BVA) assembly is not fitted, in order to physically prevent the gun firing in an unsafe state. 1.4.184

b. Amend the CHALLENGER 2 Safety and Environmental Case Report (SECR) to recognise the hazard of firing the gun without the BVA Assembly fitted, in order to demonstrate that the Risk to Life is tolerable and As Low As Reasonably Practicable (ALARP). 1.4.194

1.5.6. **The Defence Infrastructure Organisation Head of Service Delivery Training should:**

a. Ensure that explosives regulations at Castlemartin Ranges are adhered to, in order to comply with the explosives licence and reduce the risk of accidents. 1.4.298

b. Ensure that regulations regarding the storage of small arms and ammunition are adhered to by units using Castlemartin Range in order to comply with security policy and to reduce the risk of accidents. 1.4.301

PART 1.6

Convening Authority Comments

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PART 1.6 – CONVENING AUTHORITY COMMENTS

1.6.1. During the afternoon of 14 June 2017, a Challenger 2 (CR2) Main Battle Tank, suffered an internal explosion whilst conducting live-firing on Castlemartin Ranges (CMR). All four of the tank's crew sustained injuries. Following their medical evacuation, Cpl Darren Neilson (the tank's Commander) and Cpl Mathew Hatfield, (the tank's Loader) subsequently died from their injuries.

1.6.2. The CR2 (registration mark DS39AA) belonged to BADGER Squadron of the Royal Tank Regiment (RTR). BADGER Squadron was concluding a routine live-firing range package, to qualify their tank crews on their Annual Crew Tests (ACT), prior to their deployment to the British Army Training Unit Suffield (BATUS). The crew of CR2 (DS39AA)[1] was conducting an '*Experience Shoot (ES)*[2]' at the time of the accident. This shoot was not part of the formal live-firing ACT programme.

1.6.3. This tragic accident occurred at the end of what was an otherwise successful range package. The range programme to achieve ACT was appropriate and well planned. Preparations had been thorough, especially in BADGER Squadron, with their focus on equipment availability, providing an example of how they had learned lessons from their previous CMR range package in November 2016. ACT results were good, with all of BADGER Squadron passing, with time to spare. Indeed, this deployment reflected the RTR's high standards of professionalism and their long history and experience with CR2[3].

1.6.4. I am grateful to the President of this Service Inquiry (SI) and to his Panel, for their report. In meeting their Terms of Reference (TOR), I am satisfied they have correctly identified what caused this accident and its attendant Factors. The report makes recommendations that flow logically from the Panel's analysis of the evidence gathered. Together with the Urgent Safety Advice already issued[4], I am confident when met in full, the recommendations will help prevent a similar accident occurring.

1.6.5. This accident was caused by the breech of CR2's (DS39AA) 120mm L30A1 main armament exploding as a consequence of it being fired without a Bolt Vent Axial (BVA) Assembly[5]. A subsequent fire was triggered by hot gasses escaping from the breech explosion igniting 4 x Propelling Charges, which were exposed and not stowed correctly in their Charge Bins. The breech explosion and the ferocity of the subsequent fire caused, both directly and indirectly, the injuries sustained by the crew.

1.6.6. The design of the L30A1 gun was identified as a second Causal Factor. This is because the design allows the gun to be fired without a BVA Assembly in place. As a design principle, no gun should be able to fire in any state, with a Safety critical part missing[6].

1.6.7. This accident might have been the first time a CR2's main armament had been fired (firing circuits completed) without a BVA Assembly being fitted. No records could be found of any previous

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[1] I will refer to the crew of CR2 (DS39AA) at the time of the accident as the 'Experience Shoot (ES) Crew'.

[2] Experience Shoots are not formally defined Live Fire Exercises, but are a recognised practice across the Armoured Corps for demonstrating the tank's weapon systems. They involve an unqualified 'guest' sitting in the Gunner's position, under the supervision of a qualified commander, with a qualified Loader and Driver of the vehicle

[3] RTR have had CR2 since 1998.

[4] Urgent Safety Advice was given in DAIB/17/032/CMR/Triage Update dated 23 Jun 17.

[5] The BVA is part of the CR2's main armament breech, which together with the obturator pad and shim forms the gas tight seal at the rear of the gun when it fires. The BVA Assembly refers to the BVA, Obturator Pad, Shim and Thrust Housing. With no BVA fitted, the structural integrity of the breech was severely compromised, resulting in catastrophic material failure.

[6] A RARDE report from 1984 (RARDE Report (GR1) (6/84) The Design and Development of the Gun 120mm Tk XL30E, dated May 1984) suggests that the original design intention was for the gun to fail safe: so when the Automatic Tube Loader (ATL) is operated in the absence of the BVA, the Tube Vent Electric is ejected from the breech and falls to the floor. However, this feature is overridden by the Red Drill tank crews are taught to conduct. Importantly, the ability of the gun firing circuits to be completed by these actions was not a recognised hazard and effectively removed the 'Fail Safe' mechanism.

related or similar occurrences. The CR2 Project Team (PT) within the DE&S was unaware it was possible for the gun to fire in this condition and this appeared to be the view shared across the Armoured Corps, who are the user community[7]. It was therefore understandable that the PT's Safety and Environmental Case Reports (SECR) for CR2 did not identify firing of the main armament without the BVA Assembly fitted as a hazard and why there were no related warnings in respective Army Equipment Support Publications (AESPs) for the CR2 and why drills to mitigate were not included in routine training and weapon handling tests. Not recognising this hazard made the accident more likely.

1.6.8. However, it would be reasonable to expect the exhaustive testing and experimentation required of the L30A1 gun by the Original Equipment Manufacturer (OEM) during its development would have exposed this sequence of events as being possible. This would then have compelled a change to the SECR, listing the firing of the main armament without a BVA Assembly fitted, as a hazard and introducing mitigation either in gun design or operating drills, to reduce the risk of an accident occurring. The SI received no definitive answers from the current Design Authority (DA)[8] on asking if they had any information that indicated they were ever aware the L30A1 gun could be operated and fired without the BVA Assembly fitted. I find this disappointing.

1.6.9. That the accident occurred during an Experience Shoot (ES) was not considered an accident factor. The ES were simple, well understood, clearly defined and supervised appropriately. Having passed their ACTs successfully, any crew from BADGER Squadron would have been considered suitably qualified to conduct an ES with a non-CR2 qualified guest sitting in the Gunner's position. The Squadron Command Team's decision to use 2 of their 3 Regimental Instructor Gunners (RIG), to act as Commander and Loader for the ES was not only sensible, but evidence of the additional consideration they had given to supervision and the safe conduct of the shoots. Pamphlet 21[9] describes how having a non-CR2 qualified person in the tank is non-compliant with the criteria for a Safe System of Training. It states the requirement to seek 2* Operating Duty Holder (ODH) dispensation for such non-compliance. For the 'accident' ES, dispensation was not sought, but short of the ODH refusing to grant dispensation, this omission did not cause the accident or make it more likely to happen.

1.6.10. To offer structure to my comments, I will start with conclusions made in determining the first Causal Factor (that the main armament could be fired without a BVA Assembly fitted) and how the actions of the ES crew might have produced this outcome. I will then comment on the circumstances that led to the gun being fired without the BVA Assembly fitted. This will be followed by comments on the breech explosion and the violent turret fire seen by witnesses. I will consider the post-accident response, and Personal Protective Equipment (PPE) before concluding.

Determining the CR2's Main Armament (L30A1 120mm Gun) could be Fired without a BVA Assembly fitted

1.6.11. There were no witness accounts of what took place inside the tank at the time of the accident. Aside from the Live Firing Monitoring Equipment (LFME), which is designed specifically to allow gunnery staff to assess the quality of gunnery during specific live-fire exercises, CR2s are not fitted with any appropriate means for the on-board recording of crew actions[10]. The accident sequence was therefore determined through a combination of physical evidence, external witness testimony, scenario testing on

[7] The Panel found a single witness who stated he had identified, some years previously that the firing circuits could be completed in the absence of the BVA. He did not conclude that the weapon could be fired without the BVA. He did not tell anyone of his discovery.

[8] Following the merger of British Aerospace and Marconi in 1999 and, in turn, British Aerospace having purchased Royal Ordnance and the IP for the gun in 1987.

[9] Training Regulations for Armoured Fighting Vehicles, Infantry Weapon Systems and Pyrotechnics, dated April 2017.

[10] The benefits of an on-board recording system were recorded as an Observation by the Panel from which a recommendation is made. However, despite its immediate appeal, benefits need to be considered carefully against the potential risk to operational capability caused, for example, by crews becoming too dependent on instructor intervention and consequent risk aversion when no instructors are present.

reference models and other CR2s, and on what the Panel believed, based on an analysis of the evidence, the most likely actions of the crew would be from the drills they were taught.

1.6.12. Inspection of DS39AA following the accident provided key factual evidence. The BVA Assembly was found in the Ration Stowage Box. The Obturator Pad and Shim were fitted to the BVA and the Thrust Housing was under it. The serial numbers confirmed the BVA and Obturator Pad belonged to DS39AA. Further physical evidence confirmed that at the time of the accident a 120mm Squash Head – Practice (SH-P) round had been fired without the BVA Assembly fitted to the main armament. When the firing switch was pressed, the Tube Vent Electric (TVE) attached to the Firing Needle Assembly (FNA) had initiated without the FNA being attached to the Thrust Housing.

1.6.13. Subsequent tests using reference models (Classroom Instructional Models) and a CR2 concluded that the Loader initially attempted to load a TVE with the Automatic Tube Loader (ATL) in the normal manner and subsequently hand loaded a TVE on the FNA as part of the Red Drill.

1.6.14. The sequence of events that led to hand-loading the FNA with a TVE and why the crew did not notice the absence of the BVA Assembly were determined. The Loader had placed his mobile phone in the Ration Stowage Box (in contravention to Pamphlet 21[11]) and had not noticed the BVA Assembly that had been left there by the previous crew (C/S 30B). The Loading Tray was refitted before the gun was fired. Neither the Loader nor Commander noticed the BVA Assembly was missing prior to the Loading Tray being fitted and once the Loading Tray was in place they would not have been able easily to see the BVA Assembly was missing. Additionally, an FNA can be fitted into the Lower Breech Block without noticing the absence of a BVA Assembly and it is possible that a Loader can confirm there is no TVE in the TVE Chamber without noticing the BVA Assembly is missing.

1.6.15. The AESPs require a 'Prove the Gun Drill' to be conducted by the Loader prior to commencing work on the gun. It serves to ascertain the state of the gun, specifically to ensure it is clear of ammunition. The Panel had no evidence to confirm if this drill was conducted, but deduced on the balance of probability, it was conducted shortly after the crew mounted the tank. Having witnessed the 'Prove the Gun Drill' conducted by subject experts in accordance with the AESPs and as taught to tank crews, with the BVA Assembly fitted and not fitted, it was judged entirely feasible to conduct the drill without noticing the absence of the BVA Assembly. From this it was concluded the Loader probably conducted the 'Prove the Gun' drill and did so without noticing the BVA Assembly was missing.

1.6.16. The only opportunity in the Main Armament Loading Drill for the crew to realise the BVA Assembly was not fitted, would have been when the TVE fell onto the turret floor. However, with the tank engine running and the crew wearing hearing protection, they almost certainly would not have noticed this. An unfired TVE found on the turret floor supports this hypothesis. It seems that on an order to fire having been given, the Loader saw the Red NOT LOADED indication on the Tube Vent Electric Display Unit (TVEDU). The Loader would have then conducted the 'Red Drill' to ascertain why the main armament was not in the correct state to fire and how this could be rectified[12]. Observing no TVE was fitted to the FNA, the Loader probably assumed he had forgotten to operate the ATL and conducted the Red Drill without questioning the state of the gun.

1.6.17. It would be reasonable to assume both the ES Commander and Loader did not consider that the BVA Assembly was missing. Whilst the subsequent drills they would have conducted offered opportunity to highlight its absence, none required them to check specifically if the BVA Assembly was fitted. It was apparent from the drills witnessed that it was feasible to conduct the Prove the Gun drill

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[11] Pamphlet 21states that mobile phones or other personal electrical devices are not to be switched on within 5m of any electrically operated weapon system or ammunition point. CR2 has an electrically operated weapon system and the TVE is an electro-explosive device. The Panel draw recommendations from this contravention.

[12] Conducting a Red Drill is relatively common and routinely tested in Weapon Handling Tests. The most common cause for a Red Drill is 'no TVE being loaded' and tends to occur at the start of firing. The reason is equally common and a consequence of the Loader forgetting manually to operate the ATL.

without noticing the absence of a BVA. The absence of a drill, which specifically required a check to confirm the BVA Assembly is fitted, made the accident more likely to happen.

1.6.18. In summary, the Panel had proved it was possible to fire the L30A1 gun with the BVA Assembly missing. This cannot be done with the gun in its normal manner, as the ATL does not load a TVE. However, if a Red Drill is followed and a TVE hand loaded on the FNA, the firing circuit can initiate the TVE, the propelling charge would then be ignited and the gun would fire.

The Circumstances that led to the Gun being Fired without the BVA Assembly fitted

1.6.19. On 14 Jun 17, CR2 (DS39AA) was allocated to tank crew C/S 30B, who used it during the morning to complete their ACT. This was done successfully with no defects or misfires recorded. Having finished and as DS39AA was not scheduled for any more range activity, C/S 30B's Loader started post-firing cleaning of its main and secondary armaments. This was expected and routine. Cleaning of the main armament involved removing and cleaning the BVA Assembly. Although not mandated, it was accepted custom and Good Practice, to have the BVA inspected by a qualified armourer, prior to it being refitted. However, as the armourers were not available, the BVA Assembly was cleaned and returned to DS39AA, but placed inside the Ration Stowage Box, in line with what the crewman believed was common practice. Had C/S 30B realised DS39AA would be fired again they would not have removed the BVA Assembly for cleaning. C/S 30B being unaware of the subsequent shoot made the accident more likely.

1.6.20. It was intended to conduct 4 x ES. They were not scheduled on the range-firing programme, but were to be conducted on an opportunity basis, if time allowed after all planned activity had been completed. The decision to go ahead with them was taken at approximately 1430hrs, some 30minutes prior to the ES crew mounting DS39AA. The late notice of this decision was expected and understandable, owing to crew performance, equipment availability or weather conditions frequently adding volatility to range programmes. Equally, the decision to choose DS39AA at short notice was reasonable. It had been used during the morning, had proven to be reliable throughout the range package and crews were accustomed to changing tanks.

1.6.21. The ES crew were aware of the plan to conduct ES, but did not know which CR2 they would be using. It was common practice for crews to change tanks. In doing so the material/equipment state would be discussed along with the condition of the weapon and communication systems. This process was known as a Hand Over/Take Over (HO/TO). HO/TOs clearly took place successfully, but it was surprising no evidence could be found of a formal stipulated procedure for doing this. Regardless, the C/S 30B Commander and Loader would not have been available to conduct a HO/TO, as they had left the range on other business. As no HO/TO of DS39AA between C/S 30B and the ES crew took place, the ES crew on mounting DS39AA would not have been aware of its material state and specifically that the BVA Assembly was not fitted to its main armament. The lack of a HO/TO of DS39AA between C/S 30B and the ES crew made the accident more likely.

1.6.22. Having mounted at 1500hrs and loaded the required ammunition[13], the ES crew proceeded onto the range. At 1525hrs white smoke was seen coming out of the CR2's open turret hatches, accompanied by a loud hissing noise. The Commander was then seen rapidly trying to leave through his hatch. When waist-level with the top of the hatch, there was an explosion, which threw him some 5m into the air. He landed on the grass 6m to one side of the CR2. Immediately after the explosion, 2 x large, violent jets of flames were seen coming from both turret hatches, for some 5-8 seconds.

[13] For all the 4 x ES shoots a total of 4 x 120mm Discarding Sabot Training (DS-T) rounds with their propelling charges (CP-DS-T), 4 x 120mm Squash Head Practice (SH-P) with their propelling charges (CP SH-P), 400 x 7.62mm Ball for the Chain Gun and 9 x Tube Vent Electric (TVE) for initiating the 120mm charge.

The Accident – Breech Explosion and Turret Fire

1.6.23. On firing the main armament, normal levels of rearward obturation were not provided, owing to the absence of the BVA Assembly and Obturator Pad. This resulted in the hot gases produced from the rapid burn of the SH-P Propelling Charge escaping through the Breech Block, causing the loud hissing heard by witnesses. As more propellant burnt the pressure in the gun's chamber rose until reaching a point, without the BVA Assembly fitted, at which the structural integrity of the breech was compromised. This resulted in its catastrophic material failure, with the Upper Breech Block detaching from the Breech Assembly at the same time as the projectile was expelled from the muzzle. The hot, high-pressure gases from the exploding Breech flooded the inside of the crew compartment, where they ignited the 4 x Propelling Charges that couldn't be accounted for[14]. The seat of this violent fire was on the turret floor in the Loader's Station, confirming the Propelling Charges had not been stowed in the Charge Bins as is mandated. Had they been so, they almost certainly wouldn't have caught fire. Once they had been ignited, it would have been impossible for the crew to extinguish them.

1.6.24. Despite no previous recorded incidents of Propelling Charges catching fire in a CR2 during training, the potential danger posed by an accidental ignition is recognised. Their correct stowage, in the CR2's charge bins (with lids closed, at all times, except when being handled), is mandated and emphasised. Correct practice is taught and reinforced throughout a tank soldier's career and tested during Weapon Handling Tests (WHT), where neglecting to follow the correct drill, to the letter, results in a WHT failure. All RTR soldiers interviewed at CMR knew of this requirement.

1.6.25. The only reason that might 'justify' not stowing Propelling Charges correctly was in the perceived advantage gained in increasing a crew's speed and rate of fire. This was especially the case for the ACTs 3 x round SH-P engagements. However, having reviewed the Army Operational Shooting Policy (AOSP) requirement and informed by expert view of AFVTTS Gunnery Wing Instructors, the critical path during this engagement is not in time taken loading the gun, but in locating the target and laying the gun onto it.

1.6.26. Within BADGER Squadron both the ES Commander and Loader, as RIGs, were responsible for assessing WHTs. They were also tank commanders of their own tanks and aware of their responsibilities as such for the overall safety of their tank and crew and for ensuring drills were conducted correctly. Both the ES Commander and Loader would have known Propelling Charges had not been stored correctly during the ES and that this was in contravention of mandated practices. Moreover, the ES was not the only occasion during the CMR range package they had permitted this[15]. The reasons why junior tank-crew members did not challenge or report the conduct of what they knew to be unsafe practices by their seniors, merits attention. It should be the responsibility of all leaders to set an environment that encourages a positive Safety Culture in which challenge is respected[16].

1.6.27. The simplicity of the ES and the absence of (time) pressure on the crew meant there would be no advantage or benefit gained through incorrect stowage. This might have become normalised behaviour[17] where the risks of not following set procedures, in failing to materialise, encouraged further deviation to continue. I suspect the ES Commander and Loader had adopted the habit of incorrect stowage perceiving it to offer advantage and that this had become normalised. There is not one shred of

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[14] This was determined from the ammunition loaded onto DS39AA, physical evidence found post-accident and trial burns.

[15] On interviewing the Loaders from the tanks the ES Commander and Loader normally commanded, it became clear that both had permitted their crews to operate with the Propelling Charges incorrectly stowed outside the Charge Bins. This had been done during Live Fire Exercises and even ACTs.

[16] The key elements of a Safety Culture are derived from a combination of just, reporting, flexible, learning and questioning cultures.

[17] Or in this case akin to 'Normalisation of Deviance'. This is a recognised and documented practice.

evidence to suggest they set out to cause harm. Regardless, the fact the Propelling Charges were not stowed correctly in their Charge Bins made the outcome of the accident worse.

Post-Accident Response

1.6.28. In considering all aspects of the post-accident response, the courage of those members of BADGER Squadron especially, who selflessly risked their lives to recover their comrades from DS39AA, merits formal acknowledgement.

1.6.29. The benefits of a comprehensive, coherent, well-planned and understood accident response plan played out[18]. The immediate response of the range staff in closing the ranges and calling the emergency services was timely. Unit action, including senior Squadron staff insisting on a 15-minute pause before mounting DS39AA, owing to very real threat of it exploding and causing further injury, was entirely sensible. The response from unit medics and the civilian Emergency Services proved exemplary. The first unit medic arrived within 4 minutes, the second 2 minutes later. The first paramedic was on-scene within 14 minutes of being called. Within 30 minutes a significant rescue and medical capability was present. This was to involve 3 x Air Ambulances, 2 x Ambulances, 2 x Fire and Rescue teams and the Police and all despite CMR's relative isolated location. It is testament to the speed of response and especially the skill of unit military and NHS medical staff that all four casualties left the range still alive.

Personal Protective Equipment (PPE)

1.6.30. The PPE mandated for operating CR2 is stated in AOSP, Armoured Vehicle Standing Orders (AVSO) and Pamphlet 21. Combined these publications mandate wearing the following: boots, Enhanced Combat Body Armour (ECBA) when live-firing, ear and eye protection and sleeves rolled down. There is no authoritative document that states the clothing to be worn.

1.6.31. BADGER Squadron's administrative instruction for the range package instructed that Black Coveralls be worn[19]. This form of dress is unique to the RTR. Whilst the benefits it brings to Regimental identity, cohesion and the Moral Component should be respected, its material composition and lack of fire retardant, result in it offering less protection than the standard issued Personnel Clothing System (PCS).

1.6.32. The ES crew were provided with all mandated PPE. Despite there not being an authoritative clothing directive, the nature of the explosion and ferocity of fire, was such that no practical PPE solution would have offered significant protection. Regardless, PPE worn by armoured vehicle crews warrants review and consideration as part of the Safety argument presented in CR2's SECR.

Conclusion

1.6.33. This accident took place during routine live-fire training. The CMR range package had been well planned and its conduct successful. Pass rates of the ACT were good, with primary aims and objectives, being achieved with time to spare. This success offered the opportunity for ES, which the CO allowed. During the conduct of these ES, two 'firsts' conspired and resulted in a sequence of events that proved catastrophic. This was the first time a CR2 main armament had been fired without a BVA Assembly fitted and this was the first time Propelling Charges had caught fire inside a CR2 during training.

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[18] BADGER Squadron had practised the drill of extracting causalities from the CR2's fighting compartment in preparation for their range package, which meant the drill was well executed on the day.

[19] The RTR traditionally wear black coveralls. They are the only unit to do so, with the tradition stemming from the Regiment's history.

1.6.34. The design of the CR2's main armament in not 'failing-safe' and firing, despite an essential component missing, was flawed. That it had taken the Armoured Corps some 20+ years to discover should not lessen the significance of this flaw. There was no justifiable reason for the ES Commander and Loader to deviate from mandated procedures regarding the correct stowage of Propelling Charges. Both were RIGs and tank commanders in their own right and understood fully that their drills were incorrect. However, I am convinced what they didn't know was that their actions would contribute to such a catastrophe

1.6.35. This tragic accident serves as a reminder of the dangers associated with the conduct of military training. By necessity, military training must be realistic and demanding, if it is to prove effective in generating the military capabilities needed to win in combat. Training is designed to be progressive in terms of its complexity and challenge. For BADGER Squadron, even though this range package sat early in their training progression and was designed for the lower-end of complexity and challenge, the inherent risks associated with operating and live-firing Main Battle Tanks still remained.

1.6.36. Throughout this SI, the high levels of professionalism and camaraderie displayed by BADGER Squadron and the RTR have stood out. I am sure the shock of this accident alone to this close-knit family will compel exhaustive efforts to prevent this from happening again. In writing these comments, my thoughts are with the families and those who were close to Cpl Darren Neilson and Cpl Mathew Hatfield. On behalf of all members of the DSA, I offer them my most sincere condolences.

Director General Defence Safety Authority