What Value Analysis? The Historical Record of Fratricide[1]

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ABSTRACT

The primary aim of Combat Identification is to improve operational effectiveness; however, a secondary, high profile, aim is the reduction of fratricide. This paper describes two pieces of work conducted during the past year on the analysis of the historical record of fratricide:

- Analysis of root causes of fratricide.
- A determination of what can be achieved by sharing national data and analyses of fratricide incidents, the barriers to doing this, and recommendations.

Using the background of examples of fratricide incidents, the paper discusses the problems of analysing incidents with a view to determining root causes. A categorisation schema for analysing fratricide incidents is proposed and findings on the common causes of fratricide are presented. One of the fundamental problems of conducting analysis in the international arena is the use of different definitions of terms. The paper discusses differing national definitions and makes recommendations for common terminology. There are also recommendations on best practice in collecting data. The advantages which could be achieved from sharing data and analyses across nations, and the barriers to doing so, are also discussed.

1. Introduction

Fratricide is a statistically rare, but potentially high impact, occurrence in modern warfare. Whilst the numbers of incidents are very small in real terms, the reduction of losses due to enemy action serves to accentuate the deaths and injuries caused by so-called "friendly fire". Table 1 shows the attributed causes of UK and US deaths during the warfighting phase of Operation TELIC / Iraqi Freedom (21 March to 30 April 2003)[2]. These data are illustrated graphically at Annex A.

Cause	UK	%	US	%
Accident	17	51.52%	30	21.58%
Killed in Action	8	24.24%	90	64.75%
Friendly Fire	6	18.18%	19	13.67%
Natural Causes	1	3.03%		
Unconfirmed	1	3.03%		

Table 1: UK and US deaths in TELIC / Iraqi Freedom (warfighting phase)

The complexities and high tempo of modern warfare can lead to confusion on the battlefield; the fog of war remains a problem even with advances in technologies. In an effort to learn from fratricide incidents, with a view to reducing their occurrence in future, Boards of Inquiry examine each incident and identify the underlying causes of incidents, which can then be used to generate Lessons Learned. However, such analysis is not without its difficulties, and sharing such analyses and findings between nations is not always easy. This paper describes a number of recent initiatives to improve our

[2] Data are taken from: http://www.mod.uk/DefenceInternet/FactSheets/OperationsInIraqBritishFatalities.htm.

understanding of fratricide and the sharing of that knowledge with our coalition partners.

2. Example Blue-on-Blue Incidents

To place the work in context, we start by examining some case studies from March 2003, during the combat phase of Operation TELIC. The information provided here is taken from the UK MOD Board of Inquiry reports posted on the publicly-available MOD website[3].

2.1 Case Study #1: RAF Tornado – 22 March 2003

Two UK Tornado GR4s were participating in a combat strike mission over Iraq as part of Operation Iraqi Freedom. Whilst returning to base after a successful sortie, one of the aircraft was targeted by a US Patriot missile battery. The Patriot system assessed the aircraft as an anti-radiation missile (ARM), and the Patriot crew, perceiving a threat, acted in self-defence by launching a Patriot II missile to intercept it. During this engagement the RAF Tornado was shot down and its two crew members were killed.

The immediate cause of the incident was the fact that the Patriot system classified the RAF Tornado as an ARM, determined that it was a threat, and shot down the aircraft. But the subsequent Board of Inquiry determined that there were a range of factors underlying this event:

- Crucially, unknown to the crew of the Tornado, there was a fault with their Mode 4 IFF system. A Mode 4 response would have prevented the Patriot system from classifying the Tornado as a threat.
- There were problems with the classification system on the Patriot missile system: the criteria used in the system were too generic, and as a result the Tornado's flight profile fitted into the threat criteria. Furthermore, the associated Rules of Engagement were not robust enough to stop the crew engaging a friendly aircraft.
- The Patriot crew were trained to react quickly, engage early and to trust the system; they had about one minute to react. The crew were fully trained but that training had concentrated on generic threats, rather than those specific to Iraq or on identifying false alarms.
- Because the Patriot's communications suite was still in transit from the US, contact with Battalion HQ and other units was via a radio relay, so the Patriot crew didn't have access to the widest possible 'picture' of the airspace around them. The Board of Inquiry concluded that better situational awareness would have helped the crew.
- The unencrypted Mode 1 IFF codes were not loaded into the Patriot system, although the encrypted Mode 4 codes were. This was possibly due to the communications problems. The Board concluded that this was a contributory factor.
- Whilst the Tornado was following the agreed speed and height procedures for a return to their air base, this took them into the arcs of the Patriot missile system; a different routing might have helped. And while procedures were in place to deal with a situation where an aircraft's IFF system had failed, the Tornado crew didn't know that it had failed and so couldn't employ them.

We can see from this that, if you have learnt to rely on technology (such as an IFF system) and that technology fails, then you will have problems. We need "identification in depth" – a series of measures that provide a robust solution to technology failures and human errors.

[3] www.mod.uk (search on "Board of Inquiry").

2.2 Case Study #2: Queens Royal Lancers – 25 March 2003

This incident took place on the outskirts of Basra and involved several UK Challenger-2 tanks. It was a complex situation, and the Board of Inquiry report describes in great detail the positions of the troops involved and what was going on at the time. The key events were as follows.

A Challenger-2 (Call Sign I-10) of Egypt Squadron 2nd Royal Tank Regiment was positioned on the eastern side of a canal. The Commander of Call Sign I-10 identified 'hotspots', which he considered to be enemy soldiers, to the north-west of his location. Having obtained permission to engage, Call Sign I-10 fired a high-explosive round that landed near two other Challenger-2s (Call Signs N-11 and N-12 from the Queens Royal Lancers), injuring several crewmen. A few minutes later, the movement of Call Sign N-11 (QRL) reversing in the same location was mistaken for an enemy combat vehicle. This resulted in a second round being fired by Call Sign I-10 that directly hit Call Sign N-12, instantly killing two soldiers in the tank.

This was a complex situation and the Board of Inquiry identified a lot of contributory factors:

- There were oversights in planning. There was a significant terrain feature – a dam – in the area but the Brigade staff were not aware of its existence in the planning phase of the operation. The dam appeared on the 50,000 series maps, but not on the 100,000 series; nor did it appear on the available aerial photographs. Had the Brigade known of its existence the position of the dam could have been used to clarify orders.
- There were failures in the passing on of essential information. Boundaries of different units, and the changes in those boundaries, were not effectively briefed; and there was confusion about the location of friendly forces.
- There were a number of problems with command and control. The infantry Company HQ that was being supported by Call Sign I-10 had been split for a variety of reasons; this resulted in the 2nd in Command not having sufficient time to coordinate the battlespace with Battlegroup HQ, nor to keep up with boundary changes. This had a detrimental effect on the ability of the Company to receive, collate or disseminate information to the troops. In addition, firm command and control of some of the troops was not maintained, and briefings were not as thorough and as structured as they should have been; as a result the two elements, of infantry and armour, "failed to act in a unified manner".
- There were a range of factors that led to a lack of situational awareness. Assumptions were made about who knew what, and the tactical briefings and handovers of positions as the task proceeded were not as thorough as they should have been. There was a general lack of 'inquisitiveness'; as a result, key pieces of information about boundaries and the location of flanking units were not clarified with either the Battlegroup or Company HQ. The orientation of the map, the Gun Position Indicator, and the Laser Range Finder on the 'shooter' platform were inaccurate. The Board determined that if the data had been plotted accurately then it would have been clear that the target was on the friendly, rather than the enemy, side of the canal. All of this resulted in an incorrect assessment of the enemy threat.
- The Board of Inquiry determined that the crew of the 'shooter' platform did not complete the target identification process correctly, and that this resulted in the target being incorrectly identified as enemy.
- Finally, there were a number of failings in tactics, techniques and procedures. There were failures in the basic military skills involved in the handing over of tactical positions. There were misunderstandings by the crew of the 'shooter' Call Sign I-10 as to the arcs of fire and the enemy

situation; arcs had not been coordinated between the troop and the platoon. The Board decided that, if greater efforts had been made to coordinate arcs of fire between the troop leader and platoon commander, misunderstandings might have been rectified. The identified 'hotspots' were reported over the Company radio net, but grid references were not used, apart from the final contact report. This led to a critical misunderstanding of where the supposed enemy was located. And there was ineffective coordination between adjacent units; there should have been a systematic conduct of cross-boundary liaison and de-confliction.

2.3 Case Study #3: 539 Assault Squadron Royal Marines – 30 March 2003

This is another confusing situation[4]. In summary, 539 Assault Squadron Royal Marines were operating ashore on the Al Faw Peninsula. Two landing craft, one Mark IV and one Mark V (the eventual victim), with two inflatable raiding craft (IRCs), were on patrol on the river to investigate possible Iraqi radio transmissions. The Mark IV took up a blocking position on the river, while the Mark V and the IRCs headed up a tributary. The Mark IV then came under fire, from an unknown source, and reported the contact. The Mark IV then saw an unidentified craft coming towards them, which subsequently turned around to head towards friendly troops at a river Crossing Point which had previously been established by the Royal Engineers. The Mark IV again reported this sighting.

Later the Mark V and two IRCs moved back down the tributary to re-join the Mark IV. On returning down the tributary, the Mark V landing craft prepared for action by lowing its mast and its ensign, which reduced its silhouette but also made it more difficult to identify. They came within sight of troops at the Crossing Point who were unable to identify the craft. By the time the Mark V landing craft came into the sight of the troops at the Crossing Point, those troops were already primed to believe there was a hostile craft around and they engaged the landing craft with Milan missiles, and with heavy and general-purpose machine guns. The Mark V landing craft was struck by a missile on the port side; one of the Royal Marines died later that day at the Field Hospital.

The Board of Inquiry came to a number of conclusions as to the causes of the incident.

- Firstly command and control. There were problems with battlespace management in the 3 Cdo Bde rear area, partly due to the fact that 539 Assault Squadron conducted their planning and operations in isolation from the Brigade main effort. In addition, there was no clear chain of command – or associated lines of communication – at the Crossing Point; Standard Operating Procedures were not used consistently at all levels within 3 Cdo Bde; and standard battle procedures were not followed by 539 Assault Squadron during this stage of the operation.
- Communications between the units at the Crossing Point, and others in the vicinity, including the assault craft, were unreliable and convoluted. The amphibious assault units didn't have adequate means of identifying themselves to friendly forces.

2.4 Case Study Causal Analysis

From these three case studies we can note the following:

- Each incident has a wide range of underlying causes.
- Whilst technology problems do feature, many causes come from other Defence Lines of Development.
- There are similarities in the causes across the different incidents.

The multiple causes associated with any incident contribute to a chain of events which lead to the eventual fratricide incident. In this

[4] This incident was reported at length in a BBC documentary.

case the phrase "an accident waiting to happen" is a useful one. All systems have latent factors which lie within a system, which don't usually cause any problems (see Figure 1). It is only when active factors occur that the chain of events is completed and an accident – or in our case a fratricide incident – occurs.

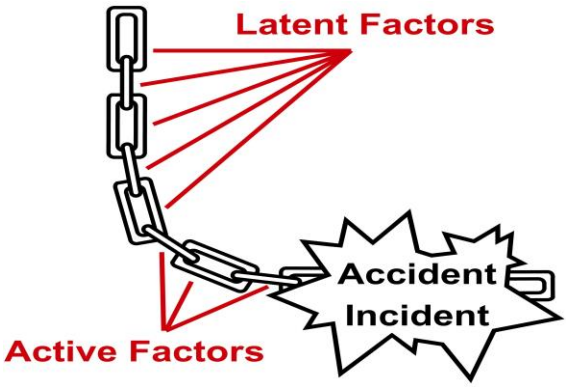

Figure 1: Latent and active factors

Professor James Reason's work on safety-critical systems provides a useful analogy for understanding failures which lead to fratricide events. Imagine the system represented by slices of Swiss cheese (see Figure 2). Each slice represents different factors which can contribute to the chain of events leading to an incident: Cultural factors; Organisational factors; Management/procedures/supervision; Preconditions/attitudes/supervision; and Unsafe acts.

The system has vulnerabilities, represented by the holes in the cheese. When several slices are stacked, it is unlikely that the holes will align, but occasionally they do; an error is able to slip through all the holes and an accident occurs.

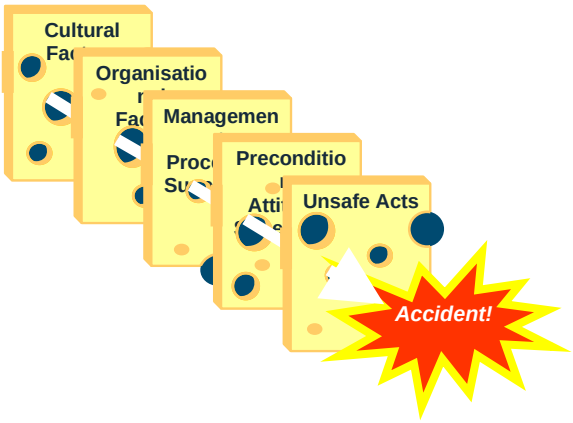

Figure 2: The 'Swiss cheese' model

When we examine the contributing factors for our three case studies, we find that there are commonalities in the causes across the incidents, see Table 2.

Causal Factor	Case Study
Equipment Operation	#1: Patriot classification scheme #1: Tornado IFF
Procedures	#1: Patriot firing doctrine & procedures #2: CR-2 basic military skills #3: 3 Cdo Bde and 539 ASRM in Al Faw Peninsula
Communications	#1: Patriot communications #3: Unreliable & convoluted comms at the Crossing Point in the Al Faw Peninsula
Battlespace Management	#1: Tornado routing & airspace control #3: 3 Cdo Bde in the Al Faw Peninsula
Planning	#2: Challenger-2 operations around the dam
Passing Information (leading to poor situational awareness)	#2: Boundaries and location of friendly forces in the CR-2 incident
Command and Control	#2: Coordination in the CR-2 incident #3: Chain of command at the Crossing Point in the Al Faw Peninsula

Table 2: Commonality of causes

We should be able to learn from these similarities in common causes, and from that aim to find commonality in solutions. But there are problems we face in doing this.

3. Root Cause Analysis

3.1 Boards of Inquiry Analyses

Boards of Inquiry in the UK are conducted in order to establish the circumstances surrounding serious accidents and incidents. Each Board determines its own approach to data collection, investigation and analysis; there is no agreed schema in the UK for categorising the root causes. It is therefore difficult to:

- Aggregate analyses across different incidents.
- Compare root causes of incidents across different types of operation.
- Determine trends in the underlying root causes and determine whether new equipments, procedures or training are improving things.

Beyond these difficulties it is, of course, even more difficult to compare data and analyses across coalition partners.

3.2 Investigation of the Historical Record

In response to the difficulties listed above, the MOD initiated research to investigate the historical record of fratricide incident in order to identify causal factors[5].

The aim of this work was "to investigate historical causes of fratricide and identify the key causes and contributing factors in order to formulate recommendations for reducing their likelihood in the future and for improved representation of such causal factors in representational models". The analysis was based on detailed case studies, using Board of Inquiry reports, using a structured approach to the analysis of the data. The intent was to identify key factors which were cited as contributing factors to the incidents, to identify trends and patterns, and to make recommendations about how we could improve things.

Ten fratricide incidents were examined in detail from:

- Operation GRANBY (US Operation Desert Storm) – 1991
- Operation PROVIDE COMFORT (humanitarian aid in northern Iraq) – 1994
- Operation TELIC (US Operation Iraqi Freedom) – 2002/2003.

These incidents were selected on the basis of the *detail* and *reliability* of the information sources available. Usually only Board of Inquiry reports will provide sufficient detail.

Before attempting to identify the causes and contributing factors of each incident, an event timeline was constructed, capturing:

- The date, time and location of events leading up to the incident, together with who was involved at each stage.
- A description of what happened.
- A reference number for the event, so that it could be correlated with the next stage of the analysis.

This enabled the analysts to extract the relevant information from the, often very detailed and complex, data sources, and to develop a thorough understanding of the chain of events. Where possible times of events were also included (if they were deemed to be accurate). This supported the identification of causal factors and also provided a high-level appreciation of the *directional* relationships (i.e. which causes gave rise to others).

[5] This research was funded by DG (Scrutiny & Analysis): "Investigation of historical records to identify causal factors behind fratricide incidents" (C Outteridge, C Blendell, J Molloy, R Pascual, QINETIQ/D&TS/CHS/CR0602195/1.0, 31 March 2006)

3.3 Fratricide Causal Analysis Schema

To ensure that all members of the project team analysed the incidents against the same set of parameters a common categorisation schema was evolved. This schema was based on earlier work which had been validated by the international community under the work described in Section 4 below.

The schema is a simple structure consisting of 12 high-level causal categories. Each main category is then broken down into associated sub-categories. The high-level causal categories are failures in:

- Command and control
- Procedures
- Equipment/technology
- Situational awareness
- Misidentification
- Physical/physiological factors
- Pre-deployment preparation
- Team work
- Environmental factors
- Communications/information
- Platform configuration
- Cognitive factors

The full schema is shown at Annex B.

There are many different categorisations which you could use for this purpose, and this is not intended to be the perfect one (problems experienced with the use of the schema are discussed later). But it provides a consistent approach which could be used by all the members of the analysis team, and which can be shared between different nations.

Once the event timeline had been established for an incident, the team then moved onto analysing the causal factors against the schema. This analysis established:

- The high-level causal factor category (such as Command and Control).
- The sub-category (such as Briefing or Planning – see Annex B).
- A brief description of the cause or contributing factor.
- The cross-reference back to the event timeline.

The analysts ensured that all potential factors (however minor they might first appear) were identified, discussed and documented. The findings were then presented in tabular format, using the Categorisation Schema, so that a high-level comparison could be made across the incidents.

As noted before, incidents rarely (if ever) have a single cause. There are often complex inter-relationships between contributing factors, which can occur at different levels (strategic, operational, tactical) and with different levels of impact. Examination of the detailed inter-linking relationships between factors was outside the scope of this project.

3.4 Identifying Root Causes

As discussed earlier, to determine the primary causes of any incident it is essential to explore the causal chain. As we have seen from the case studies examined above, fratricide incidents are rarely a direct result of a poor decision made at the "point of fire". Any incident is the culmination of a series of combat activities, and errors can occur at any of these stages:

- Root causes often originate from decisions made at the higher organisational level. Understanding how a situation has "come to be" is essential in order to identify measures for reducing the likelihood of such incidents occurring in the future.
- In many cases, errors prior to the actual engagement remain latent (that is they don't necessarily cause an incident unless the wrong conditions arise) and then a later event (typically a second error by the shooter, the victim, or someone in the command chain) combines with this latent error to turn it into an active error (see Figure 1).

Previous analyses of the causes of fratricide incidents have illustrated that there is a tendency to take too "local and narrow" a view, and only to consider the direct immediate causes of the event. A complete

understanding of an incident is only possible when all factors have been identified, considered and placed into the full systems context.

It must be pointed out that there are a wide range of constraints and limitations of this analysis:

- Although the team made great efforts to ensure consistency when categorising causes, the causes were allocated to categories using the analysts' subjective judgement.
- The causal factor frequency analysis is based on a small number of incidents; so care must be taken when making assumptions about the overall significance of the different factors.
- The classification schema includes a high-level category for "situational awareness". In many cases the team found that, although a factor might have contributed ultimately to the development of poor situational awareness, it was often more appropriate to assign the issue to a lower-level category, such as "information sharing, or "coordination". As a result, the frequency analysis appears to indicate that poor situational awareness is less of a significant factor than it actually is.

Within these constraints the team conducted high-level analysis of the prevalence of different causal factors, to highlight key patterns and trends in causality across the sample of incidents. In order to determine the relative significance of the 12 categories, the team counted the number of issues that appeared under each of the categories (for all 10 incidents). The results of this analysis is shown in Table 3 and, graphically, at Annex C.

Causal Category	Frequency
Communications/Information	42
Command and Control	27
Procedures	27
Misidentification	25
Cognitive Factors	22
Teamwork	15
Pre-deployment Preparation	14
Situational Awareness	10
Physical/Physiological	9
Equipment/Technology	5
Environmental	3
Physical Configuration	1

Table 3: Relative significance of causal categories in fratricide incidents

From these data we can see that the common causes of fratricide are often non-technological nature, and shows the prevalence of human factors issues. (Note the point that was made earlier about the under-representation of Situational Awareness as a category.) The majority of all of the 57 sub-categories in the Fratricide Causal Analysis Schema were identified across the sample of 10 incidents. The full results of the analysis are documented in the report referenced at Footnote 5.

3.5 Conclusions from UK Historical Analysis

Drawing some conclusions from the work presented so far in this paper:

- The value of historical analysis should not be underestimated. In order to gain an understanding of a problem it is necessary to examine real-life incidents in detail to identify common patterns and themes.
- In order to get the most out of this analysis *very* detailed reports of the incidents are required; these are usually only available from Boards of Inquiry.
- A categorisation schema is needed to allow comparison of causes across incidents.
- Fratricide incidents rarely have a single cause, it is necessary to examine the chain of events in detail, and not merely focus on

the immediate events surrounding the engagement itself.
- The causes cannot be examined in isolation; the relationships between the factors must be addressed, and these are often complex. Understanding these complex relationships requires more in-depth forms of analysis and modelling than this study was able to do. But it is this level of analysis which is really needed in order to identify appropriate interventions.
- As we have seen, and probably already knew, the common causes of fratricide are often non-technological in nature.
- The most prevalent categories of causes of fratricide, as identified by this particular analysis, are: Communications/ Information, Command and Control, Procedures, Misidentification, and Cognitive Factors. But poor Situational Awareness is a major contributory factor; the design of the schema means that this factor is under-represented in the results.

4. International Collaborative Research on Fratricide Mitigation

4.2 TTCP JSA Action Group 13

The work discussed so far has concentrated on UK analysis of fratricide incidents, but in many cases fratricide is a coalition issue, bringing the need to examine the problem and its potential solutions in a multi-national environment. With this is mind The Technical Cooperation Programme (TTCP) initiated an Action Group[6] to "establish a broad appreciation across the TTCP community on the evidence derived from the historical record of the past decade as to the trends in fratricide or 'friendly fire' incidents, to position this evidence in the context of military casualties more generally, to extrapolate those trends into the future as network-enabled operations gain momentum, and to postulate approaches that could/should be taken to mitigate such fratricide without negatively impacting on mission success or overall casualty rates, including through the development and application of technology".

As part of AG13's work programme, a workshop was held in UK in October 2005 to generate an understanding of:
- The different nations' approaches to the collection of data on fratricide, near misses and non-battle casualties.
- The nature of the different national records.
- The analyses conducted on those records.
- The validity and utility of those records for different purposes.
- And the potential for collaborative sharing of records, analyses and findings.

Some key points from the workshop and subsequent work are discussed below.

4.3 Definitions

The first problem the Action Group encountered was that we were all talking at cross-purposes about fratricide, because we were all working to different definitions. The key factors that differ in the various national definitions are:
- *What was the intent of the shooter?* Did he intend to kill or destroy the target – or was it an accident?
- *Who was the victim?* Was it friend, or a neutral? In other words, does the definition include what some might define as 'collateral damage'.
- *What was the result of the engagement*? Death or wounding – serious or minor? Or damage to a major piece of equipment.

These differences confound any attempt to compare data across nations.

To overcome the problems with definitions we generated agreed definitions of what we meant by both *fratricide* and *friendly fire*. It must be emphasised that there is no intention that these definitions should be formally adopted by the nations for any purpose beyond that of the Action Group research. They are merely to

[6] TTCP Joint Systems and Analysis – Action Group 13 Fratricide Mitigation. Participating nations: Canada (lead), US, Australia and UK.

enable us to work consistently and coherently, for example, in comparing fratricide statistics across nations.:

- "A **friendly fire** event is the deliberate engagement of non-enemy entities by friendly forces in the belief that the entities are enemy. 'Entities' includes both personnel and materiel."
- "**Fratricide** is a friendly fire event that results in a fatality."

We then defined a range of different types of friendly fire events:

- **Type 1**: An event resulting in one or more combatant fatalities (that is, fratricide).
- **Type 2**: An event resulting in injury to combatant personnel, but no fatalities.
- **Type 3**: An event resulting in damage or destruction to materiel.
- **Type 4**: An event where no injury or damage occurred – a 'near miss'.
- **Type 5**: An event resulting in death or injury to non-combatants.

Note that a friendly fire event could include several different types of event.

There were further discussions about what was meant by a 'near miss'. It is an ambiguous term. On the one hand it could mean that the potential shooter almost pulled the trigger, but didn't; this is close to the definition of 'near miss' in the UK Health and Safety community. On the other hand it could mean that the shooter actually fired – but missed the target, which is the more familiar use in the military domain.

We agreed on the following definitions:

- "A **near miss** is a potential friendly fire incident that could have resulted, but did not result, in human injury, property damage or other form of loss."
- "**Category A near miss**: The potential perpetrator prepared to engage the target, but realised at the last minute that it was friendly and did not shoot."
- "**Category B near miss**: The shooter engaged the friendly unit, but the shot missed and no damage was done to personnel or equipment."

The point about 'at the last minute' in the Category A definition is important, as personnel will often be preparing to shoot at as yet unidentified targets whilst they are engaged in their situational awareness gathering and target identification, but this is not important until they have made a mental commitment to shoot.

Of course we are far less likely to get data on near misses than on actual fratricide events, because perpetrators are less likely to own up! But the data, when we can get it, can shed just as much light on the causes of fratricide as real incidents do. There is more potential for getting data on near misses – of both sorts – from exercises, where systems are instrumented, observers can debrief participants (including the potential 'victim'), and there are fewer consequences from making mistakes. The question of whether data from exercises have validity in telling us about fratricides in real operations will be discussed later in this paper.

4.4 Data Collection Policy and Practice

In doing this work our aim is, in the end, to make a contribution to reducing the incidence of fratricide. To do this we need to understand what the underlying causes of fratricide incidents are. We also need to determine the most cost-effective remedial actions. The historical record (from both operations and exercises) can contribute to this understanding. But to facilitate this we need a more structured approach to both data collection and its subsequent analysis. The workshop generated requirements for a good data collection policy and good practice for data collection, as listed in Tables 4 and 5.

Requirements for a Good Data Collection Policy	
1	A champion is needed for fratricide data collection.
2	Engage training commanders early in exercise planning.

3	Those collecting data need to know: what, why and how.
4	Centralised data collection facilitates sharing and collation of national records.
5	Type 4 friendly fire data (where no injury or death occurred) also has utility.
6	A joint service approach to investigation of friendly fire is required.
7	A coalition approach to investigations would assist in data sharing.
8	A minimum set of baseline data should be collected in all cases.
9	Strongest efforts should be made to collect data from operations.
Notes	
1	A champion for fratricide / Combat ID issues can help promote the importance of data collection.
2	Early engagement of training commanders, during exercise planning, will facilitate their assistance in data collection and in making modifications to the exercise to get data that would support activities other than the main exercise objectives. There will be tensions between the exercise and data collection objectives; with the Cdr's agreement a portion of the exercise might be set aside where data collection/analysis could be a priority.
3	Those collecting data need to know: what they should collect, why they should collect it, and how to collect it.
4	Centralised data collection implies the need for common data standards and definitions, and for quality assurance.
5	Data on near misses can provide insights in understanding the causes of fratricide.
8	Data collection must be driven by the purpose to which the data will be put; but, as this will not necessarily be known at the time of planning the collection, a minimum set of standard baseline data which should be collected in all cases[7].
9	The strongest possible efforts should be made (subject to practical, legal and ethical limits) to collect data from operations. Other than that exercises will be the major source of data.

Table 4: Requirements for a good data collection policy

Good Practice for Data Collection	
1	Data collected should include the context of the incident.
2	Training/exercise data is important as a complement to data from operations.
3	Data collection should focus on both shooter and target.
4	Data should be collected as soon as possible after the event.
5	Avoid focussing on technical/instrumented data; face to face interviews are a rich source of data.
6	Where possible there should be a 'no blame' data collection policy.
7	Interview those involved separately – and in confidence.
8	Collect a core set of data elements – in operations or training.
9	Collect data from historical and current operations, and training.
10	Legal and ethical issues must be taken into account.
11	Boards of Inquiry should call on those with expertise in friendly fire.
Notes	
1	Information/data collected should extend beyond the specifics of the friendly fire incident to provide the operational context (so that the balance of risk between combat effectiveness and fratricide can be understood in later analyses).
6	It is recognised that a 'no blame' data collection policy may conflict with legal requirements in the case of fratricides in operations.
9	Each source of data – historical and current operations, and training – has its different strengths and weaknesses.
11	The advice of those experienced in friendly fire issues will help to ensure that the Board of Inquiry collect the right data from witnesses.

Table 5: Good practice for data collection

It is recognised that whilst the recommendations of Tables 4 and 5 are worthy aims, there will inevitably be practicalities and constraints on what we are able to collect. Operations – and even exercises – are not necessarily conducive to collecting the data you need, in a timely manner, in a way which can be easily accessed after the event.

[7] A checklist designed by Claire Outteridge's team in QinetiQ is included at Annex D.

4.4 The Validity of the Historical Record

Once you have collected the data, the question arises of its validity in terms of drawing conclusions from historical data. What is the validity of drawing conclusions:

- from historical operations to inform current and future operations?
- from one type of operation to another (e.g. from combat to peace-support)?
- from training and other exercises to operations[8]?

Data from historical operations

For historical operations we need to decide over what period it is valid to draw conclusions and the incidence of friendly fire incidents and their causes. This really requires military judgement as to what is still valid; typically this might be from Gulf War I onwards.

The quantity of data available from historical operations brings advantages: we are able to draw conclusions about trends throughout history in terms of the *frequencies* and *likelihoods* of different types of incidents. Contrast this with the work described earlier in this paper: if we want to determine *causality* then we need very detailed records of the incidents, which in practice can only come from Boards of Inquiry.

Data from historical operations is also key to the calibration/validation of the question of whether fratricide is a significant problem. Fratricide attracts a lot of attention politically and in the public's mind, but we need to understand this in comparison to deaths by other causes, such as enemy action or road traffic accidents.

Finally, we need to make sure we use meaningful metrics when comparing data across historical operations. For example, some comparative studies have used "fratricides as a proportion of casualties per battalion day".

Data from different operation types

Comparing friendly fire statistics across different operations is difficult, even if the statistics are, for example, all from combat phases of operations. Contrast:

- Operation Desert Storm – basically a ground war.
- Operation Iraqi Freedom – a manoeuvre war with relatively fewer battles.
- Operation Enduring Freedom – a Special Operations Forces war.

All of these operations provided very different contexts for friendly fire to occur. However, comparison across different types of operation can still provide useful insights into trends on the *root causes* of friendly fire incidents.

Data from exercises

There are cases in the UK of the use of data from exercises to provide insight into friendly fire incidents and their causes. The Land Warfare Centre collects data on an annual basis from the different training establishments and produces a database of incidents and their underlying causes. But exercises provide different physical, psychological and operational pressures:

- Training environments are often designed to be deliberately confusing – for example, participants may be deliberately given friendlies as targets in order to check out the effectiveness of equipments and procedures.
- Participants have different motivations in exercises – the consequences of simulated fratricide incidents in exercises are certainly less, and soldiers may even be settling scores from conversations in the bar the night before!
- Senior military officers sometimes argue that exercise conditions are artificial and the way the exercise was run wasn't sufficiently real to be able to draw conclusions: "we would never run an operation that way". However, experience

[8] And from synthetic environments and simulations.

indicates that in some cases exercises replicate operational issues to an eerie extent.

Are the findings still valid as indicators of what would happen in real operations? Exercise artificialities may certainly reduce or increase the occurrence of friendly fire incidents; for example:

- The level of integration of an equipment may not be up to operational standards, or there may only be a partial fit across the exercise fleet.
- In a recent exercise the lack of tracer fire meant that danger areas were not so easily identified.
- The use of the same platforms for OWNFOR and OPFOR – though this may actually reflect modern operations.

There are, however, some advantages in exercises over operations:

- We can control exercise conditions – and potentially explore a broader range of operation types.
- We can collect data from the 'victim' as well as the shooter – which allows us to find out whether the victim in some way contributed to the incident.
- Data from automated systems can be used to provide an indication of ground truth – which can be used to validate comments and observations from exercise participants.
- These automated systems will also tell you about Category B 'near misses'.
- Exercises can also be used to trial potential mitigating solutions to root causes.

Despite the fact that we don't fully understand the correlation between what happens in training and what happens in operations, we still believe that exercise data is useful. This is particularly true if the data collection is planned over a series of exercises, when you can see if any patterns are emerging.

4.5 Sharing Data Across the International Community

One of the objectives of the TTCP Action Group was to examine the utility and feasibility of sharing data and analyses from fratricide incidents across the international community. Given that a good proportion of incidents involve more than one nation, the investigations necessarily have to work across coalition boundaries. It makes sense for the research community to do the same.

There are a number of advantages to sharing data and analyses:

- It provides us with access to a broader range of data sources, such as data from different operating environments. Our Australian colleagues operate and train in a jungle environment, which is very different from the environments which, say, the US and UK have recent experience in.
- Larger data sets give us greater statistical robustness. Fratricide and friendly fire events are thankfully quite rare (although they attract a lot of publicity). If we are going to conduct proper statistical analysis of causes then we need all the data we can get.
- Sharing data allows us to understand the different perspectives of our coalition partners, including how they view the collection and generation of statistical data.
- Sharing should bring economy of effort, as long as we can agree about definitions and understand how we all conduct our analyses.
- Sharing analyses on the same incidents allows us to compare the different national sources, and in some cases de-conflict the evidence. There are often differences in people's views of the timings of events, which can be clarified by looking at the different sources – which might include war diaries and memoirs[9].

[9] Note, however, that the different sources of data will have different levels of confidence associated with them.

- Finally, we can use the relationships built up in the sharing of data as a focus for bilateral work on specific incidents.

There are, however, barriers to our aspirations:

- There may be problems with releasability of the information from national archives. And there are legal and ethical issues to deal with about how to deal with sensitive personal information. There may be differences in the ethical standards which each nation adheres to in collecting the data[10].
- There are some basic practical problems in how the data are stored; there are some spectacularly ad hoc approaches to archiving data in-theatre.
- We have discussed the problems of different definitions and terminology. This can make the seemingly simple task of comparing top-level statistics across nations a nightmare.
- We need to establish good working relationships between the analysts involved; this is something we have been able to address with our TTCP work.
- Even in this technological age, there are still problems in establishing the necessary classified communications links between the analysts, particularly when there may be significant volumes of data involved.

5. Conclusions

This paper has posed the question "what value historical analysis?" in understanding the root causes of fratricide, and from there the choice of appropriate mitigating actions. We have proposed that the insights provided by examination of real world incidents, in their operational context, are vital in identifying the factors which can lead to friendly fire incidents. The fast pace and increasing complexity of the modern battlespace, the introduction of new equipments, and the presence of new coalition partners, are providing new opportunities for fratricide to occur. Mitigating solutions, across all Defence Lines of Development, need to be focussed on the insights provided from the historical record.

Boards of Inquiry

- Whilst the approaches which are used by Boards of Inquiry, both to collection of data and subsequent analysis, are well suited to their immediate purpose, it is difficult for analysts to: aggregate analyses across different incidents; to compare root causes across different types of operation; to determine trends in root causes.
- A common approach to Boards of Inquiry involved in the investigation of fratricide incidents (at least within nations), in collecting the data and structuring the investigations, would help us to get more value from the detailed records.

Root Cause Analysis

- It is clear that fratricide incidents are caused by chains of failures, in both technologies and human actions, so attempts to reduce incidence of fratricide need to be based on 'defence in depth'; taking a systemic approach to analysing what might be done, and what the effects might be.
- The broad nature of the underlying causes for incidents indicates that relying on technology as a way out of our problems is not the answer. The more we rely on technological solutions, the more problems you have when they fail.
- Understanding the root causes of friendly fire incidents, in all their complexity, is key to improving future operational effectiveness and reducing the incidence of fratricide. But this requires: detailed records, such as those produced by Boards of Inquiry (preferably using a common approach to data collection); and structured analysis of the data in order to determine the chains of causes leading up to an incident.
- Our structured analysis has indicated that the most prevalent causes of fratricide are:

[10] For example, in the UK questionnaires can only be administered by professionally qualified personnel.

Communications and Information; Command and Control; Procedures, Misidentification; and Cognitive Factors. Poor Situational Awareness is a major contributory factor[11].

Data Collection and Analysis

- We need to make efforts to collect a common set of core data about incidents from both operations and exercises.
- There is guidance on good practice in data collection; but we do recognise that there are practical constraints which will prevent us achieving the ideal.
- We do need to take care in comparing data from historical operations to predict what might happen in future operations, in comparing across different operation types, and from exercises to operations. But there is validity in making these comparisons as long as you are clear on what conclusions can, and cannot, be drawn.

International Data Sharing

- There are advantages to sharing data between nations: to build a larger, more statistically significant, data set; to understand operations from a coalition perspective; to compare sources of evidence and de-conflict different versions of events.
- But there are barriers to sharing: we struggle with terminology and definitions; some commonality is needed in data archiving; and there will always be releasability, legal and ethical issues about sharing data on what are inevitably very sensitive events.

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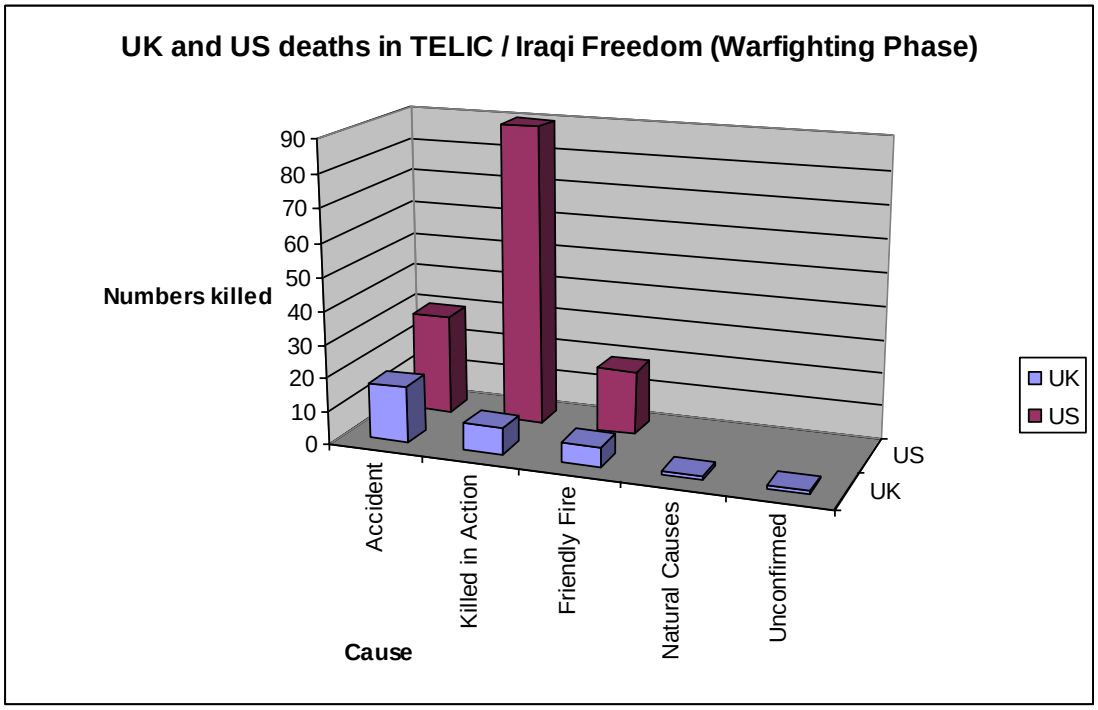
- Lt. Col. Tim John (Dstl) for his review of this paper.
- Zoe Lench (Dstl) for compiling the statistics on deaths in Operation TELIC.

[11] Noting that SA is under-reported in the statistical analysis conducted as many of the other sub-causes in essence contribute to poor SA.

Annex A – UK and US Deaths in Operation TELIC / Iraqi Freedom (Warfighting Phase)



Annex B – Fratricide Causal Analysis Schema

Command and Control (C2)
Commander's intent
Orders
Briefing
Planning
Co-ordination
Disruption of C2

Procedures
Standard Operating Procedures (SOPs)
Rules of Engagement (ROEs)
Fire control and discipline procedures
Doctrine
Navigation

Communications/information
Information presentation
Communication procedures
Communication failures
Language barriers
Information quantity
Information gathering
Information reliability
Information sharing
Auditory overload

Pre-deployment preparation
Rehearsals
Training

Misidentification
Physical features of target
Target recognition training
Combat Identification measures
Actions of target
Restricted vision

Cognitive factors
Decision making
Workload
Expectancy bias
Attention
Risk assessment

Physical/physiological
Fatigue
Stress
Anxiety
Confusion
Fear
Arousal

Equipment/technology
Equipment failure
Weapons handling error
Weapons misuse
Trust and reliance on technology
Communications equipment
Technology misuse

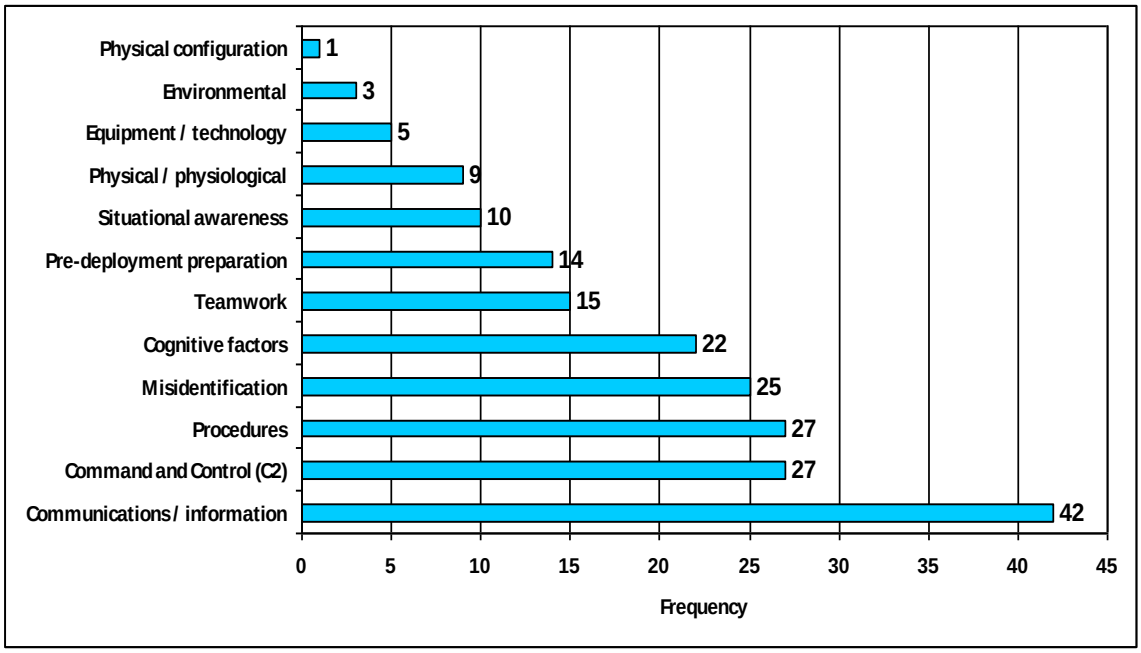
Environmental
Extreme engagement ranges
Weather conditions
Terrain
Time of day

Teamwork
Teamwork behaviours
Roles and responsibilities
Degree of distribution
Shared history
Leadership
Organisational relationships

Situational awareness
Individual
Shared

Platform configuration
Layout of platforms

Annex C – Prevalence of Causal Categories in the Sample Incidents



Annex D – Fratricide Causality Checklist

The UK have recently standardised the collection of data on 'fratricide' incidents in training exercises, based on a checklist proposed by their research programme[12]:

Fratricide Incident Causality Checklist Please use this Checklist to describe the fratricide incident, and to identify the nature of the incident and the contributory causes involved.

Date / time incident occurred:	*Please tick the relevant box:*			
			TO	
Description of incident:			**Ground**	**Air**
	FROM	**Ground**		
Unit:		**Air**		

	Factors	**Level of contribution**	
		Primary *(Please tick one box)*	**Secondary** *(Please tick any number of boxes)*
Planning / preparation	• Unclear commander's intent / orders • Inadequate planning • Unclear ROE • Inadequate preparation / rehearsal	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐

[12] "Reducing the risk of 'friendly fire' and civilian harm: a human factors perspective" - Final Technical Working Paper (C Outteridge, L Catchpole, S Henderson, P Shanahan, May 2003, QINETIQ/KI/CHS/TWP031303/1.0).

	Factors	**Level of contribution**	
		Primary *(Please tick one box)*	**Secondary** *(Please tick any number of boxes)*
Environment	• Poor visibility between units • Poor battlefield visibility: Weather Lighting levels (day / night) Terrain • More than one unit operating in the same area • Absence of recognisable features • Poor weather conditions • Extreme engagement ranges • Rapid battle tempo • Boundary violation	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
Communications	• Misinterpretation • Mis-hearing • Crosstalk lacking	☐ ☐ ☐	☐ ☐ ☐
Situation awareness	• Unknown enemy situation • Unclear friendly situation • Target in unexpected place	☐ ☐ ☐	☐ ☐ ☐
Equipment	• Friendly and enemy equipment similar • Malfunction • Misidentification of physical features of target	☐ ☐ ☐	☐ ☐ ☐
Skills / experience	• Insufficient knowledge • Assumptions / expectations • Poor navigation • Ineffective leadership style • Poor teamwork • Poor memory • Lack of confidence	☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐
Time	• Time pressure (e.g. short decision time)	☐	☐
State	• Soldier fatigue • Leader fatigue • Distraction • Confusion • Stress / anxiety • Fear	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐
Enemy	• Weak intelligence • Weak recce • Enemy intermingled with friendly forces	☐ ☐ ☐	☐ ☐ ☐
Exercise	• Exercise bravado • TES bravery • TES artificiality	☐ ☐ ☐	☐ ☐ ☐

	Factors	**Level of contribution**	
		Primary *(Please tick one box)*	**Secondary** *(Please tick any number of boxes)*
Other	*Please specify:*		