Friendly fire, historical analysis, and why database size counts

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Key words: Combat identification, amicide, amicicide, Blue-on-Blue, fratricide, historical analysis

Abstract

Since the Gulf War of 1991, the UK MoD, in collaboration with other NATO and Coalition nations, has undertaken a scientific and technical programme to reduce the incidence of fratricide or 'friendly fire'. This programme is informed by extensive operational, historical, and human factors research.

Following limited success using battle models, it was clear that a better quantitative understanding of the phenomenon was needed. In 1996, Dstl started to compile a catalogue of historical friendly fire events, including details of the participants, the operational circumstances, causes and outcomes, from a wide range of sources. It now contains around 2300 events, which allows statistically robust analyses. It has been used to identify the commonest causes of events, to estimate the impact in casualties and operational disruption, and to compare the frequencies of events between similar platforms with 'cross-environment' events, which form a large proportion of the total in complex modern operations. This analysis is being used to inform the cost-effectiveness of different ways to reduce friendly fire and minimize its consequences.

The paper concludes by discussing the role of historical data in supporting operational analysis, and in particular, the value of large, multi-use databases. Can they endure in the age of project-centric funding and throw-away data?

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Paper presented to 25th International Symposium on Military Operational Research (25 ISMOR), Bishops Waltham, Southampton, 26–29 August 2008

Introduction

'Friendly fire' (amicicide, amicide, fratricide, or Blue-on-Blue) is the accidental targeting of friendly forces in combat. During WW1 and WW2, it is thought to have accounted for 10–20% of the overall casualties, but it has been a feature of warfare since the beginning of recorded history. In the recent conflicts in the Gulf, the mismatch between forces led to low overall numbers of US and UK casualties from enemy action, highlighting those caused by our own forces.

Although a relatively minor cause of casualties on operations when compared with, for example, road traffic accidents, their impact on morale is much greater, and there is an inevitable loss in operational tempo following an incident, which could be exploited by an alert enemy. The public is naturally reluctant to accept any casualties in war, but when these casualties arise from friendly fire, the political impact is increased. Following the events in Kuwait and Iraq in 1991 the UK MoD sought a solution, but problem was not well understood.

The MoD believes that there are three broad approaches to improving combat identification (CID):

- better situational awareness (SA);
- physical devices for identification, friend or foe (IFF);
- improved training in tactics, techniques and procedures (TTPs).

In order to improve CID, the MoD asked Dstl and its predecessors which of the above approaches was most cost-effective. However, assessment of CID has not proven to be easy. It involves elements of the physical domain, such as military equipments (e.g. vehicles, uniforms, sensors etc.) and the environment (e.g. terrain and weather), together with elements of the informational (plans, briefings and communications), cognitive (e.g. training, and resolving conflicting information), psychological and physiological domains (e.g. personality, expectation, stress, fatigue).

The opportunities for improving CID also depend on the frequency of events, causes, impact, and the environment: it is not cost-effective, for example, to invest in CID for ground-to-ground engagements if the main cause of friendly fire casualties is from aircraft. Not surprisingly in retrospect, attempts in the early 1990s to simulate battles with fratricide battle modelling were largely unsuccessful. Simulation was not best suited to problem, though it did serve to reveal our lack of understanding and the dearth of data on the subject.

Implementing and developing the catalogue

In 1996, the idea of listing historical events and their causes was proposed as a means of improving our understanding, and perhaps of gathering data to improve our simulations, which were still thought to be a feasible way ahead. The catalogue was started as an 'unofficial' project, with events being gathered from open sources by those interested, in DERA/Dstl and outside. The first working paper was published 2004, and listed 1318 incidents, including 1238 post-1900. The compilation of events is still ongoing, and we have now collected around 2600.

The problem for compilation was that the accounts of events are scattered throughout the entirety of military literature. There are a few recent monographs on fratricide, such as the studies by Shrader (1982), other UK and US MoD and DoD studies, and the books by Kemp (1995) and Garrison (1999). Some sources, such as the first book on friendly fire by Percin (1921), have taken months or even years to find. But many more events are to be found in general books on military history, which typically yielding two to six events per book. Military obituaries post-1991 and web pages are increasingly reliable as sources. Over 300 sources were searched for the first published catalogue, and we now scan the Internet every week for new events.

Official military sources are remarkably poor for recording these events: often at the time an event occurs, the causes are uncertain, and therefore speculation is avoided in war diaries. Indications might be present in electronic records, but these now extend to several terabytes of material for each deployment tour, and so search will require more effort than is currently practical. Medical systems focus on treating the casualties, and do not concern themselves with the causes. Thus it is usually several years before the Boards of Inquiry have reported, people have moved on, memoirs are published, and the historical record can be examined objectively.

The initial data set was a compromise between what we would have liked to include, and what appeared to be available. It included the factual information on date, time and location (though even these were lacking in many cases), what type of event it was (Land–Land, Air–Land etc.), and whether it was an actual event or a ‘near miss’, etc.. There are then some fields describing the circumstances: who attacked whom, by day or night, in combat or not. These are followed by a short factual statement of what happened, the causes and the consequences. Since the first edition, the causes of the incidents have been systematized into nine categories, plus an ‘unknown’. The losses are listed as personnel casualties (killed and wounded) and materiel losses. Finally, there are two fields describing whether the victim returned fire on the initiator, which often happened. Full source information is listed.

Since implementing the original catalogue, Dstl has developed a confidence measure that can be attached to each incident record, and which therefore can also be used as a filter. All the sources were checked and archived electronically in 2007, an activity that was supported by DG(S&A). There is also a ‘wish list’ of additional data fields that we think should be included in future catalogues.

Some statistics from the catalogue

The numbers of incidents are dominated by World War 2, with 1130 incidents, reflecting the biases of the English-speaking literature, and of the contributors. Since WW2 however there has been a steady stream of events from smaller wars and operations, with the current decade set to be the most incidents since the 1940s. This is likely to be an artefact of better reporting, since there was greater operational activity in Vietnam. Prior to WW2 there are many fewer reported incidents, largely because only the most costly, or those involving famous people (or people who later became famous) were reported. (The small peak for Waterloo in 1815 is almost entirely due to the research on this one battle by Captain Siborne – the Napoleonic Wars were much more intense from 1812 to 1814.) Reporting and retrieving incidents is made harder by the fact that the term ‘friendly fire’ was only coined in the 1960s, and did not become the subject of serious research until Shrader (1982).

The breakdown of 20th. century incidents by domain shows that half of those currently known were land-to-land, mostly by and on dismounted soldiers, but with a significant proportion caused by indirect fire (IF) weapons, particularly in WW1 and WW2. IF has ceased to be a major cause of incidents since Vietnam. However, aircraft have become the second largest causal agent, with 19% of incidents being air-to-land, a trend that appears to be increasing. They also tend to cause more casualties per incident, due to the potency of their weapons. When all the cross-environment incidents are summed, they accounted for just less than a third of all incidents, which led the MoD to examine the capabilities of CID interventions to work across environment boundaries as one of the key performance indicators.

The two most frequent causes of incidents were command and control errors (37% of known events) and failures or inability to identify the physical features of the target (40% of events), often found in combination. These figures are broadly consistent with other similar studies. Many incidents had multiple causes, and as reported by Gadsden and Outteridge (2006), the deeper the research delved into individual incidents, the more contributory factors tended to be found. Thus the mean of around 1.5 causes per incident in the present ‘broad but shallow’ analysis is likely to be a very significant underestimate. However, it also depends on how studies classify causes, particularly whether they ‘lump’ or ‘split’ them.

Dstl has also undertaken some analysis of other factors (not briefed here) such as the number of casualties caused by the incident types, the level of operational disruption, and circumstantial factors such as day or night, whether the incident took place in the presence of real enemy, and whether the victim returned fire at the initiators.

Incident frequency on recent operations

Since history is (by definition) uncontrollable, our ability to extract quantitative data from the historical record is dependent on our ability to compensate for the different settings in which the incidents occurred. The obvious differences between operations for the purposes of comparing the expected rate of incidents, and thus to be able to see whether the friendly fire problem is getting worse, better, or staying the same, is the opportunity for the incidents to occur. Intuitively, the longer the operation and the more troops that are involved, the more incidents there are likely to have been.

Thus the incident rate was compared for three recent warfighting operations where we thought that we knew of most of the friendly fire incidents, and thought we knew of all the fatal ones: the Falklands (1982), Kuwait (1991) and Iraq (2003). The standard for normalization (from previous unpublished MoD studies) was the ‘unit-day’, i.e. one battalion-sized unit in the field of combat for a day. Thus,

Incident rate = total no. of incidents / total unit-days.

The UK incident rates calculated were as follows (illustrated graphically in the slides at the annex to this paper). Note that not all the incidents were injurious:

Operation	No. unit-days	No. UK incidents	No./unit-day
Falklands, 1982	242	20	0.08
Kuwait, 1991	87	20	0.23
Iraq, 2003	637	46	0.07

Table 1. Normalized friendly fire incident rates on three recent operations

The study found that once normalized, incident rates were broadly similar. There were however marked effects of operational tempo – Op. Granby was ‘short and sharp’, whereas Op. Corporate had a significant drop in tempo between the two phases, and Op. Telic I was largely a relief in place of US forces, and faced a less capable enemy than in 1991. More interestingly, the normalized rates from the latter two operations were very similar to a divisional sample from Normandy in 1944, at around 0.1 incidents per unit-day. This indicated that the incident rate was more dependent on ‘human factors’ than technology, at least in the short term (60 years), reinforcing the validity of using HA for these research purposes.

Although technology undoubtedly has an influence – some for the better (e.g. GPS for improved navigation) and some for the worse (e.g. thermal imagery enabling engagement of ‘hot blobs’ in 1991, beyond visual ID range) – the constant factor would appear the propensity for men to make errors in stressful environments when information inputs were missing or ambiguous. This helps to validate the application of the ‘Swiss cheese model’ of human error from civilian safety-critical systems (see Reason, 2000) to military situations (see Dean *et al*., 2005; Gadsden & Outteridge, 2006), and the belief that data from previous operations will help us understand the risks on future operations, where technology and the environment will differ.

What value has HA added to friendly fire studies?

The catalogue has compiled a sufficient number of events in total to be able to provide data sets for individual projects that are large enough to be statistically useful. This started to be the case with the first published version in 2004, which contained just over 1300 events. Since this time, it has fed around 20 UK projects addressing the friendly fire problem as a whole, and has been shared with the USA, Australia and Canada through The Technical Co-operation Programme (TTCP); see Gadsden and Outteridge (2006).

The first, largely immeasurable, benefit is the enormous improvement in understanding gained from reading and systematizing this number of events. Specific examples of this are:

- confirming the multiple causality of events;
- spotting the common causal pattern of poor C3 then poor combat ID;
- quantifying the frequency of events;
- quantifying the importance of cross-environment events;
- identifying the link with civil work on safety-critical systems.

The understanding of event timelines, causality and the contribution of human factors made it possible to develop the Integrative Combat Identification Entity Relationship model (INCIDER – see Dean *et al.*, 2005), which has been used to explore the impacts of different interventions more quantitatively. Confirming the parallels with civilian safety-critical systems has enabled the MoD to draw lessons from the well-established literature on improvements in aviation, nuclear and medical safety where appropriate (e.g. see Reason, 2000), and has thus represented a time and cost saving in not having to research some human factors issues from scratch.

This has enabled Dstl better to support the process of procuring solutions to combat identification problems in each environment, and has stressed the importance of ensuring that they work between environments. It has enabled the likely benefits of each option to be quantified, both in terms of reducing casualties, and in maintaining operational tempo. It has also enabled Dstl to respond quickly to requests for input to the National Audit Office (NAO) and parliamentary Public Accounts Committee (PAC) reports on CID in 2002, 2006 and 2007. It also supports input to parliamentary questions on CID as required.

Advantages and disadvantages of HA

Historical analysis is based on 'ground truth', albeit an incomplete sample that is biased towards the sources available to the compiler. Models and simulations are, by contrast, based on our imperfect understanding, and subject to huge personal bias: two combat modellers, or teams of modellers, might develop models of the same system that behave very differently.

On the negative side, HA is totally uncontrollable, except in selecting the subset of data selected for analysis. The only tools are retrospective statistics, whereas a combat model is a 'battle in a goldfish bowl', in which (in the ideal case) everything can be controlled. (In reality, it is constrained by what is possible within the time and cost.) If insufficient events are available for statistical analysis, then more replications can be run, whereas HA is limited the finite number of events that have happened for real. This makes simulation one of the few tools that can truly be said to be capable of exploring the future.

Both techniques should incorporate a protracted data-gathering and validation phase, but this is often curtailed for reasons of time, cost and enthusiasm: there is a tendency to regard this type of work as tedious. For HA, the consequences of insufficient data are an inability to detect the underlying trends above the noise. For combat modelling, though, a lack of validated data can be hidden by making assumptions, allowing apparently robust conclusions to be drawn from unsafe foundations; the discussion by Davis and Blumenthal (1991) makes sobering reading.

HA and combat modelling *should* be seen as complementary techniques. The former helps gain the understanding necessary to formulate valid and useful models, and provides them with some of the data they need, particularly on the softer factors (as illustrated by Dean *et al.*, 2005). Combat modelling can then be used to project these ideas into the future, where the hardware may be too new for any historical experience to be available.

Database size, and HA project management

The current database is large, but it can never be definitive, save in very limited areas (e.g. submarines lost to friendly fire, and UK fatalities post-1990). It is, however, believed to be representative, and sufficiently large for a statistically robust subset of data to be extracted when required. Projects have usually required as many incidents to analyse as possible, in a short timescale (weeks or months). There is rarely sufficient time to gather such data after the project requirement is known, therefore it must be anticipated, and the data-gathering undertaken pro-actively.

Because the exact scope of future projects is unknown, the approach has been to gather all friendly fire data within reason, with the references as 'hooks' to dig deeper as required. To have collected 2600 event records might at first appear excessive, but having applied data filters (for example by date, environment, operation, or circumstance) it is very common to be left with only a small number of relevance to a given problem. If the filtering leaves fewer than (say) 30 events, then this may be too small a sample for statistical analysis.

Database compilation is generally a 'slow-burn' activity: incident reports are scattered through the entirety of military literature, and in individuals' memories. This type of background activity does not fit well with modern project management practice. Because there is no single problem 'owner', it is hard to assign the costs of database compilation to any one budget. It is also hard to allocate analysts' time to intermittent, low priority tasks, when they must compete with intense, high-priority tasks for specific customers. The present author therefore believes that HA databases are much closer to being facilities, and ideally, should be managed and funded as such; but this still does not address the resource issue.

Compiling an HA database pro-actively has worked well for friendly fire, but could it be applied to other areas of military OR? Potentially, there is room for one in each area of study, from the top level (i.e. a database of battles, of which there are many), to the lowest level (e.g. a database of AFV losses by cause, or personnel casualties listed by weapon, etc.). But unless there is a data 'champion' for each database, they will die after the initial enthusiasm and surge in data collection has subsided, and other project priorities arise. Maintaining the background collection activity owes more to personal preferences than to project management. To this end, do we need to recruit more people who have an enthusiasm for history and gathering data? We already have many enthusiasts for the models that use the data, but (a personal opinion) too few people feeding them with good quality data. Should OA try to redress the imbalance by recruiting more history graduates?

The author believes that the 'culture' in OA needs to value its data, and the collection of data, as much as it currently values its models. Models without adequate data can, and often do, 'die'. Auditable data that can trace their origins back to real operations are also key to validating models, to have faith in the products of OA. Moreover, 'good' data (those that describe the nub of a particular problem, and where the collection has been rigorous) can serve to feed many models, and are thus arguably more valuable than the models.

Acknowledgements

Such catalogues are only possible with the contributions of many. Among these were Nigel Beer, James Bleach, Ian Budd, Dominic Davies, Ian Dewar, Julie Gadsden, Bernard Garaty, Ian Gardner, Paul Glover, Philip Hardy, Chris Hobson, Fred Hood, Richard Hurley, Nigel Johnson, Zoe Lench, Alexandra Lewis, Larry Lewis, Geoffrey Muir, Gordon Pattison, Bryan Perrett, Michael Phipp, Bob Prescott, Kirk Ramsay, Lisa Scandling, John Salt, Digby Smith, Mark Taylor, George Tomlin, Peter Trevett, Geoffrey Vesy-Holt, and Mattias Wallen. The idea for the catalogue was proposed by Di Wardleworth.

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