RISK REDUCTION IN DEFENCE RANGE SAFETY THROUGH DIGITISATION EXPLOITATION

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Abstract—**The conduct of complex live firing activities is a critical enabler to training systems underpinning force generation of warfighting capabilities in preparation for operational employment. Ensuring the safety of our warfighters is paramount. The majority of land based range safety practices and procedures are managed by Army on behalf of all of the Services. The safe conduct of range activities is highly reliant on the application of a comprehensive library of doctrine for these practices. This paper discusses a clear requirement for an innovative system to enable improved efficiency and effectiveness of range safety through a validated and controlled process. The system should have controls in place, based on verified doctrinal procedures, to identify and restrict unacceptable levels of risk being planned into practices to assure the safe conduct of live firing training activities.**

I. BACKGROUND

The Royal Regiment of Australian Artillery (RAA), like all other weapon users, conducts land-based safety planning for live firing practices by manual means. RAA doctrine has been fundamentally unchanged since the 1960s. Broadly, the process requires a suitably qualified RAA Officer to cross reference a number of doctrinal publications, determine the most contemporary and accurate source documentation and then manually develop range safety products to support a specific training outcome. The production of the range safety products is performed from first principles and is a time consuming process performed with paper maps, pencil, ruler, tracing paper and a steady hand.

II. DOCTRINE

The Defence range safety publications provide Australian Defence Force (ADF) users with the range orders required for the safe and effective conduct of range practices undertaken in order to prepare personnel to operate weapon systems on operations. Currently when doctrine undergoes change there is the risk that it may no longer be aligned with supplementary doctrinal publications. Multiple sources of critical information required for range safety planning are documented across a range of additional doctrinal publications. This presents a major risk that essential information and policy may not be fully considered before commencing complex range practice activities.

A. Current Range Safety System

The current range safety system consists broadly of key two activities: Planning and Execution. Both are performed within the context of applicable doctrine. The key weaknesses of the current range safety system are: the excessive amount of time required to produce the products; products being prone to inaccuracies and human error; overly broad and simplistic application of risk theory that creates very conservative but qualitative products; and critical information and assumptions documented across multiple publications prone to not being considered in planning.

B. Planning Phase

In the planning phase qualified Army officers develop a range plan according to a training objective and then generate a supporting range safety template and range detail. These artefacts are then independently checked and endorsed. The range safety template and range detail must then be approved for use by the Range Control Officer (RCO) prior to the live firing practice.

Range safety outputs are based on a number of assumptions being met through long-standing procedures, policies and the technical knowledge existing within the Defence Organisation and regulated by the Combined Arms Training Centre (CATC). The provenance of assumptions used in safety planning is uncertain with most considered to be conservative without links to objective quality evidence. Due to the possibility that these assumptions may not produce conservative results, planning can become inflexible and the level of safety protection afforded those involved in live firing practice uncertain.”.

Furthermore the current safety planning system is based on deterministic risk management concepts which result in ground being declared either ‘Safe’ or ‘Unsafe’. As such, current arrangements do not adequately manage new Precision Guided Munitions (PGMs) given potential failure behaviours which can result in a munition straying much further from the intended flight path than an unguided munition. Instead, the range safety system should implement quantitative probabilistic risk management concepts such that in the case for PGMs, ground is declared ‘Safe As Reasonably Practicable’ or ‘Not Safe As Reasonably Practicable’ with respect to approved safety criteria.

C. Execution Phase

Prior to the conduct of a live firing activity a number of preconditions must be met once deployed into a range environment. As long as these conditions remain valid throughout the activity, and the elements involved in the activity do not move without some form of procedural control in place, the activity can be conducted with relative safety.

All weapons whether they are mounted or dismounted, direct or indirectly fired are constantly checked and monitored to ensure they remain pointed and fired in a direction and elevation that has been calculated to ensure all projectiles and the subsequent fragments from any explosive projectiles are contained within the defined range template and danger area.

D. Precedence for a Modernised Range Safety System

Current range safety planning arrangements are now at odds with the operational system employed by the RAA, which now employs an end-to-end digital fires system. The modernised system enables an observer with a Digital Terminal Control System (DTCS) to digitally produce target coordinates and associated fire control orders. These are then sent electronically to the Battle Management System – Fires (BMS-F) for decision support to allocate resources which, in turn, are sent to the Digital Fire Control System (DFCS) at the gun to electronically apply the firing data and fuse information. Adopting digitised range safety planning enables transfer of range safety data into the end-to-end digital fires system for live fire practices enabling an overarching digitised safety management system from planning to engagement.

E. A Modernised Defence Range Safety System

A modernised Defence range safety system needs to map the current doctrine and resolve the issues and gaps associated with the current doctrinal publications, engineering data and risks through adopting a model-based systems engineering approach.

Through employing a model-based approach to early-stage design, an approach termed Model-Based Capability Design (MBCD), concept and specifications documentation can be produced directly from the model. This model would then be provided to Defence in order to guide any re-shaping, re-writing or future review of range safety publications. It would also set the conditions for many of the current publications to be combined into a single reference. Fig. 1 illustrates an example model of the artillery range safety system developed from Land Warfare Procedures (LWP)-G 7-3-3 [1].

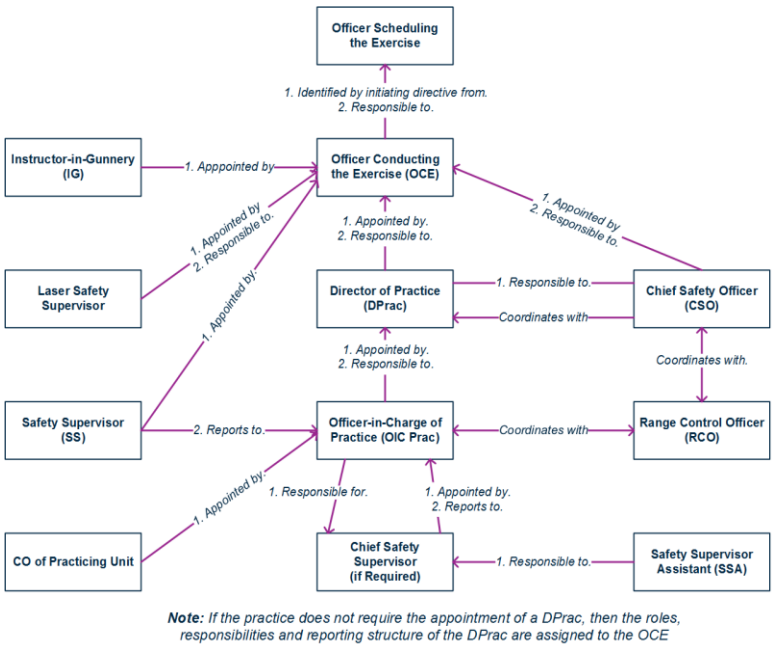

Fig. 1 Example of model based systems engineering approach applied to the Artillery Safety Approval Model

The mapping activity should feed into the creation of new range safety orders that will form the basis of a Description of Requirement (DoR) for a digitised range safety software planning tool that would be used in place of the existing manual process. The range safety software planning tool could be accessed via the Defence Protected Network (DPN) to allow the application to be employed across Defence. Alternately the application may be hosted on standalone systems and distributed amongst Defence users.

F. Digitally Aided Range Safety - Artillery

Digitally Aided Range Safety - Artillery (DARS-A) is a software planning tool shown in Fig. 2 developed by QinetiQ Australia and Shoal Engineering at the request of the RAA that digitises the current manual land-based doctrinal range safety process (LWP-G 7.3.3 [1]).

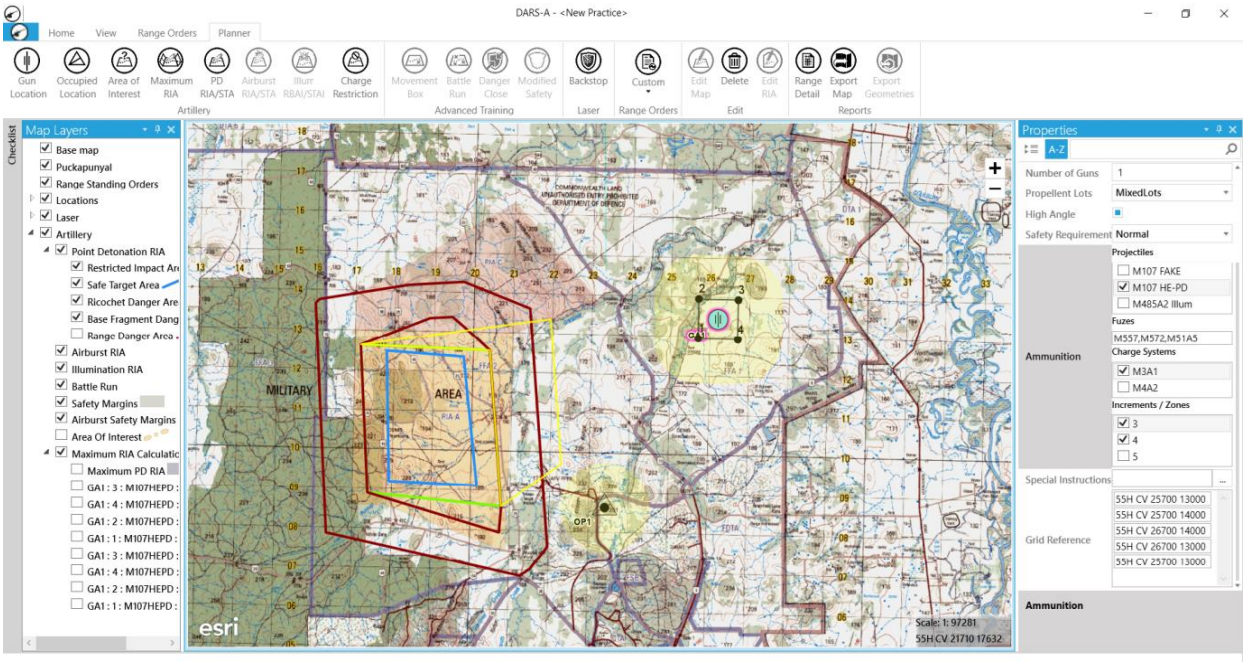

Fig. 2 Screenshot of Digitised Range Planning Process

The DARS-A software allows a range planner to create polygons on the digital map representing range safety danger areas of interest that are then used to perform all the safety calculations as per LWP-G 7-3-3 doctrine [1]. The software imports digital Firing Table data to allow the planner to select various ammunitions natures to be used in the training exercise. The Checker and Approver are able to review the range plan on the digital map and a range detail can be generated for signature for approval for live firing use.

The DARS-A solution, soon to be in use by Army, has been developed in Australia within an engineering framework that is compatible with the Technical Regulation of ADF Materiel Manual – Land (TRAMM-L) for safety assurance in order to support Design Acceptance by the Commonwealth.

The DARS-A software includes the capability to plan for the following LWP-G 7.3.3 [1] range safety activities:

- Single/multiple gun positions to Safe Target Area (STA);
- Single/multiple gun areas to STA;
- Laser safety planning;
- Terrain and boundary information in range maps;
- Approved Range Orders and utilisation of boundary layer vector elements in Approved Range Order construction;
- Direct firing practices;
- Airburst ammunition practices;
- Illuminating ammunition practices;
- Advanced Training practices including, Danger Close, Battle Run and Modified Safety;
- SMArt 155 ammunition;
- Support for export of data for Advanced Field Artillery Tactical Data System (AFATDS) for a single STA and corresponding Free Fire Area (FFA); and
- Production of the range detail and exportable safety traces.

The DARS-A software has the capability to plan with the in-service 155mm ammunition set for which Firing Tables exist. It is also able to generate a range detail in a printable format that can be utilised within AFATDS in the BMS-F environment. A key aspect of range safety is the rules required to ensure only authorised people are able to plan, check and approve safety products. The DARS-A software ensures functionality is limited by role:

- Range Planner;
- Range Planner Checker;
- Officer in Command of Practice;
- Director of Practice; and
- Commanding Officer.

In using the manual based process an operator is required to interpret when the use of a simple or complex plot calculation method is appropriate. The DARS-A software removes operator interpretation through rule based assessments in accordance with ground distance accuracy tolerance limits thereby ensuring transparency and consistency with respect to method.

G. Benefits of a Digitised Range Safety System

A modernised range safety system through digitisation will reduce the time key officers are engaged in complex range

planning while simultaneously increasing accuracy of the safety products. It will reduce safety risk and provide the flexibility for quick and simple modifications to range details that will greatly increase the ability to plan even more complex live firing practices than possible with the current manual based process. In addition, a modernised system provides:

- Digital transfer of range safety templates through the Digital Battle Management networks,
- Rapid adoption of new range safety templates and the adoption of foreign weapons systems onto Australian ranges more efficiently,
- A proven and validated systems engineering approach to the development and ongoing maintenance of range safety doctrine, process and tools, and
- A growth path towards the adoption of probabilistic range safety toolsets in support of complex weapons such as guided missiles and rockets from multiple land and air based platforms.

H. Combined Arms and Joint Practice Capability Growth

DARS has been designed using a component based framework, allowing expansion of its capabilities to other weapons types, like mortar systems and direct fire weapon systems, enabling the planning of different weapons practices using a common tool set. The planning of combined arms and joint fires practices are enabled through the electronic sharing of range planning data, allowing range de-confliction (both spatial and temporal) to be managed electronically by the local Range Control Office.

Fig. 3 illustrates the component based approach. The development of new features and new weapon platforms would be set by Defence based on agreed priorities.

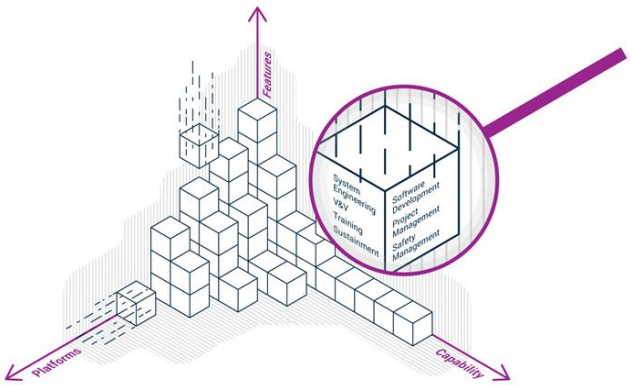

Fig. 3 Components will be developed progressively in accordance with agreed priorities on the required platform support, features and capabilities.

This growth path will provide for continued, significant enhancement of Defence's modernised range safety system within a live firing combined arms and joint environment.

III. Conclusion

A modernised range safety system is needed to integrate and digitise the highly complex domain in order to bring technical and doctrinal mastery to commanders and practitioners at all levels, matching training levels with informed risk management. A digitised range safety planning tool provides the benefits of reducing the time taken to produce range safety products while reducing the safety risks of key information not being fully considered and reducing the possibility of human error.

QinetiQ Australia along with Shoal Engineering have digitised the current land-based range safety system through development of a Digitally Aided Range Safety – Artillery (DARS-A) software planning tool for the RAA. The DARS-A software can be used in place of the manual based process to improve efficiency and effectiveness of range safety while reducing the safety risks involved in the process.

Recent safety events and resulting inquiry findings have highlighted the need to review current Army range practice doctrine and procedures using a model-based system engineering approach in order to improve the conduct and safety aspects of all land based range practices. A doctrine mapping activity should feed into the creation of new range safety orders that implement quantitative probabilistic risk management concepts to form the basis of the range safety software planning tool requirements.

QinetiQ Australia operates to support Defence as a trusted partner. With the support of QinetiQ Australia and Shoal Engineering, Defence is uniquely placed to improve range safety capability. The development of DARS-A for the RAA has proven that a low cost, efficient mechanism exists for the modernisation of range safety systems.

Acknowledgement

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References

[1] Australian Army, Land Warfare Procedures – General LWP-G 7-3-3-Indirect Fire – Range Orders, 2006.