The Disruptive Role of M&S in Capability Acquisition

Doug Stapleton[1]
Australian Department of Defence
Russell, ACT 2600
AUSTRALIA

douglas.stapleton@defence.gov.au

ABSTRACT

The services within the Australian Defence Force are now on a "Raise, Train and Sustain" model, while the Warfighting is done on a Joint basis. That same model can be applied to the modelling and simulation aspects of the capability acquisition projects, for which current guidelines set aside a percentage of project funding towards the development of synthetic models of that capability. A potential future direction is to make the Capability Acquisition Projects formally responsible for the provision of the synthetic models, to allow for the joint simulation of that platform in war gaming exercises.

The Battlespace Communications System (Land) will be used as an illustrative exemplar of the trend to use simulation for Operational Test & Evaluation (OT&E). The exercise planners in Australian Defence Simulation & Training Centre (ADSTC) can 'drag and drop' the synthetic platforms onto an exercise Battlespace. The individual synthetic platform components would be developed by their respective capability projects, to the simulation interoperability standards nominated by the ADSTC in their joint training role.

Future planning and war gaming can be disruptive using synthetic components to simulate the capability of the platform vis-a-vis the anticipated opposing platform as at the date of Initial Operating Capability. This disruptive feedback is then used to refine requirements before it is built into its physical reality.

1.0 BATTLESPACE COMMUNICATIONS SYSTEM (LAND)

The Australian Defence Force (ADF) is moving towards a digitised C4I warfare environment, that requires a Battlespace Communications System delivering Voice, Data and Video for Strategic, Deployed and Tactical information needs as illustrated in Figure 13-1.

[1] The opinions expressed in this paper are those of the author and not the Department of Defence.

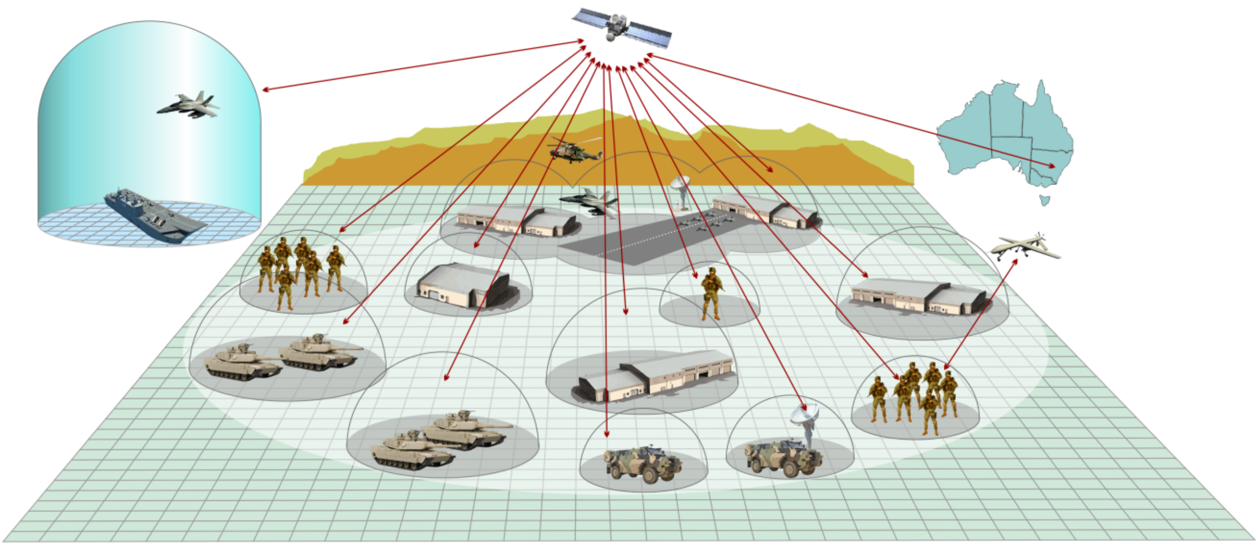

Figure 13-1 Battlespace Communications Problem Space

The Battlespace Communications System (Land) is expected to:

- provide Voice, Data and Video communications services and connectivity between deployed and tactical forces,
- interface with User Applications to enable information services as an integral element of the Land Network capability,
- provide seamless communications across ADF networks including strategic and coalition networks, and
- interface with government and commercial networks.

In operational terms, the Land Network is a single logical capability, which is expected to function as an integrated communications network infrastructure system, whose elements are subjected to resolving interfaces between them to achieve a Network-of-Networks outcome. The architecture and engineering development process follows the sequence outlined in Figure 13-2.

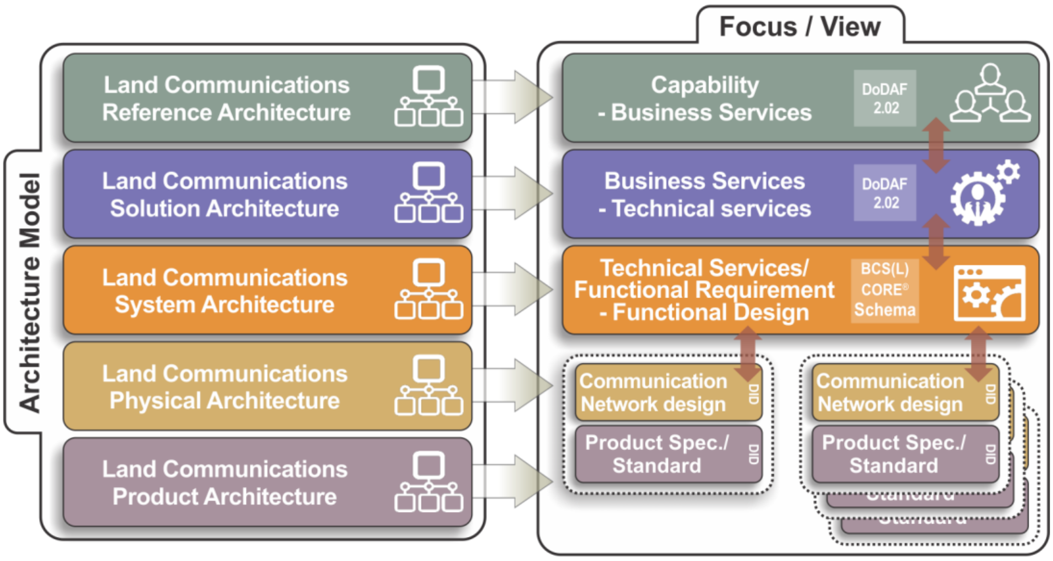

Figure 13-2 Architecture Model

1.1 RAISE, TRAIN AND SUSTAIN

The services within the Australian Defence Force are now on a "Raise, Train and Sustain" model [1], while the Warfighting is done on a Joint basis. That same model can be applied to the modelling and simulation aspects of the capability acquisition projects, for which current guidelines put aside a percentage of the project funding towards the development of synthetic models of the capability. A potential future direction is to make the Capability Acquisition Projects formally responsible for the provision of the synthetic models, to allow for the simulation of that platform by the Australian Defence Simulation and Training Centre (ADSTC).

Australia's first operational level joint headquarters was established as HQAST in 1996. The first appointment to the dedicated position of Chief of Joint Operations being LTGEN David Hurley in 2007. The joint headquarters was renamed HQJOC in 2004 and moved to its own facility at Kowen ACT, near Bungendore, in 2009. The current CJOPS is VADM David Johnston. Under CJOPS, HQJOC is responsible for the command and control of all ADF operations worldwide. This means that each of the ADF's Combined Task Forces (CTF) and Joint Task Forces (JTF), and the Australian contingents to UN peace monitoring operations, are directly subordinate to HQJOC, and their commanders' report directly to CJOPS[2].

ADSTC provides simulation support to Joint Operations Command led exercises and simulation services, project capability coordination, simulation policy and governance across the ADF. The ADSTC role in Capability Development [2] is to provide policy direction, collaboration and co-ordination of simulation activities across Defence. The role of simulation in Capability Development, apart from the delivery of actual simulation systems, is to help with analysing capability options and examining cost versus capability trade-offs.

[2] History summarised from https://en.wikipedia.org/wiki/Headquarters_Joint_Operations_Command_(Australia)

2.0 SIMULATION FOR OPERATIONAL TEST & EVALUATION

LAND 2072 as a project is moving towards a simulation capability around the essential communication characteristics of each bearer that can be added to the network. The simulation scenarios include complex deployment scenarios covering aspects such as terrain, node failures and jamming. The model tool computes end-to-end delays, packet losses and carried traffic for all flows in the network, including multiple traffic priorities and multiple protocols (e.g. UDP, TCP). Performance in Quality of Service (QoS) terms can be derived against acceptable standards for jitter (variation in latency on packet flow), network delays and packet losses.

The complex engineering work to simulate a bearer's performance and behaviour is encapsulated in a library of 'military waveforms'. There are several medium access control (MAC) protocols that are modelled in the project, being IP fixed, Satellite and Wireless. After importing the node locations and parameters, a radio propagation model is used to determine the network topology, with calculations on a log-distance path loss model.

Analysis is done at the flow-level so that average flow level statistics are calculated. For transient and other lower level effects, a packet simulator is necessary.

To provide Operational Test & Evaluation (OT&E) there are two layers of modelling necessary:

1. The performance of the individual bearer over various conditions (range and terrain etc.) must be modelled in detail using a packet simulator to validate these performance tables against real-life performance measures. This will involve the development of digital terrain models so that the position of transmitters and receivers can be modelled with the appropriate algorithms to calculate the performance measures.

2. The overall network is simulated in terms of the information flows that it can support, highlighting the links that are overloaded, for remedial action.

Communications are planned around the commander's order of battle; which is used to determine the communication nodes and network topology required to support the commander's placement of troops and military platforms. In terms of testing a large-scale deployment for OT&E purposes, it is becoming increasingly difficult to deploy all the communication platforms necessary and across a large enough area to emulate a diverse battlefield. Simulation will be the future OT&E methodology. This will necessitate the capturing of detailed performance statistics and measures for each nodal pair across bearers. The specific terrain and distance apart will impact the packet flows, as will adverse communication jamming etc. When the detailed results are measured, they can be referred to later by the higher-level flow model to calculate traffic throughput under those conditions as per the selected topology of the network instance being tested.

This concept is illustrated in Figure 13-3 where the real-world testing is illustrated on the left-hand side. Naturally enough, it is not possible to test every possible combination of parameters. It is important to choose a representative set of parameters so that the testing can then be used to derive a reliable guide for the conceptual model to follow. Next in the middle of the diagram, the conceptual model is illustrated as a wireframe diagram of the terrain and all possible parameters. Sophisticated engineering algorithms may be needed to interpolate the results in a reasonable way that will align the predicted results of the model and the real-world results if the actual test was done with the indicated parameters. Finally, on the right-hand side is illustrated the conceptual slice which is selected and the actual model results are derived from. As OT&E moves further towards simulation, this will be an important validation result; to ensure that the conceptual model results would be verifiable in the real world.

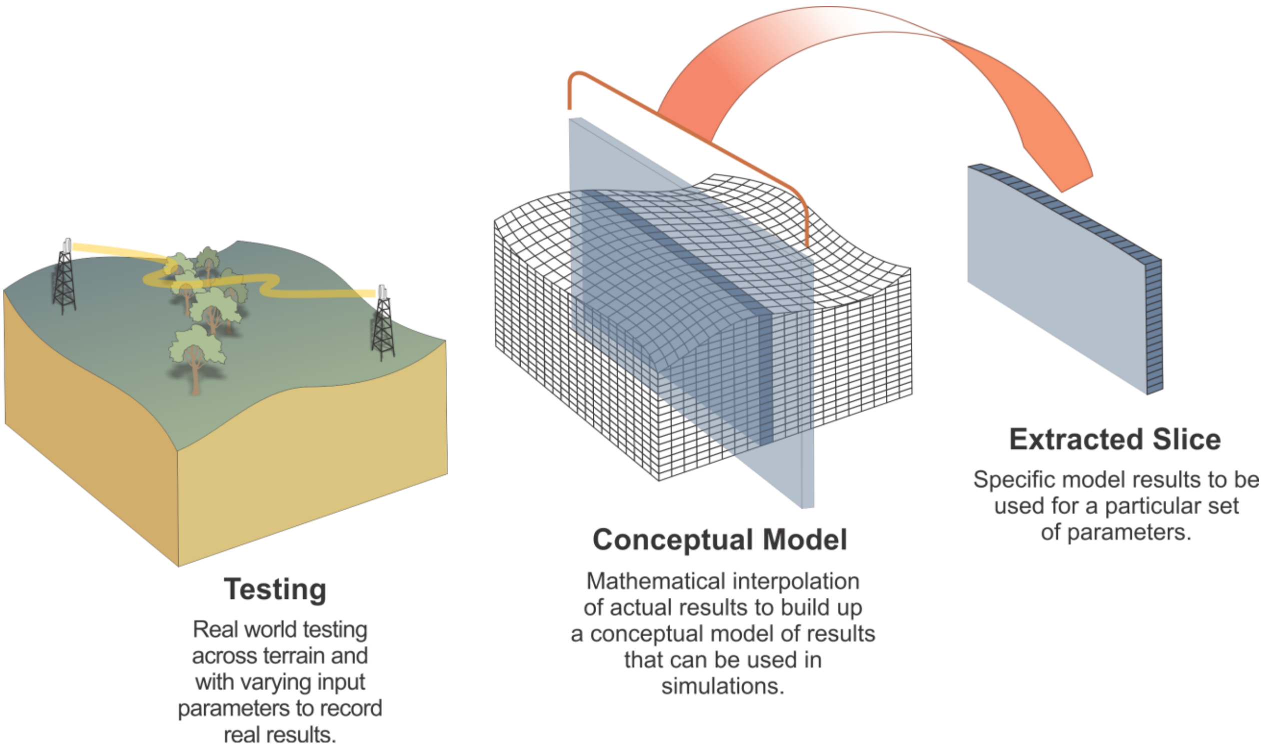

Figure 13-3 Simulation for OT&E Calculations

3.0 DEVELOPMENT OF SIMULATION CAPABILITY

Given that simulation of overall Defence capability in a war-gaming sense requires synthetic platforms to interoperate on the synthetic battlefield, the question arises as to who should be tasked with the development of the synthetic platforms. There are three broad options:

1. The group responsible for the capability acquisition, as they will have the engineering expertise from the various studies done during acquisition to drive the development of the synthetic models (even if contracted into the team).

2. The group within the Joint command who run the joint simulations (ADSTC), as they have knowledge of the required standards for interoperability and could supervise the development of suitable synthetic models. ADSTC is supervising the development of a networked training capability (known locally as JP 9711) to allow the ADF to network its simulators across a national infrastructure from simple constructive simulations through to more complex LVC scenarios and provides a network capability into the US simulation network to conduct joint and coalition exercises.

3. A third group who have no acquisition knowledge or operational knowledge of simulation could pursue the development of the synthetic models. However, this option suffers from the lack of knowledge held by the other two options and is the least likely option.

The preferred option is the Capability Acquisition group who are studying the effects of the development of this item. Engineering studies and research will enable the acquisition team to supervise the development of the simulation model for their capability acquisition. This preference is reinforced by the current funding model which is giving additional funding to the capability acquisition group in order to develop simulation models.

A potential future direction is to make the Capability Acquisition Projects formally responsible for the provision of the synthetic models, to allow for the simulation of that platform by the ADSTC. The feedback loop of the simulation capability taking part in realistic exercises can enhance the design and OT&E activities. This feedback loop can help provide references and validation to the engineering approach.

4.0 DISRUPTIVE FEEDBACK FROM SIMULATION OF REQUIREMENTS

Simulating capability as it is being acquired can simply be good engineering practice. All buyers could benefit from the advanced familiarisation of being able to use future equipment. The results of simulation in combat conditions will provide engineering level feedback as to the performance of a capability item.

How then can simulation be disruptive in the acquisition process? In the broader planning process, the overall capability is known well in advance. The broad outline of the capability is known, along with its intended introduction into service date, starting from the Initial Operating Capability (IOC) date. These broad parameters are known at the initial acquisition discussions, often referred to as Gate Zero. The Intelligence community is also providing similar information about the armed forces of other nations, whether or not they are perceived as being a potential future enemy.

Thus, looking forward, we can define in each weapons platform category, the likely contenders, and their relative IOC date. So then, let's simulate a future battle in 10 years' time. We can derive the likely platform capabilities for those future platforms that will have passed IOC at the chosen point for the battle, as illustrated in Figure 13-4.

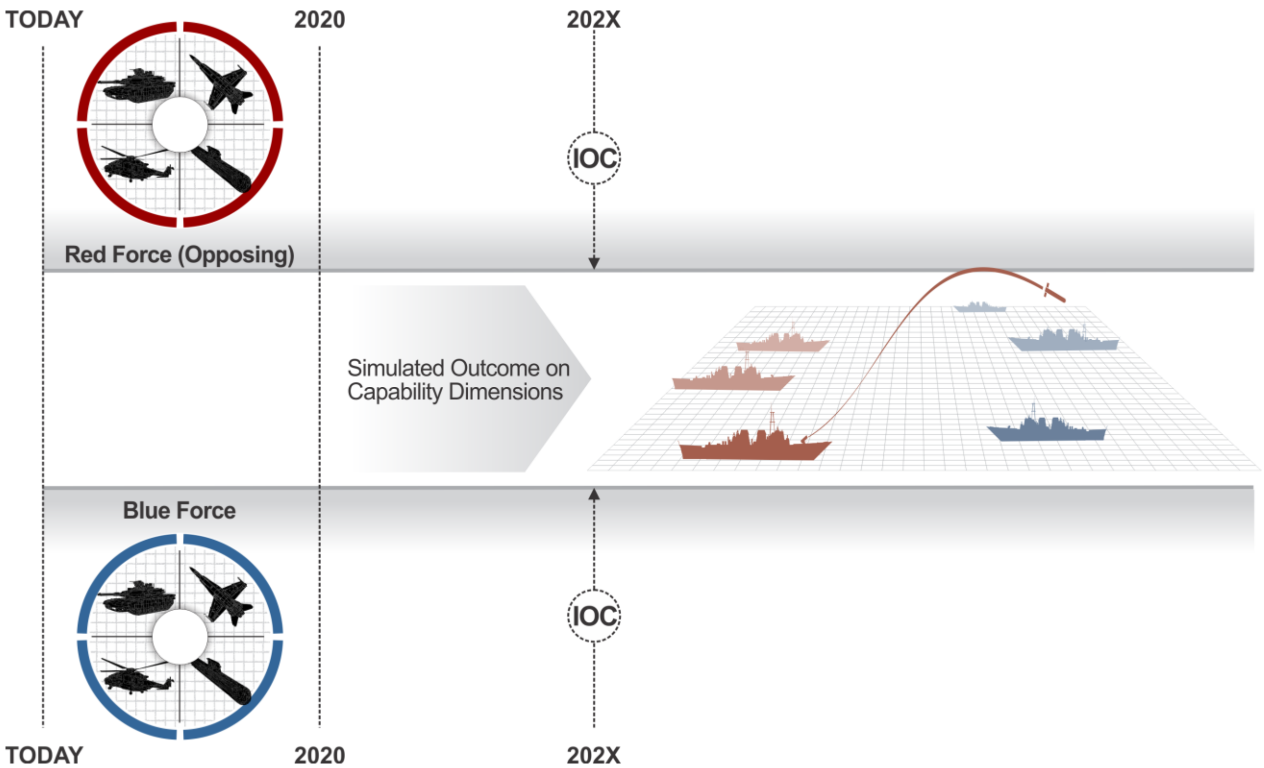

Figure 13-4 Simulated Capability Outcomes

How will this future battle work out? Given capable commanders on both sides, the capability elements themselves may be the deciding factor in victory or defeat. Rather than being discouraged about losing a future battle; we can use simulation to ask the fundamental capability questions. What dimensions of capability are needed to produce victory instead of defeat? Can a missile be fired from further away from the target to improve survivability of the crew? Will thicker armour on a platform provide the essential protection; remember the plunging fire that destroyed *HMS Hood* in WWII, as illustrated in Figure 13-5. As William J. Jurens noted in his comprehensive re-examination of the cause of the loss [3] "In the absence of any other possible energy source, like the boards, I have concluded that it is most probable that *Hood* was relatively slowly rent apart over a period of perhaps a second by the uncontrolled burning of the propellants in her after magazines. Although the actual position of the hit and the subsequent path of the projectile through the ship are problematical, it is clear that there are several routes by which one of *Bismarck's* 380mm shells might have reached the after magazines. Again, like the boards, I have also concluded that the most probable cause of the final blast was a hit from a single 380mm projectile from *Bismarck*."

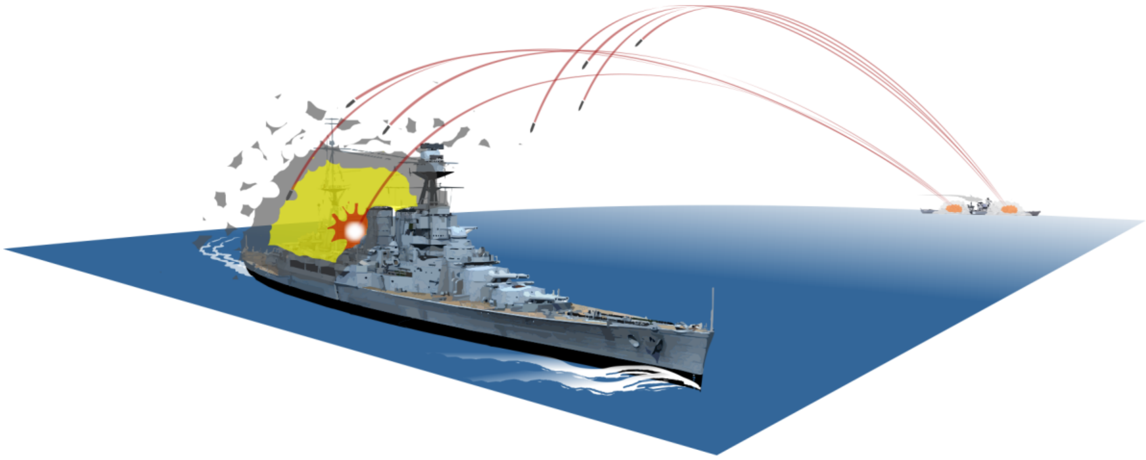

Figure 13-5 The loss of HMS Hood

This type of ship-to-ship conflict is a good example, where the conflict is relatively constrained. As a general statement, the size and range of the guns on each platform was a good indicator of the likely outcome of the battle. For *HMS Hood* to realistically compete with *Bismark*, she needed armour plating that was sufficient to withstand hits from the guns of *Bismark*. This point was by no means settled as the final results tragically showed. Must we send out a complete crew to their deaths when simulation could have forecast the result? This is not about the bravery of individual crews or their leadership, but about the fitness of the platform for the ensuing contest. It would have changed naval strategy if simulation could have shown conclusively that a platform such as *HMS Hood* could not have withstood incoming fire from *Bismark.* At a detailed level in the aftermath, those calculations were indeed done in an attempt to explain how the disaster happened and the adequacy of the various levels of armour plating.

Military platforms have long lead times in their acquisition. From the perspective of disruptive simulation, it is possible to simulate a future contest along the lines of known or likely capabilities of the various platforms that the blue force platform may have to contend with. The initial consideration of a new platform is termed "gate zero" where the overall capabilities are considered before detailed acquisition plans are made. To maintain superiority, it is therefore necessary to simulate the competitor's capabilities as a formulation of the basic capabilities that the blue force platform must provide. This can be known years in advance. Simulation of the "platform" against each known threat with its likely weapons capability can provide assurance of the required capabilities of the "platform" well in advance of funding and design commitments.

In an extreme example, we might laugh at the illustration in Figure 13-6 of pitting a famous WWII vintage

'*Spitfire'* against a modern *Joint Strike Fighter*. The capability dimensions of speed and firepower etc. that are severely mismatched over time would create a completely one-sided contest. However, near contemporary versions can be exercised relatively inexpensively through simulation of their fundamental capability dimensions. The crucial input that makes the platform survivable and leads to victory can be fed back into the real-world acquisition process.

Figure 13-6 The famous *Spitfire* is no match for the *Joint Strike Fighter*

While gate zero is the point of greatest leverage in simulation of future capability, there is still a reward for continuing to simulate the platform throughout the design and acquisition process. It can identify any capability gaps against known threats and help to crystallise the work required to maintain superiority.

The acquisition process is about translating capability requirements into detailed engineering requirements. Those requirements can be fed by simulation of competitive outcomes. The major naval engagement of WWI at the Battle of Jutland demonstrated a systemic weakness in capability that could have benefitted from early simulation during the acquisition process [4]; "Beatty also had temporarily under his command a squadron of four Queen Elizabeth class battleships which urgently tried to join the action, having been furthest from the original encounter and delayed by both the fragility of signalling and a lack of integration training. At 1602 *Indefatigable* was hit and lost due to a secondary explosion with over 1,000 deaths and only two survivors. At 1626 *HMS Queen Mary* was similarly lost with over 1,200 deaths. At this point Beatty remarked to his flag captain, "There is something wrong with our bloody ships today." Later in the battle a third battlecruiser, *Invincible*, would be lost in a similar explosion, again with over 1,000 deaths. These three ship losses amounted to half the Royal Navy's casualties at Jutland. Various explanations have been proposed but the evidence is strongly that ammunition handling had been compromised in pursuit of a higher rate of fire particularly in the battlecruiser force which, forward deployed to Rosyth to react to German raids, had less opportunity for gunnery practice. Beatty's flagship *Lion* was almost certainly saved by the safety procedures imposed by WO Gunner A C Grant and the actions of the mortally wounded Major Francis Harvey RMLI in ordering the flooding of Q turret magazine after the turret was hit."

Nathanial G. Ott notes in the conclusion to his thesis *Battlecruisers at Jutland: A Comparative Analysis of British and German Warship Design and its Impact on the Naval War* [5]; “Admiral David Beatty has been both criticized and praised for his handling of the British battlecruiser squadrons at the Battle of Jutland. The battlecruiser force under Beatty's command was severely mauled during the engagement; three of his nine vessels were destroyed by German gunfire, and a fourth—his flagship *Lion*—nearly exploded as well. Ultimately, to a large extent Beatty can be blamed for the disaster. While the proximate cause of the explosions aboard the British ships was the highly unstable and poorly protected propellant charges—something entirely out of Beatty's control—he failed to ensure safety precautions in the magazine rooms were being followed. Furthermore, his own directives concerning the rate of fire of the main battery were the cause for the discontinuation of many of these safety procedures. The failure to enforce proper handling procedures virtually guaranteed catastrophic magazine explosions would occur. This was clearly demonstrated by the incident aboard his flagship *Lion*; the fact that the magazine doors had been closed—a practice implemented only on this ship—when the turret was penetrated allowed the crew enough time to flood the magazine, which prevented the ship from being destroyed. Despite the seemingly overwhelming superiority of the British Battlecruiser Squadrons, in terms of numbers of warships and the number, caliber, and weight of shell of their guns, their German opponents emerged from the battle having inflicted much more destruction than they had absorbed. The German battlecruisers did enjoy several advantages over their British rivals; their heavier armor allowed them to stand up to more punishing fire. Their more highly-trained gun crews were on average more capable of dealing damage, even without the aid of a mechanical fire control system comparable to the Dreyer Table or Argo Clock on the British ships. A still-greater advantage was the superior performance of the German armor-piercing shells compared to the British versions. In the end, however, the performance of the ships' armaments and ammunition, fire control, and armor systems was of secondary importance. The deciding factor that led to the loss of three British battlecruisers at the hands of their German rivals was the physical differences in both sides' propellant charges and how they were handled. Both German and British battlecruisers had their turrets and barbettes penetrated and the ammunition inside ignited, though only the British ships suffered catastrophic explosions as a result. This was the direct consequence of the greater vulnerability and much faster burn rate of the British propellant and the unsafe manner in which it was handled. *Indefatigable*, *Queen Mary*, and *Invincible* might very well have survived the battle if their crews had followed the prescribed safety regulations for the handling of cordite.”

While acknowledging the undeveloped field of simulation during WW1; however, as these quotes illustrate, there would have been a rich field of competitive simulation studies available covering the armour thickness, armour-piercing shells, fire control and armour systems of the potential combatants. Even to the extent of operational procedures which in hindsight seemed to have played an important role. The outcome of these types of simulations as input into the appropriate gate zero acquisition decision could have enabled the timely acquisition of platforms that would have been capable of withstanding the expected punishment in a naval contest, at least levelling the field of combat to some degree.

5.0 CONCLUSION

A potential future direction is to make the Capability Acquisition Projects formally responsible for the provision of the synthetic models, to allow for the joint simulation of that platform in war gaming exercises.

The Battlespace Communications System (Land) is an exemplar of the trend to use simulation for OT&E. This helps overcome the budget and practical limitations against exercising all the different combinations of equipment. In practical terms, the number of combinations of testing required is making it no longer physically possible to conduct adequate testing for OT&E purposes; simulation will be the OT&E methodology of the future to extrapolate the limited physical testing that can be done into the accurate simulation of predicted outcomes.

Future planning and war gaming can be disruptive using synthetic components to simulate the capability of the platform vis-a-vis the anticipated opposing platform as at the date of Initial Operating Capability. This disruptive feedback is then used to refine acquisition requirements before it is built in its physical reality.

In the never-ending advance of military technology, we don’t just need better and better platforms; we need platforms that will be superior to those being fielded in comparable timeframes by the forces of other nations, in particular those against whom we may be in a contest at some point in time.

6.0 REFERENCES

[1] Commonwealth of Australia, Department of Defence, *The Strategy Handbook 2010*

[2] Commonwealth of Australia, Department of Defence, *Defence Capability Development Handbook 2014*

[3] William J. Jurens, The Loss of HMS Hood - A Re-Examination, *Warship International* No. 2, 1987

[4] Article on The Battle of Jutland, 31 May 1916, page 4. *All Guns Blazing! Newsletter of the Naval Wargames Society* No. 266 – December 2016

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