Supporting a Royal Australian Navy Modelling and Simulation Strategy

A Strategy-to-Task Framework
About This Report

High-end warfighting (HEWF) features heavily in the Australian government’s 2020 Defence Strategic Update. To better support its capability to successfully operate in HEWF, the Royal Australian Navy is modernising all its maritime capabilities. To focus these efforts, the Head of Navy Capability has directed the Navy Modelling and Simulation Office (NMSO) to expand upon the current Navy Modelling and Simulation (M&S) Strategy.

Navy’s Warfare Innovation Navy (WIN) Branch, which is responsible for the NMSO, commissioned RAND Australia to undertake research to review Navy M&S strategy broadly and recommend how it could be strengthened to support the ongoing modernisation, and in particular advise how M&S could be harnessed as a decision support mechanism to guide Navy’s conceptual approach to HEWF. The intent is that this research forms the evidence base for an author’s brief for an updated M&S Strategy.

Analysing information captured through a literature review, an environmental scan, and interviews, including with international subject-matter experts, we make a number of suggestions for inclusion in a revised strategy, so that Navy can better utilise more of the benefits that M&S has to offer and contribute to Navy capability in both the immediate and longer terms. These suggestions go beyond traditional training applications to include the use of M&S as a decision support tool in development and testing of HEWF concepts in the maritime domain.

This research was led by RAND Australia, with significant support provided by staff from the RAND Corporation in the United States and from RAND Europe. RAND Australia is RAND’s Canberra-based subsidiary that analyses defence, national security, economic, and social issues for Australian clients. With a commitment to core values of quality and objectivity, RAND Australia combines local research talent with world-class experts from across RAND’s global presence to solve complex Australian public policy problems.
Acknowledgements

We very much appreciate the support provided by the WIN Branch, particularly CAPT Nick Trongale, CMDR Richard Austin and Andrew Kirby. We are grateful to the senior officials in Australia, the United States and the United Kingdom who generously provided detailed insights into M&S in their jurisdictions. We appreciate the support provided by Carl Rhodes, Hannah Saul and Gordon Lee to this research, and the reviews of the report by Jim Powers and Shane Dunn.
Summary

Australia’s ‘strategic environment has deteriorated more rapidly than anticipated’,¹ and the need for the Australian Defence Force (ADF) to prepare capabilities for high-end warfighting (HEWF) in a maritime context, while remote, is assessed as increasing. The ADF also must have concepts and capabilities to counter an adversary’s grey-zone maritime operations. Growing regional military capabilities coupled with reduced warning times requires a more responsive approach to acquiring, preparing and deploying military capabilities. Coupled with these imperatives, Navy is undergoing a significant transformation, with a number of new platforms being introduced into service and existing platforms going through major upgrades. To support an increasingly critical role for modelling and simulation (M&S) in all aspects of maritime capability from decision support to training and operations, the Head of Navy Capability directed the Navy Modelling and Simulation Office (NMSO) to revise and expand the current Navy M&S Strategy to better support these changing requirements.

RAND Australia was commissioned to support the development of a revised Navy M&S Strategy, particularly by providing the evidence base for a subsequent strategy author’s brief. After an initial review of the current situation for Navy M&S and consultation with the Head of Navy capability, we identified two themes that a revised strategy should address over the immediate and longer-term future. These themes formed our research questions:

- **RQ1:** How could Navy use M&S as part of a decision support suite to address the challenges posed by HEWF, particularly to
  - prepare the current fleet for HEWF in the near term (up to 5 years) given the strategic environment
  - develop, test and explore emerging warfighting concepts given the evolving operational environment
  - inform fleet design and fleet generation over the next decade as new capabilities are designed, developed and introduced into service?
- **RQ2:** How could Navy adapt their M&S Strategy to better integrate and employ it across all aspects of the Navy program?

To support a strategy revision, we developed an approach that would most directly translate to a revised strategy, which was based upon a standard strategy-to-task logic model. To meet the requirements of this type of model, we identify and report the relevant strategic requirements and key elements of the current and forecast states for Navy M&S. These provide a basis for developing strategic focus areas for M&S lines of operation (LOOs), that incorporate enabling M&S functions (which were the focus of the 2019 Navy M&S Strategy), as well as introducing new LOOs related to the application of M&S in support of Navy’s HEWF decision support requirements. While not usurping the place of the ultimate strategy document, goals and gaps are drafted for each, from which a set of initiatives (tasks) can be identified that close the gaps between these.

To populate this framework, we commenced with a review of the strategic context and policy drivers that will shape Australia’s maritime warfighting environment over the next decade. We then reviewed Navy’s relevant strategies and plans, paying particular attention to Navy’s five strategic outcomes and their relationship to this broader environment (particularly Outcomes 1 and 2):²

1. Provide maritime forces for current operations, exercises, engagements and future contingencies;
2. Plan and deliver future maritime systems;

3. Assure the safety, seaworthiness and airworthiness of our systems;
4. Effectively lead and manage our people and culture; and
5. Provide the required enablers and oversight to achieve Navy outcomes.

Our review confirms that, like many of Australia’s allies, Navy’s current M&S capabilities predominantly focus on helping train personnel in basic and advanced competencies they need to operate platforms and weapon systems safely. We note how this should change to match the capabilities of the contemporary platforms, systems and weapons. However, we also note that an update to the M&S systems that support basic and advanced competency training needs to be proceeded by an analysis phase focused on the concepts and capabilities required for HEWF. Our analysis identifies that Navy has an unmet requirement for M&S in decision support in this regard, particularly early in the capability life cycle, and we outline a role for analytical wargaming capabilities supported by fit-for-purpose M&S tools.

While somewhat broader than a simple M&S tools approach, this analytical capability is particularly relevant for the development of warfighting concepts, and such decision support capability was previously heavily utilised by Navy but, due to changing priorities, has atrophied in recent times.3 We suggest that the renewed interest in such capability from Navy now, particularly, and perhaps critically, by Navy’s senior leadership, demonstrates their understanding of its value in informing decisionmaking in these areas4 and is particularly pertinent given the pressing challenges posed for capability development and application in HEWF and grey-zone operations in the maritime domain. However, we identify that undermining this renewed interest is a general lack in the type of M&S infrastructure and models that Navy needs, particularly to undertake M&S at a classified level.

Using this broad basis, we propose new (desired) future states for M&S, and gaps and objectives, given the changes in the strategic environment. To support our analysis, we explored other nations’ approaches to maritime M&S in order to help draw out lessons.

To support the enabling themes within the extant strategy, we developed a framework to guide the development of the emerging Maritime Synthetic Environment (MSE) for integration within the broader Defence Synthetic Environment (DSE), using classes of M&S products and services against the areas of fleet support:

1. Fleet Employment (Future)
2. Fleet Design/Development
3. Fleet Management
4. Fleet Generation
5. Fleet Employment (Current).

These areas are consistent with the responsibilities of the Chief of Navy in maritime capability.

Noting both the immediate and longer-term time imperatives that we have identified, we suggest that strategy implementation be cast in three ‘epochs’. The first two epochs directly inform the decisions and functions of the Navy enterprise requiring M&S support, while the third informs the maturing and sustainment of the MSE as it evolves as part of the overall DSE. Importantly, the M&S supported work to define the concepts and capabilities required for HEWF sets the requirements for M&S over the longer term. Our focus, then, in this report are the immediate challenges—that is, the first two epochs, acknowledging that roadmapping and prioritisation will inform the third epoch.

3 However, the Royal Australian Navy is not alone in concern for an atrophied capability for simulation-based analytical capability; see U.S. Department of Defense, ‘Memorandum on Wargaming and Innovation’, Deputy Secretary of Defense, 9 February 2015.

4 From the early 2000s, the M&S process supporting Navy was expanded to a full experimental framework known as Headmark. Informal discussion with members of the current Navy leadership revealed that they were at least exposed to this framework, if not directly involved in its application, and saw firsthand the decisionmaking rendered from it.
Finally, we present a two-part, high-level approach to strategy for Navy M&S that aligns with the Joint Simulation Strategy. The first part (an iteration of the 2019 strategy) focuses primarily on the ‘enablers’ for M&S: People; Systems; Interoperability; and Governance. Based on our analysis (including interviews with senior stakeholders), the second part identifies the need for four new application LOOs: Support to Strategic Functions; Employ the Fleet; Generate the Fleet; and Navy Information Warfare (NIW). These will need to be developed further by Navy during implementation to broaden and strengthen their M&S capabilities, particularly to revitalise their analytical wargaming capability.

As a result of our analysis, we make the following recommendations (Chapter Eight describes them in full):

- Update the M&S enablers and add a further four application LOOs (Support to Strategic Functions; Employ the Fleet; Generate the Fleet; and NIW).
- Establish an M&S-enabled analytical campaign to understand the challenges in conducting maritime HEWF, characterise gaps that emerge, and develop and test new maritime warfighting concepts.
- Develop an analytical wargaming service and follow this with augmentation of the staffing of Maritime Warfare Centre to support a fleet design function.
- Engage with the United States Marine Corps Warfighting Laboratory to understand their approach and plan, and determine the utilise of their current M&S tools.
- Scope out the M&S and decision support requirements for NIW across all classifications.
- Enhance the MSE to better support classified simulations, including updating ICT infrastructure, facilities, models and databases.
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<td>A2/AD</td>
<td>anti-access and area denial</td>
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<td>ADF</td>
<td>Australian Defence Force</td>
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<td>AI</td>
<td>artificial intelligence</td>
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<td>AoA</td>
<td>Analysis of Alternatives</td>
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<td>APS</td>
<td>Australian Public Service</td>
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<td>AR</td>
<td>augmented reality</td>
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<td>ASW</td>
<td>anti-submarine warfare</td>
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<td>AUSTEO</td>
<td>Australian Eyes Only</td>
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<td>C2</td>
<td>command and control</td>
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<td>C4ISR</td>
<td>command, control, communications, computers, intelligence, surveillance and reconnaissance</td>
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<tr>
<td>CDF</td>
<td>Chief of the Defence Force</td>
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<td>CLC</td>
<td>capability life cycle</td>
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<td>CN</td>
<td>Chief of Navy</td>
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<td>COMAUSFLT</td>
<td>Commander Australian Fleet</td>
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<td>COMTRAIN</td>
<td>Commodore Training</td>
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<td>CONEMP</td>
<td>concept of employment</td>
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<td>concept of operations</td>
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<td>commercial off-the-shelf</td>
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<td>Defence Capability Manual</td>
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<td>Defence Innovation, Science and Technology</td>
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<td>Defence Modelling and Simulation Coherence</td>
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<td>DoD</td>
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<td>EW</td>
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<td>FIC</td>
<td>fundamental inputs to capability</td>
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<td>Fleet Warfighting Plan</td>
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<td>GM-VV</td>
<td>Generic Methodology for Verification and Validation</td>
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<td>HEWF</td>
<td>high-end warfighting</td>
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<td>HLA</td>
<td>high-level architecture</td>
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<td>HNC</td>
<td>Head of Navy Capability</td>
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<td>HQJOC</td>
<td>Headquarters Joint Operations Command</td>
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<td>ICT</td>
<td>information and communications technology</td>
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<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<td>IOC</td>
<td>initial operational capability</td>
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<td>IP</td>
<td>intellectual property</td>
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<td>ISR</td>
<td>intelligence, surveillance and reconnaissance</td>
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<td>Joint Simulation Strategy</td>
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<td>LOE</td>
<td>line of effort</td>
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<td>line of operation</td>
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<td>LVC</td>
<td>live, virtual and constructive</td>
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<td>M&amp;S</td>
<td>modelling and simulation</td>
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<td>MBSE</td>
<td>model-based systems engineering</td>
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<td>MCWL</td>
<td>Marine Corps Warfighting Laboratory</td>
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<td>MOAC</td>
<td>Maritime Operations Analysis Centre</td>
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<td>Ministry of Defence [UK]</td>
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<td>North Atlantic Treaty Organization</td>
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<td>OA</td>
<td>operations analysis</td>
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<td>on-board training system</td>
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<td>One Defence Capability Model</td>
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<td>operational test and evaluation</td>
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<td>principal naval advisor</td>
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<td>R&amp;D</td>
<td>research and development</td>
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<td>RAM</td>
<td>reliability, availability and maintainability</td>
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<td>RAS</td>
<td>robotics and autonomous systems</td>
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<td>RDT&amp;E</td>
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<td>RN</td>
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<td>SICP</td>
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<td>SME</td>
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<td>suitably qualified and experienced personnel</td>
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<td>StratCom</td>
<td>Strategic Command</td>
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<td>T&amp;E</td>
<td>test and evaluation</td>
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<td>TTPs</td>
<td>tactics, techniques and procedures</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<td>UI</td>
<td>user interface</td>
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<td>U.S. Coast Guard</td>
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<td>United States Marine Corps</td>
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<td>U.S. Navy</td>
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<td>V&amp;V</td>
<td>verification and validation</td>
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<td>VCDF</td>
<td>Vice Chief of the Defence Force</td>
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<td>VfM</td>
<td>value for money</td>
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<td>VR</td>
<td>virtual reality</td>
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<td>verification, validation and accreditation</td>
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CHAPTER ONE

Introduction

Background

Australia’s ‘strategic environment has deteriorated more rapidly than anticipated’,¹ and the need for the Australian Defence Force (ADF) to be prepared for high-end warfighting (HEWF), while remote, is increasing. Growing regional military capabilities, and the speed at which they can be deployed, mean that Australia can no longer rely on long warning times ahead of conflicts. Potential adversaries will fight in different ways with advanced technologies in physical and virtual spaces and on compressed time-scales. Reduced warning times mean defence planning can no longer assume Australia will have time to gradually adjust military capabilities and preparedness in response to emerging challenges.

Within this environment, the Royal Australian Navy is undergoing a significant transformation, with a number of new platforms being introduced and existing platforms going through major upgrades. Designed for interoperability (both joint and coalition) and armed with sophisticated weapons, intelligence, surveillance and reconnaissance (ISR), battle management, and communication systems, these new and upgraded platforms will allow Navy to adapt how it delivers effects in increasingly contested environments. Built in batches, the new platforms’ designs will evolve to respond to new opportunities and threats. Further, the recognition of the importance of sovereign capability is leading to a more significant role for Australian industry in all aspects of the Defence (and Navy) system, from capability design and delivery, to sustainment, training and preparedness.

As a result of these emerging challenges, the Head of Navy Capability (HNC) directed the Navy Modelling and Simulation Office (NMSO) to expand upon the current Navy Modelling and Simulation (M&S) Strategy and develop an M&S Roadmap. These documents need to support the development, preparation and employment of capability to operate successfully when undertaking HEWF. From a top-down perspective, previous strategy documents have successfully defined and argued the case for M&S² within Defence and within Navy. Thus, it can be argued that a revised strategy or roadmap does not need to relitigate some arguments and cover ‘what’ M&S can do for Navy as earlier versions have done. Navy has already built significant M&S capabilities and has introduced strategic governance in

¹ Department of Defence, 2020 Defence Strategic Update, Commonwealth of Australia, 2020a, p. 3.
² For the purposes of this document, we use the following Australian Defence Simulation Glossary definitions:

- Modelling: The process of creating and analysing a physical model to predict its performance in the real world through multiple iterations.
- Simulation: A method for implementing a model over time.
- Modelling and Simulation: The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions.

M&S strategies published in 2016\(^3\) and 2019\(^4\). However, with some notable exceptions,\(^5\) Navy’s M&S capabilities predominantly focus on helping train personnel in basic and advanced competencies they need to operate platforms and weapon systems safely. Notwithstanding the focus of the installed base, Navy acknowledges that M&S has a critical role in analysing a range of problems, supporting decisions for future fleet design requirements, managing acquisition programs, and exploring enhancements for existing platforms. The focus of the next steps in strategy and implementation is in the prioritisation, specifics and detail. For example, the detailed application of M&S in preparing for HEWF has not been explored previously, nor details of how M&S will inform better employment of the current maritime fleet, particularly as new platforms and systems enter service.\(^6\)

Navy\(^7\) commissioned RAND Australia to undertake research to support the development of a revised version of the Navy M&S Strategy. Consistent with RAND Australia’s mandate for objective and intellectually independent research (without influence from research clients or sponsors), this report documents in detail our research and policy recommendations, providing an evidence base for an author’s brief for a revised Navy M&S Strategy and approaches to the resultant strategy and roadmap documents. It forms a deliverable to Navy.

**Objectives and Method**

The objectives of the research that Navy commissioned were quite broad initially, requiring, among others, reviews of existing documentation, work internationally and in academia and industry to inform an author’s brief on how an M&S Strategy should be crafted to meet the demand for HEWF, including, in particular, the collective training requirements in a simulation and modelling environment, preparedness, and task force certification through simulation.\(^8\) This was to be followed by research guiding the drafting of a revised set of strategy and roadmap documents.

The broad objectives of the initial research were sharply focused once the basis for the author’s brief, including a historical review of Navy M&S application to analytical concept and capability development, was presented to HNC, the senior sponsor. At this point it was evident that what Navy sought included an M&S-based decision support capability, which had existed in part previously as a shared effort between Navy and the then Defence Science and Technology Organisation (DSTO). The research remit was then broadened to accommodate the implied objective. To build the evidence base to inform the Navy M&S Strategy and support prioritisation of the associated M&S Roadmap, we sought to answer two research questions:

- **RQ1**: How could Navy use M&S to better address the challenges posed by HEWF, particularly to
  - prepare the current fleet for HEWF in the near term (up to five years) given the deteriorating strategic environment
  - uncover and explore emerging warfighting concepts given the evolving operational environment

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\(^5\) For example, Navy continue to use modelling to support workforce strategic planning and previously used it to support fleet transition planning.

\(^6\) Appendix D provides the 39 M&S services that are listed under the Defence Innovation, Science and Technology Panel. While this is predominately focused on M&S for research and development (R&D) and warfighting analysis, it does continue to demonstrate the range of potential applications for Navy.

\(^7\) NMSO is a part of the Warfare Innovation Navy (WIN) Branch.

\(^8\) These objectives have been paraphrased from the initial request for services and RAND Australia’s research proposal response. The commercially sensitive documents are not fully referenced here.
Introduction

- inform fleet design and fleet generation over the next decade as new capabilities are designed, developed and introduced into service?
- RQ2: How could Navy adapt their M&S Strategy to better integrate and employ it across all aspects of the Navy program?

The research methods used to illuminate these questions began along a number of mutually supporting paths:

1. the historical review of the application of M&S in Navy decision support, including such constructs as the Maritime Operations Analysis Capability (MOAC) and the Headmark Experiment series—and in the more traditional application to training
2. a review of international best practice, leveraging the access of the RAND Corporation and RAND Europe to deep subject-matter expertise internal to RAND and externally in the UK Defence and U.S. Defense and industry segments
3. an Australian lead review of Defence strategy requirements, existing strategy, and policy
4. a formalised consideration of the implied M&S goals, gaps and initiatives consistent with meeting the strategic objectives, using the review as a base, augmented with senior client and stakeholder interviews.

In respect of these latter two research paths, our review included the existing simulation strategy documentation for Navy and the joint domain and the strategic statements stemming from the 2020 Defence Strategic Update (DSU). We found shortcomings in the structure of the contemporary simulation strategy documents, partly stemming from a confusing conjunction of ICT product strategy terminology and traditional strategy approaches (a plethora of different approaches and templates exists). A simple update to the 2019 M&S Navy Strategy to accommodate the DSU drivers was considered to be insufficient and has not been recommended. To provide the evidence base necessary to guide a revision of Navy’s M&S Strategy and to frame an implementation roadmap and resourcing, we developed the approach documented here, based on a strategy-to-task framework (see Figure 1.1). Here the strategic requirements and current and future states provide a basis to develop strategic focus areas for M&S—in our case lines of operation (LOOs) that incorporate the enabling M&S lines of effort (LOEs; ‘enablers’) as well as the application of M&S. Goals and gaps are identified for each, from which a set of initiatives (tasks) are identified that can close the gap between the former. We note the numerous strategy frameworks available; the strategy-to-task approach is used here because (consistent with the Department of Finance requirements) it explicitly provides an audit trail from national objectives and strategies down to initiatives. This strategy-to-task logic model provides the framework for the recommendations described and tabulated in Chapter Eight.

This approach assumes that Navy—after considering and publishing an M&S Strategy informed by this research—will seek to prioritise the strategy and resource its implementation. Further, we propose that the resultant strategy will follow a strategy-to-task model that links the strategic M&S requirements to goals aligned to LOOs. For each LOO, we employed a mixture of literature review, technical knowledge, and subject-matter expert (SME) interviews to formulate our evidence base, and conducted a desktop assessment to characterise the current and required future state(s). We then identified gaps and suggested initiatives for the subsequent implementation roadmap.

To explore these questions, we identified a range of new and emerging problems that confront Navy, against which M&S capabilities could be brought to bear. We discussed approaches to HEWF in the maritime environment (and grey-zone activities) as well as in linked warfare domains (e.g., cyberspace);

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9 Department of Defence, 2020a.

this helped us to describe significant changes in the strategic requirement and, therefore, in the application LOEs for M&S. We then determined the framing of M&S that best fits these current and emerging challenges. This was intended to encapsulate how Navy should design and deliver its M&S Strategy. Of course, M&S is not applied in a vacuum, and so the implications for the broader system are also considered. Finally, we identified some M&S tools that might offer the best path forward for each component of RQ1. This provided a basis for the final step in strategic planning: resourcing and tasking implementation of the M&S Strategy.

Structure

This report is structured as follows. Chapter Two describes strategic context and policy drivers that will shape Australia’s maritime warfighting environment over the next decade. Chapter Three reviews Navy’s most recent M&S Strategy and capabilities, providing an assessment of the current state for that strategy and identifying gaps. Chapter Four identifies a new future state and gaps and objectives associated with the assessment of the strategy and the existing capabilities. Chapter Five explores other nations’ treatment of similar problems in the maritime environment through M&S. Chapter Six provides a framework for the M&S Objectives in application areas and for guiding development and implementation of Navy M&S Strategy. Chapter Seven recommends courses of action Navy can take to build an M&S support system. Chapter Eight summarises the report, providing a list of key findings.

This report, we

- identify several application LOOs\textsuperscript{11} necessary for an expanded Navy M&S Strategy
- provide evidence linking Navy M&S Strategy goals to implementation tasks, so that Navy can position itself better to operate in a HEWF environment.\textsuperscript{12}

\textsuperscript{11} We use this term to align with the nomenclature employed in Department of Defence, Joint Simulation Strategy, Commonwealth of Australia, 2018b.

\textsuperscript{12} Implementation will require Navy to both meet immediate operational challenges and position itself to better develop, integrate and employ a range of existing and emerging capabilities as its fleet evolves.
CHAPTER TWO

Strategic and Policy Drivers for M&S

Previous Navy M&S Strategies identify how M&S should be designed, deployed, managed and governed so that Navy’s current and future needs are met. However, HEWF in the maritime environment has become a strategic concern, both in terms of the increasingly complex operating environment and the likely proximity of potent threats to Australia’s security.¹ This implies a review of Navy’s approach to warfighting, which, in turn, will shape the requirements for Navy’s M&S capability. In this chapter, we discuss the implications of this changing context for Navy. We begin by describing what is driving changes in how Navy operates (including within a joint and coalition environment). We then situate Navy within this environment. Finally, we summarise how these should shape the Navy M&S Strategy.

Capability Context

Australia’s Strategic Posture

Australia has a history of articulating its strategic context, commonly through the development of white papers. Best practice in Australia dictates that the M&S Strategy drivers should be linked to the strategic context.² These are contemporised to be relevant for the current security threats and potential future risks. The DSU³ and associated Force Structure Plan 2020 (FSP)⁴ represent the most recent enunciation of that context and Australia’s planned response. They foreshadow a significant shift in the strategic context, with a particular emphasis on the Indo-Pacific region, which is ‘at the centre of greater strategic competition, making the region more contested and apprehensive’.⁵ The result is a strategic policy setting wherein the strategic objectives are ‘to shape Australia’s strategic environment; to deter actions against Australia’s interests; and to respond with credible military force, when required’.⁶ The risk of a rapid deterioration in the strategic environment, coupled with rapid changes in technology and non-conventional approaches to warfare by local adversaries, means that Australia can no longer plan assuming a ten-year warning time. Rather, reduced warning times mean that Australia can ‘no longer assume [it] will have time to gradually adjust military capability and preparedness in response to emerging challenges’.⁷ This requires that the ADF (and the Defence enterprise more broadly) ‘increase its self-reliant ability to deploy and deliver combat power and reduce its dependencies on partners for critical capability’.⁸

¹ Department of Defence, 2020a, ch. 1.
³ Department of Defence, 2020a.
⁵ Department of Defence, 2020a, p. 3.
⁸ Department of Defence, 2020a, p. 40.
Modes of Conflict

Fundamental to building an M&S Strategy and the M&S capabilities necessary for understanding problems is a working definition of the context for the problem and decisions. To aid in the analysis of what M&S is needed and why (to support prioritisation and resourcing), this section provides what we understand to be a starting definition of HEWF, using the work of the last decade. The M&S Strategy requires this understanding to articulate the capability gap against which the strategy is positioned, both in the military capabilities across fundamental inputs to capability (FIC) and in the M&S capabilities required. The process of military experimentation will necessarily amend, and possibly radically change, this, but to even set the scenarios and establish a fit-for-purpose suite of models and simulations, a starting point is required. Once refined, this definition should weave its way into root maritime doctrine—the Australian Maritime Doctrine 2010⁹ and Australian Maritime Operations 2017¹⁰—as well as into capability requirements and capability training.

While Navy will continue to support the full spectrum of operations from peacekeeping and constabulary operations to combat operations at and from the sea,¹¹ it must be prepared for HEWF operations, inasmuch as the operational circumstances can escalate rapidly, particularly in the maritime domain (e.g., with presence operations escalating to coercion and then onto combat operations).¹² Therefore, we need to define what constitutes HEWF within the maritime context.

Fortunately, the unclassified literature of the last decade is replete with work seeking to define high-end conflict or HEWF, drawing distinctions from conventional manoeuvre warfare. We draw from three other works to characterise our understanding of HEWF in the maritime domain as a valid starting point for the M&S Strategy. Firstly, Scharre draws attention to the capability challenges posed by the broadened spectrum of both counterinsurgency (COIN) and counter–anti-access and area denial (A2/AD). In identifying A2/AD as HEWF, Scharre notes that the capabilities and capacities of the United States require adjustment from the ‘traditional maneuver warfare against conventional militaries’ to meet the HEWF demands of counter-A2/AD.¹³ Scharre goes on to note that this adjustment was the particular domain of the United States Navy (USN) and United States Air Force (USAF). By extension, the platforms, doctrine, and maritime warfare capabilities of Navy have been built and prepared for conventional warfare. We observe that maritime capability is primarily designed to meet the challenges of manoeuvre warfare,¹⁴ and is routinely applied to what Scharre identifies as hybrid warfare, COIN, counterterrorism, and stability operations.

A recent RAND study into the future of conflict and its implications identifies ‘four basic archetypes for future warfare: counter-terrorism, grey-zone, asymmetric, and high-end’.¹⁵ While these are identified in the DSU, two are of particular relevance for our discussion of capability and an adjusted M&S Strategy for the maritime environment (grey-zone and HEWF). Mahnken et al.¹⁶ identify particular roles for Australia and the ADF in both grey-zone and counter-A2/AD HEWF scenarios. In a subsequent article,¹⁷

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¹² Royal Australian Navy, 2017, fig. 1 and associated discussion.
¹⁴ In particular as ‘Manoeuvre and Attrition in Maritime Warfare’ in Royal Australian Navy, 2010.
¹⁶ Thomas G. Mahnken, Travis Sharp, Billy Fabian and Peter Kouretos, Tightening the Chain: Implementing a Strategy of Maritime Pressure in the Western Pacific, Centre for Strategic Budgetary Assessments, 2019.
Mahnken et al. expand on both the roles for the ADF and need for new operational concepts. These references are of particular interest given the primary area of focus is maritime operations in the Indo-Pacific and Western Pacific.

Grey-Zone Operations

A key factor in these more recent documents is an expanding definition of what was considered as 'lower-end conflict' in order to encompass the challenges of grey-zone operations in the maritime space.\(^{18}\) Having not rated a specific mention in the 2016 Defence White Paper,\(^{19}\) the more contemporary DSU notes the growing importance of grey-zone operations. Defined as 'activities designed to coerce countries in ways that seek to avoid military conflict', grey-zone operations encompass a range of activities that focus on achieving political, economic, informational and military means to achieve a strategic ends, all the while remaining under the threshold of war, at least as nations such as Australia conceive it. In some cases, a grey-zone operation 'involves the use of covert, civilian, or proxy forces'. while in other instances it does not 'involve kinetic force at all, instead relying on information warfare, economic coercion, or cyber tools to achieve national objectives without provoking a shooting war'. China, for example, has identified information superiority as a precondition for battlefield supremacy where psychological, media and public opinion, and legal warfare is emphasised, and aimed at both military and civilian groups to build support of Chinese interests.\(^{22}\)

Cohen et al. note that a number of potential adversaries 'have sought to achieve national objectives by using coercion short of armed conflict, often by exploiting U.S. and allied thresholds for response'.\(^{23}\) As the Chief of Defence Force (CDF) noted in a 2019 speech, Western militaries, unlike those of totalitarian regimes, are not well prepared to operate in such an environment.\(^{24}\) That suggests that Navy will need to perform a range of missions that are situated between HEWF (both combat operations from the sea and at sea) and constabulary operations.\(^{25}\) As noted above, by 2040, Navy will need to be 'able to counter coercive statecraft and respond to grey-zone activities',\(^{26}\) thus widening the range of activities that have been traditionally prepared for in the maritime domain.

In the maritime domain this will include cyberspace, a domain of future conflict where potential adversaries such as China and Russia have demonstrated a willingness to operate. Indeed, some suggest that cyber will be a crucial piece of any multi-domain grey-zone strategy.\(^{27}\) This includes the ability to respond to grey-zone activities—especially in the cyber domain—that may be employed as a precursor to conventional conflict.\(^{28}\) The ability to concurrently prosecute (and counter) kinetic and non-kinetic forms of warfare is expected to become the norm.

What is unclear at this point (at least to the authors) is what aspects of Navy maritime capability will be defined by the demands of the grey-zone contest. Arguably, training (and the M&S capabilities to

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\(^{18}\) The term is often used interchangeably with others such as 'hybrid warfare' and 'political warfare'.


\(^{20}\) Department of Defence, 2020a, p. 12.

\(^{21}\) Cohen et al., 2020, pp. 50, 52.


\(^{23}\) Cohen et al., 2020, p. 50.

\(^{24}\) Angus Campbell, speech delivered at the Australian Strategic Policy Institute International Conference: War in 2025, Canberra, 13 June 2019.


\(^{27}\) See, for instance, Cohen et al., 2020, p. 24, and Table 4.4.

\(^{28}\) Department of Defence, 2020a, p. 14.
train) that captures and tests a range of possibilities will be an essential precursor to building the capability of Navy personnel for grey-zone operations. An untested hypothesis resulting from recent joint experimentation\(^\text{29}\) is that some defensive characteristics (response times, survivability, etc.) of maritime platforms might be defined by the grey-zone requirements more than for HEWF. Similarly, designing and testing capabilities and operational concepts will require realistic representations of how grey-zone effects of all types may occur, be delivered (or countered), and answered (in the case where an attack has been successful). These M&S capabilities will almost certainly be in the classified domains, and they will be operated ashore and implemented through new on-board training systems (OBTSs). These mooted impacts need to be analysed and assessed, which is beyond the limits of this report.

The implied growth in M&S capabilities will be an additional burden on Navy. The M&S systems, training and preparation for the existing competencies will almost certainly be required into the future. And there is the requirement to support the other new challenge: counter-A2/AD battle (described below).

**High-End Warfighting**

Cohen et al. comment on HEWF from the perspective of two distinct circumstances: a land-based conflict against Russia in Europe and a maritime-centric one against China in the Indo-Pacific.\(^\text{30}\) While it is likely that Australia will be operating as part of a coalition that may have better overall conventional capabilities than an adversary, the geography associated with likely conflicts poses challenges that might blunt the capability advantage. Cohen et al. observe that the adversary

> will likely have homefield advantage, localized numerical superiority, and a nearing qualitative edge—complete with sophisticated weapon systems, such as advanced air defense systems, extensive offensive and defensive space and cyber capabilities, and the ability to wage a tactical nuclear war.\(^\text{31}\)

From a capability perspective, they note that artificial intelligence (AI) will act as a disruptive technology, space will be increasingly contested, and cyber espionage and sabotage will be the norm.\(^\text{32}\) Adversaries ‘might privilege stealth and speed’,\(^\text{33}\) which may challenge Navy’s doctrinal approaches to warfighting. It is worth noting that M&S could play a key role here, supporting the development and exploration activities from which these capstone documents can be revised and updated.

From an M&S perspective, there are a number of factors that must be considered. These include (but are not limited to)

- contributions in the areas of information and cyber operations will need to be folded into planning and training activities and the M&S systems that support them
- an understanding of how the adversary may choose to operate, and where and how maritime capabilities perform their assigned tasks needs to be studied before effective fleet development can begin
- reduced access to tools that are commonly relied upon during peacetime operations (GPS, comms, sensors, etc.)
- given the reduction in warning time, the ability to achieve, certify and maintain readiness will be challenged.

\(^{29}\) Informal discussions between an author (Brennan) and representatives of the Joint Experimentation Directorate (JED) design team.

\(^{30}\) Cohen et al., 2020, p. 53.

\(^{31}\) Cohen et al., 2020, p. 53.

\(^{32}\) Cohen et al., 2020, p. 51.

\(^{33}\) Cohen et al., 2020, p. 54.
Emerging Military Technologies

Technology domains that rapidly advance are a significant driver behind the changing maritime environment, particularly those domains that are advancing to the point where they may become prominent in the operational environment over the next decade. The DSU is unambiguous as to the impact of emerging military technologies on Australia’s ability to remain relevant in conflicts over the next decade or two. It notes that ‘the rapid spread of technology will both support and challenge Defence’s requirement to maintain a regional capability edge in advanced warfighting and enabling capabilities’. These are characterised in terms of range, speed, precision and lethality. Emerging military technologies, such as ‘sophisticated sensors, autonomous systems and long-range and high-speed weapons [are] reducing decision times and improving weapon precision and lethality’, while ‘expanding cyber capabilities . . . compromise military capability and operations’. Further, the increasingly ubiquitous nature of interconnected digital systems threatens the enabling capabilities Navy will rely on in the event of a major conflict, such as supply chains, critical infrastructure and support services.

Navy is seeking to address these drivers through various programs. For instance, Navy recently released its first maritime robotics and autonomous systems (RAS) and AI (RAS-AI) Strategy. This recognised the need for Navy to ‘deliver persistent presence across a wide area of interest, complemented by capabilities that can be rapidly developed, tested, forward deployed (or rapidly deployed) and adapted in situ’. This would be encapsulated through an array of uninhabited air, surface and undersea autonomous systems, working closely with existing (crewed) platforms. The introduction of such capabilities will have wide-ranging implications across the entire capability life cycle (CLC): design and experimentation; testing and validation; operational activities and new tasks; workforce development and deployment; organisational culture and new forms of teaming; and platform reconstitution and replacement.

Australia’s allies as well as potential adversaries are also investing heavily in RAS, requiring Navy to understand not just how it will develop, deploy and sustain these autonomous systems, but also how they might be deployed against Australia and its allies. As is typical with the early days in the operationalisation of novel military technologies, there will be a learning curve, which may be steep.

RAS-AI M&S Requirements

By way of example, it is insightful to appreciate how a new technology will affect M&S—in this case, RAS-AI. Realisation of the RAS-AI capability will require M&S system decision support in the early phases...
of capability development in a similar manner to that identified above for other maritime programs. However, at the point of fleet generation, the RAS-AI capability will present two types of challenges for M&S.

The first is a requirement for ‘digital twins’ of the RAS-AI systems’ ‘effects’ and user interfaces (UIs) to be available and integrated within the Navy competence training system. This is an essentially similar requirement to training representations for ‘established’ Navy systems. However, given the ‘digital nature’ of the RAS-AI systems that Navy is likely to acquire, by establishing a contracting requirement for the RAS-AI digital twin for fleet generation use to be configuration managed alongside the ‘real’ system (in a similar manner to Navy helicopter flight sims, for example), Navy would benefit from a deliberate digital twinning approach.

The second is an M&S requirement for ‘generating’ the RAS-AI systems prior to (in particular, immediately prior to) RAS-AI employment: RAS-AI systems and HEWF effectors with high levels of autonomy (e.g., with low or no remote-control requirement for key systems functions) generally operate with on-board or pre-loaded representations of the environment and or threat/target. While the demands for each RAS system will differ, the M&S environment can be designed effectively in advance, noting the following requirements:

- ‘Terrain data’ repositories should accommodate geo-registered ‘layers’ of varying fidelity. At the basic level this will include digital terrain elevation data (DTED) for the potential areas of employment for the RAS-AI systems, at varying levels or resolution. DTED data may be required for both above and below water terrain for autonomous systems. Above-water terrain models for systems may require ‘photo real’ geo-registered drapes for navigation and/or 3D terrain feature models such as buildings. Systems operating in some parts of the electromagnetic (EM) spectrum may require EM spectrum terrain representation layers.
- Terrain data layer structure should accommodate and incorporate modern features such as ‘dynamic terrain’—a simple maritime example of dynamic terrain is the seabed debris found after the 2004 Boxing Day Tsunami, which required the rapid environment assessment (REA) capability of the Singapore Navy to model and assess for navigability.

**Capability Development**

In policy terms, the Defence Capability Manual (DCM) describes ‘high-level capability processes and how they integrate to deliver upon government’s strategic intent’, including the Chief of Navy (CN)’s delegated responsibilities as capability manager (CM). The DCM lays out four life-cycle phases through which capabilities pass during their development. Under this One Defence Capability Model (ODCM), each phase has different decision support requirements and different types of M&S to support them.

- **Strategy and Concepts**, which connects the government’s assessment of strategic risks and other priorities to alternative concepts and force design
- **Risk Mitigation and Requirements Setting**, which develops solutions to address the priorities identified through Integrated Force Design, including options, detailed specifications and risk management strategies
- **Acquisition**, which sees the capability acquired, delivered, integrated and brought into service
- **In-Service and Disposal**, which sees the maintenance of capabilities at the appropriate level of preparedness, as well as withdrawal from service and disposal of at the end of a capability’s useful life.

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41 Department of Defence, 2020c, pp. 6–7.

42 Integrated Force Design provides for the holistic analysis of capability at the Portfolio level to provide the plans for developing capability across Defence. For more information on what this process comprises, see: Department of Defence, 2020c, pp. 28-29.
Within the DCM, high-level accountability is assigned to the CM based on the Defence functions. The CM has ‘clear authority and accountability as sponsors for the delivery of capability outcomes to time and budget’. Formally, each CM is accountable for:

- program management within their organisation, including the development and implementation of Program Strategies and reporting on performance
- the development, introduction and sustainment of assets through the product life cycle, and reporting on performance, taking an end-to-end view
- generating prepared forces as required by the CDF’s Preparedness Directive.

Related Navy Plans

Five Key Navy Outcomes: Chief of Navy’s Articulated Intent

Soon after commencing as Chief of Navy, Vice Admiral Michael Noonan articulated his intent for Navy. He observed that capabilities were becoming increasingly complex and networked, that the region is dynamic and is facing evolving threats, and that this is a ‘period of unprecedented Regional Competition, with real potential for conflict in the next four years’. He set a vision that by 2022 ‘the Navy must be an agile, resilient and lethal fighting force, able to contribute to complex, joint missions in a dynamic region’. He then articulated five key outcomes that ‘Navy must deliver’, which are listed in Table 2.1.

As these outcomes are central to how Navy operates, they will form the fundamental organising construct for analysing Navy’s M&S requirements, challenges, opportunities and potential pathways. With

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43 For the maritime domain, the CM is the Chief of Navy.
44 Department of Defence, 2020c, p. 2.
45 Department of Defence, 2020c, p. 19.
46 Maintaining forces at different levels of readiness to respond to contingencies is risk managed, together with the need to sustain operations. These judgments are informed by the DCAP processes and detailed in the CDF’s Preparedness Directive. This Directive comprises part of the suite of guidance documents that support the Defence Capability Policy Framework. Department of Defence, 2020c, p. 33.
47 Department of Defence, 2020c, pp. 6–7.
49 Royal Australian Navy, 2018a, p. 4.
50 Royal Australian Navy, 2018a, p. 1.
51 Royal Australian Navy, 2018a, p. 2.
respect to the future strategy, this framework identifies an ‘accountable officer’ for all elements of Navy capability. Hence, as our advice hinges on the use of M&S for decision support, these accountabilities should flow to resourcing and prioritisation for M&S within each outcome. Additionally, we gauge the extent to which current and contemplated Navy M&S efforts adhere to or enhance the outcomes.

Three Command Themes

Fundamental to this are three command themes: A Thinking Navy, A Fighting Navy, and An Australian Navy. The first two of these have fundamental implications for an M&S Strategy. The last, An Australian Navy, reflects a need for the sovereign requirements of an M&S capability.

Through A Thinking Navy, Navy ‘will master our capability, find better solutions and challenge the status quo as we drive for an advantage’. Essential to this is ‘diversity of thought, . . . improved decision making and accountability at all levels, . . . a learning organisation that encourages continuous improvement and innovation at all levels, . . . the free flow of information throughout the organisation, challenging assumptions, promoting advice without fear, and innovation through positive disruption’.\(^{52}\) In the M&S Strategy, this is in effect a requirement for an M&S decision support capability.

The A Fighting Navy explicitly takes a system, rather than platform, perspective, recognising that Navy will operate as part of a joint or coalition force and so, ‘must be able to fight in all domains, including cyber and EW [electronic warfare], not just in physical domains’.\(^{53}\) He sought a shift in focus to the delivery of fighting capability and sustainment of our current and future force. We have a very clear understanding of what platforms our Navy will operate over the next 20 years. However, the context and needs of the future will continue to evolve and change; with it, we will be required to continually assess our capability against that of our potential future adversaries, addressing any identified deficiencies.

This includes understanding and addressing risks and issues related to our people, our tactics, our battle worthy platforms, our systems, our weapons, our sensors and each of the Fundamental Inputs to Capability that contribute to our lethality.\(^{54}\)

CN concludes by noting that Navy has ‘a number of threats to reaching our objectives and these will be addressed through updates to our Strategic Plans, Pelorus and Mercator’.\(^{55}\)

Plans Pelorus and Mercator

Following the CN’s stated intent, that Navy delivers the required capabilities to support joint operations, Navy has established a set of guidance documentation that identifies the nature of Navy’s contribution and (at a high level) how Navy modernisation plans can do this. The two primary Navy strategies are

- Plan Pelorus: a four-year strategy to meet the Headmark 2022 goal of ‘our Navy is ready to conduct sustained operations as part of the joint force’\(^{56}\)
- Plan Mercator: the longer-term Navy strategy that focuses on the transition path to the future force out to 2040, and states that Navy’s mission is ‘to prepare naval power in order to enable the joint force in peace and war’.\(^{57}\)

\(^{52}\) Royal Australian Navy, 2018a, p. 3.
\(^{53}\) Royal Australian Navy, 2018a, p. 4.
\(^{54}\) Royal Australian Navy, 2018a, p. 4.
\(^{55}\) Royal Australian Navy, 2018a, p. 5.
\(^{57}\) Royal Australian Navy, 2021, p. 4.
Mercator outlines a set of principles necessary to realise these outcomes, including the following:\textsuperscript{58}

- Grow in size
- Maintain our capacity to deploy globally
- Be embedded in partnerships across the Indo-Pacific
- Be deployed and present in the region to execute Australian statecraft and deliver strategic effects
- Improve our supply-chain resilience and therefore self-reliance
- Augment our proficiency to support civil authorities
- Be equipped with cutting-edge and emerging technologies
- Effectively apply finely graduated force across the spectrum from cooperation through to competition and if necessary, to conflict
- Be able to counter coercive statecraft and respond to grey-zone activities
- Enhance our ability to apply lethal effects, ensuring we remain a lethal fighting force
- Be a force of influence and good.

This underlines the continued and increased investment in military capabilities, particularly (from a maritime perspective) the Hunter-class frigates and the proposed nuclear-powered submarines.\textsuperscript{59} There is also increased emphasis on cyber\textsuperscript{60} and space\textsuperscript{61} capabilities, autonomous systems,\textsuperscript{62} and long-range, precision-guided weapons\textsuperscript{63} (including sovereign manufacturing capabilities for these).\textsuperscript{64} These lead to new workforce recruitment and training requirements (both military and civilian), requiring different approaches to operating and sustaining systems and platforms, and to changing the rate at which Defence identifies requirements, develops concepts, and acquires capabilities. While M&S is not explicitly named, as it has been previously, an argument can be made that these evolving policy demands represent strategic direction for it.

\textbf{Fleet Warfighting Plan 2022}

Subordinate to Plan Pelorus is the Fleet Warfighting Plan (FWP) 2022.\textsuperscript{65} Following on from the earlier Fleet Warfighting Strategy 2018,\textsuperscript{66} it focuses on supporting the delivery implications of Plan Pelorus. This is described through the Fleet Commander’s Headmark statement as ‘the sustainable delivery of Warfighting and Operational capabilities to ensure we are Mission capable, Lethal and Survivable against potential future adversary threats’.\textsuperscript{67} Lethality is a key feature of the plan, with an identified need to generate ‘greater levels of \textbf{Lethality} across the Fleet’.\textsuperscript{68} In line with Outcome 1 (see Table 2.1), one of the Fleet Commander’s stated aims is ‘the Fleet “Preparing & Ready”—for operations,

\textsuperscript{58} Royal Australian Navy, 2021, p. 10.
\textsuperscript{60} Department of Defence, 2020a, p. 36.
\textsuperscript{61} Department of Defence, 2020a, pp. 38–39.
\textsuperscript{62} Department of Defence, 2020a, p. 13.
\textsuperscript{63} Department of Defence, 2020b, p. 36
\textsuperscript{64} Department of Defence, 2020a, p. 40.
\textsuperscript{65} Fleet Command Australia, \textit{Fleet Warfighting Plan 2022}, Royal Australian Navy, Commonwealth of Australia, undated.
\textsuperscript{67} Fleet Command Australia, undated, p. 5.
\textsuperscript{68} Fleet Command Australia, undated, p. 5; original emphasis.
exercises, engagement and future contingencies’.\textsuperscript{69} The breadth of this is succinctly captured by the following statement:\textsuperscript{70}

As well as meeting our enduring preparedness commitments and our deployments to support government directed operations, activities and deployments, the Fleet must remain fully committed to Raise, Train and Sustain outputs whilst also preparing to support the delivery and introduction of many new platforms and capabilities.

FWP 2022 identifies six LOEs to deliver these: warfare, activities, enablers, major systems, people, and organisation.\textsuperscript{71} The need for M&S, while not mentioned explicitly (as it was in Fleet Warfighting Strategy 2018), is intrinsically linked to a number of these LOEs. It is instructive to note that under the Warfare LOE is an M&S requirement statement of the type that the M&S Strategy should reference:\textsuperscript{72}

Seeking to build on our professional mastery across the five domains of warfare (Sea, Air, Land, Space and Cyber) we must develop our Lethality through kinetic and non-kinetic effects to underpin our ability to exercise Sea Control, Sea Denial, Force Projection, and Manoeuvre in the Littoral and Blue-Water maritime domains. We must improve our Information Warfare capabilities and be ready to operate our networks within an increasingly contested electronic environment. An enhanced weapon firing program, improved Lethality assessments and an increasing involvement in the cybersphere will all make significant contributions to greater Joint Combat effects.

Within the enablers, there is a clear link to an enduring requirement for M&S for analytical wargaming, namely, ‘a greater understanding of our Primary Operating Environment, enabled and developed by the use of a Red Team construct, [that] will deliver improved training realism and a critical understanding of our future adversaries’.\textsuperscript{73}

**Navy’s Fleet**

It is well understood Navy is going through a major upgrade to its capabilities. In many cases, these have a direct link to investment in M&S. The M&S driving requirement in this area can be generally encapsulated through the need to accurately represent the current and planned platforms. In addition, new enabling systems (e.g., tactical uninhabited aerial vehicles\textsuperscript{74}), weapons (Evolved Sea Sparrow Missile upgrade\textsuperscript{75}) and training systems (e.g., deep water tracking range\textsuperscript{76}) will need to be considered. And there is the increased expectation that Navy assets will operate as part of coalition operation, as typified by the prevalence of Aegis-battle management systems across multiple platforms.\textsuperscript{77}

\textsuperscript{69} Fleet Command Australia, undated, p. 3.
\textsuperscript{70} Fleet Command Australia, undated, p. 5.
\textsuperscript{71} Fleet Command Australia, undated, p. 2.
\textsuperscript{72} Fleet Command Australia, undated, p. 4.
\textsuperscript{73} Fleet Command Australia, undated, p. 4.
\textsuperscript{74} Andrew McLaughlin, ‘SEA 129/5 Maritime UAS Requirements Progresses’, *Australian Defence Business Review*, 15 July 2020b.
\textsuperscript{75} Andrew McLaughlin, ‘ANZAC Class AMCAP Upgrade Put to the Test’, *Australian Defence Business Review*, 23 March 2020a.
\textsuperscript{76} Dylan Nicholson, ‘L3Harris Technologies, Ultra Electronics and Indianic Group Form Local Alliance for SEA 1350 Bid’, *Defence Connect*, 22 May 2020.
These various major platform and weapons programs are one source of current and future requirements for M&S. With the introduction of the Ship Zero\textsuperscript{78} concept, new M&S requirements for each ship or class, across the CLC (development, acquisition, training, operations, etc.), can be expected to be captured as part of the Ship Zero design idea.

However, maritime systems extend well beyond the hull or skin envelopes of ships and weapons. The concepts of continuous upgrades of ancillary ship systems, such as RAS-AI and ‘non-kinetics’ like cyber, EW and on-board ICT updates and upgrades through an ‘evergreening’ approach will influence choices around M&S systems and architectures, particularly in terms of supporting the introduction of new major platforms and integration of new and autonomous systems. Examples of this type of requirement range from a need for M&S for digital twinning of ships, maritime systems and interfaces, and systems integration to OBTSs and test and evaluation (T&E) M&S suites for these systems. No ‘systems’ equivalent of Ship Zero exists to drive coherence between the off-board systems and the M&S support requirements.\textsuperscript{79} However, an equivalent ‘Systems Zero’ concept would serve this and other related needs.

\textbf{Summary}

It is clear that the significant shift in strategic context coupled with emerging military technologies will test Australia’s ability to undertake HEWF or counter grey-zone activities. The maritime environment is particularly important from the Australian perspective, requiring the development of suitable strategies and concepts. M&S is a key contributor to this, shaped by Navy’s specific strategies and concepts. Critically, Navy has identified its five strategic outcomes, and aligning all subordinate doctrine to these. \textit{Central to our analysis, then, is the determination that the M&S Strategy must be designed around and intended to support the achievement of the Navy’s outcomes.} In doing so, Navy M&S serves a dual purpose. The first is the traditional role of building operational competencies through the delivery of training. The second is as an analytical tool to inform the development and testing of new way of warfighting, particularly in HEWF and grey-zone operations. Such an analytical functionality, using both computer- and non-computer-based approaches, allows exploration of how Navy delivers effects given the evolving threat environment. This also supports the adaptations necessary due to the major transition in naval capabilities that is underway.

\textsuperscript{78}In 2019 the then Chief of Navy, VADM Barrett ‘envisioned a future Navy where new vessels could be conceived, crews could be trained, and ongoing support and modification could be developed through a land-based simulation of each class of vessel’. He named this concept Ship Zero. The purpose of Ship Zero is to enhance the ongoing life-cycle management of capability through an M&S base. See Rob Napier, ‘Mission Control We Have Ship Zero’, \textit{Australian Defence Magazine}, 5 October 2019.

\textsuperscript{79}RAND Australia interview, conducted 9 November 2021.
CHAPTER THREE

The Current Defence and Navy M&S Strategies

Consistent with the historical application, Navy’s strategy for M&S has matured over time, with the 2019 Navy M&S Strategy document representing an extension of the 2016 version to include tasking and establishing four M&S enablers (people, systems, interoperability, governance). In this chapter we give a brief overview on the history of M&S use within Navy. We then summarise the Joint Simulation Strategy (JSS), which underpins Navy’s M&S Strategy, as representative of the Defence perspective. We follow this with a review the 2019 Navy M&S document, situating it within the context of the requirement for a new strategy appropriate for supporting the strategic drivers for HEWF. To inform a strategy-to-task revision, we describe the current state of Navy’s M&S enablers against the revised strategic requirement.

Historical Context

In an effort to ensure that our review of strategic and policy drivers for M&S was broadly based, we examined the areas of application of M&S by Navy. More information can be found in Appendix A.

In the early 2000s, Navy utilised a range of M&S activities to explore force options and confirm capability requirements (e.g., around amphibious operations). Navy’s use of these activities has since decreased due to heightened operational tempos and refocused budgets. However, since 2013 the use of synthetic environments for training has increased. In the context of a maritime M&S Strategy, and the attendant requirements, goals and objectives, this synopsis reveals that Navy has, at different times, had analysis and simulation capabilities spanning the full gamut of requirements mentioned here. Importantly, however, while Navy has attempted to centralise governance under the NMSO, the capabilities (outside the training domain) identified in the history synopsis have been largely owned, sustained and operated externally to Navy.

These M&S capabilities have evolved from simple crude physical models used for wargaming (of the sort required now) through to extensive joint simulations that mix live, virtual and constructive (LVC) simulations in a complex warfighting environment. Early use included operations analysis (OA) where modelling was extended to the acquisition of new knowledge being applied to operations planning and fleet design. As M&S technology evolved, applications emerged to link digital models with requirements definition, and, later, model-based systems engineering (MBSE).

Joint Simulation Strategy

The Navy M&S Strategy will be subordinate to the Defence and JSS environment. Aside from the capstone strategies discussed in Chapter Two, there are also a number of specific policies with which it must comply. These include those related to data, test and evaluation; industry policy; and infrastructure (see Appendix B). However, the JSS requires more attention, given its purpose ‘to define the Defence’s Joint simulation community’s strategy for enhancing Defence’s use of current and near term simulation technology’.1 Notwithstanding that it was published in 2019, prior to the release of the DSU and FSP, the

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1 Department of Defence, 2018b, p. 1.
JSS represents a key input into the Navy M&S Strategy. While predominantly focused on simulation, it articulates high-level vision and goals that will inform the Navy M&S Strategy. The JSS seeks to explain the strategic purpose and context for the employment of simulation in the Joint community, provide a vision of the target states for key elements that support Joint simulation, and identify the goals and objectives which will realise this vision.

Although it does not define simulation explicitly, the JSS notes that while simulation includes ‘both computer-based and non-computer-based modelling and simulation’, the JSS exclusively focuses on the former, and encompasses LVC simulations. These are brought together through the Defence Synthetic Environment (DSE), which seeks to coordinate synthetic environments from each of the services, the joint space (both operations and capability), industry and the Defence Science and Technology Group (DSTG). Previous iterations of Navy’s M&S Strategy acknowledge the CN’s responsibility for a Maritime Synthetic Environment (MSE) as an authoritative component of the overall DSE. The revised Navy M&S Strategy should articulate responsibilities and authorities for the MSE and its integration into the DSE. A natural alignment or authorities for definitions would seem to be associated with the Navy outcomes (which we will discuss later in this chapter).

### JSS Lines of Operation

As shown in Table 3.1, the JSS establishes three LOOs, each with supporting goals. The JSS notes that these LOOs are ‘underpinned by three key enablers of simulation capability, namely: DSE, Workforce, and Governance’. These provide a suitable framework for the revised Navy M&S Strategy; however, as we note in the following chapter, the Navy M&S Strategy focuses on tasking for the enablers, rather than in the application of M&S to support the Navy outcomes.

<table>
<thead>
<tr>
<th>Lines of Operation</th>
<th>Goal</th>
</tr>
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<tbody>
<tr>
<td>Support Defence’s strategic functions</td>
<td>Simulation supports experimentation, force design, workforce and estate planning. This includes problem definition, problem exploration, options comparison, decision justification, and experience augmentation. Simulation supports the Defence CLC. This is divided into capability development and capability delivery.</td>
</tr>
<tr>
<td>Employ the Force</td>
<td>The role for simulation in employing the force is well established. This includes individual training, team training, collective training, distributed mission training, mission rehearsal, preparedness, and operations.</td>
</tr>
<tr>
<td>Analyse and exploit emerging technologies and human trends</td>
<td>Defence identifies emerging simulation and related technologies and their human trends in order to optimise introduction and use throughout services and groups. Joint Professional Military Education utilises the optimum mix of legacy and emerging technology to engage millennial-age-group personnel. Operationalisation of commercial products, utilisation of social media, and analysis of the millennial cognitive hypothesis are the associated objectives.</td>
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2 Department of Defence, 2018b, p. 2.
3 Department of Defence, 2018b, p. 2.
4 Department of Defence, 2018b, p. 1
5 Department of Defence, 2018b, p. 4.
6 Department of Defence, 2018b, pp. 6, 8–9.
7 Department of Defence, 2018b, p. 7.
8 Royal Australian Navy, 2018a.
JSS Principles of Employment

The JSS concludes that successful delivery of joint simulations requires eight principles of employment:

- **Interoperability:** which requires a framework ‘to maintain the configuration of simulators in line with actual platforms’. This encompasses ‘persistent networks, common standards and multiple types of data, both domestically and internationally’.
- **Simulation data:** which acknowledges that ‘available and validated data is vital in providing effective simulation support to decision making’ including its availability, provenance, integrity and management.
- **Investment:** which needs the ‘effective governance of investment (people and funding) . . . to manage and support simulation systems’.
- **Simulation Integration:** which includes ‘Defence, across Commonwealth and State agencies and with industry and academia, [and] at varying levels’
- **Integration with ICT Infrastructure:** which ranges from ‘ubiquitous classified networks [and] simulation specific networks’ to ‘public telecommunication infrastructure that our allies use and . . . the private networks of industry partners’
- **Simulation Architecture:** particularly the ‘architectural modelling of . . . systems and services in support of the JP9711-1 capability development process’. This requires ‘other Service and Group simulation architectures . . . to be developed in alignment with the CIOG [Chief Information Officer Group] and ADSTC [Australian Defence Simulation and Training Centre] models in order to ensure near term and future interoperability’.
- **Simulation Workforce:** which focuses on ensuring the availability of ‘sufficient[ly] skilled, qualified and motivated members’, noting that earlier studies ‘identified that Defence could not sustain an internal simulation workforce’.
- **Enhance Training:** which emphasises ‘the creation of demanding training environments, [thus] providing new challenges to drive skills proficiency and excellence’

Modelling is not explicitly covered by the JSS. However, it recognises that ‘the term simulation includes the acknowledgement of the precursor process of modelling, although it also needs noting that there is much modelling in Defence which does not relate to simulation’. It also acknowledges that data and ICT infrastructure are critical enablers for simulation. The simulation workforce is covered, with the caveat that ‘due to the specialisation of the skills required in a simulation workforce it is likely to remain primarily sourced from the Industry FIC’. A key underlying assumption in the JSS is that all these elements will be aligned across all aspects of the enterprise, which defines an area of focus for the M&S Strategy—specifically the integration of the MSE into the DSE.

However, the JSS is not a completely suitable model for the Navy M&S Strategy and implementation roadmap. While it does a genuinely satisfactory job of describing LOOs, the JSS fails to acknowledge that a gap exists between the current capability state and each LOO’s objective states. Thus, for implementation, there is no associated measure of success or achievement (other than the eight principles of employment mentioned above). Additionally, and most critically, there is no explicit (or clearly implicit) driver or requirement for each LOO. As a result, resource allocation and prioritisation are not guided by the document. To be a useful strategy-to-task guide, the revised Navy M&S Strategy should contain all of these elements or describe a path to define these where they are currently insufficiently scoped.

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9 Department of Defence, 2018b, pp. 10–11.
10 The ADSTC is now the Joint Collective Training Branch (JCTB).
11 Department of Defence, 2018b, p. 1.
12 Department of Defence, 2018b, p. 1.
13 Department of Defence, 2018b, p. 7.
2019 M&S Strategy Synopsis

Both the 2016 and 2019 versions of the Navy M&S Strategy reflect a focus on the use of synthetic environments for competency training, which has dominated Navy’s application focus for the use of M&S. Both versions articulate a similar scope of benefits, with subtle differences. However, the earlier version identifies goals and objectives more characteristic of a contemporary strategy and more tightly coupled to the LOOs in the vision statement of the 2019 version and the JSS.

The 2019 M&S Strategy characterises Navy’s requirement for M&S in two ways: (1) as ‘sophisticated synthetic and augmented environments to train, assess and certify personnel, units and task groups across the full spectrum of high end warfighting operations’ and (2) ‘to support smart decision-making and capability management across the entire Capability Life Cycle’.14

Consistent with the JSS, the first of these aligns with the JSS Employ the Force LOO, while the latter aligns with the Support Defence’s Strategic Functions LOO (see Table 3.1). Further, the eight principles for the employment of simulation in Defence provide a basis for aligning the implementation of the Navy M&S Strategy with the broader Defence enterprise.

The 2019 Strategy lays out four M&S enablers:

1. People: Navy M&S is designed, developed, operated and supported by a highly competent workforce
2. Systems: Navy M&S Systems adequately reflect real systems’ performance and include all HEWF
3. Interoperability: Navy M&S Systems are integrated (i.e., compatible, not just connected) and routinely operate with each other and with ADF and USN systems (interoperability with other systems is well understood, allowing connection and information exchange as required)
4. Governance: Navy M&S is effectively governed across the CLC.

While not explicitly stated, these appear to be the same as in the 2016 version, with the 2019 goals reflecting a focus on enabling services. It should be noted, however, that the 2019 goals are neither explicitly, nor traceably, linked to requirements; nor are gap statements identified.15

The 2019 Strategy goes on to characterise Navy M&S capabilities as ‘a set of [six] discrete capabilities that form a system of systems enabling each of Navy’s Capability Programs’,16 these being three types of training (connected, live, and stand-alone), as well as modelling, experimentation, and R&D.17 It seeks to build these capabilities against the four enabler focus areas through a ‘system of systems’ approach that considers ‘all Navy M&S systems as one system of systems with varying interconnection and governance levels’, managed (configured) by the Navy Modelling and Simulation Architecture (NMSArch).18

Finally, the 2019 Strategy suggests that M&S offers Navy the following:19

- [It] allows training to be conducted on demand, in a controlled, safe and repeatable manner while providing fast access to data to support immediate after-action review
- Complex high-end mission scenarios, using single unit, task groups and joint or multi-national forces can be synthetically exercised utilising training scenarios and proven or experimental tactics

14 Royal Australian Navy, 2019, p. 10.
15 Royal Australian Navy, 2019, p. 5.
16 Royal Australian Navy, 2019, pp. 8–9.
17 Royal Australian Navy, 2019, p. 9.
18 Royal Australian Navy, 2019, p. 10.
• [It] allows the use of realistic threats and environments that are potentially unavailable in live scenarios and it can facilitate the integration of 4th and 5th Generation platforms into the training Order of Battle
• Certification of Composite Warfare Commanders and Battle Staffs is also feasible, including pre-deployment training and assessments
• [It allows] cost savings and increased operational availability of platforms due to a reduced reliance on at sea training
• [It] can be used across the Capability Life Cycle to analyse complex issues or problems through ‘what-if’ analyses
• Capability can be modelled across the Capability Life Cycle to assess the impact of known and expected threats, operating environments and system performance for known and expected roles and missions
• [It] can support capability needs analyses, system requirements development, resource analyses, and verification and validation programs (including capability certification) to reduce the cost and decrease the risk of procurement
• Sustainment requirements such as logistics, training, basing and personnel can be modelled over the capability life cycle to assist planning and budgeting
• During operations, the embedding of M&S in combat systems can reduce the cognitive load on operators and identify system performance shortfalls
• M&S systems can be used for experimentation to determine force structures, to assess the effects of new technologies and warfare effects on current systems, and to conduct sensitivity analyses of current systems to future threats to better understand risk

There are, however, significant differences between the 2016 and 2019 documents, demonstrating an implementation focus over time. The 2016 Strategy conforms with the competency training requirement set out above, but differs by seeking to assist ‘decision makers as they design and develop capability and generate forces’.20 It is also linked to training, experimentation, capability development, and preparedness.21 That being said, the 2019 version observes that M&S is ‘becoming a key element of Navy’s training, experimentation, capability management and decision making’.22 It notes that while employment of M&S had grown rapidly, its acquisition and use was ‘somewhat uncoordinated’ with ‘disparate systems’ acquired to meet a specific need.23

The 2019 Strategy formally introduces the concept of ‘Ship Zero’, discrete simulation systems based around specific maritime programs and functions, but does not detail related goals or objectives. The theme is that these will be connected with the enterprise through the architecture, and managed by the program sponsor.24 It recognises a role in the changing approach to major platform acquisition, including ‘what capability is included in batches in the Naval Shipbuilding Plan continuous shipbuilding process, or to better understand effects of life of type extensions’.25 The 2019 document also observes that ‘interop- erability of models will be a significant challenge’,26 so that ‘whilst commonality is an admirable goal with many benefits, it is not always the best approach noting that some applications will not be able to re-use data from another application’.27 It seeks to institute the Navy Simulation Management Information

20 Royal Australian Navy, 2016, p. 3.
21 Royal Australian Navy, 2016, p. 3.
24 Royal Australian Navy, 2019, p. 16.
26 Royal Australian Navy, 2019, p. 17.
27 Royal Australian Navy, 2019, p. 10.
System to capture ‘the full range of models, the data exchange requirements between them, validation status, etc’. Without requirements, goals or objectives as indicated in the breakdown, it is therefore somewhat deficient in terms of the normal strategy-to-task architecture.

To help determine the applicability of the documented goals and tasks associated with the enablers to the new strategy, we reviewed the status of the program of work identified in the 2019 version. We started by conducting a desktop review, filtering out tasking currently identified by the NMSO as complete or business as usual. We then were able to align the remaining tasking to the JSS Enabling Capabilities (see Table 3.1). The result of this analysis is shown in Table 3.2, where we classified each remaining task (or subtask) into one of the following categories:

- **Sustain**: the existing task is central to meeting strategic intent and can be carried through to a new strategy without substantial change
- **Improve**: the existing task is central to meeting strategic intent and but requires some modification to address the strategic intent
- **Fix**: the existing task is central to meeting strategic but requires substantial change
- **Obsolete**: the existing task is no longer central to meeting the strategic intent and can be deleted from strategy.

### Gaps to Be Addressed in the Updated Strategy

Our review of the 2019 Navy M&S Strategy suggests that it provides a useful starting point for the enablers. However, gaps are apparent between its aspirations and delivery, which should be addressed in the next iteration.

The goals and tasks described in the 2019 Strategy and detailed in its annexes are not tied explicitly to the overarching vision nor, therefore, to the JSS as a governance or enablers design template. In the absence of this link, the interoperability and governance focus areas might be compromised.

In terms of a current state assessment, the strategy currently falls short of guiding realisation of the vision of the 2019 Strategy, where ‘Navy will routinely use sophisticated synthetic and augmented environments to train assess and certify personnel, units and task groups across the full spectrum of high end warfighting operations . . . [and] also be utilised extensively to support smart decision-making and capability management across the entire Capability Life Cycle’.

The strategy is essentially silent on goals, gaps and objectives for the application LOOs in both the training application area and the fleet development and employment applications called for in our strategic analysis. These are essentially new requirements and gaps not addressed in the 2019 document, and they are our focus in Chapters Six and Seven.

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28 Royal Australian Navy, 2019, p. 17.
### TABLE 3.2
Assessment of 2019 Navy M&S Strategy Activities

<table>
<thead>
<tr>
<th>Goal Statements</th>
<th>Implementation Project/Task</th>
<th>Observation/Assessment</th>
<th>Suggested Action</th>
</tr>
</thead>
</table>
| **People:** Navy M&S systems are designed, developed, operated and sustained by a highly competent workforce. | P1.1 Increase Simulation workforce numbers  
P1.2 Implement Simulation Training  
P1.3 Determine Training Gaps  
P1.4 Align NMSO structure to meet increased responsibilities  
P1.5 Foster and Maintain an M&S Technical Support Network  
P1.6 Simulation growth/career path | Goal is appropriate for an enabler. Projects useful as identified, but under-resourced. 2019 Action on NMSO is beyond scope of office responsibilities. Revise goal in strategy and assign to accountable officer (and stakeholders). | Sustain as Focal Area. Develop M&S Total Workforce Model with consideration given to enduring cleared contracted portion to meet ‘gapped’ M&S and OA positions. Revise tasks as enabler projects. |
| **Systems:** Navy M&S systems adequately reflect real system performance and include all HEWF. | S1.1 Document the Navy Simulation needs  
S1.2 Improve training systems to simulate HEWF environment  
S1.3 Include Non-Kinetic Effects  
S1.4 Reinvigorate stimulation/Simulation Command and Control Systems  
S1.5 Assess and improve (if required) the JFBL [Joint Force Battlelab] facility  
S1.6 Assess ability of current M&S systems to be used for certification of capability systems  
S1.7 Improve After Action Review capability | Goal is appropriate as a technical governance enabler. Projects are underdeveloped, or low priority. This report sets the requirement for Projects S1.1–4, and retires or defers S1.5–7. | Fix simulation capability, including simulation capability management. Remediate M&S training systems to current real-system configuration standard. Revise and prioritise projects as enablers.  
Sustain: upgrade to the naval training baseline but include ICT infrastructure. |
| **Interoperability:** Navy M&S systems are integrated (i.e., compatible, not just connected) and routinely operate with each other and with ADF and USN systems. Interoperability with other systems is well understood, allowing connection and information exchange as required. | I1.1 Improve interoperability between Navy Simulators/Simulations  
I1.2 Improve interoperability with USN  
I1.3 Improve interoperability with other Five Eyes Partners  
I1.4 Improve interoperability with defence forces of other nations  
I1.5 Understand interoperability requirements with other Australian Government and Non-Government entities | Goal is appropriate for enabler. But tasks lack the critical ICT classified and infrastructure links. Navy capability defined by I1.1 and I1.2. | Fix: address classification of simulators, data, and long-hop and ‘last mile’ ICT while addressing interoperability of simulations. |

(continued)
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<thead>
<tr>
<th>Goal Statements</th>
<th>Implementation Project/Task</th>
<th>Observation/Assessment</th>
<th>Suggested Action</th>
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<tbody>
<tr>
<td>Governance: Navy simulation systems are effectively governed across the entire CLC</td>
<td>G1.1 Document the NMSArch</td>
<td>Goal is partly appropriate, but projects do not sufficiently support the goal. Simulation capability governance is not yet complemented by capability management, which is beyond scope of NMSO. Some projects are incorrectly targeted. JED/Force Design should be engaged re experimentation and decision support.</td>
<td>Improve 2-star with 1-star stakeholders. Fix: establish Simulation Capability Program Management Office.</td>
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<td></td>
<td>G1.2 Create Navy Simulation Policy Manual</td>
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<td>G1.3 Contribute to revision of the SIMMAN [Defence Simulation Manual]</td>
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<td>G1.4 Review role of NMSO in Simulation Capability Management</td>
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<td>G1.5 Conduct planning and engagement throughout the CLC</td>
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<td>G1.6 Work with JCG [Joint Capabilities Group] to develop decision support and experimentation</td>
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<td>G1.7 Promote use of simulation for capability certification</td>
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<td></td>
<td>G1.8 Understand Innovation Technology Advancement</td>
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<td>G1.9 Assess utility of formally managing decision support tools</td>
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<td></td>
<td>G1.10 Manage Capability Gaps, Risks, Issues and Opportunities</td>
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<td>G1.11 Coordinate M&amp;S across Navy as well as other groups and services</td>
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<td>G1.12 Promote commonality where beneficial</td>
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<td>G1.13 Assess Model Validation/effectiveness</td>
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CHAPTER FOUR

Requirements for a Revised Navy M&S Strategy

In the previous chapter, we identified the elements of the 2019 M&S Strategy that required continued effort, in effect extending the enabler focus areas and remediating identified gaps. In this chapter, we focus on the M&S requirements and objectives that Navy needs given the current and emerging strategic context, but which are not covered in the current strategy. We describe our assumptions of how M&S can address the gaps, informing a strategy future state. Drawing on this will allow the M&S Strategy to state how—by establishing goals and objectives—M&S can support this.

The Problem Statement for M&S Applications

One can conclude from the foregoing discussion of strategic and policy drivers that Navy’s preparedness and capabilities need to be adapted to meet the demands of HEWF within a short timeframe. Similarly, as has been noted,1 Defence (and Navy in particular) will need to continue to work with government and allies to characterise grey-zone operations and their required capabilities. The DSU and FSP make a provision for grey-zone challenges, without being prescriptive. Additionally, major platform upgrades, the introduction of new systems and platforms, and the integration of these into current platforms through mid-life upgrades (MLUs) are part of the analytical problem to be solved.

This sets a broad requirement for not only an M&S capability but an associated analytical framework to assist with understanding and properly characterising the actual problems (the ‘what’) associated with maritime HEWF and maritime grey-zone operations. The operational gaps and MLU requirements become essentially the context for a set of application LOOs, which we discuss later in this report. In terms of modelling, simulation and analysis, the path to solution for this part of the problem requires an accelerated military experimentation and analysis campaign of the sort that Navy conducted in the early 2000s.2 This requires engagement with OA and military experimentation providers in addition to the Defence Intelligence Organisation, DSTG and the USN (at least) to obtain suitable red and blue force models.

Notwithstanding how this accelerated analysis is performed, it remains possible that capability gaps exist in the design of platforms in the current fleet and plans for the future fleet. If so, these would extend to gaps in the base levels of competency training for individuals and collectives. An additional gap might emerge between the predominant fleet experience of constabulary-type operations, which without pejorative intent might be classed as low-end warfighting competencies, and the proficiencies that will likely be required to conduct HEWF activities.3 This suggests the requirement for a new application LOO to be addressed by the M&S Strategy.

Once identified, these new competencies and proficiencies almost certainly will be trained and exercised through stressful experiential learning using a LVC environment that should be established under

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1 Campbell, 2019.
2 See Appendix A.
3 The issues identified in this paragraph were raised in a number of the RAND Australia interviews.
the MSE, which also needs to be accelerated under a revised M&S Strategy leading to a new application LOO, but one for which the requirements need to be developed.

Having identified candidate solution paths to the actual problems, Navy will be able to prioritise some of these in an M&S Roadmap and implementation plan. This roadmap will inevitably include some extended and enhanced simulation-based training at a variety of classifications, together with OBTSs that will support proficiency training in HEWF skills by stimulating the ships’ systems with high-fidelity, high-demand training inputs. Additionally, and importantly, the M&S Roadmap and the MSE it supports will need to support external inputs to provide for operational test and evaluation (OT&E), and perhaps developmental test and evaluation (DT&E), of new systems as they are integrated, together with enhanced reliability, availability and maintainability (RAM) and personnel modelling to enhance overall preparedness.

To meet this, we assume a timeframe of up to five years, or just beyond the Australian government’s Forward Estimates period. In our characterisation of HEWF for this study (see Chapter Two), we have been agnostic about the specific geography. However, we note that any operations more remote from Australia are the most challenging. Therefore, the characteristics of the problem for fleet development scenarios and solutions (even for the current fleet) need to include both grey-zone operations and HEWF, and be mindful of the remote command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR), EW and cyber challenges. This will properly set the challenge for maritime capability, from doctrine through platforms, intra- and inter-theatre logistics, and new individual and collective training competencies and proficiencies.

Addressing Issues with Current Navy M&S Capabilities

Train the Fleet Application Area—Current State

The bulk of Navy’s M&S capability is primarily focused on competency training. This assessment is supported from two sources:

- A series of spreadsheets from the most recent (first) Navy simulation system inventory. The spreadsheet fields include simulation name, description, principal stakeholder, location, classification, platform (represented), and courses where the simulator is used or required, among other details.
- Selected senior officer interviews that are used to confirm assumptions and preliminary conclusions.

A useful, although incomplete snapshot, the spreadsheets reveal an installed base of approximately 350 simulators, simulations, training devices, or training aids, across multiple training sites. These are mainly unclassified, but include some controls associated with International Traffic in Arms Regulation (ITAR) or similar restrictions. The installed base includes a small number of networked (via a number of interface standards) simulators, together with stand-alone simulators and Defence Protected Network (DPN)-based software training tools.

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4 While preparations can be made—particularly with industry—the LVC system requirements can only be set once the required new competencies and proficiencies are identified.

5 Commonwealth Forward Estimates is a rolling three-year financial estimate of the revenues and costs of ongoing government policy decisions, after allowing for estimated movements in economic parameters (after the budget year). The forward estimates include the level of expenses proposed by the government for future years (based on relevant economic, demographic and other forecasting assumptions).

6 As provided by NMSO.

7 As classified in Department of Defence, 2019.
To estimate the applicability of the installed simulation fleet to HEWF training, we examined the classification of the simulators, the capacity for networking and, through senior officer interviews, the configuration management of some key components with respect to the current configuration of the ships and systems that the simulators represent. It was noted that while many of the components that might be useful for HEWF training were not maintained to the same configuration of the current platforms, the intent of the installed base is primarily focused on individual competency training, with some small team trainers such as bridge simulators, but that even this is individual task-focused within a bridge team environment. Principal Warfare Officer training was offered as an example of complex use of simulators for advanced competencies and proficiency training; however, the method of training delivery is again focused at the individual trainee level, supported by professional training staff on other consoles and stations.8

Navy training priorities included updating the base configurations of the simulator fleet to a current-day standard and deepening the reach of competency training to meet the ideal of completing all individual competency training ashore before joining a ship or station.

We concluded that while improving the currency of the training fleet is a necessary and important LOO for a revised strategy, the current competency-focused training fleet is not fit for purposes of training for HEWF. Developing and updating HEWF collective training activities will be an ongoing need. Following a root-and-branch review against the current training requirement for the current major platforms, weapons and systems, a significant program of replacement and refurbishment is likely while a future training plan for HEWF matures, together with an ongoing configuration maintenance program.

Fleet Certification and Planning Application Area—Current State

Specific to an M&S Strategy, Commander Australian Fleet (COMAUSFLT) is responsible for certification of ships, command teams and task groups for a range of contingencies, including HEWF before deployment. M&S is used together with live exercises to meet this responsibility. The ability to simulate maritime HEWF for certification events was discussed as a follow-up to unclassified publications following the 2020 Fleet Certification Period (in February 2020).9 Our interviews point to possible classified capability deficiencies and are therefore not detailed here.10 However, a number of issues germane to the development of an M&S Strategy can be made and discussed in this report:

1. Defence has yet to endorse a HEWF concept in response to DSU 2020. This makes it difficult for Navy to build a set of maritime concepts of operations (CONOPSs) and concepts of employment (CONEMPs) against which to train and certify.
2. The configuration differences between the training systems aboard HMAS Watson, for example, and the real systems aboard the Hobart-class air warfare destroyers sharply limit the useful involvement of the on-shore M&S suite in contemporary HEWF certification exercises.
3. The classifications of the ICT bearers, the suite of buildings, and the simulators and their associated data further compromise the utility of on-shore simulators in certification exercises.
4. Noting that the maritime fight in the near region is explicitly joint, Navy does not have at HMAS Watson or elsewhere, the sort of classified configurable Battle Sim Centres like those at Enoggera that could support a joint taskforce headquarters and training staff.

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8 RAND Australia interview, 8 November 2021.
10 RAND Australia interview, 9 November 2021.
Objective Constraints for an Expanded M&S Strategy

In addition to these application LOOs, there are some constraints that will require Navy to change the way it conceptualises the design and delivery of M&S. As putative adversary capabilities and maritime presence operations expand, the freedom to undertake live training, particularly in a maritime environment, will become problematic for some aspects of capability, with potential adversaries able to monitor such activities.\textsuperscript{11} This may allow adversaries to understand Navy’s operational concepts, identify potential weaknesses and gaps, and capture information on new capabilities and technologies. As a result, more training across the full spectrum will need to be virtualised.

A reduction in strategic warning time will require that the M&S tools and data that support planning must be current and available. This includes the planning scenarios; data on current and planned Australian, coalition and adversary forces; and the expected areas of operation. Further, those personnel and contracted resources responsible for operating the simulations must be available and have currency of skills.

The introduction of new technologies on platforms will necessitate development of new skills and proficiencies, both from an operator’s and a maintainer’s perspective. Training simulations are likely to require continual updates. This may be exacerbated if the technology turns over quickly, such as with autonomous systems. The M&S architecture will need to adopt a ‘plug-and-play’ approach and accommodate cross-domain solutions.

The digitisation of major platforms, such as the Hunter-class frigate,\textsuperscript{12} is revolutionising the manufacturing process. The creation of digital twins will help with enabling design updates as required for each subsequent ship. These digital twins can also support the through-life maintenance for each vessel by comparing the simulated version with the real one. In both cases, models and data will be required to create the digital twin, while simulation can be used to explore the impact of structural changes (for design purposes) and operational performance (for maintenance purposes).


\textsuperscript{12} BAE Systems, ‘Hunter Class Frigates: What We Do’, webpage, undated.
Lessons for International Experiences

Before determining the requirements for the new M&S Strategy, it is important to recognise that the challenges of M&S for HEWF are not unique to Australia, nor Navy. We reviewed policy and practices in the United States, United Kingdom, North Atlantic Treaty Organization (NATO), and to a limited extent China. These are included so that the M&S Strategy can benefit from the experiences of others, both in terms of the design of the MSE, and the M&S applications that fall within it. In this chapter, we identify some salient lessons for Australia, mapped to the enablers identified in the 2019 M&S Strategy. More details on the relevant strategies, policies and organisations are provided in Appendix C.

Interoperability

There is a basic tension in the development of models and simulations. On the one hand, M&S development is frequently bottom-up: commands have an interest in creating tailored models and simulations to meet their specific needs, often working closely with contractors for this purpose. On the other hand, there is also value in having some degree of top-down coordination and standardisation of M&S processes. At a minimum, creating shared awareness of different commands’ or services’ M&S efforts can help to reduce duplication, enable the reuse of code, and identify gaps and an organisation’s collective M&S capability. Ensuring adherence to common data standards can enable M&S results to be interpreted by a wider group of stakeholders, and for the outputs of one model to serve as the inputs to another. Enabling ‘handshakes’ between different systems can facilitate such data transfers. A structured service-wide or joint process for verification, validation and accreditation (VV&A) can also help to ensure that M&S outputs are both meaningful and trusted by a range of stakeholders. This can also help to reduce the desire for commands to duplicate efforts, since they have increased confidence in M&S developed by others. In some cases, service-wide or even joint models can be used to help inform collective processes or decisionmaking.

It is noteworthy that the U.S. Strategic Vision for DoD Modeling and Simulation,1 agreed by all relevant stakeholders in 2007, remains the overarching ‘glue’ to connect the various pieces (and managed through the ‘M&S Enterprise’). In contrast, the United Kingdom lacks such guidance, though it is suggested that the recent release of Joint Service Publication (JSP) 939: Defence Policy for Modelling and Simulation seeks to redress this.2 Currently, Australia lacks such overarching policy and guidance. As such, in updating the M&S Strategy, Navy will have to make assumptions as to their interoperability with the remainder of Defence. This should be less of a problem in working with the U.S. DoD and USN, given their clearer guidance.

The lack of a clear policy guidance in Australia makes it difficult to understand the importance that senior leadership places on M&S, or whether wider cooperation across Defence is needed. Having this in place helps to raise awareness within Navy of the full potential for M&S and break down any silos that sometimes characterise the use of M&S. This would benefit both current and possible future users of

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M&S: if an individual is unaware of the benefits M&S can bring, they cannot possibly leverage its advantages. Clear, well-communicated guidance (strategy or doctrine) will help to overcome these communications challenges.

M&S policymakers also need to be clear about what they are attempting to achieve at a macro level. M&S policies and oversight organisations may aim to reduce potential duplication of effort through shared awareness, to create M&S standards, to foster the use of M&S as an analytical or training tool, to enable interoperability, to help ensure that the service has adequate M&S support, or to specify VV&A procedures, among other goals. Being clear from the outset about which goals M&S policy is intended to achieve, and the priorities among them, is paramount.

Systems

Our review of international M&S experiences emphasises the importance of taking an enterprise perspective to enable the development and integration of M&S systems into the broader Navy (and joint) synthetic environment. For instance, the U.S. DoD has a nested approach, directed down from their Strategic Vision for Modeling and Simulation through various M&S-related DoD and Service-specific instructions. Similarly, the UK MOD has JS939 to ensure coherence across all of their Defence Lines of Development. This is a consequence of the inherently technical nature of M&S being seen primarily the province of specialists, thus contributing to it being organisationally stovepiped. This separation can also foster misperceptions of M&S as an end in itself: the ability of M&S to create complex worlds that echo reality becomes its perceived purpose. If M&S efforts are to have the desired impact, they must be recognised as a tool to support warfare areas and processes, then tightly integrated into both.

Drawing on these experiences, we identified a series of questions that need to be answered when considering any M&S system:

- What is the purpose of the proposed M&S effort? To what decisions, plans or actions will this effort contribute? Is there a specific problem that the M&S effort is intended to address?
- Are there complementary or better ways of achieving the desired results? Should this be done in close conjunction with real-world testing, training and/or exercises?
- Are the proposed M&S tools, whether extant or planned, appropriate for their intended use?
- Have the M&S tools been verified, validated and accredited? If not, or if they are being revised or newly developed, how will they be? How will VV&A timelines and resource requirements affect the overall plan, particularly if there are unexpected failures? No model perfectly replicates reality. How can those involved in the effort ensure that the model captures the right aspects of reality to be useful?
- What changes (e.g., to system capabilities, tactics, the operational environment, or adversary capabilities) might later invalidate some M&S findings? How will this issue be addressed?
- Are available input datasets sufficient to yield valid results? Are input datasets based on real-world data? Executing M&S with incomplete or invalid inputs will invariably lead to poor outcomes.
- Have appropriate data-analysis tools been developed in conjunction with M&S to enable the M&S output to be analysed and synthesised to meet the end objectives? Will the data-analysis tools be able to handle the volume of M&S data generated?
- How will analysis of the outputs inform decisions, plans or actions?
- How can the validity of the modelling results be effectively communicated to a range of stakeholders? What information do they need to ensure that they recognise the M&S results as convincing?

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4 MOD, 2018.
It is natural for a command pursuing an M&S approach to develop a tight relationship with a particular vendor developing the model or simulation, who may retain intellectual property (IP) rights for the resulting products. This can lead to the command being unable to modify the code for particular purposes or unable to integrate its M&S efforts with those of other vendors or other commands. IP rights may also compel the command to pay exorbitantly for training or manuals on how to use the model. The command may be locked into a permanent relationship with the vendor, lacking an ability to freely shop around for expansion or revision of the model, or even to incorporate new information into it. In some cases, the structure of the contract can also constrain the ability of the command or an oversight body to perform adequate VV&A if information about how the simulation works is deemed proprietary. Transparency regarding models helps to build confidence in their results; if a model becomes a ‘black box’ whose workings are inaccessible, confidence in it will correspondingly decline.

**Governance**

A recurring theme across the national entities is the need to establish guidance for M&S that is clear; is coherent with other strategies, doctrine and guidance; and sets realistic goals for the maritime synthetic environment. Interviewees noted the issues around losing sight of the purposes of both M&S efforts and the policies designed to guide them. This extends beyond their respective navies, as the enterprise (i.e., Defence as a whole) need to provide the guidance to the various services and other stakeholders.

Given this, there is value in having some degree of centralised oversight of M&S, while still permitting commands to have some flexibility regarding what M&S efforts they choose to pursue. Encouraging or mandating the use of the open-source M&S standards promulgated by the Institute of Electrical and Electronics Engineers (IEEE), as NATO does, ensures M&S alignment with high-quality standards without the effort to develop them. The fact that these are external standards also fosters acceptance since they are not perceived as products of a specific command or oversight body.

One of the challenges of oversight is how to make individual commands or services responsive to the need for coordination and standards. In the absence of a direct line of command or budgeting authority coming from an M&S office, commands may not devote adequate resources to adhering to standards. They may also disengage from interactions with both oversight bodies and other commands’ M&S efforts. In this context, limited incentives can play a valuable role in helping to ensure both engagement and compliance. Visible recognition of M&S efforts can be a low-cost incentive. When possible, giving an M&S office some financial resources that it can distribute to efforts that demonstrate adherence to standards, as well as success using broader metrics, can also make a substantial difference in encouraging desired behaviours. Having commands compete for that funding is an especially effective approach.

**People**

The need to build and retain a cadre of suitably qualified and experienced personnel (SQEP) is a common challenge across all those considered. Interviewees described several challenges they face, such as competition with the private sector and issues managing specialists’ career progression. Given the nature of the field, they have difficulty competing with the reward packages that the private sector can offer to personnel with training in software engineering, data science, and other skills critical to M&S.

The skills of these M&S specialists will extend beyond simply developing M&S systems. They can help to coordinate M&S efforts among different commands, contribute to contract oversight, advise commands on how best to use M&S, conduct VV&A, assess the suitability of M&S tools for specific applications, work with analysts to help assess the implications of M&S results, communicate those implications effectively, educate others about M&S, shape M&S policy, and otherwise serve as interfaces between the highly technical world of M&S and the rest of the service. In particular, emerging technical areas such as machine learning,
AI and virtual reality (VR)/augmented reality (AR) offer new opportunities to create M&S-centric roles and specialists, ranging from simulation development to post-M&S analysis.

Finally, the need to generalise in order to advance in the Navy command hierarchy discourages many individuals with key specialist skills from staying in the service, choosing instead to pursue a career path allowing them to focus on their technical specialisation. While it may be possible to ameliorate both of these difficulties by making greater use of the private sector or enabling secondment schemes, this requires a level of flexibility that is not always available or allowable. Investing in the development of M&S specialists, and creating intellectual, promotional and financial incentives to retain people with these highly marketable skills, can make M&S efforts much more effective and cost-efficient.
CHAPTER SIX

Goals, Gaps and Objectives Analysis

Having established the strategic drivers for M&S, in this chapter we analyse M&S objective statements, leaving implementation tasking and resourcing to a roadmapping exercise. Our assessment of the in-service M&S capability for two of the established application areas for Navy simulation (individual competency training, and fleet certification against the requirement) and analysis of the strategy allows us to suggest goals, gaps and objectives for a revised strategy for M&S. We also offer recommendations for implementing certain measures to improve and broaden M&S adoption and implementation in the fleet. The analysis in this chapter complements that in Appendix F, which provides more detail on what types of M&S can be used in different contexts and timeframes to support HEWF capabilities.

Framework

In earlier chapters, we established Navy's need for M&S to address maritime grey-zone and HEWF operations, and the need to invest in the enablers. This is essentially a confirmation of some of the previous M&S Strategy goal statements. However, the need is now more pressing and the balance of what is required has changed. To meet the other Navy outcomes (Table 2.1), Navy also needs to retain existing systems that support training competencies, including certification of proficiencies, up to 'ships in company' in joint and coalition settings. This is an existing application area that the M&S Strategy needs to maintain and tacitly acknowledge.

As noted in Chapters Two and Four, what is arguably different are requirements for M&S applications and systems that support training sailors to master HEWF. These include competencies that may need to be described at higher levels of classification for some systems and systems of systems that can be best practised in a synthetic environment. Navy also needs to evolve M&S support for complex systems integration to support the management of all aspects of FIC involved in the generation of ships at sea (sea days). To meet these competing needs, Navy has some suitable training tools, but our interviews and audit suggest these are fully tasked, generally on significant raise-train-sustain issues and in need of constant upgrade (see Table 3.2).

Epochs for M&S Capability and Strategy Planning

Plan Pelorus details a four-year path for Navy strategy to meet more enduring Headmark Statements in Plan Mercator¹ and the implied links to the 10- and 20-year horizons of the FSP and DSU². Consistent with these longer timelines, we identify an ‘epoch’ approach for the M&S capability and strategy. There is a temporal aspect implied in each of the research questions. The M&S Strategy must recognise these explicitly. We introduce in Table 6.1 three decision epochs for which M&S goals and initiatives are defined.

We observe that the first two epochs directly inform the decisions and functions of the Navy enterprise requiring M&S support, while the third informs the maturing and sustainment of the MSE as it evolves as part of the overall DSE. Our focus in this report is the immediate challenges, that is, the first

1 Royal Australian Navy, 2021.
2 Department of Defence, 2020a, 2020b.
two epochs, acknowledging that roadmapping and prioritisation will inform the third epoch. Appendix F provides descriptions of the types of M&S tools that can support analysis for each of these epochs, focusing on more specific aspects of warfighting capability.

Using the DCM as a guide, types of M&S for the first two LOOs in the JSS can be established (see Table 3.1). The LOOs for the categories or ‘classes’ of M&S products and services can be mapped to the Navy outcomes (see Table 2.1). With the exception of M&S for Navy Information Warfare (NIW), the classes have broadly similar data and data-management requirements. Hence, this structure can be used to develop the MSE over the longer term. These classes can be expressed as a taxonomy of M&S products and services for use in support of

1. Fleet Employment (Future)
2. Fleet Design/Development
3. Fleet Management
4. Fleet Generation
5. Fleet Employment (Current).

The first three of these relate to the ‘Support Defence’s Strategic Functions’ LOO and have a future focus. M&S systems supporting fleet generation, and again similar systems for fleet employment support an ‘Employ the Force’ LOO of the JSS. The scope of each of these support elements is described in the following sections.

Taxonomy
The taxonomy that derives from the above epochs and elements is geared for the MSE and provides a mechanism that can be linked to support prioritisation of resourcing and effort, and of scheduling for support to the Navy outcomes. At the same time, the taxonomy provides a degree of commonality within each class that should simplify the competing requirements of ownership, interoperability, data, governance and M&S integration.4

Table 6.2 provides a high-level snapshot of the relationship between key features of the Navy outcomes, the accountable officer, and features of the M&S classes from the taxonomy that service the derived deci-

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3 Department of Defence, 2020c, pp. 4–7.
4 Requirements for Simulation Workforce, associated ICT infrastructure and other ‘enabling’ simulation capability FIC are noted, but beyond the general strategy.
### TABLE 6.2
High Level Mapping of M&S to the Navy Outcomes

<table>
<thead>
<tr>
<th>Navy Outcome</th>
<th>Accountable Officer</th>
<th>Derived M&amp;S Features</th>
<th>Primary M&amp;S Tool Category</th>
<th>Derived Secondary M&amp;S Features</th>
<th>Secondary M&amp;S Tool Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome 5: Provide the required enablers and oversight to achieve Navy outcomes</td>
<td>DCN</td>
<td>1. FIC modelling 2. Simulation capability management</td>
<td>Fleet Management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
sion support and training requirement inherit in the Outcomes. Using our judgement, we have identified one or more primary and secondary classes supporting each outcome, while detailing the M&S class in the remainder of the chapter.

Within this taxonomy, the understanding of the types of M&S (and underlying models and data) that support decisionmaking for strategic functions, and for training and force employment, has matured significantly within Defence over the last two decades. Indeed, within Defence, Navy was an early adopter of M&S for training and later for decision support, as discussed in Appendix A. Elements of the capability that are fundamental to analysis for decision support remain in service, including the Joint Semi-Automated Forces (JSAF) simulation suite, albeit applied in support of a different Navy outcome.

Fleet Employment (Current and Future)

The major M&S systems supporting fleet employment feed Outcomes 1 and 2 and have a similar basis of design—that of a wargaming and analysis suite. However, the associated M&S systems and structures required to support Outcome 1 are quite different from those required to support Outcome 2.

Wargaming is a generally accepted tool for iterative structural analysis of conflicts and other complex problems, and is used worldwide for analysis of force employment problems, whether they be present-day or future-focused. As a central part of a decision support analysis suite, a wargame is usually supported by one or more adjudication tools, depending on the problem. The term ‘adjudication’ as used here is beyond ‘combat resolution’ and encompasses movement; logistics (including weapons inventory and intra- and inter-theatre supply); communication and EW; and the ‘play’ of joint and coalition assets. The type and degree of adjudication varies from SME adjudication in a seminar wargame assessing ‘conceptual problems’ to a rules adjudication system associated with tabletop wargames to rigid computer adjudication using a constructive simulation in the wargaming phase of course-of-action analysis, associated with formal or informal military planning and appreciation.

A suite of fit-for-purpose adjudication tools and procedures is therefore fundamental to analysis and decision support in fleet employment, for either the fleet-in-being or the future fleet. In terms of in-service assets, it is noted that an in-service JSAF suite is a fit-for-purpose wargame adjudication tool for some parts of the adjudication problem. However, given the unclassified nature of the databases for the in-service product and the significant overhead required to set up a JSAF adjudicated wargame and the likely continuous tasking of the in-service system, JSAF alone is unlikely to provide the flexibility that Navy will require to examine both fleet-in-being problems for Outcome 1 and future fleet problems for Outcome 2.

We also need to categorise the types of high-level areas where M&S can support Navy. A previous course-of-action study investigating wargaming for the United States Marine Corps (USMC) identified the six categories that we have adapted for M&S (Table 6.3).

Since the timeline for our report was considerably shorter and the problem scope we address is M&S strategy more broadly, we can draw a metaphorical loop around the definitions, tools and methods

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5 JSAF, developed as part of the Defense Advanced Research Projects Agency (DARPA) Synthetic Theatre of War Advanced Concept Technology Demonstration, is one of a number of distributed SAF in service worldwide. Importantly for this report, JSAF is the distributed SAF in service with the Navy and USN through the USN Navy Warfare Development Command. JSAF is a primary tool used in the FST-J exercises conducted between the United States and allies.


7 As described in Australian Defence Force, Plans Series ADFP 5.0.1: Joint Military Appreciation Process, Edition 2, esp. ch. 5.

8 Yuna Huh Wong, Sebastian Joon Bae, Elizabeth M. Bartels and Benjamin Michael Smith, Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action, Santa Monica, Calif.: RAND Corporation, RR-2227-USMC, 2019, pp. 7–10.
for Concept Development and Capability Development and Analysis (and arguably Senior Leadership Engagement and Strategic Discussions) above as ‘Fleet Employment Wargames’ associated with decision support in Outcome 2. A similar relationship could be drawn around Senior Leadership Engagement and Strategic Discussions and Support Operational Decisions and Plans, which can be associated with decision support for Outcome 1. These have associated objective statements drawn from the Marine Corps Warfighting Laboratory (MCWL) study.8

We note here the in-service JSAF is currently used by Navy for adjudication in training and education wargames, and to a lesser extent may be considered to inform operational decisions through certification exercises. We have not included S&T wargaming at this point; it is a peripheral responsibility as a support to Outcome 2 but is an accountable effort for the Chief Defence Scientist as CM for Innovation.

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8 Wong et al., 2019.

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### TABLE 6.3

<table>
<thead>
<tr>
<th>Categories</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Concept Development</td>
<td>This aligns with the Strategy and Concept phase of the ODCM, representing theoretical models ‘for how Defence should approach conflict or the potential for conflict, either at the whole of force level or by addressing specific sets of issues’.a For this, M&amp;S can be used to devise and test different approaches to HEWF. Key tasks for performing M&amp;S include eliciting and articulating new concepts; designing and implementing wargames to explore these; developing measures and mechanisms for adjudication; and capturing key assumptions and uncertainties.b</td>
</tr>
<tr>
<td>Capability Development and Analysis</td>
<td>This aligns with the Risk Mitigation and Requirements Setting phase of the ODCM, by exploring the ‘development of solutions to address the priorities identified through Integrated Force Design, including options, detailed specifications and risk management strategies’.c Wong et al. note that wargaming (and hence M&amp;S) supports ‘decisions about capability development or . . . [creating] products to support further quantitative analysis of an issue’.d Many of the key tasks for this activity are similar to concept development; however, the major difference is ensuring that the data developed has sufficient fidelity for quantitative analysis.</td>
</tr>
<tr>
<td>Science and Technology (S&amp;T)</td>
<td>These relate to characterising and exploring emerging S&amp;T concepts that may have a significant impact on the future warfighting environment. We have not included this explicitly in our analysis as it falls under the responsibility of the Chief Defence Scientist as CM for Innovation. However, if necessary, emerging S&amp;T concepts can be captured under concept development as they can be situated in terms of mission requirements or effects.</td>
</tr>
<tr>
<td>Senior Leadership Engagement and Strategic Discussions</td>
<td>While this does not represent a distinct phase of the ODCM, it is broadly captured under ‘Connecting Capability Decisions’, including decision-making and innovation.e This requires a different style of M&amp;S, that is to say, one ‘not necessarily [focused] on adjudicating outcomes but instead on enabling discussion and gaining feedback from senior decision-makers’f. Subject-matter expertise plays a key role in injecting data. As such, facilitation and consistent data capture protocols are critical.g</td>
</tr>
<tr>
<td>Support Operational Decisions and Plans</td>
<td>This is primarily focused on ‘informing current and future plans and challenges, both at the service level and the joint level’.h M&amp;S for this category is generally performed through Headquarters Joint Operations Command (HQJOC). It aligns best with the In-service and Disposal phase of the ODCM. The key elements for successful M&amp;S include a well-defined operational environment, realistic and current operational plans, the ability to inject friendly and adversarial courses of action, and a transparent operational plan that is accepted by those who are participating.i</td>
</tr>
<tr>
<td>Training and Education</td>
<td>This is the mainstay of M&amp;S in Navy, supporting the development and preparedness of all Navy staff. This differs from the other categories mentioned here given the focus on specific learning objectives and can be based on competency against these.</td>
</tr>
</tbody>
</table>

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a Department of Defence, 2020c, p. 6.
b Wong et al., 2019, p. 47.
c Department of Defence, 2020c, p. 6.
d Wong et al., 2019, p. 8.
e Department of Defence, 2020c, pp. 7–8.
f Wong et al., 2019, p. 9.
g Wong et al., 2019, pp. 48–49.
h Wong et al., 2019, p. 9.
i Wong et al., 2019, pp. 49–50.
Figure 6.1 orients these M&S categories across different time horizons, as this helps shape the information and data that are used to construct models as well as the nature (e.g., level of certainty) for the outputs of those activities M&S is supporting.\textsuperscript{10} For instance, education and training build upon organisational and individual knowledge and experience, linking that to current operational needs, and using this to inform future requirements.

**Senior Leader Engagement**

This form of wargaming is rooted in senior Navy staff knowledge of the fleet-in-being and the knowledge of coalition, joint and enabling elements typically brought to the game by knowledgeable Navy personnel. The intent of the game is not necessarily to adjudicate outcomes but instead to enable discussion and structured feedback from senior decisionmakers. What is compelling about this type of game is that the infrastructure needs can be very modest (accessible almost immediately by Navy if required). Useful wargames of this type are often ‘hex-based’ with simple rule sets that limit ‘magic moves’ by senior staff. The MCWL recently developed a game of this type called Assassin’s Mace, which is focused on the Pacific and South China Sea region.\textsuperscript{11} The compelling characteristics of Assassin’s Mace and similar tools as adjudication methods are that they can moderate a wargame at any level of classification and can be simply adjusted to include any new technology or concept.

**Support Operational Decisions and Plans**

Unlike the United States and the United Kingdom, Australia has not typically conducted adjudicated wargaming of pre- and post-H-hour plans at the service level outside of a training and certification environment where training objectives are pre-set. We note here that for Navy this responsibility falls formally to COMAUSFLT. The objective requirement was reflected in part in the synthetic training objectives and tasks in the Navy Warfighting Strategy 2018\textsuperscript{12} and particularly the recently superseded key warfighting milestone in Plan Mercator: Navy Strategy 2036, which sought Task Group Certification by simulation by 2021 and Task Force Certification by simulation in 2031, presumably assessing HEWF proficiencies for the

**FIGURE 6.1**

Wargaming M&S Categories and Their Time Horizons

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{wargaming_categories.png}
\caption{Wargaming M&S Categories and Their Time Horizons}
\end{figure}

\textbf{SOURCE:} Wong et al., 2019, fig. 2.1.

\textsuperscript{10} Wong et al., 2019, p. 10.


\textsuperscript{12} Royal Australian Navy, 2015.
ships in company and joint assets. The extent to which the first objective had been reached in 2021 reflects capability gaps beyond the classification of this report, but the underlying data and systems that would support wargame adjudication for certification decision at a classified level do not yet exist.

There are several reasons for, and consequences of, this stance. Significantly, Defence is yet to make the necessary investment and remediation to upgrade the databases to adjudicate wargames from an essentially Five Eyes–unclassified training baseline to any classified level including at the Australian Eyes Only (AUSTEO) level. Notwithstanding any enduring requirements regarding certification, training objectives for the current environment, and in particular preparing for HEWF, this upgrade is required as data listed at the unclassified level are understood to be insufficient or unrepresentative of true performance of systems, and the lack of commensurate classified systems and spaces impedes any decision-making at the levels of confidence needed. This requirement for classified systems and data can and should commence immediately for JSAF and any other constructive simulation to be considered.

To adequately and appropriately close extant capability and confidence gaps and to bring the Navy systems into alignment with ADF and allied systems, we recommend that Navy consider:

- upgrading the classification of the database used for constructive simulations to classified levels (including AUSTEO) for both blue and red assets
- securing access to configurable classified wargaming spaces capable of discussions at the required classified levels
- addressing classified ICT and workspace deficiencies to support integration of real systems and classified simulation data into fleet employment wargaming and certification.

An observation of Defence wargaming practitioners worldwide is that the classified information required for models and simulations is most available for threat systems from a single authoritative source (Defence Intelligence Organisation) and that ‘blue data’ is more difficult to obtain because of diffuse ownership. While there are analytical methods that can address this, Navy should consider a concerted effort to collect a comprehensive ‘Blue Battlebook/Databook’ for in-service Navy systems (and those approaching initial operational capability [IOC]), including, critically, CONOPPs and CONEMPs, which codify how Navy would seek to use the fleet. SMEs and decisionmakers must use this information in a wargame as a baseline. This can be reasonably assembled at varying levels of classification. This collection and curation should start immediately.

To address this shortfall and establish a auditable baseline for decisionmakers, we recommend that Navy consider establishing a comprehensive ‘Blue Battlebook/Databook’ for in-service and under-construction Navy systems.

**Fleet Development**

Consistent with Outcome 2, and within the context of Navy’s M&S Strategy, ‘fleet development’ is taken to be consistent with the CM functions within the DCM and to encompass the responsibilities and activities requiring decision support in the Risk Mitigation and Requirement Setting and Acquisition Phases of the CLC. In particular, fleet development includes the development, testing and refinement of models, simulations and exercises.
of program strategies, program operational concepts, CONOPSs and CONEMPs\(^{19}\) for maritime force groups through

- testing and refinement of Navy needs and requirements for capability development
- acquisition, test and evaluation of platforms
- (where required) development of specific initiatives including integration of new capability into an interoperable system.

The Fleet Development phase is the first place where decisions must be made about fleet design, and the last place where intractable issues that affect maritime force employment and seaworthiness and fleet management must be analysed and solved. That said, the scope of decisions and support tools required is not simply tied to a phase of the CLC, nor do the decisions deal exclusively with future liability for capability. Within Navy and Defence more broadly, input to the force-design processes is a demand of each service, be it through a ‘Gaps and Opportunities’ process or some other mechanism. Fleet design decisions typically require input from SMEs and advice on asset management, operations, and force generation, as well as the normal external inputs and constraints.

Within the DCM, the Vice Chief of the Defence Force (VCDF) is identified as the lead for the fleet design problem. In this process, CN must be equipped with the tools and analysis to meet his responsibilities to CDF as the principal naval advisor (PNA) and specifically to support his decisions and advice in ‘providing timely and accurate advice to the government on strategic direction and military capability of both the current and future force’\(^{20}\). As PNA, CN is the ultimate authority for these representations across all classifications and, as we have identified above, must have at hand a curated Battlebook/Data-book of representations of at least the current systems and those proposed.

The next generation of M&S support tools that Navy requires will be designed to reuse, export and share data across the CLC. Some interdependent modelling tools already exist to assist in understanding the interplay between the cost drivers of future proposals (future liability) and management of assets across FIC to inform fleet development decisions. Suitable tools, data sources, structures and search engines exist and have been trialled to some extent within Navy, or employed for key decisions by Australia’s allies.

**Fleet Management**

Unlike other categories of M&S, Navy’s past and existing M&S plans and guiding strategies weakly identify a need for modelling (in particular) to support fleet management. However, Navy does have a (brief) historical reliance on fleet management modelling.

Fleet management M&S systems support Outcomes 2, 3, 4 and 5. These are by nature modelling systems with associated analysis and visualisation suites. The scope of the requirement for M&S to support decisionmakers in fleet management has been touched on previously, reflecting the end-to-end interdependent nature of decision support modelling. For Navy, modelling environments supporting current and future systems of systems integration are arguably high priorities, as is the interplay between personnel management, particularly those whose skills are in short supply, and fleet management of major systems. Navy will need to continue to provide compelling cost-effectiveness evidence for entries into future editions of a FSP.\(^{21}\) What is already evident is that sustainment costs rise for fleets approaching obsolescence and planned withdrawal dates, and that those costs are often offset by trade-offs in other FIC—typically personnel time or reduced availability. Defence has contracted out characterisation of these relationships for a small number of maritime and aerospace systems, augmenting support previously provided by DSTG. The merit of this work is set by the

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\(^{19}\) See Table E.1 for definitions.


\(^{21}\) Department of Defence, 2020b.
classification of the data and scenarios that can be shared with any contractor group. As the classified fleet management work increases, Navy may seek to ensure a sovereign capability in this area, in accordance with the principles underlying the Defence Data Strategy, especially the sovereign requirements for test, evaluation, certification and systems assurance that extend from fleet design through to fleet management.

Modelling and analytical support to management of capability currently involves a number of siloed systems. What is required are models supported by a multi-use database that is open to structured queries (SQs). Until recently, the interfaces to such databases required significant attention from staff trained in structured query languages (SQLs). However, a number of projects are developing such databases using the Capability Development Management and Reporting Tool (version 2). This is utilised for monitoring project risk, and from its application Defence has a greater understanding of the small training load required to enter data and structure queries.

As previously indicated, data management and M&S for decision support is part of a virtuous circle. Navy will examine M&S capability now required to manage all aspects of FIC, providing a seamless transition of data with multiple viewpoints back to planning requirements. As capabilities are employed, for example, as data on repair pool inventories or parts and usage rates are gathered and entered into a common database, M&S systems can generate automated models and alerts. Managers can then model across time to build a case (simulation) for a capability replacement or refresh. The capability to ‘discipline the data’ and set appropriate queries is not a ‘futurist dream’—it has been demonstrated and requires initial investment. It is notable, however, that Australia’s allies’ experiences with these types of predictive reporting models identify where costs can be saved or avoided.

**Fleet Generation**

M&S systems supporting fleet generation can be recognised as those supporting a portion of Outcome 4. It is interesting to note in Plan Pelorus that responsibility for generation of naval task units, groups and forces lies with the fleet commander, but that the training and education of members of ships companies (a first-order generation task) and the associated M&S assets lie with Commodore Training (COMTRAIN). The residual constructive simulation is effectively a shared asset between commands. This provides a configuration governance, policy and scheduling challenge.

Historically, the bulk of investment in the Navy simulation capability lies in LVC simulations and simulators generating individual and small team competencies. Fleet generation is, however, more broadly defined and covers the activities involved in sailor and officer training and education (including proficiencies in maritime planning and wargaming) and the management of current Navy capabilities, particularly the ‘human asset’ base.

Given our understanding of the scope of responsibilities of COMAUSFLT for proficiency certification as described under ‘Fleet Employment’ above (and therefore the required M&S systems), for the purposes of this report, M&S for fleet generation is divided into two areas:

- a future asset scheduling capability, for all current and future FIC components contributing to the generation of cohorts of sailors and officers of various trades and skills
- a more generally recognisable use of LVC training simulators of varying fidelity, allowing training and testing of individual and small-team competencies from a novice entry level to whatever training certification level is required for the safe and effective operation of the real systems.

22 Department of Defence, *Defence Data Strategy 2021–2023*, Commonwealth of Australia, 2021a. See also Appendix B.

23 Department of Defence, *Sovereign Industrial Capability Priority Implementation Plan: Test, Evaluation, Certification and Systems Assurance*, 2020d. See also Appendix B.

24 Royal Australian Navy, 2018b.
Navy retains a number of essentially stand-alone modelling systems supporting decisionmakers for fleet generation, and modelling has most recently been successfully applied to shape the future Navy personnel profile. However, because these models are not generally designed to share data models and outputs with other systems, there is a need to ‘re-work’ input data and interdependencies when developing models informing fleet generation.

Conceptually, the requirement for M&S in management of the fleet-in-being assets for a given fleet generation cycle is simplest to conceptualise in terms of a multi-input project management and scheduling tool. A complex project management tool suite is appropriate when the details of the inputs (their number, location, capacity, throughput, etc.) are known and well characterised.

However, as Navy changes the requirements for training and certification for HEWF, some characteristics of the enabling training assets become unknowns in some respects: including, for example, the number and character of classified spaces; relativity scarce (and yet to be defined) high-fidelity simulations; and indeed, the learning pipeline for operators and trainers, which can be expected to change significantly. Capturing this capability as a connected predictive service linked to the fleet generation and fleet management systems will be required.

As noted above, Navy has an extensive in-service suite of LVC simulations and simulators for generating individual and small-team competencies and must continue to acquire training systems to support new major systems as they come into service. From a strategy perspective, we note that the basis of provisioning these systems and associated enablers is by design just sufficient at the moment to meet the training throughput as it is known. As referenced in our current-state assessment for training, we note that many of the existing operator consoles, workstations and tools were initially acquired as part of a major system capital acquisition project. However, while the major system components have had several upgrades through sustainment funding and capability-enhancement projects, the associated training consoles and systems have not been configuration-managed to the same releases, relying on separate sustainment funding. Our current-state assessment reveals that the system overall cannot meet the HEWF training requirement and will need upgrading and replacing at some point, and that an array of vendor solutions, both commercial off-the-shelf (COTS) and modifiable off-the-shelf, are available to meet the current need when replacements be required. The rebaselining of the training systems to the contemporary standard is a new goal within the ‘Employ the Fleet’ LOO, which aligns with updating extant M&S systems for new training for new major platforms and new warfighting tasks. To address this gap we recommend that Navy consider investment in remediating and managing the configuration of training consoles, systems and supporting ICT to the in-service baseline.

Our evolving understanding of how simulation will be applied in the future demands that Navy continue to examine how new technologies may help with the achievement of training outcomes. Where acquisition of simulators supporting competency training for current and future systems is time-critical, investment in virtual simulations and ‘first-person-shooter gaming infrastructure’, including VR/AR systems, could be made at relatively low cost. Here repeatable environments with a representation of the Joint Operating Environment (JOE) that permits the ultimate technical/tactical test—a reactive enemy—is again required. They must evolve to serve the higher training purpose (refocusing simulation as a means rather than an end). To that end, low-cost VR/AR systems that exist could be considered (and prioritised) for introduction into training with haptic feedback and visual and audio cues.

Regardless of what combination of systems are used to obtain the HEWF skills and competencies, at the heart of the training directives and conceptual framework lies the principle of ‘practise, but practise the right things’. With the exception of a few specialist skills, such practice must be ultimately honed, tested or assessed in a field environment that is as close as possible an approximation to the JOE, which under Plan Pelorus is ultimately the responsibility of COMAUSFLT to assess proficiency at the multi-unit level. To miss this step is not to truly practise. Thus, regardless of ‘command ownership’ here is and will continue to be a requirement for appropriate, live-instrumented simulation systems throughout the fleet generation levels, to provide a rich live-training environment that represents the JOE. Navy should expect that environment to be classified once basic competencies are achieved.
The Broader Enterprise

While our discussions of the M&S support systems have centred on Navy and its needs in relation to Outcomes 1 and 2, we cannot ignore the broader (Defence and national) enterprise within which Navy M&S will operate. These enterprise considerations will be of particular importance to how the LOOs will be delivered. In many cases, Navy will have little capacity to influence these, creating risks to Navy’s ability to achieve the desired goals. Such external factors include

- resource and budgetary considerations—particularly in terms of (priority) access to a budget sufficient to develop and sustain the M&S capabilities), and the priority given to Navy billets and/or Australian Public Service (APS) positions dedicated to M&S
- the government’s agenda and priorities—for instance, the stipulation for Australian Industry Content levels and/or the prioritisation of sovereign defence industry capabilities may disincentivise investment in M&S
- the education and training pipeline, and its capacity to deliver the type of workforce needed
- Defence policy—this includes all policy, including that dedicated to M&S; as noted earlier, the lack of a coherent M&S policy environment creates the possibility that Navy’s M&S requirements are compromised
- workforce availability and competitiveness—M&S skills are highly sought after in the commercial sector, creating challenges for Navy and the APS to offer competitive remuneration packages
- national infrastructure—while the need for bespoke classified ICT infrastructure is recognised, the national ICT systems will still have a central role for the application of M&S; increasing pressures on that pose a future risk to Navy M&S
- R&D—Navy needs to be at the forefront of advanced M&S systems (e.g., VR/AR and AI); much of the development in these is aimed at the commercial sector given broader commercial opportunities
- international partnerships—the requirement for a close relationship with USN was recognised in 2019 strategy; as such, the quality of that relationship, in terms of access and interoperability is important, particularly if those partners choose to employ standards that are not currently used by Navy M&S systems.
M&S Support System for Navy HEWF

During our discussions with Navy, the challenges for Navy associated with M&S support for current-force readiness and fleet design to be prepared for HEWF were noted. We characterise these as subcomponents of the research questions (see Chapter One); namely, using M&S to address the following within the context of HEWF:

- preparing the current fleet for HEWF given the strategic environment
- exploring and refining a set of maritime program warfighting operational concepts given the evolving nature of the operational environment, consistent with CN’s responsibilities
- supporting fleet design over the next decade as new capabilities are developed and introduced into service.

The first of these aligns with Outcome 1 (Provide Maritime Forces for Current Operations, Exercises, Engagements, and Future Contingencies), while the last leads to a wargaming capability focused on supporting Outcome 2 (Plan and Deliver Future Maritime Systems). The middle point contributes to both. In this chapter, we identify M&S courses of action Navy could consider in response to these requirements. This includes sustainment of the M&S capability. What we propose is necessarily broader than a narrow ICT-based definition of M&S; it is consistent with the definitions for modelling within the Defence Simulation Glossary. This chapter adopts the broadest definition, and these aspects are defined in sufficient detail to allow Navy to begin to assemble this capability while conducting detailed scoping of requirements. We then also detail the M&S problem space for NIW, which is effectively a new, but strategically significant, demand on M&S.

Current System

An analytical capability for fleet design, supported by M&S, has existed previously in Navy and could be re-established to support decisionmaking for Outcome 2. The MOAC was established as a precursor to the Maritime Warfare Centre. The requirement for a joint group of Navy and analysts was estimated at 60 persons, with appropriate analytical tools, including simulation. Initially, the MOAC was stood up with three Navy staff and three DSTO analysts, using a small number of analytical tools, including JSAF. Coinciding with this, the annual Headmark series of future warfighting experiments were initiated

1 Australian Defence Simulation Glossary definitions:
- Modelling: The process of creating and analysing a physical model to predict its performance in the real world through multiple iteration
- Simulation: A method for implementing a model over time
- Modelling and Simulation: The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions.

Department of Defence, 2019, pp. 9, 11.

2 As DSTG was then named.
in 2002 as a partnership between NHQ and DSTO’s Maritime Operations Division. The Headmark series used JSAD as a key tool, following the successful Army/DSTO Army Experimental Framework model.\(^3\)

The Maritime Warfare Centre as it is currently tasked supports Outcome 1 and has an immediate-term focus on ship operation and shipbuilding, consistent with the short-term fleet design problems. However, the current tasking is not aligned with what we have established in the Problem Statement (see Chapter Four). With augmentation (i.e., in both Navy staff and analytical capability), an appropriate tool suite, and classified OA capability, the Maritime Warfare Centre could meet the immediate analysis and decision support demands for Outcomes 1 and 2.

### A Future HEWF M&S Capability

Our working assumption, as detailed in the Problem Statement, is that a formal self-assessment would conclude that the fleet has significant capability gaps and is not ready, nor designed end to end, nor configured for HEWF or grey-zone operations. To the extent that this view is valid, then, the M&S analysis support system described here will support the identification of actual gaps and shortfalls in meeting both Outcomes 1 and 2 in light of HEWF. The particular shortfalls for the two outcomes are likely to be different, and the resolution/solution paths are also likely to differ in timeframe and adjustments across FIC. It is likely, however, that some shortfalls in preparedness for HEWF found to affect Outcome 1 will be addressed at least in part by fleet development solutions conducted as part of Outcome 2.

As discussed, there is an apparent absence of a comprehensive set of CONOPSs and CONEMPs (at appropriate classifications) for fleet operations in HEWF scenarios against contemporary threat systems. Appropriate M&S systems are an established enabler for the analysis and development of the maritime requirements for HEWF, and thereafter CONOPSs and CONEMPs. However, this must begin with an agreed working definition of HEWF (e.g., an expanded version of the definition presented in Chapter Two), and at least maritime CONOPSs for each region of interest. This analytical requirement is independent of the needs of Outcomes 1 and 2. However, it is most likely that the CONOPSs for Outcome 2 will evolve from those of Outcome 1. As identified in this report, this information gap stems in part from an absence of an overarching defence or maritime concept of, and for, HEWF, against which fleet design is determined. This will allow requirements to be set, and will flow through to platform and task-group CONOPSs and the individual and collective competency and mastery requirements. This is necessary for CN to meet his obligations and responsibilities.

### An Analytical Wargaming Capability

#### Analytical Wargaming

The connection between analytical wargaming, innovation and simulation can sometimes seem obtuse. However, detailed guidance on the connection can be found in U.S. DoD’s ‘Memorandum on Wargaming and Innovation’.\(^4\) As we have identified earlier, the DCM\(^5\) gives quite detailed guidance on the responsibilities of VCDF in force design and integration, but only loosely defines the requirements for other CM (including CN) in respect of program strategies and program operational concepts, other than assigning responsibilities.

CN has delegated responsibility for five maritime domain programs within the ODCM:\(^6\)

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\(^3\) See Appendix A for more details.


\(^5\) Department of Defence, 2020c.

\(^6\) Department of Defence, 2020c, p. 10. For details of each domain program, see Department of Defence, 2020a, ch. 4.
- Maritime Surface and Above Water Combat
- Undersea Warfare
- Maritime Mine Warfare, Patrol and Geospatial
- Maritime Combat Support and Amphibious
- Maritime Command and Control, Communications, Computers, Cyber, Intelligence, Surveillance, Reconnaissance and Electronic Warfare (C5ISREW).

CN also have an enduring interest in two other programs: 7

- Maritime Patrol and Response
- Integrated Air and Missile Defence.

According to the ODCM, each of these programs requires a program operational concept, which describes the warfighting and support requirements and concepts, and how capability products fit together within the program. The ODCM also describes key dependencies on, and considerations that relate to, other programs. 8

This is similar to the U.S. DoD requirement for Analysis of Alternatives (AoA) documentation. 9 As described earlier in the context of current fleet employment, the warfighting and support requirements are in essence HEWF and grey-zone CONOPSs and CONEMPs, and can be developed through wargaming and other forms of analysis 10 of the mission areas and functional areas for any of the maritime domain programs. This analysis can be set at any epoch and, considering the HNC requirement and the known schedule for delivery of major systems in the near term, Epoch 1 (to 2025) would be a suitable timeframe for wargaming and analysis. With respect to Outcome 1, the program operational concept would effectively inform a revised version of Australian Maritime Operations document at least, as well as other related strategies. 11

Analytical wargaming will require the acquisition of wargaming tools, classified spaces, and analysis staff. However, achievement of an analytical wargame along the lines identified for the USMC by RAND involves a significant deliberate design phase and data collection (see Chapter Six). 12 This includes, but is not limited to the following:

- initial identification of at least one ‘benchmark HEWF scenario’ that defines the operational characteristics for major systems, mission areas and functional areas within the program under analysis
- identification of related programs or parts thereof, which are seen as critical to the mission areas and functions in the scenario.

Together these scenarios form the target state for the fleet design for each program in the sense that if the (segment of) fleet capabilities, CONOPSs and CONEMPs can achieve the missions defined by the scenario within acceptable risk, then CN can provide forces to meet the strategic objectives ‘to deploy military power to shape our strategic environment, deter actions against our interests and, when required, respond with military force’. 13

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7 The Chief of Air Force is the CM for these.
8 Department of Defence, 2020c, paras 4.7b. and 4.10.
10 See Appendix F for typical examples.
12 Wong et al., 2019.
13 Department of Defence, 2020a, p. 6.
Each program will likely require linked wargames at the appropriate classifications, focused at

1. fleet movement
2. long-range strike and counter-strike
3. fleet combat (kinetic and non-kinetic)
4. fleet logistics (intra- and inter-theatre resupply and rearming)
5. considerations for reconstitution.

It may prove expedient to separate above-surface from subsurface wargames; however, it is likely that a 'final' integrating wargame will be required. The analysis goals for the wargame should be to characterise the mission area risks as they contribute to the maritime domain program under test and to 'ascribe' the risk where possible to the fleet capabilities, CONOPSs and CONEMPs within the program or those linked to it.

The scenario work will benefit greatly from an analysis of the JED's Joint Common Experimentation Environment products, derived from the Australian Capability Context Scenarios (ACCS) for suitability. Here it is noteworthy that the ACCS alone may be insufficient as they do not explicitly define a grey-zone scenario, although attempts at accommodation have been made. The ACCS are governed by business rules that seek to limit experimentation outside of the approved strategy without reference to senior committee.

In order to achieve such described outcomes, we recommend that Navy consider development of an analytical wargaming service to support a fleet design function (current and future fleet). It is conceded that organisational and resource options for building such capability is required. Augmentation of the staffing of the extant Maritime Warfare Centre may provide the most immediate solution here.

Lessons from USMC Experience

In considering how Navy might establish an analytical wargaming capability, it is useful to consider how a comparable Defence organisation does this. The USMC offers a useful template given the maturity of its wargaming approach and its compatibility with Navy (both in the size and functionality). Further, there are existing relationships that could be easily exploited. Also, many of their tools (and Command Professional Edition [CPE]) are familiar to the Australian M&S Assassin's Mace community. Finally, they have recently commenced a redevelopment of their wargaming infrastructure.

As discussed in Chapter Six, RAND conducted a multi-year study for the USMC on analytical wargaming best practice. This report has been incorporated into the design of a state-of-the-art wargaming centre co-located with MCWL and Combat Development Command aboard Marine Corps Base Quantico, which started construction on 12 May 2021.

While the wargaming centre has developmental plans for high-technology wargaming using AR, at its core is a dedicated facility with rooms configurable for space and classification and dedicated staff of approximately 100 marines, contractor analysts, and other services. The centre is expected to open in 2023, however in the interim the USMC will continue to build wargaming expertise by examining fleet (USMC and USN) employment problems using Assassin's Mace (described in the previous chapter) and employing computer adjudicated wargames using the COTS serious game tool CPE with a classified database, in development by MCWL in conjunction with the developers of CPE.

14 The Joint and Operations Analysis Division (JOAD), within DSTG, is a co-developer and tester of the Assassin’s Mace wargame. CPE is already in service within Defence, with licences in Force Design (JED) and JOAD.

15 Wong et al., 2019.

16 Todd South, ‘Marines Break Ground on New War Game Center’, Marine Corps Times, 16 May 2021.

17 CPE can be deployed on a single stand-alone laptop at any level of classification; however, the ‘out of the box’ database is commercial unclassified.
Considering the above, we recommend that Navy engage with MCWL:

- to receive detailed briefings on the configuration and plans for the wargaming centre and the development of their operational wargame system
- to evaluate the utility of Assassin’s Mace to determine if it offers an ‘immediate’ solution for a senior staff wargame on maritime HEWF
- to understand the development of the classified database for CPE
- to (if appropriate) acquire copies and/or licences for Assassin’s Mace, and licences and hardware for CPE.

Implementation to Support Outcomes 1 and 2

The preliminary problem analysis outline above has yet to be tested and will evolve as the details of the Problem Statement are worked through by Navy. Importantly, work on targeted HEWF competencies and proficiencies (and the training programs) can begin only once the gaps are known, the concepts outlined, and the materiel solutions scoped. Some of these solutions will inevitably suggest or require extended/enhanced simulation-based training and/or new OBTSs, for which an enhanced MSE will be required. Consideration should also be given to the conduct of grey-zone operations, especially in the context where such operations may represent precursors to HEWF, and especially those conducted in the cyber domain. Here intrusions (including in those at very early planning stages) may result in the potential for loss of a situational-awareness advantage and, worse still, the potential for maritime systems to be disabled. Some of these requirements are addressed in the next section in relation to IW, but the escalation of events and the occurrence of ambiguous events below the threshold of war also comprise further dimensions and complexities to be examined through M&S. Preparation for the MSE can begin with all these things in mind. However, significant investment in new fleet generation assets and capability must naturally follow this fundamental work.

Similarly—and noting that the gaps and the capability sets that address the gaps will be classified—the MSE will need to be built to prepare for an integration/OT&E phase that is dominated by virtual and constructive representations of real capability, rather than the traditional live trials. Planning can start now along the lines already established for the MSE. The roadmap will need to include this and the associated RAM modelling to enhance preparedness.

To address this gap, we recommend that Navy establish an M&S-enabled analytical campaign supporting Outcomes 1 and 2 that

- uses one or more techniques (analytical wargaming is recommended initially) to understand the challenges in conducting maritime HEWF
- characterises the gaps that emerge
- adapts, improves and develops the relevant warfighting concept elements for which CN is responsible
- identifies and tests potential solutions across FIC
- assigns elements of the solutions appropriately.

Specialised M&S Requirements for Information Warfare

Within Navy, the responsibilities of the Director-General Navy Information Warfare (DGNIW) are a ‘good fit’ for an end-to-end M&S support environment and, critically, information warfare (IW) is likely to play a key part in maritime grey-zone and HEWF operations. The responsibilities include18

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18 RAND Australia interview, 9 November 2021.
• NIW fleet development, from NIW CONOPs and CONEMPs development to candidate solution identification for IIP [Integrated Investment Program]19 consideration
• deployment considerations, including development, security, and operations (DevSecOps) techniques and all phases of test and evaluation of both software and hardware, and certification of these for major platform and weapons operation
• at-sea employment of patches, upgrades and loading of target and defensive packages
• provision of (in this case) M&S services for Navy training and certification evolutions.

There is, however, no installed M&S base at any classification20 from which to assess a current state. While there are as yet no detailed ‘forecast’ or future-state requirements, at an unclassified level the general requirements can be articulated here and form a basis for a detailed scoping study.

While the environment includes physical platforms, IW is conducted in/on and with electronic systems. Therefore, fit-for-purpose M&S is required across all domains and must be connected to and compatible with the ship systems to provide an environment that meets the current requirements and offer effective, and operationally safe, fit-for-purpose solutions.

Noting that maritime systems for NIW exist outside the skin of the ships, major systems, and weapons, and that these need to be carefully configuration-managed both for the NIW kit and for the platform and weapon interfaces, there is a significant challenge in the engineering approach. In consultation with DGNIW, we note that in addition to the Ship Zero engineering and configuration management approaches, NIW requires System(s) Zero for the systems that exist outside of the platform envelope but are intrinsic to the maritime fight. These must also be configuration-managed. System(s) Zero need to actively interface with Ship Zero, and given the pace of the updates of both threat and allied systems, an opportunity for NIW staff to ‘touch the systems’ is required at each port call or sustainment event. This will permit NIW technicians to do ‘evergreening’ updates—maintaining a 12–18-month cycle for software and hardware fixes and patches using DevSecOps principles. Without this or a similar approach, capability obsolescence is accelerated, and utility to allies as a partner is compromised. An evergreening engineering approach like this will occur in multiple sprints and should be dependent on digital twinning—models and simulated representations of the ship, platform, and weapon systems and interfaces.

With respect to NIW as a training service for individual competencies and fleet certification events, the current mechanisms for the classification accreditation of Defence training and experimentation networks or Navy’s equivalent, are assessed as insufficient, and, for example, HMAS Watson ICT is not fit for this purpose. Navy, and Defence more broadly, will continue to introduce into service classified NIW products and services. These will need to be exercised at the appropriate classification, for which a range of remediation and new-build activities are required across ICT, buildings and personnel.

While the strategy goal will continue to evolve quickly, in the near term it is noted that Defence and Navy will need to plug into the U.S. JADC2 [Joint All Domain Command and Control] architecture, as this evolves in response to A2/AD [Anti Access Area Denial]. Once scoped, this gap that M&S shared with the United States can begin to close.

Finally, specific M&S is required to support the communication and information systems (CIS) workforce (operators) and electronics technicians (maintainers). While not yet scoped, the support required includes AR/VR headsets to support ship system maintenance/upgrades/packet loading/configuration when disconnected. This essentially a ‘helpdesk function’ for emission control (EMCON) conditions, when NIW technicians will still need to load target and defensive payloads.

19 The IIP guides the implementation of the bulk of investment building the future force and Defence capability goals.
20 RAND Australia interview, 9 November 2021.
Wargaming Information Warfare

Currently, most wargames are based heavily on the assumption of attrition-based kinetic defeat mechanisms and do not substantially represent or account for IW dynamics.\(^{21}\) There is also a lack of formal publicly available literature on wargaming; aside from sensitivity of the information involved, most available literature consists of analysis of results of specific games, and literature documenting methods that are detailed enough to allow for replication or independent evaluation is scarce. According to Paul et al., since ‘the effects of [operations in IW] do not remain in the Information Environment’ and ‘such operations have consequences in and across the spatial domains’,\(^ {22}\) wargames should be expanded to meaningfully represent IW by including IW-related scenarios, and mechanisms to capture, assess and provide feedback on the effects of IW on military and non-military actors.

Paul et al. identify six categories of information that should be represented:\(^ {23}\)

- **Situational awareness.** This consists of awareness and monitoring of the entire operating environment, including the locations and states of military and non-military actors, the information environment, and how this may be affected by uncertainty and the ‘fog of war’.
- **C2, including communication.** This category refers to the content, availability and communication of information across networks and chains of command, including recognition of delays as ISR is processed, and differences in information relevance between tactical, operational and strategic levels.
- **C2 warfare.** This includes attacks on enemy situational awareness and C2 mechanisms and infrastructure, and the use of information to deceive or mislead enemy forces, or amplify uncertainty.
- **Information causing subordinate behaviour contrary to commander orders.** This may result from a range of reasons, including failures in C2 or situational awareness, psychological or emotional reactions (e.g., panic, distraction, shock) or disparities in perceptions of the situation leading to actions that are still consistent with commander intent or mission objectives.
- **Information for effect.** This is described as information which aims to protect against subordinate behaviour contrary to commands (as described in the category above) in one’s own force, or the use of this information to cause confusion and contrary subordinate behaviour in enemy forces.
- **Factors affecting non-enemy entities.** These entities, which may have an influence in outcomes, include civilian populations both within and outside of the immediate operating environment. This category is much broader in scope as it can include information which affects perceptions and behaviours outside of combat over longer periods of time, and as such requires tracking and understanding baseline attitudes, legitimising processes, and narratives drawn from the perspectives of those affected.

In addition to these six categories, the specific IW capabilities that are available to the force of interest, for example public affairs and cyber operations,\(^ {24}\) should also be considered as a requirement to be meaningfully represented in games.

\(^{21}\) Paul et al., 2020.

\(^{22}\) Paul et al., 2020, p. 73.

\(^{23}\) Paul et al., 2020, p. 18.

\(^{24}\) Other examples of capabilities or activities for creating effects using information can include key leader engagement, civil military operations, electromagnetic spectrum operations, military deception, space operations, signature management, and defence support to public diplomacy.
Strategy Format and Integration of Recommendations

Strategy making for an organisation has two fundamental types: the first is designed to respond to a small number of changes in the strategic and resource settings. This type of strategy making, typical of many established businesses, establishes a current posture for an organisation and describes an evolutionary path to a desirable new posture. The second type is used in response to significant changes in strategic or resource settings. This latter type requires a return to analysis of the strategic requirements, derives a ‘forecast state’ that meets the strategic requirements, and then analyses the current ‘fitness’ of the organisation to move to the forecast state—creating a gap analysis and need for prioritisation, road-mapping and resourcing of initiatives to close the gaps. The success of strategy in this second mode is measured against the gap closure or the changing strategic requirements.

This report presents our analysis, which finds that Navy requires an M&S Strategy of the second type, one born out of the significant explicit and implicit requirements of the DSU, and an evolution in the requirements on CN in managing capability across the life cycle and in meeting his requirements as the PNA to CDF.

Several elements of the initial tasking endure and are reported here to support the strategy revision. These include a review of how Navy has used M&S historically and what might be revisited; a review of international ‘best practice’ for maritime M&S; and, most importantly, a methodology for aligning strategy initiatives with strategic and policy guidance at the higher level.

This concluding chapter consolidates the key observations and recommendations made throughout the report for Navy to consider in formal strategy prioritisation, resourcing and implementation. The observations and recommendations here roughly follow the chapter structure, guiding strategy-to-task linking.

Observations

M&S Drivers

The 2019 M&S Strategy identifies triggers for review, including ‘on release of updated Defence strategic direction/guidance or policy (e.g., Defence White Paper)’. Our analysis of Navy’s strategic drivers in Chapter Two indicates that almost every relevant policy document and strategic statement has changed since 2019, including the DSU, FSP, DCM and Navy’s Plan Pelorus. This is more than sufficient to trigger a major review. A structure for such a strategy is provided and consolidated in Table 8.1 (which links strategic drivers, Navy outcomes, and authorities to the LOOs) and Table 8.2 (which identifies the necessary goals and specific initiatives to close the gaps identified in each LOO).

However, our analysis of the existing Navy doctrine and concepts that feed a capability development, training or operational requirement where M&S might be employed or required, suggests that a more far-reaching strategy, conceptual and doctrinal review is required. For M&S, the generation of a coherent set of maritime CONOPSs and CONEMPs for HEWF and grey-zone operations is one of the most pressing issues as these set not only the capability platform, systems, and weapons requirements but also
<table>
<thead>
<tr>
<th>LOO</th>
<th>Navy Outcomes</th>
<th>Focal Areas</th>
<th>Accountable Officer</th>
<th>Responsible Stakeholder*</th>
<th>Strategic Drivers/Requirements References</th>
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<tr>
<td>M&amp;S Enablers</td>
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<td>Defence Capability Manual Version 1.0, para. 1.26</td>
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<td>HNC</td>
<td>DGNIW, COMAUSFLEET, COMTRAIN, COMFLOT</td>
<td>Defence Capability Manual Version 1.0, para. 1.26</td>
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<td></td>
<td>All</td>
<td>Interoperability</td>
<td>DCN</td>
<td>DGNIW, COMTRAIN, COMFLOT, CIOG Rep, Estate Rep, HNE Rep (NMS Arch)</td>
<td>Defence Capability Manual Version 1.0, para. 1.26</td>
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<td></td>
<td>4, 5</td>
<td>Governance</td>
<td>DCN/HNC</td>
<td>COMTRAIN, COMFLOT, DGNIW, DGSCA, JOC J7</td>
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<td>Navy IW</td>
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<td>HNC (Outcome 1)</td>
<td>DGNIW</td>
<td>2020 Defence Strategic Update pp. 24–25 and p. 40 Australian Maritime Operations 2017, p. 4 Defence Capability Manual Version 1.0, fig. 1.5</td>
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<td>DCN (Outcome 2)</td>
<td>DGNIW, COMFLOT, COMTRAIN &amp; JOC J7, DGFOAP (JED), CJOAD</td>
<td>Defence Capability Manual Version 1.0 fig. 1.5</td>
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<td>2</td>
<td>NIW Deployment</td>
<td>DGNIW</td>
<td>HNE (Rep)</td>
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<td>COMFLOT</td>
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<td>Decision support system for CN as maritime domain lead</td>
<td>HNC</td>
<td>Defence Capability Manual Version 1.0 para. 1.20</td>
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<td>Functions</td>
<td></td>
<td></td>
<td></td>
<td>DGNIW, COMFLOT, COMTRAIN &amp; JOC J7, DGFOAP (JED), CJOAD</td>
<td>Defence Capability Manual Version 1.0 para. 1.20</td>
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<td>Maritime HEWF CONOPS/CONEMP certification</td>
<td>HNC/COMAUSFLEET</td>
<td>DGNIW, COMFLOT, COMTRAIN, JOC J7</td>
<td>Defence Capability Manual Version 1.0 paragraph 1.26</td>
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<tr>
<td>Employ the Fleet</td>
<td>1</td>
<td>Fleet Employment</td>
<td>HNC</td>
<td>COMFLOT, COMTRAIN</td>
<td>2020 Defence Strategic Update, pp. 24–25 and 40 Australian Maritime Operations 2017, p. 4</td>
</tr>
<tr>
<td></td>
<td>1, 2</td>
<td>Fleet Certification/Fleet Planning</td>
<td></td>
<td>DGNIW, COMFLOT, COMTRAIN &amp; JOC J7, DGFOAP (JED), CJOAD</td>
<td>2020 Defence Strategic Update, pp. 24–25 and 40 Australian Maritime Operations 2017, p. 4</td>
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</tbody>
</table>

* The accountable officer and responsible stakeholder acronyms are defined in Appendix G.
the individual and collective competency and proficiency requirements and, downstream, to the various simulators etc. that support these requirements.

However, Navy’s previous use of analytical wargaming and military experimentation methods as part of the Headmark series at the turn of the century provides a useful guiding method to address these problems. The wider commercial availability of analysis and experimentation services compared with the turn of the century, of a similar type to those providing decision support in the joint force development space, allows for an immediate solution as Navy regrows an organic analysis capability.

The Existing M&S Strategy
The 2019 M&S Strategy is really an evolutionary strategy of type 1 as indicated above; it tasks the NMSO rather than linking to Navy outcomes explicitly. It addresses the M&S enablers in the main. Our desktop audit identifies significant gaps that need to be filled given the change in strategic guidance.

The Existing M&S Capability
Our observation, based on desktop audits and interviews, is that there are significant shortfalls in the configuration management of the current M&S systems as compared with the ‘real’ platforms, systems and weapons in service. Additionally, there are significant gaps in classified ICT and training-and-exercise building and spaces that act to defeat some aspects of training for HEWF. We have not inferred the impact on capability in this report, but document it via other, more suitable channels. Remediations are part of our recommendations. An immediate issue that must be addressed is that current M&S systems ashore used for competency training are fully tasked. This will continue into the future (even as the simulators and the training change). Navy will need additional M&S resources (even if contracted) to support fleet development.

At-sea training and certification is currently limited by the number of threats (e.g., aircraft) that can be available in the simulated environment. Systems for simulating more threats and having these distributed across the ship (and the maritime taskforce) exist and have been prototyped for Navy. These offer more complex and realistic environments to test and develop Navy capabilities, CONOPSs and CONEMPs at the higher end. However, these are limited by similar gaps in classified ICT and training-and-exercise building and spaces that limit the ashore systems.

The International Model
Our review of the international experience does not reveal a single ‘winning model’ for Navy to adopt and follow. Noting, however, Navy’s close operating ties with the USN and a structural similarity with the Royal Navy (RN), some observations in the appendices to this report will be useful in roadmapping and implementation.

Linking M&S Implementation to the Navy Outcomes
An effective strategy of this type must be measured against the gaps and strategic drivers. We observe that the existing strategy lacks explicit links to the Navy outcomes and the responsible and accountable officers. We provide a suitable taxonomy that links the Navy outcomes through tasks, within a framework that can be used to develop the MSE. Much of the detail of gaps and objectives to be translated to strategy implementation is codified in this framework; the recommendations are detailed below.

Specific Observations Related to HEWF
A comprehensive strategy requires support to all Navy outcomes and M&S decision support aids to the responsible officers. However, given the significant changes in the explicit and implicit requirements for Navy, we observe that a maturing M&S capability should be approached in stages, even if rapidly. This
should, in our analysis, begin with addressing gaps in M&S supporting systems to both the ‘current fleet’ and the ‘developing fleet’—codified in the responsibilities for COMAUSFLT and HNC in HEWF (Outcomes 1 and 2)—before maturing to encompass new training simulators and engineering practices such as MBSE. M&S support systems for all Navy requirements are commercially available, or obtainable through foreign military sales, or have been prototyped by Navy recently. However, our observation is that implementation of recommendations below concerning remediation for HEWF should take precedence.

Recommendations

Throughout this report we have provided recommendations ‘in line’ to preserve the analysis context of the recommendation and the strategy links. Some recommendations or initiatives have common benefits or links across more than one strategic driver. Tables 8.1 and 8.2 provide our recommended Navy M&S strategy-to-task matrix for Navy, with the former table providing explicitly the links to the strategic drivers that were missing in the 2019 M&S Strategy, and the latter linking the LOOs to actions that could be developed further as part of implementation. To support immediate implementation, we provide a consolidation that accords with precedence or priorities mentioned above.

Our assessment is that the 2019 M&S Strategy’s focus on enablers is insufficient to meet Navy’s M&S needs, particularly around preparing for HEWF and grey-zone operations. We therefore recommend that Navy

- expand the 2019 M&S Strategy to include four application LOOs, specifically
  - Support to Strategic Functions
  - Employ the Fleet
  - Generate the Fleet
  - Navy Information Warfare.

To address the gaps in maritime CONOPSs and CONEMPs for HEWF and grey-zone operations, we recommend that Navy

- establishes an M&S enabled analytical campaign that specifically
  - uses one or more techniques (analytical wargaming is recommended initially) to understand the challenges in conducting maritime HEWF
  - characterises the gaps that emerge
  - adapts, improves and develops the relevant warfighting concept elements for which CN is responsible
  - identifies and tests potential solutions across FIC
  - assign elements of the solutions appropriately.

This capability can be used to address gaps in decision support for both Outcomes 1 and 2. In the preceding chapter, we identified how this CONOPS/CONEMP work informs the Program Operational Concept document in the five programs for which CN has responsibility. To implement this, we recommend that Navy develop an analytical wargaming service (with advice from JED’s Force Design Division) and follow this with augmentation of the staffing of Maritime Warfare Centre to support a fleet design function (current and future fleet).

We note that the USMC is establishing a dedicated staffed facility and recommend that Navy engage with MCWL

- to receive detailed briefings on the configuration and plans for the wargaming centre and the development of their operational wargame system;
• to evaluate the utility of Assassin’s Mace to determine if it offers an ‘immediate’ solution for a senior staff wargame on maritime HEWF
• to understand the development and maintenance of the classified database for CPE; and, if appropriate, acquire copies and/or licences for Assassin’s Mace, and licences and hardware for CPE.

We note that the concepts for HEWF and grey-zone operations will be heavily dependent not only on the capabilities of ships and their organic kinetic weapons, but also on non-kinetic and off-board systems—these are the remit of the Navy Information Warfare LOO. It is recommended that Navy engage to individually scope the M&S and decision support requirements for this area, across all classifications. The previous chapter outlined considerations for this work; these are consolidated for now into a handful of initiatives within the Navy Information Warfare LOO (see Table 8.2 below).

Our assessment of the 2019 M&S Strategy (Table 3.2) included a number of suggested actions to sustain, improve and fix the projects underway and planned to best align to the revised strategy. We are now able to combine those with the recommendations above and bring those forward as recommendations for the M&S enablers. Accordingly, it is recommended that Navy

- **Sustain** people as focal area and as initiatives, develop an M&S total workforce model—with significant enduring cleared contracted portion to meet ‘gapped’ M&S and OA positions. Simultaneously, with the strategy implementation it is recommended that NMSO revise ‘tasks’ in the 2019 nomenclature to ‘enabler projects’.
- **Fix** aspects of the simulation capability systems discussed here, including
  - consideration of Navy-wide simulation capability management through an M&S Capability Program Office in line with other capability programs, charged (and funded) with maintaining simulations to the ‘real system’ configuration standards.
  - remediate M&S training systems to current real system configuration standards through the Program Office.
- **Sustain** the upgrade to the Navy Training Baseline systems but include upgrading the ICT and building infrastructure.
- **Fix** the interoperability issues. The 2019 Strategy identifies an interoperability hierarchy: Navy/USN/others. This needs to prioritise the gaps by addressing the classification of simulators and data and how the ICT infrastructure is connected not only across the network but also between domains (e.g., Land to Sea) and platforms (e.g., Ship to Ship) while also addressing interoperability of the actual simulations.
- **Improve** 2-star simulation governance by including all 1-star stakeholders, including those from outside Navy.

Finally, the 2019 M&S Strategy detailed a number of programs for the NMSO to give effect to the M&S enablers for Navy. We recommend that Navy retains the four enablers—with some modifications. Consistent with providing the immediate decision support for Outcomes 1 and 2 and for building out the MSE, these include

- upgrading the classification of the database used for constructive simulations to classified levels (including AUSTEO) for both blue and red assets
- securing access to configurable classified wargaming spaces capable of discussions at the required classified levels
- addressing classified ICT and workspace deficiencies to support integration of real systems and classified simulation data into fleet employment wargaming and certification.

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1 Read Admiral level or equivalent.
2 Commodore level or equivalent.
<table>
<thead>
<tr>
<th>LOO Focal Areas</th>
<th>Goals</th>
<th>Gaps</th>
<th>Initiatives/Objectives</th>
<th>Epoch 0-4 Action</th>
<th>Epoch 0-10 Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M&amp;S Enablers</strong></td>
<td>People</td>
<td>Navy M&amp;S systems are designed, developed, operated and sustained by a highly competent workforce.</td>
<td></td>
<td>P1. Develop M&amp;S total workforce model, including incorporation of cleared contractors to meet unfilled M&amp;S and OA Navy/APS positions</td>
<td>Address OA and analytical wargaming shortfall through contract</td>
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<td></td>
<td>Systems</td>
<td>Navy M&amp;S Systems are maintained to adequately reflect real system performance and include all HEWF effects.</td>
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<td>Common 1. Remediate/replace all M&amp;S training systems to current real system configuration standard, including but not limited to JSAF</td>
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<td>Common 2. Develop ‘Systems Zero’ or ‘gold standard’ exemplar engineering approach for M&amp;S and related products and services</td>
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<td>S1. Navy will develop and use an M&amp;S certification ‘level’ system similar to those required for aviation such as the Flight Training Device</td>
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<td></td>
<td>Interoperability</td>
<td>Key Navy M&amp;S Systems Supporting Competency Training and Synthetic Certification are integrated and routinely operate with each other and with ADF and USN systems. MSE interfaces to the DSE are managed as a documented part of the NMSArch</td>
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<td>Common 3. Initiate classified ICT and building/spaces remediation</td>
<td>Remediate ICT and buildings</td>
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<td>Common 4. Scope, define &amp; implement NMSArch (see also S1)</td>
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<tr>
<td></td>
<td>Governance</td>
<td>Navy M&amp;S is structured and governed as a ‘Products and Services’ capability across the CLC and across all domains Navy M&amp;S systems and products are configuration managed as a capability, maintaining configuration alignment with ‘real’ capability and allied systems MSE and the interfaces to the DSE are managed as a documented part of the NMSArch.</td>
<td></td>
<td>G1. Realign 2-star governance with 1-star Critical Stakeholders (incl. COMTRAIN, COMFLOT, DGNIW, DGSCA &amp; JOC J7)</td>
<td>Act to initiate</td>
</tr>
<tr>
<td>LOO</td>
<td>Focal Areas</td>
<td>Goals</td>
<td>Gaps</td>
<td>Initiatives/Objectives</td>
<td>Epoch 0-4 Action</td>
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<tr>
<td>NIW</td>
<td>Development</td>
<td>NIW for HEWF and grey-zone CONOPS/CONEMP co-development</td>
<td>NIW 1. Fully scope and document requirement for M&amp;S in NIW Development</td>
<td>Commence NIW CONEMP analytical wargaming at appropriate classification with senior officers</td>
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<td>Mar HEWF 1. Establish integrated HEWF &amp; grey-zone Warfighting and support CONOPS/CONEMP sets for all maritime domain programs</td>
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<td></td>
<td>Deployment</td>
<td>DevSecOps &amp; T&amp;E support</td>
<td>NIW 2. Fully scope and document requirement for M&amp;S in NIW employment (including Systems Zero engineering approach)</td>
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<td>NIW 3. Fully scope and document requirement for M&amp;S in NIW employment</td>
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<td>NIW Service for Other LOOs</td>
<td>NIW simulated representation in training &amp; fleet certification systems</td>
<td>NIW 4. Fully scope and document requirement for NIW as an M&amp;S service (certification and training and force development)</td>
<td>Act to initiate</td>
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<tr>
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<td>Support to Strategic Functions</td>
<td>Fleet Development</td>
<td>Create a decision support system for CN responsibilities as maritime domain lead</td>
<td>Common 5. Establish Navy Analytical Wargaming Capability</td>
<td>Common Action 1. Engage with JED to plan, develop and test Maritime HEWF CONOPS/CONEMP</td>
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<tr>
<td></td>
<td></td>
<td>Maritime HEWF CONOPS/CONEMP development</td>
<td>Mar HEWF 1. Establish integrated HEWF &amp; grey-zone Warfighting and support CONOPS/CONEMP sets for all maritime domain programs</td>
<td>Common Action 2. Procure dedicated OA capability for Warfare Centre (to address DSTG OA gapped positions)</td>
<td>Act to initiate</td>
</tr>
<tr>
<td>LOO</td>
<td>Focal Areas</td>
<td>Goals</td>
<td>Gaps</td>
<td>Initiatives/Objectives</td>
<td>Epoch 0-4 Action</td>
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<tr>
<td><strong>Employ</strong></td>
<td><strong>the Fleet</strong></td>
<td>Fleet Employment</td>
<td>LVC training &amp; certification system for next-generation HEWF and grey-zone operations</td>
<td>Mar HEWF 3. Needs Statement for new HEWF training and certification system</td>
<td>TBD</td>
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<tr>
<td></td>
<td></td>
<td>Fleet Certification/Fleet Planning</td>
<td>Create a decision support system for CN responsibilities to CDF as the PNA.</td>
<td>Common 5. Establish Navy analytical wargaming capability</td>
<td>Common Action 1. Engage with JED to plan, develop and test maritime HEWF CONOPS/CONEMP</td>
</tr>
<tr>
<td><strong>Generate</strong></td>
<td><strong>the Fleet</strong></td>
<td>Individual Competencies/Proficiencies</td>
<td>Navy personnel will train and be certified for individual competencies using certified synthetic and augmented environments across all classifications and individual competencies prior to joining ships/stations. Navy personnel use certified synthetic and augmented environments across all classifications to achieve and maintain selected proficiencies on-board or off-board.</td>
<td>Common 1. Remediate/replace all M&amp;S training systems to current real system configuration standard, including but not limited to JS AF Common 2. Develop ‘System Zero’ or ‘gold standard’ exemplar engineering approach for M&amp;S and related products and services Common 3. Initiate classified ICT and building/spaces remediation</td>
<td></td>
</tr>
</tbody>
</table>
• establishing a comprehensive ‘Blue Battlebook/Databook’ for in-service and under-construction Navy systems
• investing in remediating and managing the configuration of training consoles, systems and supporting ICT to the in-service baseline.

This last point is more than a simulation capability governance issue—it reaches into systems management that normally the province of a capability program office, hence an initiative to establish an M&S Capability Program Office lies between observation and recommendation.

Proposed Navy M&S Strategy Matrix

The goals, gaps and objectives represent the central elements of the strategy-to-task logic model (see Figure 1.1). Having already established and used the strategic context (strategic requirements and current and forecast states) to shape these, we can group the recommendations together as initiatives (or objectives—depending on preferred the strategy nomenclature) as a high-level matrix that encapsulates a new Navy M&S Strategy and situates it within the broader strategy context (Table 8.1), and as a linked matrix with identifies specific gaps and objectives for each LOO (and associated focus areas) and identifies specific tasks to address them (Table 8.2). This broadens the 2019 M&S Strategy by expanding the LOOs to include both the existing set of enablers and four new application LOOs. As noted above, at least five of the initiative groupings appear common to more than one LOO.

3 In discussion with the client, we have elected not to display the ‘gaps’ in this document given their classification. These are provided separately to the client as a classified appendix and are fundamental to the strategy making and implementation as discussed.
APPENDIX A

A Brief History of Navy M&S in Australia

Until the 1970s, the main use of modelling for Navy was in complex physical calculations (e.g., ballistic projections for naval gunnery) and in tactics development for testing through fleet exercises.\(^1\) The Royal Australian Navy Research Laboratory (RANRL) (previously the Royal Australian Navy Experimental Laboratory [RANEL] and latterly DSTG Sydney) was a leader in the use of the development of tactical models for Navy that were then validated through exercises and their subsequent analysis. This work expanded as models became more sophisticated and developed into fully-fledged activity in operations research (OR) that has blossomed and is now applied to a much wider variety of Navy issues.

The OR studies backed by Exercise Analysis originally began in 1964 at RANEL and continue to this day, albeit at a much higher level of sophistication, as part of the Navy/DSTO Maritime OR program. The OR studies continue to be validated by exercises—either major ones such as RIMPAC\(^2\) and Talisman Sabre\(^3\) or as a regular part of fleet deployments for training (i.e., live simulation). Much of the analysis is now undertaken through virtual simulation, often for solely naval purposes but increasingly for joint ADF problems.

OR has flourished as a key tool in Navy since its beginning in 1964 and is used not only by fleet operations planners but also requirements generators, strategic analysts, and logisticians. Much of the technical expertise lies in DSTG, specifically JOAD, and previously in Maritime Operations Division. JOAD has a dedicated cell embedded within the Navy Maritime Warfare Centre as part of its OA support to Navy.

With the rise in capability of M&S technology in the 1990s, much of the other information that needed to be validated by extensive exercise and subsequent analysis, as well as most of the training element, could be achieved through M&S at much less cost.\(^4\) The definitive work on simulation in Defence that sets out the theoretical basis and justification for this was published by Neimeyer in 2003.\(^5\)

In the early 2000s the then DSTO RANRL M&S process was expanded to a full experimental framework known as Headmark, which consisted of a linked series of LVC simulations that experimented not only with new tactics but also new organisational structures, policies and procedures in the context of new weapons, communication tools and other equipment in as ‘whole of Navy’ environment as possible. The experiments were conducted against the backdrop of a proposed acquisition. From 2006 to 2009, the

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\(^1\) This appendix was written by Dr Roger Lough. Dr Lough was Chief Defence Scientist from 2003 to 2008. Prior to this appointment he had been director of the Platform Sciences Laboratory within the DSTO since January 2002. Dr Lough first joined DSTO’s predecessor, the Weapons Research Establishment (WRE), as a technical assistant in the 1960s and has had first-hand experience as well as oversight and responsibility for the ongoing development and application of M&S across the entire ADF over several decades. The information presented here draws on this experience.

\(^2\) Exercise Rim of the Pacific 2020 (RIMPAC 2020) is a major U.S. Pacific Fleet biennial combined exercise to strengthen international maritime partnerships, enhance interoperability, and improve the readiness of participating forces for a wide range of potential operations. See Royal Australian Navy, 'RIMPAC 2020', webpage, undated-b, for more information.

\(^3\) Talisman Sabre is a biennial exercise led by either Australia or the United States. See Department of Defence, 'Talisman Sabre 21', webpage, undated-b, for more information.


Headmark program undertook experimentation in sealift options (JP 2048), platform flexibility (SEA 5000), uncrewed systems (SEA 1778, JP 1770) and anti-submarine warfare (ASW) (SEA 1100).6

The Headmark experimental program was dropped as a headline Navy program in the late 2000s, and the name is no longer used in this context (it now has a much wider strategic interpretation).7 However, the technologies and processes of linked types of simulations continue to be widely used in support of the wider context of acquisition programs.

Although modelling is, by definition, a form of simulation, the term ‘modelling and simulation’ came about when digital computing had matured sufficiently that a computer model could interact in real, or near-real, time with an extant piece of military equipment and/or human operators. This started to occur in the 1980s, with the RAND Strategy Assessment Center8 as an early example in the wargaming area, and has evolved ever since in line with the dramatic increase in the power of digital computing.

The Missile Simulation Centre at DSTG Edinburgh was built in 1987, mirroring earlier examples in operation in the USN in the 1970s, and continues to test and evaluate Navy (e.g., Evolved Sea Sparrow) and other missiles. The design and testing of guided missiles were, and still are, characterised by the use of an anechoic chamber in the case of radar-guided missiles or an infrared (IR) source for IR-guided missiles with a 5-axis control mount for the seeker head.

Built at HMAS Watson in the mid-1970s, the Submarine Command Team Trainer featured a digital model as a simulator, although the digital model was primitive by today’s standards. Command Team Trainers utilising simulation of the actual combat system have steadily advanced in their technology and are now commonly used wharf-side with an in-service combat system rather than a separate, contained land-based facility. The long-running FFG upgrade project in the 1990s was one of the first users of this technology and was successfully used in the Triton Sim exercise in 2014. In this exercise HMAS Sydney was linked to shore-based trainers at HMAS Watson and Fleet Base East. HMAS Watson has been consolidated as the main centre for the larger-scale simulation-based programs since the 1970s, and this has provided synergies through cross-fertilisation. It is now the norm for any new class of warship (surface and submarine) to include a sophisticated Command Team Trainer as a key component of the acquisition.

Across Navy, non-computer-based simulation has continued in some areas. For example, at the Marine Engineering Demonstration Building at HMAS Cerberus, sailors undertaking their basic Marine Technician course are trained to deal with flooding and stability problems by using a training simulator constructed from materials available from the local hardware store.

An early example of M&S for combat system design and development was the DSTO Maritime Experimentation Lab and the Torpedo Systems Centre, established in 2008. This evolved into the DSTO Virtual Ship.9 This project was a reconfigurable surface warfare combat system that could simulate a number of extant or proposed combat systems, with a variety of real or virtual inputs from sensors, and that could look at the interactions between them. The Virtual Ship was one of the first examples to demonstrate the (then new) high-level architecture (HLA) protocols.

Since 2000, M&S technology has moved in two complementary directions as a result of improved ICT: increased realism for the individual, and increased fidelity of models. The latter has enabled much more use of M&S in such areas as detailed logistics planning and, especially, engineering development. For example, ‘Boat 7’ in the Collins program is a detailed digital model of the boat that includes a visual ‘walk through’ to ensure that the Navy’s requirements are accommodated and to minimise any issues that could arise in production.

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6 These abbreviations refer to Defence major capability acquisition projects.
7 See Royal Australian Navy, 2018b, for reference to how Navy currently uses the term ‘Headmark’.
Realistic Navy modelling of an environment that mimics an extensive range of human senses includes the Bridge Simulator at HMAS Watson, first initiated in 1999 and recently upgraded and duplicated at Fleet Base West. Used for training junior tactical officers, the full-motion simulator has realistic visual simulation in the same vein as high-end commercial aircraft simulators.

One area where high-end realistic stimulation of human senses is required is the aviation component of Navy, since aircraft control requires pilot coordination using external scene visuals, otic (sound and motion), and haptic realistic inputs. State-of-the-art simulators were acquired for all types of both the fixed- and rotary-wing aircraft as they were purchased and entered service with Navy, although not without problems. For example, the trailer-based simulator for the Grumman Tracker aircraft that was due to be operational in 1967 was extensively damaged by fire and did not become operational until late in 1970. However, in the 2000s, aircrew training simulators consolidated with Army as part of the Helicopter Aircrew Training System (HATS) at HMAS Albatross, which achieved IOC in 2019.

From the late 1990s, the dramatic increase in ICT technologies (computing power, displays, bandwidth, data gathering, and storage) opened up new avenues for M&S in Navy. This coincided with the evolution of a joint or combined approach between the individual services (Navy, Army, and Air Force) and others both within and outside of Defence as the bedrock of ADF operations. This is referred to as ‘Joint’. The ICT revolution has enabled connectivity and cooperation between Army, Navy and Air Force elements. In the 1990s this was known as the Revolution in Military Affairs (RMA) and in the 2000s as Network Centric Warfare (NCW). It is a moot point as to whether M&S drove NCW operational concepts or vice versa, but the two have moved hand in hand in recent years. Joint experiments have been conducted since the mid-2000s. In September 2008, Commander Australian Amphibious Task Group ran a command post exercise (CPX) in DSTO’s Maritime Modelling and Simulation Suite. The main objective was to confirm the validity of situation awareness command and control (SACC) standard operating procedures that have been developed during two previous CPXs. A further objective was to examine the interactions of the Commander Amphibious Task Force and Commander Landing Force Joint Targeting process with the SACC. The activity involved more than 40 participants from all three services.

The bringing together of the various M&S communities, both domestic and international (primarily the USN in the case of Navy), required new architectures and standards. Originally known as distributed interactive simulation (DIS), this has evolved into HLA—the current standard is Level 4. The Joint Warrior Interoperability Demonstration (JWID) in 2004 was an early example.

In summary, the above discussion highlights the evolution of the use of M&S in Navy from simple crude physical models used for wargaming through to extensive joint simulations that mix LVC simulations in a complex warfighting environment containing a large number of entities. The core use of simulation has been and continues to be for training, ranging from mechanical/technical skills through to high-level decisionmaking, but the advent of modern computing opened up a new raft of applications for M&S in Navy. Early among these was OR whereby simulation in the form of modelling was extended beyond training purposes to the acquisition of new knowledge being applied to operations planning and force design.

As the technology evolved and virtual simulators became available to complement constructive ones on the one hand and live ones on the other, applications emerged to link digital models with requirements definition, and, later on in the life cycle, engineering development. There is generally a common baseline for these applications, with the main differential being the fidelity of the model being matched to the scale and complexity of the equipment. The ability to link virtual simulators has enabled high-level tactical training in fleet operations planning and execution within Navy. It has also enabled cooperative activities with international partners and—something that is of increasing importance—the ability to plan and train with the Army and Air Force in a joint environment. In recent years, the use of M&S in Navy has become so ubiquitous that it is treated as an enterprise within Navy with its own strategy, roadmap and governance.
Defence Policy Context Relevant to M&S

The Navy M&S Strategy sits within a broader Defence policy environment that will offer opportunities and/or impose constraints on it. In this appendix we provide a summary of the relevant policy for the new strategy.

Defence Data Strategy

M&S is critically dependent on both the data it consumes and the data it produces. It is noteworthy, then, that Defence has recently released the Defence Data Strategy 2021–2023. This strategy seeks to provide a ‘strategic advantage over our competitors, make us a more effective fighting force and further support the strategic centre through improved decision-making’. This is achieved by ‘harnessing our data [which] will allow us to take decisions and actions that are backed by information and insights gained through good data management’. It is built around five pillars (govern, trust, discover, use, and share) that cover all structured and unstructured digitised data across the Defence enterprise, including mission and operational data, capability development and management data, strategy and policy data, and engineering and logistics data. While the Data Strategy does not mention modelling or simulation directly, it is clear that Defence, through its various initiatives, recognises the strategic worth of data and how it is essential for all enablers. As such, the Data Strategy informs how the data needed for Navy M&S should be managed.

Defence Test and Evaluation Strategy

T&E is recognised as a key requirement for Navy, particularly when seeking to safely and effectively integrate new systems into existing platforms. Defence recently released a revised T&E Strategy to drive a change from platform- and project-centric approaches to T&E to one focused on the enterprise level that works across all phases of the ODCM. Through this, all five types of T&E (developmental, preview, acceptance, operational, and in-service) can be delivered in a seamless manner. With a vision that ‘T&E across Defence supports risk-based capability decisions and is actively supported by a strong sovereign base’, this ten-year plan seeks to deliver ‘sovereign T&E capabilities and networks that support the delivery of effects across the warfighting domains’. Of particular note is the part of its 2030 future-state statement that envisions a ‘dynamic virtual visualisation of joint force...

1 Department of Defence, 2021a.
2 Department of Defence, 2021a, p. 9.
3 Department of Defence, 2021a, p. 11.
4 Department of Defence, 2021a, p. 10.
6 Department of Defence, 2021a, p. 10.
7 Department of Defence, 2021b, p. 4.
Drivers for this reshaping of the Defence T&E approach are the changing geo-strategic environment, emerging technologies, and increasing interoperability. The T&E strategy also notes enablers such as workforce demands, developments in physical and synthetic environments, and industry and government capacity.9

The T&E Strategy identifies four LOEs:

- governance and assurance
- workforce
- Defence training and test environment
- technology.10

The third LOE has particular relevance for M&S. In its consolidation phase (2021–2023), the T&E Strategy will identify gaps in synthetic T&E infrastructure, establish needs for T&E facilities, and explore options for ‘synthetic representations (models) of constituent platforms and systems’.11 It is anticipated these ‘synthetic representations of major platforms and systems’ will be provided by capability programs ‘as a standard function’ by 2026.12

**Defence Industry Policy**

The 2018 Defence Industrial Capability Plan (DICP)13 recognises the critical role Defence and the defence industry plays in meeting Australia’s near- and long-term defence and national security objectives. In essence, it seeks to ensure Australia can ‘operate, sustain and upgrade our defence capabilities with the maximum degree of defence and industrial sovereignty’.14 It also recognises the two-way relationship between Defence and industry, including in the M&S space, explicitly identifying ‘training platforms and simulation’ as a key enabler.15 The DICP states that ‘enhancements to weapons training facilities will continue to take advantage of advances in simulation and demonstration technologies, providing opportunities for Australian industry in the provision of hardware and software solutions to support the Australian Defence Force’s newly acquired platforms and equipment’.16 The DCIP also recognises the possibility of positioning Australian industry to compete globally, since ‘the Australian Defence Force’s adoption of digital training and simulation systems has led to an enhanced domestic capability being developed in this field. Australian industry is well positioned to pursue opportunities overseas as an experienced and mature supplier of these capabilities’.17

To help focus this, Defence has identified 14 Sovereign Industrial Capability Priorities (SICPs) that ‘will focus on areas that are operationally critical to the Defence mission’ across all parts of the CLC.18 Many of these priority areas have significance for the maritime domain, such as submarine maintenance

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8 Department of Defence, 2021b, p. 5.
9 Department of Defence, 2021b, p. 3.
10 Department of Defence, 2021b, p. 4.
11 Department of Defence, 2021b, p. 8.
12 Department of Defence, 2021b, p. 8.
14 Department of Defence, 2018a, p. 16.
15 Department of Defence, 2018a, p. 139.
16 Department of Defence, 2018a, p. 57.
17 Department of Defence, 2018, p. 59.
Defence Policy Context Relevant to M&S

and technology update; continuous shipbuilding program; enhanced active phased array radar and passive radar capability; and RAS-AI. Given that these policy instruments emphasise the two-way relationship between Defence and defence industry in the CLC, it is clear that Navy M&S must be flexible enough to enable this.

Of particular note is the recently released Test, Evaluation, Certification and Systems Assurance SICP, in which the central role of M&S is explicitly recognised. Both the Implementation Plan and the Industry Plan recognise model-and-simulation-based testing as well as LVC environments as being key enablers for critical industrial capabilities. For example, ‘Ship Zero’ testing to facilitate shore-based capability risk reduction is called out as a critical industrial capability. Underpinning this are a number of future trends in the development and employment of M&S capabilities, including

- Using broader industry and commercial sector developments in using Live, Virtual and Constructive modelling and simulation to support and improve testing and certification outcomes.
- Applying digital methods such as data analytics, machine learning and AI to develop dynamic decision-making for penetration testing and controls—especially for cyber assurance.
- Encouraging digital transformation of the verification and validation process across the capability life cycle through broader adoption of model-based systems engineering.
- Expanding the use of synthetic representations or ‘digital twins’ that allow for virtual product and production design through to real-world automated production, operating models and reduced risks of achieving performance.
- Leveraging the Defence virtual training environment to include modern Defence and industry test and evaluation facilities, training areas and ranges that are integrated, networked and incorporate routine use of Live, Virtual and Constructive modelling and simulation.
- Harnessing quantum computing and other advances in computing power to shift further into a trusted virtual environment for verification, validation and ongoing high confidence systems assurance.

Defence has developed and will soon release an enterprise-level T&E Strategy to drive this forward.

Defence Simulation Infrastructure

Defence continues to deliver simulation-enabled collective training to the ADF through the JCTB within HQJOC. However, it is recognised that the existing capabilities cannot meet the growing demand for simulation-enabled collective training, both from a tempo perspective and as a consequence of a more

20 This comprises Department of Defence, 2020d; and Department of Defence, Sovereign Industrial Capability Priority Industry Plan: Test, Evaluation, Certification and Systems Assurance, Commonwealth of Australia, 2020e.
21 Department of Defence, 2021b, states that it should be read in conjunction with the Test, Evaluation, Certification and Systems Assurance plans (p. 2).
22 Department of Defence, 2020d.
23 Department of Defence, 2020e.
24 Included among the critical capabilities are platform signature management test and evaluation capabilities; advanced information network certification and systems assurance; joint force capability assurance; and complex systems test and evaluation capabilities. See Department of Defence, 2020d, p. 3.
25 Department of Defence, 2020e, p. 12.
26 Department of Defence, 2020e, p. 18.
27 Department of Defence, 2020d, p. 4.
challenging operational environment. As a result, Defence has established Project JP 9711 Phase 1—Core Simulation Capability to create a distributed-integration synthetic training environment. This will be supported by the Simulation Service Centre, which will support the design and operation of the DSE.

As it matures, JP 9711 will 'provide the services required to deliver a Core Simulation Capability that will provide critical training support to the future force through a significant upgrade and expansion of its simulation capability. The capability will enable Defence to link live and simulated training together for large scale Joint and Combined collective training and to deliver on-demand distributed mission training to the single services of the ADF and Joint Operations Command.'28 While supporting approximately 200 training activities annually, JP 9711 will also be a basis for simulation in support of (future) experimentation and force design analysis.

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APPENDIX C

International Experiences

One aspect of this work was looking at international uses of M&S, so as to understand potential transferable lessons for Navy, specifically in terms of their strategies, policies and organisational constructs. We reviewed documents from the United States (USN, DoD and USMC), NATO, United Kingdom (MOD and RN) and China. This was supplemented with interviews with key stakeholders.

U.S. Government

The USN, USMC and DoD have extensive experience in M&S policy and oversight. Navy has an enduring relationship in the use of M&S with the USN as part of fleet training, and recent advances in wargaming capability by the USMC are of particular relevance.

Strategies and Policies

U.S. DoD Strategic Vision for Modeling and Simulation

Approved by the 15 members of the U.S. DoD M&S Steering Committee in 2007, the extant strategic vision for M&S remains to ‘empower DoD with modeling and simulation capabilities that effectively and efficiently support the full spectrum of the department’s activities and operations’.1 This leads to five broad focus areas and associated goals:

- Standards, architectures, networks and environments that:
  - Promote the sharing of tools, data, and information across the Enterprise
  - Foster common formats
  - Are readily accessible and can be reliably applied by users
- Policies at the enterprise level that:
  - Promote interoperability and the use of common M&S capabilities
  - Minimize duplication and encourage reuse of M&S capabilities
  - Encourage research and development to respond to emerging challenges
  - Limit the use of models and data encumbered by proprietary restrictions
  - Leverage M&S capabilities across DoD, other government agencies, international partners, industry, and academia
- Management processes for models, simulations, and data that:
  - Enable M&S users and developers to easily discover and share M&S capabilities and provide incentives for their use
  - Facilitate the cost-effective and efficient development and use of M&S systems and capabilities
  - Include practical validation, verification, and accreditation guidelines that vary by application area
- Tools in the form of models, simulations, and authoritative data that:
  - Support the full range of DoD interests

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– Provide timely and credible results
– Make capabilities, limitations, and assumptions easily visible
– Are usable across communities

• People that:
  – Are well-trained
  – Employ existing models, simulation, and data to support departmental objectives
  – Advance M&S to support emerging departmental challenge

SECNAV Instruction 5200.46: Department of Navy Modeling, Simulation, Verification, Validation and Accreditation Management

The 2019 SECNAV Instruction 5200.46: Department of Navy Modeling, Simulation, Verification, Validation and Accreditation Management provides guidelines about M&S, representation data, and VV&A management, and assigns responsibilities for this. It seeks to ensure that ‘common and cross-cutting enterprise approaches for M&S tools and data accurately represent platforms and systems, predict outcomes, and provide inputs to naval decision makers and operational users in support of numerous areas’, including:

- Acquisition: including S&T, RDT&E [research, development, test and evaluation], Materiel Solution Analysis, Technology Maturation and Risk Reduction, Engineering and Manufacturing Development, Production and Deployment, and Operations and Support phases for acquisition programs;
- Analysis: including planning, programming, and budgeting system support, campaign and force structure analysis, and fleet and mission operational assessments;
- Training: including individual skills level, instruction, mission preparation, battle group and force staff training; and
- Experimentation: no further details are given.

The span of issues covered includes complex warfighting analysis, MBSE, digital engineering, rapid prototyping, threat representation, LVC simulations, and the use of virtual environments. Interoperability, accessibility and cost-effectiveness are key drivers.

The instruction directs USN and USMC on how they should ensure their M&S tools and data accurately represent whatever they are intending to simulate. ICT requires organisational structures that deliver guidance and capabilities, promulgate guidance and standards, and ensure that all manuals for M&S and VV&A are up to date and available.

Commandant Instruction 5200.38A: Coast Guard Modeling and Simulation (M&S) Management

In a similar vein, the Commandant Instruction 5200.38A: Coast Guard Modeling and Simulation (M&S) Management provides the U.S. Coast Guard (USCG)’s vision, policies, roles and responsibilities for M&S. It is a reflection that M&S enhances USCG’s ability to train the workforce, plan for new contingencies, explore force structures, and develop and employ new systems. It provides ‘a cost-effective method to interact with a complex environment, allowing for the creation of realistic training, forward looking analysis, or a safe testing environment that may be too expensive or futuristic to do live . . . [and] allows

users to experience failure or create success with no risk to personnel, equipment, or the environment’. The resultant USCG M&S objectives are:

- Apply M&S to increase efficiency of USCG resources and optimise mission effectiveness.
- Make M&S capability and information readily available and apply the benefits and knowledge derived from their use throughout the Coast Guard.
- Invest in cost-effective M&S technology that has measurable benefits, provides timely insights, and builds on or leverages best practices of Department of Homeland Security (DHS), DoD, academic, or commercial entities.
- Apply USCG Research and Development Center (RDC) M&S Center of Expertise efforts ensuring the acquisition and/or development of technologies meets the M&S needs of the Coast Guard.

To achieve this, the instruction identified ten specific policy lines: life-cycle management; interoperability; M&S repository; VV&A; configuration management; reuse; workforce capabilities; alignment and integration of requirements and investment; M&S software and tools; and security.

U.S DoD Instruction 5000.61: DoD Modeling and Simulation Verification, Validation, and Accreditation

The U.S. DoD Instruction 5000.61: DoD Modeling and Simulation Verification, Validation, and Accreditation was released in 2009 and contains the responsibilities, documentation procedures, and glossary for the VV&A of models, distributed simulations, and associated data. It requires that all M&S and related data used by DoD to support the process must undergo VV&A. VV&A results must be documented and accessible to all DoD components to receive final authority for validating, and the document defines the minimum set of documentation requirements as part of VV&A.

Organisations

Defense Modeling and Simulation Enterprise

Situated under the Office of the Under Secretary of Defense (Research and Engineering) (USD[R&E]), the Defense Modeling and Simulation Enterprise coordinates all aspects of M&S across the U.S. DoD. its strategic vision and goals are those of the DoD M&S stated above. Its responsibilities fall into three broad categories:

- Governance: enterprise-level coordination among the M&S activities of the DoD Components and communities to encourage cooperation, synergy, and cost-effectiveness;
- Operations: which includes sustainment and operation of enterprise level capabilities that support USD(R&E) in the management and execution of DoD M&S Enterprise activities; and
- Technical Collaboration: a technical forum to advise and influence the DoD Enterprise on issues involving M&S.

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5 USCG, 2013, p. 2.
6 USCG, 2013, pp. 2–3.
7 USCG, 2013, pp. 3–4.
9 It was updated in 2018 with respect to assignment of responsibilities.
10 Defense Modeling and Simulation Enterprise, ’Responsibilities & Governance’, webpage, undated-d.
As the lead standardisation agency for management of M&S standards and methods, the Modeling and Simulation Enterprise coordinates:11

- DoD standardization documents in the M&S standards and method area
- Adoption of non-government standards for DoD use
- VV&A policy and best practices
- Comments on standardization documents from other defence standardisation program areas that affect M&S
- Responsible for the development, coordination, promulgation and upkeep of NATO M&S Standardization Agreements

It is also the DoD point of contact for coordinating M&S activities with international partners, including the reuse of M&S and associated data.

The Defense Modeling and Simulation Enterprise is the authoritative source for accessing a range of M&S documentation, including policy and guidance, M&S management and development, standards, and guidebooks.

Marine Corps Warfighting Laboratory

The MCWL was established in 1995 as the Commandant’s Warfighting Laboratory. It seeks to generate and examine ‘threat-informed, operating concepts and capabilities and provides analytically supported recommendations to inform subsequent force design and development activities’.12 Its functions include futures assessments, wargaming, S&T, experimentation and rapid capability injection into service. The Wargaming Division plans and executes the USMC Wargaming Program, ‘the annual syllabus of wargames conducted by the Division in support of Marine Corps equities as defined by the responsible authorities’.13 It also designs and execute wargames in collaboration with other U.S. services and international partners.

Currently, the USMC builds wargaming expertise by examining fleet (USMC and USN) employment problems using Assassin’s Mace,14 and employing computer-adjudicated wargames using the COTS serious game tool CPE15 with a classified database, in development by MCWL in conjunction with the developers of CPE.

MCWL has recently commenced construction of a new wargaming centre, which is expected to open in 2023.16 This is a dedicated facility with rooms configurable for space and classification, and a dedicated staff of approximately 100 marines, contractor analysts, and other services. This includes plans for high-technology wargaming using AR.

Center for Naval Analysis

Center for Naval Analysis (CNA) is a federally funded research and development centre that supports the USN and USMC, and other Defence agencies. Its Operational Warfighting Division supports operational-level warfighting, typically linking wargaming to concept development and testing, and exercise and

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13 MCWL, ‘Wargaming Division’, webpage, undated-b.
15 CPE is already in service within Defence, with licences in Force Design (JED) and DST (JOAD) and elsewhere. CPE can be deployed on a single stand-alone laptop at any level of classification; however, the ‘out of the box’ database is commercial unclassified. Notwithstanding this limitation, analytical tools have been developed for CPE, which have been used to support SME adjudication of wargames in the R5 subbasement.
16 South, 2021.
operational assessment. Areas of focus include naval integration, joint and combined operations, cyber effects, intelligence support, and special operations. CNA does not typically design game mechanisms requiring software programming, preferring a more flexible approach to game adjudication.

NAVSEA Warfare Centers
The NAVSEA Warfare Centers enterprise consists of the Naval Surface Warfare Center (NSWC) (eight sites) and the Naval Undersea Warfare Center (NUWC) (two sites) providing RDT&E, engineering and fleet support, and technical and subject-matter expertise to USN. This includes supporting training, concept development, senior leadership engagement, and strategic discussion. Wargaming is employed to define and explore concept development; tactics, techniques and procedures (TTPs); and CONOPPs. It primarily relies on Fleet Battle School and Virtual Worlds (government off-the-shelf [GOTS] VR), open-source software (OpenSimulator), narrative gaming (seminar style for developing innovative concepts), matrix gaming (structured between multiple teams), and stand-alone computer networks (space for new software to be used in game design, execution and analysis without posing a risk to the main system).

Naval Postgraduate School Wargaming Center
The Naval Postgraduate School Wargaming Center (NPSWC) conducts research for the Office of the Chief of Naval Operations, the Secretary of the Navy, and various other USN programs. NPSWC treats wargaming as an analytical tool for understanding and exploring the implications of human decisionmaking in maritime warfare concept development, operational decisions and plans, and training activities that use wargaming analysis, experimentation and education. Typical problems considered include developing and assessing CONOPPs for new platforms and technologies, validating and updating CONEMPs and tactics, planning against future contingencies, red teaming, and vulnerability assessments. Some of the tools and approaches used are the Joint Seminar Wargaming Adjudication Tool (JSWAT), Map Aware Non-Uniform Automata (MANA), and Massive Multiplayer Online Wargame Leveraging the Internet (MMOWGLI), as well as modified commercial board games.

Recently, NPSWC launched a wargaming course in conjunction with the European Centre of Excellence for Countering Hybrid Threats (Hybrid CoE). The course focuses on training 'strategic thinking in the context of hybrid threat scenarios' and aims to 'encourage a whole-of-society approach to cooperation in countering hybrid threats'. NPSWC has previously sponsored allied wargames with Australia on ASW in 2016 (theatre-level) and 2020 (full-spectrum).

Naval War College Wargaming Department
The Naval War College Wargaming Department (NWCWD) uses wargaming to educate and train military and civilian decisionmaking, develop and explore strategic and operational concepts, and provide operational insights across a range of topics such as space, cybersecurity, C2, emerging technologies, sea control, and international maritime cooperation. It also publishes the War Gamers’ Handbook, which includes processes and procedures for game design and management as well as wargame design criteria.

U.S. Office of Naval Intelligence
The U.S. Office of Naval Intelligence (ONI) is a core element of the Navy’s IW community. It employs wargaming largely for training purposes, providing experiential learning on roles and missions, and how

17 CNA, Wargaming with CNA, undated.
19 Naval Postgraduate School, ‘Wargaming Center’, Naval Warfare Studies Institute, undated.
20 Hybrid CoE, ‘Unique Hybrid Wargaming Course Launched’, webpage, 30 August 2021.
22 Naval War College, ‘Wargaming Department’, webpage, undated.
strategic objectives, resources, strategy and force structure need to align. Tabletop wargames is seen as a cost-effective and easily assessable tool. ONI’s primary tabletop tool is the Simulation Based Analyst Training (SimBAT). Based on commercial board games, it typically uses World War II scenarios for planning and implementing strategies for global joint warfare. Participants are able to manage air and sea assets and trade-offs between these. Such exercises are often the ‘battlelab’ component of larger training activities.

Defense Science Board Task Force on Gaming, Exercising, Modeling, and Simulation

Recently, the Defense Science Board Task Force on Gaming, Exercising, Modeling, and Simulation (GEMS) reviewed DoD’s current use of the GEMS tools to make recommendations to use those tools to their full potential. The task force observed a need for better integration, talent and resources for GEMS to reach its full potential, specifically the ability for GEMS outcomes to be integrated into senior leader decisionmaking. The report recommends investing in timely, simple models and complementary campaign analytics to meet immediate needs, as well as in new models that can use AI, machine learning and other emerging technologies. It also notes the need for cultural and technological change across the DoD to reap the full benefits from GEMS tools.

NATO

Strategies and Policies

NATO Modelling and Simulation Master Plan

The NATO Modelling and Simulation Master Plan (NMSMP) is now somewhat dated (Version 2 was released in 2012). Its vision is to ‘exploit M&S to its full potential across NATO and the Nations to enhance both operational and cost-effectiveness’. Its guiding principles are synergy, interoperability, reuse and affordability. The M&S application areas include but are not limited to Support to Operations, Capability Development, Mission Rehearsal, Training and Education, and Procurement. The NMSMP consists of two key documents:

- NATO M&S Strategic Plan (states policy, M&S vision, goals and objectives)
- NATO M&S Implementation Plan (introduces actors and stakeholders, and assigns responsibilities in M&S and within NATO).

The NATO M&S Strategic Plan serves as the implementation document for NATO M&S. Its objectives include

- Establish a Common Technical Framework
  - Develop NATO standard interoperability architecture and supporting material
  - Establish recommended standards pertaining to data interchange for M&S and C2 systems, promote true interoperability, pursue trust in M&S
  - Establish a NATO wide (incl. National Stakeholders) technical environment for distributed networked M&S application areas.
- Provide Coordination & Common Services
  - Develop common process and procedures to guide actions and decisions regarding M&S application
  - Compile M&S information
  - Establish capability to share M&S education resources with NATO organisations and Alliance nations

24 This is somewhat similar to way the Royal Australian Navy is seeking to do.
Promote the sharing of M&S resources through a knowledge management process and system

Establish a help desk to facilitate the development and use of M&S

**Develop Models & Simulations**
- Identify and prioritise M&S requirements
- Identify the most effective strategies to satisfy each simulation requirement
- Allocate resources to satisfy high priority simulation requirements
- Execute the selected and resourced development strategy
- Provide information to the large NATO community regarding the resultant simulations and any lessons learned during development

**Employ Simulations**
- Plan employment
- Provide resources to operate simulations
- Provide databases
- Operate simulations to improve all aspects of NATO/national military activities
- Conduct impact assessments and document lessons learned to guide further development/investments

**Incorporate Technological Advances**
- Monitor M&S-related technological advances
- Conduct research and development (R&D) experiments and pilot projects as needed to support Alliance requirements
- Share information on realised advances to facilitate incorporation
- Implement technological advances

The Implementation Plan also includes details from each Master Plan Objective and Sub-Objective (stakeholders involved, timeframe, first time completed, and plan for next completion). The Implementation Plan is broken up into chapters covering stakeholders and roles, M&S application areas and requirements, objectives, roles and responsibilities, and schedule, and a list of acronyms and references. There are several types of stakeholders, depending on their role in M&S:

- M&S customers who determine the operational needs for the M&S capabilities
- M&S users who demand the M&S capabilities or the capabilities supported by M&S
- M&S suppliers who develop M&S solutions or provide research on M&S solutions
- M&S coordinators to ensure consistency and legitimacy among the different stakeholders
- M&S advisors who serve as an advisory role to Customers, Users, and Suppliers

The Strategic Plan is designed for infrequent updates, while the Implementation Plan will be updated as needed.

**Modelling and Simulation as a Service Guide**

NATO also provides guidance on the concept of M&S as a Service (MSaaS). This approach has become increasingly important as it addresses the issue of high resource demands in achieving interoperability between different simulations. NATO observes that Defence organisations have come to recognise the MSaaS ‘paradigm’ as a way to overcome this. NATO describes MSaaS as ‘a new concept that includes service orientation and the provision of M&S applications via the as-a-service model of cloud computing to enable more composable simulation environments that can be deployed and executed on-demand’. This approach seeks to deliver greater agility, effectiveness and efficiency through the reuse of M&S. It also has the ability to develop new models more quickly with fewer personnel and reduce cost though

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cloud-based services. A recent report noted that an ‘M&S ecosystem driven by MSaaS, modelled around commercial app-based ecosystems, would provide greater choices of models and simulations, foster competition as well as collaboration amongst the ecosystem stakeholders, and tools to discover, compose, and execute efficiently and securely the required model, simulation or synthetic environment’. To realise this, though, it is recognised that issues such as licensing, security and assured connectivity need to be resolved.

Organisations

NATO Modelling and Simulation Centre of Excellence

The vision of the NATO Modelling and Simulation Centre of Excellence (NMSCOE) is to ‘contribute to NATO Transformation by championing the exploitation of M&S to its full potential across NATO and Nations to enhance both operational effectiveness and resource management’. Complementing existing NATO M&S capabilities, it primarily focuses on

- education and training, including certification of M&S SMEs, and operational training and support
- knowledge management, lessons learned and analysis, including shared repositories for models, simulations, scenarios and data, and definition and verification of M&S technical architectures
- support to concept development and experimentation through M&S, such as simulation-based acquisition and the use of the NMSCOE test bed
- doctrine development, standards and interoperability, including M&S system integration, linking real-world and simulation systems, and VV&A activities.

NATO Modelling and Simulation Group

The NATO Modelling and Simulation Group (NMSG) emphasises the value of M&S to facilitate cost-effective Defence planning, training, exercises, support to operations, research, technology development, and acquisition. One of its three subgroups, Modelling and Simulation Standards, works to set common standards across NATO allies to facilitate interoperability and reuse of simulation resources. NMSG activities are captured in the NATO Science and Technology Organisation’s 2021 Collaborative Programme of Work, which provides an overview of its defence and security research and technology development for enhanced operational military capabilities. This is divided into three timeframes:

- 0–3 years: focused on global M&S outreach, communication, and education, as well as fundamental S&T and technology watch.
- 4–8 years: focused on fostering applied S&T and capability development, including joint mission training through distributed simulation, joint decisionmaking capability, and a federated concept development and experimentation capability. This will contribute to CONOPSs, policies, interoperability standards, and operational capabilities.
- Beyond 8 years: NMSG aims to establish a common technical framework, provide coordination and common services, develop models and simulations, employ simulations, and incorporate technological advances.

26 Bharat Patel, ‘MSG-168 Lecture Series on Modelling and Simulation as a Service (MSaaS)’, NATO, 2019.
Centre for Maritime Research and Experimentation

NATO’s Centre for Maritime Research and Experimentation (CMRE)\(^\text{30}\) seeks to ‘leverage for the development of simulator conceptual models on both the proximity with the operational community and the knowledge and expertise of the centre in the various R&D and engineering areas of expertise (robotics, environment, communications and specific warfare areas)’. In this way, M&S can consider the behaviours of both existing systems and proposed and emerging systems to be explored through various combinations of LVC simulations. This allows M&S to extend beyond that ‘typically used for training’ in order ‘to improve the understanding and performance of systems, as well as to develop new concepts and technologies’.

United Kingdom

To understand potential lessons from the RN’s approach, we supplemented our review of open-source literature with six semi-structured interviews with stakeholders utilising M&S. The interviewees were primarily from across the RN, Strategic Command (StratCom) and industry. Unfortunately, the Defence Science and Technology Laboratory (Dstl), Defence Simulation Centre (DSC) and Navy Command Strategic Planning were unable to participate. As such, the findings cannot be taken to represent a comprehensive view of all M&S activities going on across the RN. However, common themes from the interviews and overlapping anecdotal evidence allowed the research team to identify some key findings that can inform Navy as it seeks to develop its strategy for the use of M&S.

It is evident that M&S is being used by a wide range of organisations across all the Defence lines of development (DLODs)—the MOD’s equivalent to Australia’s FIC framework. The use of M&S is only expected to grow as technology continues to advance, making M&S an increasingly cost-effective, safe and even environmentally friendly way to conduct training and exercises or inform force development and operational planning. However, the MOD’s modernisation efforts have primarily focused on providing top-down guidance and have not yet fully penetrated the various services, particularly the RN. While challenges remain in implementing more consistent, coherent and ambitious use of M&S, its use is gaining momentum.

Strategies and Policies

JSP 939—Defence Policy for Modelling and Simulation

The UK MOD’s use of M&S goes back several decades, as does its interest in creating greater collaboration across the enterprise in this area.\(^\text{31}\) The latest relevant doctrine, Joint Service Publication 939 (JSP-939), recognises the value of M&S in its unique ability to satisfy challenging Defence requirements while providing significant environmental and cost benefits over traditional options.\(^\text{32}\) JSP-939 further outlines the MOD’s strong interest in creating greater internal consistency in the use of M&S to maximise value for money (VfM) and increase the ability to collaborate not only across MOD but also across government and industry, and with international allies and partners.\(^\text{33}\) JSP-939 aims to provide guidance that is flexible enough to continue to enable innovation, but with sufficient structure to ‘ensure wide technical coherence for all M&S based systems’ across the MOD.\(^\text{34}\)

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\(^{30}\) Centre for Maritime Research and Experimentation, ‘Modelling and Simulation’, webpage, NATO Science and Technology Organization, undated.

\(^{31}\) RAND Europe interview, conducted 10 August 2021 (Interviewee A).

\(^{32}\) MOD, 2018; RAND Europe interview, conducted 10 August 2021 (Interviewee A).

\(^{33}\) MOD, 2018.

\(^{34}\) MOD, 2018.
The authors of JSP-939 recognised that the use of M&S has previously been very siloed within Defence, which precluded information sharing and collaboration between different services or organisations.\(^{35}\) The document is only part of a long-standing effort to bring increased coherence to the MOD’s use of M&S in order to improve VfM and support collaboration. The MOD has identified three key methods of fostering the desired collaboration on M&S:\(^{36}\)

- a standard framework to promote interoperability and reuse
- better sharing of data and training
- the increased use of open architectures and standards.

It was noted that work is underway to extend JSP-939’s scope reach and maintain its relevance in a changing technology landscape. Indeed its authors acknowledge, for example, that the current version focuses too much on training and not enough on other potential uses across the enterprise.\(^{37}\) Future iterations will seek to encompass uses such as experimentation, OR/OA, decision support, logistics modelling, and other applications.\(^{38}\)

Defence Modelling and Simulation Coherence

To facilitate these aims, the MOD created Defence Modelling and Simulation Coherence (DMaSC) to help develop M&S coherently across Defence and maximise the benefits of these activities.\(^{39}\) JSP-939 mandates that all M&S work within Defence be compliant with its guidance, as judged by the M&S Governance Board.\(^{40}\) DMaSC, which sits within StratCom, consequently works closely with other organisations within the MOD to achieve its ends. Notably, it works closely with the DSC, housed in the UK Defence Academy, to build corporate knowledge and training capabilities to expand the number of SQEP in M&S.\(^{41}\) DMaSC also intends to engage with the various services through Service Command Technical Authorities (SCTAs) embedded in the Front Line Commands (FLCs).\(^{42}\) SCTAs are supposed to support their services in developing their own specific strategies; however, they have yet to be fully implemented in all of them.\(^{43}\)

In addition to the other extensions to JSP 939 discussed above, the DMaSC team is also working to issue new supplementary guidance and advice. The flagship program for the latest DMaSC guidelines is the Royal Air Force (RAF)’s Gladiator technical program, now known as Defence Operational Training Centre (Air) (DOTC(A)): other programs within Defence must seek to exploit the M&S solutions used in Gladiator before they can justify the use of other options.\(^{44}\) DMaSC is also in the process of creating DOTCs in the maritime and land domains to replicate the model of DOTC(A). In addition, DMaSC is aware of, and seeking to help address, the many lingering challenges that impede information sharing, including the sharing of IP, licensing and release conditions, and questions of classification.\(^{45}\)

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\(^{35}\) RAND Europe interview, conducted 10 August 2021 (Interviewee A).

\(^{36}\) MOD, 2018.

\(^{37}\) RAND Europe interview, conducted 20 July 2021.

\(^{38}\) RAND Europe interview, conducted 20 July 2021.

\(^{39}\) MOD, 2018.

\(^{40}\) RAND Europe interview, conducted 20 July 2021.

\(^{41}\) MOD, 2018.

\(^{42}\) RAND Europe interview, conducted 20 July 2021.

\(^{43}\) RAND Europe interview, conducted 20 July 2021.

\(^{44}\) RAND Europe interview, conducted 20 July 2021.

\(^{45}\) Several interviewees alleged, for example, that some private sector providers of M&S capabilities are reluctant to use open architectures, preferring to rely on proprietary systems. RAND Europe interview, conducted 20 July 2021; RAND
Beyond the MOD, DMaSC and its members also work with various external partners. DMaSC liaises with industry through its industry advisory group to help encourage investment, consult on standards, and share new technology developments.\textsuperscript{46} DMaSC also reaches out to work with UK allies and partners. This work takes place both bilaterally and through organisations such as NATO, as well as the Simulation Interoperability Standards Organization (SISO) and the International Standards Organisation (ISO).\textsuperscript{47}

Organisations

Royal Navy

The RN has long worked with M&S across multiple areas, including training, force development, mission rehearsal, and design of new capabilities or technologies. Interviewees described the RN as being neither particularly advanced in comparison with other services nor trailing behind. Instead, they felt the three services were in similar positions.\textsuperscript{48} Within the RN, there is reportedly limited coordination or communication between users of M&S and no clear doctrine or strategy specific to the RN.\textsuperscript{49}

Further, there is no known formal guidance for maritime M&S specifically. Despite this, M&S is being applied in the maritime domain to multiple ends to better enable and improve training, force modelling, rehearsals and exercises, and conceptualisation and design in an efficient, safer, more environmentally friendly and cost-effective manner. However, the lack of an overarching direction limits the RN’s capacity to effectively and efficiently use M&S.

Being without such a policy with strong buy-in from senior leadership is one of three challenges that were identified related to enhancing the use of M&S across the RN. The other two are a lack of suitably qualified and experienced people to implement and manage M&S, and a way to better leverage the benefits of the current generation of M&S technologies. While our research suggested that a strategy could provide significant benefit to the RN, there were also clearly additional challenges that the RN will have to grapple with in order to optimise its use of M&S.

Notwithstanding this, the RN’s experiences in the use of M&S may provide a useful point of comparison with Navy, given aspects of common heritage and organisational culture, as well as the greater degree of similarity in terms of resourcing. We have identified four areas of particular relevance: training; fleet modelling; rehearsal and exercise; and ship design.

Training

The RN currently uses M&S for training in a variety of contexts, such as simulators for training on sea mine systems, including multiple mine countermeasures (MCM) vehicle simulators.\textsuperscript{50} They have clearly identified its potential wider utility for training, as MOD has recently awarded a £153 million contract to Elbit Systems Ltd to deliver the RN Future Naval Training Program.\textsuperscript{51} The contract calls for the management of legacy systems, as well as new systems, such as those involved in the establishment of a Future Submarine School.\textsuperscript{52} The contract is part of the ongoing establishment of Defence Operational Training

\textsuperscript{46} RAND Europe interview, conducted 20 July 2021.
\textsuperscript{47} RAND Europe interview, conducted 10 August 2021 (Interviewee A).
\textsuperscript{48} RAND Europe interview, conducted 20 July 2021.
\textsuperscript{49} RAND Europe interview, conducted 10 August 2021 (Interviewee A).
\textsuperscript{52} ADS Advance, 2021.
Capability (Maritime) (DOTC(M)), which is managed in part by DMaSC.\textsuperscript{53} This aligns with views from interviewees who felt training is one area where DMaSC and JSP-939 might be relevant and can provide an overarching framework for the RN.\textsuperscript{54}

Not all parts of the RN, however, are coordinating their training capabilities with DMaSC. Due to the unique position of the Royal Marines, namely their need for simulated multi-domain environments that may or may not involve ships, the Royal Marines have become users of an Army system for some of their training needs: the interviewee described them as ‘just users’ who ‘plug in’.\textsuperscript{55} This interviewee felt that the use of M&S for training was highly beneficial, given the ability to involve mentors and observers, the VfM generated by using a simulated environment or VR, and the ability to tailor training to individuals without great effort.\textsuperscript{56} Additionally, the interviewee discussed the benefits and challenges of using M&S to create combat-ready personnel without using live training or live munitions. This brings advantages from both an environmental and cost perspective, and for personnel safety.\textsuperscript{57}

Fleet Modelling

Entities across the RN also use M&S for fleet design and modelling, both for developing and testing tactics and doctrine for current operations, as well as future fleet development and experimentation to inform investment decisions.\textsuperscript{58} Fleet Operational Analysis, part of the Maritime Warfare Centre (MWC), develops much of the tactics and doctrine it provides to the RN with M&S.\textsuperscript{59} This is particularly true for areas such as air defence and the underwater battlespace.\textsuperscript{60} One interviewee pointed out that some areas are better resourced than others; certain areas lack either SQE to run models and/or generate models themselves, while some areas, particularly information operations, lack both SQE and appropriate models.\textsuperscript{61}

Despite these shortfalls, the interviewee described his team as using M&S extensively to provide the evidence base for the tactics that they recommend.\textsuperscript{62}

M&S is also used in the MarWorks program, the RN’s IW technology accelerator, to provide rapid experimentation for new technologies, validating user requirements and informing investment decisions.\textsuperscript{63} M&S gives them the ability to artificially create mass based on the results of in-person experiments run in smaller groups. For example, M&S has been used to scale a radio network to see how well it would perform within given environmental parameters.\textsuperscript{64} The use of M&S makes such experimentation more efficient and significantly less expensive.\textsuperscript{65}

Rehearsal and Exercises

The RN is currently interested in expanding the use of M&S for mission rehearsals and exercises to help prepare personnel while saving time, money and resources compared with more traditional in-person

\textsuperscript{53} The MOD established DMaSC to achieve greater cohesion in M&S across Defence.

\textsuperscript{54} There appears to be some similarities between these entities and ADSTC and JP 9711, respectively.

\textsuperscript{55} RAND Europe interview, conducted 23 July 2021.

\textsuperscript{56} RAND Europe interview, conducted 23 July 2021.

\textsuperscript{57} RAND Europe interview, conducted 23 July 2021.

\textsuperscript{58} RAND Europe interview, conducted 23 July 2021; RAND Europe interview, conducted 28 July 2021; RAND Europe interview conducted 3 August 2021.

\textsuperscript{59} RAND Europe interview conducted 3 August 2021.

\textsuperscript{60} RAND Europe interview conducted 3 August 2021.

\textsuperscript{61} RAND Europe interview conducted 3 August 2021.

\textsuperscript{62} RAND Europe interview conducted 3 August 2021.

\textsuperscript{63} RAND Europe interview, conducted 28 July 2021. For more information about MarWorks, see Royal Navy, ‘Technology and Innovation’, webpage, undated.

\textsuperscript{64} RAND Europe interview, conducted 28 July 2021.

\textsuperscript{65} RAND Europe interview, conducted 28 July 2021.
One interviewee related that their team at the MWC was currently undertaking an initiative to provide more frontline support, and therefore envisioned using M&S to plan operations in the near future or provide responsive decision support in real time.

M&S was used extensively prior to the deployment of the new Carrier Strike Group (CSG), including the two Queen Elizabeth–class (QEC) aircraft carriers. Preparation included a series of three exercises—two live and one virtual—using a consistent scenario. The scenario allowed the CSG Battle Staff in particular to practise C2 of the entire group during deployment. Pilots in the CSG were also able to use flight simulators for the F-35Bs that form part of the Carrier Air Group both prior to and during deployment: two simulators were installed in the QEC carriers to provide a capability for them to continuously train, in part to enable training in varied circumstances regardless of actual weather conditions.

Ship Design

M&S also plays an important function in ship design and construction, providing support to defence capability development, particularly as part of any engineering function. By developing and using M&S systems to support the design and conceptualisation of new systems, such as the QEC carriers, MOD has access to models and data that can theoretically be fed later into training systems, although this is complicated by a lack of standardised data and therefore limits on the ability to easily transfer data. In addition to the QEC carriers, the RN has also generated physical real-life models of the Vanguard submarine, as well as key ships. The more innovative the design, arguably, the more important comprehensive modelling is prior to building hardware in order to test concepts before using resources.

Defence Science and Technology Laboratory

Dstl is a key organisation in developing, enabling and supporting the use of M&S across the MOD. It has sought for several decades to grow MOD’s simulation capability and currently acts as a key provider of certain capabilities, such as combat simulations used to support future force development. Relatedly, it has also sought to regenerate interest and capacity for wargaming within the MOD and individual services, including manual and tabletop gaming methods alongside the computer-based M&S activities. This ambition is reflected in the establishment of the United Kingdom’s first dedicated Defence Wargaming Centre (DWC) at Dstl’s Portsdown West site near Portsmouth in late 2019.

Alongside maintaining its own M&S capabilities, Dstl offers a pool of technical expertise to provide advice to other parts of Defence and conducts or commissions research to understand new technologies and M&S approaches. This includes running the SERAPIS framework’s Simulation and Synthetic Environments program, which brings together industry, academia, and non-traditional defence suppliers to investigate and develop new synthetic environments, M&S, and associated tools and assessment

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66 RAND Europe interview, conducted 28 July 2021.
67 RAND Europe interview, conducted 3 August 2021.
69 Ebbutt, 2021.
70 Ebbutt, 2021.
71 Ebbutt, 2021.
72 RAND Europe interview, conducted 28 July 2021.
73 RAND Europe interview, conducted 10 August 2021 (Interviewee A).
74 RAND Europe interview, conducted 10 August 2021 (Interviewee A).
processes. Dstl has similarly conducted research on topics of software development, human factors, user experience (UX)/UI, and M&S through its Analysis Support Construct (ASC), Analysis for Science and Technology Research in Defence (ASTRID) and Human Social Science Research Capability (HSSRC) frameworks. Dstl staff also currently support much of the use of M&S across MOD, either directly or through secondments into other parts of Defence. For example, one-third of the staff at the MWC are Dstl employees, with many concentrated in the M&S function.

**Strategic Command**

StratCom has also been involved with efforts to support the use of M&S across MOD. Its Special Security Element (SSE) Technology Demonstrator (TD) is a high-profile effort that has been running since 2019. Headed up by the Director Joint Warfare and the head of StratCom, the program intended to establish an SSE and offer a single platform usable for M&S across all five domains through an ambitious, cloud-based architecture. StratCom was able to draw together inputs from diverse partners to enable SSE TD to model physical elements such as weather, terrain and infrastructure networks. SSE TD, which was developed with a variety of private sector partners, offers the potential to enable decisionmakers to test decisions and courses of action and assess possible consequences in a more rigorous, data-driven manner than was previously possible.

**China**

While it is not possible to gain a deep understanding of China’s approach to wargaming and M&S, it is insightful to explore publicly available information, given that their approach to its use offers a different perspective. China recognises its lack of contemporary operational warfighting experience as a major weakness for the People’s Liberation Army (PLA) and People’s Liberation Army Navy (PLAN). President Xi Jinping has previously described the PLA as suffering from 'peace disease' with inadequate combat experience and combat readiness stemming from a period of extended peace, and has directed modernisation and reform efforts aimed at advancing the PLA as a world-class military. Kania and McCaslin describe in their report how, as part of these efforts, the PLA has been 'learning warfare from the laboratory', incorporating wargaming and opposing-force training techniques as a means of augmenting force training to enhance its military preparedness.

Wargaming, particularly computerised wargaming, is increasingly used as part of professional military education and training. There is particular emphasis on decisionmaking and C2, including 'familiarizing commanders with decision-making under dynamic, constantly changing conditions', with wargames simulating accelerated decisionmaking cycles, time urgency, and uncertainty stemming from

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77 For more information, see SERAPIS SSE, ‘About’, webpage, undated.
78 For more information on the scope of these various Dstl-run research frameworks, see Dstl, 2021.
79 RAND Europe interview, conducted 3 August 2021.
84 Elsa B. Kania and Ian B. McCaslin, Learning Warfare from the Laboratory—China’s Progression in Wargaming and Opposing Force Training, Institute for the Study of War, 2021.
incomplete information and developing circumstances. The PLA leverages the civilian video game and VR industries for continual improvements that allow for increased engagement and realism, and engages universities and defence industry in national wargaming competitions. These wargaming competitions have also become a platform for the development of increasingly sophisticated AI, with objectives of leveraging AI for ‘simulations, operational planning and analysis to model complex dynamics and interactions’. The PLA has also been investing in the formation of dedicated brigades that model enemy opposing forces to enhance the realism and increase the challenge of live confrontation training exercises. The PLA’s adversary force units are encouraged to ‘study the enemies and act like the enemies’, emulating tactics, doctrine and command systems of foreign militaries with a predominant focus on the United States and Taiwan, although other militaries, including those of NATO, Japan and India, have also been simulated.

In both wargaming and opposing force training, China recognise[s] the complexity of linkages between modern political and military struggle and incorporates non-military instruments of national power that could affect conflict outcomes, including media, cyber, diplomatic, political and economic elements.

For example, political objectives are considered with the inclusion of additional third party forces, such as enemy ally or secondary enemy forces, or ‘criminals’ that aim to interfere with the red force. It has been argued that wargames developed in the United States are ‘highly detailed one-on-one or few-on-few attrition engines’, but it is ‘difficult for most American software to adjudicate more than a few days of war in a reasonable amount of time’. In this, U.S. wargames differ from Chinese wargames, which ‘can adjudicate the interplay of all elements of national power right up to the achievement of favorable war termination’.

Kania and McCaslin observe that limitations to this laboratory-based approach include the possibility of ‘distorted understanding or unrealistic expectations’, in particular when considering AI, where ‘predictions that extrapolate the future utility of AI in actual combat based on wargaming should be regarded sceptically given the current technical limitations of AI’. Additionally, ‘the PLA’s ability to incorporate and institutionalize lessons learned from these activities is difficult to accurately assess’, considering reports of bureaucracy barriers, and poor coordination, standardisation and knowledge sharing throughout the PLA.

86 Cheng, 2015.
87 For a discussion on how China is developing their VR industry considering the dual-use opportunities it offers, see William Shumate and Tim Marler, ‘Reality Check: China Is Paving a Path Toward the Virtual Future, The National Interest’, 2021.
89 Kania and McCaslin, 2021, p. 22.
91 Kania and McCaslin, 2021, p. 28.
93 Kania and McCaslin, 2021.
95 Kania and McCaslin, 2021, p. 23.
96 Kania and McCaslin, 2021, p. 29.
Simulation Interoperability Standards Organization

Using M&S always creates risks, as M&S is inherently an 'abstract representation system' rather than a perfect replication of reality. M&S stakeholders, including users, developers, sponsors and the public, must ask which M&S asset is justifiable for a particular use and which is not. Verification and validation (V&V) aids this process by producing information to be used by M&S stakeholders. V&V depends on individual needs and constraints of the M&S organisation, project and technology. V&V is often an afterthought in M&S development. Developed by SISO and released in 2012, the Generic Methodology for V&V (GM-VV) provides general application guidance for V&V that

- Facilitates common understanding and communication of V&V within the M&S community.
- Is applicable to any phase of the M&S lifecycle (e.g., development, employment, and reuse).
- Is M&S stakeholders’ acceptance decision-making process oriented
- Is driven by the M&S stakeholders’ needs and M&S use risks tolerances.
- Is scalable to fit any M&S scope, budget, resources, and use-risks thresholds.
- Is applicable to a wide variety of M&S technologies and application domains.
- Will result in traceable, reproducible, and transparent evidence-based acceptance arguments.
- Can be instantiated on enterprise, project, or technical levels alike.
- Facilitates reuse and interoperability of V&V outcomes, tools and techniques.97

Although GM-VV provides a three-part technical framework (conceptual, implementation, and tailoring framework) on M&S V&V practices, it should cater to the needs of individual V&V applications. The objective of this document is to provide an introduction and overview of the GM-VV framework.

SISO has a number of other guidance products that derive from GM-VV:98

- SISO-GUIDE-001.2-2012: Guide for Generic Methodology for Verification and Validation (GM-VV) to Support Acceptance of Models, Simulations, and Data, GM-VV Volume 2: Implementation Guide. This contains details on the implementation framework components and how to apply components with the tailoring framework to develop V&V solutions.
- SISO-GUIDE-005-2021: Guide for a Standards Profile for the Use of Modeling and Simulation in Support of Acquisition Activities. This identifies a set of M&S standards and recommended practices as tools for guiding international acquisition community in the use of M&S activities that take place across the acquisition lifestyle.
- SISO-GUIDE-006-2018: Guideline on Scenario Development for Simulation Environments. This guidance is consistent with SISO and NATO preliminary work on scenarios and conceptual modelling.
- SISO-GUIDE-007-2018: Reuse and Interoperation of Environmental Data and Processes (RIEDP) Data Model Foundations. This document promotes reusability of environmental database generation efforts and interoperability between simulations through a standardised understanding of environment data products and generation process. It also
  – formalises the high-level process and the associated data-flow stages and tasks that are used in the creation of environmental databases for M&S
  – provides a reference data model for expressing the data produced through that process
  – specifies the organisation of RIEDP-compliant data and metadata on media.


DIST Standing Offer Panel M&S Services

At the time of writing, Defence is seeking applications from service providers for the Defence Innovation Science and Technology (DIST) Standing Offer Panel. While it can be used by other Defence groups, its primary focus is DSTG. M&S is one of the identified service categories. In this case, the focus is M&S in support of DSTG technology research and OR activities. The list below represents the full set of services, many of which will support Navy directly (bold) and indirectly through support for activities such as naval shipbuilding in the Capability Acquisition and Sustainment Group (CASG) (italics):¹

- **Development of mathematical models of missile subsystems** such as seekers, autopilots, propulsion units, control systems, fusing, warheads, aerodynamics, electro optics and lasers, detonation and combustion;
- **Development of mathematical models** (e.g., flight dynamic and performance) and other simulations suitable for estimating the flight behaviour of air vehicles;
- **Verify and validate mathematical models and data characterising the flight behaviour of air vehicles**;
- Development of mathematical and physics based models, including the processing of related datasets, applied to the analysis of Chemical, Biological and Radiological (CBR) defence problems, such epidemic models, diffusion processes, and simulation of radiation interaction with matter;
- **Ship and submarine acoustics including flow and propeller noise**;
- **Modelling of unmanned systems, weapons, platforms, command and control systems, sensors, robotics systems signal processing**, real-time modelling, vision processing, computer modelling based effects of Improvised Explosive Devices (IEDs) and algorithm development;
- **Development of models and simulations of the effect of cyber and information warfare** in the air, land, maritime and space domains;
- **Development, analysis and implementation of business process models** (BPMN) in defence environments;
- Development, analysis and implementation of optimisations models (including mathematical and stochastic programming) for defence applications;
- Development, analysis and facilitation of problem structuring models for defence applications;
- Development of discrete event or continuous simulation models for workforce analysis;
- Development of physical/mathematical models of sensors, weapons, platforms, systems, systems of systems and ADF operations;
- Development of behaviour models for platforms; platform systems such as sensors, communications, weapons; and for command and control;
- **Creation of 3D models and viewers to support modelling and simulation**;
- Development of models to replicate behaviour of military units (individuals, small teams and groups of personnel/platforms) operating together for analysis and augmenting human in the loop and closed loop experimentation;
- Developing models and simulations designed specifically for wargaming, both human in the loop and closed loop;

• Systems integration and interoperability of different models and simulations from both an underlying data perspective and common inputs and outputs to enable chaining (linking/nesting) of different models and simulations as well as network architectures;
• Developing interfaces using Distributed Interactive Simulation (DIS) and/or HLA standards for connecting simulation systems;
• Design, implement and manage modelling and simulation environment including; drafting defence policy, security requirements, infrastructure, interconnectivity between other defence sites and networks;
• Design/manage database/repository for modelling and simulation data;
• Design/developing databases for logging and extracting data from simulations for use in operations analysis;
• Technical and management aspects of data re-use/interoperability;
• Analysis of data fitness for purpose, maintain currency and plan for future data requirements;
• Draft and implement defence policy for managing/archiving output data;
• Development of physical/mathematical models of sonar and above and underwater weapon sub systems such as homing sensors, effectors, C2 systems, autopilots, propulsion units, control systems, fusing, warheads and hydrodynamics/aerodynamics;
• Naturally occurring environmental conditions that have an impact on sensors, effectors and communications in both above-water and underwater environments. Such models would include such elements as clutter and multi-path, atmospheric, acoustic and oceanographic affects, sea state and terrain. Operational conditions would include above and underwater, as well as open ocean and littoral domains;
• Services for the modelling of maritime-related technologies, including but not limited to sensors and associated subsystems, robotic and unmanned systems, weapon and decoy systems, command and control systems, signal and data processing, real-time modelling, vision processing;
• Services for the modelling of maritime voice and data communication networks for exploring and assessing the operational performance and utility of maritime network concepts and designs. Specific aspects to be modelled may include: network topologies, architectures, management and methodologies; environmental characteristics; communication channel limitations (bandwidth/throughput, latency, errors, dropouts, etc.); protocols and message sets;
• Modelling of information networks, including architectures and performance;
• Modelling and simulation to support aerospace platforms and missions (including Uninhabited Aerial Vehicles [UAVs] and spacecraft);
• Development of physics-based models of environments, structures and objects;
• Development of simulation systems architectures and integration of computer models to form complete systems;
• Development of models of sensor systems including radars and sonars;
• Development of models of electronic warfare systems covering the radio frequency and electro-optic bands;
• Integration of electronic warfare algorithms into modelling and simulation architectures;
• Creating, refining and validating platform vulnerability and weapon lethality models;
• Performing modelling and simulation to assess the terminal effects of weapons on components or platforms, weapon effectiveness, platform and personnel vulnerability reduction measures; and platform vulnerability or weapon lethality;
• Biological models of pathogens and viruses at the level of DNA/RNA, in order to: simulate mutations, predict evolutionary behaviour, and understand and differentiate natural vs manmade mutations; and
• Integration of simulation systems (e.g. wargames) with command support systems (to enable simulation based stimulation of and information exchange with the command support systems).
APPENDIX E

Taxonomy of M&S

There are numerous taxonomies of M&S, and definitions of items within those taxonomies vary. In this appendix, we provide a table containing definitions from those taxonomies to enable Navy to readily reference key terms characterising different types of M&S.

Concepts

Having reviewed the relevant Australia military documentation, we have identified definitions that are doctrinally consistent and relevant for application in analytical wargaming in the maritime environment. We include clarifying comment on the requirement for maritime analytical wargaming and decision support (Table E.1).

Models

After scrutinising various taxonomies, we selected two from military sources—the U.S. DoD and NATO—as well as one from a widely respected academic source, the IEEE. The three taxonomies differ greatly in terms of their levels of specificity. The NATO AMSP-02 Modeling and Simulation Glossary of Terms, developed by the NMSG and the M&S Standards Subgroup, characterises models using ten very broad terms, such as behaviour models, combat models, and metamodels.\footnote{NATO Standardization Agency, AMSP-02: NATO Modelling and Simulation Glossary of Terms, undated.} The IEEE Standard Glossary of Modeling parses modelling categories a bit more finely, using 20 definitions, while the DoD M&S Glossary provides detailed definitions of over 45 adjectives associated with models.\footnote{IEEE, IEEE Standard Glossary of Modeling and Simulation Terminology, 15 May 1989; and Defense Modeling and Simulation Enterprise, ‘Glossary’, webpage, undated-b.} The Defense Modeling and Simulation Enterprise published its detailed glossary in 2014 to ensure that disparate M&S practitioners across DoD would be using terms the same way.\footnote{Defense Modeling and Simulation Enterprise, homepage, undated-a.} We assessed that the IEEE and NATO definitions are more accessible to general Navy audiences. Table E.2 categorises models into four application types describing the types of problems they are used for, while Table E.3 contains definitions from those taxonomies to consistently reference key terms characterising different types of M&S.
TABLE E.1
Military Concept Definitions

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capstone Concepts</td>
<td>. . . articulate a central idea on how the force will align warfighting functions with principles for force design, generation, employment and interoperability. The operational narratives in Australia's Joint Operating Concept (AJOC) and the Future Joint Operating Concept (FJOC) identifies the uniquely Australian way in which Defence achieves operational success in either the Objective Force or Future Force. These narratives include a selected operational approach to meet strategic guidance and outlines how the force will create advantage over adversaries.</td>
<td>Joint Concepts Framework Handbook</td>
</tr>
<tr>
<td>Joint Concept</td>
<td>Joint Concepts incorporate: JFA initiated concepts provide operationalisation or context to either Objective Force or Future Force subject-specific areas in support of the Capstone Concepts. Capability Manager (CM) initiated. These concepts are used for Future Force design considerations in specific domains (Maritime, Land, Air, Space, and Information &amp; Cyber). Where they have implications for the Joint Force, or interoperability requirements, they require JFA endorsement. Operational Concept Documents (OCDs). OCDs are a CM artefact used to provide direction applicable across a capability stream or program. Where they have implications for the Joint Force or interoperability requirements, they require JFA endorsement and addition to the Suite of Joint Concepts.</td>
<td>Joint Concepts Framework Handbook</td>
</tr>
<tr>
<td>Program Operational Concept</td>
<td>. . . which describes the warfighting and support requirements and concepts, and how capability products fit together within the Program. It also describes key dependencies on, and considerations that relate to, other programs. The CM may choose to produce Operational Concepts that cover several Capability Programs, or not produce an Operational Concept, if that better suits the needs of the Capability Program.</td>
<td>Defence Capability Manual</td>
</tr>
<tr>
<td>Concept of Operations (CONOPS)*</td>
<td>A clear and concise statement of the line of action chosen by a commander to accomplish the mission.</td>
<td>Australian Defence Glossary</td>
</tr>
<tr>
<td>Concept of Employment</td>
<td>A concept of operation written in narrative form for achieving a particular operational objective against a defined threat in a defined threat environment.</td>
<td>Australian Defence Glossary</td>
</tr>
<tr>
<td>Operational Concept Graphic (OV-1)</td>
<td>The OV-1 describes a mission, class of mission, or scenario. It shows the main operational concepts and interesting or unique aspects of operations. It describes the interactions between the subject architecture and its environment, and between the architecture and external systems. The OV-1 is the pictorial representation of the written content of the AV-1 Overview and Summary Information.</td>
<td>DoD Architecture Framework v2.02</td>
</tr>
<tr>
<td>Operational Doctrine</td>
<td>Navy maintains a suite of operational doctrine and directives.</td>
<td>Australian Maritime Doctrine</td>
</tr>
</tbody>
</table>

* Within military planning and hence analytical wargaming, a CONOPS is considered to be specific to mission within a 'theatre', and generally agnostic to employment of specific systems.

TABLE E.2
Model Application Categories

<table>
<thead>
<tr>
<th>Model Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical/engineering</td>
<td>These evaluate how well particular systems function under different conditions, and sometimes how they work together. Typically, this evaluation of performance does not take active attacks by an adversary into account.</td>
</tr>
<tr>
<td>Tactical/engagement</td>
<td>These focus on how small numbers of assets (such as ships, aircraft, or small-scale units of personnel) on both sides interact.</td>
</tr>
<tr>
<td>Operational/mission</td>
<td>These are used to evaluate the interactions of large groups of assets on both sides.</td>
</tr>
<tr>
<td>Campaign</td>
<td>These evaluate performance through an entire conflict scenario or a very large subset of one.</td>
</tr>
<tr>
<td>Type</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Activity model</td>
<td>A model of the processes that make up the functional activity showing inputs, outputs, controls, and mechanisms through which the processes of the functional activity are (or will be) conducted.</td>
</tr>
<tr>
<td>Analytical model</td>
<td>A model consisting of a set of solvable equations; for example, a system of solvable equations that represents the laws of supply and demand in the world market.</td>
</tr>
<tr>
<td>Base object model</td>
<td>A single aspect of federation interplay, which can be used as a building block of Federation Object Models.</td>
</tr>
<tr>
<td>Behavioural modelling</td>
<td>Modelling of representative entity behaviours in which individual or group behaviours are derived from the physical, psychological or social characteristics of the sentient and non-sentient systems represented.</td>
</tr>
<tr>
<td>Combat modelling</td>
<td>Any structural activity that is undertaken to represent higher level strategic guidance, doctrine operational concepts, concepts of operation and combat scenarios in terms of varying degrees of abstraction and reality.</td>
</tr>
<tr>
<td>Conceptual model</td>
<td>A statement of the content and internal representations that are the user’s and developer’s combined concept of the model. Note: it includes logic and algorithms and explicitly recognises assumptions and limitations.</td>
</tr>
<tr>
<td>Constructive model</td>
<td>Models that involve simulated people operating simulated systems. People stimulate (make inputs) to such simulations but are not involved in determining the outcomes.</td>
</tr>
<tr>
<td>Continuous model</td>
<td>A mathematical or computational model whose output variables change in a continuous manner; antithesis of discrete model.</td>
</tr>
<tr>
<td>Descriptive model</td>
<td>A model used to depict the behaviour or properties of an existing system or type of system; antithesis of prescriptive model.</td>
</tr>
<tr>
<td>Deterministic simulation model</td>
<td>A simulation model that does not contain any probabilistic (or random) components; antithesis of stochastic model.</td>
</tr>
<tr>
<td>Discrete model</td>
<td>A mathematical or computational model whose output variables take on only discrete values; antithesis of continuous model.</td>
</tr>
<tr>
<td>Dynamic model</td>
<td>A model of a system in which there is change, such as the occurrence of events over time or the movement of objects through space; antithesis of static model.</td>
</tr>
<tr>
<td>Error model</td>
<td>A model used to estimate or predict the extent of deviation of the behaviour of an actual system from the desired behaviour of the system.</td>
</tr>
<tr>
<td>Federation object model</td>
<td>An HLA specification that defines the information exchanged at runtime to achieve a given set of federation objectives.</td>
</tr>
<tr>
<td>Metamodel</td>
<td>A model of a model. An abstraction of M&amp;S that uses functional decomposition to show relationships, paths of data and algorithms, ordering, and interactions between model components and subcomponents.</td>
</tr>
<tr>
<td>Narrative model</td>
<td>A symbolic model whose properties are expressed in words.</td>
</tr>
<tr>
<td>Normative model</td>
<td>A model that makes use of a familiar situation to represent a less familiar one.</td>
</tr>
<tr>
<td>Numerical model</td>
<td>A mathematical model in which a set of mathematical operations are reduced to a form suitable for solution by a simpler method such as numerical analysis or automation.</td>
</tr>
<tr>
<td>Physical immersion</td>
<td>This is accomplished by presenting a virtual world to users based on their location and orientation and providing synthetic stimuli to one or more of their senses in response to their position and actions.</td>
</tr>
<tr>
<td>Prescriptive model</td>
<td>A model used to convey the required behaviour or properties of a proposed system; antithesis of descriptive model.</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability model</td>
<td>A model used to estimate, measure, or predict the reliability of a system.</td>
<td>IEEE</td>
</tr>
<tr>
<td>Scale model</td>
<td>A physical model that resembles a given system, with only a change in scale.</td>
<td>IEEE</td>
</tr>
<tr>
<td>Static model</td>
<td>A model of a system in which there is no change; antithesis of dynamic model.</td>
<td>IEEE</td>
</tr>
<tr>
<td>Stochastic model</td>
<td>A model in which the results are determined by using one or more random variables to represent uncertainty about a process or in which a given input will produce an output according to some statistical distribution; antithesis of deterministic simulation model.</td>
<td>IEEE</td>
</tr>
</tbody>
</table>
APPENDIX F

M&S Tools to Support HEWF Analytical Capability

As noted in Chapter Seven, we recommend that the Navy M&S Strategy is expanded to incorporate an analytical capability that focuses on supporting planning, preparing for, and operating in a HEWF environment. This would also incorporate those grey-zone activities that may precede and occur concurrently with such operations.

The research team drew upon its collective experience to identify different ways in which different types of M&S could contribute to HEWF over different timeframes, complementing the analysis provided in Chapter Six with additional specificity. The first step of this two-step process entailed identifying which contributors to HEWF could be effectively influenced over the near, medium and long term. For example, decisions regarding geographic allocation of forces or budgeting are inherently near term, so the M&S used to support them needs to be able to support timescales on the order of a few years. By contrast, development of new capabilities can take a decade or more, with M&S playing a supporting role in the gradual process of research, development and testing. The second step involved characterising the types of M&S to be used within each timeframe, and how they could be employed to support capabilities that can address both grey-zone encounters and HEWF. This assessment was based on interviews and documents, as well as team knowledge that is informed by decades of experience. Models can be characterised in many different ways, as discussed in Appendix E.

Epoch 1

We identified four problems on which M&S could be employed that supports preparing the current fleet for grey-zone competition and HEWF in the near term given the deteriorating strategic environment.

Allocation of Forces

There are several contexts in which M&S can be used to support force-allocation decisions. One is the use of simple spreadsheet models to inform asset movements that aim to ensure adequate presence. Such models can use standard spreadsheet functions, plus a bit of code, to ascertain how presence in different areas would vary as a function of specific decisions. As presence becomes increasingly important to contest the grey zone and be prepared for conflict, tactical-level spreadsheet models can help to inform decisions about when and where to move assets to reduce risks and avoid creating opportunities for rivals to forcefully advance their interests.

A second type of M&S that can be useful in this context is modelling of the ability to deceive or degrade a rival’s C4ISR capabilities. In both the grey zone and in wartime, hindering the ability of the other party to accurately perceive reality can shape the outcomes of encounters. Simulations that span the tactical and operational levels can characterise how well a combination of EW, cyberwarfare, use of uncrewed physical decoys, misinformation, and other methods can impede the ability of an adversary to accurately interpret what is happening. This can inform how assets are deployed to confuse rival C4ISR networks. Naturally, the simulations need to draw upon an understanding of that network and how it is used to perceive the operational environment.

A third M&S contribution could be from operational-level mission-centric simulations that would analyse the collective effectiveness of assets at accomplishing a particular mission, together with the
requirements to deter and/or win across that specific mission. For example, such simulations could ascertain the number and types of assets needed to conduct effective ASW, surface warfare, mine warfare and other missions. The results would help to shape decisions regarding where and when assets were needed to fulfil those missions.

These operational-level simulations could potentially be federated, allowing their results to inform one another. That could contribute to campaign-level understanding of trade-offs among warfare areas; for example, whether a particular asset should be diverted from ASW to surface warfare, given certain information about adversary activity, and the risks of making such a decision. This could also help to inform overall force-level requirements for a particular circumstance in the grey zone or even combat, helping to inform hard choices about which risks to assume in other parts of the world, or the risks of taking maintenance shortcuts to increase availability of platforms.

Development and Refinement of TTPs
M&S can support the development and refinement of TTPs through the use of tactical-level models to improve specific TTPs across all warfare areas, to develop TTPs to deal with emerging threats, to demarcate engagement zones in which specific tactics can be used, and to characterise the impact of both sides incorporating new technologies and their associated tactics. For example, tactical-level models can be used to evaluate how emerging EW and cyber capabilities can shape a missile defence engagement. M&S can help to inform precisely when and how these new capabilities should be used, as well as how best to integrate them with other missile defence systems. The distinct roles of multiple ships in collective missile defence, and even their relative positions, can be refined based on M&S tactical insights that include new capabilities. Anticipating that the other side may have similar capabilities can be used to conduct additional tactical-level M&S, which will inform precisely how missile barrages are fired, what measures are taken to counter the other side’s cyber and EW capabilities, and whether in-flight updates are provided to missiles. The M&S effort and its underlying assumptions will be informed by data from real-world testing. That real-world testing, in turn, will also be guided by tactical M&S that indicates what types of tests will be most valuable, given that they typically require far more resources than comparable M&S efforts. In short, real-world testing, tactical M&S, and other analytical methods are complementary approaches to improving TTPs.

Training, Testing and Experimentation
Navy already uses M&S for training. By simulating particular environments, augmenting reality, or otherwise influencing individuals’ perceptions, those individuals can learn how to perform missions at reduced risk and cost relative to live training. The ability of M&S to put personnel in simulated dangerous situations for training purposes, without actually endangering those individuals, is a key benefit. As was the case for tactical development, M&S does not eliminate the need for live training but complements it.

Extensive coordination of training M&S with the navies of ‘Five Eyes’ allies can provide two key benefits. The first is that it can reduce costs and timelines by enabling the same training M&S to be reused. The second is that personnel will be trained in the same manner across the various navies, enhancing their ability to operate effectively together. The process of tailoring training M&S for each navy can also help to reveal interoperability issues that can then be addressed.

M&S can be used for testing at all levels of command. For example, it can be used to evaluate the degree to which people or machines are experiencing information overload, or the robustness of human-machine interfaces. M&S can also enable evaluation of different ways in which emerging capabilities can be integrated with more traditional systems.

Both operational-level and campaign-level M&S can contribute to experimentation, helping to evaluate experimental approaches to warfighting at each respective level. They can also be used to evaluate experimental approaches in grey-zone situations, including the use of emerging non-lethal weapons. Game-theoretical modelling can be used to explore different approaches to deterrence at the tactical, operational and strategic levels. Normative models, which extrapolate from familiar situations to represent unfamiliar ones, can be used
to understand the dynamics of infrequent encounters that may nonetheless be important. In situations where human decisionmaking needs to be clearly understood, M&S can be used to aid in the design and implementation of tabletop, electronic and live-action wargames that elicit judgement-based decisions. This can inform mid-level and senior leadership assessments of what approaches are most likely to demonstrate resolve and achieve deterrence while managing escalation risks.

**Policy, Coordination and Budgeting**

There are many ways M&S can be used for policy, coordination and budgeting. Spreadsheet models can address multiple needs, from coordination among the services to understanding budgetary and risk trade-offs across programs. They can also be helpful in planning maintenance cycles as part of overall life-cycle management. Qualitative and quantitative political-science models can be used to prioritise and coordinate engagement efforts involving other countries.

**Epoch 2**

The medium term allows for M&S applications that peer further into the future, which means more developmental systems and more forward-looking warfighting scenarios as compared with Epoch 1. Another key difference is that as the timeframe shifts, the level of uncertainty inherent in both M&S inputs and outputs increases. Therefore, it is imperative that M&S users conduct uncertainty analysis and sensitivity analysis to bound the possible outcomes and understand the trade space. As a result, the focus for M&S uncover and explore emerging warfighting concepts given the evolving operational environment. We identified three sets of areas to which M&S could contribute to the HEWF analytical capability.

**Procurement and Acquisition**

M&S is an essential component of procurement and acquisition. For procurement, two of the most often used M&S applications are for cost analysis and force-level analysis. Cost analysis models can either be stochastic or deterministic. Such models can project rough-order-of-magnitude (ROM) future costs and examine the impacts of a variety of courses of actions or uncertainties in cost over time (labour rate fluctuations, commodity prices, etc.). Associated with cost analysis will be M&S tools that evaluate technology issues, schedule delays, and budgetary changes.

A key part of procurement is determining how many systems are to be procured. For defence systems, that typically requires analysis to generate the force levels needed. This can be computed in several ways, with varying degrees of fidelity depending on the system, and M&S is often used. For a direct replacement of a legacy system, force levels may be generated based on fairly straightforward calculations of replacing legacy systems, along with calculations for spares, replacements and assumed attrition rates. For new systems (and some replacement systems), force levels may be generated based on more robust operational- and campaign-level models, typically stochastic, which will generate metrics aimed at determining the force level required to meet mission or campaign objectives. The number of systems determined will typically need to be balanced against available budget, but these applications of M&S can provide a realistic starting point for force levels.

M&S is frequently utilised within acquisition in a manner that is similar to force-level analysis: using operational and campaign models that will generate metrics to evaluate mission effectiveness for a given a set of input conditions. While force-level analysis is more singularly focused on the number of systems needed to conduct a mission or set of missions, acquisition effectiveness analysis more broadly examines all aspects of a given mission, and therefore typically has a larger M&S footprint. Effectiveness analysis within acquisition will utilise engineering, engagement, mission and campaign models as required to derive requirements and evaluate a system’s (or systems’) ability to meet those requirements. This type of analysis will vary based on the intended mission, but M&S for newer systems may capture emergent capabilities such as cyber, EW, and the ability to operate in degraded environments.
Other types of M&S conducted during acquisition in the medium term may include modelling for personnel requirements, logistics and maintenance modelling, platform design modelling, and subsystem-level models to capture sensor and weapon system performance. All of these M&S applications are essential in the early phases of the acquisition life cycle and are included in an AoA and subsequent analyses.

Integration of Capabilities
As warfare systems are increasingly desired to be interoperable at several different levels (at the system level, at the family-of-systems level, at the service level, at the joint level across services, and at the allied level), M&S tools provide a valuable means of evaluating and ensuring integration of capabilities. Because integration can be measured from the system level to the campaign level, M&S tools across the spectrum can be used to evaluate integration of capabilities.

At the technical level, risk modelling is useful for capturing the impact if one of a set of interdependent capabilities fails—including for items purchased from different suppliers or dependent on other services. At the tactical level, modelling can be used to evaluate how capabilities complement each other and identify areas of redundancy (both positive and negative) and potential interference. Operational-level M&S can evaluate how novel capabilities interact in a mission context and can be used to provide insights on emerging areas, such as grey-zone operations, presence, and non-lethal weapons, in which coordinated operations are essential. Coordinating M&S efforts at all of these levels with allied navies can both reduce costs (if development costs are shared) and enhance interoperability.

While campaign models lack the fidelity to evaluate individual capabilities and their integration onto a system, they are essential tools for evaluating an integrated service, joint or allied capability. They can evaluate how novel capabilities interact across multiple missions, or capture the integration of emergent capabilities like cyber and EW. Similarly, they can capture some of the integration challenges that will be likely to be faced under different environments.

Finally, M&S tools provide unique capabilities to support the actual integration of capabilities in a system. Increasingly, M&S tools are integrated in an LVC construct, in which models are used with actual systems and personnel in a coordinated effort to allow humans-in-the-loop but also reap the benefit of M&S tools to evaluate a synthetic environment. In an LVC event, M&S tools serve two functions: first, they provide the ‘virtual’ portion in terms of simulated operator interface, human-in-the-loop simulation; and second, they provide the ‘constructive’ portion typically in the form of an operational simulation that can be run repeatedly, in many scenarios and with many variables. For this construct, M&S supports the evaluation of the integration of a new technology into a system, examines interface issues and human operator issues, tests the ability of different systems (including humans) to interact effectively and deconflict, ensures compatibility, achieves synergies, and reduces risks.

CONOPS Development and Refinement
In a similar vein to the tactics refinement discussed above for Epoch 1, M&S can also be utilised to develop and/or refine existing CONOPSs in the medium term, though for more developmental systems and with greater uncertainty as the timeframe is further out. Tactical or operational models will typically be used for CONOPS development, since this entails evaluating how a limited number of systems on each side interact. As new systems are developed, or as subsystems are upgraded on an existing system (i.e., new sensors or weapons), it is necessary to evaluate the efficacy of existing tactics and concepts, or perhaps even investigate new tactics and concepts.

CONOPSs are not exclusively evaluated with M&S tools; they are often evaluated and refined through other types of analysis and live events. Wargaming and tabletop exercises are frequently used to provide insights for employment of future systems, as discussed in Chapter Six. Although wargaming does not frequently involve actual simulations, it often provides an effective means of gathering qualitative insights, and those insights can further be refined with more detailed operational modelling. Additionally, in the LVC construct discussed previously, M&S tools can be used to evaluate the effectiveness of a
concept in a hybrid setting using both real systems and operators, but in synthetic environments. The pairing of actual systems and operators with M&S can reduce some of the uncertainties associated with Epoch 2 and the medium-term timeframe.

While future systems are constantly increasing in capability over time, so are the likely threats. This provides another area in which M&S can support CONOPS development and refinement. The threats that will be operational in the medium term inevitably will have some uncertainty about their actual characteristics, but in many cases the capabilities can be bounded within reasonable ranges. M&S tools are particularly useful in representing threat systems under a variety of conditions and assumptions. Warfare models at the engineering, tactical and operational levels can simulate CONOPSs against emergent threats under a number of assumptions and potential characteristics to provide insight on whether or not concepts or tactics will need to be modified as threats evolve.

**Epoch 3**

A longer timeframe allows for development of wholly new capabilities, as well as acquisition of copious additional assets that may reshape force structure. As such, we identified two areas in which M&S could help Navy (specifically) inform their fleet design and fleet generation needs.

**Planning and Shaping Investments in RDT&E to Achieve New Capabilities**

There are several ways in which different types of M&S can support long-term RDT&E. When a new system or capability is first envisioned, technical (engineering) models can be used to ascertain whether it is viable and what its potential capabilities would be. They can also help to ascertain key vulnerabilities, development risks and other issues. As the system matures through the development process, these models can incorporate more detailed design plans and real-world data from initial testing. As the system meets development milestones and is subjected to extensive T&E, models can be used to complement real-world T&E. Specifically, M&S can inform test design by revealing particularly important conditions under which to test systems, probing the limits of their capabilities. Models can also draw on experimental testing data to evaluate far more cases than could ever be analysed using live equipment: the timelines and resource costs of modelling a set of interactions can be orders of magnitude smaller than for live testing. M&S can also be used for virtual testing—directly stimulating a system’s sensors and algorithms, creating perceived testing conditions that enable evaluation of the system’s responses under those conditions. As machine learning advances, virtual testing will also inculcate systems with ‘lessons’ about what to do in real-world situations.

Technical M&S can also inform what types of capabilities Navy should seek to develop in the first place. Given its robust alliances with other nations, as well as close working relationships with other Australian services, Navy can often buy systems being acquired by others, or tailor them to meet its own needs. The fact that many advanced civilian technologies are also relevant for naval use means that commercial products are reasonable choices in many instances. Technical M&S can inform evaluation of the difficulty associated with developing new systems. It can also provide insights regarding the degree to which systems used by others are compatible with existing Navy assets, and what types of tailoring might be required to ensure a high degree of compatibility. M&S can also aid in ascertaining the extent to which systems designed for Navy are likely to be compatible with those of other services, or how to bridge any gaps. Overall, technical M&S can inform where Navy’s investments in RDT&E can have the greatest impact. In the context of Australia’s alliances with more populous nations, honing specific niche capabilities that complement those of other nations can enable it to have a substantial impact on the overall strength of alliance forces. Some aspects of emerging and disruptive technologies may lend themselves to development of niche capabilities. For example, Navy may be able to ascertain how it can cost-effectively develop cyber, unmanned, space, non-lethal, EW, or deception capabilities that are not otherwise being adequately acquired by the alliance.
The technical M&S outlined above can be complemented by other types of M&S. Simple spreadsheet models can aid in cost-benefit assessments, using quantitative and qualitative criteria to evaluate the desirability of particular systems or design choices. Spreadsheet models can also be used to assess the impact of assumptions regarding development, and the consequent risks of performance shortfalls, cost overruns, or protracted development timelines. Many of the types of M&S described in previous sections for use in evaluating CONOPSs and TTPs can also contribute to R&D, shaping requirements by indicating how the values of performance or effectiveness metrics vary as a function of system specifications. For example, M&S may enable plotting of curves of how the probability of a successful tactical engagement varies as a function of a system’s range, as well as how that range varies as a function of cost, so that informed trade-offs can be made.

A combination of technical, tactical and operational-level M&S can also be used to ascertain the potential impact of new capabilities on both sides. This is particularly useful in the context of emerging technologies such as those mentioned above, whose grey-zone or battlefield impact is not as well understood as more traditional technologies. For example, tactical and operational M&S could examine how effectively an integrated deception scheme using unmanned decoys, EW and cyber could cause an adversary’s distributed sensor network to misperceive events. In concert with spreadsheet cost models, it could be used to evaluate the effectiveness and cost-effectiveness of different measures and countermeasures by both sides, as well as the degree to which each side’s awareness of the other’s tactics would diminish their impact. Campaign-level modelling could also be used to inform how previously modelled operational effects would contribute to overall battlefield effectiveness.

**Enhanced Fleet Design and Generation**

Long-term decisions on how to design the fleet could also benefit from different types of M&S, some of which are recapitulations or reapplications of those described above. For example, many of the M&S capabilities developed for medium-term acquisition can also be used to ascertain what the future fleet should include. Similarly, the types of M&S that can inform decisions about which limited-scale systems to develop locally or buy internationally can also be used to do the same for ships, aircraft and other major purchases for the fleet.

One of the key ways in which M&S can help with long-term fleet design and generation is by shaping future modularity and interoperability. Naval assets can last for many decades, while the technologies operating from them often change over much shorter timelines: the unmanned systems or weapons that a ship may host at its inception can go through several generations of development before it is decommissioned. In designing ships, aircraft, infrastructure and other assets, technical-level M&S can be used to vary assumptions regarding the power, space, weight, cooling and other demands that future on-board systems may impose on the host platform. This can then help to shape the platform to be able to meet those demands, as well as to have margins that allow for unanticipated growth in any of them. Moreover, such M&S can also consider the potential for increased efficiencies associated with future systems. If additive manufacturing (3D printing) means that compact powders can be stored instead of a large volume of spare parts, or increasingly dense batteries or efficient lasers can reduce support requirements, those factors can shape how the space on a ship is allocated with a holistic approach to assessing costs, risks and trade-offs.

Operational and campaign-level modelling can provide insights regarding the collective and relative capabilities of given numbers of systems on both sides, given assumptions about the capabilities of individual systems. Those assumptions will themselves be informed by previously mentioned technical and tactical M&S. Campaign-level modelling can also be used to explore diverse grey-zone and HEWF scenarios, characterising the impact of different assumptions on overall warfighting effectiveness and on the necessary size of the fleet. For example, if a specific country provides forward-basing rights that enable the launch and recovery of Navy unmanned vehicles, or allows ships to conduct port visits for replenishment and low-level maintenance, that may increase on-station time and thereby reduce the necessary scale of the fleet to accomplish a particular mission. On the other hand, to the extent that such
support may be precluded due to political considerations, a larger fleet may be necessary. Similarly, varying assumptions regarding the duration and frequency of intensive maintenance for major assets can affect how many are needed to ensure adequate numbers are able to respond to a contingency. The ability to toggle such variables in campaign-level simulations can enable informed choices regarding investment trade-offs and acceptable risks. Spreadsheet-based costing models can be used in concert with campaign models, and can also have embedded risk calculations that consider the impact of potential funding shifts or shortfalls.
## Accountable Officer and Responsible Stakeholder Acronyms

Table 8.1 listed a number of Defence position acronyms; they are defined below.

### Navy

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>CN</td>
<td>Chief of Navy</td>
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<tr>
<td>COMAUSFLT</td>
<td>Commander Australian Fleet</td>
</tr>
<tr>
<td>COMFLOT</td>
<td>Commodore Flotilla</td>
</tr>
<tr>
<td>COMTRAIN</td>
<td>Commodore Training (Navy)</td>
</tr>
<tr>
<td>DCN</td>
<td>Deputy Chief of Navy</td>
</tr>
<tr>
<td>DGNFW</td>
<td>Director-General Navy Future Workforce</td>
</tr>
<tr>
<td>DGNIW</td>
<td>Director-General Navy Information Warfare</td>
</tr>
<tr>
<td>DGSCA</td>
<td>Director-General Surface Combatants and Aviation</td>
</tr>
<tr>
<td>HNC</td>
<td>Head Navy Capability</td>
</tr>
<tr>
<td>HNE</td>
<td>Head Navy Engineering</td>
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### Other (Defence)

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>CIOG</td>
<td>Chief Information Officer Group</td>
</tr>
<tr>
<td>CJOAD</td>
<td>Chief Joint Operations Division (DSTG)</td>
</tr>
<tr>
<td>DGOAP (JED)</td>
<td>Director General Force Options and Planning (Joint Experimentation Directorate)</td>
</tr>
<tr>
<td>JOC</td>
<td>Joint Operations Command</td>
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</table>
References


References

Dstl—See Defence Science and Technology Laboratory.


IEEE—See Institute of Electrical and Electronics Engineers.


MCWL—See Marine Corps Warfighting Laboratory.


MOD—See Ministry of Defence.


Patel, Bharat, 'MSG-168 Lecture Series on Modelling and Simulation as a Service (MSaaS)', NATO, 2019.


Royal Australian Navy, ‘Chief of Navy Australia’, webpage, undated-a. As of 30 September 2021:
https://www.navy.gov.au/about/organisation/cn
——, ‘RIMPAC 2020’, webpage, undated-b. As of 25 March 2022:
——, *Australian Maritime Doctrine*, Commonwealth of Australia, 2010. As of 1 October 2021:
——, *Australian Maritime Operations*, Commonwealth of Australia, 2017. As of 1 October 2021:
——, *Chief of Navy Commander’s Intent*, Commonwealth of Australia, 2018a. As of 12 October 2021:

Royal Navy, ‘Technology and Innovation’, webpage, undated. As of 25 March 2022:
https://www.royalnavy.mod.uk/news-and-latest-activity/features/innovation

Scharre, Paul, ‘Spectrum of What?’, *Military Review*, November–December 2012, pp. 73–79. As of 5 November 2021:
https://www.armyupress.army.mil/Portals/7/military-review/Archives/English/MilitaryReview_20121231_art012.pdf


SERAPIS SSE, ‘About’, webpage, undated. As of 29 September 2021:
https://serapis-sse.co.uk/about/

https://www.rand.org/pubs/papers/P7162.html


Simulation Interoperability Standards Organization, ‘Guidance Products’, webpage, undated. As of August 27, 2021:
https://www.sisostds.org/ProductsPublications/GuidanceProducts.aspx

South, Todd, ‘Marines Break Ground on New War Game Center’, *Marine Corps Times*, 16 May 2021. As of 18 November 2021:

USCG—See U.S. Coast Guard.


Growing regional military capabilities coupled with reduced warning times mean that the Royal Australian Navy requires a more responsive approach to acquiring, preparing and deploying military capabilities. The Navy is currently undergoing a significant transformation, with new platforms being introduced into service and existing ones undergoing major upgrades.

To help focus these efforts, the authors of this report provide an evidence base for an expanded Modelling and Simulation (M&S) Strategy for Navy so that it can better position itself to operate in a high-end warfighting (HEWF) environment. The authors review Navy M&S strategy broadly and recommend how it could be strengthened to support the ongoing modernisation.

Analysing information captured through a literature review, an environmental scan, and interviews, the authors make suggestions for inclusion in a revised strategy so that Navy can better utilise the benefits of M&S in both the immediate and longer terms. These suggestions go beyond traditional training applications to include the use of M&S as a decision support tool in development and testing of HEWF concepts in the maritime domain.

The authors develop an approach based on a standard strategy-to-task logic model. To meet the model’s requirements, the relevant strategic requirements and key elements of the current and forecast states for Navy M&S are identified. These provide a basis for developing strategic focus areas for M&S lines of operation (LOOs) that incorporate enabling M&S functions, as well as introducing new LOOs related to the application of M&S in support of Navy’s HEWF decision support requirements.