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Analysis Support for Land 19, Phase 7: an Integrated Approach

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Abstract: Project Land 19, Phase 7B (Land 19-7B) seeks to develop a Ground Based Air and Missile Defence (GBAMD) capability to enhance the level of force protection afforded to the Australian Defence Force.

DSTO provides a range of support to new Defence capability projects including an assessment of technical risks and technical studies in support of options analysis, requirements definition and the decision making process (Australian Government 2012a).

This paper describes the analysis support provided to Land 19-7B focusing on the underpinning philosophy and methods. A Model Based System Engineering (MBSE) methodology has been used to derive capability definition documents, encompassing the Operational Concept Document (OCD) and Function and Performance Specification (FPS). This same MBSE approach has been adopted to provide rigour and traceability to both the design of experiments, and the development of the modelling, simulations and analysis (MS&A) capability. The MS&A capability being developed has leveraged existing MS&A frameworks and portable component models.

The significant client involvement in the MS&A design is vital to ensure appropriate representation of the scenario vignettes and experiments. As the capability definition matures and the client questions change, the approach taken will ensure that the appropriate level of analysis can be conducted to inform the Government.

Keywords: *Model Based Systems Engineering (MBSE), Model Based Concept Design (MBCD), capability development, modelling and simulation, experiment design, client engagement*

1. INTRODUCTION

DSTO provides a range of support to new Defence capability projects including an assessment of technical risks and technical studies in support of options analysis, requirements definition and the decision making process (Australian Government 2012a). A Project Science and Technology Adviser (PSTA) is assigned at project initiation to plan and manage this support through the two-pass approval process. At First Pass, Government determines the capability options to be subjected to detailed consideration and the resources required for this to occur. At Second Pass, Defence seeks Government approval for the acquisition of a recommended capability option for which well-defined acquisition and through-life support costs, schedule and risk profile have been developed (Australian Government 2012a). The First and Second Pass approvals occur within the Requirements Phase of the capability lifecycle with the Acquisition Phase commencing immediately after Second Pass approval is granted, as shown in Figure 1. This paper describes the analysis support provided to Project Land 19, Phase 7B (Land 19-7B) focusing on the underpinning philosophy and methods.

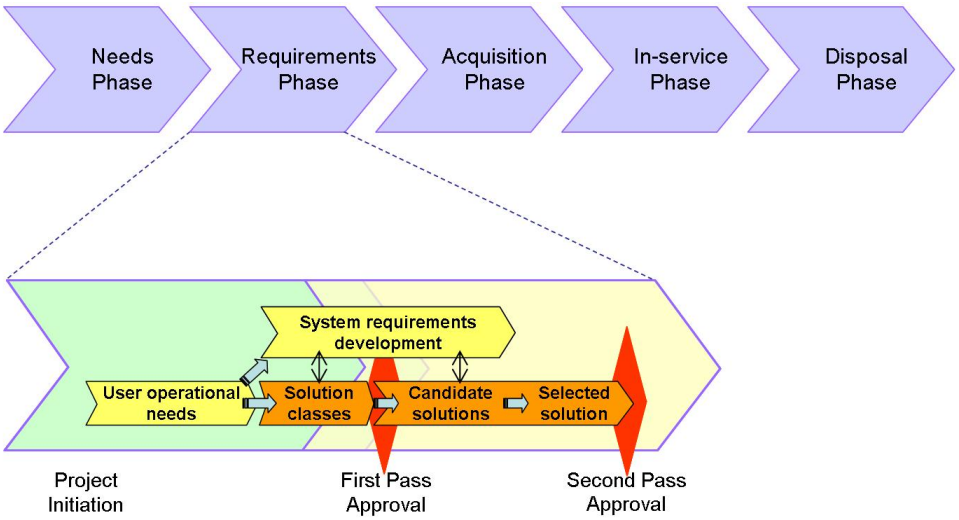

Figure 1. Capability Lifecycle (adapted from Australian Government 2012a)

2. PROJECT LAND 19, PHASE 7B

Land 19-7B seeks to develop a Ground Based Air and Missile Defence (GBAMD) capability to enhance the level of force protection afforded to the Australian Defence Force. The GBAMD capability will build on existing in-service capabilities acquired under earlier phases of the project. When introduced into service, the GBAMD capability will be able to sense, provide warning, and intercept a wide variety of threats (Australian Government 2012b). On current guidance, Land 19-7B is scheduled to undergo First Pass consideration sometime in the period Financial Year (FY) 2016-17 to FY 2017-18 and is anticipated to be considered for Second Pass approval in the period FY 2017-18 to FY 2018-19 (Australian Government 2012b).

3. CAPABILITY DEFINTION WITH MODEL BASED SYSTEMS ENGINEERING

The capability requirements for Land 19-7B have been developed iteratively using a Model Based System Engineering (MBSE) methodology. The content of the capability definition documents, comprising the Operational Concept Document (OCD) and Function and Performance Specification (FPS), was developed in a model environment as illustrated in Figure 2. Employing an MBSE methodology at once introduces the rigour and discipline associated with systems engineering, and imposes a structured, relational environment for knowledge capture. The GBAMD capability definition knowledge and the reference model and its mapping onto the OCD and FPS were developed and improved iteratively over time. These documents were auto-generated by running scripts (Robinson et al, 2010 and Tramoundanis et al 2011) from the knowledge contained in the model. This was a departure from conventional practice in Defence where drafters of these documents are guided by writing guides and document templates.

An important by-product of employing an MBSE methodology for Land 19-7B capability definition was a significant amount of re-use of the products and knowledge developed by the project. The knowledge model

schema (or reference model) and the mapping of its content onto OCD and FPS document content as well as the scripts used to export the documents, were not specific to Land 19-7B, and were able to be used for any major capability project. Indeed, these products were exploited by several other projects which were also employing MBSE. Additionally, the glossary of terms describing activities and functions and measures of effectiveness and performance were also able to be exploited by related projects, as were, the description of interfaces and the exchange of information and other needlines between GBAMD and related capabilities was knowledge that was made available for exploitation by related projects. In a return benefit to Land 19-7B, scenarios defined for an Army protected mobility project, also employing MBSE, were used as the foundation for some Land 19-7B operating scenarios because one of the missions for the GBAMD capability is to provide force protection to the land force.

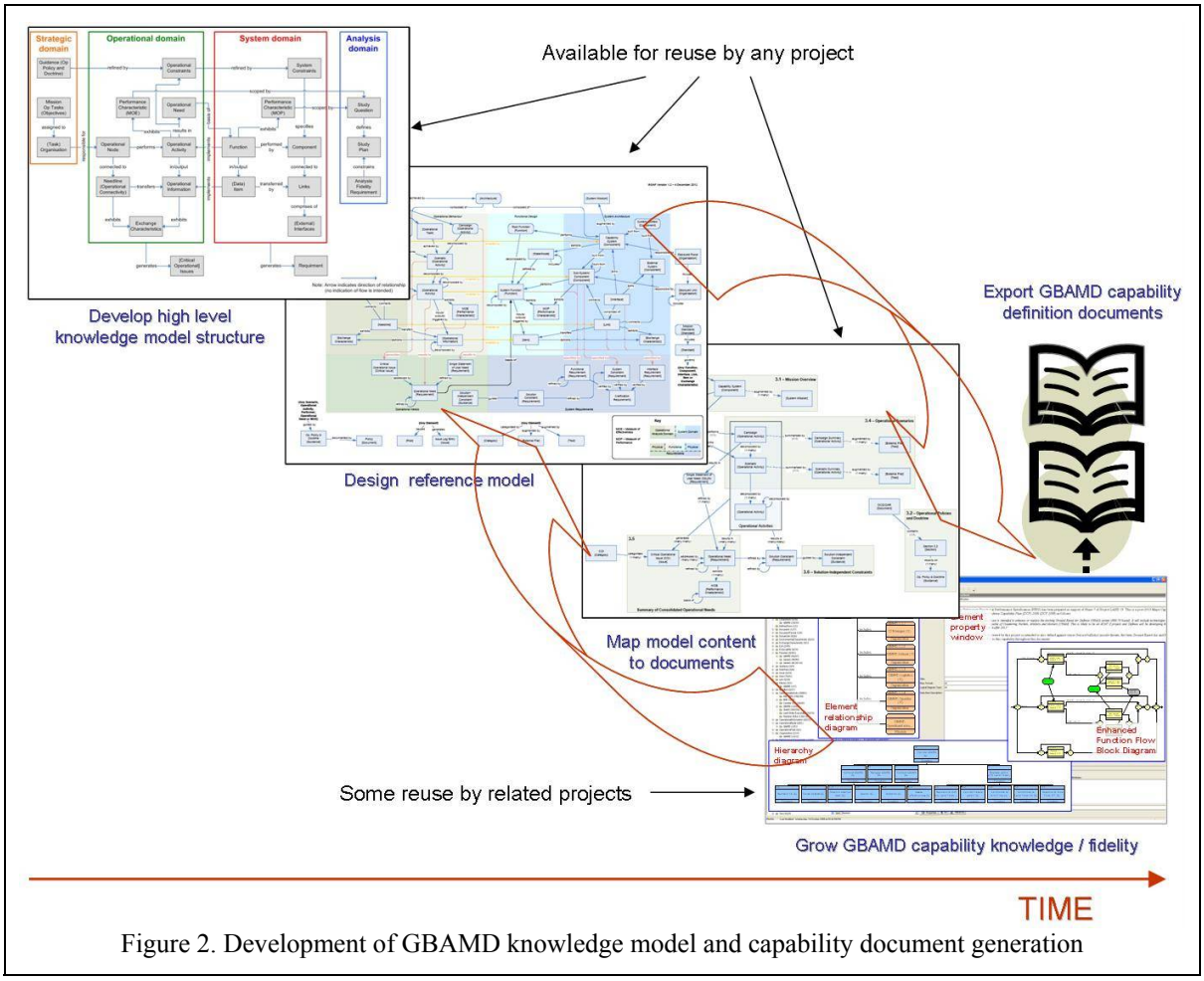

Figure 2. Development of GBAMD knowledge model and capability document generation

4. AN INTERATED APPROACH TO MODELLING, SIMULATION AND ANALYSIS DESIGN

The capability definition and the development of a modelling, simulation and analysis (MS&A) capability for Land 19-7B began several years before the project's year of decision, thereby providing an opportunity to design a MS&A capability in time to inform decision making during the project approval process. The MS&A team considered that as rigorous and disciplined an approach was needed in designing the MS&A capability as was used to develop the capability definition. Accordingly, the modelling environment, the vignettes and experiments to be modelled and the data to be extracted were designed to respond to study questions developed from the client questions. In this way the data extracted from the modelling is traceable to the capability options and key parameters such as the Critical Operational Issues (COIs) and capability mission success measures. In short, the decision support analysis requirements were integrated into the capability definition at the outset. Figure 3 comprises a simplified reference model demonstrating the relationship between the defined capability requirements and the operational employment scenarios traditionally contained in the OCD, and the MS&A capability design. The MS&A capability will evolve over time as the capability definition matures and the client questions change as the project progresses along the two-pass approval process.

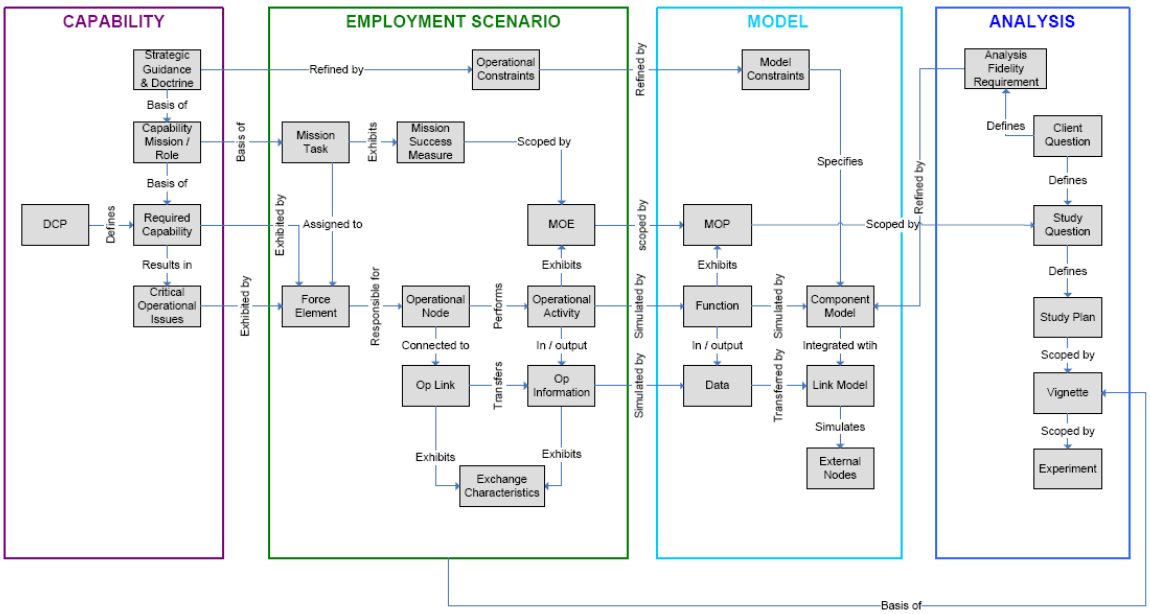

Figure 3. Simplified reference model for experiment design and metrics development (adapted from Robinson & Graham, 2010)

5. MS&A CAPABILITY DEVELOPMENT

The MS&A development approach adopted by DSTO in support of Land 19-7B is to leverage and build upon a number of existing MS&A frameworks and component models within the Weapons and Countermeasures Division (WCMD).

A key aspect to the WCMD MS&A philosophy is a focus on the reuse and portability of both models and MS&A frameworks across a number of projects. This approach has allowed the Land 19-7B project to benefit from the significant work previous projects have delivered, whilst focusing on building new capability required by the project. Often this new capability can be designed and developed in a way that future projects can utilise, adding to the total set of reusable components.

Land 19-7B adopted a number of WCMD MS&A frameworks each providing their distinct functionality by way of a number of architectural layers as shown in Figure 4. These layers provide modelling, simulation and application services. The modelling layer, Mars, is an architecture providing a portable C++ model development environment. It allows modellers to develop a wide range of component and system models. The simulation layer, SimFramework, is a C++ simulation engine that executes the models developed through Mars. Finally the application layer, Simulation Application Architecture (SAA), is a component based "plugin" application that supports the creation of applications capable of running these simulations.

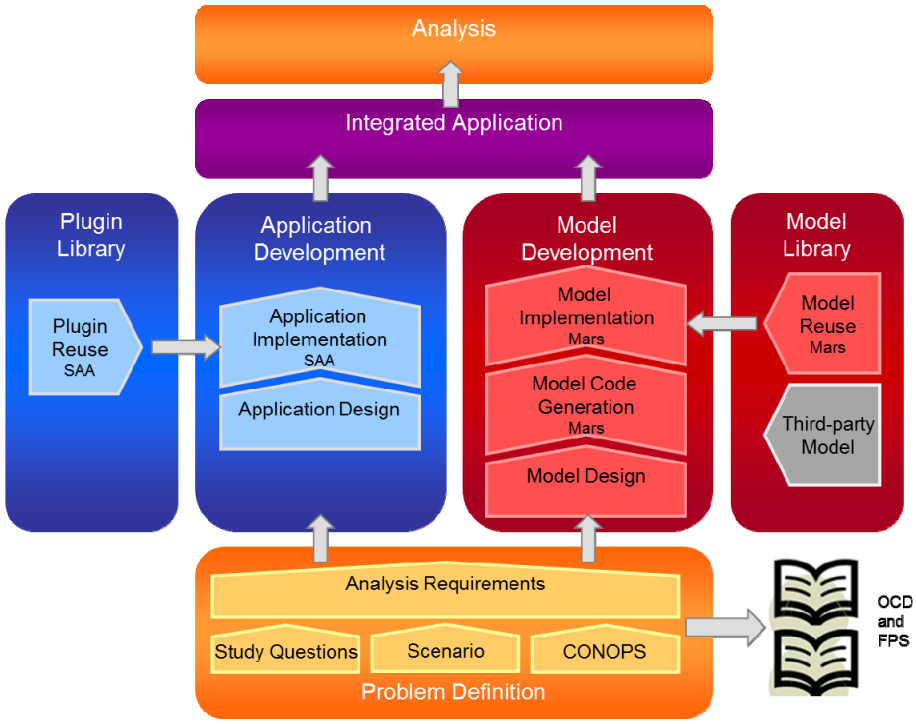

Figure 4. WCMD layered MS&A frameworks

The modelling approach taken by the Land 19-7B team was to adopt an evolutionary development methodology. The initial objective was to construct a low fidelity and generic representation of the key systems based on the capability definition described in Section 3. This establishes a prototype end-to-end modelling capability that aims to reduce the risk in the development of the baseline model used for analysis. This prototype provides a strong foundation from which to build upon, both in terms of enhancing individual component models and to exercise the analysis process.

The traceability to the capability definition and measures of performance described in Section 3 in conjunction with the exercising of the analysis process provides the rationale for the enhancement of component models. This enhancement of component models has been managed in one of two ways, either by improving the existing model, or integrating a higher fidelity model in its place.

This integration of model design to capability definition provides:

1. the client with a greater understanding of the analysis
2. improvement in the rigour and robustness of the MS&A capability
3. effective identification and efficient resourcing of enhancements to model fidelity

6. THE CLIENT AS COLLABORATOR IN MS&A DESIGN

A key potential risk to the modelling approach taken by Land 19-7B, was a misalignment of the focus of the model which would create schedule pressure later in the project life-cycle. The model is utilised as a central element in the capability analysis and definition process and as such requires direct alignment with evolving capability concepts. This extends to the alignment with stakeholder expectations to inform external preparations for model input. To that end the client and DSTO implemented a close developmental relationship during MS&A design to ensure complete compatibility of intent and outcome.

The deep interaction with the client that this arrangement provided enabled the detailed exploration of client-specific aspects relating to capability options representation, and vignette and experiment design. It also helped the construction of a hierarchy of effectiveness measures that were directly linked to critical operational issues. The mode of client-DSTO staff interaction as part of this process extends beyond the traditional one-way information exchanges, such as e-mailing questions and answers. More interactive modes

of client engagement such as brainstorming and workshops are also heavily used which helps distribute the client-DSTO relationship across all MS&A team members, not just the client and the DSTO team leader. This results in the design of an MS&A capability and MS&A objectives that are closely aligned with the client's needs as they evolve and mature through the capability definition process. Further, errors of interpretation that could arise if the analysts and model builders operate isolated from the client are also avoided. Importantly, the client's trust in and acceptance of the MS&A process and its outcomes are enhanced through the transparency of the process and their direct involvement in the MS&A design. The present positive experience resulting from close client interaction closely reflects the findings of researchers examining the role of the client in co-innovation teams (Alam 2002, Dawson, 2005).

7. CONCLUSION

Several benefits have resulted from the integrated approach for MS&A support for Land 19-7B. From the modelling perspective:

- The design of the MS&A capability, the analysis objectives and measures of effectiveness are demonstrably traceable to the capability definition and particularly to the critical operational issues and employment scenarios;
- There is now a good foundation for integrating models required for Land 19-7B and have the capacity to include future enhanced models as required;
- The model matures in line with the Government approval process to provide the appropriate level of analysis to inform the business cases of each Government pass process.
- A many versus many systems of systems MS&A capability (i.e. simulating threats versus interceptors) for Land 19-7B has been developed. This includes the ability to run multiple (i.e. thousands) simulations whilst varying model configurations parametrically or stochastically; and
- Work undertaken for Land 19-7B work is benefitting many other projects.

The lessons drawn from the present effort in supporting Land 19-7B MS&A are:

- Client involvement in the MS&A design is vital to ensure appropriate representation of the scenario vignettes and experiments so that the simulations are suitable, relevant, and support an analysis focused on answering the client questions;
- Good documentation of models is imperative for systems integration, verification validation and analysis (VV&A), and to ascertain model fitness for purpose; and
- Establishing a prototype modeling, simulation and analysis (MS&A) capability early in the project lifecycle helps identify unforeseen issues (e.g. integration issues, systems of systems interactions or analysis deficiencies) and helps verify the development process, thus reducing the project MS&A capability risk.

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