An MBSE Methodology for Capability Systems Definition

Dr Quoc Do
Group Leader
Concepts and Requirements Development
Frazer Nash Consultancy
Adelaide, Australia
q.do@fncaustralia.com.au

COL Daniel Hartigan
Vice Chief of the Defence Force Group
Department of Defence
Canberra, Australia
daniel.hartigan@defence.gov.au

Overviews

- Introduction:
  - Model-Based Systems Engineering
  - Systems Capability Definition

- MBSE for Systems Capability Definition
  - Systems Capability Design Process
  - Information Centric Model
  - Operational Analysis
  - Functional Analysis
  - Systems analysis and architecture design

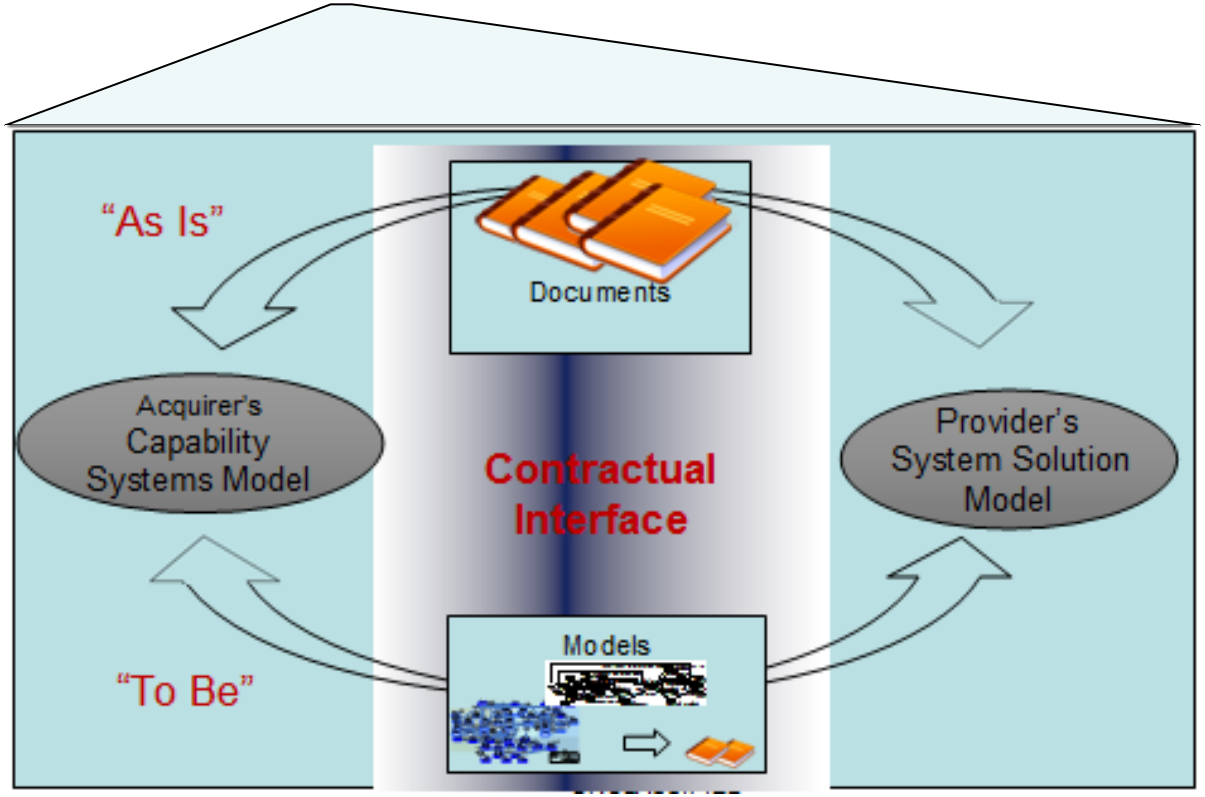
- Case study – Battlespace Communication Systems Support Centre
  - Systems engineering approach
  - Outcomes and lessons learnt
  - Recommendations

Introduction to MBSE

- The aim of MBSE is to overcome the limitations inherent in defining, designing and describing complex systems using documents.
- The heart of MBSE is an information-centric model realised through the use of computer-based models (as opposed to documents) as the primary source of project information (the 'source of truth') supporting systems engineering processes.
- When implemented appropriately, MBSE delivers effective knowledge management enhancing the ability of stakeholders to understand the system, its behaviour and performance, and thus make better decisions relating to the design of that system.

Introduction to MBSE - Defense Context

The Australian Capability Systems Acquisition Lifecycle (DCDH, 2012)



UNCLASSIFIED

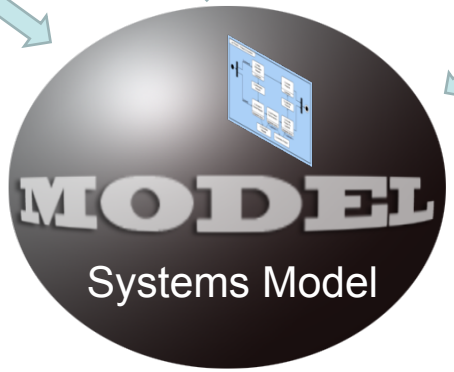
Introduction to MBSE – Model centricity

Operational Domain Expertise

Stakeholder (mental) conceptual design

Special Domain Expertise

Model Facilitates Analysis, Informing the design



Auto-generation

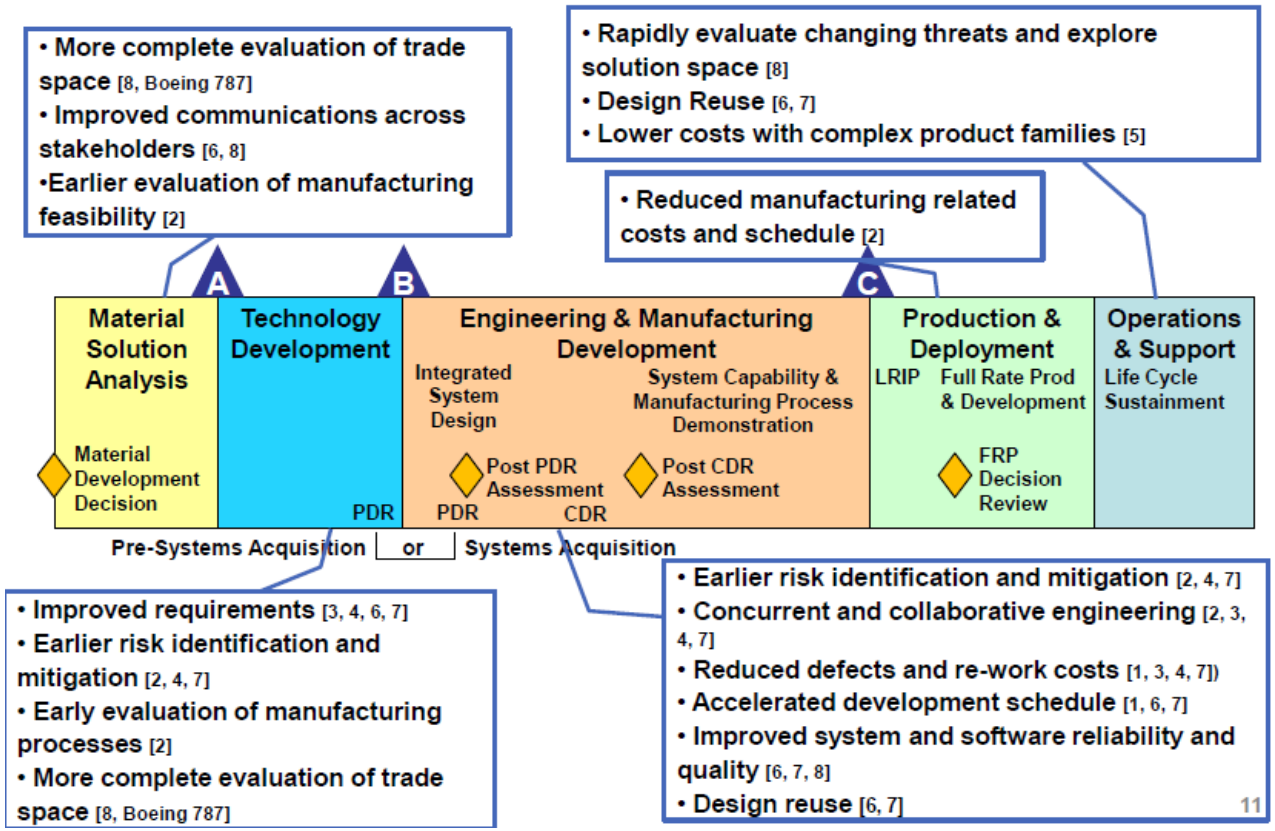
System Capability Definition Documentation

The model is the primary artifact, the reference for all project communications

Introduction to MBSE - Benefits

- MBSE provides valuable benefits for complex projects:
  - promote the early discovery of non-obvious issues and problems;
  - enable convergence from diverse stakeholder viewpoints;
  - provide traceability and transparency to all parties in a way that ensures requirements and other key design artefacts are consistently and logically linked to inform key design decisions;
  - highlight the impact of design evolution across the whole project space;
  - enhanced team communications;
  - explicit processes for reasoning about systems issues; and
  - improved systems architecture and detailed design integrity;

Introduction to MBSE – Evidence of Adoption

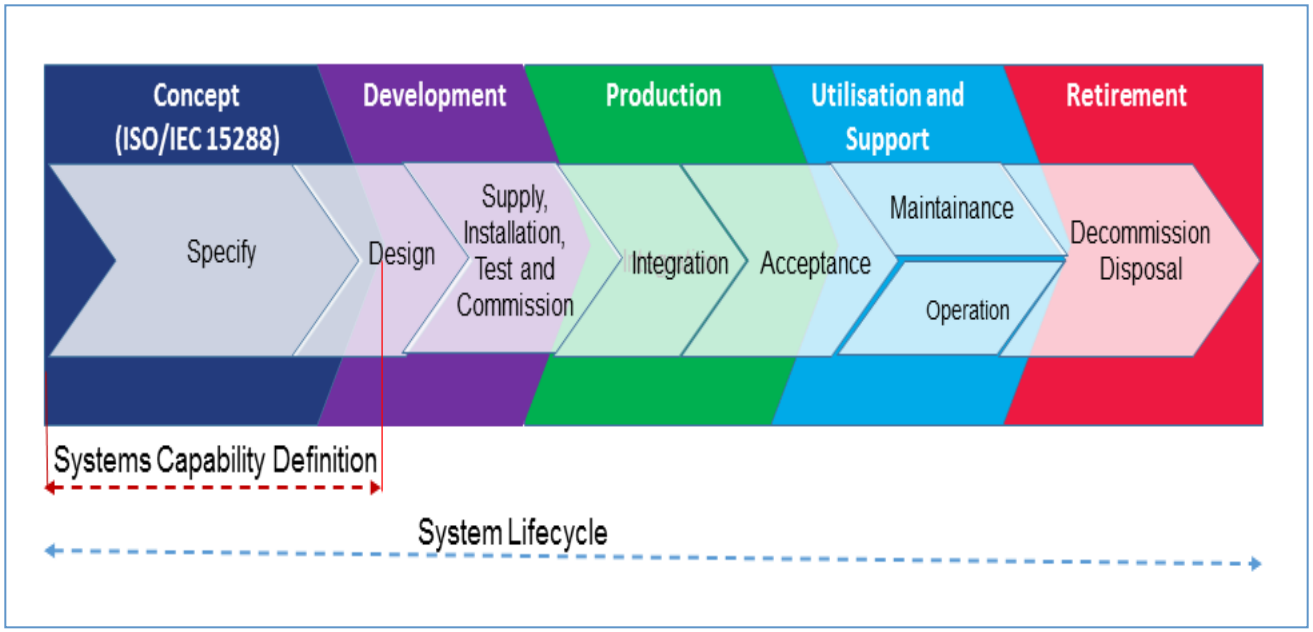


(Extracted from Bergenthal, 2011)

The National Defence Industry Association final report shows the application and benefits of model-based engineering across the US DOD acquisition lifecycle.

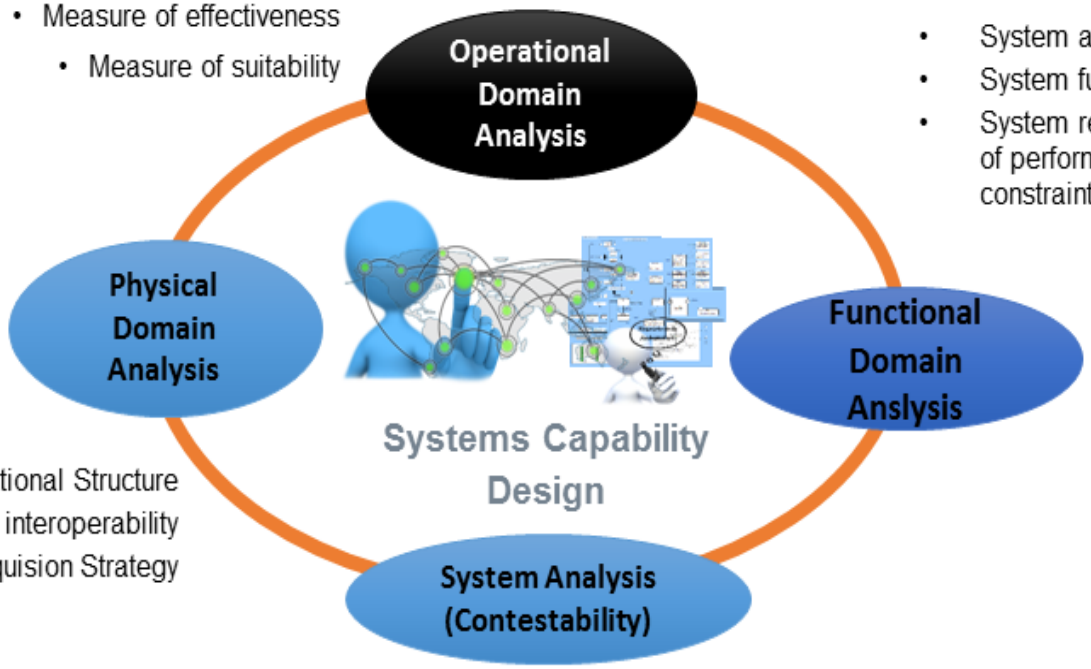
Introduction to Systems Capability Definition

- Systems Capability Definition in the context of the ISO/IEC/IEEE 15288:2015 System Lifecycle stages.



Systems Capability Design Process

- Define the problem space
  - Operational Scenrios
- End-user needs Analysis
- Measure of effectiveness
  - Measure of suitability



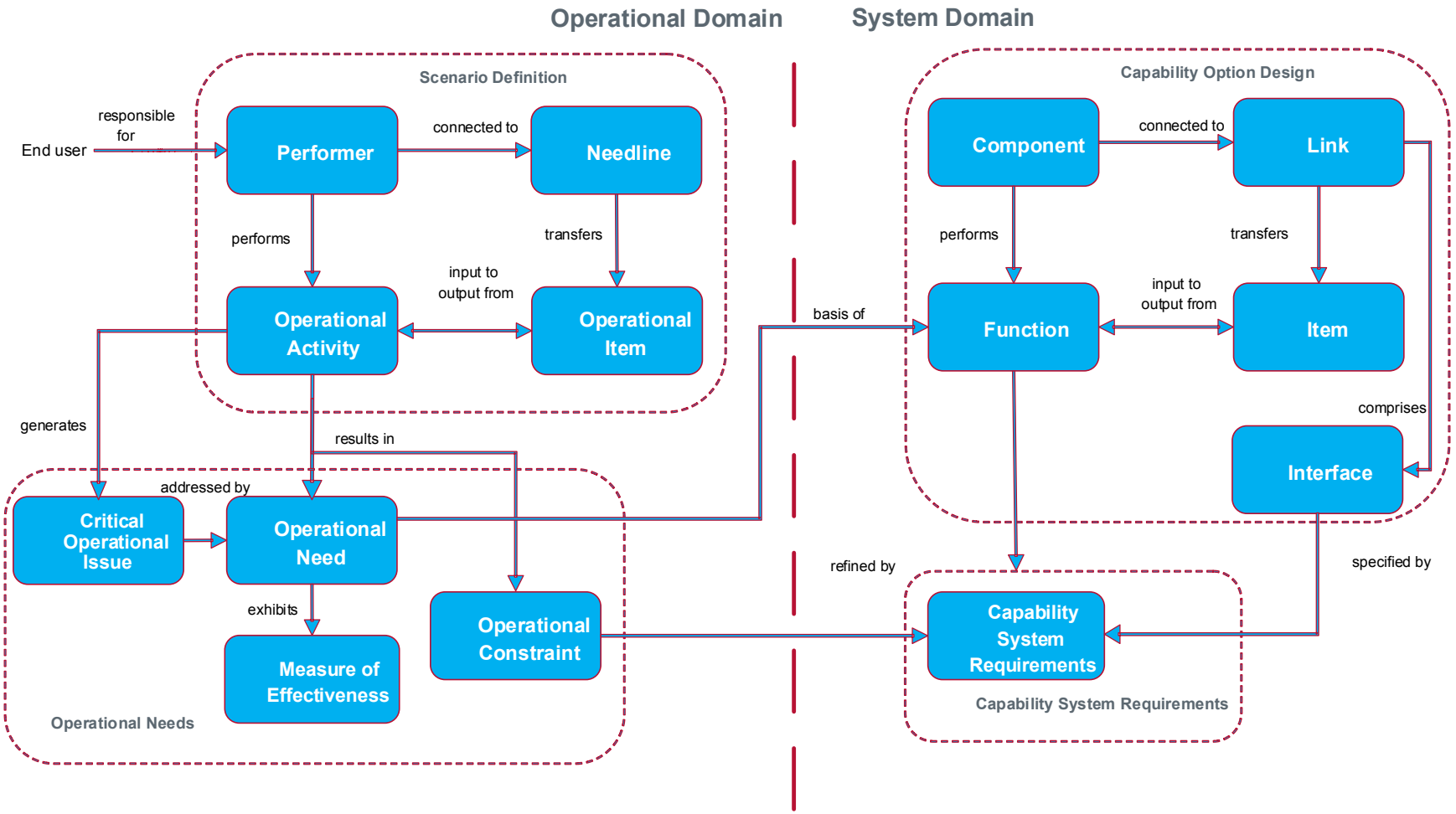
- System architecture Definition
- System functional analysis
- System requirements (Measure of performance & System constraints)

- System Organsiational Structure
- Integration and interoperability
- Acquision Strategy

- Optioneering: Solution options trade-off and selection
- Acquisition and sustainability (through-life cost)

Systems Capability Design

Information-Centric Model



UNCLASSIFIED

Case Study
Battlespace Communication Systems Support Centre

Background

- LAND 2072 is a multi-phased Major Capital Equipment acquisition project, which aims to establish both the architecture defining the Battlespace Communications System - Land (BCS(L))
- The BCS(L) will connect users with both similar and disparate tactical systems throughout the battlespace to exchange voice and data across heterogeneous networks, linking headquarters to allocated tactical units from the Australian Army, Navy, Air Force, Government and Non-Government Agencies, as well as Allied and Coalition forces.
- The Battlespace Communications Support Centre (BCSC) was identified and funded to ensure that BCS(L) and Army C4I systems remain "fit-for-service", interoperable, expandable and able to meet the ongoing operational requirements.

Case Study
Battlespace Communication Systems Support Centre

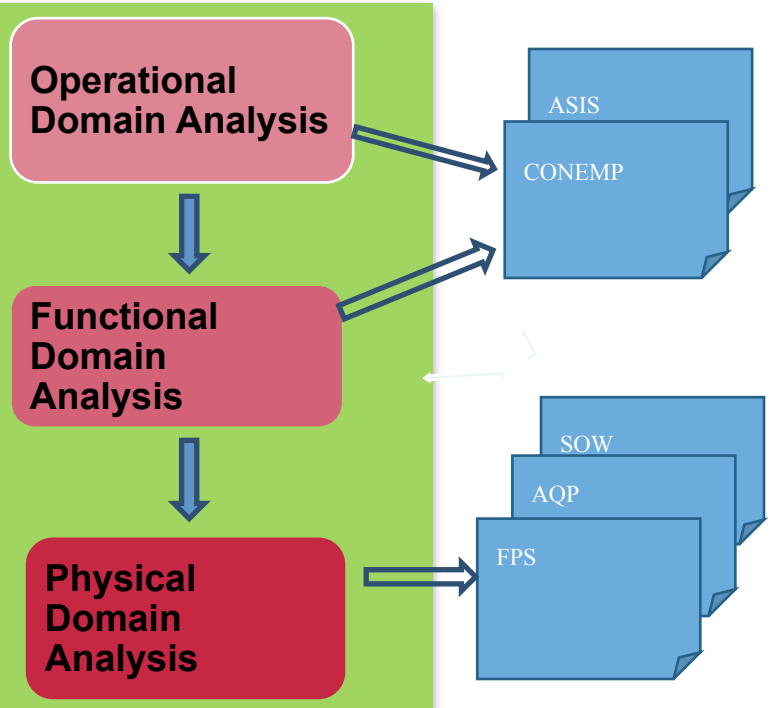
FRAZER-NASH CONSULTANCY

Development Approach

- Employment Scenarios
- End-state capability needs
- Critical Operational Issues
- Measures of Effectiveness

- Functional Architecture
- Functional Analysis
- Constraints

- Traceable set of requirements
- Form part of Industry Tender



System Analysis

Case Study
Battlespace Communication Systems Support Centre

FRAZER-NASH CONSULTANCY

Operational Domain Analysis

- Mission – To inform Chief of Army, as the Capability Manager (CM), that the current and future Land Network is *"Fit for Service"*.

- Primary Task – To inform Chief of Army, as the CM, that current and future deployable networked mission systems for Land battlespace systems are capable of providing on-demand collaborative command and control, engagement and information sharing in order to support Joint Land Combat.

Case Study
Battlespace Communication Systems Support Centre

FRAZER-NASH CONSULTANCY

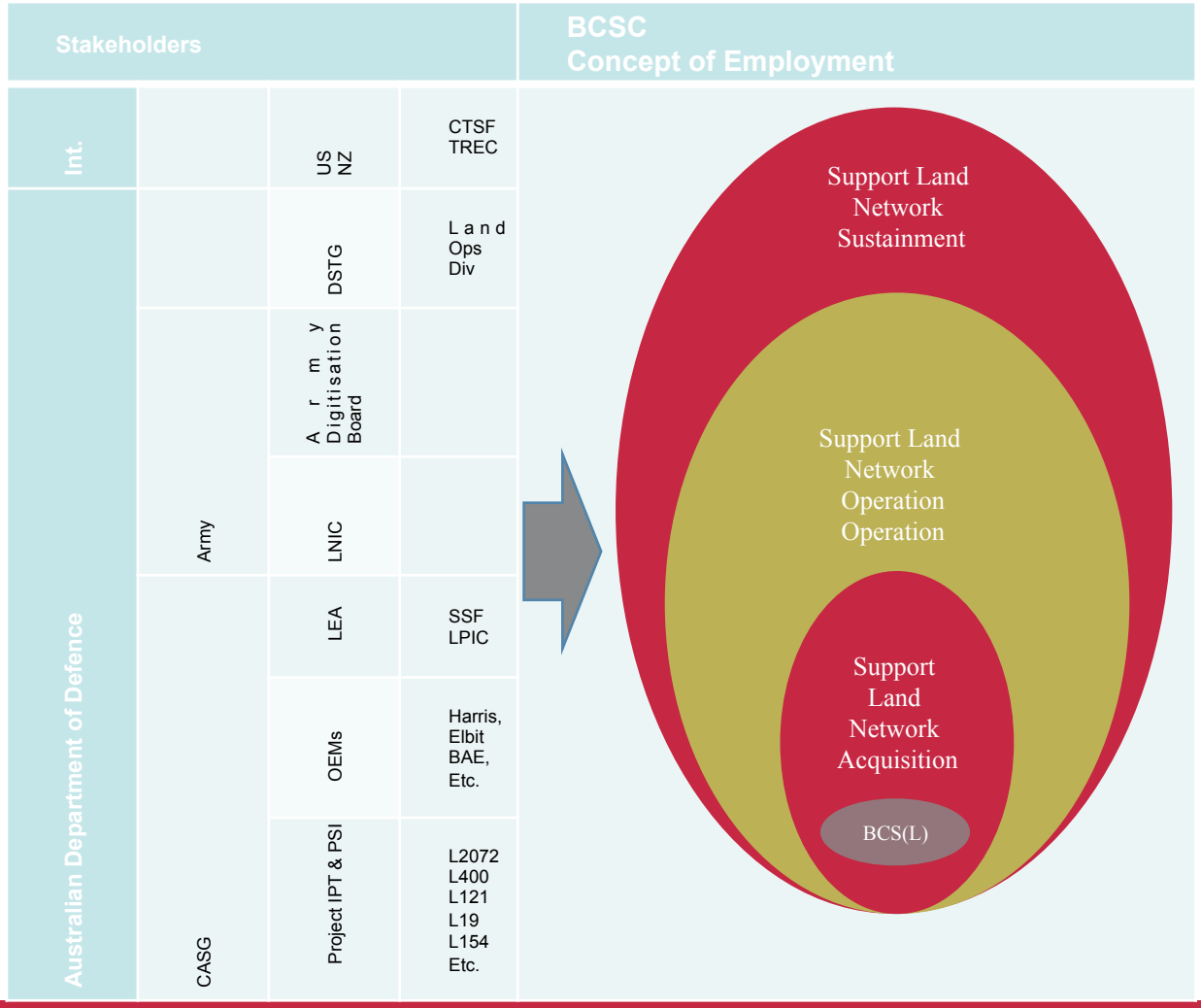
Operational Domain Analysis - Tasks

1. Design Authority: To evolve the BCS(L) systems design as the Design Authority;
2. Provide Technical Advice to the CM: To provide subject matter expertise in communication engineering, integration and evaluation to the CM in order to ensure Land C4I systems are capable of supporting Joint Land Combat through the provision of on-demand collaborative command and control information exchange;
3. Support the Capability Lifecycle: To provide ongoing support to Capability Acquisition and Sustainment Group (CASG) and relevant Land and Joint Programs for the capability definition, acquisition, validation, certification, and sustainment of deployable networked materiel systems for the Land battlespace;
4. Support Verification & Validation: To provide ongoing support to Army and CASG for integration, verification, validation and qualification, operation, innovation and evolution of C4I systems for Land battlespace; and
5. Configuration Management: To provide Land Network reference system baselines to ensure that the continuous introduction of new and upgraded C4I Systems are “fit for service”.

Case Study

Battlespace Communication Systems Support Centre

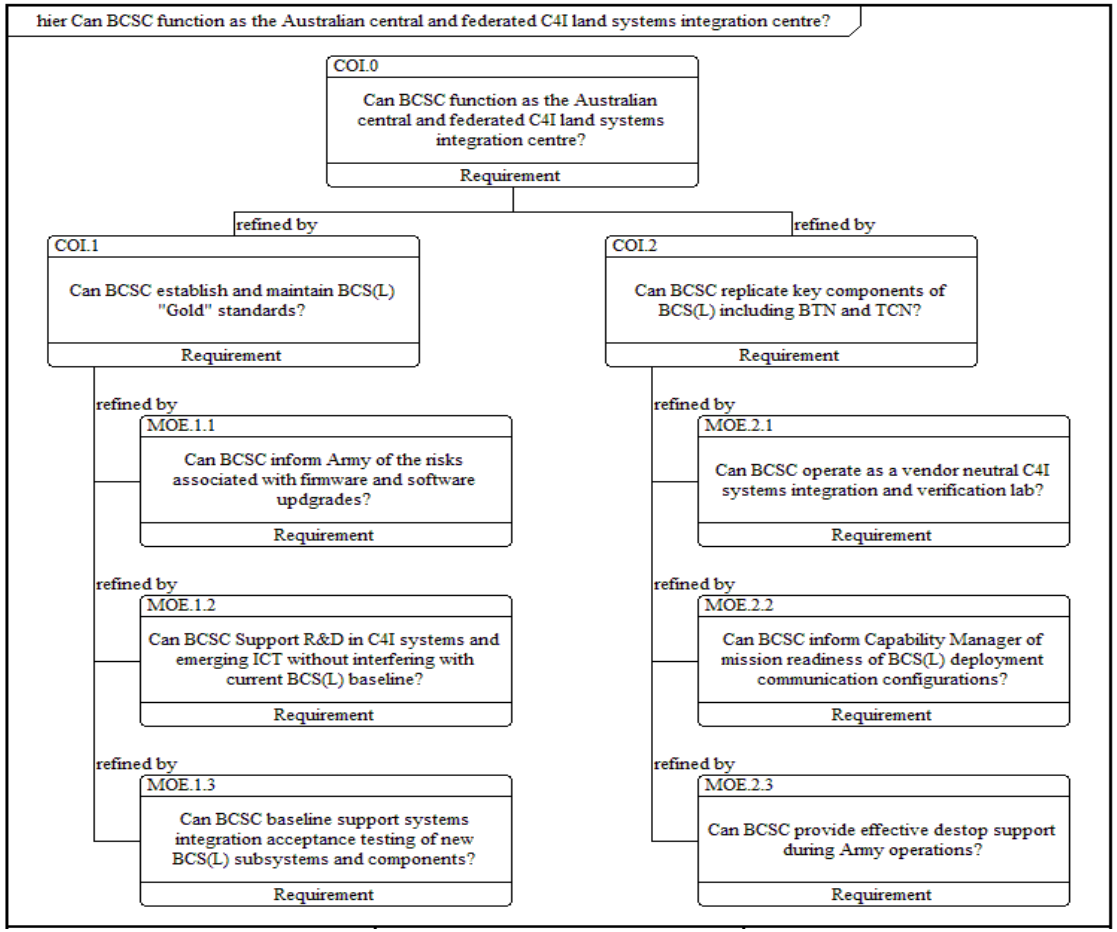
Operational Domain Analysis – Concept of Employment



Case Study

Battlespace Communication Systems Support Centre

Operational Domain Analysis – COIs and MOEs



UNCLASSIFIED

Case Study

Battlespace Communication Systems Support Centre

FRAZER-NASH CONSULTANCY

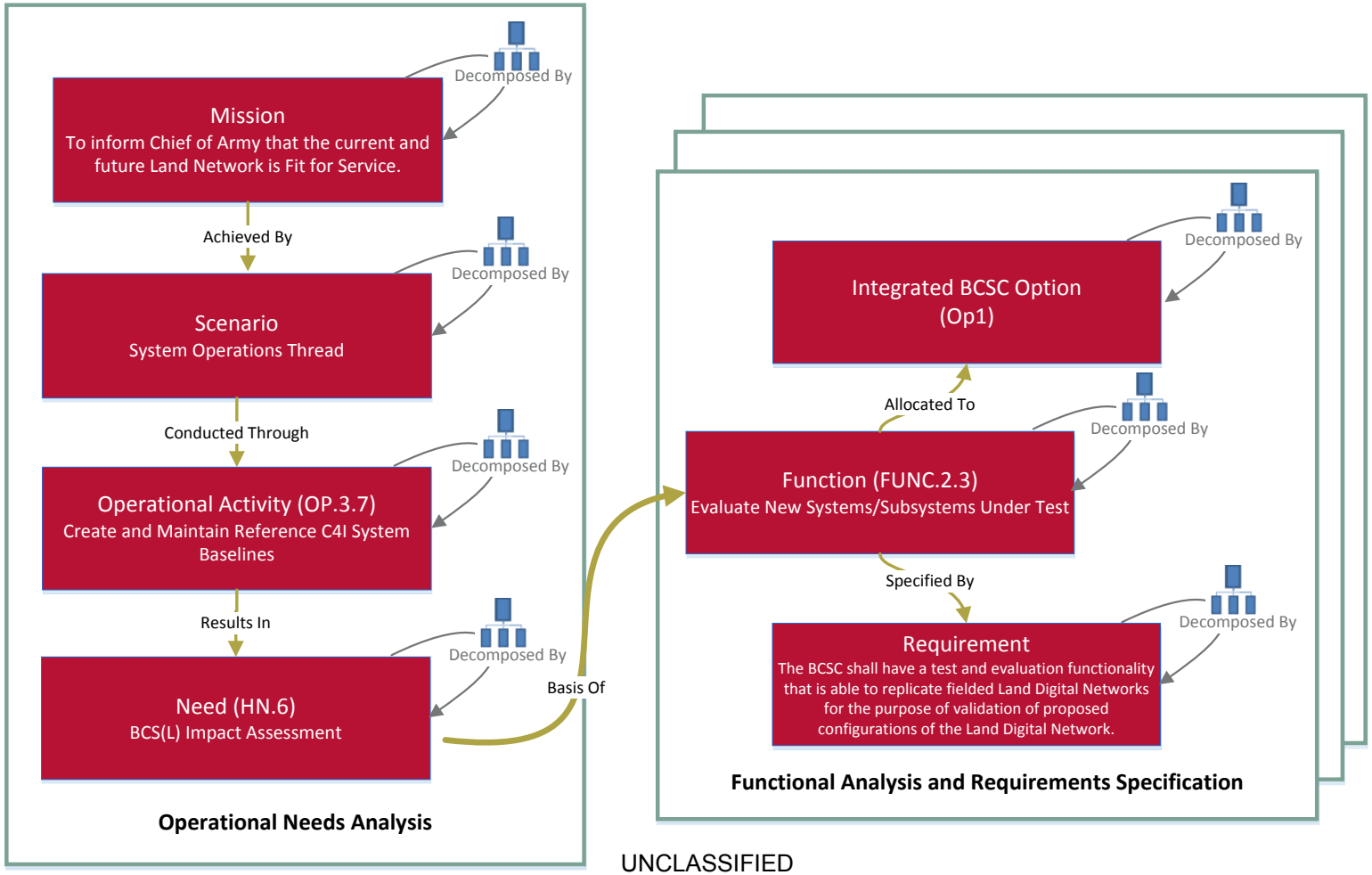
Operational Domain Analysis – Sample Capability Needs

ID	Need	Description	Trace to CONEMP
HN.1	BCSC Land Network Systems Integration Testing	The BCSC needs to provide the land system of systems integration testing environment that is capable of verification and validation of seamless integration of voice, video and data across the BCS(L).	OP.3.1 OP.3.3 OP.3.4
HN.3	Configuration Management	The BCSC needs to establish and maintain 'Gold Standards" BCS(L) Reference Systems to support the development of a valid communication configurations library to support the Land network.	OP.3.7 OP 3.4
HN.4	Land Network Evaluation	The BCSC needs to support Army, CASG, DST Group and industry to conduct feasibility study, and innovative development in commercial and military communications technology.	OP.3.1 OP.3.2 OP.3.5
HN.6	BCS(L) Impact Assessment	The BCSC needs to provide impact assessment of any hardware, firmware and software upgrades and introduction of new systems and devices into the BCS(L) network to enable joint land combat.	OP.3.2 OP.3.11
HN.8	Operations Support	The BCSC needs to provide third level desktop support and orchestration of alternative communication network plans during Army operations to ensure continued connectivity of nodes within the joint land battlespace.	OP.3.9.4

Case Study

Battlespace Communication Systems Support Centre

Operational Domain Analysis – Functional Analysis and Requirement Development



UNCLASSIFIED

Case Study
Battlespace Communication Systems Support Centre

FRAZER-NASH CONSULTANCY

Outcomes and Lessons Learnt

- ***Systematic Capability Design Processes*** – An objective approach has successfully built and gained confidence of the stakeholders and thus enabled the proffered solutions to be understood and accepted.
- ***Iterative Design*** **Approach** - Through regular stakeholder meetings to confirm the results of the operational and functional analysis, divergent (and at times conflicting) stakeholder expectations were able to be managed. Presenting previous decisions and the resultant analytical consequences enabled convergence to be achieved when describing the physical domain.
- ***Solution independent approach*** – During the Operational Domain analysis the team focused on a solution independent perspective to gain agreement on the mission and high-level needs. From this agreement, the contention from divert stakeholders in the solution space was able to be resolved, as these contentious areas were no longer valid in light of the agreed mission and needs.

Case Study
Battlespace Communication Systems Support Centre

Outcomes and Lessons Learnt (Cont…)

- ***Systems Thinking*** – An inclusive approach allowed all primary stakeholder's viewpoints to be surfaced and opened the solution space for divergence "out of the box thinking". Convergence was achieved by making collective decisions resulting in two BCSC solutions to be put forward for final consideration.
- ***Information-Centric Approach*** – Utilising the MBSE schema significantly advanced the Systems Engineer's ability to facilitate and elicit the right information classes in different workshop contexts. The information schema drove the types of questions to asked, and indicated what areas required clarification. An information-centric approach enabled key stakeholders to follow the logic flow of the consequences of previous decisions and aided in better and faster decision making.

Case Study
Battlespace Communication Systems Support Centre

FRAZER-NASH CONSULTANCY

Recommendations

- ***Engage early and often*** - resulted in the discovery of non-obvious issues and problems, the earlier empowered stakeholders are engaged, the earlier these issues can be addressed. Through the use of the model, the implications of a given decision or option can be quickly (relative to not using a model) analysed and then returned to the decision makers for resolution and further guidance if required.

- ***Prefer methodological knowledge over domain knowledge -*** MBSE enforcing good SE: expert application of MBSE on a group of domain experts will elicit a better product than a less than expert application of Systems Engineering on the same domain savvy personnel.

- ***Expose the stakeholders to the model, but not in more detail than absolutely necessary*** - The model is a tool to enable design decisions to be made not an end in itself.

Dr Quoc Do
Group Leader
Concepts and Requirements Development
Frazer Nash Consultancy
Adelaide, Australia
q.do@fncaustralia.com.au

COL Daniel Hartigan
Vice Chief of the Defence Force Group
Department of Defence
Canberra, Australia
daniel.hartigan@defence.gov.au