An MBSE Approach to Support Organisational Reform of the Royal Australian Navy

Dr Quoc Do

Frazer-Nash Consultancy
Adelaide, South Australia, Australia
Email: q.do@fncaustralia.com.au

CMDR Malcolm Gahan and
CMDR Colin Davidson

Directorate of Navy Engineering Policy
Royal Australian Navy
Email: mal.gahan@defence.gov.au

SYSTEMS AND ENGINEERING TECHNOLOGY

Overviews

- Introduction to Model-Based Systems Engineering
- Royal Australian Navy's Rizzo Reform Program
- Materiel Seaworthiness Functional Master Set (MS FMS)
- Pilot MS FMS Traffic Light System
- Results

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Introduction to Model-Based Systems Engineering

Traditional

"Future State"

- OCD, FPS & TCD
- Specifications
- Interface requirements
- System design
- Analysis & Trade-off
- Test plans

MODEL

"as is"
- Specifications
- Interface requirements
- System design
- Analysis & Trade-off
- Test plans

"To Be"

Moving from Doc-Centric to Model-Centric
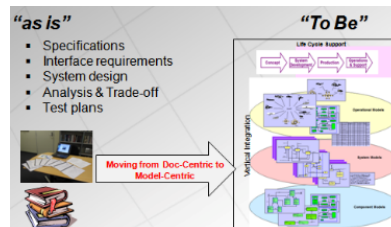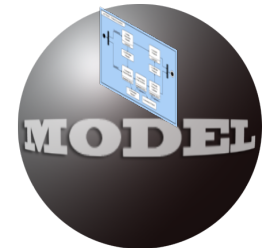
Transitioning Systems Engineering practices from document-centric to model-centric

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Introduction to Model-Based Systems Engineering

Elements of MBSE Practice

- **SE Process Standards:**
  - ISO 15288
  - IEEE 1220
  - EIA 632
  - INCOSE SE Handbook
  - …

- **SE Foundation:**
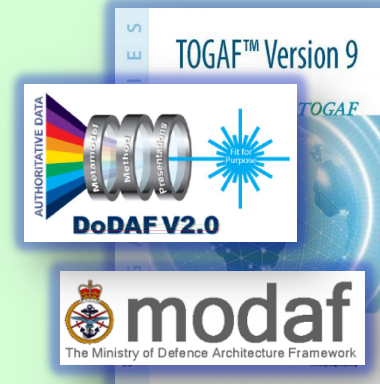 - Systems thinking
  - Systems science
  - Systems theory
  - …

- **Knowledge management:**
  - Representation:
    - Languages (syntax or Metamodel/schema, Notation, Semantic)
    - Tools
  - Interoperability standards (XMI, AP233)

- **Frameworks:**
  - DoDAF
  - AusDAF
  - TOGAF
  - MODAF
  - NAF
  - TRAK
  - …

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Introduction to Model-Based Systems Engineering

FRAZER–NASH CONSULTANCY

- **MBSE practice requires:**
  - Systems languages
  - Processes and methods
  - Tools

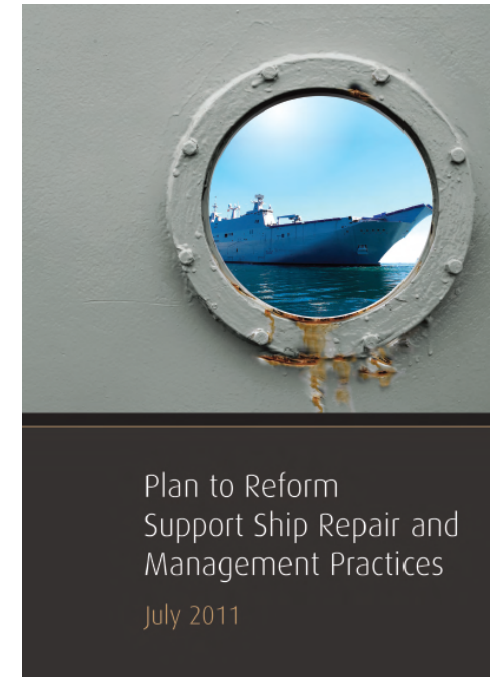- **Some MBSE methodologies are:**
  - *IBM's Telelogic Harmony – Systems Engineering*
  - *Vitech's MBSE Methodology [and its extension Whole-System Analytical Framework (WSAF)]*
  - *IBM's Rational Unified Process for Systems Engineering (RUP SE)*
  - Jet Propulsion Laboratory's State Analysis
  - Dori's Object-Process Methodology (OPM)
  - *INCOSE's Object-Oriented Systems Engineering Method (OOSEM)*
  - *Etc…*

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Royal Australian Navy's Rizzo Reform Program

- Rizzo's Review:
    - The Royal Australian Navy (RAN) is committed to continuing to improve the acquisition and maintenance of naval materiel.
    - An independent review was commissioned (Rizzo, 2011).
    - Twenty four recommendations to improve navy maintenance and management practices.

    - Three recommendations that are strongly related to systems engineering:
        - Take whole of life decisions;
        - Establish an integrated risk management system; and
        - Rebuild Navy engineering capability.

Plan to Reform
Support Ship Repair and
Management Practices

July 2011

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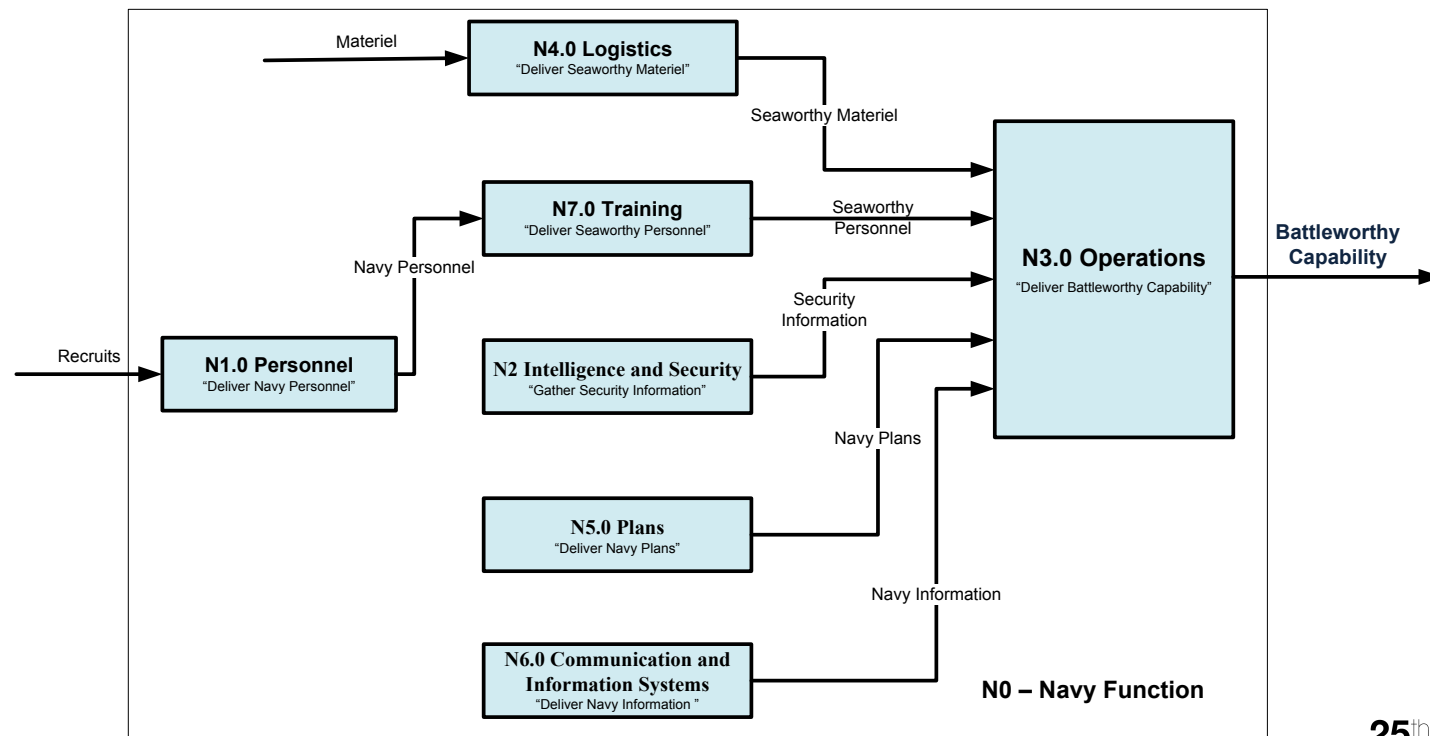
RAN's Rizzo Reform Program

- ▸ The Rizzo Reform Program established six projects to meet Rizzo's recommendations.
  - ▸ One of the projects, related to this paper, is the Rebuild Engineering Capability.
- ▸ A model-based approach to organisational reform

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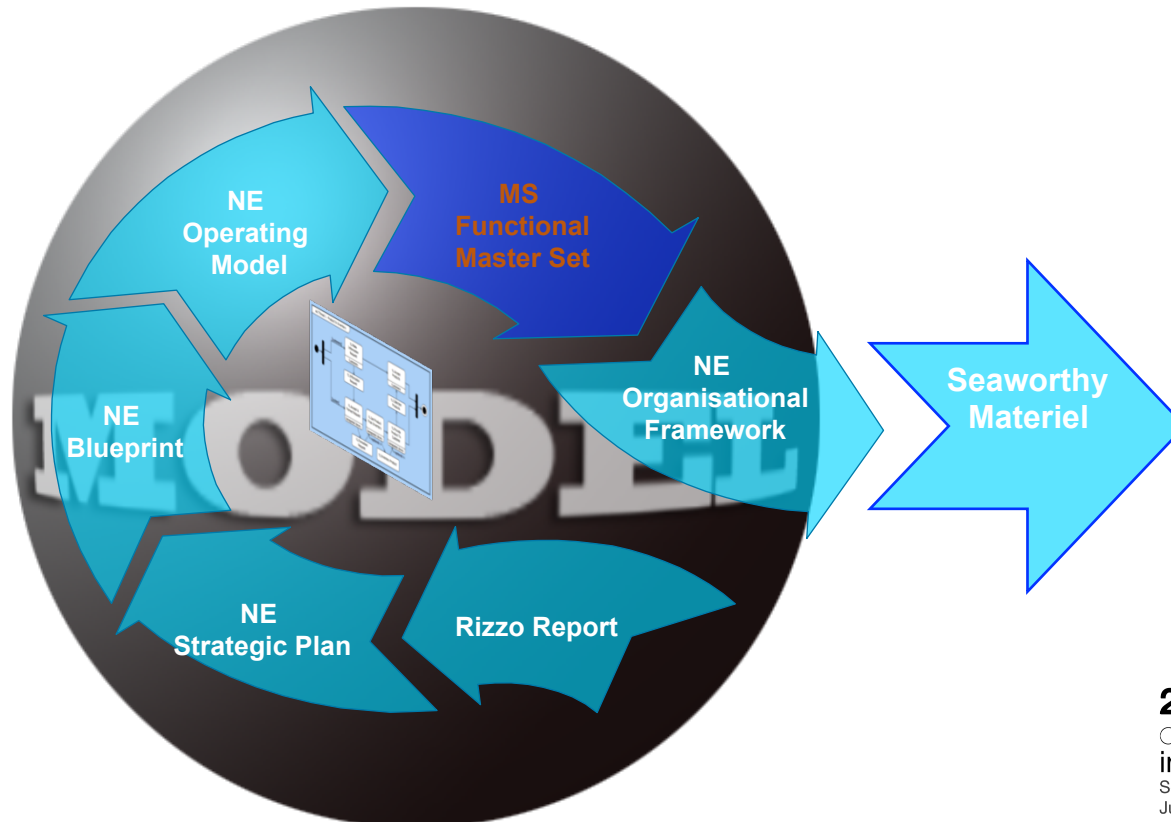
RAN's Rizzo Reform Program

▸ High-level Navy functions (that are organisationally agnostic)

High-Level Model for Navy Capability Delivery

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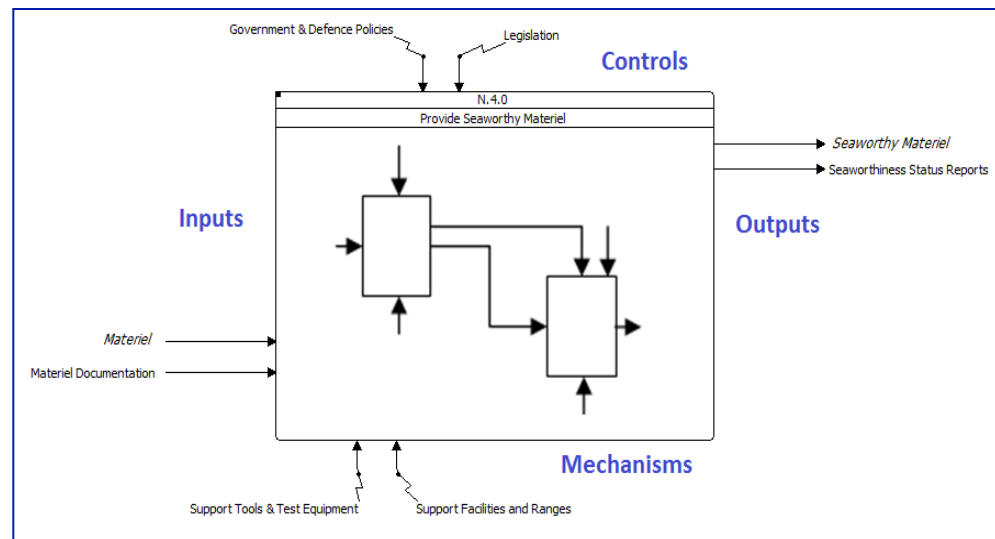July 13 - 16, 2015

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Materiel Seaworthiness Functional Master Set (MS FMS)

▸ The N4.0 Logistics function was developed and named MS FMS.

▸ It was developed by senior stakeholders within the Royal Australian Navy (RAN) over a series of workshops totaling more than 2,500 man hours;

▸ MS FMS defines the "what" that has to be done within RAN to:

   ▸ acquire, operate, sustain and retire seaworthy assets;

   ▸ provide a means to understand the Navy's engineering and administrative business; and

   ▸ support the development and delivery of training for the broader naval community.

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Materiel Seaworthiness Functional Master Set (MS FMS)

▸ MS FMS was modeled using Integrated Definition Method (IDEF0) method.

▸ The suite of IDEF methods has roots in Structured Analysis and Design, and was developed by the US Air Force Integrated Computer Aided Manufacturing (ICAM) program in the 70s.

▸ IDEF0 is a rigorous functional modelling method and was selected for its syntax simplicity to ease the engagement with senior Navy stakeholders.

IDEF0 standard A0-Context Diagram

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Materiel Seaworthiness Functional Master Set (MS FMS)

▸ The MS FMS has over 80 functions and 165 data items.

▸ Top-levels of the Materiel Seaworthiness Functional Master Set (MS FMS) are shown below.

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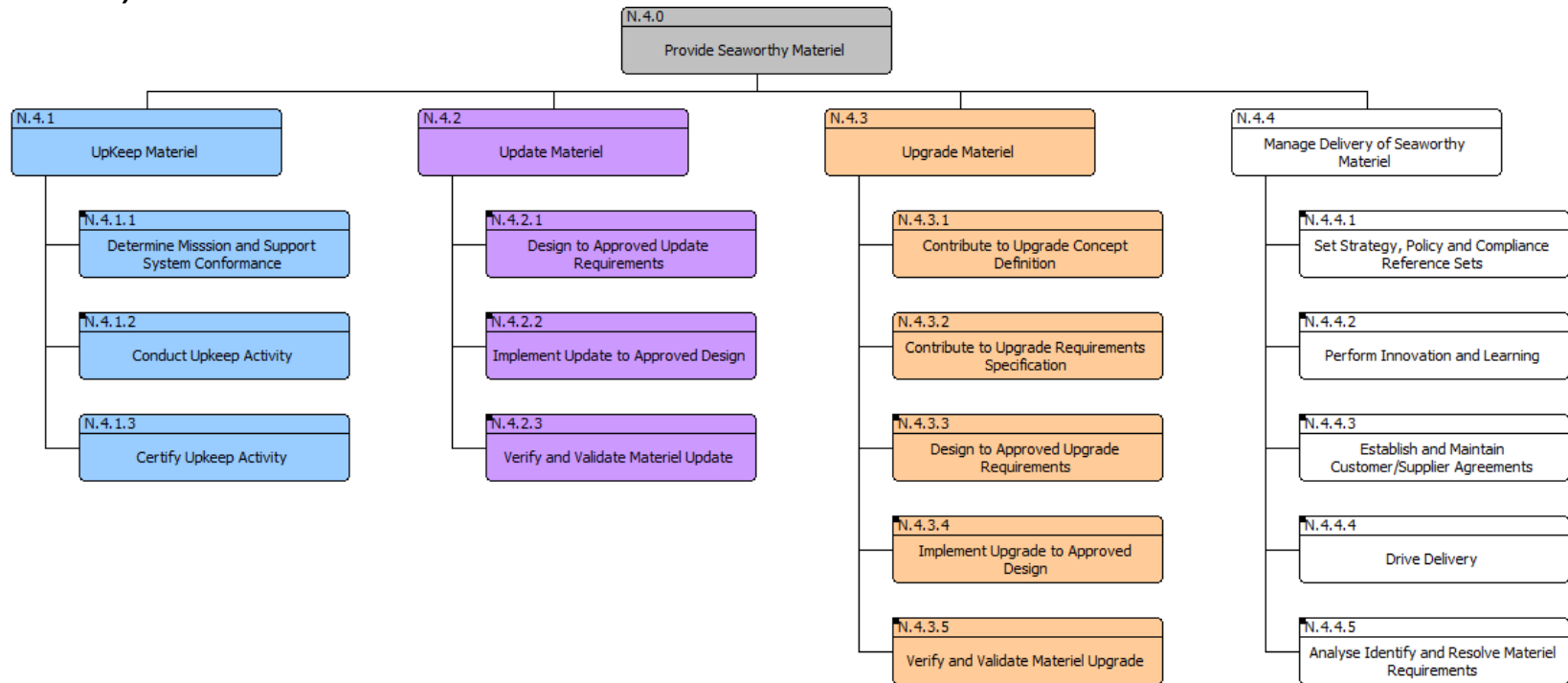
Materiel Seaworthiness Functional Master Set (MS FMS)

▸ A Sample MS FMS IDEF0 Diagram, function *N4.4.3 Establish and Maintain Customer/Supplier Agreements*

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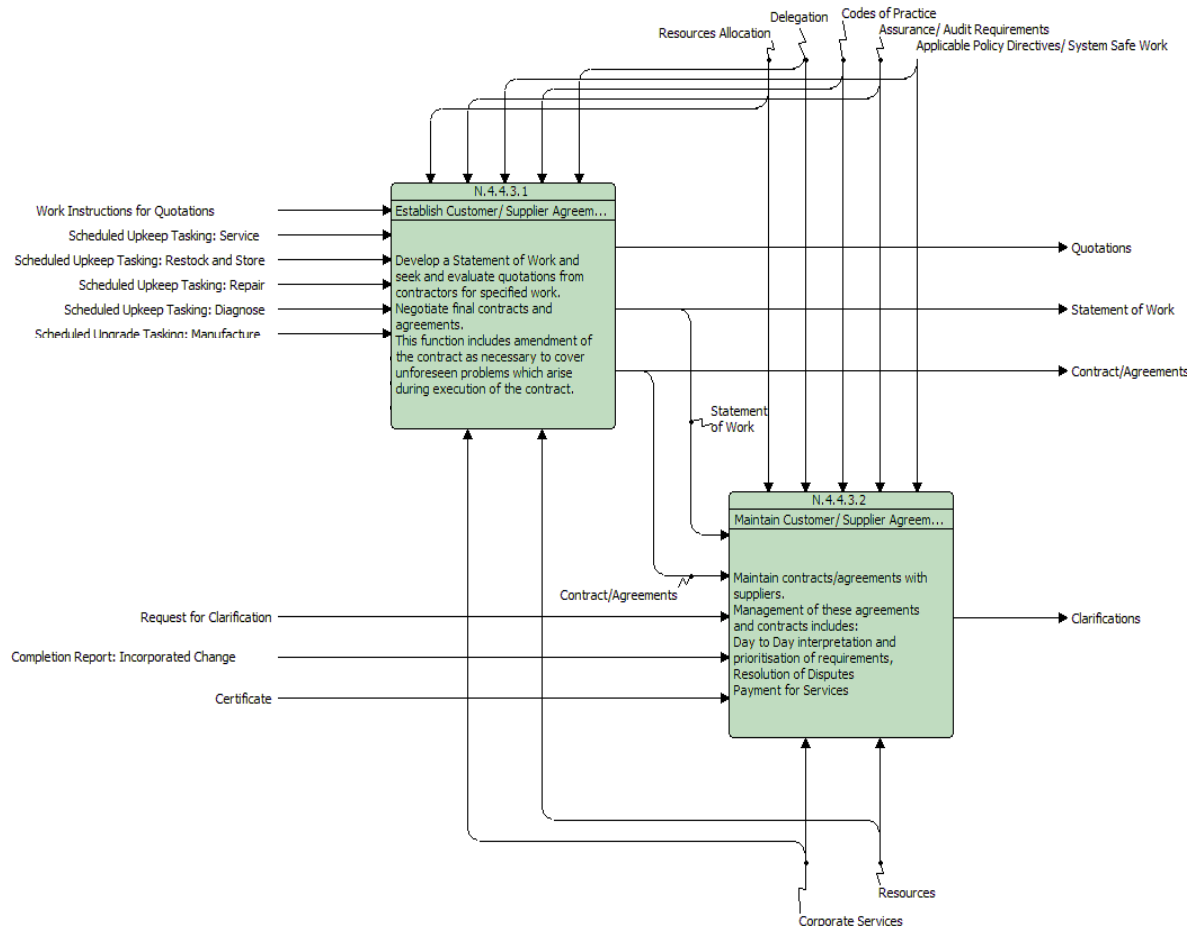
MS FMS Pilot Traffic Light System

- To further the quest to balance effective delivery with efficient resource allocation, the MS FMS is being equipped with a Traffic Light System (TLS) analysis capability" to:
  - Facilitate "what if" analysis; and
  - Ascertain indicative enterprise's functional health status to inform resource allocation and planning activities.

- TLS Design Concept:
  - A function's health is dependent on its inputs, controls and mechanisms;
  - If we quantify the relative importance of inputs, controls and mechanisms, we can predict the likely-hood of a given function in delivering its outputs
    - based on the availability and/or deficiency of its inputs, controls or mechanisms.

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MS FMS Pilot Traffic Light System

▸ A healthy function will then produce good outputs (or otherwise affected or impaired), which than enter other functions as either inputs, controls or mechanisms.

▸ The effect of a change can be assessed as it generates a ripple impact throughout the MS FMS model.

Controls

Government & Defence Policies

Legislation

Input *Materiel*

Output
Seaworthy Materiel

Support Tools & Test Equipment

Support Facilities and Ranges

Mechanisms

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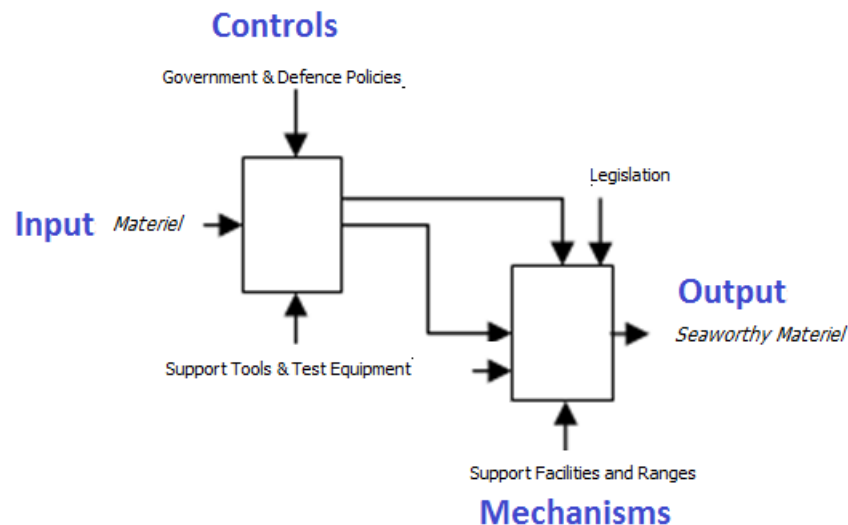
MS FMS Pilot Traffic Light System

▸ The MS FMS Traffic Light system is being piloted, adopting the Multi-Attribute Value Analysis (MVA) method to quantify the importance of inputs, controls and mechanisms to a given function.

▸ MVA is a quantitative method for choosing the best option from a set of alternatives based on conflicting stakeholders' preferences or objectives.

▸ This analytical capability is being developed and evaluated with senior stakeholders to determine its applicability and efficacy in informing assessments of high-level organisational health and resource allocation.

High-Level Attributes

```
                    ┌─────────────────┐
                    │ Function Health │
                    │     Status      │
                    └─────────────────┘
```

| Input Role (40%) | Control Role (30%) | Mechanism Role (30%) |

Low-Level Attributes

| Input 1 Priority (25%) | Input 2 Priority (25%) | Input 3 Priority (25%) | Input 4 Priority (25%) |
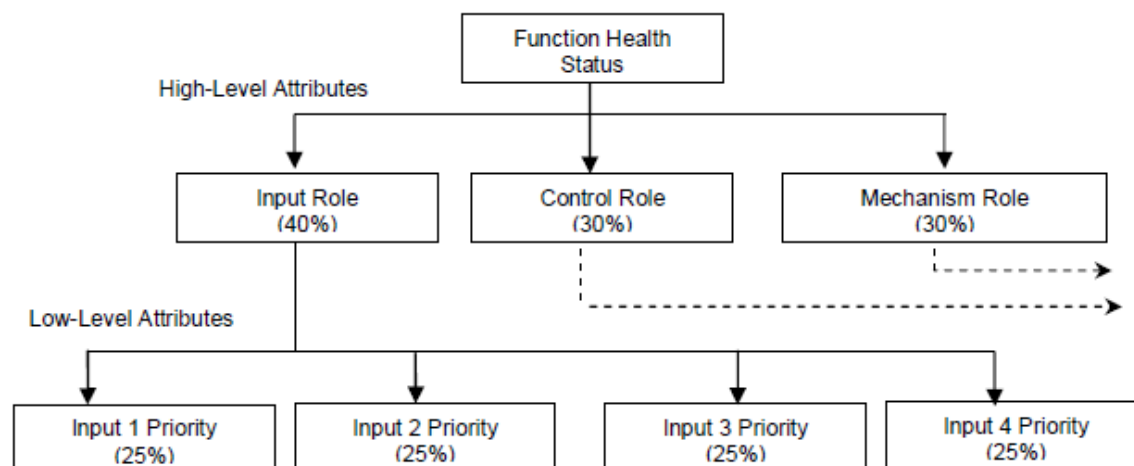
An Example: Quantify the importance of inputs, controls and mechanisms

$$V(\mathbf{x}) = \sum_{i=1}^{N} w_i v_i(x_i)$$

Where:

$V(X)$ is the overall value function;

w_i is the relative weight; and

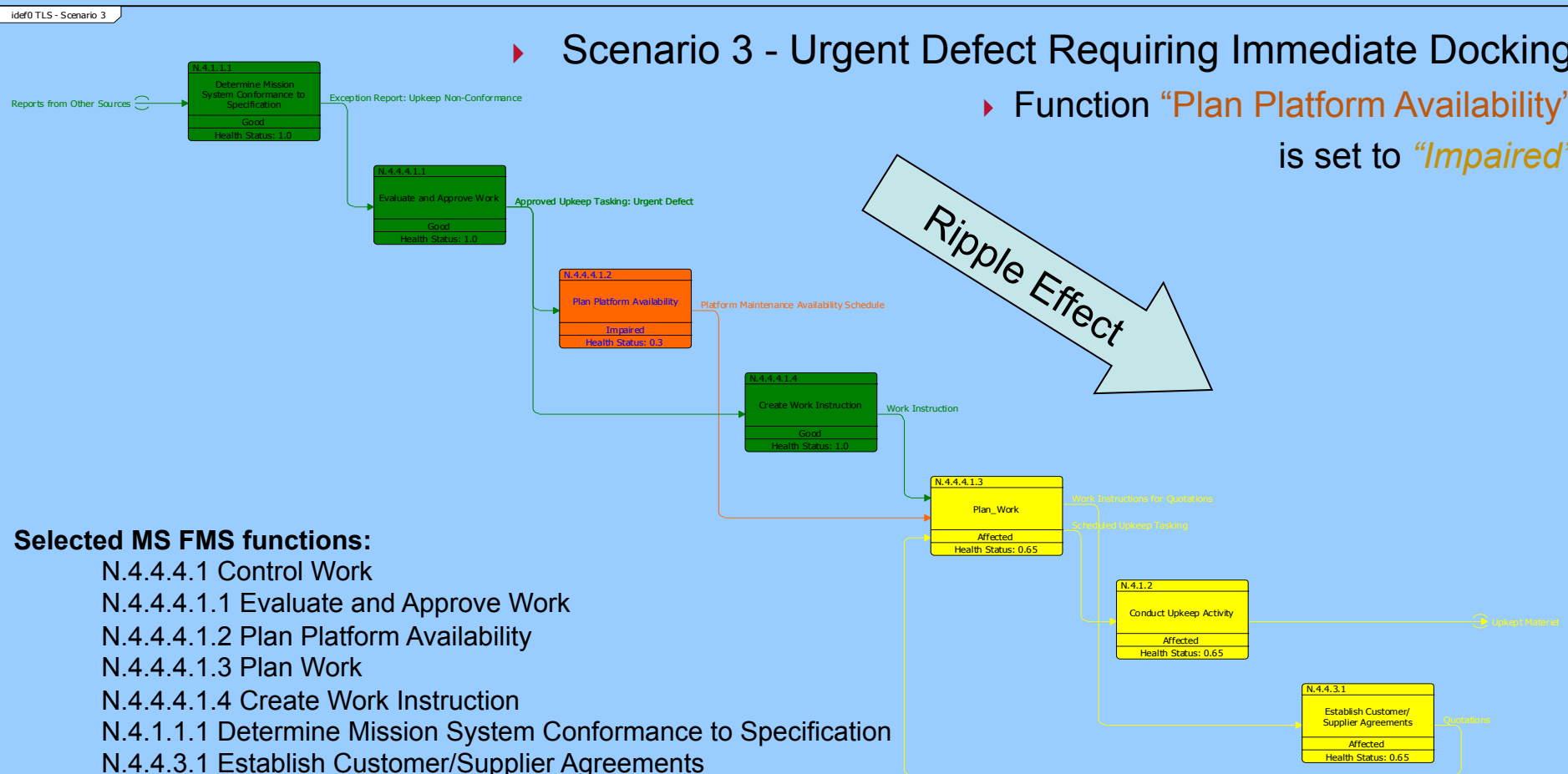$v_i(x_i)$ is the individual score for each criteria.

N is the number of attributes

MVA Equation for aggregating of objectives

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MS FMS Pilot Traffic Light System: Example 1 – IDEF0 Diagram

Scenario 3 - Urgent Defect Requiring Immediate Docking

Function "Plan Platform Availability" is set to "Impaired"

Selected MS FMS functions:
- N.4.4.4.1 Control Work
- N.4.4.4.1.1 Evaluate and Approve Work
- N.4.4.4.1.2 Plan Platform Availability
- N.4.4.4.1.3 Plan Work
- N.4.4.4.1.4 Create Work Instruction
- N.4.1.1.1 Determine Mission System Conformance to Specification
- N.4.4.3.1 Establish Customer/Supplier Agreements

Project:		Organization:		Date:	
	MS FMS TLS_Pilot V1.1		Frazer-Nash Consultancy Ltd		13 July 2015

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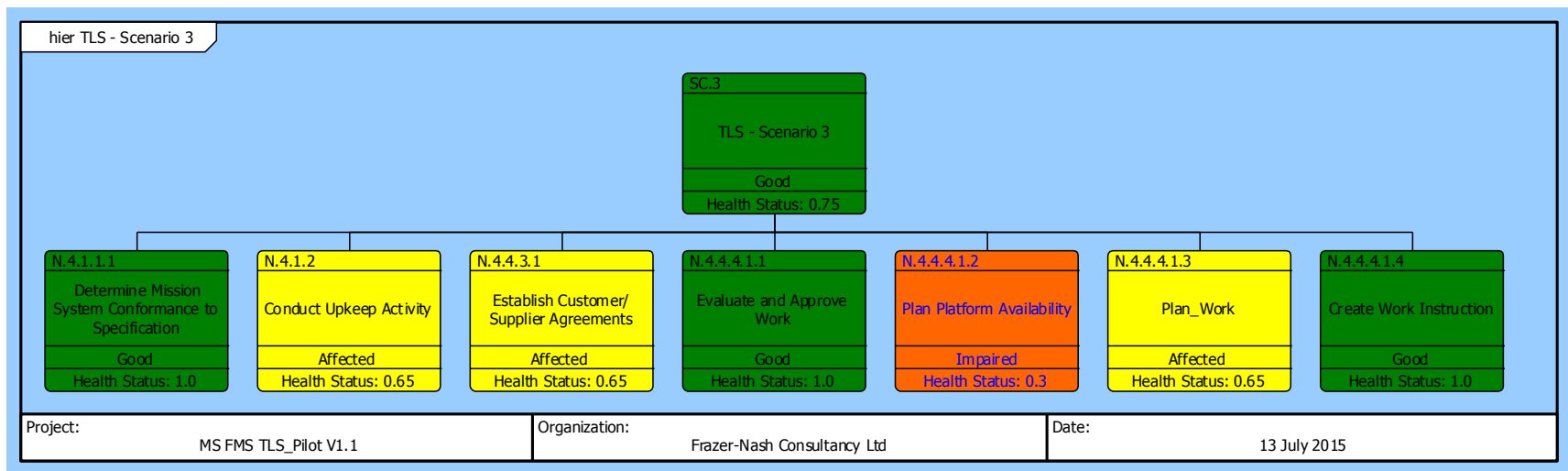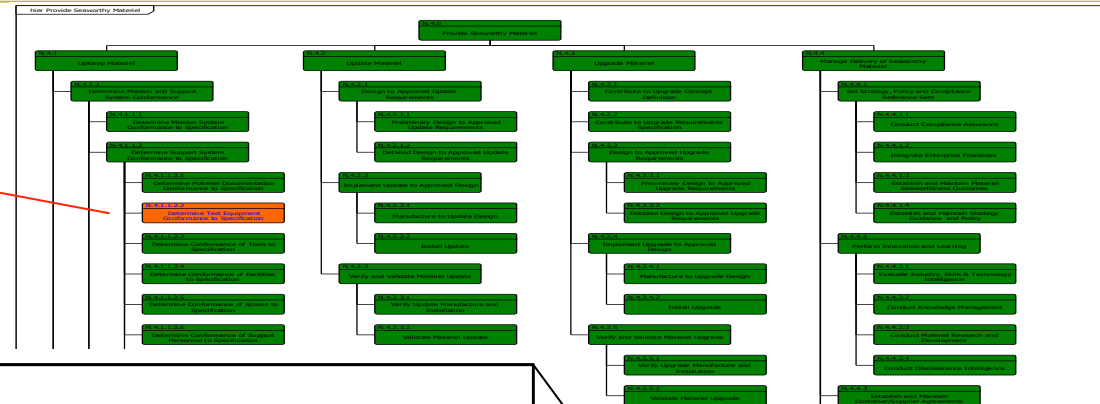
MS FMS Pilot Traffic Light System: Example 1 – Hierarchical View

▸ Scenario 3 - Urgent Defect Requiring Immediate Docking

  ▸ Function "Plan Platform Availability" is set to "Impaired"
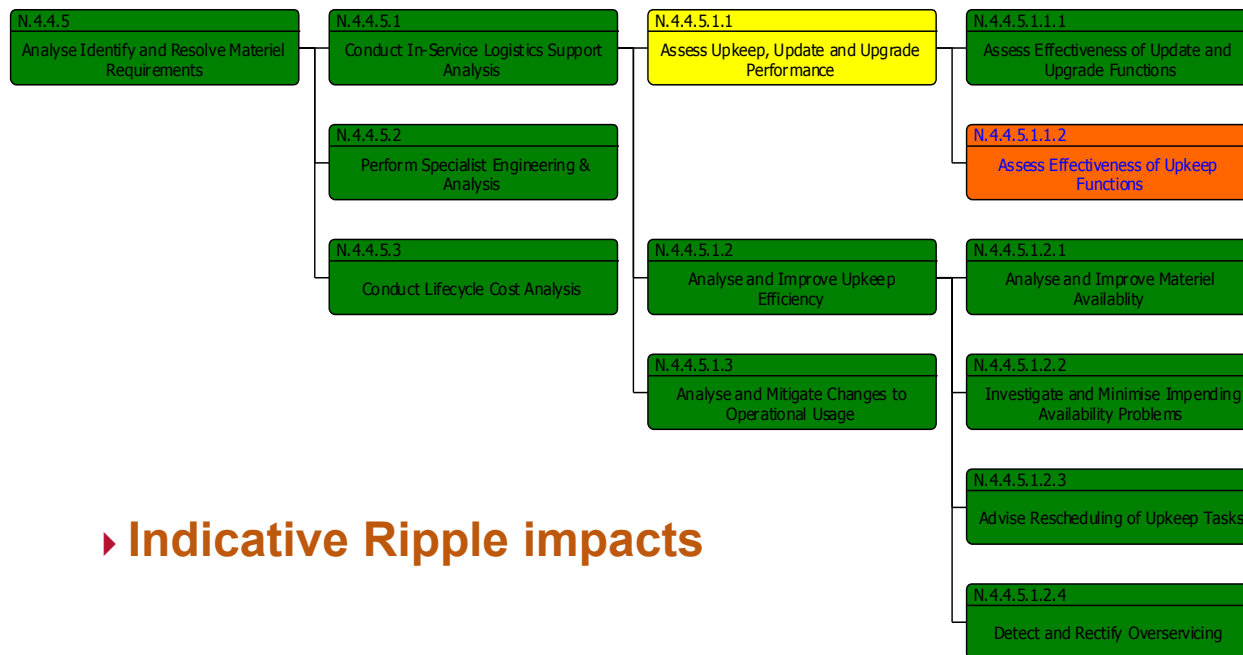
    ▸ Hierarchical View of the ripple impact of change

hier TLS - Scenario 3

SC.3
TLS - Scenario 3
Good
Health Status: 0.75

N.4.1.1.1	N.4.1.2	N.4.4.3.1	N.4.4.4.1.1	N.4.4.4.1.2	N.4.4.4.1.3	N.4.4.4.1.4
Determine Mission System Conformance to Specification	Conduct Upkeep Activity	Establish Customer/ Supplier Agreements	Evaluate and Approve Work	Plan Platform Availability	Plan_Work	Create Work Instruction
Good	Affected	Affected	Good	Impaired	Affected	Good
Health Status: 1.0	Health Status: 0.65	Health Status: 0.65	Health Status: 1.0	Health Status: 0.3	Health Status: 0.65	Health Status: 1.0

Project:		Organization:		Date:	
	MS FMS TLS_Pilot V1.1		Frazer-Nash Consultancy Ltd		13 July 2015

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MS FMS Pilot Traffic Light System: Example 2

▸ N.4.1.1.2.2 Determine Test Equipment Conformance to Specification set to *"Impaired"*

▸ **Indicative Ripple impacts**

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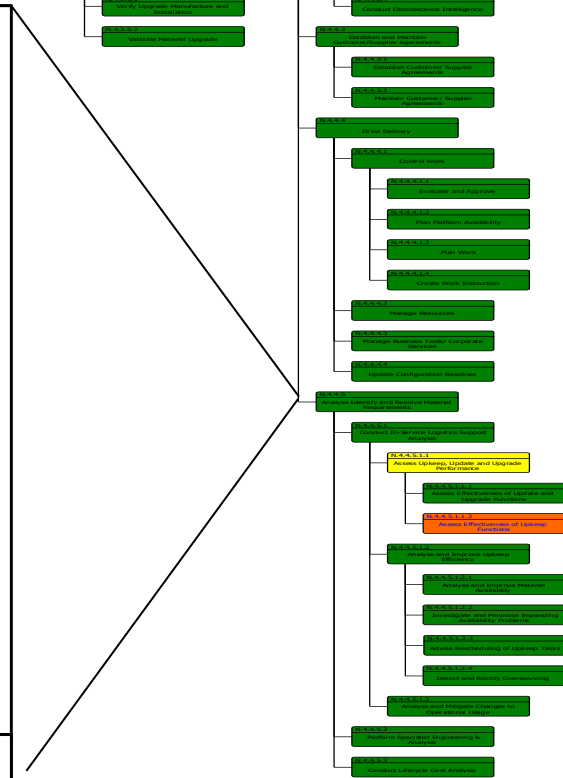
Dr Quoc Do
Frazer-Nash Consultancy (Australia)
Adelaide, South Australia, Australia
Email: q.do@fncaustralia.com.au
Ph: (08) 7325 4200

www.fncaustralia.com.au

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