

SysEng 6542

Model Based Systems Engineering

MBSE Foundation

Dr Quoc Do

What is Systems Engineering?

Systems engineering is the overarching process that a program team applies to transition **from a stated capability need to an operationally effective and suitable system**. Systems engineering encompasses the application of systems engineering processes across the acquisition life cycle (*adapted to each and every phase*) and is intended to be the integrating mechanism for balanced solutions addressing **capability needs, design considerations** and **constraints**, as well as limitations imposed by technology, budget, and schedule.

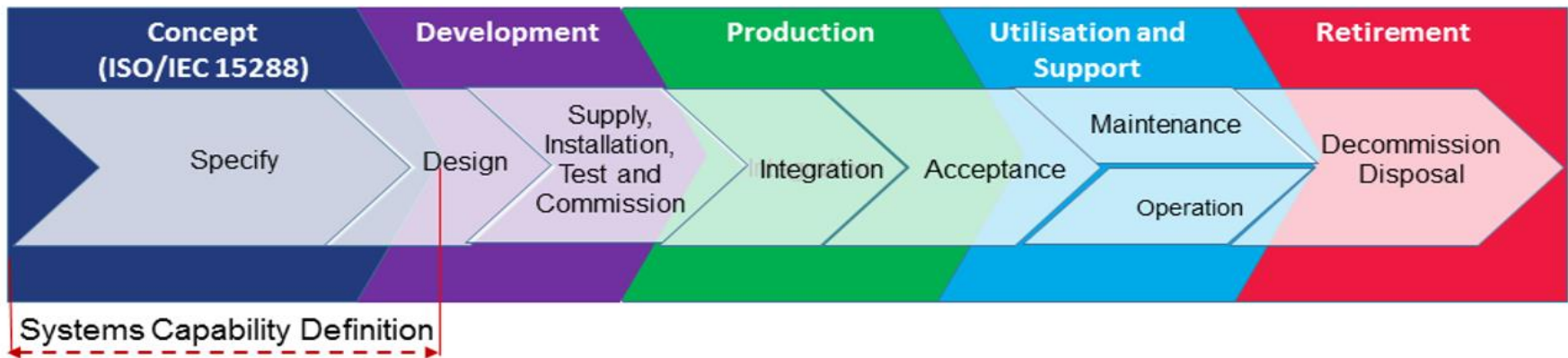
From the Defense Acquisition Guide Book

Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining **customer needs** and **required functionality** early in the development cycle, documenting **requirements**, then proceeding with design synthesis and system validation while considering the complete problem: **operations, performance, test, manufacturing, cost and schedule, training and support, and disposal**. Systems Engineering **integrates** all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the **business and the technical needs** of all customers with the goal of providing a quality product that meets the user needs.

From the International Council on Systems Engineering (INCOSE)

Systems Engineering Lifecycle

(ISO/IEC/IEEE:15288)



System Lifecycle

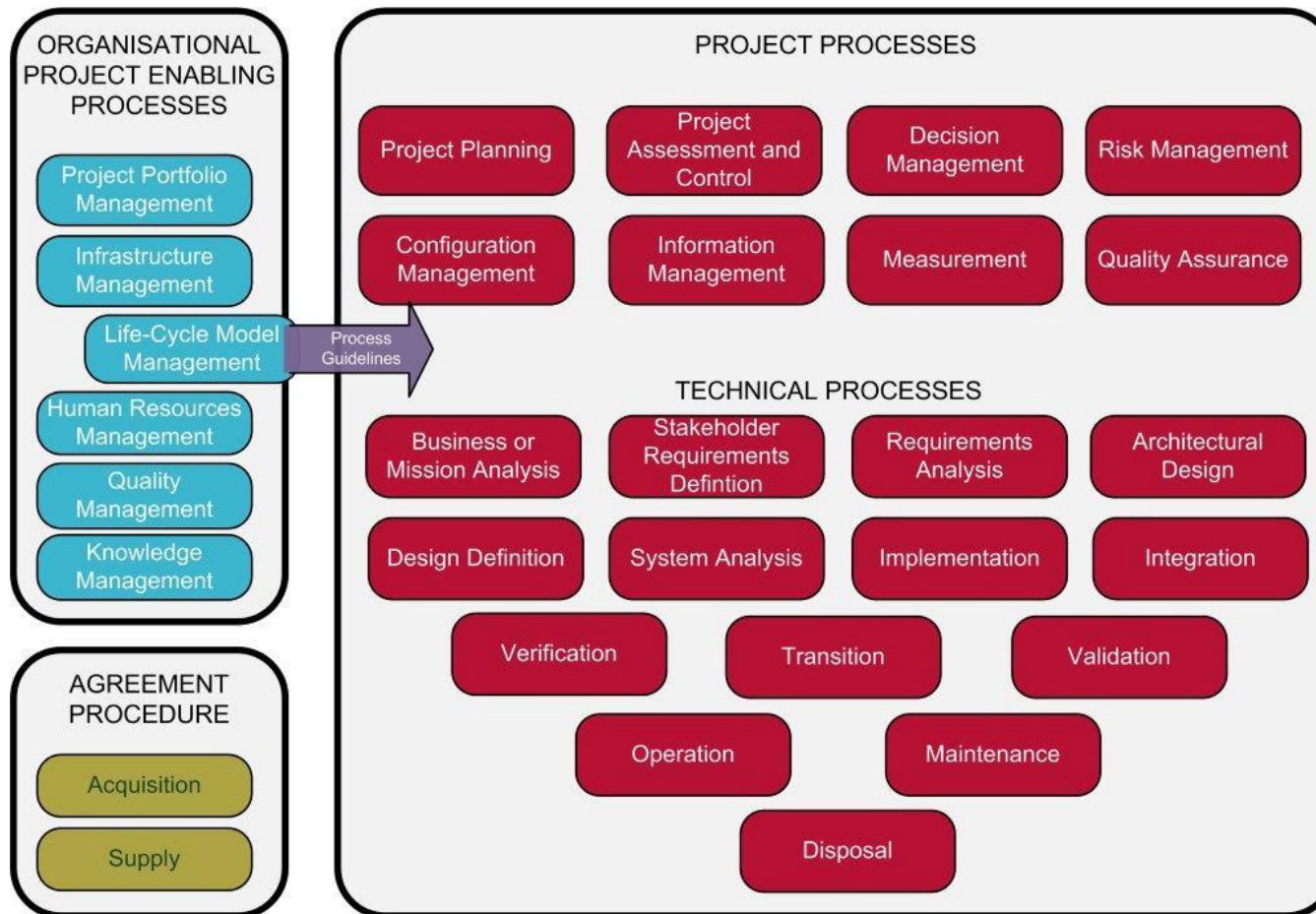
Project Lifecycle

Sustainment
LOTE

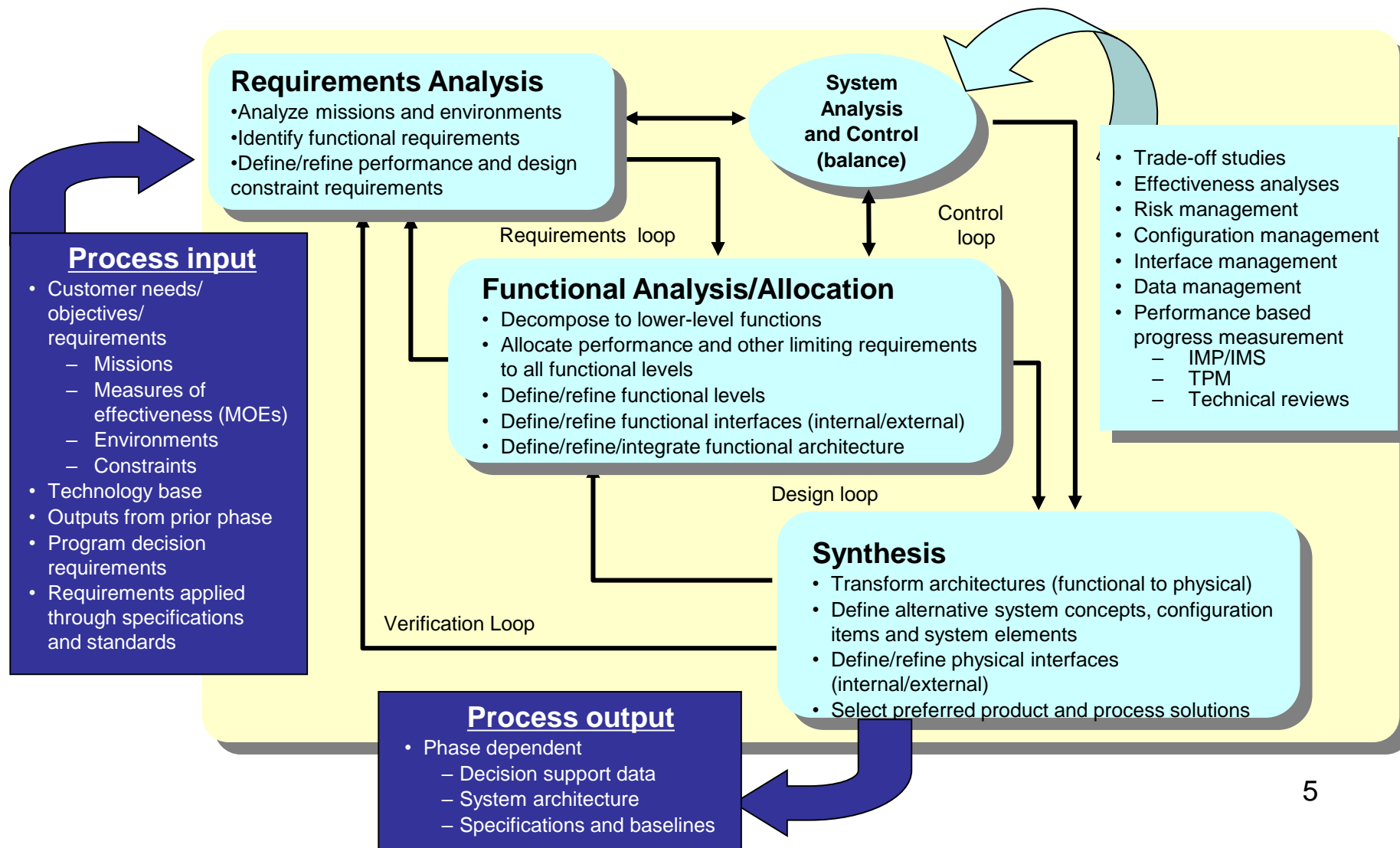


Systems Engineering Processes

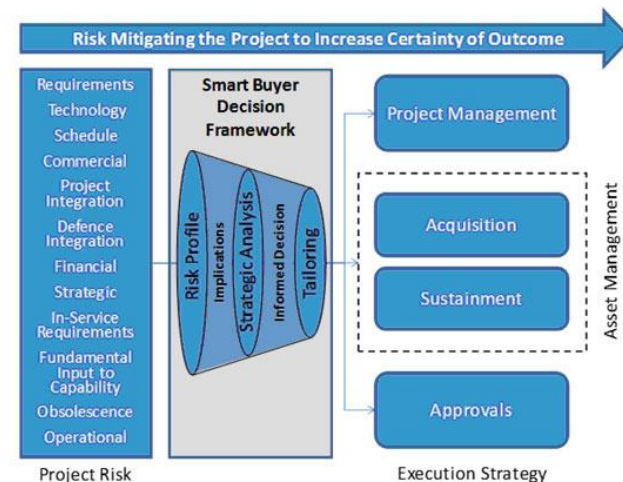
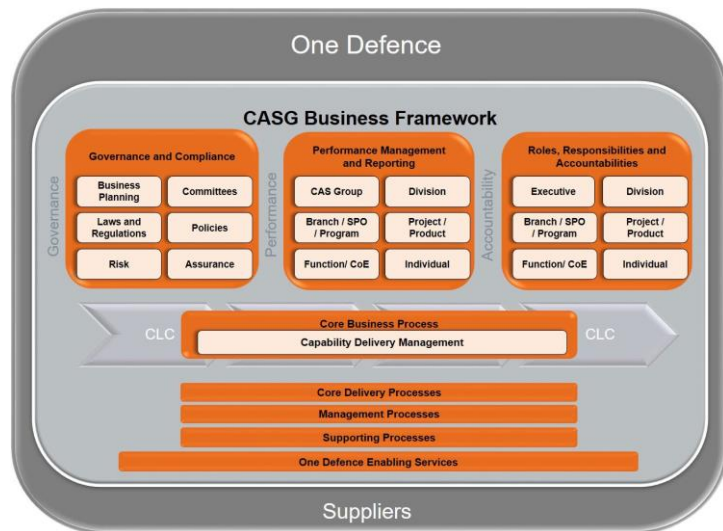
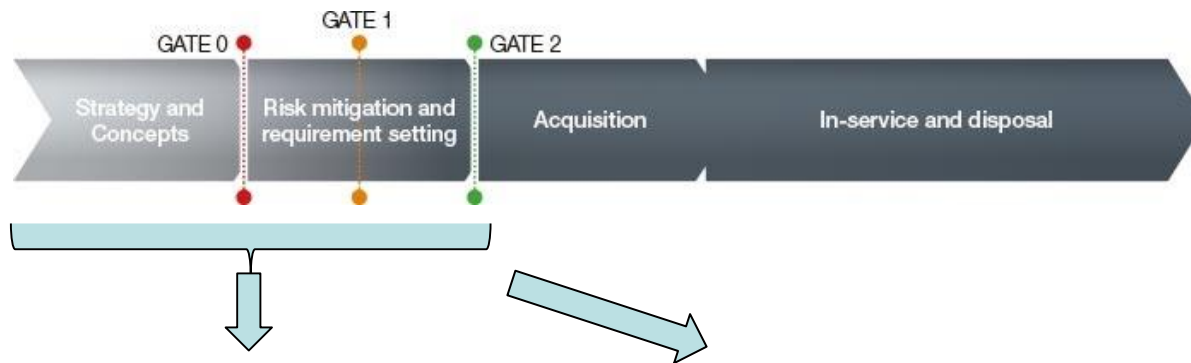
(ISO/IEC/IEEE:15288)



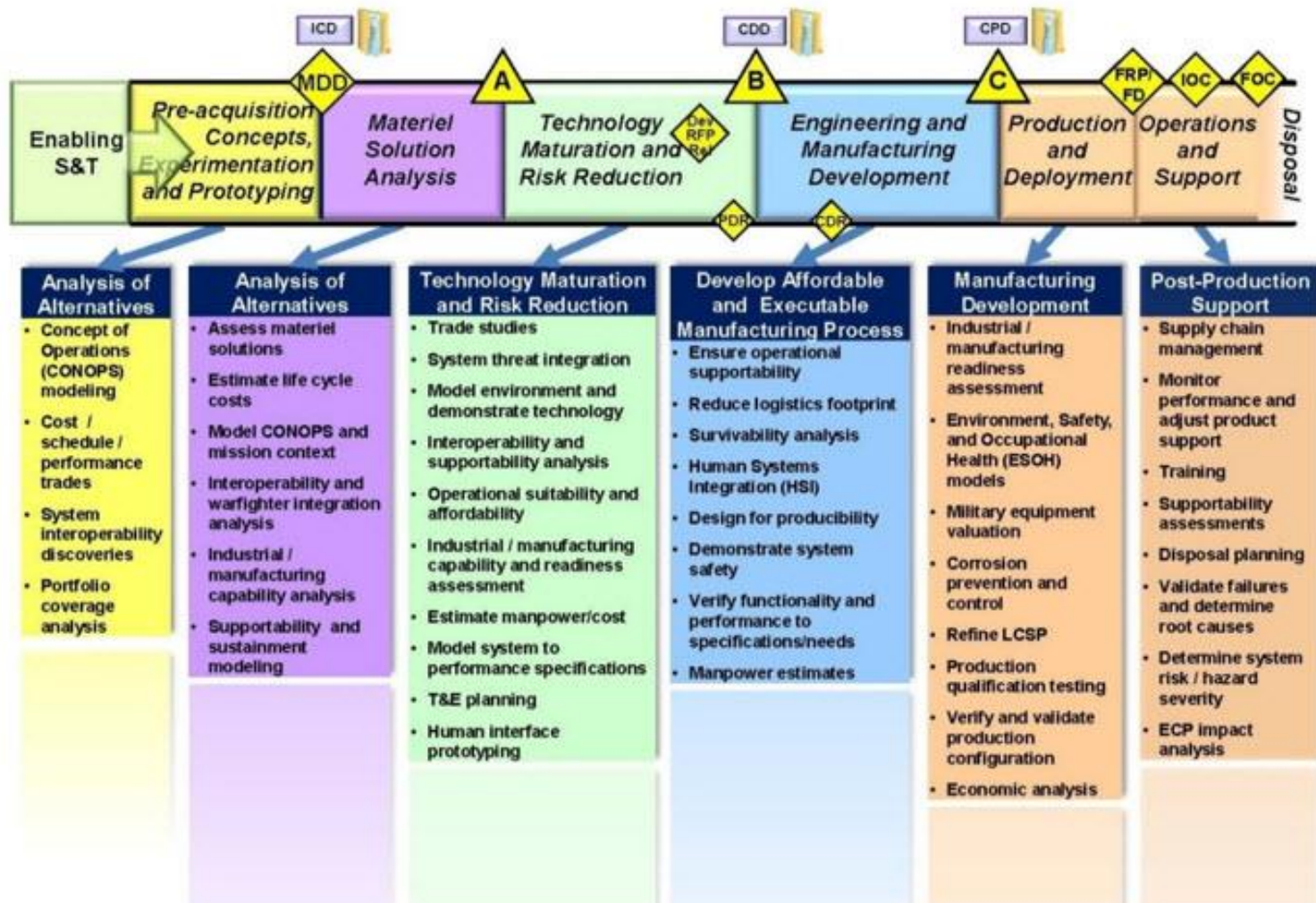
Traditional Systems Engineering Process



Systems Engineering Practice in Defence and Industry (Australia)

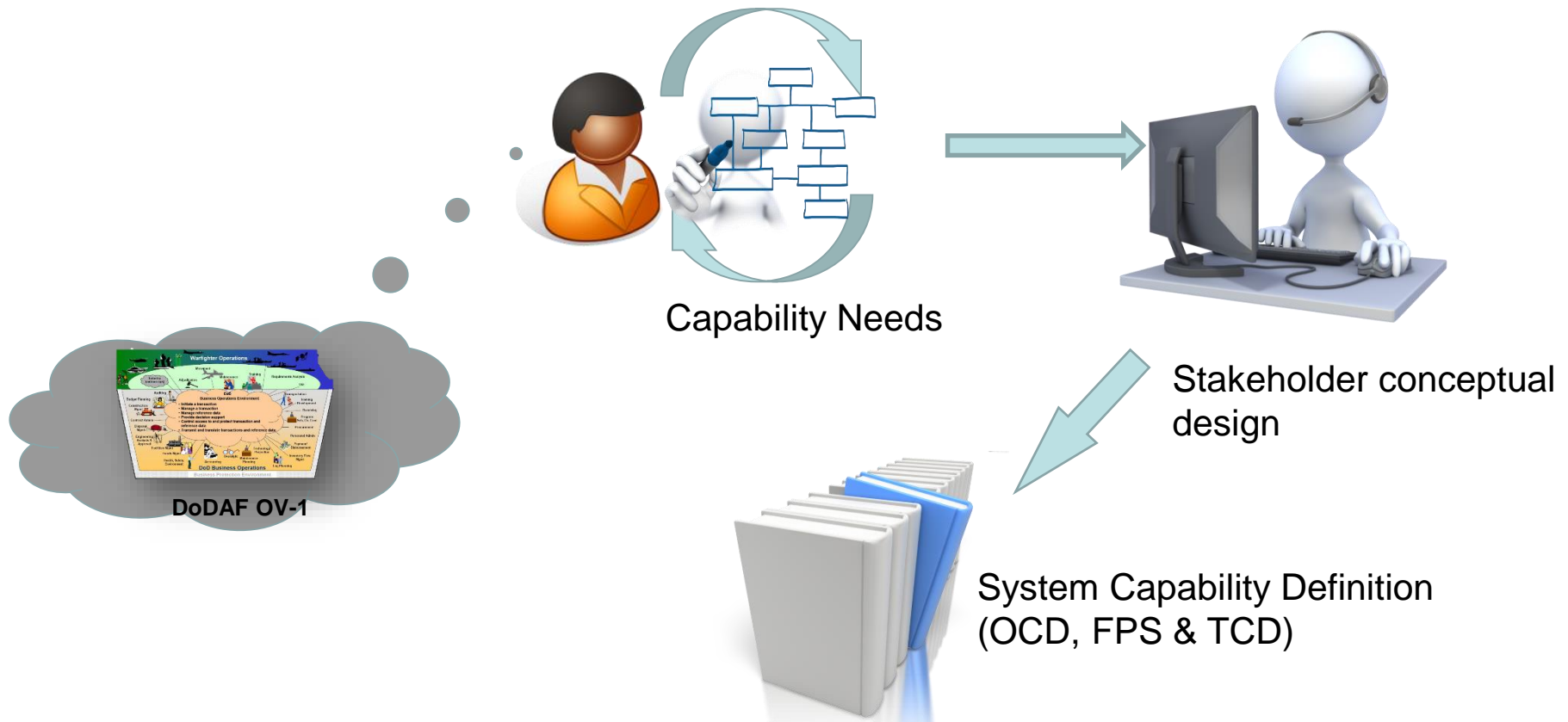


Systems Engineering Practice in Defence and Industry (USA)



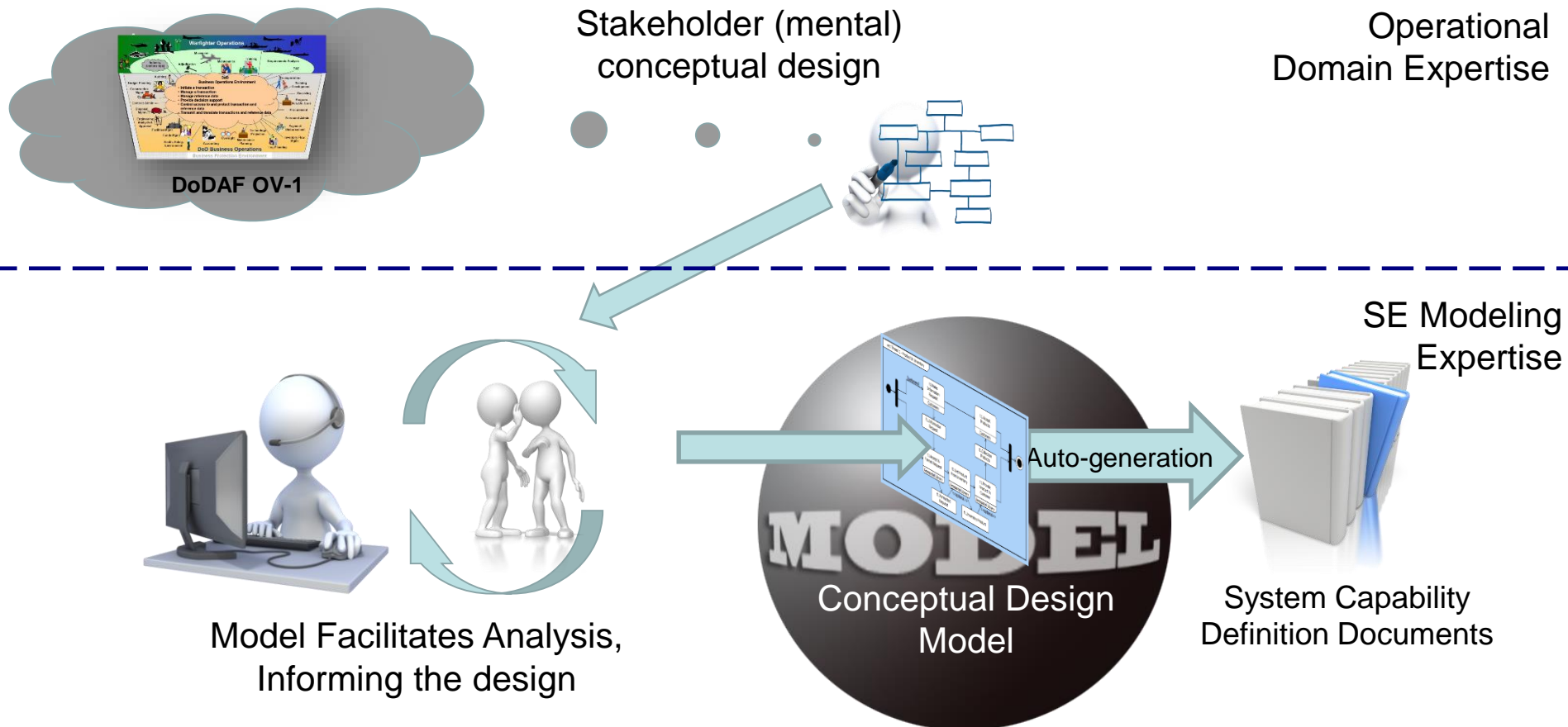
Systems Engineering Practice in Defence and Industry

The “As Is” document-centric front-end systems engineering practice



The documents are the primary artifacts

Introduction of Model-Based Systems Engineering



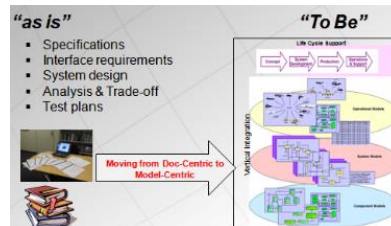
The model is the primary artifact, the reference for all communications

Introduction of Model-Based Systems Engineering

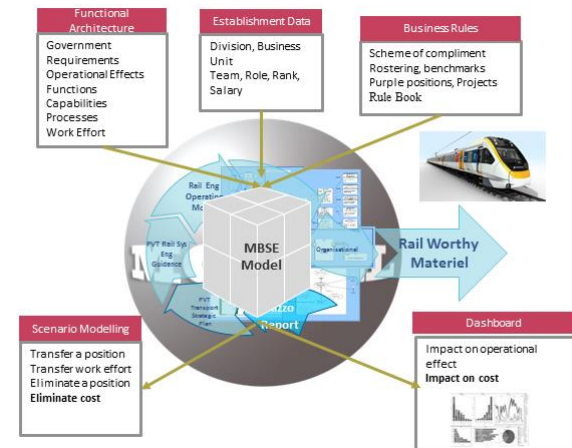
Traditional



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



"Future State"



Transitioning Systems Engineering practices from document-centric to model-centric

MBSE Definition

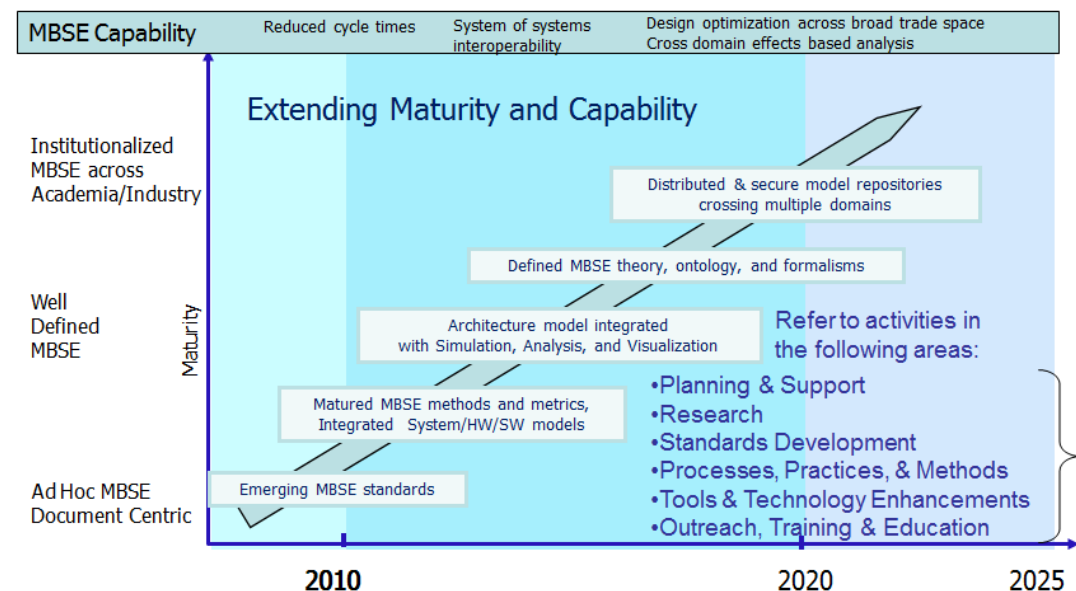
“Model-based systems engineering (MBSE) is the *formalized application of modeling* to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later lifecycle phases.”

INCOSE SE Vision

“Model-Based Engineering (MBE): An approach to engineering that *uses models as an integral part of the technical baseline* that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition lifecycle.”

Model-Based Systems Engineering Roadmap

- The INCOSE Systems Engineering vision states that "... in many respects, the future of systems engineering can be said to be 'model-based'...."
- INCOSE MBSE Initiative has developed a roadmap, outlining key milestones for MBSE research, adoption and development.



INCOSE MBSE Initiative – Roadmap

INCOSE 5-year strategic objective to transition systems engineering to model-centric systems engineering

Introduction to Model-Based Systems Engineering

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

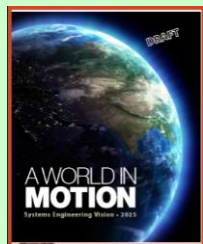
- **Estefan's methodology survey (Estefan, 2010):**
 - *IBM's Telelogic Harmony – Systems Engineering*
 - *Vitech's MBSE Methodology [and its extension Whole-System Analytical Framework (WSAF)]*
 - *IBM's Rational Unified Process for Systems Engineering (RUP SE)*
 - Jet Propulsion Laboratory's State Analysis
 - Dori's Object-Process Methodology (OPM)
 - ***INCOSE's Object-Oriented Systems Engineering Method (OOSEM)***

Introduction to Model-Based Systems Engineering

Elements of MBSE Practice

- **SE Process Standard:**

- ISO 15288
- IEEE 1220
- EIA 632
- INCOSE SE Handbook
- ...



- **SE Foundation:**

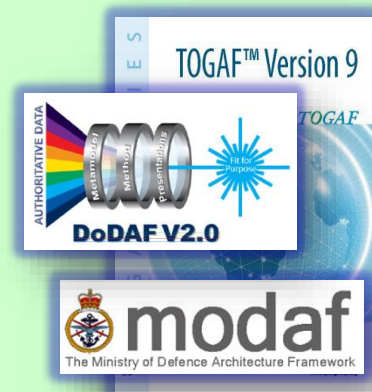
- Systems thinking
- Systems science
- Systems theory
- Lean principles
- ...

- **Knowledge management:**

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

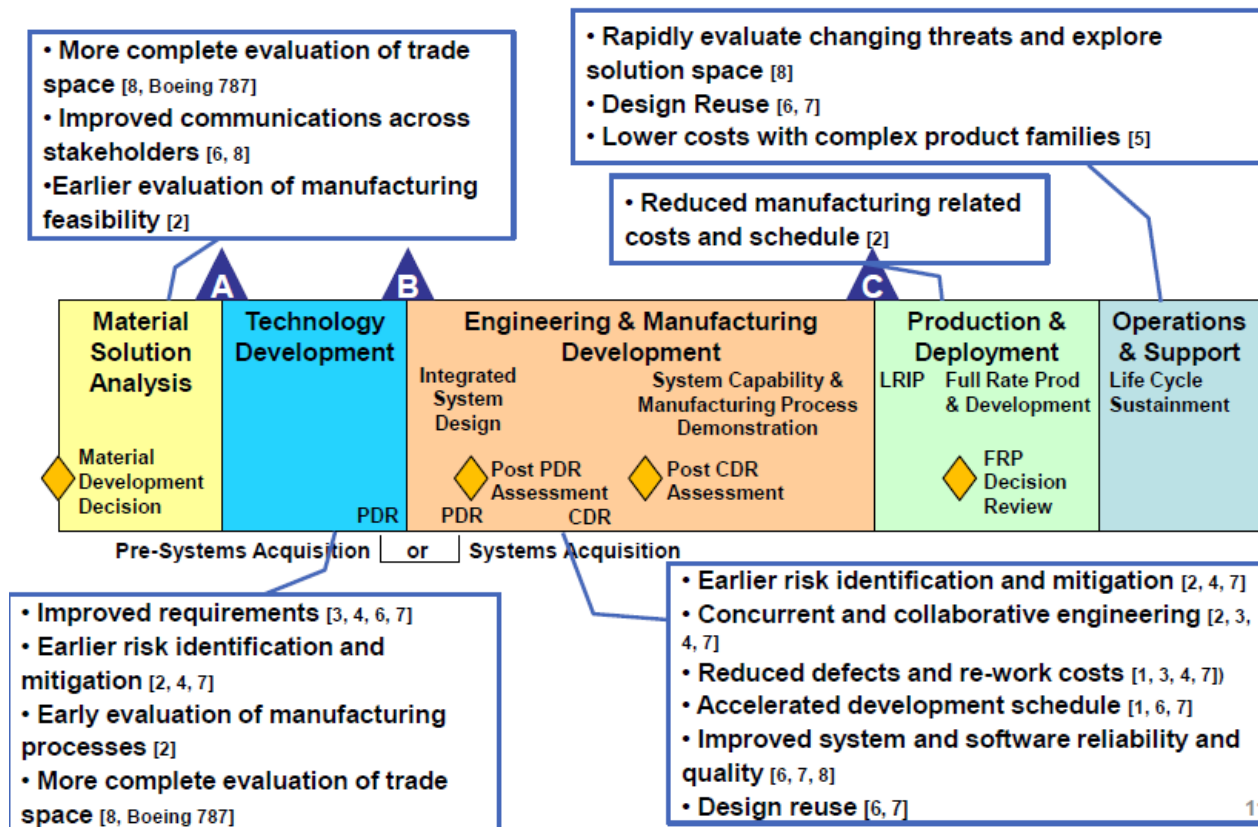
- **Framework:**

- DoDAF
- TOGAF
- MODAF
- NAF
- ...



MBSE is “more” than just its tools and languages

Introduction to Model-Based Systems Engineering



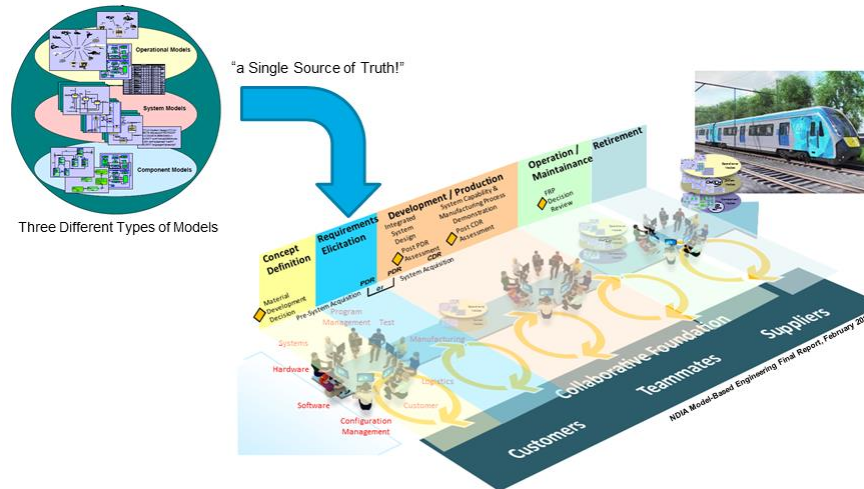
(Extracted from Bergenthal, 2011)

The NDIA final report shows the application and benefits of model-based engineering across the acquisition lifecycle.

System Engineering – Common Themes

- Top-Down Approach
- Lifecycle Perspective
- System Requirements Emphasis
- Interdisciplinary/Integrated Team Approach

MBSE Practice

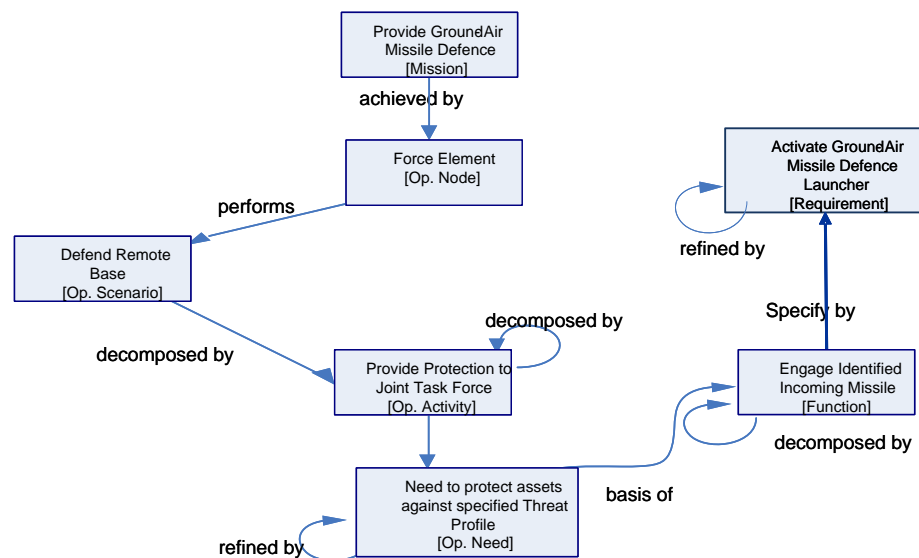


Classification of Models

- Descriptive Models – charts and diagrams
- Physical Models – geometric equivalents, either as miniatures, enlargements, or duplicates
- Analogue Models – focus on similarity in relations
- Mathematical Models – focus on performance analysis

MBSE Benefits

- Rigorous systems engineering practice
- Identify design issue early in the process
- Knowledge management
- Management of complexity
- Information sharing and management
- Single source of “truth” to inform key decisions
- End-to-end traceability (see below)



Model Examples

- A transport architecture model – Transport of New South Wales, Australia
- An enterprise model – Royal Australian Navy

Program Completed

Missouri University of Science &
Technology