

## 8. Employing Concept Definition Techniques to Deliver Value on the RAN Air Warfare Destroyer Program

**Steven J. Saunders**  
**Raytheon Australia**

### **Abstract**

Modern, complex development systems pose risks in defining the right system solution, building/integrating/delivering the capability and sustaining the capability through the complete lifecycle of that system. Major defence acquisition programs, like the SEA 4000 Royal Australian Navy (RAN) Air Warfare Destroyer (AWD) Program are no different. This presentation describes concept engineering processes employed on the AWD combat system during the capability definition stage of the Program.

Concept definition is a critical activity of any major system development, requiring a balanced approach to multiple stakeholder considerations. The AWD Program has met this challenge by employing a collaborative team approach, early systems architecting and judicious use of Model Based Systems Engineering (MBSE). In this presentation, it is shown how Operational Activity models and supporting architectural views have been successfully used to communicate the system capability with the AWD capability sponsors. As the program has progressed, this MBSE environment has been progressively expanded to include additional SysML system composition and system behaviour model elements to support the system definition activities. A significant “by-product” of the system model has been the ability to identify, quantify and perform technical risk assessment on all system interfaces in order to provide a lead indicator of the cumulative integration risk to the program. Using this information, the architecture has been incrementally refined during concept definition in order to ensure the program integration risk has been minimized whilst ensuring other key stakeholder values have been satisfied.

Key lessons from this presentation demonstrate the applicability of MBSE techniques in complex/large programs and the reality that theoretical application of MBSE must be tailored and augmented with other visualisations and tools to communicate with the variety of stakeholders engaged in the concept definition phase of the program.

### **Presenter Biography**

**Steve Saunders**, FIEAust CPEng, is an Engineering Fellow for Raytheon Australia. He received his Bachelor of Electrical Engineering from the University of Technology Sydney (UTS) with first class Honors in 1990. He has worked with Rockwell International, Boeing Australia and now Raytheon Australia on Australian Defence projects in various Systems Engineering Management, Requirements Development, Architecture, Design and Test roles. He is a Raytheon certified architect having completed the Raytheon Certified Architect Program in 2005.

# Report Documentation Page

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Steve has been involved in the Royal Australian Navy's Air Warfare Destroyer Program since 2005 as the Combat System Chief Architect working in phase 2 of the Program to establish the Combat System architecture. He is now the AWD Combat System Chief Engineer and Combat System design authority.

Steve has written numerous articles on Systems Engineering and System architecting and has an interest in improving System Engineering and System Architecting maturity and the agility of Systems Engineering to support the rapidly evolving technology environment and complexity within the defence industry.

## Presentation

**Model-Based Systems Engineering Symposium**  
**Theme: Concept Engineering**  
*Identifying and analysing capability needs*  
 27 - 28 NOVEMBER 2012, DSTO EDINBURGH, SA

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*Customer Success Is Our Mission*

**DSTO Model-Based Systems Engineering Symposium**

**Employing Concept Definition Techniques to Deliver Value on the RAN Air Warfare Destroyer Program**

Steven Saunders FIEAust CPEng  
 AWD Combat System Chief Engineer

27-28 November 2012

**REACHBACK**

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## Agenda

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- What is the Problem with Systems Engineering Today?
- How is Concept Engineering Used on the AWD Program
  - Background
  - MBSE Approach
  - Useful 'by-products'
- Lessons from the AWD Program
- Key Take-Aways
- Questions

The Term Concept Engineering is used to define the activities carried out in the "Concept Definition" phase of a Program

## What is the Problem with Systems Engineering (SE) Today?

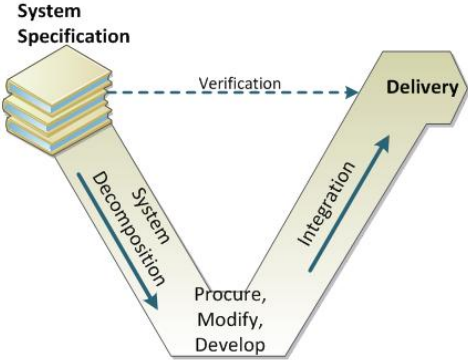
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## What is the Problem with SE Today?


➤ The **'Easy'** Phases – Systems Requirement to Delivery



- Systems Engineering Processes are mature and well understood
- Transforms Requirements to verified System
- MBSE or Document Centric or Hybrid approaches applicable
- Reasonable tool support

But...

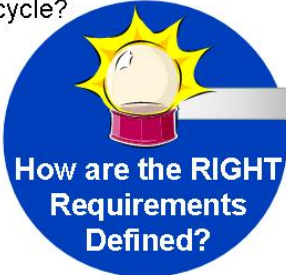
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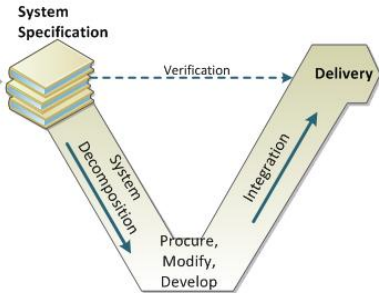
## What is the Problem with SE Today?

➤ Assertion → There is a Problem!

- How are the **right** requirements defined?
  - Will the realisation of the requirements be affordable?
  - Can the requirements be verified?
  - Realisable in available technology?
  - Considers full lifecycle?
  - Meets the need?



**How are the RIGHT Requirements Defined?**



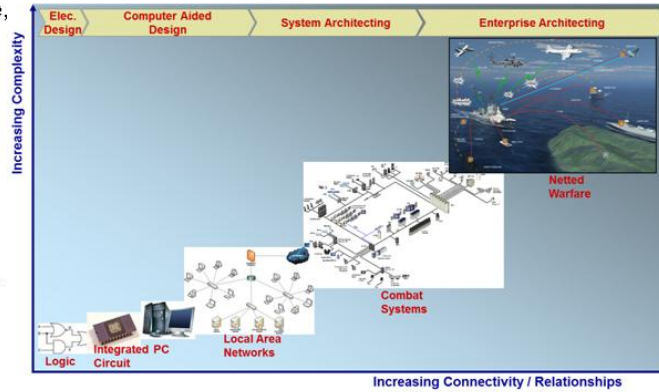
Concept Definition (Concept Engineering)  
Helps Ensure the Right Requirements are Specified

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## What is the Problem with SE Today?

> Why may Concept Definition Phase be Skipped or Superficially Addressed? -- It is **HARD!**

- **SOFT** Engineering
  - Business Language,
  - Fuzzy Criteria,
  - Best fit rather than exact answers
- It is **COMPLEX...**
  - Components
  - Systems
  - Enterprises
  - People / Processes
  - Sociological
  - Political
  - Environmental




Concept Definition is HARD(er) than System Definition  
Often Overlooked – Has potential For High Impact on Program

## HOW IS CONCEPT ENGINEERING USED ON SEA4000 AWD PROGRAM




## How is Concept Engineering used on AWD - Background



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- The Royal Australian Navy's (RAN) Air Warfare Destroyer (AWD) Program is employing a mix of strategies and contracting mechanisms to deliver a new major surface combatant to the RAN within an aggressive timeframe
- 8 Years to...
  - Select Equipment and Complete the Design
  - Build Shore Facilities & Integration Facilities
  - Build the Shipyard
  - Build the Lead Ship
  - Integrate and deliver the Capability
- The AWD Program
  - has met major Program milestones,
  - has passed System CDR,
  - keel Layed – Future Destroyer HOBART
  - ship blocks for all 3 ships are in production,
  - has excellent customer relationships,
  - is scheduled to deliver the required capability to the RAN in 2016



Courtesy AWD Alliance


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## How is Concept Engineering used on AWD – A new Way of Doing Business

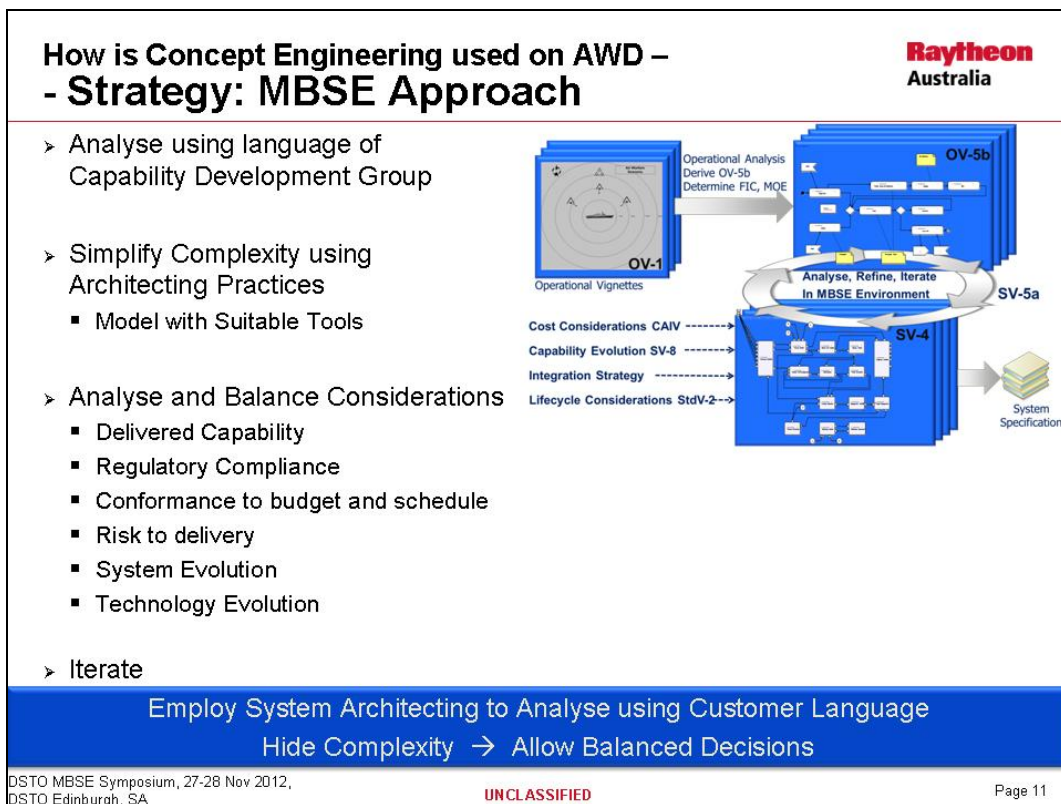
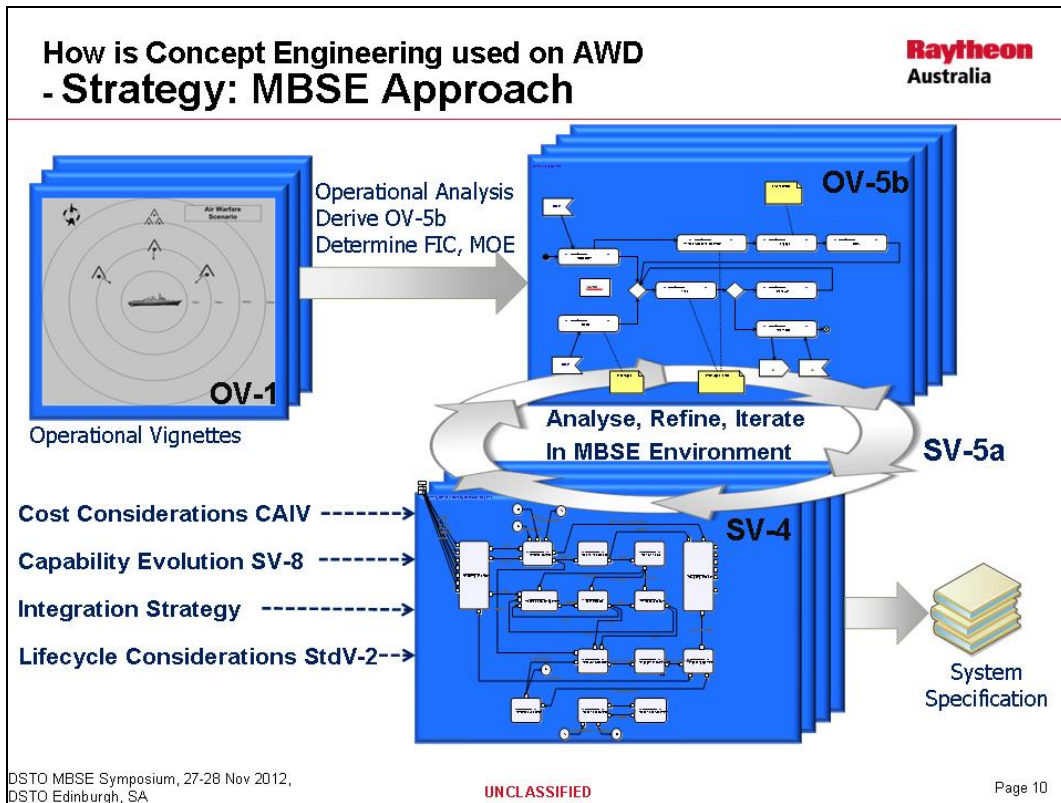


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- RAN Requires a new Capability “No Later Than” with Set Funding
- Schedule/Cost Constraints Require...
  - Collaboration between the Customer and the Mission System Integrator (MSI)
  - Stakeholders to Work Cooperatively for Improved Program Performance and Agility
  - Rapid Development of the Capability (MOTS/COTS vs New Development)
- Ensuring the System is Supportable for the Life of Type



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## How is Concept Engineering used on AWD – MBSE Architectural Model

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The diagram illustrates the MBSE Architectural Model, divided into two main sections: **Operational / Regulatory Viewpoint** (top, green background) and **System Definition Views** (bottom, blue background). The **Operational / Regulatory Viewpoint** includes **Operational Vignettes**, **Use Cases**, **(Operational) Activity Diagrams**, **Visualisations**, and **Technical Integrity Risk**. The **System Definition Views** include **System Activity Diagrams**, **Functional Hierarchy**, **Data Models**, **Block Definition Internal Block Diagrams**, **State Machines**, **Sequence Diagrams**, **Interface Report - IRL Ranking**, and **Integration and V&V Planning**. The entire model is situated within the **MBSE Environment**.

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## How is Concept Engineering used on AWD – Apply MBSE Where Appropriate

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This diagram is identical to the one on page 12, but with two blue horizontal bars overlaid. The top bar, labeled **Language of the Business / Stakeholders**, spans the **Operational / Regulatory Viewpoint** section. The bottom bar, labeled **Language of Engineers**, spans the **System Definition Views** section.

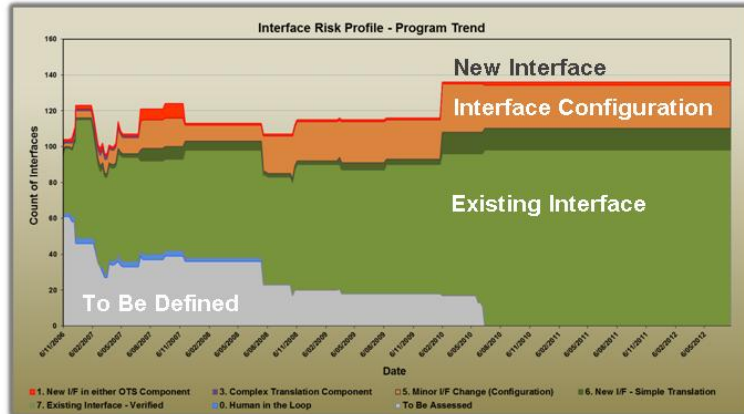
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## How is Concept Engineering used on AWD – By-Product: Minimise Integration Risk

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- Model contains all interfaces
  - Assign Interface risks (Interface Technology Level & Complexity)
  - Assess Risk Profile
  - Tune the Architecture
  - Minimise Integration Risk



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## LESSONS FROM THE SEA 4000 AWD PROGRAM



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## Lessons From the AWD Program

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- Employ System Architecting early
- Able to model capability using SYSML → Effective CDG Interactions
- Simplified complexity enables effective decision process
  - Employment of CAIV
  - Considerations for System Evolution
  - Considerations of Technology Evolution
  - Integration of Integration Strategies
- Full Employment of all SYSML elements not required (or desired)
- IP / ITAR Restrictions Constrains Completeness of a single model
- Supports Integration Risk Assessment
- MBSE helps highlight compatibility & terminology issues

Up-Front Effort in Concept Engineered  
increases confidence the capability can be developed and delivered

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## Key Take Aways


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- > Do not start with Requirements!! Define the Problem
- > Undertake Concept Definition in the Customer/User Language
- > Hide Complexity → Complexity is an enemy
- > Iterate the reference architecture / consider broad business considerations
- > Balance near term (Delivery) as well as Sustainment needs
- > Apply MBSE concepts in a targeted manner rather than theoretical
  - OV-5b (Activity Model) most beneficial in concept definition phase

Do not skip Concept Engineering Activities!


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## Questions



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### AWD MBSE Model “Factoids”


*Data as at Oct 2012*

49	Operational Vignettes
119	Use Cases
281	Segment Level Functions
787	Activities
948	Diagrams
42,222	Elements
16,069	Connections
106	Blocks in Logical Model
953	Blocks in Physical Model
432	Interface Messages









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## Glossary



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- > AWD      Air Warfare Destroyer
- > CAIV     Cost as an Independent Variable
- > CDG     Capability Development Group
- > CDR     Critical Design Review
- > COTS    Commercial Off the Shelf
- > DoDAF   Department of Defense Architecture Framework, v2.0, 28 May 2009
- > IP        Intellectual Property
- > IRL      Interface Readiness Level
- > ITAR    International Traffic in Arms Regulation
- > MBSE    Model Based Systems Engineering
- > MOTS    Military Off the Shelf
- > MSI      Mission Systems Integrator
- > OV-1    Operational Concept Graphic (DoDAF v2.0)
- > OV-5b   Operational Activity Model (DoDAF v2.0)
- > RAN     Royal Australian Navy
- > SE       Systems Engineering
- > SV-4    Systems Functionality Description (DoDAF v2.0)
- > SV-5a   Operational Activity to Systems Traceability Matrix (DoDAF v2.0)
- > SV-8    Systems Evolution Description (DoDAF)
- > SysML   Systems Modeling Language
- > StdV-2   Standards Forecast (DoDAF v2.0)

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