System Design Selection Guidance through Model Execution

William Scott and Quoc Do

Presenter: Dr Quoc Do
Defence Systems Innovation Centre (DISC),
University of South Australia

THE UNIVERSITY OF ADELAIDE AUSTRALIA

University of South Australia

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

Presentation Overview

- Introduction to Defence Systems Innovation Centre (DSIC)
  - A brief introduction to MBSE
  - A brief overview of DSIC's MBSE Research
- An integrated multiple-models architecture for model execution to inform system design:
  - Multiple-model architecture
  - 1^{st} iteration of the architectural development – A case study using ground robotic platforms
  - Preliminary results and discussions
- Current and Future Research
  - Model-Based Acquisition – A Case Study
  - Knowledge Transfer Across Domain Models
- Summary

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

Introduction to
Defence Systems Innovation Centre (DSIC)

DSIC is an Joint Venture between:

THE UNIVERSITY OF ADELAIDE AUSTRALIA

University of South Australia

Vision

To be a globally recognised national centre for advanced engineering in complex defence systems

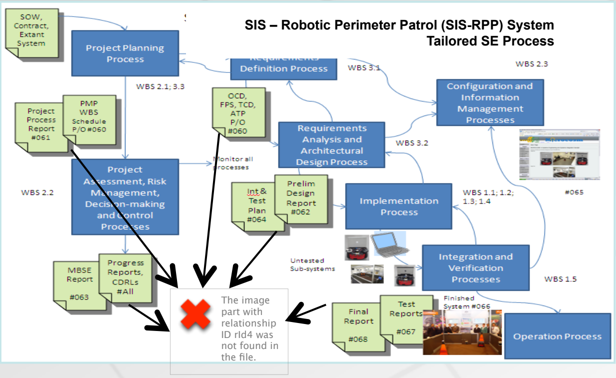
Mission

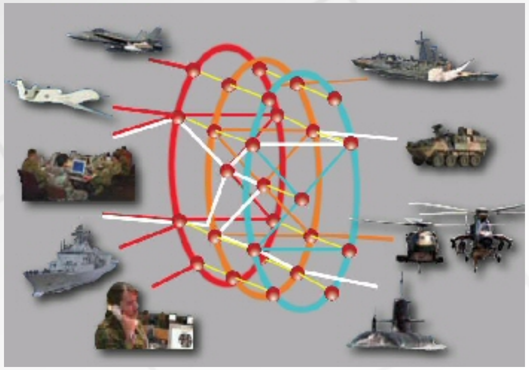
To deliver innovative, advanced engineering solutions to the Defence community via collaborative research, training and independent consulting and technical advice services

DSIC DEFENCE SYSTEMS INNOVATION CENTRE

Introduction to Defence Systems Innovation Centre (DSIC)

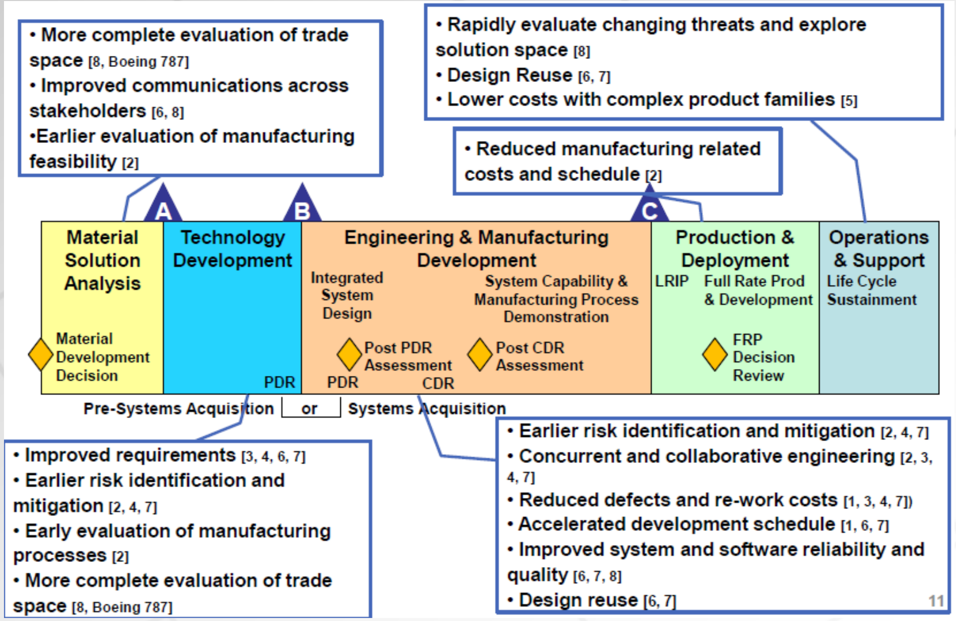
- Theme 1: Through Life Systems of Systems Engineering
  - Systems Integration across Platforms
  - **Model-Based Systems Engineering**
  - Through Life Management of COTS/MOTS Systems
- Theme 2: Networked Systems
  - Modelling and Analysis of Communication Networks
- Theme 3: Information Superiority
  - Impacts of an information rich battlespace
  - Big data (Knowledge Intensive Systems)





Introduction to Model-Based Systems Engineering

- MBSE is a paradigm shift from document-centric to model-centric practice, such that the model becomes *the primary artefact*.
- However *"MBSE is SE"!* It is seen as an enabler to provide added to the systems engineering practice.
- Some of the benefits and added values or ROIs by MBSE approaches are reported in the recent NDIA - MBE Subcommittee report.

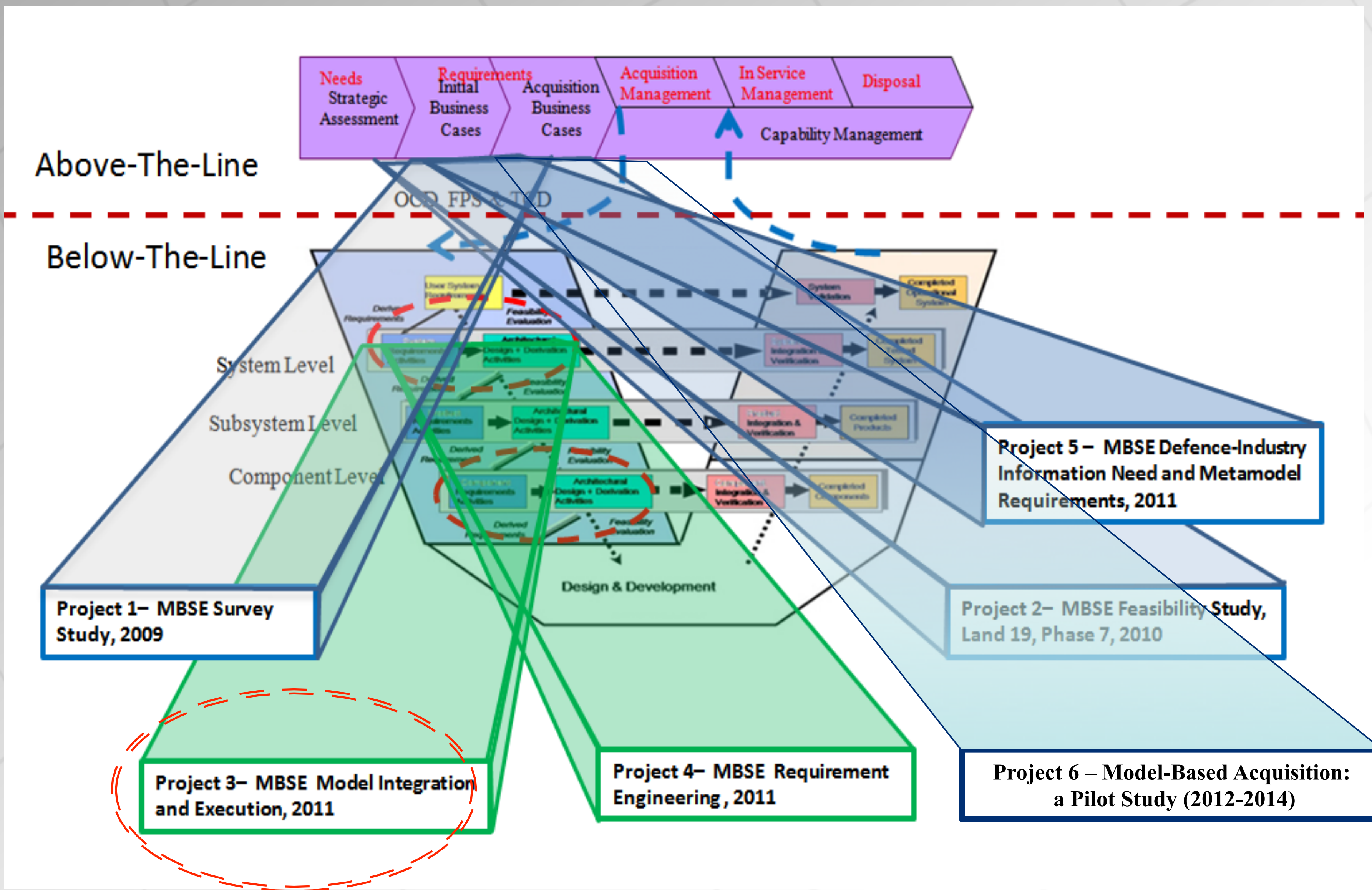


(Bergenthal, et al, 2011)

DEFENCE SYSTEMS INNOVATION CENTRE

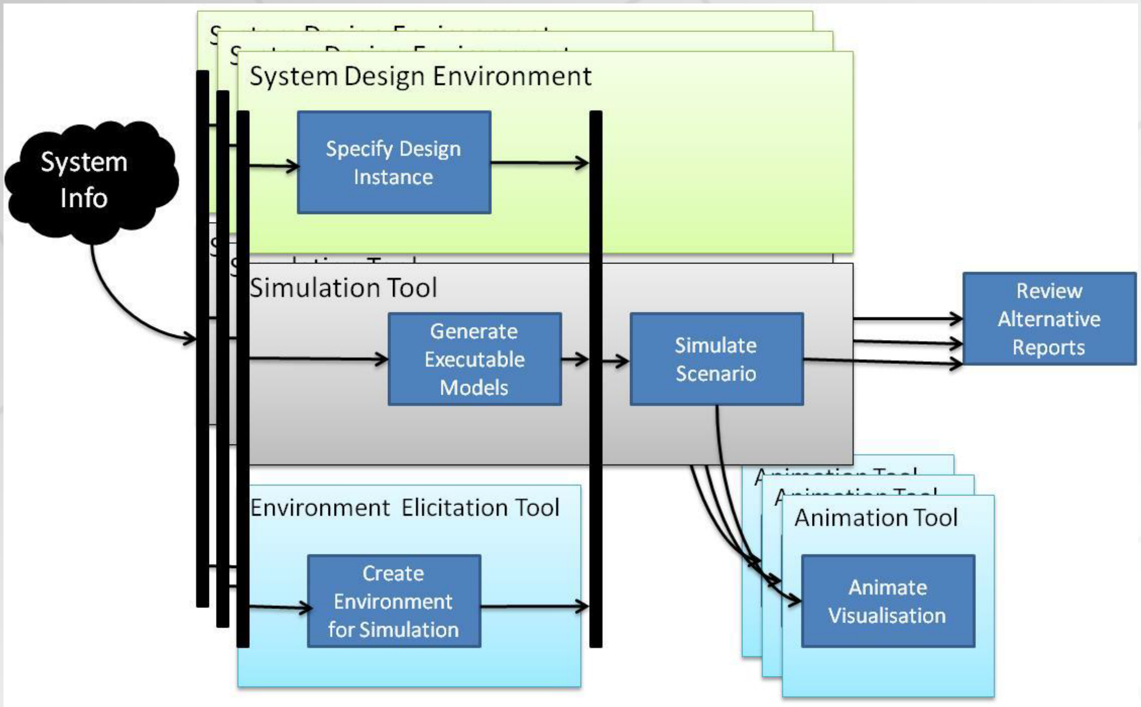
Introduction

DSIC/DASI MBSE Related Research



Model Integration and Execution project

- The aim to:
  - Integrate system models and domain specific engineering models (mathematical model, network emulation, 3DVisusation etc…) to inform system design decisions.
  - Investigate the impact of design decisions in a given concept of operations.



DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

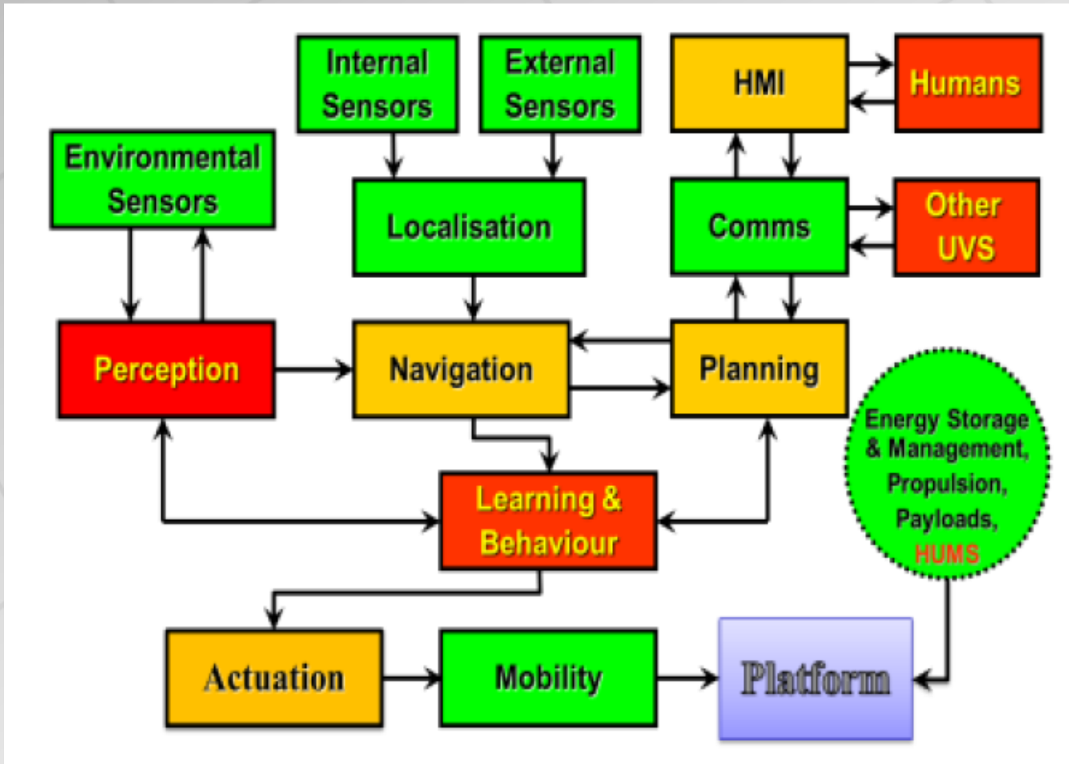
Model Integration and Execution

- Our view of model executions comprises:
  1. the execution for model checking focusing on consistency/completeness within the model,
  2. the execution of discrete-event simulation using activity or state transition diagrams; and
  3. the execution of emulated functional components to perform engineering performance analysis and trade-off.

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

Model Integration and Execution Generic Architectures

- Generic Architecture of Unmanned Ground Vehicles

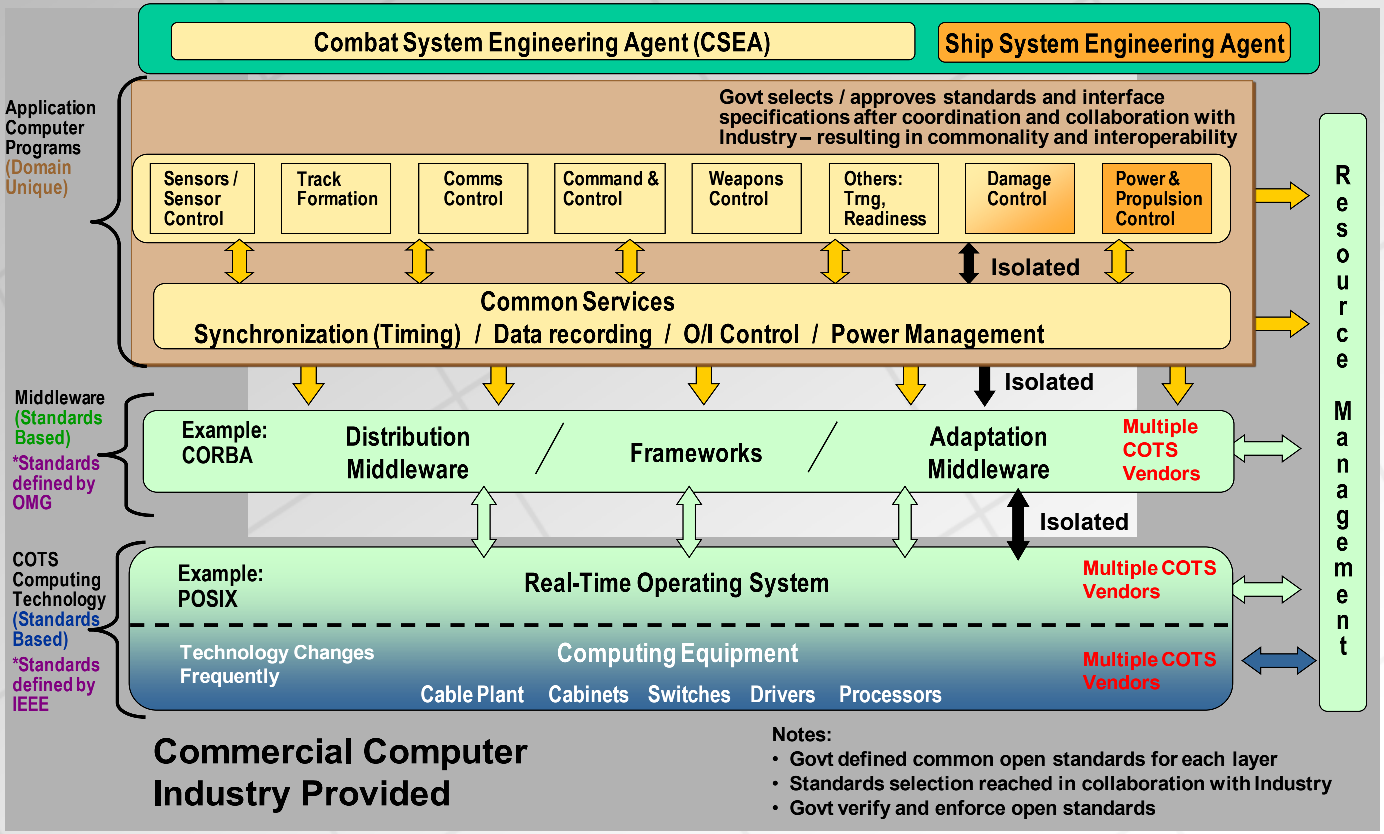


(Finn, A., 2011)

DSIC DEFENCE SYSTEMS INNOVATION CENTRE

Model Integration and Execution Generic Architectures

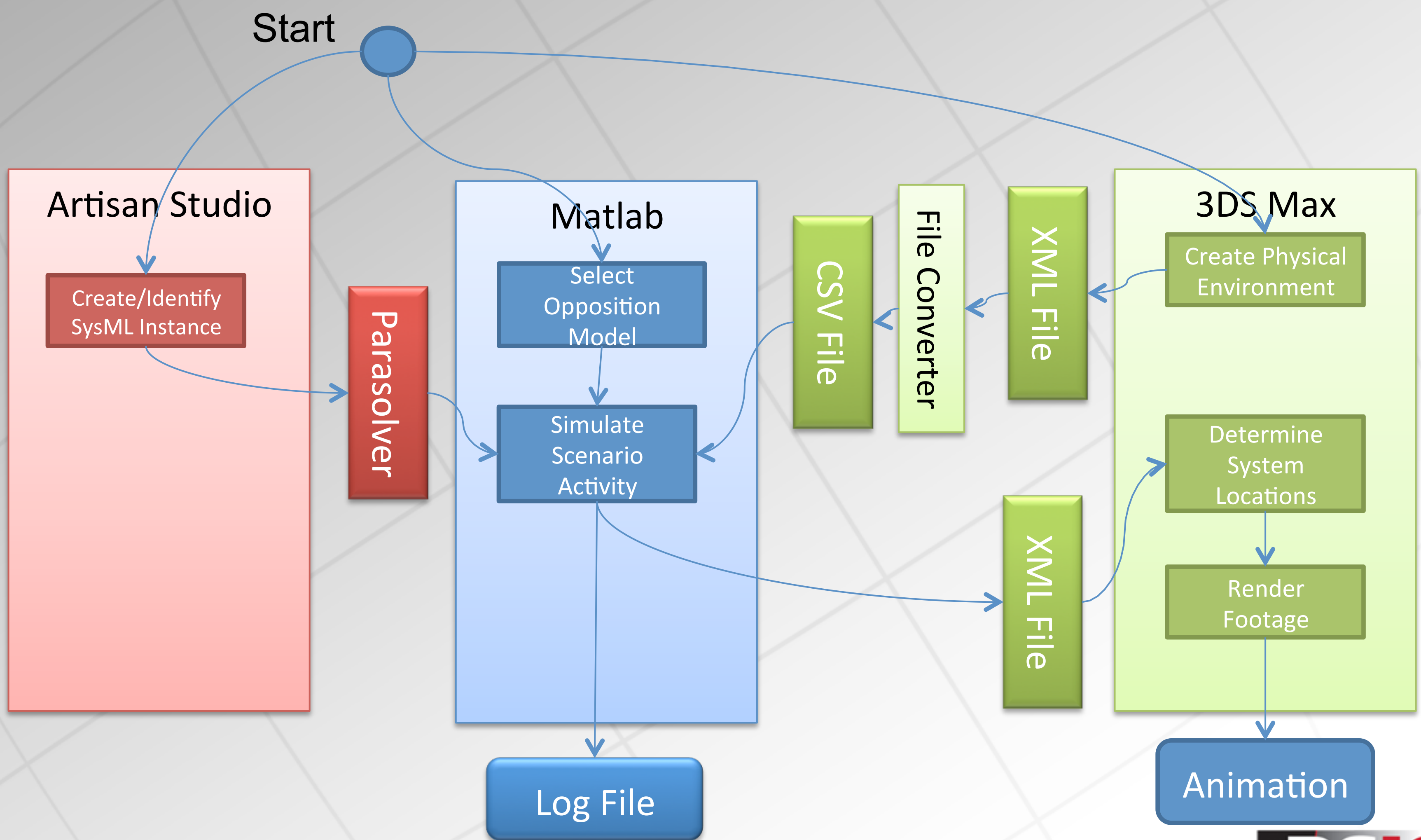
- Generic Architecture for Combat Management System
  - Based on OMG open-architecture principles (i.e. OACE)
  - Workload Modelling Language



OACE - computing model (OMG)

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

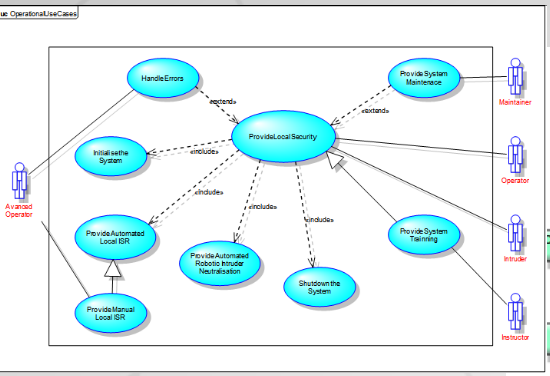
Case Study – System Implementation
An overview

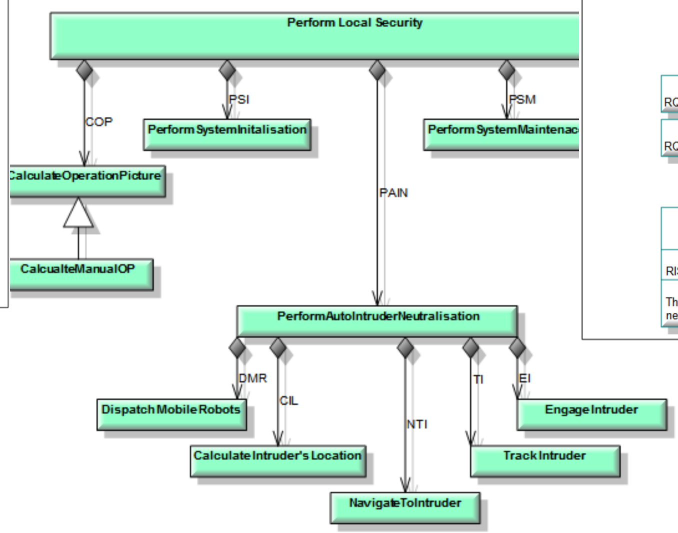


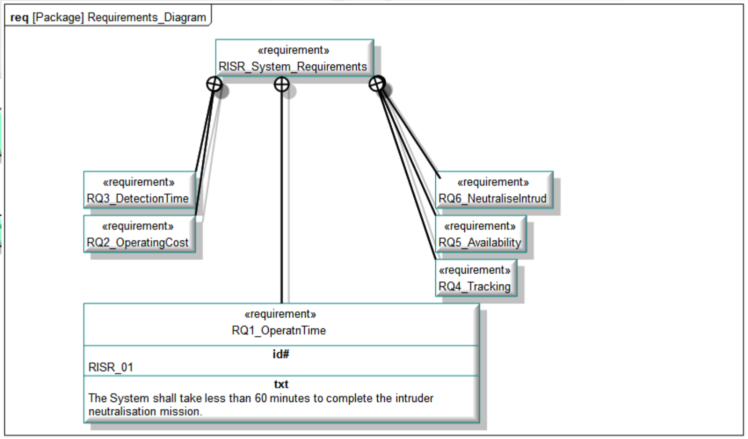
DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

MBSE Model Integration and Execution SysML Modelling

- The system modelling activity was limited to system top-level, including:
  - Use case/functional domain
  - System Requirements
  - Physical Domain – System Level
  - Parametric Model – System Level
  - Integration of SysML Model and MatLab model using Artisan ParaSolver.
  - Early systems analysis







DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

MBSE Model Integration and Execution Within an Operational Scenarios

- Key Trade-off parameters are:
  - Effectiveness (MOEs)
  - Performance (MOPs)

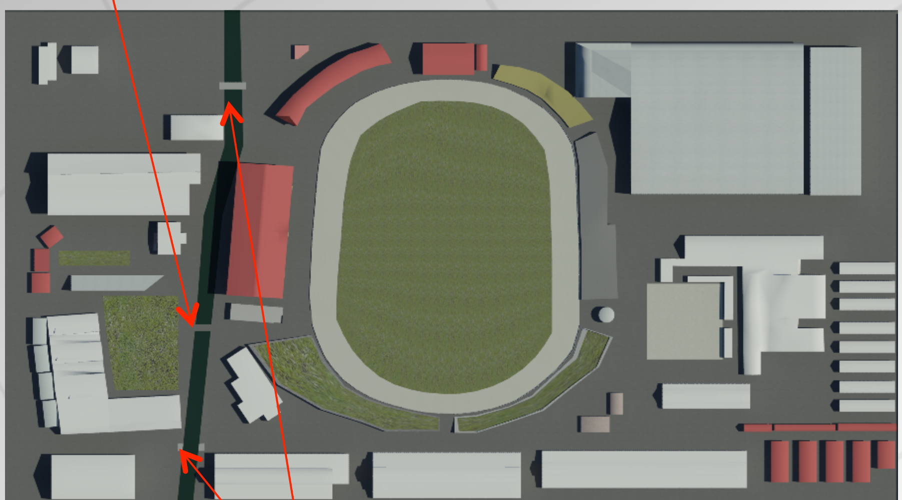
- Deployment Operational Scenario: intruder detection and engagement in a designated area.
  - Deployed location is the Adelaide Showground, Adelaide, Australia, using data from the Multi Autonomous Ground-robotic International Challenge (MAGIC) 2010 - a joint US-Australian Department of Defence robotics initiative.
  - An autonomous multiple ground-robots system is to be developed and deployed to protect the area from an intruder.

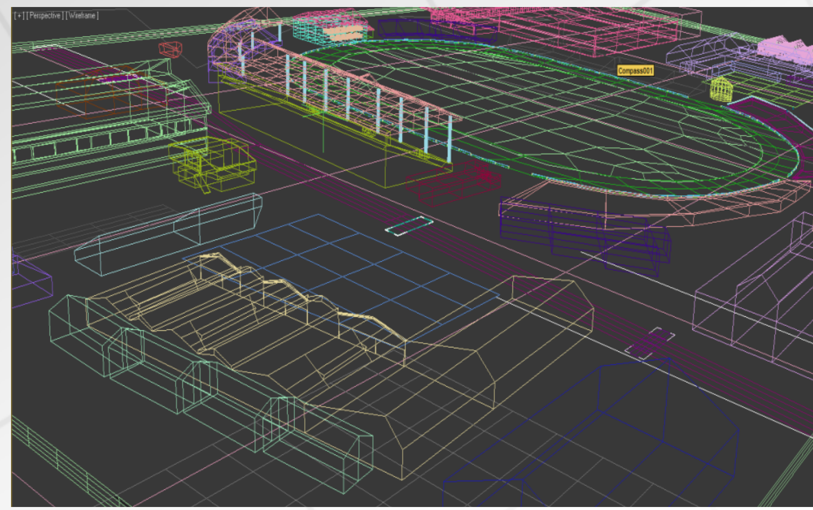
DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

MBSE Model Integration and Execution Project
3D Visualiser Model

- The visualisation tool is 3DS Max by Autodesk
- Sample model in 3DS Max is shown below
- An import and export interface have been developed that allows the exchange of information with the simulator.
  - A CSV is generated of the model as a 2D matrix of terrain traversibility
  - The locations of the elements can be imported and viewed in 3DS Max

Bridge





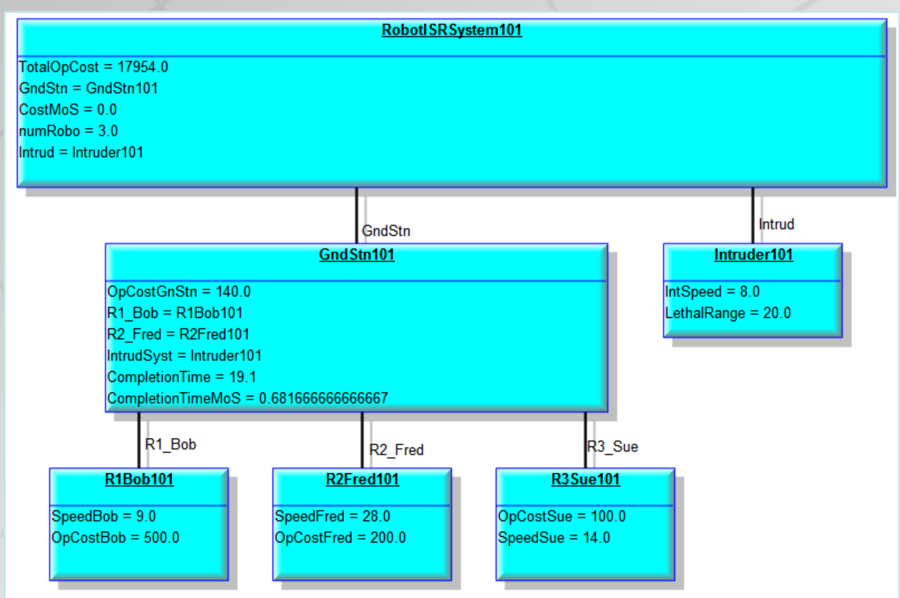
Bird Eye Views

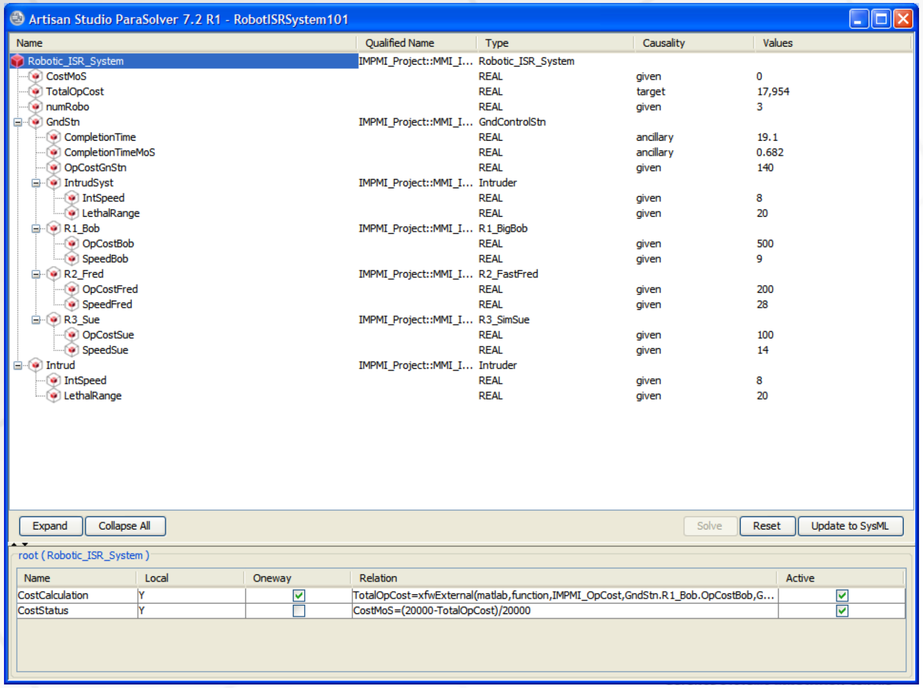
Shallow Water

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

MBSE Model Integration and Execution
SysML/Matlab Model Integration

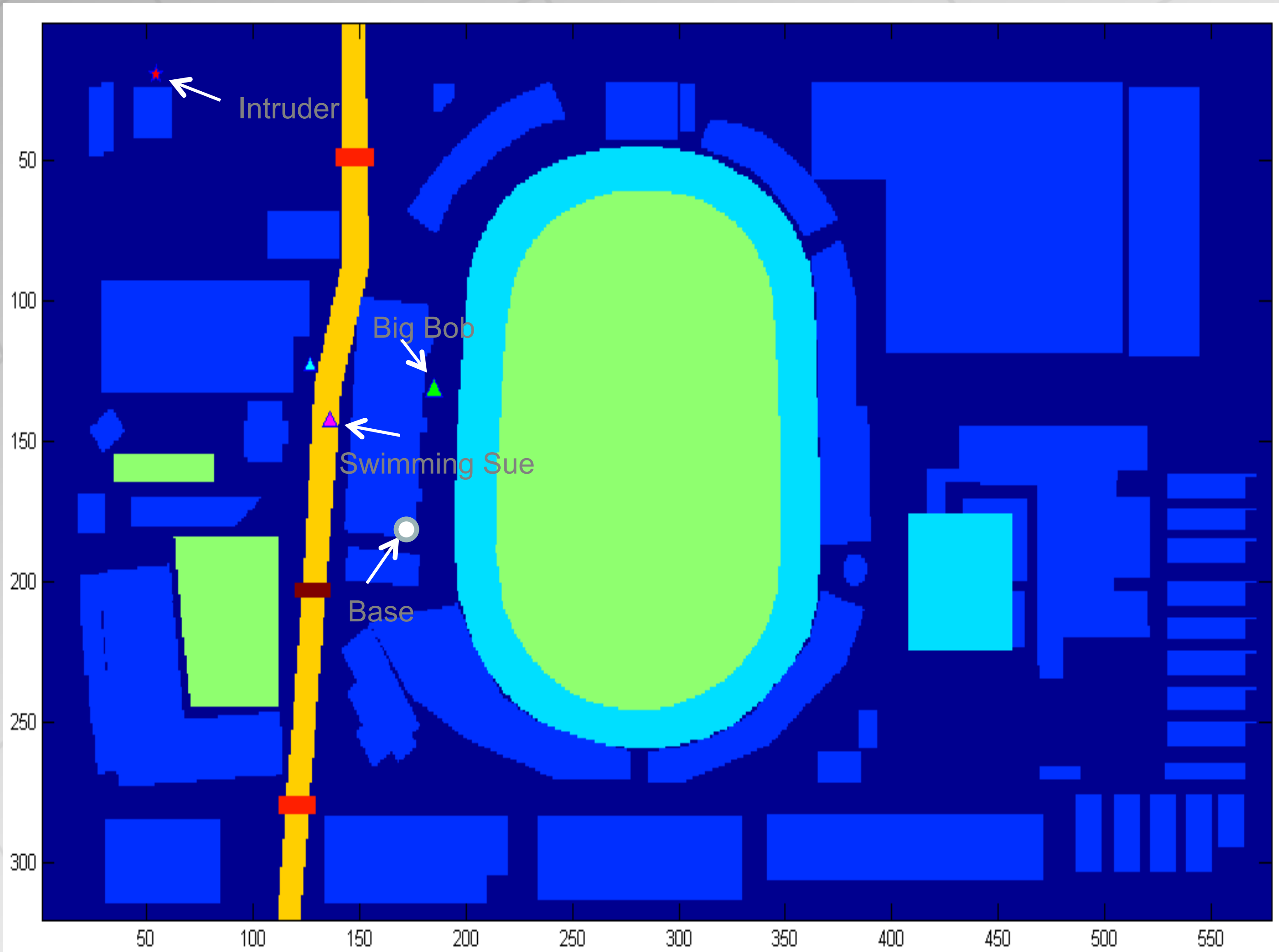
- The team integrated the SysML model and MatLab simulation model using Artisan ParaSolver.
- Firstly, an instance model was created to collect relevant parameters from the SysML model and then passed them to MatLab simulation model via a script. The Matlab simulation result then returned and updated the SysML model.





MMI System - Matlab/Simulink Operational Scenario Simulation

- Operational Scenario – Intruder Detection and Neutralisation



DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

A Case Study:
Lessons learned and Challenges

- **Insights and Lessons Learned:**
  - Support suppose "what-if analysis" – ie. if I change the available number of entrances or the capability of one of my robotic platforms, what will be the impact on the probability of not able to successfully engaged/capture intruders.
  - Gain early insights into the system's performance via model emulation and execution provide vital information that informs design decisions that would reduce project risks.
  - A metamodel or information model is required to standardise how/what information is to be stored and maintained and exchanged between models (ie UML, SysML/CORE, BPMN, UPDM/UAFP).
  - Model integration is static (via file exchange) and need to be dynamic
  - Performance modelling of a communication network and deployment options are yet to be supported (ie latency modelling)

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

A Case Study:
Lesson Learned and Insights, and Challenges

- **Challenges - Cultural Change:**
  - A shift from document-centric to model-centric practice, such that the model becomes the primary artefact. However, *"MBSE is SE"* and should support and ease the generation of all "doc" artefacts.
  - Need to produce metrics that can demonstrate Return On Investment (ROI).

- **Challenge - Knowledge Representation and Interrogation:**
  - A unified ontology for a Generic/Unified metamodel for systems engineering activities.
  - *Integrated Development Environment* **-** Achieving models interoperability across multiple-domain-specific engineering disciplines (i.e Architecture, Software, Systems, Mechanical engineering models, etc).
  - Dynamic model execution for rapid assessment of the impact of changes in design decisions (Cost/schedule/risk impacts due to a change in a requirement set)
  - Model-Based Supported Acquisition: Transition of models across the contractual boundary

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

Current and Future Work

- **Project 6: Development of MBSE Practices that can Permeate the Contractual Boundary (2012-2014)**
  - To develop MBSE practices that address the key issues and challenges inherent in utilising a single MBSE representation in a competitive tender environment.
  - To develop a Tender Request (RFT) model and a RFT response model via “role-playing”,
  - To investigate prominent issues and challenges associated with the tender evaluation and contractual negotiation processes.

- **Project 7: Improving knowledge transfer between MBSE Capability models and executable system models (2013-2015)**
  - To improve the rigour and efficiency of the knowledge transfer (e.g. system design and analysis results) between MBSE models.
  - To surface issues and challenges in developing executable system models that automatically exchange key information to address any project interdependency issues.

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE

Summary

- A brief introduction DSIC, MBSE and the project's aims and scope
- The model execution framework and
- Implementation – as a concept demonstrator:
  - Visualizer - 3D Graphical Model of the MAGIC 2010 competition environment
  - SysML system specification and model
  - Model execution of the operational scenario using Matlab
- Lessons learned, insights and MBSE challenges
- Future research

Questions ?

DSIC
DEFENCE SYSTEMS INNOVATION CENTRE