tems Integration Sandpit for renching Innovative Systems ineering Practice

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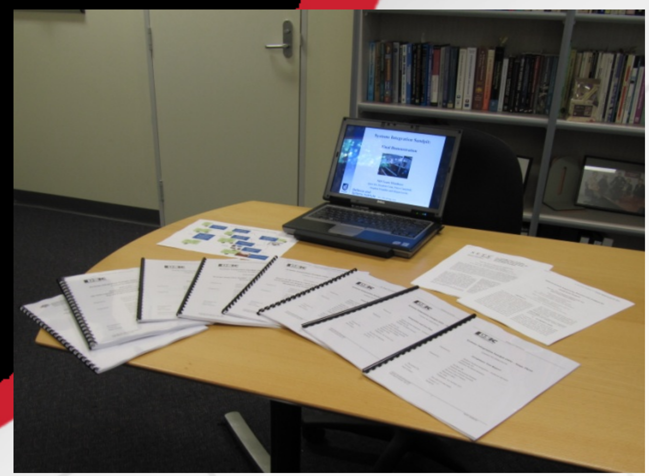

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SUB CRUCE LUMEN

University of South Australia

Presentation Overview

- Introduction to the Systems Integration Sandpit (SIS) Project
- Stage 3 Objectives
- SIS – Middle-out systems engineering approach
  - Top-down – solution independent architecture design
  - Bottom-up – constraints from available COTS/ MOTS components
- Future research:
  - Model-based systems engineering
- Stage 3 Achievements

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Stage 3 Objectives

- Run an evolutionary development project using a well-established SE approach.
  - Produce a useful increment in SIS capability
- Produce a meaningful set of work products using a contemporary document-centric SE approach.
- Investigate the utility of state-of-the-art MBSE for forthcoming Defence projects
- Enhance value of SIS for teaching and research
- Position DSIC to conduct an MBSE-based follow-on evolution phase
- Produce useful and publishable insights into SE/SI practice

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Introduction to the Systems Integration Sandpit (SIS)

SIS is built based on the concept of

"Systems Engineering in the small as a precursor to systems engineering in the large"

SIS is:

- **An environment** where the practice of Systems Engineering and Systems Integration (SE&SI) can be applied
- A "Sandpit" where **Systems Integration Scares** can be created and managed
- An environment where **SE&SI Education and Training** can be conducted
- An environment where **SE&SI Research** can be conducted

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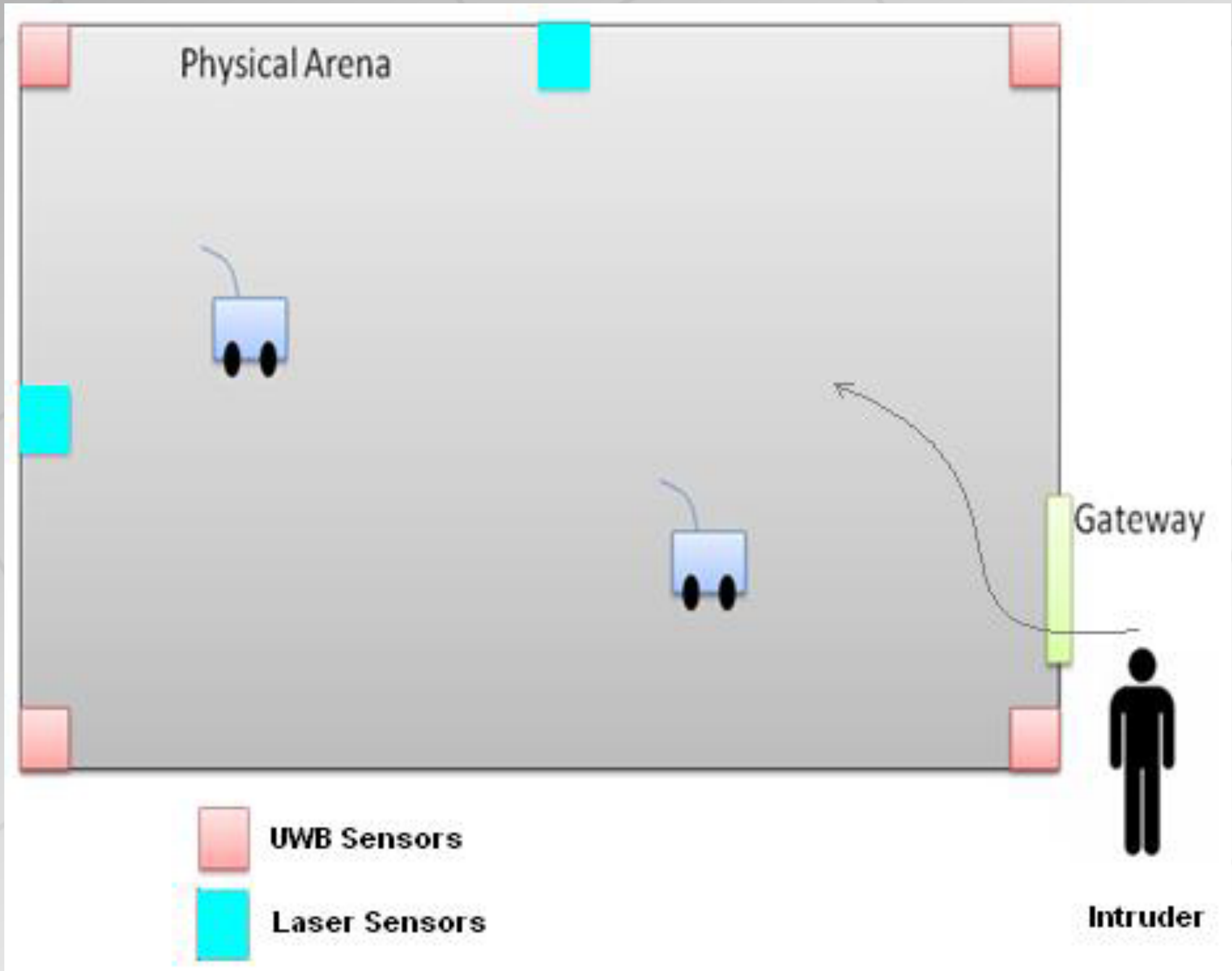
Systems Integration Sandpit
Stage Three – Operational Scenario



Systems Integration Sandpit
Project Major Activities

- Assist our stakeholders to develop Capability Definition Documents
  - OCD
  - FPS
  - TCD
- Project management
  - Project management plan
  - WBS
  - Schedule

Deliverable One

- Design/tailor a systems engineering process for SIS.
- Perform systems engineering design
  - Conceptual/Preliminary design

Deliverable Two

- Implement/test/evaluate the system
- Conduct a Test Readiness Review (TRR)
- Conduct a final demonstration

Deliverable Three

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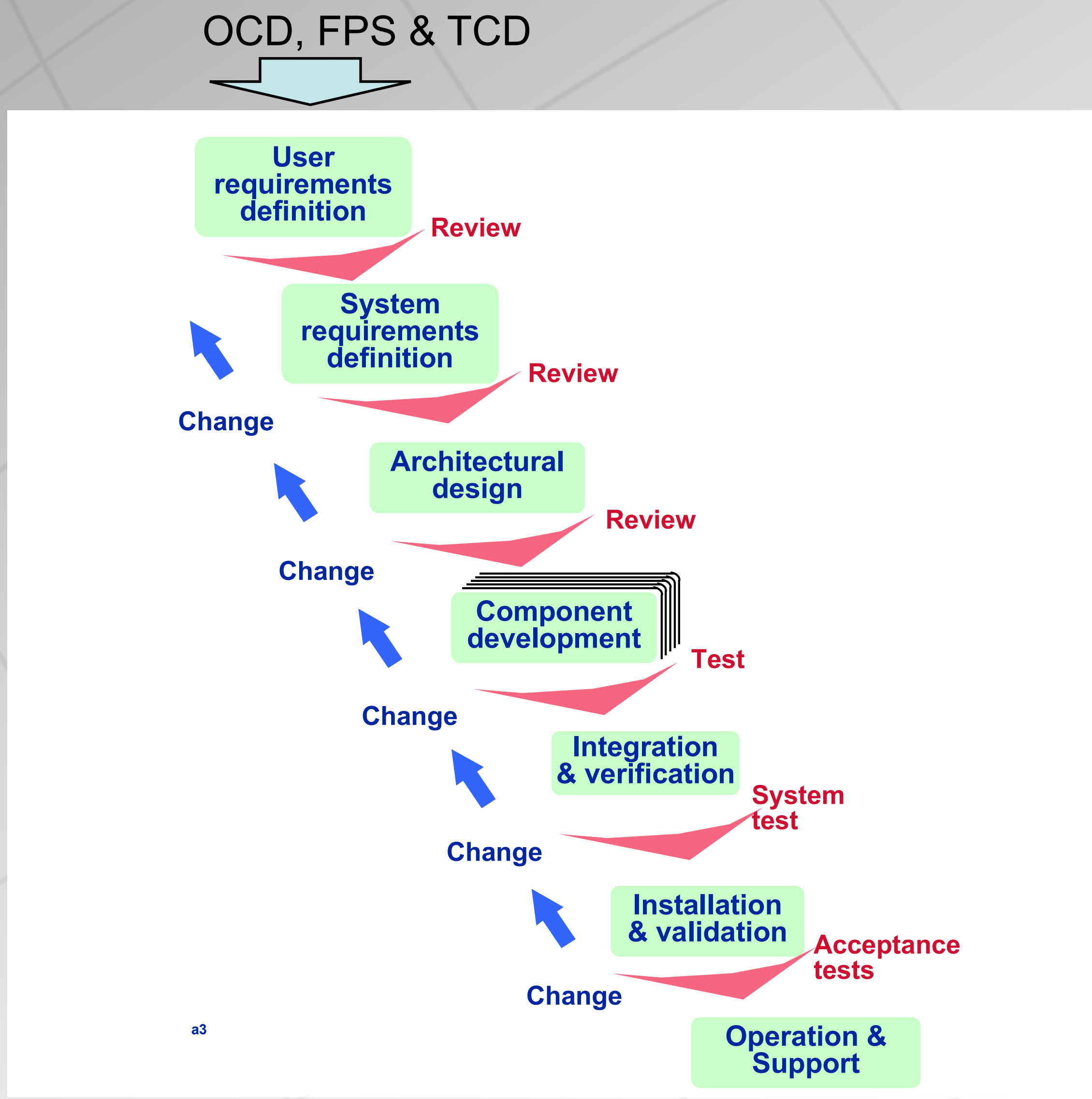
Top-Down Systems Engineering



- Great for long lead-time systems to be built ab-initio

Bottom-Up System Engineering

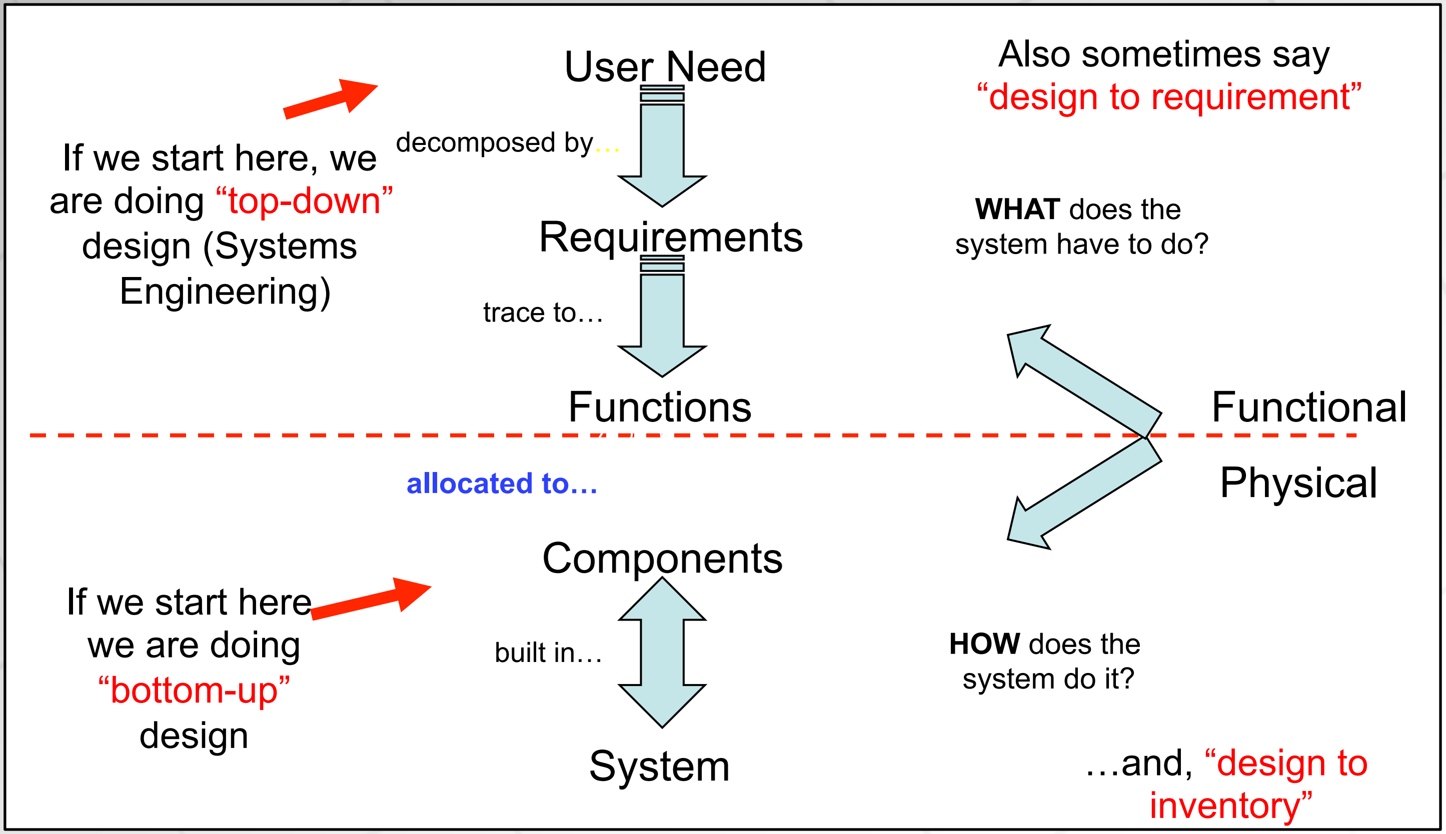
Component Selection, and Simulation and Modeling

- Can be well suited for smaller systems integration projects and evolution projects
- Promotes deep understanding of components and their behaviour and performance
- But can lead to poor architectural design and poor interoperability

- Built
  - Odometry model
  - Odometry model with global laser sensor data
  - Odometry model with data from an UWB (ultra-wide band) positioning system
  - Odometry with both UWB and laser sensor data

Employed Middle-Out System Engineering Approach

- Understand the components
- Understand the system architectures
- Design upgrade from a functional perspective
- Update the implementation and architecture



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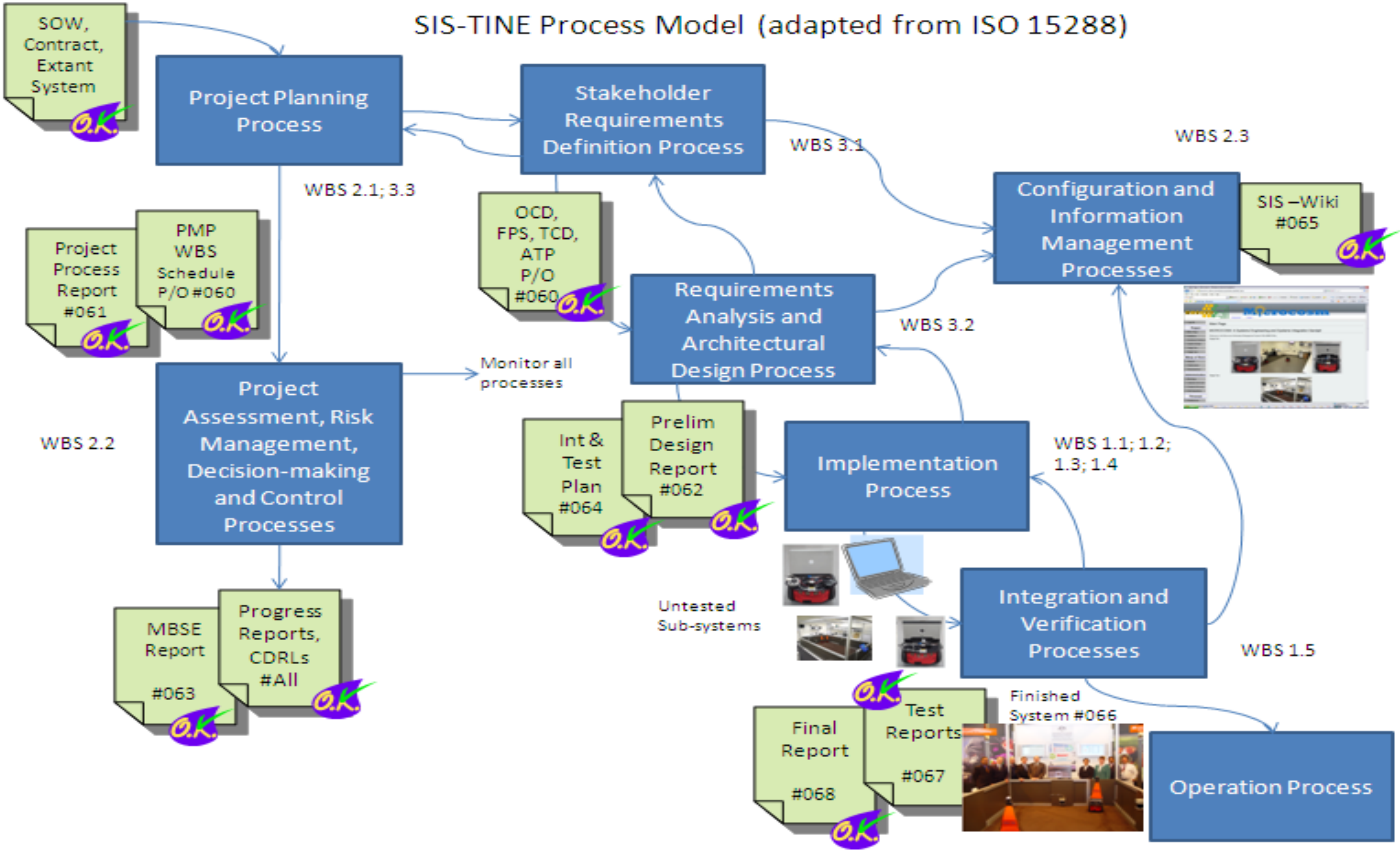
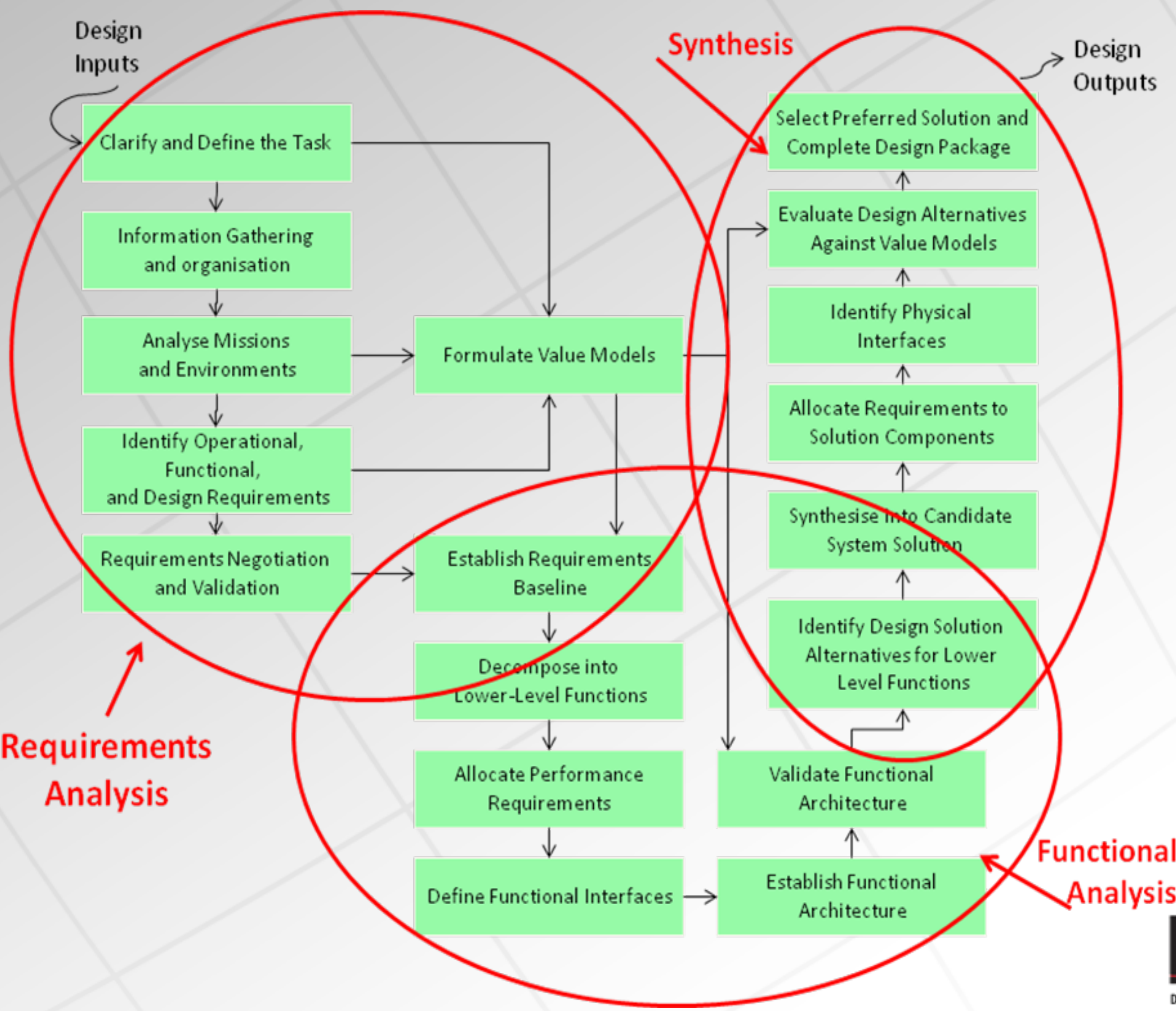
Tailored System Engineering Process (Based on ISO 15288)



System Integration Sandpit
Blended System Engineering Design Process



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System Integration Sandpit

Preliminary Design

- Requirement Analysis
- Functional Analysis
    - Function architecture
    - Requirement-to-function allocation
    - Functional Interface
- Synthesis
    - Physical architecture
    - Function-to-physical element allocation

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System Design –Sample Artefacts

- Requirement Baseline

2.2.1 Operational View

According to the IEEE 1220 Standard and the blended architectural design process, the Operational View *"establishes who operates and supports the system and its life cycle processes, and how well and under what conditions the system products are to be used"*.

Operational need description

The operational needs are described in section 4.3.5 of the SIS-TINE OCD.

Results of system operational analyses

N/A

Operational sequences/scenarios

The sequence of operational scenario is described in section 4.10.1 of the OCD.

Conditions/events to which system products should respond

These are described in section 4.6 of the OCD, as well as in section 5.3 in the FPS.

Operational constraints

Operational constraints are described in section 4.3.2 and section 4.8 of the OCD.

2.2.3 Design View

According to the IEEE 1220 standard, *"the design view describes the design considerations of the system products development and establishes requirements for technologies and for design interfaces among equipment and among humans and equipment"*.

Previously approved specifications and baselines

The approved baseline documents for the SIS-TINE project are the OCD, FPS, TCD and PMP.

Design interfaces with other systems, platforms, humans, and/or products

Personnel interfaces to the system are documented in Section 5.3.15 of the FPS.

An overview of the system level interfaces are described in section 5.3.19 of the FPS

Human system engineering elements,

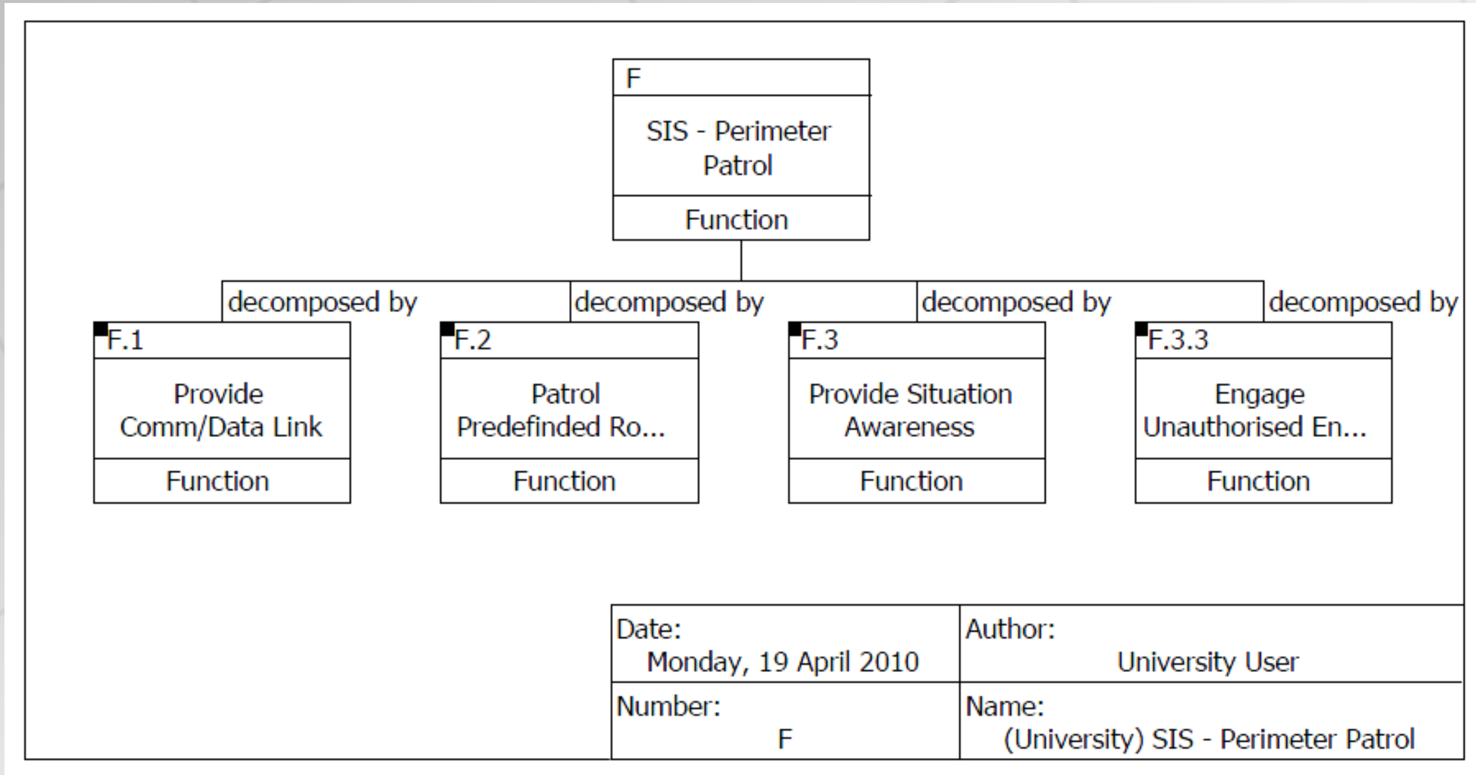
The human system engineering elements are described in section 4.3.3 and section 4.5.2 of the OCD, and section 5.3.15 of the FPS.

Characterization of operator(s)

Section 4.10.1 of the OCD provides an overview of how the SIS-TINE will be operated.

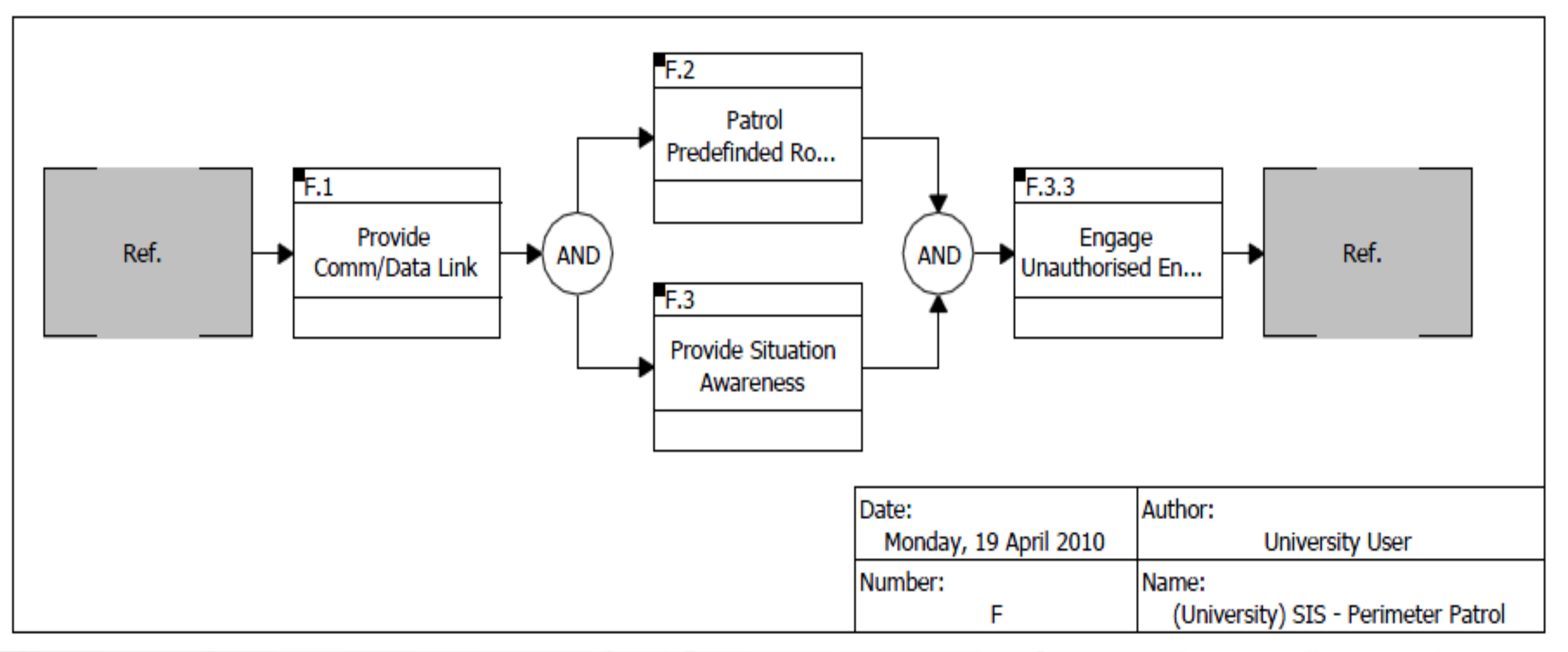
Sample Artefacts - System Design

- Functional Analysis – Top-level functional decomposition



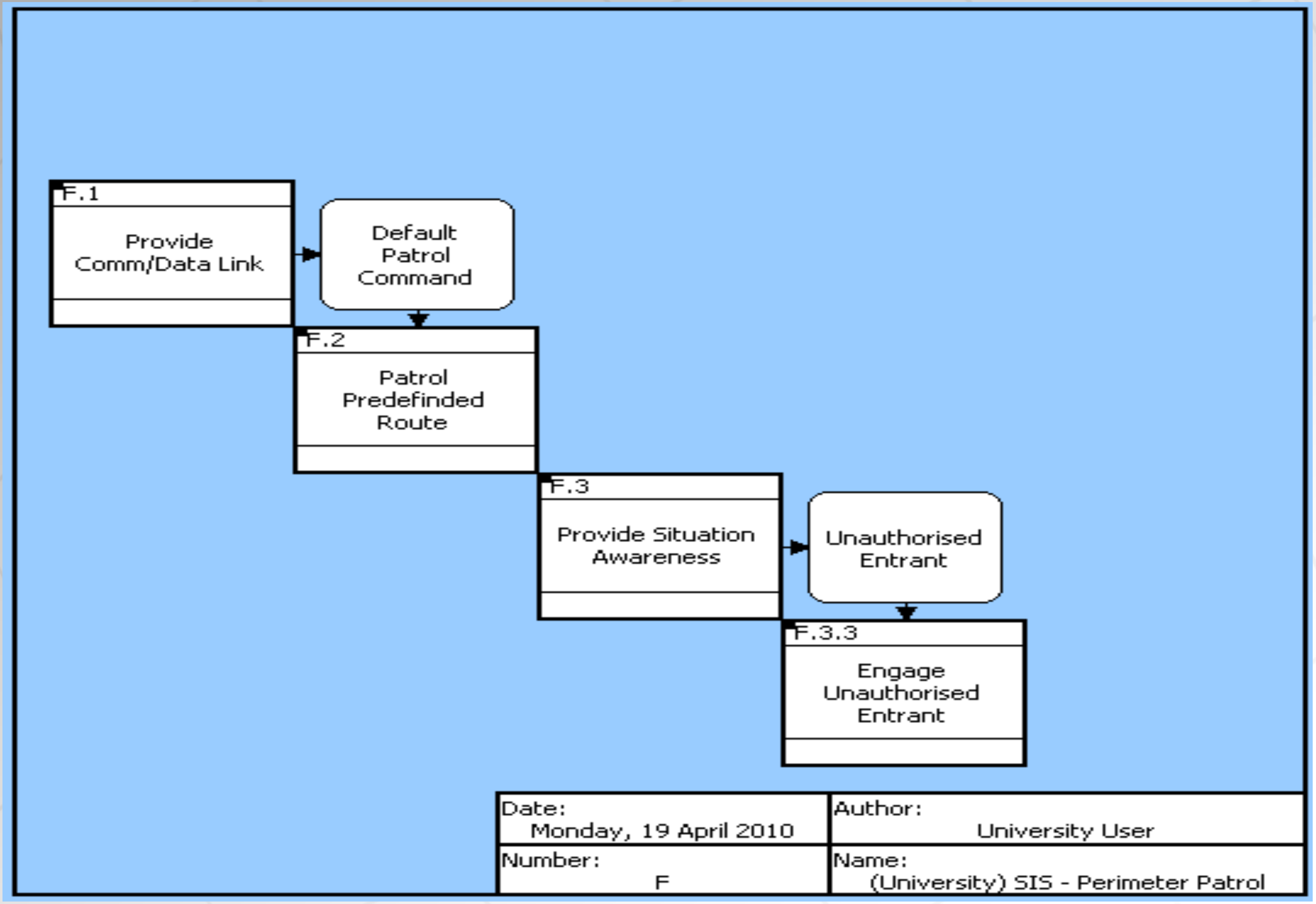
Sample Artefacts - Functional Interface

- FFBD of the top-level function



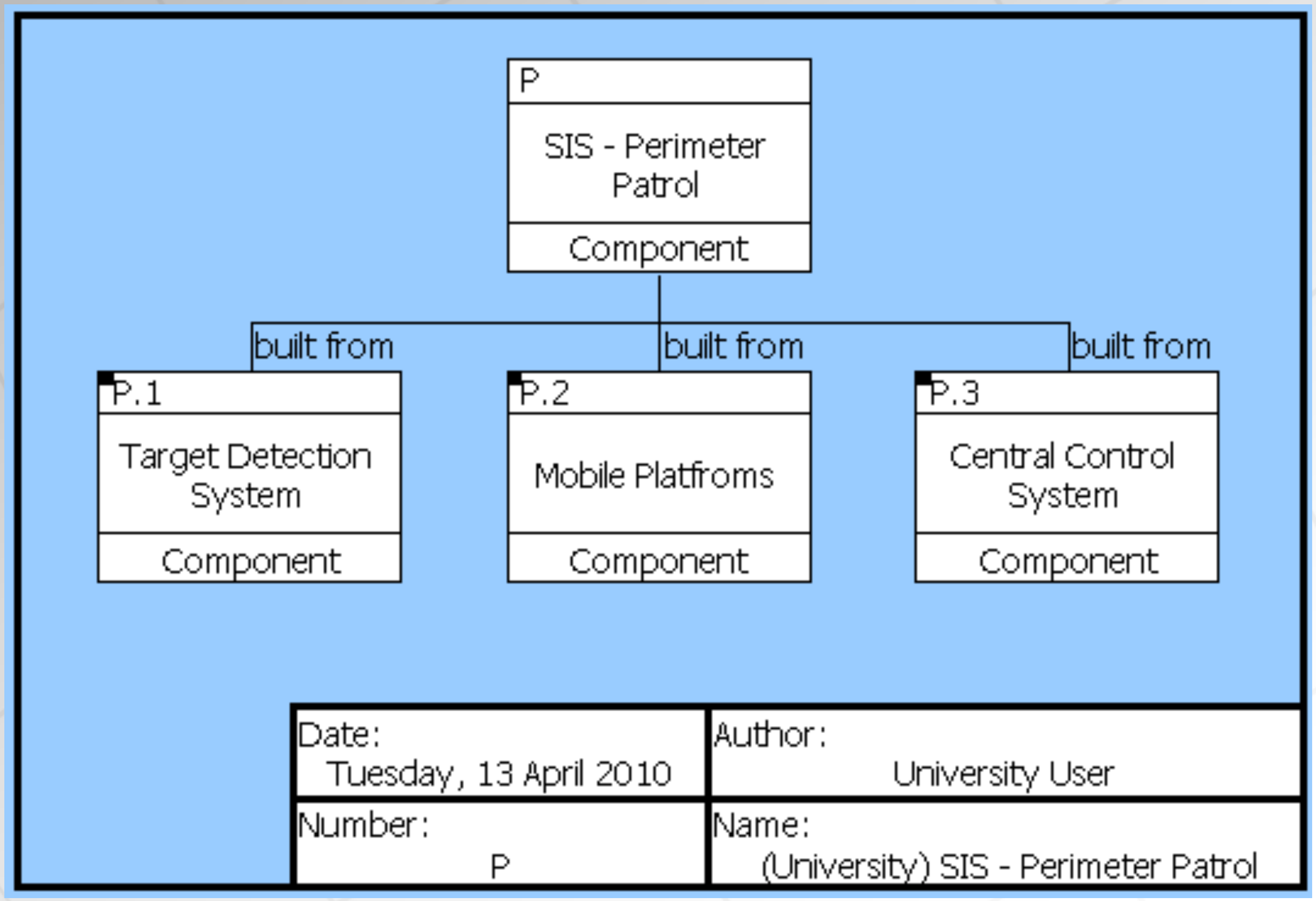
Sample Artefacts - Functional Interface

- Functional Interface – Top level



Sample Artefacts - Physical Architecture

- Physical Architecture – Top-level



Sample Artefacts - Synthesis

- Function to physical Allocation

Physical-To-Functional Allocation			
Physical Elements		**Functional Elements**	
P	SIS - Perimeter Patrol		
P.1	Target Detection System		
P.1.1	Laser Sensor One	F.3.1.1 F.3.1.3	Detect Targets Track Targets
P.1.2	Laser Sensor Two	F.3.1.1 F.3.1.3	Detect Targets Track Targets
P.1.3	UWB Positioning System	F.3.1.1 F.3.1.3	Detect Targets Track Targets
P.1.4	Sensor Fusion Processor	F.3.1.1 F.3.1.3	Detect Targets Track Targets
P.2	Mobile Platforms		
P.2.1	Robot One		
P.2.1.1	Audio System	F.4.2	Issue Visual and Audio Warning
P.2.1.2	R1_Navigating Platform	F.2.1 F.4.1 F.4.3	Avoid Obstacle Reach Unauthorised Entrant Follow Unauthorised Entrant
P.2.1.3	R1_On-board Laptop	F.2.3 F.2.3 F.2.2.1 F.2.2.2 F.2.2.3 F.4.1 F.4.3	Detect Obstacle Avoid Obstacle Perform Self-localisation Perform Path Planning Provide Speed Control Reach Unauthorised Entrant Follow Unauthorised Entrant
P.2.1.4	Hokuyo Laser Sensor	F.2.1	Avoid Obstacle

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Systems Test & Evaluation

- Subsystem Tests are defined in the Integration and Test Plan – Ref: #064):
  - Robot One
  - Robot Two
  - Sensor Fusion
  - Central Controller
- Acceptance Tests
  - These tests are defined in the Acceptance Test Plan (Ref:#060)
  - Results of subsystem and system tests are captured in the Acceptance Test Report (Ref:#067)
  - Acceptance tests were conducted on Thursday, 27/05/10 in the presence of Dr Daniel Solomon, Head of Systems Integration, DSI-TA

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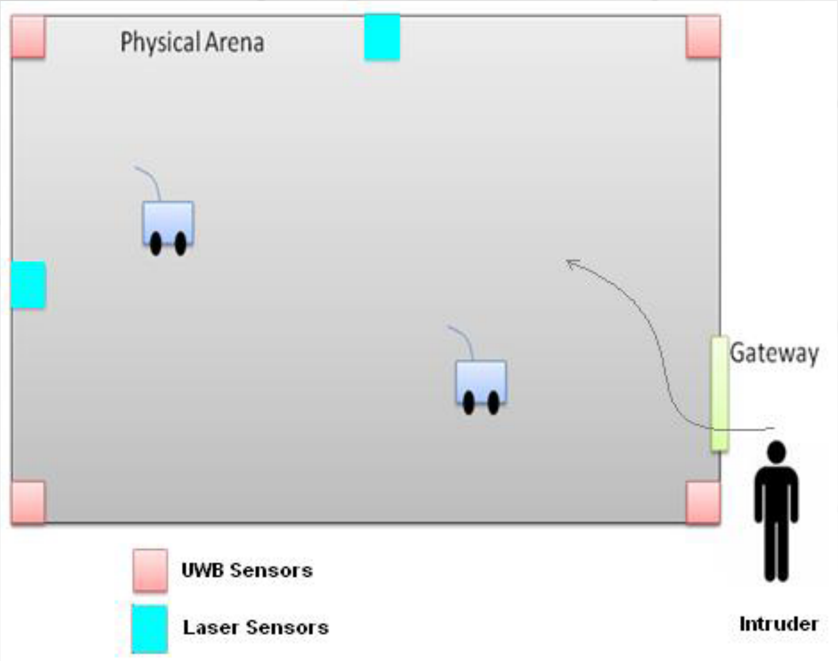
System Integration Sandpit
Final Demonstration

Click to Run Scenario



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Systems Integration Sandpit
Lessons Learnt

- System definition is challenging even for small projects
- CDD scalability is challenging
- Brownfield developments are also challenging
- Solution-independent approaches are still possible for evolutionary projects
- User/customer needs are difficult to capture
- Requirement Review meeting essential
- Appropriate concepts, tools and techniques can be guided well by external parties

Systems Integration Sandpit

Lessons Learnt

- The ideal means to address system integration is at the architecture design phase.
  - At the *integration phase is where you see the problem* (too late!!).
  - SI mistakes generally are made at the architecture design phase.
- System engineering design in an iterative process that includes aspects such as integration, maintenance as well as test and evaluation.
- For small projects, concurrent engineering is often adequate?
- Middle-out approach to system engineering seems to be more suitable for system upgrade projects.

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Systems Integration Sandpit
Future Research

- Conduct SI-Sandpit Stage 4 using an MBSE process. Compare the utility to the structured analysis and design process.
- Implement an RTI-DDS-based architecture for the SI Sandpit. Plus, a study of how such middleware can achieve Open Architectures and Service Orientated Architectures in DCP Projects such as SEA1000, LAND 400, AIR7000.
- Produce courseware on innovative system engineering processes and practices such as Model-based Systems Engineering (MBSE), Evolutionary SE, Brownfield developments for educating professionals and building national capability.
- Modelling and Simulation in support of Systems Integration.
- Identification and analysis of Systems Integration challenges associated with incorporation of MOTS/COTS components.

Stage 3 Achievements

- ✓ Ran an evolutionary development project using a middle-out SE approach.
  - ✓ Conducted systems engineering design, implementation, integration, test and evaluation, and operation.
  - ✓ Produced a useful increment in SIS capability
- ✓ Produced a meaningful set of work products using a contemporary document-centric SE approach.
- ✓ Investigated and reported the utility of state-of-the-art MBSE for forthcoming Defence projects
- ✓ Enhanced the value of SIS for teaching and research
- ✓ Positioned DSIC to conduct an MBSE-based follow-on evolution phase
- ✓ Produced useful and publishable insights into SE/SI practice

- ✓ Provided a powerful vehicle for organisational learning!

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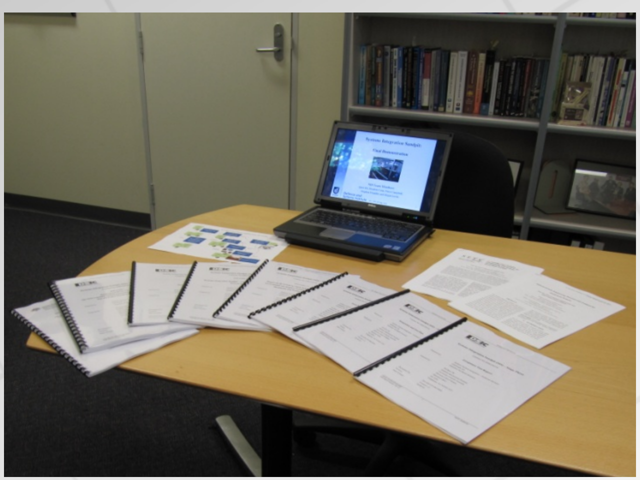
Another Successful DSIC Project

- A professionally managed project that achieved its objectives and
  - Delivered specified work products to customer satisfaction
  - On time
  - On budget



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Questions