Reusable Modules to Support Rapid Model Building: A Case Study of Defence Force Design

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Outline

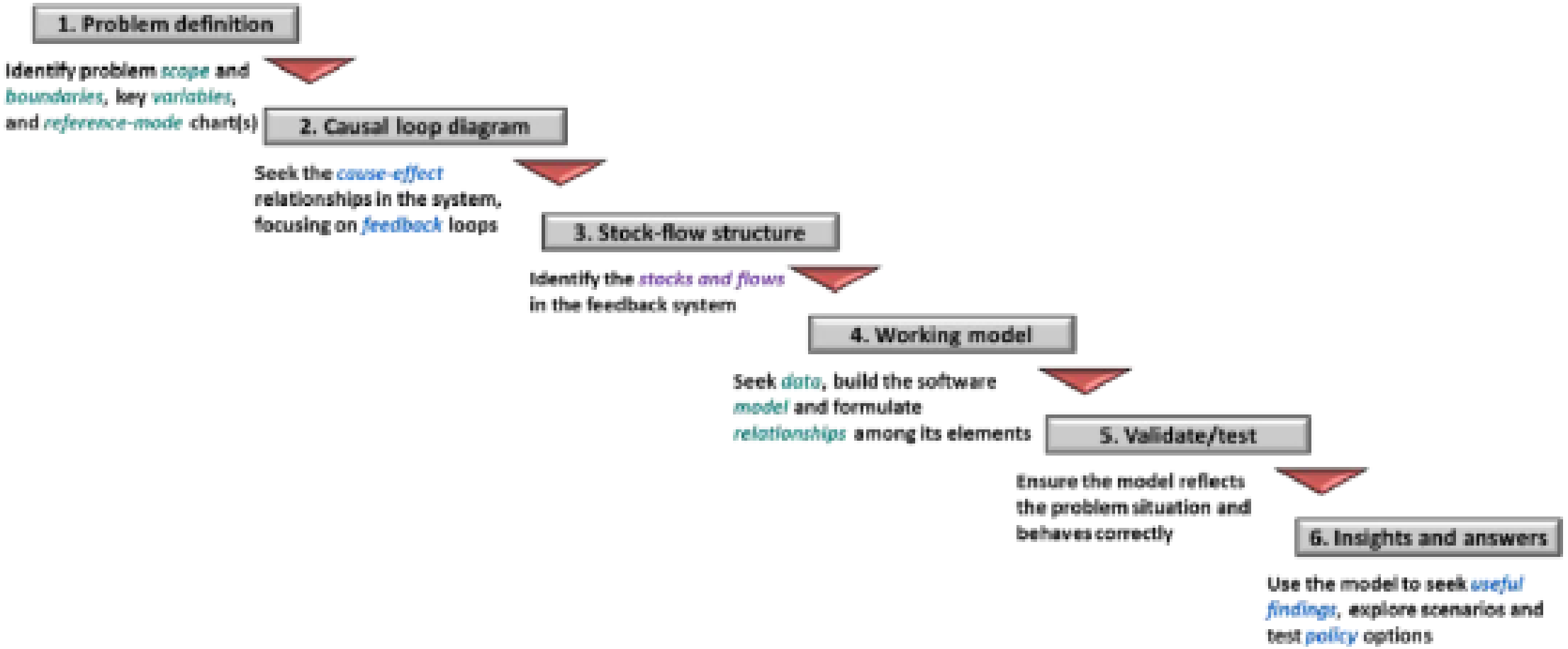
- Where are we coming from?
- Why are we doing what we are doing?
- What are we working on?
- Where have we applied it?
- Where are we heading?

System Dynamics Simulation

System dynamics provides a **powerful set of conceptual and numerical** tools to support systems design and problem solving, including the abilities to:

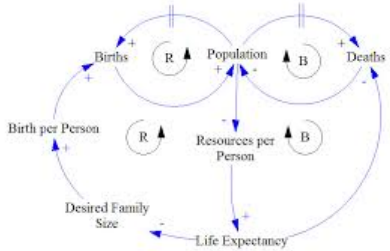
- integrate **social and technical** elements;
- model **hierarchical** systems;
- model **feedback** interactions, **non-linear** relationships, and delays;
- Address **"what-if"** questions

Standard System Dynamics Modelling



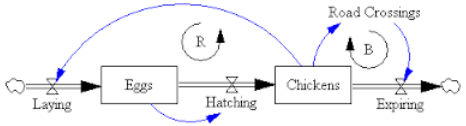
1. Problem definition

Identify problem *scope* and *boundaries*, key *variables*, and *reference-mode* chart(s)



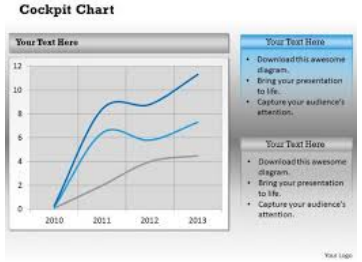
2. Causal loop diagram

Seek the *cause-effect* relationships in the system, focusing on *feedback* loops



3. Stock-flow structure

Identify the *stocks and flows* in the feedback system

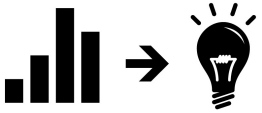


4. Working model

Seek *data*, build the software *model* and formulate *relationships* among its elements

5. Validate/test

Ensure the model reflects the problem situation and behaves correctly



6. Insights and answers

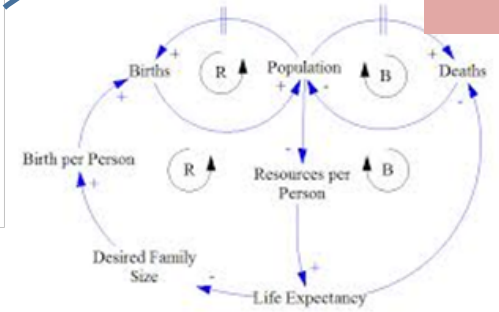
Use the model to seek *useful findings*, explore scenarios and test *policy* options

Limitations

- Time and resource consuming

<15%

>80%



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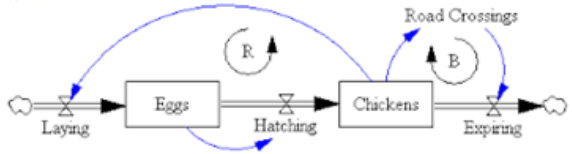

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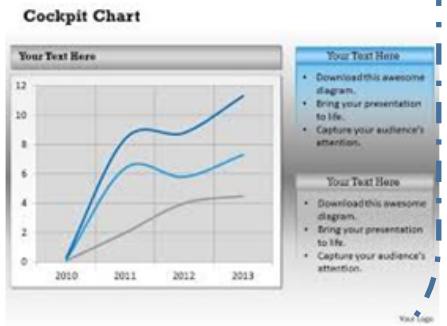

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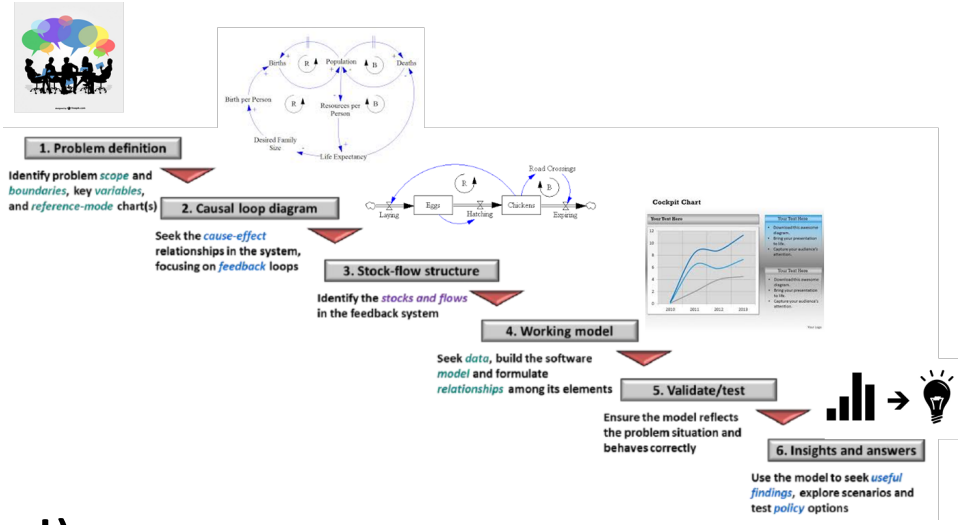
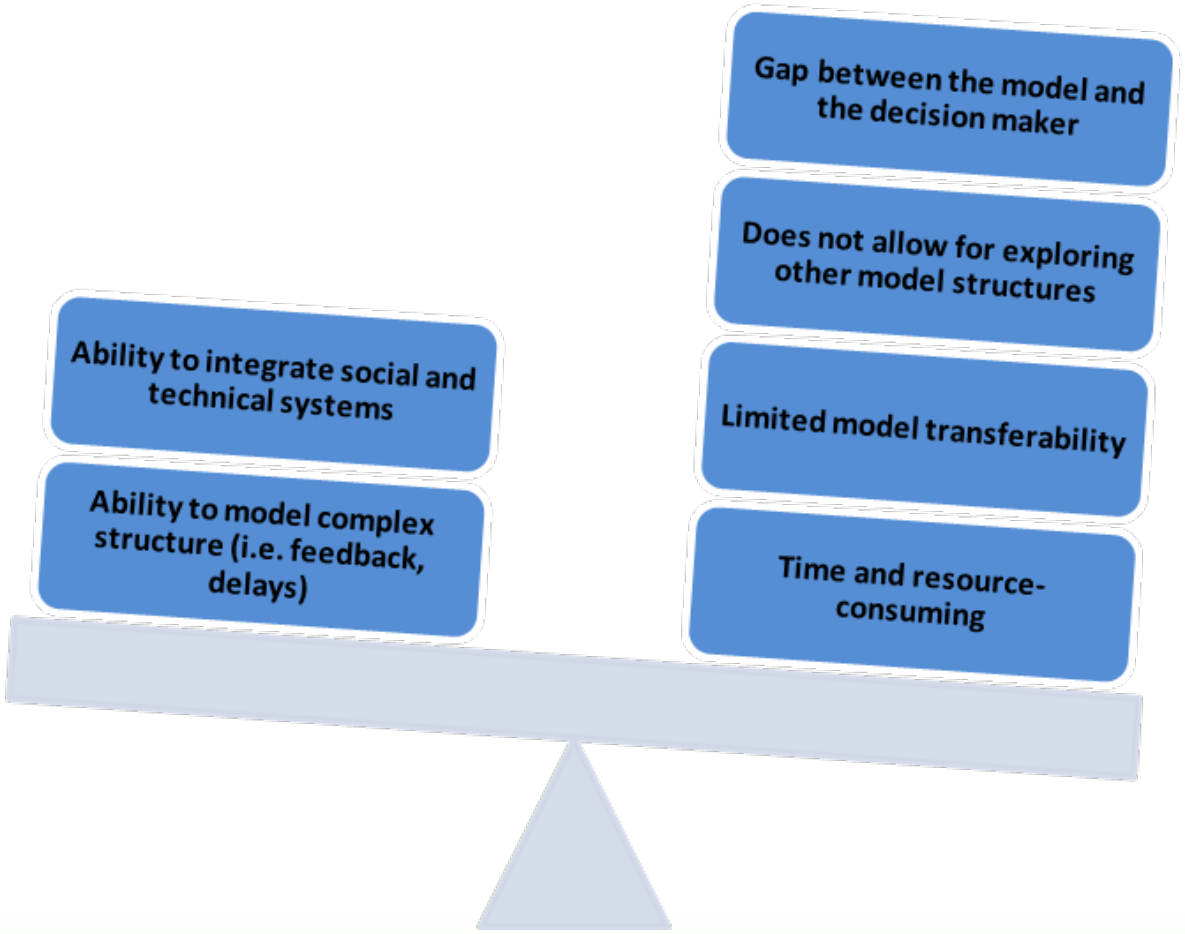


- Time and resource consuming
- Relies on mental models (which can be flawed)
- Decision makers do not understand (aka care about) stocks and flows
- Limited ability to explore new model structure(s)
- Limited model transferability

Adoption Gap



Modelling capabilities

There is a need for new modelling capabilities tools to:

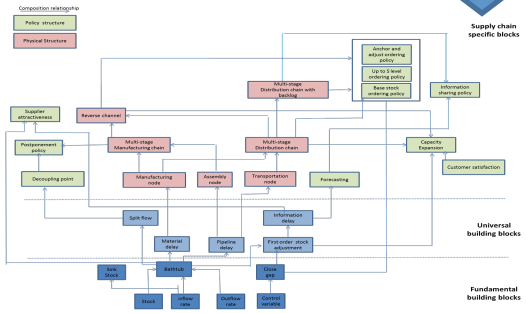
- Expedite the modelling process by providing **reusable and tested 'plug-in' components**;
- Bridge the chasm between modellers and decision makers by providing **high-level domain** objects;
- Improve learning by providing users with the **flexibility to build and experiment** with models, without being overwhelmed with the model's technical details

Domain-specific model building blocks approach

Business Layer

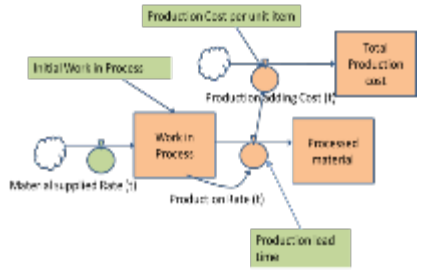
- Business rules
- Scenarios
- Decision options
- Performance indicators

Systems Models Layer



- Repository of modules
- Library architecture
- Information exchange rules

Functions Layer



- Causal structure
- Assumptions
- Data models
- Computational utilities

Business Layer

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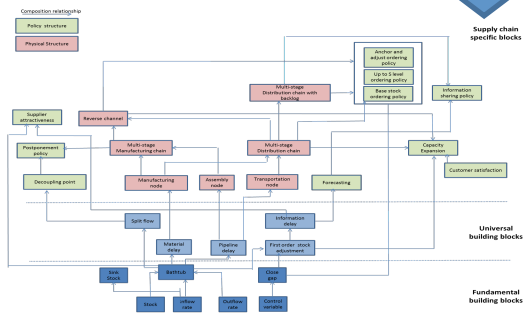
Decision Support

Systems Models Layer



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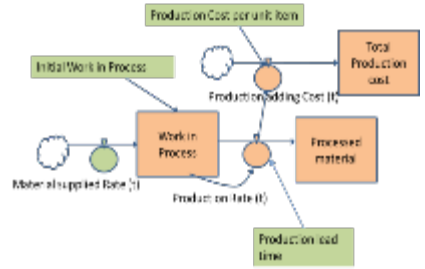
Learning/teaching

Functions Layer



- Causal structure
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- Data models
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Modelling/development

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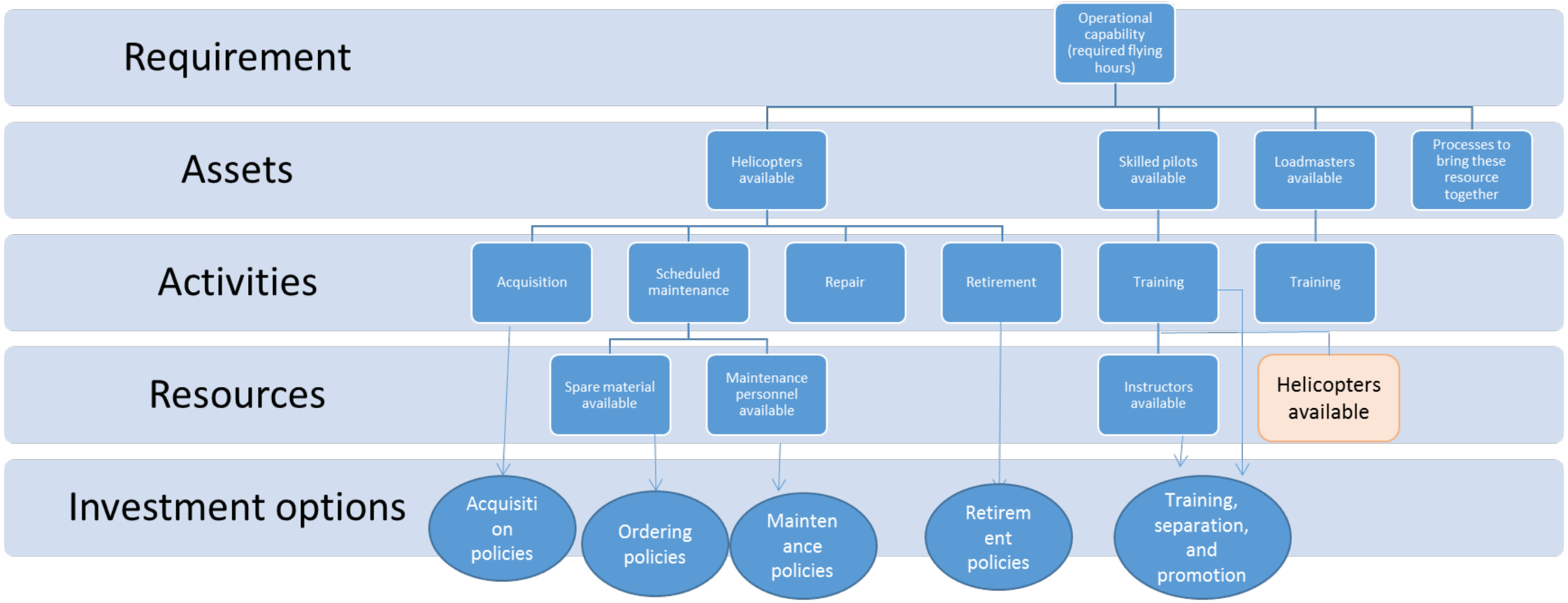
Application: Defence Capability Assessment

- In essence, capability planning is concerned with:
  - managing a complex network of supply-demand relationships
  - with the objective of delivering the right product (material and personnel), at the right time and place, with the right quality (skill).



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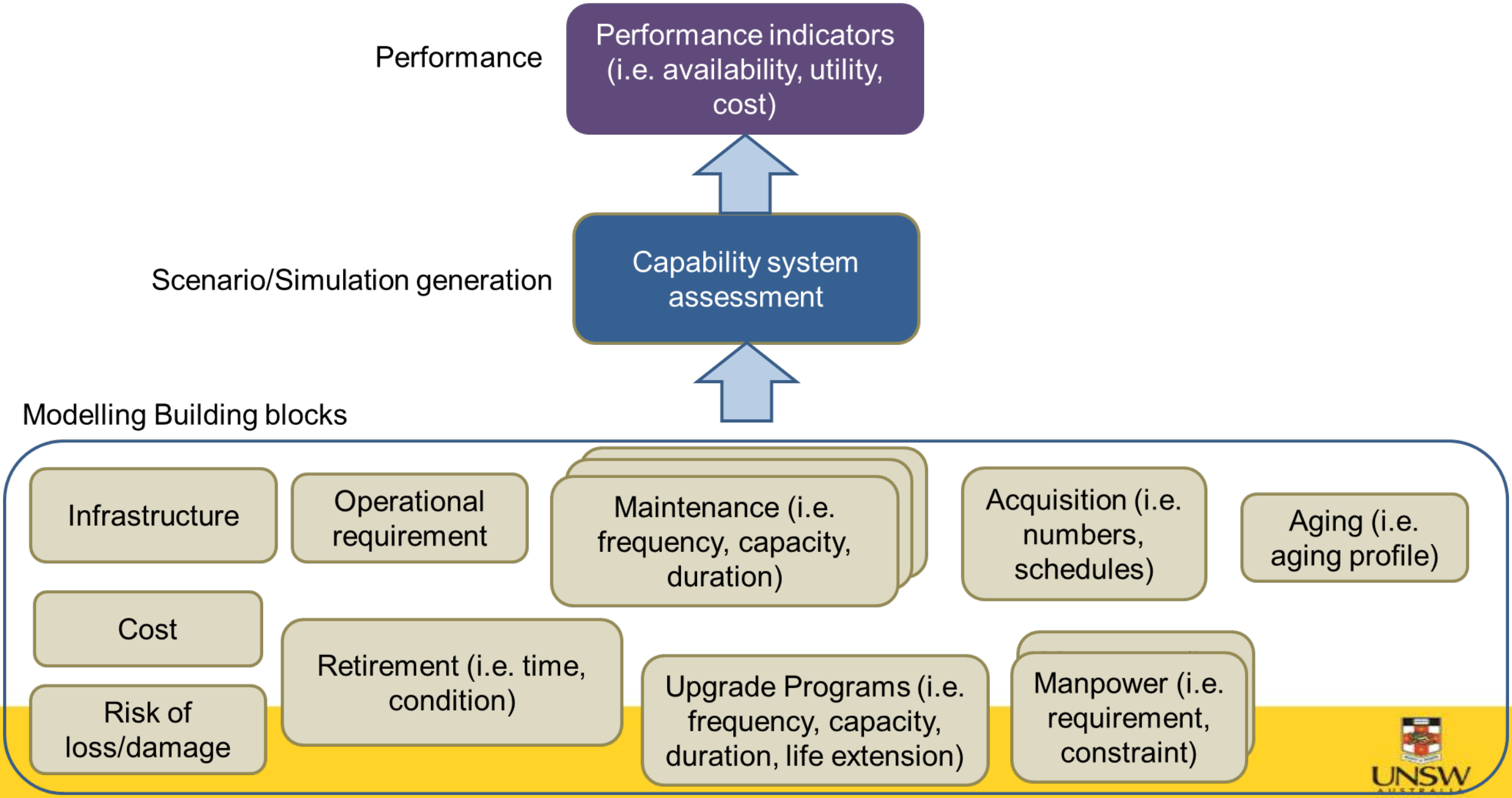
Performance
Performance indicators (i.e. availability, utility, cost)
Scenario/Simulation generation
Capability system assessment
Modelling Building blocks
Infrastructure
Operational requirement
Maintenance (i.e. frequency, capacity, duration)
Acquisition (i.e. numbers, schedules)
Aging (i.e. aging profile)
Cost
Retirement (i.e. time, condition)
Upgrade Programs (i.e. frequency, capacity, duration, life extension)
Manpower (i.e. requirement, constraint)
Risk of loss/damage

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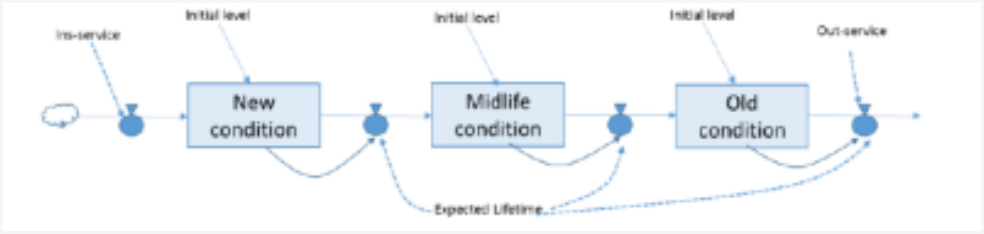
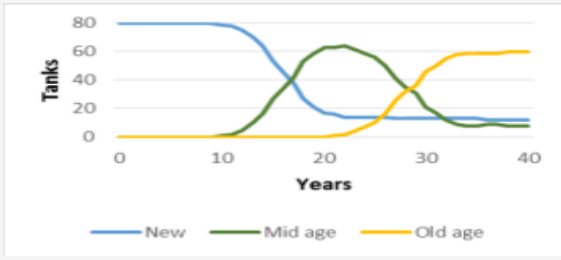
Structure



Behaviour



Assumptions

- **The aging process follows n-order exponential decay.**

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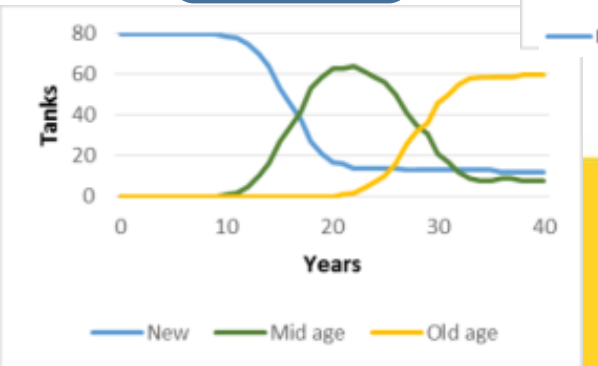
The user can determine the boundary of what to be included in the model by specifying the capability in terms of its:

- breadth (i.e. the number of assets that make up the capability);
- depth or level of detail of describing the capability as a network of interdependent resources; and
- complexity (i.e. functional dependencies among capabilities)

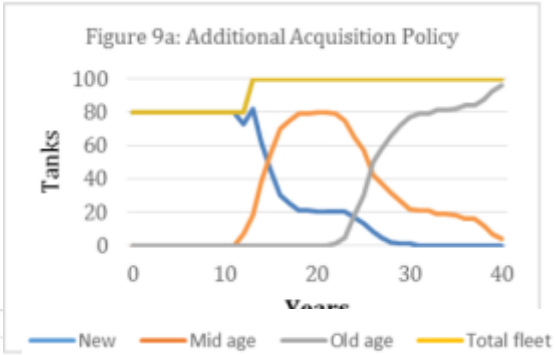
Experiments Storyboard

Aging



Aging

Acquisition



Retirement

Aging

Acquisition

Retirement

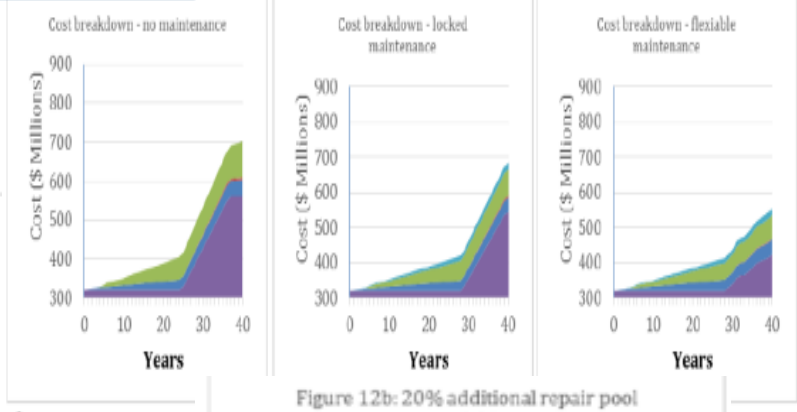
Cost

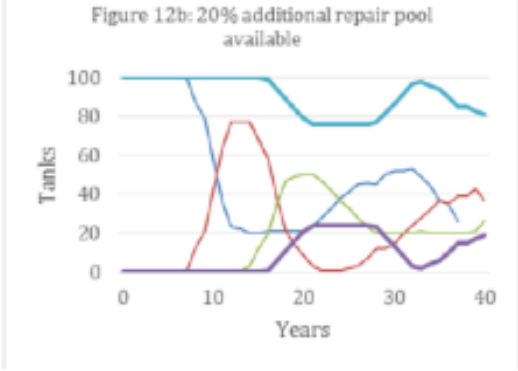
Failure

Aging

Acquisition

Maintenance





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Where are we heading?

- Further development and testing of building blocks
- Composable repository of modelling building blocks
  - Computational algorithms for automated model composability
  - Models are not just software pieces
- Experimental evaluation of the effectiveness of building blocking modelling approach

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Systems Modelling Conference

28 September 2017

UNSW Canberra

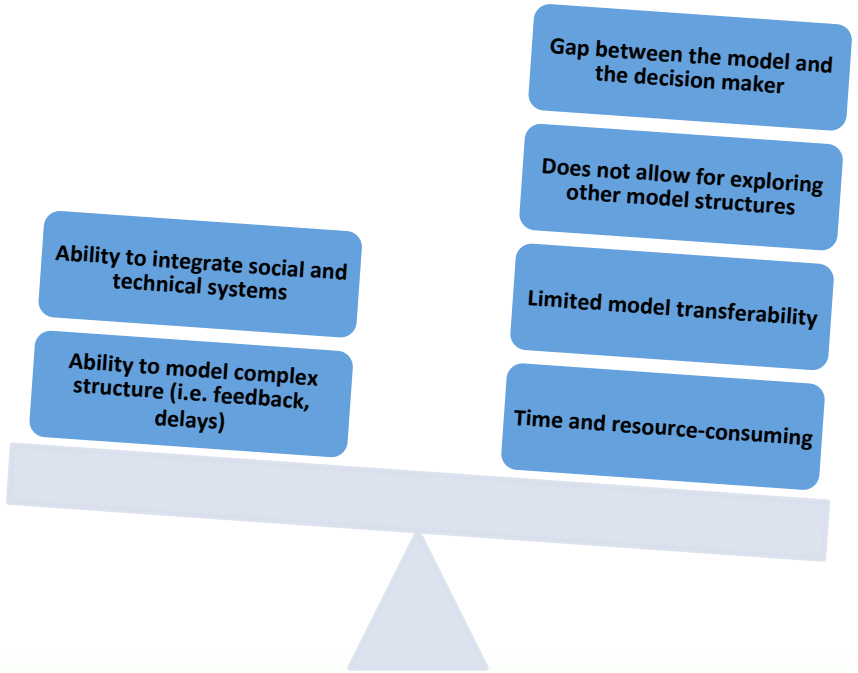
Conference Overview

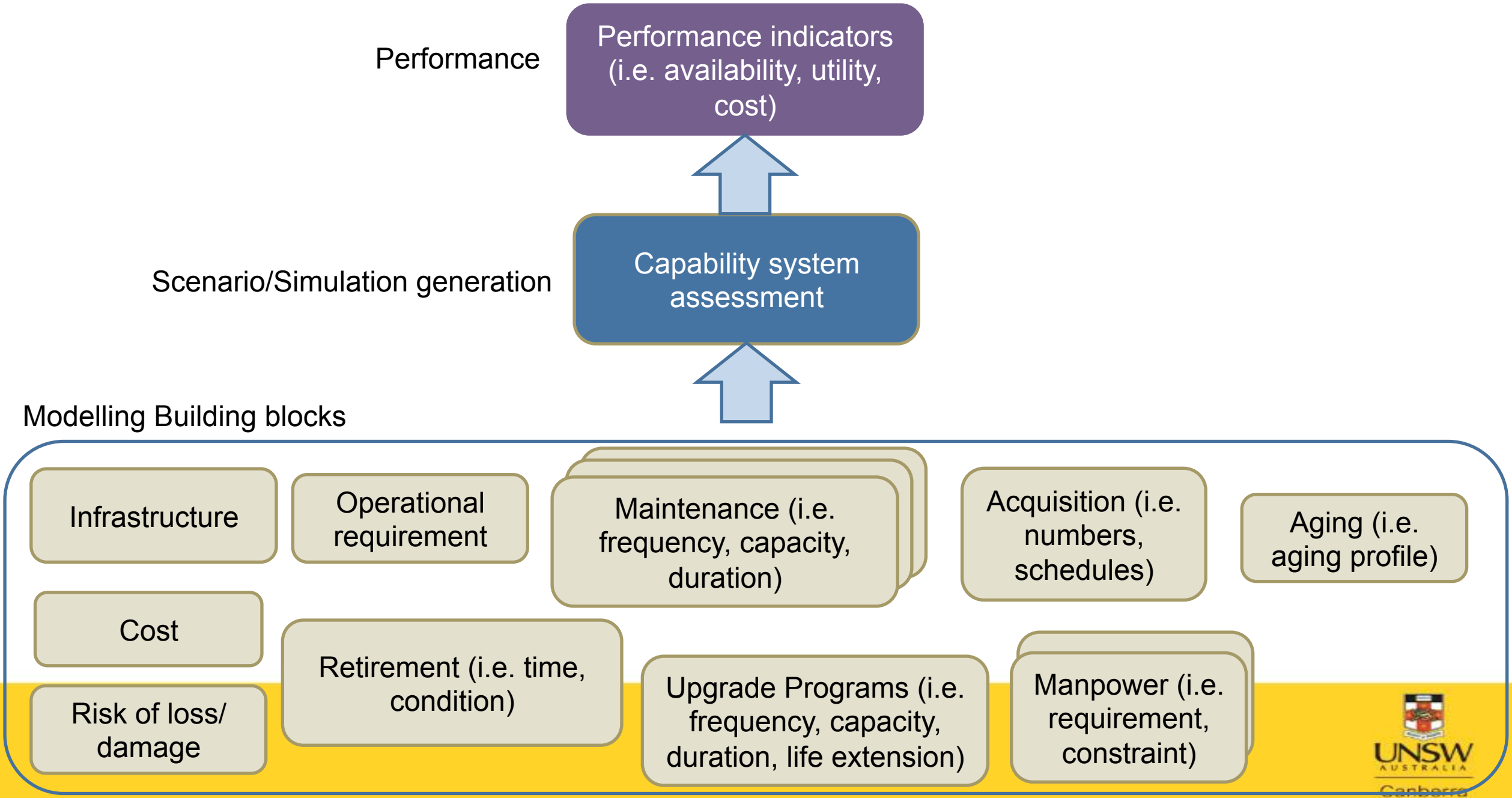
The Capability Systems Centre at the University of New South Wales in Canberra (UNSW Canberra) presents the Systems Modelling Conference 2017.

Systems Thinking and Modelling (ST/SM) is the science of integration, where every system is conceptualised as a set of inter-related components. ST/SM provides a problem solving approach that helps us develop the capacity to understand and

Keynote Speakers

- Associate Professor Shayne Gary, AGSM Fellow, UNSW Business School.
- Dr Barry Newell, ANU College of Medicine, Biology and Environment and ANU College of Engineering and Computer Science.
- Commodore Allison Norris Director General, Australian Defence Simulation and Training Centre.


Gap between the model and the decision maker
Does not allow for exploring other model structures
Limited model transferability
Time and resource-consuming
Ability to integrate social and technical systems
Ability to model complex structure (i.e. feedback, delays)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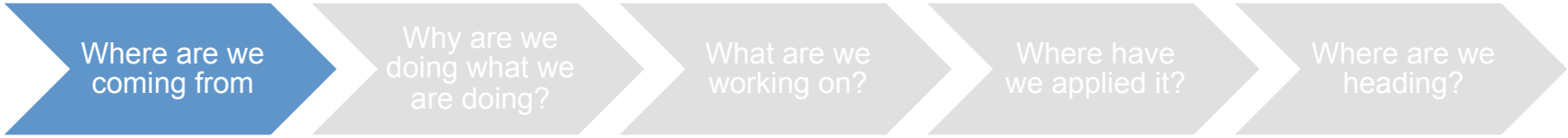
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