



Defence Simulation Investment Reference Guide

Version 1.0

Australian Defence Simulation Office

Department of Defence, Canberra

Copyright Notice

© Commonwealth of Australia

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968 (Cwlth)*, no part may be reproduced by any process without prior written permission from the Director-General, Simulation, Department of Defence.

Requests and inquiries should be directed to:

Director-General, Simulation
Australian Defence Simulation Office
Russell Offices [R1-3-B065]
Canberra ACT 2600
AUSTRALIA

Produced by the Australian Defence Simulation Office
in collaboration with:

Booz | Allen | Hamilton

Booz Allen & Hamilton (Australia) Limited
Level 7, 12 Moore Street
Canberra City ACT 2601
AUSTRALIA

Telephone: +61 2 6279 1900
Facsimile: +61 2 6279 1990

Visit us on the web: www.boozallen.com

Foreword

Defence is under increasing demands to enhance capability whilst simultaneously reducing risk and increasing efficiency. To enhance capability over the coming decade, the Defence Capability Plan (DCP) identifies a broad range of capability upgrades, and includes a substantial investment in modelling and simulation (M&S). Defence recognises that M&S can be used to enhance capability, reduce risk and save resources.

Technology continues to develop at ever increasing rates, and it is difficult for the general population to keep up-to-date with the full range of applications where benefits might be gained by leveraging M&S. While the benefits of using simulation for training are generally well understood, there is less understanding for other areas where simulation use might be increased. This guide provides general investment information to all Defence staff to assist in broadening the awareness and understanding of simulation. In doing so, it provides guidance on the *where, why* and *at what cost* for the increased use of M&S in support of Defence outcomes.

This Defence Simulation Investment Reference Guide is intended to be a living document and will be updated as required. Comments or further clarification on aspects of this guide are welcome and should be directed to:

Australian Defence Simulation Office
Department of Defence
Russell Offices [R1-3-B065]
CANBERRA ACT 2600

Dr Ed Kruzins
Director-General, Simulation
Australian Defence Simulation Office

Telephone: (02) 6265 2019
Facsimile: (02) 6265 2223
Email: ed.kruzins@defence.gov.au

Executive Summary

Simulation is increasingly used within the Australian Defence Organisation (ADO) to gain and sustain knowledge and skills – to look at, understand and prepare for the future. It is used across the Defence Groups in many applications to deal with the increasing complexity and uncertainties associated with modern warfare and its support.

Many benefits of simulation are intuitive and this has led to its increasing use, particularly in the areas of training and experimentation. Simulation can enhance capability by supporting decision-making and training personnel to higher standards. It can save resources by performing analysis faster, training people more efficiently, and reducing the use of (often expensive) operational equipment. It can reduce risk by allowing increased rigour of analysis, increasing confidence in decisions, and by providing a safe and controlled environment.

This Defence Simulation Investment Reference Guide provides information to assist with determining where, why and at what cost simulation could be employed to support Defence outcomes. This information is provided in three main sections:

- ▶ ***Applying simulation to Defence outcomes.*** This section provides guidance to identify where simulation may be applied to support Defence outcomes at each phase in the Defence Capability Life Cycle. There is no ‘one-best way’ to apply simulation, so the guidance is generic.
- ▶ ***The benefits of simulation.*** This section provides guidance to identify where simulation can provide significant benefits. It is intended to help in the development of simulation strategies by identifying areas where simulation business cases should be raised – and to reduce ‘missed opportunities’ (situations where simulation can provide clear benefits that outweigh its cost).
- ▶ ***Estimating the cost of simulation.*** This section provides guidance on estimating the cost of simulation as part of the overall acquisition and sustainment costs of capability. This information relates to the Defence Cost and Schedule Estimation Methodology Handbook but is focused on simulation specific information.

This guide can be read as a standalone document, however please note that it forms only one component of the Defence Simulation Manual. Refer to the other documents in the Defence Simulation Manual suite if further specific information is required.

Table of Contents

Defence Simulation Investment Reference Guide	1
1 Overview	1
1.1 Introduction	1
1.1.1 Purpose of the Guide	1
1.2 Relationship with other Documents	3
2 Applying Simulation to Defence Outcomes.....	4
2.1 Defence Simulation Policy	4
2.2 Identifying simulation support across the Capability Life Cycle.....	4
2.3 Timings for the Capability System Simulation Strategy.....	5
2.4 The Process.....	5
2.5 Step 1 – Confirm the context	6
2.5.1 Step 1a - Define the context.	6
2.5.2 Step 1b - Identify the focus areas and key issues	7
2.6 Step 2 – Define the scope for simulation support.....	7
2.6.1 Step 2a - Identify relevant simulation application areas	7
2.6.2 Step 2b - Identify how simulation will be applied in practice.....	8
2.7 Step 3 – Determine suitability of simulation support.....	9
2.8 Step 4 - Document results	11
2.9 Applying simulation through the CLC phases.....	12
2.9.1 Phase 0 – Identification of Needs	12
2.9.2 Phase 1 – Definition of Requirements	14
2.9.3 Phase 2 – Acquisition	15
2.9.4 Phase 3 – In-Service.....	16
2.9.5 Phase 4 – Disposal (Withdrawal).....	17
3 The Benefits (and Limitations) of Simulation	19
3.1 Introduction	19
3.2 Guidance on identifying benefits and limitations	20
3.2.1 Identifying the benefits of simulation.....	20
3.2.2 Identifying the limitations of simulation	23
3.3 Analysis by each Simulation Application Domain.....	25
3.3.1 Training and Rehearsal Domain	26
3.3.2 Capability Management Domain.....	29
3.3.3 Planning and Operations Domain.....	32
4 Estimating the Cost of Simulation	35
4.1 Introduction	35
4.2 Defence Cost Estimating	35
4.3 Simulation Specific Cost Estimation Considerations.....	36
4.3.1 Step 1 – Prepare and Plan the Estimating Activity	36
4.3.2 Step 2 – Conduct the Estimating Activity	38
4.4 Summary.....	43

Annexes

Annex A - Australian Defence Simulation Office Charter and Points of Contact

Annex B - Reference Documents

Annex C - Capability Systems Simulation Strategy Template

Annex D - Defence Simulation Benefit Examples

Annex E - Additional Detail on Simulation Benefits and Limitations

Annex F - Benefits and Limitations Mapped to Simulation Application Areas

Annex G - Useful References and Contacts for Simulation Cost Estimation

Annex H - Representative Simulation Cost Breakdown Structure

Annex I - Evaluation Form

Table of Figures

Figure 1-1. Components of the Defence Simulation Investment Reference Guide	1
Figure 1-2. Relationships of Simulation Document Suite	3
Figure 2-1. The 4 step process to identify the application of simulation across the capability life cycle.....	5
Figure 2-2. Capability Life Cycle.....	6
Figure 2-3. Defence Simulation Application Areas.....	8
Figure 2-4. Practical application areas of simulation.....	9
Figure 2-5. Relationship of Capability System Simulation Strategy to Simulation Support Plans	12
Figure 2-6. Simulation support to the Needs Phase.....	13
Figure 2-7. Simulation support to the Requirements Phase.....	14
Figure 2-8. Simulation support to the Acquisition Phase.....	15
Figure 2-9. Simulation support to the In-Service Phase.....	16
Figure 2-10. Simulation support to the Disposal Phase	17
Figure 3-1. Process Leading to the Development of a Simulation Business Case.....	20
Figure 3-2. Example purposes and benefits of Simulation.....	21
Figure 3-3. Questions Used to Identify Benefits.....	22
Figure 3-4. Some possible limitations to using simulation.....	23
Figure 3-5. Simulation Application Areas in the Training and Rehearsal Domain	26
Figure 3-6. Simulation Application Areas in the Capability Management Domain.....	29
Figure 3-7. Simulation Application Areas in the Planning and Operations Domain	32
Figure 4-1. The Defence Cost Estimating Process	35
Figure 4-2. Simulation specific cost estimation activities	36

List of Tables

Table 2-1. Key Features of Simulation	10
Table 2-2. Example of method to document data captured through 3-step process	11
Table 2-3. Example simulation application in the Needs Phase	13
Table 2-4. Example simulation application in the Requirements Phase	15
Table 2-5. Example simulation application in the Acquisition Phase	16
Table 2-6. Example simulation application in the In-Service Phase	17
Table 2-7. Example simulation application in the Disposal Phase.....	18
Table 4-1. WBS Element Data Collection Approaches	39
Table 4-2. Specific Simulation Considerations for Collecting WBS Element Data	42

1 Overview

1.1 Introduction

This Defence Simulation Investment Reference Guide provides assistance to Defence staff in understanding the application, benefits and costing of simulation. It is targeted towards desk officers and project staff by providing information to assist in considering the use of simulation to support Defence outcomes. Investing in simulation requires some form of business case which will ultimately weigh up the benefits that simulation adds to a Defence outcome, the practicality of its use and the cost at which it can be provided.

There are key questions for shaping the thinking about the potential employment of simulation capabilities:

- ▶ What Defence outcomes are being pursued?
- ▶ Where and how might simulation be of use?
- ▶ What is the purpose of the simulation?
- ▶ What broader activities does the simulation support?

From this, further analysis will define the aim, objectives, scope and the requirements for simulation. The questions and their answers will provide the framework for building the business case for simulation. Supporting data may then be gathered through a number of means, including existing corporate information, workshops, case studies and formal requirements elicitation.

1.1.1 Purpose of the Guide

The purpose of this guide is to provide high level guidance for Defence staff to assist with determining where to apply simulation; potential benefits (and limitations); and its likely cost. The guide is not intended to provide the specific answers for individual tasks or specific projects. The guide will assist staff to answer questions of *where*, *why* and at *what cost* simulation can be used as an effective contributor to a Defence outcome.

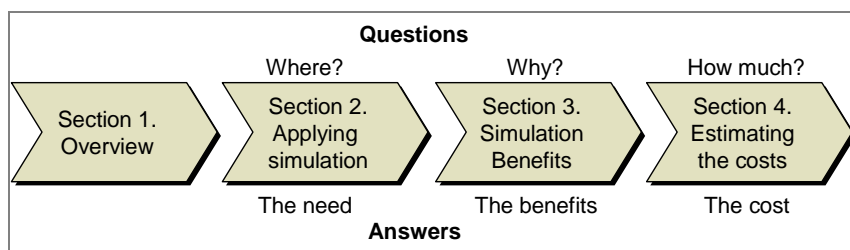


Figure 1-1. Components of the Defence Simulation Investment Reference Guide

The main sections of this guide are:

Section 1 - Overview

This section provides the *context* of the guide and its relationship to the Defence Simulation documentation suite.

Section 2 - Applying Simulation to Defence outcomes

This section provides a simple methodology for addressing the '*where*' for simulation in each of the five phases of the Defence Capability Life Cycle (CLC). A high level overview of the more detailed Defence CLC Phase Guides is provided.

Section 2 assists Defence staff to:

- ▶ Understand where simulation can be applied in the course of their work¹, and
- ▶ Initiate the development of a strategy for using simulation to support a capital equipment project across its CLC.

With the benefit of having undertaken a desktop review of where and how simulation could be applied to support their project by following the steps in this section, Defence staff should be able to initiate the development of a *Capability System Simulation Strategy* to invest in simulation at certain points of the CLC.

The guidance is generic and is not intended to provide the specific answers for individual tasks or specific projects. However, where appropriate, examples are provided to illustrate where simulation can be applied.

Section 3 - The Benefits (and Limitations) of Simulation

This section provides generic information on the benefits and limitations of simulation across each simulation application area, the '*why*' and '*why not*'. This information can be used by Defence staff to justify simulation by articulating its benefits and limitations in the area(s) in which it is to be used.

Section 3 assists Defence staff to:

- ▶ Justify the use of simulation
- ▶ Identify limitations and risks with the use of simulation.

Section 4 – Estimating the cost of Simulation

This section provides a simple, high-level methodology for Defence staff to estimate Life Cycle Cost (LCC) across the CLC.

¹ That is, how individuals or units can use simulation to support a range of defence tasks such as: developing military strategies, undertaking capability gap analysis, performing fleet management, developing and validating doctrine, etc.

Section 4 assists Defence staff to:

- ▶ Understand how cost estimation techniques can be applied when determining LCC for simulation investments
- ▶ Develop initial focus areas for developing LCC estimates for a simulation
- ▶ Highlight specific areas that should be investigated when generating LCC estimates for simulation

By following this section and with reference to the Defence Cost and Schedule Estimation Methodology Handbook, Defence staff can perform a quick desktop assessment of how cost estimating for simulation investments should be applied. This section also provides advice on a number of unique cost drivers associated with the development and use of simulation.

1.2 Relationship with other Documents

The Australian Defence Simulation Office (ADSO) has developed a series of interrelated policy and guidance documents to assist Defence understand, acquire, manage, use and support simulation. These documents have been developed as individual parts that combine to form the Defence Simulation Manual. This Defence Simulation Investment Reference Guide forms part of the Manual. The other documents developed to detail the policy and provide additional guidance for simulation are illustrated at Figure 1-2. Collectively, the documentation suite can be used to inform acquisition cases and simulation strategies.

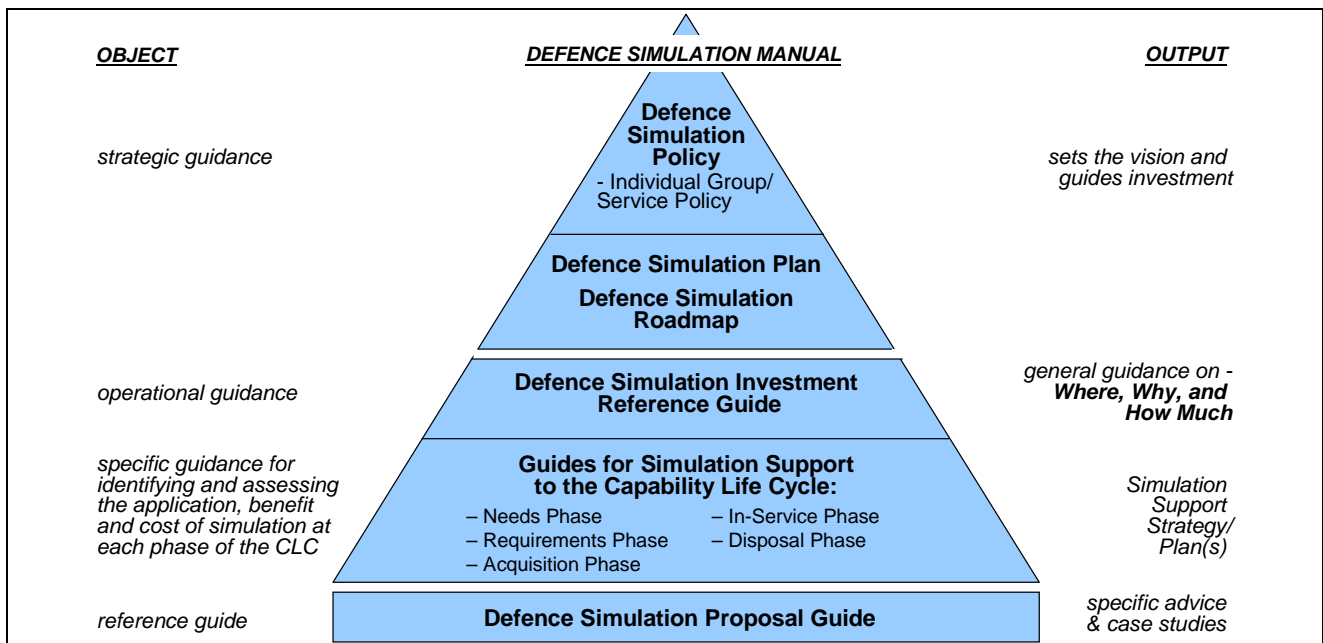


Figure 1-2. Relationships of Simulation Document Suite

2 Applying Simulation to Defence Outcomes

2.1 Defence Simulation Policy

The Defence Simulation Policy, Defence Instruction (General) OPS 42-1, is the capstone policy document for simulation and was released on 3 October 2001. The policy provides high level guidance on the development and use of simulation within Defence. It summarises the benefits of simulation as:

- “a. capability enhancement – for example, by supporting the development, selection and life cycle management of weapon systems in the Australian Defence Force inventory;*
- b. resource savings – for example, by reducing the need to use more expensive, operational assets for training and analysis tasks; and*
- c. risk reduction – for example, by supporting both training in and the analysis of life threatening situations without endangering life.”*

These three areas summarise why simulation should be applied to Defence outcomes, and are included in the Defence Vision for Simulation:

Defence exploits simulation
to develop, train for, prepare for and test military options for Government
wherever it can enhance capability, save resources or reduce risk.

2.2 Identifying simulation support across the Capability Life Cycle

In outcome terms, this section aims to help Defence staff develop an initial understanding of where and how simulation can be applied to support the definition, selection, acquisition, in-service support and disposal of capability systems, wherever it can help to enhance capability, save resources and/or reduce risk.

In output terms, it helps Defence staff involved in the development and maintenance of capability systems to develop a *Capability System Simulation Strategy* (CSSS). Its purpose is to document the strategy for the use of simulation in support of Defence capability. A CSSS evolves as a capability matures. It must be developed and updated as an integral element of Program and Project strategy and planning documents, and in-service support plans, to ensure simulation support is planned, funded and delivered consistent with capability requirements.

For staff involved in activities such as the development of military strategy, assessment of preparedness and identification of broad capability needs (activities early in the Needs Phase), the development of a *Capability System Simulation Strategy* may not be a priority. But, those staff should still undertake this cognitive and practical process to examine where and how simulation can support them in delivering outputs from the Needs Phase and then document their insights in a Simulation Support Plan. A guide to developing these plans is detailed in the *Capability Life Cycle Simulation Support: Needs Phase Guide*.

2.3 Timings for the Capability System Simulation Strategy

The *Capability System Simulation Strategy* should be developed just before or immediately after a project has been accepted into the DCP. This will largely be dependent on the staff resources available to undertake this activity, but may also be influenced by the level to which the capability system has been defined. That is, it may be difficult to develop a simulation strategy for capability systems that are broadly defined (i.e. where system options such as aircraft, ships, etc have not been identified).

For projects that already exist, a strategy should be developed as soon as practicable to inform the significant activities remaining in the current phase of the CLC and, importantly, plan for the next phases of the CLC – whether that involves acquisition, in-service support or other relevant activities that may benefit from simulation support.

At appropriate stages in the CLC process, the strategy should be updated to reflect increased understanding of the opportunities provided for simulation and where simulation has previously been used to support the capability system.

2.4 The Process

A simple process has been developed to assist Defence staff determine how and where simulation can be applied to support their capability system (or specific area of focus) and develop a simulation strategy to guide the planning and development of simulation for that purpose. The process comprises four steps (as shown in Figure 2-1):

- ▶ Step 1 - Confirm the context,
- ▶ Step 2 - Define the scope for simulation support,
- ▶ Step 3 - Determine suitability of simulation support, and
- ▶ Step 4 - Document the results.

Upon completing these steps Defence staff should have an increased awareness on how to apply simulation for various tasks and, where applicable, a Capability System Simulation Strategy and associated support plans for a current or emerging capability.

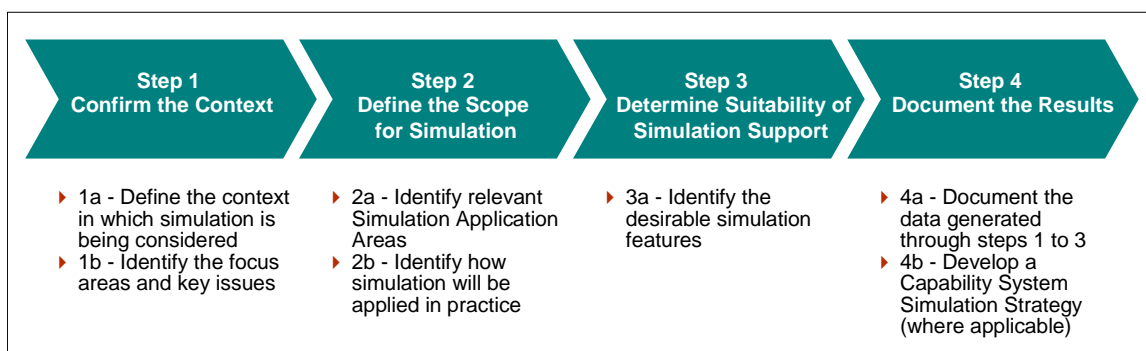


Figure 2-1. The 4 step process to identify the application of simulation across the capability life cycle

2.5 Step 1 – Confirm the context

The first step in determining ‘where and how’ to apply simulation has two components:

- ▶ Step 1a - Define the context in which simulation is being considered in terms of the fundamental Defence requirement(s) / mission(s) that are being supported, and
- ▶ Step 1b - Identify the issue(s) to be focused upon.

2.5.1 Step 1a - Define the context.

The Defence Capability Development Manual (DCDM) identifies the five phases of the CLC. Each phase has a specific focus, a number of outcomes and outputs. In delivering the outputs, a number of issues specific to each capability phase require consideration. The phases of the CLC, the focal outputs and a sample of the focus areas considered in each phase are presented in Figure 2-2.

Depending on one’s role in the Defence organisation, the context for considering the applicability of simulation can vary from focussing on a single issue within a particular phase through to considering the entire CLC. For example, a strategic planner who has the task of identifying capability gaps may focus on one application of simulation in a single phase (Phase 0). A capability desk officer has the responsibility to consider simulation across the remaining capability life cycle of their project (Phase 1 thru 4), whilst a fleet manager may only need to assess the applicability of simulation for fleet management and, possibly, disposal (Phases 3 & 4).

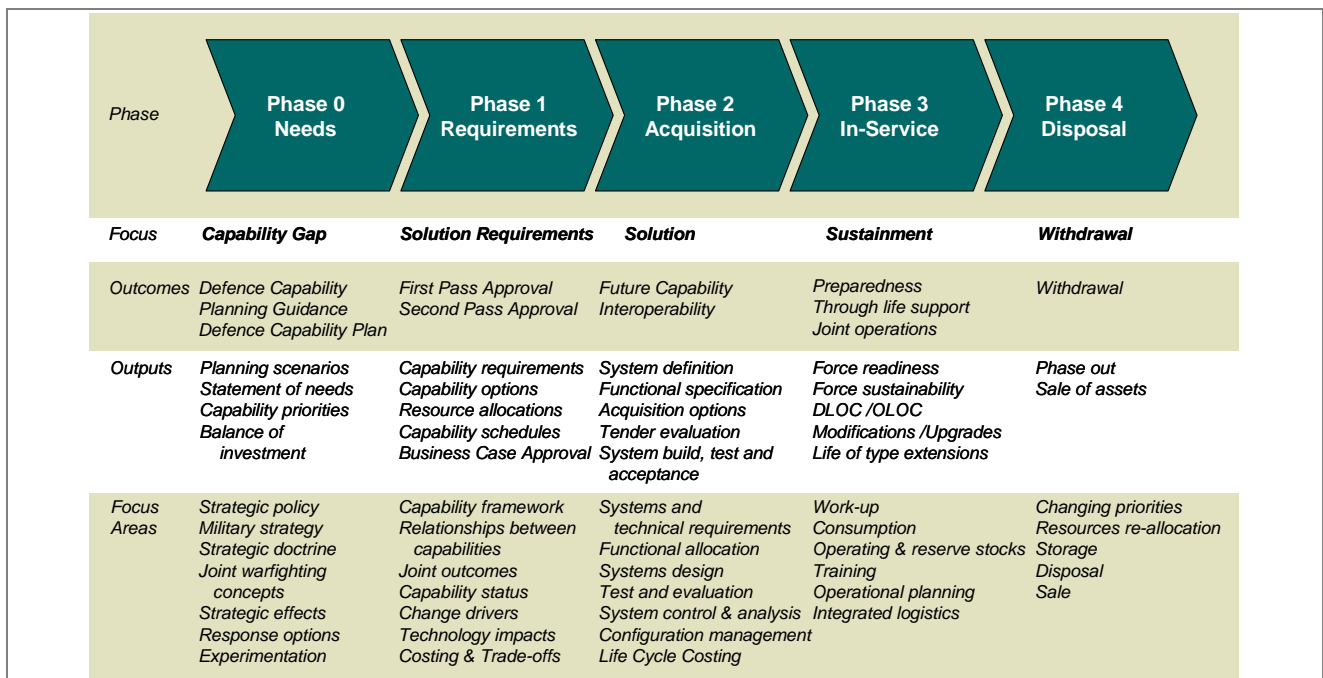


Figure 2-2. Capability Life Cycle

2.5.2 Step 1b - Identify the focus areas and key issues

The focus areas (and the key issues addressed by these areas) identified in Figure 2-2 are often at the heart of Defence's ability to deliver the outputs in each phase of capability management. Their resolution will likely have a significant impact on Defence and the impact may apply across a number of phases. In identifying and defining the key issues for a given context, Defence staff should consider the potential consequences across other phases.

Such considerations will help to develop a clear statement of the critical issues being addressed by the project/activity, and sharpen the focus for how simulation may support the capability during its life cycle.

2.6 Step 2 – Define the scope for simulation support

Having defined the applicable phases and key issues relevant to the project/activity, one can define the scope for simulation support. This is achieved by identifying the simulation application areas that are most relevant to supporting the phase outputs and focal issues. This involves two steps:

- ▶ Step 2a - Consider which of the nine simulation application areas defined in the simulation policy apply, and
- ▶ Step 2b - Consider the application in practice of those areas.

2.6.1 Step 2a - Identify relevant simulation application areas

The Defence Simulation Policy (DSP) identifies nine application areas that illustrate the full scope and scale of simulation interest in Defence. These application areas are further defined at Chapter 3 of the Defence Simulation Proposal Guide (SPG). The general applicability of simulation application areas to specific phases of the CLC is shown in Figure 2-3 below.

Using Figure 2-3 and the definitions provided in the SPG as a general guide, Defence staff should identify those simulation application areas that are relevant to the project/activity being supported.

		Simulation Application Areas ²								
		Force Assessment	Experimentation	Research & Development	Acquisition	Training	Mission Rehearsal	Crisis Mgmt & Planning	Operations	Life-cycle Management
Capability Life Cycle Phase	Phase 0 – Needs	✓	✓	✓				✓		
	Phase 1 – Requirements	✓	✓	✓				✓		✓
	Phase 2 - Acquisition	✓		✓	✓	✓				✓
	Phase 3 – In-Service	✓	✓	✓		✓	✓	✓	✓	✓
	Phase 4 - Disposal			✓						✓

Figure 2-3. Defence Simulation Application Areas

2.6.2 Step 2b - Identify how simulation will be applied in practice

The nine simulation areas identified in the Defence Simulation Policy cover a wide range of practical applications of simulation. A sample of the practical application areas is presented in Figure 2-4, to illustrate how simulation might be applied to support a capability or activities across the CLC.

The identification of how simulation may be applied in practice to support a capability or activity represents the initial stages of describing the functional requirement for simulation.

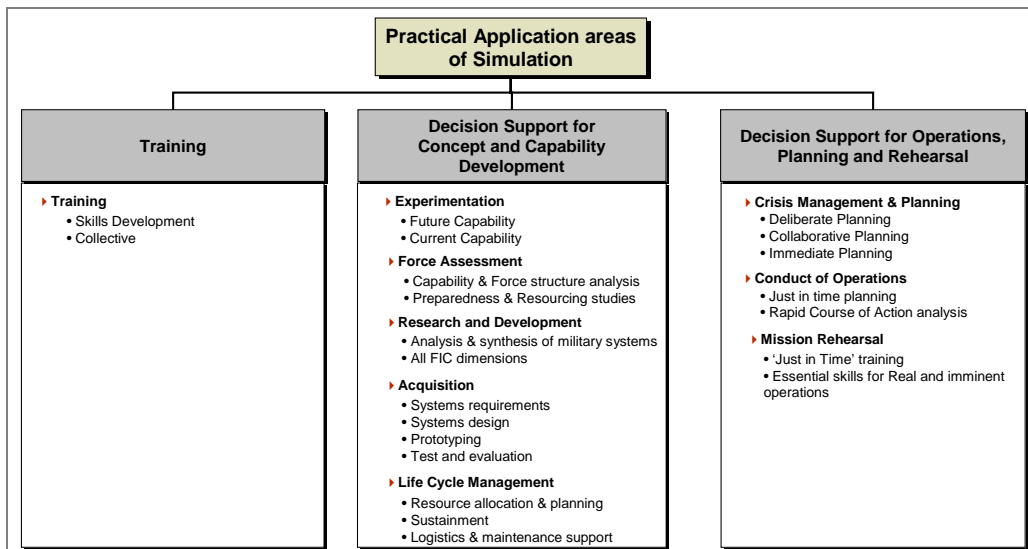


Figure 2-4. Practical application areas of simulation²

2.7 Step 3 – Determine suitability of simulation support

Having identified - by CLC phase - the practical areas where simulation can support the issues relevant to a project/activity, the next step is to consider what specific features of the practical application area within the project context might lead to simulation actually being applied.

Clearly, the needs of the project and the potential solution offered by simulation must align. In taking this next step, Defence staff can begin to create an understanding of the benefits that could be derived from the use of simulation (see Section 3). This step also sets the scene for developing an initial set of user requirements and assists in developing a basis for determining whether or not to invest in simulation for a specific application.

In undertaking Step 3, one activity is required:

- ▶ Step 3a - Consider which of the practical simulation application areas lend themselves to being supported by a simulation within the context of the case and the identified issue(s).

The following questions will help Defence staff to consider the features of the practical application area that indicate the required features of the simulation support:

- ▶ What time constraints apply to the activity? (i.e. is the ability for simulation to perform numerous instantiations of a problem in quick time a required feature?)
 - This may indicate that a desirable feature of the simulation is speed – the ability to simulate the problem at high speeds.
- ▶ Does the activity require players to have a good appreciation of time/space issues and relationships?

²The nine simulation application areas are defined in Defence Simulation Policy (DI(G) OPS 42-1), and have been grouped into three principal domains.

- This may indicate that a desirable feature of the simulation is the ability to incorporate dynamic interactions.
- ▶ What is the need to test/train/conduct the activity across many scenarios and environments?
 - This may indicate that a desirable feature of the simulation is the ability to represent different scenarios (different periods in time, different geography, different entities).
- ▶ How close to 'reality' does the activity need to be?
 - This may indicate that a desirable feature of the simulation is the ability to represent a large number of dimensions/parameters of the problem.
- ▶ Is there a need to reproduce the activity a large number of times (with deliberate injections of small variations)?
 - This may indicate that a desirable feature of the simulation is repeatability/reproducibility.

Table 2-1 provides an indicative set of the key features of simulation, grouped into the three elements of Speed, Representation and Data capture & feedback. The questions posed above demonstrate how one can determine the features of simulation that may apply/be desirable to support the activity under consideration.

Table 2-1. Key Features of Simulation

Element	Key Feature	Example/Purpose
Speed	<ul style="list-style-type: none"> ▶ Ability to simulate problem/context at high or advanced speeds ▶ Ability to simulate problem at slow speed ▶ Ability to incorporate dynamic interactions 	<ul style="list-style-type: none"> ▶ Fast play (calculation) of operational scenario to provide outputs of many instantiations in quick time ▶ Deceleration of time to analyse sub-component performance ▶ Dynamic play to simulate real-time interactions by players
Representation	<ul style="list-style-type: none"> ▶ Ability to represent past, present & future entities/environments ▶ Ability to represent a large number of dimensions/parameters of the problem (nearing reality) ▶ Ability to represent high risk environments/events 	<ul style="list-style-type: none"> ▶ Represent future fighting environment to educate ▶ Representation of three dimensional landscape to provide improved understanding of battle (e.g. vis-à-vis a two-dimensional map) ▶ Representation of environment or event that is too risky to achieve in live training/testing
Data capture and feedback	<ul style="list-style-type: none"> ▶ Repeatability/reproducibility ▶ Data recording and capture ▶ Feedback mechanisms 	<ul style="list-style-type: none"> ▶ Can repeat the simulation or problem a number of times ▶ Records and stores data and results ▶ Provides mechanisms to provide automatic feedback and/or to document report results

2.8 Step 4 - Document results

A Capability System Simulation Strategy (CSSS) documents the planned and actual use of simulation over the life cycle of a capability, and necessarily evolves as a capability matures. It is intended to be updated in conjunction with Program and Project strategy and planning documents, and in-service support plans, to ensure simulation support is planned, funded and delivered in alignment with capability requirements.

The design and evolution of a CSSS begins by documenting the insights gained by following the steps of this guide. Whilst these insights may be captured in a number of ways, the following table (Table 2-2) presents a method of capturing the issues, simulation applications and features by CLC phase (derived from following the preceding three steps).

Table 2-2. Example of method to document data captured through 3-step process

Step	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4
Step 1: Context					
Focus Area	▶ Military Strategy	▶ Costing & trade-offs	▶ Verification and Validation	▶ Operational planning	▶ Disposal
Key Issue(s)	<ul style="list-style-type: none"> ▶ What effects are required? ▶ How should the ADF create these effects? 	<ul style="list-style-type: none"> ▶ What capability options exist to meet requirements? ▶ What are the trade-offs between the different options? 	<ul style="list-style-type: none"> ▶ How can V&V be conducted to test high-risk events? ▶ How can V&V be conducted at minimum cost? 	<ul style="list-style-type: none"> ▶ How can the employment of the capability be optimized as part of a larger force? 	<ul style="list-style-type: none"> ▶ What is the potential environmental impact of disposal? ▶ How can disposal costs be minimized?
Step 2: Likely Simulation Application Areas					
Simulation Application Areas	▶ Experimentation	▶ Force assessment	▶ Acquisition	▶ Crisis Mgt & Planning	▶ Life cycle management
Applied in practice	▶ Explore novel future concepts	▶ Capability & force structure analysis	▶ Test and evaluation	▶ Collaborative planning	▶ Resource planning & allocation
Step 3: Simulation Features					
Desirable simulation features	<ul style="list-style-type: none"> ▶ Simulate at high speed ▶ Represent # of variables ▶ Represent future environment 	<ul style="list-style-type: none"> ▶ Simulate at high speed ▶ Represent # of variables ▶ Repeatability 	<ul style="list-style-type: none"> ▶ Dynamic play ▶ Simulate at high speed ▶ Represent number of variables ▶ Represent high risk environment ▶ Repeatability 	<ul style="list-style-type: none"> ▶ Dynamic play ▶ Simulate at high speed ▶ Represent # of variables ▶ Repeatability 	<ul style="list-style-type: none"> ▶ Represent # of variables ▶ Repeatability

Where a project is being raised to develop and introduce a capability system, a Capability System Simulation Strategy should be developed. A template for a *Capability System Simulation Strategy* is provided at Annex C. This simulation strategy provides the guiding document for subsequent Simulation Support Plans that will be developed to support various stages of the CLC, as illustrated in Figure 2-5.

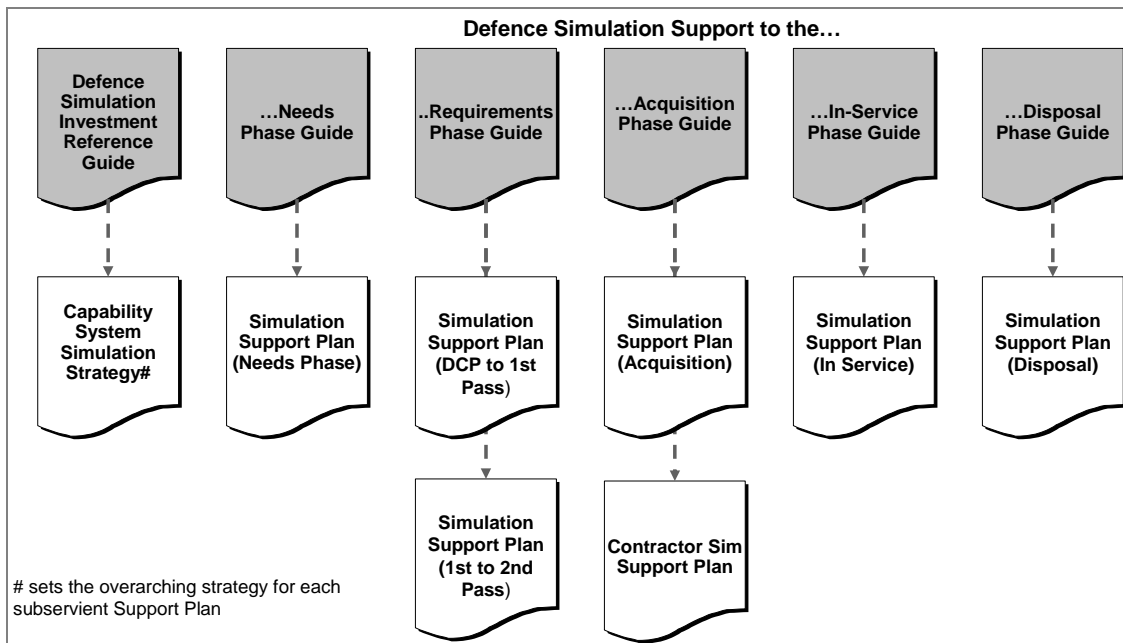


Figure 2-5. Relationship of Capability System Simulation Strategy to Simulation Support Plans

2.9 Applying simulation through the CLC phases

The following sections illustrate the typical target issues and the likely application areas, and key features for simulation support of those issues – by CLC Phase. An example of how simulation has been applied to support an activity within these phases is also provided.

Once a simulation strategy has been developed, readers should consult the relevant phase guide for further guidance on how to translate the strategy into a plan for simulation support. Relevant documents are identified in Figure 2-5 and Annex B.

The Australian Defence Simulation Office (ADSO) can also be contacted to obtain examples of Capability System Simulation Strategies and to provide further guidance where required. Contact details are provided in Annex A.

2.9.1 Phase 0 – Identification of Needs

At the outset of the capability definition process, Defence staff are faced with a high degree of uncertainty, where the scope for ambiguity and disagreement is greatest. This situation provides a significant opportunity for utilising simulation to improve the decision-making process. The potential exists for high payoff in terms of better informing the decision-makers about capability needs and options, and setting the right direction for capability investment.

The target issues, application areas and key characteristics of simulations supporting the Needs Phase are shown in Figure 2-6.

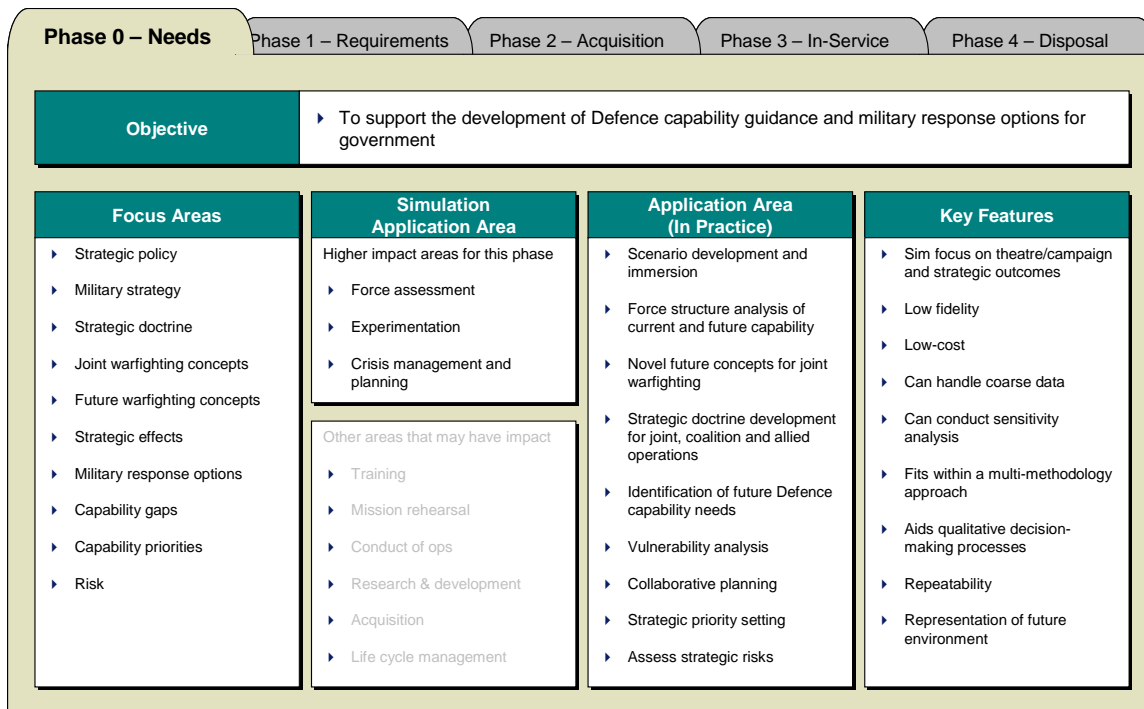


Figure 2-6. Simulation support to the Needs Phase

The possible combinations of target issues, application areas and key features that might be required in a simulation are extensive. A sample combination is illustrated in Table 2-3.

Table 2-3. Example simulation application in the Needs Phase

Focus Area	Simulation Application Area	Application Area (In Practice)	Key Features
▶ Future warfighting concepts	▶ Experimentation	▶ Novel concepts for joint warfighting	<ul style="list-style-type: none"> ▶ Repeatability ▶ Representation of future environment
Applied Simulation			
▶ JANUS	<ul style="list-style-type: none"> ▶ Brigade-level human in the loop constructive simulation supporting Joint Operations deliberate planning ▶ Used in Headline experiments in combination with CAEN to better define future warfighting concepts 		
▶ CAEN	<ul style="list-style-type: none"> ▶ A closed loop constructive simulation up to company-level in close combat ▶ Evaluation of new urban concepts at sub-unit level to provide combat resolution 		

2.9.2 Phase 1 – Definition of Requirements

Capability requirements are defined and progressively refined in the Requirements Phase to move from the output of the Needs Phase as a broad statement of need to becoming an approved project ready for acquisition. At that time, a capability will have an operational concept description, a functional performance specification, test concept document and costed business case prepared. Simulation support to the Requirements Phase will also need to be able to progressively improve the fidelity of the decision support it is able to provide.

The target issues, areas of practical application for simulation and the key features of simulation as it applies to the Requirements Phase are summarised in Figure 2-7.

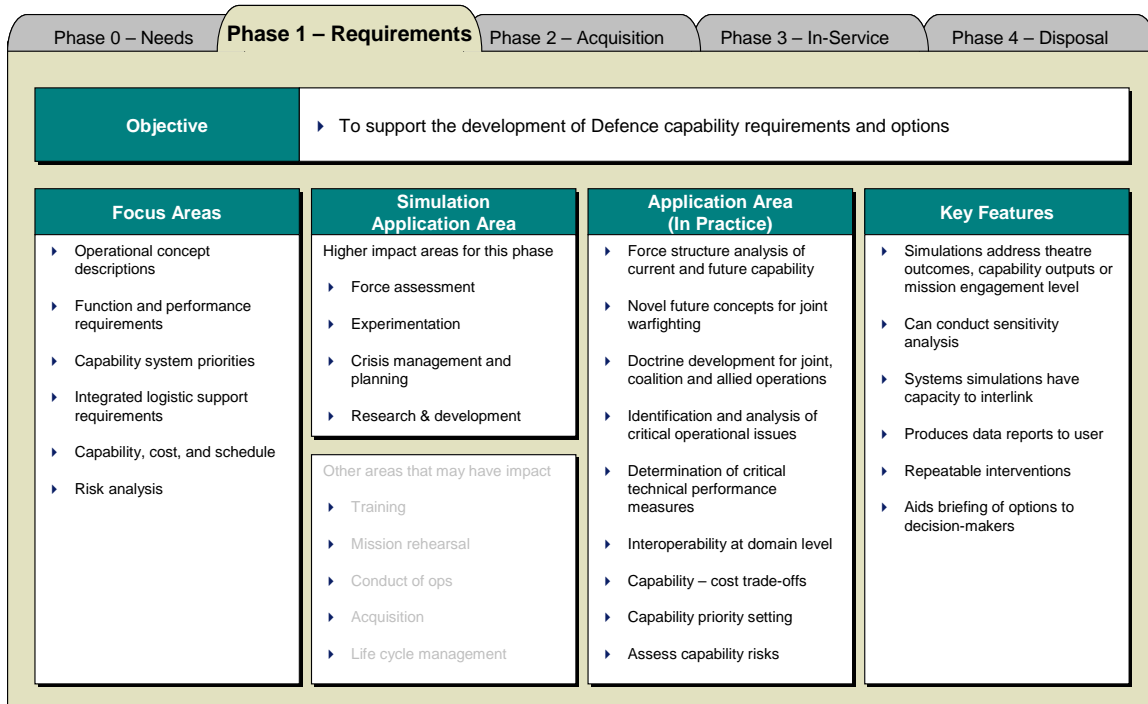


Figure 2-7. Simulation support to the Requirements Phase

A sample combination of target issues, simulation application and simulation features, is presented in Table 2-4.

Table 2-4. Example simulation application in the Requirements Phase

Focus Area	Simulation Application Area	Application Area (In Practice)	Key Features
<ul style="list-style-type: none"> Operational concept descriptions 	<ul style="list-style-type: none"> Research and Development 	<ul style="list-style-type: none"> Identification and analysis of critical operational issues 	<ul style="list-style-type: none"> High calculation rates Repeatability Representation of a large number of dimensions Data recording and capture Feedback mechanisms Representation/visualisation
Applied Simulation			
<ul style="list-style-type: none"> DSTO Virtual ship 	<ul style="list-style-type: none"> A combat system laboratory for operational concept development incorporating hardware in the loop and virtual simulation techniques. 		

2.9.3 Phase 2 – Acquisition

The refined capability requirements involve the production of detailed specifications for the Acquisition Phase, for delivery of effective proposal responses by industry. Defence acquisitions such as the introduction of a new class of ship are some of the most complex acquisitions in existence today. Simulation enables project managers to deliver capabilities that are cost effective and fit for the purpose.

The target issues, areas of practical application for simulation and the key features of simulation as they apply to the Acquisition Phase are summarised in Figure 2-8.

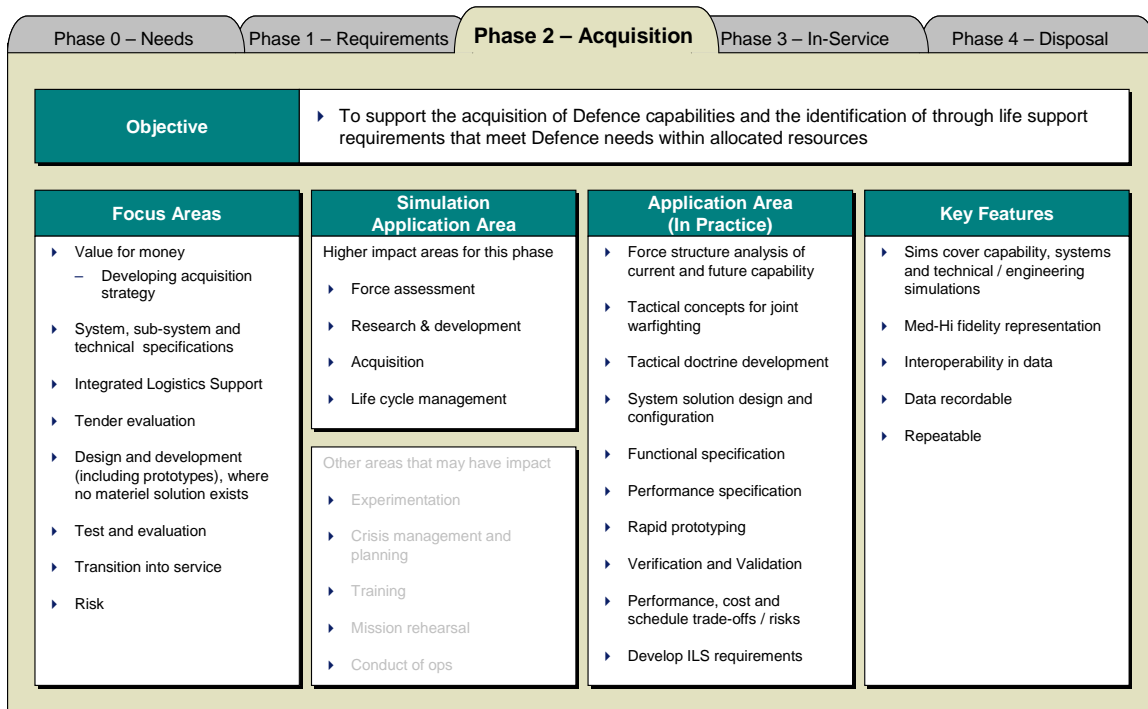


Figure 2-8. Simulation support to the Acquisition Phase

A sample combination of target issues, simulation application and simulation features, is presented in Table 2-5.

Table 2-5. Example simulation application in the Acquisition Phase

Focus Area	Simulation Application Area	Application Area (In Practice)	Key Features
▶ Test and Evaluation	▶ Acquisition	▶ Test and evaluation	<ul style="list-style-type: none"> ▶ High calculation rates ▶ Repeatability ▶ Representation of a large number of dimensions of the problem ▶ Data recording and capture
Applied Simulation			
▶ F-111 WSSF	▶ Used to perform test and evaluation of software modifications for the F-111 mission system		

2.9.4 Phase 3 – In-Service

The in-service phase encompasses a broad range of requirements to meet the objectives to operate, maintain and sustain a capability. The in-service phase presents opportunities for using simulation to address the issues facing those involved in the preparation and conduct of operations and the various supporting functions. Throughout this phase the level of capability and its economic life-of-type is assessed to support timely capability life-of-type planning.

The target issues, areas of practical application for simulation and the key characteristics of simulation as they apply to the In-Service Phase are summarised in Figure 2-9.

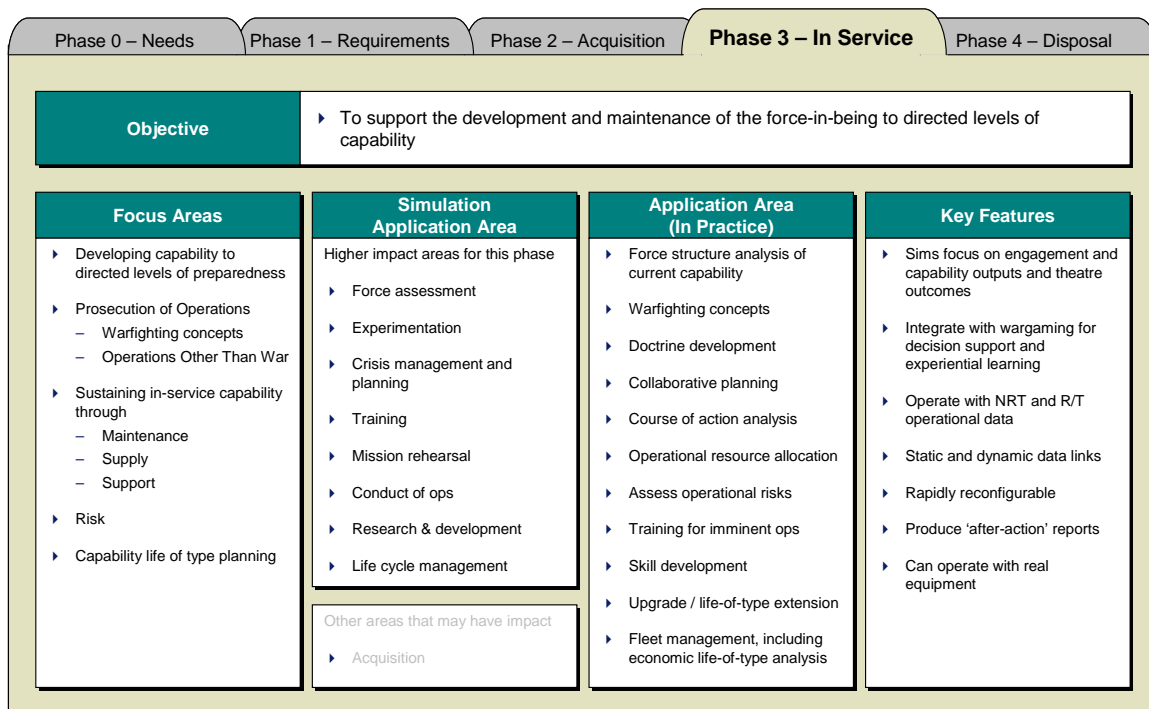


Figure 2-9. Simulation support to the In-Service Phase

A sample combination of target issues, simulation application and simulation features, is presented in Table 2-6.

Table 2-6. Example simulation application in the In-Service Phase

Focus Area	Simulation Application Area	Application Area (In Practice)	Key Features
<ul style="list-style-type: none"> ▶ Developing capability to directed levels of preparedness 	<ul style="list-style-type: none"> ▶ Training 	<ul style="list-style-type: none"> ▶ Skill development 	<ul style="list-style-type: none"> ▶ Repeatability ▶ Data recording and capture ▶ Feedback mechanisms ▶ Representation of large number of dimensions of reality
Applied Simulation			
<ul style="list-style-type: none"> ▶ Combat Training Centre - Live Instrumented System 	<ul style="list-style-type: none"> ▶ Able to be used to test and evaluate the operational employment of various capabilities in a live simulation environment. 		

2.9.5 Phase 4 – Disposal (Withdrawal)

The final phase of the CLC is often overlooked, in spite of potential for political, environmental and other issues that can arise without careful consideration of disposal options. Simulation support to the Disposal Phase can assist those responsible on the most appropriate and cost effective means of a capability withdrawal. Simulation may be used in this context to assist with developing acceptable options for retiring ADF systems. This type of activity could take on the appearance of earlier CLC phases for those systems being considered for on-selling to other nations.

The target issues, areas of practical application for simulation and the key characteristics of simulation as it applies to the Disposal Phase are summarised in Figure 2-10.

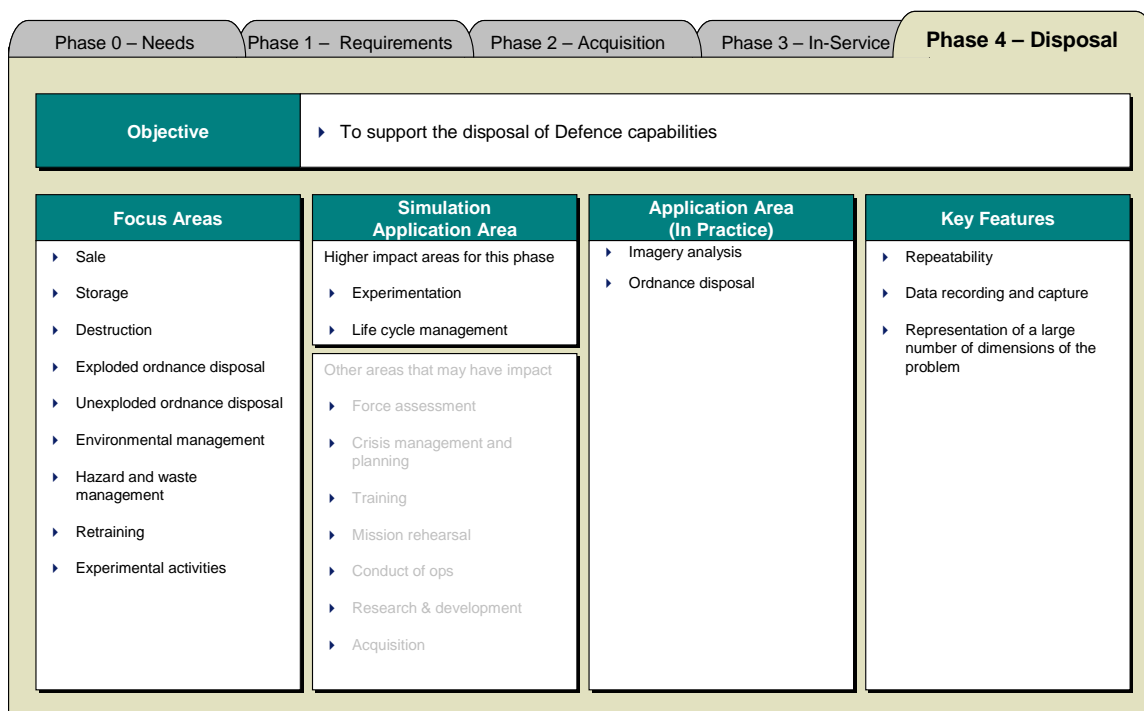


Figure 2-10. Simulation support to the Disposal Phase

A sample combination of target issues, simulation application and simulation features, is presented in Table 2-7.

Table 2-7. Example simulation application in the Disposal Phase

Focus Area	Simulation Application Area	Application Area (In Practice)	Key Features
<ul style="list-style-type: none"> ▶ Unexploded ordnance disposal 	<ul style="list-style-type: none"> ▶ Lifecycle management ▶ Research and Development 	<ul style="list-style-type: none"> ▶ Ordnance disposal ▶ Ordnance detection and location 	<ul style="list-style-type: none"> ▶ Repeatability ▶ Data recording and capture ▶ Representation of a large number of dimensions of the problem ▶ Potential to verify models using actual data
Applied Simulation			
<ul style="list-style-type: none"> ▶ No examples provided 	<ul style="list-style-type: none"> ▶ N/A 		

3 The Benefits (and Limitations) of Simulation

3.1 Introduction

This section describes the benefits (and limitations) of simulation across each simulation domain. This can be used to justify simulation by articulating its benefits as well as limitations in the area(s) in which it is to be used, and also to 'screen out' applications where the limitations may outweigh the benefits.

It is essential to identify both the benefits and limitations associated with simulation prior to progressing to the detailed assessment required for acquisition.

Simulation is increasingly used within the Australian Defence Organisation (ADO) to gain and sustain knowledge and skills – to look at, understand and prepare for the future. It is used across the Defence Groups in many application areas to deal with the increasing complexity and uncertainties associated with modern warfare and its support.

Many benefits of simulation are intuitive and this has led to its increasing use, particularly in the areas of training and experimentation. Simulation can enhance capability by supporting decision-making and training personnel to higher standards. It can save resources by performing analysis faster, training people more efficiently, and reducing the use of (often expensive) operational equipment. It can reduce risk by allowing increased rigour of analysis, increasing confidence in decisions, and by providing a safe and controlled environment.

Simulation can be a viable, flexible and rigorous tool. Simulation allows issues to be identified, analysed and resolved before they manifest into problems. It can deal with more complexity and variables than the human mind, and can encourage users to think at a higher level where systems are more than the sum of their components. Using simulation in process or product design can save resources by identifying design errors earlier and reducing the number of prototypes or trials required. Simulation enables the smart buyer by allowing them to more fully develop requirements and assess performance. With the ability to quantify effects through simulation, a much greater degree of insight and understanding can be brought to bear on the decision-making process leading to increased communication and consensus building.

Simulation provides a level of robustness to complex decision-making – the basis for the decisions can be scrutinised, the scenarios can be re-run, the outcomes can be tested, the inputs/actions/variables can be altered to see and measure their effects. This enables broader participation in the decision-making process, visualisation of the results, shared awareness of the outcomes, and thus increases the credibility of the decision.

Issues raised in the **Defence White Paper** highlight the potential for simulation, including wargames, to improve the available range of Defence tools for analysis, research and development experimentation, acquisition, training and operations.

Specifically the White Paper states:

*"In addition to the application of science and technology directly to our combat capabilities, the emerging information-based technologies have the potential to change the way we train for operations. Advances in computer-based simulation can provide cost-effective planning and training tools using virtual reality-based simulations."*³

And...

*"The ability to identify effectively and incorporate those technologies that sustain the capability of the ADF will be guided by simulation and modelling, through both qualitative and quantitative wargames. Defence will evaluate its current warfare concepts and seek to capitalise on opportunities and prevent or dominate potential threats to our security."*⁴

3.2 Guidance on identifying benefits and limitations

This section focuses on the areas highlighted in Figure 3-1 and can be used to support the justification for simulation as part of developing a simulation business case. *In conjunction with the information contained in Section 2, this section aims to guide Defence staff to those Defence outcomes where the time and effort applied to developing a full business case or investment proposal for simulation is likely to be successful.* Guidance on the remaining areas shown in Figure 3-1 can be found in the Defence Simulation Proposal Guide.

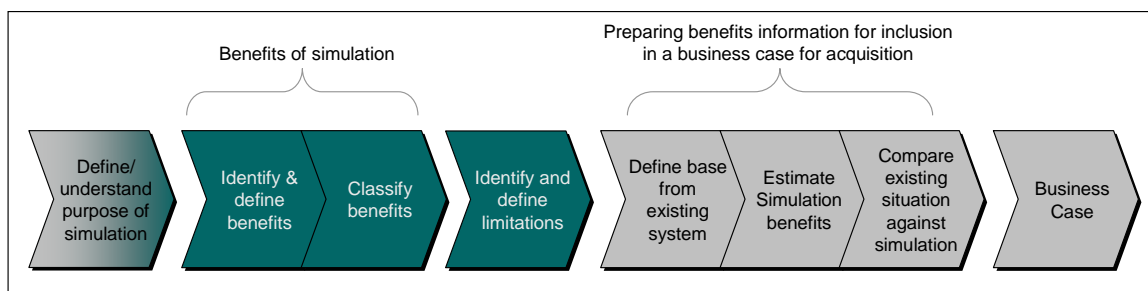


Figure 3-1. Process Leading to the Development of a Simulation Business Case

3.2.1 Identifying the benefits of simulation

The business case justification for simulation is broadly related to the purpose and benefits that can be derived (see the additional information on benefits and limitations at Annexes D, E and F). Often the purpose for a simulation is to exploit one of its benefits.

³ Defence 2000: Our Future Defence Force. P. xvi

⁴ Defence 2000: Our Future Defence Force. P. 111

Purpose	Benefit
<ul style="list-style-type: none"> ▶ To substitute for primary equipment that may be expensive (to purchase or operate) ▶ To reduce risks to personnel or equipment ▶ To shorten an otherwise long training time ▶ To shorten the product lifecycle or decision time. ▶ To improve decision-making to optimise the use of resources ▶ To substitute for primary equipment that may be scarce or have limited availability ▶ To enable multiple scenarios to be run ▶ To enable repetitive tasks to be conducted ▶ To reduce other constraints (eg. limited access to equipment due to poor weather, multiple staff required but unavailable, etc) 	<p>Enhanced Capability</p> <ul style="list-style-type: none"> ▶ Permits mission rehearsal (improved operations) ▶ Increased throughput of trainees during contingencies (tempo) ▶ Permits rapid change for training across diverse operational environments (adaptable) ▶ Permits increased rate of training (day/night, all year) ▶ May provide increased skill levels through increased training levels ▶ Rapidly assess Course of Actions (COAs) (timeliness in developing operational plans) ▶ Force assessment <p>Saved Resources</p> <ul style="list-style-type: none"> ▶ May cost less than actual equipment to acquire ▶ May require less actual equipment dedicated for training ▶ May cost less than actual equipment to operate <p>Reduced Risk</p> <ul style="list-style-type: none"> ▶ Permits training for dangerous conditions ▶ Increases familiarity/recognition of exceptional situations ▶ Reduces risk and safety hazards of actual equipment <p>Other</p> <ul style="list-style-type: none"> ▶ Reduces impact on environment ▶ Provides features for instruction and feedback ▶ Provides storage of outcomes and lessons learnt

Figure 3-2. Example purposes and benefits of Simulation

Benefits are positive outcomes that results from a change. In the context of simulation, benefits are the positive outcomes that result from using simulation instead of traditional (often manual) approaches.

Benefits:

- ▶ Represent the primary means of justifying the use of simulation
- ▶ Allow comparisons to be made between using existing approaches versus using simulation, and also between different types of simulations
- ▶ Represent a primary input to analyses that form the basis of business cases such as:
 - Economic assessments
 - Financial assessments
 - Multi-criteria analysis

Some benefits may be identified through considering the questions in Figure 3-3.

▶ Simplicity	Will operations be simplified or made more complex?	▶ Production	Will capacity increase and can more be done with less?
▶ Speed	Will you be able to respond more quickly to situations?	▶ Quality	Will the quality of outcomes be increased?
▶ Redundancy	Will the simulation reduce redundant tasks?	▶ Versatility	Will the scope and ability of staff increase because of the system?
▶ Accuracy	Does the capability reduce error rates or improve accuracy of information?	▶ Flexibility	Will staff be able to respond to a greater number and variety of requests?
▶ Reliability	Will the new system increase the reliability of the achieving outcomes?	▶ Facilities	Can facility space be reduced or eliminated?
▶ Adaptability	Is the simulation adaptable to changing needs?	▶ Security	Will general security and the ability to protect information increase?
▶ Materials & supplies	Will the amount of materials and supplies decrease?	▶ Consistency	Will the capability outcomes be achieved more consistently?
▶ Morale	Will the new system improve the working environment?	▶ Administrative actions	Will the amount of administrative work decrease?
▶ Management Effectiveness	Will the system improve the ability to manage decisions?		

Figure 3-3. Questions Used to Identify Benefits

The value of the benefit is sometimes difficult to quantify for the first use of a simulation – but simulation can be used repeatedly over many years, and so its value can be enduring.

An additional benefit may exist in terms of the *cumulative value* from multiple simulations – that is, when more and more models and simulations are available and connected. The cumulative capability may provide a Force Assessment tool.

For example, a surveillance aircraft such as AEW&C can be modelled in its environment, then JORN could be added to model combined JORN/AEW&C surveillance operations, then F/A-18 can be added, then UAVs, then Joint Strike Fighter, then Air Warfare Destroyer, then P-3C and then Australian Air Defence System components etc. Different sensor systems could then be added to each of the platforms, then different communications links, then different C2 systems etc. Once these models exist, various threat elements can be injected under various scenarios over a variety of environments.

So, whilst the *value* of modelling any one of these components may be difficult to justify, it becomes clear that the *only* cost-effective way to experiment and learn about potential combined effects is through an integrated simulation system. Once this exists, the delta cost to experiment with, for example, a new radar type, or a new combat identification system etc is very small. This is because previously developed scenarios can be rerun and the outcomes due to each change can be measured and compared. Without simulation, any small change would require additional manual analysis.

Thus, analysts may often need to ask themselves questions such as ‘*will the results of my analysis be sufficiently robust without the support of simulation*’ and ‘*if I need to establish a means for others to understand the effects of situation ‘y’ under various scenarios repeatedly over a long period of time, what is the best way to do it?*’.

The process of defining benefits can be aided by considering the constraints, or limitations, that are inherent in the traditional (often manual) approach. That is, shortfalls or

limitations with the way things are done today can often represent the reason for applying simulation. These limitations will often represent the primary areas that simulation improves on and can often represent the main justification. Example constraints and limitations from traditional approaches that may result in simulation benefits are:

- ▶ Prime equipment may be expensive (to design, construct, purchase or operate)
- ▶ Activities may present risks to personnel or equipment
- ▶ Manual training time may be overly long
- ▶ Access to prime equipment may be limited
- ▶ Need to consider a large number of scenarios
- ▶ Tasks may be repetitive
- ▶ Other constraints (for example, limited access to training sites due to poor weather, multiple staff required but unavailable, difficult to generate the full range of environmental conditions, etc)

3.2.2 **Identifying the limitations of simulation**

It is important to understand and articulate the limitations and restrictions on simulation capabilities. Unless potential limitations are identified and assessed, a simulation *may* be used in situations for which it was not designed or it may be used inappropriately given its purpose. It is therefore essential to identify both the benefits and limitations prior to progressing to the detailed assessment required for acquisition.

Fidelity

- ▶ Overstating fidelity can lead to inaccurate or misleading training
- ▶ Can adversely affect training readiness if confidence in actual equipment is reduced

Cost effectiveness

- ▶ May cost more than actual equipment to acquire and operate

Introducing risk

- ▶ May instil habits that are incorrect for use in actual equipment
- ▶ May desensitise operator's to critical situations
- ▶ Potential compromise to security for networked simulations

Figure 3-4. Some possible limitations to using simulation

All simulations are a simplification of the real world and are inherently approximate and this limitation must be taken into consideration when developing, acquiring or using simulations.

Simulation is effective only if both the model and the data used to drive the model accurately reflect the real world to a sufficient degree for the purpose of the simulation.

For simulations to be effective, they must have the right level of detail and fidelity for the chosen application. For a simulation to be effectively employed, the user must understand the implications of the simulation's limitations. Limitations can be considered in two ways:

- ▶ As an initial check into the appropriateness of the simulation
- ▶ As constraints, or limits, on the amount of benefit that can be derived from a simulation

The former is more relevant for a generic business assessment, as it helps to ensure that the simulation is selected for the correct reasons, and applied in the correct way. This aligns the objectives of the simulation with the capabilities and purpose for which it was designed.

The latter is more relevant in the detailed business case that would be developed as part of the acquisition process. Defining the constraints that limit a simulation's projected use ensures the credibility and robustness of evaluations. These limitations define the rules of applying simulation, which should be considered in conjunction with the limitations of the traditional approaches, in order to provide a valid 'like-with-like' comparison. For example, comparing hourly costs between real equipment and a simulator on a one-for-one basis would be inappropriate if the real equipment could only be used for half the number of hours per year than the simulation.

Cost is a significant factor in both the purchase of a simulation and its ongoing maintenance – these costs may exceed available funds. In that context cost could also be considered as a form of limitation.

The main questions become: is the simulation fit for purpose? Will it do what we need? Does it need to meet minimum safety/security/other accreditation requirements?

The assessment of limitations should also encompass an initial review of:

- ▶ How effective is the simulation compared to the traditional approach which it is to supplement or replace?
- ▶ How costly is the simulation compared to the traditional approach?

Limitations can be considered as a range of broad categories:

- ▶ Physical limitations (e.g. the physical elements of the task at hand cannot be adequately replicated in a simulation)
- ▶ Practical limitations (e.g. simulation cannot be scaled up to train the required numbers of staff in the time available)
- ▶ Financial/economic (e.g. the cost of the simulation is greater than either the traditional approach or than the available funds)
- ▶ Environmental (e.g. simulation cannot replicate the impacts of all likely weather conditions)

- ▶ Performance (e.g. the simulation cannot adequately represent the real situation, resulting in negative training value)
- ▶ Political (e.g. there is a requirement for an Australian solution, but there are no Australian simulations available)
- ▶ Export (e.g. the simulation is only available from the US, but cannot be exported to Australia)
- ▶ Military (e.g. the simulation is not physically robust enough for deployment)
- ▶ Temporal (e.g. the real world changes faster than the simulation can)
- ▶ Spatial (e.g. simulation spatial experience does not sufficiently match the real world)

No one particular simulation has the capacity to be a 'one size fits all'. The real needs and outcomes need to be carefully evaluated against the potential results that simulation can provide, to ensure most appropriate use of simulation.

Finally, simulation is not necessarily a 'turn key' activity. Often, significant time is required in the planning and preparation of a simulation event – and failing to identify this can result in poor outcomes, or an unanticipated demand on key staff.

Annex F contains further guidance on the types of limitations that can be experienced in different Application Areas.

3.3 Analysis by each Simulation Application Domain

For simplicity, simulation can be categorised into three general domains. Further details on the benefits and limitations of simulation in each of these domains can be found in Annexes D, E and F.

3.3.1 Training Domain

The Training Domain is the area where the majority of Defence's current and past simulations are and have been applied. Simulation for training prepares personnel to employ forces, use systems and apply technologies in generic operations. This Domain includes the Simulation Application Areas shown in Figure 3-5.

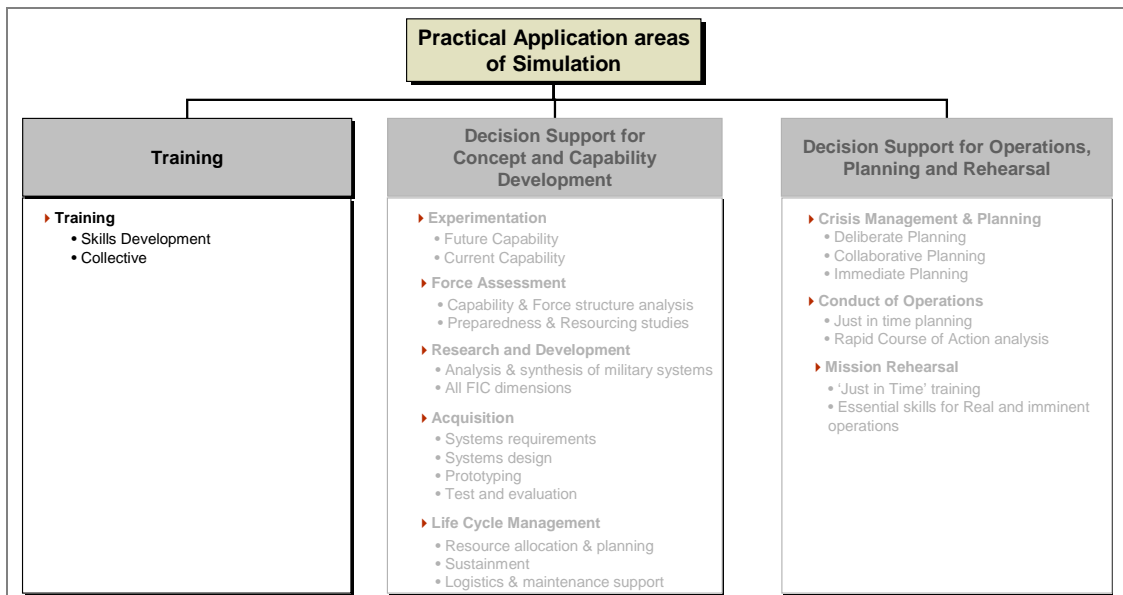


Figure 3-5. Simulation Application Areas in the Training Domain

- ▶ **Training** – Simulation for training covers the routine learning, development and refresh of essential skills across all ranks, levels and specialties by individual and collective single Service training, joint and combined training and through e-learning. Training can also include acclimating to areas of responsibility, methods of operation, and learning for overall efficiency and effectiveness. Live, virtual and constructive simulations plus combinations of any of these might be employed.

There are a considerable number of studies available on the subject of learning, with many (especially childhood) researchers concluding that the essence of learning is discovery through play. Many support the notion of hands-on problem solving, the benefits of learning cause and effect through trial and error, and *experiencing* stimulus caused by previous actions.

Any 'performed' training can be considered as 'simulated activities', however, for this section we are considering the benefits of applying modelling and simulation *technology* to support training rehearsal. Consider the following alternatives:

The alternative to...	Is the use of ...
the use of simulation technology for training	▶ traditional training and education techniques such as books, workshops and classrooms
experiential learning	▶ 'live' training, with fabrication of physical environment mock-ups, the staffing of opposing forces and civilians with 'live actors', the use of actual or mock-up opposing force weapon systems, all monitored and controlled by experienced staff.
experiential maintenance learning	▶ real equipment or physical mock-ups, failure events injected for students to resolve
identifying, targeting, and firing missiles in a simulator	▶ conducting these activities in restricted areas using expensive live or training rounds with instrumentation to attempt to monitor all events and apportion any errors

The ADF's higher operational tempo has demanded shortened training refresh times to ensure skill currency. This combined with the increased costs of live training places an increased burden on scarce resources making the use of simulation more desirable.

Potential benefits from using simulation in support of Training include:

- ▶ Enabling staff to experience multiple potential futures, and experience how their decisions and actions can alter the outcomes, is a powerful learning method.
- ▶ Generating higher skill and performance levels from the configurable nature of simulation, allowing greater variety in situations and conditions, and its increased availability compared to using real equipment (for example poor weather might prevent real equipment use).
- ▶ Conduct training even whilst real equipment is unavailable (i.e. it is deployed or in maintenance).
- ▶ Enabling higher training rates to be achieved, and facilitating a better focus of training onto specific training needs.
- ▶ Practicing complex manoeuvres using simulation beforehand, facilitates the 'ironing' out of timing and other coordination issues, enables potential flaws in the plan to be teased out early, enhances shared understanding of the operation and its constituent parts, and helps reduce the 'fog of war' by testing alternative adversary responses.
- ▶ Simulation's ability to capture and play back data results in better feedback allowing personnel to gain a better awareness of the outcomes of training activities.
- ▶ Feedback from simulation is generally more consistent, more immediate, better targeted and less subjective than other feedback.
- ▶ Simulation allows emergency response and dangerous condition scenarios to be repeatedly rehearsed and trained in a safe and controlled environment, reducing stress on personnel and increasing OH&S compliance.
- ▶ Whilst simulation-supported training is unlikely to ever replace the need for live exercises, there is evidence that performance levels in the live environment are

increased after participants have had the benefit of preliminary, simulation supported training.

- ▶ The use of simulation leaves the path open for innovative training techniques that would not be possible without it, for example rapid test-feedback-test cycles to reinforce and enhance performance.
- ▶ Using simulation for training has potential for saving resources. Because simulation can replace training and exercises using real equipment it can result in a reduction in the support costs (e.g. for highly expensive items such as aircraft, ships, armoured vehicles), damage or loss of that equipment, reduced personnel support costs (e.g. rations, transportation), reduced field allowances, a reduction in consumables required (ammunition and expensive munitions such as guided weapons, petrol, oil and lubricants (POL) for weapons platforms and vehicles, batteries and other lifted items etc), a reduction in cancelled training days due to poor weather and a decrease in time required by other Defence personnel to support exercises.
- ▶ Training simulations reduce risk by allowing a larger number of scenarios and conditions to be trained on than other methods, including dangerous and emergency situations that are not possible through other means. This decreases the risk that personnel would not perform satisfactorily in these situations and increases the confidence in the results of their training activities.
- ▶ Limitations testing can also be conducted in a safe and controlled simulation environment to familiarise personnel with the effect of operating at the edge of their equipment design envelope, while suffering from fatigue or drugs or to assess operator response times.

3.3.2 Concept and Capability Development Domain

Simulation for concept and capability development helps to develop, provide and support the systems and technologies underpinning the forces that the commander uses in operations. This Domain includes the Simulation Application Areas shown in Figure 3-6.

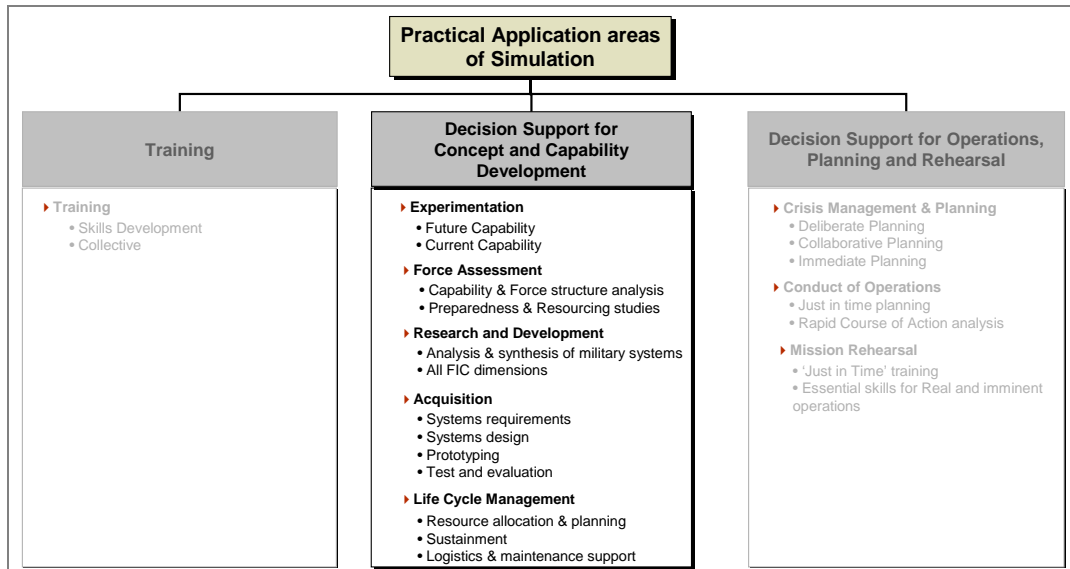


Figure 3-6. Simulation Application Areas in the Concept and Capability Development Domain

- ▶ **Experimentation** – Experimentation is defined within Defence as the ‘application of the structure and methods of experimental science to support the understanding and determination of future Defence capability via the exploration of novel future concepts and contexts to illuminate a pathway from today's Defence force towards tomorrow's Defence needs’.
 - It is also considered to cover an experimental approach to providing analytical support to the force-in-being including development and testing of doctrine and tactics, systems evaluation and improvement. In this application area, simulation helps Defence to learn about doing novel things that may prove to be better than current available means for achieving outcomes.
- ▶ **Force Assessment** – Simulation for force assessment supports decision making in the areas of capability and force structure analysis, including preparedness and resourcing studies from tactical operations, operational and theatre levels, through to campaign and strategic levels.
- ▶ **Research and Development** – Simulation for research and development supports both the analysis and the synthesis of military systems encompassing the full spectrum from technical components to overall ‘systems of systems’. In this application area, simulation supports operational and technical analysis within and across all dimensions of the fundamental inputs to capability.
- ▶ **Acquisition** – Simulation for acquisition helps Defence determine and refine user requirements, develop system performance requirements, identify key critical operational issues and key measures of performance, systems design, prototyping and

system test and evaluation for procurement decision purposes, technical regulatory purposes, assessment of fitness for purpose, and engineering support and analysis.

- ▶ **Life Cycle Management** – Simulation helps Defence conduct resource planning and allocation for sustaining military systems through-life and optimising sustainment functions such as supply chains, sparing numbers and locations, distribution and warehousing etc. It is not only an adjunct to the acquisition process, but also an essential ingredient to the logistics and maintenance support activities from planning to operations.

The potential benefits of simulation in providing insights into the questions facing Defence capability managers must be compared with the alternative, *'How will I generate insights without using simulation?'*.

The following ten typical questions facing capability developers⁵ capture the essence:

- ▶ What scenarios will arise requiring action by the ADF?
- ▶ What will be the prevailing social and cultural climate?
- ▶ What economic and political pressures will there be?
- ▶ How might we improve the way our Forces operate?
- ▶ What are the likely impacts of our military strengths and weaknesses on outcomes?
- ▶ What are the benefits of investment in one capability compared with another?
- ▶ What do we need to provide to support our Forces during operations?
- ▶ What innovations should we pursue for future investment?
- ▶ How can we integrate, test and evaluate new systems with legacy systems?
- ▶ What will be the possible outcomes from different operational decisions?

The benefits from applying simulation to Concept and Capability Development include:

- ▶ A greater number of designs or systems, with an increased number of variables and alternatives, can be evaluated or analysed with simulation resulting in improved evidence for decisions and faster decision making.
- ▶ Increasingly complex concepts and systems can be analysed and more innovative concepts and designs can be tested with the use of simulation and optimal solutions can be more readily identified.
- ▶ Extreme conditions such as heat, cold, wind and vibration can be tested easily and safely.
- ▶ Simulation provides improved visualisation and demonstration capabilities that facilitate the explanation of designs and concepts to stakeholders and create better solution and option awareness in decision makers and stakeholders.

⁵ Cliff White, DGSIM, keynote address to SimTecT 2004 Conference, Canberra, 2004

- ▶ Designers and promoters gain a better understanding of the consequences of change(s) through simulation and requirements can be assessed and incorporated earlier in the design phase to produce products with enhanced capability.
- ▶ The ability to visualise products with users early in their design phase increases their input and creates greater ownership of the product.
- ▶ Simulation enables the optimisation of system performance versus total ownership cost by early and continuing collaborative exploration of the largest possible trade space across all of a system's life cycle activities, within and among multiple government and commercial organisations, across professions and disciplines, and up through system of systems mission area perspectives.
- ▶ Resources can be better prioritised and coordinated through simulation support to life cycle management, especially through logistics simulations and improved inventory tracking that also increase the sustainability of the force.
- ▶ Using simulation during acquisition can determine skill requirements before purchasing equipment; and so ensuring sufficient expertise exists or can be grown before committing to equipment.
- ▶ Simulation can improve interoperability with the existing force by simulating its interaction and ensuring necessary requirements are included in tenders.
- ▶ Using simulation for testing results in fewer partial and full-scale constructions and tests because more tests can be completed virtually.
- ▶ Design changes can be identified earlier with the help of simulation, which reduces the cost of implementing them, and infeasible or poor design solutions are more readily identified earlier in their life cycle, enabling earlier termination and saved resources.
- ▶ Simulation use can result in better designs for maintainability, and hence lower maintenance costs and reduced component specification for manufacturing errors.

Although there are alternatives to using simulation to address these questions, such as studying historical events and conducting live exercises, through to conducting operations research using manual tools, simulation can provide additional advantages. These alternative methods will continue to be employed, but they are unlikely to provide the depth of insight available from testing various alternate future outcomes under repeated simulated conditions.

3.3.3 Operations, Planning and Rehearsal Domain

Simulation for planning, operations and rehearsal assists decision makers to conceive and use equipment and forces as a 'system-of-systems' to achieve national objectives. This is due to greater awareness and consideration of the 'big picture'. Simulation for Mission Rehearsal provides 'just-in-time' training for specific operations. This Domain includes the Simulation Application Areas shown in Figure 3-7.

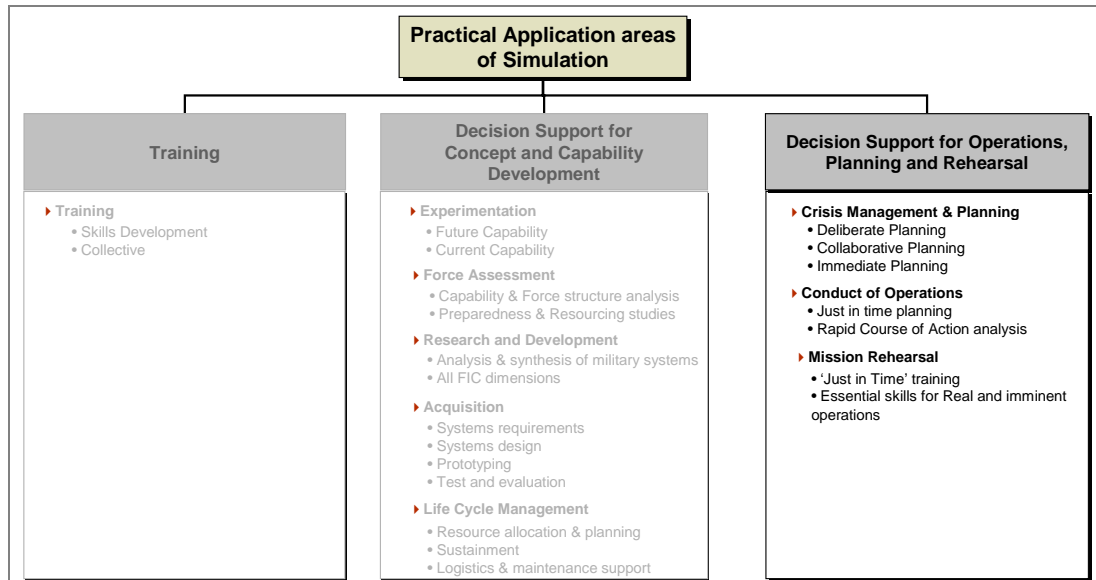


Figure 3-7. Simulation Application Areas in the Planning and Operations Domain

- ▶ **Crisis Management and Planning** – Simulation supports deliberate planning for potential/plausible future crisis scenarios in the area of crisis management and planning. This is a collaborative planning activity that can include participation by distant, distributed teams of specialists, analytical support to the immediate planning approach of the Joint Military Appreciation Process, and the determination of logistics support requirements associated with possible future military operations. This area also includes simulations used for analysis of business processes, finances and workforce planning.
- ▶ **Conduct of Operations** – Simulation assists the conduct of operations with just-in-time planning information, providing real-time (or very near real-time) decision support to military operators during military operations via the rapid performance of course-of-action analysis; applicable to strategic, operational and tactical levels of command.
- ▶ **Mission Rehearsal** – Simulation for mission rehearsal may be thought of as just-in-time training, or preparation for an actual operation. Therefore the scope of simulation for training mentioned earlier, applies equally for mission rehearsal, with the significant added demands of specifically developing essential skills for a real and imminent operation.

Benefits from applying simulation in support of Planning and Operations can include:

- ▶ As with the Training Application Area, the benefits of enabling staff to experience multiple potential futures, and experience how their decisions and actions can change the outcomes, provides a powerful learning method and so offers enhanced capability.
- ▶ Rehearsing complex manoeuvres using simulation beforehand, facilitates the 'ironing' out of timing and other coordination issues, enables potential flaws in the plan to be teased out early, enhances shared understanding of the operation and its constituent parts, and helps reduce the 'fog of war' by testing alternative adversary responses.
- ▶ Conducting mission rehearsal for covert operations can avoid unwanted detection and so enhance capability by maintaining the element of surprise.
- ▶ Simulation's ability to capture and play back data results in better feedback allowing personnel to gain a better awareness of the outcomes of rehearsal activities.
- ▶ Rehearsals reduce risk by allowing a larger number of scenarios and conditions to be followed than other methods, including dangerous and emergency situations that are not possible through other means. This decreases the risk that personnel would not perform satisfactorily in these situations and increases the confidence in the results of their rehearsals.
- ▶ Scenario-based thinking and planning, using simulation to calculate the outcomes based on the inputs, assumptions, and rules, with uncertainty built-in where possible, enhances capability by allowing staff to experience many possible future outcomes.
- ▶ Improves evidence for decisions and increases the awareness of the issues surrounding them, resulting in a more informed decision with an increased understanding of the potential impacts.
- ▶ With simulation support, some decisions can be made faster, as can responses to changes and 'what if' requests.
- ▶ Simulation can evaluate an increased number of plans and concepts than manual methods of analysing potential courses of action (COA).
- ▶ Supporting crisis management and planning and the conduct of operations with simulation decision support tools allows more COAs to be developed and analysed resulting in more robust plans. These in turn increase the confidence levels of personnel and through this enhance capability.
- ▶ Plans developed with simulation support often coordinate and prioritise resources better than those developed without, and result in more efficient use of operational assets, greater awareness of fragilities and risks, and improved manpower management.
- ▶ Built-in checklists and the ability to visualise situations may lead to better coordination with non-military officials.

The alternative to the use of simulation for operations, planning and rehearsal is to do either no planning and simply experiment via trial and error; rely on joint decision-making through workshops and meetings; or use traditional manual techniques supported where possible by planning and decision-support tools. Some of these tools have

simulation extensions that allow scenarios to be 'run through', and allow 'what if' analyses to be conducted, and so we are seeing a blending of simulation technologies into everyday toolsets.

4 Estimating the Cost of Simulation

4.1 Introduction

This section provides guidance for estimating the cost of simulation. It leverages the overarching approach promulgated in the Defence Cost and Schedule Estimation Methodology Handbook. This detailed Handbook should be used to gain a thorough understanding of the overall cost estimation process. Note that the DCDM also contains a good introduction to the issue of developing cost estimates for Defence materiel. Other useful references and points of contact for cost estimation guidance are provided in Annex G.

4.2 Defence Cost Estimating

*'Cost estimating is the process of collecting and analysing historical data and applying quantitative models, techniques, tools, and databases to predict the future cost of an item, product, program, capability, system, or task. It is also the art of approximating the probable cost of something based on information available at the time.'*⁶

Cost estimating for all capabilities, whether simulation related or not, follow the processes detailed in the Defence Cost and Schedule Estimation Methodology. The Handbook details the estimating process consisting of 4 Steps and 10 Activities, as depicted in Figure 4-1. An understanding of this process is critical to the successful cost estimation of simulation.

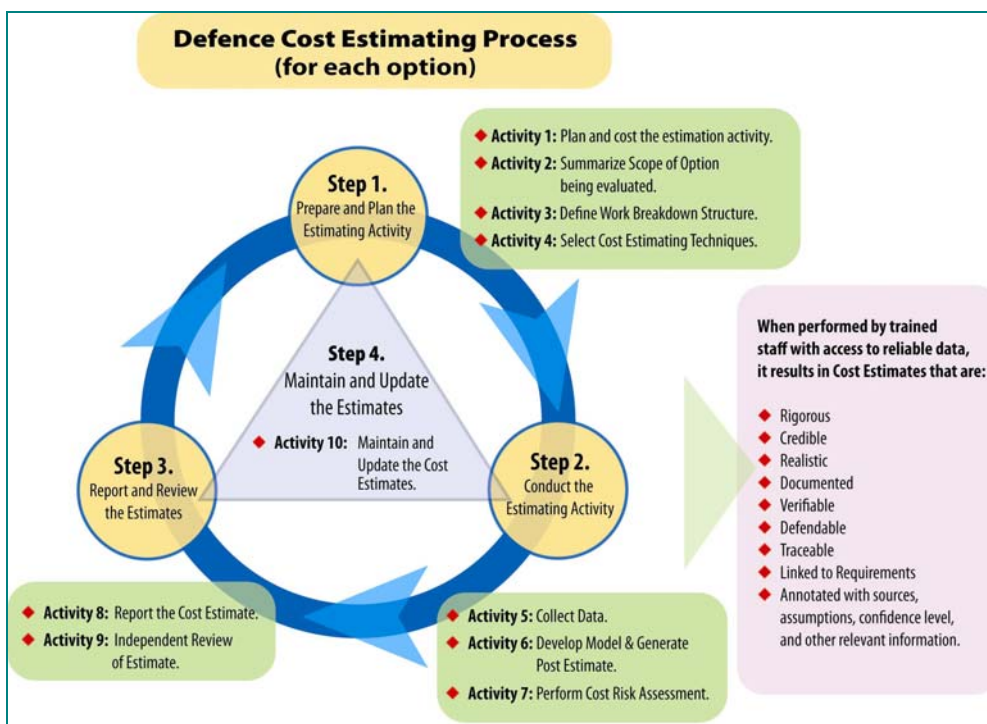


Figure 4-1. The Defence Cost Estimating Process⁶

⁶ Defence Cost and Schedule Estimation Methodology

4.3 Simulation Specific Cost Estimation Considerations

Simulation costing, although following the same process as the Defence Cost and Schedule Estimation Methodology, must consider some specific issues. As such, simulation domain expertise is usually required in developing a cost estimate for a simulation system. For example, a background in aircraft simulators would be a distinct advantage in estimating future costs for aircraft simulators.

There are specific Simulation considerations in Activities 1 to 5 of the Defence cost estimating process shown in Figure 4-2. Activities 6 through 10 do not entail any unique simulation issues or considerations and so are not discussed further in this guide.

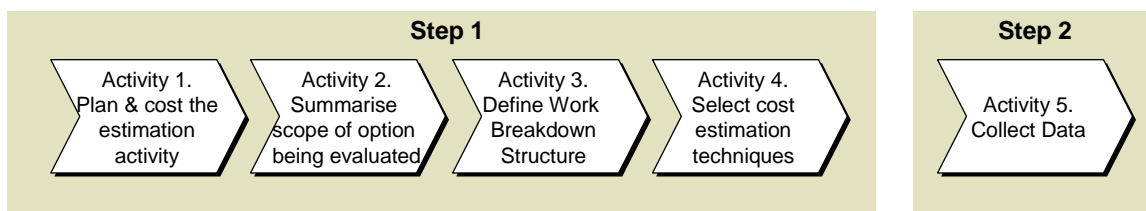


Figure 4-2. Simulation specific cost estimation activities

4.3.1 Step 1 – Prepare and Plan the Estimating Activity

4.3.1.1 Activity 1 – Plan the Cost Estimation Activity

Simulation-specific considerations for Activity 1 include:

- ▶ Simulation is often purchased as part of a major project, but can still be a large acquisition in its own right. It may be necessary to plan for the generation of separate cost-estimates for *each* of the simulation options within each major capability option.
- ▶ Simulation investments span the full gamut from low-cost desktop software packages, to expensive virtual reality simulators. It follows that generating robust life cycle cost estimates can vary from being quick and easy, to requiring significant time and specialist input.
- ▶ The outputs required for simulation cost estimates can vary from obtaining simple quotes for low-cost commercial-off-the-shelf software packages, to the need for full Capability Definition Documents and Business Cases in accordance with the Defence Capability Development Manual.
- ▶ In the early phases of the life cycle, there is often a broad range of potential capability options being considered, which creates even greater uncertainty when options for simulation support to these capabilities are trying to be defined. There is no simple solution to this, other than to consider these difficulties in the up-front planning, and ensure that adequate time and resources are made available to gradually work through the uncertainties. (The Simulation Support to the Needs Phase Guide provides assistance in understanding these issues and acts as a useful reference in solving the uncertainties.)
- ▶ Gaining access to information on viable simulation options and associated cost drivers and estimates can prove difficult. Arrangements should be made for in-depth data

collection or perhaps the purchase of simulation options and costing data from industry. (Activity 5 – Collect Work-Breakdown Structure (WBS) Element Data provides further details on this specific topic.)

- ▶ From a cost/benefit perspective simulation investments are often compared against the alternative – that is, doing the same thing manually or without simulation. Therefore, planning the cost estimation activity for a simulation investment may need to consider the generation of a full life cycle cost estimate for the status quo, or for the traditional method of achieving the same Defence outcomes. This can require substantial additional time and effort to complete. (Section 10 of the Defence Simulation Proposal Guide details the Costs / Benefits of Simulation and should be referred to for assistance with understanding and assessing simulation investments)
- ▶ Cost estimates prepared for first pass approval need to include the costs required to progress from First Pass to Second Pass. For the acquisition of high cost or high risk simulation capabilities, substantial resources may be needed to develop the requirements and options for consideration at Second Pass approval, and may include the effort and costs of releasing an RFT to get firm proposals for Government consideration. (The Simulation Support to the Requirements Phase Guide provides detailed information that will assist in gaining First Pass approval while the Simulation Support to the Acquisition Phase Guide should be referenced when transitioning to Second Pass approval.)
- ▶ Part of the planning process is to ensure a full understanding of the format in which the cost estimates are required to be presented. The CDE website contains templates for Cost Spreads, which contain all the requirements for currency conversion and inflation plus are authorised for DCC and DCIC requirements.
- ▶ ADSO should be consulted to gain access to staff with simulation domain expertise when planning the cost estimation for large or complex simulation acquisitions. ADSO may have ready access to simulation options and/or previous costings, or know how and where these can be readily obtained.

4.3.1.2 Activity 2 – Summarise Scope of Option being Evaluated

Simulation-specific considerations for Activity 2 include:

- ▶ The potential for simulation to enhance capability, save resources and reduce risk across all nine simulation application areas should be fully explored, so that the benefits of simulation are properly identified. Detailed information on the benefits of simulation has been provided in Section 3 of this guide.
- ▶ The early stages of the Defence Capability Development Process are often characterised by significant uncertainty surrounding simulation system characteristics, and therefore a large number of ground rules and assumptions are often required to enable broad cost estimates to be generated. Many issues that form part of the Project Baseline are often still being progressively developed and assessed, making it difficult to formulate detailed strategies for the use of simulation. The Simulation Support to the Needs, Requirements and Acquisition Phase Guides will assist in framing the thinking around simulation and include templates to guide simulation support planning.

- ▶ For large projects that include simulation or simulators that by themselves represent high cost items, it may be necessary to develop a full Project Baseline for the simulation component(s), in lieu of relegating the simulation to a single line item under 'support system' or 'training system of the overarching project'. The simulation system will often require different acquisition and sustainment strategies to the operational systems, and therefore efficiencies can often be gained by unbundling the simulation strategies from the broader project.
- ▶ Simulations themselves are required to be supported throughout their life, and therefore it is not just the acquisition cost of simulations that needs to be estimated, but the full in-service support for operations, training, engineering, supply, and maintenance. This should be included in the scope for each simulation option being evaluated.
- ▶ Simulations can often be major items in their own right, requiring a full NPOC assessment as part of the investment proposal. If required, the NPOC analysis should be included in the scope for each simulation option being evaluated.

4.3.1.3 Activity 3 – Define Work Breakdown Structure

Simulation-specific considerations for Activity 3 are provided in Annex G, which provides a representative breakdown of acquisition and sustainment cost elements for a large-scale simulation system.

4.3.1.4 Activity 4 – Select Cost Estimating Technique(s)

Simulation-specific considerations for Activity 4 include:

- ▶ Cost estimates can be extrapolated from actuals if the data is available and no technique has been selected. This is useful when buying additional quantities of a system that is already in service.
- ▶ Factors can be used in an estimate. Beginning with an assumed factor (for example, A percentage of the Prime Mission Equipment) the estimator uses this estimate, and then allocates the cost being factored (e.g. acquisition costs, project management, systems engineering, test and evaluation, and ILS elements) as percentages of prime equipment cost back to the cost element. Over time, 'rules of thumb' can be collected, for example 'an aircraft simulator costs x% of an aircraft'. This technique is useful in the early phases when there is little data available for some of the items where factors are commonly used. But this approach can sometimes prove to be highly inaccurate - for example, technologies continue to rapidly evolve and often become cheaper, which can invalidate the old *rules of thumb*.

4.3.2 Step 2 – Conduct the Estimating Activity

Step 1 provides a completed and agreed Estimating Plan, identifies and documents the scope of simulation options, generates the WBS, and selects the cost estimating techniques. The cost estimating activity is conducted in Step 2, and this is where the majority of time and effort is expended. Step 2 includes simulation specific considerations for Activity 5.

4.3.2.1 Activity 5 – Collect WBS Element Data

Simulation-specific considerations for Activity 5 include:

- ▶ Simulation specialists from ADSO can assist in obtaining WBS element data from previous simulations, or may have knowledge about where to get them to assist in the data collection process.
- ▶ There is a possibility that releasability of simulation and entity data from overseas sources may be an issue. Releasability may prove difficult if simulation data includes performance, doctrine, tactics, techniques, or capabilities of overseas forces, or if it has been security classified.
- ▶ Typical data collection methods that can be used to support simulation data gathering are shown in Table 4-1.

Table 4-1. WBS Element Data Collection Approaches

Method	Expected Result
Visits	<ul style="list-style-type: none"> ▶ Visit the manufacturer, with a view to overseeing the current activities in the production of the simulation system(s) ▶ Visit the operator, with a view to overseeing the current activities in the operation of the simulation system(s) (if the system is in service) ▶ Gauge the level of capability of the manufacturer versus what is being seen and heard during the visit ▶ Gauge the difference between manufacturer sales pitch versus operator experience ▶ Use reports resulting from the above to support cost estimation and risk assessments
Trade Shows	<ul style="list-style-type: none"> ▶ Collect information and data on simulation systems of interest or like systems for comparative purposes. ▶ Attend briefings ▶ Use reports resulting from the above to support cost estimation and risk assessments
Internet	<ul style="list-style-type: none"> ▶ Many industry groups, manufacturers and vendors provide cost information on their web-sites.

Method	Expected Result
Conduct Studies	<ul style="list-style-type: none"> ▶ Visit the manufacturer, with a view to overseeing the current activities in the production of the simulation system(s) ▶ Visit the operator, with a view to overseeing the current activities in the operation of the simulation system(s) (if the system is in service) ▶ Gauge the level of capability of the manufacturer versus what is being seen and heard during the visit ▶ Gauge the difference between manufacturer sales pitch versus operator experience ▶ Use reports resulting from the above to support cost estimation and risk assessments ▶ Commission a manufacturer to generate LCC data ▶ Commission an independent to generate LCC data ▶ Use reports resulting from the above to support cost estimation and risk assessments
Market Survey	<ul style="list-style-type: none"> ▶ Collect information and data on simulation systems of interest or like systems for comparative purposes. ▶ Attend briefings ▶ Use reports resulting from the above to support cost estimation and risk assessments ▶ Conduct a market survey of manufacturers to gauge the market availability of simulation systems sought. ▶ Commission an independent consultant to conduct a study of market survey outcomes ▶ Understand the real players in the market sector responsible for the desired simulation capability
Third Party Collection	<ul style="list-style-type: none"> ▶ Use an in house or external agency to collect information on nominated systems through newspapers, periodicals, magazines and official government documents available to the public. ▶ Use Embassy or Defence officials to collect information on an opportunity basis ▶ For US based systems seek Price and Availability (P&A) from the US Military. This approach will generally provide unit costs of the prime equipment, selected peripherals and high level support costs. This approach cannot be used if an ITR, RFP or RFT has been issued.

- ▶ The stage of the system evolution will define the level of information and data that is available. Systems that are in production or in service offer the best opportunity to obtain robust information concerning the proposed simulation capability. Systems in the early planning phases or design and development phases will require substantially more effort to identify and estimate costs and cost drivers.
- ▶ Cost drivers will be the source of major expense in the estimate as well as the focus of cost trade studies and 'what if' estimates. Consider:
 - High-end simulation systems have historically been regarded as having 'high acquisition, low operation' costs. However, modern simulations are shifting this paradigm, towards 'medium acquisition, medium operation' costs.

- Software is a major cost driver both for acquisition and sustainment. The cost of manipulating software to meet ADF requirements during the acquisition process can be expensive, especially if the source code (intellectual property) is not available for export. During in service there is often a requirement to update software interfaces to recognise upgrades to current ADF equipment(s) and the introduction of new equipment(s).
 - Information Technology (IT) infrastructure is another major cost driver. The current trend of upgrading or acquiring simulation capability to interface with other systems to provide an integrated air, sea and ground environment has greatly increased the IT infrastructure requirements especially communication bandwidth. Section 8 of the Defence Simulation Proposal Guide provides details on some technology issues and answers the question of how a potential technology approach can be analysed and evaluated.
 - Simulation data often represents a major cost driver, yet some simulation data for the same entities and geographies is being purchased multiple times through lack of coordination.
 - Verification, Validation and Accreditation (VV&A) requirements need to be scoped and the necessary activities costed. Further information on data availability and reliability can be found in Section 7 of the Defence Simulation Proposal Guide.
 - Sustainment costs over years of operation can be many times the initial acquisition costs.
- ▶ Normalisation. Once the collected data has been analysed and determined to be appropriate for use, the data must be normalised for consistency in technology, operational profiles, operational availability and environments as well as inflation and foreign currency fluctuations. Normalisation allows the data to be used consistently in the estimate, and enables costs for different options to be compared *like for like* - this is especially important when comparing simulation options against any non-simulation options.
 - ▶ A checklist of questions that should be asked by staff when collecting WBS element data is provided in Table 4-2. More detailed information on these considerations and how they relate to developing a simulation proposal can be found in the Simulation Proposal Guide.

Table 4-2. Specific Simulation Considerations for Collecting WBS Element Data

Question	Issues
What is the level of simulation contemplated?	<ul style="list-style-type: none"> ▶ Level of technology involved ▶ Defence capability to control and support ▶ Defence Need clearly defined ▶ What level of in-service support is required? ▶ What level of contractor support is envisioned? ▶ Can Defence obtain economies of scale by combining simulation support and operation from multiple areas into a single operation and support contract?
Simulation operation – is this offset by the reduction in equipment operation costs?	<ul style="list-style-type: none"> ▶ What is the cost reduction in operational equipment annual operation costs? ▶ Can a case be made for introducing simulation capability on cost alone? ▶ If not, does the simulation capability allow for the training of dangerous tasks in a safe environment which overrides any cost impact?
Simulation maintenance – is this offset by the reduction in operational equipment maintenance?	<ul style="list-style-type: none"> ▶ What is the cost reduction in operational equipment annual maintenance costs? ▶ Does the equipment have to be maintained even if not used for training (i.e. calendar/time based maintenance)?
Are there any trade-off requirements between simulation and actual training?	<ul style="list-style-type: none"> ▶ Simulation may not recoup the total cost reduction identified by its use. For example, although simulation may replace a substantial part of artillery training, there is still a requirement to fire a certain number of rounds of each type for the proof testing of ammunition lots/batches on an annual basis ▶ Can training fleet numbers be reduced or eliminated to reduce cost?
What are the facilities implications for Simulation?	<ul style="list-style-type: none"> ▶ Modern simulation systems usually contain high technology systems to provide the level and depth of training fidelity. ▶ Simulators often requires a dedicated building with air conditioning, utilities and possible chilled water reticulation systems ▶ Simulation facilities can be high maintenance facilities. ▶ Dedicated simulator facilities are often high cost facilities (recent -2004 costs indicated the average cost for construction of such a facility is A\$7.5m)
What are the personnel implications for Simulation?	<ul style="list-style-type: none"> ▶ Are there enough Defence personnel to operate and maintain the simulation? ▶ If not, what level of contractor support is necessary?
What are the computer and software support implications for Simulation?	<ul style="list-style-type: none"> ▶ Is the source code available for manipulation within Australia? ▶ Will there be a need for system, hardware and software upgrades to ensure the configuration and capability of the simulation remains representative of the operational equipment, environment, threats etc? ▶ Will there be a current or future need to integrate the simulation with other simulations or systems, for Service, Joint or Combined use? ▶ Will there be a need to vary the data, scenarios, logic etc to enable decision support or experimentation to be conducted? ▶ Will there be a need to manipulate the data in Australia? ▶ If so, is the capability to manipulate the data available within Australia? ▶ If not, what opportunity exists for a joint operation with another nation? ▶ What are the security implications for Australia?

Question	Issues
What are the information infrastructure implications for Simulation?	<ul style="list-style-type: none"> ▶ How many different facilities are required to be connected? ▶ How often and for how long are connections required? ▶ What bandwidth requirements have been identified? ▶ Will communications lines need to be upgraded to cope with the new capability? ▶ What is the level of security concerning data transmitted between sites? ▶ What information management infrastructure will be required?
What are the data, IP and licensing implications for Simulation?	<ul style="list-style-type: none"> ▶ Does Defence already have the necessary data, in the right format(s) and to the right levels of fidelity? ▶ Does the data in the simulation need to be altered or augmented for Defence use? ▶ Does Defence need to purchase any IP for the system? (The answer is often linked to the earlier question regarding the need to update or interface the system) ▶ Does Defence already own any IP that may be part of the system? ▶ Given that simulations often need to have models of multiple systems, and that the manufacturer of the simulation is often different to the manufacturer of the prime equipment being simulated, does Defence have access to the data and IP for these other systems to provide to the simulation vendor? ▶ What opportunities are there to negotiate an optimised licensing agreement (i.e. full ownership, pay per use, annual licensing, enterprise licence versus buying a licence for each user, site, desktop etc)

4.4 Summary

Estimating costs for the acquisition and sustainment of simulation capability, as with all defence capabilities, is a complex task that requires consideration of many issues and factors. Adherence to the Defence Cost and Schedule Methodology as well as specific simulation considerations provided herein will assist in ensuring a well constructed estimate is developed. The other parts of the Simulation Manual, specifically the Simulation Support to the Capability Life Cycle Phase Guides and the Simulation Proposal Guide should also be referenced when developing the simulation business case data.

Annex Information for Defence Simulation Investment Reference Guide

Annex A – Australian Defence Simulation Office Charter and Points of Contact

Annex B – Reference Documents

Annex C – Capability Systems Simulation Strategy Template

Annex D – Defence Simulation Benefit Examples

Annex E – Additional Detail on Simulation Benefits and Limitations

Annex F – Benefits and Limitations Mapped to Simulation Application Areas

Annex G – Useful References and Contacts for Simulation Cost Estimation

Annex H – Representative Simulation Cost Breakdown Structure

Annex I – Evaluation Form

Annex A

Australian Defence Simulation Office Charter and Points of Contact

ADSO has been established to provide policy direction, coordination and assistance on simulation-related activities and their early advice should be sought for any simulation-related activities. ADSO can be contacted to provide case studies of how the methodology detailed in this guide has been used to frame simulation strategies for specific projects. The points of contact are as follows:

	DGSIM R1-3-B065, Ph: 02 6265 2019			
	ADSO – N1 Ph: 6265 4797	ADSO – A1 Ph: 6265 5109	ADSO – AF1 Ph: 6265 7823	ADSO – J1 Ph: 6265 7011
Defence Groups	<ul style="list-style-type: none"> ▶ Navy* ▶ Personnel ▶ DMO Corporate 	<ul style="list-style-type: none"> ▶ Army* ▶ Industry 	<ul style="list-style-type: none"> ▶ Air Force* ▶ Science & Technology 	<ul style="list-style-type: none"> ▶ Joint* ▶ Operations ▶ Strategy ▶ Intelligence ▶ CIO
Simulation Application Areas	<ul style="list-style-type: none"> ▶ Acquisition ▶ Lifecycle Mgmt 	<ul style="list-style-type: none"> ▶ Crisis Mgmt ▶ Conduct of Operations ▶ Mission Rehearsal 	<ul style="list-style-type: none"> ▶ Training ▶ Research & Development 	<ul style="list-style-type: none"> ▶ Experimentation ▶ Force Assessment
Technology Areas	<ul style="list-style-type: none"> ▶ Distributed Simulation Technology 	<ul style="list-style-type: none"> ▶ Live Simulation 	<ul style="list-style-type: none"> ▶ Virtual Simulation ▶ Intelligent Agents 	<ul style="list-style-type: none"> ▶ Constructive Simulation

* Includes the relevant environmental areas within DMO, DSTO, CIO and Capability Systems.

Annex B

Reference Documents

The documents referenced in this guide are shown in the following table. Copies of these and other documents were reviewed while developing this guide and can be sourced from ADSO.

File Name	File Type	Main Topic(s)
Accident investigation	Text	Crisis Management and Planning
BAE SYSTEMS Designs Mount for Ministry of Defense	Web	Acquisition
Canadian_Forces_UOTS_Project	PDF	General
Case Study – Team New Zealand	MS Word	Acquisition and Research and Development
Defense Case Study	Web	Research and Development
DGSP – Scenario Operational Capability Risk Assessment Model	Web	Force Assessment
Evaluating Workload Capabilities with the Ship Manpower	PDF	Acquisition
Lanner	PDF	Life Cycle Management
Life Cycle M&S	MS Word	Research and Development
M&S Economic Analysis	MS PowerPoint	General
Macro-Level Simulation Model of Space Shuttle Processing	PDF	Life Cycle Management
Modeling & Simulation Return on Investment (ROI)	MS Word	Acquisition
NTSA – Simulation – Effectiveness	Web	General
NTSA – Simulation – Efficiency	Web	General
NTSA – Simulation – Risk Reduction	Web	General
Numerical Simulations of Explosive Fragmentation Munitions	PDF	Research and Development
Perspectives on Perspectives on SBA	PDF	Research and Development
SBA Roadmap SEC6 Return on Investment	PDF	General, Acquisition, Life Cycle Management and Research and Development
Simulation – an Enabling Technology in Software Engineering	Web	Acquisition and Research and Development
Simulation and Defence Capability	MS Word	General
Simulation Solutions	Web	Training

File Name	File Type	Main Topic(s)
Simulation-Based Performance Benefits Analysis of Recapitalization Programs	PDF	Life Cycle Management
Success	Web	Acquisition
Value of Modeling and Simulation (economics), USN	MS PowerPoint	General

Annex C – Capability System Simulation Strategy Template

A *Capability System Simulation Strategy* documents the planned and actual use of simulation over the life cycle of a capability. It necessarily *evolves* as a capability matures.

Early versions may not have all of the following content, but the headings in Table C1 below should be kept in the document as placeholders for future inputs. It is intended that each CSSS be updated as an integral element of Program and Project Management Plans (PMPs) and in-service support plans to ensure simulation support is planned, funded and delivered in alignment with capability requirements.

Table C1: Capability System Simulation Strategy Template

Serial	Heading	Description
1.	Purpose	▶ Define the purpose of this document
2.	Overview of project / capability system	▶ <i>Outline</i> the project or capability system (if in-service), including: <ul style="list-style-type: none"> ○ the capability objectives ○ current status of the project / capability ○ key decision or operational milestones ahead
3.	Vision for Simulation Support	▶ Define a vision for the use of simulation to support the project/capability system / operational / training needs
4.	Summary of Outcomes and Benefits	▶ Summarise the anticipated/planned benefits that will be provided by achieving the proposed vision for simulation support
5.	Simulation Application	▶ Define the specific and practical objectives, application areas, targets and benefits by CLC phase. For example: <ul style="list-style-type: none"> ▶ Requirements Phase ▶ <i>Objective:</i> To support the selection of the optimal capability solution ▶ <i>Application areas:</i> Experimentation & Force Assessment ▶ <i>Target 1:</i> To support trade-off analysis of capability and cost in integrating <x> with <y> to achieve <z> by <time>. ▶ <i>Target 2:</i> To support cost and risk analysis in optimizing <x> capability while seeking to achieve <y> outputs within cost <z>. ▶ <i>Benefit:</i> Enhanced capability – selection of the optimal solution

Serial	Heading	Description
6.	Characteristics of project/capability system	<p>▶ Outline the features required of the simulation system to integrate successfully with the business process / operations / training (as applicable) now and in the future</p> <p><i>This section is intended to draw out the characteristics of the project / capability and the issues/events being assessed and/or supported. The characteristics will help the reader understand why the project and capability system will benefit from simulation and how the simulation fits within the business, operational or training process.</i></p>
7.	Simulation Support and Resource requirements	<p>To the extent that it is possible / practical</p> <p>▶ Briefly define the resource requirements and how these will be met</p> <ul style="list-style-type: none"> ○ Funding required ○ Personnel ○ Data ○ Infrastructure ○ Follow-on support
7.	<p>Other simulation considerations</p> <ul style="list-style-type: none"> ▶ Re-use of simulation ▶ Contribution to other activities/projects 	<p>▶ Describe the potential for re-use across the CLC phases. Identify where investments have already been made and how simulations have been used to support the project/capability system to date.</p> <p>▶ Identify Defence-wide benefits that may be derived. That is, benefits that may extend the immediate project/capability system.</p>

Annex D – Defence Simulation Benefit Examples

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
	Composite shock and anti-vibration mount	Acquisition	<ul style="list-style-type: none"> ▶ Ability to meet shorter timescales and to remain commercially competitive ▶ Ability to modify designs quickly and easily, with few prototypes ▶ Ability to duplicate harsh under water explosive conditions necessary for accurate simulation of the mount stress state and equipment response ▶ Ability to analyse the properties of the composite materials 					BAE SYSTEMS Designs Mount for Ministry of Defense.mht
	Corrective action plan	Acquisition	<ul style="list-style-type: none"> ▶ Intangible measure of savings consisted of reduced Manpower, Personnel and Training (MPT) burden over the life of the system ▶ Minimized contract modification and schedule impact reduction 	<ul style="list-style-type: none"> ▶ Perform its mission 12% faster than the existing system ▶ Program savings - ROI=return/cost, 66.67= \$4M/\$0.06M 	Indirect life cycle savings - intangible returns (MPT savings) over the service life of the system were achieved which are estimated to be in excess of \$137.5 M for a ROI of 2291.67			Modeling & Simulation Return on Investment (ROI).doc
AIM-7P Sea Sparrow	US Navy was able to decrease number of launches by using an engineering game effectiveness model to predict lethality of the missile	Acquisition		Testing required reduced from 50 to 10 launches			DF	Case study - team new zealand.doc
ALQ-99 and ALQ-149	ALQ-99 receivers and ALQ-149 communications countermeasures equipment used on board the EA-6B aircraft	Acquisition		Reduced flight test hours and costs by a third			DF	Case study - team new zealand.doc
AMRAAM GWEF	Guided Weapons Evaluation Facility (GWEF)	Acquisition			Simulated AMRAAM shots in the GWEF cost an average of US\$150 per trial, compared to the typical costs of US\$3M for a single flight test		DF	Value of Modeling and simulation (economics), USN
APG-63	Radar system tested using PRIMES (Preflight Integration of Munitions and Electronics Systems)	Acquisition	<ul style="list-style-type: none"> ▶ Reduction in cost ▶ Increase in data capture during a recent flight test 	<ul style="list-style-type: none"> ▶ 35 percent reduction in cost ▶ 300 percent increase in data capture 			DF	Case study - team new zealand.doc
Boeing 767	Strut design	Acquisition		New strut for 767 designed in 17% less time through digital data process			DF	Value of Modeling and simulation (economics), USN
Bridge Durability	US Army Bridge durability testing	Acquisition	<ul style="list-style-type: none"> ▶ Reduced numbers of test crossings required 	Testing time reduced from 12 weeks to 9 weeks			DF	Case study - team new zealand.doc

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
JPATS	Leg clearance ejection simulations. Simulation to quantify the possible foot and/or shin strikes with the instrument panel.	Acquisition	<ul style="list-style-type: none"> ▶ Reduce design time (due to changes) ▶ Avoid cost of design changes 				DI	NTSA - Simulation - Risk Reduction.mht
NLOS	US Army Non-Line Of Sight (NLOS) program.	Acquisition	Distributed virtual simulations to meet OT&E requirements; such virtual distributed systems were shown to be highly effective.	Testing of NLOS prototype with Helos in 1988 took 13 months. This was reduced to 3 months in 1989 by using a NLOS simulator and a helo simulator in a distributed virtual simulation.	NLOS testing reduced from US\$15.5M to \$2M		DF	Value of Modeling and simulation (economics), USN
Phalanx		Acquisition			US\$125M saved through simulated performance evaluation of Phalanx CIWS		DF	Value of Modeling and simulation (economics), USN
Ship Building		Acquisition		Newport News Shipbuilding reduced design time by 40%			DF	Value of Modeling and simulation (economics), USN
SMART	Ship Manpower and Requirement Tools - Addresses human workload, performance, safety and task skill requirements during the early phases of the ship acquisition process.	Acquisition	<ul style="list-style-type: none"> ▶ Efficient allocation of manpower ▶ Advance determination of skill requirements ▶ Timing of manpower efforts (and peak identification) 					Evaluating Workload Capabilities with the Ship Manpower.pdf
Submarine Programs	<ul style="list-style-type: none"> ▶ Hull Penetration Test/Shock Qualification ▶ Torpedo testing 	Acquisition	Time required to turnaround analysis (time savings)	<ul style="list-style-type: none"> ▶ Number of shock trials (reduced from 23 to 10, @\$308K per test) ▶ Replacement of live fires with simulated tests (saving \$50-80K per test) 				M&S economic analysis.ppt
Torpedos		Acquisition	100-300 simulated tests executed for the cost of one in-water torpedo test (US\$50,000 to US\$80,000)				DF	Value of Modeling and simulation (economics), USN
UOTV	Urban Operations Training Village	Acquisition	<ul style="list-style-type: none"> ▶ Environment options (terrain visualisation) ▶ Significant time savings ▶ Significant cost savings 					Canadian_Forces_UOTS_Project.pdf
TAMPS	US Tactical Aircraft Mission Planning System	Conduct of operations, Crisis Management and Planning	It has been estimated that TAMPS cuts mission planning time by 50% for Navy squadrons				DF	Value of Modeling and simulation (economics), USN
Accident investigation	Flight Simulator	Crisis management and planning	<ul style="list-style-type: none"> ▶ Accident reconstruction (investigate, and re-create serious real world aviation accidents) 					Accident investigation.txt
Hospital Emergency Room	Virtual emergency room, for diagnosis and treatment of patients	Crisis management and planning	<ul style="list-style-type: none"> ▶ Reduce hospital costs ▶ Reduce length of stay ▶ Suitable for mobile hospitals ▶ Greater realism 					NTSA - Simulation - Risk Reduction.mht
NAVSEA	Radar cross section analysis	Force Assessment		Radar cross section analysis by NAVSEA reduced from 57 days in 1990 to 16.75 days in 1996 through M&S tool utilisation			DF	Value of Modeling and simulation (economics), USN

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
SOCRAM	Scenario Operational Capability Risk Assessment Model (SOCRAM) is used to determine the level of demand for operational assets in order to assess the consequent impact of this demand on an assumed amount of operational assets.	Force Assessment						DGSP - Scenario Operational Capability Risk Assessment Model.mht
ATLAST UH60 (Helicopter)	ATLAST (Aircraft Total Life-Cycle Assessment Software Tool) Used for predicting performance metrics of operations, maintenance and supply for an aviation based asset or series of assets.	Life Cycle Management		<ul style="list-style-type: none"> ▶ \$4.5M Cost Avoidance (Purging of Bad Cooling Plates) ▶ \$22M Cost Avoidance in Power Turbine and Matched Rotor Maintenance Costs ▶ UH60A readiness gains of 20% and reduced field level workload of 15% 				Simulation-based Performance Benefits Analysis of Recapitalization Programs.pdf
Space Shuttle	Space shuttle processing	Life Cycle management	<ul style="list-style-type: none"> ▶ Supports safety, schedule, supportability, and cost reduction goals. ▶ Provides recommendations on achieving higher flight rates. 					Macro-Level simulation model of space shuttle processing.pdf
WITNESS	Business process re-engineering (Process evaluation for environmental compliance)	Life Cycle Management	<ul style="list-style-type: none"> ▶ Reduced staff requirements ▶ Increased staff effectiveness ▶ Greater depth in evaluations ▶ Avoid excess material usage 	\$US300,000 cost avoidance per year		Properly validated, simulation models reflect existing systems within a 5% tolerance range.		Lanner.pdf
WSSF	Weapon System Support Facilities. Aircraft navigation and weapon integration	Life Cycle Management	<ul style="list-style-type: none"> ▶ Safety-of-flight ▶ Verification ▶ Validation ▶ Cost effective ▶ Saves money ▶ Testing of impossible scenarios ▶ Prototyping and testing ▶ Repeating tests ▶ Interoperability with other simulators 					NTSA - Simulation - Effectiveness.mht
EADSIM	Combat operations analysis	Mission Rehearsals	<ul style="list-style-type: none"> ▶ Saved lives ▶ Saved resources 					NTSA - Simulation - Risk Reduction.mht
EADSIM	For analysing command, control, and communications	Planning and Operations	<ul style="list-style-type: none"> ▶ Saved lives ▶ Saved resources ▶ Identified lower risk options ▶ Identified equipment needs ▶ Allowed choreography of events ▶ Mission review 					NTSA - Simulation - Effectiveness.mht
Abrams and Bradley Tank Vehicles	<ul style="list-style-type: none"> ▶ Engine Replacement Analysis ▶ Anti-Armor KE Projectiles 	Research & development	Faster development time to achieve accuracy	<ul style="list-style-type: none"> ▶ Time required (half a man month vs 4-6 man months) ▶ Quantity of projectiles used in testing (30% less) 				M&S economic analysis.ppt
ADEC Wind Tunnel	Air Force's Arnold Engineering Development Center	Research & development	Lower cost of testing	Average time in the PWT-16T wind tunnel has decreased from six weeks to 3-4 days			DF	Case study - team new zealand.doc

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
ANSYS	Research into innovative ship forms	Research & Development	<ul style="list-style-type: none"> ▶ Design benefits ▶ Understanding requirements 					Defense Case Study.mht
BURNSIM	Test burn hazard associated with aircraft and life support systems.	Research & Development	Avoid using animals in testing					NTSA - Simulation - Risk Reduction.mht
CALE	Numerical simulations of explosive fragmentation munitions	Research & Development	Better understanding of fragment spray patterns					Numerical simulations of explosive fragmentation munitions.pdf
Comanche Helicopter	Helicopter Design and Development	Research & development	<ul style="list-style-type: none"> ▶ Reworking minimized by precisely designing parts to fit together ▶ Maintenance considerations incorporated into preliminary design ▶ Tooling design efforts commenced during preliminary design phase 	<ul style="list-style-type: none"> ▶ It took 38 Sikorsky drafters six months to come up with working drawings for the CH-53E Super Stallion's outside contours. Using modelling and simulation, one engineer took one month ▶ Compressed six year design/build phase into 3 years. 	<ul style="list-style-type: none"> ▶ Avoided estimated US\$673M in flight test costs ▶ Team estimated that average unit cost of Comanche was reduced by 20-30 percent 		DF	M&S economic analysis.ppt Life cycle M&S.doc Value of Modeling and simulation (economics), USN
Joint Strike Fighter F-22/FA-18 Boeing 777	<ul style="list-style-type: none"> ▶ Aerodynamic Performance Analysis ▶ Weapons Store Certification ▶ Fuel Tank Separation ▶ Antenna Systems 	Research & Development Acquisition	Test range costs	<ul style="list-style-type: none"> ▶ Cost and quantity of wind tunnel tests (\$10K per hour) ▶ Number of designs tested (\$15-50K per design shift) ▶ Cost of physical mock-ups (\$millions) ▶ Live flight costs (\$20-30K per hour) ▶ Refly rate (reduction from 100% to 15%) ▶ Reduction in scrap material and rework (30%) 				M&S economic analysis.ppt
Pilatus	Aircraft design and testing	Research & development Acquisition	<ul style="list-style-type: none"> ▶ Shorter time-to-market ▶ Lower investment costs ▶ Lower life cycle costs ▶ Minimization of technical risk 					Success.mht
Team NZ	Development and testing of components for the sailing team from NZ	Research & Development Acquisition	<ul style="list-style-type: none"> ▶ Reduced time between simulation, manufacture and testing ▶ Removed need for prototyping and scale model testing ▶ Removed need for expensive wind and water testing facilities ▶ Reduce cost of development ▶ Increased number of tests possible ▶ Reduce acquisition cycle time 				O	Case study - team new zealand.doc
Use of Composite Materials for Air and Ground Vehicles (FCS)	Pouring and Fusing of Resin Materials	Research & development	<ul style="list-style-type: none"> ▶ Cost per pound/ton of waste/scrap product and amount eliminated ▶ Patent value and potential commercialization of process 	Faster curing process (from 10 hrs to 2 hrs)				M&S economic analysis.ppt

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
Various	Concept design to approval	Research & Development	Reduced design time	<ul style="list-style-type: none"> ▶ Various examples: ▶ Automakers have reduced concept approval to production time from five to three years ▶ Electric Boat has cut submarine development time from 14 to seven years ▶ Fourteen engineers at the Tank and Automotive Research and Development Center designed a low-silhouette tank prototype in 16 months. It would have taken 55 engineers three years to do the same using traditional methods 				Life cycle M&S.doc
Various*	Examples of benefits from simulation, and metric used	Research & Development Acquisition Life cycle management		Significant number of benefits mentioned across a range of application areas.				SBA roadmap SEC6 return on investment.pdf
AIM-9X	Missile simulation during developmental flight testing	Research & Development, Acquisition	<ul style="list-style-type: none"> ▶ Risk reduction ▶ Cost savings ▶ Schedule (time) savings 	Number of test firings reduced from 129 to 31	<ul style="list-style-type: none"> ▶ Avoided approximately \$110M testing cost ▶ US\$16M saved through simulation in lethality analysis of AIM-9x 		DI	Perspectives on Perspectives on SBA.pdf Value of Modeling and simulation (economics), USN
Boeing 777	Commercial - Boeing 777 digital design process	Research and Development	<ul style="list-style-type: none"> ▶ Incorporated numerous design changes to meet customer requirements ▶ Less isolation of design/build disciplines, more cooperation in defining solutions 	<ul style="list-style-type: none"> ▶ 93 percent reduction in design changes compared to previous aircraft ▶ Improved accuracy of tool design by a factor of 10 ▶ Reduced manufacturing cycle times more than 50% (from 13 months to 6 months) ▶ Reduced number of wings tested in wind tunnel from 77 for 767 to 18 for 777 			DF	Value of Modeling and simulation (economics), USN
Caterpillar	Improving the design process using virtual reality	Research and Development	Faster prototyping capability Visualisation capabilities					NTSA - Simulation - Effectiveness.mht
Electric Boat Development	Commercial - General Dynamics – Electric Boat Division	Research and Development	<ul style="list-style-type: none"> ▶ Better tool design: tools can get into tight spaces during manufacturing and assembly ▶ Properly sequenced plans for manufacturing assembly ▶ Early make-buy decisions ▶ Component lead times improved 	<ul style="list-style-type: none"> ▶ Weight study preparation time reduced by 60% compared to manual methods ▶ Standardized fasteners with a reduction in variation of 62% 			DF	Value of Modeling and simulation (economics), USN
McDonnell-Douglas	Commercial - McDonnell-Douglas virtual prototyping	Research and Development	McDonnell-Douglas has stated that it anticipates a 50% reduction in acquisition costs due to cycle time/personnel savings resulting from their virtual prototyping initiative				DF	Value of Modeling and simulation (economics), USN

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
SBD	Simulation based design for ship construction	Research and Development	Reduced design time Cost savings in total project expenditure					NTSA - Simulation - Effectiveness.mht
WEES	<ul style="list-style-type: none"> ▶ Weapon Emulation and Evaluation System ▶ Selection and engagement models of various weapons hosted by the F-14D avionics. 	Research and development	<ul style="list-style-type: none"> ▶ Improves code verification ▶ Reduced software integration testing requirements ▶ Allows detection of software errors, and software computational issues ▶ 	Efficiency increases of 100% stated				NTSA - Simulation - Effectiveness.mht
Joint Strike Fighter	Virtual manufacturing techniques	Research and Development, Acquisition	Projected that the virtual manufacturing techniques may see as much as 3% of the program's life cycle cost, which could be US\$5 billion					Simulation – an Enabling Technology in Software Engineering
M2 Bradley FVS		Research and Development, Acquisition			US\$30M saved in engineering design phase of M2 Bradley FVS		DF	Value of Modeling and simulation (economics), USN
	Flight Simulators	Training	<ul style="list-style-type: none"> ▶ Reduce flight time ▶ Improved skills 		<ul style="list-style-type: none"> ▶ Cost 5-20% of aircraft cost ▶ Median cost ratio estimated at 8% 			NTSA - Simulation - Effectiveness.mht
	Flight Simulators	Training	<ul style="list-style-type: none"> ▶ Emergency exercises conducted safely ▶ Evaluate operational procedures ▶ Check flights 			<ul style="list-style-type: none"> ▶ Up to 50% of minimum flying hours ▶ Up to 50% of minimum flying requirements for instrument rating 		NTSA - Simulation - Risk Reduction.mht
	<ul style="list-style-type: none"> ▶ Making it safe to fly dangerously ▶ Testing/training with complex mission scenarios ▶ (QinetiQ) 	Training	<ul style="list-style-type: none"> ▶ Create a high threat, dynamic and 'collective' environment ▶ Enable them to plan and fly the mission ▶ Test out the 'what ifs' of their contingency planning. ▶ Survey of pilots showed – “better training environment than their aircraft, for tactics and countermeasures training and a number of role-specific tasks”, and “as good as live training for almost all the training objectives ▶ Markedly better for exploring the 'what ifs' of training scenarios” 				DI	Simulation Solutions.mht
Aircraft Qualification	US Air Force aircraft qualification 160 th SOAR (A)	Training	Reduce annual qualification Operational cost through 60% aircraft, 40% CMS hours		Cost avoidance of 37% - US\$6.02M reduced to US\$3.76M		DF	Value of Modeling and simulation (economics), USN

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
Advanced Air Defence Simulator	The Advanced Air Defence Simulator (AADS) constructed in South Australia during 2004 provides the Australian Army with a collective training capability for Ground Based Air Defence (GBAD) Detachments.	Training	<p>The Detachment enters the AADS, takes post at a realistic facsimile of a Short Range Air Defence (SHORAD) Missile Weapon System and is immersed into the simulated training environment, projected on a 12.2m diameter dome. Upon completing the tactical scenario, which may take minutes or hours, the Detachment moves to the debriefing room, where the full complement of audio and visual recordings, computer generated replays, accuracy scoring, event and action logs are available</p> <p>The AADS will enhance the operational effectiveness of RBS70 equipped SHORAD batteries by providing a facility which can frequently exercise the Detachment Commander in C3 and tactical decision-making (TDM) functions in a simulated environment. The AADS: simulates multiple aerial targets; simulates weapon system missile flight; allows a full engagement sequence to be assessed; and recreates a simulated battlefield environment with noise, obsuration, weather and ambient light effects. The capability will complement other collective training normally conducted in the field with real aircraft and live missile firings.</p>	<p>Resources Saved</p> <p>Cooperative resources in the field that provide multiple threat training with live system data feeds for TDM training costs approximately \$0.5m per day. This estimate covers operating costs only. The AADS will cost approximately \$5,000 per day. This estimate includes full life-cycle costs.</p> <p>Live firing exercises become more efficient as the live fire scenario can be proven and rehearsed in the AADS. For example, target test runs in the field (usually one or two at a cost of approx \$5,000 each) are no longer required.</p> <p>Risks Reduced</p> <p>An immersive simulation environment such as the AADS, can provide infinite threat scenarios in a safe environment. Realistic flight profiles can be witnessed without breaking aircraft safety regulations. In fact, less dependence on air support in general, equates to less risk of aircraft incident.</p> <p>When the AADS is a proven training capability, the user may then consider concessions to local area and field training. It is anticipated that within two years, Detachment level lead-up activities in the field can be culled and the Air Defence Batteries may progress directly into Troop level training. Any reduction in local area training, or shortening of field exercises equates to less probability of injury or illness in the field.</p>				Project Land 19

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
Advanced Gunnery Training System (AGTS)	The Advanced Gunnery Training System (AGTS) provides precision gunnery training for individuals, crews and platoons.	Training	<ul style="list-style-type: none"> ▶ AGTS enables soldiers to become highly proficient and make a rapid transition to live fire training and combat gunnery. AGTS enables individuals and crews to develop the necessary skills to survive gunnery direct fire engagements on the battlefield using an embedded, focused instructional system. The training device can be installed in fixed facilities, relocatable shelters, or on transportable platforms to support training in any environment. AGTS devices have been built to support training on the M1A2, M1A1, M60A3, M2A2, and LAV-25 armoured vehicles. 	<p>Defence Capability Enhanced</p> <ul style="list-style-type: none"> ▶ Develops and sustains precision gunnery skills that enables the rapid transition to live fire gunnery. ▶ Provides a tool for commanders to evaluate and track the tank gunnery skills of their personnel. ▶ Provides a "turn-key" training system that maximizes training time and minimise set-up/tear-down. <p>Resources Saved</p> <ul style="list-style-type: none"> ▶ Savings of \$1,625,000 in training ammunition cost per year, per US Army battalion. This was achieved by reducing the annual tank training round requirement. The US Army has one AGTS crew station per active duty battalion. ▶ The cost of the AGTS simulator was recouped in the first year by the saving in ammunition costs alone. ▶ Additional significant savings include: (1) reduced wear & tear on the weapon systems, (2) longer gun tube life, (3) less fuel consumption, and (4) lower live-fire range cost (manpower to operate range, target destruction, etc). <p>Risks Reduced</p> <p>Provides ability to train malfunctions and emergency conditions in a safe training environment and avoidance of third-party damage costs associated with live fire.</p>				Lockheed Martin
Apache Longbow	Force deployment test and experimentation (FDT&E).	Training	<ul style="list-style-type: none"> ▶ More trials at lower cost ▶ Fewer personnel required ▶ Shorter time frame ▶ Lower risk 					NTSA - Simulation - Effectiveness.mht
Blackhawk Mission Simulator	Blackhawk pilot training	Training	Reduce flying hours of helicopter	3 aircraft released from training activities to operational activities			ADF	Simulation and Defence Capability
Boeing 707 flight simulator	Training pilots to fly B707	Training	Reduce flying hours of plane	500 hrs reduction in flying time			ADF	Simulation and Defence Capability
Exercise Reforger	US Army live large-scale exercise in Europe.	Training	Reduction in cost, especially in terms of the damage to the local terrain, roads, and fields through using a simulation approach in 1992		US\$53.0M cost for 1988 exercise reduced to \$19.5M in 1992		DF	Value of Modeling and simulation (economics), USN
FAA	Commercial - Federal Aviation Administration (FAA) Flight simulator	Training	Training and assessment for qualifications				C	NTSA - Simulation - Effectiveness.mht

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
Fighter training	Top gun fighter weapon school	Training		Improved exchange ratio from 2.4 to 12.5				NTSA - Simulation - Effectiveness.mht
Fire Fighting	Ship board fire fighting in immersive virtual environments	Training and Rehearsal	<ul style="list-style-type: none"> ▶ Improved navigational ability ▶ Increased confidence 					NTSA - Simulation - Effectiveness.mht
IDCTT	<ul style="list-style-type: none"> ▶ Integrated damage control training technology ▶ Training though interactive damage control scenario 	Training	<ul style="list-style-type: none"> ▶ Lower cost ▶ Increased skills ▶ Enthusiasm of students and trainers 					NTSA - Simulation - Effectiveness.mht
ISMT	USMC Indoor simulated marksmanship trainer	Training	<ul style="list-style-type: none"> ▶ Maintained quality of training at lower cost ▶ Ability to fire on equipment ▶ Able to determine the affect on target 	Reduced cost of operation by \$16M				NTSA - Simulation - Effectiveness.mht
LCAC FMT		Training	<ul style="list-style-type: none"> ▶ Estimated that the FMT reduced actual LCAC flying time by 40-45 hours per crew training course ▶ FMT avoids weather, ship availability, system casualty severity, or similar restrictions 		FMT costs \$300/hr versus \$3000/hr for operating an LCAC		DF	Value of Modeling and simulation (economics), USN
Manufacturing	Manufacturing line virtual reality	Training	<ul style="list-style-type: none"> ▶ Potential to save money ▶ Lower error rates 					NTSA - Simulation - Effectiveness.mht
Military Flight Simulators	Military Flight Simulators	Training	<ul style="list-style-type: none"> ▶ Increased skill level ▶ Not constrained by logistics and scheduling operational costs ▶ Not constrained by safety, environmental, diplomatic, security, etc ▶ Greater flexibility in scenarios ▶ More feedback ▶ Targeted/focused exercises (eg. Specific activities/skills) ▶ Reproducible scenarios ▶ Better debrief/critique from instructors 		<ul style="list-style-type: none"> ▶ Cost 10% of actual equipment (when both already in inventory) ▶ Cost 33% of actual equipment if simulators need to be procured and maintained 			NTSA - Simulation - Effectiveness.mht
P-3C SASP Acoustic Trainer	Provides real time simulation of target acoustic signals and aircraft navigation data.	Training	<ul style="list-style-type: none"> ▶ Extensive target options ▶ Extensive input/parameter options for scenarios 					NTSA - Simulation - Effectiveness.mht
PGTS	Simulation versus Live fire	Training	<ul style="list-style-type: none"> ▶ Target engagement at any time ▶ Extensive Feedback possible ▶ Recoding and Repays possible including visual feedback ▶ Unlimited target options available ▶ Unlimited terrain options available ▶ Performance measures available ▶ Target size/parameters can be changed ▶ User acceptance ▶ User confidence 	<ul style="list-style-type: none"> ▶ "At least equal to" live fire ▶ Better first hit values than non-trained personnel 				NTSA - Simulation - Effectiveness.mht
RDT	Red flag remote debriefing tool	Training	<ul style="list-style-type: none"> ▶ Allows off-site monitoring and critique ▶ Inexpensive ▶ Portable 					NTSA - Simulation - Effectiveness.mht

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
ROI	Return on Investment calculations for training simulations – ROI = ({ A/C Ops Cost - Simulator Ops Cost } - Simulator Dev Cost) / Simulator Dev Cost	Training	Simulation is cheaper than using operational equipment and consumables	<ul style="list-style-type: none"> ▶ Apache Simulator = 2340 ▶ M1 Tank Table = 1908 ▶ M2 AFV Table = 432 ▶ M1 Tank Driver Trng = 35 ▶ TILV = 31 ▶ VPG = 3.91 ▶ Apache = 4.68 ▶ AP/UE Ex = 12.79 ▶ FFG7 = 115 ▶ DD 963 = 425 ▶ DDG 51 = 190 			DF	Value of Modeling and simulation (economics), USN
Submarine Training		Training	<ul style="list-style-type: none"> ▶ “Estimated cost to develop the CCS MK-2 IETM and provide electronic classrooms with 10 years of ILS support is \$25.6M. Projected cost avoidance over these ten years will give the Navy a return on its \$25.6M and provide an estimated additional cost avoidance of \$30.6M.” (N879 Master Plan, Page 3-23) ▶ “A conservative cost estimate showed that the CIITA development costs for BEES was \$140,000 which provided an equivalent traditional training aid capability of \$520,000 for that one course at one site.” (N879 Master Plan, Page 3-39) 				DF	Value of Modeling and simulation (economics), USN
Tank Gunners		Training	Tank gunners trained on UCOFT fire opening round 25% faster than conventionally trained gunners				DF	Value of Modeling and simulation (economics), USN

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
Tank Driver Training (TDT)	Tank Driver Trainers (TDT) are sophisticated training devices that provide highly effective training to tank vehicle drivers without incurring the high cost of vehicle maintenance, wear-and-tear, and fuel.	Training	<p>TDT provides training for combat driving skills from basic to advanced driving in all types of terrain, visibility, and weather, and under conditions that range from malfunctioning equipment to enemy fire. Vehicles simulated include the M1, M1A2, Leopard 1 and M60.</p> <p>Lockheed Martin delivered 10 M1 TDTs to the US Army in 1992 and 1993, each system consisting of two trainers with independent operations. The results show that US Army drivers trained in TDTs are more skilled than those using vehicle-only training. Further, drivers obtained tank licensing with minimal in-vehicle time. The TDT is a thoroughly proven training device, it combines the visionics technology of the Compu-Scene PT 2000 with the Lockheed Martin armour training system leadership design experience.</p>	<p>Defence Capability Enhanced</p> <ul style="list-style-type: none"> ▶ Provides for entry level driver training for new tank crewman. ▶ Provides driver training in a variety of simulated driving scenarios in a relatively short period of time, to including: basic operation of the driver station, convoy driving, driving in confined areas, rail and aircraft loading/unloading, driving over/around obstacles, and driving in a variety of light and weather conditions. ▶ Provides a "turn-key" driver training system that maximizes training time and conserves resources (fuel & spare parts) ▶ Response to unexpected malfunctions is learned from preprogrammed or instructor-induced fault conditions. <p>Resources Saved</p> <ul style="list-style-type: none"> ▶ Prior to fielding the 10 TDT systems (20 driver stations) at Fort Knox, the US Army conducted all tank driver training on real tanks. This activity was very costly due to fuel consumption, spare parts usage, and track wear. ▶ From March 1993 to January 2003, based on the number of simulated miles driven at the Fort Knox TDT Training Facility and the typical tank cost per mile, the cost of operating the 20 TDT systems has been \$6,217,463 while the total cost savings over those 9 years and 10 months. was \$170,934,517, resulting in reduced driver training costs due to reductions in fuel consumption, maintenance, and vehicle downtime. TDT training versus real tank training results in a cost savings ratio of 50:1. <p>Risks Reduced</p> <ul style="list-style-type: none"> ▶ Provides safe, high quality training in vehicle operations, how to deal with malfunctions and emergency conditions while avoiding injury, damage and wear and tear. <p>Significantly reduces the environmental impact from heavy tracked vehicles and increases availability of vehicles for operational deployment without reducing training services</p>				Lockheed Martin

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
UOTS	Urban Operations Training System	Training	<ul style="list-style-type: none"> ▶ Integration with Weapons Effect Simulation (WES) system ▶ Increase soldier readiness ▶ Increase safety ▶ Efficient use of resources and budget 					Canadian_Forces_UOTS_Project.pdf
US Navy Training	Air intercept training	Training		M&S for air intercept training in US Navy reduces operational equipment support required by 50%			DF	Value of Modeling and simulation (economics), USN
Various*	Examples of training simulation results/benefits	Training		Significant number of benefits mentioned across a range of application areas.				NTSA - Simulation - Efficiency.mht
WES	Weapon Effects Simulation Project	Training	<ul style="list-style-type: none"> ▶ Immediate feedback ▶ Objective evaluations of engagements ▶ Detailed feedback 					Canadian_Forces_UOTS_Project.pdf

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
VISTA™ Synthetic Maintenance Training Technology	A synthetic maintenance training application, VISTA™, provides the means to effectively train maintainers of complex equipment while minimizing the need for access to actual equipment.	Training	<p>Within the application is a synthetic model of the equipment and of all the tools and test equipment that the maintainer may need to diagnose faults and repair equipment. Utilizing the latest high fidelity graphics and multi-media technologies, the applications provide the visual and aural stimuli that the maintainer would experience when working with real equipment. VISTA™ is both highly effective in an individual student environment (self-paced refresher training) and when interfaced with IN-CONTROL™ in a classroom Instructor-led and CONTROL-led environment.</p> <ul style="list-style-type: none"> ▶ IN-CONTROL™ is the control and execution software that enables VISTA™ applications to be used to their full potential in the networked electronic classroom. A transparent software overlay, it enables a single instructor to manage the learning of multiple students. Students are allowed to proceed at their own pace while the instructor has complete insight into their activities and is able to take direct control and effectively mentor individuals or the whole class. 	<p>Defence Capability Enhanced</p> <ul style="list-style-type: none"> ▶ Maintainers trained using synthetic maintenance trainers assessed by US and Canadian Navies as much more proficient upon completing training. ▶ Enables refresher training (critical to addressing skill fade) to be accessed as required and without the need to return to the training establishment. ▶ Enables objective rather than subjective readiness assessments. ▶ Enhanced availability and performance of systems ▶ Enhanced self-sufficiency within operational units <p>Resources Saved</p> <p>Numerous business cases have been conducted for the US Navy to ensure that the proven benefits of using synthetic maintenance trainers, including effectiveness of training and quality of life (e.g. reduction in time away from home port for training during shore time) extend to cost. Examples of cost savings are:</p> <ul style="list-style-type: none"> ▶ DDG 51 Flt IIA Machinery Control System vs VISTATM 9:1 ▶ SPS 73 Radar vs VISTATM 28:1 ▶ SQS 510 Sonar vs VISTATM 10:1 <p>Mechanisms through which savings are achieved include reduced course duration (60% demonstrated), reduced training equipment acquisition costs, minimising/eliminating training equipment ownership costs and minimising training associated travel and accommodation costs.</p> <p>Risks Reduced</p> <ul style="list-style-type: none"> ▶ Provides the capability to train for hazardous situations in a safe environment. ▶ Availability of specific equipment model to train on rather than the typical equipment reduces potential risks through unfamiliarity. ▶ Maintainers are proficient on completing training reducing hazards to equipment and personnel through inexperience. <p>Capability to conduct refresher training allows proficiency levels to be sustained.</p>				Lockheed Martin

Title	Description/Purpose	Application Area	Stated Benefits	Benefit Results	Costs	Limitations	From	Source
Weapon Training Simulation System	The Weapon Training Simulation System (WTSS) provides Defence the training opportunity that would be difficult or impossible to replicate in the real world such as repetitive training in a controlled environment to maintain shooting proficiency with instant feedback, after action review, force on force training in geographically diverse environments.	Training	<ul style="list-style-type: none"> ▶ Networked training that allows sub units to realistically represent the manoeuvre units dispersion around the battlefield. ▶ Provides initial training without tying up valuable resources or the use of high cost resources. ▶ Does not consume unit resources and is available day and night regardless of weather. ▶ Networking allows multiple users to train jointly from a number of different locations. ▶ Has very limited safety restrictions and allows for realistic training in a safe controlled environment 				DI	FATS Australia

From

- ADF - Australian Defence Force
- DF - Defence Force (Not Australia)
- DI - Defence Industry
- O - Other

* Tagged items are particularly useful and/or have a significant amount of data of various systems.

Annex E - Additional Detail on Simulation Benefits and Limitations

This Annex provides further details on the categories of simulation benefits as well as the benefits and limitation of Simulation in each of the three Domains. These benefits are also included at Annex F, where they are mapped against each of the Simulation Application Areas.

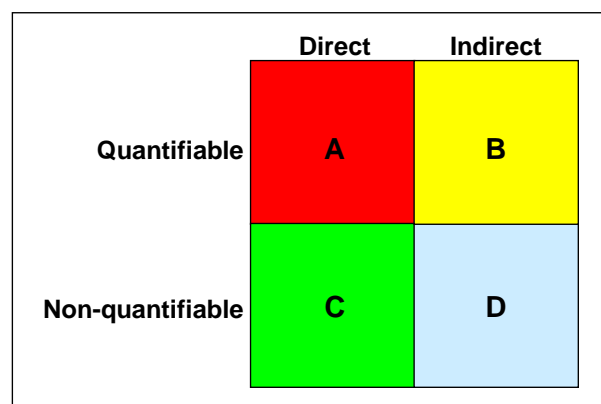
Categorisation of Simulation Benefits

The benefits associated with each simulation domain can be categorised based on their characteristics:

- ▶ A - Direct Quantifiable
- ▶ B - Indirect Quantifiable
- ▶ C - Direct Non-Quantifiable
- ▶ D - Indirect Non-Quantifiable

'Direct benefits' are those that relate to the primary purpose of the simulation.

'Quantifiable benefits' are those that can be monitored and measured. This categorisation is also shown in the following figure.



The most crucial benefit areas are those that are direct quantifiable, as these represent the primary impact to economic and financial analyses. However, both the direct non-quantifiable, and the indirect quantifiable are relevant in the context of a broader review of the viability and suitability of an investment in simulation. Often the data for direct quantifiable benefits is difficult to obtain causing them to be treated as direct non-quantifiable.

Training Domain

Benefits of Simulation

Enhanced Capability

The benefits of simulation in training that enhance capability are well known and have led to the increasing use of simulations across the ADF in this core Application Domain. The benefits of enabling staff to experience multiple potential futures, and experience how their decisions and actions can alter the outcomes, provides a powerful learning method and so offers enhanced capability.

Using simulation for training can enhance capability by generating higher skill and performance levels from the configurable nature of simulation, allowing greater variety in situations and conditions, and its increased availability compared to using real equipment (for example poor weather might prevent real equipment use). Capability can be enhanced through simulation by being able to conduct training even whilst real equipment is unavailable (i.e. it is deployed or in maintenance). Capability can be enhanced via increased operational availability of assets through decreased demand in support of training. Simulation can also enhance capability by enabling higher training rates to be achieved, and can often facilitate a better focus of training onto specific training needs. Both of these offer enhanced capability through increased Defence readiness.

Simulation's ability to capture and play back data results in better feedback allowing personnel to gain a better awareness of the outcomes of training and rehearsal activities. Feedback from simulation is generally more consistent, more immediate, better targeted and less subjective than other feedback. The number of independent observers required for a training exercise to assess participants is reduced which can result in more natural behaviour by the participants (no one performs their best with someone watching over their shoulder). Simulation facilitates the sharing of knowledge in part through playback facilities used in feedback, but also through visualising concepts and instructions during training and the use of recorded data for activities such as benchmarking.

Simulation allows emergency response and dangerous condition scenarios to be repeatedly rehearsed and trained in a safe and controlled environment, reducing stress on personnel and increasing OH&S compliance. Training and rehearsing some of these scenarios was not possible before simulation.

Using simulation to train personnel before training using real equipment can result in personnel obtaining greater benefit due to familiarity with the equipment and confidence in its capability. Simulation also supports the undertaking of collaborative training with coalition partners prior to deployment. It could eventuate that ADF elements may be precluded from exercises such as RIMPAC unless they 'pass' a pre-exercise simulation-based work up. So, whilst simulation-supported training is unlikely to ever replace the need for live exercises, there is evidence that performance levels in the live environment are increased after participants have had the benefit of preliminary, simulation supported training.

The use of simulation leaves the path open for innovative training techniques that would not be possible without it, for example rapid test-feedback-test cycles to reinforce and enhance performance. These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ Higher skill level attained ▶ Improved performance levels ▶ Increased throughput of candidates ▶ Increased rate of mission success 	<ul style="list-style-type: none"> ▶ Increased readiness ▶ Increased ability to share knowledge ▶ Emergency response training/scenarios can be conducted ▶ Reduced stress ▶ Greater outcome awareness ▶ Ability to use simulations while real equipment not available ▶ Increased ability to undertake collaborative training with coalition partners prior to deployment ▶ Reduction in observers required leading to more natural behaviours ▶ Greater benefit from training on real systems through better preparation using simulation 	<ul style="list-style-type: none"> ▶ Increased data capture and play back ▶ Historic comparisons possible (benchmarking) ▶ Greater operational availability of prime equipment through reduced demands 	<ul style="list-style-type: none"> ▶ More efficient use of operational assets and resources ▶ Improved training techniques can be developed & employed (e.g. rapid-test-feedback-test cycles) ▶ Improved OH&S compliance and procedures

Saved Resources

Using simulation for training has potential for saving resources. Because simulation can replace training and exercises using real equipment it can result in a reduction in the support costs (e.g. for highly expensive items such as aircraft, ships, armoured vehicles), damage or loss of that equipment, reduced personnel support costs (e.g. rations, transportation), reduced field allowances, a reduction in consumables required (ammunition and expensive munitions such as guided weapons, petrol, oil and lubricants (POL) for weapons platforms and vehicles, batteries and other lifted items etc), a reduction in cancelled training days due to poor weather and a decrease in time required by other Defence personnel to support exercises.

The potentially saved resources are amplified for joint exercises where integrated operations of air, land and sea platforms are involved. The cumulative costs of actual training using real equipment can be extremely large. Real equipment usage is decreased, increasing its life of type (LOT) and increasing the time available for other activities such as operations, testing and maintenance. With extended LOT and less damage and loss, less time is spent on procurement for resource replacement. A reduction in field exercises leads to a decrease in injuries and a productivity gain due to injury time avoidance.

Simulation is often a more efficient way to perform training, resulting in faster completion times for set tasks. Time can also be saved through conducting mission rehearsal and preparedness workup(s) while en route to operations (this saves resources by reducing the time spent on pre-deployment training).

These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ More efficient execution (e.g. faster completion time) ▶ Reduced equipment damage or loss ▶ Fewer field tests and live exercise required ▶ Reduced equipment usage (extended LOT) ▶ 	<ul style="list-style-type: none"> ▶ Reduced cancelled training, exercise or test days (due to poor weather) 	<ul style="list-style-type: none"> ▶ Less time spent on procurement for resource replacement ▶ Increased time available for testing and maintenance works ▶ Reduced transportation costs to/from exercises ▶ Reduced time required by other Defence personnel to support exercises 	<ul style="list-style-type: none"> ▶ Productivity gain due to injury time avoidance

Reduced Risk

An important role of simulation is to reduce risk for the ADF. In many instances, cost is *not* the most important metric, measures such as safety/ security/risk reduction and mission success can often drive a more expensive solution.

Training simulations reduce risk by allowing a larger number of scenarios and conditions to be rehearsed or trained on than other methods, including dangerous and emergency situations that are not possible through other means. This decreases the risk that personnel would not perform satisfactorily in these situations and increases the confidence in the results of their training or rehearsal activities. Limitations testing can also be conducted in a safe and controlled simulation environment to familiarise personnel with the effect of operating at the edge of their equipment design envelope, while suffering from fatigue or drugs or to assess operator response times. All these activities present a very high safety risk if performed on real equipment.

from exercise accidents will also be reduced. Fewer accidents result in less environmental damage and reduced risk to emergency response personnel who recover the personnel or equipment. Mission rehearsal simulations can lead to reduced collateral damage through thorough rehearsal and also reduced friend, neutral and foe casualties. The reduction of field exercises and more efficient use of operational equipment can reduce pollutant levels reducing health risks and minimising environmental damage.

These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ Larger number and greater range of tests, conditions or scenarios can be conducted ▶ Reduced equipment damage and loss (through accident and ware) ▶ Fewer casualties (reduced training /testing accident rates) 	<ul style="list-style-type: none"> ▶ Safe and controlled environment ▶ Ability to conduct dangerous/emergency exercises ▶ Limitations testing safer ▶ Increased confidence in results 	<ul style="list-style-type: none"> ▶ Reduced collateral damage ▶ Fewer casualties (friend, neutral, foe) ▶ Reduced pollutant levels (reduced health risk) 	<ul style="list-style-type: none"> ▶ Minimised environmental damage ▶ Reduced risk to emergency response personnel

Limitations and Risks

Training simulations often need high fidelity, that is, to closely represent the real world to meet their objectives. Limited fidelity can lead to inaccurate or misleading training and simulator sickness can occur if the time delay between issuing a command (through instruments or controls) and the simulator response is too long. In addition, peripheral cues that are essential during real operation may not be present in training simulations that do not represent the full 220-degree field of human view. Most simulations are also limited in how they represent the physical response of the equipment, for example, prolonged acceleration can only be simulated through the use of a centrifuge.

However, cost effectiveness is a serious issue with simulation fidelity, because fidelity can be an aggressive cost driver. The correct balance between cost and fidelity should be the result of simulation need analysis. Simulation acquirers must decide when enough is enough. Fidelity needs can vary throughout the simulation, and 'high fidelity' is not always the right answer, for example, a cheap PC-based commercial flight simulator can be a much more cost-effective training device than a multi-million dollar, full six-degree of freedom flight simulator for some (limited) training requirements. Striking the right balance between 'live' and 'simulation-supported' training requires careful thought, and should be supported by a Training Needs Analysis.

Some entities and phenomena are hard to quantify and model, such as potential future events, decisions and responses from other nation states, individual people, fear and morale. Simulations that do model these may have limitations in how realistically this is done which then impacts upon the quality of training. For many training simulations, real people playing the role of personnel that the student interacts with directly such as air traffic controllers or other pilots, overcomes this limitation. As technology increases, intelligent agents may better represent the individual in simulations however they will always be only an approximation of people and may either react quite differently, or cause a different reaction than a real person.

Even validated, verified and accredited (VV&A) simulations are not necessarily 'right' and suffer limitations. Such simulations have undergone sufficient testing to ensure that there is sufficient confidence that the simulation is correct for the application for which it was

built. Even simulations that have undergone VV&A cannot be assumed to be suitable to other applications. For example, a part task trainer cannot be assumed to be suitable for training on related tasks even if they are represented in that simulation, as they may well be represented with less accuracy than required.

There are limitations to maintaining simulations, especially when the real world changes faster than the simulation can. Gathering the necessary data, and keeping this data up to date, can be difficult. Keeping the simulation up to date with real equipment can also be a challenge. Often simulations are not upgraded at the same time as the real equipment, causing a gap in capability between the simulation and what it is simulating. There are also potential limitations in the language or protocols used to develop the simulation. With the rapid changes in technology that occur, it is possible that the expertise required to upgrade or fix a simulation may not be available towards the end of its life. Simulations must be built by, or in close consultation with, personnel who not only understand the equipment to be simulated, but also military operations, their context and how the equipment is used in them to ensure that the simulation correctly represents the situations to be trained on.

A good quality training simulation may cost more than actual equipment to acquire, support and operate, especially if the equipment being simulated is relatively cheap. This limitation should however, be offset against the limitations of training without simulation. Styer rifles are not expensive and all personnel have access to one, so at first glance the rifle may not be a candidate for simulation. However the Weapons Training Simulation System (WTSS) is a viable simulation due to increased throughput and feedback, its convenient locations and the ability to train in a controlled environment.

Available bandwidth can be a limitation for distributed simulations where more than one training or rehearsal simulation is connected. This limitation is being overcome through developing more efficient ways of utilising existing bandwidth. Distributed simulations may also potentially compromise security if not connected through secure means.

Some of the most important limitations to be aware of are those that affect the performance of those trained in simulations. Simulation use may instil habits that are incorrect for real equipment, or may cause operator over confidence leading to more risks being taken than usual. Personnel may become complacent or desensitised with heavy simulation use due to the lack of real consequences. For example, an explosives expert may become less cautious with real explosives because his fear has been reduced through using simulations where an accidental detonation has no physical effect. Personnel may also feel that they have encountered all possible scenarios through the use of simulation, which may reduce their anticipation of, and performance in, unexpected events. In some cases, heavy simulation use can lead to a reduced confidence in operating actual equipment which in turn decreases readiness and capability.

Individual training simulations may also have their own limitations such as visualisation limitations, approximations in representation, availability, etc. These must be considered on a case-by-case basis.

For all these reasons, simulation cannot entirely replace training with real equipment. It is necessary to complete at least some training including exercises in a real environment with real consequences.

These limitations are also listed at Annex F where they are mapped against the Simulation Application Areas.

Planning, Operations and Rehearsal

Benefits of Simulation

Enhanced Capability

As simulation is increasingly used in the Planning, Operations and Rehearsal Application Domain, benefits that enhance capability are being realised. As with the Training Application Area the benefits of enabling staff to experience multiple potential futures, and experience how their decisions and actions can change the outcomes, provides a powerful learning method and so offers enhanced capability. Scenario-based thinking and planning, using simulation to calculate the outcomes based on the inputs, assumptions, and rules, with uncertainty built-in where possible, enhances capability by allowing staff to experience many possible future outcomes.

Simulation use in this Application Domain improves evidence for decisions and increases the awareness of the issues surrounding them, resulting in a more informed decision with an increased understanding of the potential impacts. With simulation support, some decisions can be made faster, as can responses to changes and 'what if' requests. Simulation can also evaluate an increased number of plans and concepts than manual methods of analysing potential courses of action (COA). Decision Superiority is a key component of Network Centric Warfare, therefore the use of simulation to improve the timeliness and quality of decisions clearly contributes to enhanced capability in this area.

Supporting crisis management and planning and the conduct of operations with simulation decision support tools allows more COAs to be developed and analysed resulting in more robust plans. These in turn increase the confidence levels of personnel and through this enhance capability. Plans developed with simulation support often coordinate and prioritise resources better than those developed without, and result in more efficient use of operational assets, greater awareness of fragilities and risks, and improved manpower management. Built-in checklists and the ability to visualise situations may lead to better coordination with non-military officials.

Practicing or rehearsing complex manoeuvres using simulation beforehand, facilitates the 'ironing' out of timing and other coordination issues, enables potential flaws in the plan to be teased out early, enhances shared understanding of the operation and its constituent parts, and helps reduce the 'fog of war' by testing alternative adversary responses. Using simulation to conduct mission rehearsal for covert operations can avoid unwanted detection and so enhance capability by maintaining the element of surprise.

These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ Increased number of plans, concepts, designs, systems can be evaluated ▶ Increased number of variables and alternatives ▶ Faster decision making ▶ More COAs developed and analysed in time available ▶ More personnel aware of force capabilities ▶ Decreased lag in doctrine and tactics development 	<ul style="list-style-type: none"> ▶ Better understanding of the impacts of decisions ▶ Increased awareness of issues (situation, problem) ▶ More efficient use of operational assets and resources ▶ Improved/increased confidence levels (of personnel) ▶ Improved evidence for decisions ▶ Improved responsiveness to changes and requests ▶ Better coordination and prioritisation of resources ▶ Improved force mix 	<ul style="list-style-type: none"> ▶ Increased data capture and playback ▶ Historic comparisons possible (benchmarking) ▶ Greater operational availability of prime equipment through reduced demands 	<ul style="list-style-type: none"> ▶ Improved OH&S compliance and procedures ▶ Improved manpower management (right people at right time) ▶ Better coordination with non-military officials

Saved Resources

Planning, operations and rehearsal simulations have benefits that can save many resources. Some of these benefits are the same as discussed for field exercises in the training domain and are therefore not repeated here.

Simulation used in this domain results in faster completion times for planning and analysis activities that could result in reduced staff requirements. Simulations supporting crisis management and planning, the conduct of operations, and mission rehearsal can also determine optimal personnel requirements and efficiently allocate personnel and equipment to make best use of available resources. Additionally, simulation can result in reduced equipment damage and loss through better testing plans and identifying high-risk strategies before implementation.

These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ More efficient execution (e.g. faster completion time) ▶ Reduced staff requirements ▶ Reduced equipment maintenance costs ▶ Fewer field tests and live exercise required 	<ul style="list-style-type: none"> ▶ Optimal personnel requirements determined ▶ Efficient personnel allocation ▶ Efficient equipment allocation ▶ Better prioritisation of funding 	<ul style="list-style-type: none"> ▶ Increased time available for testing and maintenance works ▶ Reduced transportation costs to/from exercises ▶ Reduced time required by other Defence personnel to 	<ul style="list-style-type: none"> ▶ Productivity gain due to injury time avoidance

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ Time saved through conducting mission rehearsal while on route to operations 	<ul style="list-style-type: none"> ▶ More focused reviews/assessments 	<ul style="list-style-type: none"> support exercises 	

Reduced Risk

Benefits of simulation use in planning, operations and rehearsal that reduce risk include those benefits already discussed for exercises under training and these are not repeated here. A larger number and greater range of scenarios can be tested using simulation and this results in deeper analysis being performed in a fixed time. Simulation also allows for the early identification and containment of problems and issues, which limits their escalation. This increases the confidence in results and reduces the risk that the outcome could be less than optimal. Sensitivity analysis that portrays the impact of uncertainty in key events also increases confidence and reduces the risk that an unforeseen event occurs.

Simulation for crisis management and planning and for the conduct of operations can reduce evaluation and decision time, which decreases the risk of events occurring before plans are complete. It can also result in faster access to equipment and skilled personnel due to better planning and identification of resources. Easy access to expert advice embedded in simulation software can also reduce the risk associated with plans, as can the early identification of planning oversight or flaws through simulating plans. Plans and rehearsals tested with simulation are also likely to result in less collateral damage.

The reduction in real equipment use afforded through the use of simulation and its use for the rehearsal of missions can lead to reduced equipment loss and damage as a result of wear and accidents thereby reducing the risk of injured personnel. Casualties

These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ Larger number and greater range of tests, conditions or scenarios can be conducted ▶ Reduced evaluation and decision time ▶ Faster access to needed equipment ▶ Faster access to skilled personnel 	<ul style="list-style-type: none"> ▶ Safe and controlled environment ▶ Deeper analysis in fixed time (more options) ▶ Portrays the impact of uncertainty in key events (sensitivity analysis) ▶ Easier access to expert advice embedded in software ▶ Identification of planning oversight/flaws ▶ Earlier identification and containment limiting escalation of problem 	<ul style="list-style-type: none"> ▶ Reduced collateral damage ▶ Fewer casualties (friend, neutral, foe) ▶ Reduced pollutant levels (reduced health risk) 	<ul style="list-style-type: none"> ▶ Minimised environmental damage ▶ Reduced risk to emergency response personnel ▶ Ensures the right number of items are acquired

Limitations and Risks

For simulations to be effective, they must have the right level of detail and fidelity for the chosen application. For a simulation to be effectively employed, the user must understand the implications of the simulation's limitations. Therefore questions such as, 'do we understand enough about the future operations and scenarios to construct a meaningful model' and 'do we have the data to make it work?' This can point to limitations in using simulation. Still, the opposite is also true, do we understand enough about the future to make a decision without the rigour of simulation? This type of questioning may drive the search for additional information before making any decision. The increased rigour that is required to make simulation useful may itself present an obstacle to its acceptance as an approach.

There is often the fear that important decisions are being based on inaccurate simulations, where either relationships between events and actors may not be fully addressed, or where small data errors can grossly influence the outcomes. 'Proving' the accuracy of a simulation to provide insight into an unknown future is, of course, very difficult. The outputs of simulation-supported scenario based planning should not be relied upon as being an accurate prediction of the future. This type of simulation support is more focussed on helping decision-makers imagine many potential futures, and helping decision-makers experience the cause and effect that comes from taking alternative options. Simulation support to planning, operations and rehearsals is more about generating the 'aha' experience from decision-makers, so that they make decisions different to those they might otherwise have made.

Simulations for planning and operations often do not need to represent the real world as accurately as training simulations, at least in the visual sense. They are often at a higher level of abstraction. However, limitations in the ability to represent difficult-to-quantify phenomenon, such as cohesion, morale and fear, may affect some of these simulations. For example an army simulation used for experimentation may produce battle outcomes that differ from the real world due to the lack of consideration of these phenomena. Simulations that use entropy based warfare and intelligent agents go some way to address this limitation.

As with training simulations, even simulations that have undergone VV&A are not necessarily 'right'. Such simulations have undergone sufficient testing to ensure that there is confidence that the simulation is correct for the application for which it was built. Completed VV&A simulations, like all other simulations, cannot be assumed to be suitable to other applications. For example, a simulation used to experiment with tactics cannot be assumed to be suitable for force assessment of the whole force. It would likely take an inordinate amount of time to enter all the necessary data and run the simulation when a less detailed simulation would be sufficient.

It is also important to note that the predictive power of a simulation (or the confidence that can be placed in the results) is strongly dependent on how well the underlying models have been validated. Simulations developed without information from experienced military operators are likely to be severely limited in their predictive capability. In addition, sometimes it is necessary for users to have experience in the simulation and an

understanding of its workings to ensure that reliable results are obtained. Many planning and operations simulations are sensitive to the type of data entered and how it is entered, following the 'garbage in, garbage out' principle.

Heavy use of simulations for conduct of operations, crisis management and planning, and mission rehearsal may lead to an over confidence in the simulation results which may replace intuitive insights to the detriment of the planning process or operational outcome. Data availability may be even more of a limitation for planning and operations simulations as data may be required from all parts of the capability life cycle including areas currently not well recorded. Again, this data may be difficult to update with the real world changing faster than the simulation, or its data, can be updated. Obsolescence of the language or protocols used in a simulation towards the end of its life can also be a limitation for its modification, upgrade and maintenance.

Bandwidth can be a limitation for distributed simulations, however, only simulations used for experimentation are likely to be distributed and this limitation is being overcome through more efficient use of the available bandwidth. Distributed simulations may also potentially compromise security if not connected through secure means.

Many simulations sourced from overseas for this Application Domain are not immediately applicable for Australian use. US simulations, for example, may be based on different geographical areas than Australia's particular interests and may not cater for the extremes of temperature and terrain the ADF encounters. They may also be based on a much larger entity size than Australia uses due to their much larger forces. Of course these simulations may be modified to address these limitations at a cost. For simulations used to support the conduct of operations, the robustness or ruggedness of the simulation and the support required may be limitations when considering its deployment to an Operating Area.

As with training simulations, individual planning and operations simulations may have their own limitations such as numbers and types of entities and their representations, visualisation limitations, underlying assumptions and levels of aggregation that must be identified and considered before their use. Due to these limitations, simulation should never replace decision making: it should provide support through insights and evidence for decisions, not a single right answer.

These limitations are also listed at Annex F where they are mapped against the Simulation Application Areas.

Concept and Capability Development

Benefits of Simulation

Enhanced Capability

As for planning, operations and rehearsal domain, the Concept and Capability Development Domain also has similar benefits to the training domain. This is because field trials or exercises may be held to evaluate tender options in the Acquisition Simulation Application Area.

Many benefits deriving from the use of simulation to support decision making in planning, operations and rehearsal are equally valid in this domain. A greater number of

designs or systems, with an increased number of variables and alternatives, can be evaluated or analysed with simulation resulting in improved evidence for decisions and faster decision making. Increasingly complex concepts and systems can be analysed and more innovative concepts and designs can be tested with the use of simulation and optimal solutions can be more readily identified. Extreme conditions such as heat, cold, wind and vibration can be tested with greater ease and safety.

The use of simulation in experimentation can increase the number of concepts that can be tested and result in a decreased lag in doctrine and tactics development. For the same reason, force assessment simulations can improve the force mix for the ADF and make more personnel aware of ADF capabilities.

Simulation provides improved visualisation and demonstration capabilities that facilitate the explanation of designs and concepts to stakeholders and create better solution and option awareness in decision makers and stakeholders. Designers and promoters gain a better understanding of the consequences of change(s) through simulation and requirements can be assessed and incorporated earlier in the design phase to produce products with enhanced capability. The ability to visualise products with users early in their design phase increases their input and creates greater ownership of the product.

Simulation enables the optimisation of system performance versus total ownership cost by early and continuing collaborative exploration of the largest possible trade space across all of a system's life cycle activities, within and among multiple government and commercial organisations, across professions and disciplines, and up through system of systems mission area perspectives. Resources can therefore be better prioritised and coordinated through simulation support to life cycle management, especially through logistics simulations and improved inventory tracking that also increase the sustainability of the force.

Using simulation during acquisition can determine skill requirements before purchasing equipment; and so ensuring sufficient expertise exists or can be grown before committing to equipment. It can also improve interoperability with the existing force by simulating its interaction and ensuring necessary requirements are included in tenders. Simulation can provide better integration across the acquisition life cycle by utilising the knowledge gained in several of the phases.

Improved corporate competitiveness can also be a benefit of simulation use in research and development and acquisition due to the advances in effectiveness and efficiency gained. These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ Increased number of plans, concepts, designs, systems can be evaluated ▶ Increased number of variables and alternatives ▶ Faster decision making ▶ Increased sustainability 	<ul style="list-style-type: none"> ▶ Better solution/option awareness ▶ Improved evidence for decisions ▶ Concepts of increased complexity can be analysed ▶ Improved visualization/demonstration of capabilities ▶ Better coordination and prioritisation of resources ▶ More innovative concepts, designs, systems can be tested ▶ User requirements can be assessed and incorporated in the design phase ▶ Extreme conditions can be tested ▶ Optimal solutions can be identified 	<ul style="list-style-type: none"> ▶ Increased data capture and play back ▶ Historic comparisons possible (benchmarking) ▶ Greater operational availability of prime equipment through reduced demands 	<ul style="list-style-type: none"> ▶ Designers and promoters gain a better understanding of the consequences of changes ▶ Improves corporate competitiveness ▶ Input and testing by users creates greater ownership of the product ▶ Advance determination of skill requirements ▶ Improved interoperability with existing force ▶ Provide better integration across acquisition life cycle ▶ Better inventory tracking

Saved Resources

Once again, there are benefits for using simulation instead of conducting field tests and exercises discussed under Training. These are also applicable in this domain but that are not repeated in this section.

Using simulation for concept and capability development has the potential to save many resources. It can result in more efficient execution through optimised cost/capability trade-offs, reduced component manufacturing time, reduced test iterations, reduced access time to inventory (because equipment is located properly), reduced inventory requirements, less testing time required (due to faster and fewer tests) and reduced time to develop fewer prototypes. These efficiencies mean that opportunity costs may be realised through using personnel in other productive pursuits. Simulation can also lead to better prioritisation of funding by identifying high pay off areas.

Force assessment using simulation can be more focussed than without as a high level simulation can be used to rapidly identify areas where further assessment is required. The increased ability to assess the force afforded by simulation also flows on to better prioritisation of funding for new equipment and upgrades through the increased identification of capability gaps.

The use of simulation for research and development and acquisition, can lead to fewer wasted resources if used to test prototypes before they are built and used to identify efficient ways to cut out materials and assemble them. Using simulation for testing results in fewer partial and full-scale constructions and tests because more tests can be completed virtually. Necessary design changes can be identified earlier with the help of simulation,

which reduces the cost of implementing them, and infeasible or poor design solutions are more readily identified earlier in their life cycle, enabling earlier termination and saved resources. Simulation use can result in better designs for maintainability, and hence lower maintenance costs and reduced component specification for manufacturing errors. Simulation use can increase spin-offs to commercial industries and increase patent value.

Simulation support to life cycle management can result in more efficient supply processes and product orders. This reduces supply delays and errors, moving towards 'just in time' supply. This can reduce or eliminate facilities space requirements. Better coordination throughout the supply chain and improved maintenance scheduling and plans can also be obtained through simulation. Simulating the match of training to training needs can provide an optimal training system for a capability. Finally, simulation can be used to identify the optimal disposal option for equipment to ensure efficient use of resources and to minimise damage and danger to the environment.

These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ More efficient execution (e.g. faster completion time) ▶ Reduced access time to inventory ▶ Eliminate or reduce facilities space required ▶ Minimised resource wastage ▶ Fewer partial and full-scale constructions and tests ▶ Fewer prototypes required ▶ Fewer supply delays and errors 	<ul style="list-style-type: none"> ▶ Better coordination throughout supply chain ▶ Better prioritisation of funding ▶ Avoid cost of design changes (fewer and quicker changes made earlier) ▶ Non-feasible or poor solutions are more readily identified earlier in their life cycle, enabling earlier termination decisions ▶ More efficient supply processes ▶ Improved maintenance scheduling ▶ Improved disposal of assets 	<ul style="list-style-type: none"> ▶ Component specification for manufacturing time reduced ▶ Component specification for manufacturing errors reduced 	<ul style="list-style-type: none"> ▶ Personnel can be used in other productive pursuits (opportunity costs) ▶ Lower maintenance costs through better design ▶ Increased spin-offs to commercial industries ▶ Increased patent value ▶ Better matching of training to training needs to give optimal training system ▶ Simplification of product orders ▶ Simplification of maintenance plans

Reduced Risk

Simulations used for Concept and Capability Development reduce risk in many ways. Some of these are similar to those benefits gained from simulation replacing field tests and exercises as discussed in training. They are not repeated here.

Simulation use in this domain can lead to reduced equipment damage due to component failure because of the ability to conduct failure testing prior to development and other rigorous testing prior to its in-service date. Simulation can also be used to identify safety

problems and performance limits, and resolve them before human testing is required, reducing the risk of injuries and accidents.

Fewer manufacturing iterations obtained through simulation use means that each iteration is more advanced than it would be without simulation support, reducing the risk of malfunction. Simulation provides greater confidence in analysis and testing results due to the deeper rigour, traceability of results and increased identification and understanding of system limitations and constraints.

Using simulation for force assessment indirectly ensures that the right number and type of items are acquired through better identifying capability gaps. This reduces the risk that the ADF cannot meet capability levels.

Although not a major issue for Defence, simulation can be used for tests where animals once were used, decreasing the risk of politically unacceptable practices. Simulation can also be used to identify damaging products such as carcinogens in the design phase or when disposing of equipment and suggesting suitable substitutions.

Using simulation for acquisition ensures that the right number and types of items are required; reducing the risk of capability gaps once equipment is introduced into service. These benefits are shown in the following table.

Direct Quantifiable	Direct Non-Quantifiable	Indirect Quantifiable	Indirect Non-Quantifiable
<ul style="list-style-type: none"> ▶ Reduced equipment damage (due to component failure) ▶ Failure testing possible prior to development ▶ Fewer manufacturing iterations ▶ Fewer animals used in testing 	<ul style="list-style-type: none"> ▶ Increased identification and understanding of system/solution limitations and constraints ▶ Increased confidence in results ▶ Ensures the right number of items are acquired ▶ More safety problems resolved prior to human test 	<ul style="list-style-type: none"> ▶ Reduced pollutant levels (reduced health risk) ▶ Reduce personal injuries (due to equipment failure) 	<ul style="list-style-type: none"> ▶ Minimised environmental damage ▶ Reduced risk to emergency response personnel ▶ Identification and substitution of damaging products (e.g. carcinogens)

Limitations and Risks

Concept and Capability Development requires scenarios and thinking to take account of the substantial complexity, dynamics and uncertainties inherent in crisis and conflict situations, many years into the future. Similar to planning and operations, questions such as ‘do we understand enough about the future capability requirements and scenarios to construct a meaningful model’ and ‘do we have the data to make it work?’ This can point to limitations in using simulation. Yet, the opposite remains true, do we understand enough about the future to make a decision without the rigour of simulation? This type of questioning may drive the search for additional information before making any decision.

Simulations used for Concept and Capability Development often need to closely represent the real world, however it is at a more detailed level and narrower scope than training and rehearsal simulations and is not so affected by limitations in representing hard to quantify entities and phenomenon, except for simulations used to evaluate equipment options during the acquisition process. These simulations have similar limitations to planning and operations simulations.

Once again, VV&A simulations are not necessarily 'right' but have undergone sufficient testing to ensure that there is sufficient confidence that the simulation is not incorrect for the application for which it was built. VV&A simulations, like all other simulations, cannot be assumed to be suitable to other applications. For example, a simulation used to test a component of an aircraft cannot be assumed to be suitable for testing a similar component in a land vehicle. The predictive power of a simulation is strongly dependent on how well its underlying models have been validated. For example, if there is an undetected error or inaccuracy in the simulation, the simulation may fail to detect design flaws. Like simulations for planning and operations, experienced users with an understanding of how the simulation works may be required to have confidence in the results as these simulations also may suffer from the 'garbage in, garbage out' principle.

Heavy use of simulation in research and development and acquisition may lead to an over confidence in its results. For example, the DARKSTAR UAV crash in the US was directly traceable to deficiencies in the system modelling and simulation performed as part of the data analysis of first flight⁷.

Some life cycle management simulations, such as logistics simulations, need to be built by, or with the support of, those who understand military operations and their context to ensure that they include appropriate algorithms. For example, supply chain models tailored to a commercial 'just in time' approach may not adequately cater for military contingencies or war stocks.

Data availability may be a limitation for capability management simulations as data may be required from all parts of the capability life cycle including areas currently not well recorded. Again, this data may be difficult to update with the real world changing faster than the simulation, or its data, can be updated. Obsolescence of the language or protocols used in a simulation towards the end of its life can also be a limitation for its modification, upgrade and maintenance.

Individual simulations used for concept and capability development may have their own limitations such as number of iterations, size of supply chain that can be modelled, number and types of entities that can be modelled, number and types of conditions that can be modelled. For these reasons, simulation cannot replace decision making in capability management completely, it should support it through providing insights and evidence for decisions, not the single right answer.

These limitations are also listed at Annex F where they are mapped against the Simulation Application Areas.

⁷ Powerpoint file: Value of Modeling and simulation (economics), USN

Annex F - Benefits and Limitations Mapped to Simulation Application Areas

dq direct quantifiable dn direct non-quantifiable
iq indirect quantifiable in indirect non-quantifiable

Table F-1. Consolidated benefits from simulation - enhanced capability

Consolidated Benefits - Enhanced Capability	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Users can 'test' equipment in the design phase							dn	dn		
User requirements can be assessed and incorporated in the design phase							dn	dn		
Reduction in observers required leading to more natural behaviours	dn									
Reduced stress	dn	dn	dn	dn						
Provides access to scenarios and experiences more readily	dn	dn	dn	dn	dn	dn				immersion easier
Provide better integration across acquisition life cycle								in	in	
Permits rapid change in training and rehearsal conditions and circumstances	dn			dn						
Overcomes training equipment shortages	dn									
Optimal solutions can be identified							dn	dn	dn	
More personnel aware of force capabilities					dq	dq				
More innovative concepts, designs, systems can be tested					dn	dn	dn	dn	dn	
More extensive conditions training (e.g. all-weather, different operational scenarios, dangerous terrain)	dn			dn						nbc

Consolidated Benefits - Enhanced Capability	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
More efficient use of operational assets and resources	in	dn	dn	in	in	in			dn	eg releasing them from training, more efficient deployment and use
More COAs developed and analysed in time available		dq	dq							
Increases operational availability of prime equipment through reduced demand	iq			iq		iq	iq	iq	iq	less wear and tear on real equipment
Integration with other systems/components can be achieved							dn	dn		
Input and testing enables stakeholders to visualize and understand the impacts and effects, creating more buy-in and less resistance							in	in		
Input and testing by users creates greater ownership of the product							in	in		
Increased throughput of candidates	dq			dq						
Increased sustainability									dq	eg LOT
Increased rigour in analysis		dn	dn		dn	dn	dn	dn	dn	
Increased reproducibility of conditions (repeatability)	dn			dn	dn	dn	dn	dn	dn	
Increased readiness	dn	in	in	dn					dn	eg more equipment on line due to optimised maint and mod sched
Increased rate of mission success	iq	dq	dq	dq						
Increased numbers of people can evaluate the systems								dn		
Increased number of variables and alternatives		dq	dq		dq	dq	dq	dq	dq	deeper analysis possible
Increased number of repetitions	dn			dn						
Increased number of plans, concepts, designs, systems can be evaluated		dq	dq		dq	dq	dq	dq	dq	wider analysis possible

Consolidated Benefits - Enhanced Capability	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Increased management continuity								in		Simulation can be used to rapidly brief incoming personnel on what is being acquired and where the process is at. This leads to greater continuity during posting cycles
Increased enthusiasm	dn			dn						
Increased data capture and play back	iq	iq	iq	iq	iq	iq	iq	iq	iq	
Increased competition between participants	in									
Increased competency of training staff	in									
Increased awareness of issues (situation, problem)	dn	dn	dn	dn	dn	dn				
Increased access to training and rehearsal	dn			dn						may not have to travel far eg firing ranges can't be in suburbia
Increased ability to undertake collaborative training or rehearsal with coalition partners prior to deployment	dn			dn						There is a growing view that ADF elements in future will be precluded from exercises such as RIMPAC unless they 'pass' a pre-exercise simulation-based work up
Increased ability to share knowledge	dn	dn	dn	dn	dn	dn	dn	dn	dn	
Increased ability to focus on specific components of training or mission	dn			dn						
Improves corporate competitiveness							in	in		
Improved/increased confidence levels (of pers)	dn	dn	dn	dn						
Improved visualization/demonstration of capabilities		dn	dn		dn	dn	dn	dn	dn	
Improved training and rehearsal techniques can be developed & employed (e.g. rapid-test-feedback-test cycles)	in			in						
Improved responsiveness to changes and requests		dn	dn		dn	dn	dn	dn	dn	
Improved planning and management skills		dn	dn							
Improved performance levels	dq			dq						
Improved operational concepts can be developed		dn	dn		dn	dn		dn		
Improved OH&S compliance and procedures	in					in	in	in	in	

Consolidated Benefits - Enhanced Capability	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Improved morale	in			in					in	
Improved manpower management (right people at right time)		in	in					in	in	
Improved interoperability with existing force								in		
Improved force mix					dn	dn				
Improved evidence for decisions		dn	dn		dn	dn	dn	dn	dn	
Improved effectiveness and/or productivity of staff							dn	dn	dn	
Improved ability to identify capability gaps					dn	dn				
Historic comparisons possible (benchmarking)	iq			iq	iq	iq	iq	iq	iq	
Higher skill level attained	dq			dq						
Greater outcome awareness (e.g. results can be scored, can see impact on target, etc)	dn		dn	dn						
Greater benefit from training on real systems through better preparation using simulation	dn									greater confidence, better use of time
Faster decision making		dq	dq					dq	dq	
Extreme conditions can be tested							dn	dn	dn	
Enables the clear and supportable representation of the dynamics and interdependencies of battlespace phenomena	dn	dn	dn	dn	dn	dn				
Emergency response training/scenarios can be conducted	dn	dn	dn	dn	dn	dn				that are too dangerous in the real world
Detailed performance measures allow comparisons across design efforts							in	in		
Designers and promoters gain a better understanding of the consequences of changes							in	in		
Decreased lag in doctrine and tactics development						dq				
Concepts of increased complexity can be analysed		dn	dn		dn	dn	dn	dn	dn	

Consolidated Benefits - Enhanced Capability	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Clear understanding of individual role		dn	dn	dn						
Can perform collaborative training over greater distances	dn									
Better understanding of the impacts of decisions	dn	dn	dn	dn	dn	dn	dn	dn	dn	
Better understanding of potential strategic and tactical methods						dn				
Better teamwork		dn	dn	dn						
Better solution/option awareness		dn	dn		dn	dn	dn	dn	dn	
Better quality plans (greater detail, more rigorous)		dn	dn	dn					dn	
Better location and spatial awareness			dn	dn						
Better inventory tracking									in	
Better feedback (consistent, more immediate, better targeted, less subjective)	dn			dn						assess LOC
Better coordination with non-military officials		in	in							
Better coordination and prioritisation of resources		dn	dn						dn	including staff, leading to greater staff responsiveness
Allows scenario and accident or incident reconstructions		dn	dn							
Allows mission review		dn	dn							
Allows choreography of events		dn	dn		dn	dn				
Advance determination of skill requirements								in		
Ability to use simulations while real equipment not available (eg on ops, poor weather, maintenance)	dn			dn		dn	dn	dn	dn	prep and assessment of rotation personnel prior to deployment to area of ops, all weather, day/night
Ability to undertake mission training or rehearsal in the absence of other mission participants	dn			dn						

Table F-2. Consolidated benefits from simulation – saved resources

Consolidated Benefits - Saved Resources	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Ability to reduce the number of product types								dq	dq	
Adjustments/alterations can be specified prior to purchase							dn	dn		
Avoid cost of design changes (fewer and quicker changes made earlier)							dn	dn		
Better coordination throughout supply chain		dn							dn	
Better matching of training to training needs to give optimal training system								in		use of sim in aqu phase to identify training needs early - eliminates unnecessary training
Better prioritisation of funding					dn	in	dn	dn	dn	
Component specification for manufacturing errors reduced							iq			
Component specification for manufacturing time reduced							iq			
Consolidate purchasing for price reductions									dq	
Cost avoidance from not building replica environments for mission rehearsal				dq						
Efficient equipment allocation (reduce equipment by having right type and amount first time)		dn							dn	
Efficient personnel allocation (right # of staff at right location at right time)		dn							dn	not paying for pers not required. staff scheduling
Eliminate or reduce facilities space required							dq	dq	dq	
Fewer field tests and live exercise required	dq					dq		dq		
Fewer partial and full-scale constructions							dq	dq		
Fewer partial and full-scale tests required							dq	dq		Eliminates unnecessary ones
Fewer prototypes required							dq	dq		
Fewer supply delays and errors									dq	just in time
Improved disposal of assets									dn	incl when, how, where, min env impact to make most \$
Improved maintenance scheduling									dn	

Consolidated Benefits - Saved Resources	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Increased patent value							in			
Increased spin-offs to commercial industries							in			
Increased time available for testing and maintenance works	iq					iq		iq	dq	
Less testing equipment used							dq	dq		
Less testing time required (faster and fewer tests)							dq	dq		
Less time spent on procurement for resource replacement	iq		iq	iq		iq		iq		
Less training equipment required	dq									
Lower maintenance costs through better design							in	in		
Minimised resource wastage							dq	dq	dq	
More efficient execution (e.g. faster completion time)	dq	dq	dq	dq	dq	dq	dq	dq	dq	Reduced design time (concept to approval), Reduced acquisition cycle time (shorter time to acceptance), Faster design to implement time (fewer physical iterations reqd), reduced tender evaluation time
More efficient supply processes									dn	time and resources
More focused reviews/assessments					dn				dn	
Optimal (from a cost perspective) components selected and tested							dn			
Optimal personnel requirements determined		dn			dn					
Personnel can be used in other productive pursuits (opportunity costs)							in	in	in	
Product substitution (higher to lower cost products)									dq	
Productivity gain due to injury time avoidance	in	in	in	in		in	in	in		
Reduced access time to inventory (equipment is located properly)		dq							dq	
Reduced cancelled training, exercise or test days (due to poor weather)	dn					dn		dn		
Reduced consumables required (eg ammo)	dq					dq	dq	dq		

Consolidated Benefits - Saved Resources	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Reduced equipment damage or loss	dq		dq	dq		dq		dq		Lower attrition cost through better mission rehearsal
Reduced equipment maintenance costs	dq					dq		dq		
Reduced equipment usage (extended LOT)	dq					dq		dq		
Reduced field/exercise allowances	dq					dq		dq		
Reduced inventory required	iq									
Reduced personnel support costs (e.g. rations)	dq					dq		dq		
Reduced staff requirements	dq					dq	dq	dq	dq	Design teams can be smaller, Reduced man hours required for testing
Reduced test iterations								dq		
Reduced time required by other Defence personnel to support exercises	iq					iq		iq		
Reduced time to develop prototypes							dq			
Reduced training set up time	dq									
Reduced transportation costs to/from exercises	iq					iq		iq		
Reduced/optimised inventory requirements		dq							dq	
Simplification of maintenance plans									in	
Simplification of product orders									in	
Time saved through conducting mission rehearsal while on route to operations				dq						eg shipboard stimulators
Infeasible or poor solutions are more readily identified earlier in their life cycle, enabling earlier termination decisions							dn			
Minimised schedule delays							dq	dq		

Table F-3. Consolidated benefits from simulation – reduced risk

Consolidated Benefits - Reduced Risk	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Ability to assess emergency procedures						dn				
Ability to conduct dangerous/emergency exercises	dn			dn		dn				
Ability to conduct complete long duration tests							dn	dn	dn	
Complete environmental testing can be done							dn	dn		
Complete life cycle testing can be conducted							dn	dn		
Deeper analysis in fixed time (more options)		dn	dn		dn	dn	dn	dn	dn	More thorough trade-off analysis in acq, Larger number of checks possible in R&D, greater width and depth
Earlier fault identification							dn	dn		
Earlier identification and containment limiting escalation of problem		dn	dn							
Easier access to expert advice embedded in software		dn	dn		dn					
Elimination of unsafe tests							dn	dn		
Ensures the right number of items are acquired					in			dn		
Failure testing possible prior to development							dq	dq		
Faster access to needed equipment		dq			dq					
Faster access to skilled personnel		dq								
Fewer animals used in testing							dq			
Fewer casualties (friend, neutral, foe)	iq	iq	dq	iq	iq	iq				
Fewer casualties (reduced training /testing accident rates)	dq					dq		dq		
Fewer manufacturing iterations							dq			
Fewer planning errors		dn	dn							
Force assessment confirmation (optimal personnel and asset mix determined)				dn						

Consolidated Benefits - Reduced Risk	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Identification and substitution of damaging products (e.g. carcinogens)									in	
Identification of lower risk options		dn			dn					
Identification of planning oversight/flaws			dn	dn						
Increased confidence in results		dn	dn	dn	dn	dn	dn	dn	dn	
Increased evaluation of safety performance							dn	dn	dn	
Increased identification and understanding of system/solution limitations and constraints		dn	dn		dn			dn	dn	
Increased risk analysis capability		dn	dn		dn	dn				
Increased tender evaluation capability reducing performance risk								dn		
Larger number and greater range of tests, conditions or scenarios can be conducted	dq	dq	dq	dq	dq	dq	dq	dq	dq	
Limitations testing safer (e.g. operator response times, fatigue, drugs, etc)	dn									
Minimisation of technical risk through reduced error rates							dq			
Minimised environmental damage	in	in				in	in	in	in	
More safety problems resolved prior to human test							dn	dn		
Portrays the impact of uncertainty in key events (sensitivity analysis)		dn	dn		dn	dn	dn	dn	dn	
Reduce personal injuries (due to equipment failure)									iq	
Reduced collateral damage	iq	iq	iq	iq	iq	iq				pers, infrastructure, equipment
Reduced contract risk								dn		
Reduced equipment damage (due to component failure)						dq	dq	dq	dq	
Reduced equipment damage and loss (through accident and ware)	dq		dq	dq		dq		dq		
Reduced evaluation and decision time		dq	dq		dq					
Reduced exposure to live ammunition	dq							dq		

Consolidated Benefits - Reduced Risk	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Dev.	Acquisition	Life Cycle Management	Description
Reduced pollutant levels (reduced health risk)	iq					iq	iq		iq	
Reduced risk to emergency response personnel	in					in	in	in		
Safe and controlled environment	dn			dn		dn		dn		

Table F-4. Consolidated limitations from simulation

Limitation	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Devpmt	Acquisition	Life Cycle Management	Description
Simulation is a simplification of the real world and inherently approximate	y	y	y	y	y	y	y	y	y	it is not possible for a simulation to be absolutely correct. It is only correct enough to be useful.
Simulation is effective only if both the model and the data used to drive the model accurately reflect the real world to the level required by the application	y	y	y	y	y	y	y	y	y	If the real world is not represented, the simulation will not react the same way the real world and this would result in inaccurate results.
Must have right level of fidelity or detail for job	y	y	y	y	y	y	y	y	y	It would be a waste of resources to use accurate virtual world representations for a force assessment simulation, however this would be used for a training simulation
Hard to quantify issues are difficult to model, eg morale, individuals, fear, cohesion	y	y	y	y	y	y				These issues difficult to model and the more they effect the real world example being simulated, the less accurate the simulation results

Limitation	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Devpmt	Acquisition	Life Cycle Management	Description
VV&A'd simulations are not necessarily 'right'.	y	y	y	y	y	y	y	y	y	Just means sufficient tests have been completed to ensure that there is sufficient confidence that the simulation is not incorrect
VV&A'd simulations only suitable for use in area in which they were assessed	y	y	y	y	y	y	y	y	y	high level simulations eg force assessment can not replace a detailed combat assessment tool. This is also applicable to simulations that are not fully VV&A.
Must be built by, or with the support of, those who understand military context and operations	y	y	y	y	y	y			y	just as important as programming skills to ensure the simulation behaves in a way applicable to Defence
Gathering data can be difficult, especially when over whole capability life cycle	y	y	y	y	y	y	y	y	y	Not all data that may be required for a simulation is located in one place, some data is not stored at all.
Real world changing faster than sim can	y	y	y	y	y	y	y	y	y	With technology changes occurring rapidly, it is possible that the simulation becomes out of date fast and there are no resources to upgrade it
Obsolescence of language or protocols over LOT	y	y	y	y	y	y	y	y	y	impacts upgrades, maintenance and fixes as the expertise required may not be available
Individual simulations may have their own limitations such as numbers and types of representations, visualisation limitations	y	y	y	y	y	y	y	y	y	These will vary from simulation to simulation
Limited fidelity can lead to inaccurate or misleading training	y									Visual feedback to trainee may not be correct
Simulator sickness can occur if the time delay between issuing a command and the response of the simulation is too long	y			y						Dizziness, nausea etc. Eg you turn the wheel of a car in a simulation and there is a perceptible delay before the car turns in response
Peripheral cues may not be present in equipment simulations	y			y						most are 140 deg, can see to 220 deg and also side and roof windows of helos may be used during operations but aren't included in all simulations
Not all physical effects of equipment can be simulated	y			y						eg. Prolonged acceleration only possible in centrifuge

Limitation	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Devpmt	Acquisition	Life Cycle Management	Description
Different decisions may be made in training than in operations due to the safer environment	y			y						Eg less stress and urgency may lead to better decision making and fewer mistakes than would be encountered in real world
Keeping sim up to date	y			y						eg don't always update when update aircraft
May cost more than actual equipment to acquire, support and operate	y									Particularly the case for inexpensive equipment. This limitation needs to be offset against the limitations of the current training system.
Bandwidth	y			y		y				Overcome through more efficient use of existing bandwidth
Potential compromise to security for distributed simulations	y			y		y				linking simulations over distance has a chance of transmitted information being intercepted
May instil habits that are incorrect for real equipment	y			y						eg if the simulation is not accurate or there is a lack of consequences. May not check blind spot because it is not simulated.
Heavy reliance on simulation can cause over confidence	y	y	y	y				y		eg DARKSTAR UAV crash - directly traceable to deficiencies in the system modelling and simulation performed as part of the data analysis of first flight
May foster complacency	y			y						i.e. get used to lack of real consequences.
May desensitise operator's treatment of explosives	y			y						fear of explosives removed through extensive practice on simulation where there is no danger
Assumption that simulation covers all possibilities	y			y						Although more options or variations can be explored with simulation, users can forget that this does not represent all realities and assume that if it didn't occur in the simulation it will not occur
Reduced confidence in actual equipment due to sim use	y			y						If simulation is used too much, personnel may forget the intricacies of the real equipment and lose confidence in using it
Cannot replace training in real equipment totally	y									for all the reasons stated in the limitations here

Limitation	Training	Crisis Mgmt & Planning	Conduct of Operations	Mission Rehearsal	Force Assessment	Experimentation	Research & Devpmt	Acquisition	Life Cycle Management	Description
Predictive power strongly dependent on how well models validated		y	y		y	y	y	y	y	confidence in the simulation's correctness effects its ability to predict outcomes accurately
Experience in operating a simulation and understanding of its workings required for confidence in some simulations		y	y		y	y	y	y		Some simulations sensitive to where and how data is entered and variables are set
Garbage in garbage out		y	y		y	y	y	y	y	If poor data and scenarios are used, poor results will be obtained
Keeping data up to date		y	y		y	y	y	y	y	Data may change month to month or year to year, especially things such as use rates or even ORBAT details
US sims not always usable for AS analysis					y	y				geographic, scale, conditions
Robustness for deployment may be an issue for decision spt			y							Can not deploy simulations that are on non-ruggedised computers or that require many support personnel to run them
Cannot replace decision making completely, only supports it		y	y		y	y	y	y	y	for all of the reasons included in the limitations stated here

Annex G - Useful References

The main reference guide for cost estimation is the Defence Cost and Estimation Methodology Handbook. Other useful references are provided in the following table:

Reference Title	Author	Main Topic(s)
AS/NZS 4536:1999 Life Cycle Costing – an application guide		Section 4.2
Defence Capability Development Manual		Section 7 – Cost Estimation

Useful Contacts

The points of contact for Costing matters are as follows:

Position Title	Organisation	Contact
Director Operations - Cost Estimation	Capability Systems, CDE	R1-1-B004 Tel: 02 6265 5146
Investment Analysis	Capability Investment and Resources Division	Tel: 03 925 64846
Cost Analysis Branch	Capability Investment and Resources Division	
Director Supportability	Standardisation Branch, DMO	
Support Office Foreign Military Sales	Industry Division DMO	R2-6-C126, Tel:02 6265 1443

Annex H - Representative Simulation Cost Breakdown Structure

1	Simulation acquisition cost elements
1.1	Simulation Unit Cost (including licences)
1.2	Simulation Options Unit Cost
1.2.1	Option 1
1.2.2	Option 2
1.2.3	Option 3
1.2.4	Option 4
1.2.5	Option 5
1.3	Technical Data
1.3.1	Operator Manuals
1.3.2	Training Manuals
1.3.3	Intellectual Property
1.4	Training
1.4.1	Development of Operator Training Courses
1.4.2	Development of Operator Instructor Training Courses
1.4.3	Conduct of Initial Operator Instructor Training Courses
1.5	Personnel
1.5.1	Field Service Representatives
1.6	Facilities
1.6.1	Headquarters
1.6.2	Operations/Crew Facilities
1.6.3	Air Conditioning
1.6.4	Maintenance Workshop/s
1.6.5	Supply Storage/Warehousing
1.6.6	Transport/Vehicles
1.6.7	Civil Works
1.6.8	Misc Support Infrastructure
1.6.9	Simulator Facility
1.6.10	Facilities Project Management
1.6.11	Facilities Design
1.7	Development and Testing
1.7.1	Development Costs
1.7.1.1	Software Development
1.7.1.2	Hardware Development
1.7.1.3	Integration Development
1.7.1.4	Software Development Testing
1.7.1.5	Hardware Development Testing
1.7.1.6	Integration Development Testing
1.7.2	Acceptance Testing
1.7.3	Verification, Validation and Accreditation
1.7.4	Acceptance Testing Training
1.7.5	Testing of Logistics Products
1.8	Warranty
1.9	Project Management
1.9.1	Program Management
1.9.2	ILS Management

- 1.9.3 Quality Assurance Management
- 1.9.4 Configuration Management
- 1.9.5 Systems Engineering Management
- 1.9.5.1 Hardware Engineering Management
- 1.9.5.2 Software Engineering Management

2 Simulation In-Service Cost Elements (per annum)

- 2.1 Commonwealth In Service Support Costs
 - 2.1.1 Technical Data
 - 2.1.1.1 Annual Maintenance Cost
 - 2.1.2 Personnel
 - 2.1.3 Training and Training Devices
 - 2.1.3.1 Annual Cost for Operator Course/s Maintenance
 - 2.1.3.2 Annual Maintenance Cost for Operator Instructor Training Course
 - 2.1.3.3 Simulator/s-System Operations
 - 2.1.4 Packaging, Handling, Storage and Transportation
 - 2.1.4.1 Packaging
 - 2.1.4.2 Handling
 - 2.1.4.3 Storage
 - 2.1.4.4 Transportation
 - 2.1.5 Computer Support
 - 2.1.5.1 Annual cost for Computer Support
 - 2.1.5.2 Annual Software Maintenance Agreements
 - 2.1.6 Facilities
 - 2.1.6.1 Headquarters
 - 2.1.6.2 Operations/Crew Facilities
 - 2.1.6.3 Air Conditioning
 - 2.1.6.4 Maintenance Workshop/s
 - 2.1.6.5 Supply Storage/Warehousing
 - 2.1.6.6 Transport/Vehicles
 - 2.1.6.7 Civil Works
 - 2.1.6.8 Misc Support Infrastructure
 - 2.1.6.9 Simulator Facility
 - 2.1.7 Energy Consumption
 - 2.1.7.1 Commercial Electricity
- 2.2 Contractor Maintenance
 - 2.2.1 Support & Test Equipment
 - 2.2.2 Simulator/s-System Operations
 - 2.2.3 Simulator/s-System Maintenance
 - 2.2.4 Simulator/s – Consumables
 - 2.2.5 Contract Management Fees
 - 2.2.6 System Engineering Support
 - 2.2.7 Systems Program Office
 - 2.2.8 Packaging, Handling, Storage and Transportation
 - 2.2.9 Technical Data
 - 2.2.10 Repair Parts
 - 2.2.11 Verification, Validation and Accreditation of changes/updates
- 2.3 Annual Licences

3 Simulation System Breakdown Structure

- 3.1 Simulator

3.1.1	Visual Display System
3.1.1.1	Visual Display
3.1.1.2	Image Generator
3.1.2	Motion System
3.1.3	Library System
3.1.4	Sound System
3.1.5	Safety System
3.1.6	Instructor Work Station on Simulator
3.1.7	Instructor Work Station off Simulator
3.1.8	Scenario Generator
3.2	Data
3.2.1	Terrain Modelling
3.2.2	Library Development
3.2.3	System Modelling
3.2.4	Scenario/s Development
3.3	Processing
3.3.1	Central Processor Unit
3.3.2	Interfaces
3.3.3	Other
3.4	Communications
3.4.1	Transmitter
3.4.2	Receiver
3.4.3	Antenna
3.4.4	Terminal
3.4.5	Radio
3.4.6	Modems
3.4.7	Comsec
3.4.8	Communications link
3.4.9	Cable Fibre/Wire
3.4.10	Other
3.5	Peripherals
3.5.1	Mission displays
3.5.2	Printers
3.5.3	Disk drive
3.5.4	Tape drive
3.5.5	Optical drive
3.5.6	Other
3.6	Environmental Support
3.6.1	Power supply
3.6.2	Cooling/heating
3.6.3	Security
3.6.4	Other
3.7	Simulator Application Software/Firmware
3.7.1	Software
3.7.2	Firmware
3.7.3	Built In Test Equipment (BITE)
3.7.4	Other

Annex I - Evaluation Form

Because this Guide will continue to be a 'living' document, ADSO welcomes your comments and will use the feedback to ensure that the Guide meets the needs of the audiences for which it is intended. Please take a moment to answer some or all of the five questions below. Including your name and address will be appreciated but is not necessary. Send your responses to:

ADSO
e-mail: adso@defence.gov.au

* * * * *

1. According to your understanding of simulation and the Capability Life Cycle, is any information presented in the Defence Simulation Investment Reference Guide incorrect or inaccurate? (You may want to attach a copy of the page marked with your suggested changes.)

<i>Page and line number</i>	<i>What is in error in this statement or discussion, in your estimation?</i>

2. In your opinion, should any discussions in the Guide be expanded and presented in greater detail? Is any statement or discussion unclear?

<i>Page and line number</i>	<i>What unanswered question(s) do you have after reading this material?</i> <i>For the work you do, what additional information do you need? Is this statement or discussion unclear?</i>

3. In your opinion, should any material in the Guide be eliminated or condensed?

<i>Page and line number</i>	<i>Why do you believe these statements or discussions should be omitted or shortened? (eg, 'too detailed for my needs,' 'redundant,' 'irrelevant for my needs,' 'too elementary.')</i>

4. Did you find any typos, misspellings, or other production errors in the Guide?

<i>Page and line number</i>	<i>Error</i>

5. Do you have any other suggestions for making the Guide a more effective and usable document?

Optional	
Name	_____
Address	_____ _____ _____
Phone	_____ Fax _____
email address	_____

Thank you for taking the time to share your opinions with ADSO.