Document:

Reference Architecture

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# Simulation Reference Architecture

References:

1. Defence Simulation Manual (SIMMAN, AL2), dated 11 Oct 13
2. Solution Reference Architecture (), dated 24 May 16
3. ,
4. Identity Reference Architecture (draft)
5. Authentication Reference Architecture (draft)

## Introduction

Defence uses simulation to be prepared to meet ‘The Strategic Defence Objectives’ including the training of its people, both military and non-military[[1]](#footnote-2). When Defence is not conducting operations, fundamentally they are utilising simulations for training purposes. Some Defence personnel use simulation as their primary business to help assess the performance of a variety of Defence functions and systems.

1. Essentially any activity, which is not performed ‘for real’, is simulation. Accordingly it is generally accepted that 80% of Defence’s activities, particularly with regard to Preparedness is Simulation and much of that effort is attributable to Training.
2. Reference A directs that simulation be ‘…coordinated at the enterprise level’ and that ‘…it is fit for purpose, is appropriately integrated with, and supported by, the underlying information and communications technology (ICT) environment, and to ensure the maximum utilisation of simulation products and services with minimal duplicated investment’.
3. As technology’s pervasiveness increases in Defence business, the ability to distinguish between simulation and the real use of systems and data increases in criticality. It is absolutely critical to ensure that simulation data does not result in a real world effect. Separately as identity and roles become more tightly controlled by ICT systems and processor so the cost of mocking them increases. It is therefore, imperative that the architecture ensures the separation of concerns between real and simulated data and that then need to mock certain inputs be articulated from the start.
4. This reference architecture introduces the concepts and models that support the SIMMAN policy through the application of guidance and constraints to be applied to simulation solutions. It introduces the following concepts:
5. Simulation actors,
6. Simulation forms,
7. Simulation uses,
8. Simulation phases, and
9. Simulation components,

### Definition

Simulation is the imitation of the operation of a real-world process or system over time[[2]](#footnote-3). The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviours of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

### Scope

This reference architecture applies to all of Defence.

### Audience

This reference architecture is applicable to staff supporting the capability definition process and to solution architects and solution design authorities.

## Discussion and Concepts

Simulation typically covers two concepts (from Reference A):

1. **Modelling.** A model is a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. Some models are representations of physical objects, such as an armoured vehicle, and may be designed to function like the real thing. Other models are representations of a conceptual process, such as human behaviour, and are used to help understand the system, entity, or process they represent. The fidelity required of a model depends on the purpose of the model, and cost and benefit need to be balanced to achieve the fidelity required.
2. **Simulation.** The execution of a model over time. For Defence purposes it can be said that simulation is an abstraction of a defined reality for a specified purpose. Simulations can run in real time, non-real time (including both at different speeds and stepped) or be event driven. Simulations may require a range of inputs that are mocked versions of the real ones.
3. Simulation supports a wide variety of Defence activities and involves a range of actors that are can be modelled or interact with/in the simulation.

### Simulation Actors

The discussion of simulation in SIMMAN introduces different types of Actors relating to the conduct of a simulation. Extrapolating and abstracting them, they are:

1. **Players.** Defence or Partner Parties that form part of the execution of a simulation.
2. **Observers.** Defence or Partner Parties function is to observe the activity to determine lessons learnt and provide feedback on the conduct.
3. **Controllers.** Defence or Partner Parties who act outside the context of the simulation to either guide its execution or inject ‘simulated’ behaviour and/or determine results and or adherence to rules regarding the execution of a simulation.
4. For the definition of the Parties see Reference B.
5. Depending on the simulation form, the actors may be real or simulated. A primary factor in determining the simulation form is nature of the player.

### Simulation Forms

Simulations consist of the players and environments; either can be real or simulated (modelled). Examining the simulated and real combinations of player and environment gives the matrix at Figure 1. The cells have been labelled with the terms often used to describe the forms of simulation.

| Environment►  Player▼ | Simulated | Real |
| --- | --- | --- |
| Simulated | Constructive | - |
| Real | Virtual | Live |

1. Figure 1: Simulation player vs environment types
2. The Simulation Form terms used in the cells in Figure 1 are taken from Reference A. In summary they are:
3. **Live.** A simulation involving real people operating real systems. Military training events using real equipment are live simulations.
4. **Virtual.** A simulation involving real people operating simulated systems. Virtual simulations inject a Human-in-the-Loop as a player into a central role in a simulated environment such as a flight simulator. Virtual simulations can exercise fine motor, decision or communications skills.
5. **Constructive.** A simulation involving simulated people operating simulated systems. A constructive simulation is a computer program and can be used to help analyse anything from battle damage assessment through to financial expenditure forecasts.
6. Another aspect to consider is the situation. Applying the situation to the Forms leads to the uses of simulation.

### Simulation Uses

Extending the Simulation Forms to include the situation provides a further decomposition that allows for a clearer classification of how simulation is used across Defence.

| Situation►  Form▼ | Simulated | Real |
| --- | --- | --- |
| Live | Exercises[[3]](#footnote-4) | **Operations** |
| Virtual | Training | Rehearsals |
| Constructive | Experimentation | Analysis |

1. Figure 2: Simulation Forms vs Situation
2. Of the six cells in Figure 2, only five are relevant to simulation as clearly Operations are not simulations. Rehearsals and Analysis directly support Operations; while Exercises, Training and Experimentation enable/inform them.

### Simulation Lifecycle

Like many other activities simulation activities involve a development lifecycle. The following phases have been identified:

1. Planning,
2. Setup,
3. Conduct,
4. Cleanup, and
5. Review.
6. Any activities and any consequences of running a simulation need to be isolated so that a simulated activity does not cause any side effects outside the simulation. Consequently the Conduct Phase must be appropriately isolatable from the real-world.
7. During the Review Phase the Conduct Phase is analysed. This could involve replaying sections of the simulation; therefore, potentially able to cause side effects outside the Review. Accordingly, the Reviews phase should also be isolated from the real-world.
8. Conversely, the Simulation Planning, Setup and Clean-up Phases may be undertaken in the real-world.
9. This leads to the Simulation Isolation Principle: ‘During the Conduct and Review Phases of a simulation, the simulation must cause real-world side effects.’

### Data Characterisation

Data pertaining to simulation needs to be clearly categorised to ensure that is managed, transmitted and interpreted correctly across the enterprise. This is important to ensure that simulations and operations don’t impact each other, and that simulation control/measurement data does not impact the results.

1. There are fundamentally two types of data:
2. **Operational Data.** Data that would be used by the business to conduct day-to-day operations whether in a simulation or not. Within a simulation it can take two forms:
3. **Exercise Data.** Mock data that is being generated or consumed for the conduct of the simulation. It MUST not have real world side effects.
4. **NODUF**[[4]](#footnote-5) **Data.** Real-world actionable data generated or consumed during the conduct of a simulation. This is typically used when an event outside the context of the simulation requires real world action. For example a casualty evacuation request resulting from a real injury as opposed to a simulated one.
5. **Simulation Data.** Telemetry, control, management and coordination data that is unique to conducting the simulation event and is not necessarily of the same format as Operational Data. Simulation data can take two forms:
6. ***Execution Data.*** *Supports the running of the simulation specifically to keep multiple synthetic constructs synchronised.*
7. ***ExCon Data.*** *Supports the command, control and situational awareness of the Monitors and Controllers; possibly separately.*
8. **Network Traffic.** The network traffic created by transmitting the data will be described the same way as above as it just the data in transit. Simulation Data becomes Simulation Traffic, etc.

### Simulation Model

To describe components of a simulation the following model has been developed that builds on the use of player, environment and situation. The components are:

1. World ??????. This is the controlling system that maintains and executes the models that are being applied in the simulation. These can include both player and environment models. The World ?????? can be software agents, people (Controllers) or a combination of both.
2. Simulation environment. This is the environment in which the player(s) play. The environment must be able to support the use of mock operational data and also:
3. Mock time.
4. Mock space.
5. Mock persona.
6. Simulation adaptors. Simulation adaptors are required to transform data into and out of the simulation environment. So there is an:
7. Input adaptor. This is responsible for transforming operational and simulation data into mock data for consumption by the simulation.
8. Output adaptor. This is responsible for transforming mock operation data for consumption in the simulation, or when NODUF for forwarding as real traffic.
9. Simulation mode. When real players and/or their systems are engaged in a simulation, it is imperative that their activities do not result a real world incident. While it is intended that the Output Adaptor is primarily responsible for this; complex scenarios may limit its effectiveness. Systems (and players) should ‘understand’ they are operating in a simulation and be in ‘Simulation Mode’. This is a system equivalent of a blank firing attachment for a rifle.
10. mock data for the consumption of the simulation.
11. There is basically data that is of the same form as being use
12. The concept of the Player has been introduced but there are also staff members who exist outside the simulation. These staff have roles such as controlling or directing the simulation, and monitoring or assessing it.
13. Simulation. Attempting to predict aspects of the behaviour of some system by creating an approximate model of it; therefore, creating a virtualisation of it. This can be done by physical modelling, by writing a special-purpose computer program or using a more general simulation package. When real world components are introduced into the simulation to either form part of the model (to any extent), interact with the model or both, it is known as live simulation. Simulations can be defined by:
14. The components that constitute them:
15. Live
16. Virtual
17. Constructive
18. The way they interact with the real world:
19. Standalone
20. Integrated
21. Environment
22. Real Virtual
23. Player Real Real Virtual
24. Virtual N/A Constructive
25. Player. An entity that is being evaluated or trained via a simulation.
26. Simulation Enclave
27. For live simulations the environment in which the player(s) exist will need to
28. Simulation Data. Telemetry, control, management and coordination data that is unique to conducting the simulation event and is not operational data.
29. Operational Data. Data that would be used by the business to conduct operations whether in a simulation or conducting real world operations.
30. Mocked Operational Data. Operational data that is being generated or consumed for the sake of the simulation only. It MUST not have real world operational side effects.
31. NODUF Operational Data. Operational data that is real, even if a simulation is being conducted. It MUST not have real
32. Mocked Persona
33. Mocked
34. Simulator
35. Simulation Enclave
36. Simulated World
37. Figure 1: A demo figure
38. Annex:
39. An example annex

Enclosure:

1. There isn’t an enclosure

* to  
  Template  
  Dated 31 Mar 2022

# An example annex

This is an example Annex.

1. Appendix:

* An example appendix
  + to  
    Annex A TO  
    Template  
    Dated 31 Mar 2022

# An example appendix

This is an example annex.

1. [↑](#footnote-ref-2)
2. [↑](#footnote-ref-3)
3. [↑](#footnote-ref-4)
4. [↑](#footnote-ref-5)