Australian Government

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Simulation Data Guide

Australian Defence Simulation Office

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Foreword

Simulation data is a critical element of simulation feasibility, acquisition and operation. Data plays a major part not only in enhancing simulation capability but also in the cost and overall fidelity of the resultant simulation. The availability of suitable simulation data can not be assumed and a process for identifying, acquiring and managing simulation data must be established early in any simulation system lifecycle.

Simulation data is a dynamic area and this guidance document is a living document and must be updated as required. Comments or further clarification on any aspect of the simulation data guidance are welcomed. Please complete the evaluation form at the back of this document.

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Serial	Amendment	Date Effected

1 INTRODUCTION

1.1 BACKGROUND

1. The Australian Defence Organisation looks increasingly to Simulation[1] as a way to help decision-makers take better account of the complexity, the dynamics and the uncertainties that pervade modern warfare and management. However, we must acquire, develop, manage, use and support simulation in an environment that ensures the overall credibility of simulation outcomes. The Defence Simulation Policy emphasises the need for careful analysis to determine whether simulation offers a suitable and viable solution for a particular use. One of the six criteria[2] by which an informed assessment needs to be made is data availability and reliability. The Defence Simulation Policy states[3]:

> ***Data availability and reliability****—how well can these representations be activated?—does the necessary data exist?—can the appropriate data be found?*

2. Determining the need for simulation systems and acquiring those systems is a complex undertaking requiring the coordination and cooperation of a number of technical and non-technical disciplines and resources. Central to the capability of a simulation system is the availability, cost and lead time associated with the data necessary to support the definition, acquisition and operation of the system.

3. Strategists, acquirers and operators of systems involving simulation must understand what data is required to develop a satisfactory simulation. The data is defined by attributes including data quantity, quality and availability. This understanding is simply the first step in the complete appreciation of the simulation data issue. The next issue that requires a sound appreciation is the availability of the data necessary to support the simulation. The so-called "data gap" becomes apparent by considering what data is required versus what data is available.

4. The time and cost associated with closing this data gap often cuts to the very feasibility of simulation systems. Stakeholders involved in the definition, acquisition and operation of simulation systems must not assume that suitable data is available within their cost and time constraints. In fact, it is much safer to assume that the necessary data is not currently available and to put in place a process that addresses the lack of availability. Simulation data requirements definition, acquisition and management must, therefore, be a planned activity.

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[1] As defined in DI(G) OPS 42-1, a **model** is a physical, mathematical or otherwise logical representation of a system, entity, phenomenon or process. A **simulation** is the implementation or exercise of a model over time.
[2] Refer to paragraph 22.
[3] Paragraph 22c.

1.2 PURPOSE OF THE SIMULATION DATA GUIDANCE

The purpose of this guide is to assist the Acquirers, Developers, Managers, Supporters and Users of simulation systems in gaining an understanding of the many issues and challenges associated with simulation-related data. Simulation data is absolutely critical to the success of simulation projects as the data is the defining variable in the equation that determines simulation fidelity and utility. Simulation data is generally expensive, often difficult to obtain and can involve lead times in excess of the simulation acquisition schedule. To that end, simulation stakeholders must consider data issues very early on in acquisition lifecycles and must continue to manage data throughout the life of the resultant simulation.

5. The principle objective of the Guide is captured in the sixth strategy[4] to achieve the Defence Organisation vision for simulation:

> **Secure access to data to support simulations:** Access to adequate data is essential to support the development and through-life management of simulations. The data concerned includes not only data about the entities and elements of the natural environment which are being simulated, but also design, maintenance and similar data about the simulation itself. Defence will implement measures to ensure that it has access to, and where appropriate ownership of, data of the quality required to support approved simulation activities.

6. The purpose of the Simulation Data Guide (SDG) is to provide guidance for managing the simulation data process for Australian Defence simulations. In particular, the SDG details the standards, support, acquisition and the verification, validation and certification (VV&C) of simulation data. This Guide offers an introductory overview, and readers are directed to sources of more information and advice in the text as may be required.

7. The SDG is one of the Defence Organisation policy initiatives that will help lead the simulation community to grow and realise their vision:

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.

[4] Paragraph 25 of DI(G) OPS 42-1.

2 OVERVIEW OF SIMULATION DATA MANAGEMENT

2.1 INTRODUCTION TO SIMULATION DATA MANAGEMENT

8. Behind every effective simulation system is a large set of simulation data. To that end, any process designed to define, acquire, operate or modify simulation systems must consider the definition, acquisition and management of the necessary simulation data. Simulation data is generally very expensive and can impact on the very feasibility of a simulation system unless the cost has been estimated and allowed for. In addition to the cost, the lead-times associated with the acquisition of some data can be excessive and add substantial delays to the development of the simulation system. In some cases, the very availability of suitable simulation data is not guaranteed, placing the performance of the resultant simulation in doubt.

9. The recommended approach, therefore, is to assume that the necessary data is unavailable and put in place a satisfactory process for acquiring the data.

10. To effectively manage the definition and acquisition of simulation data, a number of issues need to be considered:

a. simulation data requirements including the judgement of the necessary data quantity and quality;

b. data acquisition, cost and schedule; and

c. confirmation of the adequacy of the simulation data used to design and test the simulation system.

2.2 DATA REQUIREMENTS

11. The data requirements for each simulation system will be slightly different but should always be driven by the intended application of the simulation system. By continually referring back to the intended purpose of the simulation system during the analysis of the data requirements, focus will be maintained on what level of data is required. Without this focus, the definition of data requirements is likely to aim for “perfection” rather than “adequacy”. Apart from the fact that “perfect” data does not exist, attempting to acquire it generally proves prohibitively expensive in both time and money without enhancing the ability of the simulation system to successfully perform its role.

12. Chapter 3 (Simulation Data) provides a comprehensive description of simulation data by describing what simulation data is and how it supports simulation systems. Chapter 4 (Simulation Data Standards) follows on from Chapter 3 by describing the extant standards employed in the simulation domain to maintain some definition, control and certainty over the content of the various categories of simulation data. Standardisation of simulation data is critical when issues such as interoperability and data sharing between simulation systems are considered.

2.3 DATA ACQUISITION, COST AND SCHEDULE

13. In a lot of cases, data will exist within the Defence Simulation Environment (DSE) that can be used to support new or modified simulation systems. It is not advised, however, to

assume that there will be adequate data readily available to support simulation systems. In actual fact, it is recommended that stakeholders assume that the necessary data is not available. Stakeholders involved in the definition, acquisition and operation of simulation systems must consider data acquisition as a separate but key activity associated with simulation system acquisition.

14. Chapter 5 (Simulation Data Support and Sources) provides information on Defence and non-Defence entities within Australia and abroad that may be able to assist with the provision of simulation data. Chapter 6 (Simulation Data Acquisition) recommends a lifecycle approach to simulation data definition, acquisition and management. This concept sees the requirements for simulation data being analysed very early in the life of a simulation system. In fact, the data requirements for a simulation system should be considered before a decision to proceed with the simulation system acquisition is made. In this way, the likely lead time, cost and availability of suitable simulation data can be allowed for in early budgeting and feasibility. Chapter 6 advocates that a formal process for identifying, acquiring and managing simulation data is established early in the acquisition. This process helps to ensure that adequate data is available at the appropriate times throughout the simulation system design process and throughout the operational life of a simulation system.

15. Chapter 6 also states that the issue of simulation data acquisition and cost remains throughout the life of the simulation system. Simulation systems must remain current and accurate throughout their operational lives and this usually requires the maintenance, enhancement and supplementation of simulation data.

2.4 DATA ADEQUACY

16. Underlying the entire subject of simulation data is the issue of data adequacy. The issue of data adequacy starts with the analysis and definition of the data requirements to support the simulation system (recalling the fact that the data needs to be sufficiently adequate to support the intended use of the simulation system regardless of whether the intended use is training, through life support or analysis for example). Once defined, the acquisition of the simulation data can proceed in accordance with the process mentioned in the preceding paragraphs. As with any rigorous process, there is a need to formally confirm that the data being applied to the simulation system has achieved this “sufficiently adequate” level. Chapter 7 (Verification, Validation and Certification of Simulation Data) addresses the need to check the data and confirm its adequacy. This process ensures that the data used by the simulation system is satisfactory and that the simulation system performance is tested against adequately representative data.

17. The process of VV&C of simulation data is necessarily intertwined with simulation system design, testing and operation as described broadly in Chapter 7.

3 SIMULATION DATA

3.1 WHAT IS SIMULATION DATA?

18. To understand what simulation data is, it is necessary to understand the concept of models and simulation. In the context of the Defence Simulation Environment (DSE), a Model can be described as 'a physical, mathematical or otherwise logical representation of a system, entity, phenomenon, or process.'[5]. A model could be a bridge, an island, a weather system, a ship, a missile or a radar. A model does not necessarily move (although many can) and is not in itself a simulation. A Simulation is 'the implementation or exercise of a Model over time'[6] hence, the simulation, utilising models, becomes the dynamic representation of a real world activity or entity.

19. In order to develop a Model of a real world activity or entity, a certain amount of data will be required. The amount, accuracy and detail of the necessary data is determined directly by the objectives which the Simulation is designed to achieve. The goal in simulation acquisition and design should be to achieve the minimum required simulation sophistication (which includes data volume, detail and accuracy) necessary to achieve the simulation objectives. This approach ensures the lowest risk and most cost effective solution will be pursued.

3.2 WHAT IS METADATA?

20. Metadata is the information which describes the particular details of another piece of data. As an example, the metadata for a geographic terrain file may include fields on the name, size, version, and date along with other extended attributes such as the source, resolution, boundaries, minimum and maximum elevations, classification, key words etc. Metadata is an essential tool in managing simulation data and provides the basis for configuration management of a simulation data archive. Without a reliable and well managed metadata library, accreditation of simulations becomes very difficult and the veracity of the core simulation data will eventually diverge from the design baseline to the point that it can no longer be used with any confidence.

21. An example of a metadata file for a geospatial data product is shown at Annex A.

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[5] DI(G) OPS 42-1

[6] DI(G) OPS 42-1

3.3 MAIN TYPES OF SIMULATION DATA

22. In the context of the DSE, simulation data can be segregated into four main categories:

a. Environmental Data.

b. Entity Data – Physical.

c. Entity Data – Behavioural.

d. Entity Data – Design.

23. The segregation applied here is not definitive but is well suited to the types and designs of simulations currently in service within the DSE as well as those likely to be acquired in the future.

3.3.1 Environmental Data

24. Environmental data is that which describes the physical environment of a simulation incorporating texture and detail such as terrain relief, weather, day, night, terrain cultural features, and sea states.

25. Environmental data can be further segregated into three sub categories:

a. Geospatial,

b. Hydrographic, and

c. Meteorological.

3.3.1.1 Geospatial

26. Geospatial data describes the material characteristics of a terrain environment such as elevation and topography, features such as rivers and roads, and objects such as buildings, pylons and oil rigs.

27. Geospatial data is used in a huge range of industries globally and accordingly, is one of the most prolific categories of simulation data available. Geospatial data can take a range of forms from complete world data sets and individual regional topography files to hard copy maps, satellite imagery and photographs. Some specific formats and standards of geospatial data are defined in Chapter 4 (Simulation Data Standards).

28. In order to understand the compatibility and potential for interchange between different geospatial data sets, it is necessary to understand the difference between raster-based data files, vector-based data files and compiled databases.

29. Raster data is an interpretation of geospatial data represented by a matrix of data points evenly spaced in rows and columns. The position of the data point within each row and columns determines the geographic position whilst the value at that point represents the object. Raster data structures are typically used to record scanned maps and charts, image data, or grided data.

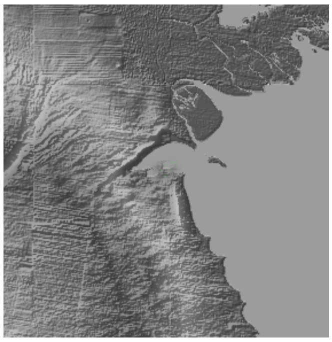

Figure 3-1 Raster Data

30. Vector data represents each cartographic feature by associating location and attribute information with each entity. The map data is therefore stored as points, lines, and areas rather than as an image or continuous tone picture. Geographic positioning may be two dimensional or three dimensional (including elevation) and features are categorised as a point, line, or area (an area would be represented by the line which bounds it). Vector data structures are typically used to represent continuous features such as lakes and rivers, political boundaries, and topographic contours. Vector data tends to be less voluminous than raster data.

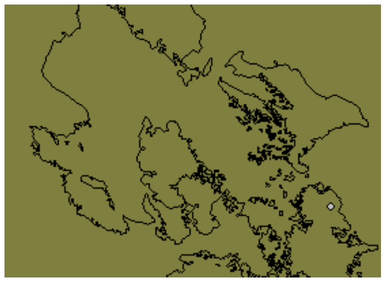

Figure 3-2 Vector Data

31. A compiled database is neither raster nor vector formatted but may contain data extracted and converted from both formats. A visual (including infrared and radar) database is usually developed in a proprietary format driven by the software development tools and image generation environment used.

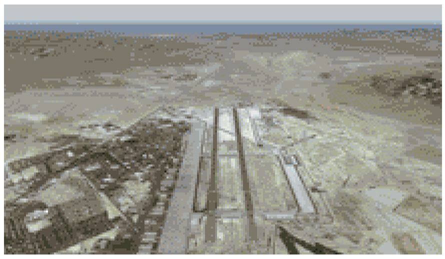

Figure 3-3 Compiled Database

32. Within these three data types there are also numerous sub-formats as well as international standards which define the interfaces and specifications for interoperability and efficient data exchange (these include the incorporation of Hydrographic, Meteorological and some entity data). These standards are addressed in more detail in Chapter 4, however it is important to appreciate that the disparity between the data currently held with legacy simulations (and older archives) and that being developed currently (and in the future) will not always facilitate compatibility.

33. Some examples of Geospatial data are shown in the figures below:

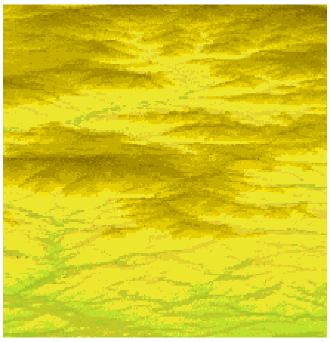

Figure 3-4
Digital Terrain Elevation Data (DTED) file

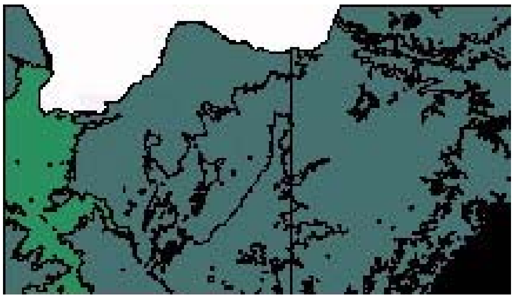

Figure 3-5
The Digital Chart of the World

Figure 3-6
Topographic Line Map (TLM)
(Raster Scan)[7]

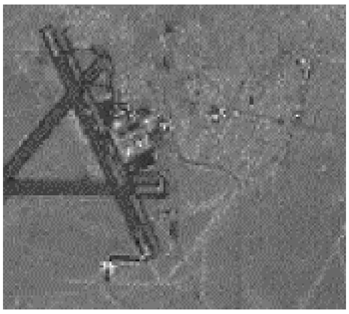

Figure 3-7
Aerial photographs of an airfield

3.3.1.2 Hydrographic

34. Hydrographic data describes the physical and behavioural features of an aquatic environment. Attributes such as sea states, ocean thermal profiles, saline concentration profiles, sea floor topography and current behaviour may all be important in providing a simulation which captures the necessary realism to meet the defined objectives. Hydrographic data is used predominantly in naval simulations and is gathered by a range of specialist surveying equipment including laser airborne depth sounders, echo-sounders, sonar, differential, Real Time Kinematic (RTK) and geodetic Global Positioning System (GPS), theodolites, tide-gauges and current meters.

35. Some examples of Hydrographic data are:

a. high and low seasonal tide levels for a specific harbour;

b. The World Ocean Database; and

c. rapid surface current strength and direction tables for specific operational areas.

3.3.1.3 Meteorological

36. Meteorological (Met) data captures specific localised weather conditions as well as regional trends for meteorological characteristics such as rainfall, wind speed, wind direction, air temperature, cloud cover, relative humidity, water evaporation and solar radiation. In a simulation environment, Met data can be used to create an autonomous weather system in

[7] A lithographic map that portrays topographic and cultural features.

which to conduct the simulation activities or to initiate specific targeted meteorological conditions focused on a particular objective.

37. When applied to Flight Simulators, Met data is also often required to include more sophisticated behaviour such as wind shear, micro bursts, turbulence and variations of air density and temperature with altitude.

38. Some examples of Meteorological data are:

a. General weather parameters (wind, temp, rain) for a specific location.

b. Observed wind, temperature and moisture figures from geo-specific cloud formations.

c. Measured windfield behaviour around an airfield to simulate local wind shear effects.

d. Sunrise and sunset parameters correlated to calendar events.

3.3.2 Entity Data

39. Having established the environment in which a simulation will operate (and defined the data necessary to support it), it is necessary to identify the particular characteristics of certain entities within the simulation. In terms of data management, an entity is considered anything within a simulation, which requires specific detail in order to create a static or dynamic model of its real world equivalent (other than Environmental categories). Entities can range from the ‘ownship’ on which the simulation is based, through intangibles such as radar and ECM effects to static physical models such as a bridge or oil rig. In addition, it is important to understand that multiple individual entity models may be integrated into a high level entity which combines features and behaviour from all of its subordinates. This process is known as “aggregation”. An example of aggregation is an aircraft carrier model consisting of radars, aircraft, engines and other models all interacting to present a real world representation.

40. Entity data can be further segregated into three sub categories. This segregation is not definitive and in some instances the data describing a particular entity may fall into more than one of the categories below:

a. Physical.

b. Behavioural.

c. Design.

41. As an example, data defining the physical characteristics of a weapon such as dimensions, weight and sounds could be categorised as Physical as well as Design data since the dimension element of the data may be used to develop a simple static visual model and a complex dynamic performance model.

3.3.2.1 Entity Data - Physical

42. Physical entity data is used to define the physical characteristics of an entity such as colour, length, height and general appearance when it is viewed in any part of the electromagnetic spectrum such as infrared, radar, or visual. Although not strictly ‘physical’,

sound data such as engine noise or weapon firing is also included in this category. Accordingly, for a model of an armoured personnel carrier for use in a military helicopter simulation, there may be several categories of physical entity data required in order to define the appearance of the vehicle in all sensor and visual spectrums from all applicable ranges and angles.

43. Some examples of physical data are:

a. Air Traffic Control (ATC) tower external dimensions and texture.

b. Submarine periscope image when displayed on sea search radar.

c. Enemy fighter visual image from 5kms.

d. Weapon initiation sound including volume, pitch variation and duration.

3.3.2.2 Entity Data – Behavioural

44. Behavioural entity data defines the manner in which an entity will conduct itself when subjected to a given stimulus/i (including no stimuli at all). Behavioural data can be applied to individual entity models such as an enemy submarine as well as co-ordinated group simulations involving multiple different entities interacting with each other. The range of behaviours which can be modelled extend from simplistic combat responses such as releasing chaff/flares in reaction to a missile lock to complex coordinated actions involving evasive manoeuvres and group behaviour based on operational doctrine and SOPs.

45. Some examples of behavioural data are:

a. Evasive flight path response of an enemy aircraft to radar illumination by ownship.

b. Coordinated movement of aircraft around the visual circuit of an airfield.

3.3.2.3 Entity Data – Design

46. Design data for an entity incorporates all of the necessary design parameters required to ensure that the entity functions consistently with its real world equivalent. This data includes dynamic information such as aerodynamic and hydrodynamic design data as well as functional data such as the operation of radios, sensors and weapons.

47. Some examples of design data are:

a. ATC tower communications radio network functionality.

b. Helicopter centre of gravity, maximum all up weight, fuel distribution and maximum speed.

c. Patrol boat stopping distances, turning circle, radar operation and fuel consumption.

d. Small arms trainer, rates of fire, weapon range, projectile velocity and recoil force.

4 SIMULATION DATA STANDARDS

4.1 THE NEED FOR STANDARDS

48. As seen in the previous chapter on Simulation Data, the scope and depth of data necessary to conduct an effective simulation can be extremely far-reaching. The role of standards and standardised formats in the effective management of simulation data cannot be overstated. As well as providing known baselines concerning the resolution, consistency and integrity of the supplied data, the use of standards and formats also provides an invaluable aid to sharing resources, facilitating interoperability (see Distributed Simulation Guide) and extending the useable life of data.

49. Although some simulations may have been developed from "first principles" that allow them to be relatively independent of data, the vast majority of non-trivial simulations depend critically on data and, accordingly, should be considered for the application of standardisation wherever possible.

50. In selecting an appropriate standard or format, those standards already adopted by simulation systems currently in service within the DSE (and, if appropriate, internationally) should be considered, with a particular emphasis on interoperability and exchange of data. Where there is no obvious extant standard, users should, as a minimum, seek policy guidance from ADSO and consult other in-service simulation system managers before imposing compliance with a specific standard on a supplier.

4.2 METADATA STANDARDS

51. As with the core simulation data, it is essential that the corresponding metadata should comply with applicable standards whenever practical. The value of the information contained in metadata files can be significantly compromised if the file content is not consistent across all data of a similar category or format. In addition, the certification of specific simulation data may be prevented if sufficient information about the source data is not captured in the metadata records. Given the time and effort associated with compiling simulation data of a high standard and the specific application for which the data is relevant, it is essential that the suitability of the data is comprehensively captured and that the information allows the data to be evaluated for alternative uses, interoperability and certification.

52. Metadata standards vary depending on the type of source data to which they correspond and in many instances there are no obvious choices of metadata standard corresponding to a particular type of data. In particular there are no specific metadata standards dedicated to the categories of simulation Entity data identified in the previous chapter (Simulation Data). In such instances the user should apply the necessary analysis to determine what information needs to be captured and then select an appropriate metadata standard with which to ensure consistent application and exchange with other simulations.

4.3 ENVIRONMENTAL DATA STANDARDS

53. The range of data standards and formats applicable to environmental data, and in particular geospatial data is extremely broad. As well as raw data standards and transmission protocols, there are also numerous formats for prepared databases and compiled cartographic

data. Nevertheless, the judicious application of selected standards and formats at each stage of the model/database development process will encourage a rigorous, consistent and transposable output. The eventual product/model/database format and structure should be taken into account when selecting preliminary formats and standards for raw data as compatibility with, and exchange between, various development tools may be affected by data formats.

54. The following diagram shows a typical path for the production of a simple visual/sensor database from various data resources and demonstrates the need for compatibility and standardisation when considering the data formats for a consolidated visual and behavioural database.

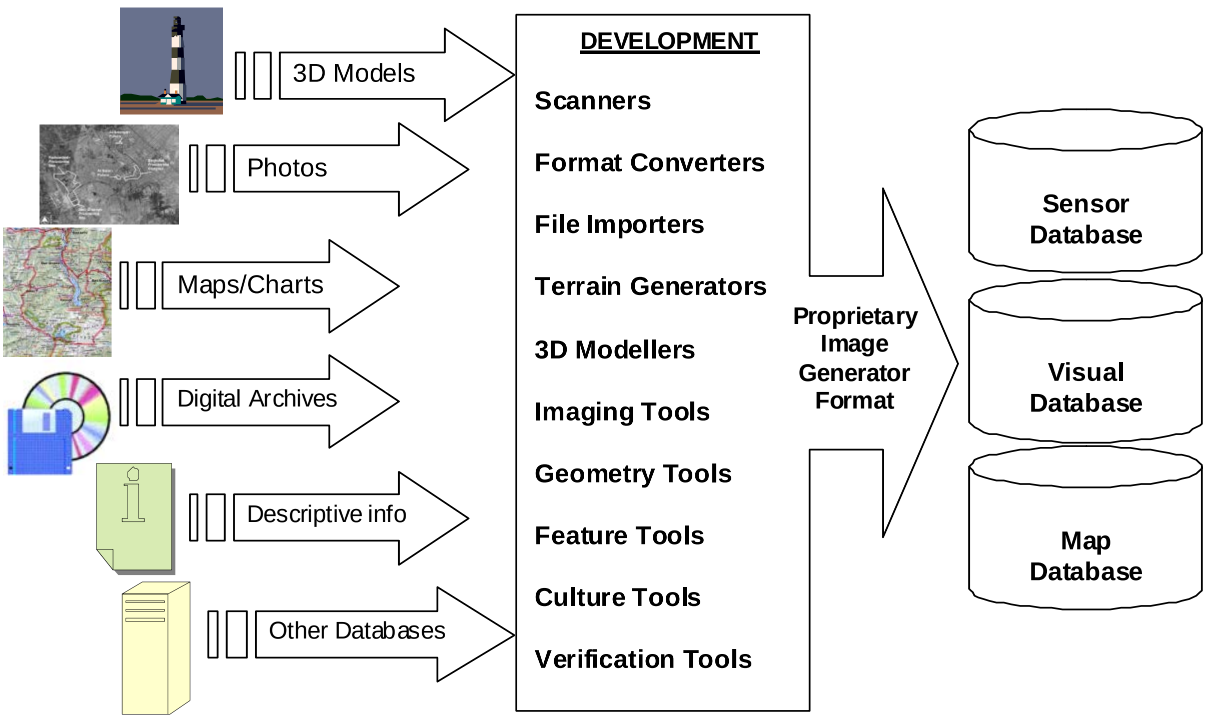

Figure 4-1: Conventional Environmental Database Process

55. Although there are many standards in use in the simulation sector, there are a number which are considered to be 'core' formats or specifications, particularly in the DSE. The following chapter briefly introduces these core standards/formats and their uses. Further detail on the main simulation data/database standards and formats in current use can be found in Table 2 at Annex B.

56. It is worth noting that the standards described below are often interrelated and, in many cases, can be grouped into overarching, equivalent and subordinate formats. The diagram below shows the interrelationships between some of the major formats and standards discussed in this chapter.

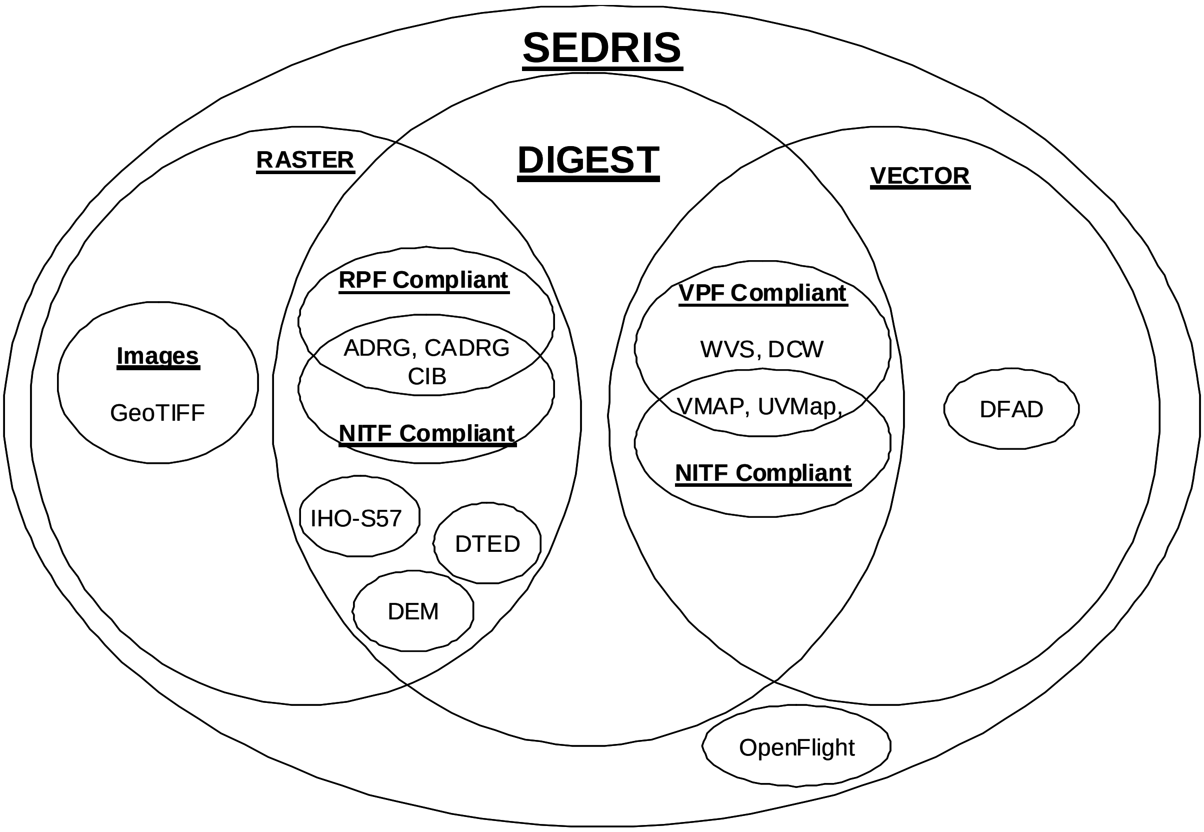

Figure 4-2: Key Standards Relationships

4.3.1 Arc Digitised Raster Graphics

57. Arc Digitised Raster Graphics (ADRG) is a standard US National Imagery and Mapping Agency (NIMA) digital product designed to support applications that require a raster map background display. Paper maps and charts are converted into digital format by raster scanning, transforming the data into the equal arc-second raster chart/ maps. CADRG is a compressed version of ADRG. ADRG and CADRG are Raster Product Format compliant (see RPF later in this chapter).

4.3.2 Controlled Image Base

58. Controlled Image Base (CIB) is a dataset of unclassified panchromatic (black and white) digital orthophotos made from rectified imagery produced to support a variety of mission planning and command, control, communications, and intelligence systems. CIB are produced from digital source images and are compressed and reformatted to conform to the RPF and NITF standards. CIB is produced at standard resolutions of 10 metres, 5 metres and 1 metre ground sample points however custom resolutions can be developed if required.

59. The standard CIB resolutions are as follows:

CIB Level	Resolution (ADRG equivalent)
CIB-1	1:10 000
CIB-5	1: 50 000
CIB-10	1:100 000

4.3.3 Digital Chart of the World

a. The Digital Chart of the World (DCW) is a comprehensive 1:1,000,000 scale vector base map of the world based on paper maps, particularly the Operational Navigation Chart (ONC) series. It consists of cartographic, attributes and textual data including major road and rail networks, major hydrologic drainage systems, major utility net-works, all major airports, elevation contours, coastlines international boundaries and populated places. The DCW is gradually being replaced by VMAP Level 0 (See VMAP later in this chapter) as the primary source for this resolution of data.

4.3.4 Digital Elevation Model

60. Digital Elevation Model (DEM) is a standard established by the United States Geological Survey (USGS) which consists of a grid of regularly spaced terrain elevation values in a raster format. The elevation data has been primarily derived from the USGS topographic map series and is provided at a resolution of 30m in most instances with 10m available in some US areas. USGS produces 5 types of DEM in quadrangles from 7.5-Arc Minute DEMs (1:24,000) to 1-Degree DEMS (1:250,000). This format has been superceded by the USGS's own SDTS format, however it remains popular due to large numbers of legacy files, self-containment, relatively simple field structure and broad, mature software support. It should be noted that outside of USGS, the term "Digital Elevation Model" is sometimes used as a generic term for the wide range of digital raster elevation formats which use the regular grid representation for elevation values.

61. The standard DEM resolutions are as follows:

DEM Level	Resolution
7.5 minute	1:24 000
15 minute	1:63 360
30 minute	1:100 000
1 degree	1:250 000

4.3.5 Digital Feature Analysis Data

62. Developed by NIMA, Digital Feature Analysis Data (DFAD) is a vector format product which defines a range of terrain features (as apposed to elevation) both natural and cultural. Although DFAD was originally developed for radar simulation applications it is now commonly used in weapon system flight simulators and other types of simulation that require line of sight, obstruction, and perspective views. It is compiled from cartographic and photo-grammetric source data and is available at 2 primary resolutions with the lowest resolution only suitable for large scale generic textural surfaces, whilst the higher resolution is more applicable to navigational and realistic terrain interpretation.

63. The standard DFAD resolutions are as follows:

DFAD Level	Resolution
Level 1	1:250 000
Level 1C	*1:250 000 - 1:1 000 000*
Level 2	1:50 000
Level 3C	*1:50 000 - 1:250 000*

4.3.6 Digital Geographic Information Exchange Standard

64. Digital Geographic Information Exchange Standard (DIGEST) is a collection of standards capable of supporting the exchange of raster, matrix, and vector data (and associated text) which can accommodate the entire range of levels of topological structures. DIGEST is constantly evolving in order to achieve compatibility with more geographic information standards including Hydrographic and Meteorological formats. DIGEST compliant standards include ADRG, DCW, DTED and VMAP (see DTED and VMAP later in this chapter).

4.3.7 Digital Terrain Elevation Data

65. Developed by NIMA, Digital Terrain Elevation Data (DTED) is a collection of standard digital datasets representing a uniform matrix of terrain elevation values for use in applications that require terrain elevation, slope, and/or surface roughness information. DTED is gathered by sampling terrain surface elevation at specific intervals and there are several levels of DTED resolution, ranging from sample distances of 1km (DTED Level 0) down to 1m (DTED Level 5). DTED is a widely available resource however it is somewhat limited at higher resolutions (DTED 3-5 is still in draft specification form) and in some geographic locations where sampling has not been a priority.

66. The standard DTED resolutions (approved standards) are as follows:

DTED Level	Resolution
Level 0	1:1 000 000
Level 1	1:250 000
Level 2	1:50 000

4.3.8 GeoTIFF

67. The GeoTIFF format is a non-proprietary raster image format that is used for charts, aerial photographs and other images that have a location on the Earth's surface. It is an extension of the popular TIFF (Tagged-Image File Format) image standard. GeoTIFF images contain additional information that allows them to be tied to known chart projections by implementing a tag structure which embeds the geographic information methodically and interoperably inside the TIFF file.

4.3.9 National Imagery Transmission Format

68. National Imagery Transmission Format (NITF) is a compressed imagery file format used to exchange imagery and text among secondary imagery dissemination systems that are otherwise incompatible. NITF is endorsed by the US DoD and is a prerequisite baseline for all future US image distribution networks.

4.3.10 OpenFlight

69. The OpenFlight file format, is a leading commercial visual database format developed by MultiGen Inc. Used primarily for flight simulators (but not exclusively), the MultiGen Inc suite of software tools has been adopted by many major modelling and simulation suppliers and as such has become the defacto standard for 3D visual databases. Multigen Inc develops

a range of data processing and transfer tools which facilitate the interchange of OpenFlight databases with a variety of international standard formats including SEDRIS (see SEDRIS later in this chapter).

4.3.11 Raster Product Format

70. Raster Product Format (RPF) is a NIMA standard for storing and handling raster based digital products such as satellite imagery and digitized aeronautical charts. Amongst the variety of raster products which are available, only some are compatible with the RPF standard (for example, ADRG is compatible but DTED is not).

4.3.12 S-57

71. S-57 is a hierarchical collection of spatial and feature objects with detailed attribute and relationship data used for oceanographic applications. It is the standard for vector based ENC (Electronic Navigation Chart) data for use in ECDIS (Electronic Chart Display and Information System) systems and is mandated by the International Maritime Organisation (IMO) and is defined in the International Hydrographic Organisation (IHO) Special Publication 57 (S57).

4.3.13 Synthetic Environment Data Representation & Interchange Specification

72. Developed by the Defence Modelling and Simulation Office (DMSO), Synthetic Environment Data Representation & Interchange Specification (SEDRIS) is a combination of enabling methodologies (including tools) and specifications to facilitate the exchange of databases (not in real time) between different simulations. SEDRIS supports ‘out-the-window’, infrared and radar simulations and is in the process of becoming an ISO standard.

73. The diagram at Figure 4-1: Conventional Environmental Database Process showed the typical process for the development of a visual database. In particular, it can be seen that a wide range of data types and formats must be converted and aggregated into a configuration which can be used by the target image generation platform. This means that for every image generation system, it is necessary to re-format the source data according to the specific requirements of its hardware and software. The objective of SEDRIS is to provide a universally compatible interface specification (and tools) to allow any environmental database system to seamlessly import a compiled database.

74. The diagram below demonstrates the concept of the SEDRIS program.

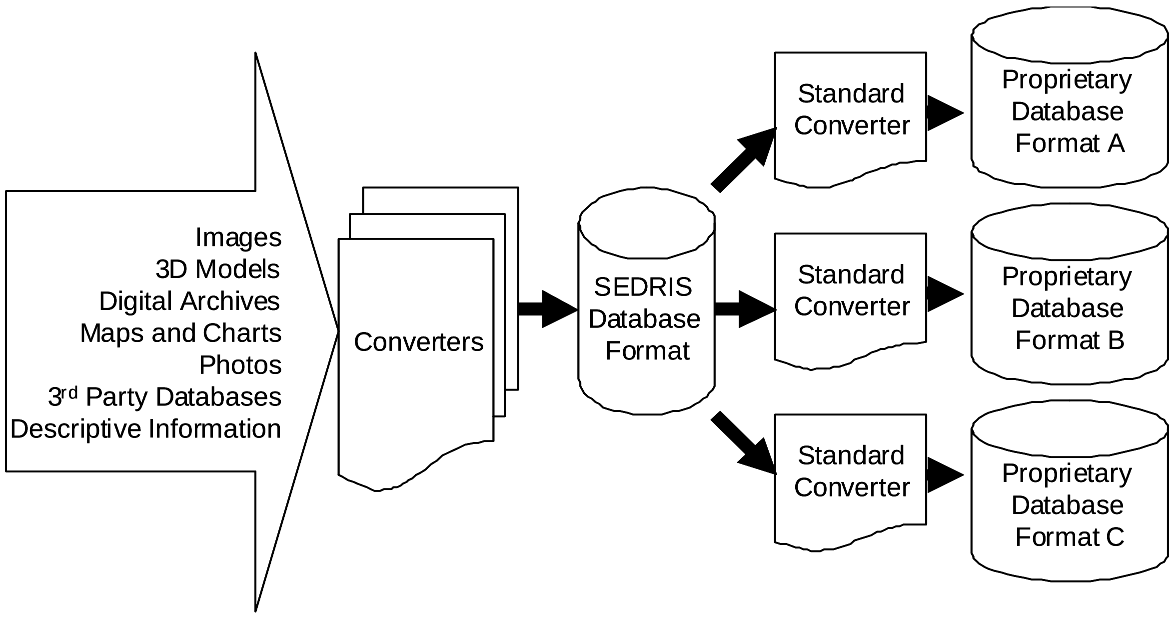

Figure 4-3: SEDRIS Environmental Database Process

4.3.14 Vector Product Format

75. Vector Product Format (VPF) is a NIMA standard for storing and handling vector based digital products, in particular georelational databases. Since the inception of the standard, NIMA has produced numerous products in this format including the Digital Nautical Chart (DNC), VMAP (see VMAP below) and WVS (see WVS later in this chapter).

4.3.15 Vector Smart Map

76. Vector Smart Map (VMAP) is a collection of data bases that provide vector-based geospatial data at low, medium, or high resolution. The data is separated into 10 thematic layers (boundaries, elevation, hydrography, industry, physiography, population, transportation, utilities, vegetation, and data quality) which are topologically structured and is designed to support geographical information system analysis. There are 3 levels of resolution from VMAP Level 0 (low resolution feature and attributes) to VMAP level 2 (feature and attribute content similar to the TLM scale 1:50k).

77. A variation of the VMAP format is the “Urban” Vector Smart Map (UVMap) which contains detailed feature information combined with limited geographic data for use in a tactical rather than strategic context. UVMaps are compiled from a variety of sources with geographic, image and textual data depending on what information is available for the target location.

78. VMAP is available in a number of standard resolutions as follows:

VMAP Level	Resolution
Level 0	1:1 000 000
Level 1	1:250 000
Level 2	1:50 000

4.3.16 Word Vector Shoreline

79. Word Vector Shoreline (WVS) is a vector based product that portrays shorelines, maritime boundaries, international boundaries, country areas and selected depth information. The coastal shoreline feature is derived from Digital Landmass Blanking data, supplemented by ONCs and Tactical Pilotage Charts. WVS is VPF compliant.

4.4 ENTITY DATA STANDARDS

80. The application of standards and formats for the capture and recording of entity data is far more subjective than for environmental data and in most cases, is feature specific. Depending on the entity to be modelled and the particular characteristics of the entity needed to create the model (height, colour, sound, speed, frequency etc), the type and scope of required data may come from any number of sources, many of which may have no formal standardisation associated with them. Accordingly, it is the responsibility of the modeller to determine which information is necessary to develop the model and also the format in which the information is required. This process may require the development of a number of data templates into which the required technical or design information is transposed once it has been gathered. It is clear that this process exposes the risk of compromising the integrity of the source data, since there may be no standardised system in place to verify the compatibility of the format or the veracity of the data once it has been collected. Further guidance on appropriate methods for acquiring and managing entity data can be found in Chapter 6 (Simulation Data Acquisition).

4.4.1 Physical Entity Data Standards

81. At this time there are no formal recognised data standards for Physical Entity Data. This section represents a place marker to document current standards when they become available.

4.4.2 Behavioral Entity Data Standards

82. At this time there are no formal recognised data standards for Behavioural Entity Data. This section represents a place marker to document current standards when they become available.

4.4.3 Design Entity Data Standards

83. At this time there are no formal recognised data standards for Design Entity Data. This section represents a place marker to document current standards when they become available.

5 SIMULATION DATA SUPPORT AND SOURCES

5.1 AUSTRALIAN DATA SOURCES

5.1.1 Government

GENERAL SUPPORT

Australian Defence Simulation Office

84. The Australian Defence Simulation Office (ADSO) is a Defence branch whose role is to provide support and advice to stakeholders involved with simulation. Although ADSO does not maintain a DSE data repository, it can provide advice and guidance to stakeholders in relation to data support, resources, acquisition and relevant points of contact.

Website: http://defweb.cbr.defence.gov.au/capability/ADSO/adso.htm

Defence Science and Technology Organisation

85. Defence Science and Technology Organisation (DSTO) is a Defence group whose role is to ensure the expert, impartial and innovative application of science and technology to the defence of Australia and its national interests. In the context of simulation data, DSTO conducts a wide variety of activities involving entity data (and some geospatial although there are better resources for this) including the development of flyout models for aircraft and missiles, distributed interactive training scenarios and data validation. DSTO can provide both data and support and is a valuable source of technical advice.

86. The types of data and support available from DSTO include:

a. Behavioural simulations for multiple entity forces.

b. Virtual air environments.

c. Model validation (through aero/hydrodynamic analysis).

d. Countermeasure performance.

e. Data V&V guidance.

Website: http://www.dsto.defence.gov.au/

ENVIRONMENTAL DATA

Defence Imagery and Geospatial Organisation

87. Defence Imagery and Geospatial Organisation (DIGO) was created by amalgamating the Canberra-based Australian Imagery Organisation and Directorate of Strategic Military Geographic Information, and the Bendigo-based Defence Topographic Agency. DIGO is the lead imagery and geospatial organisation in the Department of Defence and its primary role is the acquisition, production and distribution of imagery and geospatial data in support of the ADF and Government. DIGO is a primary source for geospatial data.

88. The types of data available from DIGO include:

a. Topographic Line Maps (TLM).

b. Digital terrain elevation data.

c. Digital feature data.

d. Digital imagery.

Website: http://www.defence.gov.au/digo/digo/index.htm

Geoscience Australia

89. Geoscience Australia is a prescribed agency within the Australian Government Department of Industry, Tourism and Resources and is Australia's national geoscience research and spatial information agency.

90. Within this organisation, the National Mapping Division (NMD), formerly AUSLIG, is Australia's national mapping agency and delivers spatial information services. NMD is responsible for mapping, measuring and monitoring the continental landmass and associated territories at a broad scale. Note that requests for simulation data support from Geoscience Australia are to be staffed through the appropriate contact at DIGO.

91. The types of data available from NMD include:

a. Small and medium scale topographic maps of Australia.

b. Medium scale satellite imagery.

Website: http://www.ga.gov.au

Australian Spatial Data Directory

92. The Australian Spatial Data Directory (ASDD) is a national initiative maintained by Geoscience Australia on behalf of ANZLIC - the Spatial Information Council. The ASDD is an essential component of the Australian Spatial Data Infrastructure (ASDI) and aims to improve access to nationally consistent spatial datasets for industry, government, education and the general community through effective documentation and distribution. Note that requests for simulation data support from ASDD are to be staffed through the appropriate contact at DIGO.

93. The types of data available from ASDD include search interfaces to geospatial dataset descriptions (metadata) Australia wide

Website: http://www.ga.gov.au/asdd/

Australian Hydrographic Service

94. The Australian Hydrographic Service (AHS) is part of the Royal Australian Navy (RAN) and is the Australian Government's agency responsible for the publication of nautical charts and other information required for the safety of ships navigating in the Australian region. The

AHS maintains the single most comprehensive collection of Hydrographic data for Australia, most of which is currently being converted into a digital form.

95. The types of data available from AHS include:

a. Electronic Navigational Charts (ENCs).

b. Paper charts.

c. Tidal information.

d. GeoTIFF (raster) versions of the Australian Navigational Series.

Website: http://www.hydro.gov.au

Australian Oceanographic Data Centre

96. The Australian Oceanographic Data Centre (AODC) forms a part of the Navy's Directorate of Oceanography and Meteorology, which in turn, is a component of Navy's Hydrographic Force Element Group.

97. As well as participating in various national and international oceanographic data collection, exchange and management programs within the International Oceanographic Data and Information Exchange forum, the AODC is also responsible for providing non real-time data, specialised datasets, information products and consultancy services in support of maritime activities of the ADF. The primary focus is the development and maintenance of the Navy's Marine Environmental Database (MEDB) which provides most of AODC's products.

98. The most significant data sets within the AODC portfolio have come from the Global Ocean Data Archaeology and Rescue (GODAR) project of the IOC and the new World Ocean Database from World Data Center-A (Oceanography) in Washington DC, USA which have added over 5 million ocean observations to the AODC's databases.

99. The types of data available from AODC include:

a. The Marine Environmental Data Information Referal Catalogue.

b. Global bathymetry data.

c. Wave height climatology.

d. Coastal sea surface salinity and temperatures.

Website: http://www.metoc.gov.au/

Bureau of Meteorology

100. The Bureau of Meteorology is Australia's national meteorological authority, whose overall mission is to observe and understand Australian weather and climate and provide meteorological, hydrological and oceanographic services in support of Australia's national needs and international obligations.

101. Meteorological data collected from the Bureau's observational data network are held in the National Climate Data Bank. This database contains millions of records of Australian climate and related data, which is readily available to interested users in both hard copy and computer - compatible forms and new data types are progressively being added. Climatic summaries and atlases are published regularly.

102. In addition to the generally available meteorological data provided by the Bureau of Meteorology, specialist support to Defence is also provided.

103. The types of data available from the Bureau of Meteorology include:

a. surface climate,

b. upper air,

c. marine,

d. solar radiation, and

e. cyclones.

Website: http://www.bom.gov.au/

ENTITY DATA

104. This section is a place holder in this document to be filled in by ADSO staff as relevant information becomes available.

5.1.2 Commercial

ENVIRONMENTAL DATA

105. There are many commercial entities in Australia capable of providing a range of environmental data that may be suitable for some simulation applications. It is recommended that contact and agreements between Defence and these commercial entities be established and managed by DIGO in the first instance if required.

5.2 INTERNATIONAL DATA SOURCES

5.2.1 International Government

ENVIRONMENTAL DATA

USA – National Geospatial Intelligence Agency

106. Formerly the NIMA, the National Geospatial Intelligence Agency (NGA) merges imagery, maps, charts, and environmental data to produce what they term “geospatial intelligence”.

107. Note that requests for simulation data support from NGA are to be staffed through the appropriate contact at DIGO.

108. The types of data available from the NGA include:

a. Digital Chart of the World.

b. VMAP Level 0.

c. Software tools.

d. Standards.

e. Aeronautical Electronic Chart Updating Manual.

Website: http://www.nga.mil

USA - Federal Geographic Data Committee

109. The Federal Geographic Data Committee (FGDC) is a 19-member interagency committee which is developing the National Spatial Data Infrastructure (NSDI) in cooperation with organizations from government, the academic community, and the private sector. The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The committee administers the National Geospatial Data Clearinghouse which is a collection of over 250 spatial data servers that have global digital geographic data primarily for use in Geographic Information Systems (GIS), image processing systems, and other modelling software. The National Geospatial Data Clearinghouse is searched through a single interface employing metadata records.

110. Most, if not all of the data managed by FGDC is US data however requests for simulation data support from FGDC are to be staffed through the appropriate contact at DIGO.

111. The types of data available from the FGDC include:

a. Metadata standards and resources.

b. National Geospatial Data Clearinghouse.

Website: http://www.fgdc.gov

USA - DMSO Master Environmental Library

112. The DMSO Master Environmental Library (MEL) provides direct access to natural environment information, data, and products, wherever they reside including non-geospatial data such as models, algorithms, and documents, as well as basic environmental data. The library provides a digital metadata database plus a universal interface that together enable a user to browse descriptive metadata through a single web site. After reviewing metadata results, the user can select and order the appropriate data. Note that requests for simulation data support from DMSO are to be staffed through the appropriate contact at ADSO.

113. The types of data available from the MEL include:

a. Digital feature data.

b. Digital terrain elevation data.

c. Nautical charts.

d. Ocean models.

e. Simulator databases.

Website: http://mel.dmso.mil/

USA - National Oceanographic Data Centre

114. The National Oceanographic Data Centre (NODC) archives & provides public access to global oceanographic and coastal data, products, and information encompassing physical, chemical and biological data sets. Note that requests for simulation data support from NODC are to be staffed through the appropriate contact at AODC.

115. The types of data available from the NODC include:

a. World Ocean Atlas.

b. Coastal water temperature guides.

c. Global sea level data.

d. Ocean current data.

Website: http://www.nodc.noaa.gov

UK – UK Hydrographic Office

116. The UK Hydrographic Office (UKHO) is part of the Ministry of Defence and their primary activity is the provision of navigational products and services to the Royal Navy and the merchant marine. Marketed under the Admiralty brand, the UKHO's product portfolio offers worldwide coverage in the form of 3,300 Standard Navigational Charts and 220 Navigational Publications. In addition to these more 'traditional' products, we also produce a range of electronic charts known as ARCS (Admiralty Raster Chart Service).

117. Note that requests for simulation data support from UKHO are to be staffed through the appropriate contact at AODC.

118. The types of data available from the UKHO include:

a. Tidal prediction programs.

b. Charts of navigation and fog light locations worldwide.

c. Digital shipping routes.

d. Wrecks database.

e. Global navigation charts.

Website: http://www.hydro.gov.uk

USA - earth-info

119. The earth-info (previously "Terrain Modelling Project Office") web site is an Internet resource that provides anyone with a computer access to imagery, maps, and other information. The earth-info site allows users to view and obtain geographic information available through government and commercial providers with a simple map-based interface. The earth-info web site was developed by the National Technology Alliance (NTA), for which the U.S. National Geospatial Intelligence Agency (NGA) serves as the executive agent.

120. The types of data available from the Earth Info include:

a. 1.25 million satellite images.

b. Scanned maps.

c. Digital orthorectified imagery.

d. Digital elevation data

Website: http://164.214.2.53

5.2.2 International Organisations

ENVIRONMENTAL DATA

USA – Synthetic Environmental Data Representation and Interchange Specificatrion

121. SEDRIS is a range of technologies which provide the means to represent environmental data (terrain, ocean, air and space), and promote the unambiguous, loss-less and non-proprietary interchange of environmental data. The core technology is a range of enabling software tools, models, formats and standards which, when combined, facilitate the presentation and transfer of environmental data.

122. The types of data and support available from the SEDRIS include:

a. SEDRIS Development Kit (tools, standards, formats, models etc).

b. Guidance on interoperability and networking data requirements.

c. Guidance on database formats and standards for reuse (internationally).

Website: http://www.sedris.org/

USA - Digital Geographic Information Exchange Standard

123. The Digital Geographic Information Exchange Standard (DIGEST) standard was developed by the Digital Geographic Information Working Group (DGIWG) to support efficient exchange of standardised Digital Geographic Information among nations, data producers, and data users. As DIGEST-compliant (STANAG 7074) datasets are being produced throughout the world, this site provides a description, theoretical model, specifications for file, image and feature interchange and a data dictionary. DIGEST differs from SEDRIS in that it is only applicable to geospatial data and not to amalgamated environmental databases.

124. The types of data available from DIGEST include the DIGEST standard.

Website: http://www.digest.org/

USA - Simulation Interoperability Standards Organisation

125. Focused primarily on networked simulations, Simulation Interoperability Standards Organisation (SISO) is an organisation which concentrates on facilitating simulation interoperability and component reuse across the US DoD, other government, and non-government applications and seeks to serve the broad modelling and simulation community. Through a program of conferences and workshops, SISO addresses a broad range of modelling and simulation issues and applications including state-of-the-art methodologies, tools and interoperability techniques. SISO membership exceeds 1400 from 28 countries, representing well over 400 organizations, including commercial, academic, government, and military agencies.

126. The types of data and support available from SISO include:

a. SISO Standards.

b. Reference products.

c. Interaction with active study groups and workshops.

Website: http://www.sisostds.org

6 SIMULATION DATA ACQUISITION AND SUPPORT

127. Simulation data is absolutely central to the successful performance of simulation systems. Identifying and acquiring simulation data is the responsibility of the Commonwealth Project Office or organisation responsible for acquiring the simulation system itself. The responsible organisation must assume in the first instance that adequate simulation data to support the design, development, testing and/or operation of the simulation does not exist and must therefore be acquired. It is strongly recommended that liaison with ADSO is established early in any simulation data acquisition process.

128. A comprehensive description of a simulation data acquisition process is provided at Annex C. This Chapter aims to summarise this process and highlight the major steps that should be considered. The process at Annex C is designed to be tailored depending on the scale of the data acquisition undertaking. For example, for large data acquisitions involving significant risk, cost and time, a rigorous process closely matching the Annex C process would be expected. However, for smaller acquisitions dominated by readily-available data sets, a tailored and less onerous process could be satisfactory.

129. In reading this Chapter, however, it must be emphasised that simulation data is generally very expensive, often hard to get and can be the difference between a successful and unsuccessful simulation system. Some estimates put the cost of simulation data at up to 80% of the simulation system itself[8] but examples exist where the geospatial data requirements alone for a simulation project could easily cost more than the entire simulation system[9].

130. The process recommended in this Chapter and Annex C is designed to protect the Commonwealth from the risks associated with simulation data acquisition.

6.1 SIMULATION DATA LIFE CYCLE

131. Simulation data acquisition can be considered in stages starting with the initial identification of the need for simulation data, through the actual acquisition of the data and ending when the data is no longer required and disposed of. The collection of these stages arranged from start to end is called a lifecycle. The lifecycle model chosen for this discussion consists of the following major stages[10]:

a. **Concept Stage.** The concept stage commences with the identification of a need or concept for a set of simulation data and investigates the broad availability, feasibility and cost associated with providing the necessary data. This investigation must take account of the simulation data that is currently available from other DSE resources. Key achievements in the conceptual stage include funding and project approval, requirements definition, and possibly source selection and contract signature. Note that further refinement of data requirements is expected beyond this point as the design of the simulation system begins to take form.

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[8] Defence Simulation Proposal Guide, ADSO, Canberra, 4 October 2002.

[9] The design of the F-111C Mission Simulator in the mid 1990s relied on the Commonwealth provision to the contractor of 400,000 square nautical miles of DTED and DFAD at various levels. Following contract signature, the Commonwealth discovered that the provision of this amount of data was going to cost more than the entire simulator project and cause substantial project delays. The database size was subsequently revised down to 80,000 square nautical miles with provision for expansion when suitable data became available.

[10] ISO/IEC 15288:2002, Systems Engineering - System Life cycle Processes.

b. **Development Stage.** The development stage concentrates on translating the broad data requirements from the preceding stage into detailed and precise descriptions of the data requirements and planning data acquisition. Data requirements become increasingly detailed and mature in parallel with design and development of the associated simulation system.

c. **Production Stage.** The production stage is the final stage in the acquisition phase of the data lifecycle where data sets are collected or acquired, processed or translated into suitable formats and generally made ready for use by a given simulation system(s). Major data-related activities conducted in this phase include VV&C considerations detailed in Chapter 7 (Verification, Validation and Certification of Simulation Data).

d. **Utilisation and Support Stages**. Once the simulation system and its data have been installed onsite and ownership transitioned to the Commonwealth, data configuration management, storage and maintenance dominate.

e. **Retirement Stage.** The simulation system enters the retirement stage when planning for retirement or replacement of the simulation system commences. Simulation data employed by the simulation system may be either discarded (if deemed of no further use) or made available to current or future simulation systems.

6.2 CONCEPT STAGE ACTIVITIES

132. Data is considered to be one of the six simulation "issues" to be explored when assessing a simulation proposal[11]. The main aim of the Concept Stage is to understand what data is needed to support the simulation, what data is currently available through the DSE and therefore what data needs to be acquired. This process is called "scoping the data requirements" and must be done as early as possible to allow accurate costs and schedules to be developed. During the scoping exercise, stakeholders need to understand their simulation data requirements and shortfalls or gaps, and ensure that an adequate process is put in place to close the data gap.

6.2.1 Determination of Data Requirements and Gaps

133. During the conceptual design stage of the acquisition process, effort should be put into determining the major categories of simulation data required using Chapter 3 (Simulation Data). In parallel with this effort, the Commonwealth stakeholders should engage in discussions with ADSO, DIGO and other points of contact listed in Chapter 5 (Simulation Data Support and Sources) to ascertain the extent of pre-existing data that may at least partially satisfy the data requirement of the simulation project.

134. The data gap between what is required and what is available then becomes apparent and can be quantified in terms of data availability, cost and schedule. This process is summarised below:

[11] DI(G) OPS 42-1Defence Simulation Policy, 2001.

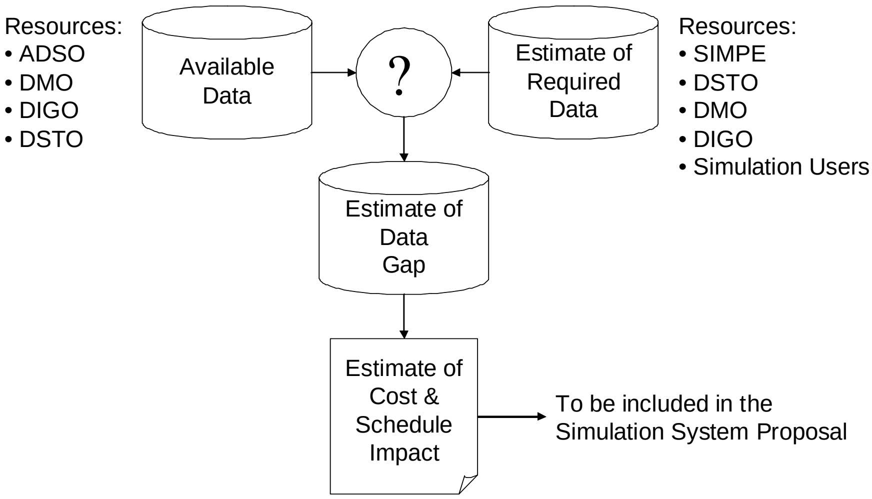

Figure 6-1: Commonwealth Estimation of the Data Gap

135. The process should be repeated by tenderers associated with the simulation data acquisition. The tenderers should be asked to communicate their estimations of:

a. currently available and suitable simulation data;

b. their understanding of data-related constraints;

c. detailed data requirements to support the relevant simulation;

d. the current data gap between available and required simulation data;

e. the proposed data acquisition process including draft documentation; and

f. the risks associated with the proposed data acquisition.

136. This process is illustrated below:

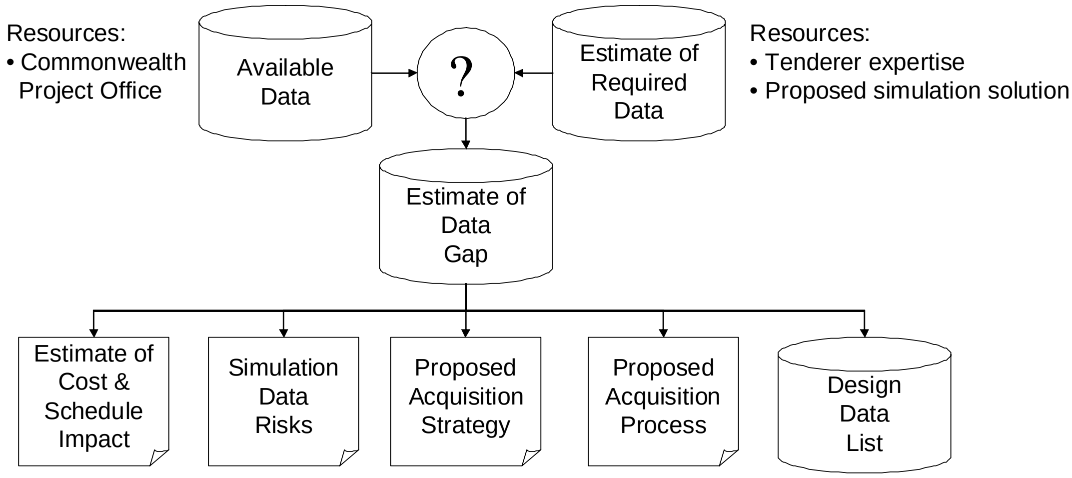

Figure 6-2: Tenderer Estimation of the Data Gap and Development of Data Acquisition Strategy

6.2.2 Draft Statement of Work Issues

137. The draft SOW must contain some additional data-related issues to clearly communicate responsibility for the provision of the different data sets listed in the data requirements and gap document. The Commonwealth project officers should exercise extreme care before accepting responsibility for the acquisition and provision of simulator data.

138. Reasons for exercising extreme care are described in Annex C but are summarised here. Inadequate data leads directly to an inadequate simulation and whoever provides the simulation data must be willing to accept responsibility in any shortfalls in simulation performance caused by that data. The developer (contractor) is best placed to determine what data is required and when it is required (regardless of who is responsible for its provision). A recommended approach would be for the Contractor to accept responsibility for the identification and acquisition of the simulation data on behalf of the Commonwealth. The Commonwealth retains ownership of the data and provides it back to the simulation system developers as Government Furnished Material (GFM).

139. Additionally, simulation data often remains incompletely defined until completion of the development stage of the simulation lifecycle. If the Commonwealth accepts responsibility for the acquisition of simulation data prior to development of the simulation system, they are effectively accepting responsibility for the provision and associated costs of an unknown quantity.

140. The SOW should require the process developed by the tenderer prior to contract signature to be followed when data is acquired. It is important to ensure that simulation data-related SOW clauses remain in the document that eventually forms the contract between the Commonwealth and the Contractor.

6.3 DEVELOPMENT AND PRODUCTION STAGE ACITIVITES

141. Data will be acquired during this period in accordance with the data acquisition process agreed and documented in the contract and Contractor plans. The quantity of data tends to increase during this process and continues until the design and development of the simulation is complete.

142. It is expected that the data acquisition strategy implemented by the Contractor will feature an iterative application of a process containing data requirements analysis, data identification and acquisition proposals, acquisition approval and acquisition. Figure 6-3 below attempts to overlay the simulation data acquisition process with typical milestones associated with the acquisition of any major simulation system.

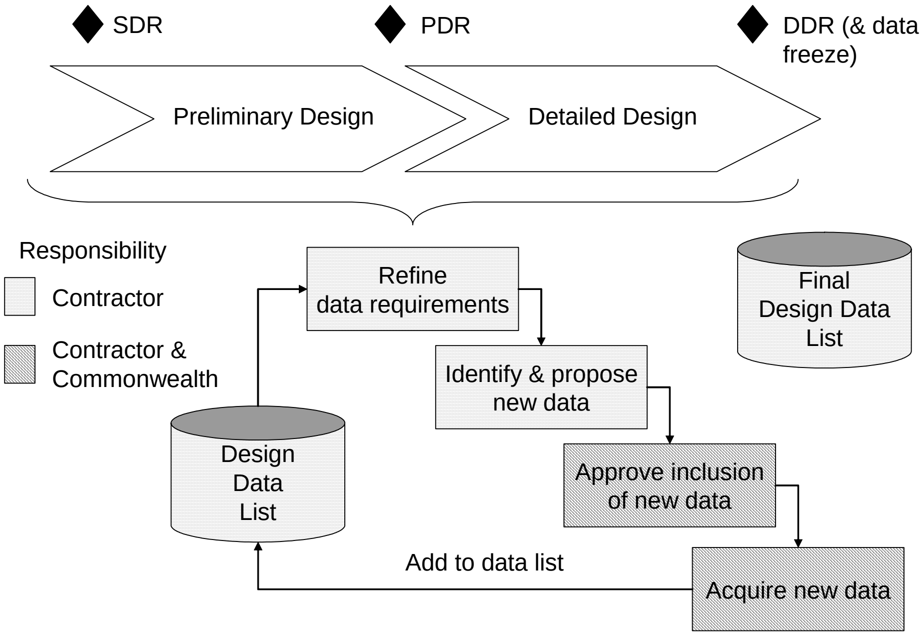

Figure 6-3: Data Acquisition Process leading to Data Freeze at DDR

143. During the early stages of preliminary design, major categories of data supporting the design of the simulation are identified and processed. During the latter stages of preliminary design and into detailed design, the data requirements are likely to become much more focused and detailed. As new data is acquired, it is added to the data list developed and maintained by the Contractor. The data list is frozen following successful DDR.

144. Following DDR, the design and development concludes and integration and testing begins. Clearly the use of design data in this process is of critical importance. The foundation of the simulation design is based on the use of approved data during the development process. For guidance on approval of simulation data, see Chapter 7 (Verification, Validation and Certification of Simulation Data).

6.4 UTILISATION AND SUPPORT STAGE ACTIVITIES

145. The simulation system is likely to spend a vast majority of its life in a stage called utilisation and support. The key activities that will occur during this stage that impact on simulation data include the maintenance of simulation data and the inevitable, periodic need to modify the simulation system.

6.4.1 Maintaining Simulation Data

146. Simulation design and acquisition is often based on what is generally referred to as "best available data". "Best available data" as the name suggests is the best data available at the time that fulfils data requirements within the time and cost constraints of the acquisition. It is therefore recommended that those managing the simulation system maintain a watch over data availability with a view to upgrading the simulation data where possible.

147. Another maintenance aspect to be considered is that some simulation data becomes "stale" over time and needs to be updated and maintained. Examples of stale data are provided in Annex C. The examples emphasise that simulation data does not necessarily remain valid for the entire life of the simulation. Active steps must be taken during utilisation and support to ensure that the simulation remains sufficiently faithful and representative of the real world to fulfil the original objectives of the system.

6.4.2 Simulation System Modifications

148. If changes or modifications occur to the system being simulated, then it stands to reason that the simulation itself will also be subject to modification to ensure continued simulation fidelity.

6.5 RETIREMENT ACTIVITIES

149. Ultimately, every lifecycle concludes with replacement or retirement of the system. In the case of simulation systems, the data underpinning the simulation may still be of use elsewhere in the Defence simulation community. Defence simulation users should therefore consult with the support organisations listed in Chapter 5 before disposing of simulation data.

6.6 OTHER DATA ACQUISITION ISSUES

150. It is also worth mentioning some important peripheral issues that should be addressed during any data acquisition process. These issues include the ownership of the data, and interoperability and reuse issues, and data security.

6.6.1 Intellectual Property and Ownership

151. Some of the data that is acquired with a simulation will be provided under some form of user license or agreement that limits the subsequent use, distribution and modification of the data. These limitations must be known and recorded during the acquisition process. Limitations on the use of data may make otherwise suitable data unsuitable for use. To that end, when acquiring data, the Commonwealth must ensure that intellectual property rights and ownership/licensing issues do not preclude current and future use of the data in a realistic set of circumstances. At the same time, the Commonwealth should not insist on complete ownership and freedom of simulation data unless it is justified. Significant cost increases may result from the desire to have total ownership and control over some types of simulation data.

152. Similarly, if data is provided by the Commonwealth, the Commonwealth should consider limiting the use of the data to preclude Contractors from exploiting Commonwealth data without adequate benefit to the Commonwealth.

153. Where the Commonwealth wants to own simulation data for possible future reuse without exposing itself to acquisition risks detailed in this Chapter, the Commonwealth could engage the Contractor to identify and acquire suitable data on behalf of the Commonwealth. The Commonwealth can then provide that data back to simulation contractors as GFM for use during the design, development and testing of the simulation system.

6.6.2 Interoperability and Reuse

154. Where possible, data should be acquired against preferred data standards as detailed in Chapter 4 (Simulation Data Standards) or advised by ADSO. By acquiring data that complies with standards, the possibility of reuse of the data or data sharing with other simulations within the DSE increases. Most current Systems Engineering standards implore the use of open standards to attempt to "future proof" systems from changes in direction as the system moves through its lifecycle[12]. Issues such as through-life support are enhanced by the use of industry standards in design (including data).

155. Where simulation data is acquired against known data standards, the acquirer maximises the chances of being able to import that data into a range of simulation data tools and applications. The tools and applications are then capable of translating, manipulating and reformatting the data according to their own requirements. By using known data standards, acquirers protect themselves against data loss during the importation or translation process. Similarly, storage of simulation data in data repositories is likely to be much simpler and more successful if the data is acquired in recognised formats.

6.6.3 Data Security

156. It is probable that simulation systems within the DSE will make use of sensitive data. Examples include weapon system performance, sensor capability and EW vulnerabilities. It is critical that the data list developed during the acquisition process and maintained throughout the simulation system's life records the classification of items of data. It is similarly critical that the appropriate handling and storage procedures associated with classified data and classified data processing systems are adhered to[13].

157. Another related issue occurs where the combination of an unclassified simulation and appropriate unclassified data results in the derivation of classified performance information. This issue relates more to the security of the simulation system itself rather than the security of the data. It does, however, serve as a reminder that a collection of unclassified data may result in a classification higher than that of the individual items of data. This concept is called "aggregation". Areas where there are collections of different data types of different classifications need to be mindful of the aggregated classification of the data set as well as the individual classification.

[12] For example, starting with MIL-STD-499B Systems Engineering developed during the 1980s.

[13] Readers should refer to the Defence Security Manual (DSM) series of publications and their Unit Security Officer (USO).

7 VERIFICATION, VALIDATION & CERTIFICATION OF SIMULATION DATA

7.1 INTRODUCTION

158. Verification, Validation and Accreditation (VV&A) is the term associated with the activities necessary to demonstrate that a simulation is fit for the purpose for its intended use. In the specific case of a simulation, it is an attempt to prove that the simulation has been built to the design specification (verification), that the simulation design represents its intended real world equivalent (validation) and that the simulation has been authorised for a specific application by an appropriate body (accreditation). Together, these activities essentially define whether a simulation is "fit for purpose" and authorised to be used for that purpose.

159. Since all simulations are driven by their source data, it follows that the credibility of this data is of key importance in achieving the successful VV&A of the end simulation. Regardless of the quality of the model algorithms, development tools, application or operating environments, if the integrity of the source data is not assured, then the validity of the final simulation cannot be confidently known.

160. It is therefore essential to a successful simulation that the source data is subjected to a Verification, Validation and Certification (VV&C) process.

7.2 VV&C OF SIMULATION DATA

161. Given the extensive volume, subject areas, sources and types of data used in a typical simulation and the specialised nature of simulation data V&V, it is impractical to impose on developers or users the requirements of the accreditation system normally associated with a VV&A program. This is due to data being certified to a particular standard as opposed to a particular use to ensure its availability to many differing purposes. Instead, the process of Accreditation is replaced with the act of Certification hence the acronym VV&C rather than VV&A.

162. When applied to simulation data, Certification can be defined as:

"*The determination that data has been verified and validated for a particular use*[14]"

163. Therefore, the entire process of VV&C for simulation data is that of verifying the internal consistency and correctness of data, validating that it represents characteristics of real world entities appropriate for its intended purpose and certifying it as having a specified level of quality or as being appropriate for a specified use(s).[15]

164. More than any other V&V process, the V&V of simulation data relies heavily on the knowledge and experience of SMEs. Due to the diverse nature and behaviour of the real world entities being modelled, it is not possible to establish a set of template formats against which to measure conformance of the sourced data. Instead, it is necessary for an appropriate SME (often a producer and/or developer) to review the specified data requirements for their

[14] DoD 5000.59-P, "Modeling and Simulation Master Plan," October 1995
[15] IEEE Std 1278.4-1997

particular domain (radar, aero/hydrodynamics, ballistics) and make an assessment on the suitability of that data to support the designated application.

7.3 VV&C OBJECTIVES

165. VV&C has a number of key objectives:

a. To ensure that the data selected is the most appropriate for the model or simulation for which it is designated.

b. To ensure that the data is correctly prepared for its target model and has not been degraded during any transformation processes.

c. To ensure that the data accurately represents the real world to be simulated.

d. To provide a valid determination that the data is "fit for purpose".

166. As with the models for which simulation data is intended, it is often a fact that the data collected will only be suitable for certain model applications. This is not always the case, for example a digital terrain file in standard format may be usable in dozens of different applications even outside the simulation domain. However, with more specialist models such as weather simulations or aircraft sensors, the gathered data will often only be applicable to the specific application for which it has been sourced. To this end, it is necessary for the relevant SME to ensure that the scope and type of data corresponds to the requirements of the simulation model.

167. Once it has been determined that the correct scope and type of data has been obtained, the user needs to be sure that the data is in a usable format and structure to meet the needs of the modeller and model. It creates a great deal of nugatory effort when a data source needs to be manually reformatted to get the information into a structure where it can be accessed by the modelling software. In addition, it needs to be assured that any decomposing or reformatting of the original data to meet the interface requirements of the target software does not alter or in any way degrade the quality of the original data.

168. Finally, after the data has been assessed as suitable to meet the requirements of the target model, both in format and appropriateness, the user needs to establish that the data is an accurate representation of the real world entity, phenomena or effect which is being modelled. Since the V&V of simulation data and that of the overall simulation (including models) is inextricably linked by the interaction of the source data with the programming code, this activity is essential to the ongoing V&V activities of the simulation system and the determination of its real world accuracy.

7.4 V&V PROCESS

169. The V&V process for simulation data should start at the very beginning of a project and should be conducted hand in hand with the V&V activities for the models and simulation itself. In addition, the process and particulars for VV&C of the simulation data should be included in the VV&A plan for the simulation. There are a number of reasons for this approach:

a. Errors discovered earlier in the process will be less costly to rectify.

b. Data limitations may drive design changes which are difficult to implement in the later stages of development.

c. Certain objectives (operational, functional or training) may be deemed unacceptable due to the effort or cost of obtaining appropriate data.

d. The security classification of certain data types such as ESM or weapon capabilities may drive handling, access and management overheads and also the development approach.

e. As with any acquired system, the early and successful conduct of V&V activities lowers the overall risk of the program in terms of cost and schedule.

170. Figure 7-1 shows the typical correlation between data V&V activities and those of the overall simulation project. It should be noted that although there are convenient associations between the data activities and overall simulation activities, the enormity and intricacies of simulation data mean that it is often necessary to commence the data related activities in advance of the main simulation development and continue them long after the major development for the simulation has passed. This means that the process of data V&V evolves very much into an iterative process until the delta between the available data and required data is within acceptable tolerances (as determined by the source requirements and the objective of the simulation).

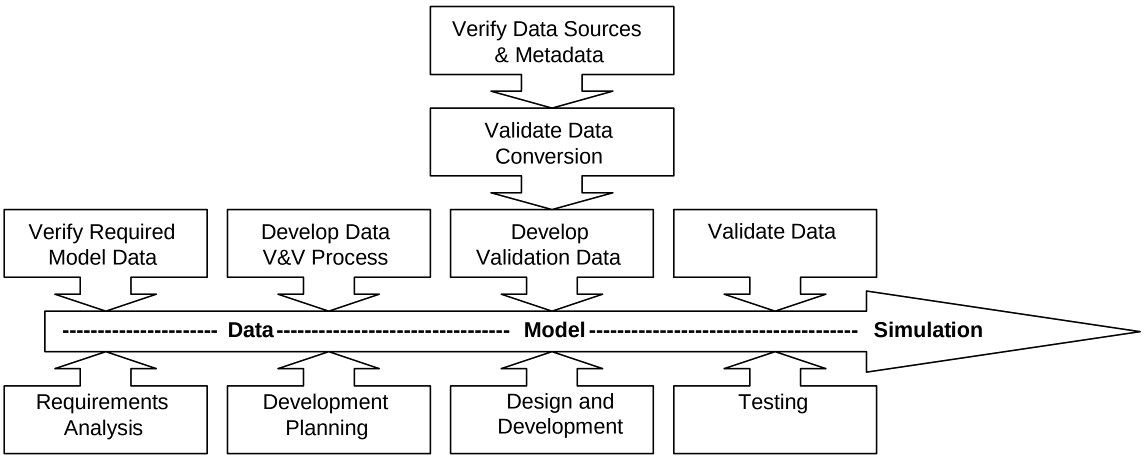

Figure 7-1: Data V&V Correlation with Simulation V&V

7.4.1 Requirements Analysis

171. As soon as the requirements for the overall simulation system are being defined, the analysis of the data to support the models should commence. This analysis should include two main areas:

a. The limitations presented by the management criteria of the overall simulation which may affect the ability to obtain or process adequate data such as cost, schedule and risk.

b. Refining the requirements of the simulation data to support the intended application including detail, accuracy and volume. This information will need to be defined for each category and subset of data required for the entire simulation.

172. At the completion of this process, the user, developer and associated SMEs should have verified (given the maturity of the model requirements) that the specified data requirements will meet the needs of the simulation conceptually and in terms of accuracy, fidelity, and availability of each subset or aggregation.

<u>DATA AIM</u> *Verify that the data requirements, if met, will satisfy the needs of the model and the simulation*

7.4.2 Development Planning

173. In planning the overall simulation development, it is essential to take into account the requirements of the simulation data. Given the direct reliance of each model on the data assigned to it, the design and implementation of the simulation will be impacted by the eventual decision on data types and sources.

174. As the simulation requirements analysis process is being refined, the data sets chosen to meet the requirements should begin to be sourced. This includes identifying appropriate resources and where possible gathering candidate data and metadata records. Metadata in particular can be invaluable in determining whether a particular data set is appropriate for its designated model (defines resolution, limits, currency, revisions etc). This process of identifying appropriate resources will also isolate those data sets for which a suitable source does not exist and therefore feed back into the requirements analysis and project management reviews to determine whether new data should be developed or requirements changed.

175. This is also the stage at which the formal verification and validation process for the data should be determined. In most cases, it is the interaction between the model code/algorithms and the input data which produces the simulation of the real world object, effect or phenomena and therefore the validation of the model and that of the input data are almost always allied. The inputs, outputs, visual renders and behavioural effects must be defined and shown to validate each data set (and model) before the development process commences.

<u>DATA AIM</u> *Plan the Verification and Validation process*

7.4.3 Design and Development

176. The development of the models and overall simulation involves the translation of the original requirements into functional, behavioural and physical representations that meet the simulation objectives. As soon as the design and development phase begins (and often sooner if it can be done with an adequate level of confidence) the metadata from the confirmed candidate data sources identified during the planning phase should be formally reviewed for compliance. The objective of this activity is to ensure that the quality, currency, resolution, accuracy and availability etc of the designated data (from the identified data source) will meet the development program management and technical requirements. If it is decided that a particular dataset (identified from a specific source) is not appropriate, the user must make a determination as to whether a different source should be found or, depending on the reason for unsuitability, whether it will be necessary to alter the driving requirements and thus repeat the earlier phase of requirements review and source selection.

177. It is also during the design and development phase that validation data should be collected. In those instances where the model or simulation is of a complex system it is necessary to gather real world data (reference data) against which the model can be validated. This is the same data which was defined in the planning phase. Where real world data is not available, or appropriate, SMEs should define the expected outcomes from given scenarios and inputs. Again, these outcomes should correspond to the validation activities identified in the planning phase.

178. At this stage in the program the developers will make any necessary changes to the format and structure of the supplied data in order to configure it for use in the target model. It therefore becomes necessary to validate the techniques and methodology used to convert the data and, upon completion of the conversion process, verify that the data has not been degraded or altered in any way which will affect its suitability for the target model (note, a change may occur which does not affect the performance of the end model and therefore is acceptable).

DATA AIM *Validate data conversion techniques and processes* *Verify data sources, suitability of metadata and data conversion results* *Develop validation data for testing*

7.4.4 Testing

179. Once development of the models has been completed, they will be 'exercised' to assess whether the correct outputs are being generated (visual, behavioural etc). In the case of simple physical entity data such as dimensions, colours and textures, this process is less complicated; however, for complex systems such as sensors and dynamic models the activity is usually multi layered and incremental in order to capture the full range of inputs and responses within a defined operating range, both for individual models and integrated simulations (boundary conditions, operating limits, etc). This process is, in effect, validating the models and their source data simultaneously. The outputs are compared with those documented in the V&V plan and the resulting data is assessed for compliance.

180. If any output data diverges from the expected baseline it becomes necessary to evaluate the results and trace the source of the divergence through the model design and back to the source data (if it goes that far). Following the evaluation, the cause of the variation is assessed and a course of action determined. If the course of action results in changes to the source data or the core simulation model then it is necessary to revisit the sequence of activities defined in this Chapter and repeat those affected by the design changes up to and including retesting (revalidation).

181. Once the validation results correspond to the defined outputs documented in the V&V Plan, it can be considered that the data has been validated as appropriate for use in a particular model or simulation.

DATA AIM *Validate data against defined results* *Assess variations* *Implement review, rectification and revalidation*

7.5 CERTIFICATION

182. Certification of simulation data has two perspectives; producer and user.

183. Producer certification is essentially a determination by the data producer that the subject data conforms with the specified standards and criteria defined by the user. For example, if a user required a selection of geographic terrain data in a particular format and to a particular standard (e.g DTED Level 1), then the producer certification is simply a declaration that the supplied data complies with these standards. This principle applies to almost any type of data. In terms of a simulation procurement lifecycle (and in an ideal world), producer certification should be achieved well in advance of the VV&A activities for the entire simulation (even before development commences if possible). This will allow the user certification to be conducted with a high level of confidence in the supplied data.

184. User certification however is more subjective and is not always confined by specific standards or criteria. User certification is the determination by the simulation sponsor that the data used in a specific model has been verified and validated as suitable for that particular purpose. User data certification is therefore implicit in the acceptance of the data for use in the accreditation of the simulation. The data user should support the VV&A of the simulation by applying the data metadata to demonstrate the suitability of the sourced data to meet the model requirements. Unlike producer certification, it is unlikely (in most cases) that user certification will be achieved prior to the VV&A of the simulation models. This is because the very act of exercising each simulation model and determining that it meets the requirements of the simulation is necessary before it can be categorically stated (certified) that the supplied data is appropriate for the intended simulation purpose.

185. Certification of simulation data therefore involves two activities.

a. Confirm that the produced/supplied data meets the specific technical requirements, standards and criteria defined by the user.

b. Confirm that the verification and validation of the data was successfully completed for the specific simulation application.

DATA AIM

Certify that the data was delivered to the specified standards and that the V&V process was successfully completed for the designated simulation.

ANNEX A - EXAMPLE METADATA FILE FOR GEOSPATIAL DATABASE

USGS 300 Meter Resolution, 1-Degree Digital Elevation Models (DEM) for CONUS, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands
(Source:
http://www.epa.gov)

Identification_Information:

Citation:
Citation_Information:
Originator: U.S. Environmental Protection Agency/Office of Water/OST Basins
Publication_Date: 19980401
Title:
USGS 300 Meter Resolution, 1-Degree Digital Elevation Models (DEM) for CONUS, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands
Publication_Information:
Publication_Place: Washington DC
Publisher: US EPA/Office of Water
Online_Linkage:
For BASINS model and hydrographic data <http://www.epa.gov/OST/BASINS/>
For original metadata and documentation of source data <http://nsdi.usgs.gov/products/dem.html>
Description:
Abstract:
Digital Elevation Model (DEM) is the terminology adopted by the USGS to describe terrain elevation data sets in a digital raster form. The standard DEM consists of a regular array of elevations cast on a designated coordinate projection system. 1-degree DEMs (3- by 3-arc second data spacing) provides coverage in 1- by 1-degree blocks. The basic elevation model is produced by or for the Defense Mapping Agency (DMA), but is distributed by the USGS in the DEM data record format. Coverage is for the United States.

The US EPA 1-degree DEM shapefiles are polygonal representations of the original USGS DEM raster files resampled to a 300m x 300m cell size. Catolog Units (CU)in each of the ten US EPA Regions were buffered by a two mile distance. The buffered CUs were used to clip corresponding areas from the DEM raster files. The resulting files were output in Environmental Systems Research Institute's (ESRI) shapefile format. Two attribute fields were added to each shapefile's database component to represent elevation in both meters and feet.

Purpose:
DEM's can be used as source elevation data for digital orthophotos, and, as layers in geographic information systems, for earth science analysis. DEM's can also serve as tools for volumetric analysis, for site location of towers, or for drainage basin delineation. The ESRI shapefile format allows for analysis involving elevational data and also provides for the possibility of contour generation.
Supplemental_Information:

One degree DEM's have rows and columns which are based on the geographic coordinate system. The use of this system results in a rectangular DEM which shares a common edge and therefore duplicate points with other adjacent 1-degree DEM's.

The original USGS DEMs were downloaded and imported into ArcInfo grid format using the demlattice command. An Arc Macro Language (AML) procedure was used to create Arcview shapefiles for each CU in the United States. Processing started with generating a list of CUs in an EPA Region and reading the list into ArcInfo. For each CU in the list, an ArcInfo coverage was generated by reselecting all polygons associated with the CU from a nationwide CU coverage. The individual CU polygon coverage was then buffered with a two mile buffer distance. The buffered coverage was overlayed onto an index coverage of 1:250,000 scale DEMs for the United States. A list was generated of all the DEMs that the buffered coverage touched on the index. Each DEM grid coverage in the resulting list was then mosaiced into a single grid coverage. This single grid coverage was then projected from a geographic-decimal degrees to an albers-meters projection. The single grid coverage is resampled to a 300 meter x 300 meter cell size and converted from a raster coverage to a vector polygon coverage. The polygon grid coverage was clipped by the buffered CU coverage and projected back to geographic-decimal degrees. Polygons were built for the clipped DEM grid coverage and an ArcView shapefile built. Once the shapefile was built, the database component was modified to include fields for elevation in both meters and feet.

Converting the original 1-degree DEMs into ESRI shapefile format reduced the number of cells in each DEM coverage by unioning adjacent polygons with the same elevation.

DEM files for Alaska, Puerto Rico, and the U.S. Virgin Islands would not initially import into ArcInfo. ArcInfo versions below 7.1.2 have a bug in the DEMLATTICE command that incorrectly reads the accuracy code found in the first line of the file. This code needs to be changed to 0 from the original codes of either 2231 or 2232. The changes were made by changing the block size of the file. The command line for this step is:

dd if=file.dem of=file.var ibs=4096 cbs=1024 conv=unblock.

The first line of code was then edited to change the accuracy code. This step is done by replacing the each character of 223 with a space and the final character of the four digit code with a zero.

Reviews_Applied_To_Data Upon completion of processing, each CU shapefile was viewed in an ArcView project to verify the completeness of the datafiles, to look for holes in the data, and to look for spikes in the data. Individual polygons were measured to verify the 300 meter x 300 meter cell size. Additionally, a coverage of all CUs in the US EPA Region was drawn on top of the 1-degree DEM shapefiles to verify that each CU was processed.

References_Cited U.S. Geological Survey, 1993, Digital Elevation Models-Data Users Guide 5, National Mapping Program, USGS, Reston, Virginia <http://edcwww.cr.usgs.gov/glis/hyper/guide/usgs_dem>

U.S. Geological Survey, 1995, Metadata for 1-degree Digital Elevation Models. U.S. Geological Survey, Reston, Virginia. <http://nsdi.usgs.gov/products/dem.html> and <http://edcwww.cr.usgs.gov/glis/hyper/guide/1_dgr_dem>

Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 19791000
Ending_Date: 19900401
Currentness_Reference: Publication date
Status:
Progress: Complete
Maintenance_and_Update_Frequency: Irregular
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -170.0000
East_Bounding_Coordinate: -65.0000
North_Bounding_Coordinate: 70.0000
South_Bounding_Coordinate: 17.0000
Keywords:
Theme:
Theme_Keyword_Thesaurus: none
Theme_Keyword: DEM
Theme_Keyword: digital elevation model
Theme_Keyword: digital terrain model
Theme_Keyword: hypsography
Theme_Keyword: altitude
Theme_Keyword: height
Theme_Keyword: contour line
Theme_Keyword: digital contours
Theme_Keyword: shapefile
Place:
Place_Keyword_Thesaurus: Geographic Names Information System
Place_Keyword: Conterminous United States of America
Place_Keyword: Puerto Rico PR
Place_Keyword: U.S. Virgin Islands VI
Place_Keyword: Alabama AL
Place_Keyword: Alaska AK
Place_Keyword: Arizona AZ
Place_Keyword: Arkansas AR
Place_Keyword: California CA
Place_Keyword: Colorado CO
Place_Keyword: Connecticut CT
Place_Keyword: Delaware DE
Place_Keyword: District of Columbia DC
Place_Keyword: Florida FL
Place_Keyword: Georgia GA
Place_Keyword: Hawaii HI
Place_Keyword: Idaho ID
Place_Keyword: Illinois IL

Place_Keyword: Indiana IN
Place_Keyword: Iowa IA
Place_Keyword: Kansas KS
Place_Keyword: Kentucky KY
Place_Keyword: Louisiana LA
Place_Keyword: Maine ME
Place_Keyword: Maryland MD
Place_Keyword: Massachusetts MA
Place_Keyword: Michigan MI
Place_Keyword: Minnesota MN
Place_Keyword: Mississippi MS
Place_Keyword: Missouri MO
Place_Keyword: Montana MT
Place_Keyword: Nebraska NE
Place_Keyword: Nevada NV
Place_Keyword: New Hampshire NH
Place_Keyword: New Jersey NJ
Place_Keyword: New Mexico NM
Place_Keyword: New York NY
Place_Keyword: North Carolina NC
Place_Keyword: North Dakota ND
Place_Keyword: Ohio OH
Place_Keyword: Oklahoma OK
Place_Keyword: Oregon OR
Place_Keyword: Pennsylvania PA
Place_Keyword: Rhode Island RI
Place_Keyword: South Carolina SC
Place_Keyword: South Dakota SD
Place_Keyword: Tennessee TN
Place_Keyword: Texas TX
Place_Keyword: Utah UT
Place_Keyword: Vermont VT
Place_Keyword: Virginia VA
Place_Keyword: Washington WA
Place_Keyword: West Virginia WV
Place_Keyword: Wisconsin WI
Place_Keyword: Wyoming WY

Access_Constraints: None
Use_Constraints: None

Security_Information:
Security_Classification_System: None
Security_Classification: UNCLASSIFIED
Security_Handling_Description: None

Native_Data_Set_Environment: ArcView 3.x shapefiles on Windows 95 PC

Data_Quality_Information:
Attribute_Accuracy:

Attribute_Accuracy_Report:
The accuracy of a DEM is dependent upon the level of detail of the source and the grid spacing used to sample that source. The primary limiting factor for the level of detail of the source is the scale of the source materials. The proper selection of grid spacing determines the level of content that may be extracted from a given source during digitization.
Logical_Consistency_Report:
The fidelity of the relationships encoded in the data structure of the DEM are automatically verified using a USGS software program upon completion of the data production cycle. The test verifies full compliance to the DEM specification
Completeness_Report:
The DEM is visually inspected for completeness on a DEM view and edit system for the purpose of performing a final quality control and if necessary edit of the DEM. The physical format of each digital elevation model is validated for content completeness and logical consistency during production quality control and prior to archiving in the National Digital Cartographic Data Base. Level 2 DEM: Level 2 DEM's may contain void areas due to interruptions to contours in the source graphic or DLG. Void area elevation grid posts are assigned the value of -32,767. In addition, suspect elevation areas may exist in the DEM but are not specifically identified. Suspect areas can be located on the source graphic as a "disturbed surface" which are symbolized by contours overprinted with photorevised or other surface patterns.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
Digital elevation models meet horizontal National Map Accuracy Standards (NMAS) accuracy requirements. NMAS horizontal accuracy requires that at least 90 percent of points tested are within 0.02 inches of the true position. The primary reference from which 1-degree DEM accuracy is derived is source-based, as a minimum, meeting NMAS For 100,000-scale USGS topographic series maps.
Quantitative_Horizontal_Positional_Accuracy_Assessment:
Horizontal_Positional_Accuracy_Value: 300
Horizontal_Positional_Accuracy_Explanation:
Digital elevation models meet horizontal National Map Accuracy Standards (NMAS) accuracy requirements. RMSE of the DEM. The 1-degree DEM accuracy is source-dependent and is based on the 1:100,000-scale USGS topographic series map.
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report:
The vertical root-mean-square error (RMSE) statistic is used to describe the vertical accuracy of a DEM, encompassing both random and systematic errors introduced during production of the data. The RMSE is encoded in element number 5 of record C of the DEM. Accuracy is computed by a comparison of linear interpolated elevations in the DEM with corresponding known elevations. Test points are well distributed, representative of the terrain, and have true elevations with accuracies well within the DEM accuracy criteria. Acceptable test points include, in order of preference: field control, aerotriangulated test points, spot elevations, or points on contours from existing source maps with appropriate contour interval. A minimum of 28 test points per DEM is required to compute the RMSE, which is composed of a single test using 20 interior points and 8 edge points. Edge points are those which are located along, at, or near the quadrangle neatlines and are deemed by the editor to be useful to evaluating the accuracy of the edge of the DEM. Collection of test point data and comparison of the DEM with the quadrangle hypsography are conducted by the

quality control units within the USGS. There are three types of DEM vertical error; blunder, systematic and random. These errors are reduced in magnitude by editing but cannot be completely eliminated and may be encountered.

Blunder errors are those errors of major proportions and are easily identified and removed during interactive editing. Systematic errors are those errors that follow some fixed pattern and are introduced by data collection procedures and systems. These error artifacts include: vertical elevation shifts, misinterpretation of terrain surface due to trees, buildings and shadows, and fictitious ridges, tops, benches or striations. Random errors result from unknown or accidental causes. DEMs are edited to correctly depict elevation surfaces that correspond to water bodies of specified size.

Level 2 DEM: A vertical RMSE of one-half of the contour interval (of 100,000-scale source), determined by the source map, is the maximum permitted. Systematic errors may not exceed one contour interval, determined by the source map, is the maximum permitted. Systematic errors may not exceed one contour interval specified by the source graphic. Level 2 DEM's have been processed or smoothed for consistency and edited to remove identifiable systematic errors.

Lineage:
Process_Step:
Process_Description:
Example of the GIS process for the DEM convertion to shapefiles

PROJECT COVER DEMCLIPPED OUTCOV BUILD OUTCOV POLY IMPORT COVER outcov.E00 outcov

Process_Date: 19980401

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Geographic:
Latitude_Resolution: 0.0001
Longitude_Resolution: 0.0001
Geographic_Coordinate_Units: Decimal Degrees
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6,378,137
Denominator_of_Flattening_Ratio: 298.257
Vertical_Coordinate_System_Definition:
Altitude_System_Definition:
Altitude_Datum_Name: National Geodetic Vertical Datum of 1929
Altitude_Resolution: 1
Altitude_Distance_Units: meters
Altitude_Encoding_Method:
Explicit elevation coordinate included with horizontal coordinates

---

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: DEM.SHP
Entity_Type_Definition: DEM shapefile

Entity_Type_Definition_Source: USEPA/OW
Attribute:
Attribute_Label: ELEV_M
Attribute_Definition: Elevation in meters
Attribute_Definition_Source: Generated during ArcInfo processing
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Integer
Enumerated_Domain_Value_Definition: 8 11 F 0
Enumerated_Domain_Value_Definition_Source: USEPA/OW
Attribute:
Attribute_Label: ELEV_FT
Attribute_Definition: Elevation in feet
Attribute_Definition_Source: Generated during ArcInfo processing
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Integer
Enumerated_Domain_Value_Definition: 8 11 F 0
Enumerated_Domain_Value_Definition_Source: USEPA/OW

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: USEPA Office of Water/OST Basins
Contact_Address:
Address_Type: mailing address
Address: 1200 Pennsylvania Ave., NW (4305T)
City: Washington
State_or_Province: District of Columbia
Postal_Code: 20460
Contact_Voice_Telephone: (202) 260-7301
Contact_Facsimile_Telephone: (202) 260-9830
Hours_of_Service: 9-3 EST
Distribution_Liability:
Although these data have been processed successfully on a computer system under contract to the U.S. Environmental Protection Agency (USEPA), no warranty expressed or implied is made by the USEPA regarding the utility of the data on any other system, nor shall the act of distribution constitute any such warranty. The USEPA will warrant the delivery of this product in computer-readable format.
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name:
Environmental Systems Research Institute (ESRI) ArcView Shapefile
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name: <http://www.epa.gov/OST/BASINS/>
Offline_Option:

Offline_Media: CD-ROM
Recording_Format: ISO 9660
Fees: None
Ordering_Instructions:
When requesting data by phone or mail, please inquire about spatial data sets that work with Better Assessment Science Integrating Point and Nonpoint Sources (BASINS). The BASINS web page has instructions for downloading datasets. It also has a link to The National Center for Environmental Publications and Information (NCEPI), from which BASINS CD-ROMs may be ordered. Each CD-ROM contains the BASINS v2.0 Application and this data set along with others covering the spatial extent of an EPA Region.

Metadata_Reference_Information:
Metadata_Date: 19980401
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: USEPA Office of Water/OST/SASD Basins
Contact_Address:
Address_Type: mailing address
Address: 1200 Pennsylvania Ave., NW (4305T)
City: Washington
State_or_Province: District of Columbia
Postal_Code: 20460
Contact_Voice_Telephone: 202-260-7301
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: 19940608

ANNEX B - REFERENCE DATA STANDARDS

The table details the reference documents relevant to this guide.

Table 1 - Simulation Metadata Standards

Data Type	Applicable Metadata Standard	Notes
Environmental		
• Geospatial	ISO/ TC211 19115	This metadata data standard is being harmonised with FGDC Content Standard (see below).
• Geospatial (including maps, and place descriptions)	FGDC-STD-001- 1998 Content Standard for Digital Geospatial Metadata (CSDGM)	US Government standard for geospatial metadata.
• Shoreline Data	GDC-STD-001.2-2001 Metadata Profile for Shoreline Data	To be used as an extension or profile to the existing CSDGM.
• Hydrographic		
• Meteorological	ISO DIS 19115	ISO 19115 has been deemed an acceptable metadata format for meteorological data when combined with XML formatting and file naming conventions.
Entity Data – Physical		
• Images, animated images, sound recordings, 3D	IMS Dublin Core Metadata Element Set (DCMES)	
• Images	NISO Z39.87-2002 AIIM 20-2002 Data Dictionary - Technical Metadata for Digital Still Images	Currently in draft trial form.
Entity Data -Behavioural	Dublin Core Metadata Element Set (DCMES)	There are no obvious choices for behavioural metadata standards.
Entity Data - Design	Dublin Core Metadata Element Set (DCMES)	There are no obvious choices for design metadata standards.
General		
• Text	TEI (Text Encoding Initiative)	Descriptive metadata for encoding text in SGML.
• Comprehensive	Dublin Core	

Table 2 - Simulation Environmental Data Standards

Data Type	Applicable Standard	Notes
Geospatial		
• Raster Formats		
o RPF	MIL-STD-2411	Raster Product Format
o ADRG	MIL-A-89007	Arc Digitized Raster Graphic
o CADRG	MIL-C-89038	Compressed ARC Digitized Raster Graphics
o JPEG		Joint Photographic Expert Group format 24bit compressed image (raster). JPEG is designed for compressing either full colour or grey-scale digital images of 'natural', real-world scenes. It does not work so well on non- realistic images, such as cartoons or line drawings.
o GeoTIFF	MIL-C-89038	Georeferenced raster imagery (scanned maps, satellite images, results of geographic analysis, etc) in a non proprietary TIFF format.
o CIB	MIL-PRF-89041 MIL-PRF-89041(A) DRAFT	CIB is unclassified panchromatic (black and white) digital imagery produced to support a variety of mission planning and command, control, communications, and intelligence systems.
• Vector Formats		
o VPF	MIL-STD-2407	Vector Product Format
o WVS (WVSP)	MIL-W-89012 MIL-PRF-0089012A	World Vector Shoreline (Plus)
o VMAP		Vector Smart Map
o DCW	MIL-PRF-89039	Digital Chart of the World
o DNC	MIL-D-89023	Digital Nautical Chart
• Other Formats		
o DTED Level 0	MIL-PRF-89020A	
o DTED Level 1	MIL-PRF-89020A STANAG 3809	Performance Specification for Digital Terrain Elevation Data (DTED) level 1 19 April 1996.
o DTED Level 2	MIL-D-89020 STANAG 3809	Product Specification for Digital Terrain Elevation Data Level 2, Second Edition, April 1986.
o DFAD Level 1	MIL-PRF-89005	Digital Feature Analysis Data(DFAD) Levels 1/2, 5 August 1994. Replaced MIL-D-89005 and MIL-D-89006.
o DFAD Level 2	MIL-PRF-89005	Digital Feature Analysis Data(DFAD) Levels 1/2, 5 August 1994. Replaced MIL-D-89005 and MIL-D-89006.

o DFAD Level 3c	MIL-PRF-89017	Digital Feature Analysis Data (DFAD) Levels 1C/3C, 5 August 1994.
o WPI		World Port Index
o ONC		Operational Navigation Chart. The ONC is the standard worldwide small- scale (1: 1,000,000) aeronautical chart series, and contains cartographic data with an aeronautical overprint depicting obstructions, aerodromes, special use airspace, navigational aides and related data.
• Image Formats		
o JPEG		Joint Photographic Expert Group format 24bit compressed image (raster). JPEG is designed for compressing either full colour or grey-scale digital images of 'natural', real-world scenes. It does not work so well on non- realistic images, such as cartoons or line drawings.
o GeoTIFF	MIL-C-89038	Georeferenced raster imagery (scanned maps, satellite images, results of geographic analysis, etc) in a non proprietary TIFF format.
• Database Compatibility		
o SIF	MIL-STD-1821	Standard Interchange Format
o OpenFlight		Multigen Inc database file format.
o SEDRIS		Synthetic Environment Data Representation & Interchange Specification
o DIGEST	STANAG 7074	Digital Geographic Information Exchange Standard
Hydrographic		
o IHO S57		International Hydrographic Organization Transfer Standard for Digital Hydrographic Data, v3.1, November 2000.
Meteorological		
o FM 94-X-BUFR		Binary Universal Form for the Representation of Meteorological Data. Created by the World Meteorological Organization (WMO) in 1988. Besides being used for the transfer of data, BUFR is used as an on-line storage format and as a data archiving format.

ANNEX C - SIMULATION DATA ACQUISITION PROCESS

1. Acquiring simulation data can be a major undertaking. Major acquisitions, whether for systems like aircraft or warships or large quantities of simulation data, must be managed through a comprehensive process involving the identification of requirements, sourcing of appropriate solutions and the evaluation of those solutions against the initial requirements.

2. This Annex is written around the acquisition of significant quantities of simulation data. For smaller acquisitions or acquisitions that carry less technical risk, a tailored (or cut-down) version of this process may be adequate.

3. Significant simulation data acquisition projects should pass through a number of well-established stages as defined by standard system lifecycle models. There are many lifecycle models in existence but each model recognises that the project begins its life when a need is identified for a quantity of simulation data and ends when that data is eventually disposed of[16]. In middle of each lifecycle model consists of a number of stages defined by level or focus, the major products to be produced, and the preceding and succeeding stages surrounding it.

4. The acquisition of simulation data is usually considered to be merely a part of the overall lifecycle of a simulation system. Whilst this is a valid interpretation and may be fine when the required simulation data is readily available, stakeholders must be cognisant of their data requirements and must assume that the necessary data is not available. To that end, it is recommended that data requirements and data acquisition be considered as a major undertaking. Action must be taken to ensure the appropriate amount of data, to the appropriate level of fidelity and standards, is available at the appropriate times throughout the broader simulations system acquisition.

5. By way of a summary of this process and an example, it is instructive to walk through the development of one type of simulation system; a training simulator.

a. **Conceptual Design.** During the conceptual stages of a training simulator's lifecycle, training need and training method are considered to help justify and define the simulator acquisition. During this stage, the availability, fidelity, cost and lead time of major pieces of simulation data should be considered as the data defines the likely training utility possible from the simulation. During the tendering and source selection stages, contractual responsibility for acquisition and supply of simulation data must be considered, agreed and finalised. The contract can be thought of as a risk and responsibility allocation device and accordingly, responsibility for simulation data must be clear.

b. **Preliminary and Detailed Design.** During preliminary and detailed design, simulation data becomes increasingly important as simulation software, models and hardware are designed, populated and tested. A mechanism needs to be in place to allow both the Commonwealth and the contractor to propose, consider and approve major pieces of data for use in the design and testing of the simulation.

[16] R.I. Faulconbridge and M.J. Ryan, "Managing Complex Technical Projects – A Systems Engineering Approach", Artech House, Boston, 2003.

c. **Simulation System Acceptance.** During the latter stages of simulation system design and construction, test and evaluation become increasingly relevant to the Commonwealth and testing is done against specifications and results defined by simulation data. Accreditation of the simulation system is likely to be a prerequisite to Acceptance and as such will rely on the provision of certified simulation data.

d. **Simulation System Operation.** Even following acceptance, simulation data continues to be relevant to the operators of simulation systems. Whether the operators are ADF organisations or civilian contractors, there will be a need to continually maintain the simulator against some performance baseline. For example, if the training simulation system in this example supports training of aircrew on a certain aircraft, the simulation system must reflect changes to that aircraft system. Changes to the simulation system throughout its lifecycle continually place a need and focus on the acquisition of suitable simulation data.

6. During the definition of simulation data requirements, the concept of reuse of existing data must be considered to ensure the cost effectiveness of future simulation system acquisitions. To that end, ownership of the simulation data acquired to support a simulation system must be with the Commonwealth wherever possible and simulation data must be procured against agreed standards that are likely to support future reuse of the data.

SIMULATION DATA LIFECYCLE

7. The lifecycle model chosen for this discussion consists of the following major stages[17]:

a. **Concept Stage.** The concept stage commences with the identification of a need or concept for a set of simulation data. Often the need for a set of simulation data is driven by the development or modification of a related simulation system. Regardless of the driving force behind the need for the simulation data, this stage is an exploration and planning stage where important tasks such as availability/feasibility, market surveys and initial data requirements analysis are conducted. The concept stage of the lifecycle roughly corresponds to the Defence acquisition activities that lead up to contract signature. Key achievements in the conceptual stage include funding and project approval, requirements definition, and possibly source selection and contract signature. Note that data requirements continue to be refined after this point in parallel with the design and development of the simulation system.

b. **Development Stage.** The development stage concentrates on translating the broad requirements from the preceding stage into detailed and precise descriptions of the data requirements. The detailed descriptions of data requirements should be documented in the form of a data specification and should describe the type of data required, the quantity, quality and format needed and the recommended sources or collection processes. A mechanism may need to be established during this stage to approve sets of data requirements and authorise data collection activities to commence.

[17] ISO/IEC 15288:2002, Systems Engineering - System Life cycle processes.

c. **Production Stage.** The production stage is the final stage in the acquisition phase of the data lifecycle where data sets are collected or acquired, processed or translated into suitable formats and generally made ready for use by a given simulation system(s). Major data-related activities conducted in this phase include VV&C considerations detailed in Chapter 7 (Verification, Validation and Certification of Simulation Data).

d. **Utilisation and Support Stages**. Once the simulation system and its data has been installed onsite and ownership transitioned to the Commonwealth, data configuration management, storage and maintenance dominate. As described earlier in paragraph 5, there will be an ongoing need to update the data, add new data and remove old data from the simulation system throughout its life.

e. **Retirement Stage.** The simulation system enters the retirement stage when planning for retirement or replacement of the simulation system commences. Simulation data employed by the simulation system may be either discarded (if deemed of no further use) or made available to current or future simulation systems.

8. In major simulation data acquisitions, it is recommended that all of these stages and their individual activities are considered. In smaller data acquisitions or data acquisitions of commercially-available data, a tailored process involving blended stages is likely to be satisfactory. The most likely blending will be of the Development and Production stages.

9. During each of one of these stages, activities and products relating to simulation data must be considered. It is the intent of this section to investigate the major simulator data activities and products associated with the simulator lifecycle.

10. Note that ISO/IEC 15288 has been selected in lieu of other lifecycle models[18] as it provides sufficient detail in the acquisition stages of the simulation data lifecycle to support a discussion on the simulation data issues in each lifecycle stage. The ISO/IEC 15288 model is also extremely compatible with popular military[19] and, more recently, commercial[20] systems engineering standards widely used to support acquisition of broader simulation systems.

CONCEPT STAGE ACTIVITIES

11. Data is considered to be one of the six simulation “issues” to be explored when assessing a simulation proposal[21]. Scoping the data requirements for simulation systems must be done as early as possible and is therefore included in the Concept Stage of the lifecycle. This data scoping exercise ensures that any acquisition proposal contains accurate information relating to data requirements, data availability and possible data costs. The data scoping exercise must be performed with the overall simulation application in mind to ensure sufficient data is acquired to support the target simulation system. Scoping data requirements

[18] Other relevant lifecycle models such as the one contained in the Capability Systems Life Cycle Management Manual 2002 are valid and useful capability life cycle models but necessarily lack the detail to support a discussion on simulation data acquisition.

[19] Such as MIL-STD-499B Systems Engineering (Draft)

[20] Including IEEE-1220-1998 Application and Management of the Systems Engineering Process, and ANSI/EIA-632-1998 Processes for Engineering a System.

[21] DI(G) OPS 42-1 Defence Simulation Policy, 2001.

with the simulation application in mind also protects against the danger of over-specifying the simulation data requirements.

12. Current direction in Defence acquisition places considerable importance on accurate estimates of lifecycle costs from the very earliest stages in any system's lifecycle[22]. An accurate estimate of simulation lifecycle cost is simply not possible unless the total cost of simulation data acquisition and support is factored into the overall cost of the simulation capability. Some estimates put the cost of simulation data at up to 80% of the cost of the simulation system itself[23]. Even this estimate could be considered conservative as the requirements for data in some simulation situations is almost boundless[24].

Determination of Data Requirements and Gaps

13. During the conceptual design stage of the acquisition process, effort should be put into determining the major categories of simulation data required. Chapter 3 (Simulation Data) will assist in determining these categories. In parallel with this effort, the Commonwealth stakeholders should engage in discussions with ADSO to ascertain the extent of pre-existing data that may at least partially satisfy the data requirement of the simulation project.

14. When investigating existing simulation data, it is critical to determine whether the data has been through a formalised VV&C process and against what applications the data has been certified. This may save time and money in later lifecycle stages if the data does not need to repeat the VV&C process, but it will also ensure that the data is not applied to simulations for which it is not suitable.

15. With information regarding currently available simulation data in hand, and an understanding of the likely data requirements for the acquisition, the gap between what is required and what is currently available becomes obvious. This gap should be considered a potential risk due to the traditional difficulties associated with acquiring suitable simulation data within time and cost constraints. An estimate of the likely cost in terms of time and money associated with closing the gap can be made. Expert judgement is likely to be the best tool in determining this estimate. The main purpose of estimating the cost of the gap at this stage is to highlight the gap as a risk and to ensure that the existence of the gap does not impact on the very feasibility of simulation acquisition.

16. The data gap, the risks associated with closing the gap, and the cost and schedule impacts must be included in any proposal to acquire a simulation system when seeking project and funding approval. The process of determining the simulation data gap prior to submitting the simulation system proposal is illustrated below.

[22] See Capability Definition Documents Guide V1.1 November 2002 and Capability Systems Life Cycle Management Manual 2002.

[23] Defence Simulation Proposal Guide, ADSO, Canberra, 4 October 2002

[24] For example, the terrain database for a fast military aircraft is normally limited by the simulation budget rather than training requirement and the simulator operators would invariably like a larger area within which to train.

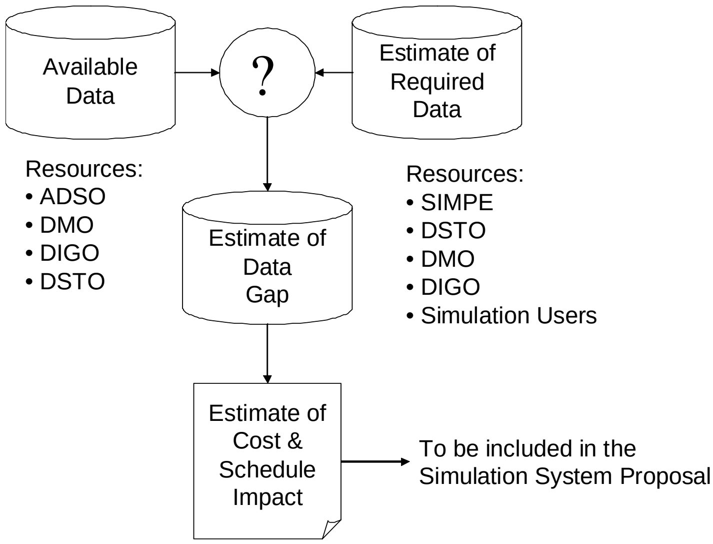

Figure C-1-1 : Commonwealth Estimation of the Data Gap

17. During the latter stages of conceptual design, the Commonwealth may seek information from industry in the form of tender responses. The tender responses must provide data-related information and demonstrate a commitment to the Commonwealth's preferred approach to data acquisition and management. As a minimum, the tender process should communicate the following information:

a. **Available Data**. The tenderers must know what data is available from the Commonwealth for use during the subsequent acquisition process. This allows tenderers to provide a more accurate estimate of the necessary effort to address any shortfall in the available data. Sufficient information about the data set must be provided to reduce the chances of invalid assumptions being made about the data's suitability. Note that by providing this information to the tenderers, the Commonwealth should not be perceived as guaranteeing the data as suitable for the particular purpose, but rather stating that the data is available if the tenderer considers it suitable.

b. **Data-related Constraints**. The Commonwealth must communicate any constraints being imposed on the data requirements of the undertaking in accordance with any extant Defence policies for data standards or reuse. These constraints may extend to intellectual property issues and licensing requirements.

c. **Detailed data requirements**. The Commonwealth is often not in the best position to determine detailed requirements for simulation data. The Commonwealth has estimated the requirements for data and the cost and schedule associated with its acquisition, but detailed information must be solicited from the tenderers during the RFT process. Each tenderer typically proposes slightly different solutions to simulation requirements and accordingly it can be expected that individual data requirements will also be slightly different. Tenderers must advise the Commonwealth of the data requirements for their simulation solution so that the cost and effort associated with data acquisition can be included in the tendered costs.

d. **Current Data Gap**. The tenderer should also be requested to provide detailed information on the gap that exists between the simulation data available from the

Commonwealth and detailed data requirements of the simulation. The data gap should be described in terms of the cost, ownership (for reuse), characteristics, timescales involved with acquisition. The cost of closing the gap must be included in the total tendered cost. The tenderer may need access to examples of the available data or may request additional information about the data during the tendering process in order to complete this step.

e. **Data Acquisition Process**. The tenderer should provide details of the recommended process for closing the gap during the acquisition contract. Information that should be provided includes the process used to analyse data requirements, responsibilities for data acquisition, sources and management approach. The tenderer should also provide a template called the data register (or similar) to be used throughout the acquisition process to record the simulation data being employed.

f. **Data Acquisition Risks**. In all likelihood, some of the data described in the data gap will be either extremely critical to the performance of the simulation and/or difficult to obtain. In either case, this type of data should be considered a risk and should be managed in accordance with the risk process detailed in the project's Risk Management Plan (RMP). Other risks might include the inability to obtain sufficient data or data of sufficient accuracy to perform the simulation. As with all risks, the tenderer should state what the risk is, the severity of the risk (in terms of probability of occurrence and impact), possible indicators that the risk is occurring and risk management strategies to be applied to manage the risk.

18. Although the process described in the preceding paragraph and sub-paragraphs sounds like a virtual repeat of the process undertaken by the Commonwealth during the simulation proposal development, there are important differences. Firstly, the estimation of data gap is being performed by each of the tenderers with their particular solution in mind. These estimates are likely to be much more refined than the estimates made by the Commonwealth during project approval. Additional information relating to data acquisition process and deliverables is also a key difference. The process is illustrated below:

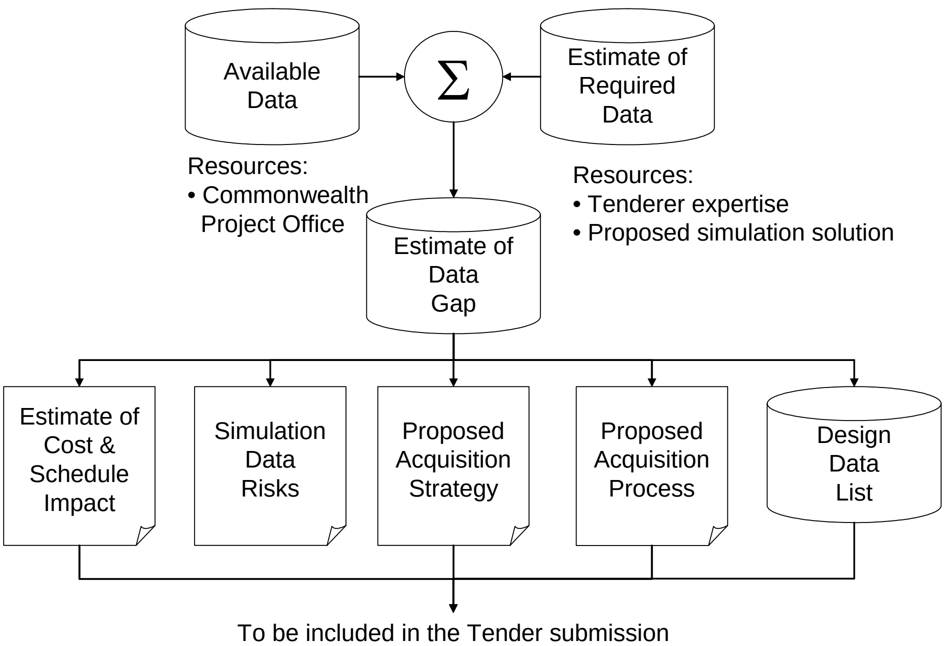

Figure C-1-2 : Tenderer Estimation of the Data Gap and Development of Data Acquisition Strategy

Draft Statement of Work Issues

19. There are additional data-related issues that should be captured in the appropriate places in the draft SOW issued by the Commonwealth during tendering. The draft SOW must clearly communicate who has responsibility for the provision of the different data sets listed in the data requirements and gap document. A recent report from the Australian National Audits Office[25] suggests that the Commonwealth should accept responsibility for data acquisition and provision. That suggestion was only partially accepted by the Commonwealth and project officers should exercise extreme care before accepting responsibility for the acquisition and provision of simulator data.

20. The Commonwealth must decide who is to take responsibility for the simulation data requirements because with responsibility comes acceptance of a certain amount of risk. Inadequate data leads directly to an inadequate simulation and if the Commonwealth has accepted responsibility for the provision of data, the Commonwealth must be willing to accept responsibility in any shortfalls in simulation performance caused by that data. In fact, the task of acquiring simulation data is likely to be a joint exercise shared by the eventual contractor and the Commonwealth. In some instances, the Commonwealth is likely to be the sole source of data. For example, behavioural data is likely to come from operating procedures and doctrine developed and owned by the Commonwealth. In other cases, data is most efficiently sourced commercially. For example, physical models of generic aircraft, ships and vehicles. Whatever the eventual devolution of responsibility for the actual provision of the data, management of the process best rests with those designing and developing the simulation. The developer (contractor) is best placed to determine what data is required and when it is required. It is recommended that the draft SOW detail responsibilities for management and acquisition of simulator data. A recommended approach would be for the Contractor to accept responsibility for the identification and acquisition of the simulation data on behalf of the Commonwealth. The Commonwealth then owns the data and provides it back to the simulation system developers as Government Furnished Material (GFM). The following paragraphs elaborate on why extreme caution should be exercised.

21. For data to be provided by the Commonwealth, there must be an agreed mechanism in place to ensure that the data is adequate in terms of its fidelity, availability and format. Care must be taken if the data provided by the Commonwealth has not been previously certified for use in a similar simulation application (see also Chapter 7). It may seem to be a cost-saver to undertake data acquisition as a customer but this may cause excusable delays and excusable cost overruns if the data is unavailable in the timeframe promised. There are also raising issues associated with the fidelity of the simulation. Time, cost and quality are dependent on this data.

22. Another major reason why the Commonwealth should be cautious of accepting responsibility for the acquisition and supply of simulation data is that simulation data often remains incompletely defined until completion of the development stage of the simulation lifecycle. If the Commonwealth accepts responsibility for the acquisition of simulation data, they are effectively accepting responsibility for the provision and associated costs of an unknown quantity. The contractor is in the best position to predict the data requirements for a

[25] ANAO Report – Acquisition of Aerospace Simulators, Commonwealth of Australia, 1998.

given simulation project and therefore accept the associated risks due to their experience and expertise with previous simulation contracts.

23. The SOW should require the process developed by the tenderer prior to contract signature to be followed when data is acquired. This process must include a data proposal and approval process, data acquisition and data registration and configuration management process. This is directly associated with the need to establish and maintain verified, validated and certified data (see Chapter 7) for use in the simulation design. Design reviews conducted at discrete points in the simulation system acquisition process are ideally suited to review of design data. This is further discussed later.

24. It is important to ensure that simulation data-related SOW clauses are discussed and clarified during contract negotiation, as a risk reduction activity, to remove uncertainty and ambiguity in responsibilities.

DEVELOPMENT AND PRODUCTION STAGE ACITIVITES

25. Following contract signature, the process enters lifecycle stages aimed at developing and testing the simulation design. It is important to note a change in focus and a change in roles of the Commonwealth and the Contractor at this stage. Prior to this stage, the focus has been on developing a sound understanding of the simulation application and estimating of the type and quantity of data required to support the simulation. This focus provides a functional understanding of what has to be achieved by the simulation, how well it needs to be achieved, under what conditions the simulation needs to be faithful and what other simulations may be involved. The focus during development and production changes to a physical design where the Contractor defines and design a simulation capable of meeting the various requirements derived during conceptual design.

26. The other major change is the role of the Commonwealth and the role of the Contractor. The Contractor's role is an active design, development and testing role (with the emphasis on active). In contrast, the Commonwealth's role becomes one of a monitor and controller.

27. Data will be acquired during this period in accordance with the data acquisition process agreed and documented in the contract and Contractor plans. The quantity of data tends to increase during this process and continues until the design and development of the simulation is completed. This amplifies why the Commonwealth should be wary of accepting responsibility for the data acquisition early in the process. The Commonwealth will be involved in the data process to the extent detailed in the contract. Major acquisition activities such as design reviews, project management meetings and test and evaluation events provide visibility into the data acquisition and management process. Major sets of plans, procedures and results for testing will also be written, approved and applied during this time.

28. It is expected that the data acquisition strategy implemented by the Contractor will feature an iterative application of a process containing data requirements analysis, data identification and acquisition proposals, acquisition approval and acquisition. Figure C.1.3 below attempts to overlay the simulation data acquisition process with typical milestones associated with the acquisition of any major simulation system.

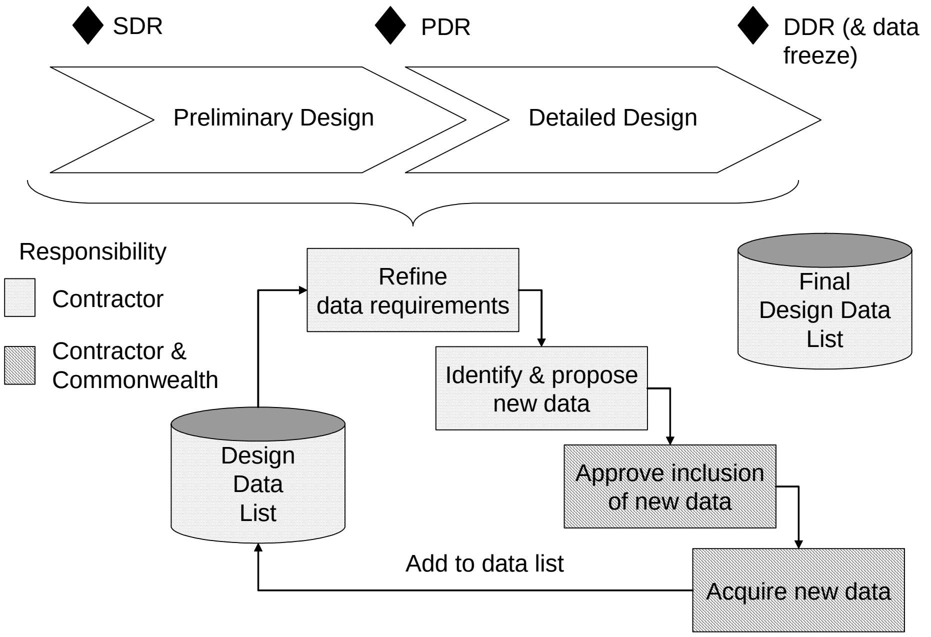

Figure C.1.3 : Data Acquisition Process leading to Data Freeze at DDR

29. During the early stages of preliminary design, major categories of data supporting the design of the simulation are identified and processed. During the latter stages of preliminary design and into detailed design, the data requirements are likely to become much more focused and detailed. As new data is acquired, it is added to the data list developed and maintained by the Contractor. The data list is frozen following successful DDR.

30. A well-known illustration of the design and development effort undertaken by many major projects is known as the "V diagram"[26]. A variation of the V diagram is shown below.

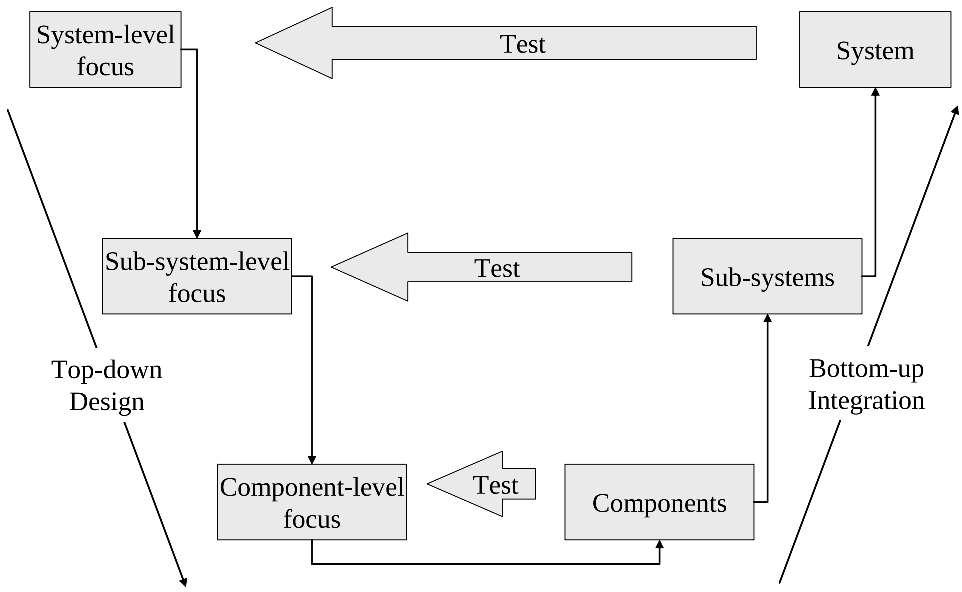

Figure C.1.4 : Representation of the "V" Diagram

31. The V diagram shows the top-down design and development process on the left-hand side. The system-level simulation requirements are largely completed by the Commonwealth during the Concept Stage. In the latter parts of this stage, tenderers and then the Contractor are involved and the stage is generally completed with a design review called the system

[26] The V diagram concept was first popularised by DOD-STD-2167A.

design review (SDR)[27]. At this stage, the major categories of simulator data will have been determined, estimated and allowed for in the project estimates. Detailed design data requirements will continue to be determined as the process matures and additional data will be acquired. It is recommended that contracts relating to simulation systems require the Contractor to maintain a list of design data that has been approved and acquired for use on the project. A mid-term design review called the preliminary design review (PDR) is conducted once the simulation design has become sufficiently mature and allows the contractor to move onto detailed design of the simulation. During detailed design, more detailed data requirements are identified, approved, acquired and added to the design data list. At the completion of detailed design, a critical design review called the detailed design review (DDR) is conducted. The simulation design is frozen at this review. To that end, design data should also be frozen at this review. There should be no additional requirement for design data following design freeze. If the design data list or register is incomplete, the project office should strongly consider not allowing the contractor to enter DDR.

32. Following DDR, the development has reached the bottom of the "V" and the bottom-up integration and testing process begins. At this stage, simulation software and hardware systems will begin to be integrated and the design is tested against the relevant design specification and design data. Information regarding the content of design specifications can be found in many engineering standards[28]. Eventually the prototype of the simulation is completely integrated and tested against the system-level requirements and data contained in system specifications and the SOW.

33. Clearly, the use of design data in this process is of critical importance. The foundation of the simulation design is based on the use of approved data during the development process. The performance of the simulation performance is confirmed against this data during the integration process. It is critical to note, however, that this process is aimed at verifying and validating the simulation, not the simulation data. The process merely tests that the simulation achieves a performance representative of the performance described by the approved data. For guidance on confirming the veracity of the simulation data, see Chapter 7 (Verification, Validation and Certification of Simulation Data).

34. At the conclusion of the development and production stage, the simulation undergoes system-level testing aimed at allowing the Commonwealth to contractually accept the simulator into service. The testing verifies that the simulator's performance meets the requirements the contract requirements. Following this process, the simulator is accredited and accepted by the Commonwealth into service.

UTILISATION AND SUPPORT STAGE ACTIVITIES

35. The simulation system is likely to spend a vast majority of its life in a stage called utilisation and support. There are some key activities that will occur during this stage that impact on simulation data. The activities include the maintenance of simulation data and the inevitable and periodic need to modify the simulation system.

[27] The name of these reviews has been taken from "System Review Guide for Australian Defence Contract (Strategic Management) Version 1.0, September 2003. Additional information on design reviews and their individual objectives can also be found in MIL-STD-1521B which is a foundation reference for documents such as the System Review Guide.

[28] Additional information on design specifications can be found in MIL-STD-490A, MIL-STD-960E and MIL-STD-498. Although MIL-STD-498 is a software development standard, it contains very practical information on design specifications and their content.

Maintaining Simulation Data

36. The previously described acquisition process is characterised by finite time scales that place pressure on the identification and acquisition of simulation data. The net result of time pressure is that the simulation design is often based on what is generally referred to as “best available data”. “Best available data” as the name suggests is the best data available at the time that meets the data requirements of the simulation within the time and cost constraints of the acquisition.

37. During the utilisation and support stage of the lifecycle, it is reasonable to expect that data availability, cost and quantity will change. Usually more suitable simulation data will become available over time. It is therefore recommended that those managing the simulation system monitor data availability with a view to upgrading the simulation data where possible. For example, an aircraft simulator may have a terrain database limited in size due to a lack of terrain data available during acquisition. As more suitable terrain data becomes available, it may be possible to add to the existing database.

38. Another maintenance aspect to be considered is that some simulation data becomes “stale” over time and needs to be updated and maintained. Examples in each of the data categories explained in Chapter 3 (Simulation Data) that can become stale include:

a. **Environmental Data**. Geospatial data (an example of Environmental data) becomes stale when features and objects such as roads, bridges and buildings are built or replaced in the real world. The change to the real world environment opens a gap between the actual terrain and the simulated terrain. In these cases, the environmental data needs to be maintained to ensure correlation between real and simulated spaces.

b. **Entity Data – Physical**. Physical characteristics of various entities need to be maintained in the simulation. For example, in the mid-1990s, the RAAF F-111 aircraft fleet was repainted and transitioned from a camouflaged paint scheme to a single colour (air superiority grey) paint scheme. Simulations that contain F-111 entities may need to be updated or maintained to ensure that the simulated representation of the F-111 remains faithful to the actual aircraft appearance.

c. **Entity Data – Behavioural**. Behavioural data defines the manner in which an entity will conduct itself when placed in a given situation. This behaviour may be based on a number of factors including operational procedure or doctrine. For example, when confronted with the presence of pulse compression radar, a submarine with periscopes above the surface may drop all of the periscopes for a defined period of time. The simulation of the behaviour of the submarine is based on this defined operational procedure or doctrine. If this doctrine changes, then the behavioural data in the simulation must also be updated.

d. **Entity Data – Design**. Design data provides technical information about the operation of a given entity. For example, design data for a radar system will include information about the transmission frequency, power and rates of the radar. Clearly if that radar system is changed in some way so as to alter its technical characteristics, any simulation of that radar will need to be updated.

39. These examples are provided to emphasise that simulation data does not necessarily remain valid for the entire life of the simulation. Active steps must be taken during utilisation and support to ensure that the simulation remains sufficiently faithful and representative of the real world to fulfil the original objectives of the system.

Simulation System Modifications

40. Often major systems undergo upgrades or modifications throughout their life. These modifications generally drive corresponding modifications to the applicable simulation system. For example, a training simulator for a given warship takes account of the performance of the warship and its constituent sub-systems such as communications, weapons, navigation and so on. When that class of warship goes through a modification program that results in a change to the ship's performance, a corresponding change to the simulation must be considered. The change to the simulation should be considered a project or sub-project in its own right and the identification of data requirements needed to effect the modification should be integral to the modification program.

41. There will be times when modification programs to major weapon systems do not require changes to simulations. For example, modification programs that enhance reliability or maintainability of a system but that do not alter the weapon system performance may not require any change to the relevant simulation.

42. Either way, modifications to any major systems should consider the requirement for a simulation upgrade or change as part of the modification program itself. In this way, the cost of incorporating the modification to the major system automatically accounts for the cost of upgrading the simulation and helps ensure that the simulation remains an accurate reflection of the system it is trying to simulate.

RETIREMENT ACTIVITIES

43. Ultimately, every lifecycle concludes with disposal or retirement of the system. In the case of simulation systems, the data underpinning the simulation may still be of use elsewhere in the DSE. Defence simulation users should therefore consult with the support organisations listed in Chapter 5 and ADSO before disposing of simulation data.

ANNEX D - ABBREVIATIONS AND ACRONYMS

The table defines the acronyms and abbreviations used in the guide.

Acronym/ Abbreviation	**Explanation**
ADF	Australian Defence Force
ADRG	Arc Digitised Raster Graphics
ADSO	Australian Defence Simulation Office
AHS	Australian Hydrographic Service
ANZLIC	Australian and New Zealand Land Information Council
AODC	Australian Oceanographic Data Centre
ARCS	Admiralty Raster Chart Service
ASDD	Australian Spatial Data Directory
ASDI	Australian Spatial Data Infrastructure
ATC	Air Traffic Control
AUSLIG	Australian Land Information Group (now NMD)
CADRG	Compressed ADRG
CGM	Computer Graphics Metafile
CIB	Controlled Image Base
CSDGM	Content Standard for Geospatial Metadata
DCMES	Dublin Core Metadata Element Set
DCW	Digital Chart of the World
DDR	Detailed Design Review
DEM	Digital Elevation Model
DFAD	Digital Feature Analysis Data
DGIWG	Digital Geographic Information Working Group (United States)
DIGEST	Digital Geographic Information Exchange Standard
DIGO	Defence Imagery and Geospatial Organisation
DMO	Defence Materiel Organisation
DMSO	Defence Modelling and Simulation Office (United States)
DNC	Digital Nautical Chart
DSE	Defence Simulation Environment
DSTO	Defence Science and Technology Organisation
DTED	Digital Terrain Elevation Data
EA	Electronic Attack
ECDIS	Electronic Chart Display and Information System
ECM	Electronic Counter Measures (also called EA)
ENC	Electronic Navigation Chart
EPS	Encapsulated Post Script
ES	Electronic Support
ESM	Electronic Support Measures (also called ES)
EW	Electronic Warfare
FGDC	Federal Geographic Data Committee (United States)
GeoTIFF	Geo-referenced Tagged Image File Format
GFM	Government Furnished Material
GIF	Graphics Interchange Format
GIS	Geographic Information System

GPS	Global Positioning System
GODAR	Global Ocean Data Archaeology and Rescue
HGL	A Hewlet Packard Graphics Language Image Format
HPGL	A Hewlet Packard Graphics Language Image Format
IHO	International Hydrographic Organisation
IMO	International Maritime Organisation
IOC	Intergovernmental Oceanographic Commission
ISO	International Standards Organisation
JPEG	Joint Photographic Expert Group
JPG	See JPEG
MEDB	Marine Environment Database
MEL	Master Environmental Library
MET	Meteorological
NGA	National Geospatial Intelligence Agency (United States)
NIMA	National Imagery and Mapping Agency (United States)
NITF	National Imagery Transmission Format
NMD	National Mapping Division (formerly AUSLIG)
NODC	National Oceanographic Data Centre (United States)
NSDI	National Spatial Data Infrastructure (United States)
NTA	National Technology Alliance (United States)
ONC	Operational Navigation Chart
PCX	PC Paintbrush Exchange
PDR	Preliminary Design Review
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RFT	Request for Tender
RMP	Risk Management Plan
RPF	Raster Product Format
RTK	Real Time Kinematic
SDG	Simulation Data Guide
SDR	System Design Review
SDTS	Spatial Data Transfer Standard
SEDRIS	Synthetic Environmental Data Representation and Interchange Specification
SIF	Standard Interchange Format
SIMMAN	Defence Simulation Manual
SISO	Simulation Interoperability Standards Organisation (United States)
SGML	Standard Generalised Markup Language
SHP	Shape (an ESRI Format)
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SOW	Statement of Work
TEI	Text Encoding Initiative
TIFF	Tagged Image File Format
TLM	Topographic Line Map
UKHO	United Kingdom Hydrographic Office (United Kingdom)
USGS	United States Geological Survey

UVMap	Urban Vector Smart Map
VPF	Vector Product Format
VMAP	Vector Smart Map
V&V	Verification and Validation
VV&A	Verification, Validation and Accreditation
VV&C	Verification, Validation and Certification
WPI	World Port Index
WMO	World Meteorological Organisation
WVS	World Vector Shoreline
WVSP	World Vector Shoreline Plus
XML	Extensible Markup Language

ANNEX E - DEFINITION OF TERMS

The table defines the Simulation specific terminology used in the guide.

Term	Definition
Accreditation	The official certification that a Model or Simulation is acceptable for use for a specific purpose.
Aggregation	A collection of models or entity grouped together to form a more sophisticated model or entity.
Best available data	The best simulation data available at a given time that meets the data requirements of the simulation within the time and cost constraints of the acquisition.
Data Certification	When applied to simulation data it is the determination that data has been verified and validated for a particular use.
Data Validation	Confirmation by examination and provision of objective evidence that the specific intended use of a collection of data is accomplished in the intended usage environment.
Data Verification	Confirmation by examination and provision of objective evidence that the specified requirements against which data has been obtained have been fulfilled.
Data gap	The gap between the currently available set of simulation data and the set of simulation data deemed necessary to support the simulation.
Entity	A distinguishable element in the synthetic environment excluding geographic, atmospheric, and bathyspheric objects.
Georelational	A representation of features (in a database) as an interrelated set of spatial and descriptive data.
Geospatial	A class of data that has a geographic or spatial nature.
Interoperability	The ability to effectively and accurately exchange data, offline and in realtime, between disparate hardware and software systems.
Metadata	Information about data; more specifically, information about the meaning of other data.
Model	A physical, mathematical or otherwise logical representation of a system, entity, phenomenon, or process.
Orthophoto	Photograph of the earth's surface in which geographic distortions due to variations in scale and displacements (relief) have been removed.
Simulation	The implementation or exercise of a Model over time.

Simulation Data Guidance
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:

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* * * * *

1. **According to your understanding of simulation data, is any information presented in this Guide incorrect or inaccurate? (You may want to attach a copy of the page marked with your suggested changes.)**

Page and line number	*What is in error in this statement or discussion, in your estimation?*

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