Abstract. Acquisition and management of data is a critical issue in the development of simulators. Papers presented at previous SimTecT conferences have discussed a suggested process for military simulators regarding the acquisition and subsequent management of data that is intended to create a partnership between the customer and the simulator manufacturer. This paper provides a further view on the topic, based on experience gained from implementing the process. The paper also looks at alternative approaches that may be beneficial to consider for future projects.

1.1 Introduction

1.2 Topic History

Data are the lifeblood of any simulation project. Without data describing, to an appropriate accuracy and level of detail, the characteristics of elements of the aircraft and real world that are to be simulated, there is no way of knowing whether a given simulation provides a suitable level of fidelity for a given platform and training task. The importance of data in setting the level of fidelity of a simulator has been a topic in previous SimTecT papers (see for example Simulation Fidelity – Getting in Touch with Reality[6]), and will not be discussed in this paper.

Papers presented at SimTecT '97[5] and SimTecT'99[7] have discussed an approach to the management of the data needed for a successful flight simulator development. The focus in those papers, as for this paper, is on flight simulators for military aircraft.

1.3 Data Requirements for Flight Simulators

For a civil aircraft, the requirements for data related to the aircraft being simulated are specified in an International Air Transport Association (IATA) publication, Flight Simulator Design and Performance Data Requirements[2]. This document describes different types of data, differentiating between data used for design purposes and data used for validation (accreditation). Also described are the categories of data, which includes requirements for aerodynamic data, engine data, aircraft systems data and avionics data.

The IATA document is addressed at the needs of civil fixed wing aircraft simulation, and significant additional data must be added for military aircraft. The additional data covers areas such as weapons and sensor systems, weapons themselves (for post launch modelling) and tactical entity data. In addition, the data requirements for aerodynamic modelling do not include manoeuvres that a military aircraft simulator is expected to provide.

At this point in time, there is no known equivalent to the IATA document that attempts to cover the data requirements of military aircraft.

1.4 ADF Flight Simulator Policy

The current (draft) policy[1] of the Australian Defence Force (ADF) is that all new flight simulators be accredited to an appropriate accreditation level. The accreditation levels and requirements to achieve each level are defined in FSD-1[2]. This policy has implications for the data requirements for development of flight simulators for the ADF, particularly for the flight test data needed for the development and accreditation of the aerodynamic model.

The IATA document referred to above can be used to provide guidance in defining the data requirements for flight simulators required to conform to FSD-1 Level 5, but as mentioned above, this only assists for the overlap between the military and civil areas.

1.5 Advanced Flight Simulator Project Background

This paper focuses mainly on activities carried out under the Contract for the development of the AP-3C Advanced Flight Simulator (AFS) that was let to Thales Training & Simulation Pty Limited (TT&S) (then Wormald Technology) in August 1998.

The scope of the Contract is for the supply of a full flight simulator matching the configuration of the AP-3C aircraft being developed under the P-3C Upgrade Project (Air 5276 Phase 2). The AFS is being developed to the equivalent of FSD-1 Level 5.
2. AP-3C AFS CONTRACT REQUIREMENTS

2.1 Process Requirements

The Data Management process described in the Contract Statement of Work is divided into the following phases:

- Identification – analysis of data requirements and potential sources,
- Collection and Acquisition – acquisition of data from the identified sources,
- Analysis – review of the acquired data to confirm suitability and completeness, and
- Authorisation – agreement that the acquired data is suitable for its intended purpose.

Once authorised, the data is known as “Design Criteria”.

The above process is managed by a Design Data Management Board (DDMB), which consists of Commonwealth and TT&S representatives, and is co-chaired by the RAAF Project Manager or delegate, and the TT&S Project Manager or delegate.

The DDMB functions as:

a. Approval authority for acquisition of Design Data,

b. Approval authority for Design Criteria,

c. The body responsible for resolving identified Design Data conflicts and discrepancies, and

d. A Board of Reference on the use and application of Design Data.

The Contract also contains the concept of a “freeze date”, at which all data is baselined. Changes to the data baseline subsequent to this date may involve a Contract Change Proposal (CCP). The freeze date is defined as 30 days prior to the Preliminary Design Review.

2.2 Relationship with Specification

The link between the Statement of Work data management process and the Contract Specification is in the form of Design Criteria requirements embedded in the specification.

For example, the requirement for Flight Controls was stated (slightly paraphrased) as follows:

“The control wheels, control columns and pedals (including adjustments) for the flight controls shall be in the correct location, and have the appearance and feel of the aircraft equipment as defined by the approved Design Criteria”.

Similarly, the requirements for simulation of aircraft performance simulation involved the concept of Design Criteria, as shown by the following example:

“The Ownship shall respond to flight and powerplant controls and the simulated environment in accordance with the requirements of this Specification and the approved Design Criteria.”

Some 163 requirements (out of around 1600 requirements) are expressed in this way, with topics ranging from aircraft aerodynamic and systems, aural cues and natural environment simulation.

3. IMPLEMENTATION

3.1 Data Identification

The starting point for identifying data needs was the Contract Specification. As noted above in 2.2, a large number of requirements essentially identified themselves as needing data.

In addition, the IATA Flight Simulator Design and Performance Data Requirements document was used for guidance.

The experience of people within the TT&S organisation was also used to define data needs.

3.2 Data Acquisition

It is worth noting at this point that a major category of data had been identified by the RAAF prior to contract. This was the flight test data that forms the basis for the aerodynamic and related models. The approach to acquiring this data has been described in an earlier SimTecT paper[4].

The vast majority of the data required to develop the AFS was held by the RAAF. For aircraft systems, the relevant Australian Air Publications (AAP) provided much of the needed information. A significant amount of data regarding the aircraft upgrade program was also required. This data was also provided by the RAAF.

Data sourced from overseas companies, particularly the USA, can cause significant schedule risks, as approval for the release of data usually needs to be obtained from the relevant government. Unfortunately, such approvals need to be specific in naming the company to which the data will be supplied, thus it is not possible to apply for such approval prior to contract signature.

The main area of data acquisition that was provided by sources external to the Commonwealth was data for visual databases. Indeed, apart from a requirement to visit a supplier associated with the AP-3C upgrade program, visual data was the only area for which the acquisition approval role of the board was exercised.

A summary of the different types of data acquired can be found in section 3.6.

3.3 Analysis

3.3.1 Creation

As could be expected, the analysis part of the data management process proved to be the most time consuming of all the data management related activities.
The process used followed a system-based approach, rather than a document based approach. This means that the aircraft was divided into systems, and the available data for each system was analysed and synthesised into a document known as the “Design Criteria” for the system in question.

The process began with the engineer assigned to develop the simulation developing a first draft of the Design Criteria. In the Design Criteria, the engineer described the extent of the simulation being implemented, with extensive referencing of the documents being used.

The draft Design Criteria was then discussed with the appropriate member of the RAAF Resident Team. The role of this review was to ensure that the extent of the simulation was sufficient and that the Design Criteria was based on the “correct” documentation. In the event that the available documents did not address the data needs, assumptions were agreed and clearly identified as such in the resulting Design Criteria document.

### 3.3.2 Data Capture

All Design Criteria were managed using the DOORS™ Requirements Management tool from Telelogic. All Design Criteria were entered into a module, known as the Design Criteria List module, in the Systems Engineering database. A small number of Design Criteria required supplementary external documents.

Each Design Criteria entry in the DCL module was linked to the contract requirement that the Design Criteria fulfilled. This is shown in Figure 1, which depicts a subset of the Systems Engineering database.

Given the implementation described above, it is possible, for example, to search for any given document to determine if it is referenced by Design Criteria, and then, using the links, to establish exactly where in the simulator design the information derived from that document has been used.

The key data captured in each item of Design Criteria are shown below in Table 1. Note that in order to fully scope the simulation, each item of Design Criteria may reference a number of documents.

### Table 1: Key Design Criteria Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATOM</td>
<td>The requirement identifier of the source requirement.</td>
</tr>
<tr>
<td>Specification</td>
<td>The paragraph reference of the source requirement in the Contract</td>
</tr>
<tr>
<td>Document Title</td>
<td>The title of the source document used to create the Design Criteria</td>
</tr>
<tr>
<td>Document Number</td>
<td>The document identifier assigned by the source organisation.</td>
</tr>
</tbody>
</table>

Wherever possible, a copy of the relevant sections of the referenced document were attached to the Design Criteria form, as an aid for review and also to ensure that the same information was available at a future date.

The Design Criteria List module formed the basis of the deliverable Contract Data Requirements List (CDRL) item of the same name. In order to provide a meaningful Design Criteria List deliverable, it was decided to deliver the module as a part of the overall Requirements Database CDRL item, which was delivered in DOORS format. The Requirements Database CDRL item consists of a DOORS partition containing all modules shown in Figure 1, with the exception of the CI Level Specifications modules.

![Figure 1: Outline Systems Engineering Database Structure](image)

### 3.4 Review and Authorisation

Following in-principle agreement between the engineer and the RAAF Resident Team member, the Design Criteria was circulated internally for review. In general, each Design Criteria was reviewed by the following TT&S AFS engineering team members:

- **Software Lead Engineer** - to ensure that the information contained in the design criteria was complete and in a form that could be translated into the software design.
- **Hardware Lead Engineer** - to ensure that any hardware related implications of the Design
Criteria were recognised and addressed in the hardware design.

- **Test Team Leader** - to ensure that the information in the Design Criteria was in a form suitable for use in the drafting of any associated Acceptance Test Procedures (ATPs).

- **Project Chief Engineer** – to confirm that the Design Criteria process had been followed, and that the information within the Design Criteria was inside the contract scope.

Following the internal sign-off, the Design Criteria was then issued to the RAAF for formal review. Any comments received at this stage were incorporated before final authorisation. Final authorisation was signified by the co-chairs of the DDMB signing the Design Criteria form.

The role of the DDMB in this process was to monitor progress and discuss issues. Items of Design Criteria were generally not actually authorised during a meeting, authorisations occurred out-of-session, and the formal meeting simply recorded the list of Design Criteria authorised since the last DDMB.

### 3.5 Usage in Test Procedures

For a Test Team member writing an ATP that verifies compliance of the system with a contract specification requirement, the link from the source requirement to any Design Criteria allowed easy retrieval of the additional information needed to write a complete test.

A cross-reference matrix at the end of each ATP lists any relevant Design Criteria along with the usual list of contract requirements verified by the procedure, thus completing the traceability chain.

### 3.6 Some Statistics

During the period from contract signature in August 1998, until the time of writing, a total of 551 items of Design Criteria were authorised. These Design Criteria covered topics ranging from aircraft systems, such as fuel, hydraulics and electrical systems, communications systems, navigation systems, to functionality associated with the image generator, instructor station and tactical environment. Detailed descriptions of malfunction cause and effects for each malfunction were also captured in Design Criteria.

Figure 2 shows a month by month analysis of the authorisation of Design Criteria over this period.

The peaks shown in the figure generally coincide with the major design review milestones on the programme.

### 4. DISCUSSION OF RESULTS AND ISSUES

#### 4.1 Benefits

The authors believe that the Design Criteria process has given the Commonwealth far greater visibility and influence during the development of a flight simulator than for any previous project.

For TT&S, the benefits mainly relate to the aircraft systems and natural environment simulations. The process provided TT&S engineers with a framework in which they could work through the analysis of a system in conjunction with Subject Matter Expert and capture the essential characteristics to be included in the simulation. On a number of occasions during testing, analysis of a Deficiency Report was
concluded by referring to the relevant Design Criteria, and noting that the system performed in accordance with the information provided there.

The number of Acceptance Test Discrepancy Reports logged during formal acceptance testing is considered to be relatively low for a “first of type” simulator of this complexity.

A major area where the Design Criteria approach provided clear benefits is simulated malfunctions. The process used in this particular area clearly led to a very good understanding of the malfunction cause and effects required, with relatively few acceptance problems reported in this area.

The other main area of benefit was the ability to freeze data associated with the AP-3C upgrade program, allowing a stable baseline for development and testing.

4.2 Amount of Effort
As noted above in 3.6, a significant amount of effort was expended by both TT&S and the Commonwealth on the data management process.

It is fair to say that neither TT&S nor the Commonwealth teams anticipated the amount of time that would be taken to work through the process.

4.3 Locational Issues
A number of difficulties were due to the fact that TT&S was performing design activities in two different countries, Australia and the UK. The close interaction during the development of Design Criteria described in 3.3 was not possible for the UK team, with resulting increase in the time taken to complete the process.

4.4 Extent of Coverage
Despite best endeavors on both sides, it is inevitable that there will exist one or more Design Criteria that do not provide a complete coverage of the aspect of the simulation that they describe.

The question then arises as to how to treat any such situation. In one sense, the Design Criteria forms a part of the Functional Baseline of the system, since requirements in the contract are defined in terms of Design Criteria (see section 2.2). Given this, it could be argued that a change to the Design Criteria is equivalent to a specification change, and should be dealt with via a Contract Change Proposal (CCP).

In practice it is rarely this clear cut, and such issues generally arise during acceptance testing, when the contractor is doing everything possible to achieve customer acceptance of the system and wants to doing everything possible to achieve this milestone.

4.5 Data Freeze
The AFS Contract nominated Preliminary Design Review as the date by which data is to be frozen. As can be seen from Figure 2, a significant amount of Design Criteria was being frozen after this date. In a number of cases, it proved to be difficult to close out a particular Design Criteria in a timely fashion.

One cause of problems in this respect is in the area of data identification. The simulator manufacturer is required to identify the data that is needed, but is not in a position to do so until a significant amount of analysis is performed to develop a top down understanding of the aircraft and systems. Often when this is done, a new set of questions emerges that require new data. In some cases, there may be gaps in the understanding of a particular system (perhaps due to gaps in the original documentation) that mean particular issues are not identified, and no data is requested. When the gaps are discovered, perhaps at a Design Review, it can be difficult to determine the responsibility for rectifying the situation. Does the responsibility with the contractor for not identifying the missing data, or with the customer for not identifying the issue?

4.6 Data Types
The process described in section 3 worked best when applied to the more objective and easily defined area of aircraft systems simulation. With flight test data and the associated modelling tasks, it is much more difficult to tie things down as precisely as the process would imply, or by the PDR freeze date. This is also the area in which there is the least benefit in the detailed interaction between with the RAAF resident team, as aerodynamic modelling is a very specialised area of expertise.

5. ALTERNATIVES

5.1 Air 87 – Authorised Data Concept
A variation of the AFS approach is being followed for the Air 87 Armed Reconnaissance Helicopter (ARH) Training Devices. In the Air 87 case, the DDMB is replaced by a Design and Validation Data Management Board (DVDMB), with membership from the Commonwealth, Eurocopter International Pacific (EIP) (the ARH Prime Contractor) and TT&S.

Since the Commonwealth does not currently operate the ARH, aircraft related data will be obtained from equipment manufacturers. The cost of this data acquisition is the responsibility of the prime.

In addition, due to the large amount of re-use from training devices being developed in Europe, there is less emphasis on design data, and more on validation data.

The role of the DVDMB is similar to that of the DDMB on the AFS, however the roles of the participants are different. The author believes that Commonwealth’s main interest in the DVDMB is

• to ensure that there is an adequate and well defined process for data management,
• to ensure that the process is being followed, and
to ensure that the data that will be ultimately used for training device validation (which includes ADF accreditation) has a clear and suitable pedigree.

5.2 F/A-18 Hornet Aircrew Training System
At the time of writing, the Hornet Aircrew Training System (HACTS) Request for Tender (RFT) had not been released, however a draft RFT was released at the end of March. This document had no Commonwealth involvement in data management, instead all data responsibilities are placed on the contractor.

5.3 A Civil Simulator Example
TT&S is currently developing three FSD-1 Level 5 flight simulators. For each of these aircraft simulators, there is a clear definition of the responsibilities of the aircraft manufacturer, aircraft operator and the simulator manufacturer.

For each of these simulators, the following data management process is being followed:
- The aircraft operator is responsible for specifying the aircraft baseline that is to be simulated, and for providing the data.
- The majority of the data is in the form of a “data package” provided by the aircraft manufacturer, supplemented by the Operator’s Manual (the civil equivalent of an ADF aircraft Flight Manual).
- If any needed data is unavailable, TT&S is to propose substitution data to use in its place.
- TT&S is to provide a list of the data used in the design and manufacture of the simulator. The list is known as the Schedule of Approved Data.

The task of assessing the validation data has been simplified recently by the production by aircraft manufacturers of a Validation Data Roadmap (Boeing), or Recommended Qualification Test Guide (Airbus). These documents focus on flight model qualification, and provide a mapping between the aircraft data package and the Qualification Test Guide, nominating the specific data that should be used for Accreditation, and providing a rationale for the selections.

6. A WAY AHEAD?
The Data Management process used for the AP-3C Project represents an approach that is designed for an aircraft that has been in service with the ADF for a significant amount of time. The process relies heavily on ADF expertise in the aircraft itself, the way the aircraft is operated and the training needs. It also relies on the availability of ADF personnel with the above expertise for significant periods of time.

For situations where the ADF does not have this level of expertise or resource availability, alternative sources of expertise must be found.

Where new platforms are being acquired, the data clearly needs to come from the platform supplier and associated equipment providers. Where this is case, sufficient provisions need to be inserted in the platform acquisition contract to ensure the prime will make the necessary data available.

It is difficult to define a general model for the data management process that will address all possible circumstances. It is possible, however, to suggest guidelines that can be used to assist.

The authors would like to propose the following:
1. The distinct roles, responsibilities and expertise of the aircraft operator, platform design authority¹ and simulator manufacturer need to be recognised and clearly described.
2. The aircraft operator’s role should be to define, in conjunction with the design authority, the aircraft baseline that the simulator is to be designed to, and to define the training tasks for which the simulator is to be used. This information should be used to create a clear specification of the level of fidelity required to meet the training needs.
3. The simulator manufacturer should identify the data that is needed to achieve the defined level of fidelity.
4. For an in service aircraft, the aircraft operator should define the data that best reflects the behaviour of the aircraft to be simulated.
5. Acquisition of data must be a joint effort between the simulator manufacturer and the aircraft operator.
6. The aircraft operator, in conjunction with the Accreditation Authority², should also be responsible for approval of data that is to be used for qualification (validation data).

7. CONCLUSION
It is clear that a rigorous and well defined data management process needs to be implemented if a flight simulator is to achieve it’s training goals. It is also clear that a number of parties must be involved in this process, these parties being the aircraft operator, the aircraft manufacturer (and associated equipment providers) or suitable equivalent design authority, the accreditation authority and the simulator manufacturer.

¹ In the context of this paper, “Design Authority” is defined as the organisation holding configuration management authority for the aircraft.
² For ADF aircraft, the Accreditation Authority is the Director General Technical Airworthiness (DGTA). For civil aircraft, the Accreditation Authority is the Civil Aviation Safety Authority (CASA).
Each of the above parties must play their role for the process to have any chance of succeeding.

Contractual mechanisms that fail to clearly address the responsibilities of each party and the specific circumstances under which the simulator is being acquired are bound to experience problems.

**DISCLAIMER**

The views expressed in this paper are those of the authors and do not reflect any position or policy of Thales Training & Simulation.

**REFERENCES**


2. Civil Aviation Safety Authority “FSD-1 - Operational Standards and Requirements-Approved Flight Simulators” Version 6.1 dated August 1999


