# Needs Driving Design – A Training System Case Study

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***Abstract*** *– Training systems are acquired to support the training of personnel in the operation, maintenance and support of a given system. Training system acquisitions are traditionally challenging due to the difficulty in deriving detailed requirements from statements of training need. Project Air 87 is a very large aircraft acquisition project currently underway in Defence responsible for the acquisition of an Armed Reconnaissance Helicopter (ARH) for the Australian Army. A major aspect of Project Air 87 is the acquisition of a training system to support training on the ARH. The Commonwealth Project Office was faced with some unique challenges in their effort to define the ARH training system in addition to the traditional challenges associated with training system acquisition. This paper investigates the unique and traditional challenges faced by Project Air 87 and describes the systems engineering approach it adopted during the early stages of acquisition to overcome those challenges.*

***Keywords*** *–Training system, systems engineering, challenges.*

## Introduction

The focus of SETE2003 is on complex problem solving using systems engineering principles. The acquisition of effective training systems is a complex problem plagued by traditional challenges such as appreciating training needs, translating needs into effective system specifications and accepting the system based on both verification and validation. These challenges face all acquirers of training systems and systems engineering processes have evolved accordingly to overcome them. Project Air 87 is a current Department of Defence aircraft acquisition project involving the acquisition of an advanced military aircraft and its associated systems (including a large training system). The acquisition of the Air 87 training system faced additional challenges including acquiring the training system for an unknown aircraft and an aircraft type whose operational concepts were still evolving. This paper investigates the traditional challenges facing training system acquisitions and the additional unique challenges facing Air 87. It goes on to explain the systems engineering process adopted by Air 87 to address the challenges and comments on the effectiveness of the process.

## A Brief Introduction to Project Air 87

The scope of Project Air 87 is enormous and includes the acquisition of a number of Armed Reconnaissance Helicopters (referred to as ARH), an instrumented ARH, the necessary ground mission and flight test equipment, a training system, ground electronic warfare and self protection equipment, and a weapon system software support facility. Contracted logistic support for the aircraft and associated systems is also part of the Air 87 project.

To appreciate the complexity of this undertaking, it is worth briefly investigating each of the constituent elements of the project listed in the preceding paragraph.

When the ARH aircraft arrives in Australia, it will arguably be the most complex military aircraft ever operated by the Australian Defence Force (ADF). The ARH aircraft will be capable of day and night operations in all weather conditions and will have a ferry range of approximately 500 nautical miles. The aircraft will make use of advanced Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems and will include a fully integrated electronic warfare self-protection (EWSP) system. The aircraft is planned to be maritime deployable and deployable by C-130 transport aircraft.

The sensor suite onboard the ARH aircraft will include a thermal imager (TI) and television and its weapons will include a cannon, air to ground missiles (AGM) and rockets. Pilotage of the aircraft will be assisted by TI, night vision devices (NVD) and an integrated helmet mounted display (HMD). Mission planning, briefing and debriefing will be assisted by a mission management system onboard the aircraft.

The aircraft selected by the ADF to fulfil the ARH role is the Eurocopter Tiger. A photograph of an early version of the Tiger during a visit to Australia is shown in Figure 1.

Figure 1. The Eurocopter Tiger [1]

In addition to the operational aircraft, Air 87 will also procure an instrumented aircraft to reside at the ADF's Aircraft Research and Development Unit (ARDU) in South Australia for flight test purposes. The instrumented aircraft will also be considered an attrition aircraft should the need arise in the future.

Ground Mission Equipment (GME) will be procured by Air 87 to support ground mission management of the aircraft and will include the ground communications suite needed to support and operate the aircraft. Ground EWSP equipment will also be procured including the mission support system and electronic warfare terminals.

Support for the ARH aircraft will be supported by a Maintenance Management System (MMS) and the ARH Software Support Capability (ASSC).

The training system for the ARH will consist of training devices including simulators and part-task trainers, training courseware and training delivery. It is the acquisition of this training system, and particularly the training devices that is the subject of further investigation in this paper.

## The Scope of the Air 87 Training System

The Air 87 training system is a very large and complex acquisition in its own right but is considered part of the ARH System for acquisition purposes. The Air 87 training system includes all of the training equipment, courseware and training delivery necessary to train aircrew, groundcrew and maintainers in the operation and support of the ARH.

Aircrew for the ARH will consist of a pilot responsible for the safe and effective pilotage of the aircraft and a new aircrew position known as a battlecaptain. As the name suggests, the battlecaptain will be responsible for “fighting” the aircraft as opposed to flying the aircraft. It is expected that ARH pilots will graduate to the position of battlecaptain after accruing sufficient experience and training as an ARH pilot. ARH groundcrew will be responsible for mission and aircraft support during aircraft operations and maintenance personnel will be responsible for maintenance and support of aircraft systems, avionics, structures, armaments and life-support systems.

## Traditional Training System Challenge 1 – Specifying the Requirements

Training system acquisitions always face the same challenges regardless of the system for which training is being acquired.

One challenge that continually surfaces in training system acquisition is the difficulty associated with appreciating the complete set of training needs. The tendency is to jump straight to specifying training solutions without first understanding the complete set of training needs. This leads to the acquisition of training systems that fail to address all of the training needs, or training systems that provide more capability than necessary. In the former case, expensive modification programs result as operators attempt to address the training gap following acquisition and, in the latter case, the acquisition costs and schedule are likely to be greater than was really necessary.

Even when a complete set of training needs are appreciated as a first step, the subsequent analysis of needs into clear, concise and complete statements of function and performance is difficult. Customers often understand what their systems are, how they are operated and the environment within which they operate. This puts the customer in the position of being able to understand their training needs. Training system design organisations (or contractors) are in the business of designing, building and delivering training systems. These organisations are generally expert in taking a set of functional and performance requirements in the form of a draft functional baseline, refining that baseline and ultimately delivery a compliant system.

There is often a gap left in the middle of the training system continuum between the customer and the designer. There must be a training development step that converts training needs into a draft functional baseline for the training system. The draft functional baseline needs to contain the function, performance, interoperability and environmental requirements for a system that, if compliant, will satisfy the training needs. The training development gap needs to be filled by a conscious translation process that is executed with a sound knowledge and appreciation of both the customer's training need and the technology capable of delivery that training.

The complete continuum is illustrated in Figure 2.

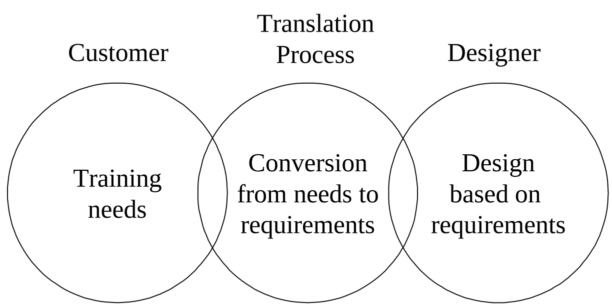


Figure 2. The training system development continuum

Often, the customer and the design organisation each attempts to fill the hole in the continuum by developing respective ideas of a training system draft functional baseline. The result is usually unsatisfactory for two reasons

- the customer understands its needs but is often not well placed to determine how best to satisfy them and therefore tends to take the conservative approach of over-specifying the functional baseline
- the design organisation wants to minimise its exposure to technical risk during acquisition for commercial reasons and therefore tends to understate the functionality required.

Either way, the end result is a training gap between what is needed and what is specified and eventually delivered.

**Traditional Training System Challenge 2 – Verifying AND Validating**

An additional challenge arises whenever a gap exists between what is needed to support training and what is specified in the draft functional baseline documentation. The challenge is gaining sufficient confidence during training system acceptance that the training system meets the specified functional baseline and meets the training needs. In systems engineering parlance, this means verification and validation.

There is a subtle but very important difference between the two terms. Verification is described by ANSI/EIA-632 as confirmation that specified requirements have been met and validation is a confirmation that the intended use of the system can be accomplished by the delivered system. [2] More colloquially, verification and validation confirm that not only have “we built the system right but we have also built the right system”. [3]

If the draft functional baseline of a training system is poorly related to training needs, verification becomes less meaningful and validation nearly impossible. Verification is less meaningful because it is performed against specified requirements that do not necessarily reflect training need. Validation is nearly impossible as the relationship between function and performance and training need is poorly understood. It is only during the subsequent operation of the training system (following acquisition) that the gap between what is needed and what was delivered becomes clear.

The complete training continuum showing the direction of training system development and the roles of verification and validation are shown in Figure 3.

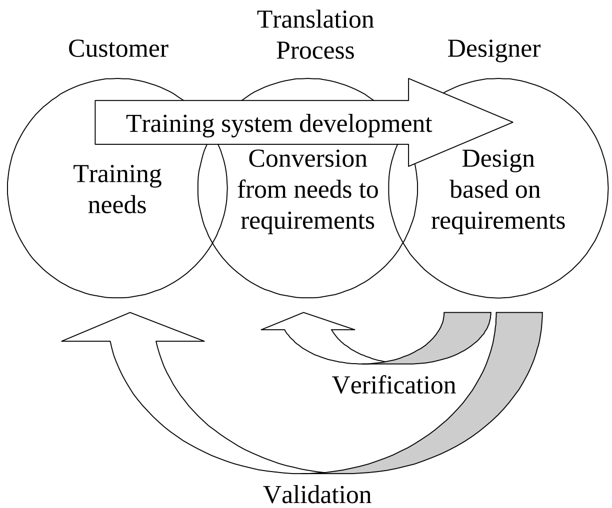


Figure 3. Training system continuum showing verification and validation

**Unique Challenges Facing Project Air 87**

The traditional challenges discussed in the previous sections apply to the acquisition of most training systems. Often, however, the acquirers of the training system are reasonably well-acquainted with the system for which they are acquiring training. This was certainly not the case during the early stages of the Air 87 training system acquisition.

The acquisition of the ARH training system had to occur at the same time and under the same contract as the rest of the ARH System. This meant that the Air 87 project office personnel were unaware of the aircraft system the training system was to support. There were four aircraft competing for the ARH contract during the development of the training system requirements including (in alphabetical order):

- A129 Scorpion from Augusta Westland
- AH 1-Z Viper from Bell Helicopter
- AH-64D Apache from Boeing
- Aussie Tiger from Eurocopter

Each aircraft was quite different in key areas including design maturity and technological advancement meaning that striking a “middle ground” for the training system would be unsatisfactory. Additionally, all of the aircraft brought unfamiliar technology with them which represented a significant advance upon existing Australian Army helicopters. The ARH capability provided by each of the contenders was also a new concept to the Australian Army meaning operational concepts were in their infancy and likely to develop over time.

The traditional training system challenges coupled with the unique Air 87 challenges made this training system acquisition particularly difficult and risky.

## The Project Air 87 Training System Development Process

To overcome the traditional and unique challenges facing the Air 87 training system acquisition, the ARH Project Office developed a multi-stepped process called the training system development process (TSDP). The TSDP is a process designed specifically for Air 87 based on an established training development process [4] and applied systems engineering philosophy. The process involved the Commonwealth and the tenderers for the ARH project in a series of work packages and reviews aimed at:

- Addressing the traditional and unique challenges facing the acquisition
- Reducing the risk to the Commonwealth of acquiring an inadequate or excessive training system
- Assisting the tenderers and (eventually) contractor to understand the relationship between training needs and training system function and performance.

### Step 1 – A Generic Training Needs Analysis

The Commonwealth produced a generic Training Needs Analysis (TNA) as a first step in the TSDP. The TNA was based around established training frameworks for the technical trades [5] and a series of studies into aircrew competencies that were being sponsored by the Australian Army at the time. The TNA resulted in a list of competencies (organised by trade) needed to operate and support a generic ARH helicopter. From this work, it was possible to identify the likely gap between current Australian Army training and the training necessary to support the ARH capability.

### Step 2 – Generic TNA Validation

The generic TNA was provided to all of the tenderers for their review and validation. The review and validation was conducted against each of the tenderer’s specific aircraft solutions. Competencies were added, modified and deleted from the generic TNA during this process and the tenderers added competency levels to each of the competencies as a first step toward specifying level of expertise required to operate and support the aircraft. The Commonwealth reviewed the validated TNAs and provided feedback to each of the tenderers.

**Step 3 – Completion of the Training Devices Report**

Training devices are the major part of the training system acquisition and include high-cost items such as full-flight simulators, mission simulators, part-task trainers and computer-aided training. The tenderers were asked to complete a Training Devices Report detailing the training device alternatives being considered for their ARH proposals. The aim of this report was to show trade-offs between device alternatives and justify the selection of a suite of training devices needed to meet the training requirements contained in each of the tenderers validated TNA. In addition to justifying the selection of the training devices, the tenderers were asked to produce a matrix called a Competency Traceability Matrix (CTM) showing the relationship between training competencies and training devices. The CTM concept is shown in Figure 4.

| Competencies | Training Devices/Aircraft | | | |
|---|---|---|---|---|
| | Device 1 | Device 2 | Device N | Aircraft |
| CompA.1 | | | | |
| A.1.1 | X | - | - | - |
| A.1.2 | - | - | X | - |
| …… | - | X | - | - |
| A.1.X | - | - | - | X |
| CompA.2 | | | | |
| …… | | | | |
| CompZ.Z | | | | |

Figure 4. Competency Traceability Matrix

The CTM showed all of the competencies in the validated TNA, grouped by trade, in the left hand column. The training devices proposed for use in the training system were listed horizontally at the top of the matrix. The tenderers then proceeded to allocate competencies to training devices. In this way, the CTM clearly showed how each of the competencies was to be trained. In some instances, one competency was allocated to more than one device in which case an explanatory note was required. In addition, by choosing any training device and looking vertically down the matrix, it became very clear what training was to be supported by that device (and what training it did not need to support).

The tenderers also produced a more detailed matrix called the Allocation Matrix (AM) for each of the training devices listed in the CTM. The AM was designed to show what training requirements were likely to drive the function and performance of each of the subsystems in each of the devices. An example of an AM for Device 1 is shown in Figure 5.

| Competencies | Device 1 | | | |
| --- | --- | --- | --- | --- |
| | Mot. Sys | Vis. Sys | IOS | Comp. Sys |
| CompA.1 | | | | |
| A.1.1 | X | - | - | - |
| A.1.2 | - | - | X | - |
| …… | - | X | - | - |
| A.1.X | - | - | - | X |
| CompA.2 | | | | |
| …… | | | | |
| CompZ.Z | | | | |

Figure 5. Allocation Matrix for Device 1

Again by referring vertically in the AM, readers could quickly relate the function and performance of subsystems to training competencies. The tenderers were asked to use this information to produce a draft specification for each of the devices in the CTM. The draft specification contained a basic description of the device and detailed functional descriptions of its subsystems showing the expected level of performance needed to support the allocated competencies in the CTM and AM.

With this suite of documentation, a reader was able to take a generic training need from the initial TNA and trace it all the way through the TSDP documentation to see how it was going to be trained and whether it was a significant design driver.

**Step 4 – Request for Tender and Acquisition**

The Request for Tender (RFT) for the training system was a continuation of the TSDP where tenderers were asked to provide more detailed technical specifications for each of the devices whilst maintaining the traceability with the preceding stages. Standard contractual and management documentation such as plans, schedules and costs were also delivered in response to the RFT. Typical evaluation techniques were employed to determine the preferred training system tenderer and this assessment was combined with the rest of the ARH tender process to determine a preferred overall solution. The documentation suite delivered as part of the TSDP process and the RFT process formed the basis of the draft specification for the training system contained in the Air 87 contract which was for a training system designed to meet training need, and a minimum level of function and performance.

## The Current Situation and Conclusions

The TSDP process described in this paper was designed specifically to address traditional and unique challenges facing the acquisition of the ARH training system. It was a successful process in that it addressed each of these challenges. Training needs were identified and requirements analysed and derived from those needs. Traceability via a series of matrices was established to ensure that both verification and validation of the delivered training systems was possible and meaningful. The process took account of the many unknowns associated with the Air 87 project during the tender period including an unknown aircraft and uncertain training needs.

Its success as an engineering process beyond this is currently very difficult to assess as the training system is currently at different stages of development in various parts of the world. Its success as a development process will ultimately be measured by the Australian Army when the ability of the delivered training system to meet training need is tested.

A large number of factors will influence the ultimate success of the acquisition of the Air 87 training system including the TSDP process described in this paper. Regardless of the ultimate results of the acquisition, the TSDP was a rigorous and methodical approach to a challenging acquisition that resulted in the documentation of training needs and the consideration of those training needs during the earliest stages of design. To that end, the TSDP achieved its aim of emphasising training needs and ensuring that these needs drive the design and testing of the resultant training system.

## About the Author

Ian Faulconbridge received BE and MEngSc degrees in electrical engineering from the University of New South Wales in 1990 and 1999 respectively and an MBA in project management from the University of Southern Queensland in 1996. Since 1990, he has held a number of systems engineering and project management positions in the fields of avionics, simulation and communications systems.

Ian is a Senior Lecturer in the School of Information Technology and Electrical Engineering at the University of New South Wales (Australian Defence Force Academy). He teaches electronics, systems engineering, avionics and radar and is the author of a book on radar and radar electronic warfare, and co-author of a book on systems engineering.

Additionally, Ian manages his own engineering consultancy providing short-term, independent, on-demand consulting in systems engineering management and a number of technical domains.

## References

1. SGT Brian Hartigan, Army Newspaper. 2001. Reproduced with permission.

2. Electronic Industries Association. 1999. *ANSI/EIA-632 Processes for Engineering a System*. Arlington. p 64.

3. Faulconbridge, R. Ian, and Michael J. Ryan. 2003. *Managing complex technical projects – a systems engineering approach*. Boston: Artech House. p 128.

4. Australian Army Manual of Land Warfare – Part 3 Training Vol 4 Pamphlet No 2. 1997. *The Handbook of the Army Training System*. Sydney.

5. Australian National Training Authority. 1997. *National Aeroskills Framework*. Brisbane.