CHAPTER 1

1 Introduction

1.1 Preface

This thesis details the work accomplished on the research *project "Conceptualisation and Automatic Generation of Test & Evaluation Master Plans for Defence Acquisition Test Programs"*. This work was conducted by John S. Nissyrios, one of four project postgraduate research students working under the guidance of Professor Peter Sydenham at the Australian Centre for Test & Evaluation (ACTE) and Mr Viv Crouch of the Aircraft Research & Development Unit (ARDU) of the Royal Australian Air Force (RAAF), on a full-time basis at the Salisbury Campus of the University of South Australia (UniSA), over 1994 to 1996 inclusive, whilst also employed as a casual tutor/practical supervisor in the School of Electronic Engineering.

The aim of the collaborative project, involving both the ACTE and the ARDU of the RAAF, was to conduct research which would "assist in the design of telemetry data formats and contribute to assuring end-to-end data traceability of test programs" (ARDU, 1993). Research has been conducted in four primary areas. These research areas and associated ACTE researchers are:

1. **An Analysis of Test and Evaluation in the Acquisition of Defence Systems**. This research project was conducted by Mr Mark Dvorak[1], *"is to investigate worldwide T&E policies and practices in an effort to increase understanding of the T&E process and to suggest areas of improvement"* (Dvorak, 1996).

[1] Mark Dvorak is the ARC Collaborative Project Leader, and has recently completed his research project leading towards a Masters Degree on, *"The Definition and Characteristics of Test and Evaluation in the Acquisition of Defence Systems"*.

2. **Computer Aided Synthesis of Measurement Schema's for Telemetry Applications**. Mr Peter Evdokiou is currently conducting research into the *"development of a methodology, and associated software based tool, that will allow a non-telemetry expert to specify test measurement schema's given a high level test requirements and a test measurand database"* (Evdokiou, 1996).

3. **Configuration of Flight Test Telemetry Formats**. Mrs Mouna Samaan is currently conducting research to improve the efficiency in the configuration of flight test data telemetry formats. *"Efficiencies sought are a reduced use of allocated telemetry bandwidth and increased data capabilities through an enhanced approach to the production of PCM telemetry data formats"* (Samaan and Cook, 1995).

The fourth research area and the subject of this thesis, is the automation or knowledge based computer-assistance in the manual generation of a Test & Evaluation Master Plan (TEMP), from functional requirements, along with the production of the TEMP document associated with the real-time Test & Evaluation (T&E) of complex systems, such as the highly instrumented fighter aircraft F/A-18 Hornet.

While the concepts are widely applicable, the project specifically targets, the large, multi-sensor and high speed systems such as those involved in aircraft testing and the telemetering of the data to land based stations (Sydenham, 1993a). However, the concepts and design methodology is not intended to be constrained entirely to aircraft, such as the F/A-18, but to a more general and diverse array of test recipients, from aircraft carriers, submarines, complex weapons systems, missiles, spacecraft, etc., to the likes of automobiles, computers, mobile phones, and even physical processes.

This work forms an integral part of the Heuristic Transaction Shell (HTS), at the Aircraft Research Development Unit (ARDU) of the Royal Australian Air Force (RAAF), which is to enhance the current ARDU Flight Test Information Management System (FTIMS) through improved test management, data traceability, and Data Cycle Map (DCM) synthesis (Dvorak, 1994), of which will be discussed further on.

The research is concerned with an approach to automating the primary stage of a Defence Acquisition Test Program (DATP), that being the preparation of the fundamental Test and Evaluation Master Plan (TEMP) document associated with the real-time T&E of a complex system, as mentioned previously. The TEMP is a high level document that is continually evaluated and updated, and finally verified and validated (V&V), over the duration of the test program.

1.2 Aim of the Research

The aim of the research was to produce an automated, or at least a computer-assisted method to aid in the manual generation of a TEMP, from the Functional Requirements Specification (FRS) of any DATP.

A further aim was to produce a TEMP document in a form that can be used for both technical, management, and contractual purposes, conforming to military standards, such as the Australian Defence Force (ADF) Capital Equipment Procurement Manual (CEPMAN 1) instruction.

1.3 Background

Test and Evaluation is practiced by many defence sectors around the world, such as the United States of America, United Kingdom, France, Israel, Germany, Republic of China and Australia. Whether they are testing F/A-18's for the RAAF or carrying out research on submarines at the Naval Postgraduate School in the States, there are T&E processes that these groups follow (Nissyrios, 1995b).

The Sensor Science and Engineering Group (SSEG) in conjunction with the Australian Centre for Test and Evaluation(ACTE) has won an ARC grant for a collaborative research project with the RAAF. The project, co-located at the Salisbury Campus of the University of South Australia and at ARDU, Salisbury, South Australia, is envisaged to ***improve computer-based means of handling the large quantities of data associated with the real-time Test and Evaluation (T&E) of complex systems*** *(Nissyrios, 1994b).*

The ARDU has developed a limited capability to manage test programs through the development of a prototype Flight Test Information Management System (FTIMS). This system is under continuous development at ARDU to meet new flight test task commands.

Traditional software development methods used to upgrade FTIMS have been proven to be skill intensive, whereby specialist contracted programmers are needed, and costly to maintain, i.e., beyond the skill level of organic staff to do other than minor amendments (ARDU, 1993).

The Australian Research Council (ARC) recognised the need for the development of improved methods for Test and Evaluation (T&E) management, planning and execution and granted funding for a collaborative research project with the ARDU of the RAAF and the Australian Centre for Test and Evaluation (ACTE) (Dvorak, 1995a) to conceptualise and bring into fruition a suitable Heuristic Transaction Shell (HTS) for the FTIMS that will encapsulate the ***"business rules"*** related to test management and design, bring discipline to data identification handling, quality monitoring and interpretation processes and have the capacity to build on future lessons learned, i.e., knowledge-based. The FTIMS HTS will be a by-product of that research with the specific aim of improving flight test operations at ARDU.

1.3.1 HTS Primary Mission

The mission of the HTS segment is to assist ARDU test personnel in the full range of flight test management. The HTS is intended to aid in the traceable formulation of quantitative test measurements derived from high level qualitative test requirements. It will then translate the required measurements into an optimised telemetry stream format through a computer-aided Data Cycle Map (DCM) synthesis procedure. The proposed system is intended to support ARDU task management through the entire process of planning execution and reporting (Dvorak, 1995a).

1.3.2 HTS Secondary Mission

The secondary mission of the HTS is to support test management externally to ARDU. Future growth should consider links with associated test facilities, laboratories and administrative offices (Dvorak, 1995a).

1.3.3 System Architecture

The overall system of which the HTS segment is a part is known as AIMS. AIMS resides on the ARDU Unix based network known as ARDUNET, which comprises several Sun Sparc Workstations and host computers. The HTS segment is purely software based and resides on the same host computer as AIMS and therefore does not contain internal Hardware Configuration Items (HWCIs) (Dvorak, 1995a).

1.3.4 AutoTEMP© Beta 2.0 CSCI

AutoTEMP© Beta version 2.0 is a by-product of this research, with the specific aim of automating the manual generation of the fundamental underlying document of any DATP, namely, the TEMP. The HTS segment incorporates the following Computer Software Configuration Items (CSCIs) depicted in Figure 1-1.

With reference to Figure 1-1, the CSCI AutoTEMP© comprises of the following CSCIs: T&E Information CSCI and Task Management CSCI.

1.3.4.1 T&E Management Module

This module assists the user by providing an interactive map of the T&E process with support for a logical flow of test planning documentation from the TEMP through detailed test plans for each phase of a given project. The module also supports evaluation report writing ensuring that results reported are linked to the originally defined test objectives (Dvorak, 1994). The direct benefits to ARDU from this module of the HTS are:

1. Disciplined, repeatable testing.
2. The ability to capture corporate knowledge in an expert flight test system instead of having that knowledge reside with a select number of experienced test engineers (expert). The captured knowledge will be clearly visible allowing simpler development, extension, and modifications, as requirements change.
3. The system will increase the efficiency of training new flight test personnel, as traditional methods have proven to exceed both budget and time scales.

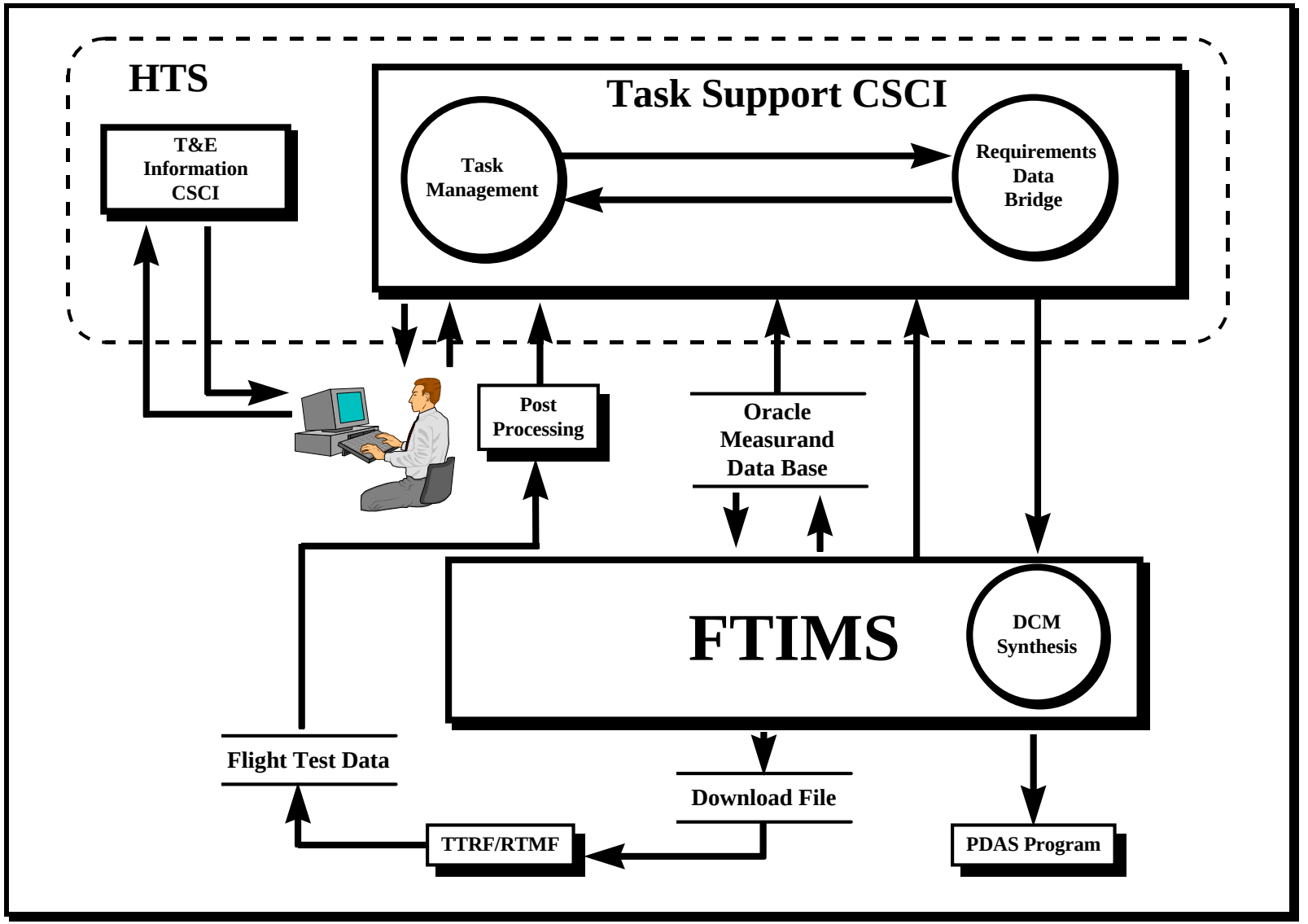

Figure 1-1 (Top Level Segment Architecture of HTS (Dvorak, 1995a))

1.4 Structure of the Thesis

This thesis is divided into two volumes. Volume I contains the main text, namely, seven chapters and references, whilst Volume II contains the appendices as is depicted in the table of contents. Chapter 1 introduces the topic of the research, the aim of the research, gives an overview of the background that gave rise to the research project, and it's contributions that it has made to Australia and world wide.

Chapter 2 discusses a review of the literature pertaining to T&E, and how these theories and practices have evolved into the automation of T&E processes & procedures. After a brief introduction to T&E, a description of the history of T&E is given, outlining the traditional scientific method and how T&E has evolved from systems engineering practices. The majority of the remainder of this chapter is devoted to defining T&E, describing the two types of T&E, and such things as the reason, need for conducting, and the importance of T&E.

Chapter 3 gives a genealogy of aircraft flight testing outlining its relation to T&E. An overview of the ARDU is presented describing the FTIMS project further, as well as a discussion on flight test planning and a brief description of major range and test facility bases in the United States of America as well as telemetry formats used in flight testing.

Chapter 4 analyses and compares T&E structures and processes pertaining to the most well documented T&E system developed in the United States and the present one in Australia, with a lean towards the RAAFs paradigm. This chapter presents a comprehensive description of the differences between the United States and Australian T&E perspectives and TEMP formats.

Chapter 5 examines the need for automating the T&E process, along with the requirements for the implementation via computer-aided methods. Against this background, a review of two other well authorised theses pertaining to the automation of a process, and a commercial piece of software developed by the Pentagon in the United States is discussed and analysed. This is followed by an outline of the requirements for generating a TEMP, namely, content of the TEMP, and the automation of the extraction process with respect to the Software Requirement Specification (SRS).

Chapter 6 describes AutoTEMP© Beta 2.0, the knowledge based software system that uses a computer to aid in the generation of a TEMP for any DATP, and embraces the ideas of chapter 5. This chapter discusses the selection of the development software, the selection of the host machine and hardware requirements. The remainder of this chapter is devoted to the three modules that make up AutoTEMP© Beta 2.0, namely, the Defence Phased Acquisition Process (PAP) tutorial, the TEMP Generator Module, and TEMP Document Generator. The chapter also gives a description of the lessons encountered from sample tests of the software, namely, developmental and operational software related bugs, and user related problems. This is followed by a discussion of the quality of the TEMP document automatically generated by AutoTEMP© Beta 2.0.

Chapter 7 concludes the thesis by summing up the achievements of all phases of the research project and the contribution it has made to knowledge. The chapter also presents a discussion on further research, in particular, the use of AutoTEMP© Beta 2.0 on the Information super highway known as the Internet. Finally a description of a research outline at the Doctorate level (PhD) is presented as a possible extension of the current research.

1.4.1 Thesis Editorial Format

This Thesis was prepared using Microsoft *Word* Version 7.0, on a Windows® 95 platform and the "Thesis1" template which comes with this version of Word. The structure of the Thesis abides by the *"Guidelines for the Preparation of Theses" - Section 5* of the Academic Procedures and guidelines for Masters Degrees by Research, located in the 1996 University of South Australia Research Degree Student Information Folder.

1.5 Contribution to Australia

The development of this project has provided a tool (AutoTEMP© Beta Version 2.0) of immediate benefit to ARDU, and a spin off value to other Australian agencies faced with test and evaluation problems on a similar scale. In particular, those agencies involved with aircraft, ships, submarines, large simulation and modeling tasks, command, control, and communication (C^3I) systems, air traffic control systems, and space related activities (Sydenham, 1993a).

The United States of America, Canada, France, and the United Kingdom have made investments in test & evaluation amounting to billions of dollars. The high volume of work

required at some overseas agencies has resulted in their facilities being fully booked in advance for the next four years. It is not possible to make quantum leap changes to present test & evaluation technology without delaying the existing programs at huge expense. Australia does conduct high volume testing, and does not have large investments in past programs. The opportunity exists to make radical changes to uneconomic and obsolescent processes using new generation technologies, which could then be marketed in other countries. *An integrated KBS based test and evaluation system, namely, AutoTEMP© Beta 2.0, for the computer-aided generation of TEMPs, can save the agencies involved in high volume testing hundreds of millions of dollars, due to a reduction in time, cost, and effort taken to manually produce a TEMP,* whilst offering more thorough and reliable testing, and increasing confidence in the safety and predictability of complex systems, such as the highly instrumented fighter aircraft, F/A-18 Hornet.

Test and evaluation program management in the United States alone represents a $3Billion annual turnover in technology and services. The potential for attracting US investment in proving the economy of test and evaluation is high with a prospective world market that at present impacts on a $70Billion capital investment.