CHAPTER 3

1. The Genealogy of Aircraft Flight Testing

1.1 Introduction to Flight Test

The first flight tests took place over two hundred years ago in a balloon in France. Credit for the invention of the balloon goes to *the Montgolfier Brothers, Joseph and Jacques,* who were sons of a wealthy paper bag manufacturer. They developed the technology for both hot air and hydrogen systems but they were not the intrepid pilots. The test crew for the first full scale test was a cock, a duck and a sheep. The operational role of each in the test mission is unknown but they obviously did not know enough about flying because it was immediately proposed to have a human crew for the next flight. Two prisoners were proposed by *King Louis XVI over the protests by Jean Francois Pilatre de Rozier who believed this to be an honor* and not a sentence. In the end he prevailed and was given the nod for being the first test pilot of the first manned flight (Schweikhard, 1991).

The "testability" (of say an aircraft) is defined by the Encyclopaedia Britannica (Benton and Benton, 1980b) as follows:

> *"**Testability**, in the philosophy of science, the capability of a scientific hypothesis to be tested by comparing the predictions that it formulates with observational or experimental data that are capable of either indicating the falsity of the hypothesis or of corroborating, though not necessarily proving, its validity".*

The increasing complexity and volume of the information needed to support test missions has led to a need to expand the capability of current test data management systems. While the abilities currently exist to collect and manage calibration and telemetry information in an automated fashion, new requirements have emerged to link this data with other systems and to expand the functions and devices supported (Hoaglund and Gardner, 1993). As a result, a large volume of data is generated for each test conducted. This is not only computationally expensive, making data processing very time consuming, and stretches the telemetry bandwidth to it's limit in the case of air and space-ground telemetry, bus also hinders the design of test and evaluation programs to accurately validate the function of the systems (Teng et al, 1994).

The thrust of this research is based on the highly instrumented fighter aircraft F/A-18 Hornet, however the research is not intended to be constrained entirely to the test and evaluation of FA/18's, but to a more general and diverse array of test recipients (Nissyrios, 1994a).

The process of testing an aircraft such as the highly instrumented fighter aircraft F/A-18 Hornet, equipped with over 500 onboard sensors and 6000 measurements available from the internal MIL-STD-1553[1] (Chavez and Sutherland, 1990) avionics bus for both onboard tape recording and telemetering, is very complicated because of a number of resource limiting factors such as (Nissyrios, 1994b):

1. Telemetry bandwidth considerations, as for each half-hour flight test, there is approximately 1.2GigaBytes (GB) of measurement data generated with the serial Pulse Code Modulated (PCM) streams produced at a rate on the order of 100kbits per second.
2. Wish to know numerous amounts of information (very large numbers) in a very short span of time.
3. Speed at which the test takes place is sometimes in the vicinity of twice the speed of sound[2].
4. Further exacerbated with missile testing as the entire process is completed within a few minutes, hence is only carried out once a year as it requires $US1Million dollars for each test.
5. Severe space problems, because of the clutter of sensors onboard the aircraft which are also constrained to very strict safety regulations.

The complexity, size, and the number of people involved cause the user to lose contact with what happens to and hence otherwise affects his/her data. Pressures on the cost of testing,

[1]Note that MIL-STD-1553 multiplex data buses are commonly used to link complex software-controlled systems in modern aircraft (Fletcher, 1992) such as the Hornet F/A-18.

that is, want more effective systems for less cost and in less time. However every variable of any significance is under threat, and thus T&E is seen as one of the main ways of reaching those goals

1.1.1 Flight Test Defined

Flight Test is a very important and very expensive portion of the Test and Evaluation activities that support the acquisition of new aircraft capabilities. The data gathered during flight or ground test forms the foundation for major acquisition decisions, and the accuracy and efficiency of the testing process is vital to the entire acquisition effort (Hoaglund and Gardner, 1993). Of all the research papers that the author has come across on flight test, the most prominent one would have to be *"Flight Test - Past Present and Future"* by Schweikhard (1991). Schweikhard defines flight test as follows:

> ***"Flight test*** *is a process by which quantitative and qualitative results are obtained on an air vehicle."*
>
> ***"Evaluation*** *of flight test results is a process by which cognitive or knowledge-based conclusions of the flight test process are arrived at."*

No matter what type of aircraft or type of testing is being done, or whether we are recording the data by hand or we are using the most sophisticated of data acquisition systems, there are certain elements that remain the same. They are (Schweikhard, 1991):

1. Planning and coordination
2. Instrumentation and calibration
3. Flight test operations
4. Data acquisition
5. Data processing
6. Data analysis and interpretation
7. Reporting of results

Flight test is a *"process"* whereby we (Schweikhard, 1991):

[2] Example: Flying at Mach 2 (twice the speed of sound) and moving a wing on the aircraft whilst simultaneously recording and telemetering numerous measurements.

1. Evaluate an air vehicle (aircraft).
2. Prove or disprove new concepts or designs.
3. Identify design problems or deficiencies.
4. Prove or certify the airworthiness of an aircraft.

Two very important questions that one needs to ask continually are (Schweikhard, 1991) "*How much do we really need to measure ?" and two is "How much money for manpower and equipment is it worth ?"*.

As stated previously a number of parameters can cause the user to lose contact with what happens to and hence otherwise affects their data. So we need to ask ourselves the questions, "Who is looking at the data and evaluating it ?" and "Do we really need it all ?" (Schweikhard, 1991). Off course we appropriately archive the data and almost always never go back to look at it again. A paraphrased variation of Parkinson's Law for instrumentation says that *"The number of parameters requested will grow to fill the capacity of the data acquisition system"* !. We become like kids in the toy department and want everything insight. "Top-down" flight test planning results in the recording of too many parameters. Hence need to (Schweikhard, 1991):

- Keep it ***S****imple*
- Keep it ***S****mall*
- Keep it ***E****conomical*
- Keep it ***M****anageable*

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The more sophisticated weapons become, the more information required for thorough system test and evaluation. With the increasing capability in instrumentation technology, more data is being generated, and this is turn is stressing the amount of telemetry bandwidth available (Hoefner, 1992). A constant question thus put forth is *"What information is required not what data can be made available"*, and that, *"It is not enough to just do things right, first, we must be doing the right things" (Schweikhard, 1991).*

1.1.2 Aircraft Research & Development Unit

The Aircraft Research Development Unit (ARDU) is the flight test authority for the Royal Australian Air Force (RAAF). ARDU was born out of a requirement to handle the testing of developmental aircraft and weapons during Word War II. Its nucleus was established in 1941 and one of its first tasks was to evaluate qualities and performance of captured aircraft (Slezak and Crouch, 1992). The ARDU is the prime Australian Defence Force (ADF) agency for the collection and analysis of flight test data for military aircraft, airborne systems and weapons. As directed by the Royal Australian Air Force (RAAF), ARDU (ARDU, 1989):

1. Executes Research, Development, Test and Evaluation (RDT&E) tasks and trials.
2. Provides flight test data that is essential to monitor the effectiveness of other ADF and Defence Science and Technology Organisation (DSTO) Research Development Test & Evaluation (RDT&E), modelling and software verification and validation (V&V).

The ARDU performs flight testing on Royal Australian Navy (RAN) aircraft. There are fifty or more flight test tasks of varying complexity at any one time. Flight test missions in ARDU inventory currently include (Slezak and Crouch, 1992):

- Test and Evaluation requirements for flight loads measurement.
- Software verification and validation.
- Flying qualities measurement.
- Weapons clearance and release.
- Validation of simulations and models.
- Tactical testing.

Amongst the numerous amounts of issues that the ARDU must take into consideration when undergoing flight testing to ensure that all avenues for mishap have been looked at, the most prominent issues that must always be considered are:

1. Time to deliver the interpretation of the results of any one test.
2. Quality of performance that applying T&E will bring along.
3. Cost of carrying out a test.

At present, the most important of the ARDU's tasks include participation in international Hornet F/A-18 (Fighter Aircraft) test programs with the Canadian Forces (International Follow on Structural Test Program) and with the United States Navy (Software Verification and Validation). A diagram of the Hornet Integrated Flight Test Data Acquisition and Analysis System is shown in Figure 1-1. Figure 1-2 illustrates some of the parameters as shown on the screen in the control room, illustrating such things as altitude, roll rate, torque, elevation, fuel in both left and right wing compartments, rudder position, etc. Note however, the parameters shown are those depicted at that instant in flight and are continuously being updated during the test.

In fulfilling its role the ARDU mandatory tasks are classified into seven categories, as follows (Ward, 1995):

1. Conduct, DT&E for the RAAF and Australian Army on aircraft, aircraft weapons and associated systems.
2. Process Electronic Warfare (EW) data collected by RAAF resources.
3. Conduct software support of RAAF EW systems.
4. Conduct specialised EW training.
5. Develop and maintain appropriate capabilities, facilities, equipment, expertise and techniques required for the real-time qualitative and quantitative flight test activities in DT&E and EW.
6. Maintain and operate all aircraft, aircraft weapons and associated systems permanently allocated to ARDU.
7. Maintain an EW reference library.

ARDU's main product is therefore intellectual property (outcomes of the tasks), and is used by customers to make informed decisions.

1.1.3 Flight Test Information Management System (FTIMS)

1.1.3.1 Overview

The FTIMS as mentioned in Chapter 1, performs those transactions needed to manage the flow of information related to quantitative flight testing. This will involve management of information associated with flight test planning, data acquisition and reduction, configuration management of test aircraft and ground systems, inventory control of flight test systems, identification of type records, and data traceability and validation.

1.1.3.2 FTIMS Operation

The ARDU of the RAAF has developed a prototype FTIMS (as illustrated in Figure 1-1). FTIMS provides a limited capability to manage flight test related data, specifically for the support of the Hornet F/A-18 flight testing effort. The FTIMS allows the definition and acquisition of flight test related data (ARDU, 1994b).

From an identified task, a test flight or series of test flight may be initiated. Flight test Engineers or Task Managers (TM) (as they are sometimes referred to) from Flight Test Squadron define information that they wish to acquire and retain from a test flight. Engineering squadron then determines the specific measurands to be captured, and the configuration required, in order to satisfy the request.

There are two types of measurands that are directly accessible on a test article, Mux-bus measurands and Non-Mux-bus measurands. The availability and characteristics of the Mux-bus measurands are dependent on the specific hardware and software configuration of the bus-interactive systems fitted to the test article. The availability and characteristics of all non-mux-bus measurands (both residual and non-residual) are defined by the ARDU.

Flight test requirements are defined including the measurands required and the desired sample rate. Calibration is defined for the Total Tape Relay Facility (TTRF)/Real Time Monitoring Facility (RTMF) to process the test data received and the PCM details are also defined.

A Data Cycle Map (DCM) is then produced that is used to program the Programmable Data Acquisition System (PDAS). Also produced are Download files for the TTRF/RTMF and PDAS calibration system amongst others. This file is used to automatically program the TTRF/RTMF with the measurand information, de-commutation rules and measurand calibration particulars.

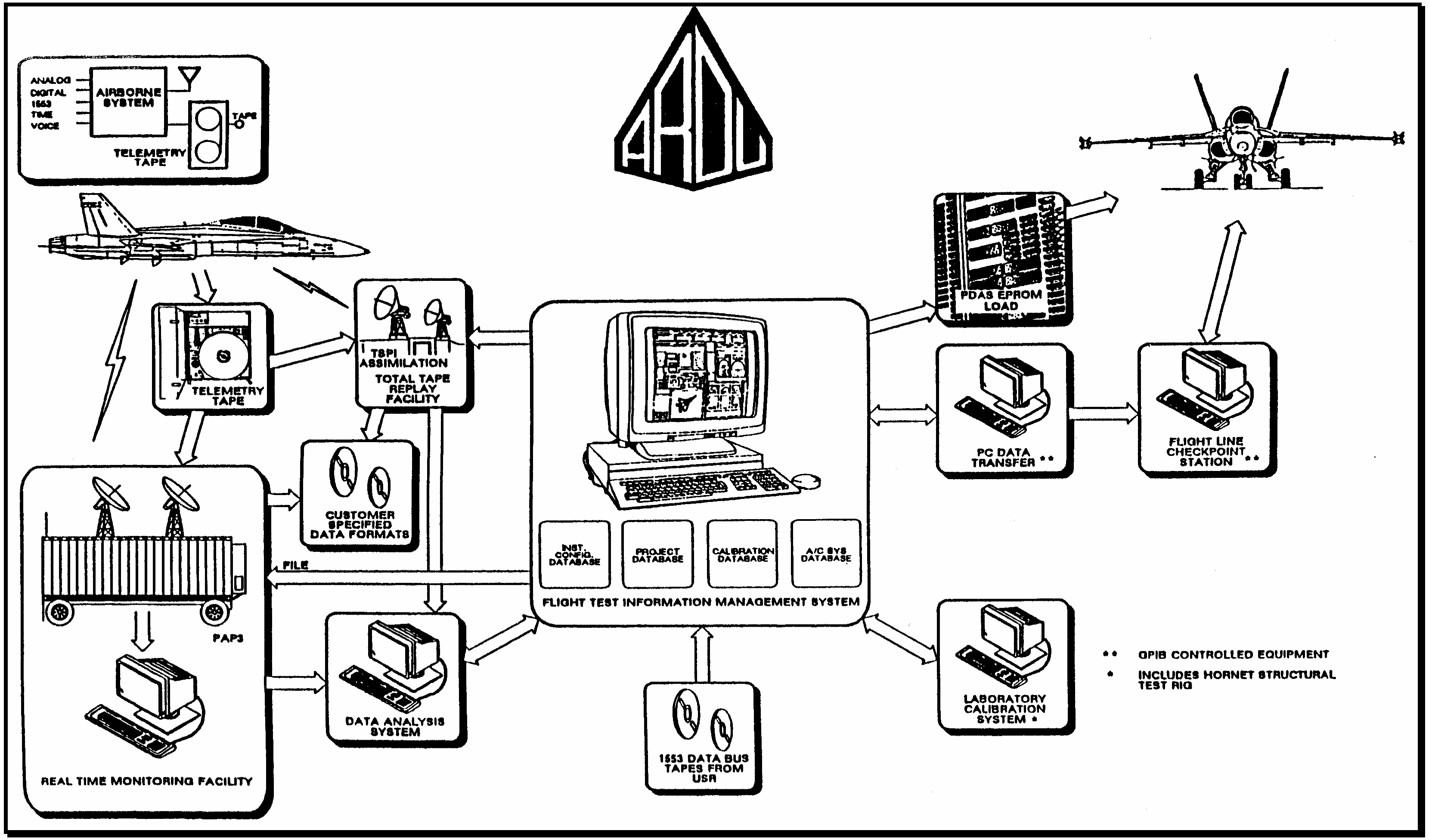

Figure 1-1 (Hornet Integrated Flight Test Data Acquisition and Analysis System)

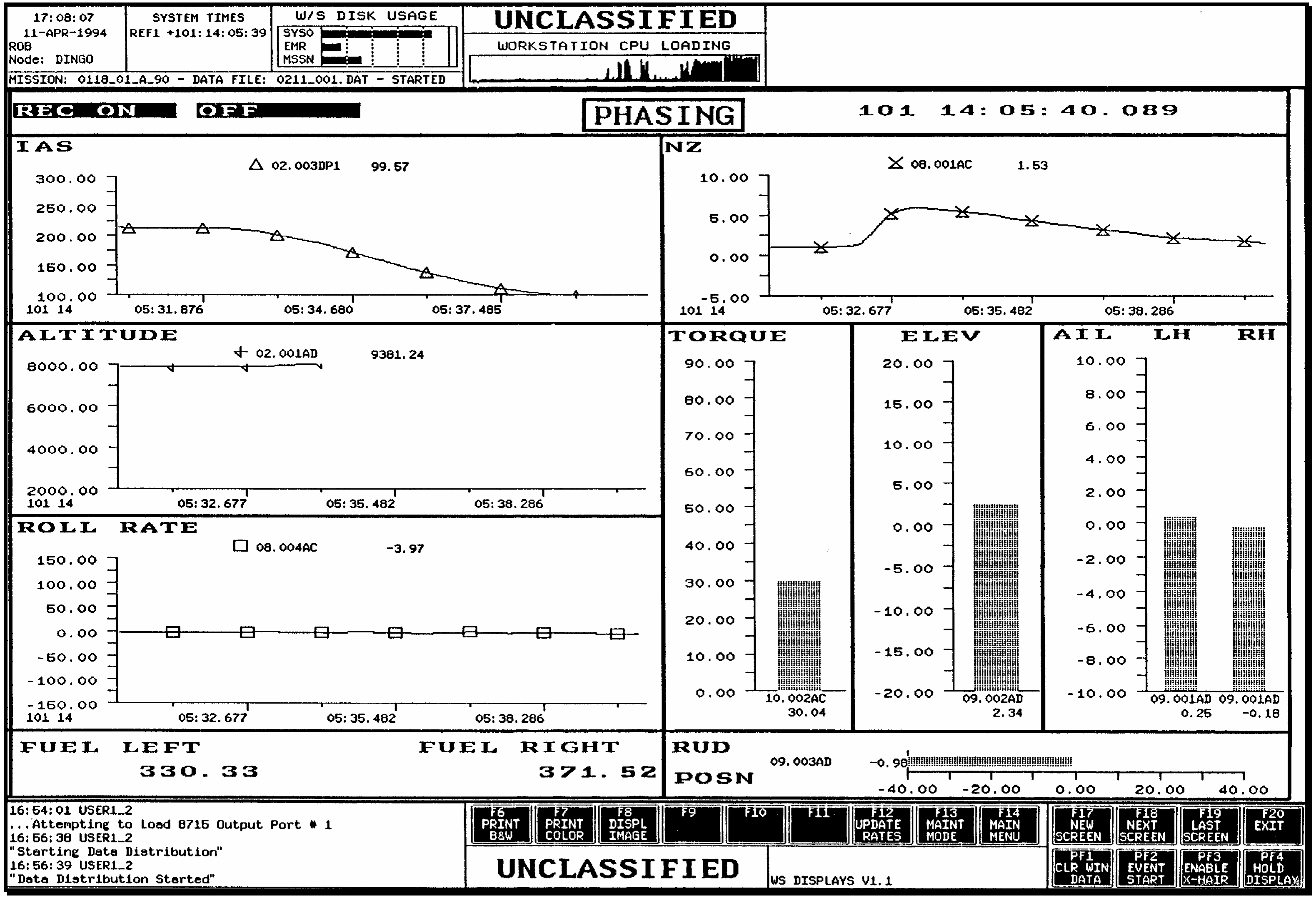

Figure 1-2 (Telemetry Flight Test - Outputs that can be achieved with Flight Test Data Acquisition Systems)

1.1.3.3 Data Cycle Map

Once all the data to be acquired on a test flight is known, along with the selected frequency of acquisition and preferred spacing, a transaction shell has been written for the data base as an aid to designing a suitable data format for the telemetering and/or on-board recording.

Once linked to the data attribute records in the data base, this enables the Data Acquisition System (DAS) on a test aircraft to be automatically programmed, the decommutation rules of Engineering Unit (EU) conversion rules to be commonly down loaded to the RTMF and TTRF, and the test aircraft configuration to be fixed.

1.1.4 Flight Test Planning

Flight test planning is a multi disciplinary endeavor which defines *test* and *test support requirements*. *Test requirements* include defining the *test objectives, the test procedures, and test evaluation criteria.* *Test support requirements* include scheduling test range assets, configuring the test article and its data collection system, and defining data products. The process must consider (Bender et al, 1993):

- Flight safety.
- Aircraft limitations.
- Test constraints.
- Range support requirements.
- Instrumentation requirements.
- Aircraft configuration.
- Data output requirements.

Miller and Sears (1993) states that “failing to plan is planning to fail”, which in reality is a very realistic statement to make especially when your talking about the procurement of a multi-million dollar project. Test evaluation criteria describes how the data collected during test are to be evaluated and how to determine the success of the data. Test support planning includes scheduling range airspace, control room and data acquisition, processing, display systems, frequency allocation, chase aircraft, vehicle tracking, fire truck and medical coverage. It also includes defining instrumentation system measurands to collect telemetry transmission format and frequency, general aircraft configuration (i.e., fuel, load, weight, balance, etc.), aircraft specific system hardware, software, and firmware configuration (Bender et al, 1993).

Single test planning systems will probably not be useful for all test programs. Having all the test points accessible to the test mission planning system and by marking them with status indicators like *"planned", "flown", and "complete" (Bender et al, 1993)*, a simple database query will provide the desired reports instantly. The application of an Knowledge-based system (KBS) can validate a planners ideas and provide an environment for exploring alternate plans. In conclusion, software saves *Flight Test Engineers* (FTE) time, ultimately reduces data processing costs for the whole test program.

One should avoid ad hoc testing. There should always be a *written test plan*. Writing it down helps communicate to those who must approve the plan, what your intentions are, as well as the ability to communicate (Seglie, 1993b) what must be the necessary preparations to those who must support the plan. The task of writing down our plans is far from new, and can be traced back to biblical times, as is written in The Holy Bible (Nelson, Deutronomy, 5:22, 1983):

> *"These words the Lord spoke to all your assembly, in the mountain from the midst of the fire, the cloud, and the thick darkness, with a loud voice; and He added no more. And He* ***wrote them*** *on two tablets of stone and gave them to me."*

1.1.4.1 The Test Plan

It is impossible to meaningfully consider a "cookbook" approach to test planing. For it to be effective and affordable, the test plan must be tailored to both the type of system and to the risks (technical, schedule, and cost risks) inherent in the particular program. Nevertheless, we have the intelligence to use some sort of test plan writing guidelines, based on the more common problems from test plans written in the past that could have been reduced with better test planning. The following is a fifteen point summary of test planning rules compiled by Reynolds and Damaan (1994) and also applies to T&E defence acquisition programs:

1. Plan early and thoroughly.
2. Integrate the test program.
3. Focus on the operational.
4. Pick the right measures.
5. Make the T&E events complement each other.
6. Design for testability.
7. Test reliability throughout development.
8. Use models and simulations, wisely.
9. Establish a failure reporting system early.
10. Ensure disciplined computer software testing.
11. Tailor design-limit testing.
12. Conduct life-testing during engineering and manufacturing development phase.
13. Ensure the whole system is ready for OT&E.
14. Determine test resources needs early.
15. Collect and use initial field feedback.

Figure 1-3 (Flight Test Planning Rules (adopted from Reynolds and Damaan, 1994))

1.1.4.2 Analysing Test Data

In a flight test, the analyst of the final data should always witness trials, as there is no other way to visualise the context in which the data takes on meaning, and hence save time. Trying to recreate the test procedure or trial from the gigabytes of data collected during a one hour flight test is worse than blind men trying to describe an elephant. The following suggestions depicted by Seglie (1993b) will have the capacity to speed up the analysis by focusing in on the drivers for mission success, the most important aspect of the evaluation.

1. Keep all the data for analysis.
2. Determine if the trial lead to a mission success.
3. Assign a probable cause for each mission failure.
4. Determine if there are any order effects or apparent learning during the test.
5. Search for other confounding effects.
6. Find out why things happened the way they did.

Figure 1-4 (The Flight Test Data Analysis Rule Set (based on Reynolds, and Damaan, 1994))

1.1.4.3 Evaluation of Flight Test Data

The evaluator will experience many pressures from individuals who have a stake in the answer (Seglie, 1993b), who may want the answer to come out one way or another. The following suggestions aim to make the evaluator's difficult task as unstressful as possible by: playing by announced rules, not winking at faults in the test or the system under test, and by being complete in the evaluation.

1. Evaluation criteria should be available before test planning starts.
2. Evaluate against all stated evaluation criteria.
3. Don't put blinders on during the evaluation.
4. Keep the evaluation objective.
5. Evaluate the test as well as the system under test (SUT).

Figure 1-5 (Evaluation of Flight Test Data Rule Set (based on Reynolds, and Damaan, 1994))

From Figure 1-5, it is evident that the evaluator must carefully consider all the "surprises" to determine if the test as executed is adequate for the decision makers purposes. Often the test is evaluated in terms of it's "limitations" rather than conventional rules.

1.1.5 Test Resources

According to DoD 5000.2-M (1993), the term "test resources" is a collective term that encompasses elements necessary to plan, conduct, collect and analyse data from a flight test event or program. These elements include (DSMC, 1993):

- Funding (to develop new resources or use existing ones)

- Manpower for test conduct and support
- Test articles
- Models
- Simulations
- Threat simulators
- Surrogates
- Replicas
- Test-beds
- Special instrumentation
- Test sites
- Targets
- Tracking and data acquisition instrumentation
- Equipment[3]
- Frequency management and control
- Base/facility support services

Part eight, of the DoD Instruction 5000.2 (1993), states that the following about testing with reference to the Test and Evaluation Master Plan:

> *"**Testing** shall be planned and conducted to take full advantage of existing investment in DoD ranges, facilities, and other resources, whenever practical, unless otherwise justified in the **Test and Evaluation Master Plan.**"*

1.1.5.1 Major Range and Test Facility Base in the United States

All services operate ranges and test facility for test, evaluation and training purpooses. Twenty one of these activities constitute the DoD Major Range and Test Facility Base (MRTFB). The United States Department of Defence has a number of Major Range and Test Facilities Bases located all over the country for carrying out test and collating flight test data, as depicted in Figure 1-6. One of the more prominent ones is the Air Force Flight Test Centre or AFFTC, at Edwards Air Force Base (AFB) California, USA. The AFFTC handles a large

[3]For data reduction, communications, meteorology, utilities, photography, calibration, security, recovery, maintenance and repair.

number of highly diverse flight test programs on a continuing basis (Gardner, 1992). Goals of the AFFTC mission planning effort are to (Bender et al, 1993):

1. Reduce the cost of T&E testing.
2. Enhance flight safety.
3. Capture corporate test knowledge.
4. Standardise and automate common test support functions where it makes sense.
5. Provide a standard architecture to meet test data management needs of future complex projects.
6. Increase management oversight.

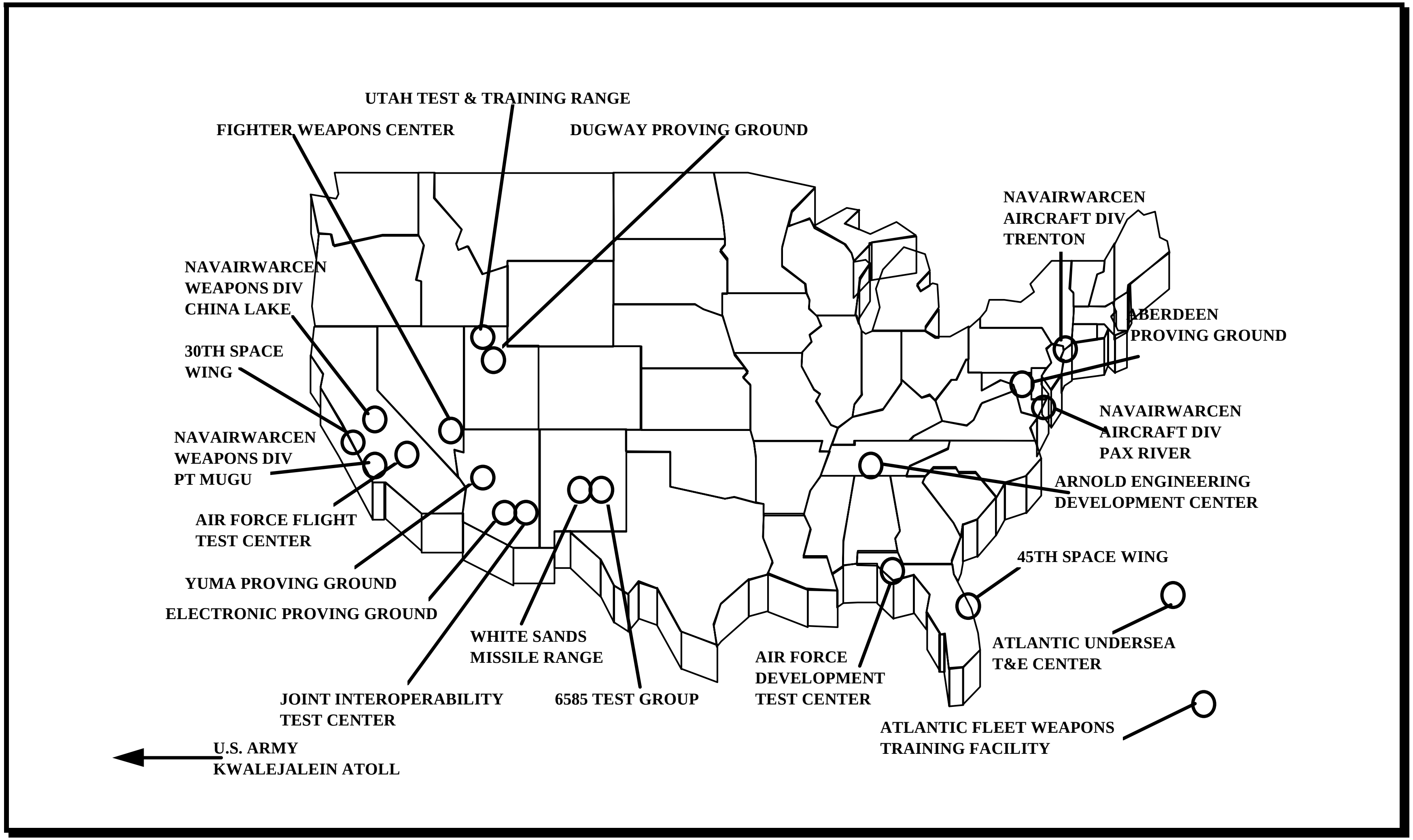

Figure 1-6 (Major Range Test Facility Bases (MRTFB) (based on DSMC, 1995))

Another prominent centre is the Air Force development Test Centre or AFDTC, of the Air Force Materiel Command, located at Eglin AFB, Florida, in the United States. In short, major tests on or above AFDTC's ranges involve all types equipment, including (Nissyrios, 1994c):

- Aircraft systems
- Subsystems
- Missiles
- Guns
- Bombs
- Rockets
- Targets and drones
- High powered radar's
- Airborne electronic countermeasures equipment

The AFDTC, is now in the process of "reinventing" test and evaluation (Cranston, 1995), focusing on better testing through better planning, better business practices, and better teaming.

1.1.5.2 TEMP Requirements

The program manager must state all key test resource requirements in the TEMP and must include items such as unique instrumentation, threat simulators, surrogates, targets, and test articles. Included in the TEMP (DSMC, 1993) are a critical analysis of anticipated resource shortfalls, their effect on systems T&E and plans to correct resource deficiencies.

1.1.5.3 Australian Defence Ranges Suitable for T&E Activities

All Defence ranges within Australia come under the control of one of the three Services, i.e., Army, Navy or Air Force. Some ranges have a specfic function or specialisation but most are general training ranges.

Wallace (1995) states that the Air Force ranges are controlled by either Air Headquarters Australia (AHQAUST) or Headquarters Training Command and are administered by the nearest RAAF Base. The major Air Force ranges are:

- Evans Head, New South Wales;

- Woomera Instrumented Ranges, South Australia;
- Delamere, Northern Territory;
- Learmonth, Western Australia;
- Halifax Bay, Queensland;
- Saumarez Reef, Queensland;
- Saltash, New South Wales;
- Dutson, Victoria; and
- Muchea, Western Australia.

The Woomera Prohibited Area (WPA) is not a dedicated range, and encapsulates approximately 130,000 square kilometres (about the size of England) located in the north west part of South Australia which under the Defence Act can be declared a prohibited area for the testing of military weapons.

1.1.6 Telemetry Formats used in Flight Testing

1.1.6.1 What is Telemetry

The ARDU (1993d) states that telemetry is the process of measuring quantities at a data source (such as an aircraft or missile), transmitting the results to a distant station, and thereby displaying, recording, and analysing the quantities measured.

Further more, in today's high volume telemetry applications, it would be costly and impractical to use separate transmission channels for each measured quantity. Therefore, the telemetry process involves grouping the measurements (such as pressure, speed, and temperature) into a format that can be transmitted as a single data stream. Once received, the data stream is separated into the original measurement components for analysis.

1.1.6.2 Why Use Telemetry

Telemetry gives one the option of staying in a quite safe and convenient location in order to monitor what is happening in an unsafe or inconvenient location. Aircraft development for example, is a major application for telemetry systems. During initial flight testing, an aircraft performs test maneuvers and undergoes certain aerobatic trials. In this instance, the critical flight data from a particular maneuver is transmitted to Flight Test Engineers (FTE's) at what is known as a ground station and thereby analysed within minutes of that maneuver prior to the next one taking place. After real-time analysis, the maneuver can be repeated, and perhaps the next maneuver performed, or the test pilot can be instructed by the ground station and two-way radio, that the test mission has been successfully accomplished and that it is now safe to return to base.

1.1.6.3 Telemetry System Configuration

Telemetry systems are usually configured differently to meet the needs of each user and in which are unique to that user, however, they all have some common elements, as is shown in Figure 1-7. These are (ARDU, 1993d):

- Electrical data starts at sensors. Some sensors measure electrical quantities (like gain, voltage, and current) directly. Others (such as thermocouples, resistance-temperature devices, bridges, and potentiometers) convert physical conditions like temperature, pressure, and acceleration into a proportional amount of electrical voltage.
- A multiplexor combines these electrical voltages and timing data (frame synchronisation and subframe synchronisation) into a single data stream.
- The transmitting device (radio transmitter, coaxial cable, telephone line, tape recorder, etc) then passes the data stream to the distant receiver.
- A decommutator (also called a demultiplexor),like the DS 100, accepts the data stream from the receiver and separates it into its original measurements.
- The original measurements are then selected, processed, and displayed in accordance with the specific test plan. In many telemetry systems, this select, process, and display action is done by independent general purpose digital processor: however, the ADS 100 is designed with these capabilities built in.

All the data is transmitted from the transmitter to the receiver at the ground station using Pulse Code Modulation or PCM, which is a serial bit stream of binary-coded time-division multiplexed words, as defined by the ARDU (1993c).

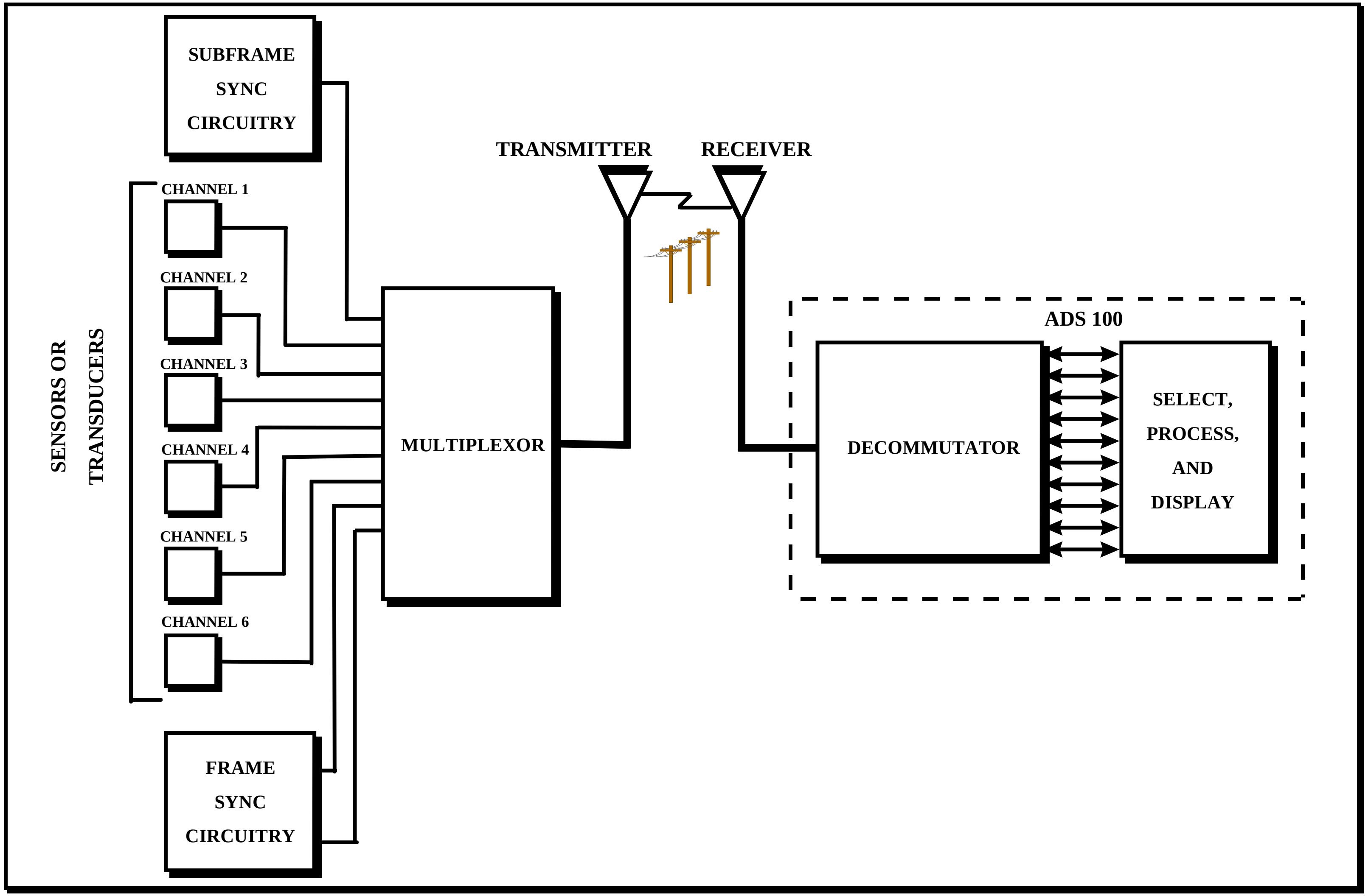

Figure 1-7 (Simplified Telemetry System Configuration (based on ARDU, 1993d))

1.1.6.4 Flight Test Data Management Systems

The telemetry format is a key piece of information utilized by both the flight segment and the ground segment of a mission. The conventional Relational Data Base Management Systems (RDBMS) do not work well with telemetry formats because of the multi-dimensional nature of most telemetry formats (Li, 1990). A Flight Test Data Management System (FTDMS) is currently being developed at the ACTE, as outlined in (Samaan and Cook, 1994b) as part of a Masters Degree research program, that is envisaged to reduce to complexity, size, and cost of managing dynamic telemetry formats, as part of the ARDU collaborative program. (Li, 1990) however, utilises object-oriented concepts in managing the creation, evolution, and the utilisation of telemetry formats. There are three key Object Orientated Design (OOD) concepts, namely, Abstraction, Encapsulation, & Inheritance. These are defined as follows (Li, 1990):

> *“**Abstraction** is the ability to specify generic attributes and necessary operations required for modeling a class of objects with respect to a problem domain. A model defined by a set of representing attributes and operations is often called an abstract data type.”*
>
> *“**Encapsulation** is the ability to hide non-essential and implementation dependent information from the user of abstract data types.”*
>
> *“**Inheritance** is the ability to defining subtypes by inheriting type specifications i.e., attributes and operations, from a parent type. This feature allows one to build new data types upon existing ones.”*

The advantage that these OOD concepts encapsulate are as follows (Li, 1990): Abstraction allows one to ***THINK*** at a higher level; Encapsulation allows one to ***WORK*** at a higher level; Inheritance allows one to ***EVOLVE*** at a higher level.

Managing the huge volume of telemetry information required to support flight test at the AFFTC requires new paradigms and system development strategies (Gardner, Hoaglund, and Painter, 1992). The collection of decommutation and calibration information from contractors present significant challenges to any system proposing to manage that information (Gardner, 1992). Calibration and decommutation can be defined as follows (Gardner, Hoaglund, and Painter, 1992):

> ***"Calibration*** *is the translation process in which a raw measurement from the aircraft is turned into a meaningful data value."*
>
> ***"Decommutation*** *is the process by which the incoming telemetry data are broken into tag/data pairs. The initial decoding of the signal."*

Any system that truly manages decommutation and calibration information must (Gardner, 1992):

1. Have a flexible input processor to accommodate information from many different instrumentation groups.
2. Maintain an efficient historical record of all changes in the instrumentation throughput in a project.
3. Have a flexible output processor to provide various set-up files required by ground analysis systems.
4. Be capable of rapid transfer of information via high speed networks and/or magnetic tape.
5. Process the information quickly and accurately to keep pace with the set-up speed of airborne systems.

1.2 Conclusion

This chapter gave a brief introduction and history of flight test, outlining the relevance between flight test and the thrust of the research topic, being the highly instrumented fighter aircraft F/A-18 Hornet. Much like test and evaluation it was determined that flight test is another process whereby quantitative and qualitative results are obtained on an aircraft. A description of the Aircraft Research Development Unit and its affiliation with the Royal Australian Air Force and research collaboration was given, outlining the Flight Test Information Management System as being the main thrust of their work with the Canadian forces and United States Navy. Finally, a discussion on flight test planning, flight test centres in the USA and telemetry formats used in flight test was presented.

The next chapter will look at the comparison and analysis of the United States and Australian test and evaluation processes, their individual defense acquisition structure and Test & Evaluation Master Plan formats, according to their respective military standard and respective nature.