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AERONAUTICAL RESEARCH LABORATORY

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General Document 029

BRIEFING NOTES ON A MANNED AIRCRAFT RESEARCH AND SUPPORT SIMULATION FACILITY

by

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SUMMARY

The proposal by Aircraft Systems Division to acquire a manned aircraft research and support simulation facility is outlined here in a background briefing document for use at a preliminary planning workshop being held in June 1992. It is envisaged that MARSSF will comprise a series of simulator stations with various degrees of fidelity networked together in a simulated tactical environment thus providing flexible, scenario-driven tools for future research, development and support to the ADF.

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EXECUTIVE SUMMARY

A proposal is in preparation for Department of Defence to fund a major new simulation facility, entitled the Manned Aircraft Research and Support Simulation Facility (MARSSF), at the Aeronautical Research Laboratory (ARL). In connection with this an international workshop on research simulation is to be held at ARL in June 1992.

This background briefing document provides information on simulation activities and plans for future facility developments at ARL. The paper should be read as a canvassing of issues which are likely to be topics of discussion at the workshop, rather than as a firm plan or proposal for a facility.

MARRSF will support research and evaluation activities related to the effectiveness of avionics systems and human-machine integration in military operations. This will require the simulation of realistic real-time missions with sufficient complexity to ensure that results are transferable to real world situations.

Real-time interactive simulation has been an important tool in the Aircraft Systems Division (ASYD) of ARL since the Division's formation in the mid 1960s. The research and development activities in ASYD are primarily aimed at supporting the Australian Defence Force (ADF) in the acquisition and effective operation of advanced aircraft systems.

Examples of work undertaken in the Division are the conduct of operational effectiveness analyses, the investigation of human-machine interface issues, the development of flight management and avionics concepts, and support for training. The latter includes the development and demonstration of simulator concepts to meet specific ADF requirements.

With the growing emphasis on the human operator as a key determinant of overall system performance, combined with the increasing complexity of mission systems and tactical scenarios, there is a major growth in the use of simulation as a cost effective means for assessing total system effectiveness and for supporting and enhancing military aircraft mission capability. ASYD is looking to build on the significant advances in simulation technology over the past decade to ensure that its simulation facilities are able to meet future research, development and support needs.

Over the next four years substantial Defence Science and Technology Organisation (DSTO) funds will be invested in enhancing the existing facilities. A wide field of view visual system and high quality image generator will be added to an existing cockpit, and a second generic cockpit will be acquired. Real-time computing hardware and simulation management software will provide for the networking of distributed systems to enable multi-operator mission scenarios to be simulated.

In the longer term the proposed MARSSF will support an increased capability for research and evaluation activities related to the effectiveness of avionics systems and human-machine integration in military aircraft operations. Major areas to be addressed are:

(i) studies of the relative effectiveness of air weapon systems, using total system simulation as a means of assessing system strengths and weaknesses and of identifying gaps in knowledge;

(ii) support and upgrades of avionics, including identifying benefits and contributing to a self-reliant capability for making incremental changes to avionics systems;

(iii) aircraft-aircrew integration, to enhance overall military system performance; and

(iv) the effective use of simulators for training, including team training and special applications.

The ability to simulate realistic team-versus-team missions in a distributed real-time computing environment will be a primary requirement for many of these applications. However since the facility will be employed for research and not for procedural training it is thought that sufficient reality will be achieved using simulated aircraft cockpits of moderate physical fidelity. There will be special demands on ready reconfigurability, using cockpits representative of an aircraft type, such as an air superiority fighter, rather than a precise physical reproduction of particular aircraft. Reconfigurability will require software flexibility and consideration of interfacing requirements, and the emphasis on research applications will require the capability for extensive system performance measurement and analysis.

The MARSS facility is intended to focus on aircraft types, environments, and missions of specific interest to the ADF. It should enable effective support to be provided in the analyses, requirements definition and procurement processes for a number of ADF projects, for fixed and rotary wing aircraft, into the next century.

1. INTRODUCTION

A major new manned simulation facility is planned in the Aircraft Systems Division (ASYD) of the Aeronautical Research Laboratory (ARL), for carrying out research and development activities in support of the acquisition and operation of military aircraft systems, both fixed and rotary wing, by the Australian Defence Force (ADF). The facility is referred to as the Manned Aircraft Research and Support Simulation Facility (MARSSF) in this brief.

In responding to the needs of its military customers, the Division has, since its formation in the mid 1960s, accumulated extensive experience in real-time interactive simulation technology. Initially, when developing aircraft and missile systems, hardware-in-the-loop simulation predominated, but over the years the focus has shifted more towards the part played by the human operator.

ASYD currently concentrates effort in areas such as investigation of the relative effectiveness of air weapon systems and research on flight and mission management technologies to support the upgrading of avionics and on simulator applications to operator training. Where necessary, the Division has developed systems to meet specific simulation requirements resulting in it having become a centre of expertise in human-machine interface aspects of aircraft systems.

As technological progress expands the capability of equipment, systems integration issues are becoming increasingly important to the ADF, especially in relation to total mission effectiveness. Military aircraft contain many systems which may be effective in isolation but which in combination can perform well below expectation and impose a workload that severely strains or even exceeds the operator's capacity to comprehend and interact.

With the growing emphasis on the operator's cognitive processes (in activities such as situation assessment, tactical decision making, and managing workload) as a key determinant in overall system performance, human-in-the-loop simulation becomes a vital tool for research and development. Co-ordinated military action between multiple operators, each controlling complex systems requiring rapid decision-making, is gaining in importance (air combat, air defence, airborne surveillance) and requires more emphasis on team-in-the-loop simulation. The continued advancement of ASYD activities in these directions will require a major expansion of the current research and military support simulation facilities.

In developing MARSSF, it will be important to emphasise features which distinguish a research simulation facility from a training or engineering simulator. In general, the more generic focus of a research simulation facility requires much greater flexibility and reconfigurability. Much of the system is composed of software, which tends to be complex. Research support features require special attention, and are likely to include extensive data collection and analysis capabilities (including measurements of human performance), flexible and interactive scenario development and control, facilities for training participants, and so on.

This brief provides, in the next section, some background on past and present simulation activities within ASYD, and in Section 3, a summary of planned development of the existing facilities in the immediate future. In Section 4, the discussion is extended to cover future work thrust areas in the Division with implications for simulation capability requirements. Finally, some of the major elements and support features proposed for the facility are listed and briefly discussed. The brief is intended to form a basis for further studies and wide ranging discussions involving the Service customers and other users, research practitioners, and the simulator industry.

2. PAST AND PRESENT SIMULATION ACTIVITIES

The areas of aircraft and missile systems research and development in which ARL has been active over the past four decades include aircraft flight simulators, training simulators, human factors research, flight management systems and avionics developments, and air operational effectiveness research.

2.1 Aircraft flight simulators

The first hardware-in-the-loop modelling for the IKARA project (an antisubmarine weapon system) was performed on analogue machines and then continued through hybrid to, finally, fully digital environments. The hybrid simulation facility was later employed for work on manned flight simulation, resulting in the Multi-Crew Aircraft Simulator (MCAS) development. However, activity on the MCAS was suspended to concentrate on ADF simulator projects. Following the completion of these, work has resumed on research simulator development with the multi-purpose Air Operations Simulator (AOS) project to meet the anticipated requirements of other research activities in ASYD.

The MCAS, which first *flew* in 1979, was a hybrid simulator which featured a four degrees of freedom (DOF) motion base, a reconfigurable *glass* cockpit and a visual system with a computer generated colour image on an external wide-angle display. It employed multiple digital processors, a feature which necessitated detailed investigation of inter-processor communication and scheduling.

The AOS, which is currently being developed, is an all-digital flight simulator with a fixed base. It incorporates a six DOF dynamic model of the aircraft and a representative avionics sub-system model, with a medium fidelity representation of the F/A-18A cockpit, and a single channel out-of-the-window view from a fixed display system. One application for the AOS is to be the piloted element of the SASS described below.

ASYD's research activities in the field of simulator technology have included work on computer generated imagery (CGI) and VLSI microchip technologies. As well, experience has been acquired in hardware and software systems design for real-time simulators, in hardware and software design for graphics applications, in systems integration and evaluation, in aircraft and missile modelling, in modelling of aircraft systems and displays and in multiple non-homogeneous processor applications.

2.2 Training simulators

Activity in this area has included the design and development of a prototype for a field training simulator for the Army's Rapier surface-to-air missile (SAM) system and of the AUSTOWER visual air traffic control tower training simulator for the RAAF.

The Rapier Field Training Simulator was designed to provide training for the operator of the Rapier Optical Tracker, firing simulated missiles against real aircraft targets flying normal attack profiles. This training aid, which was field-mountable onto a Rapier Fire Unit, incorporated simulated missile images which were inserted into the optics of the tracker system.

AUSTOWER, which is a cost effective facility for integrated training of air traffic control procedures, provides a high resolution colour image on a wide field of view (WFOV) projected display, overcoming several shortcomings of past training technology. The system displays vehicles, both ground-based and airborne, moving in real-time and capable of responding to the trainees' instructions during exercises which can be preplanned to ensure adequate control over the training situation. A licence has been granted to a commercial firm, Ferranti Computer Systems Australia, and the first installation is nearing completion at the RAAF Base at East Sale.

Through the expertise gained in the work on developing training simulators, ASYD has been able to provide support to the Services in specifying and assessing training simulators for aircraft including the F-111C, the F/A-18A, the Black Hawk and the S-70B-2 and the RAN bridge simulator.

2.3 Human factors investigations

Research into problems associated with aircrew operations has also been a major activity in ARL over a period of more than 30 years. Past activities have included investigations of aircrew workload in the Boeing 707 airliner in inter-continental operation and evaluation of the effect of heat stress on Sea King helicopter crews during anti-submarine warfare (ASW) operations. Systems developed to improve safety include the T-VASIS ground installation for guidance in visual landings, now installed at many commercial airports. Current research covers a number of visual and workload problems associated with aircraft in military operations (e.g. maritime patrol by P-3C and the operation of electronic warfare (EW) systems in F-111C).

The consequences of excessive mental workload can range from the neglect of useful information to the damage to or destruction of an aircraft. Techniques being developed for the evaluation of operator workload centre on monitoring cognitive activity, including the non-intrusive means of eye movement recording. ASYD can now record head and eye movements in laboratory settings with high accuracy, and flight-rated equipment is expected to be developed to allow observation in operational aircraft. ASYD's equipment has been used for an evaluation of the use of colour in aircraft head-up displays (HUD) in a collaborative experiment using a UK simulator.

2.4 Flight management systems and avionics developments

ASYD has been active for over a decade in the field of passive navigation systems, coupled with terrain-following/threat-avoidance techniques. A terrain matching navigation system (TACTERM), which is expected to form the basis of self-contained precision navigation systems for helicopters and transport and patrol aircraft, has been developed and successful trials in helicopters and fixed-wing aircraft have been carried out in Australia and in the USA.

The design of aircrew displays (including such aspects as location, content and configuration) is being investigated using a programmable cockpit simulator with avionics prototyping software. The Division is currently active in complex precision-approach displays, radar warning displays and navigation aids. A specialized electronic system for rotation of bit map imagery is being developed. Applications of displays with images synthetically generated from terrain-referenced data are being investigated. Other areas of research soon to be commenced include integrated navigation and tactical data displays, synthetic imagery combined with electro-optic imagery, and HUD information content and configurations.

The Orion Avionics Concept Laboratory (ORACL) is currently being developed within ASYD. This facility is based on a P3-B fuselage and is fitted out so that research and development in avionics systems, displays, cabin configurations and human factors aspects of long-range maritime patrol aircraft operations can be realistically investigated. Work involving ORACL will include the simulation of present and future operator displays, avionics and full-scale mock-up layouts of various cabin configurations so that human factors issues can be tested. Currently, a simulation of the P3-C Tactical Data System (TDS) is being developed to help define a new system, and future enhancements, for a proposed refurbishment of the aircraft. The simulated TDS uses a network of workstations to simulate the individual operator stations and to provide inputs to the system when modelling mission scenarios; touch-sensitive displays simulate the operators' switch panels. However, the facility has the capacity to simulate avionics aspects of a wide range of multi-crew aircraft. ORACL when fully developed, will be an important part of the Division's simulation facilities.

2.5 Air operations research

Broadly, the purposes of this work are to determine the effects of parametric variations and technological changes on the relative effectiveness of air weapon systems under realistic operational conditions, to assist in the development and evaluation of tactics, to support design and acquisition projects, and to contribute to increasing capability whilst reducing attrition.

2.5.1 Air to air combat

ASYD has been engaged in the study and analysis of air to air combat since 1980 and is currently undertaking research in this field for the RAAF. Two computer models are being employed in this research, one (PACAUS) developed within ARL and the other (ATEM) procured in a cooperative agreement with the Royal Aerospace Establishment

(UK). Both models are large and include models of radar and EW systems as well as target signatures and various atmospheric models.

Situation assessment and team cooperation, both involving human perception, judgment and communication, are critical elements in combat success but little hard data on human decision-making in combat aircraft is available. The difficulties of modelling decision processes are being tackled on two fronts:

(a) by placing a pilot in the loop, and
(b) by developing artificial-intelligence (AI) reasoning techniques.

PACAUS provides a stereoscopic view of the combat geometry and is being modified to provide external control, through stick and throttle. The use of AI methodology to allow a more flexible representation of pilots, one which is more amenable to interactive *on-screen* modification, is being investigated. Data for the development of an expert-rule database representing the pilot's decision processes will need a simulator to explore pilot behaviour.

2.5.2 Air to surface combat

Facilities are being constructed for the Study of Air Strike and Survivability (SASS) to investigate the effectiveness and survivability of air weapon systems in attacking defended surface targets.

The first version of the SASS will simulate an F/A-18A attacking a target defended by SAMs controlled in the simulation by a single air defence commander. Progress to date includes the acquisition and adaptation of computer models of the weapon systems, including radar and infra-red models. The appropriate models have also been combined to obtain exposure data for standard attack profiles for RAAF use. The ground defence command model is nearing completion and the simulator is expected to be operating within the next year.

3. SHORT TO MEDIUM TERM FACILITY DEVELOPMENT

The current workstation-based simulation facilities will be further developed in a manner complementary to the proposed MARSSF capability and technology over the next four to five years. With advances in simulation technology allowing increased realism and fidelity at an acceptable cost, together with distributed simulation, networking of facilities and representative tactical environments, ASYD will be directing its effort towards understanding and using these newer approaches in a variety of scientific investigations, as has been indicated earlier. For example, one main operational research aim is to provide environments containing multiple opponents, allies and neutrals, to extend the SASS scenario.

The facility development will provide the AOS (F/A-18A) with more capable medium to high resolution wide field of view (WFOV) visuals, using a helmet mounted display or a dome with head-slaved projector, and a lower-end image generator capable of being upgraded. A staged development culminating in a high resolution, area-of-interest inset system is planned, with eye-slaving of the inset if cost permits.

This flexible, and comparatively high quality, visual system will enable exploration, demonstration and development of potential training applications including ground-based weapons training and both basic and tactical flight training. It will also provide the flexibility to represent visual environments such as the view through night vision goggles (NVGs) which are expected to become more widely used tactically by the ADF in the next few years. The flexibility of the WFOV visuals could be used to explore the possibility of using cheaper visual systems (e.g. virtual reality-type helmets) by establishing the information and scene content needed by an operator to function effectively as a representative player in an operational scenario.

A new cockpit, this one generic and capable of being reconfigured into either side-by-side (F-111C) or single place, will be networked with the existing F/A-18A and, eventually with other manned *flying desk* stations. Weapon systems and navigation displays (including radar, moving map, FLIR) will be simulated to a limited extent using graphics workstations. The WFOV visuals and the system currently under development (based on a workstation graphics providing single channel low fidelity scenes) will be exchanged between the existing AOS and the generic cockpit as required by the application.

Provision of tactical environment simulation software containing mechanisms for using intelligent decision techniques to simulate the active and reactive behaviour of weapon systems including their human operators will enable building of more complex scenarios than those planned for SASS. To support this software, enhanced real-time computers operating in distributed networks will be purchased.

It is envisaged that by providing WFOV, an extra cab and extended scenarios, this enhanced system will provide a useful adjunct for both separate and integrated studies with MARSSF. The system standing alone from MARSSF would be limited to those uses allowing lower fidelity and less mission complexity and it would not by itself fulfil many of the MARSSF roles (as delineated in the following pages). The development of these systems in the medium term will provide the experience and technical expertise necessary to address the advanced technology involved in MARSSF.

4. MARSS FACILITY - FUNCTIONS AND APPLICATIONS

The basic function of the proposed MARSS facility is to support research and evaluation activities related to the effectiveness of avionics systems and human-machine integration in military aircraft operations. Total system simulation, involving all relevant aspects of participating aircraft, their sensors and systems, the human operators, and the environment, provides a powerful tool for evaluating and analysing the strengths and weaknesses of such complex manned systems. The particular applications which will be of interest to ARL in the future are outlined below.

4.1 Relative effectiveness of air weapon systems

The objectives of operational effectiveness studies include comparison of equipment options (e.g. radar, weapons, etc.), supporting major equipment acquisition programs, comparison and evaluation of tactics, sub-system trade-off evaluations (e.g. stealth versus agility), identification of dominant system parameters in whole system performance, and estimates of capability in defined scenarios.

Team-versus-team air-to-air combat effectiveness is likely to be one of the most challenging applications of the facility, with a requirement for at least four piloted stations for two-versus-two engagments. Additional aircraft will have to be represented to exercise fully the aircraft systems under realistic battle conditions, including communications, EW and multi-targetting capability. Facilities for the incorporation of combat commanders (GCI or AWACS) and for the control of extraneous aircraft (civil, tankers, etc) will be required.

Air-to-surface combat missions involving more than one cooperating aircraft, with scenarios comprising ground and maritime air defence systems incorporating various types of sensors and weapons, will also need to be simulated. Rotary wing applications include the effectiveness of naval helicopter operations in anti-surface unit warfare and antisubmarine roles, and of Army helicopters in armed reconnaissance missions, in close air support and in point air defence.

These applications require real-time interaction between several players in a distributed simulation environment, possibly involving networking with remote sites. The mission complexity and level of operational realism must be sufficient to ensure that the results, obtained are transferable to equivalent real world situations.

4.2 Support and upgrading of avionics

Software based avionics systems provide the potential to modify aircraft system capability. The ADF has recognised the emerging need to be able to make incremental changes to avionics software and associated equipment in order to respond to changing circumstances with a degree of self reliance. MARSSF is intended to support the development or modification of avionics software and equipment by providing a test bed for investigation of new concepts and system integration issues in a realistic operational setting, thereby enabling avionics upgrade options to be assessed in terms of benefits to ADF operations. It will complement ADF weapons and avionic system engineering support facilities.

Examples include the interfacing of prototype and experimental avionics equipment and computers in a simulated aircraft environment, or the demonstration of new concepts in flight and mission management. The latter may include integrated control and navigation systems, or intelligent decision aids to assist the aircrew in systems management, data fusion, threat assessment, and generation of tactical options. Other areas of interest are the potential data linking between aircraft in a team, and applications such as the fusion of data from passive sensors on co-operating aircraft as a means of passive localisation of targets.

These applications imply an extremely flexible software environment in the simulation facility, together with the capability for emulating existing flightworthy system code on the simulator computers, and for interfacing with actual or prototype avionics hardware. Additionally, the capacity for networking with existing research facilities such as the P-3C TDS simulator, referred to in Section 2.4, is highly desirable.

4.3 Aircraft-aircrew integration

The human operator is a key determinant in overall military system performance. Issues affecting the integration of the aircraft-aircrew system require investigation within a realistic mission and workload environment. Among these are task distribution between several crew members, the effectiveness of communications, the influence of workload on operational capability, the development of operational procedures associated with the introduction of new or proposed equipment, and evaluation of future avionics and display proposals.

The latter may include the study of the use of NVGs and FLIR viewing systems in tactical aircraft missions. The use of helmet-mounted displays of tactical and weapon systems data and associated symbology, the use of eye and head slaved sensor controls, and advanced auditory and tactile interface systems are also likely candidates for investigation.

These applications call for readily reconfigurable cockpit environments, and an extensive capability for measuring and analysing aircrew performance and workload.

4.4 Training and special applications

The effectiveness of simulator technology for training will be an important concern with the continuing need to support the acquisition of training simulators by the ADF. The flexible nature of the facility will enable it to be used for investigating issues such as the training effectiveness of simulators with various degrees of fidelity, and for demonstrating the feasibility of technological solutions to new applications or problem resolution. Team training, mission rehearsal, and other applications which may not be available in existing ADF simulators could also be demonstrated.

Some applications of interest, such as adverse weather shipboard helicopter operations, or low level and night time operations of either fixed or rotary wing aircraft, make particular demands on simulator fidelity. These would need to be balanced against overall facility priorities and may be subject to continuing enhancement efforts, provision for which would need to be included in the facility planning.

4.5 Indicative range of aircraft types and environments

The primary focus of MARSSF will be the support of the major types of ADF aircraft, both fixed and rotary wing, which possess advanced mission equipment. Currently these include the F/A-18A and F-111C aircraft, the S-70B-2 helicopter, and surveillance aircraft such as the P-3C. Thus single, and dual place (tandem and side-by-side) aircraft are of interest. Additionally, provision needs to be made for interactions between all flight and aircrew in aircraft such as the S-70B-2 and P-3C, including back seat and tactical operators.

During the next ten to fifteen years development activities planned for the ADF will require a significant level of support from ARL. Projects will include options for:

a. the replacement of the F/A-18A and F-111C fleets;
b. the replacement of the Macchi jet trainer for lead-in and fighter/strike training and ADF support;
c. the acquisition of an airborne early warning and control capability;
d. upgrade of the F/A-18A flight simulation facilities to provide enhanced operational training capability;
e. the acquisition of a battlefield reconnaissance helicopter capability; and
f. the acquisition of replacement C-130 aircraft.

The environments to be considered include ground terrain and maritime environments in any weather, with naked eye or assisted vision conditions. The helicopter-ship deck situation as well as contour and nap-of-the-earth (NOE) flight will be areas of interest.

5. THE BROAD CONCEPT OF THE MARSS FACILITY

Research emphasis demands stricter control and more flexibility than a training simulator traditionally provides; hence flexibility, both in terms of the physical arrangement of *crew stations* and in the configuration of the computing software systems, will be an important attribute of the MARSS facility.

The major differences from a training simulator, apart from ready reconfigurability, are the required capabilities for scenario development and execution, control and monitoring by the experimenter and simulator operator, and performance measurement. The design of the experimenter support features is considered to be a critical part of a simulation-based research system.

5.1 Operational reality

Operational reality in air operations demands that MARSSF provide team-versus-team simulation, both by several high fidelity interactive stations and through networking with other simulators. Integration with automated opponents is also planned. This will require a mix of high fidelity pilot stations, or *cabs*, and lower cost ancillary pilot stations. The former will enable pilots to interact realistically in an operational environment, while the ancillary stations (sometimes called *team stations*) will be employed for roles which can be carried out in the absence of such realistic interaction (for such aircraft as AWACS, tankers and non-combatants). One issue of interest is the experience of operators about the necessary balance between the number of participants and the level of simulator sophistication over the range of military air operations.

5.2 Computer system

The facility is envisaged as being built around distributed computer processing and graphics systems. These systems need to be readily reconfigurable and the local network must be capable of being divided into independent sub-networks to allow two or more experiments to be run simultaneously. It will be necessary to be able to readily implement changes to the computer models of the aircraft, sensors and weapons as well as to the geographic environment and opposing military systems.

Also it is proposed that the computer operating system be designed to provide replay repeatability to enable starting the simulation from any point in the scenario. Further, it is desirable that the computer operating system allow precise repeatability of simulations using records of all interactive operator actions, which implies precise control of the computer operating system and modelling software.

5.3 Software

The generic focus and great flexibility required of a research facility will require software to be a major component of the MARSS facility. This will be achieved with software which is well structured and capable of being quickly adapted by ARL research workers for their particular purposes.

The configuration of the computing systems will be under software control to enable the rapid tailoring of the system to the requirements of various experiments. This will include operations such as assembling aircraft simulation models, aircraft avionic systems, weapon systems, communications, support, ground defence and tactics. The tactical environment, which will be required to represent computer simulated opponents, will also have to be readily reconfigurable, adaptable and fully accessible for development by ARL research staff.

There will be benefits in having a common central facility containing wargaming software, data base and terrain libraries shared among multiple simulator users. It will be important that the MARSS facility provide extensive capabilities for software and data base development. These will be facilities such as graphics terminals, perhaps employing CASE tools, with direct access to the manned simulation stations for testing and validating developments.

5.4 Scenario development

A researcher responsible for an experimental scenario will need facilities which give access to the full simulation system data bases. Scenario development will involve the generation of a study plan, the preparation of the test, the formation of an experimental strategy and the collection of data. The facilities provided to researchers for efficiently carrying out these preparations must be sophisticated enough for scenarios to be explored without impeding the concurrent operation of MARSSF on other work. The combination of scenario development with visual and model development in a single common area would be advantageous.

5.5 Aircraft cockpits

The fidelity necessary for a cockpit, including motion cueing, for investigations into various types of military operations is a controversial topic. Consideration of operational situations such as air combat, air strike and nap-of-the-earth navigation indicates that situational awareness demands a whole FOV if the pilot is to react realistically. This suggests that a specification for a pilot station of reasonable cost will need to find an economical balance between providing adequate visual and adequate aircraft fidelity.

It is expected that adequate operational realism with ability to reproduce realistic workload levels will be possible if aircraft cabs are constructed as generically representative of aircraft of interest, rather than being engineering simulations. Cabs may employ CRT, plasma, LCD or projected displays (with masks to delineate individual instruments) to enable them to be readily reconfigured to represent different aircraft types.

Most questions associated with aircrew workload concern the assimilation and processing of information displayed either acoustically, visually or tactually. The ability to reconfigure display parameters is an essential aspect of the envisaged facility. While there is a requirement to represent in-service configurations so that changes can be demonstrated realistically, there is also a need to be able to prototype less refined representations which illustrate the general concepts of a proposed display.

5.6 Fidelity of avionics

Although generic cockpits are expected to be adequate in most work, some investigations are likely to be more realistically pursued if actual aircraft hardware and software can be linked into the facility to provide pilots with displays exactly matching those in the aircraft. The following distinctions may assist in clarifying the various approaches possible:

Simulation involves driving displays realistically through systems which have been created independently of the aircraft;

Emulation uses software from a flight worthy system which is reproduced in a computer and used to drive displays in the simulator; and

Stimulation where the actual piece of avionics hardware is attached to the simulator and used to drive the displays.

Stimulation will require ship's power and interface to the MARSSF computing system, but can save time and add realism where it is essential for a particular study. Emulation will require the use of a simulation computer and operating system able to use the code employed in the aircraft system. The comparative value of each of these techniques for various investigations will be a topic of interest.

5.7 Team stations

Ancillary aircraft and other vehicles might be represented through graphic workstations with simple control sticks and with information presented for good situation awareness and flight path control without attempting to represent strict operational realism. It is thought that such operators will not normally be subjects in a study but will provide important inputs to operational scenarios and therefore their actions will need to be recorded if the system is to be able to replay a simulation.

5.8 Networked stations

Facilities will be required for networking with other simulators, such as ADF training simulators, other ARL facilities, or possibly combat simulators in other countries. Networking will extend the value of MARSSF through increasing the complexity of operational scenarios with a greater number of interacting players. The methodology for networking remote stations will be of considerable interest, with particular emphasis on the achievement of economical data rates through system configuration design. When such external players are in the system it will not be possible to have *replay repeatability* and on these occasions it will be essential to record all performance data as it is generated.

5.9 Aircrew performance and data collection systems

The increased emphasis on aircrew behaviour as a factor in system performance stresses the requirement to monitor, record and analyse pilot activities and physiological data. Performance measurement is required for evaluation of simulation-based research methods, evaluation of the efficacy of current or proposed field operational procedures and management of the overall simulation-based research. It is required to provide information on skill acquisition and quality of performance during training of subjects and to provide diagnostic information to the experimenter for discovering procedural difficulties requiring modification.

The MARSS facility will need a comprehensive performance measurement system. One aspect of research concerns the extent to which the pilot can meet the demands of the task. Behaviour oriented studies will require recording of physiological data, simulated physical data, video and audio records, data from observers and results from questionnaires. The system must be easy to configure for the requirements of particular research and be economical in its storage requirements. Retrieval of various subsets of data from a relational database will be necessary as will the ability to specify the rate of data collection.

Research requirements may dictate that some pilot activities be recorded and analysed in real-time while other variables may be able to be measured after the event during a scenario reconstruction. Indices of aircrew cognitive and physical workload may be obtained from recording video pictures or from movement trackers. Other electrically based parameters of physiological states may also be recorded.

5.10 Design for experimenter control tasks

It is expected that the researcher will assume the role of coordinating the planning, scheduling and operation of the simulator. It has been suggested that the task of implementing scenarios and controlling runs should be made as easy as possible for researchers who will use the simulation facility only occasionally. The researcher's console needs to enable one person to operate, control and check the simulation.

5.11 Training of pilot participants

Most studies will require familiarisation and, training of participating pilots the amount received depending on previous experience and the nature of the particular research task. Separate facilities, such as interactive workstations, will be required in MARSSF to provide the capability of teaching the procedures and operations necessary to perform in the full simulator. The training system must have sufficient similarity to the simulator for experienced aircrew to have little difficulty in learning the task and translating that learning directly into the research exercise.

5.12 Facility maintenance

Regular maintenance requirements should be minimized as far as possible in the design of MARSSF. On-going support costs should likewise be minimized, with configuration management and data-base generation facilities under the control of ARL staff. The use of on-site contractor personnel for maintenance and support may be a cost-effective option.

5.13 Facility administration

MARSSF will need a comprehensive software system for administration, for controlling access, protecting data, scheduling resources and providing planning support.

5.14 Security requirements

The security classification of the work can be at any level from UNCLASSIFIED to SECRET. MARSSF must satisfy the requirements specified by the Director of Security as to physical and electronic security.

Names and acronyms used in this document.

ADF	Australian Defence Force
AI	Artificial Intelligence
AOS	Air Operations Simulator (ASYD design)
ARL	Aeronautical Research Laboratory
ASW	Anti-Submarine Warfare
ASYD	Aircraft Systems Division
ATEM	Aircraft Tactical Engagement Model
AUSTOWER	Airfield control tower simulator (ASYD design)
AWACS	Airborne Warning and Command System
CASE	Computer Assisted Software Engineering
CGI	Computer Generated Imagery
CRT	Cathode Ray Tube
DOF	Degrees of Freedom
DSTO	Defence Science and Technology Organisation
ECM	Electronic Counter Measures
EW	Electronic Warfare
FLIR	Forward Looking InfraRed
FOV	Field of View
GCI	Ground Controlled Intercept
HUD	Head Up Display
IKARA	Australian designed ship launched ASW missile
LCD	Liquid Crystal Display
MCAS	Multi-Crew Aircraft Simulator
NOE	Nap-of-the-Earth
NVG	Night Vision Goggle
ORACL	Orion Avionics Concept Laboratory
PACAUS	Piloted Air Combat engagement computer model
RAAF	Royal Australian Air Force
SASS	Study of Air Strike and Survivability
T-VASIS	Tee Visual Approach Slope Indicator System (ASYD design)
TACTERM	Terrain referenced navigation system (ASYD design)
TDS	Tactical Data System
VLSI	Very Large Scale Integration
WFOV	Wide field of view

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16. ABSTRACT

The proposal by Aircraft Systems Division to acquire a manned aircraft research and support simulation facility is outlined here in a background briefing document for use at a preliminary planning workshop being held in June 1992. It is envisaged that MARSSF will comprise a series of simulator stations with various degrees of fidelity networked together in a simulated tactical environment thus providing flexible, scenario-driven tools for future research, development and support to the ADF.

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