THE SEA KING MK 5 FULL MISSION SIMULATOR FOR THE ROYAL NAVY PROCUREMENT, PRODUCTION AND PERFORMANCE IN SERVICE

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ABSTRACT

A Naval Staff Requirement for a Sea King Mk 5 Full Mission Simulator was issued to the Procurement Executive of the United Kingdom Ministry of Defence in April 1981. The Full Mission Simulator comprises a Cockpit Dynamic Simulator and a Rear Crew Trainer consisting of three identical Rear Crew Trainer Cabins which provide multiple crew training.
As is normal with United Kingdom Ministry of Defence simulator procurements, contracts were awarded at a fixed price through competition. Ferranti Computer Systems was awarded the contract for the Rear Crew Trainer and overall integration, whilst Rediffusion Simulation was awarded the contract for the Cockpit Dynamic Simulator. Late delivery of aircraft parts and an unrelenting customer, requiring absolute replication of the real aircraft interior and systems performance, put great demands on management and engineering skills.

The requirement for cross-cockpit viewing and 200° horizontal field of view encouraged Rediffusion to develop its WIDE II Visual Display System. The additional requirement for a textured daylight Image Generator led to the visual system being a unique device in UK military helicopter simulation. Aircraft performance data shortfalls necessitated a programme of 'tuning' utilising the skills of Test Pilots resulting in a much improved and acceptable level of simulation.

Programme delays resulted in the Ready for Training date being two years later than planned, but with the benefit of an enhanced simulator performance.

Now in service at Royal Naval Air Station, Culdrose, England, the Full Mission Simulator has allowed a change in the training philosophy, and for the first time, given the Royal Navy a training system where operational squadrons can practice co-ordinated operations over prolonged periods in a realistic environment.

INTRODUCTION

The Anti Submarine Warfare (ASW) Sea King Helicopter was introduced into Royal Naval Service in 1969 with a mission system based around a medium range active sonar. Simulation was provided by a cockpit Dynamic Simulator and a rear crew cabin which fully met the training requirement until the late 70's. At this time a change in the concept of operations for the Sea King, towards passive ASW and larger squadrons began to make the simulator less representative and unable to meet the training demand. When, in 1980, the Sea King 5, with a very much updated mission and accoustic system was introduced, it became apparent that if operational standards were to be maintained, a new simulator would be required.

The aim of this paper is to explain the formation, purpose and responsibilities of the Procurement Executive of the United Kingdom Ministry of Defence and its role in the procurement of flight simulators. Managerial, technical and programme aspects of production are described by both contractors and the performance in service is reviewed by the Royal Navy customer. Lessons learned are identified.

PROCUREMENT

The Formation of the Procurement Executive

The Procurement Executive (PE) was formed within the United Kingdom (UK) Ministry of Defence (MOD) in 1971. It brought together under, the Secretary of State for Defence, all defence research, development and procurement activities. This made possible the formation of smaller units of accountable management, for equipment projects, in the form of project management teams and project-oriented line management structures.

The Purpose of the Procurement Executive

The task of the PE is to procure, for the UK Armed Forces, the equipment they require, within agreed timescales and in the most cost effective way. In fulfilling this role the PE maintains close working relationships with the Defence Staff, the Service Departments and Industry. The PE handles the largest procurement task in the UK, the procurement budget for 1986/87 being in excess of £9,000 Million ($16,650 Million). More than 90% of this expenditure is within the UK, directly supporting 250,000 jobs in industry. The PE employs some 33,000 people of which some 4% are Service personnel.

Ministry of Defence Central Organisation

The Secretary of State for Defence (SofS) is responsible for the overall control and direction of the MOD. His principal official advisors are the Chief of Defence Staff (CDS) and the Permanent Under Secretary of State (PUS). The PE is headed by the Chief of Defence Procurement. Close working relationships are maintained between the various elements of the MOD. The Services' requirements must be kept in balance with the resources available for equipment procurement within the defence budget. The PE maintains close day to day liaison with staffs responsible for matters such as operational requirements and logistics.

Procurement Executive Management Responsibilities and Structure

The Chief of Defence Procurement (CDP) is responsible through PUS to SofS for the central direction and overall management of all aspects of work of the PE. As the Accounting Officer, he is responsible for the propriety, regularity and value for money of all PE activities, expenditure and receipts. CDP is Chairman of the PE Management Board. The Board is concerned with all aspects of procurement and provides top management direction and coordination. A member of the Board is the Controller Aircraft (CA) who is responsible for the procurement of Air Systems equipment for the Royal Air Force, Royal Navy and British Army. Figure 1 shows the management structure under CA through Director General (DG) level to the specialist Directorates. The Directorate of Avionic Equipment and Systems (DAES) has responsibility for procurement of all aircraft flight simulators and trainers for the three armed services.

Procurement of the Sea King Mk 5 Full Mission Simulator (FMS)

The procurement procedures used for the Sea King Mk 5 Full Mission Simulator were very similar, but not identical, to those used by DAES for current simulator procurements.

For the Sea King Simulator project to start, financial provision was made within the long term costings, this being based on an estimate of cost which was provided by the Project Manager designate based on his experience of previous similar projects. An estimate of timescale for the complete programme was made at the same time.

The Directorate of Operational Requirements (Sea) raised a Naval Staff Requirement for a Full Mission Simulator, delivery into service, ready for training, was required December 1985. The DAES Project Manager and a Project Officer initially produced a single specification covering both the cockpit and rear cabin elements. The specification had been issued to the prospective contractors in order to attract their comments and in parallel the aircraft manufacturer had been contracted to produce a Preliminary Data Pack (PDP) for distribution to the same prospective contractors. The draft specification and PDP were amplified by means of two presentations, one being given by the Service customer which explained the operational needs and the other by the aircraft manufacturer. A major change to the Staff Requirement was introduced by the Royal Navy's urgent need for a single stand-alone Rear Crew Trainer Cabin to be introduced into service ahead of the other elements. At the same time it was considered by the Project Officer that no single prospective contractor had the total capability required to produce the Full Mission Simulator. It was therefore decided that two specifications were required, one for the Cockpit Dynamic Simulator and another for the Rear Crew Trainer. Production of the two specifications was eased by the appointment of two full time Royal Navy Flight Simulator Liaison Officers (FSLOs), one Pilot and one Observer, both current on the Sea King Aircraft. The FSLOs influenced the content of the specifications in those areas where interpretation of the Staff Requirement needed clarification and the operational aspects could be amplified. The two separate specifications were approved in January 1983 and issued to prospective contractors for comment. At the same time the contractors were requested to indicate those aircraft parts which they considered necessary to meet the specifications. Responses were collated and this allowed the formulation of a consolidated list of aircraft parts by the Project Officer. Lateness in identification, and agreement of the list of aircraft parts, delayed the award of a contract to the aircraft manufacturer for those parts. Quotations of long delivery timescales for some of the parts delayed the progress further, since the list and delivery timescales would form part of the Invitation To Tender to the prospective contractors.

The Invitation To Tender for the Rear Crew Trainer was issued with a definitive specification in June 1983. The prospective contractors were requested to return their fixed price tenders by September of that year, with a three month price validity. Detailed examination of all tenders then culminated in formal presentations by each prospective contractor to the PE and the Service representatives. Each tender was assessed against the specification requirements, then a decision was made to let the Rear Crew Trainer contract to the lowest priced compliant tenderer, Ferranti Computer Systems, who offered an 18 month delivery for the first Rear Crew Trainer Cabin with the second and third cabins following at 27 months. The contract was placed in December 1983.

In the meanwhile, a similar procurement process was taking place for the Cockpit Dynamic Simulator, which culminated in an award of contract to Rediffusion Simulation in April 1984,

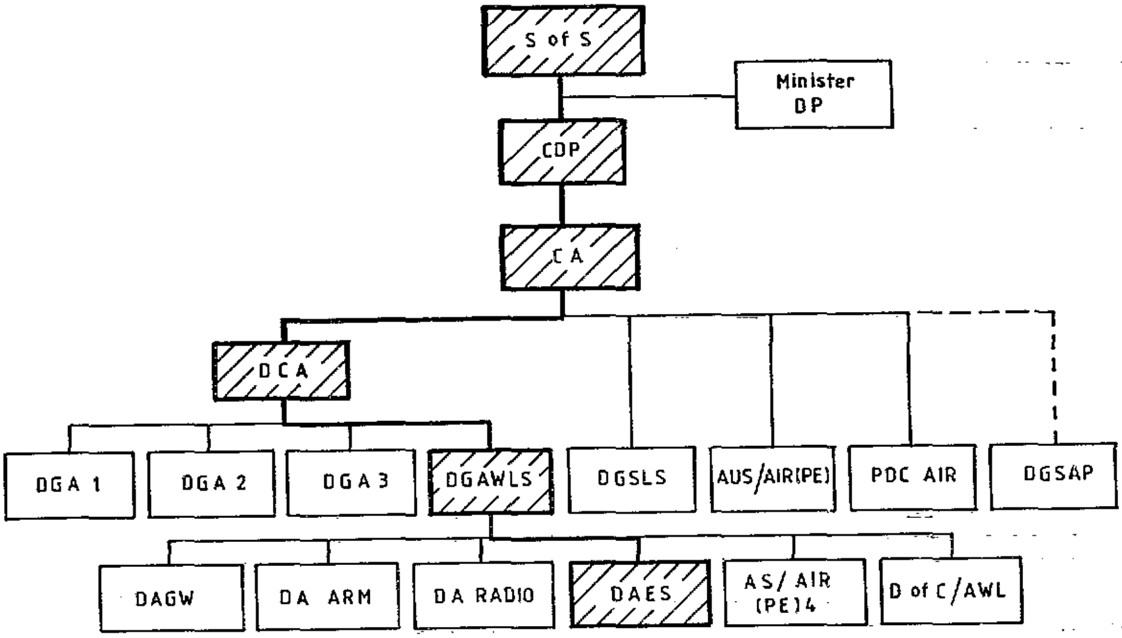

FIGURE 1.

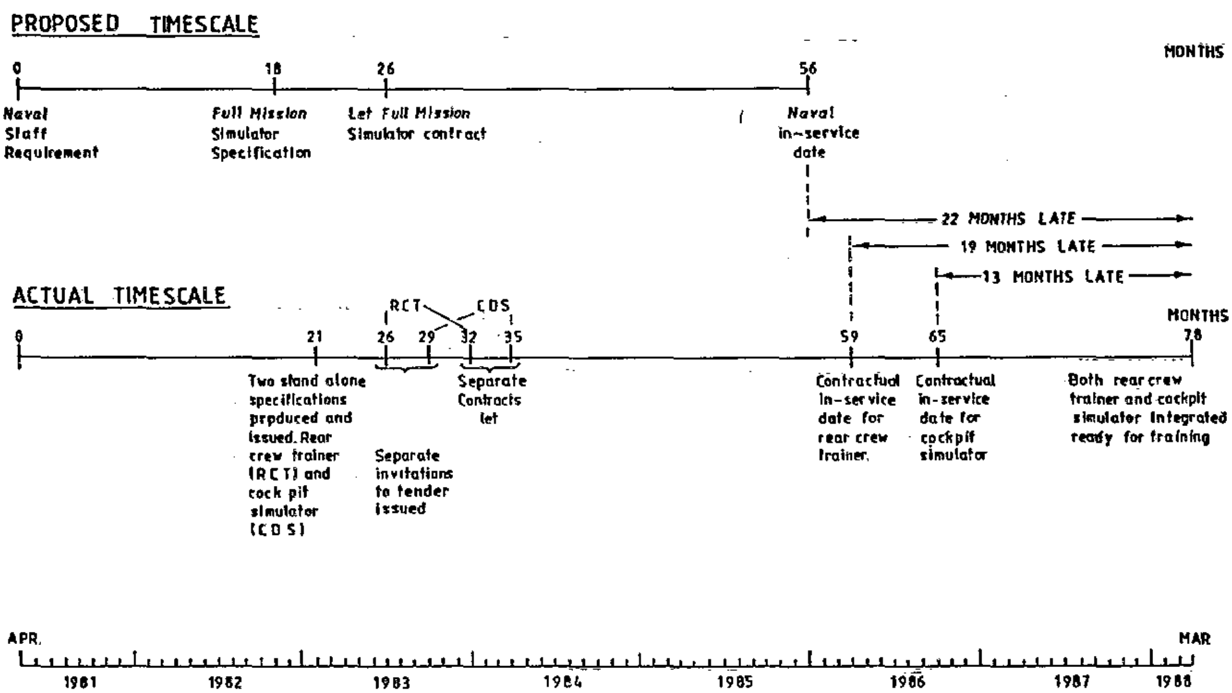

FIGURE 2.

with an offer of delivery into service within 30 months.

The proposed procurement and delivery timescales, compared with actual timescales achieved, are shown in Figure 2. A number of factors influenced the slippages in timescales and are amplified in the following paragraphs. The acceptance phases were significantly under-estimated by both contractors, as was the integration of the Cockpit and Rear Crew Cabin elements. The unrelenting pressure of the FSLOs for as-aircraft performance highlighted weaknesses in the aircraft and equipment data acquired by the contractors. A number of major design changes were initiated in order to reflect aircraft changes and enhanced performance requirements. These not only resulted in delays, but also an increase in cost of 7%. The delivery timescale for aircraft parts was not achieved by the aircraft manufacturer and this affected the Rear Crew Trainer badly.

PRODUCTION OF THE REAR CREW TRAINER

After a keenly contested tender Ferranti was awarded the contract for the Rear Crew Trainer (RCT) which comprised three containerised Rear Crew Trainer Cabins (RCTC). In accordance with the specification, the RCTCs were to be capable of operating both independently, each with its own unique scenario, or linked, with all units operating in the same scenario. In addition, any of of the RCTCs was to be capable of being linked with the cockpit Dynamic Simulator (DS) in order to provide full mission training for a complete crew. Ferranti was responsible for leading the integration exercise. In addition to the normal complexities of integration, Ferranti was also responsible for the simulation of all tactical sensors including the Orange Crop ESM system, the display for which is positioned in the cockpit. At the time of the RCT contract award, the DS contract had not been let and the Ferranti team did not therefore know with which contractor it would eventually be working.

Project Organisation and Planning

On receipt of the contract, Ferranti appointed a Project Team which included staff members who had been actively involved in the tender. This team was organised to reflect the three major parts of the project which were to be undertaken - system design, hardware and software design, and production.

The initial task of the combined Project Team was to review the contractual and technical requirements and to formulate detailed project plans based on the outline plans put forward in the proposal documents. In essence, these consisted of the System Design Specification, Work Schedules and a Quality Plan. The System Design Team performed a re-appraisal of the requirements and produced the detailed design and interface specifications for the various sub-systems so that the necessary hardware could be acquired and software development could begin. The Hardware Team then ordered the bought out equipment that was required and undertook the prototyping and production of special to project items required to implement the system design. The Software Team designed, wrote and proved all the programs needed to control the simulation and provide efficient instructor facilities.

The System Design Team, after the initial activity, kept a watching brief on the total system development to ensure that the system went together as planned and to resolve minor integration problems that inevitably arise in a complex programme.

As defined by the System Design Team, and indeed as planned in the tender, several aspects of the project build were outside Ferranti's normal range of manufacturing facilities, and sub-contracts were placed with appropriate specialist manufacturers as soon as the project plans were finalised. Such aspects included sub-contracts for the containers and their air conditioning, the fabrication of the simulated rear cabin shells, simulated instruments and computer equipment. The need for containers was brought about by the completion date for the RCT being in advance of the purpose-built, permanent accommodation. To meet the requirements for temporary and final installation at RNAS Culdrose, each RCTC was configured as a stand-alone system housed in two containers; one for the rear crew cabin (see figure 3) and the other for the computer, simulation equipment and instructor console. Liaison with the MOD building contractor was necessary during the design of the permanent accommodation to ensure that equipment layouts, cable ducts, power requirements and air conditioning were adequately defined.

Each of the three RCTCs had to have complete stand-alone capability. Integration between individual RCTCs and between any one of the RCTCs and the DS was achieved through inter-computer links. When the permanent housing became available the training compartments were installed as integral units. The equipments in the other containters, ie computers, simulation hardware and instructor's consoles were stripped out of their containers and installed as suites. In summary, the three sets of computers and simulation hardware were installed in the computer hall along with those required for the DS, and the three instructor's consoles were assembled as a suite in the same instructor's area as the console for the DS. This latter feature was of course necessary for efficient running of full mission exercises.

Project Control

In order for the Project Manager to maintain tight control of the project, regular design and progress reviews were held with the project team and sub-contractors and quarterly meetings were convened with MOD to discuss progress and changes to the specification. The FSLO Observer was resident at the company premises by this time and acted in an advisory role, providing input on the Royal Navy's requirements, but having no executive authority to commit Ferranti to extra work. This presence is beneficial to the customer in ensuring that the contractor's *interpretation of the specification remains in* line with the Royal Navy requirements and to the contractor in realising the finer points of the system performance and in the optimisation of the instructor's man-machine interface.

The availability and reliability of Government Furnished Equipment (GFE) proved to be a major problem during the production phase. Late delivery of GFE and the MOD's insistence on totally realistic cabin environment led to prolonged production times. This was characterised by the large number of authorised design changes introduced, which had an adverse effect on both timescales and costs.

The most significiant change concerned the GFE sonar equipment which, for operational reasons, had been modified. Other major changes included modifications to the communications system and associated data bases. Further problems, which were not appreciated initially, were to lie in the integration phase when the RCTCs were linked to the DS.

System Implementation

The customer's implementation plan called for a phased approach, with each RCTC being accepted first in a stand-alone mode, then in combination with the other two, and finally linked to the DS as an integrated FMS.

The first RCTC underwent stand-alone acceptance and was subjected to a Reliability, Maintainability and Availability demonstration for a fixed *period whilst being used for training. The* result of this test showed that the RCTC achieved an availability of 99.86% against a specification requirement of 98%. A similar exercise was carried out on RCTC 3 after the second and third RCTCs had been integrated. Operating in the 'same sortie' environment, with RCTC 2 linked to RCTC 3, the system again exceeded the specification requirement by a significant amount.

Integration

An initial system concept meeting was convened to discuss how the two major elements of the simulator could best be integrated. Agreement was reached on areas of responsibility and the *overall technical solution to be employed, but* it became apparent that the task was more complex than had been originally envisaged, since each company employed different simulation methods, concepts and architecture.

Regular integration meetings were held between Ferranti and Rediffusion as the project developed. These were mainly at a technical level, refining the agreed broad solutions into practical applications. However, it was not possible to test fully all the applications until the total system was integrated on site.

An interesting aspect of the integration was associated with the simulation of the Orange *Crop ESM. In the aircraft the display is in* the cockpit with the associated audio available at all stations. This audio is of tactical *significance to the rear crew.* Since the RCT and the DS need not necessarily be operated in the same scenario, there is a requirement for a stand-alone mode where the audio received in the RCT is unrelated to the audio and display in the cockpit and a combined mode where the RCT audio and DS audio are the same and correlate with the display in the DS. Ferranti was responsible for all tactical sensor simulation in the complex; this particular problem was solved using an emulation technique which employed only one operational front panel in the DS cockpit. This approach resulted in a very cost effective and well synchronised solution.

Another technical feature worthy of note is the highly sophisticated level of sonar simulation which was required to produce not only correct correlation between the sonobuoy system and dipping sonar within a particular RCTC, but equally good correlation between the three RCTCs which are required to operate together in a tactical formation.

While there were some problems in the integration of the two highly sophisticated elements of the FMS, the good working relationship which had been developed during the course of the project enabled both companies, the PE and the user to reach amicable solutions to all problems encountered.

PRODUCTION OF THE COCKPIT DYNAMIC SIMULATOR

When the contract for the cockpit Dynamic Simulator was placed with Rediffusion Simulation, *it presented several management and technical* problems to the company. The managerial problems, common to many MOD simulator procurements, were associated with the specification being a general statement of the requirement, the FSLO being resident in the factory and the timescale required to deliver the simulator. The technical problems related to the visual field of view, the mission capability of the simulator and its ability to integrate to another contractor's RCT and the problems of obtaining good aerodynamic data so that the flight performance would be representative.

MANAGERIAL PROBLEMS

MOD Specifications

The specification for the Sea King DS was typical of most MOD specifications in that it had very wide implications, eg "The simulator shall be like the aircraft". This is reflected in the size of the document - the Sea King DS specification had 75 pages, including definition of malfunctions.

As a direct comparison, the MOD cardinal point specification for the E3-AEW simulator was 50 pages, compared with the US Air Force's 235 pages for the same simulator. This obviously presents problems to the contractor as the MOD specification is all encompassing, covering *aspects not necessarily itemised. However,* it is an advantage to the end user as he has a higher chance of obtaining exactly what he

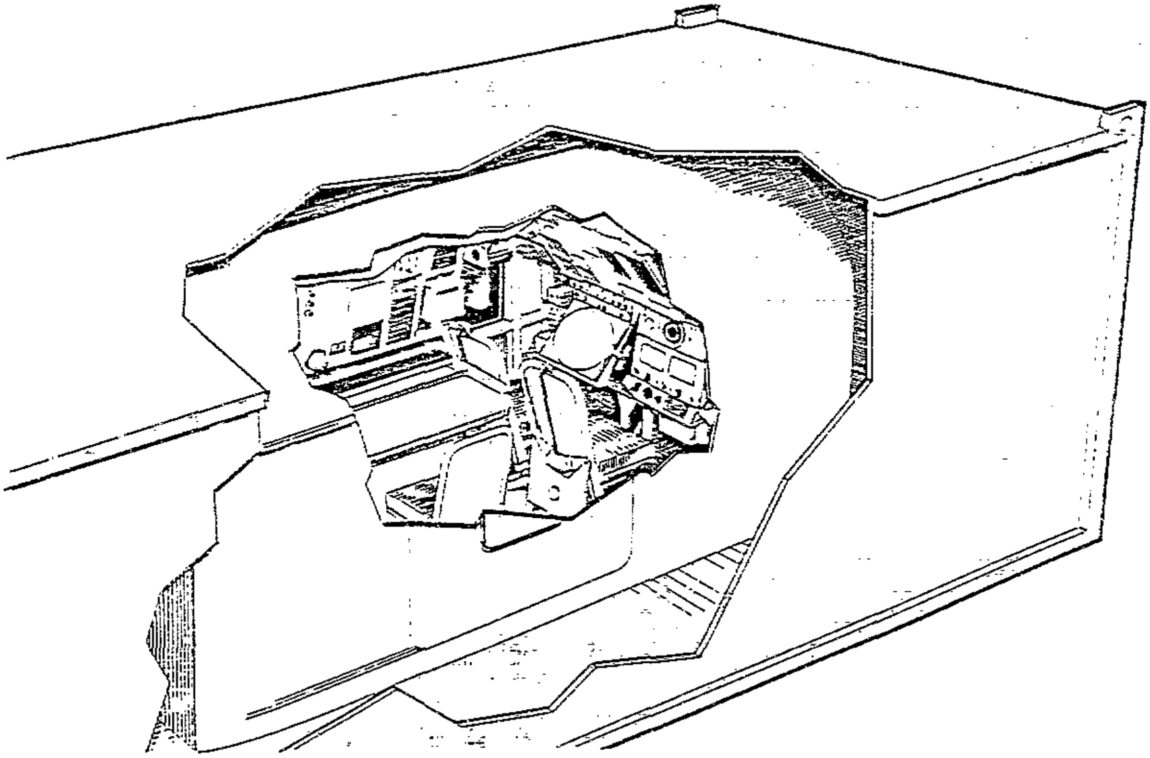

FIGURE 3
REAR CREW CABIN

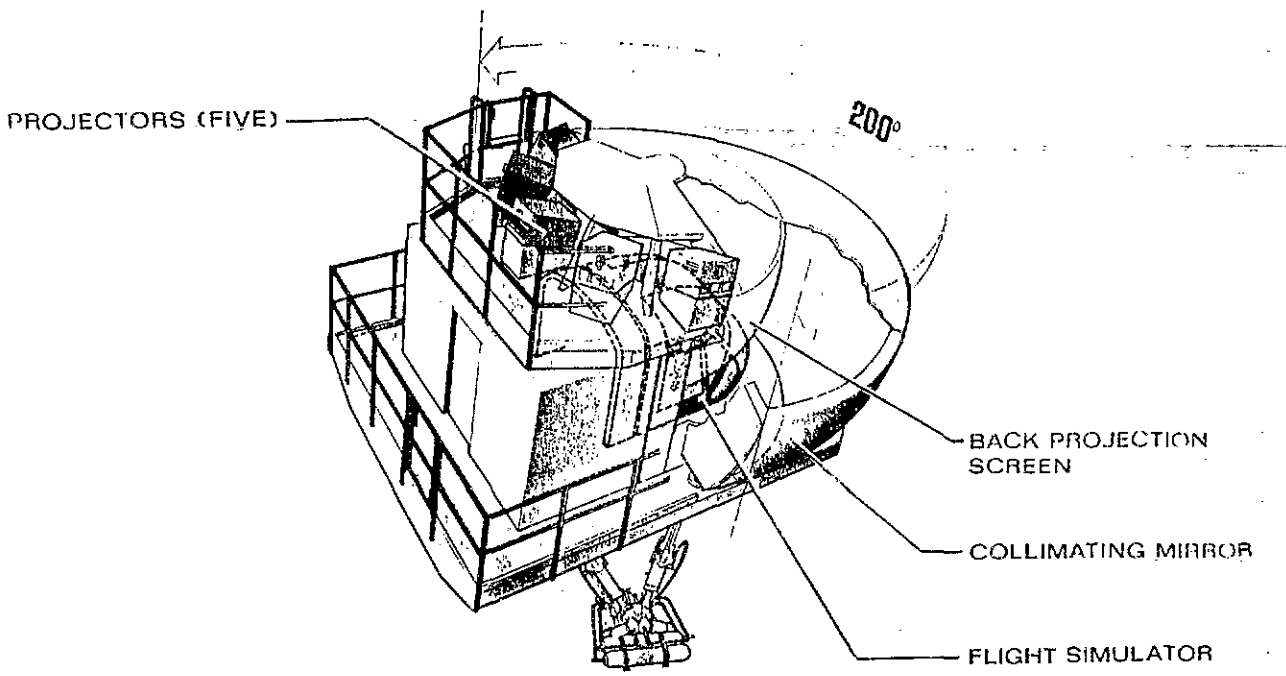

FIGURE 4
WIDE II DISPLAY

requires, including his interpretation of some of the more open items.

Flight Simulation Liaison Officers (Pilot)

The resident FSLO(pilot) was joined by two further FSLO(P)s during the last 18 months of the programme. This presented the Project Manager with the problem of ensuring the engineering team was controlled in the discussions with the FSLOs, so that minor changes were not agreed to which firstly, would not be documented and hence possibly missed from acceptance testing, and secondly, might impact on other systems which had not been correspondingly modified. The presence of a full-time representative also costs money, simply in the time spent in discussions with various people. However, there are advantages to the contractor in being able to obtain the end user's interpretation of the requirement and his knowledge of the actual aircraft systems.

Timescale

This contract had a 30 month delivery timescale. Initially, this seemed very reasonable, and by commercial standards, should have been easily achieved. The programme was however delayed in the early stages, due to the late delivery of aircraft parts, then again towards the end of the build programme by the final development of the visual display. When the simulator was offered for factory testing, it was three months late. The period originally allocated for testing was two months - this actually took nine months, and was attributed to the unrealistic flying characteristics, a greater depth of testing than the proceedures indicated and the unrelenting customer looking for perfection.

The normal sequence of events during MOD testing is to run the system checks as stand alone tests and then, when these are complete, run the sorties, written by the FSLO, which are meant to represent the typical use of the equipment during training. This latter phase revealed discrepancies at the end of a very long system testing phase, and in some instances highlighted basic problems with the overall interaction between systems, when used as a total mission trainer. It would have been benficial if these sorties had been run at the start of testing to indicate any fundamental problems with the total integration of the sytems, as opposed to the long drawn out serial activity.

The opinion after completion of the testing phase was that the original timescale was not representative of that required during MOD testing, and that an allowance should be made for the subjective tuning and evaluation of the flying characteristics.

TECHNICAL PROBLEMS

Visual Display

The specification required cross cockpit field of view and for the pilot to see out of the side window. During the proposal stage, Rediffusion made the commitment to develop the WIDE II Display which would give a 200° horizontal by 40° vertical continuous field of view, thus allowing a compliant response. This development was progressed in parallel to the project build programme and culminated in the final development taking place on the simulator (see figure 4).

The major problems faced were the mechanical structures required to mount five projectors in the display platform, and the electronic alignment of the images to minimise the effect of the four areas of over-lapping images which form the joins in the total image. This required additional effort from the Project Management Team to ensure the latest developments were embodied in the project hardware and co-ordinated with the normal project build schedule.

Mission Capability

The requirement to use the DS in a mission environment was understood in the stand alone functions, but was not fully appreciated as an integrated system. This was not highlighted until the sorties at the end of testing were run and some of the problems faced were:

- Geographical Correlation.

Initially the visual databases were correctly modelled in terms of ground height above sea level around the various operational airfields, but away from them they were generic terrain and flat. The host computer however had the correct geographical terrain modelled around and away from the airfield, thus providing the correct ground height above sea level. With a fixed wing simulator this is usually adequate, since away from the airfield there is no requirement to approach the ground. In the DS there was a requirement to fly close to the ground in various locations away from the airfields. Thus a discrepancy was revealed between the correctly modelled terrain height and the flat visual model which was at the airfield height, in particular along the coast where there was a 200 ft cliff - although this latter point had been covered by a separate visual database to allow cliff rescue training to take place. This required the terrain to be modelled to match the visual capabilities and not necessarily the real world, and also included several hundred miles of coastline. The result being the correct correlation between the visual scene with respect to the height above the land and sea and thus the ability to land on either.

- Deck Landing

The basic requirement to land on ships was easily satisfied with some additional work. The ability to land on moving, rolling and pitching ships was also achieved. The requirement to stay on the ship's deck while the ship continued to move and turn for up to 30 minutes, presented problems not anticipated at all. This was accentuated by the fact that the ship's geometry was provided by the RCT computer, thus the DS and RCT had to calculate the position in latitude and longitude and provide the same answer. This was necessary as the DS had to be able to taxi on the ship's deck and therefore could not take the position from the ship but had to have the ability to update its own position.

The other problem associated with ships was the ability of the helicopter to stay on the deck when the ship was rolling violently, as the original helicopter aerodynamic model had not allowed for such eventualities.

Tactical Scenarios

The DS has the ability to display visually the five nearest targets from the total of nineteen targets in the FMS scenario. As the DS could only display five targets, the instructor had to manage the scenario carefully to ensure a realistic picture would be obtained and targets did not pop into view as others went out of view.

In the display of targets one feature, not initially catered for, was the ability to sink targets or to cause a submerge and still track it as a target but not to contine to see it on visual display. This came about by the wrong assumption that all ship targets only required x and y co-ordinates, not height or depth.

Flight Characteristics

The initial reaction to the flying qualities of the DS was that it was unrepresentative, and in some cases not like a helicopter. These problems are common with simulation of helicopters, as the data available is never as good as the normal quality found in fixed wing simulators. The DS was no exception, and matters were made worse by the fact that the Sea King aircraft is effectively an old design with no demand for the manufacturer to carry out additional analysis and flight tests to update the aerodynamic data to latest standards.

These problems were not clearly defined until the Aeroplane and Armament Experimental Establishment at Boscombe Down provided test pilots to analyse the DS. As a result of this exercise, they devised a series of objective tests which covered the areas of concern. These tests were carried out in the actual helicopter and then repeated in the simulator. This allowed the Flight Systems Engineer to tune the aerodynamic data and equations to match these objective tests. Final adjustments were then made on a subjective assessment to obtain the best handling qualities possible within the aerodynamic model used.

The end result is a simulator which is considered to be flying in the region of 95% like the actual helicopter. This exercise highlighted the need for better aerodynamic data and actual flight test results, to check out the simulation of helicopters, and also the advantage of access to test pilots in the analysis of any handling problems.

PERFORMANCE IN SERVICE

The Royal Navy finally received the fully integrated Sea King Mk 5 FMS into service on 9 March 1988, when the DS was accepted from Rediffusion. It was a long awaited moment which would allow the Royal Navy to conduct, for the first time, valid full crew and full squadron training without having to climb into an aircraft. But how is the complex being managed and what is being done to get the most from this expensive investment?

Maintenance

The Staff Requirement called for 98% availability for 18 hours per day, 5 days per week, 46 weeks per year. Clearly under such circumstances, to achieve the serviceability required, the maintenance crews must be well trained, well motivated and knowledgeable. They must also be able to carry out periodic revalidation exercises to ensure that the simulator continues to behave like the aircraft it represents.

With only three major flight simulator complexes it is not possible to establish a viable simulator branch within the Royal Navy. Therefore, reliance has always been placed on Contractor Maintenance. This has certain advantages. The men come to the complex ready trained, are a stable workforce and can operate undistracted by the frills of service life. They get to know their equipment intimately, providing a continuity unachievable with Service maintainers, allowing the Service to conduct training, secure in the knowledge that commercial incentives will ensure the availability required. In short, experience has shown Contractor Maintenance to be an extremely cost effective and efficient way of operating.

Instructors

In contrast to the policy on maintenance staff, and unlike the apparently increasing trend in the USA, the Royal Navy has elected to keep training within the Service. The Officer in Charge remains a serving officer, with his Instructors all being current and experienced aircrew. Wherever possible pilots are Qualified Helicopter Instructors, who have completed at least one instructional tour on a training squadron. Likewise, observers and aircrewmen are qualified instructors able to provide training for the ab initios, as well as the advanced exercises required by the front line squadrons. The front line are however encouraged to run their own games under the supervision of senior squadron personnel with the simulator staff on hand for advice, only when required. Whenever possible the FSLOs are appointed to the simulator staff after Acceptance to provide a basic core of knowledge, of a system on which others can draw, and to forge the vital links between the Service and the contractors in the early stages of Post Design Services.

Training

Although it is still early days, the new simulator is already having a significant effect on the management of training, for both pipeline and frontline aircrew.

Pipeline. The ability to put trainee aircrew into a highly representative cockpit and cabins is starting to bear fruit. Instead of flying a simulator, aircraft, simulator pattern, pilots now fly complete stages in the simulator before the same sorties in the aircraft. Thus, for example, the whole instrument flying stage will be rehearsed in the simulator before venturing into the air. Results so far are encouraging. On average, having completed the syllabus in the simulator and about a third of the airborne sorties in each stage, students have reached the required standard. This then gives more time for consolidation, and thus a better, more rounded, pilot is passed onto the operational stage of flying training. The other advantage is that programming is simplified, as for each course the planners can see well in advance when the simulator training will be required. Availability for other users is thus clearly indicated. For the rear crews, the advantages are obvious. The completely representative cabins in the RCT not only enable the young men to develop their confidence and skills before being subjected to pressure in the air, but also gives ample opportunity for the weaker student to develop at his own pace. It is of significance that the sonar simulation is considered so good that the majority of the basic sonar handling exercises are no longer performed in the air.

Frontline. Perhaps it is in the frontline that the most significant changes will be seen. To succeed in anti submarine warfare in the RN Sea King, not only must crew cooperation be good, but so must inter-aircraft cooperation, with each observer having an innate understanding of his partner's plans and intentions. The standard modus operandi from the INVINCIBLE class aircraft carriers is a three aircraft programme. This always gives a minimum of two aircraft on task. With three cabins in the Rear Crew Trainer, squadrons can realistically train over prolonged periods, rehearsing the full range of procedures necessary to locate, track and kill submarines. In addition, by linking one of the RCTCs to the DS the pilots can be integrated into the teams. It is expected that this will facilitate a far higher level of war readiness and enable a better utilisation of expensive and increasingly scarce training assets when at sea.

SIMULATOR SICKNESS

The Royal Navy in selecting the WIDE II Display System, was aware of the school of thought which said that a wide field of view would lead to problems with simulator sickness. The advantages of cross cockpit viewing however, were considered to outweigh this unproven risk. Experience so far would appear to vindicate this decision, though not without some penalty. Whilst instances of nausea have been reported, and only by the more experienced aircrew on their first or second sorties, disorentation effects are however more prevalent. These effects appear to be related to the simulator conditions at the completion of the mission. (ref 1). For example, crews leaving the simulator after having crashed, and before the visual system is re-erected, take time to re-adapt to reality. Perhaps of more significance, are the effects experienced by pilots flying day sorties in the simulator during the hours of darkness or in conditions of poor visibility outside. Many crews have reported a loss of depth perception and a feeling of being out of touch with reality, and difficulties with driving (cf ref 1,2,3). Aircrew are currently banned from flying for 12 hours after a simulation session (cf ref 1,2,3).

CONCLUSIONS AND LESSONS LEARNED

As a result of a competitive procurement by the UK MOD, the Royal Navy received into service a Full Mission Simulator for Sea King Mk 5 aircrew training. Although the Ready for Training date achieved was nearly two years later than anticipated the final product is a highly capable training device.

Lessons learned which will influence new UK Military Helicopter simulator programmes were:
- Early agreement on procurement strategy.
- Timely identification of as-aircraft parts.
- Specifications may well have to include details of the customer's planned useage of the device in training.
- Flight Simulation Liaison Officers will continue to be employed.
- Critical Design Review Meetings should be introduced.
- Integration aspects must not be underestimated and need to be identified closely in both specification and contract.
- Acceptance Testing must involve Test Pilots.
- Acquisition of Data by PE must be considered.

References

1. R S Kennedy, K S Berbaum, M G Lilienthal, W F Dunlap, B E Mulligan, J F Funaro. 'Guidelines for Alleviation of Simulator Sickness Syptomatology'. NAVYRASYSCEN TR-87-007, Naval Training Systems Centre, Orlando, Florida. March 1987.

2. J S Crowley. 'Simulator Sickness : A Problem for Army Aviation'. Aviation, Space, and Environmental Medicine, April 1987, pp 355-357.

3. J Chappelow. 'Simulator Sickness'. Air Clues, January 1988, pp 22-24.

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John Tickle is the Marketing and Business Development Manager for training systems activities with Ferranti International, and was heavily involved in the preparation of the tender for the RCT. He has been in the simulation industry for some 19 years, initially as a Sales Executive prior to taking up his present position. In this position he has been involved in all aspects of simulation as featured in a wide variety of training applications, primarily for the Armed Forces.

Alan Warrell works as a Manager in the Military Simulation group at Rediffusion Simulation and has been in the aviation industry for twenty four years, the last fourteen years in flight simulation. As a Programme Manager, he has been involved with commercial, US military and UK military projects and covered a range of aircraft types and requirements.

Commander John Wright is the Desk Officer in the UK Ministry of Defence Directorate of Operational Requirements (Sea) responsible, amongst other things, for rotary wing simulation. A Psychology Graduate from the University of Reading in England. He is an Anti Submarine Warfare specialist, having spent the past 14 years as an observer in the Sea King and Wessex 3 helicopters and on the staff of what is now Com ASW Strikeforce.