GEC AVIONICS

Annual Report 1988

Flight Automation Research Laboratory

FLIGHT AUTOMATION RESEARCH LABORATORY

1988 Annual Report

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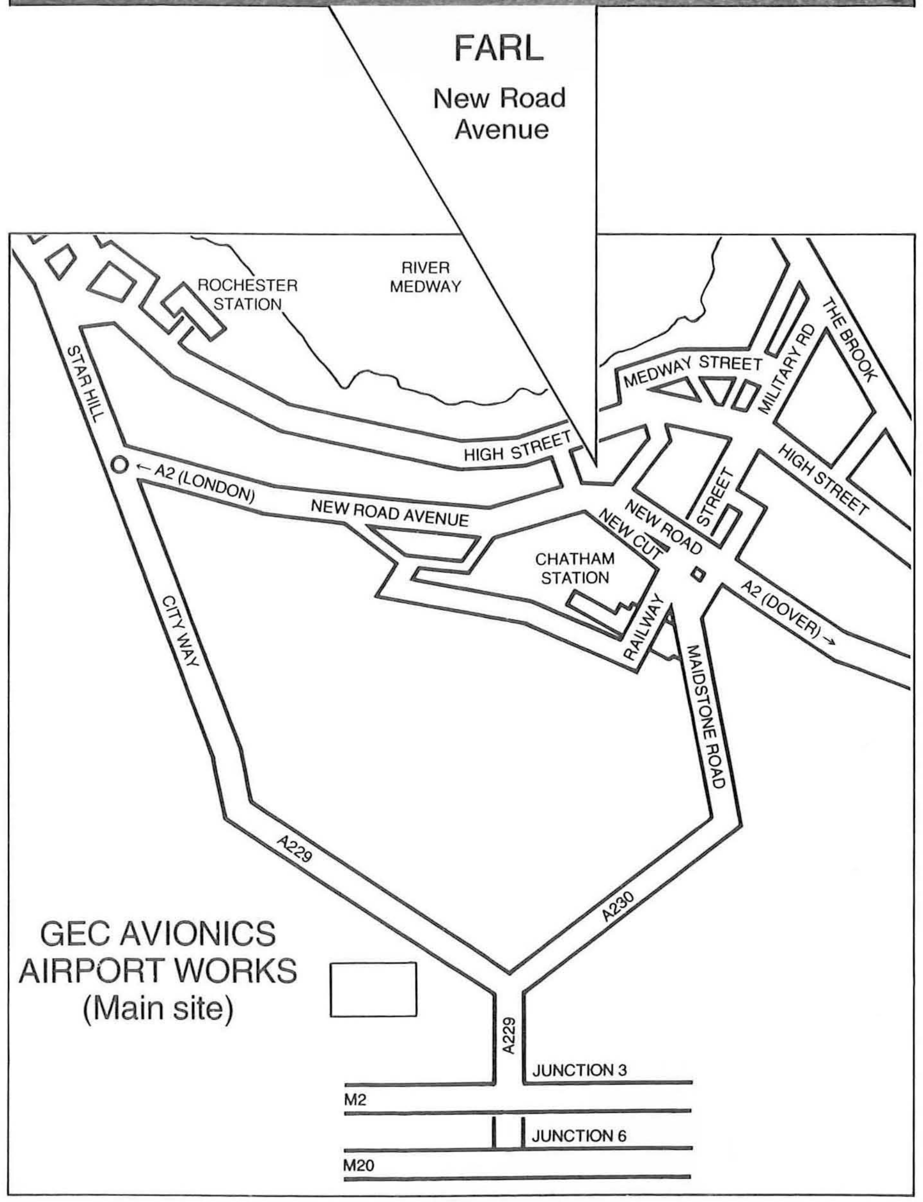
DIVISIONAL MANAGER



INTRODUCTION

Introduction

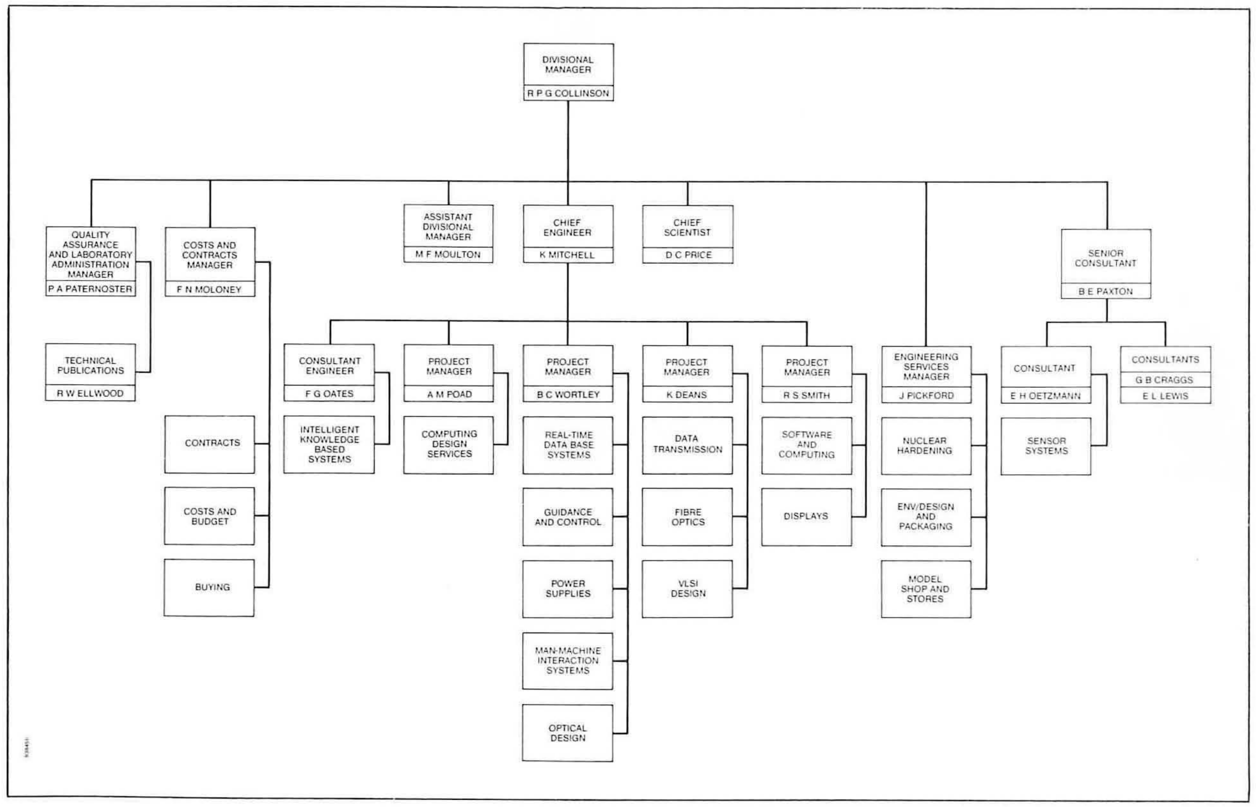
The Flight Automation Research Laboratory which was formed in 1961 currently occupies 10,200 square feet in the New Road building, Chatham, and employs approximately 100 people including about 80 engineers with Graduate or equivalent qualifications in Electronic, Electrical and Mechanical Engineering, Physics, Computer Science and Mathematics.

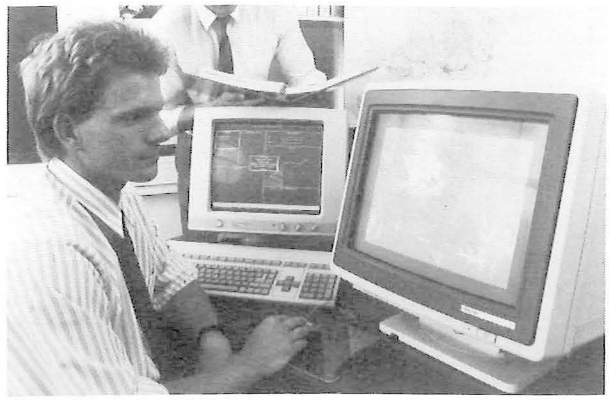
The role of the Laboratory is to provide the Product Divisions of GEC Avionics with new systems and technology which will enable them to maintain a competitive edge in their products and also enable them to establish themselves in new product areas.

The Laboratory is organised into teams (Figure 1) whose specific skills embrace the following areas:

- Future Avionic Systems
- Man Machine Interaction Systems
- Intelligent Knowledge Based Systems
- Guidance and Control Systems
- Sensor Systems
- Software and Computing
- Data Transmission and Data Management
- Displays
- Optical Design
- VLSI Design
- Environmental Design and Packaging
- Power Supply and Analogue Design

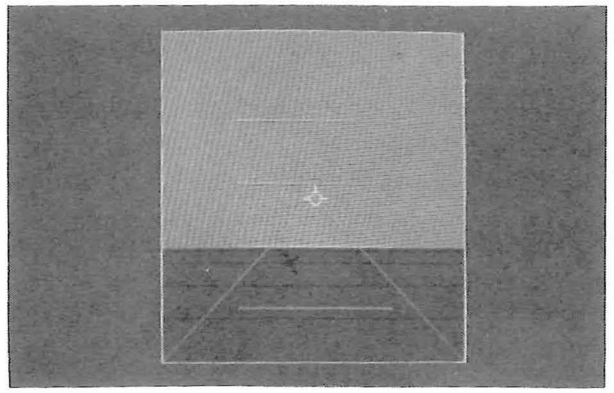
Figure 1



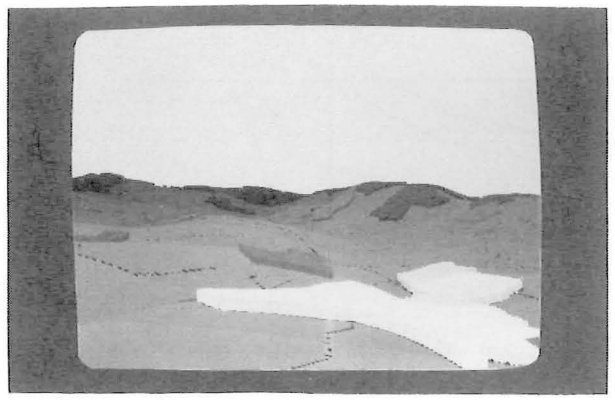


IKBS Route Planner

General Dynamics Land Systems Bino HMD Trials

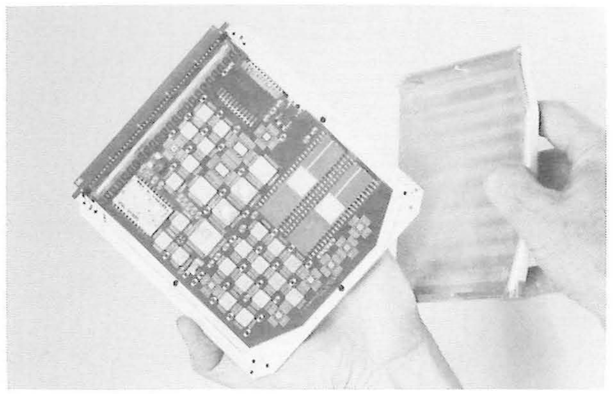


Fly-By-Wire Control Stick Demonstrator

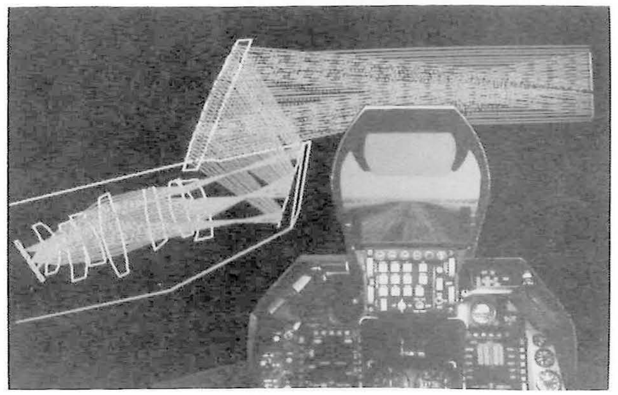


Digitally Generated 3D Map Display

Airship Industries Skyship 600 Optically Signalled Flight Control System



SEM'E' Processor Module



Holographic HUD Design

MANAGEMENT SUMMARY

This report covers the period from November 1987 to November 1988.

A number of new Company–funded R&D programmes which had just started at the time of last year's report have made substantial progress – such as the High Speed Data Bus terminal designs for both Eurofighter and the ATF, and the novel virtual cockpit concept based on exploiting a binocular helmet–mounted display system. Our work on the use of IKBS technology has resulted in a contract from MOD(PE) to produce an Intelligent Displays Management demonstrator for RAE.

External funding, mainly from MOD(PE), has remained at about the same level as the previous year, absorbing about 20% of our engineering resources.

Company–funded R&D programmes to support common enabling technology for the GEC Avionics Product Divisions, such as Software Engineering, IKBS Applications, Data Transmission, Nuclear Hardening Design, Electronic Packaging, Power Supply Design, and MMI Research (virtual cockpit) accounted for a further 40%.

The remaining 40% was absorbed in direct support to the Product Divisions in such areas as software, fibre optics, VLSI design, nuclear hardening expertise, power supply design, systems studies, sensor systems, display generation etc.

The engineering strength has remained unchanged at around 83 with an overall divisional strength of around 100. The main highlights of our activities and achievements are summarised below.

Edge Detection Navigation has made very good progress; robust algorithms have been developed which have overcome the problems of 'rogue' fixes and give very impressive navigational accuracy. Further externally funded development is anticipated. The system fits in well as a complementary navigation system which can be readily integrated with Guidance Systems Division's SPARTAN terrain referenced navigation system.

Intelligent Displays Management demonstrator programme was launched in April 1988 and the knowledge elicitation phase derived from detailed consultation with experienced RAF pilots has been completed. The system uses two 'Expert' systems; the first derives aircraft state and the second uses this information to manage the display of appropriate information to the pilot to reduce workload during the mission, particularly in dealing with unscheduled events/emergencies.

IKBS Route Planner development has been taken to a demonstrable stage and future development as part of a mission planning system, either ground or cockpit based, is anticipated.

Mission Management Aid studies have involved full time participation by one senior member of the FARL IKBS team as part of the joint IAWG/RAE activity over the last 12 months in what promises to be a very effective exercise.

Virtual Cockpit R&D programme has demonstrated the combination of collimated (infinity) displays and 3D stereo displays of cockpit instruments and a cursor controlled multi–function keyboard display. This utilised the head–steered Stereo Display Head (ex Underwater Viewing System equipment); a more representative binocular HMD system is nearing completion. The advent of laser eye damage threats to aircrew gives added impetus to the programme.

Binocular HMD Systems designed and developed over the last 2 years are now undergoing trials and have received very favourable comment – the 'bino' HMD has been flown in the RAE Lynx helicopter and the 'skeleton' helmet version is currently being used in trials in the USA.

New Helmet Sight has been designed for the Alpha Helmet to provide a simple lightweight helmet sighting system for the RAE to carry out off-bore-sight target designation flight trials in a Jaguar aircraft.

Raster Overlay Generator design and development for the C-130H programme for ADD has been completed and the display generator cards, which use the Texas GSP graphics processing chip set, are now in production in ADD. Work on non-interlaced displays is under way using the AMD QPDM graphics processing chip set – non-interlaced map displays present a far superior visual appearance.

Flat Panel Display investigation and evaluation of both the LCD active matrix addressed panels being developed by the GEC Hirst Research Centre and the colour LCD matrix panel being developed by Eurodisplay look very promising.

Space Suit Displays and Speech Recognisers suitable for astronauts during extra vehicular activities have been investigated as part of the man–machine interaction studies being carried out by the European Space Agency, the activity forming part of a sub–contract package from Avions Marcel Dassault–BA.

Passive Sensors exploiting fibre optic interferometry principles have been investigated under a research contract we have placed with the University of Kent at Canterbury over the last 3 years. A very promising pressure sensor development has resulted using a dual wavelength technique to give a high resolution, high accuracy digital output. Applications include engine control sensors and 'down hole' pressure measurement in the oil industry. Further development in FARL is anticipated and includes an angular position sensor derivative.

Airship Optically Signalled Flight Control System developed several years ago by FARL and recently refurbished by the Laboratory with latest state-of-the-art connectors and cables is now being installed in the Airship Industries Skyship 600 Airship in the USA for flight trials for the US Navy. *

Fibre Optic data transmission development has covered a wide range of applications from the STANAG 3910 and USA High Speed Data Bus systems to a demonstration of a bi–directional link for a future fibre optic guided air vehicle using a long single mode fibre cable provided by GEC Optical Fibres.

High Speed Data Bus development has progressed well – detail system design is being carried out for both the European standard STANAG 3910 for the Eurofighter (EFA) programme and the USA Linear Token Passing Bus, with the aim of VLSI implementation. Close collaboration with the Product Divisions is being maintained.

ASTRID (Avionic Serial Transmission Interface Device) chips have now been successfully processed from the design we have carried out in conjunction with Combat Aircraft Controls Division. These represent a complexity/device count approximately three times greater than our 2–chip 1553B design. A 99% Built–in Test facility has been successfully integrated into the design.

Guidance and Control activities over the year have primarily involved supporting Flight Controls Division in generating the test software for their new primary flight control computers developed for the Boeing 7J7 programme and refurbishment of the Airship optically signalled FCS equipment for USA trials. Other tasks have included generation of 3D displays for a virtual cockpit and generation of aircraft model flight simulation software using discrete time matrix techniques. Tracking algorithm development has also been carried out for Maritime Aircraft Systems Division.

Software and Computing team activities have been mainly concerned with supporting Flight Controls Division in the above Flight Control Computer test software – the size of the task requiring a joint team of 12 engineers at one stage. The installation of 6 Sun Workstations in January/February 1988 has made a big step in improving software generation efficiency and accompanying documentation.

Software Research activity has been directed into three areas. Firstly, development of software architectures to be used in future display systems to provide optimum partitioning between the software task and the new graphics processing devices. The second activity, which has just started, is an investigation and evaluation of Formal Methods for software generation. The third activity has been a limited evaluation of GEC Software's GENOS tool for software project management – results to date support its effectiveness.

Alvey 'Trailblazer' programme for 'top down' design of electronic devices for implementation in VLSI technology has made good progress. The methodology being developed in conjunction with the University of East Anglia aims to map the mathematical description of the circuit functions in OCCAM to ELLA, a hardware description language, and thence by an already established route to silicon. The aim is a 'right first time' method instead of 'cut and try' as at present.

Optical Design of single combiner holographic HUDs in support of Airborne Display Division (ADD) has been a major activity over the year. A novel design to meet the exacting requirements for the ATF has been produced in collaboration with ADD.

Power Supply design support to the Product Divisions continues to be an important role for our power supply experts. New designs of switched mode converters operating at higher switching frequencies are being investigated and promise significant improvements over current designs.

Environmental Design activities have covered three main areas over the past year. Firstly, support to Product Divisions responding to nuclear hardness requirements in their EFA proposals. Secondly, liaison with British Aerospace and the Product Divisions on EFA electronic packaging. Thirdly, a hardware demonstrator programme to assess problems of high density electronic packaging – surface mount technology – thermal aspects – EMH aspects of the standard electronic modules envisaged for the future avionic systems.

Computing Design Services are an essential element for our expanding use of CAD techniques in all the research areas we cover, ranging from optical design to VLSI design. The Laboratory's computer network has been further expanded with the installation of thin wire Ethernet in all office and workbench areas, interconnecting PC's served by the two VAX's.

Finally it is gratifying to report that two FARL engineers and one ex–FARL engineer, now with ADD, were this years winners of the HASKETT TROPHY for engineering achievement for their entry – 'Binocular Helmet Mounted Display System'. The Haskett Trophy Competition is held annually by GEC Avionics and is awarded for the entry which is judged to be the best engineering achievement of the year that is likely to lead to a new product for the Company. It is interesting to note that engineers from FARL have now either won, or been part of the winning team, in 5 out of the 10 annual competitions held so far.

Dick Collinson

*** Stop Press ***

Airship fly-by-light optically signalled flight control system flew for the first time on the 23rd October 1988 at Weeksville, North Carolina.

It was reported by Mr Roger Munk, Technical Director of Airship Industries that the Airship 'handled superbly with its controllability transformed' during its first hour-long test flight.

A series of very successful flights have now been made. This is the world's first air vehicle to be controlled entirely by optical signals with no mechanical reversion.

1 REAL–TIME DATABASE SYSTEMS

Project Manager: Brian Wortley
Project Leader: Derek Jordan

1.1 Introduction

The Real–Time Database Systems Team currently comprises six software/systems engineers and one trainee computer programmer. During 1988, the team's activity in map–based systems has continued with further investigation of the Edge Detection Navigation technique and a limited amount of work on data editing facilities for the Real Time Map Demonstrator. The team has diversified its' activities in several areas, with the production of a new suite of image–generation software for the Advanced Ground Station (MOD contract organised as a sub–contract through Flight Controls Division); feasibility studies of extracting features from digitised SPOT satellite images (PV); demonstration of algorithms for measuring pilot's eye gaze angle and helmet position; writing a package of software for Combat Aircraft Controls Division as a joystick demonstration facility ; and work on the Alvey Trailblazer programme. Further details on selected work items are provided below.

1.2 Edge Detection Navigation Studies

Work has continued during 1988 on Edge Detection Navigation under external funding. Studies have concentrated on determining the accuracy and robustness of the algorithms in different conditions and over various types of terrain using actual flight trials data acquired from a number of sorties.

Technique simulations during the past year have been designed to indicate how the system would perform in an integrated navigation system and results are very encouraging.

Figure 2 shows a sequence of 'position likelihood' distributions which indicate how the position estimate improves as feature boundaries are detected.

Reports available on request

1.3 RTMD Data Preparation Facility

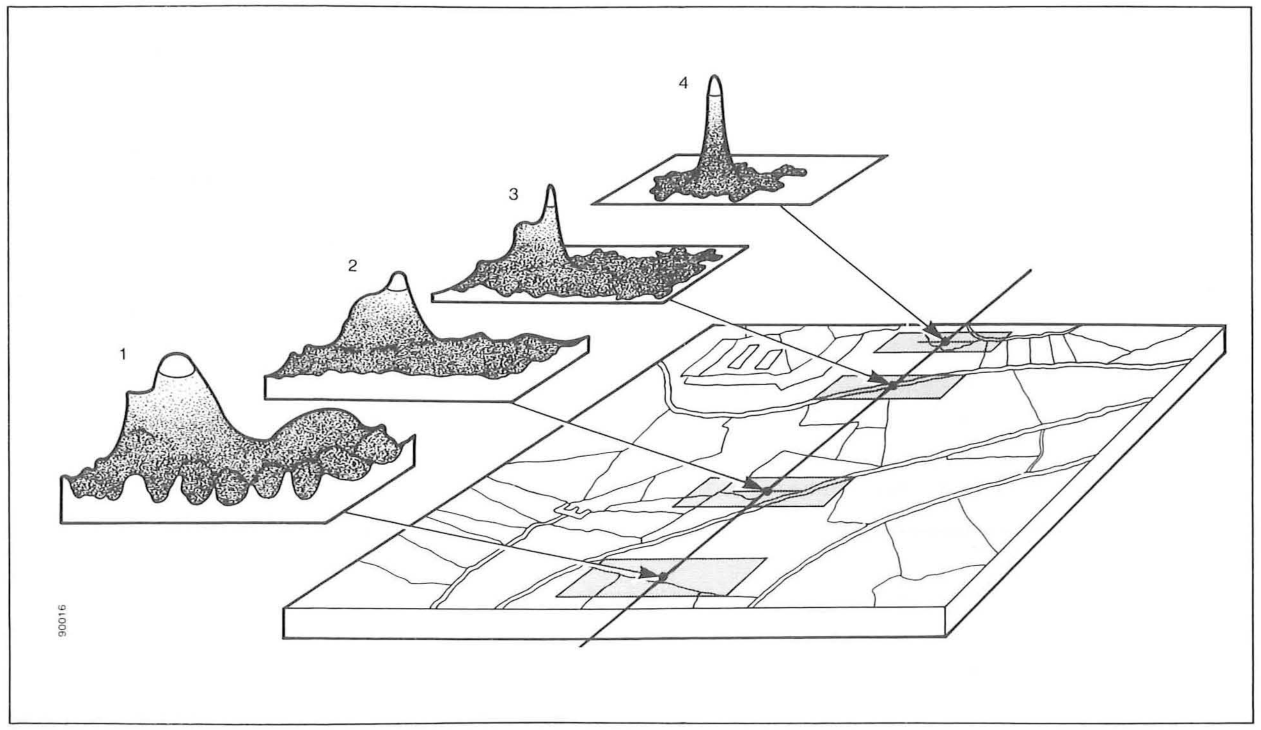
No further development of the Real Time Map Demonstrator (RTMD) equipment described in previous reports has been undertaken during 1988. Company funded effort has been directed to map data editing and format conversion required by the Demonstrator. In the past, the data editing process required manual intervention and the elimination of data errors was time consuming. A suite of programs for the automatic elimination of a range of error cases has now been developed and this has dramatically reduced the processing time required with the added advantage that data editing and re–formatting can now be performed as an over night computer batch job. The software has been tested by processing data from 500 map 'tile' areas from south Wales and western England.

A subsidiary area of work concerned the inclusion of map text (such as town, airfield, river or area names and even special symbols) in the feature database. This requires the expansion of the map index structure as well as the enlargement of the feature co–ordinate database. A software facility has therefore been developed to handle the database expansion automatically, so that the user has only to specify the text (or symbol) string required and its location on the map.

Relevant Reports: *262/2337 Real Time Map Demonstrator Data Processing and System Development –Aug–Oct 1987.*

262/2428 Development of Automatic Data Editing Software.

Figure 2



1.4 Graphics Control Software

During the first half of 1988, the graphics control software within the Advanced Ground Station (AGS) was re–written to simplify its operation and provide additional facilities. The AGS has been supplied by Flight Controls Division to the Ministry of Defence for use on aircraft test ranges and several changes were required after a couple of years of operational use. Graphics displays within the AGS are provided by a special–purpose Programmable Raster Display Generator (PRDG). Modifications to the definition of the display interface, the number of display screen formats, the layout of the Instrument Screen and several other areas were implemented in a two phase work programme funded by an MOD contract via FCD in June 1988 and were integrated into previously supplied AGS equipment during July and August.

Relevant Reports: *262/2474 APSE Bibliography which lists a total of 18 documents produced for this project, covering Project Definition, Software Description, Acceptance Tests and Integration Specifications.*

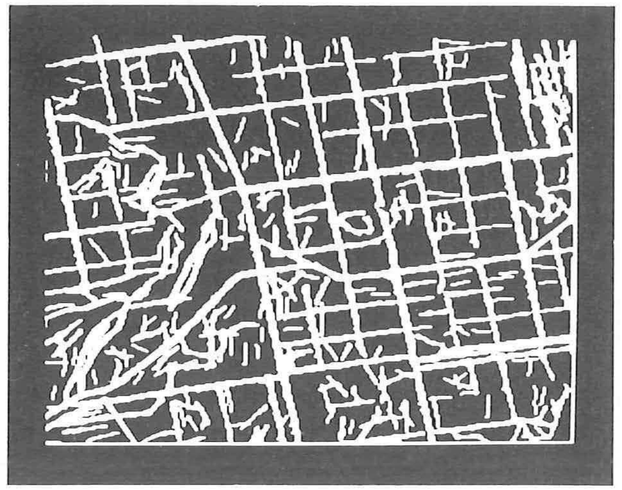
1.5 SPOT Satellite Image Processing

This is a private venture feasibility study investigating the use of images from the French SPOT satellite to provide feature boundary information. The programme of work has involved experimentation with various image processing algorithms to enable boundary vectors on the image to be identified and extracted, thereby providing the necessary information to generate boundary maps of the area covered by the image. The study was based around the use of two particular algorithms; the Lateral Inhibition Algorithm (LIA), which is a technique designed to emulate the ability of the human eye to enhance edge contrast, and FFCE. The latter is a simpler method which uses a local–averaging technique to produce similar results.

Both algorithms have been the subject of previous investigations by the team and are described in earlier reports. The algorithms were used, along with various noise suppression routines, to pre–process the satellite image in readiness for further processing by algorithms developed to identify and extract the vectors enhanced by LIA or FFCE. Figure 3a and 3b illustrate the 'before and after' results of the processing technique.

Figure 3a

Figure 3b



The study has successfully demonstrated the feasibility of producing boundary maps. Work remains to be done, however, in the areas of feature classification, boundary concatenation and noise removal.

1.6 FBW Pilot's Control Stick Demonstrator

During the summer of 1988 the team was responsible for designing and implementing software for a Fly–by–Wire (FBW) Control Stick demonstrator rig exhibited at the Farnborough International Air Show by Combat Aircraft Controls Division. A computer 'game' has been designed, the object of which is to shoot down a randomly manoeuvring target aircraft in the shortest possible time by 'flying' a HUD type of display using the FBW Control Stick and pressing a 'fire' button. The software, comprising 2600 lines of assembler source code, produces smoothly moving colour graphics output on an Atari micro–computer with capability for future expansion.

1.7 Alvey Trailblazer Project

The team has become involved with the Alvey 'Trailblazer' Project which aims to create VLSI designs from a description in a high level language. The resulting system will accept an algorithm in a high level language and convert it, with suitable user interaction, to a low level hardware description language, ready for delivery to a silicon house.

Our involvement has been with the system compiler. One area has been the design of the syntax for the rule bases of the system. This was critical to the efficient design of the compiler which must be able to handle rule bases for different architectures. It has been necessary to develop the proposed rules so as to model the final silicon layout correctly rather than merely its theoretical behaviour. We have also been instrumental in the implementation of the rulebase driven translator section of the compiler.

2 GUIDANCE & CONTROL

Project Manager: Brian Wortley
Project Leader: Phil Lamb

2.1 Introduction

The team comprises 7 engineers who have built up considerable experience in processor architectures, software development, digital flight control and digital aerodynamic modelling.

The team has been engaged on a variety of projects during the last year and has been almost totally directly funded.

Considerable effort has been expended in support of two crucial Flight Controls Division contracts:-

i) Development of test set software for the Boeing 7J7 Prototype Primary Flight Control (PFC) System.

ii) Refurbishment of the FARL built Optically Signalled Flight Control System, including subsequent USA flight trials support, which forms part of the ODM contract awarded by Airship Industries.

Additional work for Maritime Aircraft Systems Division and support of other teams within the Laboratory have also been a prominent part of the team's work.

2.2 Boeing PFC Test Set

Three team members have been engaged almost full time in developing software for the Primary Flight Control (PFC) test set in collaboration with the FARL Software & Computing Team. The Guidance & Control Team effort has been primarily in the areas of User Interface software development and the implementation of a multiple mode small perturbation digital simulation of a 7J7 type aircraft.

The flight simulation block diagram is shown in Figure 4.

Considerable experience in the use of formal Object Oriented Design techniques has been gained during the course of this work.

2.3 Airship Optically Signalled FCS

Flight Controls Division has been awarded a contract to develop a Flight Control System for the new Airship Industries 'ODM' Airship proposed for use by the US Navy. The primary features of the system are the use of fibre optic signalling and electric actuation of the control surfaces as a substitute for the primitive pulley and cable control system currently in use. A simple prototype system was developed by FARL during 1983, but regrettably was never flown. The decision was taken to refurbish the system as a proof-of-concept demonstrator. The fibre optic assemblies have been replaced by units more representative

Figure 4

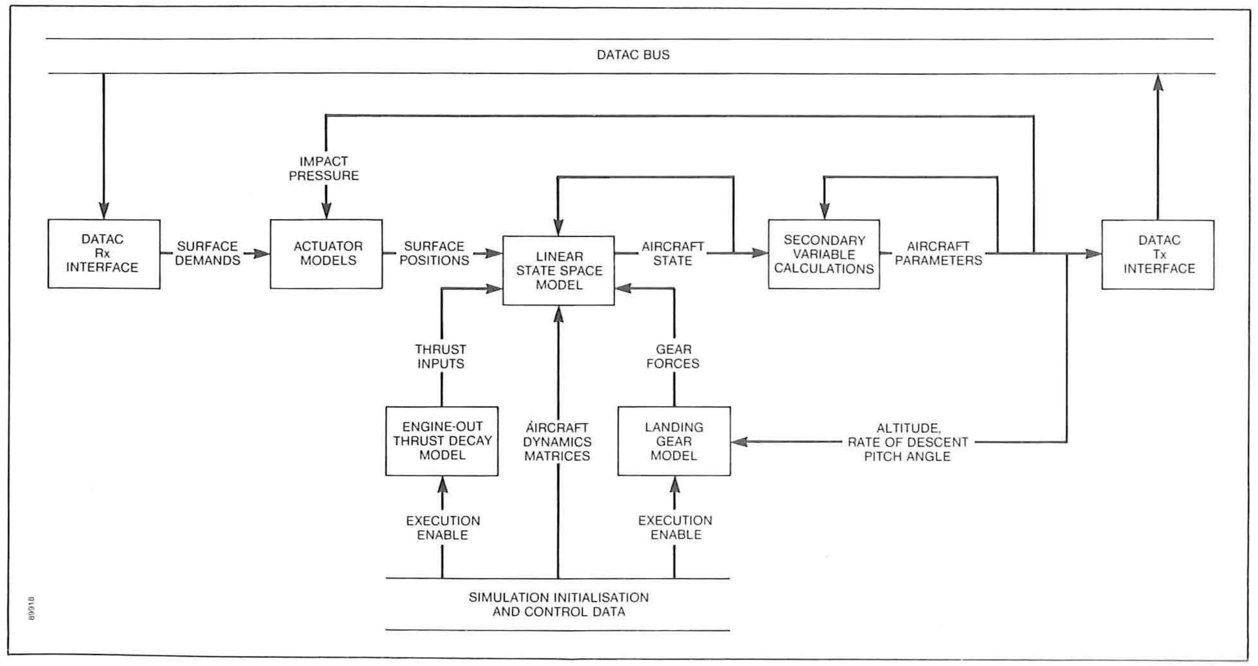
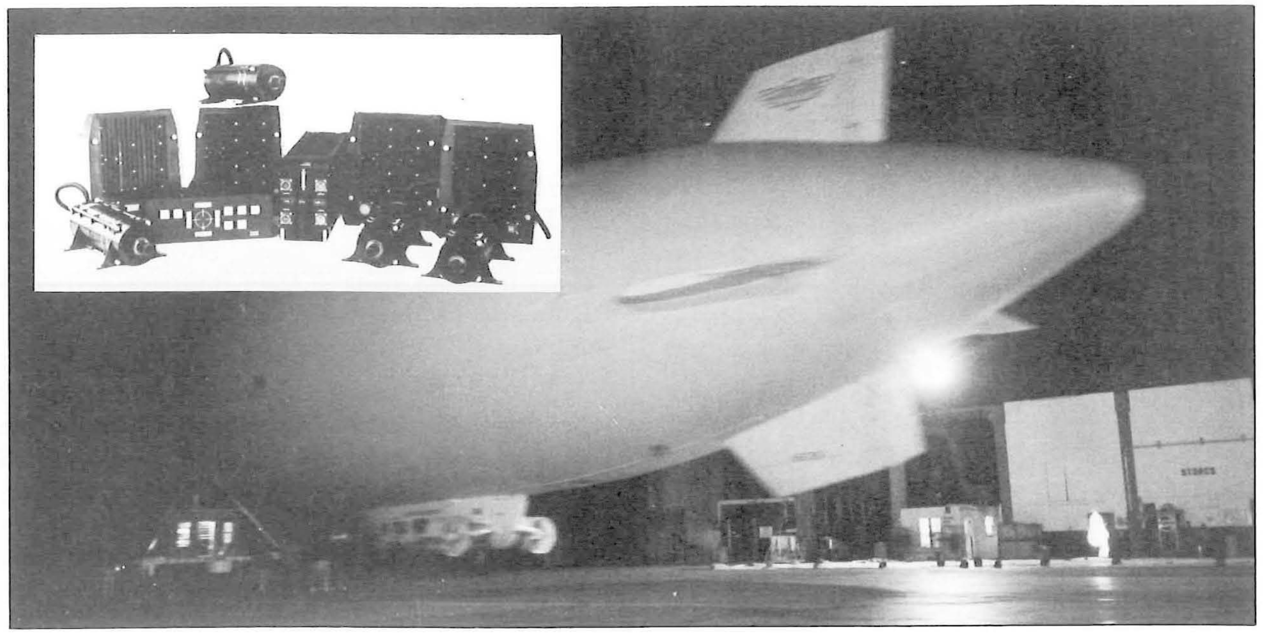


Figure 5



of those proposed for the new airship, and the entire installation details reviewed. The system has been sent to Weeksville, North Carolina, USA for extensive flight trials in the presence of US Navy officials. At the time of writing the system is being installed in an Airship Industries' SKS600 by a small team of FARL/FCD engineers. FARL will provide continuous on–site support for the entire flight trials programme.

Figure 5 shows the SKS600 Airship at Weeksville, North Carolina – the world's first 'Fly – by Light' air vehicle without mechanical backup for the controls.

2.4 Sonar Tracking Algorithm Development

One team member has been working with Maritime Aircraft Systems Division on the development of a sonar processing tracking algorithm for unstable spectral lines.

A number of tentative ideas have been pursued with extensive testing and repeated algorithm refinement to the point where acceptable results have been achieved with simulated and 'real' data.

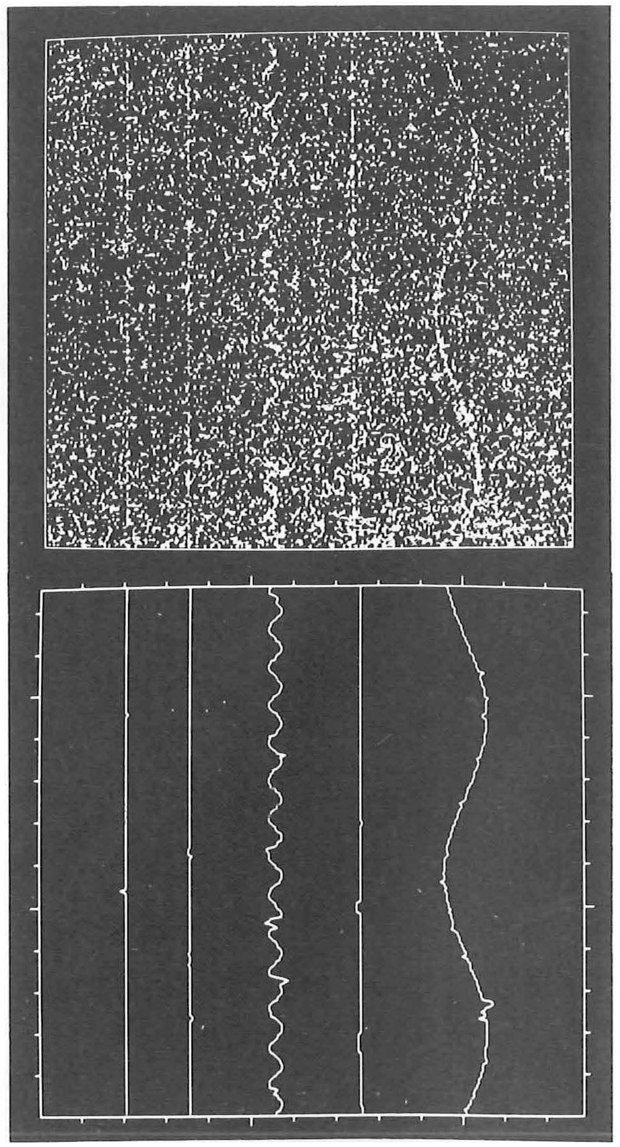
Figure 6 illustrates the effectiveness of the processing algorithm at recovering the signal from the noise.

The work is drawing to a close and the final report will be produced soon.

2.5 Fibre Optic Guided Air Vehicle

Remotely piloted vehicles have been the subject of much work within FARL over the past decade.

Figure 6



More recently the Guidance & Control Team were involved in a private venture study involving missile aerodynamic design for various wing arrangements and a scenario strategy demonstration for a Fibre Optic Guided Helicopter Anti-Tank missile (FOGHAT). As a result, over the past few months one member of the team has been involved in such a study for the design of a fibre optic guided vehicle for close battlefield surveillance as part of a Company presentation to the army and RARDE. The work covered such areas as canard versus standard wing and tail configuration, estimates for drag versus lift, and characteristics of the dynamic motion of the vehicle. Alternative techniques for producing a cost effective control system were also considered.

2.6 Virtual Cockpit

FARL has been working on a proof of concept for a virtual cockpit for the past year or so and during this period one of the main areas of work has been the development of a demonstrator.

One member of the Guidance & Control Team has been involved in this project, working with the Man Machine Interaction Team producing software to generate '3D stereo' graphics images for the demonstrator. Software was also generated which enabled information from a set of head position resolvers on the demonstrator to control the displayed images and hence provide a 'look around' image system.

3 POWER SUPPLIES

Project Manager: Brian Wortley
Principal Engineer: Dave Morris

3.1 Introduction

The Power Supply Team consists of two engineers providing assistance to the Product Divisions on an 'as and when required' basis as well as carrying out privately funded work in new power supply configurations and techniques. Support from other teams in the Laboratory is available on a matrix basis.

The Company funded work has included bread-boarding and computer simulations of different configurations for use in high frequency switching power supplies whilst the Product Division support has covered design and fault finding assistance on production power supply units.

3.2 Product Division Support

Airborne Display Division

A pre–regulator power supply designed by FARL in previous years has now gone into initial production. The team has provided technical assistance including commissioning the first production unit. Other assistance has included help on Skyshadow power supplies and proposal generation.

Combat Aircraft Controls Division

The team has provided some assistance to Combat Aircraft Controls Division on their single board PSU's for the ATF.

3.3 FARL Project Support

The team has designed and built the PSU's for the binocular Helmet Mounted Displays for Airborne Display Division and RAE Farnborough, and continues to assist other teams when required.

3.4 Power Supply Research

Privately funded work has continued throughout the year into components and techniques for high frequency switching power supplies.

A computer simulation has been written in order to evaluate a number of suitable resonant configurations. The first resonant model studied was a series–parallel combination and the computer simulation was used to assess the effect of increasing either the series resonance or the parallel resonance. The second model was a zero–current switching quasi–resonant converter.

Breadboards were also built to assess the accuracy of the computer models and to look at certain aspects of operation in more depth. In both cases the voltages and currents measured on the breadboards agreed with the simulations to within 10%.

From these simulations it is now intended to breadboard a zero–current switching quasi–resonant converter with the appropriate isolation transformer and feedback control with a realistic output similar to previously tested types.

Other work has included testing a 200 kHz half bridge converter providing 200 Watts. A report is now being written.

Relevant Report: *262/2340 Initial Study on High Frequency Power Supplies.*

4 DISPLAYS

Project Manager: Renny Smith
Project Leader: Dave Thorndycraft

4.1 Introduction

The Displays Team, which comprises 6 engineers, has been primarily concerned in the past year with consolidating the work initiated in 1987 on graphics generators based on the TEXAS Graphics System Processor (GSP). In addition, and complementary to these studies, have been investigations into Active Matrix Addressed Liquid Crystal Display panels. Recently the team has been awarded a contract by RAE Farnborough to develop a lightweight Helmet Mounted Sight.

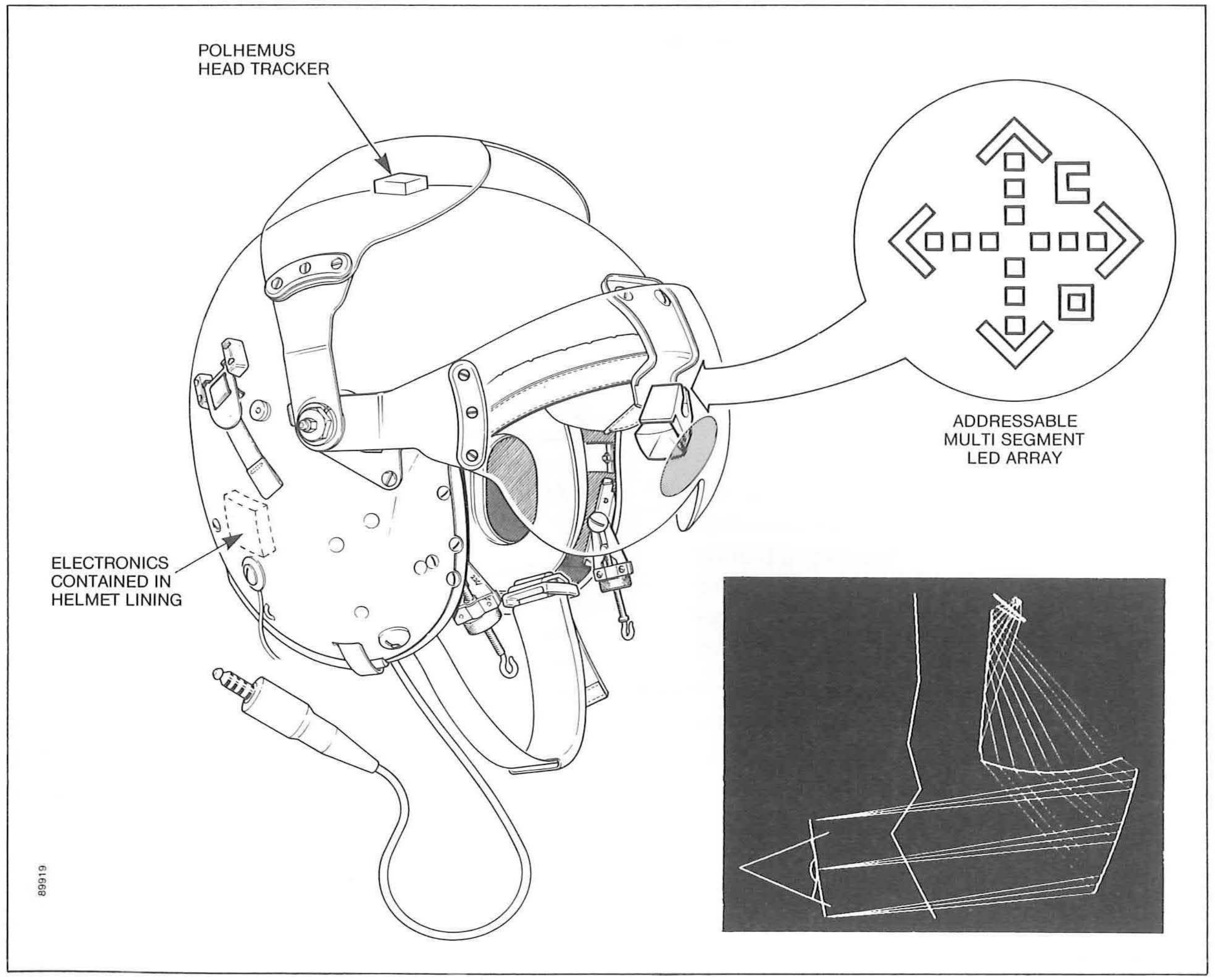
4.2 C-130H Display Generator Unit

The work initiated in 1987 on a Display Generator for the Airborne Display Division C–130H programme has now been completed. Deliverable equipment included a complete Display Generator Unit, comprising 4 graphics generators each packaged on 2 cards, and a video input multiplexer card. The graphics generators are based on the Texas GSP. The system is capable of selecting from six 875 line video sources and mixing a synthetic overlay with the signal. The output drives four video monitors. In addition, the team has supplied production quality artwork for two of the printed circuit boards.

4.3 Alpha Helmet Mounted Sight

FARL has recently been awarded a contract by RAE Farnborough for the design and supply of three Helmet Mounted Sights based on the lightweight Alpha Helmet (see Figure 7). This work is the culmination of the many years experience the Displays Team has in supplying

Figure 7



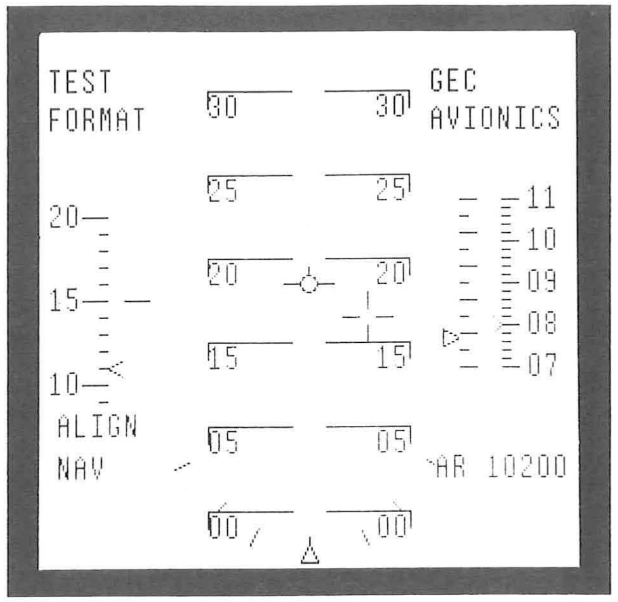
LED based sights and displays. The sight uses a novel prism design, a custom made LED reticle and compact drive electronics. Principal features of the sight are that modifications to the basic helmet have been kept to a minimum, and that the additional weight imposed by the sight is low (100g). When completed this helmet will be used as part of an integrated Helmet Sight System for flight trials of off–bore–sight target designation in the RAE Jaguar aircraft.

4.4 Active Matrix Addressed LCD

Work has continued steadily in the past year on investigating Active Matrix Addressed (AMA) LCD panels. These hold great promise as an eventual replacement for conventional CRT's in avionic applications. The experience gained with the TEXAS GSP has benefited this programme in providing an easy method of generating symbology in the form required by the panel.

Two panels, one from the GEC Hirst Research Centre, and the other from Eurodisplay, have so far been evaluated. Work has now commenced on investigating the feasibility of producing a 'custom shades of grey' LCD driver chip as part of an FARL/ADD programme. Figure 8 shows a typical EADI display on the Hirst 256 x 256 pixel AMA LCD panel.

Figure 8



4.5 Other Activities

The team has also assisted in a study of displays suitable for an astronaut carrying out Extra Vehicular Activities (EVA), i.e. outside the space vehicle, for ESTEC.

Relevant Report: *262/2499 Study on EVA Information Systems.*

5 SOFTWARE AND COMPUTING

Project Manager: Renny Smith
Senior Software Engineer: Steve Carter

5.1 Introduction

The Software and Computing Team currently comprises 10 software engineers and 2 trainee computer programmers.

The workplan is basically divided into researching software productivity, demonstrating results on real projects together with the Product Divisions, and investigating emerging technology.

To this end, in addition to support to Divisions, the team collaborates fully with the *ASET initiative, providing expert advice representation on external committees (eg. Software Engineering Working Group of ASSC and GEC Technology Information Pool) and support for ASET sponsored research programmes.

**ASET (Advanced Software Engineering Taskforce) is a software engineering initiative supported by GEC Avionics, GEC Sensors and Marconi Software Systems. The principal objective of ASET is to provide a focal point for the Companies Software Engineering expertise.*

5.2 Software Development Support

This years major project has been the development of Test Set Software for Flight Controls Division's new Primary Flight Control Computer. This has taken 8 man years of effort with a peak involvement of 12 engineers. The design phases have used the FARL software design tools and workstations, although the equipment and tools arrived too late to allow their full capabilities to be employed. The development was on a VME–based rack system with two Motorola 68020 processors interfacing to analogue sensors and switches, and digital buses (DATAC), all requiring responses in real time. The coding was in Pascal and the assembly language for the 68020 processor.

Software engineering support to Maritime Aircraft Systems Division has assisted in the Event and Tracking component for AQS 903. We have also provided effort to Airborne Display Division for two of their programmes involving software development for the Texas Instrument's Graphics System Processor.

Relevant Report: *262/2459 Test Set Software Design*

5.3 Software Research

The main research activities over the year have been the GENOS evaluation and an investigation of high order graphics languages. An investigation into Formal Methods and their implications has been started. These are described below.

5.3.1 GENOS Evaluation

Integrated Project Support Environment (IPSE's) are software frameworks enabling a number of software tools to be integrated. As such they offer the capability of improving software project management.

The Laboratory was accordingly sponsored by ASET to carry out a limited evaluation of GENOS, an IPSE which has been developed by GEC Software. GENOS was installed on a SUN Workstation and the VAX.

The main conclusions from the evaluation were:

- The control of existing tools and system functions was good.
- The learning time for a new user was short and the system was easy to use once it was well understood.
- Integrating tools into GENOS is totally dependent on their flexibility and requires care and attention. For instance, the integration of FARL's design tool and a Pascal compiler was relatively simple, while the difference in philosophy taken by CC2, ADD's Configuration Control tool, prevented any practical work in the time available.
- The discipline imposed by GENOS, which formalises the development process for software projects and defines controls and deliverables within a project environment, should improve the management of software projects. However, it was not possible to establish the cost effectiveness on a limited evaluation.

Figure 9 (next page) shows the project control structure used for the evaluation exercise.

Relevant Report: *262/2553 Final Report on the GENOS Evaluation*

5.3.2 High Order Graphics Languages

The new generation of dedicated graphics processors implemented in VLSI chips has provided greater processing power for display systems. To exploit the power available, the team are investigating the development of higher level interfaces to graphics sub–systems through the use of High Order Graphics Languages (HOGLs).

A high order graphics language allows an operation, such as 'Draw a dial on a head–down display', to be programmed into a display processor as one of its primitive operations at system start–up and then be drawn by issuing one command every frame at run–time. This frees the host processor for other operations, utilises the full power of the display processor, and reduces bus traffic. It has the potential for making the display processor more general purpose with application–specific symbol generation replacing the need for special purpose display processors.

Considerable progress has been made in the design and development of a prototype system using a Texas Instrument's GSP (Graphics System Processor) connected to an IBM PC with an interface language based on PHIGS (Programmers Hierarchical Interactive Graphics Standard) studied by the Department of Defence, and our activities complement those of ADD, who are using PHIGS on their latest HUD development.

Relevant Report: *262/2514 Concepts and Requirements for High Order Graphics Specifications.*

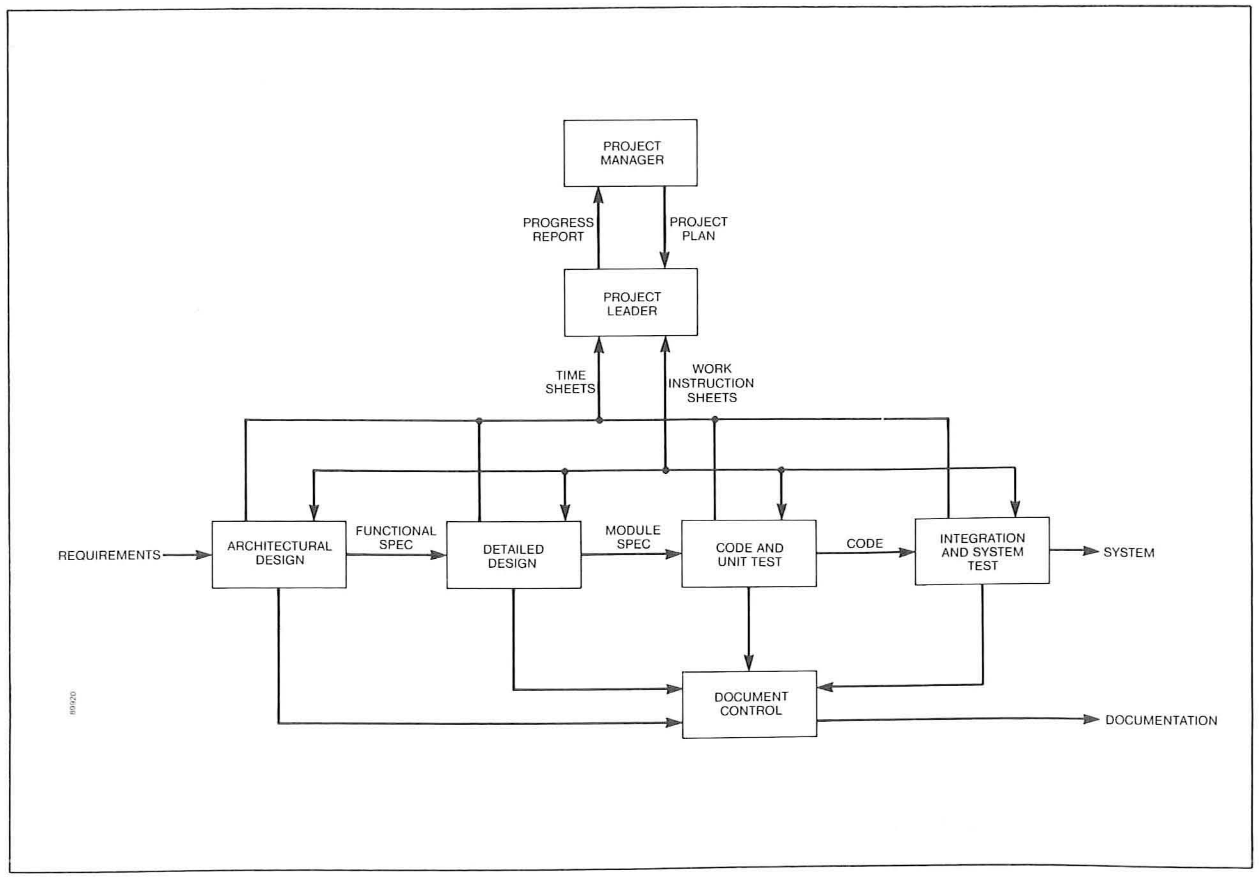
5.3.3 Formal Methods

Interest in Formal Methods arises from their potential to reduce programming errors by using mathematical formalism in the design process. The announcement of the new Def Stan 00–55 which will lay down rigorous standards for the development of Safety Critical Software has focussed increased attention on their use.

The new standard will affect the work of a number of Divisions, requiring them to produce mathematically formal specifications for all their safety critical software. Work on Formal Methods has only recently resumed in FARL because of other commitments and we will be looking at the effects of the standard on software development, where it impacts not only on the technical aspect of software generation, but also on the management of the development process.

It is also our intention to research some of the advanced areas of formal methods; in particular, animating formal specifications to allow investigation of the specific behaviour of systems. Mathematical proofs of formally specified systems will also be studied.

Figure 9



6 MAN–MACHINE INTERACTION SYSTEMS

Project Manager: Brian Wortley
Project Leader: Steve Heptinstall

6.1 Introduction

Work this year has been broadly in the two related areas of virtual cockpit research and helmet mounted displays development, the majority of this work having been privately funded. However, liaison on these subjects has continued with Airborne Display Division and RAE Farnborough through our support on Binocular Helmet Mounted Display trials.

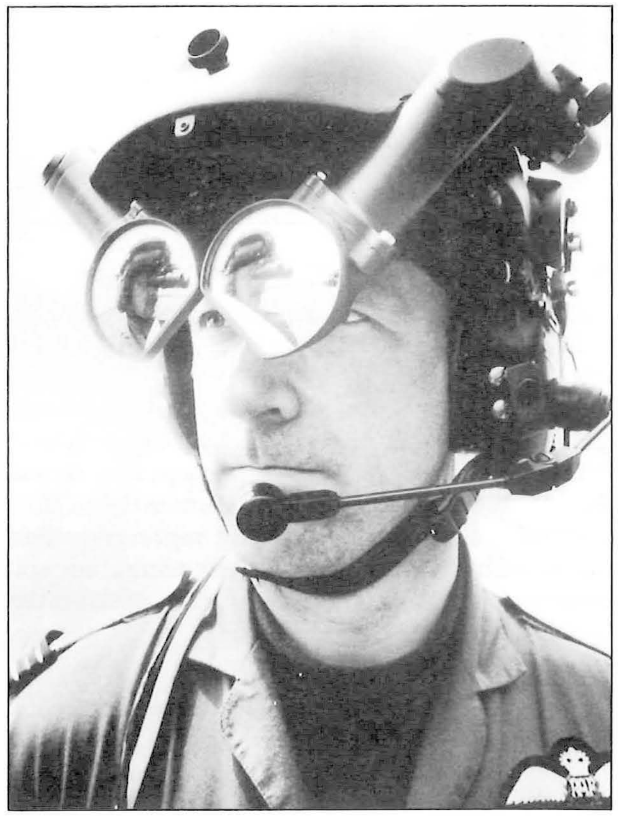
The team currently comprises 5 engineers, one technical assistant, and mechanical and optical support from other teams when required.

6.2 Binocular Helmet Mounted Display Trials

The first Binocular HMD system was delivered in March 1988 to RAE Farnborough and comprises a Mk 4 flying helmet with two optical/CRT assemblies mounted on a brim attached to the helmet, an Electronics Unit and a pilot's Control Panel. It was installed together with RAE's Symbol Generator, Helmet Position Sensor and Image Intensifier Camera, on their experimental Lynx helicopter. Several flight trials have now been completed involving both indirect viewing in low light conditions and the projection of symbology into the pilot's line of sight. The results of these flights are very encouraging, showing that the system is easy to use, clear and versatile. The helicopter is now in the hangar for refit until early 1989; meanwhile the BHMD is being temporarily used by the RAE Simulator Section at Farnborough, for trials in their fixed wing ground attack simulator. Further flight trials are planned for 1989. Figure 10 shows the final delivered helmet.

The other system delivered this year was to Airborne Display Division and is similar to that discussed above except that the optical/CRT assemblies, rather than being attached to a helmet, are mounted on a skeleton framework with a 'hard hat' liner support in its centre. After delivery to ADD in May 1988 it was sent to the USA for tests and trials by several organisations. In June and July 1988 the system was evaluated by Teledyne on a ground rig, prior to carrying out air–to–air refuelling in a McDonnell Douglas

Figure 10



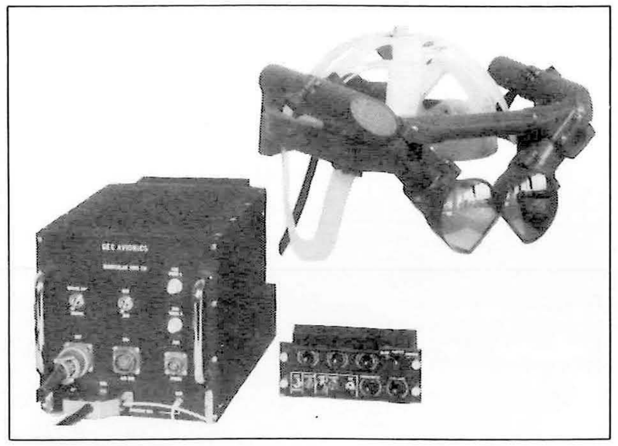
KC10 Tanker aircraft. The aim is to provide the tanker boom operator with a 3D view of the incoming aircraft from a pair of cameras mounted on the refuelling probe and to assist him to accurately steer the boom. Flight trials have been postponed until early 1989, but the initial trials have been very encouraging, with very favourable comments on the 3D stereo image quality.

After these trials were completed the system was sent to General Dynamics Land Systems where it is being used in another indirect–viewing mode on unmanned land vehicles. For this application the system has had to be temporarily re–mounted on an existing helmet which already incorporates a Honeywell optical head position sensor system. It is envisaged that several other interested companies may wish to evaluate the BHMD in the near future for various applications. The complete system can be seen in Figure 11.

Relevant Reports: *262/2411 BHMD Acceptance Tests*

262/2418 BHMD Final Report/Operators Handbook

Figure 11



6.3 Virtual Cockpit Research

In combat in a modern high performance aircraft it may be difficult or impossible for a pilot to view his instruments directly. Indeed, if he can be supplied with a sufficiently good computer generated image of them, they may not even have to be fitted. This leads to the concept of a 'virtual cockpit' in which both instrumentation and controls might perhaps be 3D representations, operated by looking towards their normal cockpit location and using a keypad. Other possibilities include the use of an eye gaze angle sensor/ designator and Direct Voice Input.

For such a virtual cockpit to succeed the HMD would have to be able to replace the other display surfaces.

The exploitation of a binocular HMD as part of a virtual cockpit concept is shown in Figure 12.

The majority of the work being performed over the last year has been in support of this activity. It is planned to build up progressively to a laboratory demonstrator system similar to that shown in Figure 13. This will provide the ability to simulate, investigate and evaluate the entire virtual cockit environment.

At the start of the year the final touches were made to the virtual grid and stereoscopic designator, both of which have proved important aspects of stereo work. The former gave experience in working out how to produce a convincing stereoscopic image, and the latter has shown that a stereoscopic cursor can be used as an accurate ranging mechanism for remote manipulation tasks.

Work then proceeded on a preliminary non-real-time virtual cockpit research programme using a Texas Instrument Graphics Card installed in an IBM PC and the head steered Stereoscopic Display Head which originally formed part of the Underwater Viewing System developed in FARL. The pan and tilt sensors on the Viewing Head have enabled the 3D images to be positioned according to the operator's viewing angle, that is,

head up: collimated (infinity) displays

head down: instrument and multi-function displays

Figure 12

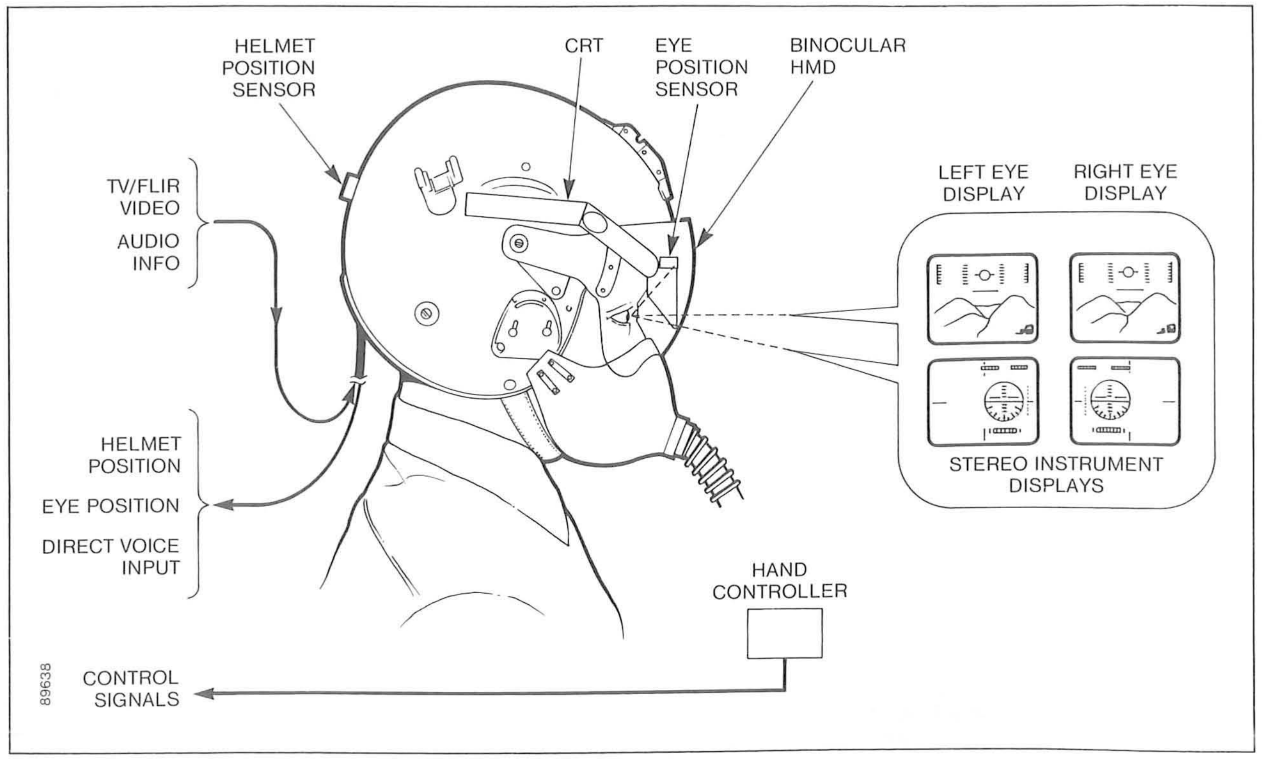
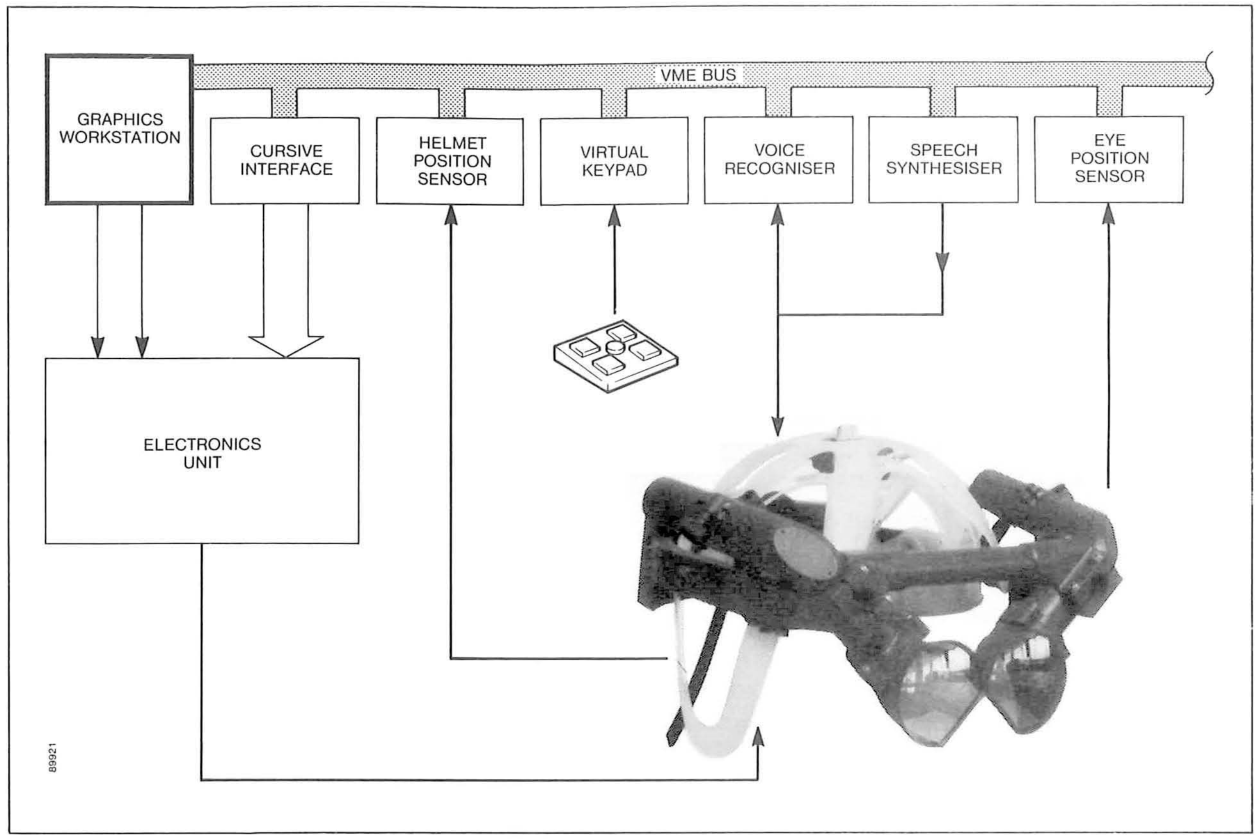


Figure 13



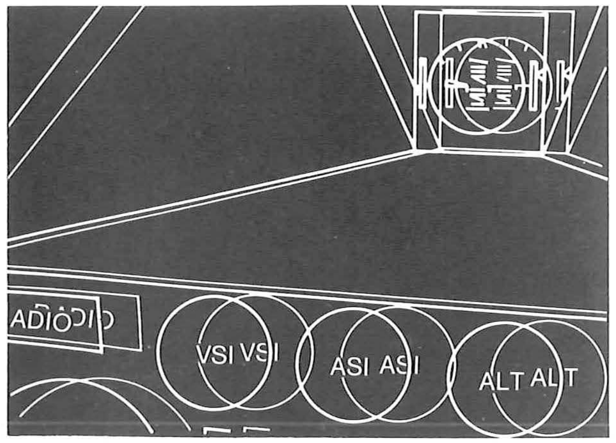
lateral: placing virtual instument displays in their 'standard' positions by looking to left or right.

A cursor controlled virtual image of a multi-function keyboard/display has been demonstrated.

Figure 14 is a photograph of the left/right superimposed 3D images generated for this initial investigation.

A more representative laboratory demonstrator binocular HMD system has been built and is at present in the final commissioning and setting up stage. This is virtually a replica of the ADD 'skeleton' BHMD.

Figure 14



A study has been completed of the requirements for real-time stereoscopic display generation and the availability of commercial high speed Graphics Processing Systems. A suitable system has been configured by a company called 'Primagraphics' and this system is being procured for the next phase of the virtual cockpit research programme.

This will cover the integration of a Polhemus head position sensing system with the laboratory demonstrator BHMD and the evaluation of stereo displays and virtual keypad concepts.

Relevant Reports: *262/2437 Design for the Virtual Grid Display*

262/2497 Virtual Grid Display: Description of Hardware and Software Design

6.4 Two-Colour Binocular Helmet Mounted Display

As part of the development work on helmet mounted displays a two-colour Binocular Helmet Mounted Display is being investigated. This will allow several modes of drawing: Single colour raster, single colour cursive, two colour raster, and one colour of raster with another colour of cursive. This is achieved by using a two colour, one inch 'Penetron' crt developed by Thompson CSF and which produces a bright green and a not-so-bright red. The system can also drive a pair of liquid crystal shutters which, when used with a white phosphor crt, will produce a similar effect.

The laboratory demonstrator BHMD can be fitted with a two-colour system at a later date.

6.5 Cursive Symbology Generation

To use the above system satisfactorily the cursive elements are being improved so that cursive symbology can be drawn in 3D from an IBM PC. This will allow the laboratory demonstrator to be operated in its most useful mode, comprising green (bright colour) raster symbology overlaid on sensor images, with red (not so bright) cursive moving symbols and annunciations (dials, numbers, characters, warnings, etc). Using the slow cursive drawing speed allows the red brightness to come up to that of the green.

6.6 Other Activities

The team has been involved in a number of related areas of business. One of particular importance is the space environment where there are specific displays requirements for astronauts performing operations outside the space vehicle. Studies into displays and speech processing requirements have been carried out under sub-contract from Avions Marcel Dassault–BA as part of an ESA-funded project.

Other work has covered helmet and eye position sensors and related technology areas.

7 INTELLIGENT KNOWLEDGE BASED SYSTEMS

Consultant Engineer: Frank Oates
Project Leader: Neil Milner

7.1 Introduction

The IKBS Team currently comprises 5 engineers and can also draw on the IKBS expertise at the GEC-Marconi Research Centre, Great Baddow.

Intelligent Knowledge Based Systems (IKBS) technology is at the point where the techniques may be applied to real problems using readily available hardware and software. In response to this, the theme for the team's work for the first half of this year has been 'Practical IKBS'. The second half year's activities have been mainly concentrated on the Intelligent Displays Management demonstrator programme.

7.2 Intelligent Displays Management

Following an earlier 'Study for Research into the Application of Knowledge Based Systems to Fixed Wing Aircraft' a contract has now been received from RAE, Farnborough for the development of an Intelligent Displays Management Demonstrator. This will be used to explore ways in which IKBS techniques can assist the pilot and reduce his workload, by managing the various display surfaces and showing only data appropriate to the current phase of the mission.

The system is shown in schematic form in Figure 15.

Project completion is set for August 1989 with a demonstration using a computer work-station modelling a 'long range air interdiction'. This will show how the knowledge based scheduling of information can reduce workload in a dynamic situation.

The project is well under way. A detailed knowledge gathering exercise has been undertaken which has involved a number of interviews with aircrew from the Experimental Flying Squadron, RAE, Farnborough. These showed that it is the unexpected or uncontrollable that leads to an excessive workload, examples being:–

- the 'Bounce' – interception by a counter attacking aircraft

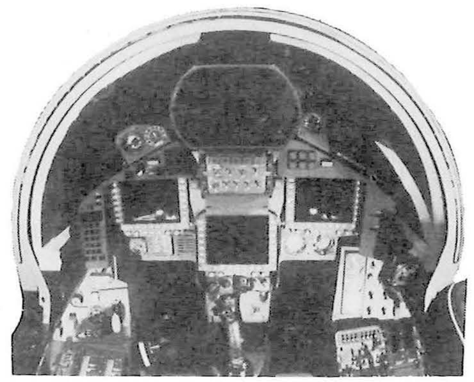
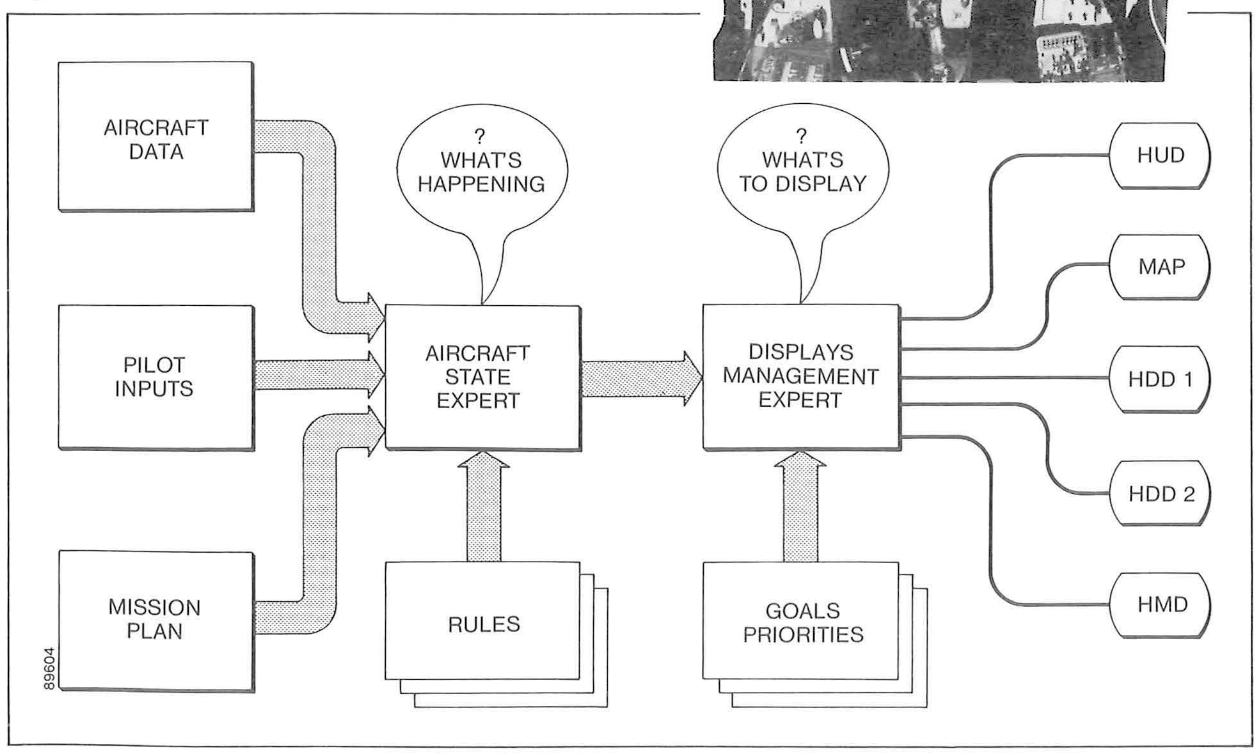


Figure 15



- evasion of ground threat – SAM
- weather abort or weather diversion emergency

The interviews were conducted in a structured but informal fashion using 'scripts' to represent sequences of action, and information priority charts. These have led to the development of software for aircraft and mission simulation, and for displays generation, together with detailed design of the necessary expert systems.

Figure 16 illustrates the documentation used to gather the information.

The first part of the programme, the 'knowledge elicitation' phase, has now been completed.

7.3 Aircraft Route Planner

The concept of an automated route planning aid operating with the same rules as aircrew has been demonstrated using an advanced Artificial Intelligence development facility programmed in LISP.

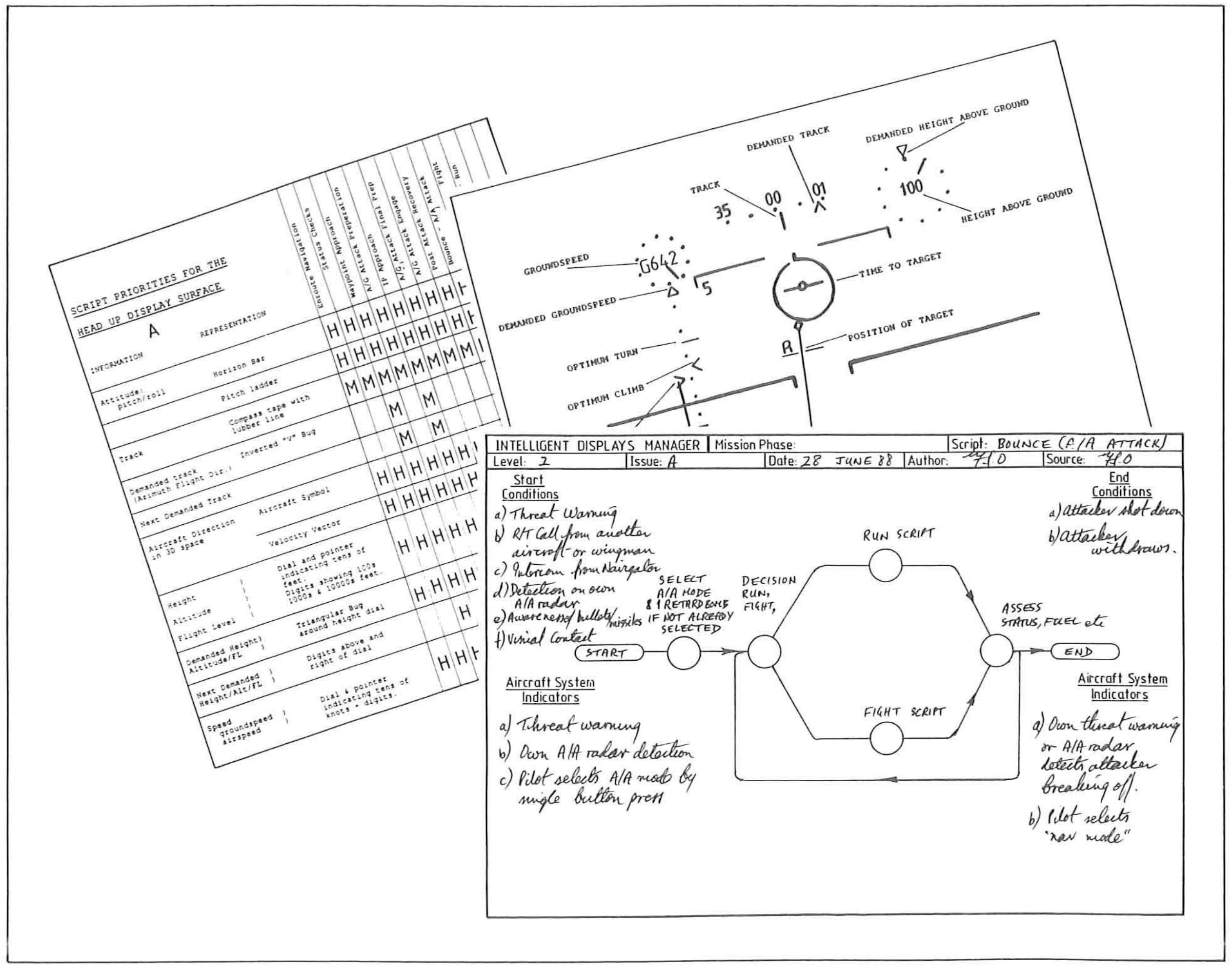
The rules have been recoded in the conventional language PASCAL and run successfully on an IBM PC, showing the advantages of prototyping in an optimised environment and then, when the requirement is well understood, transferring to a conventional machine. The work has also shown that meaningful applications can be run on a small machine.

Recently a digital map data base has been moved to the IBM where it allows an automatically planned route to be shown in context. This gives confidence that IKBS techniques may be used to build and enhance mission and flight planning products for both ground based and in–cockpit applications.

7.4 Feature Extraction from Map Data Base

An effective route planner requires a knowledge of terrain and navigation features derived from a map data base. Because of the huge quantity of information, there is a need to automatically extract and classify the features which a pilot might use. An initial demonstrator has been developed and has established the feasibility of automatic feature extraction.

Figure 16



7.5 MMI for Industrial IKBS

In partnership with the University of Twente (Netherlands), Dornier (West Germany) and Aeritalia (Italy) a proposal was submitted to the Commission of the European Communities as part of the ESPRIT II (European Strategic Programme for Research in Information Technology) initiative.

The proposed project builds on the concepts identified for Intelligent Displays Management. It seeks to use IKBS techniques to assess operator workload and then select the most appropriate means to present information so that it may be readily and accurately absorbed. The method of presentation, visual, aural or tactile is chosen dynamically. An emergency in a civil cockpit was selected as an appropriate demonstrator.

The Commission recommended that additional partners with acknowledged skills in Man Machine Interface be sought and the proposal resubmitted.

7.6 IAWG MMA Initiative

One member of the team is now seconded to the Industry Avionics Working Group (IAWG) Joint Venture team working on a Mission Management Aid (MMA) initiative in conjunction with staff from the RAE and is relating the needs of that activity to IKBS.

The first phase of the programme was completed in July 1988 (starting 1st October 1987) and was carried out at British Aerospace, Weybridge.

The second phase is under way and the activity is now being carried out at the RAE, Farnborough – the move to Farnborough taking place in October 1988.

8 OPTICAL DESIGN

Project Manager:	Brian Wortley
Senior Systems Engineer:	Dave Hubbard

8.1 Introduction

The Optical Design Team provides an optical design facility to the Product Divisions and to other teams within FARL. The main work during the year has been in support of ADD in the field of off-axis holographic HUD design.

Other work has included optical designs for wide field of view HMD's and variations to existing HMD's.

The team is also involved in the optical design of a helmet mounted sight for RAE Farnborough in conjunction with the Displays Team.

In parallel with this design work the team continues to develop and improve the suite of optical design programmes to increase the facilities offered.

8.2 Off-Axis Holographic HUD Design

The team has been involved throughout the year in a number of off-axis designs. The two main designs are for ATF and EFA. The EFA design has been used to assist in feasibility studies in support of proposal generation, whilst the ATF design forms part of ADD's contract with the customer. The ATF space envelope has required the development of a novel optical configuration (patent pending) as well as a holographic combiner. The basic optical design is now complete and work is centred on optics to construct the hologram. The main constraints on the design of these construction optics are to ensure that the optics are practicable and as simple as possible to reduce the manufacturing costs of the optics and the tolerances required.

8.3 Optical Design for Helmet Mounted Systems

The main work in this area has covered the design of a helmet mounted sight optic for RAE Farnborough. This system relays an image of a LED sighting array into the pilot's field of view by reflecting the image off the inside of his visor.

The team has also continued to support optical designs initially developed in previous years, such as the binocular HMD system and PEPS, as well as further developing a wide FOV helmet mounted display (60° X 60°). This HMD has now been built as a space model to assess its acceptability to the users.

Other work has included an HMD design for use with space suits.

8.4 Software Development

The optical design program suite is continually being developed and refined in line with requirements. Continual improvements to the holographic design capability are being incorporated, the major area involving tolerancing options. By enabling the system to analyse the manufacturing tolerances of a design it is possible to improve the designer's appreciation of manufacturing problems and hence the quality of his design.

8.5 Other Optical Designs

The team has been involved in a number of design studies for systems proposed by other FARL teams. Examples are a prism for an optical pressure transducer and a projection scheme for a large display monitor.

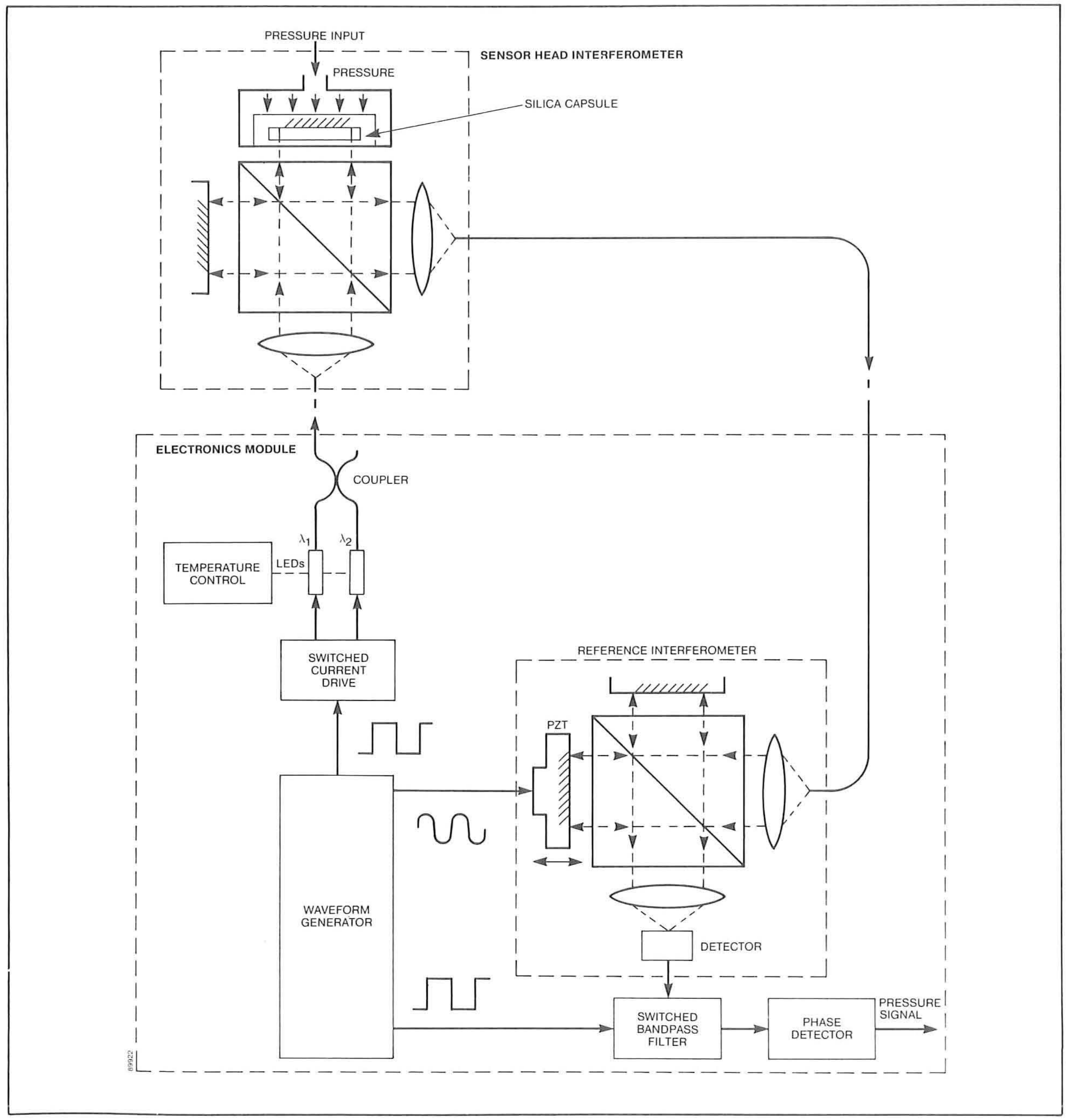
9 SENSOR SYSTEMS

Senior Consultant:	Em Oetzmann
Consultant:	Ted Lewis

9.1 Introduction

The Consultant Engineers have continued work in sensors and related systems topics. The pilots eye position sensor work was brought to a successful conclusion at the beginning of the year. Support for Divisions on this topic continues as applications arise. The related requirement for helmet angle sensing has been investigated both in the lower accuracy/low cost and high accuracy areas. A considerable amount of investigation has been carried out into the use of, and protection from, lasers in the aircraft environment. Magnetic sensor developments and applications have been spread to wider fields involving other parts of the Company.

Figure 17



Liaison with the University of Kent at Canterbury has continued while its work on the high temperature fibre optic pressure sensor has concluded with promising results. The intention is to pursue this work in-house for a number of potential applications.

9.2 High Temperature Pressure Sensor

High temperature pressure sensor research has been carried out at the University of Kent at Canterbury under Company sponsorship and FARL monitoring. This year sees the completion of the research project and the transfer of the technology to FARL.

The basic object has been to produce a system that allows remote monitoring by a passive sensor head in an adverse environment such as an aircraft engine. Although pressure was the chosen parameter to be sensed the technique is applicable to a wide range of measurements (eg temperature, displacement, torque). The research investigation has proceeded through a wide range of possible techniques assessing their suitability for the avionics environment. The most promising has been built as a demonstrator to show that it functions as anticipated and was shown at FARL's management presentation in the Spring.

In outline, it uses an interferometer, a mirror and a pressure sensitive diaphragm at the sensor head to produce a delay in light fed to the sensor head via fibre optics. Interference is produced at a second, reference interferometer within the electronics module which receives its light input from the sensing head via a second fibre optic. Multimode fibres may be used throughout. Fringe ambiguity is removed by using light of two wavelengths to produce a 'Vernier effect'. Fringes are made visible by a scanning technique that repeatedly sweeps the interfering pattern through a single fringe cycle (otherwise known as pseudo–heterodyning). The relative phase of the resultant output is used to derive pressure to a high order of accuracy over a wide range. Figure 17 shows a block schematic of one such system to achieve this.

Future work on this device in FARL is to proceed through a careful assessment of system parameters to ensure that the required accuracy can be met in a practicable sensor at minimum weight and cost. Investigation of sensor heads for measuring a variety of parameters has already started and schemes for multiplexing a number of sensors are under consideration. See Figure 18

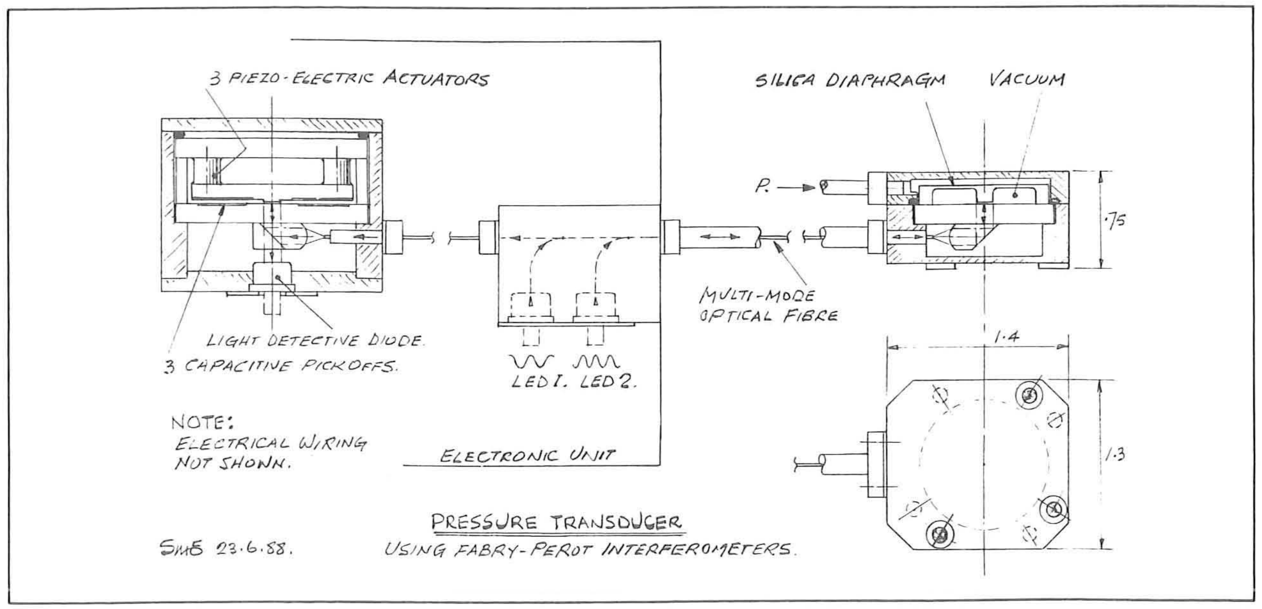
Relevant Reports: *Research Thesis in preparation.*

9.3 Magnetic Sensors

The fibre optic magnetic sensor and PVDF magnetometer demonstrators have not been developed further this year as there has not been a direct application forthcoming. However, a sensor and test generator have been supplied to Marconi Underwater Systems Ltd. (MUSL) who are anticipating exploiting the work.

There has also been interest in other related applications of magnetic sensors. The most promising of these is for helmet mounted displays and ROV's (Remotely Operated Vehicles). A programme to develop a helmet tracker is currently being formulated and it is expected to utilise a considerable amount of the previous work on magnetic sensors coupled with some novel solutions that have arisen in recent studies.

Figure 18



10 DATA TRANSMISSION SYSTEMS

Project Manager: Kenny Deans
Senior Software Engineer: Alan Birch (Data Bus Systems)
Senior Systems Engineer: Rob James (Fibre Optics)

10.1 Introduction

The major emphasis for the Data Transmission and VLSI Design teams has been the development of High Speed Data Bus Systems, in particular STANAG 3910 and the Linear Token Passing Bus (LTPB) networks. In the first of these, specific requirements have been identified for the European Fighter Aircraft (EFA) and detailed work on the critical items, both fibre optics and VLSI, has commenced.

The LTPB system has been proposed for the USA Advanced Tactical Fighter (ATF) aircraft and, in conjunction with Instrument Systems Division, FARL has been actively involved in the system definition for an LTPB module of an Avionics Ground Prototype.

In support of the systems work for both networks, the Fibre Optic and VLSI teams have been involved in the specification of components, and additional work which is required for the development of fully integrated modules.

The team comprises 3 engineers on fibre optics, 3 engineers on data transmission systems and 5 engineers on VLSI design. There is significant cross-involvement between the three groups and consideration of the difficulties in each of the areas is of prime concern.

10.2 STANAG 3910 Developments

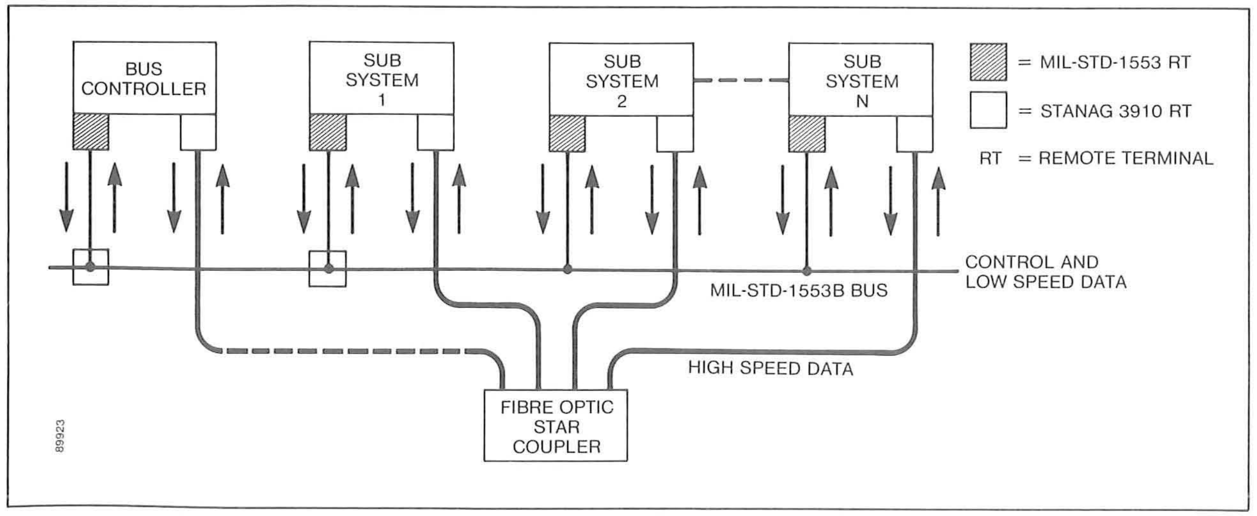
For a number of years it has been realised that the most widely established avionic data bus (MIL–STD–1553B) has insufficient data throughput to support future avionics architectures. This has led to a number of international initiatives in the development of High Speed Data Bus (HSDB) standards, STANAG 3910 being one of these standards.

STANAG 3910 systems consist of a Bus Controller (BC) and a set of Remote Terminals (RT) on a MIL–STD–1553B (STANAG 3838) data bus, with some of the RTs (and optionally the BC) connected by a High Speed (20 Mbits/sec) fibre-optic network as shown in Figure 19. The 1553 electrical bus controls the RTs and tells them when they may send data on the fibre optic links. This reduces the workload of the '1553' bus and so increases throughput. The use of a 1553 bus to control the High Speed network allows an evolutionary growth in data bus capacity while utilising experience and equipment from previous systems. For these reasons STANAG 3910 is being considered for use on the European Fighter Aircraft.

FARL has been involved in a number of activities which will enable GEC Avionics to use STANAG 3910 technology. In addition, a discussion forum with a GEC–Marconi–wide involvement has been set up in which FARL has been actively involved. This forum brings together the companies within the group who will bid on EFA programmes.

An initial design group was set up to examine the systems and terminal aspects of the network. Representatives from FARL, Maritime Aircraft Systems Division and Airborne Display Division, produced a preliminary design for a STANAG

Figure 19



3910 terminal. To minimise the development risk the design makes use of existing MIL–STD–1553B components as far as possible. It requires the development of fibre optic transmitter and receiver components, and Protocol and Front End ASICs. The design is shown in Figure 20.

Engineers from the VLSI team are currently designing the ASIC parts of this terminal. Further evaluation work of the proposed vendor's technology (Plessey) permitted the Protocol and Front End Devices to be integrated into a single gate array.

Engineers from the Fibre Optic team are currently producing procurement specifications for transmitter and receiver devices. These will then be designed and manufactured outside FARL. The work undertaken will also provide a significant basis for future developments in the area of military qualified fibre optic components.

FARL is also in contact with British Aerospace to try to eliminate potential problems with the STANAG 3910 system on EFA. This includes both the protocol and fibre optic specifications.

FARL also has a continuing commitment to STANAG 3910 Design Group activities which are now directed towards module designs for EFA and supporting the Divisions in EFA bids.

10.3 High Speed Data Bus

10.3.1 Standardisation

FARL has continued to participate in the USA Society of Automotive Engineers (SAE) High Speed Data Bus standardisation effort. Two systems have been proposed, the Linear Token Passing Bus (LTPB) and the High Speed Ring Bus (HSRB). While FARL has previously been most involved with the HSRB, the developments of the

Figure 20

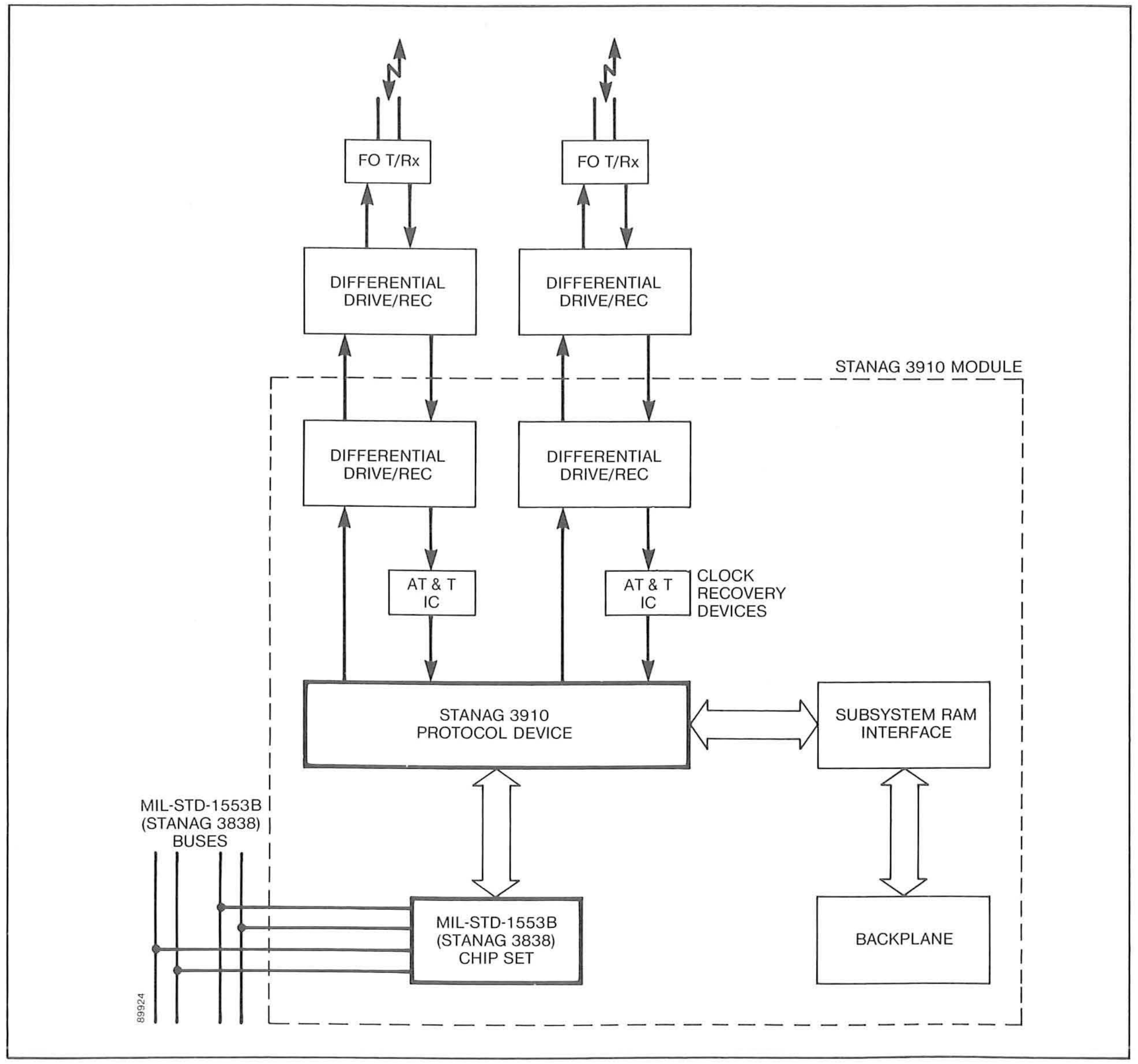
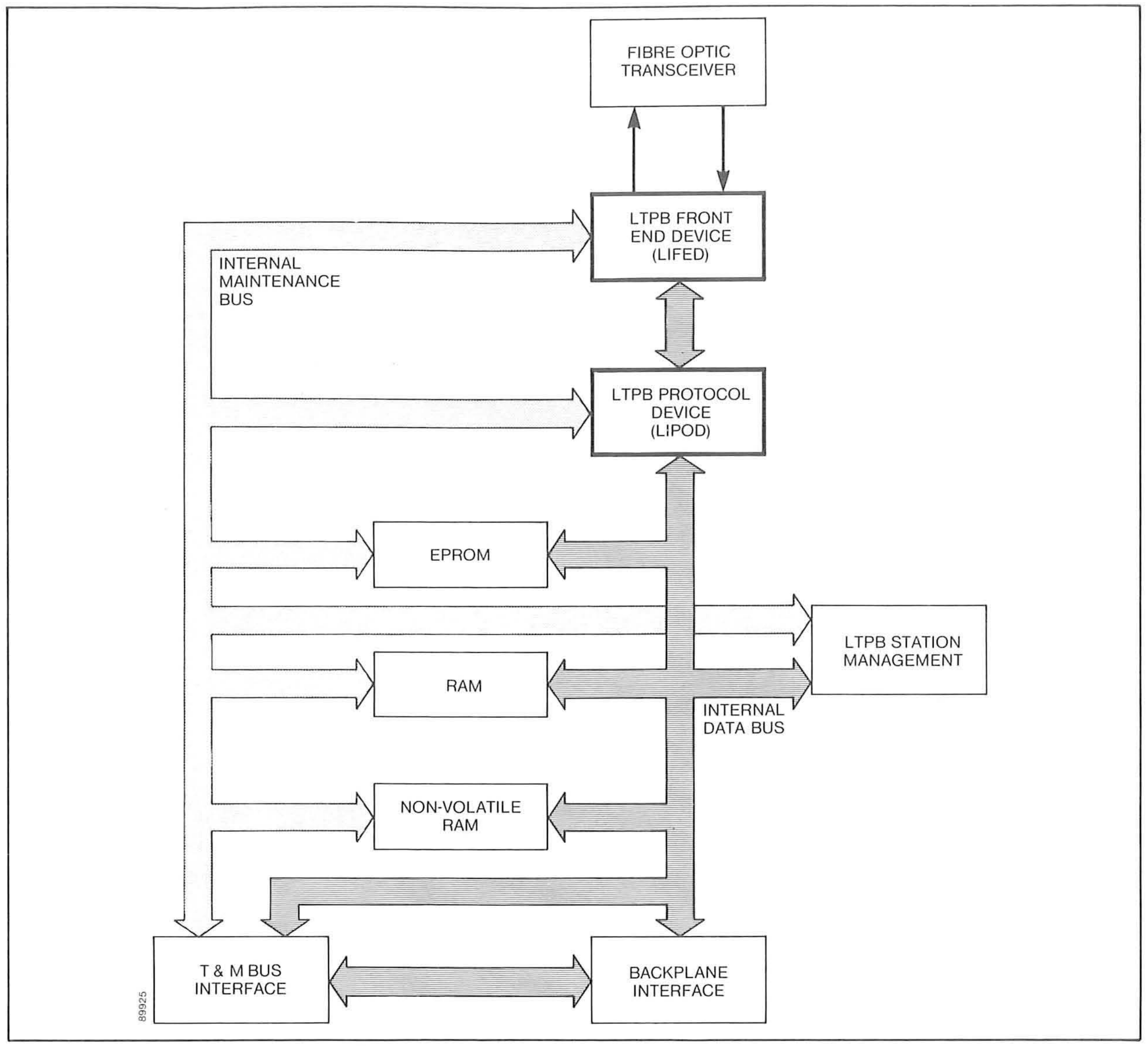


Figure 21



Advanced Tactical Fighter (ATF) meant that a switch of attention to the LTPB group was required to support ATF proposal requests. The HSRB is still being monitored via the Avionics Systems Standardisation Committee (ASSC) here in the UK.

A new force in the standardisation of avionic systems has been the formation of the Joint Integrated Avionics Working Group (JIAWG) by the USA Congress. This group, comprising the prime contractors of the major aero projects, has been tasked to define standard hardware which may be interchangeable between aircraft across all four USA services. A similar group looking at longer term standardisation, the Modular Avionic System Architecture (MASA) group, has also been set up.

FARL has continued to share knowledge accumulated on the various data buses including a recent report outlining future avionic data buses.

10.3.2 HSDB System Study

With the definition of new system architectures, where the High Speed Data Bus (HSDB) is the vital link interconnecting all subsystems, different characteristics of the HSDB become important. These have been highlighted in a recent study together with examples showing how the HSDB systems will be designed. This study and understanding of HSDB system will be useful in the definition of requirements for future HSDB station developments.

10.3.3 LTPB Station Design

With the imminent requirement for LTPB stations for the ATF, FARL has begun to design an LTPB station to interface to the bus. This is based on the terminal design carried out for STANAG 3910 and a block diagram is shown in Figure 21. The station will provide a flexible interface to the subsystem, allowing subsystem specific backplanes to be accommodated.

10.3.4 ATF Involvement

As a result of Lear Astronics Inc winning the Lockheed team contract to produce the Integrated Vehicle Subsystem Control (IVSC), FARL and ISD are now jointly developing a Flight Critical Avionics Bus Interface (FC ABI) module design for the Avionics Ground Prototype (AGP) with a view to full scale development of a Standard Electronic Module-revision E (SEM-E).

10.3.5 SAE Bus Demonstrators

During the past year the second of the SAE Bus technical demonstrators (that for the LTPB) has been completed. This has particularly shown the simplicity of a ringing tank circuit for clock recovery and allowed a XILINX programmable logic cell array to be evaluated.

10.4 MIL-STD-1553B

The consultancy role of the Data Transmission team has continued to develop, in line with its experience in 1553 electrical data bus systems. Originally conceived for avionic environments, MIL–STD–1553B has now been accepted by all three services and has had some success in the commercial field. As a result, the standard does not necessarily meet all the requirements of some of the typical applications.

Figure 22

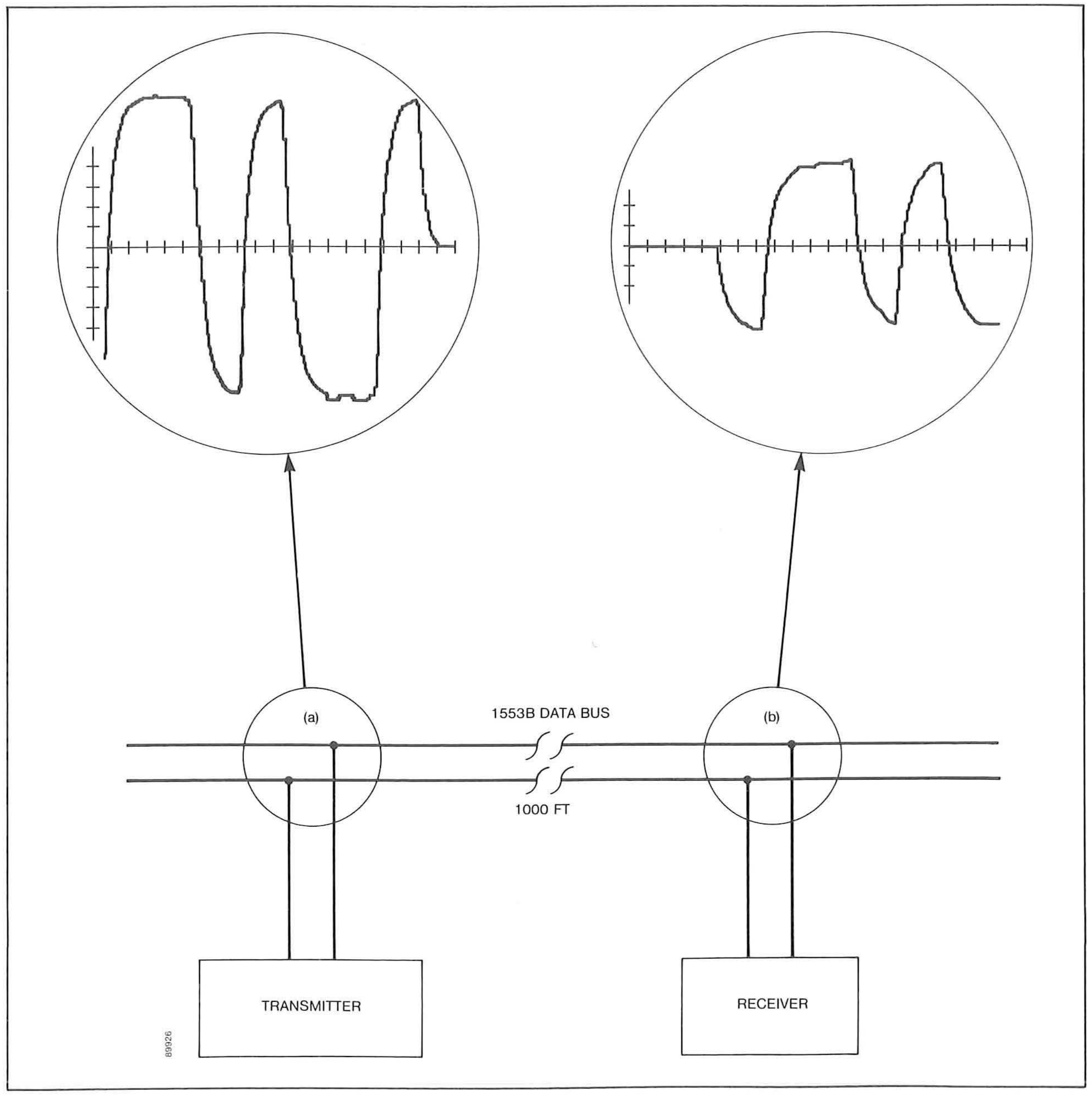
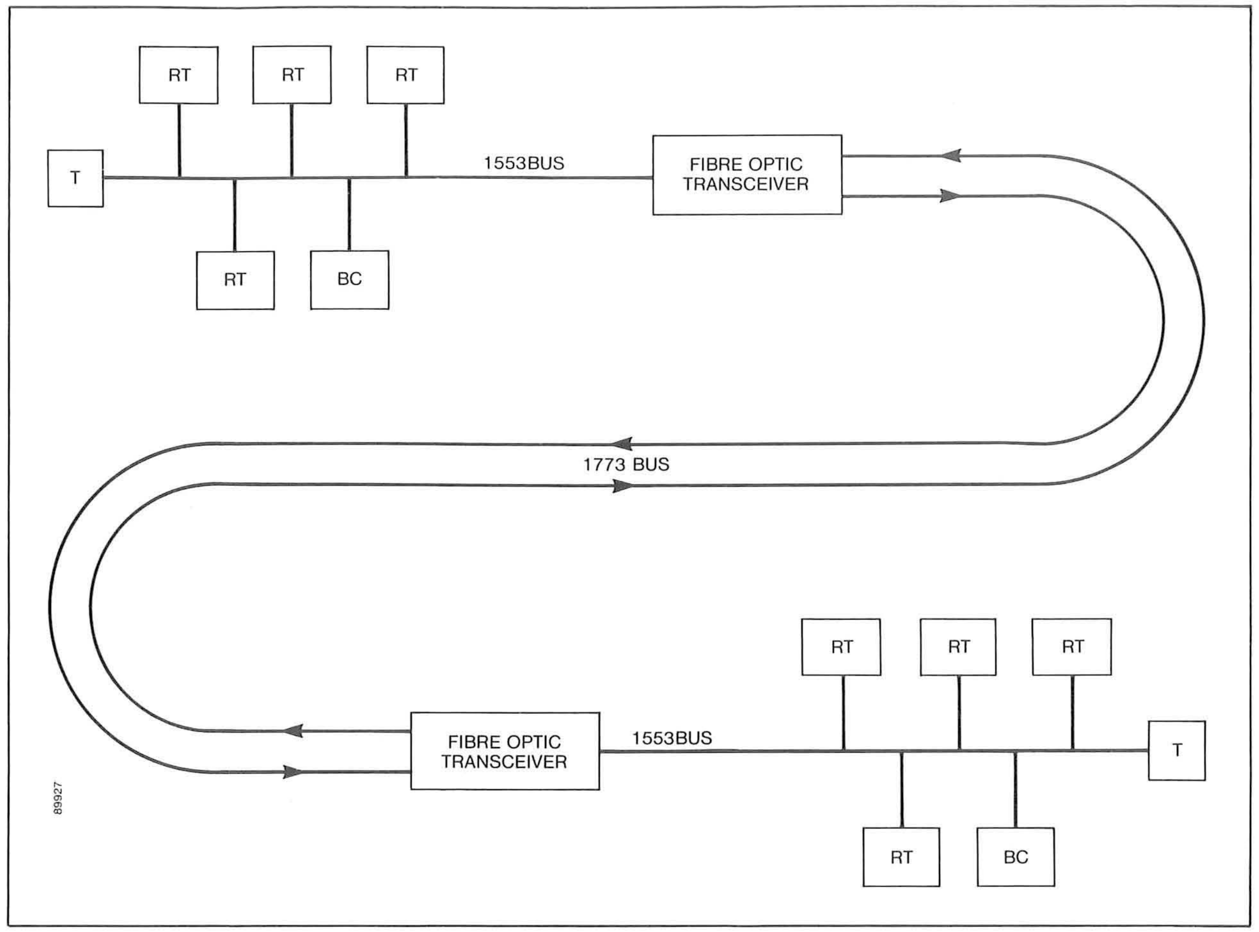


Figure 23



10.4.1 Consultancy

FARL has assisted Marconi Communications Systems in their efforts to define a long data bus for marine applications. FARL identified and evaluated the critical areas, examined possible solutions and made recommendations based on the analysis.

Long data buses create their own problems, particularly with regard to attenuation along the transmission line and the time taken for transmitted signals to arrive at a receiver (see Figure 22). One station, the Bus Controller, keeps track of all transmissions on the bus. If one of the stations does not respond within a certain time, the Bus Controller registers that station as failed (time–out). This bus time–out needs to be larger for longer buses.

FARL examined methods of meeting these specific requirements in buses of 1000ft or more with 1553. Amongst the various solutions suggested were the use of repeaters, both electrical and fibre-optic (shown in Figure 23).

10.4.2 Bus Analysis Software

Another side to 1553 is the growing need to simulate the bus waveform. Ensuring that a data bus can meet 1553 in terms of time delays and attenuation is still no guarantee that it will meet the system specification. Physical layout has a considerable effect on waveform distortion. For long or complex layouts this means that analysis of the harness is necessary. FARL is evaluating a software package to do this.

The advantages of software techniques over hardware tests (cutting up various lengths of cable and setting up the desired harness on a laboratory bench) are flexibility and speed of operation.

The simulations are useful for highlighting bus configurations which are likely to contain excessive reflections. Some software packages contain algorithms to simulate attenuation. These are very useful to determine the waveform expected at any terminal on a long bus, enabling the avoidance of hazardous configurations. The worst reflection arises with a short circuit where one of the stations connects to the bus. Such a case is shown in Figure 24.

Relevant Reports: *262/2422 Functional Specification of Protocol and Front End Devices for STANAG 3910 and EFA Bus applications*

262/2426 High Speed Data Bus Programme Executive Summary

262/2438 EFA Bus/STANAG 3910 High Speed Terminal Application Notes

262/2484 Logic Cell Array Investigation Report

262/2493 High Speed Data Bus System Study

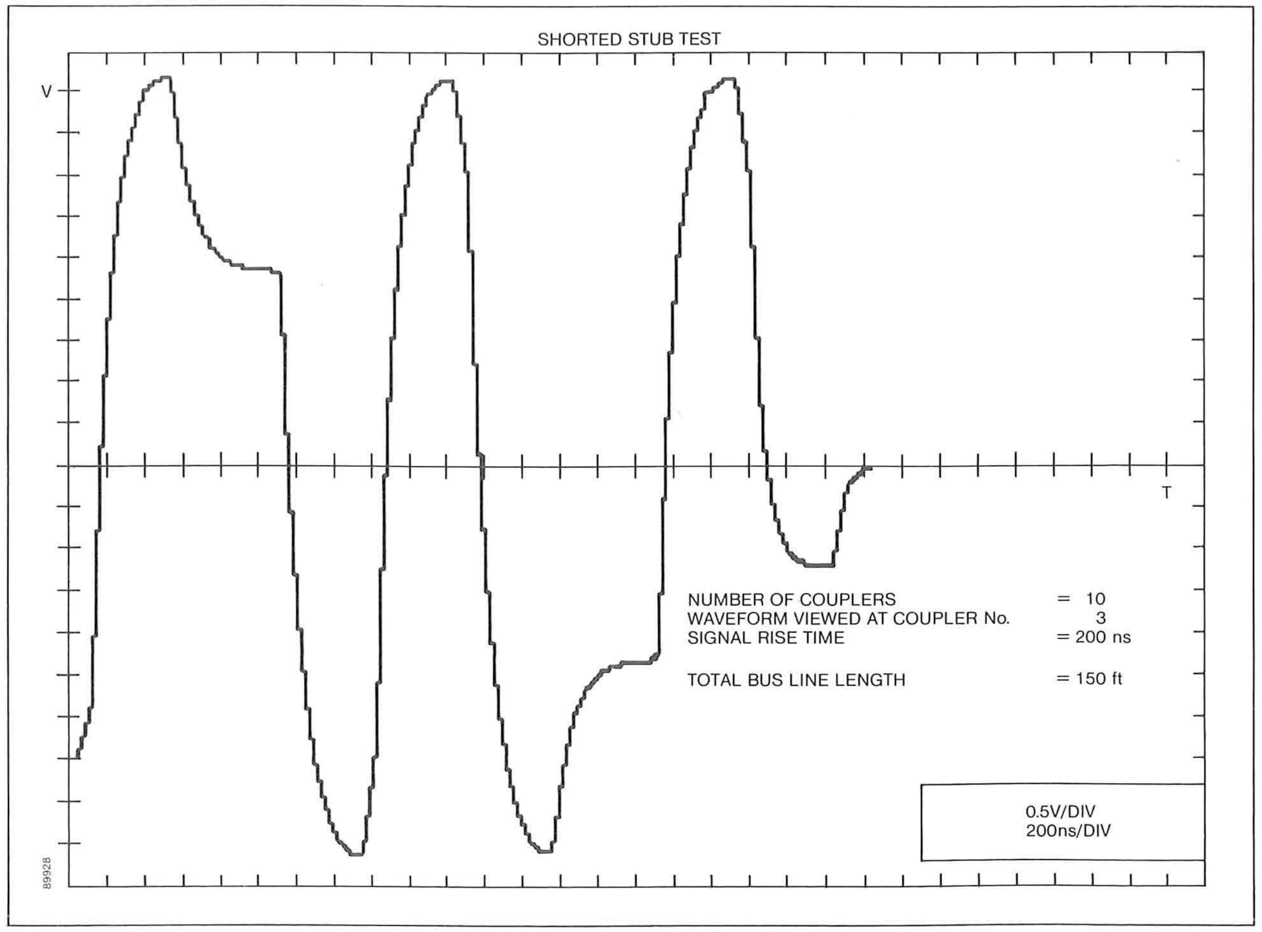
262/2513 Future Avionic Data Buses

262/2522 Adapting 1553B to Long Data Buses.

10.5 Fibre Optics

The activities which have been undertaken by the Fibre Optics team have covered a number of different areas, ranging from completion of the installation of the Airship Industry's Skyship 600 Flight Control System to the development of STANAG 3910 procurement specifications. In addition, collaborative work was completed on a Company funded demonstration system of a Fibre Optic Guided Air Vehicle concept.

Figure 24



10.5.1 Airship FBL System

A complete overhaul and refit of the optical system for the SKS600 Airship has been completed.

Multiway 38999 connectors with optical inserts were used to replace the old style 602 connectors. Bought–in, pre–terminated fibres were fusion spliced to the existing transmitters and receivers and then fitted to the new connectors. All units were temperature cycled to check the system performance.

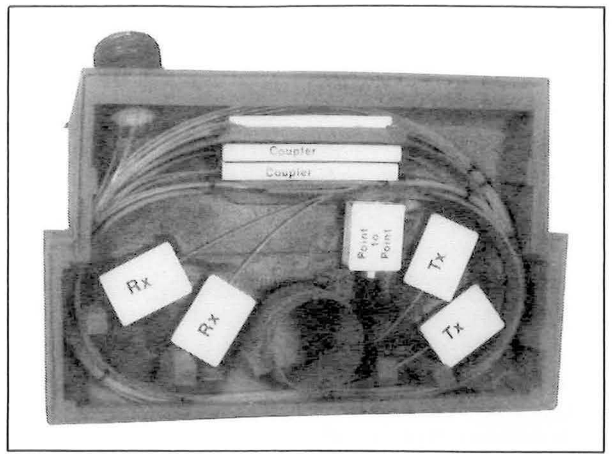
The fibre optic loom was also redesigned to allow bought–in cable assemblies to be fitted directly to the airship without any on–site terminating being required. The cable assemblies comprise a main gondola loom and four gondola–to–fin sub–looms. These were from ITT Cannon and feature military avionic fibres and type 38999 connectors.

Installation of the full flight control kit is currently underway in North Carolina, USA and flight trials are expected to start in October/November 1988.

10.5.2 STANAG 3910

The major thrust is the development of suitable procurement specifications for the optical components of the system: fibre optic receiver/transmitter, cable, couplers and connectors. FARL is closely liaising with other GEC companies in this area. A set of procurement specifications for components to meet STANAG 3910 requirements has been drawn up and will be used as the basis for development of the critical components. This is foreseen as the first stage in the development of other, related fibre optic system components for use in the Linear Token Passing Bus system.

Figure 25



FARL has also been working with the Product Divisions to study physical installation of the fibre optic components for EFA avionic units– Figure 25 shows a fibre optic interface for 3910 fitted into a 'dog–house' module.

10.5.3 COBSS

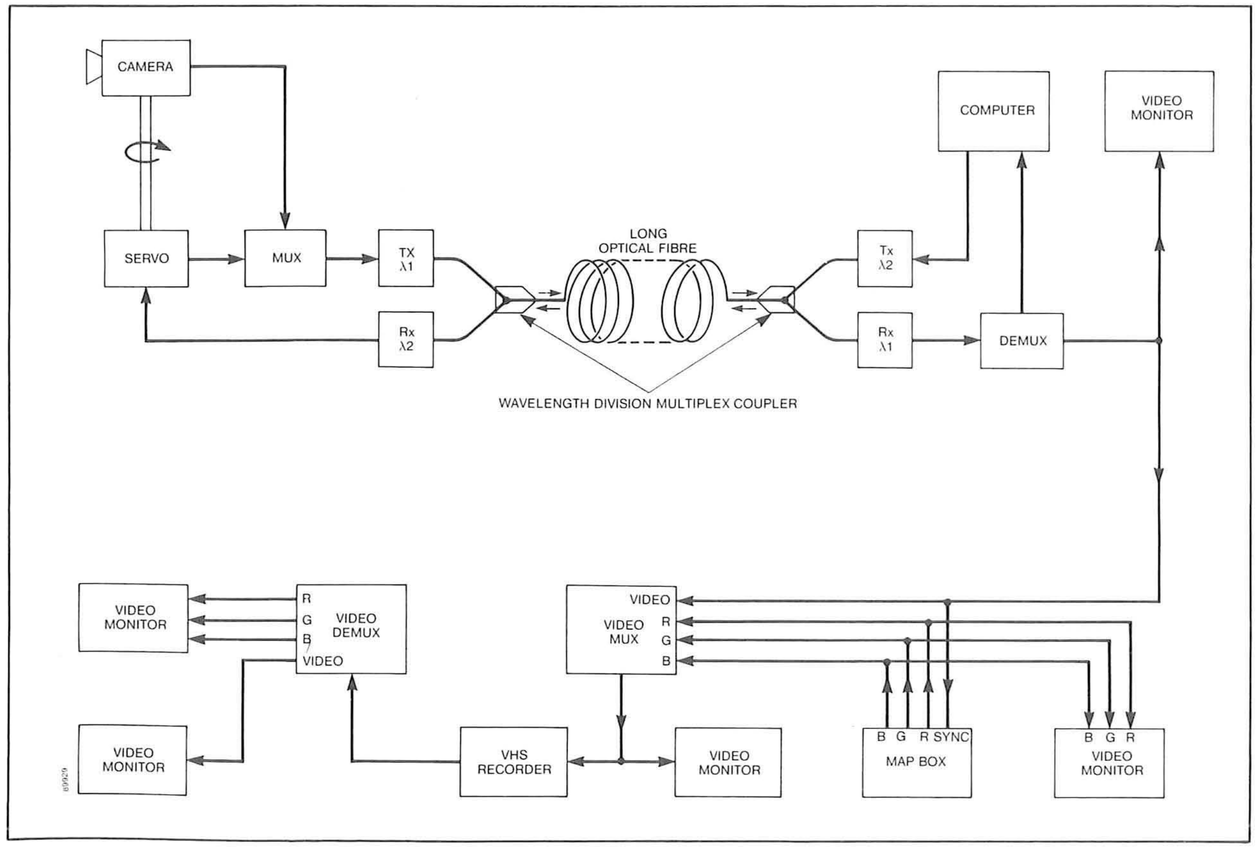
As part of a demonstration to the British Army a system was put together to show how a Fibre Optic Guided Vehicle could be constructed. Fitting the vehicle with a low light or infra-red camera gives the Close Observation Battlefield Surveillance System concept (COBSS). The system is illustrated in Figure 26.

The demonstration showed two–way transmission of data over a fibre optic link. This included video in one direction along the fibre and control information in the other. Integration with other GEC Avionics subsystems such as the moving map demonstrator from Guidance Systems Division and a record/replay system from GEC Avionics, Nailsea, was used to demonstrate the capabilities of the system.

10.5.4 Fibre Optic Power Budget Analyser

To meet the needs of the various fibre optic systems being considered (STANAG 3910 and Linear Token Passing Bus), FARL has developed a Computer Aided Design (CAD) package for power budget analysis. The program is menu driven, runs on a BBC microcomputer and

Figure 26



permits the user to define the required optical layout in pictorial form by using icons.

A set of standard values, or user defined values, can be applied to the system to give a graphical readout of the optical power throughout the system. Using maximum and minimum values for the system components, parameters such as the maximum dynamic range, minimum detectable power and maximum system attenuation can easily be seen.

Examples of the typical graphical outputs can be seen in Figure 27 and 28. These demonstrate the different power requirements for a reflective and transmissive star topology, which is of particular relevance to STANAG 3910.

The program has also been adapted for use on electrical bus systems and allows comparisons between optical and electrical systems to be readily made.

Relevant Reports:

262/2424 STANAG 3910 Optical Transceiver Design Considerations

262/2502 Optical Fibre Transmitter Specification

262/2503 Optical Fibre Receiver Specification

262/2505 Optical Fibre Cable for avionic Data Transmission systems: general specification

262/2511 Optical Fibre Couplers four port passive: general specification

262/2342 Optical Fibre Connector for avionic Data Transmission systems multiway: general specification.

Figure 28

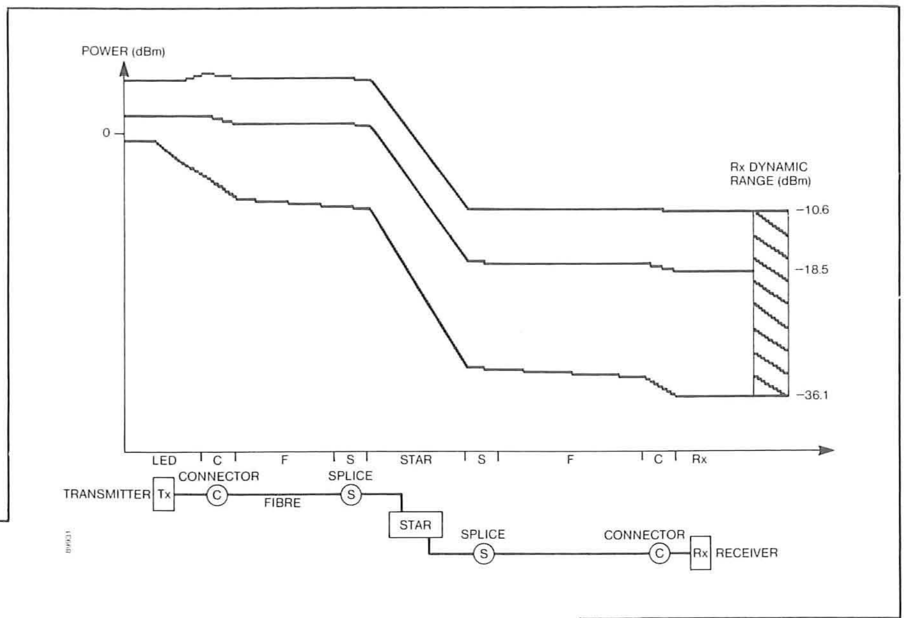
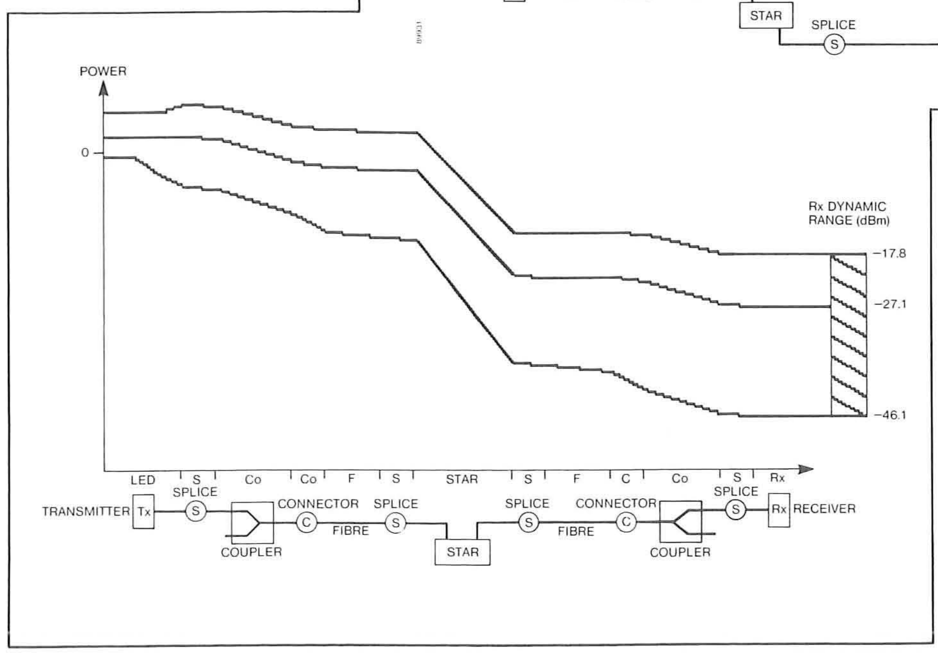


Figure 27



11 VLSI DESIGN

Project Manager: Kenny Deans
Senior Systems Engineer: John Gilmour

11.1 Introduction

The VLSI Design team has a complement of 5 engineers who have built up particular expertise in the VLSI implementation of complex serial data transmission systems. The team, in fact, 'cut its teeth' on the design of the MIL–STD–1553B data bus interface which resulted in the highly successful 5 chip implementation by a sister company, MEDL. This has been followed by the 2 chip '1553' and the 'ASTRID' serial interface chip design for Combat Aircraft Controls Division.

The team's activities over the past year have been mainly directed to supporting the High Speed Data Bus programme, in particular the VLSI implementation of STANAG 3910.

The more general R&D activities have covered ASIC verification and VLSI Design methodology using 'CORE' and 'ELLA' software tools.

11.2 ASIC Verification

During the year considerable interest and concern has been shown in the area of chip verification testing. With more Application Specific IC (ASIC) designs taking place within the Company, verification testing has become an important development factor, particularly in determining the cause and possible rectification of any faults introduced in the design phase.

For this reason FARL carried out a survey of the different types of verification systems available to establish the requirements of the Product Divisions and also to see if the purchase of a verification system would improve this area.

The different systems were examined with the following criteria in mind:

- Ease of use – preferably menu driven
- IBM–PC driven
- Ability to down–load waveforms and to use waveforms developed during the simulation phase
- High pin count – to cover future requirements
- High clock rate – to allow real time testing
- Technologies – tunable to various technologies
- Real time comparison – error flagging capability.

Many systems were in a modular format, allowing expansion to be carried out over a period, spreading the cost accordingly.

Divisional requirements were widely spread, reflecting their commitment to incorporate VLSI devices within programmes. Those currently involved in semi–custom work normally insert the device in its final circuit for any form of verification testing to be carried out. Some Divisions considered the purchase of such a verification system essential to enable any form of debugging to be productive and achieved in realistic timescales.

Of the verification systems looked at, the overwhelming factor against purchase was cost, and the majority of Divisions considered this too high a price for few benefits. Most considered the original manufacturer would continue to increase and improve the service provided which is certainly the trend at present. If in–house testing were carried out, a general purpose digital analysis equipment was considered capable of fulfilling the need.

All Divisions, however, considered that the incorporation of a hardware compiler would improve design capability. These are intended to enhance the front end design stage and allow more comprehensive system simulations to be carried out. These, too, are expensive and most Divisions use a variety of simulation packages. A whole suite of different hardware compilers would thus be required, again making for unacceptable cost.

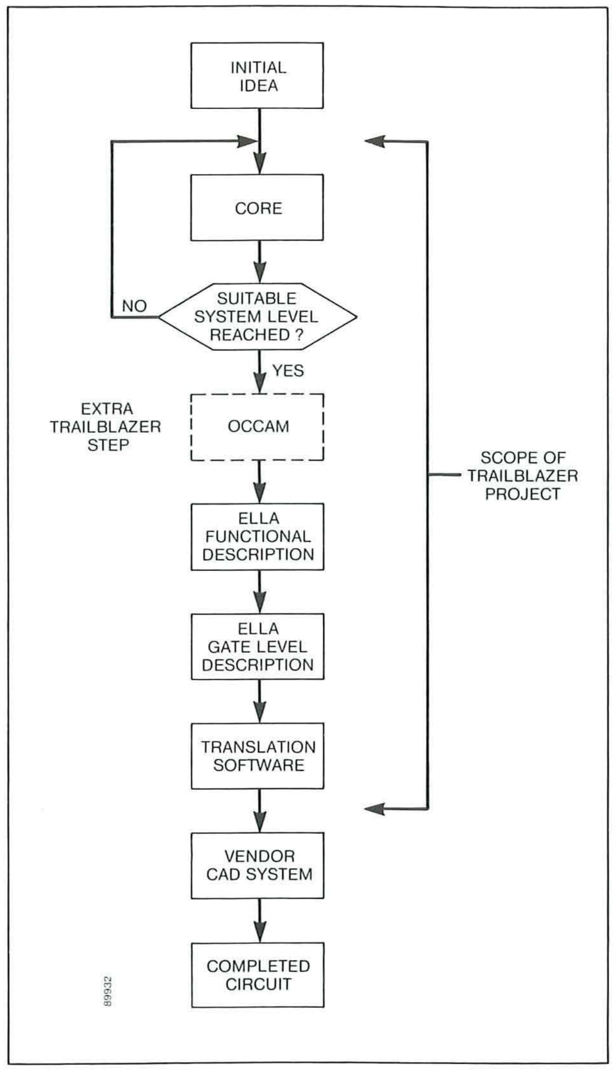
The overall conclusion was that, unless a large increase in ASIC design was made, no significant benefit could accrue from the purchase of specialist verification test equipment. However, this is an item which will be reviewed at regular intervals.

11.3 VLSI Design Methodology using CORE and ELLA

With more sophisticated software tools becoming available, it was decided to investigate a more formal way of designing VLSI circuits to allow more direct input to the CAD systems with a minimum of rework.

The approach adopted was to use CORE (Condition Requirements Expression) to create the initial specification and then ELLA to implement the design. This work was seen as complementary to work on the Trailblazer project. Indeed, the process of using CORE as an initial system input is now proposed to be investigated in the Trailblazer programme. See Figure 29.

Figure 29



CORE was developed at British Aerospace, and is a set of steps to be followed during the initial specification of a system. It provides the connectivity between blocks and also allows the specification to be checked thoroughly.

ELLA (Electronic Logic Language) developed by RSRE Malvern is an example of a Hardware Description Language. It can model circuits at both functional and gate level. Its attraction is that the overall functioning of a circuit can be simulated without having to refer to a particular architecture, circuit element or vendor.

Once an ELLA description has been generated and tested it needs to be translated into a form suitable for a vendor. It is necessary to use a gate equivalent style to describe the circuit in ELLA, although separate gates can be funtionally described. With ELLA in this form more and more vendors are producing translation software to generate code suitable for input into their CAD system.

The work carried out to date has been very limited because of other commitments, but sufficient work has been done to confirm the power of the method.

Relevant Reports:

262/2375 Specification for a translator to convert a HIL03 ATG results file into a Scan Path format.

262/2466 ASIC VLSI Verification System Survey

262/2412 Initial CORE Design Methodology Assessment

262/2486 VLSI Design Methodology using CORE and ELLA

262/2360 ASTRID Design Report

12 ENVIRONMENTAL DESIGN AND ELECTRONIC PACKAGING

Engineering Services Manager: Jim Pickford
Project Leader: Clive Goodchild

12.1 Introduction

The team comprises 11 people, of whom 4 specialise in design requirements for nuclear hardening. The rest of the team is concerned with a variety of activities, including advanced electronic packaging research, mechanical design and prototype manufacture.

12.2 Modular Avionics

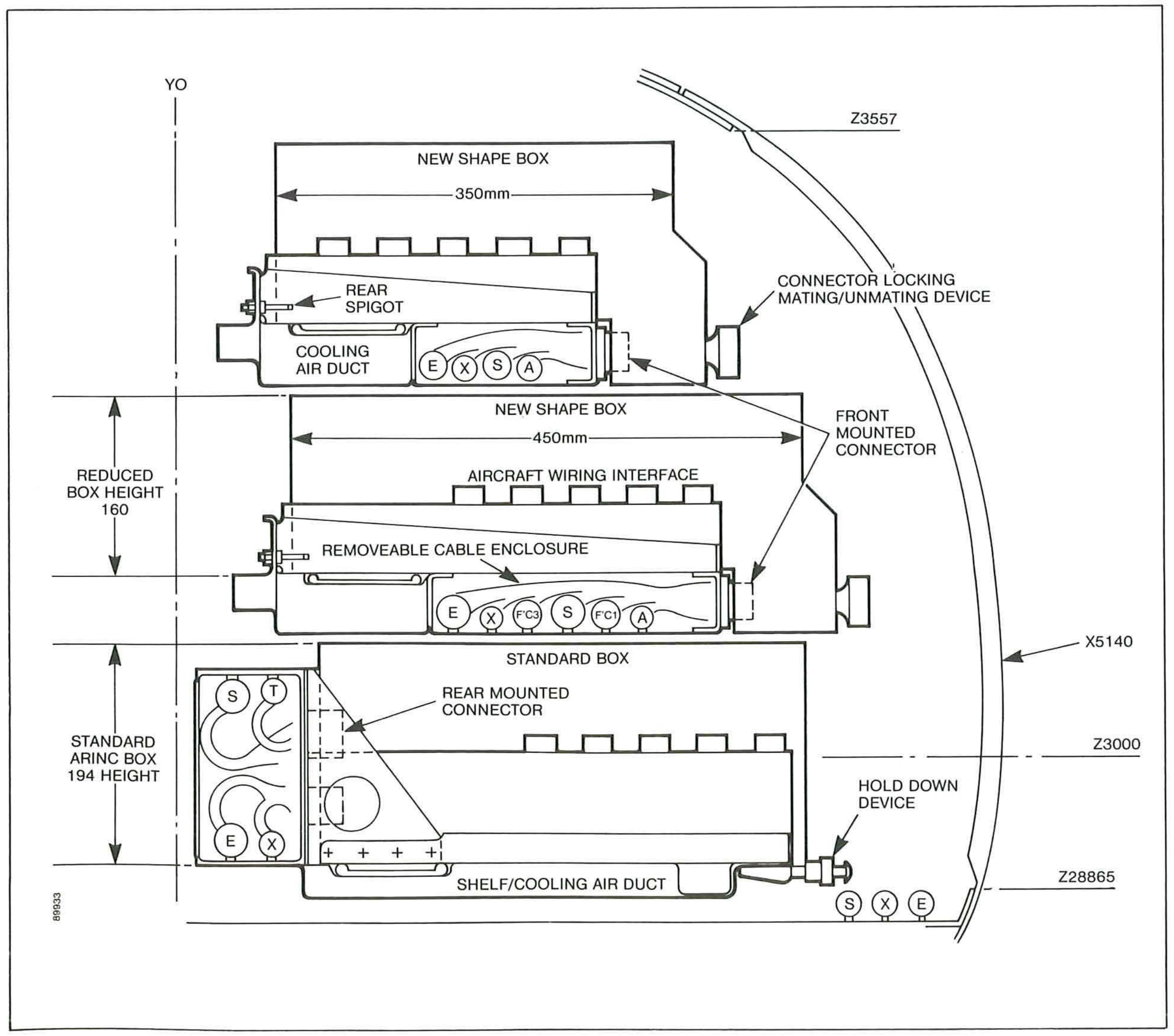
12.2.1 Chin Strap Module

Packaging work related to EFA racking systems has been monitored and Figure 30 shows the proposed EFA racking system. Of the six avionic box trays five are proposed as 'Chin Strap' or 'L' shaped boxes and the sixth a standard ATR racking system. The standard ATR system is expected to be replaced with the proposed new fit.

12.2.2 Committee Membership

FARL is represented on the ASSC (Avionic Systems Standardisation Committee) packaging committee which primarily considers the Pave Pillar packaging development and A^3P (Advanced Avionic Architectures and Packaging) activities, with particular interest in keeping abreast of USA developments, and adding influence where applicable.

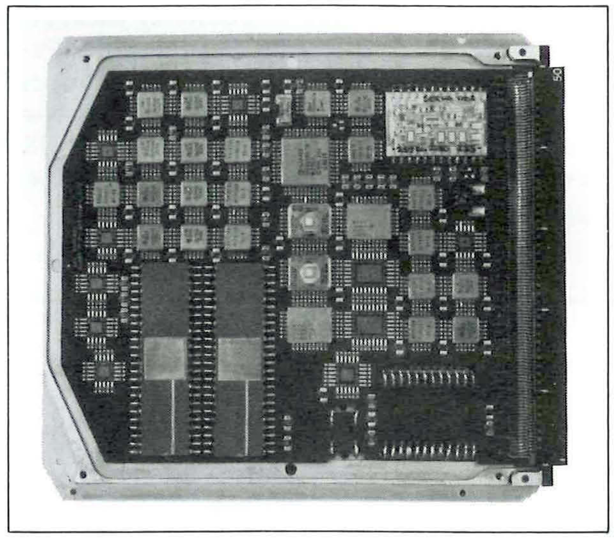
Figure 30



12.2.3 Pave Pillar Module

The major efforts this year have gone into producing a representative prototype of a SEM 'E' type module to identify the detail design and manufacturing difficulties using surface mount technology. The module is shown in Figure 31 and comprises a typical 16 bit microprocessor with memory devices and a MIL–STD–1553B data bus interface. A nuclear event detector circuit is incorporated to give memory protection. When fully commissioned the module will be used for practical assessment purposes including thermal and EMC considerations.

Figure 31



12.3 Nuclear Hardening

The team has mainly been engaged on Company funded research this year, and has concentrated particularly on design requirements to meet increasingly stringent electromagnetic specifications.

The studies have been mainly aimed at Pave Pillar type packaging designs, and the nuclear hardening requirements of the European Fighter Aircraft (EFA).

12.3.1 Electromagnetic Studies

Initial research into the implications of electromagnetic interference (EMI) on future packaging concepts has been completed. The studies involved theoretical analysis of enclosures, using software developed by the Nuclear Hardening team, together with practical testing of the enclosures in the FARL TEM cell for correlation of results.

Current studies involve an in–depth appraisal of a representative conduction cooled processor module, built to the SEM 'E' packaging specification. Analyses are also being carried out on several aspects of the Pave Pillar architectures.

Relevant Report: *262/2440 EMH Consideration in Future Packaging.*

12.3.2 EFA Nuclear Hardening

The team is involved in assisting Product Divisions in responding to the EFA Nuclear Hardening requirements specified in the RFP's.

The work included a presentation to the Product Divisions and the compilation of a report, intended to explain and clarify the requirements of the nuclear hardening specification and verification documents. In addition, text is provided for inclusion in proposals where applicable.

Assistance has been given to the following Product Divisions in producing nuclear hardening designs for inclusion in the EFA proposals:–

PSD – Digital Engine Control Unit
PSD – LH & RH Glareshield
ADD – Cockpit Interface Unit

12.3.3 Nuclear Event Detector

The Microsystems Department of Instrument Systems Divisions is currently re-packing the FARL event detector. The ruggedised version will then be tested by FARL engineers to ensure that it will meet military specifications.

12.3.4 Future Work

Several proposals are under consideration by the Ministry of Defence for both INR and electromagnetic work.

13 CONSULTANCY

Senior Consultant: Brian Paxton
Consultant: Geoff Craggs

13.1 Introduction

The consultancy service has continued in 1988, covering support for projects in FARL, Universities and Divisions. This has been in the form of contributions to proposals, studies, advice and general liaison. The year has seen further interest in integrated avionics systems architectures and liaison between Divisions and with other companies to promote research and development in advanced system concepts.

13.2 ASSC Steering Committee

Two Steering Committee meetings of the Avionics Systems Standardisation Committee were attended this year. These have proved useful for keeping the Company informed of trends in both standards and advanced architecture topics. The latest moves have been towards a four nation initiative to promote a standard avionics architecture by 1995 via the ASAAC (Allied Standard Avionics Architecture Council).

Relevant Reports: *262/2454 ASSC Activities 1987*
262/2539 ASSC Activities 1988

13.3 IAWG

The Industrial Avionics Working Group – an inter–company liaison activity to pool technical expertise to generate a consensus viewpoint on topics of mutual interest – now has a FARL member representing the Company. (The four companies collaborating through the IAWG are British Aerospace, Ferranti, GEC Avionics and Smiths Industries). There have been seven meetings this year, covering a considerable amount of work to determine the requirements of future aircraft systems avionics architectures. In addition such topics as Test and Maintenance, Fault Tolerance, Functional Breakdown and Communications have been studied.

Relevant Report: *MA11 Issue 4 Viewpoint Analysis of System Drivers (held as FARL 262/2518).*

13.4 Displays Processing

The first stage of the evaluation work on the AMD Quad Pixel Dataflow Manager was completed at the beginning of the year. This showed that although a few problems and deficiences were encountered the detailed function of the complex and powerful graphics chip performed as specified. It was clear that it is more efficient than many graphics processors – particularly in applications where its parallel architecture can be fully utilised.

This programme is now being continued as part of an overall plan to provide an evaluation facility for real–time colour raster display hardware, driven by the requirements of the next generation of cockpit displays. To this end the QPDM board has been updated to include four memory planes and a colour palette. It will be used to demonstrate typical future displays such as non–interlace colour maps and EADI with a flexible interface to allow the quality of various options to be considered in trade–off studies. The QPDM system is ideal for this purpose since it is easy to program and fast enough to serve as a good benchmark for the evaluation of alternative hardware solutions.

Relevant Reports: *262/2381 An Evaluation of the Quad Pixel Dataflow Manager.*

13.5 Advanced Avionic Architectures

Work has continued to define a plan of activity in response to the MOD(PE) initiative for a four phase demonstrator programme to investigate advanced avionics architectures and packaging. The emphasis has been on combining a complete review of aircraft mission requirements for the next two decades with the ability of new technology to allow a modular approach to equipment design, and improved logistics while keeping life cycle costs down. Results from the initial study are expected to point the way to balancing the use of common modules and standards against the more complex designs required to satisfy a multitude of system demands and still provide flexibility. In addition, the bus structure, use of High Speed Data Bus, backplane bus, Test and Maintenance (T&M) bus and signal data network standards need to be decided, together with preferred standards for line replaceable modules and their grouping in enclosures.

14 COMPUTING DESIGN SERVICES

Project Manager:	Andy Poad
Consultant:	Arie Vandertak
Senior Software Engineer:	Peter Holland

14.1 Introduction

The Computing Design Services team currently consists of 4 engineers and a trainee computer programmer, covering advanced Computer Aided Engineering techniques and management of the Laboratory's computer networking facilities. The work carried out in 1988 involved the Alvey 'Trailblazer' Project, the Alvey Design–to–Product Demonstrator, and the continuing system support for the Laboratory's general computers.

14.2 Alvey 'Trailblazer'

This two year collaborative research programme between the University of East Anglia at Norwich, GEC–Marconi Research Centre at Great Baddow, and FARL, will be completed in March 1989. It involves investigation into advanced design methodologies at the system level for VLSI implementation.

The work centres around two commercially available languages and their support software. These are OCCAM, based on the formal semantics of Communicating Sequential Process (CSP) theory, for the high level system model and ELLA, a Hardware Description Language (HDL), supported by the UK as a common interface to silicon vendors' CAD systems.

The main aim is to demonstrate design methods on a Sun Workstation by producing a prototype system to 'compile' OCCAM into ELLA in order to generate sensible hardware.

The approach is to develop software based on synthesis rules for point–to–point and bus based architectures with built–in testability measures.

A number of existing GEC Avionics designs have been modelled in OCCAM and ELLA and will be used to prove the 'compiler' system and demonstrate design methods.

In addition, since VHSIC Hardware Description Language, VHDL, (the USA equivalent to ELLA), is now an IEEE standard the project will outline the differences between the two languages. To carry out this task an engineer has attended a VHDL training course.

Relevant Reports: *262/2335 Trailblazer Annual Report 1987*
262/2373 Initial Specification
262/2479 Interim Progress Statement

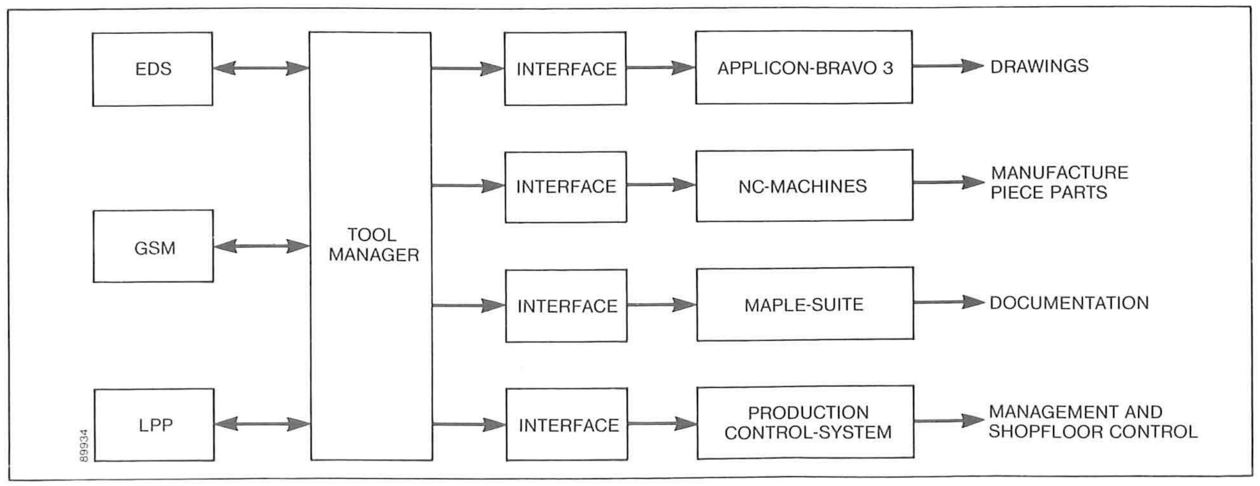
14.3 Alvey Design–to–Product

The Alvey funded Design–to–Product Demonstrator programme, led by GEC Electrical Projects and aiming to apply Artificial Intelligence technology to design and manufacture, is now in its full demonstrator phase.

FARL completed a study into the initial requirements for Engineering Information Management Systems, and is now investigating the implications of interfacing the Edinburgh Designer System to third party software for GEC Avionics to benefit the most. The possible third party software interfaces are shown in Figure 32.

The Edinburgh Designer System (EDS) has recently been installed on a Sun 3 Workstation in FARL using a POPLOG environment. The Leeds Geometry Solid Modeller (GSM) and the Loughborough Process Planner (LPP) will be installed in the near future when the Tool Manager has been completed at Leeds University. The interface required for GEC Avionics will be between the Tool Manager and the chosen third party software.

Figure 32



Relevant Report: *262/2443 Initial Requirements for Engineering Information Management Systems.*

14.4 Computer Management

The Laboratory's computer network has been expanded with the installation of Thinwire Ethernet in all office and workbench areas. IBM PCs have been connected to this network and are served by the two VAX's using DECnet protocols.

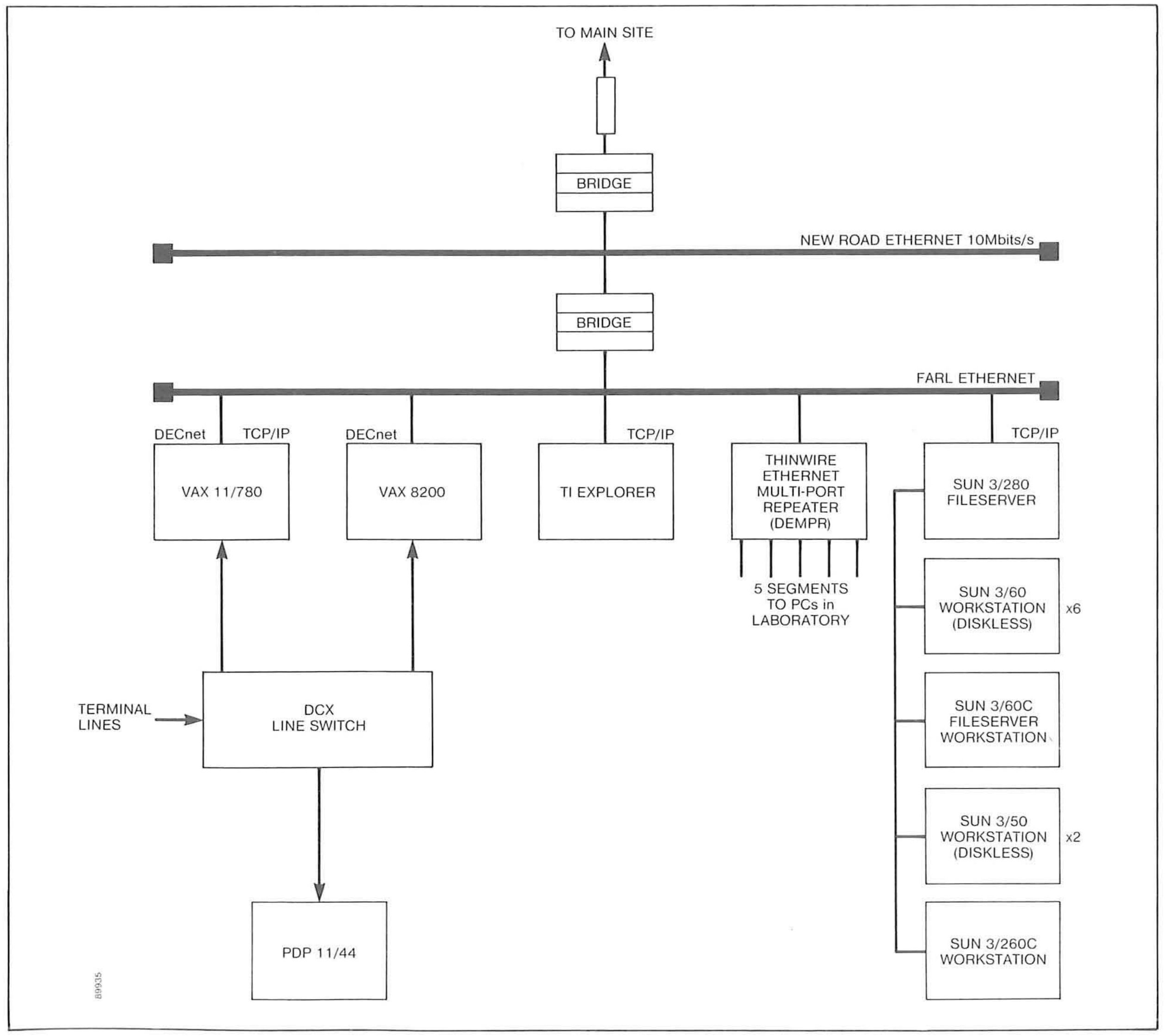
The possibilities of linking New Road and Main Site networks have been evaluated, the recommended solution has been approved and the link is expected to be operational by November 1988. See Figure 33 for details of FARL's computer network facilities.

The VAX 11/780 now has the ability to serve SUN workstations with the addition of WIN/NFS giving the SUNs transparent access to VAX/VMS files.

Existing in–house software facilities continue to be enhanced, and new software to aid divisional administration is currently under development.

Relevant Reports: *262/2352/TN Information System Software Documentation*
262/2270 Computer Management: Final Report on DA 262/701
262/2399 FARL VAX Report Transfer System – User Guide
262/2475 Linking the FARL Computing Facility with the Main Site Computer Network.

Figure 33



15 COMPANY REPRESENTATION

A number of senior FARL personnel are tasked with representing Company or Group interests by serving on a number of Committees which recommend policy to industry and the Government or represent GEC Avionics' interests in GEC inter Company Committee activities. These activities together with the current FARL contact are listed below for information.

* ESASC:	The EEA and SBAC Avionic Systems Committee Current contact: Malcolm Moulton
* FSRCC: and NCRCC	Research consultative committees of ESASC, with MOD, for flight systems and NCRCC navigation and communications. Current contact: Malcolm Moulton
* IAWG:	Industrial Avionics Working Group. Current contact: Brian Paxton
* ASSC:	Avionic Systems Standardisation Committee Current contact: Brian Paxton (representing ESASC) Software Engineering Working Group Current contact: Renny Smith
* HPSSC :	High Performance Semi–conductor Systems Club (of DTI) Current contact: Don Price (Secretary)
* SIGSAS:	Special Interest Group (of HPSSC) for systems Architecture on Silicon Current contact: Don Price (Chairman)
* RAeS:ASG:	Avionic Systems Group of the Royal Aeronautical Society Current contact: Malcolm Moulton
* RAE, Bedford:	GEC Avionics technical liaison FM2 Operational Systems Current contact: Keith Mitchell
* VLSI Working Party:	Comprises GEC–Marconi companies Current contact: Kenny Deans (Secretary)
* Flat Panel Display:	GEC inter–company committee Current contact: Keith Mitchell (Secretary)
* Technical Exchange Group:	GEC inter–company committee Current contact: Jim Pickford
* Special Interest Group:	GEC inter–company committee High Integrity Systems Current contact: Renny Smith

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AIRBORNE DISPLAY DIVISION | AIRBORNE DISPLAY DIVISION | AIRBORNE DISPLAY DIVISION | INSTRUMENT SYSTEMS DIVISION

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