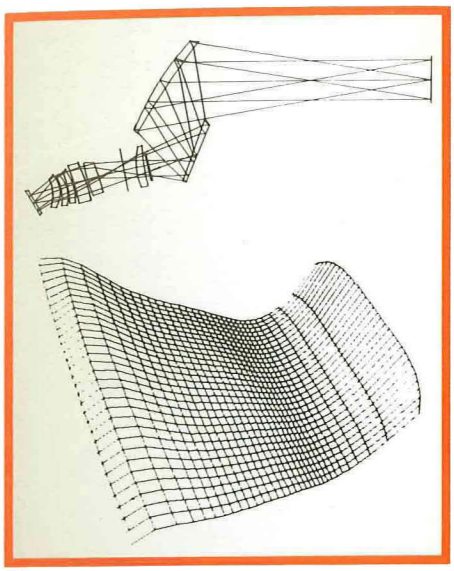
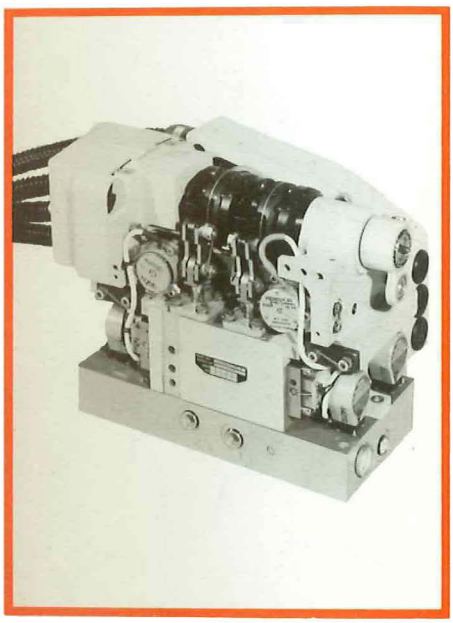
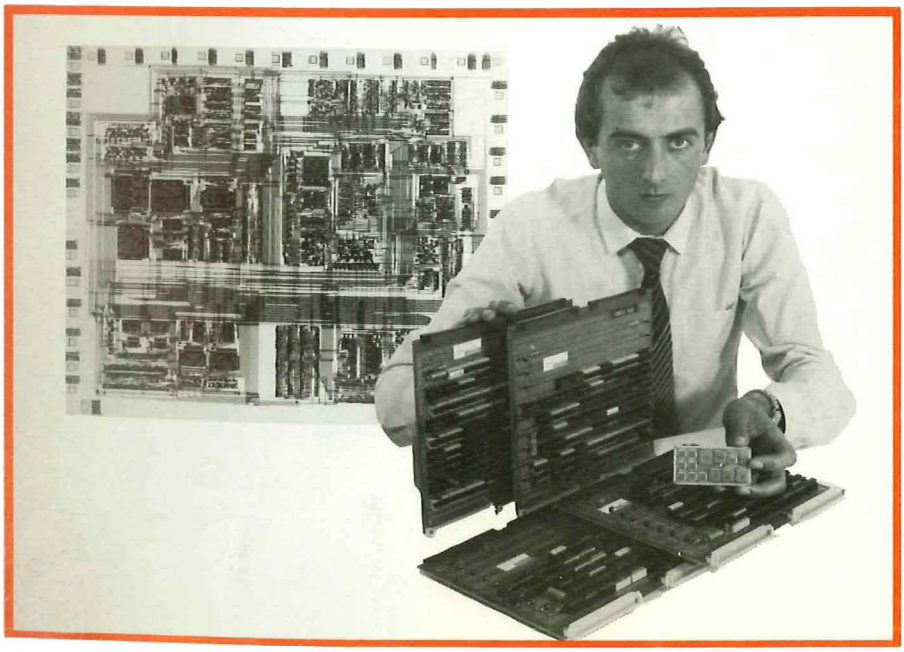
GEC AVIONICS

FLIGHT AUTOMATION RESEARCH LABORATORY







ANNUAL REPORT 1986

FLIGHT AUTOMATION RESEARCH LABORATORY

1986 Annual Report

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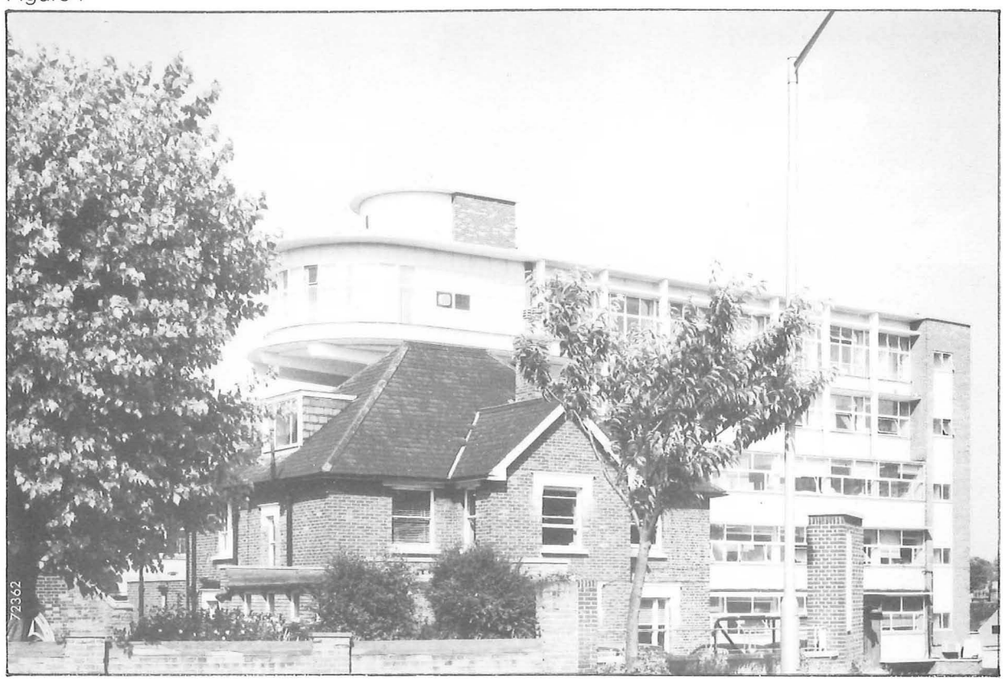
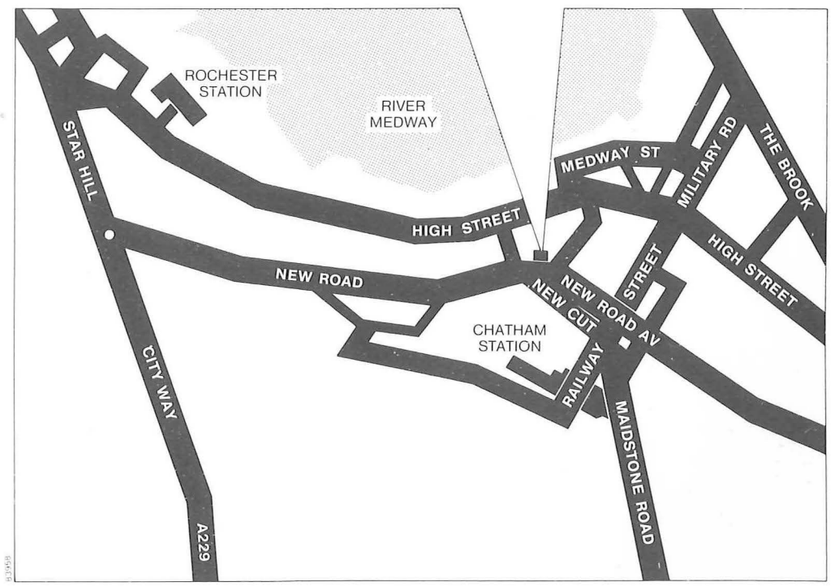
DIVISIONAL MANAGER

Figure 1





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 Products 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 components of an avionic system are illustrated in Figure 2, and the Laboratory is organised into teams whose specific skills embrace the following areas:

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

Figure 2

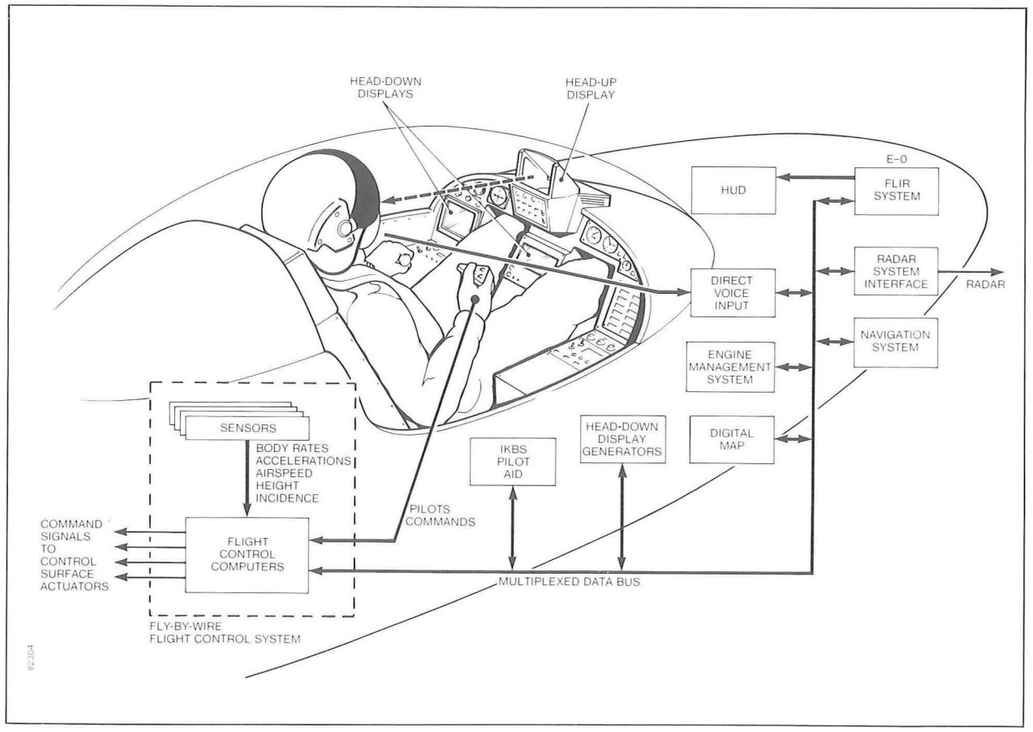
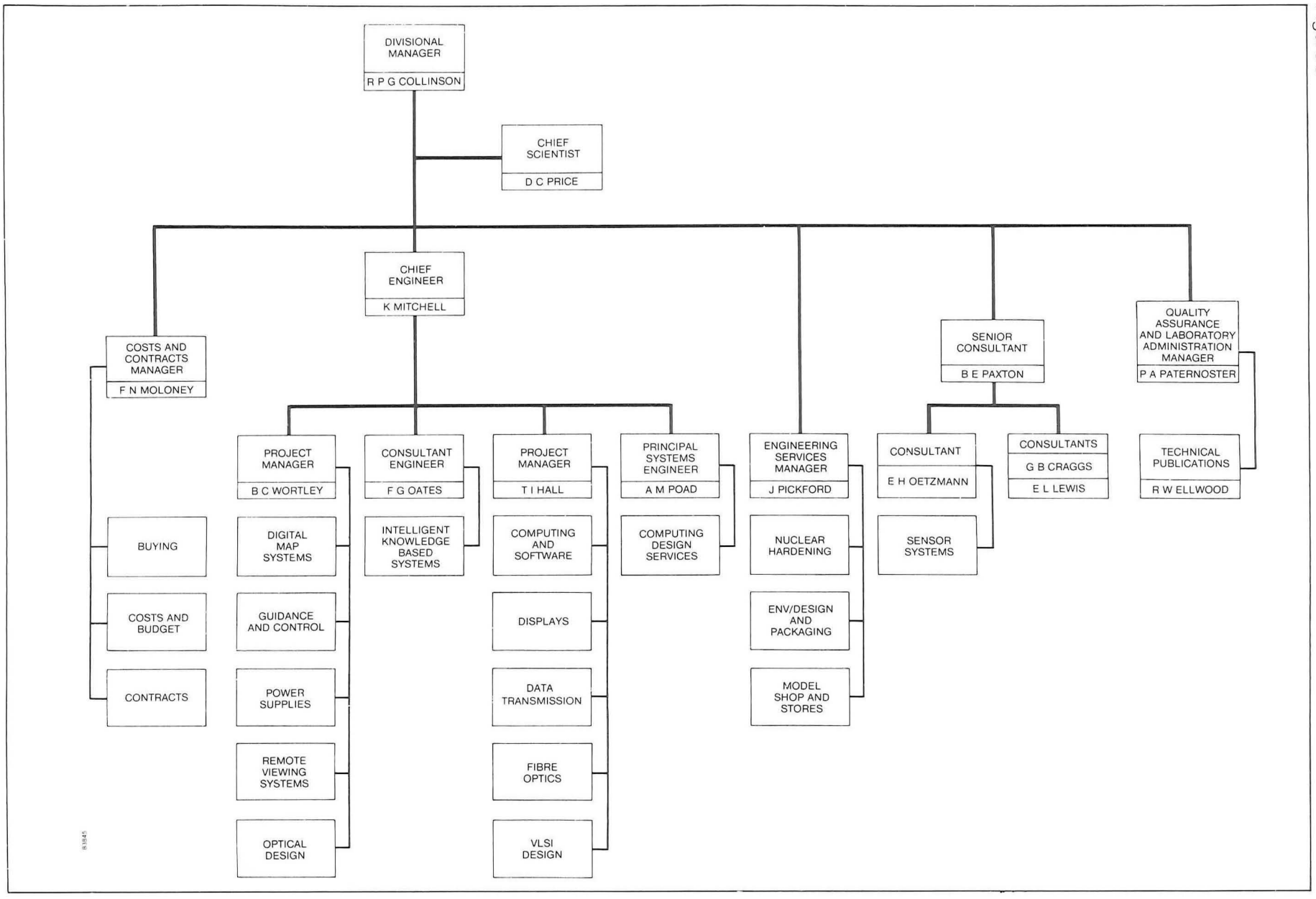


Figure 3


DIVISIONAL MANAGER
R P G COLLINSON
CHIEF SCIENTIST
D C PRICE
CHIEF ENGINEER
K MITCHELL
COSTS AND CONTRACTS MANAGER
F N MOLONEY
BUYING
COSTS AND BUDGET
CONTRACTS
PROJECT MANAGER
B C WORTLEY
DIGITAL MAP SYSTEMS
GUIDANCE AND CONTROL
POWER SUPPLIES
REMOTE VIEWING SYSTEMS
OPTICAL DESIGN
CONSULTANT ENGINEER
F G OATES
INTELLIGENT KNOWLEDGE BASED SYSTEMS
PROJECT MANAGER
T I HALL
COMPUTING AND SOFTWARE
DISPLAYS
DATA TRANSMISSION
FIBRE OPTICS
VLSI DESIGN
PRINCIPAL SYSTEMS ENGINEER
A M POAD
COMPUTING DESIGN SERVICES
ENGINEERING SERVICES MANAGER
J PICKFORD
NUCLEAR HARDENING
ENV/DESIGN AND PACKAGING
MODEL SHOP AND STORES
SENIOR CONSULTANT
B E PAXTON
CONSULTANT
E H OETZMANN
SENSOR SYSTEMS
CONSULTANTS
G B CRAGGS
E L LEWIS
QUALITY ASSURANCE AND LABORATORY ADMINISTRATION MANAGER
P A PATERNOSTER
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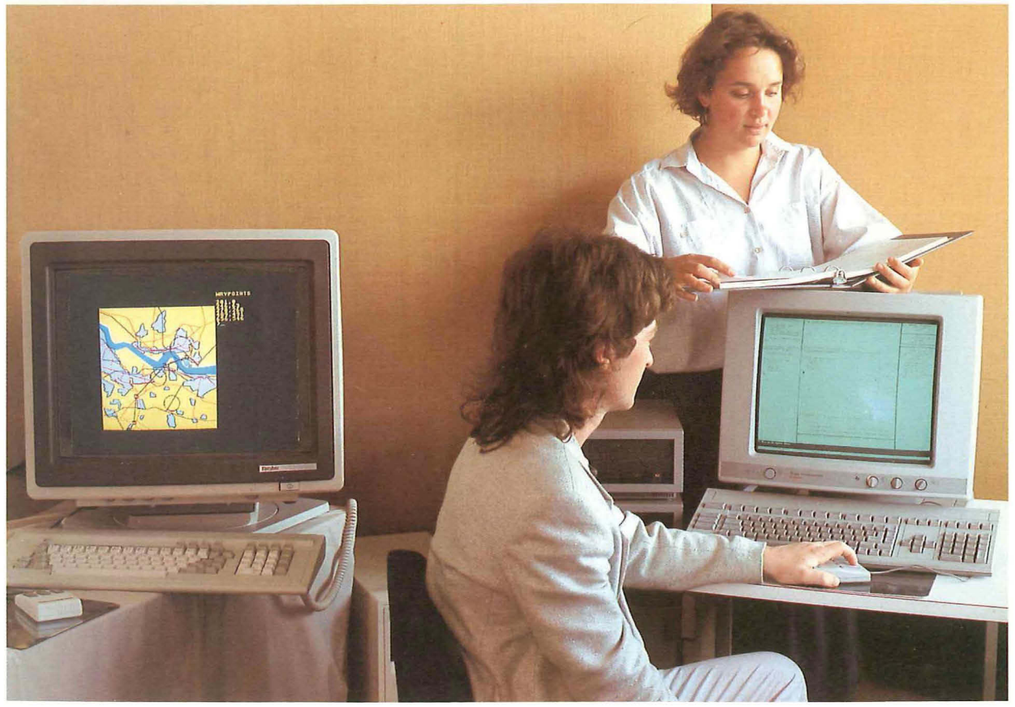


MANAGEMENT SUMMARY

During the reporting period November 1985 to November 1986 the Laboratory celebrated 25 years of operation. The cover of this report illustrates some of the successful Company products and projects where the Laboratory has played a major role.

We are confident that a number of the developments described in this report will be similarly successful.

The lack of MoD (PE) funding for R&D Avionic projects has been evident for some time and we have attracted more GEC Avionics divisionally funded work. The allocation of resources has been approximately 20% to Externally Funded, 40% to Divisionally Funded and 40% to Company Funded R&D work.

The size of the Engineering Department is about the same as a year ago at 82. Staff losses and transfers to Divisions are balanced by the intake of 11 new graduates of high quality and potential. Three of our Project Managers (Andy Fordham, Colin Tredwell and Malcolm Earl) have recently transferred to a Product Division as part of their career development.

EXTERNALLY FUNDED R&D

Our main activities and achievements on externally funded programmes are briefly described below.

Stereo Viewing System

Successful undersea trials of the Stereo Viewing System were carried out in March 1986 as part of the trials of the GEC Avionics/OSEL 'DRAGONFLY' sub-sea vehicle. The advantages of high quality stereo vision in carrying out remote manipulative tasks were convincingly demonstrated and favourable comments were made by the operators.

New Helmet Mounted Displays

Last year we carried out a Company funded design for a new optical configuration of a Helmet Mounted Display with a 40° x 30° FOV and a Binocular or Monocular capability.

On the basis of this prior design we have now won two competitive MoD (PE) contracts for Helmet Mounted Display Systems with a high degree of commonality. The first is a monocular HMD system for RARDE (Chertsey) for remote control of experimental Unmanned Land Vehicles, and the second is a binocular HMD system for RAE's LYNX helicopter.

Edge Detection Navigation

We have been working for several years on a technique which is called 'Edge Detection Navigation' for precision navigation fixing using a stored terrain feature data base. This technique looks very promising and we were awarded a contract in June 1986 to carry out further studies complementing the activities of Guidance Systems Division.

IKBS Application to Fixed Wing Aircraft

We were awarded a contract in April 1986, following a competitive tender by the RAE (MoD(PE)), to study the application of IKBS to fixed wing aircraft. The study has embraced a wide area of applications and has now 'homed in' on the Displays Management task as a fruitful application for an IKBS system.

Alvey 'Design to Product'

We are collaborating with GEC Electrical Projects who are responsible for an Alvey funded demonstrator programme called Design to Product (D-to-P). This is aimed at extending Computer Assisted Design Methods, and using Artificial Intelligence techniques to support all the phases of producing a product from DESIGN, PRODUCTION, PLANNING, AUTOMATED ASSEMBLY and TESTING to MAINTENANCE. Our experience to date indicates that the D-to-P project could have far reaching implications and benefits to our future products.

PROJECTS FUNDED BY THE PRODUCT DIVISIONS

Our main activities and achievements on projects for the GEC Avionics Product Divisions are described below.

Magnetic Sensor System for MASD

Maritime Aircraft Systems Division have sponsored the development of new sensitive magnetic sensors with high bandwidth and directionality characteristics to complement their sensor processing systems. Excellent progress has been made on the Fibre Optic Magnetic Sensor. A new low cost magnetic sensor/compass is also being investigated which could have particular application in sonobuoys.

Colour Head-Down Display for ADD

A new Colour Head-Down Display Head has

been developed for Airborne Display Division and forms an integral part of Guidance Systems Division Digital Map System.

Two Colour-Display Heads have been designed and built in six months; one is now flying in a Grumman A-6 aircraft in the USA with good pilot reports received.

Off Axis CGH HUD Combiner for ADD

Good progress has been made in designing the Computer Generated Holograms (CGH's) for a new single-combiner HUD. These correct the optical aberrations which otherwise result from a large off axis mounting with respect to the pilot's line of sight (35° in the case of the F-16).

Software Engineering Workcentre Evaluation – All Divisions

The increasing software element in avionic systems together with the move to increasing system integration places severe demands on the finite resource of systems/software engineers. Accordingly the Laboratory has embarked on a pilot programme, funded by the Product Divisions, to evaluate the effectiveness of a SOFTWARE ENGINEERING WORKCENTRE (SEW) provided by GEC Computers Ltd. An improvement in productivity in the region of 30% is anticipated.

Boeing 7J7 Primary FCS – Support to FCD

Flight Controls Division have recently been awarded a contract by the BOEING COMMERCIAL AIRPLANE COMPANY to develop the Primary Flight Control System for the new 7J7 civil transport. We are actively supporting them in the VLSI design and digital flight control system areas.

VLSI Design Support to CACD, FCD, and MASD

We are designing an AVIONIC SERIAL TRANSMISSION INTERFACE DEVICE (ASTRID) for Combat Aircraft Controls Division. This performs the intercommunication function in a quadruplex Flight Control Computer System and will replace 3 PCB's.

An interface chip to couple the 2-Chip SOS 1553 to a Z8000 microprocessor is being designed for Maritime Aircraft Systems Division. This will result in a very compact Bus Controller.

Design support for Flight Controls Division on the 7J7 PFCS has already been mentioned and will commit most of the team's resources in the New Year.

Surface Mount Technology – All Divisions

Surface Mounted Devices (SMD) offer a large increase in packing density but can suffer unpredictable failures in the solder joints due to stresses resulting from differential thermal expansion effects. A study has been carried out over the last year in collaboration with the Marconi Research Centre, Great Baddow, to assess the viability of computer modelling techniques to predict stress levels and hence derive design rules and guidelines which will ensure reliability. The study results are encouraging and a follow on programme is now needed to prove the methods in practice.

Systems/Software Support – FCD, MASD

We have undertaken a number of specific work packages for Flight Controls Division in the systems/software area over the past year. These have included PHOENIX related studies involving our Distributed Processing and Digital Map System expertise, Advanced Ground Station Software and Airbus Slats & Flaps Computer Test software.

We have also assisted Maritime Aircraft Systems Division on the Indian SEA KING programme in both the system definition and software areas.

Power Supply Design – FCD, ADD, PCSD (Nailsea)

Our small, but expert, power supply design team has been nearly 90% committed to design consultancy support over the year to Flight Controls Division, Airborne Display Division and Power Conversion Systems Division Nailsea and their contribution to the divisions designs has been invaluable.

COMPANY FUNDED R&D

Some of our larger R&D programmes which are Company funded are summarised below.

High Speed Data Bases

The increasing emphasis placed on avionic systems integration in new aircraft projects to reduce weight, improve mission effectiveness and reduce life cycle costs, requires high speed data buses and data management systems to provide the necessary intercommunications. We have been keeping abreast of all developments – attending the relevant standards meetings in the US and UK and investigating the critical technical areas in the two candidate systems (LINEAR BUS and RING).

Display Generation

We have developed a very versatile display generation architecture which exploits the new display graphics chips.

The system is able to accommodate more advanced chips as these become available and is frame store based. It is equally effective driving raster colour CRT displays or flat panel matrix displays.

Flat Panel Displays

Flat Panel Display technology has made rapid progress and both matrix LCD and matrix EL panels are becoming available which are near to meeting the cockpit requirements. We have been evaluating both technologies and the programme is now being supported by Airborne Display Division.

Distributed Processing

The second phase of our programme on high integrity distributed processing systems has been completed with a fully working rig comprising four independent processors communicating by shared memory control and which reconfigures the allocated tasks in the event of failures.

Vector Data Base Map Generation

We have developed a real time Map Display System using Graphics Microprocessor Chips with some novel software to draw and infill the vector polygons to form the map features at very high speed. It can generate and display a complete map image in one second and is able to move the map to correspond to any likely aircraft speed or turn rate.

Nuclear Hardening Technology

We have further developed the Nuclear Event Detector/Circumvention circuit, and also Laser Pulse Test Equipment to generate photo current pulses to simulate the effects of INR. We are also building up a simulation suite to computer model the effects of EMP on circuits, devices and components such as cables.

IKBS Route Planner

We have successfully completed the first phase of a programme to demonstrate the applicability of a rule based Expert System in a Flight Route Planning Aid. Further development using our new EXPLORER Work Station is planned.

Software Engineering

New software engineering tools and techniques for Rapid Prototyping are being investigated as effort becomes available, and look most promising.

Fibre Optic Rotary Position Transducer

Engineering development of this transducer has continued and it is planned to transfer development to Combat Aircraft Controls Divison/ Flight Controls Division in the New Year. Considerable interest is being shown in the transducer by both Boeing and BAe.

1 DIGITAL MAP SYSTEMS

Project Manager: Brian Wortley
Project Leader: Derek Jordan

1.1 Introduction

Following the delivery of the Digital Map Display (DMD) simulator system to RAE (Farnborough) at the end of 1985, several related areas have been under active investigation.

These include the design of a prototype real-time DMD system and further development of map-related display concepts incorporating ground height as well as buildings, roads, and other culture features.

Investigations of the Lateral Inhibition Algorithm (LIA) for enhancing the edges of features in noisy images have continued, with a one-pass derivative of the algorithm also being studied for the first time.

1.2 Digital Map Display Simulator System

The DMD simulator system, based on a general purpose computer, was delivered to RAE (Farnborough) at the end of 1985. The system, which is for ground use only, produces a realistic-looking map display which, although map scale changes are not in real-time, is suitable for simulator use. During 1986, work on the system has been concerned with peripheral facilities (such as the graph plotter) and interfacing the DMD system to the other on-site computers required for the planned simulations.

Unfortunately, staff shortages at RAE have delayed this process and the planned simulation survey with RAF aircrew has been postponed indefinitely.

1.3 Real-time Vector Data Base 2-D Map Display System

Following the success of the Graphics Microprocessor Chip evaluation system (see FARL Annual Report 1985) a prototype real-time Vector Data Base 2-D Map Display System has been designed and built. This plan-view system is based on the concepts inherent in the DMD simulator supplied to RAE (Farnborough) but the hardware architecture and software have been designed specifically for real-time operation.

The overall system, shown in Figure 4, will allow a chosen area of map to be displayed and subsequently moved and updated as required by any change in aircraft position. Commands to change scale, mark a waypoint or target, and to look ahead are provided. The map data is at present stored in 2 Megabytes of EPROM, but alternative high density memory media can be evaluated for use in a future system.

A system operator's console which is being built will enable the simulated aircraft to carry out predetermined sorties, or to be controlled manually.

At the time of writing, the system hardware has been constructed, commissioning is almost complete, and the software design and map data preparation phases are nearly ready for the initial evaluation. It is intended to continue the software development to enable free standing, real-time demonstrations of digital map techniques as part of a continuing programme of enhancement to the map display.

The real-time system will have an impressive performance; a complete new map image can be drawn on the CRT screen in one second (compared with approximately two minutes for the simulator system). Translations in any direction can be made at a speed equivalent to over 3500 knots on a 1:250K scale map (compared with 700 knots for the simulator system). Rotation rates can be achieved which are more than an order of magnitude higher than those attained by any aircraft.

The system also incorporates a programmable raster display generator to give a full overlay capability; the total system hardware could be packaged to fit into a ¾ ATR Short box.

Relevant Reports:-

262/2016/TN Real-time Digital Map Demonstrator

262/2021 Graphics Manipulation for the Graphics Microprocessor

262/2126 Architecture for Real-time Digital Display Systems

262/2141 An Investigation of Real-time Perspective Map Systems

1.4 2-D and Perspective Map Integration Studies

Several aspects of the use of combined culture (towns, roads, railways, woods etc) and ground height data bases have been under active investigation during 1986; brief descriptions of some of these studies are given below.

- Demonstration software has been developed to show the ability of an integrated 2-D/perspective map system to calculate target ranges and bearings (from specified eye positions) of designated locations at ground

level. The 'target-designation' demonstration allows the user to select up to twenty locations within the perspective field of view from a chosen eye position, calculates the necessary ranges, bearings and coordinates and then displays the target locations on both the perspective and 2-D (plan-position) maps. Additionally, detailed information on four of the targets can be displayed in a strip along the bottom of the perspective image as shown in Figure 5. 'Steppiness' in the picture foreground is being overcome in current work with the adoption of a new algorithm using a grid technique.

- All of the perspective-image generation work to date has been performed on the Graphics Processing System. This is based on a general purpose computer and thus suffers from poor performance when constructing map images. As an initial stage in development towards real-time perspective-image generation, the algorithms and map drawing software have been enhanced with two aims:

a) To increase the image drawing speed (within the limitations of the GPS) by simplifying the software and by investigating high speed area-filling techniques.

b) To improve the quality (resolution, crispness of culture feature edges, etc) of the final image. This becomes particularly important when the range from the eye position to the terrain is less than about a kilometre, when approximations inherent in the culture component become obvious. Several short

Figure 4

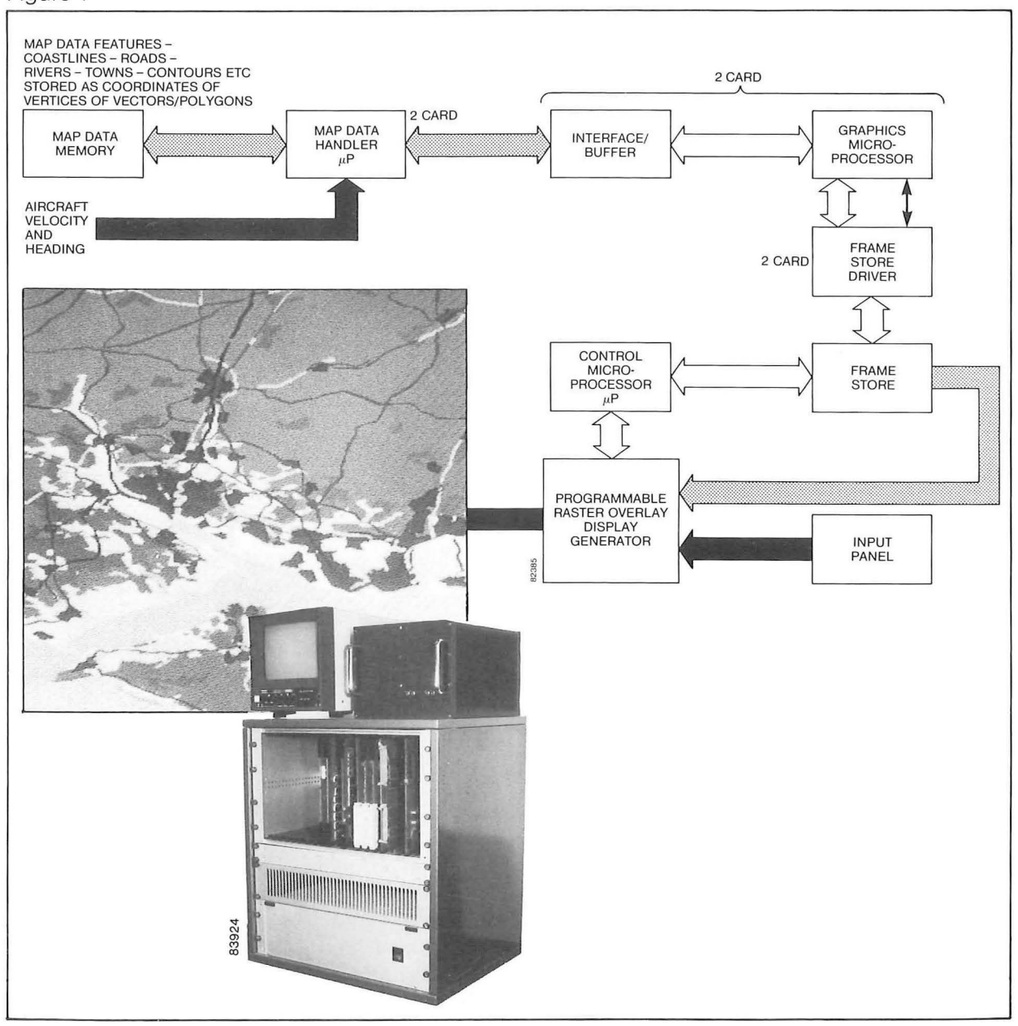
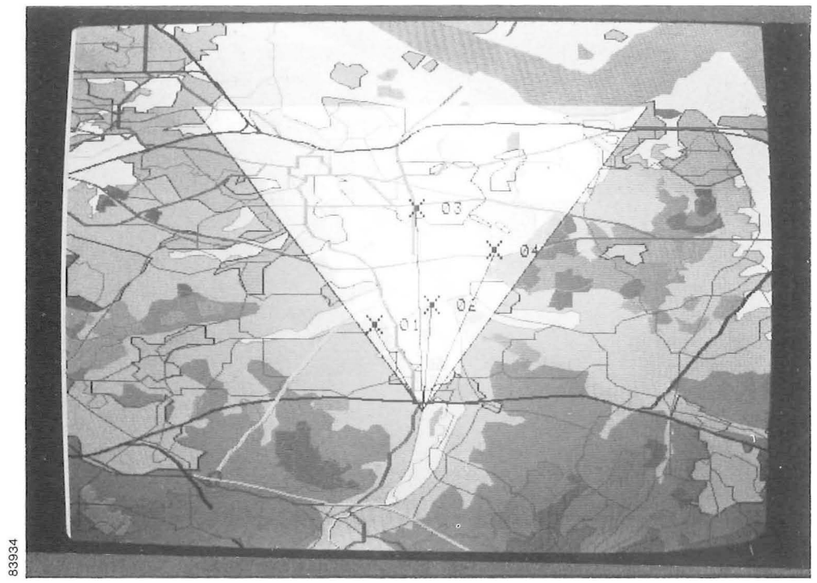


Figure 5



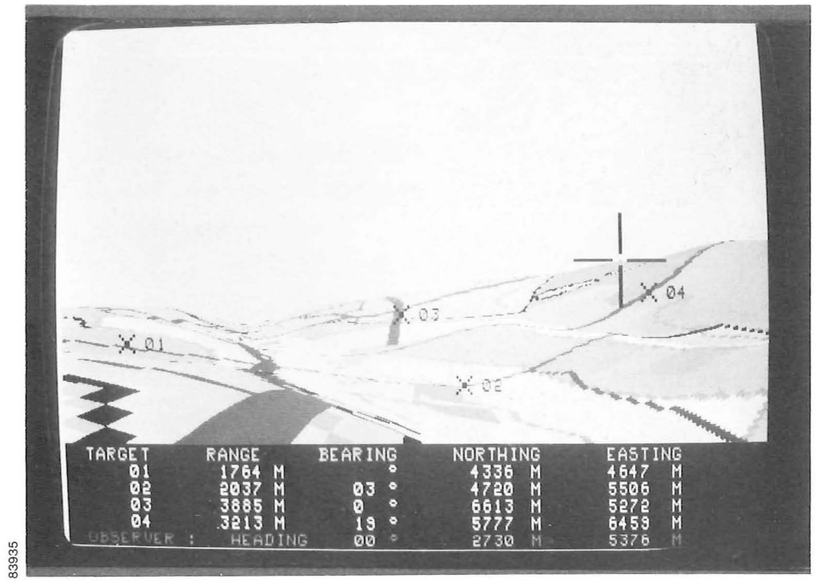
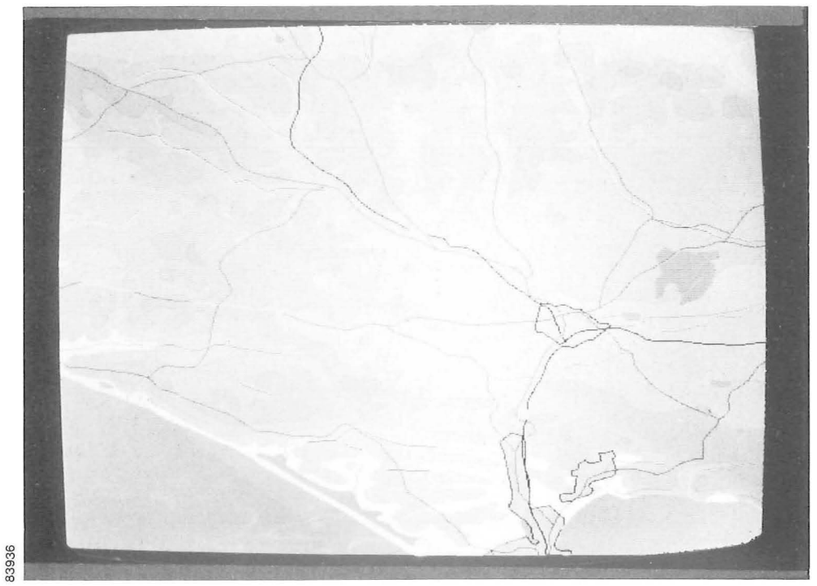


Figure 6



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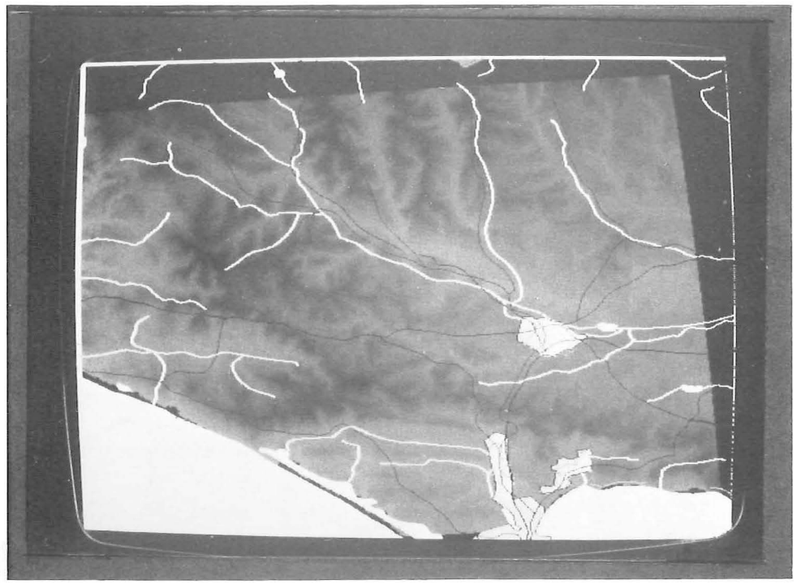

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studies have been undertaken in this area, ranging from modifications to the edge of vector culture features, (such as roads or railway lines), to a progressive change of terrain colour with increasing range combined with hill shading.

- In past years, studies have been undertaken into reducing the memory requirements of a vector culture database. For a combined 2-D and perspective system it is clearly necessary to store a suitable quantity of terrain height data to be used in association with the culture data. Storage requirements for a height database (most conveniently stored as a grid of sampled terrain heights) do not behave in the same way as vector storage of features, and so methods suitable for minimising the height database for any selected area have been developed. This is particularly important for airborne applications of integrated DMDs, where the maximum area of map coverage must be provided from the minimum amount of database memory.
- In order to show the ability of an integrated DMD system to work with dissimilar databases, a demonstration program suite has been developed. These programs, implemented on the Graphics Processing System, use one database for the culture component and a second for terrain height data, both of an area in Dorset, UK. The suite can present perspective images, as viewed from a user selected position, or can superimpose terrain height related overlays such as sun-shadowing on a 2-D map display. Figure 6 shows the map drawn from the first database, and the effect of overlaying height-related shading generated from contour data held in the second database.

Relevant Report:- *262/2066 A Study into Possible Methods of Compressing Digital Map Data*

1.5 Adaptive Image Processing

Studies have continued during the year of the Lateral Inhibition Algorithm (LIA), a technique used by the human eye and fully described in last year's FARL Annual Report. Progressing from the determination of optimum algorithm parameter values, the LIA has been used to extract target-image boundaries from a 'noisy' image. A low-pass filter has been incorporated to make the technique even more noise tolerant by 'blurring' the input image and thus reducing the effects of single-pixel 'noise'.

Investigations of another algorithm, referred to as 'FFCE', have commenced. FFCE has been developed from the LIA by Professor Dick Bosman's team at Twente University in Holland, who wrote the original algorithm, in order to produce a similar edge-enhancement effect in just one computational 'pass'. This algorithm looks very promising because of its speed, and can produce edge-enhancement (and therefore an edge-detection capability) similar to the LIA, although it is currently more sensitive to the nature of input image noise. Trials have been undertaken using each of these algorithms with the target – image progressively moved in the field-of-view to simulate actual movement.

Relevant Reports:- *262/2136 Behaviour of LIA and FFCE Edge Enhancement Algorithms in the Presence of Target Image Movement*

262/1989 An Investigation into the Lateral Inhibition Algorithm

1.6 Terrain Database Study

During the summer the Laboratory assisted FCD in the preparation of a Proposal to utilise a digital terrain height database in a future ground station for a remotely-piloted vehicle.

Relevant Reports:- *Classified*

1.7 Hybrid Navigation Studies

A follow-on contract was awarded by MoD(PE) in July 1986 to carry out further studies for RAE on a navigation fixing technique we have been working on for several years. The technique detects feature boundaries and matches them with a stored terrain database.

Relevant Reports:- *Classified*

2 GUIDANCE AND CONTROL

Project Manager: Brian Wortley
Project Leader: Phil Lamb

2.1 Introduction

Work has continued on the subjects of distributed processing, conceptual Fibre Optic Guided Helicopter Anti-Tank (FOGHAT) missile systems and microprocessor evaluation, as described in the FARL Annual Report 1985.

Work on state vector matrix methods as a means of real-time control system simulation has been carried out and used in conjunction with the Distributed Processing Rig hardware to produce a FOGHAT concept system demonstrator.

The team have also expended considerable effort on designing hardware for two Digital Map System Team tasks; a real-time 2-D Digital Map Display (DMD) system, and the Proposal for a terrain database study for FCD.

An evaluation of the VIPER microprocessor developed by RSRE for safety-critical applications has recently started.

2.2 Microprocessor Evaluation

In recent years there has been a great increase in the number of microprocessor types being produced by a wide range of manufacturers. Some devices are aimed at specific applications, but many are worthy of consideration for future avionics usage. The Laboratory has obtained Company funding to provide a facility for evaluating any new device potentially useful for future Company products.

The Texas 32020 Digital Signal Processor (DSP) has been shown to be very useful in the field of digital control system simulation, although it represents an early example in a fast growing field of DSP development, and newer devices have been recognised as having even greater potential.

A study of the Intel 80286 has given the confidence necessary to use it as the controlling processor of the real-time 2-D DMD System. Preliminary studies of the Inmos Transputer have also been carried out.

Relevant Report: *262/2128 Transputer Evaluation with Particular Reference to Flight Control*

2.3 FOGHAT System Studies

The team has been involved in a combined study with RAE (Farnborough) to investigate specific aspects of a conceptual Fibre Optic Guided Helicopter Anti-Tank (FOGHAT) missile system. A computer simulation of an aerodynamic missile configuration proposed by RAE has revealed certain inadequacies and the design has been modified to improve its control characteristics, and modelled.

In addition, a study of FOGHAT system deployment features has been performed and material provided for a joint GEC Avionics/RAE presentation to interested parties.

A FOGHAT system demonstrator utilising the Distributed Processing Rig hardware has been produced.

Relevant Report:- *262/2158 FOGHAT Missile Configuration and Control Laws*

2.4 Digital Control System Simulator

A digital, general purpose control system simulator has been developed, using discrete time matrix manipulation techniques to implement the 'state vector' first order equation matrix representation of the systems dynamic behaviour. The simulator is implemented on a TMS32020 DSP, which is ideally suited to fast matrix multiplication and can simulate a tenth order system having ten inputs and ten outputs, with an overall iteration rate of approximately 9kHz.

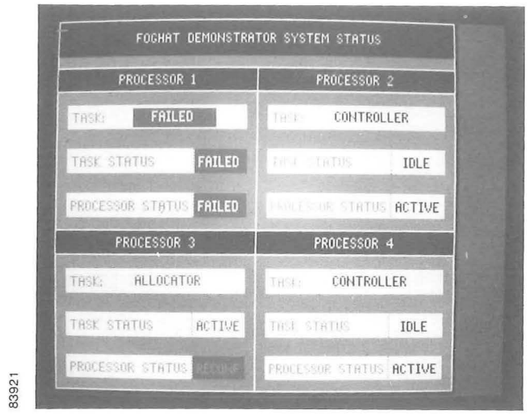
It has also been shown that similar techniques could be used to perform aircraft CSAS and similar functions. A practical demonstration of this has been produced using the Distributed Processing Rig.

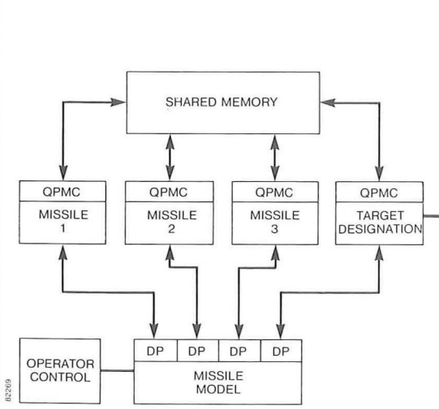
Relevant Report:- *262/2028 Digital Simulation of Multi Input/Multi Output Systems Using Discrete Time Matrices on a TMS 32020 Digital Signal Processor*

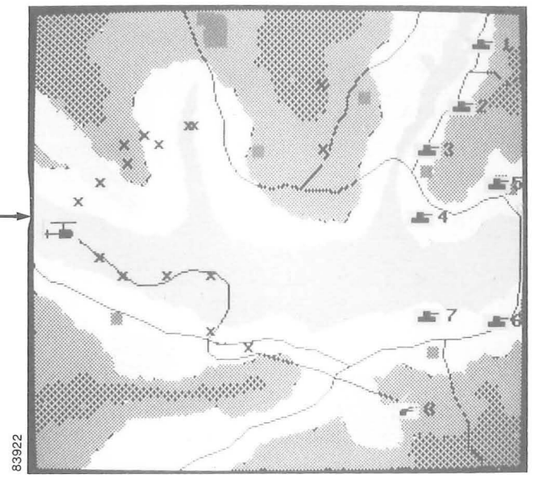
2.5 Distributed Processing

Initial distributed processing studies have resulted in the design of a breadboard Quadruple Port Memory Controller (QPMC) which can provide a means of interprocessor communication in a multiprocessor system. The second phase of the distributed processing work has been involved with the development of a demonstration rig comprising four TMS32020 Digital Signal Processors (DSP) which communicate via four QPMC's and a shared memory module. The rig hardware has provided a means of combining many facets of the work carried out by the team during the last year, and has been configured as a FOGHAT multiple missile command system simulator (see Figure 7) to demonstrate its multiprocessing capability.

Figure 7







The target designation computer may be operator controlled to identify targets and deploy missiles as required. The remaining three processors attached to the shared memory each represent a missile control/autopilot system and will autonomously track the designated target. The flight characteristics of each missile are individually modelled by the TMS32020 simulator to provide full closed loop control.

All target positions, missile tracks etc, are overlayed on the displayed map image. The system is also able to demonstrate reconfiguration and re-allocation of tasks when simulating a processor failure.

The rig hardware remains flexible enough to be reconfigured for alternative multiprocessor studies, if necessary.

Relevant Report: *262/2175 Distributed Processing Final Report*

2.6 VIPER Microprocessor Evaluation

VIPER is a microprocessor which has been designed by RSRE, using mathematical techniques for proof of correctness of operation, and it is intended for use in high integrity applications. It is also designed to operate with a reduced instruction set, and to be programmed in a language called 'NEWSPEAK' (after George Orwell's '1984') which is intended to increase integrity by restricting the type of operation carried out, by not permitting operations which could result in, say, register overflows etc.

FARL is currently engaged in the evaluation of the VIPER microprocessor as part of a co-ordinated evaluation being carried out by a number of potential users and research establishments on behalf of RSRE.

The evaluation is aimed at verifying the processor design and assessing it's suitability for use in future Company products. Initial estimates of the performance of the first 'breadboard' evaluation system provided by RSRE have been made by coding three typical flight control tasks and comparing them with the results obtained for the other processors.

The results indicate an average performance compared with current microprocessors, a number of which offer superior performance. A chip set implementation, which has been produced by our sister company MEDL under contract from RSRE, will be available later this year for evaluation.

Further work will include liaison with other Company divisions in order to ensure that a thorough evaluation is performed. More detailed software implications of the VIPER design are being examined by the Systems and Computing Team.

2.7 Boeing 7J7 Primary Flight Control System

Flight Controls Division (FCD) have recently been awarded a contract by the Boeing Commercial Airplane Company to develop the Primary Flight Control System (PFCS) for the new 7J7 airliner.

The design requirements of the system are for a high integrity (Probability of Loss of Function less than 10^{-10} /hour) and a very high overall MTBF (95% confidence level of 'Despatch with Integrity' after operating for over 60,000 hours i.e. aircraft life).

A very advanced digital flight control system is required with a high level of redundancy so that a number of failures can be absorbed without loss of performance and still meet the specified integrity. The system also requires dissimilarity in the software and the hardware to avoid the possibility of common mode failures and extensive use of VLSI is essential to meet the MTBF requirement.

The team is actively supporting FCD in the VLSI design and digital flight control system areas.

3 POWER SUPPLIES

Project Manager: Brian Wortley
Principal Engineer: Dave Morris

3.1 Introduction

The power supply design group is a small team of engineers whose role is to investigate new technology relevant to power conditioning systems and analogue electronic circuits, as well as providing a consultative design service for Products Divisions in those areas.

Power supply activities over the year have mainly been in support of particular Product Division activities and the main ones have been:

- Design and build the low voltage power supply for the Airborne Display Division's Colour Head-Down Display Unit.
- Continuing support to Flight Controls Division on the A320 Slats and Flaps computer power supply.
- Design and build the PSU for FARL Helmet Mounted Displays.
- Power conditioning studies for FCD's Phoenix programme.
- Research into latest technology components and switching techniques.
- Miscellaneous support to Product Divisions on technical enquiries and proposals.

3.2 PSU for ADD Colour Head-Down Display Unit

A pre-regulator power supply designed for ADD last year has been modified to meet the requirements for a multi-output power supply for the ADD Colour Head-Down Display. This completed CHDD is now undergoing flight trials in both the USA and this country.

A second generation power supply is being built to supply the slightly different voltages to ADD's second generation colour tube.

3.3 FARL Helmet Mounted Displays PSU

A further variant of the PSU designed for the ADD CHDD is being developed for contracts from RARDE and RAE for Helmet Mounted Displays. Again, slightly different output voltages are required and also a pre-converter is required for the RARDE unit to enable it to be driven from 24V dc rather than aircraft power.

3.4 A320 Slats and Flaps Computer PSU

Having designed the power supply, FARL are now assisting on an 'as and when required' basis as the initial production units are built and tested.

3.5 Power Conditioning Studies for Phoenix

FARL have assisted in analysing the Phoenix air vehicle's power generation system and have advised on the most suitable architecture and components.

3.6 Power Supply Research

The team is investigating future technology components and design techniques for even more densely packaged power units. In particular, high frequency switching components are being assessed for power supplies with switching frequencies approaching 1 MHz.

4 DISPLAYS

Project Manager: Trevor Hall
Project Leader: Dave Thorndycraft

4.1 Introduction

The Displays Team has continued to pursue projects in both display symbology generation and display head technology.

Good progress has been made in the development of a frame store architecture display generator which is being used to evaluate new display generation components and display technologies. This development has used the considerable experience gained from the previous development of the Programmable Raster Display Generator (PRDG).

This year also saw the completion of a programme to provide an enhanced PRDG system and accompanying software to Flight Controls Division, where it has been successfully used in their Advanced Ground Station.

The work on display head technology consists of both CRT electronics development and flat panel research. The CRT work has resulted in the production of two flightworthy Colour Head-Down Displays for ADD and the development of miniature CRT displays for helmet mounted displays.

In the area of flat panel research, the team has been continuing the RAE funded programme for Liquid Crystal Display standby instrument evaluation. In addition, a collaborative venture has begun with Airborne Display Division in the study of matrix displays for future CRT replacement.

The detailed design for the electronics for two new Helmet Display Systems for RARDE and RAE has also been undertaken.

4.2 Display Generation Techniques

In the past year, the team has designed and commissioned a Programmable Video Development System (VDS) which is based on a frame store architecture. The system is a 'test bed' for evaluation of current and forthcoming graphics processor chips and peripheral devices and is shown in Figure 8. The Thomsom CSF 68483 device has been extensively evaluated and benchmark timings established, and both static and dynamic symbology have been generated as part of these benchmarks. Texas Instruments graphics generation chips have recently become available and will be evaluated shortly.

The design of the VDS is such that both CRTs and matrix addressed panels may be driven. Recently, the team has successfully used the system to drive an electroluminescent display panel, and other technology flat panels will be evaluated in the near future.

The VDS is also capable of providing map overlay generation as part of a Digital Map Display System

A derivative of the VDS to provide a Helmet Symbology Generator for use with the LED Matrix Helmet Mounted Displays supplied to RAE (Farnborough) has been recently proposed to RAE as part of a follow-on programme.

Relevant Report:- 262/2164 Video Development Systems Design Study

4.3 Colour Head-Down Displays

The team has recently completed designing, building and commissioning a flightworthy Colour Head-Down Display (CHDD) in collaboration with ADD. This display is based on a Matsushita 5 inch delta gun tube which has been installed in a rugged assembly, with deflection coils supplied by Rank Brimar Ltd. The CHDD has been successfully flown on a Grumann A-6 Intruder aircraft in the USA and is due to be flown by RAE (Farnborough) in their Hunter aircraft to provide the Map Display for the Digital Map Display Generator developed by Guidance Systems Division.

Figure 9 shows details of the rugged construction of the unit, and the photo in the 'Management Summary' in this report shows the unit delivered to ADD.

4.4 Flat Panel Displays

The team has collaborated with Powerplant Systems Division to provide RAE (Farnborough) with an LCD Standby Instrument Panel for flight trials in their Hunter aircraft. A chassis has been constructed on which the PSD Standby Instrument Panel is mounted, the chassis being designed so that it could be fitted into the cockpit in place of the existing High Contrast Display Unit (HCDU) supplied by FARL several years ago. The PRDG which currently drives the HCDU has been modified to enable it to drive the LCD panel.

Work has also continued on an RAE contract to evaluate LCD Standby Displays in their flight simulator. Figure 10 shows a new 'three in one' display using one LCD panel with a suitable cut out mask. The display driver chips are mounted on the back of the display.

Work on other display technology is in progress,

Figure 8

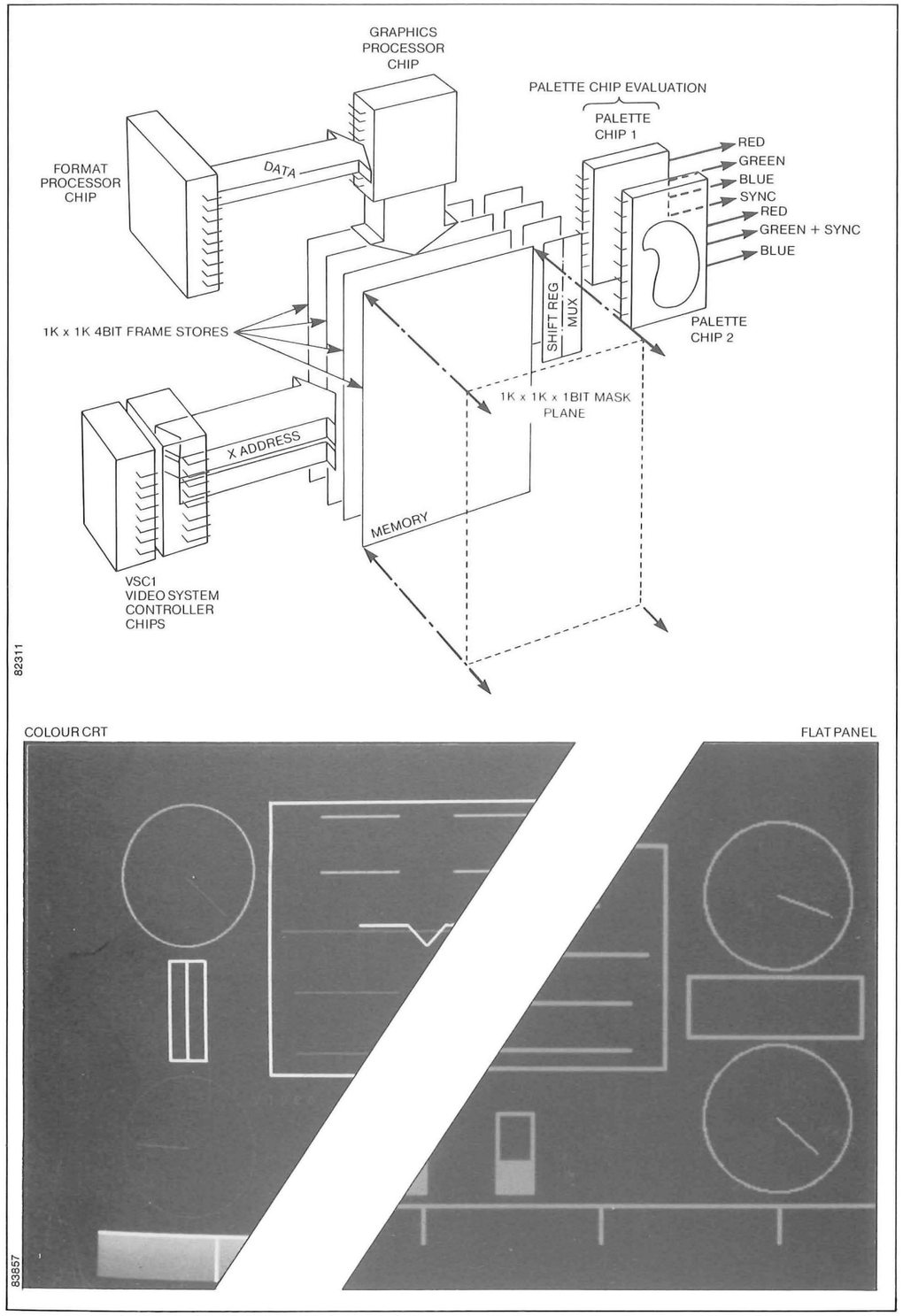


Figure 9

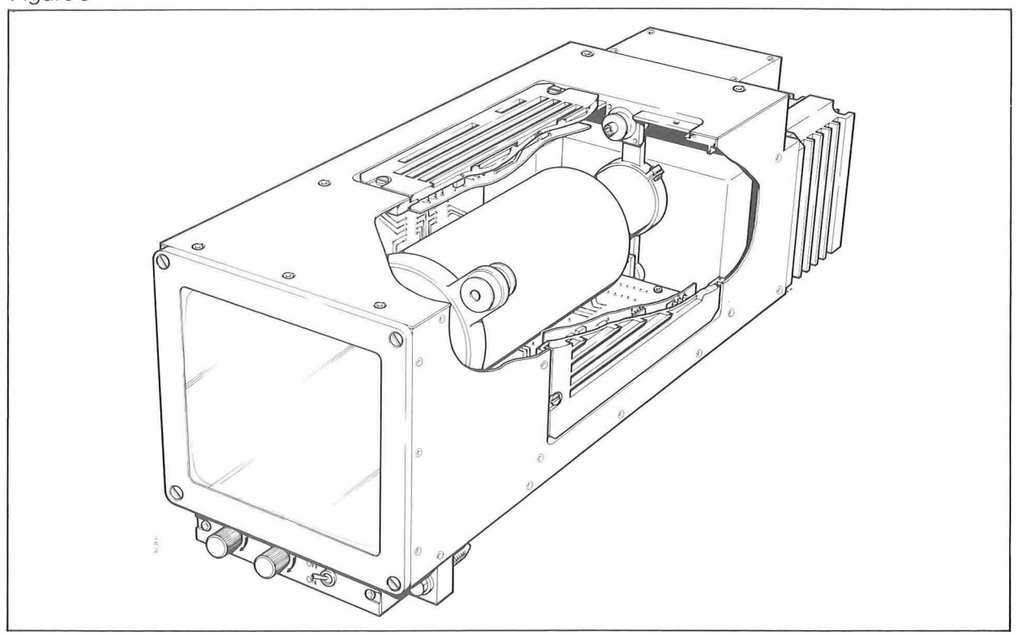
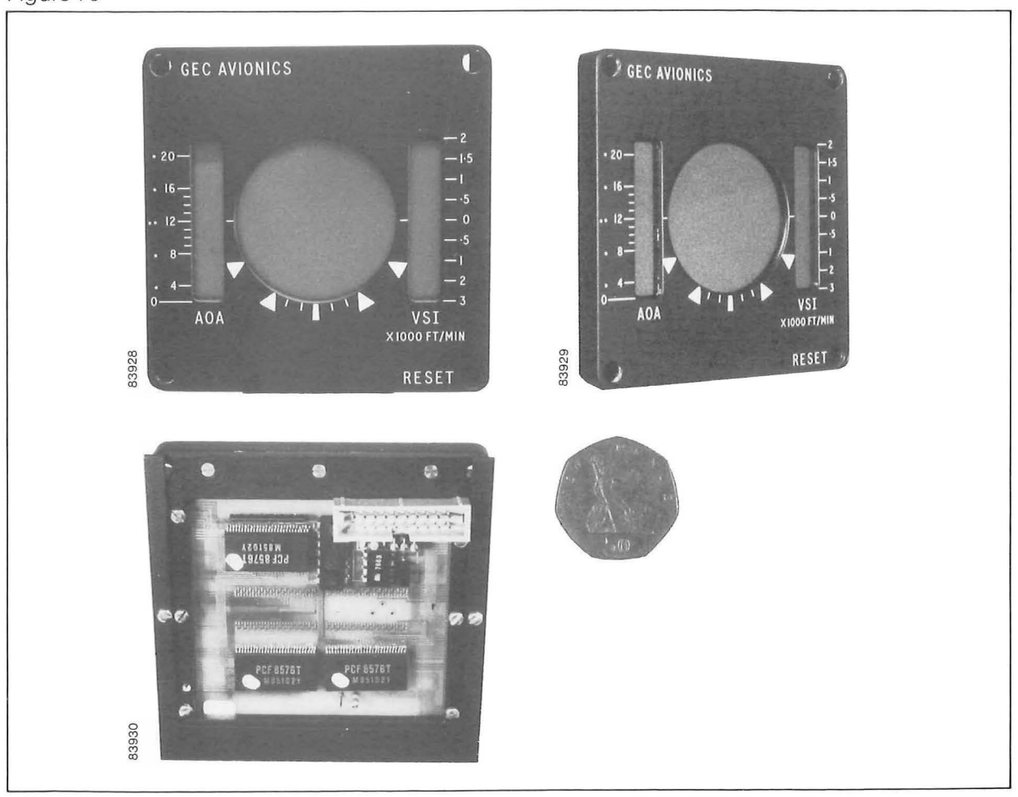


Figure 10



with a Company funded collaborative programme with Airborne Display Division.

An evaluation of electroluminscent (EL) matrix displays is being performed by the team to ascertain the future suitability of EL as CRT replacements. This evaluation will involve studies into driving techniques to establish the feasibility of, for example, producing grey scales and minimising the 'steppiness' of matrix displays by using anti-aliasing techniques.

4.5 Electronics System for RARDE Helmet Display

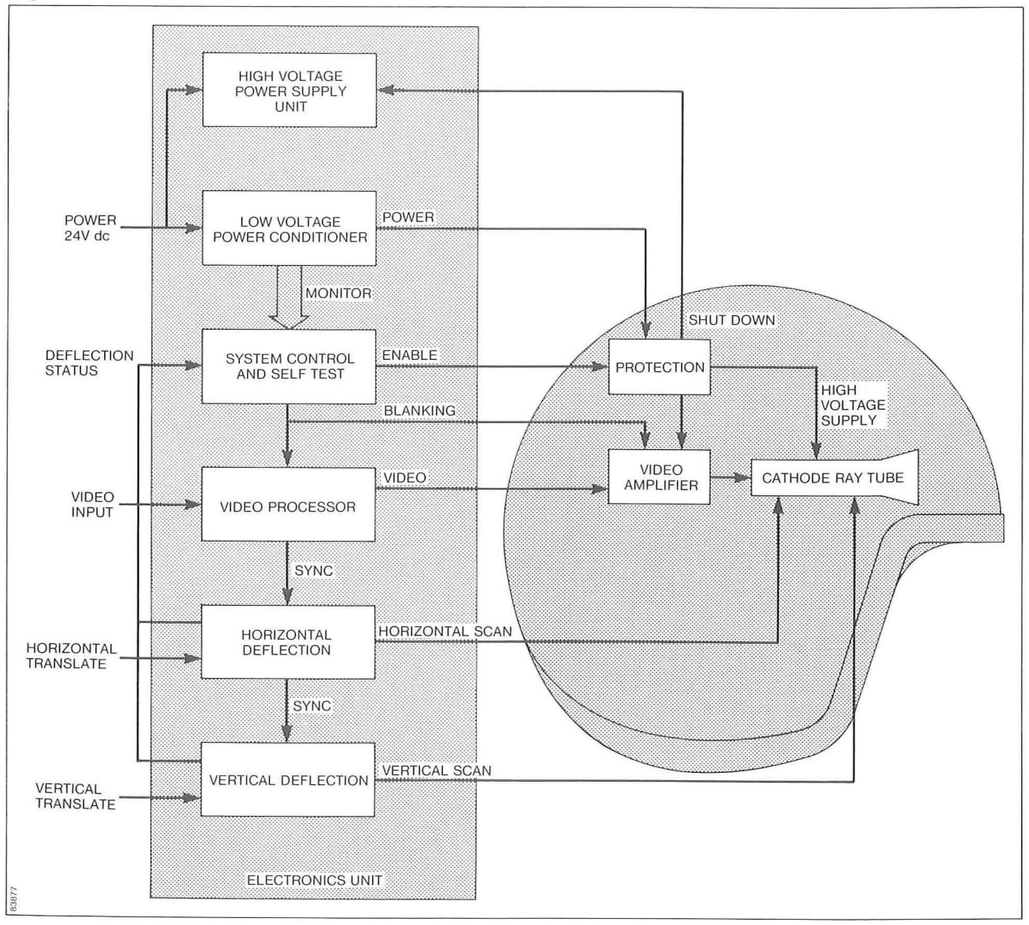
The electronic system comprises two elements; a CRT module which is mounted on the Armoured Fighting Vehicle (AFV) Helmet, and an Electronics Unit (EU) which is remote from the Helmet. Figure 11 shows a block diagram of the system.

The CRT module contains the final high voltage section of the Video Amplifier to minimise interconnection capacitance and to ensure maximum video bandwidth with minimum power requirements. It also incorporates electronic shut down of the CRT drive during system faults and accidental helmet disconnection, upon receipt of a control signal from protection circuitry in the High Voltage Power Supply Unit in the EU.

The EU contains all the power conditioning, including the high voltage power supply unit, deflection amplifiers, video processing and display control modules, and provides controls for contrast, brightness and line standard selection (625 line/50Hz or 875 line/60Hz). It operates from a 24V dc supply.

Design of the electronics system is complete and manufacture is in progress, with critical circuits being breadboarded where necessary.

Figure 11



4.6 Electronics System Design for Binocular HMD

The Electronics Unit has a somewhat greater capability than the RARDE system described above as, apart from the twin CRT drive, it can also write in either cursive or raster mode.

The detailed design has now been completed and submitted to RAE together with a cost proposal to build a flightworthy system for the next phase of this programme. The design has been accepted by the RAE and authorisation to build a flightworthy prototype is expected.

4.7 Other Activities

Support of the existing PRDG's being used by RAE has continued, and involved completion of enhancements to the Matrix Display Symbol Generator, which in turn was a derivation of the PRDG. Both Display Generators were used by RAE for their exhibit of Advanced Displays at the SBAC Exhibition in September 1986.

The team also has a representative on the video transmission working group of the Avionic Systems Standards Committee (ASSC).

5 SOFTWARE AND COMPUTING

Project Manager: Trevor Hall
Project Leader: Renny Smith

5.1 Introduction

The last year has seen a considerable growth in the activities of the Software and Computing Team and the instigation of new working methods. Our general plan is to try to divide the team's activities evenly between research into new software techniques and development of software for external projects. The latter is important because it provides the opportunity to apply the new techniques being studied and, just as important, ensures that the team remains aware of the 'real world'.

The main activity on the 'research side' has involved the considerable preliminary work leading up to the evaluation of a Software Engineering Workcentre aimed at increasing software productivity. Other activities have included an investigation into software prototyping and the continuation of Ada studies.

The main development project undertaken over the last year has been the provision of the software for Flight Controls Division's A320 Test Set. Another project was the provision of test set software for FCD's Advanced Ground Station (AGS). This year has also seen the completion of the display software for the AGS.

5.2 Software Engineering Workcentre

The team is currently evaluating a Software Engineering Workcentre (SEW) aimed at increasing software productivity. The evaluation is by means of a pilot project which is to produce display software, written in Ada, for Airborne Display Division's 1750A processor based Head-Up Display.

The SEW, which is a multiuser development system based on a Sun Microsystems' workstation, has been provided by our sister company, GEC Computers Ltd, and is shown in Figure 12 The main function of the SEW is to provide the engineers with a user friendly and interactive environment. The intention is for the SEW to reside between the engineers and the existing computer resources such as a VAX main-frame computer and perform the time consuming input/output tasks. These tasks also include very interactive development tools such as design and documentation aids which are poorly supported at present.

The display software produced will conform to UK MoD requirements (referred to as UKSS - UK Symbology Software). The first phase of this project will be to produce an emulation of the HUD display hardware on the SEW. The UKSS will then be demonstrated on the SEW with suitable software test harnesses exercising the display.

The development of the UKSS will use comprehensive 'design tool' software which provides a drafting aid to assist the engineer in interpreting the customers requirements (requirements capture).

Relevant Report: *262/0353 Proposal for SEW Evaluation*

5.3 Software Prototyping

A private venture study is currently underway to investigate software (or rapid) prototyping. Software prototyping uses powerful functional languages such as LISP and PROLOG to give the engineer confidence at the design stage that his software will work. The benefits of such techniques will be twofold; firstly, the design of the software can be shown to meet the requirements before detailed coding has commenced and, secondly, the customer can be shown, again at an early stage, a model of the final system.

5.4 A320 Test-set Functional Software

A programme to develop Test-set Functional Software (TFS) for FCD's A320 Engineering Development Test Set is nearing completion. The test set provides all the interfaces to the A320 Slats and Flaps Control Computer and provides a simulation of the aircraft, including the power controllers, wing tip brakes etc.

The software (which will eventually reside on a 68000 processor) was developed on the VAX with configuration control being maintained using ADD's CC2 package. Documentation is in accordance with Joint Services Publication (JSP) 188.

Relevant Report: *262/2083 Software Structure Document for the A320. SFCC Test-set Functional Software*

5.5 Advanced Ground Station

The team has been involved in two aspects of the Flight Controls Division's Advanced Ground Station programme.

Firstly, as a conclusion to the development of the display software, assistance has been provided for the integration of the display hardware and software into the AGS.

Secondly, the implementation of an Active Test Set was undertaken. The software which was for a 68000 processor, was held on a Motorola VME10 microcomputer. The VME10 and Active Test Set software simulate the remote aircraft telemetry and are required to test the AGS.

Relevant Reports: *262/2043 Advanced Ground Station Test Simulation Software Requirements*

262/2113 Advanced Ground Station - Active Test-set Software Description: Level 3 Documentation

5.6 Other Activities

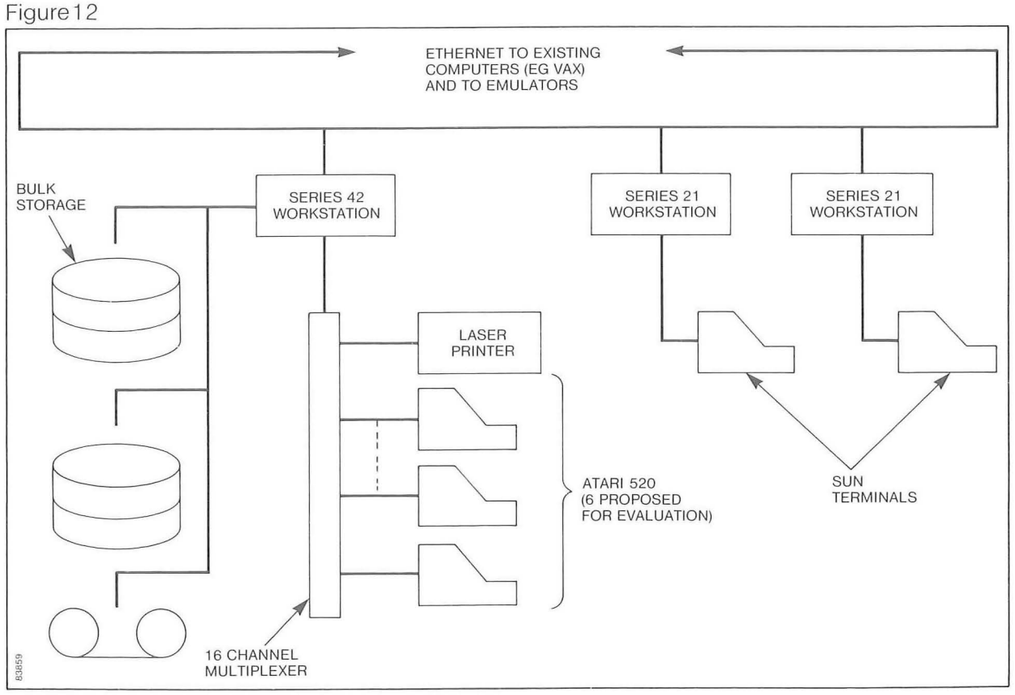
The team's expertise in Ada has been used to undertake a detailed survey of Ada compilers for FCD, to assist in the generation of the proposal to Boeing for the very high reliability flight control system for the 7J7 aircraft. The capabilities of existing and potential compilers for targeting to 1750A and 68000 processors were assessed.

Other work has involved an appraisal of the programming languages for the RSRE VIPER processor. As already mentioned in Section 2, VIPER is aimed at high integrity applications and results from a mathematically proved design approach. The objective of the appraisal was to identify possible software coding standards for the use of VIPER in safety critical applications.

Three languages are associated with VIPER: VITAL, a basic assembler; VISTA, a structured assembler; and NEWSPEAK, a high level language which is claimed to be highly predictable. NEWSPEAK will also provide extensive compile-time analysis.

Relevant Report: *262/2142 Assessment of the Ada-1750A Cross Compiler market*

Figure 12



6 REMOTE VIEWING SYSTEMS

Project Manager: Brian Wortley
Project Leader: Alex Cameron

6.1 Introduction

There are a number of projects which come into the general category of remote viewing systems and which share the following characteristics.

- The scene is viewed by TV or infra-red camera(s) remotely controlled by the operator.
- The system has a Head Position measuring system and the camera mount is slaved to the operator's line of sight.
- The displayed image (or images in the case of a stereo, or binocular system) is optically collimated and presented close to the operator's eyes.

The display may be mounted on a helmet so as to move with the operator's head or, as in the case of our underwater stereo system, on a display mount which he hand steers to follow his line of sight.

- The display can have symbology overlaying the TV picture to present additional information to the operator or to display an aiming graticule for 'target' designation, stereo ranging for instance.

The operator may be situated fairly close to the cameras as with a helicopter pilot with Helmet Mounted Display and Helmet Position Sensor controlling a gimballed camera (low light TV/FLIR) slaved to his line of sight. Alternatively, the operator may be a kilometre (or more) away, with the camera(s) mounted on an unmanned vehicle operating in a hostile environment, for example a battlefield on land, or at great depth at sea.

Other applications include nuclear reactor inspection where the separation between remotely controlled camera mount and the operator is of the order of 50 metres.

6.2 Remote Underwater Stereo Viewing System

The main aim of the advanced underwater stereoscopic viewing system is to provide the operator of a remotely controlled underwater vehicle with a high quality stereoscopic view of the underwater worksite; in addition, a high speed pan and tilt gimbal allows the underwater cameras to be slaved to the position of the hand steered display unit which is situated inside the control cabin on board ship. This arrangement provides the user with a strong impression of actually being at the worksite by allowing him to 'look around' and also greatly facilitates the performance of manipulative tasks by presenting him with a three dimensional view of the task.

This development was started in 1982 and followed the earlier development and trials of a monocular helmet display system controlling an RCV225 'Flying Eyeball' submersible. The programme was supported by the Department of Energy, (OSO), as part of a long term programme to advance underwater viewing technology – our first contract was awarded in 1980.

Laboratory commissioning of the system was completed in November 1985; during the commissioning period over a hundred people had the opportunity of using the stereoscopic viewing system and of passing their subjective comments regarding its performance. Of this group, only those with acknowledged eye defects had any difficulty in obtaining a three dimensional image. Those with normal eyesight found the images easy to fuse and did not suffer from any eyestrain problems.

After preliminary pressure tests on each separate item of the underwater system at the GEC Avionics' facility, Nailsea, the system was taken to Slingsby Engineering Limited, North Yorkshire, for a fully operational pressure test during December 1985. The system was pressurised to the equivalent of a depth of 100 metres of water, and operated correctly.

Having proved the operation of the system at pressure, it was decided to subject the system to trials on the Company's 'DRAGONFLY' submersible during the latters own North Sea trials. The stereoscopic viewing system was therefore adapted to fit the vehicle, installed and partially commissioned during the Dragonfly's performance trials at Peterhead Harbour towards the end of January 1986. Both the stereoscopic viewing system and the Dragonfly were then shipped out on the STENA SEASPREAD service vessel to the THISTLE Oilfield, which is north of the Shetlands. During the course of the Dragonfly trials (February and March 1986), stereoscopic viewing was used on a number of occasions in the performance of typical underwater tasks, such as attaching and fastening shackles to objects, and general inspection work.

Apart from the need to replace a faulty camera cable, the viewing system proved to be extremely robust and performed very well despite being launched with Dragonfly into very rough seas. The main conclusion from these trials was that high quality stereoscopic viewing greatly enhanced the performance of tasks using remotely controlled manipulators.

Figures 13, 14, 15 show the equipment on the STENA SEASPREAD.

Further trials of the stereoscopic viewing system are currently being discussed with the MATE

Figure 13

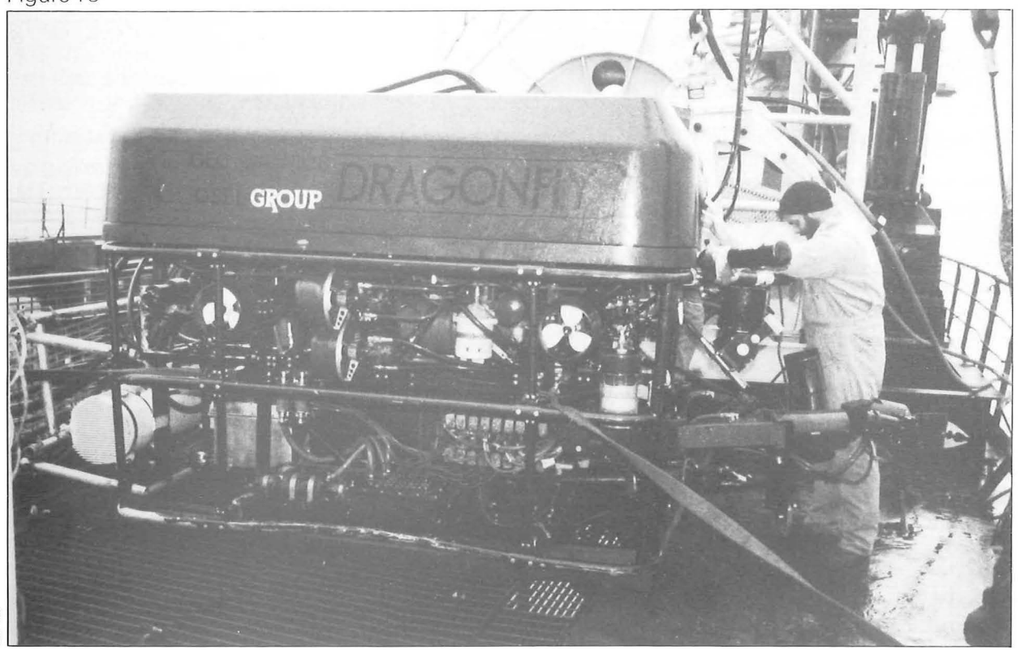


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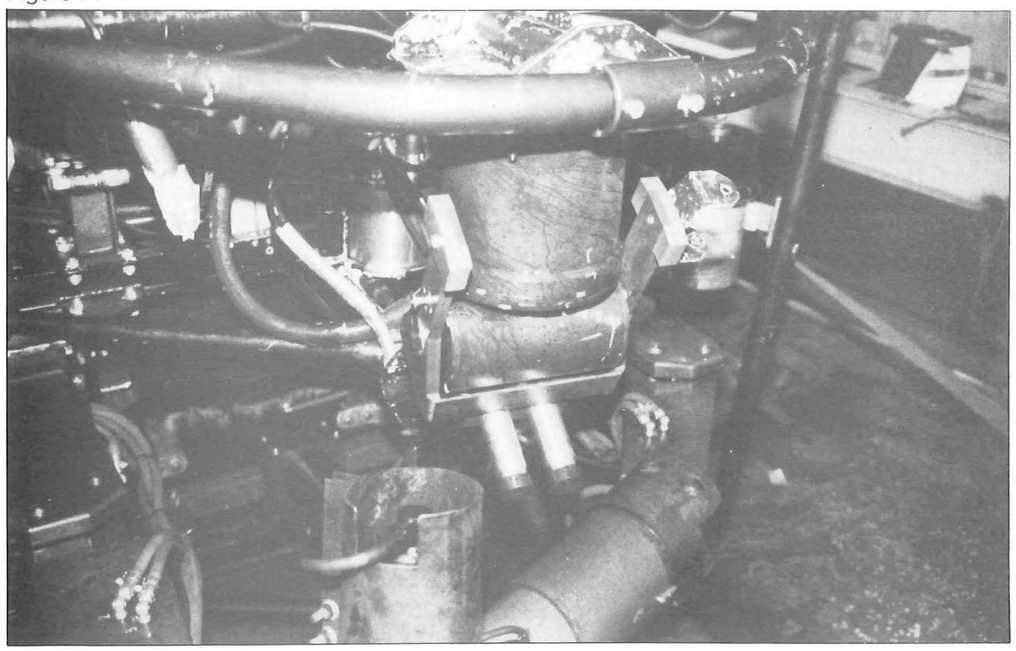
Figure 14



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Experimental Diving Unit at HMS Vernon, Portsmouth and with RARDE, Chertsey.

Relevant Reports:- *262/0350 Proposal for Stereoscopic Viewing System Trials on the Dragonfly ROV*

262/2076 Stereoscopic Viewing System Trials Report

262/2057 Executive Summary of the Underwater Stereo Viewing System

262/2046 Final Report for Advanced Stereoscopic Underwater Viewing System

6.3 Stereo Designation/Ranging System

A technique is being developed for electronically overlaying a separate cross in the field of view of each eye to enable the stereo display to measure range.

The superimposed crosses can be 'zoomed' out or in until the composite cross appears to overlay the 'target' or centre of interest, when its range is readily computed from the perspective geometry (Figure 16).

This work is being carried on a Company funded basis and the electronic hardware is currently being commissioned.

The technique has particular application when the system is used in conjunction with a remotely controlled manipulator, as the 'target' line of sight and range can be converted into x, y and z coordinates to 'command' the position of the manipulator.

6.4 Remote Stereo Viewing System for Nuclear Reactor Inspection-CEGB

Detailed technical discussions are being held with the Central Electricity Generating Board (CEGB) on the application of the Remote Stereo Viewing System to nuclear reactor inspection. The hand steered Display System would be more or less identical with the system developed for underwater use but a much more compact Camera Mount is required to probe into the Reactor.

A suitable design for a very compact camera mount, less than 200mm (8ins) diameter, has been produced by Mr S M Ellis, the Company Design Consultant.

6.5 Monocular Helmet Mounted Display System for RARDE

As part of a research programme on remotely controlled ground vehicles, RARDE (Chertsey) have awarded a contract to FARL to provide a monocular Helmet Mounted Display system which will form part of a visually coupled remote control system.

A two-axis gimbal carrying a conventional TV camera (or cameras), or other sensors is mounted on a remotely controlled vehicle. A radio data link between the vehicle and the control cabin allows

Figure 15

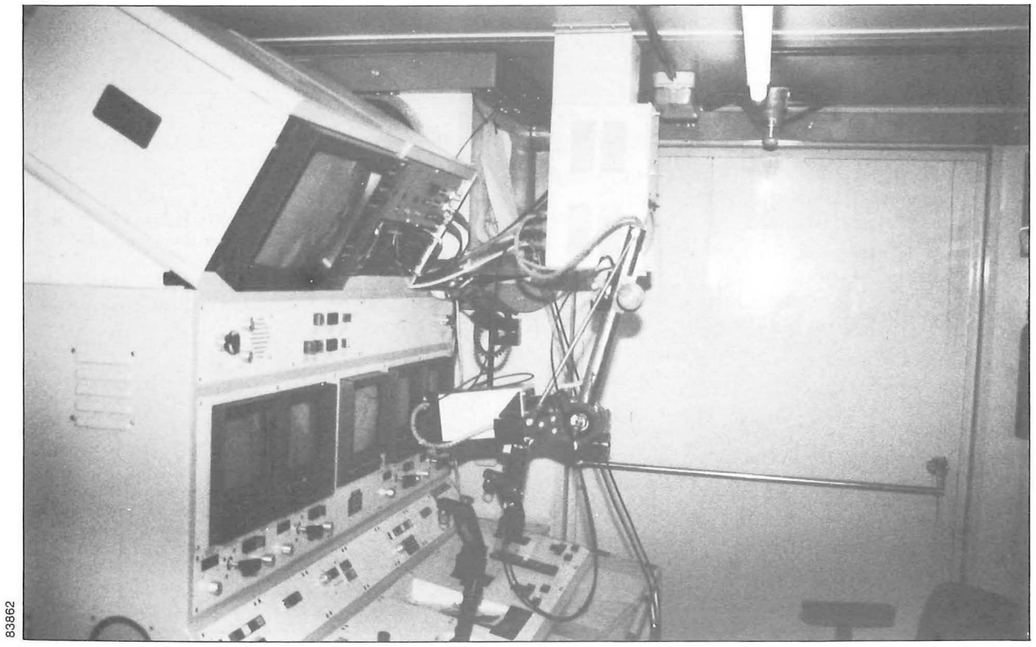

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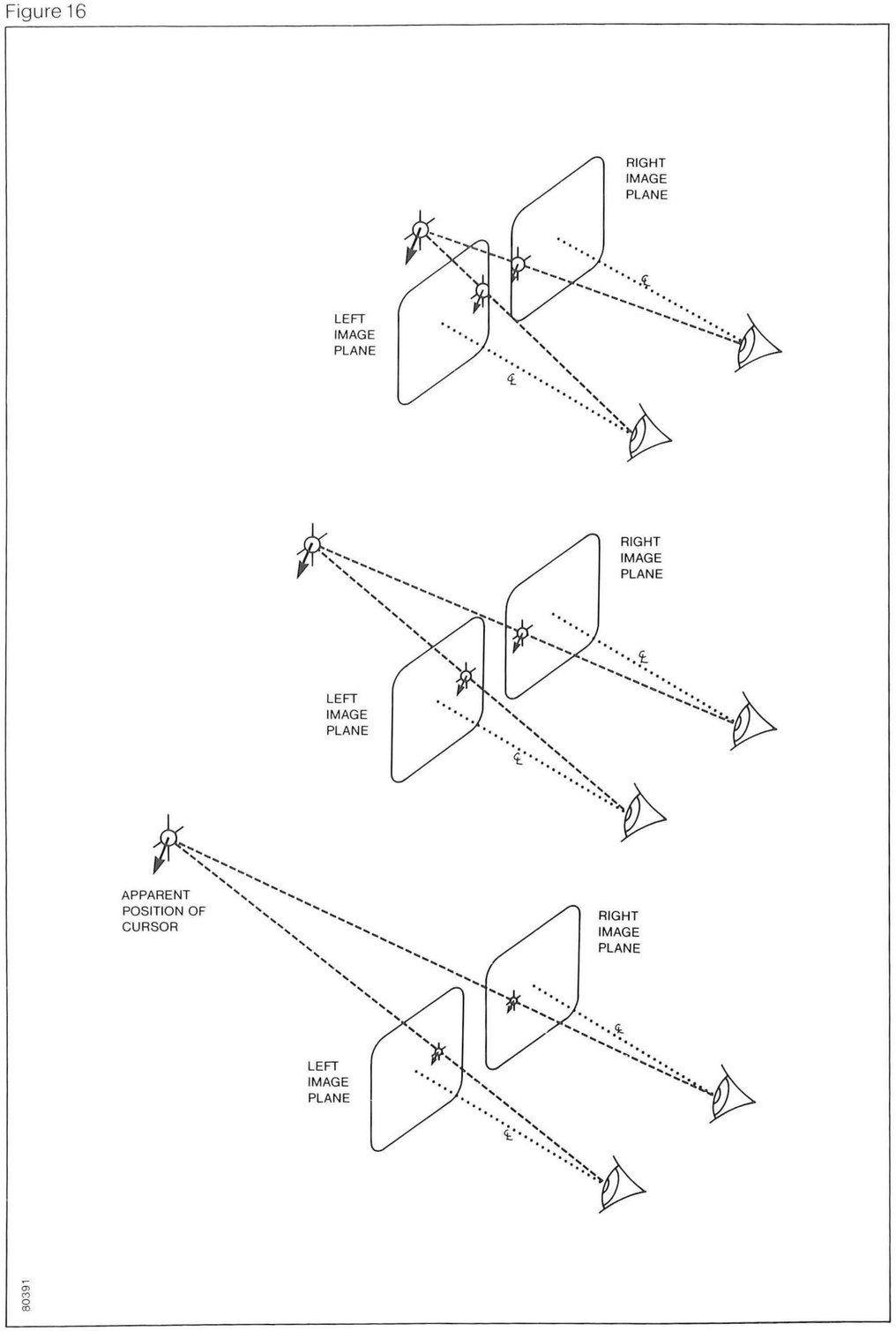
Figure 16



control signals to be transmitted to the vehicle and camera video signals to be received. The gimbal is slaved to a helmet pointing system so that it follows the operator's line of sight. The video output from the camera is fed via the radio link to the Helmet Mounted Display system to provide the operator with a raster picture of the real world from the vehicle's position.

For this application the HMD System comprises the Helmet Display and an Electronics Unit (EU).

Figure 17 illustrates the ergonomic model of the HMD.

Figure 17

The system has a dual line standard capability and can receive either 875 line/60Hz or 625 line/50Hz video. Inputs are provided to enable the raster to be translated and rotated under external control, allowing the displayed image to be spatially stabilised.

The main features of the Helmet Mounted Display, which is similar to the binocular design, are summarised in the next section.

6.6 Binocular Helmet Mounted Display System

In April 1986 FARL were awarded a contract by RAE (Farnborough) to carry out a design study of a Binocular Helmet Mounted Display system. This study has been completed and a follow on contract for the manufacture of the display system is anticipated.

The Binocular Helmet Mounted Display system will form part of a visually coupled system being assembled by RAE (Farnborough) for use in an experimental Lynx helicopter.

Figure 18 is a block diagram of the system which comprises the Helmet Mounted Display, the Electronics Unit and the Pilots Control Panel.

A three-axis gimbal which can carry conventional TV cameras, FLIR sensors or low light cameras will be mounted in the nose of the helicopter. Initially, a single sensor will be fitted on the gimbal but it is understood that two sensors could be installed later to assess the benefits of stereo imagery. The gimbal will be slaved to a Helmet Pointing system so that it tracks the pilot's line of sight. Video outputs from the camera are fed to the Helmet Mounted Display system to provide a raster picture of the real world to the pilot. The system can be extended to include a Programmable Raster Display Generator which would provide symbology overlaid on top of the TV image. For daytime use the HMD can also display standard slow cursive symbology from an external Cursive Symbology Generator.

The Helmet Mounted Display is shown in Figure 19 together with a table summarising the main features. It is designed to be fitted to a Mk4A helmet via a Stage 1A mounting plate and modified visor attachment points.

The optical assemblies are bonded into a rigid brim structure which also contains compact CRT drive electronics, resulting in a rugged lightweight system. The brim assembly has been designed so that it is easily removable from the helmet to permit the use of Night Vision Goggles which also interface with the Stage 1A mounting plate.

Relevant Reports:- *262/2081 Binocular Helmet Mounted Display System Optical Design Report*

262/2114 Binocular Helmet Mounted Display System Electronic System Design

Figure 18

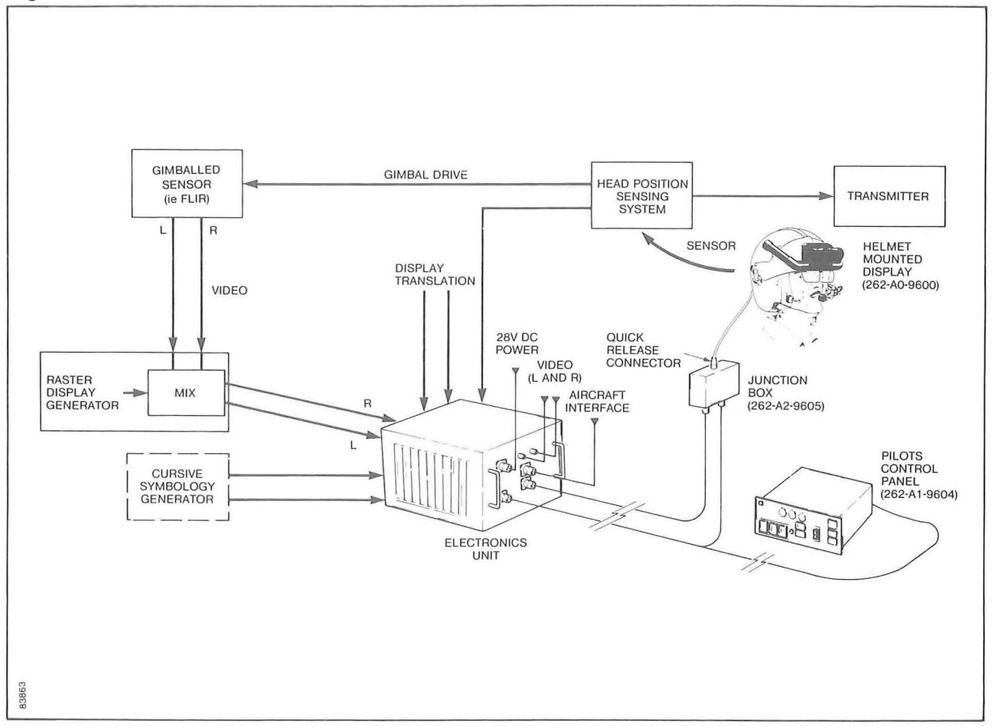
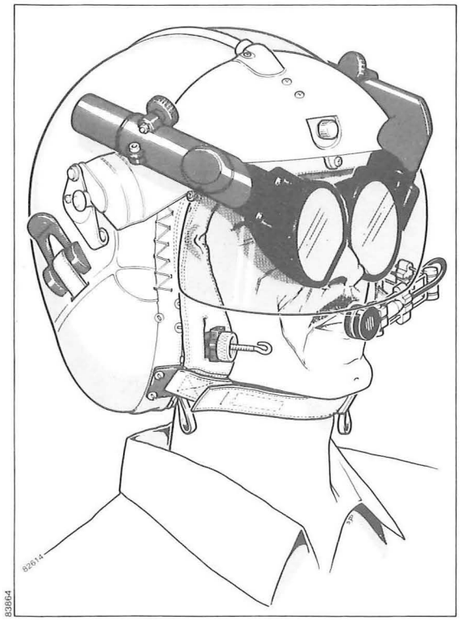


Figure 19



Binocular Helmet Mounted Display Specification	
Field of View:	40° Horizontal x 30° Vertical
Exit Pupil:	14 mm diameter
Eye Relief:	35 mm (NBC mask compatible)
CRT Size:	19 mm active screen diameter, 1 inch CRT's
Distortion:	Less than ±1%
Accuracy:	Better than ±1 mRad
Resolution (Optical):	Diffraction limited
Binocular Disparity:	On-axis: less than ±1 mRad Off-axis: less than 8 mRad divergence, 20 mRad convergence
Weight:	Less than 900 gms
Adjustments:	Accommodates >90% of users

7 INTELLIGENT KNOWLEDGE BASED SYSTEMS

Consultant Engineer: Frank Oates
Project Leader: Elizabeth Doe

7.1 Introduction

During the past year the IKBS team has been involved in both externally funded and Company funded work and has acquired a 'LISP' Workstation for its future development work.

7.2 IKBS for Fixed Wing Aircraft

Following a competitive tender, FARL has been awarded a nine month IKBS Application Study contract by MoD(PE). This study contract into the application of IKBS to the cockpit systems of fixed wing aircraft has been divided into two stages: The first stage is aimed at examining a small group of potential applications in order to select one which is worthy of further examination while the second stage is aimed at a more detailed study of the application selected.

The group of applications considered during stage one were:-

- Navigation systems
- Displays management and weapon aiming
- Engine monitoring
- Stores management
- Communication systems management
- Threat assessment and ECM
- Tactical planning, targetting and route planning.

Assessment of these various applications was based on the following criteria:-

- **Potential Benefits –** workload reduction, improved human interfaces and increased effectiveness.
- **IKBS Content –** the need to apply IKBS techniques, the predicted complexity of the IKBS system.
- **Feasibility –** the availability of hardware, software and methodologies, as well as the amount of effort required to produce the system and its amenability to the aircraft cockpit.
- **Cost –** the predicted cost of developing and implementing the system.
- **Timescales –** the time likely to elapse before the arrival of new Artificial Intelligence technologies required by the application, as well as the time required for development and implementation of the system.

Stage One has now been completed and the application for further study during Stage Two has been selected. A report on Stage One of the work is currently being prepared and will form part of the Final Report for this contract.

Stage Two is currently underway and is aimed at studying the application of IKBS technology to a Displays Management System. It is intended that this should form the basis of a comprehensive cockpit management system, to be studied and implemented in future stages.

The Company's expertise in HUDs, HDDs, Digital Map Displays, Stores Management and Navigation Systems, Weapon Aiming and Flight Control Systems, Flight and Engine Instruments, and Displays puts us in a very strong position to exploit IKBS technology effectively for avionic applications.

7.3 Flight Planning Aid

The Company funded work has encompassed the completion of the first prototype of a ground based route planner for a single jet aircraft on a low level mission. This was developed using POPLOG on the Vax 780 and used a BBC microcomputer as a display head for the map and the route generated.

This system has been developed to evaluate and suggest alterations to a route input by the user. It makes use of a number of independent sources of knowledge concerned with threat avoidance, hazard avoidance and ground clearance which assess possible alternative routes. The optimum route is then selected from these.

Figure 20 shows the Route Planning Display.

7.4 LISP Workstation

Having proved the practicability of the Flight Planning Aid system, it was decided to expand it, so that the map could also be used to input waypoints. For this type of application a single user graphics workstation was required and it was decided that a LISP Language Operating Workstation was necessary for speed of execution and the ability to express the system functionally.

The machine selected was a Texas Instrument's EXPLORER LISP Workstation connected via a DMA link to a Raster Technologies Inc. 'One/75' colour graphics system; this also provides a powerful development environment.

It is proposed that the Colour Graphics System displays the map and routes, and that the workstation be used to drive a cursor over the map, allowing waypoints to be input via a 'mouse'.

The system will have three modes of operation:

- the user plans a route and the system comments on it
- the system plans a route between two waypoints
- the system replans a previously planned route, given additional information

Relevant Reports:-

262/1820 Preliminary Description of a Knowledge Based Flight Planning Aid

262/1984 Intermediate Report – Software Description

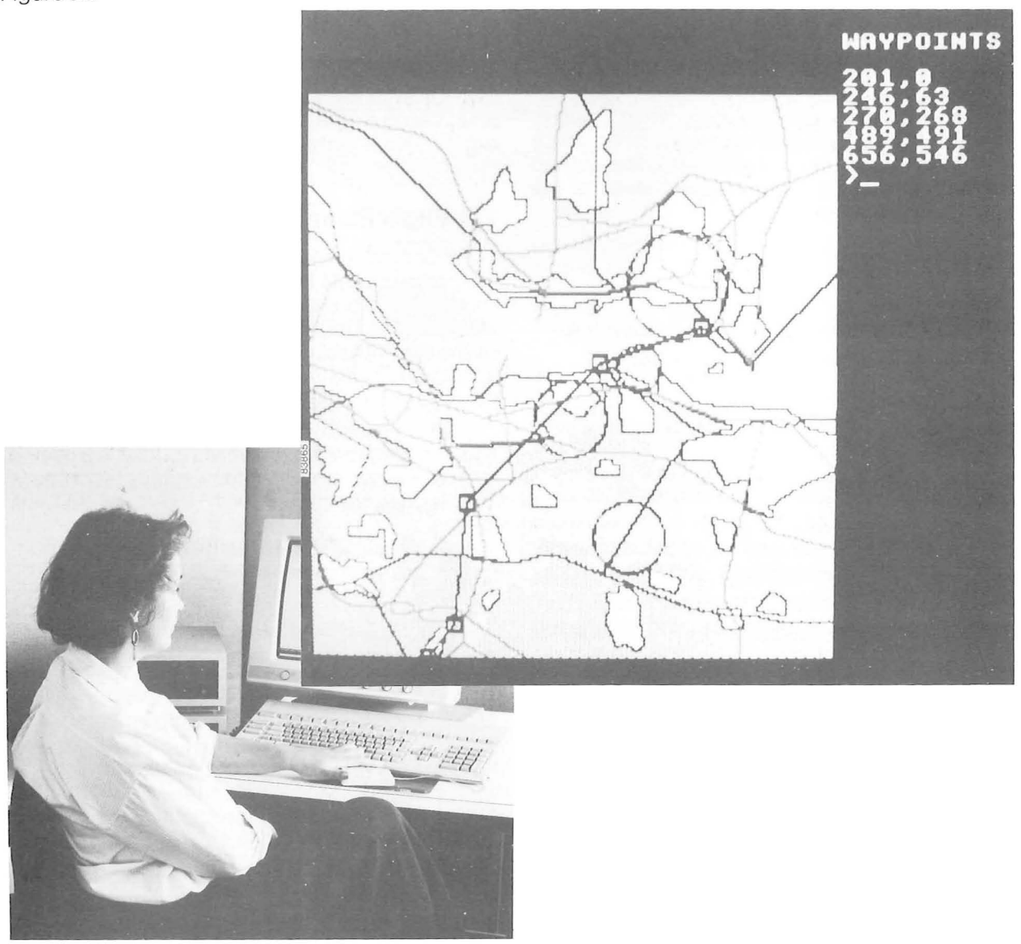
262/2029 Final Report on the Knowledge Based Flight Planning Aid

262/2135 Functional Spec. for a Workstation Based Flight Planning Aid

262/0347 Proposal for a Study into the Application of Knowledge Based Systems to Fixed Wing Aircraft

262/2129 Study Research into the Application of IKBS to Fixed Wing Aircraft Progress Report No 1

Figure 20



8 OPTICAL DESIGN

Project Manager: Brian Wortley
Senior Systems Engineer: Dave Hubbard

8.1 Introduction

The Optical Design team has continued to provide support for the Product Divisions (principally ADD) as well as assisting other teams in the Laboratory on various projects. Current activities are mainly concerned with the design of holographic Head-Up Display optics and Helmet Mounted Display Systems.

Facilities available to the team include an extensive suite of computer programs, written in the Laboratory, which allow complex optical systems to be modelled mathematically and optimised. The suite employs a damped least squares algorithm and automatically optimises systems which may contain de-centred lenses or holographic elements, and can also be used for the automatic design and analysis of Computer Generated Holograms.

8.2 Off Axis Holographic HUD

A recognised technique, used to correct HUD configurations with relatively low off axis angles, is to introduce aberration correction via the holographic combiner and the relay lens system. However, in the highly off axis F-16 configuration, the technique permits insufficient correction. The ability to use Computer Generated Holograms (CGHs) to manufacture the holographic combiner provides an additional degree of freedom in the optical design allowing the use of CGH to achieve the required optical power. Work on the exploitation of CGH's was initiated over 2 years ago and very real progress has been made on the design of a 35° off axis Holographic HUD System with acceptable parallax errors and chromatic spread performance over most of the field of view.

The key features of the specification are given in the following table which also provides a comparison between the conventional F-16 C/D optic currently in production, the LANTIRN Holographic optical unit and the new off axis 'CGH HUD'.

This work is being done in close collaboration with Airborne Display Division, who are providing funding and overall programme control, and HRC and MRC who provide the CGH and Hologram manufacturing facilities respectively.

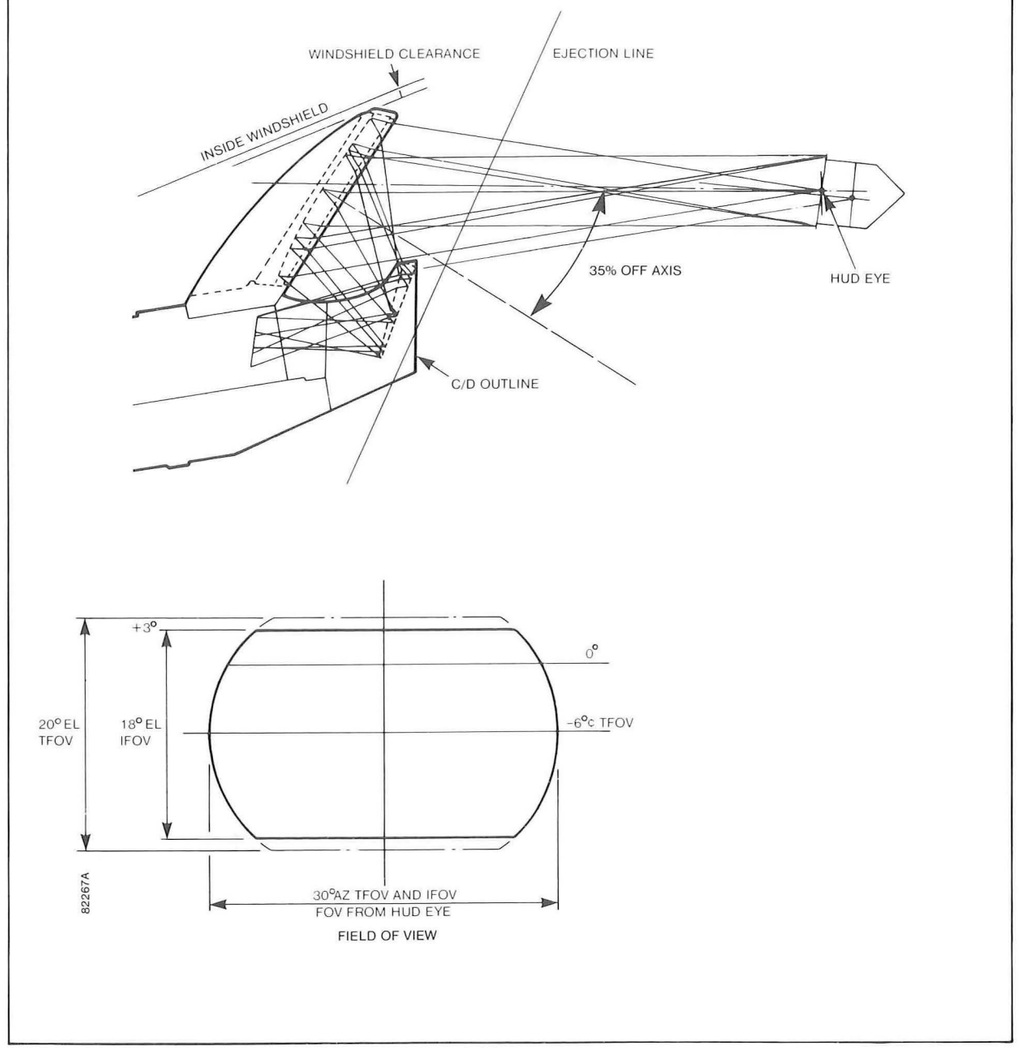
Recent innovations include the ability to analyse skewed general aspherical surfaces, and a facility for raytracing multiple hologram systems (arbitrarily defined and faster convergence techniques).

Future work will now involve an in depth study of the feasibility of the hologram construction geometry. This will entail the back raytrace of each recording wavefront through suitably designed low order shaping and filtering lenses, and the mathematical construction of a Computer Generated Hologram.

Figure 21 illustrates the concepts.

	F-16 C/D	F-16 LANTIRN	Off Axis CGH
Inst FOV	15° x 25°	18° x 30°	18° x 30°
Total FOV	25° x 25°	20° x 30°	20° x 30°
Off Axis Angle	0°	11°	30° – 60°
Head Motion Box	3″ x 5.5″	3″ x 5.5″	3″ x 5.5″
Transmission	70%	70%	80%
Brightness	20%	35%	40%
Accuracy	1.5mRad	2.5mRad	3.5-4.5mRad

Figure 21



8.3 Optical Design for Wide FOV Helmet Mounted Display

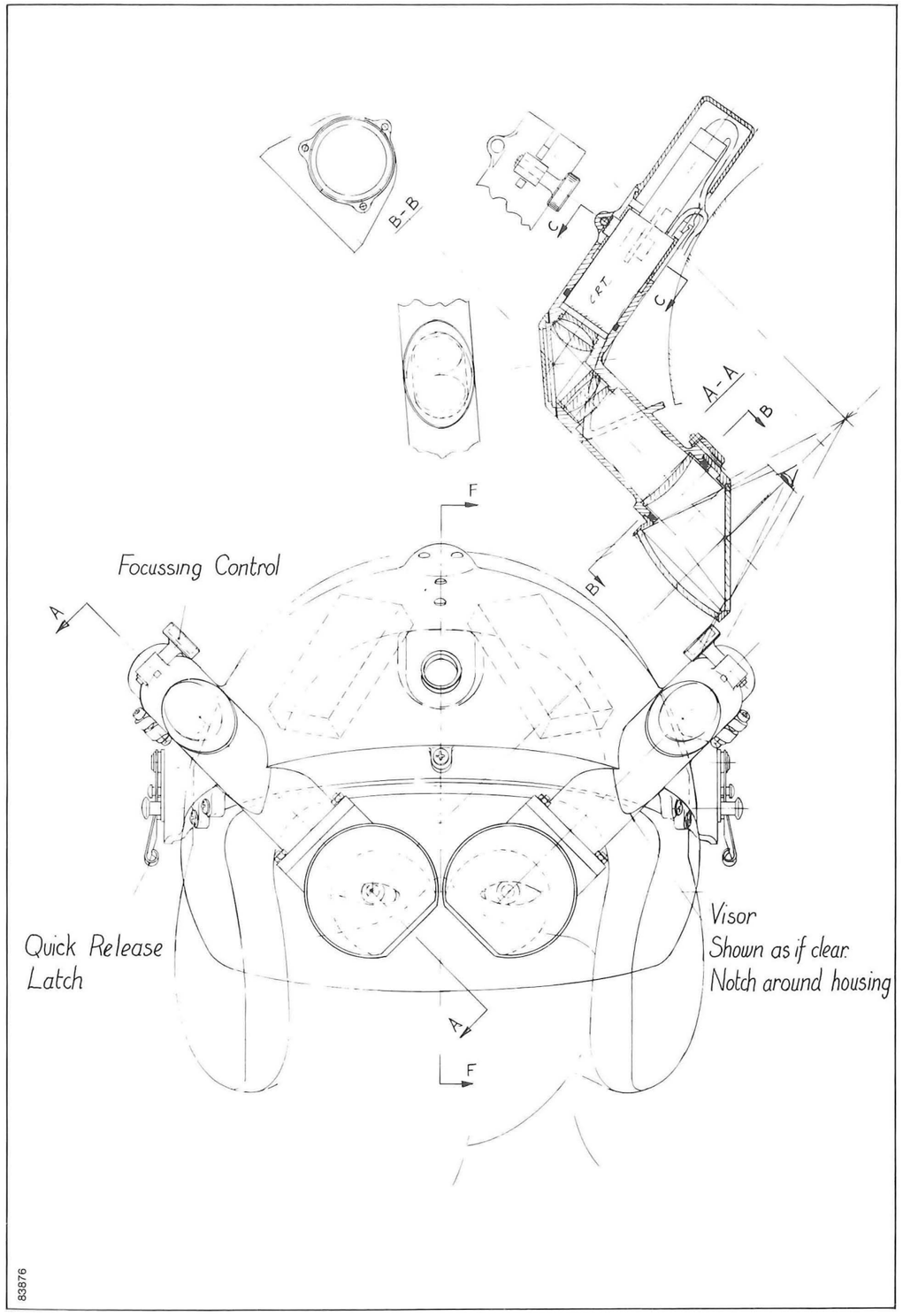
In late 1985 and early 1986 the team carried out the detailed optical design for a new wide field of view (FOV) (40° x 30°) Helmet Mounted Display system (HMD) with a common design of optical elements to provide either a monocular or binocular display. As mentioned earlier this design is being used in HMD's for RARDE and the RAE.

The basic configuration is shown in Figure 22.

The optical module consists of a CRT, a relay lens and an eyepiece. The relay lens transfers and magnifies the CRT image from a convenient location on the helmet, in this case the side of the head, to the image plane of the eyepiece, which presents imagery at a comfortable viewing distance, in this case infinity.

The particular advantage of the concept is the use of centred conventional refractive optics throughout, which keeps the optical design and lens mounting arrangement simple.

Figure 22



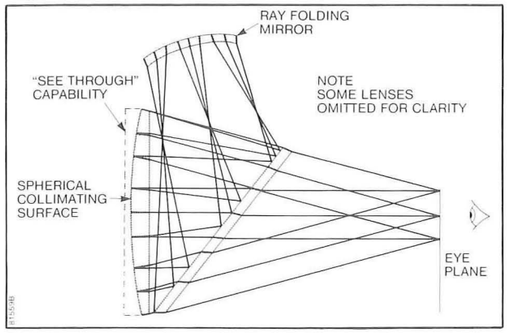
The eyepiece design is illustrated in Figure 23. Collimation is achieved by using a concave mirror and a folded optical path. This type of eyepiece also has the added attraction that a see through capability can be provided which has negligible parallax or distortion. The eyepiece also permits excellent unobscured downward and sideways vision which is a great advantage for map reading and for providing peripheral cues.

8.4 Helmet Mounted Maintenance Aid

FARL has completed work on the development of a Helmet Mounted Maintenance Aid for Aviation Service and Repair Division. This consists of a miniature 1 inch Sony CRT and simple optical assembly fitted on a standard FAA 'Hard Hat', and enables the maintenance engineer to see video images of handbook pages for example, by just raising his eyes from the job.

Six of these displays have been manufactured in the Laboratory and AS&R are now commencing manufacture of further units to drawings supplied by FARL. AS&R Division have taken on responsibility for future manufacture and exploitation of this system.

Figure 23



9 SENSORS SYSTEMS

Senior Consultant Engineer: Em Oetzmann
Consultant Engineer: Ted Lewis

9.1 Introduction

Development of fibre optic sensors continues to be a major part of the team's activities, particularly the Fibre Optic Magnetometer. In the longer term the team has sponsored the initial development of fibre optic pressure sensors capable of operating at high temperatures both for engine monitoring applications and for oil drilling bore hole instrumentation. This work is being carried out in collaboration with the University of Kent at Canterbury and continues the relationship built up during the development of the Fibre Optic Magnetometer.

This year has also seen the invention of a new range of magnetic sensors utilising the properties of PVDF, a piezo-electric polythene-type material produced by MRC, and 'METGLASS' produced by Hirst Research Centre. These materials were used to construct a compact magnetometer and a compass. A range of other sensors utilising these materials has been postulated and a number of patents filed.

9.2 Fibre Optic Magnetic Anomaly Detector

Fibre optic interferometers offer the ability to measure minute displacements with very high resolution. FARL are exploiting these techniques in the development of a fibre optic Magnetic Anomaly Detector (MAD) for Maritime Aircraft Systems Division.

Interferometry provides two advantages in this application. Firstly, it is possible to detect higher frequency magnetic fields than presently possible with MADs, thereby giving significant signal-to-noise ratio improvements, and a potential for target classification. Secondly, since fibre optic MADs are directional, they can be configured to detect magnetic gradient, from which target bearing could be ascertained.

The Fibre Optic MAD Sensor assembly is a fibre optic Mach Zehnder interferometer in which one fibre arm (the sensing arm) is strained by a magnetic field by fixing the fibre to a magnetostrictive material, while the other fibre arm is strained by applying a signal to a piezoelectric cylinder around which the fibre is wound. This configuration is operated in a closed loop mode and differential output is fed back to the piezoelectric cylinder to phase lock the system. The electronics unit effectively filters out any non magnetic signals produced by the sensor (ie microphonic noise, thermal noise etc) and provides an output signal which is related to the magetic source.

The laboratory model fibre optic MAD has yielded excellent results with detectability (in the 1 gamma region) limited only by background site noise levels rather than by inherent sensor noise.

The design and construction of a portable fibre optic magnetometer is well underway and consists of two main units, the sensing head assembly and the electronics unit, and results in a system capable of increased performance. The electronics unit will be very similar to the prototype though with a number of processing enhancements and with provision for a digital readout, a chart recorder and a tape recorder output. To enable remote testing the unit will be capable of being battery or mains powered.

Relevant Report:- *PVDF Magnetostrictive Sensor UK Patent Application No 8605871*

9.3 Fibre Optic Pressure Sensor For High Temperature Environments

There is a requirement for sensors, and particularly pressure sensors, which will operate at high temperatures. Discussions with oil companies show that they require sensors which will operate reliably over a long period at constant temperatures up to 200°C for 'down-hole' instrumentation.

Powerplant Systems Division requires pressure sensors that will operate at temperatures in excess of 350°C.

To investigate the possibility of fulfilling these requirements, FARL are collaborating with Kent University in the development of fibre optic pressure sensors and are providing some research funding to sponsor a PhD student to carry out an investigation of possible techniques.

Though in the early stages, the work has yielded two potentially viable schemes for interferometric fibre optic sensors and these are being investigated further.

A number of Product Divisions are monitoring this work, including Instrument Systems Division, Powerplant Systems Division and Offshore Projects Group.

9.4 Fibre Optic Rotational Position Transducer

Work has concentrated on improving the performance of the transducer. Tests have been conducted on the effects of fibre reconnection and vibration, as well as temperature effects on the transducer. Improvements are being made to the

device which should greatly reduce its sensitivity to such effects.

An investigation is currently being made into the tracking performance, which is the ability of a number of devices to give identical outputs in the same conditions. This work has begun with a thorough study of the light beam profile within the sensing unit, for which a computer aided measurement technique has been devised.

Consideration has also been given to miniaturising the interfacing electronics. It is planned to transfer development to Combat Aircraft Controls Division or Flight Controls Division in the very near future.

Relevant Reports:- *262/2117/TN FORPT Temperature Correction Report*
262/2173 Test Specification (FORPT) Report

9.5 Flex-wave Flowmeter Signal Processing

The Flex-wave Flowmeter basically consists of a vibrating beam in the fuel flow. The phase difference between the 'upstream' and 'downstream' ends of the beam is proportional to fuel flow velocity and the frequency is a function of fuel density, so that true mass flow can be extracted. Its advantages are simplicity, ruggedness, low impedance in the fuel flow line, 'solid state', high reliability, low cost of ownership and lower production costs than current electromechanical flowmeters.

However, its performance can degrade if it is subjected to severe vibration with frequency components close to the operating frequency of the beam. The present signal processing system is unable to distinguish between the two vibrations and this can result is unacceptable errors under these conditions.

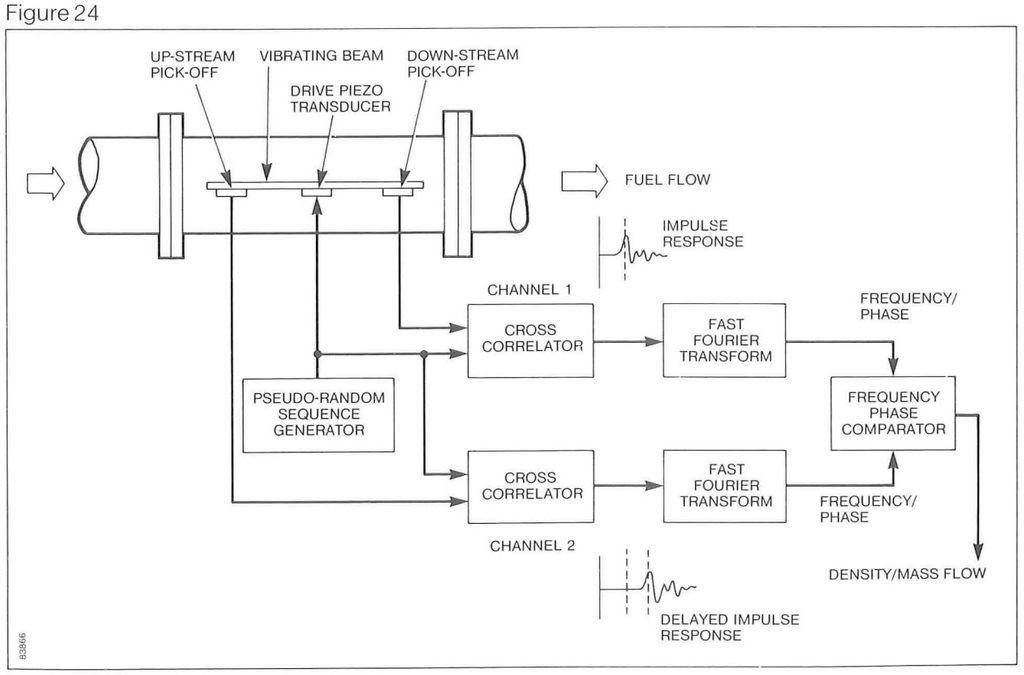
A cross correlation technique using pseduo-random noise sequences is being investigated as a means of improving the performance of the flow meter under certain vibration conditions.

Cross correlation techniques utilise the principle that if a linear system is driven by a random noise sequence, then a comparison between the system input and output can yield the system impulse response. By applying signal processing to the impulse responses extracted from the 'upstream' and 'downstream' ends of the sensor beam (which is excited at its centre) it is possible to derive the mass flow. The important feature of the correlation technique is that any noise (due to engine vibration etc) is uncorrelated with the pseudorandom input signal and so does not appear at the output of the correlator.

The system concept is shown in Figure 24. Initial investigations look promising, and further work is being carried out in conjunction with Powerplant Systems Division using data derived from measurements which will be made in the Fuel Flow Laboratory.

A patent is being applied for.

Figure 24



10 DATA TRANSMISSION

Project Manager: Trevor Hall
Project Leader: Kenny Deans (VLSI Design and Electrical Data Tx)
Senior Systems Engineer: Rob James (Fibre Optics)

10.1 Introduction

The Data Transmission team has been going through a period of transition, as the loss of funding from RAE (Farnborough) has changed the overall direction of development, and the team is now operating on Company funded projects and working closely to Product Division requirements. Involvement with the High Speed Data Bus work in the USA has been maintained. The Fibre Optic team has devoted its efforts to producing the Optical Backplane. Recent work has been with Flight Controls Division assessing the implications of Boeing's proposed 'DATAC' data bus system for commercial aircraft, to assist them in their successfull bid for the primary flight control system for the new Boeing 7J7 airliner.

10.2 High Speed Data Bus

Due to the lack of external funding, the demonstration of the High Speed Data Bus (HSDB) Ring front end has not been possible. Instead, Company funding has been used both for some theoretical studies and also to monitor the progress of both the Linear Token Passing Bus (LTPB) (Figure 25) and the High Speed Ring Bus (HSRB) (Figure 26) at the Society of Automotive Engineers (SAE) AE-9B Subcommittee meetings held in the USA.

Figure 25

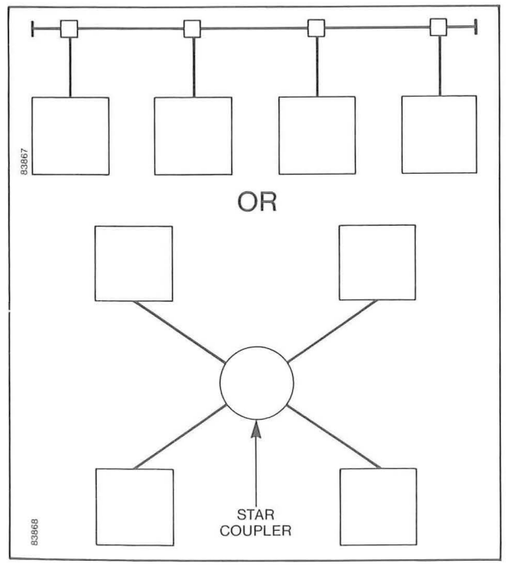
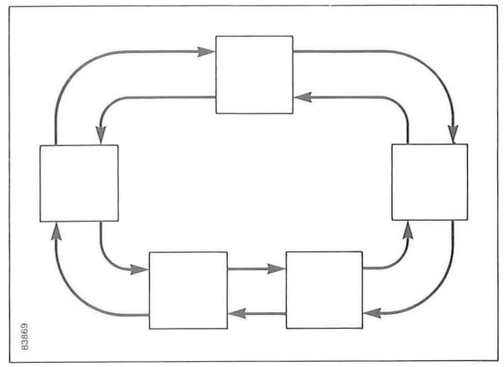


Figure 26



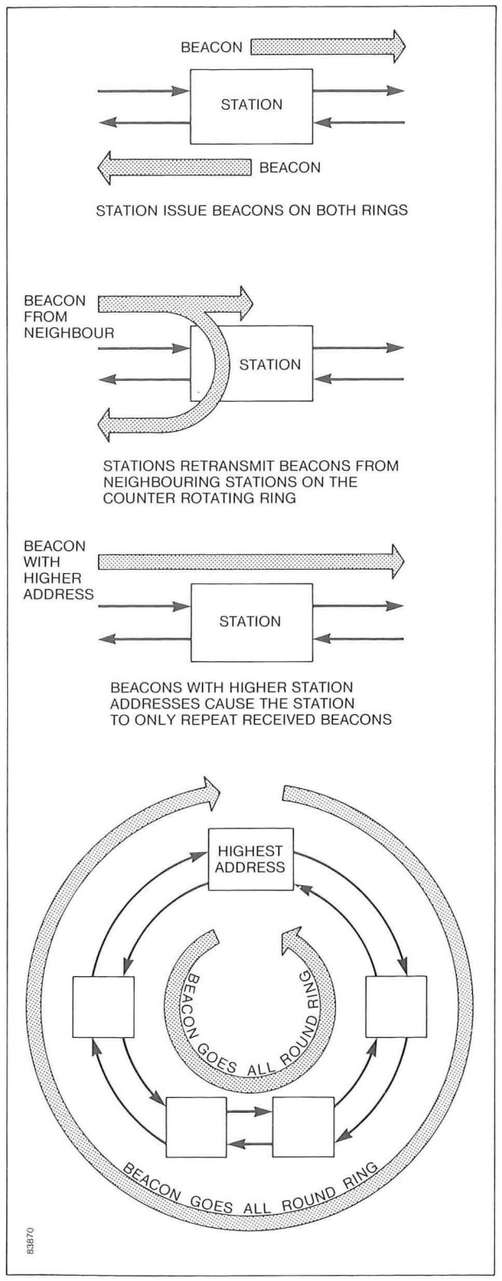
Over the past year the two 'strawman' standards have been considerably refined, with the finer points such as 'start up' and 'reconfiguration', being defined. These two standards will be presented at the SAE AE-9 Committee meeting in November 1986 as standards to be adopted by the military in the USA (as a MIL-STD), the UK (DEF STD) and throughout NATO (STANAG).

The two standards are creating a good deal of interest, with the LHX helicopter Request for Tender specifying that one of these data busses should be used. The two standards have moved away from the original requirements and are specialising in the applications best suited to the bus characteristics - the LTPB being suited to small airframes using a short bus and a few terminals, while longer cables and more terminals favour the HSRB. Further work towards a demonstrator for one or other of the busses will depend on which of the two standards becomes the most commonly used.

FARL are still mainly working on the HSRB, since it has been determined that this has growth potential for increasing data throughput without major protocol implications. However, to provide support for the product divisions the LTPB must also be considered, since it may be more applicable to small fighter aircraft such as the forthcoming Advanced Tactical Fighter (ATF). The main work has been over the definition of ring reconfiguration using 'beacons', and the definition of terminal operation in a state diagram format. Beacons are special messages issued by a station detecting a fault, to reconfigure the ring. As each station on the ring receives beacons from its neighbours it repeats them on the counter- rotating ring to verify that the links on both sides of it are working. If a station receives a

beacon with a higher source address than its own it will stop transmitting beacons. Eventually, only the station with the highest address is left transmitting beacons and this station will inform the other stations of the new ring configuration. See Figure 27.

Figure 27



FARL are also participating in the System Requirements group which is attempting to identify the problems and issues encountered by data bus system designers, in order to highlight what should be considered during the data bus system design. The group is currently defining what should pass across the host/data bus interface.

10.3 Optical Backplane

An avionic 'backplane' is the chassis wiring carrying signals between the cards and modules within one box.

In 1985 a Company funded programme was launched in FARL to investigate the feasibility of building an optical backplane. This was originaly conceived as a method of communicating between the modules in a Limited Integration Cabinet (LIC) but has potential applications within any unit with complex inter-connecting wiring.

In such applications an optical backplane has a number of advantages over its electrical counterpart. It provides electrical isolation between modules, is immune to electromagnetic effects and can be operated at high data rates without cross-talk or termination problems.

A number of different optical arrangements were considered for this project. The ring system concept had to be abandoned due to the complexities of failure survival. The star and point-to-point configurations could create problems with the size of the backplane (in particular its depth) due to the bend radius of the fibre. Whilst a 'T' highway system would normally be very difficult to implement (the optical receivers would require a large dynamic range because of connector losses in a large optical system) a highway with a controlled number of terminals would be practicable.

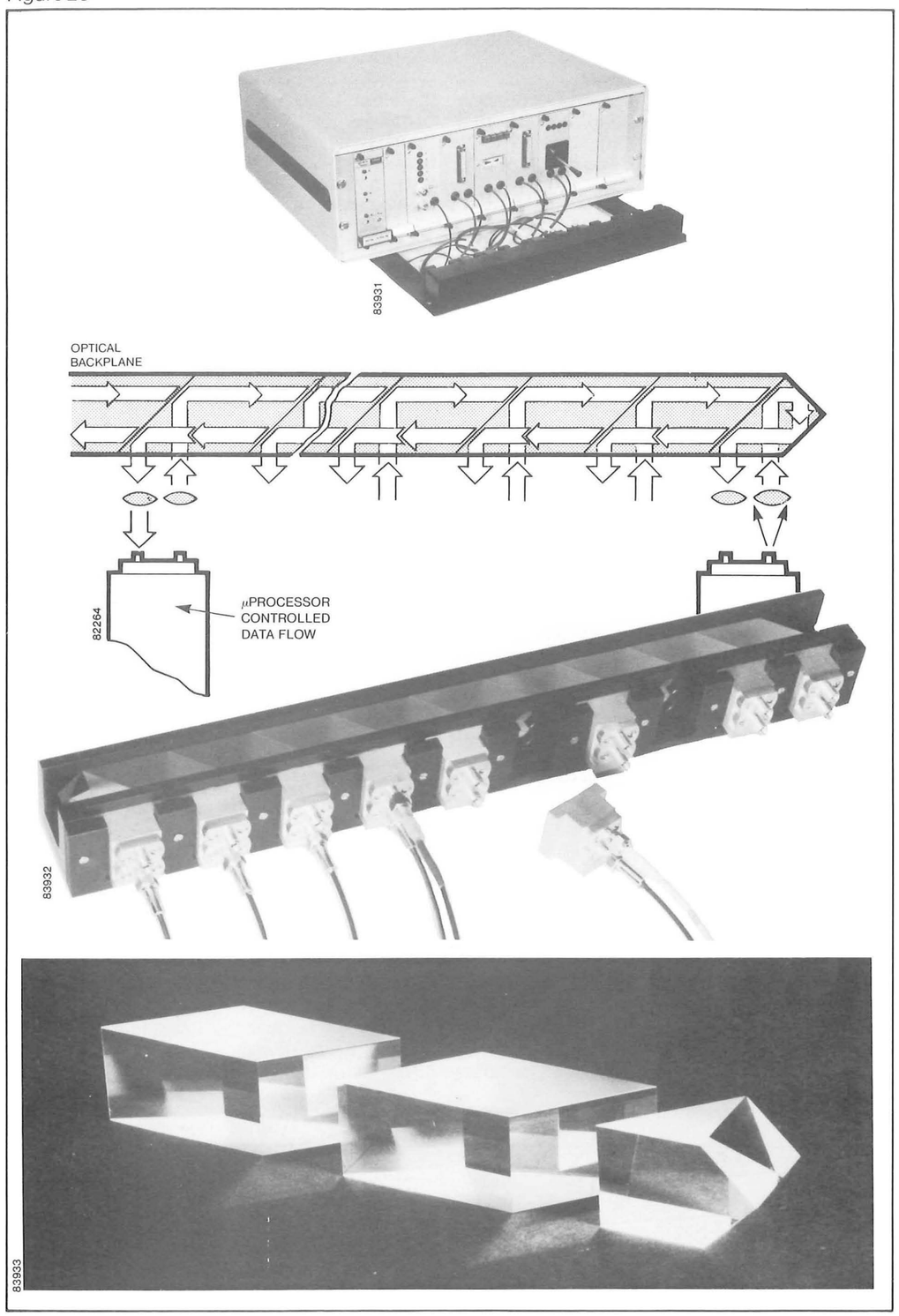
The optical design adopted allows up to 40 modules to communicate over a passive linear bus. In an optimised form the dynamic range needed by the receivers would be very small.

A laboratory demonstration has been built in which five modules can communicate over a 10 port linear bus - see Figure 28.

The control of the communication process is handled by a microprocessor within each module. These use a simple token passing protocol and incorporate error checking and failure recovery algorithms.

Currently, this system operates on only one optical wavelength; it is hoped to demonstrate a wavelength division multiplexing capability on the system in the near future by using different wavelengths (colours) of light to pass separate messages simultaneously. It is also

Figure 28



planned to define increased system performance and environmental evaluation in the phase two work.

Relevant Reports: *262/2100 Progress Report*
262/2182 Development of the Optical Backplane

10.4 DATAC Evaluation

The Digital Autonomous Terminal Access Control system (DATAC) is a 1MHz multiplexed data bus developed by the Boeing Commercial Airplane Company (BCAC) for use on future commercial aircraft. Gate array implementations of a DATAC terminal were made available by Boeing to a number of avionic equipment manufacturers, including GEC Avionics Flight Controls Division, for familiarisation and comment on its suitability and integration. Because of its experience with other multiplex busses, FARL provided help in formulating the test plan and investigating the operation of the terminals for FCD.

10.5 ASSC Committee

The Data Transmission Standards Committee (DTSC) re-emerged in January 1986 as the Avionic Systems Standardisation Committee (ASSC). Its scope has expanded into new areas which include 16 and 32 bit processing, packaging and backplanes. FARL has maintained its involvement in the Electrical Data Transmission, High Speed Bus and Fibre Optic Committees.

11 VLSI DESIGN

Project Manager: Trevor Hall
Project Leader: Kenny Deans

11.1 Introduction

The VLSI team has been actively involved in development of both standard cell and gate array chip designs over the past year. A gate array design is one where the customer is presented with a predetermined pattern of logic arrays on a silicon slice and may have them connected up in any circuit configuration he chooses which can be achieved with one or two layers of interconnecting 'printed circuit'. It is quick, cheap and constraining.

In a standard cell design the customer chooses logic components from the silicon manufacturers library of standard blocks, arranges them in any pattern he likes on the slice and connects them up as he wishes. The technique is slow and expensive, but very flexible.

The gate arrays were aimed at proving the concept of low cost VLSI components for Product Divisions.

A large standard cell design is currently underway in collaboration with CACD.

Development of an interface for the 1553B SOS chipset is proceeding from an initial base defined by prototype gate array designs. The 1553B chipset has been taken over by MEDL and is being put forward to industry as a standard product.

11.2 ASTRID

FARL are currently designing an Avionic Serial Transmission Interface Device VLSI chip (ASTRID) to meet a specification set by Combat Aircraft Controls Division. ASTRID contains one serial transmitter and four independent receiver channels, as well as a flexible input/output (I/O) controller function and a 16-bit parallel interface.

A single ASTRID will be capable of meeting the serial communication requirements, both in and between computing lanes, of a quadruplex or triplex flight control computer. The I/O controller function will also allow ASTRID to perform autonomous control of the I/O subsystem of the flight control system. The device is being designed with several potential applications in mind, including EFA and the F-111 Update Programme.

Figure 29 shows the 'ASTRID' functional block diagram.

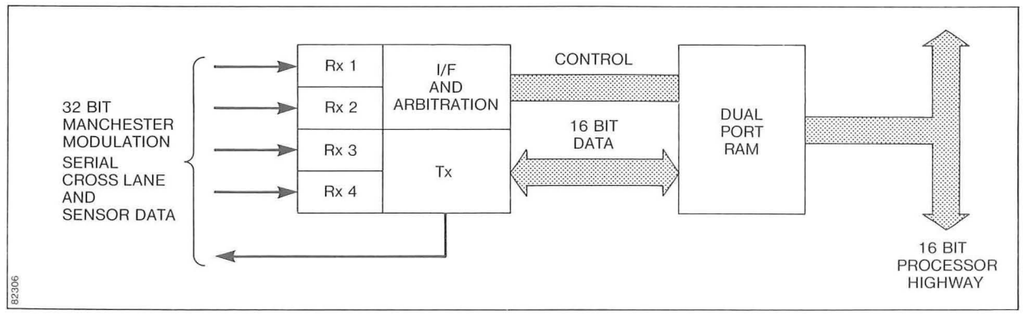
The device contains approximately 8000 gates and will be manufactured by Plessey Semiconductors using their 2 micron (effective) gate length CMOS technology. The main CAD suite in use will be Plessey's CLASSIC which features simulation, testability analysis, fault simulation, automatic routing, post-layout resimulation and test program generation. The layout will be carried out on a graphics terminal using the MEGACELL standard cell technique.

Each ASTRID will replace approximately 3 cards of discrete TTL/CMOS logic per computing lane, (4 ASTRIDs replacing 12 cards per aircraft). This will lead to substantial reductions in production cost, and increased reliability.

The use of a standard cell technique as opposed to a gate array further reduces the unit cost in production. At the likely production volume (2000+ devices) the reduction justifies the increased nonrecurring costs of a standard cell design. In addition, the reduced die size of a standard cell design will allow the device to be mounted in a 48 pin DIL package.

ASTRID also has more capability than the current discrete designs, including operation at increased data rates and a high level of Built In

Figure 29



Self Test, allowing in-service testing of the devices during preflight checks. The effectiveness of the self test sequence will be evaluated by fault simulation.

A further development of 'ASTRID', involving ROM storage, is being considered for the Boeing 7J7 Primary Flight Control System.

11.3 MIL-STD-1553B SOS Interface Chip

A single-chip interface between a MIL-STD-1553B terminal and a 16-bit microprocessor is being developed from an earlier ULA6 SOS 2-chip set interface. The specification for the device has been drawn up in conjunction with Maritime Aircraft Systems Division. The device, which allows a microprocessor to communicate with other equipment via the aircraft data bus, is primarily aimed at MASD's future requirements for interfacing the FARL SOS 2-chip set 1553B Terminal to the Z8000 processor. However, it is also intended as a general device catering for systems with 1750, 68000 and 8086 microprocessors. As with the earlier gate arrays, the single-chip interface will support both the Bus Controller and Remote Terminal modes of operation of the 1553B Terminal. Similarly, it employs a shared memory architecture but also incorporates a double buffering scheme to overcome the problems associated with contention of access to the shared store.

Although the size of the device is modest at about 2000 gates, it will provide FARL with the opportunity of investigating any potential hazards inherent in the use of a high pinout device. The large number of pins (approx 120) is necessary because of the architecture.

11.4 Gate Array Development

One of the major reasons for introducing semi-custom designed VLSI chips into any system is the reduction of production costs. However if, as in most major systems, a period of prototype development is required, the costs for Gate Array development have been viewed as too high and the time to obtain samples too long. Consequently, a number of companies have attempted to solve this problem by using either a multi-project approach, where the costs are spread over several projects, or a direct writing electron beam system where a photographic circuit printing mask is not required.

FARL became involved with the development of four SOS designs one of which, the ATE 1553B error injector, was subsequently taken to a limited production run of 20 devices. The capability of the Silicon-on-Sapphire technology was also tested with the design and manufacture of a radiation detector designed for FARL's Nuclear Hardening team. This device was succesfully tested to 10^8 Rad S^{-1} (transient) with a total dose of 500 Rads.

The designs also permitted FARL to use simulators to produce testable designs without breadboards, contributing to working devices being obtained in all cases on the first iteration.

12 ENVIRONMENTAL DESIGN AND ELECTRONIC PACKAGING

Engineering Services Manager: Jim Pickford
Project Leader: Clive Goodchild
Consultant: Arie Vandertak

12.1 Introduction

The Environmental Design and Electronic Packaging team comprises a total of 14 people over a wide range of activities, providing design and manufacturing support to other FARL project teams in addition to a consultancy service to Product Divisions on all aspects of environmental design. This year considerable emphasis has been placed on the two major study areas of future avionics packaging and of the requirements and problems of designing electronic systems to meet a nuclear environment.

12.2 Modular Avionics

Work by the team on new packaging standards and modularisation for the Limited Integration Cabinet (LIC) concept has continued and draft specifications have been produced by BAe in conjunction with the IAWG that define a standard tailored to the European Fighter Aircraft (EFA). The work has highlighted the following areas of high technical risk:

- Design

  The LIC is a very complex system which directly relates to Avionic LRU Black Box design requirements, where all the expertise is held by the avionics companies. It is therefore essential in our view that an avionic company and NOT the airframe manufacturer is responsible for the technical management of the system design.

- Cooling

  The thermal management associated with a LIC system presents a significant risk area particularly as, for EFA, BAe intend to restrict the aircraft environmental control system basically to that of the Tornado.

- Electromagnetic Hazards (EMH)

  EMH presents particular problems when filling a LIC cabinet with modules from different suppliers, especially as there is insufficient design information on 'current practice' available.

- Backplane and Connectors

  The Backplane requirements are expected to be an order more complex than current motherboards in ATR boxes. There are at present no suitable connectors in existence, although some development is underway; the major system limitation is the number of pins required.

- Time Scales

  It may prove impossible within the EFA time scales to produce a design standard for a LIC capable of housing the wide range of systems it is expected to contain. A compromise may be to produce a customised LIC to house a particular set of subsystems.

- Need for VHSIC

  The nonavailability in the UK of VHSIC technology components makes a LIC system using LRM's with todays components a heavier and more expensive solution than an equivalent ATR packaged system.

Because of these risk factors and the time scales involved, British Aerospace (Warton) have decided that modular packaging is not mandatory for the EFA. However, it appears that they intend to continue their studies on modular avionics.

The USA scene is being continually monitored and it is understood that an avionics subsystem with modular packaging, named PAVE SPRINTER, will be flying in an F-16 in early 1987.

12.3 Surface Mount Technology

A small team has been established over the past year to work on Surface Mount Technology (SMT) for use in modular standard electronic assemblies.

A feasibility study which constitutes Phase 1 of a research programme has been completed and was aimed at investigating the possibility of introducing computer prediction software to assess the 'life' and MTBF of chip carriers on surface mount boards. Particular consideration has been given to large leadless ceramic chip carrier assemblies. Figure 30.

The main benefits of SMT are space and weight saving, since SMT offers higher packaging densities and a larger number of pins on a single device; over 200 compared with the 64 pin dual in- line package. It also offers a reduction in the number of pc boards and connectors, and therefore represents a potential improvement in reliability.

However, there are major problems in mounting these devices since the very high stress regions on the board or substrate may cause premature solder joint failure, and there is firm evidence of such boards failing in storage. This stressed solder joint problem does not arise with the older dual-in-line mount technology as the leads on the

devices are able to provide sufficient compliance to avoid any high stresses. Computer studies and the prediction of stress levels are being carried out at MRC, Great Baddow. Ultimately, it is intended that the MTBF prediction software will form the basis of a CAD suite for the design of SMT assemblies utilising new Company design guidelines to ensure satisfactory life and MTBF.

Figure 31 illustrates the type of CAD modelling being carried out and Figure 32 shows a possible technique for a leadless ceramic chip carrier using preformed 'solder pillars'.

The conclusion of the Phase 1 study is that the overall project aims are considered achievable and that Phase 2 – an in-depth detail study together with hardware testing and investigation into manufactuing technique, is essential if SMT is to be exploited with confidence of meeting life and reliability requirements.

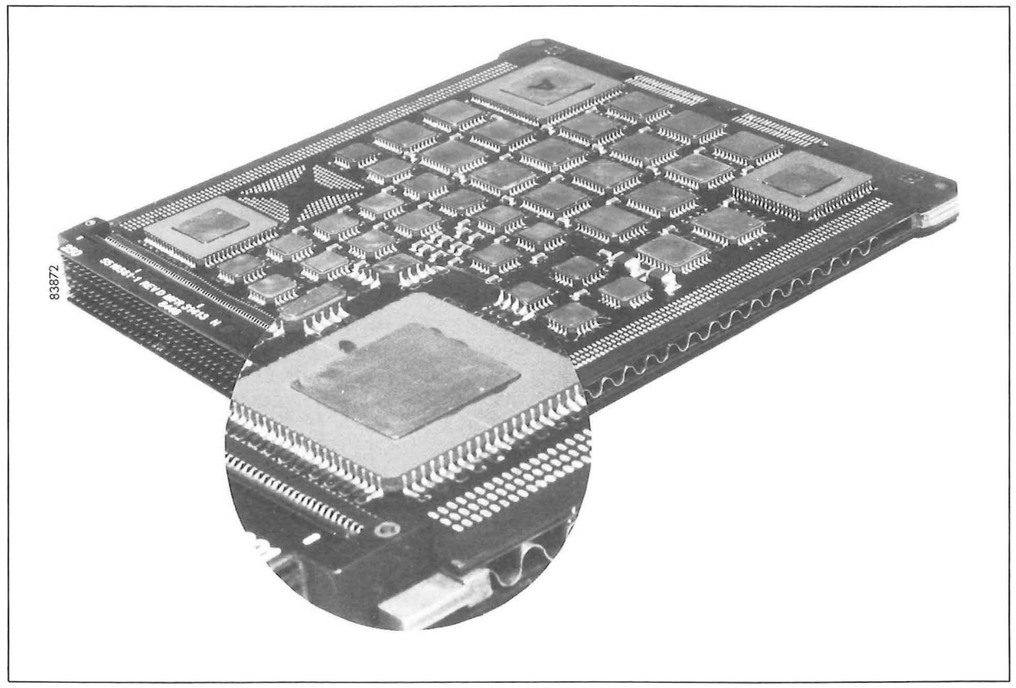
Relevant Reports: *262/2166 SMT Executive Summary*

262/2122 Report on Phase CAD/SMT Project

12.4 Nuclear Hardening

The Nuclear Hardening team has been primarily engaged on Company funded R&D since successfully completing four MoD contracts. Some further MoD funding is expected in the next financial year.

Figure 30



12.4.1 Initial Nuclear Radiation (INR)

During 1986, private venture work has been carried out in three areas and the preliminary investigations are now nearing completion.

12.4.1.1 Local Firmware Protection Device and Event Detector

For avionics, the most damaging effect of nuclear radiation is the peak gamma pulse, which will upset circuitry and cause burnout in some types of component. The FARL protection device and detector switches off susceptible devices to guard them from burnout and can also be used to re-initialise the avionics by restoring memory contents after the Event. Several breadboard models have been designed and successfully tested to determine the most suitable configuration for a hybrid package. It is now recommended that a particular design be suitably packaged in an engineered form, and fully evaluated.

Relevant Report:- *262/2178 Local Firmwave Protection Device Preliminary*

12.4.1.2 Photocurrent Generation in Integrated Circuits

A study has been carried out to investigate the use of solid state lasers to irradiate semiconductor devices to simulate gamma dose rate effects for in-house qualification testing. Control electronics for shaping a semi-conductor laser pulse have been designed and constructed, and Figure 33 shows a power MOSFET undergoing a laser test. Several types of component have been irradiated and the results have compared favourably with test results using the LINAC reactor at the Atomic Energy Research Establishment (AERE) at Harwell. Initial tests have indicated that the LINAC may have too slow a gammma pulse rise time for power MOSFET qualification, but extensive investigation will be required to confirm this. The study has confirmed the feasibility of the laser technique for in-house component testing; further work is now required to engineer the system and to calibrate it for a range of component technologies.

Relevant.Report:- *262/2183 Local Nuclear Effects Simulator*

Figure 31

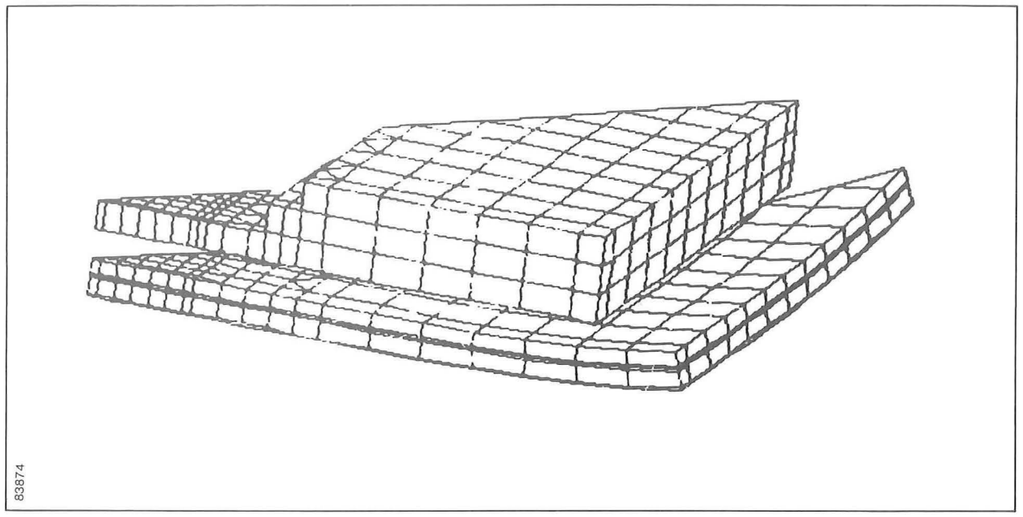
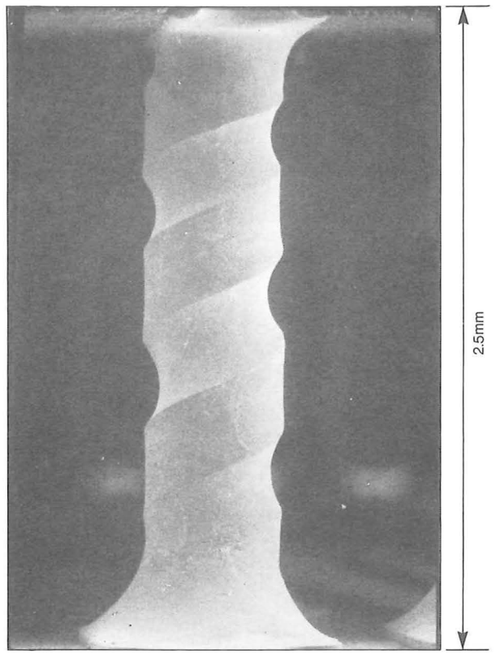


Figure 32



12.4.1.3 'SPICE' Circuit Simulation Program

A study is being carried out on the modification of the SPICE circuit simulation program to allow it to model gamma dose rate effects. This will allow designers to analyse analogue circuits for radiation transient effects. For the study, computer programs have had to be created to model:-

- OPERATIONAL AMPLIFIER circuit
- POWER MOSFET device
- SCR device
- TRANSFORMER
- SAMPLE AND HOLD circuit

These models are currently being appraised and a program is being written to create SPICE files automatically.

12.4.2 Electromagnetic Hazards (EMH)

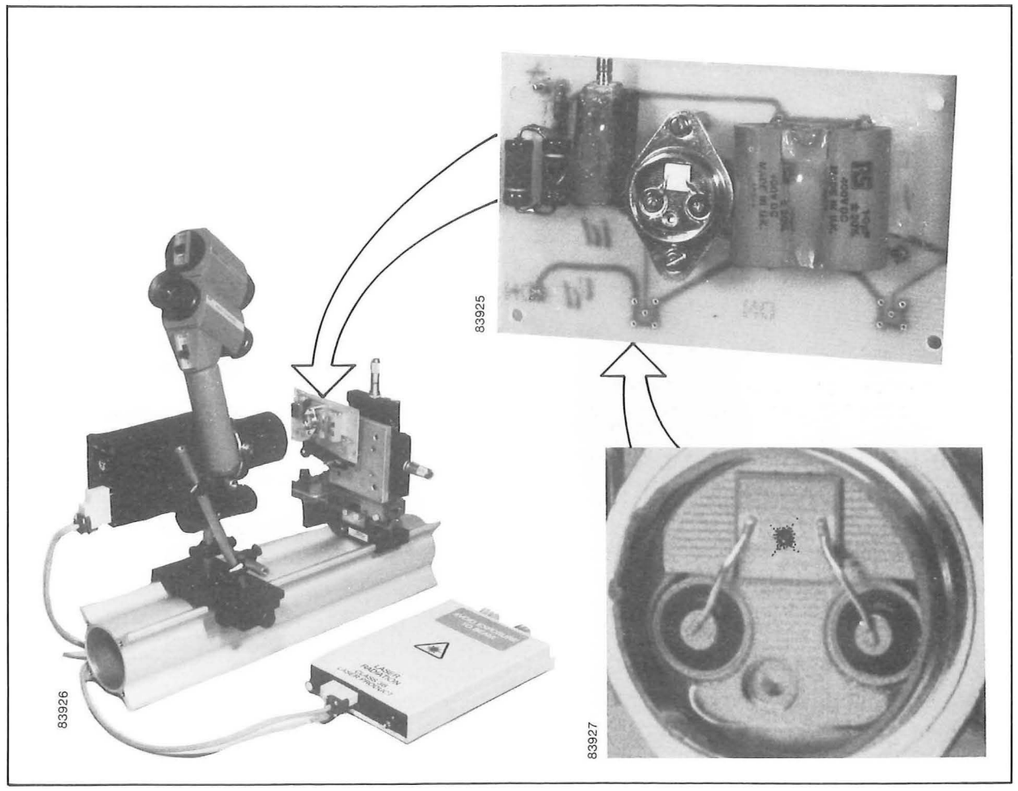
Preliminary investigations into the prediction, using software tools, of the coupling of electromagnetic pulses onto cablelooms, circuit boards and backplanes are currently being carried out on a Company funded basis.

12.4.3 Consultancy Support

The team has provided assistance to various Product Divisions over the year, primarily in the writing of proposals:

1) GEC Avionics Inc. (Atlanta) - assistance in writing nuclear hardening section for their proposal for the Laser Range Finder for the M1 battle tank.
2) GEC Avionics - Airborne Warning Systems Division (Borehamwood) - overview of the nuclear hardness of the AEW Nimrod.
3) GEC Avionics - Power Conversion Systems Division (Nailsea) - assessment of the EMH of the input/output cables and circuitry of the AQS903 power supply unit.

Figure 33



13 CONSULTANCY

Senior Consultants: Brian Paxton
Frank Oates

13.1 Introduction

The role of the two Senior Consultants has continued throughout the year. Areas of work have included assisting with current projects, formulating proposals, system studies and liaison with the Product Divisions. The main emphasis has been on forward looking projects considering the application of AI techniques to a wide range of avionics systems.

13.2 Liaison with Product Divisions

Following on from the future work assessment programme carried out last year, liaison with Product Divisions has continued with the generation of a newsletter and the formulation of a specific liaison programme with the Navigation Group of Divisions. It is intended to expand this activity to ensure good contact with all Divisions and the continuing relevance of all FARL research activities.

13.3 Application of IKBS Techniques to Avionics

13.3.1 Contextual Direct Voice Input

The use of context to assist a voice input system in the cockpit has been studied as part of a contract for Airadio Systems Division, Basildon. By using information from aircraft systems to deduce the current phase of a mission and using the grammatical context of the phrases the pilot is likely to use, it has been found that interpretation of the speech input can resolve ambiguities and hence improve reliability.

At the same time it was seen that contextual information can be used to assist other systems, where the information presented to the pilot and the choices he has to make can be limited to those relevant to the prevailing circumstances.

Figure 34 illustrates the system concept.

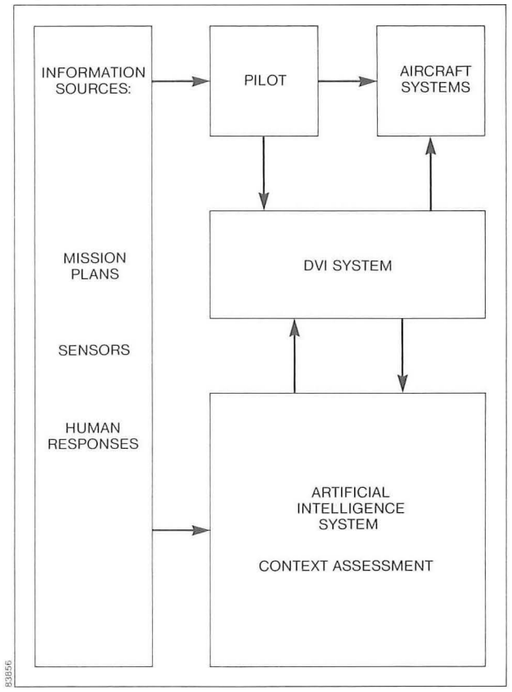
Relevant Report:- *262/2078 Contextual Information Applied to Speech Recognition: Final Report*

13.3.2 Navigation Management System

To reduce pilot workload and increase the chances of mission success, the pilot needs to be supported by reducing the amount of information he has to handle and by being relieved of minor decision making. A study has been carried out in the area of navigation system management. This has shown how IKBS techniques can reduce the effects of navigation subsystem errors and present complex directive information in a form more easily assimilated.

Relevant Report:- *262/2075 Navigation Management System Development*

Figure 34



13.3.3 Application of IKBS Techniques to Fixed Wing Aircraft

Considerable time has been spent by the Consultants on advising and assisting the relevant teams in responding to a Request for Tender from MoD(PE) for the application of IKBS to Fixed Wing Aircraft resulting in the award of a contract. See Section 7.

13.4 UK HUD Symbology

As part of the Software Engineering Workstation evaluation exercise it was decided to generate software to produce symbology relevant to UK

Head-Up Displays, (which is significantly different from US formats), and a study has been carried out to define the essential features of a suitable set.

Relevant Reports: *262/2093/TN Comparison of US and European HUD Symbology: Navigation Mode*
262/2101/TN UK Navigation Symbology: Detailed Specifications
262/2124/TN UK Weapon Aiming Symbology: Detailed Specification

13.5 Alvey Design to Product Demonstrator

The Design to Product Demonstrator seeks to show that some of the technologies emerging from current Artificial Intelligence research may be applied to the development, manufacture and support of real products.

The five year programme is structured as a two and a half year pilot study followed by a full demonstrator. This will integrate intelligent knowledge based design, geometric modelling, flexible manufacture, automatic generation of machining and assembly data, robotic assembly, robot calibration and man/machine interface studies.

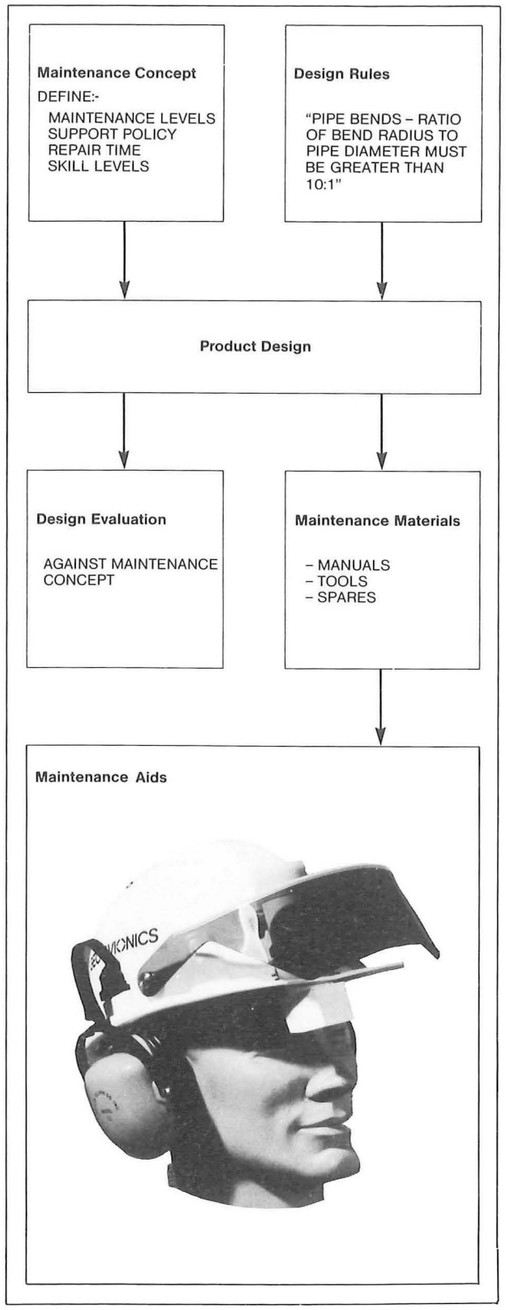
The programme, which involves industrial and academic collaborators, is being managed by GEC Electrical Projects. FARL is supporting the maintainability aspects of the Intelligent Knowledge Based Designer System (IKBDS).

In order to gain a better understanding of the capabilities of the IKBDS, work has been undertaken on the development of knowledge modules to support electromechanical design. Initially, the design of a 'C-core Coupler', a transformer device used in sub-sea applications, was studied. Knowledge modules were developed taking into account theory, worked examples, manufacturers data and design experience. Interim results have shown the ease of constructing such knowledge modules and the flexibility of use. Further examples from switch mode power supply designs are now being studied.

Currently, much of the information used to achieve readily maintainable designs is implicit but seldom written down. Work is being undertaken to establish design rules for maintainability in a form suitable for use by a knowledge based system able to advise on and assess maintainability (Figure 35).

Relevant Reports: *262/1979 PREDICTOR as a Design Tool*
262/1958 Reliability Analysis as a Design Tool
262/2022 Aspects of the Design Process in GEC Avionics
262/2112 Alvey Design to Product Demonstrator. Interim Progress Report:

Figure 35



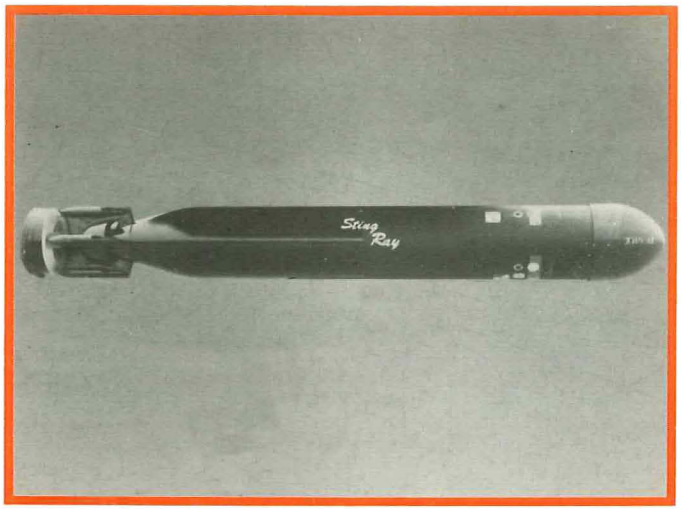
13.6 FOGHAT

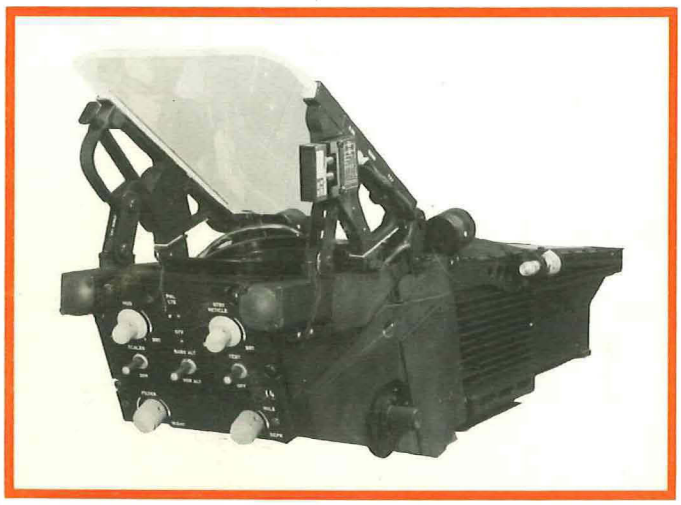
The Laboratory has continued to assist RAE (Farnborough) in the study of various aspects of the control and guidance of a fibre optic guided missile. The Consultants have continued to study system concepts while supporting the Guidance and Control Team in their work on aerodynamic and control issues and the Maps team in their work on target designation and imaging.

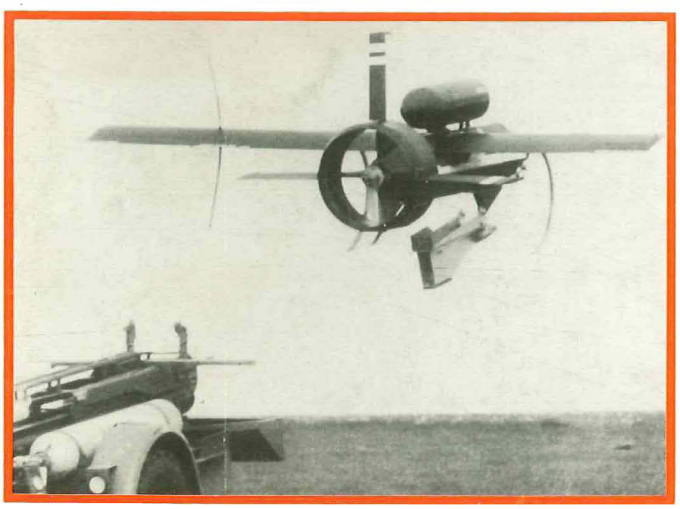
13.7 ASSC Committee

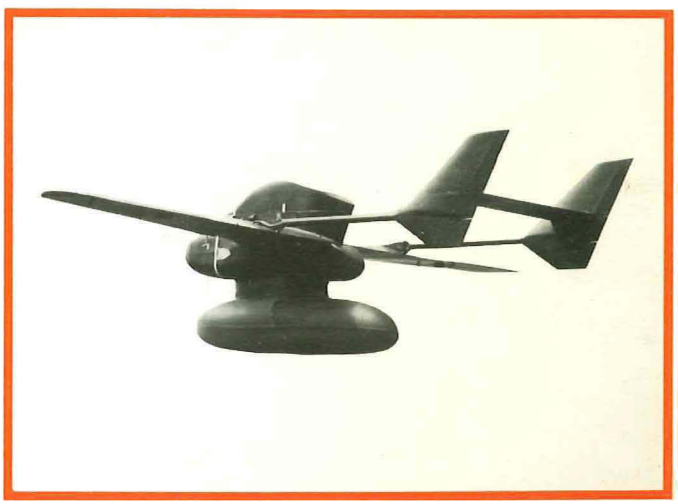
One of our Consultants, Brian Paxton, has become a member of the Steering Committee of the newly formed Avionic Systems Standardisation Committee (ASSC).

He represents both GEC Avionics Ltd and ESASC, the latter being the EEA/SBAC Avionics Systems Committee, a group looking after the interests of the manufacturing side of the electronics and avionics industries.









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1983 MARITIME AIRCRAFT SYSTEMS DIVISION

1983

1985 AIRBORNE DISPLAY DIVISION

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