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The EH101 Electronic Instrument System

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ABSTRACT

This paper describes the background to the introduction of an electronic instrument system on the Anglo-Italian EH101 helicopter. The demanded flexibility to accommodate the display needs of several roles leading logically to the adoption of full colour multi-purpose display surfaces and the drive to achieve maximum commonality between military and civil variants is discussed.

The configurations arrived at for both variants are described together with the operating philosophy and display formats developed during an ongoing simulator program.

The paper also deals with a detailed description. of the hardware implementation of the EIS including the fully integrated systems architecture and details of the symbol generators (SGs), display units (DUs) and display mode selectors (DMSs). Emphasis is placed on the robust integrity characteristics and reversionary switching philosophy of the system.

1. INTRODUCTION

The EHlOl is a multi-role helicopter being developed to satisfy civil, naval and utility operational requirements. These include :

Civil : Offshore oil support, computer services, and corporate use.

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Naval : Anti-submarine warfare **(ASW),** anti-surface vessel (ASV), and search and rescue (SAR) .

Utility (with rear ramp) : Gffshore oil support, civil defence, vehicle transportation, air ambulance, exploration, logging; and SAR.

The cockpit had to be designed to satisfy all the particular crew rote requirements specified for each variant :

Civil and Utility : Twin pilot instrument flight rules.

Naval : Single or twin pilot.

The electronic instrument system **(EIS)** combines the expected capabilities of an electronic flight instrument system **(EFIS)** and an electronic engine indicating and caution and advisory system (EICAS). However the EIS traverses the boundary between conventional EFIS and EICAS systems to take full advantage of display and symbol generation flexibility and reversionary capability.

The EHlOl is the first helicopter to be developed with an all-CRT (cathode ray tube) cockpit and is destined to go into production in 1990 for the civil/utility variants and 1992 for naval variant.

1.1 Background

The fore-runner of the EHlOl was the WG34, a UK-only project meeting the role requirements of the Royal Navy and potential civil operators. Project definition of the WG34 commenced in the mid 1970s with a series of design studies which by the beginning of the **1980s** proposed a cockpit design based on conventional displays but employed a degree of display integration providing integrated power systems, torque and torque margin display and 'message panel' central warning systems as shown in Fig. 1. Even at this phase of the program, it was **recognised** that display integration was necessary due to the amount of flight and mission data which had to be presented to the crew.

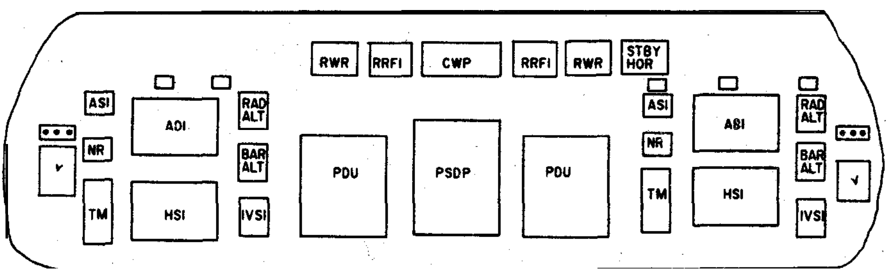

Figure 1. Conventional instrument panel layout.

When the WG34 project became the Anglo-Italian collaborative EHlOl project, the development of electronic displays for presentation of aircraft flight and power systems data had reached a point where they were-gaining world-wide acceptance and market appeal.

Encouraged by the UK Ministry of **Defence** (Procurement Executive), the crew **station** design groups at **Westland** Helicopters Ltd. **(WHL)** and Agusta embarked on a study phase to assess the applicability of CRT technology to the EHlOl role requirements. The main aim of the study was to integrate as far as possible the display requirements for flight, navigation, power systems (engine, transmission, fuel hydraulics, **electrics)**, crew alerting systems and mission. The major constraints for the display system design were :

- **(i)** Operation throughout the full ambient light range expected in the **cockpit,** i.e., up to **10^5 lux;**
- (ii) Equipment commonality between all helicopter variants; and
- (iii) A fixed mission display standard based on 625 line raster video.

At that time it was impossible with the available technology, to reconcile the high resolution requirements for mission displays based on **625** line' raster and yet achieve the display luminance necessary for the display of flight parameters in high ambient light conditions.

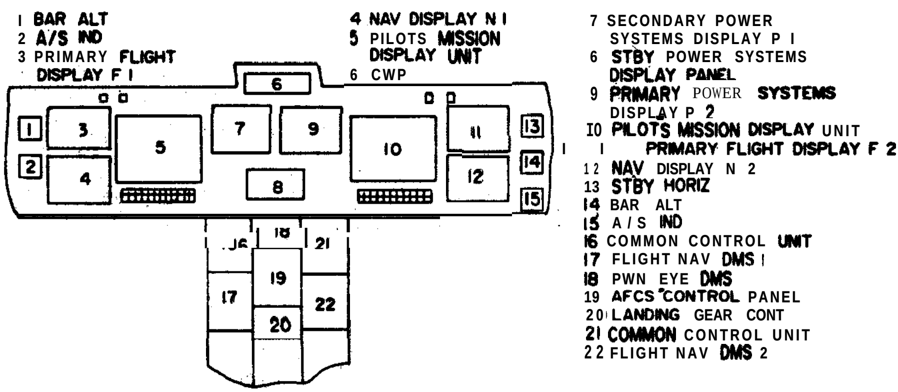

Figure 2. EH101 instrument panel layout (naval).

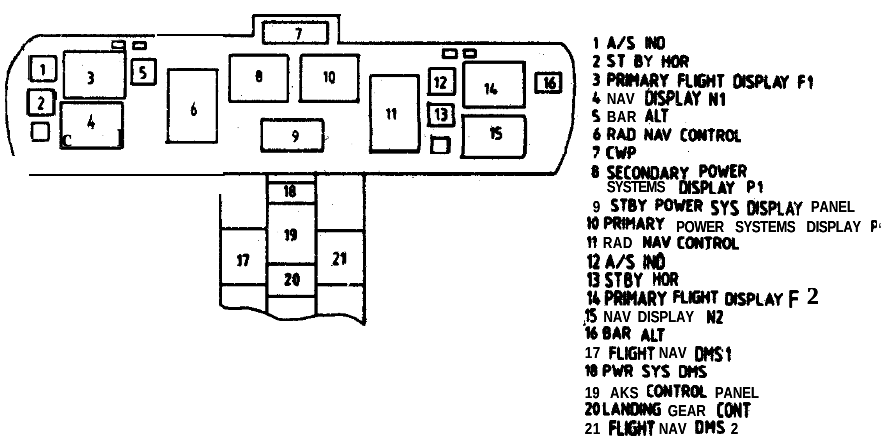

Figure 3. EH101 instrument panel layout (civil).

The naval system configuration which kept within the constraints (particularly the mission display requirement) and was acceptablefrom a cost, weight and acceptable technical risk was a combination of 6 off 7 x 6" **colour** stroke **DUs** with 2 offll" diagonal monochrome raster mission **DUs** as shown in Fig. 2. To retain equipment commonality between the variants, the civil cockpit is configured as shown in Fig. 3.

2. DESIGN REQUIREMENTS FOR AN ELECTRONIC INSTRUMRNT SYSTEM

As part of the equipment procurement activity it was necessary to partition the avionic system into a number of equipment requirement specifications which could be offered to equipment manufacturers as bid packages. The EIS was one of the major avionic sub-systems but, although the basic configuration and display technology had been decided, further design work had to be undertaken to define precisely the requirements related to display formats, reversionary capability and system interface.

2.1 Preliminary Design

2.1.1 Initial Display Format Development

During this early period, facilities available to embark on CRT display format development were rudimentary although **Westland/Agusta** did have a moving base cockpit simulator at their disposal albeit with CRT displays which were not to the full performance standard required for airborne application. Development commenced by listing all the parameters required for display at each crew station and establishing degree of importance of each parameter.

An early decision to follow established, conventional instrumentation forms of display was taken on the basis of minimum development time and least risk for civil certification.

Display format philosophy and basic formats were schemed and discussed at several sessions involving designers, human factors' specialists, test pilots and representatives of the UK RAF's Institute of Aviation Medicine. The agreed display format standard was programmed into the cockpit simulator for real-time 'flight' test and evaluation. Again more sessions involving the above parties established the basic display format requirements to be included as part of the EIS requirement specification which was issued with requests to tender.

2.1.2 Reversionary Capability

One obvious major disadvantage of an EIS based on CRT technology is the possible single failure causing the loss of one DU and therefore a significant amount of flight data. This disadvantage is more than compensated by its ability to be reconfigured to restore all lost data and further, this very flexibility enables different formats to be made available according to flight crews' requirements.

Westland/Agusta design teams considered all possible 'worst cases' first and failure effects second, and thus display modes were defined to minimise the effects of system failures.

2.1.3 EIS Interface

As the EIS was undergoing preliminary design definition so the configuration of the total helicopter avionic system architecture was being addressed (Fig. 4). It is a naval specification requirement for the avionic system data bus system architecture to be based on MIL-STD-1553B as far as possible. From early discussions with the civil certification authorities it was determined that certification of this form of bus architecture, while not impossible, would be protracted and high risk.

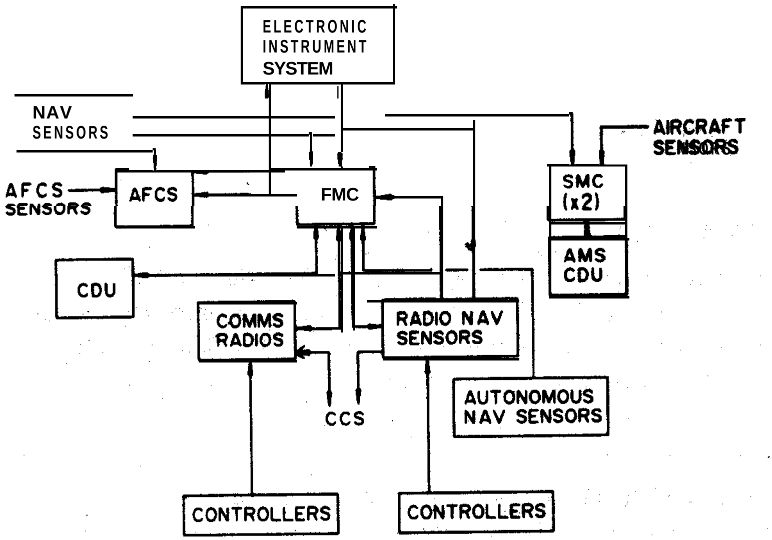

Figure 4. EH101 civil variant avionics architecture.

Therefore an early decision was taken to adopt a civil avionic system architecture based on ARINC 429 which is now the standard interface for the EIS on all EH101 variants.

2.2 Current EIS Design Requirements

2.2.1 System Equipment

The EIS comprises the following line replaceable units :

(i) 6 off colour , raster/stroke DUs 7” x 6” ARINC form sector B ;
(ii) 3 off SG units;
(iii) 2 off flight/navigation DMSs; and
(iv) 1 off power systems DMSs.

Each unit of common function is interchangeable and its mode of operation is determined by where it is located within the aircraft installation.

2.2.2 Primary Configuration

The EIS is arranged as shown in Figs. 2 and 3 to comply as far as possible with the configuration specified for the layout of conventional instruments. Thus the EIS

DU which presents primary flight. to the crew is located on the centre line of each pilot on the upper part of the instrument panel. Below the primary flight DU, the DU presenting navigation data is located. The navigation DU presents one of several navigation formats including horizontal situation, map and hover selected as required by either pilot.

Two power systems DUs are located centrally presenting primary and secondary engine and transmission data, fuel, hydraulics, cautionary and status data.

Essential data is supplied to EIS from duplex system management computers or direct from duplicated sensors (attitude, heading). Each pilot has control of the primary flight and navigation data presented at his crew station; this control being provided by the flight/navigation (F/N) display mode select panels (one at each crew station). Either pilot can control the data presented on the power systems DUs by means of a centrally located display mode select panel in the interseat console.

2.2.3 Reconfiguration

To meet the reversionary capability expected from the EIS, the system must be reconfigured to ensure that, if possible, all data is restored. Reconfiguration should not be automatic but the crew should be alerted to the failure condition and respond by selecting the required new configuration.

2.2.4 Cross Monitoring

Under normal operation, each crew station sources independent data even though each symbol generator must be supplied with all source data to meet the reconfiguration requirements described above. Therefore the EIS should be capable of comparing data to ensure that it is within comparable limits. The crew should be alerted to 'out of limit' comparisons.

Table 1

State	Switch action	Co-pilot		Centre		Captain	
Normal	None	F1	N1	SPS	PPS	N2	F2
SG1 fail	DU copy 1	F2	N2	SPS	PPS	N 2	F2
SG2 fail	DU copy 2	F1	N1	SPS	PPS	N1	F1
SG3 fail	XFR	SPS	PPS	SPS	PPS	N2	F2
	DU copy 1 + XFR	F2	N2	SPS	PPS	N2	F2
SG1 & SG3 fail	DU copy 1 + N/P XFR 2	cFN2	CPS2	-	-	CPS2	CFN2
SG2 & SG3 fail	DU copy 2 + N/I' XFR 1	CFN1	CPS1	-	-	CPS1	CFN1
SG1 & SG2 fail	None	-	-	SPS	PPS	-	-

Abbreviations used - CFN : Combined flight and navigation (format); CPS ; Combined power systems (format); PPS : Primary power systems; SPS : Secondary power systems; XFR : transfer.

2.2.5 Display Mode Requirements

The EIS can provide complete flexibility enabling the presentation of any display format of any one of the display units. However the interchange of all formats between all displays is not considered desirable in the cockpit (Table 1) and this has led to four basic display modes for the primary configuration from which it is possible to page to secondary or reversionary display formats.

The basic modes were derived to ensure the display of required data on EIS initialization and to cater for an unlikely, although possible significant electrical power supply interrupt during flight. EIS re-initialization in flight must present the crew with minimum change of the expected in-flight display formats.

2.3 Primary Flight and Navigation Display Units

2.3.1 Basic Mode

Primary flight and navigation DUs replace all the conventional flight indicators traditionally located in front of each pilot on the instrument panel such as vertical and horizontal situation, airspeed, barometric altitude, radar altitude, instantaneous vertical speed, torque, engine and rotor speed, outside air temperature, and autopilot annunciation.

The format layout of all the parameters associated with the above indicators is organised similar to a conventional layout. The flexibility of the EIS permits suppression or re-organisation of certain parameters depending on crew requirement during various flight conditions.

2.3.2 *Secondary Modes*

Throughout all the expected helicopter operational roles, the basic flight data is unchanged although the relative importance of some data may change. However the various operational roles do demand additional or alternative navigation data to be presented. For example :

(i) Airways : waypoints, radar navigation data, helicopter track, precipitation severity, etc.
(ii) Search and rescue : left/right, fore/aft groundspeed, etc.
(iii) Anti-submarine warfare : left/right, fore/aft groundspeed, cable position, etc.

Furthermore each DU is able to present reversionary composite formats which combine all critical flight and navigation data onto one display screen.

2.4 Primary and Secondary Power System Display Units

2.4.1 Basic Mode

Primary and secondary DUs replace all the conventional power systems indicators traditionally located in the centre of the instrument panel and shared by each pilot :

like engine speed and temperature, temperature and pressure of engine and transmission oils, hydraulic pressure, fuel quantity, and cautionary and advisory status.

In the basic mode, primary engine and fuel quantity data is presented on the primary DU and the remainder is presented on the secondary DU. On EIS initialization a cruise version of power system is presented.

2.4.2 *Secondary Modes*

To assist the crew during the helicopter preflight phase, a secondary START-UP power systems mode has been devised to give a more detailed presentation of power systems data and cautionary status, Other secondary modes principally associated with the secondary power systems DU are provided for pilot recall.

For reversionary operations each DU is able to present a composite version of combined primary and secondary power systems information.

2.5 Display Formats

The basic philosophy for the display format development is based on symbology and colour which is in accordance with conventional cockpit instrumentation and military and civil standards for electronic displays.

Shape coding is used as the primary codification method to minimise the effect of CRT gun failure. The following colour coding has been applied to the display symbology :

(i) Red : warnings and failure indications;
(ii) Yellow : cautionary indications, fixed and reference marks;
(iii) Green : advisory indications, safe conditions;
(iv) White : spontaneously variable values, digital readouts, pointers, scales;
(v) Magenta : pilot input variables and values;
(vi) Cyan : waypoints, labels;
(vii) Light blue : sky on attitude display; and
(viii) Brown : ground on attitude display.

2.5.1 Primary Flight Format

The basic flight format is shown in Fig. 5. Derived from conventional indicators, most of the symbology is self-evident but certain facilities have been introduced to aid the pilot.

Altitude : Figure 5 shows the main altitude indication as barometric altitude (derived from the air data system) with a digital readout radar altitude (bottom right). However, the pilot is able to interchange the two indications, thus providing a full, but dissimilar, analoge/digital presentation of radar altitude and a digital readout of barometric altitude.

Torque margin : Associated with the torque indication is a variable limit and digital readout to indicate to the pilot'the relationship between current demanded power (torque) and the turbine inlet temperature limits of the 'hottest' engine. The

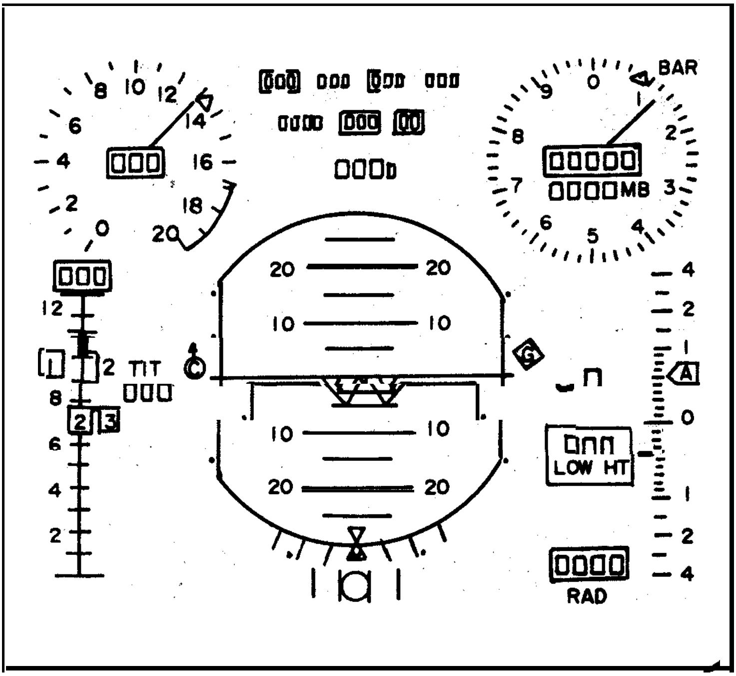

Figure 5. Primary flight format.

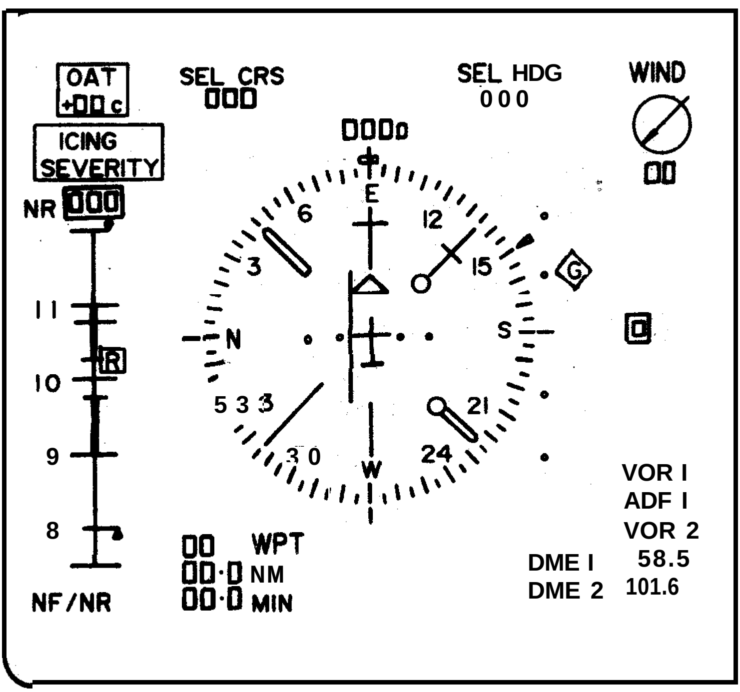

Figure 6. Navigation format-HSI.

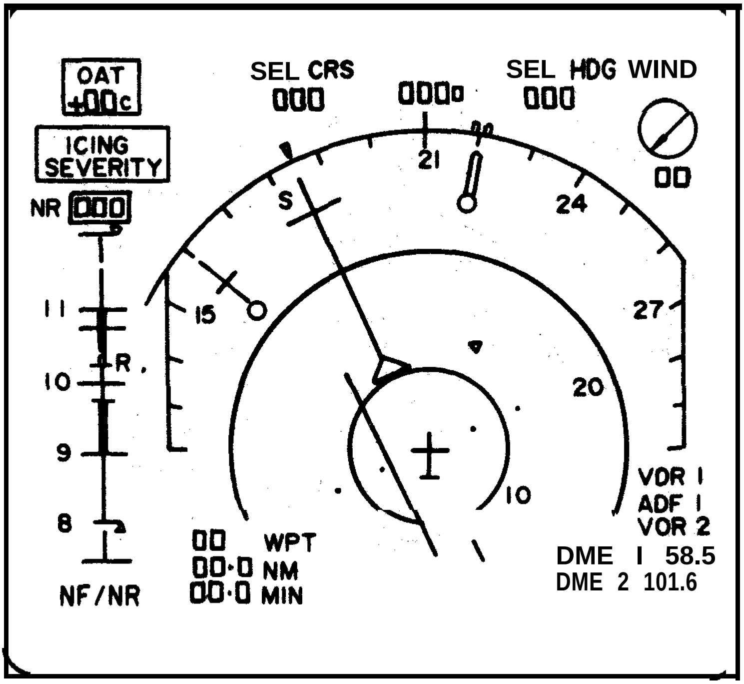

Figure 7. Navigation format–MAP.

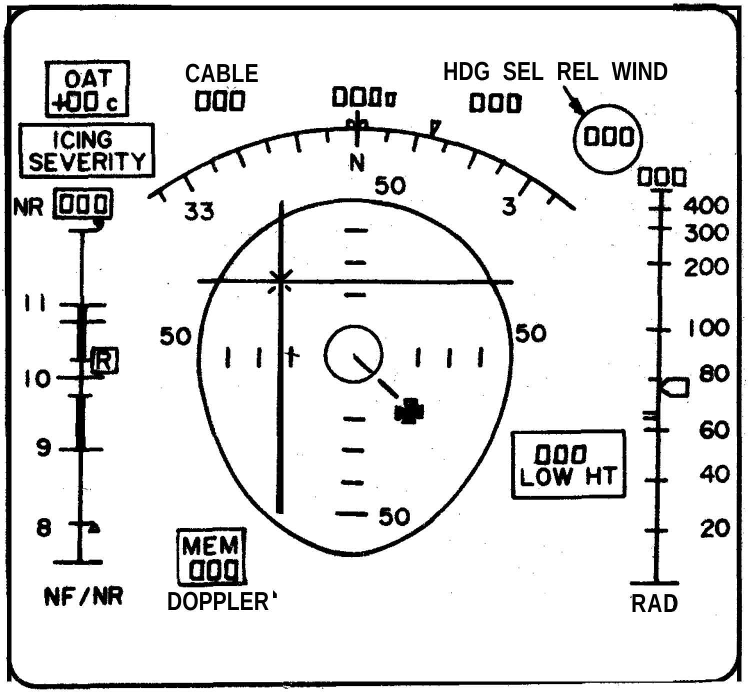

Figure 8. Navigation format–Hover.

digital readout shows the actual temperature of the hottest engine. The variable torque margin limit and digital readout are suppressed until the actual engine temperature is within 100°C of the maximum continuous limit.

Low height warning : The low height digital readout is set by the pilot. Should the helicopter descend to within 100 feet of the set decision height, the digital readout is 'boxed' and the digits change from green to yellow. When the helicopter descends to the set decision height the box flashes for 5 seconds. These indications augment the auditory/voice warnings mandatory for low height warning.

Autopilot annunciation : The autopilot annunciators are augmented to indicate 'armed' and 'captured' -modes and, where required, an annunciator is enhanced to indicate that either or both cyclic and collective autopilot channels are active.

Navigation formats : The basic and secondary navigation formats are shown in Figs. 6 to 8. Most of the symbology is again self-evident but it should be noted that the indications of quadruple tacho (engine-free turbine and rotor speed), outside air temperature, icing severity and wind speed/direction are common to all navigation modes.

2.5.2. *Primary Power* Systems *Formats*

Selectable 'cruise' and 'start-up' formats of primary power systems are available to the pilot (Figs. 9 and 10).

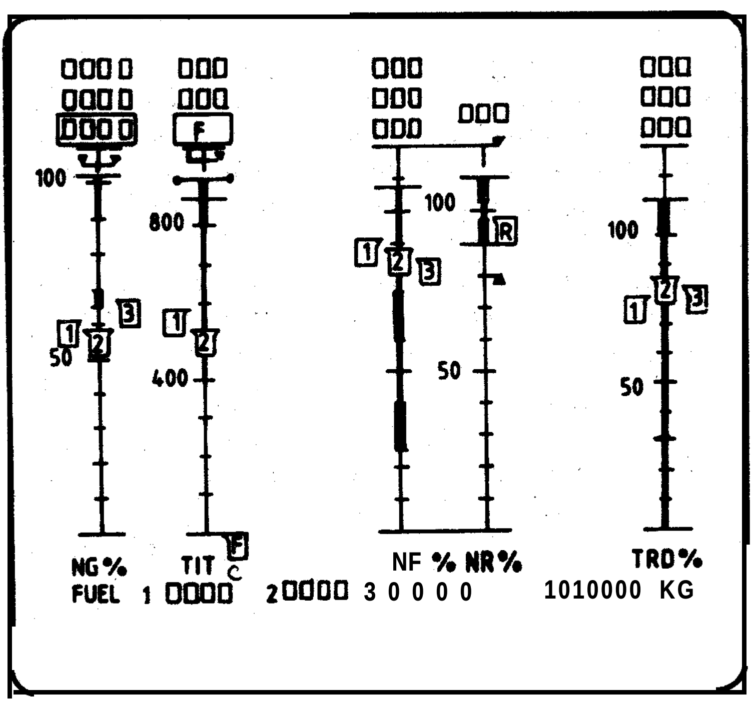

Figure 9. Primary power systems format–start.

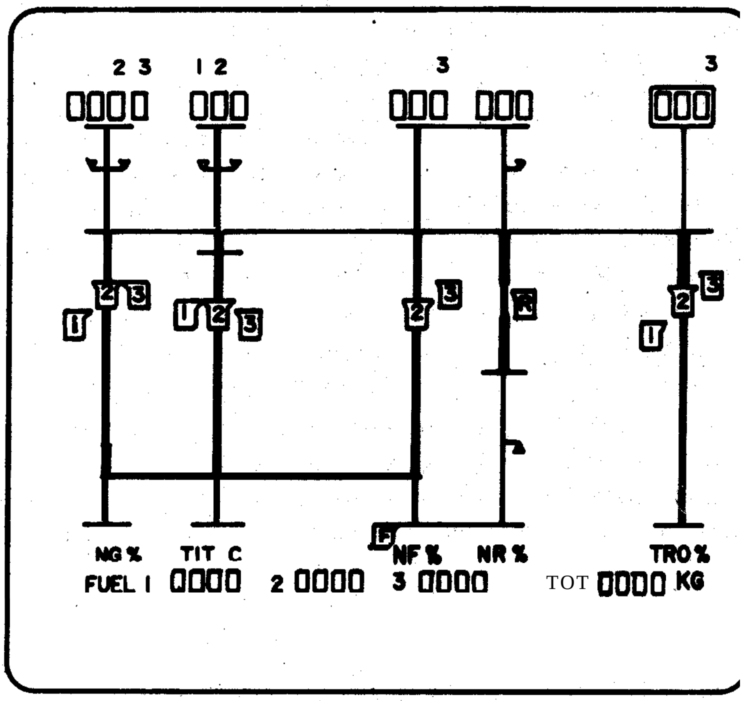

Figure 10. Primary power systems format–cruise.

The cruise format was derived to maximise available screen area to the normal operating range of each parameter and to normalise, as far as possible, all the operating limits. Scale quantifiers are omitted but a digital readout presents 'worst case' instantaneous value. When an indice enters a limitation zone, the indice is infilled and the digital readout boxed with the appropriate colour.

The torque, engine turbine and rotor speed indications are repeats of those displayed on the primary flight and navigation DUs, included on the primary power systems for appreciation of the total power systems' situation.

2.5.3 Secondary Power Systems Formats

The basic format of secondary power systems is shown in Fig. 11. Here scale quantifiers are omitted and the limits are normalised to provide trend rather than actual values. The area on the right of the display screen is dedicated to a listing of up to nineteen ten-character caution and advisory messages; the caution list starts from the top, down (with the last in at the top of the list) and advisory list is at the bottom. This list can be paged if the total of nineteen cautions and advisories is exceeded. Selectable secondary formats are available which include digital readouts of all secondary data, complete caution/advisory listing, and system status for electrics, hydraulics fuel and ice protection systems.

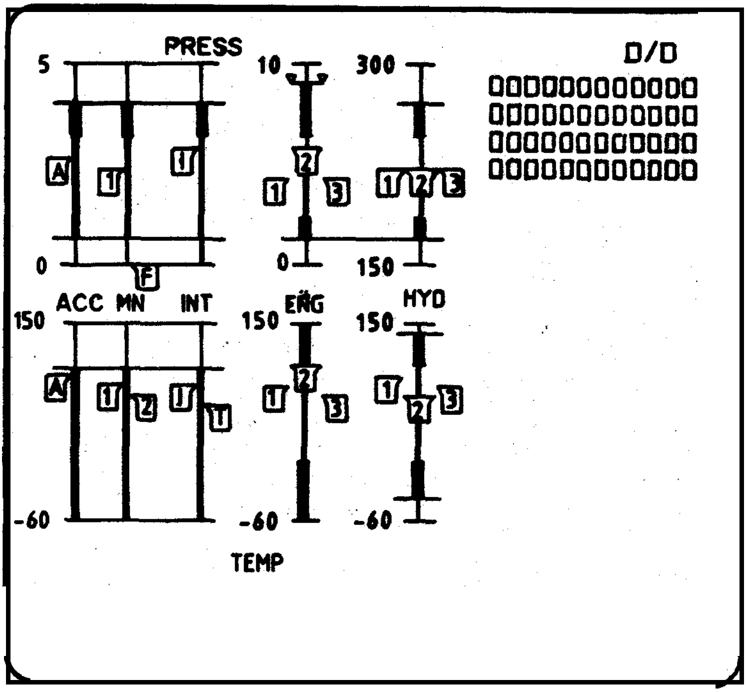

Figure 11. Secondary power systems **format.**

3. EIS HARDWARE IMPLEMENTATION

In 1985 Smiths Industries of the UK and OMI of Italy responded to the request for proposals issued by European Helicopter Industries (EHI) to provide the electronic instrument system for the EH101.

'The baseline requirement specified an aircraft a set of 6 DUs, 3 DMSs, and 4 SGs. Of this, 4 DUs, 2 DMSs, and 2 SGs were meant for display and selection of primary F/N information and 2 DUs, one DMS and 2 SGs were to be utilised for display and selection of power systems and status information (Fig. 12).

If possible, similar hardware and common software between the F/N and power systems components was to be provided. The SGs were required to interface with other avionics systems via ARINC 429 links from aircraft sensors and sub-systems. The system so specified was essentially a conventionally separate EFIS and EICAS as adopted for a number of fixed wing programmes typified by the B757/767.

After consideration of the requirement, Smiths industries concluded that increased flexibility to the user, more efficient use of symbol generation, computing and superior redundancy paths could be achieved by implementing a- fully integrated flight navigation and power systems architecture using 3 SGs to drive the 6 DUs. This architecture was assessed and accepted by WHL and in turn EHI as providing these benefits. Smiths Industries and OMI were selected to develop the EIS and the 3-SG solution was chosen, contract award taking place in 1986.

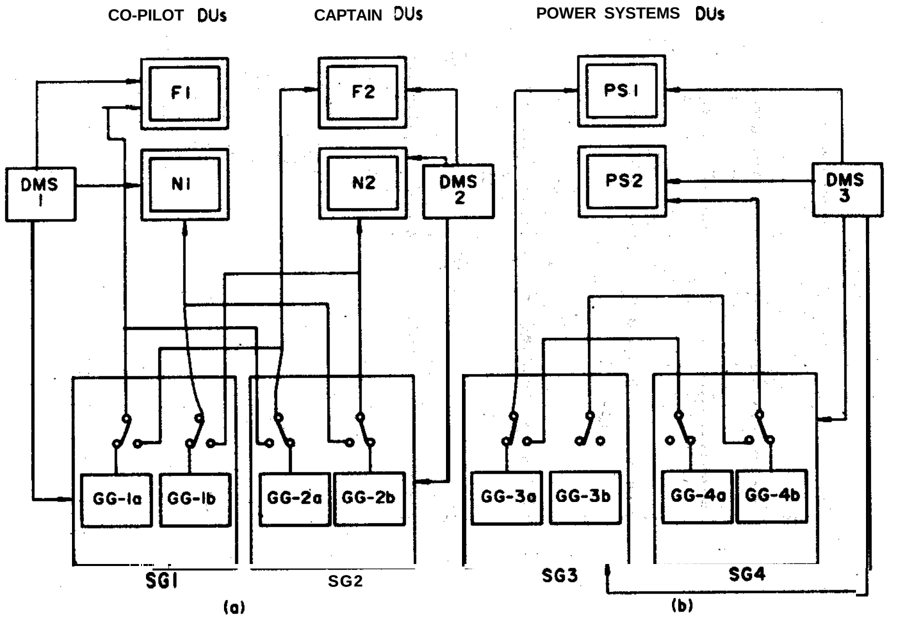

Figure 12. **Original 4-SG EIS system architecture : (a) flight/navigation display sub-system, and (b) power systems display sub-system.**

4. SYSTEMS ARCHITECTURE

The EIS under development is shown in Fig. 13. The architecture includes the 3 identical dual channel SGs collecting and formatting data to be displayed on 6 DUs. Crew control of the system is via the 3 DMSs.

4.1 Symbol Generators

The 3 SGs are identical, each housed in a 3/4 air transport racking (ATR) box, containing the modules of I/O (input/output) processing, MAP data processing, weather radar, (WXR) data processing, two graphic generators, two output drivers, and main power supply.

The I/O processor provides the interface with the majority of external equipment 'via ARINC 429 interfaces. The received data is decoded, processed, and lodged in a random access memory (RAM) buffer store for use by the graphic generators. The input/output processor also provides the facility for cross monitoring data being used by the other SGs and for internal self test.

The MAP processor provides the interface for the ARINC 702 serial map data plus the remaining ARINC 429 interfaces not catered for by the I/O processor. The received data is decoded, processed and then passed to the I/O processor for access by the graphics generators (GGs).

The WXR information (ARINC 453) is received and processed according to the requirements of ARINC 708. From the data the display is constructed as 625 line

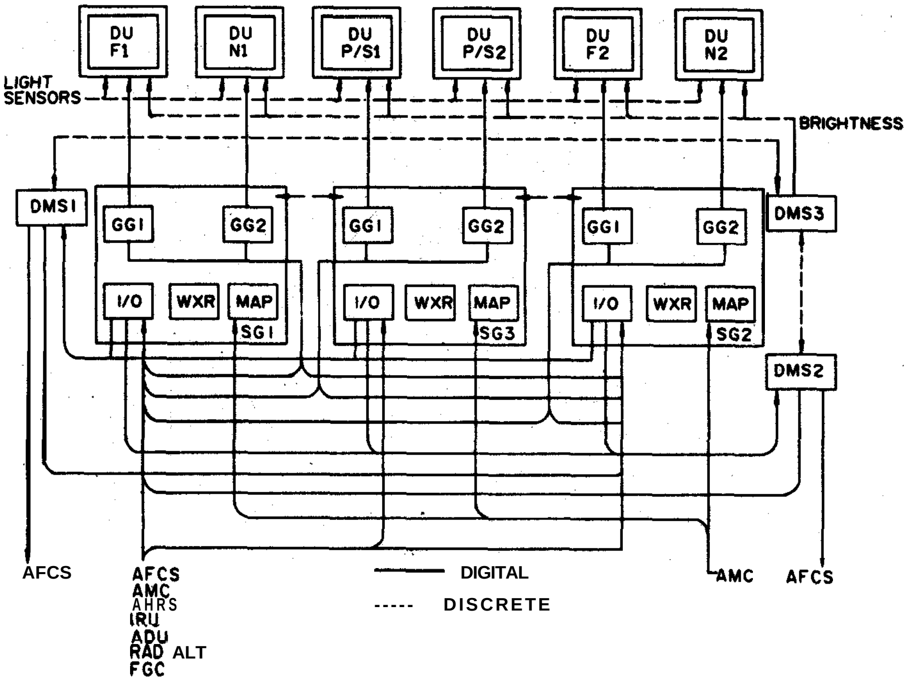

Figure 13. 3-SG integrated EIS architecture (military).

horizontal interlaced raster refreshed at 35/70 Hz. Each field occupies approximately half of the display frame time of 14.28 ms, odd and even fields being displayed alternately every other frame. The top and bottom portions of the raster are blanked to prevent obscuration of the heading scale and aircraft symbol. The WXR video output is synchronised to the graphic generator during the raster period and transmitted to the output drivers.

Two identical GGs are contained in each SG. The program memory of each GG holds all the available data formats, so that each GG may produce and display any format upon command. The GG provides the X, Y, *Z* and colour signals to the appropriate output drivers, operating in two modes; stroke and raster. In the stroke mode the GG receives symbol description data from the I/O processor which is operated on to construct the desired lines, arcs and symbols.

In the raster mode the GG provides the X and Y ramp wave form to describe the raster, either internal video (sky/ground shading) or external video (WXR) operation is available. When part of the display is constructed using the raster mode, the display frame time is split into two periods. The stroke display is written in one period and one field of the raster is written in the other period. The odd and even raster fields are written in one period and one field of the raster is written in alternate display frames. The display frame may be split into any combination of raster and stroke periods.

The output drivers convert the digital symbol X and Y deflection instructions from the graphics generator into the appropriate analogue signals to drive the DUs. The output drivers also control the routing of discrete signals such as bright-up and

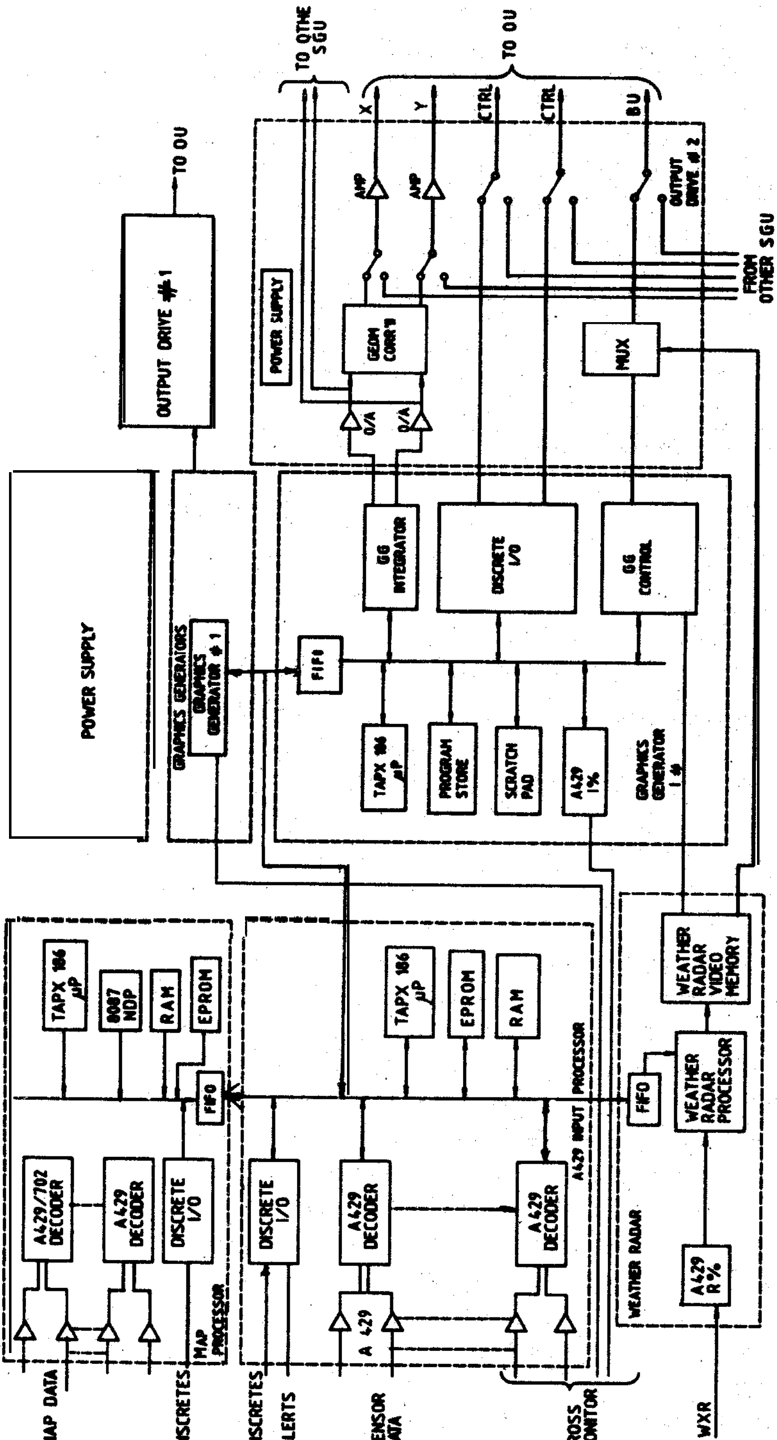

Figure 14. Symbol generator block diagram.

colour codes and provides the necessary output buffers. The input signals may be sourced from either the GG within its own SG (normal source) or a GG in one of the other SGs (reversionary operation) in the event of failure of GG or I/O processor.

4.2 Display Units

The display units are full colour 7 X 6" displays conforming to ARINC form factor B with total usable screen area of 5.8 x 4.8".

The units accept input signals, describing the display format, from the SGs and take the -115 V, 400 Hz ac aircraft supply from which the necessary low and high voltage supplies are generated.

All six DUs are identical providing the display of stroke or a combination of stroke and raster symbology dependent on the format being shown.

The CRT is a high resolution high brightness rugged shadow mask tube with a precision in line guns. structure and high voltage electrostatic focusing system. The screen is of the 'black matrix' type using a three colour triangle phosphor dot matrix, pigmented and aluminised giving a reflectivity to ambient light of less than 28 per cent. The shadow mask has a nominal pitch of 0.3 mm between the phosphor triads, each phosphor dot being nominally 0.1 mm diameter.

A spectrally selective filter is bonded to the face plate to provide display contrast enhancement and provide protection from tube implosion.

Twin ambient light sensors are embedded in the bezel at two corners of the display surface and provide automatic control of the display brightness.

4.2.1 Environmental Considerations of Display Unit Design

In common with most helicopters and some fixed wing aircraft, the EHlOl does not have forced air cooling available at the instrument panel, and use of an integral fan has been deemed unacceptable for this application. Any equipment mounted in the panel must therefore dissipate internally generated heat through convection. Equipment of the EIS-type would normally require some form of forced air cooling however by careful attention to the design of the DU. The EIS units operate under all conditions using only convective cooling.

4.3 Display Mode! Selector Panels

The DMS panels provide all the controls needed for normal operation of the EIS and allow reconfiguration of the system in the event of failures.

The philosophy adopted for the panels is based on momentary operation push buttons under software control rather than rotary switches with dedicated positions. This approach allows for different role configurations, for example, numbers of sensors, radio, navigation aids fitted to be catered for without the need to change the control panel layout and also reduces the number of controls required.

The DMS for control of F/N displays is divided into 3 functional areas as shown in Fig. 15. These are :

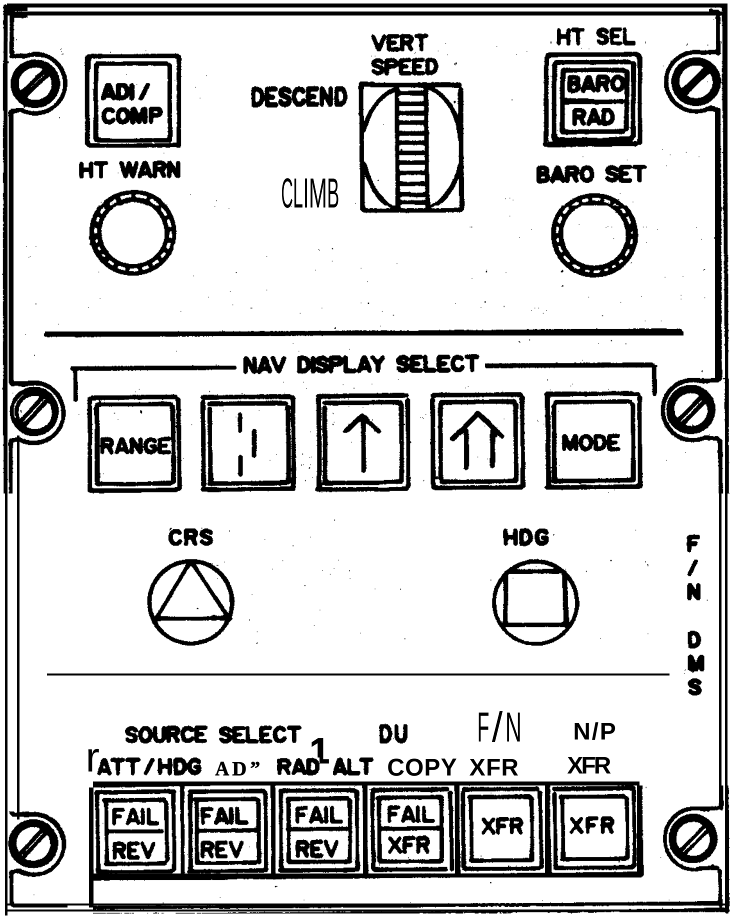

Figure 15. Flight/navigation DMS front panel layout.

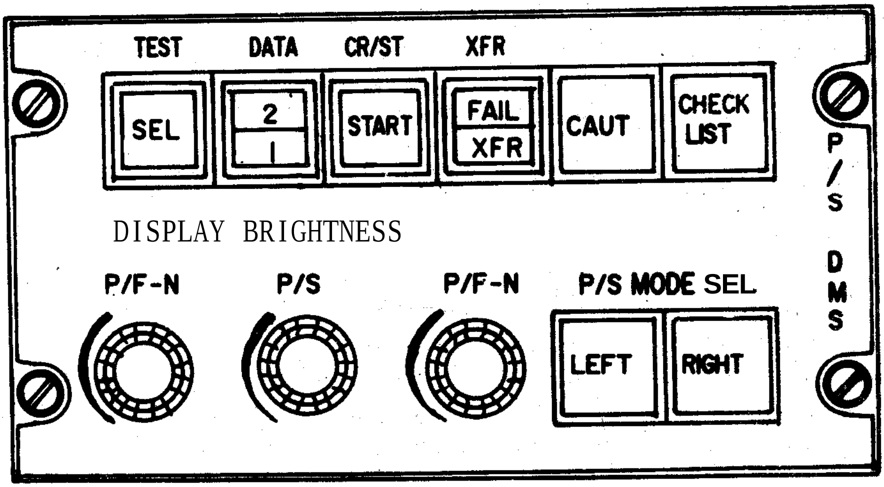

Figure 16. Power systems DMS front panel layout.

(i) Controls associated with the flight display;
(ii) Controls associated with the navigation display; and
(iii) Sub-system reconfiguration controls.

Operations within the F/N DMS are controlled by a micro controller providing processing of external discretes and push button operations, including the functions provided on the power systems DMS, for transmission to the SGs via a digital link.

The DMS for control of power systems (P/S DMS) is divided into 3 functional areas as shown in Fig. 16. These are :

(i) Display brightness control for all DUs;
(ii) Controls associated with the power systems display; and
(iii) Control of system test.

Apart from the DU brightness control, which interfaces directly with the DUs, all control functions are output to both F/N DMSs, via discrete links, for processing prior to being transmitted to the SGs.

5. SYSTEM INTERFACES AND DATA SOURCES

All of the raw data required to generate the display formats is provided, via ARINC 429 digital links, from various aircraft sensors or sub-systems as shown in Fig. 13.

Primary flight data is provided by the attitude and heading reference system/inertial reference unit (AHRS/IRU for aircraft attitude data), air data unit (ADU for barometric height, vertical speed and air speed) and radar altimeter.

Navigation data is provided by the AHRS/IRU (aircraft heading), aircraft management computer (MAP data, waypoipts, position, etc.) and a selection of radio navigation aids such as VOR/ILS, MLS, DME, etc. Selection of the navigational data is via the F/N DMS.

The interface with the AFCS is bidirectional, the EIS provides the AFCS with heading, course, vertical speed, navigation sensor data as selected on the F/N DMS, and receives flight director and auto pilat mode data for display.

Power system data is initially collected by the aircraft management systems (AMS) computer, processed and transmitted to each SG in the required format for display. Cautionary warning data is also provided by the AMS. Each SG provides BITE data to the AMS for logging in the maintenance files.

6. SYSTEM INTEGRITY AND REVERSIONARY SWITCHING

6.1 General

In contrast to a conventional instrument panel, where dedicated instruments provide primary flight and navigation information and engine and transmission parameters, the electronic instrument' system allows maximum flexibility of presentation of this data:

Although normally the upper and lower display in front of each pilot will show primary flight and navigation data respectively and the centre displays will show power systems, should failure of a DU, SG or sensor occur, the EIS can be reconfigured to maintain all the available data.

SG failures can take two forms, I/O processor failure or graphic generator failures. I/O processor failure will cause the loss of that SG only. In this case the remaining SGs can be reconfigured, by operating hardwired switches in the SGs, to copy data to the displays previously driven by the failed SG. Graphic generator failure will have the same effect as a DU failure and is catered for in the same manner.

DU failure is covered by either software switching of the failed data to another DU or selecting composite formats. In either case all data can be accessed by selection on the remaining serviceable DUs.

Under normal operation each crew station sources independent data. In the event of single source failure, each crew station is supplied with data from the remaining sources, maintaining full display capability.

A study to determine the optimum reversionary switching scheme was based on objectives of maximum system availability whilst retaining simplicity of implementation and operation. The following criteria were identified as being desirable when considering the choice of scheme :

(i) Use of a single button (DU copy) to transfer F/N displays;
(ii). Use of a single button (XFR) to restore P/S displays on centre DUs;
(iii) Fail light lit in appropriate button to aid crew action;
(iv) Provision of F/N data from the other F/N SG (XFR);
(v) Support of centre DUs if SG 3 fails; and
(vi) No more than two outputs per SG.

The switching scheme meeting these objectives is summarised in Table 1.

6.2 Cross Monitoring

During normal operation the displayed data at the pilot and co-pilot stations is provided from separate sources and hence malfunction of a single sensor will result in a mismatch of the displayed parameter between pilot and co-pilots DUs. In order to ensure that the crew are alerted when a mismatch does occur, cross monitoring and comparison of all data is continually carried out. If a mismatch exceeds acceptable limits the crew are alerted They may then troubleshoot to determine which sensor is in error by comparison with standby instruments or external vision. Once the source at fault has been identified that sensor is de-selected and the display system is then single-sourced from the remaining serviceable sensors.

7. CONCLUDING REMARKS

The EH101 EIS represents the first implementation of a fully integrated flight navigation and power systems full colour CRT display system in a military helicopter. Optimisation of display formats to meet both military and civil requirements is being continuously addressed during the development program.

Through considerable work on the reversionary mode philosophy, superior redundancy characteristics are demonstrated compared with functionally separated flight/navigation and power systems display system. The EIS is inherent& more flexible than conventional instrument systems and future extensions of EH101 operating roles are catered for without the need fur hardware changes.