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EH101 COCKPIT DESIGN

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Abstract

This paper describes the work undertaken on the EH101 "all CRT" cockpit design from initial conception through to system design, detailed format development and proposed certification programme covering the approach to the many topical issues such as power systems formats, integrity, reversion, software certification and the problems of three engine instrumentation.

Described are the trade-off studies on weight, screen size, configuration and flexibility. The resulting selected system is described, including architecture, interfaces and modes of operation including reversion.

The work undertaken on format development particularly the power system displays with the problems of instrumentation for three engines, torque margin and hover formats is covered.

The proposed certification programme is described before finally drawing conclusions from the work undertaken to date and discussing possible future enhancements to the EH101 Cockpit Electronics Display System.

1. INTRODUCTION

This paper describes the work undertaken on the EH101 "all CRT" cockpit design from critical studies through to system design, detailed format development and proposed certification programme covering our approach to the many topical issues such as power systems formats, integrity, reversion, software validation /verification and the problems of three engine certification.

2. WHY SELECT AN "ALL CRT" COCKPIT?

The fore-runner of the EH101 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 1970's with a series of design studies which by the beginning of the 1980's proposed a cockpit design based on conventional displays but employing a degree of display integration providing integrated power systems, torque and torque margin display, and "message panel" central warning systems as shown in Figure 1.

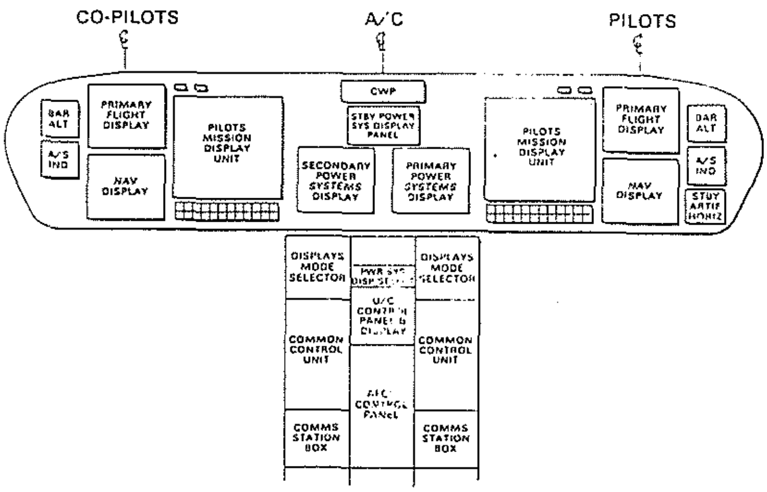

Figure 1 Conventional Primary Flight Instrument Display

Display integration was deemed necessary due to the amount of data which had to be presented to the crew - not only aircraft systems data but also mission data.

When the WG34 project turned into the collaborative EH101 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.

The crew station design groups at WHL and Agusta embarked on a study phase to assess the applicability of CRT technology to the EH101 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 main constraints around the display system were as they are still today:-

i) operation throughout the full ambient light range expected in the cockpit i.e. up to 10^5 lux

ii) equipment commonality between helicopter variants

iii) a fixed mission display standard based on 625 line raster video

The outcome of the study proposed a number of display system options summarised below.

Option 1 - Conventional cockpit with EADI, EHSI and EPSD
Two 9" diagonal raster-scanned monochrome displays

Option 2 - Five 8" x 8" raster-scanned monochrome displays

Option 3 - Three 8" x 8" stroke-written shadowmask colour displays
Two 9" diagonal raster-scanned monochrome displays

Option 4 - Three 8" x 8" stroke-written shadowmask colour displays
Two cursive/raster scanned beam penetron displays

Option 5 - Five 8" x 8" raster-scanned shadowmask colour displays

Option 6 - Six 7" x 6" stroke-written shadowmask colour displays
Two 9" diagonal raster-scanned monochrome

The main problem related to the incompatibility between the mission and flight display requirements. It was impossible within the available technology to reconcile the high resolution requirements for mission displays based on 625 line raster and yet achieving display brightness necessary for the display of flight parameters in high ambient light conditions.

The study also looked at combinations of display screen sizes including 6¼" square, 7" x 6" and 8" x 8" with up to 11" diagonal for mission displays but it was eventually agreed to compare weight cost and reliability between the proposed Option 6 and a display suite based on conventional electro-mechanical instrumentation.

The results of these comparisons are given in Table 1 below and at first sight quite surprising.

	Conventional Instruments *	Electronic Instruments
Weight	106Kg	107Kg
Development Costs	6556 (£K)	6298 (£K)
MTBD	2.5×10^{-2}	7.6×10^{-3}

* Including Interface Units for Digital Analogue conversion.

TABLE 1 - Weight Cost & MTBF Comparison

If one tries to compare a one to one trade off i.e. ADI versus 7" x 6" CRT then there is no comparison, the electro-mechanical instrument with reference to weight and cost will always win with large margins. However when considered as a total system, i.e. flight, navigation and power systems with the interfacing required to a digital avionic system such as the EH101 then cost and weight are quite comparable. What cannot be readily demonstrated in table form is the significant major advantages that electronic display systems provide:-

i) Ability to suppress large amounts of data, displaying certain types of information only when required thereby reducing crew workload.

ii) Improved reversion capabilities with the ability to drive any head with any format and combined display formats when required.

iii) Improved cost of ownership. The maintenance costs of electro-mechanical instruments with the watchmaker type skills will be high compared to the relative unskilled tasks of printed circuit throw-away and replace concept.

The system configuration therefore which kept within the constraints (particularly the mission display requirement) and acceptable from a cost, weight and reasonable technical risk was a combination of six off 7" x 6" display units colour cursive with two off 11" diagonal mission display units monochrome raster as shown in Figure 2.

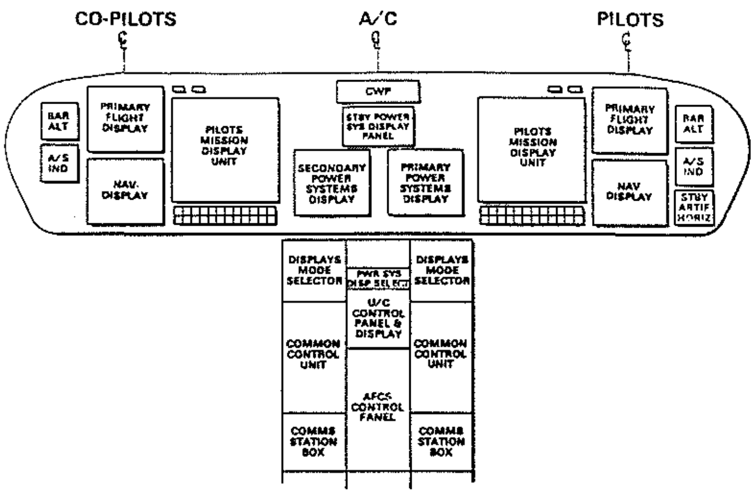

Figure 2 Selected Display Configuration Option

The display system architecture was configured such that with 3 off common symbol generators, display flexibility could be optimised to permit display of any format could be presented on any of the 7" x 6" display units. Display flexibility also permits a significant amount of display and symbol generator redundancy. However it is still necessary to retain a limited amount of standby instrumentation for altitude, heading, airspeed, barometric altitude and power systems. It was also thought prudent to retain dedicated display of all the emergency warnings whereas the cautionary warnings are integrated within the electronic display system.

3. SYSTEM ARCHITECTURE

The EH101 Electronic Instrument Systems is shown in Figure 3. The architecture is based round three identical symbol generators (SG's), collecting and formatting data for display on six display units (DU's). Control of the system is via three Display Mode Selectors (DMS's). The following paragraphs provide details on each aspect of the architecture.

SYMBOL GENERATORS (SG'S)

The three SG's are identical, each housed in a 3/4 ATR box, containing the following modules (see figure 4 - Symbol Generator Block Diagram):-

- I/O processing
- MAP data processing
- WXR data processing
- Two graphic generators
- Two output drivers
- 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 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 SG's 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.

The WXR information (ARINC 453) is received and processed according to the requirements of ARINC 708. From the data the display is constructed as 256 line 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 alternatively every other frame. The top and bottom portions of the raster are blanked to prevent absuration of the heading scale and aircraft symbol. The WXR video output is synchronised to the graphic generator during the raster period and output to the output drivers.

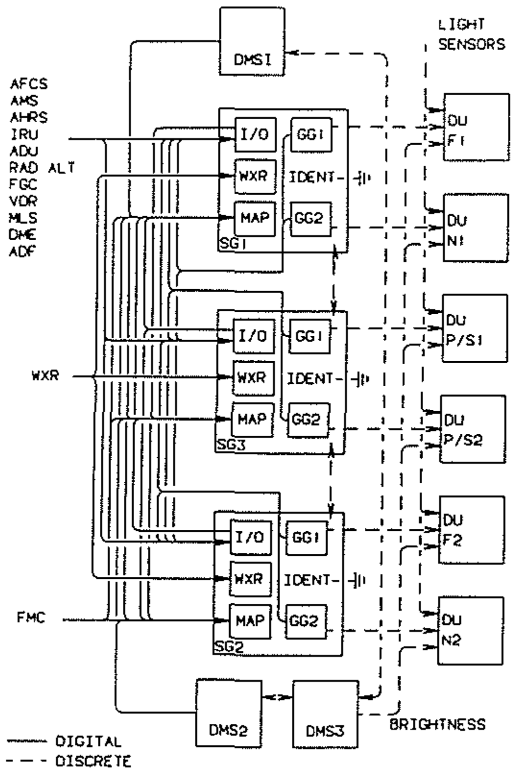

Figure 3 EH101 Electronic Instrument System Architecture

Two identical graphics generators (GG) are contained in each SG. The programme 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, cursive and raster. In the cursive 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 waveform 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 14.28 ms display frame time is split into two periods. The cursive 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 alternate display frames. Depending on the raster mode the cursive writing is not limited to 50% of the frame time.

The output drivers convert the digital symbol X and Y deflection instructions from the graphics generator into the appropriate analogue signals to drive the Display Units. The output drivers also control the routing of discrete signals such as Bright-Up and 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 SG's (reversionary operation) in the event of failure of the GG or I/O processor.

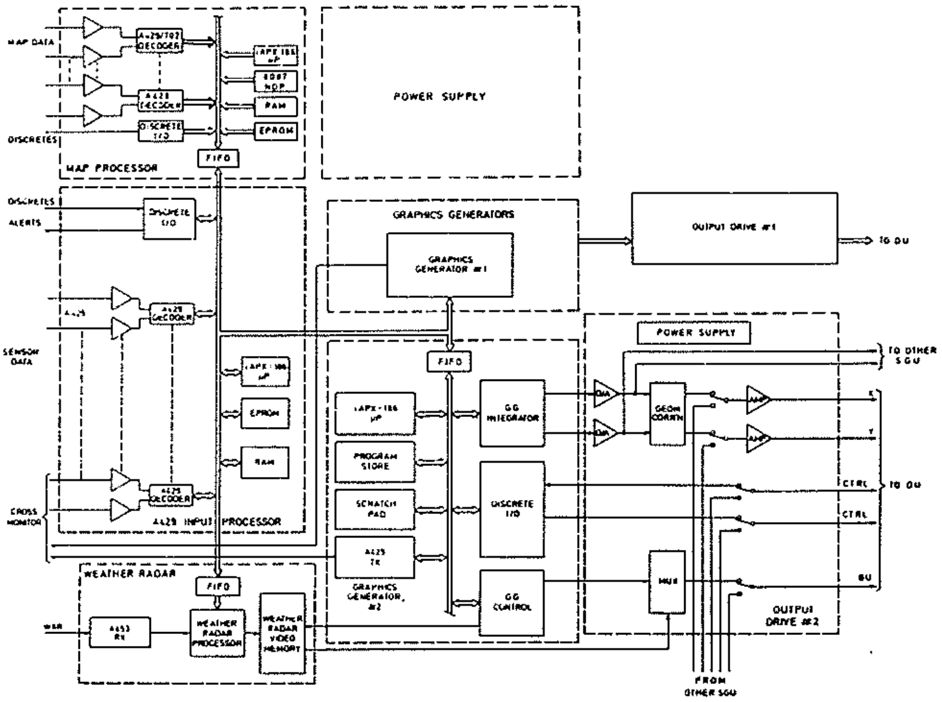

Figure 4 Symbol Generator Block Diagram

Each SG has its own power supply module, operating from the aircraft 115V 400Hz ac supply, to provide all the necessary stabilised dc voltage for correct operation of the SG unit, apart from the output drivers which have their own power supply, derived from the aircraft, 115V 400Hz ac supply, independent of the main power supply to enhance failure survivability of the system.

DISPLAY UNITS

The display units are full colour 7" x 6" displays to ARINC form factor 'B' with a total usable screen area of 147mm by 121mm.

The units accept input signals, describing the display format, from the SG's and accept the 115V 400Hz ac aircraft supply from which are generated the necessary High and Low voltage supplies.

All six DU's are identical providing the display of symbology, with the exception of the WXR overlay and ADI sky/ground shading, cursively written in order to achieve maximum definitive and contrast.

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

A spectrally selective filter is bonded to the faceplate 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, these together with an external forward looking sensor, provide automatic control of the display brightness.

DISPLAY MODE SELECTOR PANELS

The Display Mode Selector (DMS) Panels provide all the controls needed for the normal operation of the EIS and also for reconfiguring the system in the event of equipment failures.

The philosophy adapted for the control panel is based on momentary operation push buttons under software control, rather than rotary switches with dedicated position, this enables different role configurations i.e. number of sensors, radio nav aids fitted etc, to be catered for without the requirement for charging the control panel layout for differing roles it also reduces the number of controls required.

Two types of DMS are provided, one for control of power system displays and the other, for which there are two one for each Pilot, for control of Flight/ Navigation displays.

The DMS for control of Flight/Navigation displays (F/N DMS) is divided into three functional areas as shown in Figure 5, these are:-

i) Controls associated with the Flight display
ii) Controls associated with the Nav display
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 P/S DMS, for transmission to the SG's via a digital link.

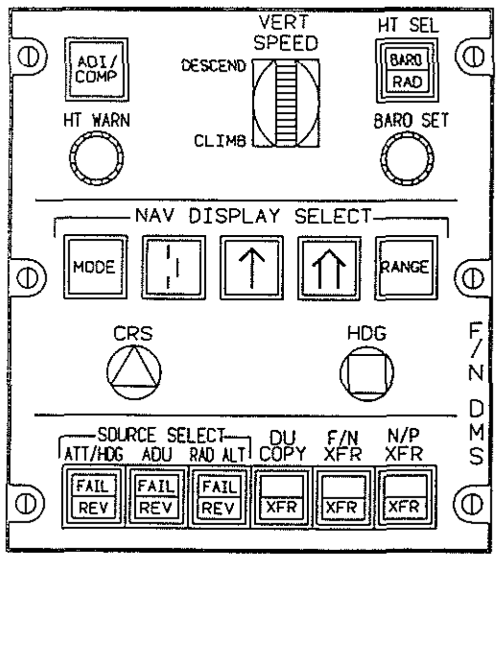

Figure 5 Flight/Nav DMS Front Panel Layout

The DMS for control of Power Systems (P/S DMS) is divided into three functional areas as shown in Figure 6, these are:-

i) Display brightness control for all DU's

ii) Controls associated with the Power Systems display

iii) Control of system test

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

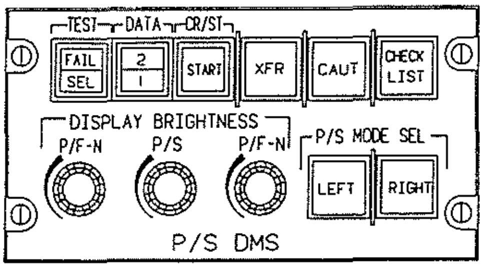

Figure 6 Power Systems DMS Front Panel Layout

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 Figure 3.

Primary Flight data is provided by the AHRS/IRU (aircraft attitude data), ADU (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, waypoints, position etc) and a selection of radio nav aids such as VOR/ILS, MLS, DME etc. Selection of the nav data is via the F/N DMS.

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

Power system data is initially collected by the Aircraft Management Systems (AMS), 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.

REVERSIONARY CAPABILITY

Unlike a conventional instrument panel, which has dedicated instruments positioned in specific locations, the EIS has total flexibility as to where information is displayed. Under normal operating conditions the conventional 'T' configuration of primary flight data is generally adopted with power systems displayed in the centre of the instrument panel, refer to Figure 2.

However under failure conditions i.e. DU failure, SG failure or sensor failure the EIS can be reconfigured to maintain the ability to display all available data.

To cover sensor failure all the essential sensors are either duplex or there are two in the system. Under normal operation each crew station sources independent data. In the event of sensor failure each crew station sources the remaining sensor, maintaining full display capability.

DU failure is covered by either software switching the failed DU data to another DU, or selecting composite formats, in either case all data can be accessed by selection on the remaining serviceable DU's.

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

CROSS MONITORING

As the displayed data at each crew station is sourced from different sources, protection against the crews being given different information is required. This is provided by cross monitoring and comparing data to ensure it is within acceptable limits, should the comparison be out of limits both crew are alerted. The discussion as to which sensor is in error is up to the crew, by using external vision or the standby instruments. The sensor in error can then be deselected and the data single sourced.

4. ELECTRONIC INSTRUMENT SYSTEM DISPLAY PHILOSOPHY

The very flexible nature of an electronic instrument display system created its own problems i.e. where do you start? where do you draw your boundaries? what is acceptable to the crew? what is practical? and many others. It was therefore necessary to provide a framework and following detailed discussions with pilots and fixed wing airtransport users the following display philosophy was adopted:

SYMBOLOGY

The form of the symbology is initially based on traditional design i.e. sphere for altitude, vertical and circular analogue scales with the information as appropriate and failure flag annunciators.

CODING

Shape coding is used as the primary codification method, to minimise the effects of CRT gun failure, augmented by the use of colour.

COLOUR

The following use of colours when applied to display symbology has been adopted:-

RED - warnings and failure indications
YELLOW - cautionary indications, fixed and reference marks
GREEN - advisory indications, safe conditions
WHITE - spontaneously variable values, digital readouts, pointers, scales
MAGENTA - pilot input variables and values
CYAN - waypoints, labels
LIGHT BLUE - sky on attitude display
BROWN - ground on attitude display

PRIMARY DISPLAY CONFIGURATION

The display units are located (see Figure 2) such that in the primary configuration, 2 off flight displays are in the traditional attitude indicator position on centre line of each pilot. 2 off navigation displays are in the traditional heading indicator position on centre line of each pilot. While the power systems displays (2 off) are centrally located on the instrument panel, shared by both pilots.

DISPLAY MODES

The flexibility of the system provides an opportunity to condition the presented symbology according to the flight conditions, allowing the selection of barometric of radar altitude as the primary altitude display. For the engine start phase of flight the full range of power systems data is provided but during cruise, data is limited to operational ranges only. Engine and transmission limits are displayed or suppressed according to three-engine or two-engine operation, whilst a torque margin indication has been developed which informs the pilot of available torque before maximum continuous and contingency engine limits are exceeded.

Facilities are provided to suppress the secondary engine parameters which will be continuously monitored by the aircraft (avionic) management system. As soon as any parameter value is outside pre-determined limits, the secondary display will be automatically restored and the pilot will be queued to the appropriate parameter indication.

5. DISPLAY FORMAT DEVELOPMENT

During the above-mentioned study phase WHL had undertaken preliminary definition of display formats covering flight, navigation and power systems to demonstrate the feasibility of displaying helicopter data. This definition was based on sketches and a series of discussions with WHL test pilots.

At the earliest opportunity, the preliminary definition was embodied onto the simulator and it was soon realised that while it had been necessary to sketch formats to demonstrate feasibility, its usefulness is very limited. Useful development can only be achieved with dynamic symbology on representative display units and preferably assessed in a flying environment.

An extremely useful design aid, which in fact became available late in the format development programme, is a graphics terminal. At WHL, this is an extension to the CAD/CAM system which enables designers to construct, develop and refine format symbology and layout on a CAD terminal. This facility is a much more useful first step in format design since a more representative format is produced and therefore the final design needs minimal refinement after it has been incorporated into the Simulator for assessment.

As stated previously, it is possible to display all formats on any display unit but part of the development programme is to determine the primary flight configuration and subsequent display switching in the event of display unit and/or symbol generator failures. Consequently the display modes have been organised into the following main groups:-

- Primary Flight
- Navigation
- Primary Power Systems
- Secondary Power Systems

Each group contains alternative display formats selectable on the DMS's. However, under normal operating conditions only one of each group may be selected by the pilot for display on his four DU's, and the co-pilot may only select one format from each of the Primary Flight or Navigation groups.

During development and assessment of formats on the simulator several methods of presenting the data was tried. Vertical strip scales for airspeed and altitude, clock presentation for power systems etc after several iteration the following formats have evolved and generally accepted.

PRIMARY FLIGHT FORMATS

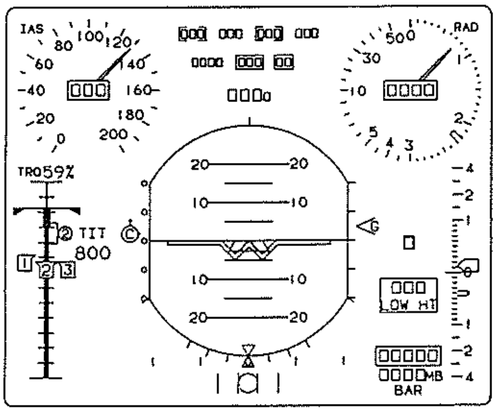

Figure 7

Two formats are available, one as shown in Figure 7 the other differing only in the selection of a Baro altitude display in place of Rad altitude, whichever is selected a digital readout of the other is presented at the bottom right of the display. The engine torque display is a copy of that presented on the primary power systems display with the addition of torque margin. This display is unique to helicopters and a new concept developed for CRT cockpits.

NAVIGATION

The Navigation group consists of five basic formats, HSI, Map, Map plus Weather Radar, Doppler Hover and Cable Hover, sequentially selectable on the F/N DMS mode button.

The HSI format is presented as a standard rotating compass rose, heading up, with conventional course, heading, nav pointers and deviation bar. In addition waypoint distance/time to go, OAT, wind vector and quad tacho are displayed on all nav formats. The map display, shown in Figure 8, consists of an expanded compass arc, covering 180 degrees, surrounding the map data. Map data is represented as waypoint symbols positioned relative to the aircraft position (centre). Waypoints are joined by straight lines representing the selected route. The selected range of the map data is presented as range rings centred on the aircraft. The quad tacho is a copy of that displayed on the primary power systems cruise format. Space has been provided for an ice severity warning which is still under development.

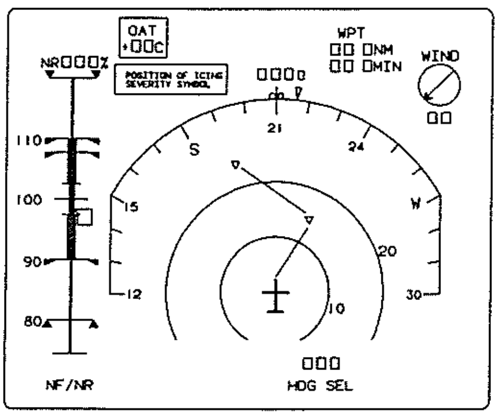

Figure 8 Map Display Format

When map plus weather radar is selected, the WXR data underlays the map data.

Two Hover formats are available, Doppler and Cable Hover. Figure 9 shows the cable hover format. The cable angle/position is presented as a Maltese cross subtended by a line from the aircraft centre. The egg shaped figure represents the limit of the cable angle. Cable length deployed is given in the digital readout. Doppler lateral and for/aft velocities are presented as cross wires against a scale up to 50 knots with the resultant velocity shown in the digital readout. Radar altitude is presented as a vertical scale with a digital readout and selectable low height warning bug and digital readout. The Doppler Hover format is identical to the Cable Hover format with the cable data removed.

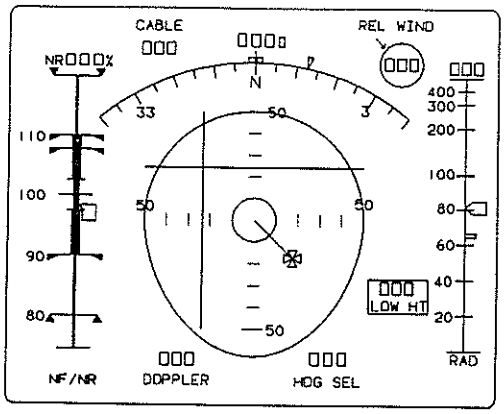

Figure 9 Cable Hover Format

PRIMARY POWER SYSTEMS

Two selectable formats are available to present the Primary Power Systems, Start Up and Cruise. Figure 10 shows the start up format presenting vertical scales for engine speed, turbine inlet temperature, free turbine speed, rotor speed and engine torque for each engine, a digital readout of each parameter is given above each scale. When a pointer enters a yellow or red zone it is infilled with that colour and the digitial readout for that parameter is surrounded by a box of that colour. Fuel total is presented in digital form.

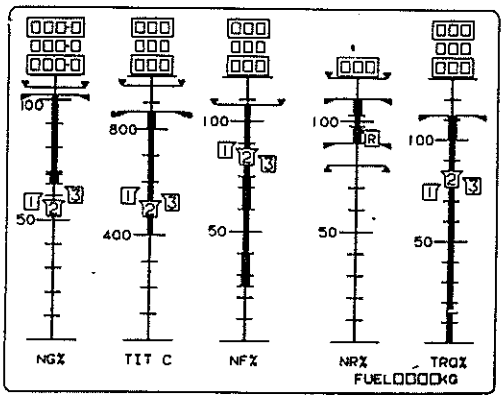

Figure 10 Primary Power Systems Start Up

The cruise format presents the same parameters as the start up format but the vertical scales are normalised without scale markings to represent trends, rather than actual readings. A digital readout of the highest parameter of each scale is given.

SECONDARY POWER SYSTEMS

The Secondary Power Systems group consists of the following formats:- Secondary power systems display (analogue and digital), Hydraulic system display, Fuel system display, Electrical system display, cautionary data and checklists. These formats are sequentially selected on the P/S DMS mode buttons. The Secondary Power System (analogue) is shown in Figure 11. As with all secondary formats the right hand one third of the available display is dedicated to cautionary and advisory data, with the exception of the dedicated cautionary format which is totally dedicated to cautionary and advisory data.

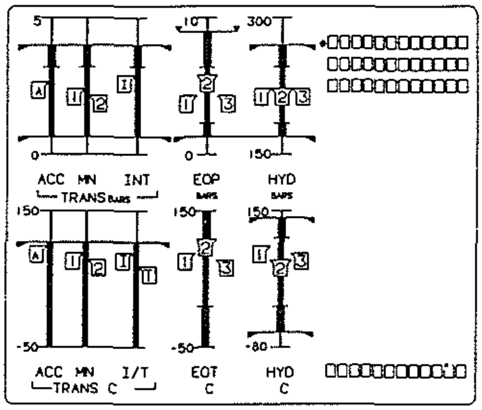

Figure 11 Secondary Power Systems

Up to sixteen captions (64 on dedicated format) can be displayed at any one time with the facility to page if a greater number of captions are set.

The display of Transmission, Engine and Hydraulic oil and temperature data is presented in the same manner as the primary power system cruise format showing trends, digital readouts of these parameters are available on the digital format.

The remaining formats are specific to system data and generally take the form of strip scales e.g. electrical system voltage and current status.

COMPOSITE FORMATS

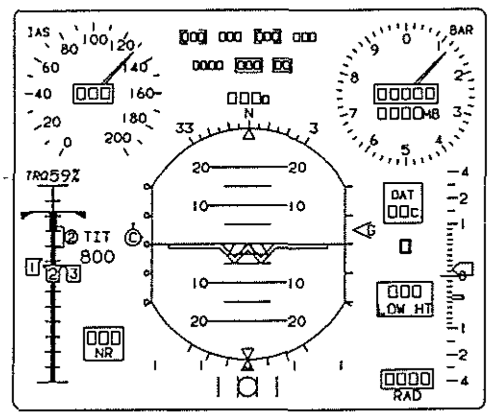

Figure 12 Composite F/N

Two composite formats are available in the event of loss of DUs. These cover Primary Flight/Nav data and primary/secondary power systems data. The composite F/N format, Figure 12, is the same as the primary flight format with the addition of essential data displayed on the HSI format albeit, in a limited form. Heading data is presented as a compass arc at the top of the ADI with only the heading bug displayed, course and nav pointers are not available on this format. Rotor speed is displayed as a digital readout only, a box, of the relevant colour, is generated round the digital readout when the parameter is outside normal limits. OAT is displayed as a digital readout.

The composite power systems format, Figure 13, is basically a combination of the primary power systems and secondary power systems formats. The cautionary data is removed and replaced with the engine speed and turbine inlet temperature scales (torque, rotor speed and free turbine speed are displayed on the F/N displays). Up to two cautionary captions are displayed at the bottom of the display with the facility, as for the normal display, to cycle through all captions set.

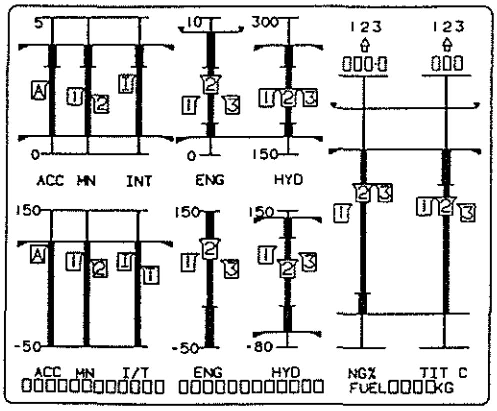

Figure 13 Composite Power Systems

As previously mentioned all the normal formats are available for selection if required for detailed display of data.

In summary, from the above discussions on display formats, it can be seen that with the two composite formats displayed all essential data is presented on only two display units.

6. CERTIFICATION ASPECTS

OBJECTIVES

To determine the steps taken in the certification of the EH101 cockpit systems, we have to take account of the possible means at our disposal of demonstrating compliance with the requirements and utilising those methods which will demonstrate the required level of safety at least cost. This aspect is particularly important when considering the failure analyses and performance analyses of the systems. For example, as we shall see later, extensive use of ground test facilities, rather than flight test is to be preferred, but only if the cost of providing the ground based test rig(s) is less than that of extensive flight testing (this is in fact the case).

WHL has extensive experience in the utilisation of such facilities, and having adopted a modular approach to the design of these rigs for other projects, a rig for the performance analysis of the EH101 systems can be provided at a realistic cost.

It is not the purpose of this paper to describe at any great length the details of the design of the EH101 integration rig, but the main features are summarised in 'System Description' below.

BASES OF CERTIFICATION

The EH101 is designed to satisfy the requirements of BCAR Section G, and where these requirements are qualified by CAA Blue papers and Airworthiness Notices, and also FAR Part 29. However, these regulations were written essentially prior to the incorporation on a large scale of the electronic flight deck. An evolution of the regulations is currently perceived, and WHL is taking an important role in the formulation of the revised regulations, by sitting on those Airworthiness committees (EUROCAE) concerned with these matters.

SYSTEM INTEGRITY DEMONSTRATION

OBJECTIVE

To satisfy ourselves, as aircraft constructors, that the design of the cockpit systems is compliant with the bases of certification, and to record the steps taken in demonstrating the system integrity, to support the application for a Certificate of Airworthiness for the aircraft.

WHL have unrivalled experience in the certification of EFIS equipped helicopters for IFR operation. On the basis of this experience, extensive effort is being applied to three aspects of demonstrating the airworthiness of the EH101 cockpit systems.

- preliminary hazard analysis
- system description
- safety assessment

PRELIMINARY HAZARD ANALYSIS

This part of the safety assessment has been undertaken throughout the system design, and has contributed to the levels of system redundancy incorporated in the system, and the determination of the criticality level of those parts of the system associated with the cockpit displays, for example:- attitude, heading, airspeed and altitude sensors, Aircraft Management System, Fuel Gauging System, Caution and Warning system.

This is a particularly important phase in the systems design because without an accurate assessment of the criticality of the other systems, serious delays later in the certification programme may arise, at great cost to the constructor (e.g. more extensive software testing and documentation than planned/budgetted for).

In a digital system of this complexity, the difference in cost of certificating software to essential or critical levels can be considerable, therefore the earliest opportunity in the development programme to determine the criticality of each system is of paramount importance.

SYSTEM DESCRIPTION

The System Description is a top-down design document which covers:-

- overview of system hardware
- system functional description
- overview of system processors

This latter is of particular importance. The EH101 EIS is handling critical functions such as attitude, airspeed and altitude. To reduce the dependance on standby instruments (thus saving cost and weight), extensive use will be made in the EIS of comparator functions, to alert the aircrew to anomalous situations in the sensing and presentation of these critical parameters.

SAFETY ASSESSMENT

The safety assessment will be the procedure by which compliance with the requirements will be demonstrated. An extensive bottom-up FMEA is not appropriate to digital systems, only to LRU pin connection level to determine the integrity of power supplies and earthpoints from a system segregation point of view.

The means most appropriate to determine the level of safety of the display system, is to apply a top-down analysis of each critical and essential function (ie those contributing to catastrophic or hazardous failures), and to compute the failure probability for each function, the fault tree analysis. Probabilities of failure can be obtained from MIL-HDBK-217D calculation (manufacturers data) or from in service field data (R and M Data Bank).

SOFTWARE VALIDATION

This function will be performed by the application of recognised software procedures, such as those described by RTCA Document DO 178A, and the WHL/ Agusta internal software standard. Extensive use will be made of the Integration Rigs in test procedures.

RIG FUNCTION - (Performance Analysis)

The primary function of the rig is the stimulation of the software under test, by a computer based, dynamic representation of the aircraft systems. The rig provides an emulation of the aircraft systems required to stimulate the systems under test, which will include:-

- AMS - providing display data to EIS
- EIS

Those systems being emulated in the AMS/EIS test environment comprise:-

- Attitude Sensors (AHRS, IRU)
- Heading Sensors (AHRS, IRU)
- Air data computers
- Radar altimeters
- Doppler velocity sensors
- Aircraft power systems sensors

Data is provided to these systems under test by means of these emulators. The source of the data is a computer based model of the aircraft flight dynamics, engine/transmission and other systems.

Data is routed to the emulators by the rig control. Output data from the systems under test is extensively monitored by the rig, and is routed by the rig control to facilities for performance analysis (i.e. cross checking of actual system output with input/expected output) and data logging. The facility is also provided for the storage and retrieval of input data, to allow extensive repeatability of tests.

FLIGHT TRIALS

The flight trials of the EH101 Cockpit displays will determine crew acceptability of the EIS by company Test Pilots and CAA/FAA flight inspectors. The flight trials will assess colour, legibility, symbology, pilot workload, and ergonomic control facilities. Furthermore, the flight trials will provide confirmation of rig and simulator trials in a flight environment.

7. CONCLUSIONS

A considerable amount of work in the past has been undertaken to ensure that adopting an all CRT cockpit for the EH101 gives quantifiable advantages over a conventional cockpit. Following the selection of a system, many months of format development, particularly displaying those parameters peculiar to helicopters in a unique and refreshing way we are convinced the right choice and balance was made.

System Implementation and format development is continuing as we discover new methods of exploiting the electronic displays, the only limitation initially being programme timescale constraints to meet certification dates. To that end we have given detailed thought to the approach and made a significant investment in both simulation and integration rigs as part of our goal to obtain a cost effective approach to certification.

The future offers exciting possible enhancements for the EH101 CRT cockpit, the first step being to agree an acceptable approach to greater data suppression leading to a reduced number of display heads. However what really excites us is the promise of all raster flat CRT colour display heads giving acceptable levels of brightness to allow mission, flight and navigation information on the same display heads. This will allow future development of formats that utilise electronic displays to the maximum rather than at present generally copying electro-mechanical counterparts. Such formats on all raster displays can make the highway in the sky concept a reality giving a pictorial representation of the outside world both in real-time and look ahead mode.

GLOSSARY OF ABBREVIATIONS

AMS	Aircraft Management System
EFIS	Electronic Flight Instrument System
IFR	Instrument Flight Rules
WHL	Westland Helicopters Limited
EADI	Electronic Altitude Direction Indicator
EHSI	Electronic Horizontal Situation Indicator
EPSD	Electronic Power Systems Display
MTBF	Mean Time Between Failures
ADI	Altitude Direction Indicator
HSI	Horizontal Situation Indicator
SG	Symbol Generator
DU	Display Unit
DMS	Display Mode Selector
I/O	Input/Output
WXR	Weather Radar
GG	Graphics Generator
EIS	Electronic Instrument System
F/N	Flight/Navigation
P/S	Power/Systems
AHRS	Altitude and Heading Reference System
IRU	Inertial Reference Unit
ADU	Air Data Unit
AFCS	Automatic Flight Control System
MLS	Microwave Landing System
DME	Distance Measuring Equipment
CAD	Computer Aided Design
WPT	Way Point
OAT	Outside Air Temperature