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HIFLAS - Helicopter Infrared Flight Command and Landing System

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HIFLAS HELICOPTER INFRA-RED FLIGHT COMMAND AND LANDING SYSTEM

1. INTRODUCTION

Since its foundation, ESG has been concerned with a number of programmes and experimental studies dealing with problems of helicopter ability to fly at night and in poor weather.

In the late 1960's/early 1970's the comprehensive AWE (All-Weather Electronics for Helicopters) study pin-pointed possiblilities of systems engineering and technological implementation, and system conceptual designs were produced for the AL-II, UH-1D and CH-53G helicopters then flown by the armed forces.

Of the sensor technology programmes two are particularly worth mentioning in this respect. In partly very extensive flight tests in a UH-1D advanced FLIR and LLLTV sensors were studied as to their suitability under European meteorological conditions.

In another programme the BNS self-contained navigation system - a highly accurate gyro-based doppler system - was developed, integrated and proved.

Finally, mention should be made of a series of flight tests on the integrated presentation of video images with superimposed symbols for flying by display. These tests were also made in a UH-1D.

The collective findings of these and several other programmes resulted in the birth of the programme under discussion, viz. HIFLAS.

In general and simplified terms, HIFLAS is an avionics package that provides helicopter pilots with an opportunity to perform, without assistance from the ground, en-route navigation and approaches in visibilities which at the present time either prevent helicopter operations completely or permit them only in non-tactical conditions.

To achieve these objectives, the following system functions are necessary:

- Self-contained navigation at low altitudes and when hedge-hopping, with continuous automatic position finding;
- Obstacle warning for hedgehopping (ideally permitting recognition of wires);
- Landing aid, i.e. search and recognition of and approach to landing area.

HIFLAS contains the following components to meet these requirements:

. The BNS self-contained navigation system referred to above;

. A forward looking Infra-Red System (FLIR)

. Integrated presentation of all data, including the FLIR video, relevant to helicopter command on a modern vertical situation display.

2. THE BNS NAVIGATION SYSTEM

As a presentation on BNS was already held in Bückeburg last year, its important characteristics of interest in connection with HIFLAS will be described in the following.

BNS navigates with a mean accuracy of 0.35% of the distance flown.

Intermediate position corrections and radio and/or radar aids are not necessary for this purpose, as BNS operates independently of the ground.

The helicopter ground speed is determined by means of a Doppler; the angle between true north and the roll axis of the system carrier is determined inertially by the BNS heading and attitude reference system, i.e. without magnetic backup. Data supplied by these two sensors are further processed by a digital computer into navigation information for the pilot, and are normally indicated on suitable standard instruments which are as follows:

A moving map display and an alphanumeric display on the navigation control unit for displaying present position, a BDHI (Bearing, Distance, Heading Indicator) for displaying bearing and distance for a selected destination, and a cross-pointer instrument for indicating off-track distance.

This information is required to be combined in a practical manner with other items of flight command information for HIFLAS.

BNS, which should be considered a subsystem of HIFLAS in this case, was developed for the CH-53, but can also be used in other aircraft. The system is basically suitable for all slow-flying aircraft which have to fly to a certain point in the terrain under bad weather conditions or at night without ground approach aids. This applies both to rescue missions (SAR) and transport and combat missions. Owing to its modular design BNS - and thus HIFLAS - can be tailored to its respective carrier and, depending on operational requirements, modules can be either added or removed.

3. SELECTION OF A SUITABLE IMAGING SENSOR

3.1 General Requirements

An imaging sensor in the optical and infrared ranges is an absolute necessity.

This sensor should provide an optimum natural, synchronous image of the terrain in front of and below the helicopter, and of any dangerous obstacles. An essential requirement is that sensor operation is possible at night without additional illumination.

3.2 Approach

In general, a great number of imaging sensors may be used:

TV	(e.g. with a SIT tube)
LLLTV	(e.g. with an ISIT or Isocon tube)
FLIR	(e.g. 3-5 μm or 8-14 μm)
ICCD	(= imaging charge coupled devices)

The conventional TV system is very limited with regard to its low-light capabilities, and is therefore not suitable for HIFLAS.

LLLTV is also limited with regard to low-light capabilities and also modern tubes are not fully protected from over-exposure effects caused by external sources of illumination.

Both systems operate in a radiation wave band, from the visible range to the near IR (1 µm approx.), in which atmospheric scattering is relatively high (haze). The original scenic contrast can, under certain conditions, be reduced by scattering to such an extent that no further details can be resolved as of a certain distance and the image is blurred completely.

FLIR (Forward Looking Infrared) is a relatively new technology. The first sensors were manufactured in the U.S. about 10 years ago. The major difference between the latter and the TV systems mentioned above is that the characteristic radiation of the scene or objects is received by the highly sensitive radiation detector. This means that no illumination of the scene is required. As the maximum radiation contrast of objects of approx. 300 K (approximate ambient temperature) is on a wavelength of 9 µm, the "atmospheric window" between 8 µm and 14 µm is particularly suitable. The production of IR detectors for this wave band is no longer a problem. A distinct advantage of this waveband is the low radiation damping under bad weather conditions (haze). Preliminary tests have indicated that at visibilities between 2 and 5 km improvements in range of a factor of 5 are possible.

With regard to cost and reliability it may be said that the critical assemblies - detector, cooling unit and optics, including the scanner mechanism - have been improved during the past few years to such an extent that MTBF values of 1000 h have been obtained. An important contributory factor has been the modular technique of Texas Instruments ("Modular FLIR") which now uses quasi-standardized subassemblies. As a result of the award of contracts by the US Army for the TOW FLIR and Tank FLIR for the production of systems in correspondingly large numbers, it can be assumed that FLIR will be able to compete in price with advanced TV systems within the next few years.

3.3 Results Obtained with FLIR (Preliminary Tests 1973/74)

Two- to five-fold improvements have been obtained in tests with several "artificial" and "natural" objects (houses, streets, trees, rivers) under optical visibility ranges (not standard visibility in this case) of between 2 and 5 km.

SAR tests on firm ground showed ranges of about 1 km with single persons; dinghies on water were detected at a distance of 3 km.

The following table shows a survey of the actual ranges of detection obtained for the various objects.

	Detection Range
Autobahn, runway, Autobahn junctions, Autobahn exits, Autobahn bridges	5 km - 10 km
Rivers, locks, bridges	5 km - 8 km
Villages, factories	5 km - 10 km
Railroads	3 km
High-voltage transmission towers	1.5 km
Forest peripheries	2 km
Detached houses	2 km
Single trees	0.3 - 2 km

It is our opinion that FLIR is the most suitable imaging sensor for night time operation and is therefore proposed for HIFLAS. However, the latest technologies are being observed and can be introduced into HIFLAS when they are fully developed, for instance the charge coupled devices (CCDs).

3.4 Imaging Charge Coupled Devices (ICCDs)

This latest technology uses a mosaic arrangement of radiation-sensitive cells from which the image signal is read out electronically. Its advantages are small size, low weight and high reliability. Even now it can be seen that it will be possible in the future to manufacture CCD's for the longwave IR range, and thus considerably to simplify the FLIR systems known today. New technologies of this kind can be integrated in the HIFLAS at any time to improve system properties in general.

The use of CCDs would also enable relatively simple generation of stereo images, with the help of which it will probably be possible to display to the pilot an image of the environment which is far easier to interpret.

4. The Overall HIFLAS System

4.1 Information Spectrum

The important navigation data, attitude/command information and FLIR image are displayed on a TV monitor on the helicopter instrument panel. A symbol generator with an image mixer is also included. The interface with the BNS is of the digital serial type with a data word length of 16 bits. At present it is planned that the following information will be accepted in digital serial form from the BNS:

- horizon
- pitch
- roll
- heading
- baro height
- airspeed
- vertical velocity
- ground speed (from heading velocity and drift velocity)
- track

This information, together with other items that are not provided by the BNS and which will be dealt with later, is converted into symbols and superimposed by electronic means on the FLIR video signal. If no image signal is available from the imaging sensor, e.g. due to a fault, symbology may of course be displayed on its own.

The following information is not accepted from BNS, but from the appropriate sensors themselves in partly analogue and partly discrete form:

- radar altitude
- warning (failure)
- laser range
- imaging sensor field of view and depression angle
- off-flag
- H/C reference
- torque
- gas temperature

4.2 Symbol Layout

The layout of the individual symbols is of great importance, in order to enable the pilot to receive and process the information within a short time and with the accuracy desired, and also without any risk of misinterpretation.

HIFLAS information is presented in the following manner:

. fixed scales
. band scales
. digital indicators
. tendency indicators
. indicators of true value/set value
. combined indicators

As important as the layout itself is proper arrangement on the monitor. It is intended, for the time being, to use an arrangement to which the pilot is accustomed, where this is possible.

One of the tasks of the HIFLAS experimental programme is the optimization of system layout and local arrangement of the symbols. The symbol generator used is freely programmable and thus enables relatively simple and rapid modification of the symbology.

4.3 Flight Command Modes

Differentiation is made between two main display modes:

- Vertical display
- Horizontal display

The vertical display mode is intended for normal forward flight. In this case the FLIR or imaging sensor presents an image in virtual horizontal vision with a natural horizon.

In the horizontal or lower display mode the imaging sensor looks downwards at an angle of 90°. The special feature of this display mode is the reproduction of a ground speed symbol for heading and magnitude (vector) which is intended to make hovering easier for the pilot without drifting.

In the vertical display mode it is intended to differentiate between the following operating modes:

. Take-off
. En route
. Approach
. Terrain following

These different operating modes will ensure that relevant information can be selected as and when required. In this way the monitor will not be overloaded with symbology, thus resulting in a reduction of the pilot's workload.

5. SUMMARY AND PROSPECTS

The HIFLAS concept was defined such that it can be adapted to be made suitable for different platforms and adjusted to embrace new sensor technologies at any time:

. Other navigation systems such as doppler and strapdown navigation systems may be used instead of BNS

. The use of data bus interfaces is theoretically possible.

. Different imaging sensors, that is FLIR, TV, LLLTV, ICCD, may be used

. Different displays, that is vertical situation, head-up and helmet-mounted displays, may be used

. "Electronic map" display is theoretically possible

. The control unit can be expanded to form a computer terminal which ensures random intervention, i.e. as and when required

. The number, shape and location of symbols may be modified at any time owing to the free-programming facility.

It is to be expected that HIFLAS or similar systems will become more efficient, reliable, smaller and cheaper as a result of the introduction of CCD technology for both computer memories and imaging sensors and the use and development of microprocessors for minicomputers.

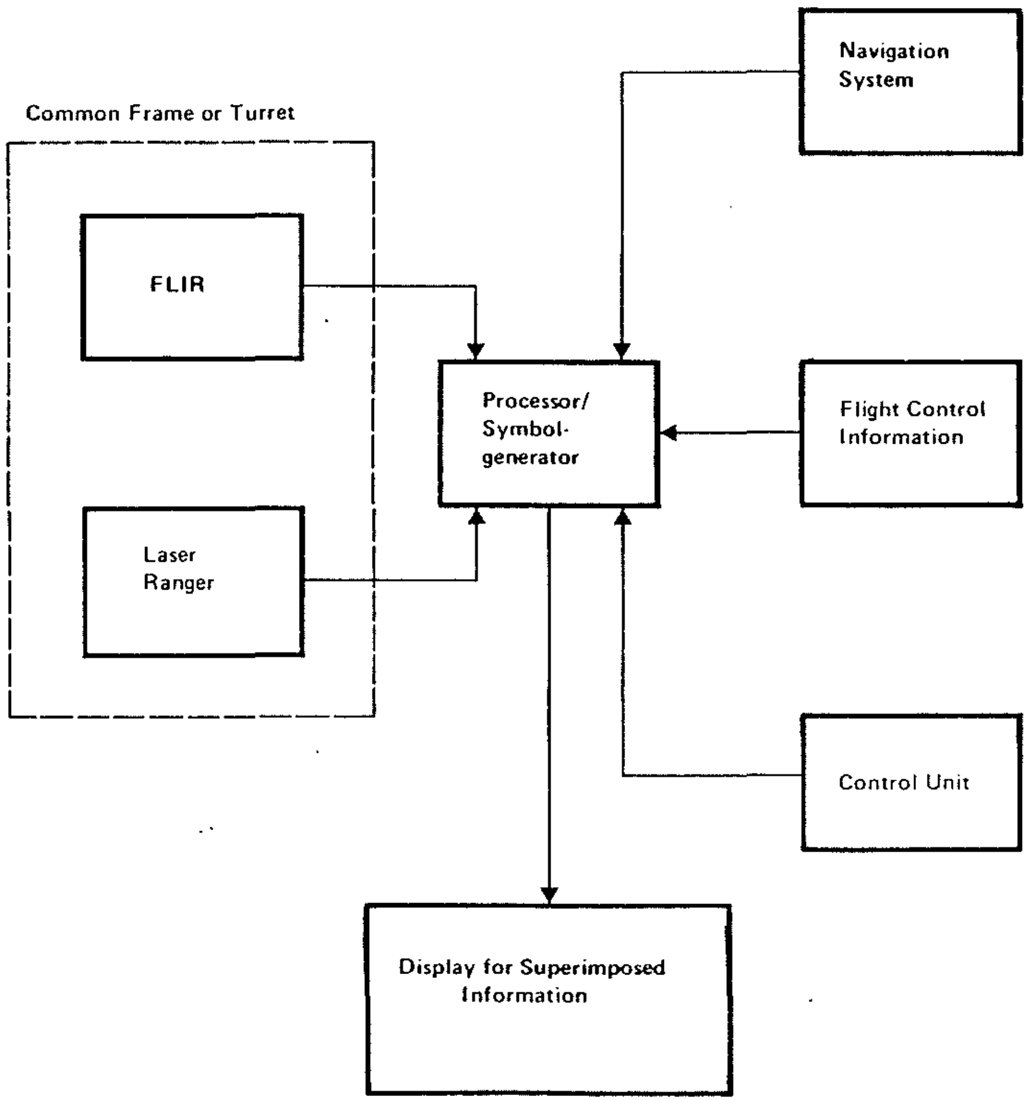
HIFLAS-Objectives

- To add to the range of helicopter missions currently possible and to raise mission frequency by means of modem electronic and optoelectronic technologies
- To achieve high system flexibility i.e. transport, anti-tank and SAR capability
- To produce a favourable cost/benefit ratio

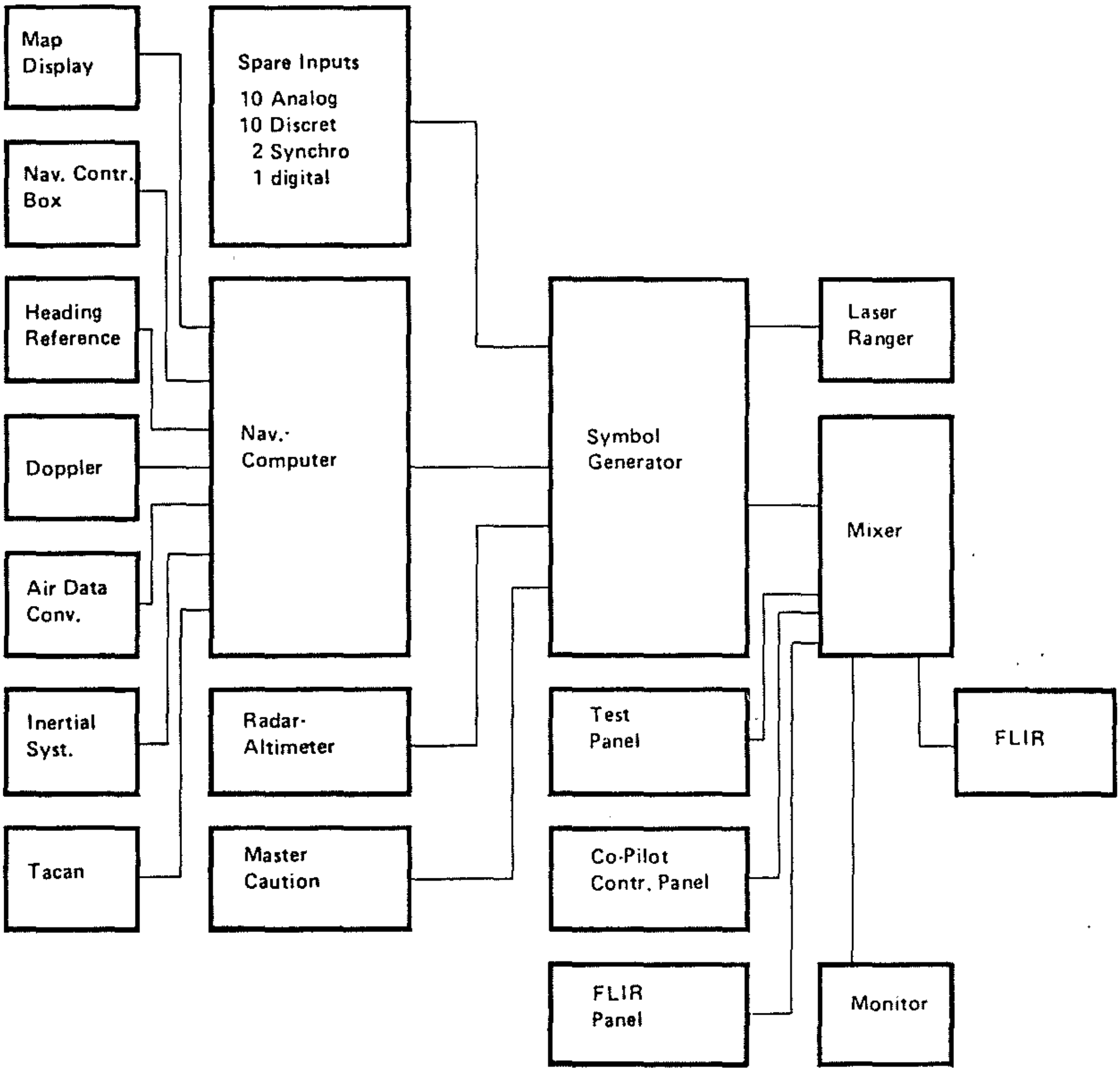
HIFLAS-Components

- Self Contained Navigation System
- Central Digital Information Processing (Computer)
- Forward Looking Infrared
- Laser Ranger
- Central Information and Image Display
- Control Units

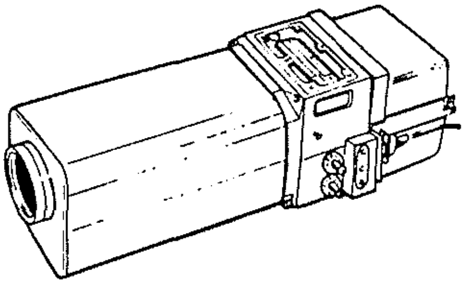
HIFLAS – Schematic Diagram



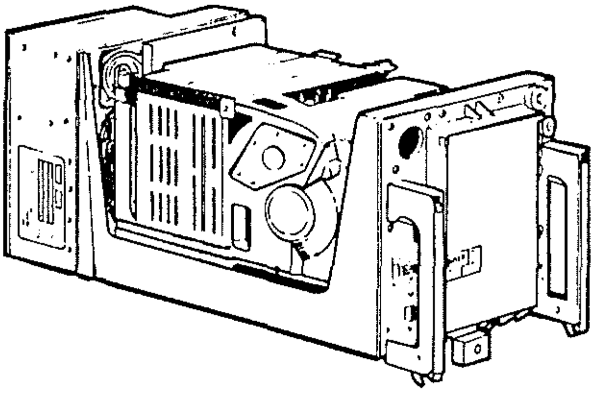
HIFLAS-Block Diagram



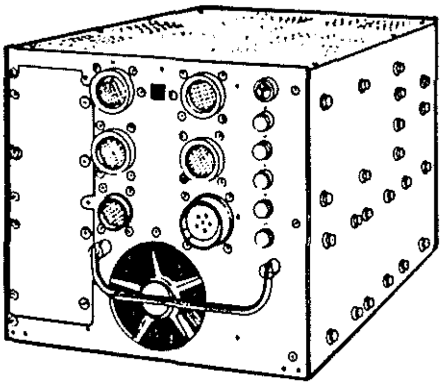
HIFLAS Components



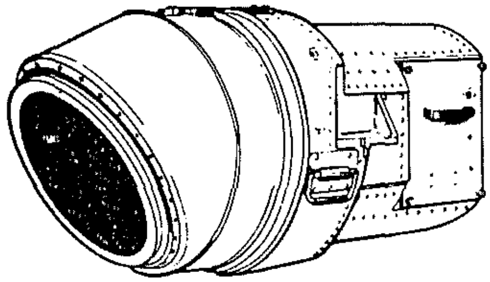
Laser Ranger



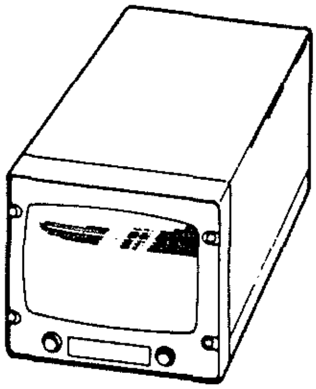
BNS (partly)



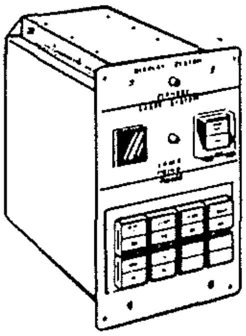
Symbol Generator



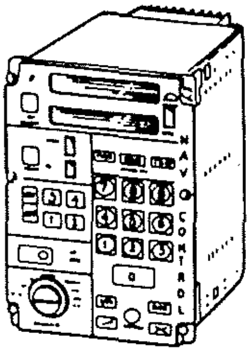
FLIR



Monitor



HIFLAS Control



BNS Control Box