ADVANCED ALERTING SYSTEM - CAPABILITIES FOR PART TIME DISPLAY OF VEHICLE PARAMETERS

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Abstract

The evolution of glass cockpit design shows a trend to reduce the installation of conventional mechanical instruments. Current display technology and cost allow the installation of screens with large display surfaces. In a given instrument panel layout, the installation of bigger screens leads to a reduction of the number of displays. Additionally the amount and detail of mission information which has to be displayed is increasing. As a consequence, information associated with routine tasks of vehicle monitoring is likely to be displayed part time in order to make room for indications currently more relevant for the crew. As indication and monitoring of vehicle parameters is needed for maintaining a safe flight, Eurocopter is developing a part-time-display concept in combination with an advanced alerting system.

1. INTRODUCTION

Eurocopter proposes an innovative approach, which reduces the workload of the crew to analyse and interpret the situation of the aircraft thanks to a new design of a crew alerting system associated with a sophisticated monitoring of vehicle parameters. The innovative design elaborated during an ongoing phase of research, that supports this approach will be presented.

2. STATEMENT OF ISSUE

The evolution of glass cockpit design shows a trend to reduce the installation of conventional mechanical instruments. Current display technology and cost allow the installation of screens with large display surfaces. In a given instrument panel layout, the installation of bigger screens leads to a reduction of the number of displays.

Additionally the amount and detail of mission information which has to be displayed is increasing (i.e. enhanced navigation aids to determine the position of the helicopter and to manage the flight parameters according to ongoing / foreseen operational constraints, helicopter resources and external world aspects).

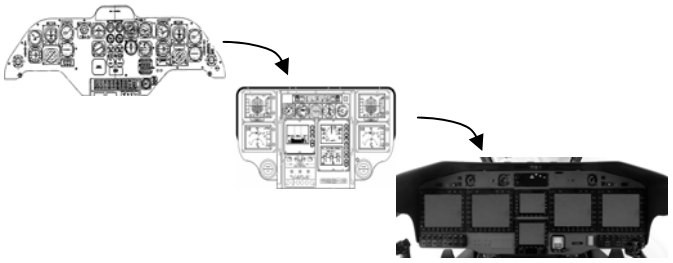

Figure 1: cockpits evolution

As a result, few displays concentrate the information in such a way that the number of Multi-Function Displays (MFD) is smaller than the number of displayable pages. This induces change in information presentation, which is structured hierarchically from primary information to complementary and secondary information. Then, information is distributed in the screens among full time and part time displayed.

Pilot's interaction with such highly integrated systems takes place within a flight activity which carries by itself factors of mental workload because of its dynamism [1]. To cope with this situation that goes and evolves even if she/he does not intervene, the pilot carries out strategies to save time and to favour anticipation.

Within this framework, innovative features of Eurocopter glass cockpits are designed in order to support those flight crew's strategies, hence to reduce workload.

Through the automated monitoring of vehicle parameters, novel technical functions aim to save pilot time, letting her/him more focused on the mission, and favouring her/his ability to anticipate a degraded vehicle status.

Those novel technical functions consist first in a new design of a crew alerting system, and second in the part time display of several vehicle parameters.

3. COCKPIT DESIGN

To manage systems of the rotorcraft is a huge operational function that encompasses several operational sub-functions to initialize, configure, control and monitor the various systems of the rotorcraft.

Within the framework of innovative Eurocopter avionics, glass cockpits are built on a basic configuration of the instrument panel with 2 MFD for the pilot. From this base, it is possible to build variable additional screen configurations depending on the intended operation of the H/C.

A clear and permanent view of the aircraft system status is achieved in normal and emergency conditions through the outboard MFD, configured in basic PFD page. It displays essential information regarding primary flight and navigation systems, full time displayed vehicle parameters, alerts and information messages.

Complementary information is provided through the other pages which are displayed on pilot request on the inboard MFD. For example, the vehicle Monitoring Display (VMD) page is displayed this way.

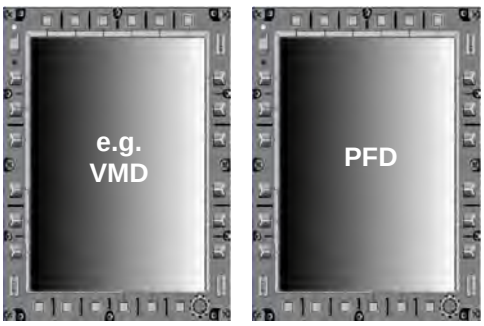

Figure 2: Basic configuration

An integrated alerting system allows managing globally all the events where it is necessary to warn the flight crew using the same prioritization scheme.

3.1. PFD page

The PFD displays permanently indications for flight (Basic-T Layout), autopilot indication, navigation information, alert messages and dedicated vehicle parameters:

- First Limitation Indicator (FLI)

  The FLI is a Eurocopter proprietary concept.

  It is a synthesis of all the Main Gear Box and Engine limitations (N1, TOT, TRQ), represented as the available power margin.

- Rotor speed and power turbine speed indicator
- Synthetic representation of fuel quantity

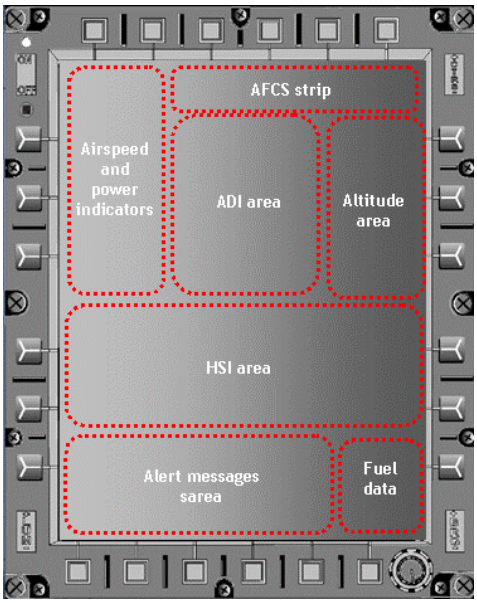

Figure 3: PFD page

3.2. VMD page

The VMD is the page that is dedicated to engine and vehicle parameters. It is displayed on pilot request, except at the power up of the rotorcraft where it is displayed by default. It remains displayed until the pilot replaces it by another page. The VMD page can be displayed on each MFD, which is not used as PFD.

4. ALERTING SYSTEM

4.1. Principles

The design of the alerting system, which in current installations is based on pilot's interpretation of discrete lights, is now based on avionics system synthesis. The result of this processing is displayed as explicit messages in a dedicated and full time displayed area of the PFD.

This new concept for the alerting system aims to limit the indications presented to the crew to the alerts which are relevant in the current situation.

This is obtained by using helicopter state interpretation algorithms, alert suppression and alert combination mechanisms (Eurocopter patent pending). In addition, prioritization scheme, alert number reduction and aural alerts insure the attraction to the most critical event.

Using this concept, the necessary time for situation interpretation by the crew is reduced, as a set of time-consuming tasks are performed by the avionics system.

Additionally, the risk of misinterpretation and by consequence an inadequate reaction by the crew is limited.

4.2. General Design

The alerting system is composed of a central warning panel (CWP), an aural alert generator with interfaces to the intercommunication system and a visual alert generator including display on PFD.

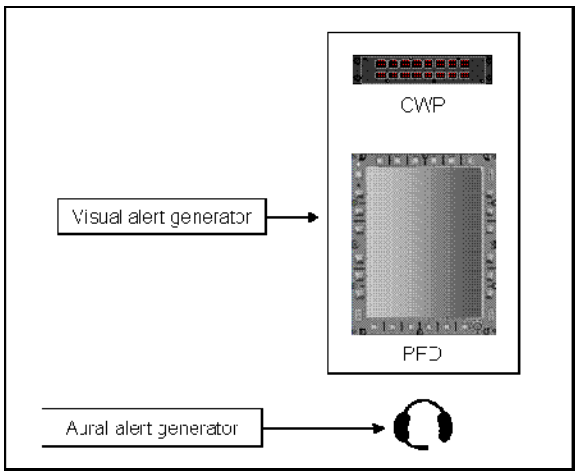

Figure 4: Alerting system

The CWP and the MFD in the basic PFD format are the permanent and dedicated displays to present alerting items in front of the pilot.

Within the PFD, the “master list” designates the area where alerts regarding non-normal aeroplane system conditions and annunciations are displayed as messages. The indications in master list are the primary alerting cues.

Figure 5: Master List

The concept of the alerting function relies on a categorization of alerting items in order to discriminate events regarding their real degree of urgency and the nature of the event. Each category of alerting item is associated to specific visual and aural features.

4.3. Master list

The intended function of the Master list used by the flight crew is to display prioritized failures and degradations.

The location of the master list within the PFD, itself installed within the primary field of view of the pilot, aims at insuring the visibility of the alerting cues and the readability of the messages.

Management of the messages in the master list relies on synthesis of data performed dynamically by H/C system, applying concatenation and suppression logics [2]:

- Concatenation logic is implemented by the system in order to alleviate the number of messages.
- Suppression logic is managed by the system in order to reduce the messages to the relevant information.

In all cases, filtering is used to provide a stable display of alert messages to the crew, giving consideration to the context.

5. PART TIME DISPLAY OF VEHICLE PARAMETERS

5.1. Principles

The concept of part time display of vehicle parameters is based on the assumptions that some vehicle parameters are full time displayed in PFD and that other vehicle parameters are not permanently presented through a dedicated display.

This concept induces a change of tasks and responsibilities for the pilot. Formerly, the pilot was intended to monitor regularly, including in normal operating ranges, all the indicated parameters. Now, the monitoring task to detect a significant behaviour of a vehicle parameter has become a responsibility of the avionic system.

The automated monitoring capability of the avionics system constitutes the first compensating factor for part time display of vehicle parameters. Using a systematic automated monitoring provides an enhanced performance compared to a conventional monitoring achieved in a non systematic way by the pilot.

Nevertheless, this automation itself brings a risk of complex design, because new configurations are created for which it is necessary to provide additional information and procedures for the pilot [3]. To avoid information overload, indications provided to the pilot are managed through the new alerting system mechanisms. This constitutes the second compensating factor for part time display of vehicle parameters.

With the prospect of a certification process, that may follow the ongoing phase of research, the concept of part time display of vehicle parameters will represent a sophisticated novel design feature regarding Certification Specification and compared with current certified aircraft state of the art. Certification Specification 29/27-1305, 1351 and 1435 - covering conventional dial/rotating needle - requires permanent instruments installations that enable full time display and direct reading of powerplant instruments, as well as electrical and hydraulic systems. Today conventional display of vehicle parameters in modern avionic systems is designed consistently with those requirements.

5.2. General Design

Intended functions of the part time display used by the flight crew, is to detect unusual trend for vehicle parameters within their normal operating range.

The following vehicle indications are eligible to part time display, because their continuous display is not necessary for short term piloting tasks or is permanently displayed by other means (e.g. via First Limit Indictor):

- Fuel quantity for each tank
- Main gearbox oil pressure
- Engine oil quantity
- Main gearbox oil quantity
- Engine oil temperature (EOT)
- Engine gas temperature (TOT)
- Engine gas generator speed N1/delta N1
- Engine torque
- Engine fuel pressure
- Engine oil pressure
- Voltage (bus, generator, battery)
- Current (generator, battery)
- Hydraulic power system pressure

Compensating factors to part time display of the parameters listed above rely on the following principles:

- Full time monitoring of all vehicle parameters by the avionics system compensating the crew monitoring when the VMD is not displayed.

  The concept of part time display of vehicle parameters requires that the architecture of the avionic system provides all the necessary information for the monitoring algorithms with the adequate level of safety.

  Full time monitoring of vehicle parameters requires that dedicated logics of monitoring which take into account the qualitative behaviour of the monitored parameters, and the operational phase of flight of the aircraft (e.g. stabilized flight, stabilized vehicle system).

  The detailed description of monitoring algorithms is not part of this paper.

- The monitoring performed by the system leads to the presentation of suitable annunciations which make the crew aware that a given part time displayed parameter behaviour needs to be monitored.

  Two kinds of annunciations are provided by the alerting system that triggers and displays messages on the master list:

- Advance notice is provided when system monitoring detects a significant behaviour of a vehicle parameter inside its normal operating range.

- On each exceeding for maximum / minimum and precautionary operating range, advanced notice is superseded by relevant alert.

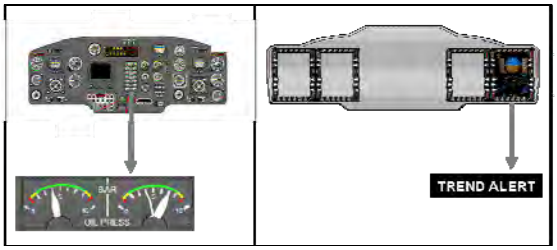

Figure 6: Monitoring in normal operating range

After a message related to part time display monitoring has been triggered on the PFD master list, the crew has to check the related parameter on the VMD.

The display of the parameters can always be manually selected by the flight crew (i.e. displaying the VMD page) without interfering with the display of other required information in PFD.

6. ASSESSMENT OF PART TIME DISPLAY COMPENSATING FACTORS

The assessment of compensating factors designed to cover the part time display of the vehicle parameters covers the items listed above:

- Flight crew ability to properly monitor the vehicle systems:
  - Alerting for part time displayed parameters
  - Manual selection of part time displayed parameters
- Usefulness and correctness of monitoring and display functions for vehicle parameters
- Safety aspects:
  - Cases when a specific parameter fails to be displayed when necessary
  - Failure effects and compounding effects

7. CONCLUSION

Eurocopter is designing a concept to display part time a set of vehicle indications necessary for the flight crew.

Advantages regarding flight crew activity are the following:

- A gain of room on the instrument panel in order to display mission indications

- An enhancement of the surveillance of H/C vehicle systems, because the monitoring is performed continuously, systematically and even in the normal operating range

- A gain of time for the flight crew, because the avionic system performs routine monitoring tasks

8. ABBREVIATIONS

- CWP: Central Warning Panel
- MFD: Multi-Function Display
- PFD: Primary Flight Display
- VMD: Vehicle Management Display

9. ACKNOWLEDGMENTS

Works presented in this paper are included within the framework of Eurocopter Research and Development directorate.

10. REFERENCES

[1] Amalberti, R. (1996). La conduite des systèmes à risques. Paris: PUF.

[2] Federal Aviation Administration (2003) Human Factors Design Standard (DOT/FAA/CT-03/05, HF-STD-001). Washington, DC.

[3] Parasuraman, R., Riley, V. (1997). Humans and automation: use, misuse, disuse, abuse. Humans Factors, 39 (2), pp. 230-253.