Flightcrew Light Alerting Design with Dark Cockpit Philosophy

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Abstract. An effective and reasonable flightcrew light alerting design in civil aircraft flight deck based on dark cockpit philosophy has been proposed. Considering the human factor engineering and airworthiness requirement, the paper analyses flight deck alerting system and defect of bright cockpit philosophy, then the state-of-art light alerting design using dark cockpit philosophy is given. According to operation scenarios and architectures of different aircraft systems, three type of the new design is presented. This approach consists of general light alerting part, standby system light alerting part and special light alerting part. The proposed design ensures that the flight crew not only obtain the aircraft system status intuitively, but also decrease their workload during the whole flight phase.

1. Introduction
Civil aircraft puts forward higher requirements on light alerting in cockpit with the development of human factor engineering. Because light alerting reflects the status of corresponding aircraft system, the effective and reasonable light alerting ensure the flight crew to obtain the flight information quickly and accurately.

According to FAR 25.1322(a)(1)(2)[1], flightcrew alerts must provide the flight crew with the information needed to identify non-normal operation or aircraft system condition, and determine the appropriate actions, if any; be readily and easily detectable and intelligible by the flightcrew under all foreseeable operating conditions, including conditions where multiple alerts are provided. Bright cockpit philosophy is adopted in light alerting design, and Flight Deck Alerting System (FDAS) and push button annunciator (PBA) on system control panel (CP) is used to realize light alerting. FDAS calculates alert to drive PBA which lights up to indicate that the corresponding aircraft system is working normally, on the opposite, the aircraft system closed when PBA is extinct. Under this condition, it is difficult for flightcrew to acquire the target system status from multiple lighten PBAs.

Aiming to solve the defect of light alerting based on bright cockpit philosophy, the paper considers operation scenarios and architectures of different aircraft systems, then proposes a light alerting design which is under the guidance of dark cockpit philosophy.

2. Bright Cockpit Philosophy Based Light Alerting Design
AC 25.1322-1[2] requires that the purpose of flight crew alerts on aircraft is to attract the attention of the flightcrew, to inform them of specific non-normal aircraft system conditions or certain non-normal operational events that require their awareness, and, in modern alerting systems, to advise them of possible actions to address these conditions. Flight crew alerts are divided into visual, aural and tactile elements in term of the way people receive information, and FDAS provides visual alerts to the flightcrew through flight displays and specific lights.
The principle of light alerting is shown in Figure 1. The data which is required from aircraft systems such as fuel, bleed, hydraulic and so on is output to FDAS. FDAS centralizes, controls and processes the data, then outputs the calculated alert to the corresponding system CP to drive the PBA. This is an ideal model which only focuses on terminals, and complicated intermediate is omitted, for example data format conversion, verification, etc.

![Figure 1. Light alerting principle](image)

It is bright cockpit philosophy based light alerting that the character on PBA is “ON” which is used to indicate the normal status of aircraft system. After the aircraft is powered on, the “ON” on the system CP goes out to indicate the system is shut down. When the PBA is pushed, the system is working and the “ON” lights up to indicate the working status. After the PBA is pushed again, the system is closed and the “ON” lights out to indicate the closed status. However, in the whole flight phase, most of the systems work normally and the relevant PBAs are lighten. So flightcrew is hard to obtain the target system status in bright cockpit.

All elements of the system are influenced by human performance. In turn, human performance is affected by many aspects of system design, including the equipment that personnel interface with, training they receive, procedures they use, and teamwork needed for personnel to work with each other to perform their various roles[3]. The flightcrew may miss some information when driving the aircraft. So it is necessary to reduce the information received by the flightcrew, and obviously bright cockpit can not meet this demand. But the light alerting with dark cockpit philosophy solve the problem.

3. Dark Cockpit Philosophy Based Light Alerting Design

It is dark cockpit philosophy that the light is extinct when the relevant aircraft system is working normally, so the distraction of flightcrew is reduced. When the aircraft system is shutdown or in fault state, the corresponding PBA is lighten. Flightcrew can obtain aircraft system status through corresponding PBA in dark cockpit environment.

3.1. General Light Alerting Design

The characters on the PBA are “OFF” and “FAULT”. The PBA is extinct under normal working condition. The “OFF” is not driven by FDAS, and after the aircraft is powered on, the “OFF” lights up automatically to illustrate the relevant system is shutdown. When the PBA is pushed, the system is working and the “OFF” is in extinct status. After the PBA is pushed again, the system is shut down and the “OFF” lights up. If the system can not work correctly, the “FAULT” lights up which is driven by FDAS. Under this condition, the flightcrew can easily find the lighten PBA in the dark cockpit environment. Figure 2 shows general light alerting design.
The waveform of the general light alerting design is shown in Figure 3. The bottom line represents the PBA switch status, and the PBA light status is illustrated by the up line. When the switch is pushed, the aircraft is working and the “OFF” is in extinct status.

3.2. Standby System Light Alerting Design

In order to improve the safety and reliability of civil aircraft, primary/standby architecture is adopted. For example, the fuel system supplies fuel to engine through AC fuel pump in normal condition, but in the case of AC power is fault, DC fuel pump also provide fuel instead which meets the pressure and flow required by engine. AC fuel system adopted the general light alerting design shown in Figure 2, but DC fuel system is realized by standby system light alerting design in Figure 4. Because the standby system is working when the primary system is fault, the flightcrew is reminded of this state.

The characters on the PBA are “ON” and “FAULT”. The “ON” is driven by FDAS, and it is lighten under normal working condition. When the PBA is pushed, the system is working and the “ON” is in lighten status. After the PBA is pushed again, the system is shut down and the “ON” lights out. If the system is fault, the “FAULT” lights up which is driven by FDAS.
The waveform of the standby system light alerting design is shown in Figure 5. When the switch is pushed, the aircraft is working and the “ON” is in lighten status.

![Figure 5. Waveform of the standby system design](image)

3.3. Special Light Alerting Design
Alternate PBA is described in chapter 3.1 and 3.2, that is, push the switch to keep the pressed status, push the switch again to keep the ejected status. Therefore, it is necessary to push the PBA manually to light up and light out the PBA.

However, flight crew also need momentary PBA which lights out automatically without the intervention of flight crew when the special condition is reached. For example, when PBA is pushed to start engine, “START” driven by FDAS is in lighten status to indicate starting process. But when engine start process is over, “START” lights out automatically. This special light alerting design is shown in Figure 6, and the waveform is presented in Figure 7.

![Figure 6. Special light alerting design](image)

![Figure 7. Waveform of special light alerting design](image)
4. Summary
The paper analyses flight deck alerting system and defect of bright cockpit philosophy, then a new flightcrew light alerting design based on dark cockpit philosophy is given. According to operation scenarios and architectures of different aircraft systems, this approach consists of general light alerting part, standby system light alerting part and special light alerting part. The proposed light alerting design ensures that the flightcrew not only obtain the aircraft system status quickly and accurately, also decrease their workload during the whole flight phase.

5. References
[1] FAA, Airworthiness standards: transport category airplanes, FAR 25, 2012.
[2] FAA, Flightcrew alerting, AC 25.1322-1, 2010.
[3] NASA, Design development, testing, and evaluation: human factors engineering, 2006.