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Research on Civil Aircraft Powerplant System EICAS Messages Design Approach

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Abstract

The powerplant system is very critical to the aircraft during the flight. Once some failures happen on the powerplant system, it's important for the flight crews to take correct and appropriate actions to continue the safe flight. As we know, the powerplant system is comprised of millions of components, not all the components failures will influence the flight safety. This article introduces a method to identify the failures that need to be noticed by the flight crews. Besides, this article also describe the inhibition of the EICAS messages and consideration of the initialization time difference when designing EICAS logic.

Keywords: powerplant system, engine, EICAS message, inhibit, initialization time

1. Introduction

The primary objective of all the information that is available in the modern commercial cockpit is to fly the aircraft safety by providing the pilot with the pertinent information needed, when it is needed. The secondary objective is to operate the aircraft efficiently. Because of these objectives, the goal of EICAS (Engine Indication and Crew Alerting System) is to assist the pilot in assimilating, interpreting, prioritizing, and acting upon the large amount information that is available. In the design phase of an EICAS development program, careful attention must be paid to the various methods used to present information to the pilot. Since the largest portion of all air traffic accidents are attributed to 'pilot error', careful attention to human factors during the design phase of these cockpit information systems will help reduce the potential for these types of errors[1].

For the powerplant system which is critical to the flight safety and has a large number of faults, it's very difficulty for the engineers to identify which faults need to be informed via

EICAS messages and when the EICAS messages should be displayed. This paper introduces an approach on how to design the powerplant system EICAS messages.

2. Category of the EICAS messages

Figure 1 is an example of how EICAS messages are displayed in the display.

Usually, the EICAS messages are classified into four categories: Warning, Caution, Advisory and Status[2]. Warning messages are used when a failure condition requires immediate flight crew attention and immediate flight crew response. Caution messages are used when a failure condition requires immediate flight crew awareness and possible future action. Advisory messages are used for conditions where the flight crew requires timely awareness and eventually timely response. Status messages indicate system state information where additional crew awareness is desired.

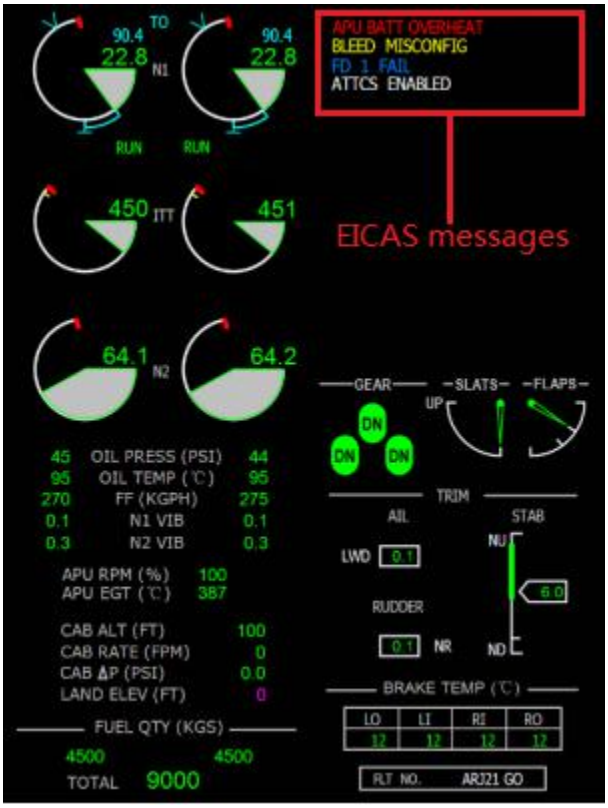

Figure 1 — The EICAS display in the cockpit

3. Identify the powerplant system EICAS messages

The powerplant system is comprised of engine, nacelle, TCQ (Throttle Control Quadrant), EICU (engine interface control unit), etc. The EICAS messages related to powerplant system are usually identified through the following aspects.

a) Analyze the failure conditions of the system functions

According to the ARP 4754A, the airframer need to conduct the safety assessment for the aircraft functions[3].

Generally, there are 4 kinds of failure conditions for each function, which are total loss,

partial loss, inadvertent functioning and erroneous or erratic functioning.

The main functions of the powerplant system can be found in table 2. We can analyze the failure conditions of these functions and distinguish which failure conditions need to be noticed by the pilots.

Table 2 Powerplant system functions

NO.	Function Name
1	Provide Forward Thrust for Aircraft
2	Provide Engine Start Function
3	Provide Engine Parameter and State Information
4	Provide Thrust Control
5	Provide Reverse Thrust for Aircraft
6	Provide Source of Power for the Generator
7	Provide Source of Power for Hydraulic Pump
8	Provide Bleed Air for Pneumatic System
9	Provide Engine Shutdown Function
10	Provide Engine Overspeed Protection

In this paper, we will take some important functions as examples to show how to identify the EICAS messages. For the other functions, we can use the similar method.

1)The failure conditions of Function 1 'Provide Forward Thrust for Aircraft' includes total loss of the thrust or partial loss of the thrust. Both of these failure conditions need to be noticed by the pilots immediately and take necessary actions, like restart the engines. So we need to set the EICAS messages 'engine 1 or 2 fail ' and 'both engine fail' to inform the pilots to take actions.

2)The failure conditions of Function 2 'Provide Engine Start Function' includes start valve failure and ignition failure. When the start valve fails on the ground, the maintenance personnel need to open this valve manually during engine start and close it when the engine starts successfully. When the ignition fails, the pilots need to escape the terrible weather in the flight. So we need to set the EICAS messages 'start valve fail' and 'igniter A/B fault' or 'both igniters fault'.

3)The failure conditions of Function 4 'Provide Thrust Control' includes loss of ambient air data, loss of control. When the engine control system lose the ambient air data, the pilots need to be aware of this failure and can select the alternative control mode as required. When the engine is out of control, the pilots need to observe the parameters of the failed engine and make the decision on whether to shutdown the failed engine. So we need to set the EICAS messages 'engine degrade' and 'engine 1/2 control fault'.

4)The failure conditions of Function 5 'Provide Reverse Thrust for Aircraft' includes thrust reverser inoperative and loss of the thrust reverser protection. When the thrust reverser fails before landing, the pilots need to be prepared not to use the thrust reverser during landing. When this failure happens during landing ,the pilots need to take actions to correct the aircraft direction immediately. When some of the thrust reverser protection is lost, the pilots need to land as soon as possible. So we need to set the EICAS messages 'thrust reverser inoperative' and 'loss of thrust reverser protection'.

b) Engine parameters exceedance

When the engines are operating normally, the parameters are within the limits. If the engine parameters are exceeded because of some reason, while the pilots don't take actions in time, it will do harm to the engines. For example, if the oil quantity is low, it may result in the engine wear because of lack of lubrication. So, for the exceedance events, we need to set the EICAS messages. Usually, we need to set the EICAS messages for the N1/N2/N3 speed exceedance, N1/N2/N3 vibration exceedance, ITT exceedance, oil level low, oil pressure low, oil temperature high and oil temperature low, etc.

c) Regulation requirement

The CCAR Part 25 contains the requirements of the powerplant system EICAS messages. The related requirements refer to table 1.

Table 1 — Requirements from the CCAR regulation

Requirement No.	Content
CCAR 25.1019(a)(3)	The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate an indicator that will indicate contamination before it reaches the capacity established in accordance with paragraph (a)(2) of this section.
CCAR 25.1305(a)(1)	A fuel pressure warning means for each engine, or a master warning means for all engines with provision for isolating the individual warning means from the master warning means.
CCAR 25.1305(a)(5)	An oil pressure warning means for each engine, or a master warning means for all engines with provision for isolating the individual warning means from the master warning means.
CCAR 25.1305(c)(4)	A means to indicate, to the flight crew, the operation of each engine starter that can be operated continuously but that is neither designed for continuous operation nor designed to prevent hazard if it failed.
CCAR 25.1305(c)(6)	An indicator for the fuel strainer or filter required by CCAR 25.997 to indicate the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with CCAR 25.997(d).
CCAR 25.1305(c)(7)	A warning means for the oil strainer or filter required by CCAR 25.1019, if it has no bypass, to warn the pilot of the occurrence of contamination of the strainer or filter

Requirement No.	Content
	screen before it reaches the capacity established in accordance with CCAR 25.1019(a)(2).
I25.6(a)	A means must be provided to indicate when the ATTCS is in the armed or ready condition

We need to set dedicated EICAS messages to fulfill the regulation requirements.

d) Normal Conditions

The EICAS messages not only can inform pilots the failure conditions, but also can indicate the normal conditions, like the state of the starter valves and igniters during engine start or the state of the igniters when the aircrafts encounter severe weather. For the aircrafts which install ATTCS (Automatic Takeoff Thrust Control System) function, the EICAS messages can be used to indicate the state of the ATTCS which is requested by the regulation.

Anyway, the normal conditions EICAS messages can be replaced by the icons in the display. For example, the state of the starter can be indicated by the icon in Figure 2. The left icon means the valve is closed and the right icon means the valve is open.

Figure 2 — Icon of the starter valve

e) Other considerations

For the aircrafts that don't have the dedicated dispatch page, the dispatch information can be indicated by the EICAS messages, like engine no dispatch, engine short dispatch. This kind of EICAS messages is mainly used by the maintenance person and will be inhibited after takeoff.

4. Inhibition of the EICAS messages

The AMC 25.1322 request Alerts inhibits function must be used to prevent the presentation of an alert that is inappropriate or unnecessary for a particular phase of the operation[4].

Generally, the EICAS messages should be inhibited on the following conditions:

a)Secondary EICAS messages inhibited by the primary EICAS messages

b)EICAS message inhibited by flight phase.

4.1 Inhibition of secondary EICAS messages

The normal operation of the powerplant system need support from the aircraft public systems, like the electrical system, hydraulic system and avionics system. When the public systems fail, they will derive the related powerplant system faults and the related secondary EICAS messages. For example, the electrical system failure will derive the engine ignition system and other system faults. Usually, there are many EICAS messages of other systems triggered by the electrical system failure, the pilots will get confused facing too much EICAS messages. In order to identify the primary failure which is the electrical failure from these faults and take appropriate actions, we need to inhibit the derived faults that don't influence the flight safety,

such as the ignition system. While for the important systems, we should not inhibit the related EICAS messages. Anyway, all the inoperative systems caused by the primary failures should be informed to the pilots by some means, like putting it in the FCOM.

For the other systems of the aircraft, the powerplant system is the public system, like the electrical system and hydraulic system will extract power from the engines, many systems of the aircraft get the ENG RUNNING signal from the powerplant system. So, the powerplant system failure will also derive some other systems' failure and related EICAS messages. We need to analyze whether to inhibit the derived EICAS messages from the safety aspect.

4.2 Inhibit by flight phase

Basically, a fault can occur in any time of a flight, while the effect can be quite different if a fault happens in different flight phase. For example, the state of the starter is very important during the engine start, so it's necessary to report the starter fault message to the pilots at this stage. When the engine is started successfully and the aircraft is taking off, reporting the starter fault message to the pilots is unnecessary. Because the pilots need to do a lot of work during takeoff and the starter fault can be dealt with after takeoff phase without safety effect. This starter fault message should be inhibit at this stage.

For all the EICAS messages, we need to analyze whether it's necessary to inhibit them in different flight phases.

5. Consideration of the initialization time difference of different equipments

The trigger logic of the powerplant system EICAS messages might use the signals from other systems or equipments. When the aircraft is powered on, all the equipments will initialize and start to send signals after completing the initialization. Because the initialization time for different equipments is different, it is possible that the powerplant system EICAS message is triggered because of not receiving some signals, and disappears when the related equipments complete the initialization and start to send signals. For this scenario, the EICAS messages don't reflect the real faults and is resulted from the initialization time difference. So, we need to avoid this issue by considering the equipments initialization time difference in the EICAS message logic.

6. Summary

The EICAS messages are a very important way to inform pilots the failures or faults of the aircraft and to take appropriate actions during flight. On one hand, the correct and appropriate EICAS messages are helpful to the flight safety, on the other hand, the incorrect and unnecessary EICAS messages will bother the pilots or increase the workload of the pilots. This paper introduces an approach on how to identify the EICAS messages of the powerplant system and some other issues that need to be considered when designing the EICAS messages.

References

[1] Janalee M. Kosowski. EICAS in an integrated cockpit Engine Indication Crew Alerting System, International Symposium on Aviation Psychology, 6th, Ohio State University, Vol.1(A92-44901 19-53), pp 166-171, 1991.

[2] CCAR Part25 Airworthiness Standards: Transport Category Airplanes. 4th edition, Civil Aviation Administration of China, 2011.

[3] ARP 4754A Guidelines for Development of Civil Aircraft and Systems. 2nd edition, SAE Aerospace, 2010.

[4] CS-25 Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes. Amendment 11, European Aviation Safety Agency, 2011.

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