Research on Civil Aircraft Cabin Service Availability
Analysis and Application

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Abstract. Reliability is one of the important characteristics of civil aircraft, it is an important factor to ensure flight safety and high punctuality, and to obtain good economy. The cabin service availability analysis is a key segment in the overall reliability analysis. This paper focuses on the determination principle of functions related to cabin service availability and the judgment of failure effects and other contents, and establishes a civil aircraft cabin service availability analysis method and analysis process.

Keywords. Cabin Service; Aircraft Function; Failure

1. Introduction
Cabin service availability means that cabin-related functions, systems, and usage items on the aircraft are available to passengers and crew. The loss or reduction of functions related to cabin services due to technical reasons can cause aircraft delays, reduce passenger comfort, and cause significant commercial losses. In aircraft commercial operations, in order to improve passenger satisfaction, recognition, acceptance and loyalty to the brand, airlines are paying more and more attention to passenger flight experience. The airline can decide whether the aircraft is dispatched based on the impact of unavailability of cabin service related items on passengers of different classes. Therefore, the cabin services availability will greatly affect the dispatch of aircraft. It is an important goal that airlines are concerned about. Therefore, in the initial stage of aircraft development, it is necessary to analyze the functions related to cabin services, put forward design requirements for the cabin services availability, and take relevant control measures to implement them in the aircraft design.

2. Cabin service availability design requirement
In order to ensure the maximum dispatch rate of the flight, in the design process of the aircraft, it must consider whether the cabin service availability will affect passenger comfort, and set a quantitative reliability design objective for this. In order to identify these commercial/comfort reliability targets and effects classification, the method shown in Table 1 was adopted. Based on the
loss of functions related to the cabin services availability, function failures can be classified into a certain category in the table.

Table 1. Classification of Commercial Effect

| Commercial Effect | Effects Description |
|-------------------|---------------------|
| No Comfort Effect | A failure of this function does not have any effect on passengers comfort or will not be recognized by the passenger. |
| Com Go            | A failure of a function is leading to some minor effects for single passengers |
| Com Go if         | A failure of a function is leading to a loss of comfort for the passenger or having commercial effects. Compensation is possible (e.g. neighbor, reseating etc.) or is acceptable due to flight duration. |
| Com No Go         | A loss of a function is leading to discomfort for one or more passengers or to commercial disadvantages which cannot be compensated for the flight. |

Regarding the setting of the probability requirements corresponding to the commercial effects classification of the failure condition, “No Comfort Effect” and “No Comfort Effect” do not have probability requirements. The probability requirements corresponding to “Com Go if” and “Com No Go” lie on the aircraft-level target value of cabin service availability and dispatch reliability.

3. Cabin service availability analysis process

Cabin service availability analysis is an analysis process that focuses on the availability of service oriented installations on-board, especially the availability of equipment for passengers in the cabin (also including some cargo-related equipment), it examines functions related to aircraft cabin services, identifies various failure condition of functions, and classifies them according to the severity of the effects of failure condition on aircraft comfort [1][2]. The Cabin service availability analysis process is a specific FHA (Functional Hazard Assessment) which focuses on the set of Cabin service [3]. It is a top-down analysis method. The key is to determine cabin-related functions and failure states and evaluate their impact. The analysis process is shown in Figure 1.
3.1. Identification of considered Cabin Functions
Before performing cabin service availability analysis, you first need to determine which functions are required for cabin service availability analysis. The Cabin functional identification considers four aspects:

a) Function related with crew, passenger;
b) Function related to the accommodation of common resources;
c) Function to support the operation and maintenance;
d) Function related to the safety of the aircraft and operation.

3.2. Identification of the Dependent External Systems, Events and Aircraft Configurations
Based on engineering experience as well as on aircraft specification and Airworthiness Authorities/customers’ requirements, the identification of the dependent external systems, events and aircraft configurations step shall identify the items out of the aircraft (e.g. Communication system including on-board Wi-Fi, telephone, etc.) which may affect Cabin functions in case of malfunction and, consequently, the following points must be considered in the analysis:

Figure 1. Cabin service availability analysis process
a) Identification of the functions exchanged between the aircraft and dependent external systems (e.g. ground support, other aircraft, satellite constellations), which are necessary for the operation or used for safety and Cabin functions. The exchanged function list shall have to consider the signals or power exchanged (input or output) between lower level aircraft functions and items of the dependent external systems.

b) Identification of the environmental events, which may have an impact on Cabin functions. Special environmental events that affect the cabin function of the aircraft must be considered.

According to the above principles, the detailed list of functions related to cabin services that need to be analyzed should be determined, and then relevant stakeholders will be invited to review and confirm the list of functions for further analysis.

3.3. Identification of Failure Conditions and Analysis of their repercussions on Comfort

This step is the identification and description of Failure Conditions associated with Cabin functions and the identification of the repercussions considering, for each phase of the flight, single and multiple function failures in normal and specific aircraft configurations or in combination with events or functions exchanged with dependent external systems.

The repercussions on the aircraft, crew and occupants and on the reliability will determine the associated classification.

3.4. Identification of Failure Conditions Effect Classification and Probability Requirement

According to the degree of effect of the failure condition on the comfort of the aircraft, and according to the effect category in Table 1, the effects classification of the failure condition comfort shall be determined.

3.5. Elaboration of Justifications/Supporting Material

Supporting materials should be provided in the cabin service availability analysis to prove that the determination of the effects classification is correct and reasonable. These supporting materials include engineering experience, similar aircraft experience, and airworthiness regulations.

3.6. Exporting cabin service availability analysis results

The results of failure condition analysis should be filled in the analysis table to form an analysis report, as shown in the following table.

| Function Title | Failure Condition Title | Description of Recipient 1—Comfort Effect on A/C, occupants, maintainers and third parties 2—Detection Means (flight/ground crew) 3—Crew corrective action and A/C condition after crew action | Flight Phase | Operation Environment | Class | Justification Material | Validation Method |
|----------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------|-------|------------------------|-------------------|
| N O. Function Title | N O. Failure Condition Title | Function Title | Description of Recipient 1—Comfort Effect on A/C, occupants, maintainers and third parties 2—Detection Means (flight/ground crew) 3—Crew corrective action and A/C condition after crew action | Flight Phase | Operation Environment | Class | Justification Material | Validation Method |

4. Application of cabin service availability analysis

Aircraft-level functions "provide kitchen" and "provide lavatory" are used as examples to specify the analysis of cabin service availability.
4.1. Identify the relevant failure status of cabin services

The following table shows aircraft-level functions and related failure conditions.

**Table 3.** Aircraft-level functions and related failure conditions.

| Aircraft Function | Failure Condition                        |
|-------------------|------------------------------------------|
| provide kitchen   | Total loss of galley area lighting.       |
| provide lavatory  | Total loss of lavatory function in cabin area |

4.2. Analyze the effects of failure condition on aircraft comfort

The effects of total loss of galley area lighting are that the galley areas are unavailable, which will increase the cabin workload, and discomfort to the passengers due to lack of in-flight services. In the detection means, the cabin crew can visually detect that the lighting function is unavailable. Regarding the crew corrective action and A/C condition after crew action, it needs to consider different flight phases. On ground, function can be restored prior the take-off. In flight, it is possible to use emergency lighting. Based on commercial influence, the captain makes the decision whether the aircraft is dispatched.

The effects of total loss of lavatory function in cabin area are that the cabin areas are unavailable and passengers are uncomfortable due to the lack of this service in flight. In the detection means, the passengers and cabin crew can be visually inspected. Regarding the crew corrective action and A/C condition after crew action, on ground, function can be restored prior the take-off. If it is in the flight phase, it will cause inconvenience to multiple passengers. Based on commercial influence, the captain makes the decision whether the aircraft is dispatched.

4.3. Identification of failure conditions effect classification and probability requirement

Based on effects of the failure condition, The effects classifications of the two failure conditions of "All loss of lighting function in the kitchen area" and "All loss of bathroom function in the cabin area" are Com Go if and Com No Go.

4.4. Exporting cabin service availability analysis results

After the above steps are completed, the results of the cabin service availability analysis for the given failure conditions can be obtained, as shown in Table 4.

**Table 4.** Cabin service availability analysis example

| No. | Function Title | Failure Condition | Description of Repercussion | Flight Phase | Operation Environment | Class | Justification Material | Validation Method |
|-----|----------------|-------------------|-----------------------------|--------------|-----------------------|-------|------------------------|------------------|
|     | provide kitchen| Total loss of galley area lighting | 1 – Unavailability of the galley areas. Increase of the cabin workload and discomfort to the passengers due to lack of in-flight services. 2 – Visually detectable by the cabin crew. 3 – On ground: restore the function prior the take-off. In flight: Possible emergency lighting activation, Captain’s commercial decision | All | normally | Com Go if | 1-Meeting minutes 2-research report | FTA FMEA |
|     | provide lavatory| Total loss of lavatory | 1 – Unavailability of the lavatory in cabin areas. Increase of discomfort to the passengers due to lack of in-flight services. | All | normally | Com No Go | 1-Meeting minutes 2-research | FTA FMEA |
5. Conclusion
Cabin service as a key factor affecting aircraft dispatch must be guaranteed to be available in airline operations. It is an important part of improving the overall reliability of the aircraft. Based on the functions of cabin services, this paper puts forward the reliability objective and analysis methods of cabin service availability, and performs cabin service availability analysis based on specific aircraft functions, establishes a complete cabin service availability analysis process to guide the subsequent aircraft reliability work, and then achieves the purpose of improving the reliability and economy of civil aircraft, ensuring civil The commercial success of the aircraft.

References
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