The Design Philosophy for Civil Aircraft Cabin

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Abstract. This paper presents a comprehensive exploration of the design philosophy for civil aircraft cabins, emphasizing the importance of human factors engineering in creating safe, comfortable, and efficient environments for both passengers and crew. The design principles are categorized into four key areas: safety, comfort, efficiency, and enjoyment. These principles not only ensure compliance with airworthiness and safety regulations but also address the ergonomic and emotional needs of passengers, thereby enhancing their overall travel experience. The discussion extends to the modularity and flexibility of cabin designs, which cater to diverse customer requirements and market demands. The study concludes that a human-centered design approach is critical for developing cabin environments that meet the expectations of all stakeholders, including airlines, passengers, and regulatory bodies.

Keywords: Civil Aircraft, Design Philosophy, Comfort, Cabin environment, Flight Safety

1 INTRODUCTION

Cabin is an integration compartment of the environment for the passenger in journey, for the cabin crew to accomplish their tasks, for airline to operate the configuration. Stakeholders.The stakeholders about cabin includes attendants, passengers, operation of airline, maintenance, ground service and civil aviation administration.

1.1 Cabin Related Scenario

The normal scenario of the cabin includes pre-flight preparation, boarding, safety demonstration, pre-flight safety inspection, meal preparation and recycling, passenger service, use of lavatory, personal activities of passengers, crew rest, pre-landing safety inspection, departure, post-flight cleaning and inspection; Abnormal cabin scenarios include bumpiness, land evacuation, ditching, cabin decompression, cabin smoke, public safety disposal and emergency rescue.

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1.2 Cabin Related Requirement

Cabin-related requirements are detailed in Table 1, covering both functional and non-functional aspects crucial to the overall design. These requirements are carefully cascaded from the top level down through various systems, ensuring that the cabin operates as a fully integrated product. This approach guarantees that every component works in harmony to deliver a superior passenger experience.[1] The design philosophy emphasizes not only safety, comfort, health, efficiency, and flexibility but also the importance of diversity and adaptability to different needs and preferences. Moreover, the cabin design is aligned with the latest industry standards and anticipates future trends, ensuring that the cabin remains relevant and competitive in the ever-evolving aviation industry. This comprehensive strategy results in a cabin environment that provides a pleasant and enriching experience for passengers, enhancing their overall journey.

Table 1. Cabin related requirements.

Requirement Document name	Content Architecture
Aircraft Level Functional Requirements FRD2—Provide and Control Accommodation and Access for Payload/Crew/Passenger	Provide and Control normal external accesses and exits
	Provide and control internal accesses and exits
	Provide crew/passenger/luggages accommodation
	Provide and control accesses and exits for payload
	Provide Cargo loading, storage and unloading facilities
Aircraft Level Functional Requirements FRD3—Provide human comfort and service	Provide Galleys
	Provide Lavatories
	Provide Rest Facilities for Crew
	Control Noise Propagation
	Provide passenger entertainment and service
	Provide Personal CommunicationProvide Personal Power Supply
Aircraft Level Functional Requirements FRD4—Provide and Control Environment	Provide Internal Lighting
Aircraft Level Functional Requirements FRD9—Provide Human-Machine Interface	Provide Data Display for Cabin Crew
	Provide Operation and Data Input for Cabin Crew
	Provide Cabin Internal Communication
	Provide HMI for Passenger
Aircraft Level Functional Requirements FRD10—Ensure Safety of Human	Provide Emergency Medical Support
	Provide protection and survival means in emergency situations
Cabin Safety Design Requirements	Cabin environment
	Human protection
	Flammability and Fire protection
	Evacuation and escape systems
	Cabin security

Aircraft Exterior Markings and Placards Requirements	Markings and Placards Basic requirement
	Cockpit Markings and Placards Design Requirement
	Cabin Markings and Placards Design Requirement
	Cargo Markings and Placards Design Requirement
	Exterior Markings and Placards Design Requirement
	Other Markings and Placards Design Requirement
Cabin and Cargo Integrated Design Requirements	Arrangement integration
	Design performance
	Operation and Customization
Aircraft Cabin Human Factors	Physic Engineering
	Display
	Information
	Usability
	Error-proofing

2 GENERAL PRINCIPLE

To make it more concrete, 4 top level principles for Cabin design philosophy are proposed and shown as below. The figure1 describes the hierarchy schema.

- Safety;
- Comfort;
- Efficiency;
- Enjoyment.

2.1 Safety

Safety is the basic requirement for cabin design, to create a safe environment for passenger, crew and ground maintenance. It includes airworthiness safety, safe design and security.[2]

2.2 Comfort

Human factors are guidelines for comfortable and health cabin design. It includes environment, physical Ergonomics, aero-medicine, usability and conscious and behavioral.

2.3 Efficiency

Human factors also effect the efficient for the work of crew and ground service. Nevertheless, more flexibility cabin design, more diversified configuration and more customization cabin design will provide efficient and economical work for airline operators.

2.4 Enjoyment

Enjoyable experience comes from the combination of design and services. Design is the basic of experience, then, cabin will give the differentiated offerings as well as emotional design for different customer. Finally, it is a product which passengers are willing to take, and airline is eager to use.

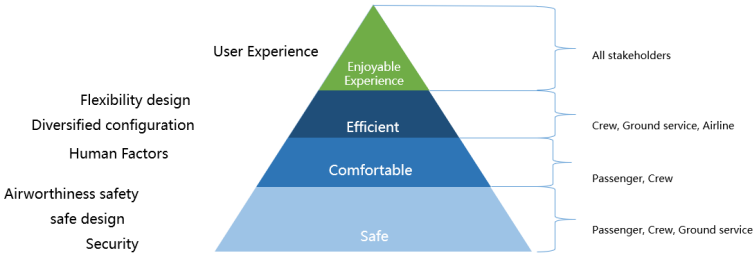

Fig. 1. Design philosophy hierarchy.

3 CABIN SAFETY

Aircraft cabin safety is a discipline that addresses occupant protection/survival, provides conditions for rapid evacuation from the aircraft, and obtains time as long as possible to evacuate the aircraft; focuses on the safety issues of the occupants after the fall and in flight. It includes: crash Dynamics, human tolerance, flammability/fire protection, emergency evacuation systems, imprinting equipment, cabin layout and security.

This is a topic dedicated to provide passengers and crew members with a safe environment at all stages of flight and reducing their casualties due to aircraft accidents; [3]its focus is on solving bumps in the flight, cabin decompression, on-board fires and after-falls' survivability and other issues, including the structure's fall ability, member's impact protection, emergency evacuation, post-fire protection and water evacuation.

3.1 Cabin Environment

The cabin provides a safe environment for the crew, including the structural safety of the aircraft, the passage and access of the cabin, the exit location, the layout, the aisle width, the floor slip, the pressure relief analysis, emergency lighting, emergency evacuation and cabin broadcasting.[4]

3.2 Human Protection

The cabin provides personnel with protection against rides and physical protection in emergency situations, including dynamic design and 16g impact test seats, oxygen systems, life equipment and an interior environment with no sharp design.

3.3 Fire Protection

The material of the cabin must meet the flame retardant properties and the smoke detection equipment and fire extinguishing equipment are arranged in the cabin.[5]

3.4 Cabin Security

In response to terrorist hijackings and bomb attacks, the cabin was designed with safety protection in mind, with FAR 25.795 and its AC, FAR 25-127 amendments, etc.; details include minimum explosive location design, cockpit and cabin smoke Protection, anti-hijacking door or isolation device design, easy to search cabin interior design.

3.5 Placards

Placards are used to guide passengers to escape and to alert and alert the equipment.

4 CABIN HUMAN FACTOR

The task of cabin human factor is to ensure that cabin products and services meet the needs and expectations of the users (operational crews and passengers) and allow a maximum efficiency of operations for the customers (airlines). [6]The consideration of cabin human factor is to provide a comfort, health and efficient cabin. The elements of human factor are shown in figure2.

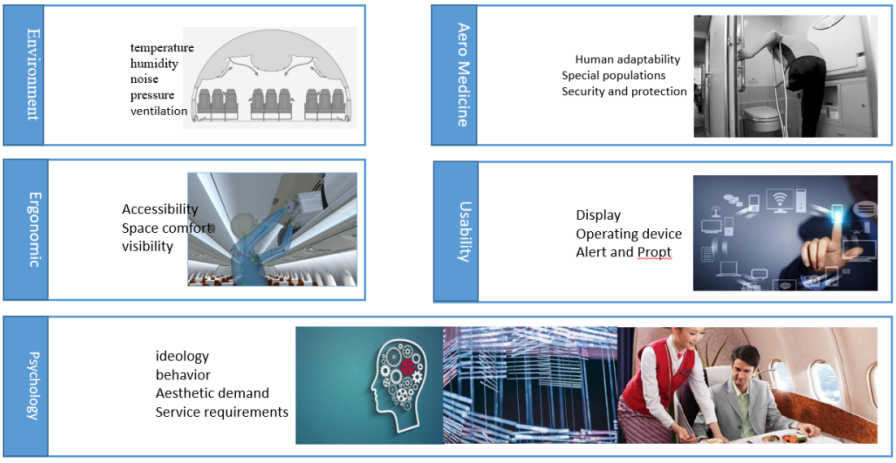

Fig. 2. Cabin human factor elements.

4.1 Environment

Comfortable environment considers temperature, humidity, noise control, pressure control and ventilation design according to the comfort human request.

4.2 Physical Ergonomics

Physical Ergonomics includes Accessibility, spatial comfort and visibility.

4.3 Aero Medicine

Aero medicine includes the design of human fitness, special population assurance and safety protection.

4.4 Usability

The usability includes friendly human-machine interface, operational device usability and effective alert method.[7]

4.5 Conscious and Behavioral

It mainly includes the consideration of users' conscious behavior, the demand of aesthetics and service.

5 DIVERSIFIED DESIGN AND CONFIGURATION

The diversified reflected in the aircraft is that it will provide more cabin options to customer. Provide customizable configuration for customers.

5.1 Cabin Options

The aircraft conducts adequate market research and analysis to provide adequate cabin options based on customer requirements.

5.2 Customization

Cabin will provide customizable parts in interior, cabin systems and mood lighting.[8]

6 FLEXIBILITY DESIGN

Flexible design provides the ability of quickly adapted of cabin, which reflected in the modular design of the cabin, the product has a unified interface design, the door area installs unified floor rail, which can match different service facilities. The interior of

cabin products adopts standard physical interfaces, such as galley insert adopt ARNIC 810.

6.1 Modularization

Modular design ideas include the definition of standard compartment, uniform installation interface, provide configurated cabin environment.[9]

6.2 Universality

Universality is reflected in the design of products using relatively uniform industry standards, the development of family and series of products.

7 ENJOYABLE EXPERIENCE

Enjoyable experience comes from the environment, the individual factor and the effect of surrounding. The feeling of enjoyable in ideal user experience includes emotion, deep first impression and Exceed expectations.

7.1 Emotion

Emotional design of products focuses on people's emotional needs and spiritual needs. Under the premise of guaranteeing the basic functions of products, some information that conforms to user needs is transmitted to users, so as to stimulate users' emotions and make them gain some kind of experience. Cabin design such as interior, color, graphic and IFE system will consider the user's emotional, belonging and self-realization needs.

7.2 Deep First Impression

A special, interesting or unusual design can make a strong first impression on the user, such as the new cabin color scheme and the configuration of smart equipment. Some of the design of the cabin makes a strong first impression on the user, which can deepen their sense of identity and make them willing to try again.

7.3 Exceed Expectations

Unexpected designs that give users a sudden sense of pleasure, and they are the result of capturing and optimizing for the pain points in current cabin. For example, improved leg space, larger overhead stowage, electric stowage, sensor flush/faucet.

Aircraft cabin design based on service design thinking, through effective planning and organization of people involved in the service, infrastructure, communication and related factors such as material, dig the stakeholders in the cabin encountered in the

work experience and the "pain points", conducting user research, to shape the ideal user experience model, put forward feasible and effective solutions.

8 CONCLUSIONS

Human-centered design processes will ensure efficient, effective, user acceptable Flight Deck HMI that will be easy to train, operate, and maintain. Human Factors Engineering evaluation play a very important role in the design of the Flight Deck HMI. The "high-level" design-review principles here represents the generic HMI characteristics necessary to support flight crew performance. While these principles are not detailed review guidelines, they may serve several purposes. First, they might be used to develop many of the detailed review guidelines for HMI design. Second, as general principles, they could be used to support the preliminary evaluation of aspects of the novel HMI design, such as new display formats or new interactive method etc.

References

1. Kleemann, F., & Maglio, P. (2021). Flexible design in aviation: Approaches for enhancing cabin configurations. Procedia Manufacturing, 55, 276-283. https://doi.org/10.1016/j.promfg.2021.10.047【CrossRef】
2. Lee, Y., & Chen, H. (2020). Safety design strategies for civil aircraft cabins: A human factors perspective. Safety Science, 129, 104763. https://doi.org/10.1016/j.ssci.2020.104763【CrossRef】
3. Jones, M. L., & Smith, A. (2020). Exploring the ergonomics of aircraft seat design. International Journal of Industrial Ergonomics, 77, 102941. https://doi.org/10.1016/j.ergon.2020.102941【CrossRef】
4. Hart, S. G., & Staveland, L. E. (2020). Revisiting NASA-TLX (Task Load Index): Empirical updates and theoretical implications. Human Factors, 62(1), 31-44. https://doi.org/10.1177/0018720819876130【CrossRef】
5. Gargiulo, L., & De Fazio, S. (2021). Enhancing passenger experience through cabin design innovation. Journal of Air Transport Management, 58, 25-35. https://doi.org/10.1016/j.jairtraman.2021.01.004【CrossRef】
6. Kleiber, M., & Andersen, H. (2021). Advanced human-centered designs for aircraft cabins. Aerospace Science and Technology, 110, 106543. https://doi.org/10.1016/j.ast.2020.106543【CrossRef】
7. Petersen, J., & Schreiber, A. (2020). Modular cabin design strategies in commercial aviation. Aerospace Engineering Review, 68(2), 75-84. https://doi.org/10.1016/j.aereng.2020.01.007【CrossRef】
8. Sundaram, B., & Kim, S. (2021). Evaluating the influence of cabin environment on modern passenger comfort. Transportation Research Part F: Traffic Psychology and Behaviour, 77, 52-62. https://doi.org/10.1016/j.trf.2020.12.009【CrossRef】
9. Müller, R., & Vogt, S. (2021). Passenger-oriented design principles in aircraft cabin architecture. Journal of Aerospace Engineering, 33(4), 58-72. https://doi.org/10.1061/(ASCE)AS.1943-5525.0001145【CrossRef】