Research on Key Technology of Intelligent Civil Aircraft

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Abstract—Under the background of large-scale civil aircraft development and engineering practice, research on the key technology of the new generation civil aircraft is the important start point to achieve multi-point technology breakthrough and product innovation of civil aircraft. In this paper, the concept of intelligent aircraft products is followed and developed to aircraft level. Under the precondition that the intelligent aircraft will be the development goal for a new generation of civil aircraft, then intelligent aircraft is the carrier of intelligent technology, and intelligent technology is the core of intelligence aircraft. The key technologies of intelligent aircraft is identified and defined , the corresponding research is explored , and the engineering application is developed.

1. Introduction

In face of the current difficulties in the transformation of traditional industries, a new round of technological innovation and the accompanying leap-forward development in the field of civil aviation is ready to emerge. In this paper, the concept of "new generation" intelligent aircraft product is put forward, and the definition of intelligent air transport system is described. The intelligent aircraft is defined as the target of customer's demand in 2030. Through synthesizing the comprehensive perception, computation, network communication and control technology, the intelligent aircraft is proposed as the future air transport system node, and becomes one of the possible future development goals. In the following discussion, a brief description of the key techniques is given.

2. Intelligence functions

Facing the fierce competition of civil aviation market in 2030, the major civil aircraft manufacturers have launched a smart technology research and reserves. Earlier, based on technology trends and market demand, Boeing and Airbus has proposed the general idea of the next generation of civil aircraft, which is showed in Figure 1. The application of intelligent technology in civil aircraft has become the general consensus.
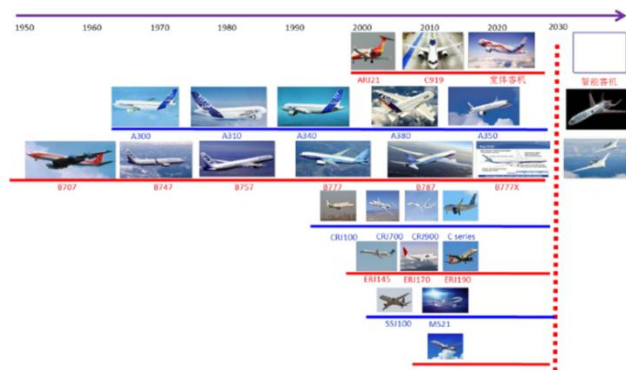

Figure 1. the world's major manufacturers of large civil aircraft product development context

Civil aircraft (intelligent) will be the main products in the future customer and market demand in 2030. It not only meets the demand of market segmentation, but also creates and leads the technical requirements of the technology and upgrade of new generation civil aircraft. Through the perception of information inside and outside the aircraft, information synthesis, analysis, judgment and reasoning, intelligent control, intelligent aircraft achieves a good interaction between aircraft carriers and airlines, crew, passengers. Intelligent aircraft should contain intelligent functions as shown in Figure 2. The description of intelligent functions is described in Table 1.
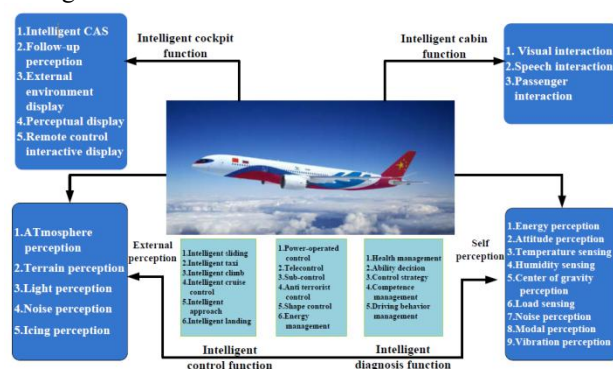

Figure 2. Intelligent aircraft functions definition

Number	Function definition	Functional description
1	Intelligent display	The engine, fuel, hydraulic, power supply diagram page are flowed visualization.
2	4D navigation	Intelligent takeoff, climb, approach, landing.
3	Intelligent taxi	Self sliding, self sliding after the ground, tire wheel speed protection.
4	Intelligent climb	According to the engine, curve of height and speed, continuous climbs up to the ceiling.
5	Intelligent airport operation	Select the departure runway, planning climbing track, reduce the wake effects.
6	Intelligent flight envelope	Center of gravity and weight aware, compute optimal flight attitude.
7	Information sharing	All weather information sharing between the aircraft and the ground, to increase the availability of weather data.
8	Interaction control	Exchange information with pilot at the whole process, to provide support in the emergency procedures, reduce the burden on the pilot.
9	External situational awareness	Approach and landing situation awareness, impact analysis and avoidance of low altitude bird impact.
10	flight crew information perception	Record crew action, sensing crew behavior.
11	Storage	Flight recorder data is stored in remote storage.
12	Intelligent Energy	According to the flight phase and mission，Rational planning and use of energy，Reduce engine and other energy consumption.
13	Intelligent Loading	Passenger weight characteristics is embedded into flight management and related to the plane food.
14	Intelligent Maintain	Combine aircraft components and design parameters to reduce the timing of maintenance.

Table 1 intelligent function description of intelligent aircraft

3. The definition of intelligent aircraft

The intelligent aircraft is an airplane that combining all the intelligent functions. Intelligent aircraft can sense the operation information, have the ability of machine learning, autonomous control and planning, behavior decision, also can provide the natural human-machine interface. The intelligent aircraft have the follow characters:

1) Situation sense: the intelligent aircraft can obtain the inside information dynamicly, including the plane crew, passenger, cargo, energy information, and etc; also can obtain the real-time information outside, including weather, terrain and etc. All the information will be processed together and make a prediction.
2) Machine learning: the intelligent aircraft can restore the information using the cloud storage, and get the new ability through the machine learning.
3) Autonomous control and planning: the intelligent aircraft can Autonomous control, auto flight control, and can plan the route, behavior based on the combination of flight plan, task and the weather, terrain.
4) Behavior decision: the intelligent aircraft have the ability of behavior decision, it can make the right decision based on the environment and situation sense. The aircraft can improve the ability through machine learning.
5) Natural human-machine interface: the intelligent aircraft can provide a high-efficient, convenient, timely interface to the crews and passengers.

4. Key technologies of intelligent aircraft

Compared with the traditional civil aircraft, intelligent aircraft is no longer a simple air transport aircraft, but a intelligent network node which realizes the airline intelligent operation , intelligent control and constructs the intelligent space. Not only the aircraft itself is intelligent, the intelligent aircraft will interact with the outside world intelligently and friendly, as shown in Figure 3, which will definitely challenge the traditional aircraft requirement and aircraft architecture. The key technologies of intelligent aircraft is described below:

3.1 Information sensing technology

With the development of intelligent technology such as artificial intelligence technology and Internet technology, it provides a new way of information perception and processing. The whole machine operation information sensing is the prerequisite and the necessary condition for intelligent aircraft to produce intelligent activities. Because of the large amount of data involved, the types of the information are interrelated and dynamic. Although the traditional aircraft has internal and external information perception, but the perception of data sources scattered, without comprehensive treatment, cannot form a unified and effective data set, intelligent aircraft cannot meet the intelligent function of perceived needs. Comprehensive information processing technology can capture, analyze and deal with the operation information of the whole machine. It integrates the operation information of the whole machine into an organic whole. It provides the whole aircraft operation information of the intelligent aircraft and constructs the whole machine operation perception information system. In addition to perceptual crew, passenger and cargo information, the operational perception of the aircraft also involves external weather, airports, visibility, route terrain, and sharing information with other aircraft.

3.2 Intelligent Behavior Self - determination and Security Decision Technique

Intelligent aircraft behavior autonomy mainly rely on large samples and experience accumulation, with neural network to improve machine learning ability and adaptive ability, so that intelligent aircraft with behavioral autonomy and security decision ability, enhance intelligence plane behavior autonomy and driver monitoring interaction ability. Intelligent behavior autonomy and security decision-making

technology will establish an integrated processing and computing center, the information can be processed in real time, can store the perception of external information and knowledge derived from reasoning, and can use the existing knowledge of information analysis. Association and decision-making, with learning and adaptive ability, that is, through interaction with the environment, learning to accumulate knowledge, so that they can adapt to environmental changes, relying on large data and artificial intelligence memory / learning ability to solve intelligent behavioral security.

The intelligent mission not only includes the dynamic planning tasks such as 4D flight management, dynamic planning management and authorization management, but also include flight profile tasks such as intelligent taxiing, intelligent climbing, intelligent cruise and intelligent approach. Intelligent mission will integrate the dynamic planning tasks, flight profile tasks, and synthesized environment information inside and outside aircraft, to achieve intelligent flight.
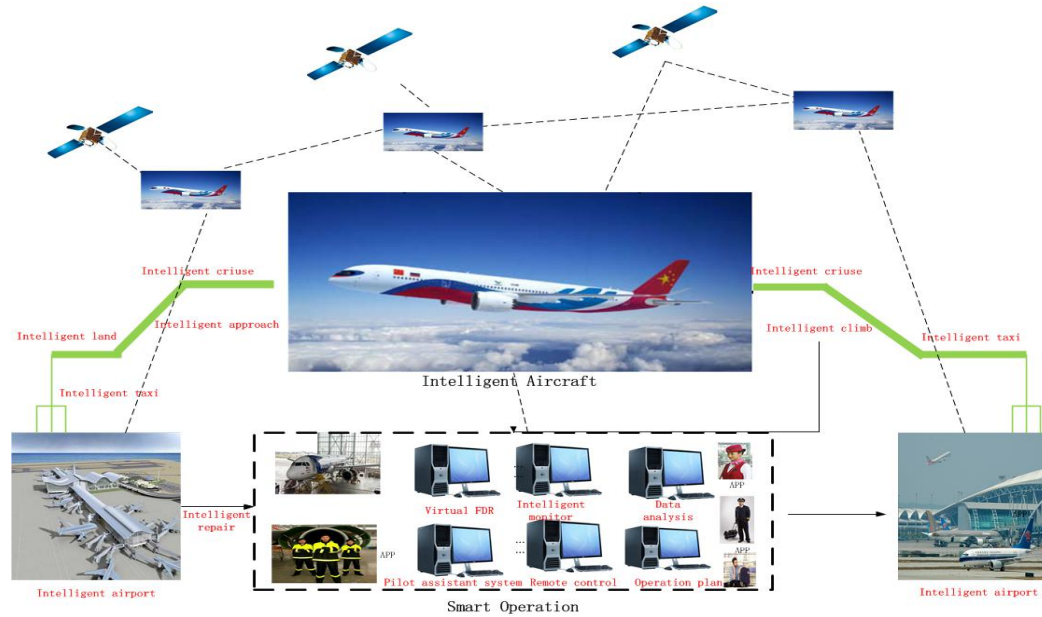

Figure 3. Intelligent aircraft in the Intelligent air transport system

3.3 Intelligent Interactive Technology

Intelligent aircraft behavior autonomy mainly rely on large samples and experience accumulation, with neural network to improve machine learning ability and adaptive ability, so that intelligent aircraft with behavioral autonomy and security decision ability, enhance intelligence plane behavior autonomy and driver monitoring interaction ability. Intelligent behavior autonomy and security decision-making technology will establish an integrated processing and computing center, the information can be processed in real time, can store the perception of external information and knowledge derived from reasoning, and can use the existing knowledge of information analysis. Association and decision-making, with learning and adaptive ability, that is, through interaction with the environment, learning to accumulate knowledge, so that they can adapt to environmental changes, relying on large data and artificial intelligence memory / learning ability to solve intelligent behavioral security.

3.4 Intelligent Flight Mission Technology

planning tasks such as 4D flight management, dynamic planning management and authorization management, but also flight profile tasks such as intelligent taxiing, intelligent taxiing, intelligent climbing, intelligent cruise and intelligent approach. Intelligent mission not only to the airport, route, weather and other external environment, but also involves the aircraft body. In order to

achieve intelligent needs and autonomous behavior, intelligent aircraft using fully integrated system intelligent architecture, the intelligent architecture involves the physical architecture and software architecture. The open architecture adopted by the intelligent aircraft system not only guarantees the continuous upgrading of the intelligent aircraft, but also guarantees the realization of the neural network memory and autonomous learning ability. It is the key to the comprehensive information processing and calculation. On the basis of fully integrated intelligent architecture, the intelligent mission will integrate the dynamic planning tasks, flight profile tasks, and integrated aircraft inside and outside environment, to achieve intelligent flight.

3.5 Intelligent Flight Simulation Scenarios Technology

Intelligent flight mission verification technology will simulate the flight and test scene to achieve the system user interaction with the system model, identify missing needs, confirm the system requirements and reasonable system architecture. Intelligent flight mission verification technology will also adopt the full flight profile scenario. The aircraft flight demand are assessed, the aircraft functional architecture, the aircraft system physical architecture are evaluated, the design iteration of the aircraft's top-level requirements is completed, the intelligent integrated mission-based aircraft system integrated design is realized under this scenario.

5. Summary

This paper puts forward the implementation plan of intelligent aircraft from the top requirement of aircraft function. Although the technology is still in the basic research stage, and need to be solved. The research on intelligent technology is an important process which is indispensable to implement the intelligent aircraft. On the basis of the possible technology of intelligent aircraft design, combined with the intelligent aircraft system functional architecture, this paper combs the key technology, which lays the foundation for further technical research. The design of intelligent aircraft should take into account the scientific objectives and engineering objectives of the civil aviation development plan, so that the complicated research task can be carried out from the top of the scientific exploration, and the technology can be effectively implemented. To explore and pre-research the intelligent aircraft, do the necessary technical reserves is imperative.

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