A Research on the Intelligent Flight Deck Development Trend for the Civil Aircraft

Hua Meng(✉), Qinpeng Dong, Chunling Zhao, Xianchao Ma, and Dayong Dong

Shanghai Aircraft Design and Research Institute, Shanghai 201315, China
{menghua,dongqinpeng,zhaochunling,maxianchao,dongdayong}@comac.cc

Abstract. The Flight Deck is the brain of the aircraft and is the key to controlling the operation of the aircraft. With the development of industrial technology and information technology, the Flight Deck of civil aircraft has roughly experienced two main stages of electronicization and informatization, and in recent years, with the rapid development of intelligent technology, the concept of intelligent Flight Deck has received more and more attention and favor, and has also become the focus of the development of the next generation of aircraft. This paper mainly studies the application scenarios and development trends of future advanced technologies in intelligent Flight Decks, takes the three aspects of intelligent "information perception, collaborative decision-making and processing execution" as the main line, and explores the application prospects of cutting-edge technologies such as artificial intelligence, big data, multi-channel interaction, machine vision/infrared detection, 5G/ATG/high-speed satellite communication/navigation technology in the Flight Deck of civil aircraft, so as to analyze the main directions of future intelligent Flight Deck design and formulate a roadmap for the development of intelligent Flight Deck technology of civil aircraft.

Keywords: Intelligent · Flight Deck · Development trend · Advanced · Automated Cockpit · Road map · civil aircraft

1 Introduction

Reviewing the development history of civil aviation in the past 100 years, "The evolution of aircraft cockpit can be roughly divided into two stages. Before the 1970s, along the path from simplicity to complexity, various instruments and switches in the cockpit continued to increase and gradually became saturated; Starting from the late 1970s, with the continuous development of avionics technology, it began to shift from complexity to simplicity." (Zhou Qihuan. 1998).

"The civil aircraft cockpit design have grown through generations, and the characteristic of cockpit have evolved from the original simple to complex integration, then to the direction of simple and intelligent." (Feng Zhixiang et al. 2021).

Since the beginning of the 20th century, human industrial civilization has experienced a development process of mechanization/electrification, electronic/informatization and

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intelligence/interconnection, and the civil aircraft cockpit accompanying its development has also undergone obvious upgrades in three aspects: "information perception, collaborative decision-making and execution processing".

So, this paper holds that the civil aircraft cockpit has roughly experienced two stages: the Electrified Cockpit (the first stage) and Informative Cockpit (the second stage), and is now in the early stage of Intelligent Cockpit (the third stage).

The information perception referred to in this article mainly refers to the perception of aircraft system status (normal, abnormal) and the acquisition of external environmental information (terrain, meteorology, air traffic control, routes, terminals, and other aircraft, etc.).

The collaborative decision-making referred to in this article mainly refers to the processing of information by human or aircraft systems, as well as the relevant tools needed in this process.

The processing execution referred to in this article mainly refers to the interaction between humans and machines, as well as the execution subjects and methods for decision instructions.

2 Characteristics of Electrified Cockpit (The First Stage)

The period from 1900 to 1980s was a period of rapid development of the electrified cockpit. "For a considerable period of time, with the rapid, long-range, and large-scale development of aircraft, airborne equipment has become increasingly complex. The cockpit equipment has evolved from fully mechanical instruments and handle switches to more complex electromechanical instruments, lighting and audio signals, and knobs. In addition to the pilot, the crew members will also be equipped with random mechanics, and remote aircraft will also be equipped with random telegraph operators, navigators, and ultimately a 5-person crew. Due to the fact that each instrument panel can only provide one piece of information, dozens of instruments and over a hundred switches are distributed throughout the cockpit, requiring the driver to operate in all directions, forming a crowded and chaotic maze like cockpit." (Zhou Qihuan. 1998).

During this period, the main characteristics of the civil aircraft cockpit in the three aspects of "information perception, collaborative decision-making and processing execution" were as follows:

a) **Information Perception:**

System status awareness: In the cockpit at this stage, the flight crew obtains the status information of the aircraft system through various instrument panels and complex and diverse mechanical dials installed in the cockpit. They need to concentrate highly to deal with complex and diverse information; When the system fails, it mainly depends on the human response to the aircraft itself and the independent distributed single system warning (warning lights and warning sounds) to perceive the aircraft status.

External environment perception: in the cockpit at this stage, the ground-based radio navigation represented by visual landmark navigation, PAPI light and NDB/VOR/DME/ILS is the main navigation means for the flight crew at this stage;

the flight crew obtains terminal and route information through paper charts and meteorological reports (TAF/METAR, etc.); The voice communication using HF/VHF is the main way for the cockpit to communicate with the outside world; The conflict between aircraft mainly depends on the visual guidance of the crew and the ground radar.

b) **Collaborative decision making:**

At this stage, the cockpit, because of the complex and diverse information perceived, is not intuitive enough, and the relevant decision-making basically depends on the flight crew itself.

Because the aircraft system is difficult to provide effective decision-making assistance, the crew of piloting, navigation, communication and system management has a high workload. The cockpit is composed of a five-person/three-person crew composed of pilots, co-pilots, mechanics, communicators and navigators. The crew cooperates closely to complete relevant collaborative decision-making.

c) **Process execution:**

At this stage, the cockpit has a low degree of automation, and the pilot needs to operate "two levers and one rudder" for a long time to drive manually; the mechanical control handle, switch and knob are the main human-computer interaction modes, and the flying quality and safety are highly dependent on the pilot's "driving skill level" and the mechanic's "troubleshooting level".

During the execution of the mission, the flight crew mainly relies on the paper manuals such as AFM/FCOM/QRH to execute the corresponding operating procedures. In order to avoid human errors, the paper Checklist is gradually introduced into the cockpit and becomes an important means to ensure flight safety.

On the whole, the first stage of the electrified cockpit has a high workload, and the safety of aircraft take-off and landing and route planning are greatly affected by the external environment, which greatly limits the safety, efficiency and economy of civil aviation operation (Fig. 1).

1900-1940 1940-1980

Fig. 1. Typical representation of the first stage cockpit

3 Characteristics of Informative Cockpit (The Second Stage)

Since the 1980s, with the introduction of electronic technology into the aviation industry, the transformation of the cockpit has entered a new stage, evolving into the mainstream glassy cockpit today. Electronic instruments have replaced traditional mechanical instruments, and various parameter information of the aircraft has been digitized. A single screen can integrate and display multiple information, and the functions of various equipment are integrated with each other. The number of instrument equipment in the cabin has been greatly simplified, and pilots have transformed from a multi person crew to the standard two person crew today. (Feng Zhixiang et al. 2021).

Thus, From the 1980s to the 2010s, with the vigorous development of electronic information technology, especially computers, The cockpit has ushered in a significant historical revolution.

a) **Information Perception:**

System status awareness: In the cockpit of the second stage, the cathode ray tube (CRT)/flat panel liquid crystal display (LED) quickly replaced the mechanical instrument, and the cockpit entered the era of "glass cockpit". The flight crew can obtain digital and graphical aircraft status information through the integrated display; In addition, the concept of "quiet and dark cockpit" is introduced, which greatly liberates the workload of the crew under normal conditions, especially for the abnormal state under system failure, the central electronic integrated crew warning system helps the crew to quickly achieve fault location through CAS message/warning light/warning tone/PBA/electronic checklist and other related elements. Greatly enhance the situational awareness of the crew.

External environment perception: In the cockpit at this stage, due to the popularity of electronic computer, high-precision inertial navigation and GNSS satellite-based navigation technology, VOR/DME/ILS/GLS/FLS integrated navigation has become the mainstream; the data link communication technology based on ACARS and broadband satellite communication has been promoted on a large scale; Pilots can also obtain electronic charts, weather reports and other terminal and route information in time through EFB (Electronic Flight Bag) and CPDLC. In addition, with the continuous upgrading of airborne equipment, Doppler color weather radar, EGPWS (Enhanced Ground Proximity Warning System), TCASII, ADS-B and other technologies have greatly enhanced the integrated monitoring capability of the crew to deal with weather, terrain and other aircraft.

b) **Collaborative decision making:**

At this stage of the cockpit, the large screen display replaces the traditional mechanical instruments, the cockpit is greatly simplified, the cockpit information is concise and intuitive, and the flight crew can make relevant decisions more easily.

At the same time, with the improvement of automation of key systems represented by flight control computer and flight control computer, some functions (such as flight guidance FD, electronic checklist ECL, flight plan, performance calculation) have become effective tools for pilots to make decisions, which greatly reduces the workload of the flight crew, and also allows the pilot and co-pilot to have enough. The "mechanic, communicator and navigator" became history, and the two-person crew became standard. Although the pilot's driving ability is decreasing day by day, the requirements for the pilot's situational awareness and the ability to deal with unexpected situations are greatly increased. Therefore, the current civil aircraft cockpit still needs a standard two-man pilot, relying on the good crew resource management level of PF and PNF (PM). Correspondingly, in addition to the conventional aircraft knowledge training and skill training, in order to meet the procedural rules of various new navigation technologies, Airlines need to spend a lot of money to maintain the qualifications of the crew (such as CATIIIb, HUD, etc.).

c) **Process execution:**

In the second stage of the cockpit, the civil aircraft cockpit began to have a real sense of "man-machine function allocation". Due to the improvement of automation level, Fly by wire operation, FADEC engine full authority digital control, Autopilot autopilot, AutoThrust automatic thrust management and other technologies were introduced into the cockpit by leaps and bounds. The role of the flight crew has gradually changed from "controller" to "monitor" of the aircraft. In addition to critical stages such as aircraft take-off and landing or some abnormal situations, most of the energy of the crew is released. Of course, the current automation is still a conventional automation application that needs the crew to lead. At this stage, new human-computer interaction methods such as PBA, CCD, MKB and touch screen have been promoted, and flight safety in the "quiet and dark cockpit" has evolved from relying on the pilot's "driving skill level" to "situational awareness level".

In the process of mission execution, electronic checklists and FCOMs are gradually introduced into the cockpit, which improves the efficiency of the crew in mission execution and becomes an important means to ensure flight safety. Airlines gradually accept and promote the "paperless" cockpit. At the same time, with the introduction of IMA (Integrated Modular Avionics System)/CCR (Common Computing Resource), the cockpit has gradually begun to modularize integrated avionics.

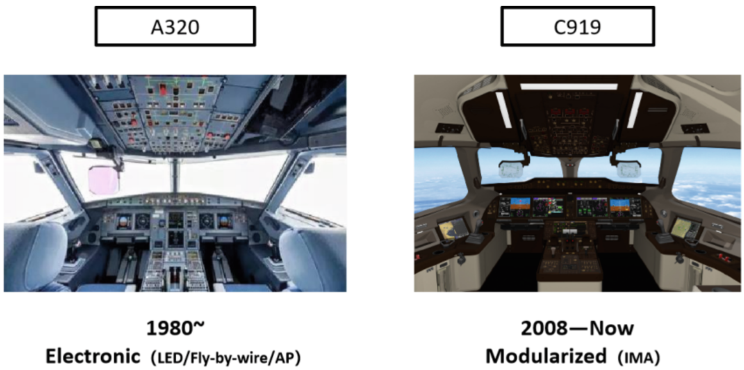

Fig. 2. Typical representation of the second stage cockpit

To sum up, thanks to the development and application of computer technology, the second stage of the cockpit has greatly liberated the attention of pilots, greatly guaranteed the safety of civil aviation operation, and greatly improved the efficiency of flight operation (Fig. 2).

4 Latest Technologies and Research Status

The design of civil aircraft cockpit has evolved from the concept of "function centered" to the design concept of "people centered". Today, when the new scientific and technological revolution breaks out, it will bring a wide imagination space to the design of civil aircraft cockpit. After fully considering the characteristics and use needs of pilots, the cockpit with new technology will achieve cross generational development. (Feng Zhixiang et al. 2021).

In the era of intelligence, intelligent systems based on artificial intelligence (AI) technology are gradually entering people's daily work and life, and entering the cockpit of large commercial aircraft is no exception (Bailey et al., 2017).

Looking forward to the future aircraft cockpit, a new generation of technological revolution led by 5G technology, artificial intelligence, new display and control technology is breaking out. When 5G technology is integrated with artificial intelligence, new display and control technology, the future cockpit will be more intelligent, equipment and functions will be more integrated, and the space will be more spacious and comfortable.

In the 21st century, especially from 2010 to now, companies and institutions represented by Boeing, Airbus, Gulfstream, Thales and NASA have carried out a number of studies on the future intelligent cockpit, such as the Gulf 650 cockpit and the concept cockpit proposed by Thales. Compared with the current mainstream second stage cockpit, it has made a bold partial breakthrough. This paper analyzes some of the key achievements (Fig. 3).

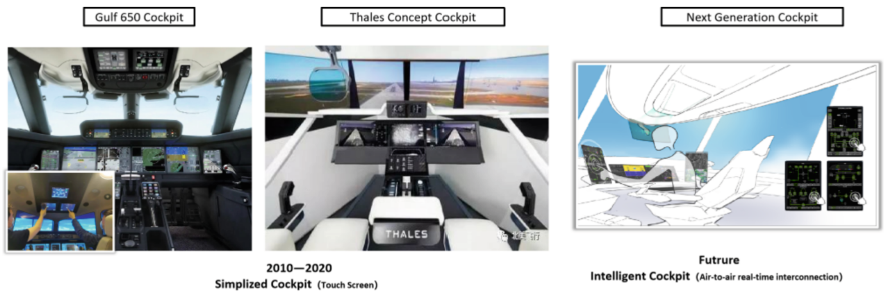

Fig. 3. Concept of the future third stage cockpit

Unmanned technology has great potential in reducing the cost of research and development/use of civil aviation airliners, improving flight safety and improving flexibility of use, so it has always been highly concerned by the aviation industry, airlines and even the general public in various countries. As one of the two giants in the world's civil aircraft manufacturing industry, Boeing has invested a lot of manpower, material and financial resources in the field of unmanned airliners for many years, and has made significant progress in the long-term research and testing of unmanned airliner related technologies. At present, Boeing is preparing to adopt single-pilot technology in the next generation of airliners before the technology of unmanned airliners is fully practical, which can be used as a necessary link and transition before the final realization of unmanned airliners, and can also br e economic benefits to airlines. At present, Boeing's related research demonstrates a single-person driving mode, which is intended to be applied to its latest generation of Boeing 797 airliners, hoping to serve as a link and transition before civil airliners are fully unmanned. In this mode, there will be only one pilot in the cockpit of the airliner flying in the air, who can provide backup and monitoring for the airborne unmanned system, especially responsible for dealing with various unexpected situations during the flight. At the same time, there will be another "pilot" on the ground, who is somewhat similar to the ground operator in the current UAV system, who can share part of the work for the pilot on board and the UAV system, and can monitor multiple aircraft at the same time. In addition, in view of the increasingly mature touch technology, Boeing has fully used touch screen technology in its latest B777X model, and touch screen technology is in the stage of transformation from research to application.

Since 2014, under the "Clean Sky" program of the European Union SESAR program (Tatjana Bolic et al. 2021), Airbus has carried out a study on the subversive cockpit technology "DISCO", aiming at studying the driving technology of a single pilot, the head-mounted display with specific SVS function can improve the situational awareness of a single pilot, and the sensor based on lidar can be used in the icing environment of traditional air hostels. It can also sense clouds, wind shear or icing environment, etc. AI speech recognition technology will convert voice to steady, reduce the workload of manual input by pilots, and enhance the efficiency of communication with air traffic controllers. It is expected to reach TRL3 in 2021 (to be updated) and TRL5 in 2023. In June 2020, based on A350-1000, Airbus completed the test flight of the ATTOL project, successfully verified the fully automatic flight based on machine vision, and expanded the research direction of unmanned aircraft. The technology is derived from the Wayfinder autonomous flight control system at Airbus A3 Innovation Center. The team developed software based on computer vision and machine learning to examine the environment around the aircraft and calculate the best navigation scheme by using sensors (including cameras, lidar) and more powerful computers. Autonomous technology frees pilots from routine tasks such as take-off and landing, cruise and so on, and puts more energy on decision-making and mission management, which helps to make the best decisions in emergencies, thus improving flight safety. At the same time, only airborne systems are used to achieve autonomous flight, which gets rid of the dependence on external equipment, thus reducing the cost of airport infrastructure construction.

From 2012 to 2014, through FDDLR laboratory, NASA carried out special research on single-person crew cockpit, including crew cooperation in operating procedures, use of automation, responsibilities and division of labor between cockpit and ATC, etc. In 2015, the relevant report was released, but the report only gave the results of the principle test. (Cynthia A. Wolter et al. 2015).

In 2018, the Display and Decision Support of Intelligent Cockpit System, published by China Institute of Aeronautical Radio Electronics, focuses on the integrated intelligent cockpit technology proposed by NASA, and discusses the display and operation capabilities, information processing and collaborative decision support of the next generation cockpit from the conceptual level, in order to better cope with future changes in air traffic management.

In 2019, “Research on Efficient Human-Computer Interaction Methods in Future Aircraft Cockpit Design” proposed a new type of human-computer interaction method for aircraft cockpit, this “data glove” interaction system constructs a highly reliable and efficient human-computer interaction platform between pilots and aircraft, which provides flight data acquisition and analysis. It is an important part of the efficient man-machine integration of the future cockpit.

In February 2020, the team of Wang Zhao and Xiao Gang of Shanghai Jiaotong University applied for the “Single Pilot Driving System and Control Method”, and proposed the SPO mode organization and operation mode for four different scenarios. (Wang Zhao 2020).

PBN is one of the core technologies for building a new generation air transportation system, which can accurately guide aircraft and improve flight operation safety; Provide vertical guidance, implement continuous and stable descent procedures, and reduce the risk of controllable ground collision; Improve round-the-clock operations, improve flight normality, and ensure the safety of airport operations with complex terrain; Realize flexible and optimized flight paths, increase aircraft load, reduce flight time, and save fuel; Avoid noise sensitive areas, reduce emissions, and improve environmental protection level; By implementing parallel routes and increasing the positioning points of inbound and outbound routes within the terminal area, traffic flow can be increased; Reduce the horizontal and vertical spacing between aircraft and increase airspace capacity; Reduce the demand for ground to air communication and radar guidance, facilitate command, and reduce the workload of pilots and controllers; Reduce investment in navigation infrastructure and operational costs, and improve the overall economic efficiency of operations. (Huang Jing. 2014).

Speech recognition technology, as part of human-computer interaction, is essential for machine intelligence. The utilization of robots as the co-pilot in civil aircraft is a major breakthrough and innovation direction in the civil aviation industry. The application of speech recognition technology to the co-pilot of the robot can make the command of the captain directly to the co-pilot program, making it possible to cooperate between the captain and the robot pilot. In 2020, a standard yelling speech database was established by Civil Aviation Flight University of China. (He Liqing. 2020).

Based on the above research on the three stages of cockpit development, with the third stage of intelligent cockpit, it will achieve leapfrog development in information perception, collaborative decision-making and execution processing, change the current human-computer collaborative work mode, reduce the workload/qualification requirements/quantity of the unit, and improve system management and fault handling. Improve the adaptability of terminals and routes, and realize the development of civil aviation airliners from “low visibility operation” to “all-weather operation”.

5 Development Trend of Intelligent Cockpit (The Third Stage)

There is currently no specific and complete solution for the future intelligent cockpit, but researchers have looked forward to the development of intelligent cockpit based on the advantages of intelligent technology, the limitations of automation technology, flight safety, and the needs of airlines. (XU Wei, 2022).

From 2010 to now, with the vigorous development of advanced technologies such as artificial intelligence, big data, multi-channel interaction, machine vision/infrared detection/airborne image recognition technology, 5G/ATG/high-speed satellite communication/navigation technology, and the continuous innovation of civil aviation authorities and main manufacturers in various countries, new technologies of civil aircraft cockpit have sprung up like mushrooms. The cockpit is ushering in a new historical revolution. This paper is briefly summarized as follows:

a) **Information Perception:**

System state perception: At the current stage, "glass cockpit" will be further developed with the application of touch screen technology, and "display and control integrated super-large screen cockpit" may become the next trend. At the same time, on the basis of the concept of "quiet and dark cockpit", more intelligent algorithm rules will be used to further reduce unnecessary redundant information. Only the key information required in the current stage is provided, and the situational awareness of the crew will be further enhanced; on the basis of ECAM/EICAS + ECL, the aircraft will monitor and even predict the state change of the aircraft in combination with the real-time health state management system, and realize automatic isolation and disposal in case of system failure (Fig. 4).

Fig. 4. Conceptual Diagram of Future Cockpit (Picture from Internet)

Perception of external environment: In the past decade, with the maturity of infrared detection technology, airborne image recognition technology and GNSS technology and the increasingly powerful function of airborne navigation database, HUD/EVS/SVS/CVS/PBN (especially high-precision RNP) technology has been partially promoted and will gradually become the "standard configuration" of future intelligent cockpits; At the same time, the further maturity of data link communication technology based on 5G/ATG/high-speed satellite communication (high bandwidth/low latency/high availability and integrity) will support the real-time detection, sharing and avoidance of meteorological risks between aircraft and aircraft, aircraft and the ground. At the same time, the real-time interconnection of aircraft status information with ATC/AOC/other aircraft information (including the real-time uplink and downlink of airborne database) is realized; in addition, with the maturity of machine vision technology, the importance of “human eye recognition” will be further reduced.

b) **Collaborative decision making:**

At present, with the rapid development of artificial intelligence technology, big data and multi-channel interactive technology represented by automobile automatic driving, combined with the development of the new generation of communication/navigation technology and flight control computer mentioned above, the automation level of civil aircraft cockpit is expected to evolve to the direction of “intelligent AI”, on the basis of obtaining sufficient internal and external information. Automation is upgraded from an “effective assistant tool” to a “reliable assistant” that can replace most of the pilot’s duties by means of “intelligent algorithm and autonomous learning of pilot’s behavior patterns” to help pilots automatically perform tasks at critical stages. For example, TCAS automatic avoidance function under AP connection and automatic emergency descent function under pilot disability have been realized on A350 and other aircraft. In addition, when the communication technology is mature enough, real-time remote control on the ground will also become possible.

Based on the above prediction, the man-machine cooperation mode of the third stage cockpit may also undergo a subversive change, from the mainstream pilot-co-pilot-automation (aircraft system) to the multi-mode driving mode of “pilot-automation (AI), pilot-ground controller, automation (AI)-ground controller”.

c) **Process execution:**

Based on the above, the third stage of intelligent cockpit, human and automation (AI) will be complementary/alternative roles, therefore, based on artificial intelligence, big data, multi-channel interaction, machine vision, 5G/ATG/high-speed satellite communication technology based on 4D track “intelligent flight” will become an intelligent cockpit. Including but not limited to “automatic taxi/automatic takeoff/automatic interval management/automatic descent/autonomous route planning/wake prediction and active avoidance/automatic landing”.

Among them, the multi-channel interaction technology represented by touch control, voice control and gesture control will further simplify and improve the efficiency of interaction between the crew and the aircraft.

At the same time, the intelligent management of the system under normal conditions (such as intelligent environmental control) and knowledge-based autonomous fault isolation and disposal under abnormal conditions will also greatly reduce the workload of the crew and reduce the requirements for the qualification/quantity of the flight crew.

6 Development Route

Based on the above analysis and summary of the development stage of civil aircraft cockpit, combined with the current development direction of future cockpit at home and abroad, we can see that the main direction of future civil aircraft intelligent cockpit is the following three points:

a) Intelligent information perception: study how to improve the accuracy, timeliness and reliability of aircraft perception of internal and external information such as external environment (weather, terrain, airport, ATC, other aircraft, etc.), aircraft system status, personnel status and operation intention. Including but not limited to: touch screen technology, machine vision technology, information detection and sharing technology based on data link communication, CVS technology and high-precision PBN technology.
b) Intelligent collaborative decision-making: After obtaining sufficient perception information and authorization, based on technologies such as big data analysis model, high-speed computing system, specific algorithm and deep learning, intelligent AI assistant decision-making instructions are provided. Some instructions can try to control the aircraft directly instead of people, so as to better cope with interference, special cases or unexpected situations. Including but not limited to: research on multi-mode man-machine interaction decision-making mode between "pilot-automation (AI), pilot-ground controller, automation (AI)-ground controller".
c) Intelligent disposal execution: research to improve the automation level of the existing aircraft system, and execute relative procedures or actions according to the set rules to cope with the conventional and normal operation process. In addition, through big data and machine autonomous learning technology, specific procedures or actions can be completed to meet abnormal operational needs under special circumstances. Including but not limited to: "intelligent flight" based on 4D track, such as "automatic taxi/automatic takeoff/automatic interval management/automatic descent/autonomous route planning/wake prediction and active avoidance/automatic landing"; multi-channel interactive technology represented by touch control, voice control and gesture control; Knowledge-based system intelligent management, autonomous fault isolation and disposal technology under abnormal system conditions (Fig. 5).

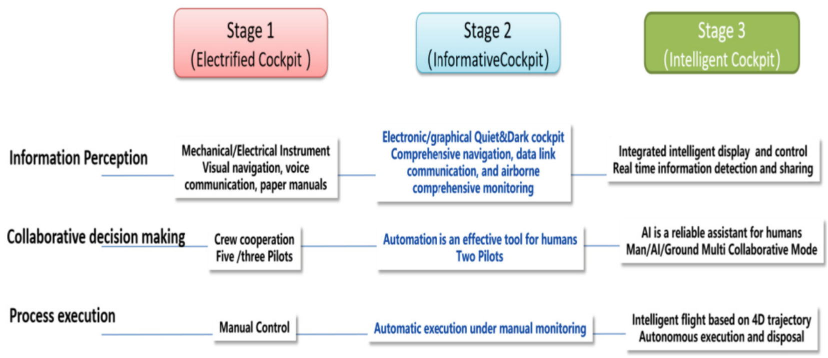

Fig. 5. Summary of Cockpit Development History

Through the above three aspects of research, ultimately, the intelligent cockpit can be upgraded synchronously with the future air traffic control, dispatch, maintenance, airport and other interactive subjects, and deeply integrated with the next generation of the entire civil aviation transport system, so that the elements of the system play their respective maximum efficiency, so that the cockpit's operational safety, human-computer interaction comfort, operational economy, etc. All of them have been greatly improved to achieve high-density, all-weather, single or even unmanned driving, and enhance the operational efficiency and benefits of the company, air traffic control, airport and other main bodies.

7 Apply Strategies and Recommendations

The Intelligent Flight Deck technology is a future project for domestic OEMs, It will take the subsystem or prototype as the carrier, and complete the laboratory test and typical real environment verification by setting the typical operating environment and working conditions. Some technologies can be combined with future test aircraft and real flights to test and improve the real operating environment.

In terms of strategy, it is suggested to start from two aspects of "difficulty": on the one hand, fully tap the potential of existing mature technologies and carry out creative applications (such as comprehensive utilization of GLS/SVS/EVS/laser radar/camera and other technologies to achieve automatic take-off and landing), in order to further improve flight safety and efficiency; On the other hand, we should make full use of new technologies such as artificial intelligence, large data analysis, high-bandwidth air-ground integrated communication, touch screen technology, machine vision technology, information detection and sharing technology based on data link communication to upgrade key systems intelligently in an all-round way and to drive, navigate, communicate and manage systems. To realize "intelligent flight" based on 4D track, such as "automatic taxiing/automatic takeoff/automatic interval management/automatic descent/autonomous route planning/wake prediction and active avoidance/automatic landing", as well as knowledge-based intelligent system management, so as to solve the difficulties and pain points in the current civil aviation operation mode with "intelligence".

The key technical points listed above can be carried out in parallel, and the overall research process can be divided into six steps:

a) **Intelligent Cockpit Requirements Capture and Validation**

Based on the current operation system, the advanced driving, navigation and communication functions that have been used in the most advanced aircraft or will be applied in the near future are studied. Including: intelligent braking mode BTV, anti-run-out protection, take-off safety monitoring, intelligent taxiing and airport ground guidance, automatic landing based on PBN or machine vision, intelligent display and control information push, intelligent monitoring status monitoring, etc.

To study the future development trend of civil aviation transportation system at home and abroad, such as the Single Sky Program in Europe, the NEXGen Program in the United States, Airbus DISCO (Single Pilot) and other market operation requirements expected by airlines.

Through investigation and research, combined with the adaptability and maturity of existing advanced technology and potential new technology, especially combined with artificial intelligence technology, big data technology and air-ground integration technology, the relevant technical characteristics of future intelligent cockpit are analyzed and demonstrated. Including but not limited to intelligent interaction technology, intelligent driving technology, intelligent navigation technology, intelligent communication and monitoring technology, and intelligent state management technology. Through the trade-off, the conclusive analysis and prediction are given.

b) **Research on Intelligent Driving Mode Technology**

According to the driving characteristics of intelligent cockpit, advanced control technology, navigation technology, automation function and auxiliary control technology of ground equipment are considered to determine the man-machine cooperative decision-making mode of supporting flight piloting under normal and abnormal flight conditions, to construct the normal and abnormal abilities and behaviors of pilots, and to support the health of pilots. Set up a driving mode oriented to the flight process and the pilot's ability.

c) **Research on Human-Machine Interaction Decision-Making Mode of Intelligent Cockpit**

According to the flight process status and intelligent driving characteristics (such as single-person SPO), the organization regulates the flight and non-standard flight conditions and flight process requirements, determines the man-machine function allocation, determines the normal and abnormal behavior and ability modes of pilots, and constructs the responsibilities and objectives of pilots, automatic systems and other roles (such as ground operators).The interactive decision models of knowledge and cognition, rules and logic, and events and conditions are established.

d) **Research on Intelligent Technology and Credibility Evaluation Technology of Pilot Interaction**

Establish the validity area analysis of driving knowledge, cognition and rules, logic coordination of intelligent cockpit (such as single-person system), construct the conformity analysis of flight process events and conditions with process and state coordination, determine the process of knowledge, rules, events and conditions coordination in decision-making process, and establish the driving mode ability of intelligent cockpit. And an interactive credibility evaluation index system is realize.

e) **Research on Safety Analysis Technology of Flight Process under Human-Aircraft Cooperative Decision-Making**

Based on the possible functions of intelligent cockpit, such as intelligent interaction, intelligent driving, intelligent navigation, intelligent communication and surveillance, and intelligent state management, and aiming at the safety problems caused by system environment perception deviation and pilot's situational awareness understanding error, the operation scenario of cockpit system is analyzed, and the failure modeling and analysis method of decision support function are studied. Construct the verification environment of the expected functional safety requirements to support the safety verification of the simulation system.

f) **Development and Test of Intelligent Cockpit Simulation System**

Build the intelligent cockpit simulation system and platform, and carry out the mission simulation of the whole flight process based on the engineering simulator. In the process, it is necessary to complete the corresponding layout of the intelligent cockpit, the preliminary design of the human-computer interface and operation procedures.

8 Conclusion

This article studies the application scenarios and development trends of future advanced technologies in intelligent cockpit, with the main focus on intelligent "information perception, collaborative decision-making, and processing execution". It analyzes the three development stages of civil aircraft cockpit, and combines current research on the development direction of future cockpit at home and abroad to explore artificial intelligence, big data, multi-channel interaction, machine vision/infrared detection The application prospects of cutting-edge technologies such as 5G/ATG/high-speed satellite communication/navigation technology in civil aircraft cockpit were analyzed to analyze the main directions of future intelligent cockpit design, and a preliminary roadmap for the development of domestic civil aircraft intelligent cockpit technology was formulated.

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