Study on Key Technologies of ARJ21 Aircraft Engineering Simulator

(ARJ21飞机工程模拟器关键技术研究)

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Abstract:

Development of flight simulator is a complex project. The simulators are usually divided into engineering simulators and training simulators by the function. The distinction between engineering simulators and training simulators, and the technology status and development trends of engineering simulators were analyzed. The key technologies of ARJ21 aircraft engineering simulator were emphasized, including general design, engineer's platform. It can analyze and solve the technical problem found after trial flight of aircraft; it can make pilot take part in aircraft design and development early. The successful development on ARJ 21 aircraft engineering simulator has laid solid foundation for follow-on large civilian aircraft engineering simulator development.

Key words: *engineering simulator; modeling; simulation; engineer's platform*.

Introduction:

The emergence of flight simulators has a long history in the aviation industry. It is an aviation subfield that develops almost simultaneously with the development of aircraft. Flight simulators are usually divided into flight training simulators and engineering simulators. The so-called engineering simulator is a simulation verification in the process of transforming the design concept into a system prototype based on the verification needs of the aircraft design. It can expose many problems before a prototype is produced. It is the intermediate process from wind tunnel to flight and is a process that must be carried out and cannot be jumped. Engineering simulation verification can improve the success rate of prototypes, reduce costs, and shorten the development cycle. The development of aircraft engineering simulators has become an indispensable tool for aircraft overall design units and system design units. The ARJ21 aircraft is a medium- and short-range turbofan regional aircraft with 70-90 seats. It adopts a double circular section fuselage with five seats in each row, a low single wing, a high horizontal tail, a three-point retractable landing gear in the front, and two tail-mounted engines. . The selected engine has the characteristics of low fuel consumption, low noise, high reliability and easy maintenance. The cockpit adopts a two-person system, the avionics system adopts bus technology, LCD flat panel display and is highly integrated, and the mechanical system adopts internationally mature advanced technology. In order to cooperate with the engineering research of the ARJ21 regional passenger aircraft and the training of pilots before the aircraft test flight, the development project of the ARJ21 aircraft engineering simulator was launched. The simulator can provide cockpit layout and ergonomics studies. Provide aircraft customers, test pilots, project directors, leaders at all levels, etc. with an environment to evaluate aircraft in the design process, and provide system designers with a physical environment for technical coordination; aircraft aerodynamic layout design and handling quality research; aircraft and engines Performance matching research; flight control system design and verification research; information cross-linking and comprehensive verification of avionics, instruments and other airborne equipment; early flight crew evaluation, customer use opinion collection and airworthiness authority review; preparation of flight operation procedures; flight crew and Ground maintenance personnel training; performance demonstration of aircraft and certain systems; reproduction, fault analysis and troubleshooting research of problems discovered during aircraft ground tests and test flights;

1 Overview of Engineering Simulator

The development of flight simulators is a complex project. The flight simulator is a typical human-in-the-loop simulation system. The training flight simulator can reproduce the aerial flight environment and is used to train pilots in takeoff, landing, climbing, turning, maneuvering, etc. It can also be used to evaluate aircraft flight performance, Analyze and study aircraft control quality and airborne system performance. Engineering flight simulator is an important tool for aircraft design and development. Engineering simulators need to provide a simple and reasonable human-machine interface and safe and effective test data recording functions during aircraft design, development and testing. Engineering flight simulators can detect problems early and reduce risks; conduct comprehensive verification of airborne systems to solve the dynamic matching relationship between systems; accelerate the system test process and shorten the development cycle; analyze and solve technical problems discovered after aircraft test flights; Encourage pilots to participate in the design and development of aircraft as early as possible.

Engineering flight simulators have developed along with the development of China's aviation industry, but the emergence of my country's engineering flight simulators was in the early 1990s. With the expansion of the concept of aircraft handling and stability quality design, the aircraft has transitioned from static stability design to relaxing static stability restrictions, and finally allows the aircraft to be longitudinally statically unstable. This change is a challenge to the design of aircraft control laws. Therefore, there must be a ground simulation environment. This environment includes accurate aerodynamic models and control laws that can withstand repeated verification, allowing engineers to work in this comprehensive simulation environment. , verify and modify the control model, modify the control model, and even modify the aircraft configuration to ensure that the designed aircraft is safe enough to fly and can meet the performance design requirements. Of course, such a comprehensive environment requires information feedback of sight, hearing, touch and movement. my country's first military aircraft engineering flight simulator was born under such demand. The configuration of this simulator fully reflects the similarities and differences between engineering flight simulators and training flight simulators. The similarity is that the establishment of the visual, auditory, tactile and dynamic environments is similar, but the indicators of the visual, auditory, tactile and dynamic simulation equipment are selected based on the budget. The most important difference is that the cockpit environment is not required to be realistic, but the software model of the engineering flight simulator that affects the performance and quality of the aircraft is pursued to be the most refined, comprehensive and accurate.

In recent years, my country's engineering flight simulators have developed rapidly, especially in terms of quantity. Almost all aircraft design units are using national technical transformation funds to develop engineering flight simulators. Not only the overall aircraft design unit needs engineering flight simulators, but also each aircraft system design unit. For example, in the absence of a ground engineering flight simulator for a mounted weapon designed by a weapons manufacturer, the performance and logic of the weapon and the mounted fire control system cannot be comprehensively verified. As a result, the real aircraft is regarded as a real aircraft. As a test platform, it not only causes expensive expenses caused by a large number of aircraft taking off and landing, but also increases many unsafe factors, causing dissatisfaction to aircraft manufacturers. In the past few years, weapons and fire control system design manufacturers have built engineering simulators for weapons and fire control systems for specific aircraft. Many problems have been solved in the environment of engineering flight simulators before going to space. All airborne equipment designers and manufacturers have similar needs. For another example, in the early years, Honeywell of the United States provided flight control systems for XAC’s MA-60 aircraft.

It is impossible to obtain the aircraft data package, and it is impossible to implement ground engineering simulation. The system can only be installed on the aircraft and tested while adjusting parameters. After hundreds of takeoffs and landings, the parameter adjustment work is completed. If there is a ground simulation environment, most of the work can be performed on the ground, which can greatly save money. The control law parameter adjustment work of the ARJ21 aircraft under development is carried out on an engineering flight simulator. It can be said that engineering flight simulators are indispensable equipment in the aircraft design process.

2 Analysis of key technologies of ARJ21 aircraft engineering simulator

The engineering simulation and implementation of the ARJ21 aircraft engineering simulator involves multiple majors and disciplines. The simulator structure builds a complete platform for the entire system, providing a reasonable and convenient installation environment and maintenance channels; the main control computer provides simulation software for each system of the simulator. Operating environment; the visual system provides simulator users with realistic geographical environment and scene environment information; the interface system collects cockpit instruments, control boxes, electrical switches, indicators and other signals, and converts them into digital information for the simulation software; sound system Digital simulation is used to simulate environmental sound and audio, warning and other effects in the aircraft; the control load system provides simulation of stick force, stick displacement and other effects of flight driving; the system console provides a convenient human-machine control interface for the entire simulator; engineers The platform provides aircraft designers with an open simulation software modeling and model verification platform; the power management system of the simulator provides stable power and power for each system of the simulator. From the specific projects of the ARJ21 aircraft engineering simulator and the current technology development situation, the key technologies of the ARJ21 aircraft engineering simulator project mainly include the following aspects:

- Overall design
- Design and implementation of engineer platform
- Selection and simulation implementation of control load system
- Modeling and simulation of each subsystem
- Establishment of model library/database
- Modeling and simulation support environment
- Network technology
- Visualization technology

This paper focuses on the overall design of the simulator and the design and implementation of the engineer level.

3 Overall design of ARJ21 aircraft engineering simulator

The overall design of the ARJ21 aircraft engineering simulator is based on engineering research requirements. In addition to satisfying engineering research, it also needs to provide a training environment for the pilots of the first flight of the ARJ21 aircraft. The hardware equipment configuration is basically the same as that of the flight training simulator. At the same time, the overall design fully takes into account the actual needs of future projects. An engineer platform is provided to facilitate the debugging of flight, power, flight control and other system engineers. At the same time, in order to meet the needs of equipment debugging, interface monitoring and debugging software was developed on the instructor's desk. In the design of the application software, the development idea of combining standard C language and MATLAB is adopted to facilitate the modification of the model. The appearance and internal layout of the ARJ21 aircraft engineering simulator are shown in Figure 1 and Figure 2:

Figure 1 Appearance of ARJ21 aircraft engineering simulator cabin

Figure 2 Inside the ARJ21 aircraft engineering simulator cabin

The ARJ21 aircraft engineering simulator has the following features:

- Cockpit layout and ergonomics research (including human-machine interface of communication, navigation, instrumentation, integrated avionics and other systems). Provide aircraft customers, test pilots, project directors, leaders at all levels, etc. with an environment to evaluate the aircraft in the design process, and provide system designers with a technically coordinated physical environment (including various conditions on the ground and in the air);
- Research on aircraft aerodynamic layout design and handling quality. (Study changes in performance quality caused by changes in aerodynamic layout or changes in center of gravity, weight, etc.);
- Research on aircraft and engine performance matching;
- Flight control system (including autopilot) design and verification research;
- Comprehensive verification of information cross-linking for avionics, instruments and other airborne equipment;
- Early flight crew assessment, solicitation of customer opinions and airworthiness authority review;
- Prepare flight operation procedures;
- Flight crew and ground maintenance personnel training;
- Performance demonstration of aircraft and certain systems;
- Reproduction, fault analysis and troubleshooting research of problems discovered during aircraft ground tests and test flights;

4 Design and implementation of engineer platform

With the widespread application of engineering simulators, more aircraft design engineers have begun to get involved in the use of engineering simulators, verifying data and models, and testing human sensing systems on engineering simulators. Since engineering simulators refer more to flight simulator solutions during the design and manufacturing process, they are lacking in meeting the needs of aircraft design engineers. For example, aircraft design engineers want to know more about the operation of the simulator. information, more convenient parameter modification, model verification, etc., it is necessary to configure a more convenient human-machine interface for the engineering simulator.

Prior to this, the use of engineering simulators often focused on the simulator itself, with program replacement, compilation, downloading, running and other steps to be repeatedly tested. At the same time, engineering and technical personnel were behind the pilots to observe parameters and communicate with the pilots. This method will interfere with the pilot's independent judgment and affect the flight effect. It will also cause the engineer's judgment of the aircraft status to be unrepeatable, greatly reducing the efficiency of the engineering simulator.

The engineer platform is a newly added environment when developing the ARJ21 aircraft engineering simulator. The simulators produced in the past were targeted at air crews and paid more attention to the operating logic and flight quality of the aircraft, as well as convenient maintenance and concise Equipment operation. However, during the development and production of the ARJ21 aircraft engineering simulator, it was faced with aircraft designers and test pilots. Due to the differences in objects, functions and usage conditions, the concept of an engineer platform was proposed during the design of the entire aircraft. The purpose was to To fully improve the efficiency of the simulator, the engineer platform has the following functions:

- Real-time monitoring and playback of engineering simulator;
- Non-real-time system engineering simulation test (establishment, modification and verification of aircraft system data and models);
- Provide aircraft performance and fidelity analysis environment;
- Provide an environment for aircraft customers and project managers to visit and provide guidance;
- Technical coordination platform for designers and engineers;

While the ARJ21 aircraft engineering simulator is running for testing, the simulator transmits performance parameters such as the flight system, power system, and flight control system to the engineer platform computer. The engineer uses simple vision and virtual instruments to view the status of the aircraft and monitor the performance curve at the same time. Evaluation and analysis of aircraft performance while modifying data, parameters and models. Through the compilation of the simulator host and the re-running of the simulator, the effect of the modification is verified and evaluated, and relevant data are collected in a sequential cycle to form the data package of the engineering simulator.

The engineer platform is equipped with 6 computers, each of which can be used as a development terminal to provide aircraft performance model correction and verification computers. The engineer platform includes: main control computer, flight software computer, power software computer, flight control software computer, virtual instrument computer, and backup computer.

The engineer platform computer loads the models and parameters of each subsystem, and the model parameters can be modified through an intuitive interface. At the same time, the change curve of the relevant parameters can be drawn. The modified model can be uploaded to the simulator host through Ethernet for closed-loop verification. In order to facilitate the subsequent testing work of aircraft design engineers, the modeling of each node adopts a modular and hierarchical approach to establish general and special models; at the same time, the model and data are separated to facilitate the modification and replacement of design data in the future.

The composition of the engineer network platform is shown in Figure 3, and the page diagram of the engineer platform is shown in Figure 4:

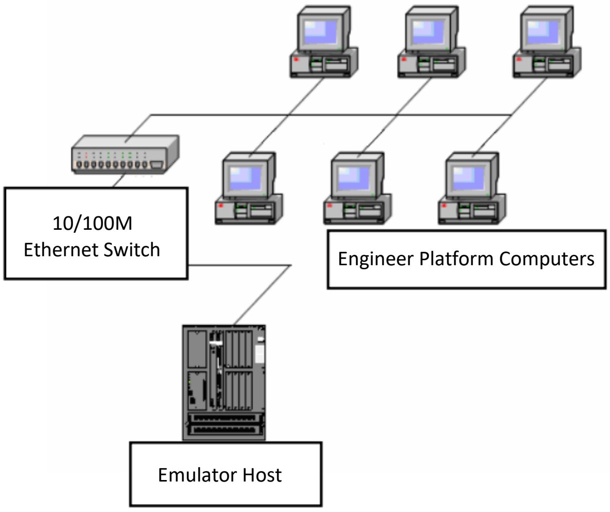

Figure 3 Schematic diagram of the engineer platform

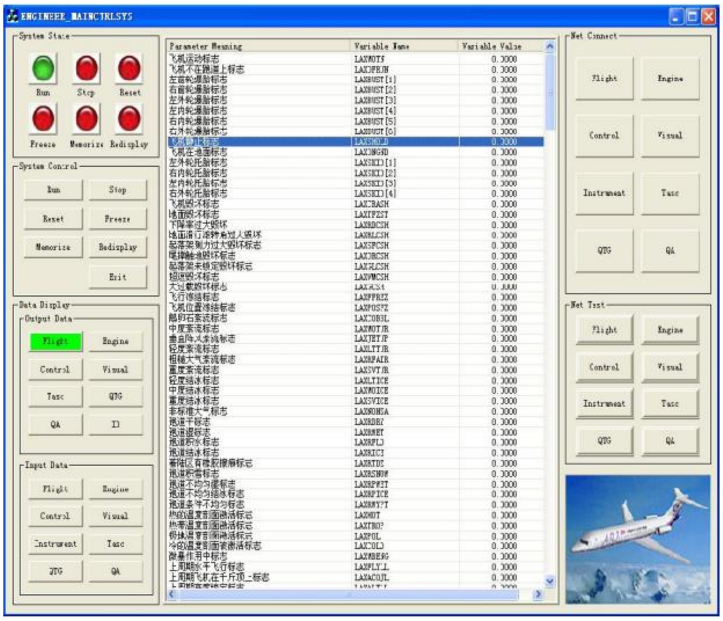

Figure 4 Engineer platform page diagram

5 Conclusion

As the role of simulators is increasingly recognized by relevant units, the requirements for simulator quality are also increasing. The previous simple aircraft driving mechanism can no longer meet the needs of flight training and engineering verification. Modular and hierarchical simulation requirements are the development direction of subsequent simulator simulation technology. At the same time, extensive research and international cooperation have also begun on the research and development and performance improvement of key simulator systems, with the aim of further reducing development risks, cycles and expenses. With the launch of my country's large aircraft development project, it will also drive technological progress and rapid development of engineering simulation.

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