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Civil Aircraft Maintenance Simulation Technology and Exploration of Application

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Abstract: The troubleshooting in aircraft maintenance engineering is an important activity. Accuracy and proficiency of troubleshooting directly affect flight safety and economic efficiency. Traditional training methods were in real aircrafts. They need large investment, while poor scalability and lead to largely restrict the level of education and training to aircraft maintenance personnel, and airlines need a lot of human resources and costs for this. This paper is on the really demand of simulation and training about modern aircraft fault troubleshooting, it studies main simulation technology about aircraft systems, virtual cockpit, virtual three-dimensional aircraft, and aircraft systems' schematic based on the person, the loop simulation models. It introduces the relevant technology and skills about repairing aircraft that the engineer acquires, and training costs that airliner reduces through example. There is important significance.

Introduction

With the development of computer science, computer-aided education CBE (Computer Based Education) has been widely used in pedagogy. It is a new cross-disciplinary, involving multiple disciplines of education, psychology, information, systems, computer science and mathematics.As CBE category, CBT teaching is a teaching method developed quickly in recent years, and it is widely used in courses teaching in aviation training department and aviation training institution, and it meets part of the demand about new advanced aircraft [1]. However, with the development of large commercial aircraft, many of the advanced technology used on these aircrafts in recent years, the traditional education CBE has been difficult to adapt to the training of aircraft maintenance technology, it must use more advanced aircraft technology and system simulation technology to train. Generally, main steps about aircraft maintenance simulation process include the following [2]: System analysis and description, establishment a mathematical models of system, the original data acquisition, establishment simulation model of the system , model verification and validation, design of experiments, the simulation operation study, simulation results analysis and modeling phase, total of 10 stages.

Therefore, aircraft systems simulation is not a simple process from the model to the calculation. In order to get an accurate simulation models or using simulation statistics and optimize system performance, we must go through in-depth study of the model, repeatedly revise and run it many times. In this paper, it will apply a preliminary analysis and exploration about the existing major aircraft maintenance simulation model, including its fundamental elements, advantages and process of the modeling.

Aircraft Maintenance Simulation Model

In engineering applications, depending on the features and implementation of simulation models, the simulation of aircraft maintenance model can be divided into 3 categories: Mathematical simulation, semi-actual substance simulation and simulation of man in the loop.

Mathematical simulation Model [3]. This simulation model is to establish the system model (including the mathematical model, the mathematical model or physical effects - physical effects model), and the process of testing on the model.

For the mathematical simulation models, it is to establish a system of mathematical models and tested on a computer. Thus, the three basic elements of mathematical simulation are: system, mathematical models and computer. They build relationships through the following three activities: a mathematical modeling (or mathematical modeling, a modeling), the establishment of simulation program (also known as simulation modeling, secondary modeling) and simulation testing. The relationship among them is shown in Figure 1.

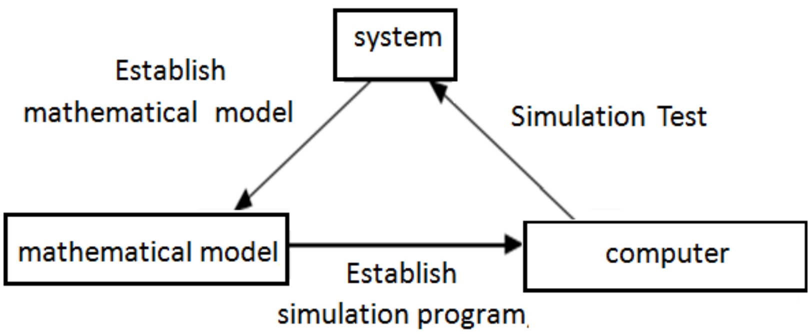

Fig 1. Relationship between the three elements of the mathematical simulation and three activities

Figure 1 shows that, in order to make the mathematical simulation models have satisfactory and credibility, it must be Verification, Validation and Accreditation (VV & A) during the primary and secondary modeling.That is VV & A to the mathematical model and simulation program. Thus, the credibility of the mathematical simulation model base on the credibility of the mathematical model and simulation program. The mathematical model represents the system characteristics in the form of the mathematical structure; it is the basis of mathematical simulation. It can reveal the performance of systems and operation of internal systems through the study of the mathematical model of the system. To ensure the credibility of the mathematical model, it must be Verification in the entire process of the primary modeling. The primary modeling process can be divided into five steps, namely: modeling preparation, model assumptions, model setting, the model solution and model Analysis. The process shown in Fig. 2.

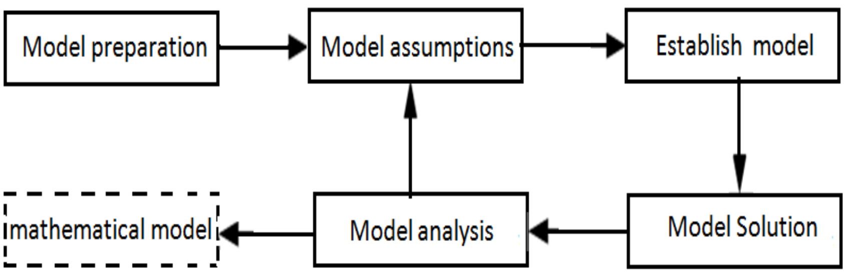

Fig. 2. A modeling process

After confirming credible mathematical model, the mathematical model can be converted into a simulation program, thereby it may perform solver or test on a computer. The mathematical model changes into the simulation program available, that secondary modeling includes the following three processes: Select the simulation algorithm, draw the block diagram and write program code.

Therefore, in order to obtain credible simulation program, it should be checked in the process of the secondary modeling, and the resulting simulation program should be verified.

The mathematical simulation is not an expensive system, and it need not simulate the real environment to generate various physical effect device, but a mathematical model re-evaluation of the characteristics of real-world things through computer programming test. Keyboard and other input devices can change the system parameters or system configuration. Outputs of simulation result can be displayed by a printer and /or plotter ,and stored on disk, shown in Fig. 3. The mathematical simulation should select the appropriate bits ,can be run in real time, in less time or overtime. The mathematical simulation is particularly suitable for research, program demonstration and design phases:

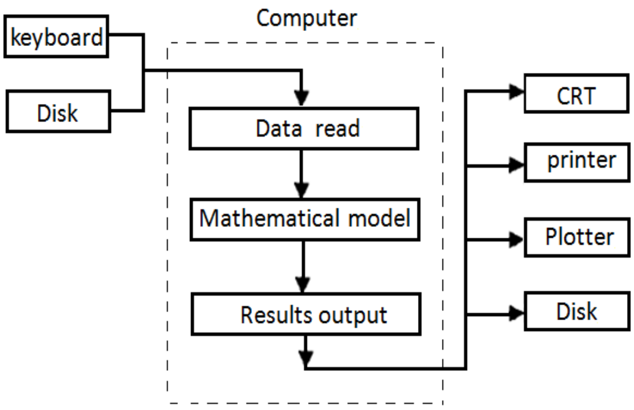

Fig. 3. The mathematical simulation

Semi-actual Substance Simulation [5]. The Semi actual substance Simulation also known as actual substance loop simulation. It connects parts of actual substance of the system (such as the control system, sensors, computer, and servo actuators) to the test loop. Dynamic characteristics of this simulation of object are on a computer running by mathematical modeling and programmed, but also requires a corresponding analog devices for generation various physical effects, as shown in Figure 4

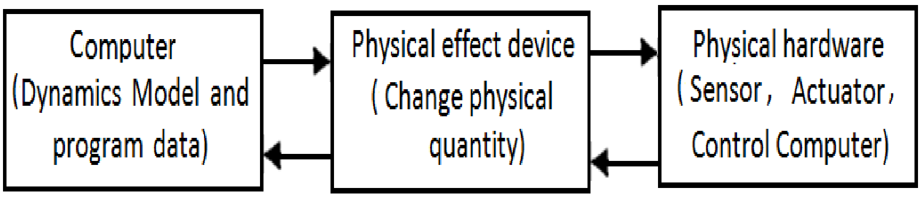

Fig. 4. The semi actual substance simulation

Compared with full mathematical simulation technology, it is a more realistic simulation technology [4]. This technique is basic on the study of the design on aircraft systems –document of Interface Control and requirement of the detailed design. It summarizes the aircraft system data structures and communication message format. and then it designs the simulation model database, attribute model and interface model as a basis, so that the simulated object is independent simulation platform ,and realizes the versatility of simulation equipment, and the simulation model is achieved by filling simulation database table, also makes the simulated device flexible;

In addition, We develop a fully functional general simulation software in Lab windows / CVI development environment based on simulation modeling analysis, and in accordance with the operational principle of aircraft systems and equipment requirements, and finally in the Visual C ++ environment, the software is optimized.

The computer provides hardware and software interfaces for data exchange between simulation devices and an external simulation. During the simulation, the simulation device is arranged to support the UDP protocol Winsock Control. It receives real-time flight data via Ethernet, these data are filled in data table in accordance with the requirements of network users, and processed. The results update the list of data elements, used by other devices in the system. These achieve dynamic simulation of the aircraft systems in ground simulation. Semi-actual substance Simulation technology will be applied to the design of simulation equipment. The hardware involved in the loop of simulation to ensure the real-time simulation, and simulation results make more real and effective.

At present, semi-actual substance Simulation equipment of aircraft systems has been handed over to the user, and played an important role in some aircraft system .While there are several drawbacks need further improvement about simulation equipment from the effects of the actual use. For example, the simulation interface of the display device is not intuitive: the simulation interface of the existing text should change into a graphical display; some form design is not perfect. It should design more a reasonable simulation database in accordance to the user demand base on more in-depth and detailed analysis.

Simulation of man in the loop. The simulation of man in the loop is a simulation which an operator manipulates in the loop. Dynamic characteristics of this simulation of objects run on a computer except the establishment of a mathematical model and programmed, also they require simulation of various physical effects devices about man feel environment, including: visual, tactile, dynamic simulation and other the physical environment that man can perceive .It is shown in Fig. 5. Since the operator is in the loop, simulation system about man in loop must be run in real time.

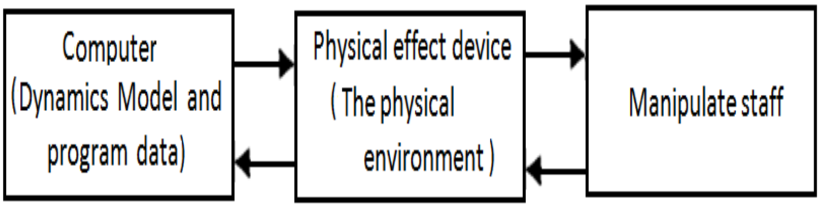

Fig. 5. Simulation of man in the loop

Therefore, maintenance simulation is modern aviation research, teaching, testing and other essential technologies. The researches in aircraft performance, aircraft maintenance training and other aspects have a high economic value. First, for the engineering and research, it gets the best results, and the analysis and evaluation of existing systems by optimization and adjustment of flight controls, Instrument display, and powerplant and systems parameters. The second, it is used for maintenance training without being affected by external environmental factors. The aircraft maintenance personnel familiars with maintenance technology about the new models of aircraft in a short period of time, thus saving real maintenance hours, with high security and less costs [6].

Examples of Applications Based on Simulation Model Simulation Aircraft Maintenance

VMT (Virtual Maintenance Technology). Construction of VMT simulation model based on aircraft maintenance and aircraft maintenance original data

This system can simulate faults and troubleshooting training about aircraft. It is suitable for classroom teaching. It typically includes a number of students' end and faculty end. The system is running on the respective server, equipped with a projector. It is constituted by a local area network, and data is exchanged by used TCP / IP communication protocol standards. The network structure shown in Figure 6.

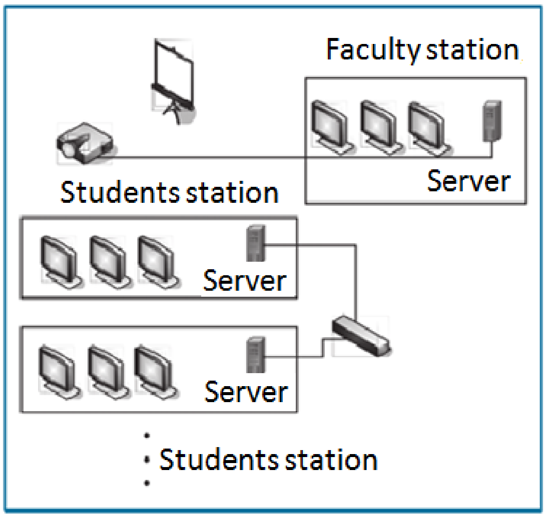

Fig. 6. The network structure of VMT

The VMT single device consists of a server and three monitors, namely to display the virtual aircraft, the virtual aircraft cockpit and teaching content. VMT is based three-dimensional digital model processing technology, aircraft system simulation technology, virtual reality and cartoon interactive technology. It achieves aircraft systems, virtual cockpit, virtual three-dimensional plane, aircraft manuals, and schematic modules. And meets the initial training and advanced aircraft maintenance training requirements for analog devices [7].

MTD system. The simulation system is developed based on platform of Visual C ++ 6.0 programming language. It achieves operating logic of each system according to the corresponding aircraft manuals and data. It simulates typical Operating Characteristics of aircraft systems by using of this kind of aircraft engineering data packet. The design of simulation starts from the top, it divides into normal logic simulation, fault logic and energizing check. It covers the system specifications section about type maintenance training involved on ATA100. The fuel system, for an example, is used illustrate logic and thinking about simulation systems. The simulation model about this system includes fuel indicating system and fuel distribution system. During operation of the engine or APU, fuel consumption is calculated, based on the actual amount of fuel consumption and distribution of fuel in the tank. The relationship between the input and output interface in this system is shown in Figure 7

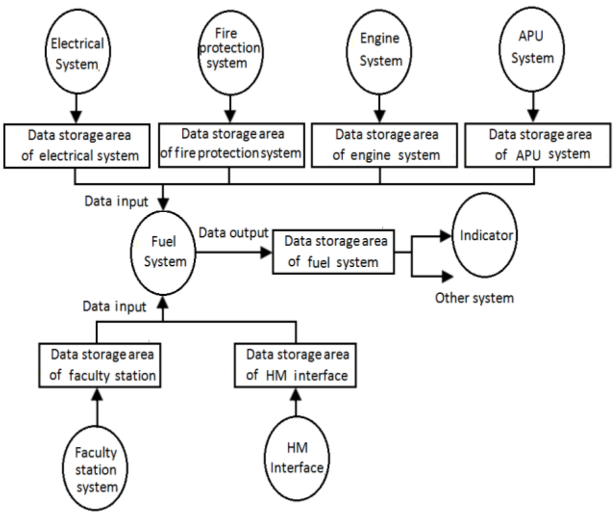

Fig. 7. Output interface of the simulation System

The processing logic within the system includes system initialization, fill and discharge system, the response of the input to control panel, and output data of other instrument parameters and lights. Each module operates in linear. The operation logic is shown as Figure 8.

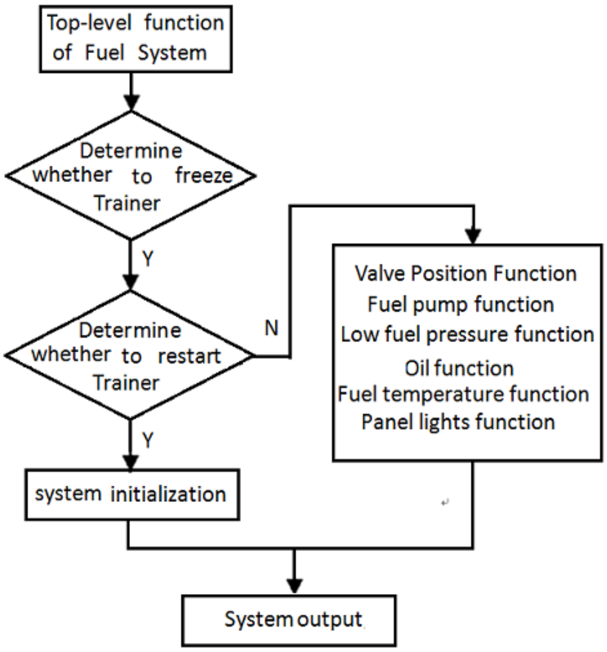

Fig. 8. Internal logic of simulation system

For example, the emergency electric fuel pump failure in the system failure, according to the "Aircraft maintenance manual" and "Schematic Handbook" ,The fault settings includes the cockpit control setting, the simulation system receiving the fault data , judgment and activation and failure in accordance with the fault number, the corresponding component failure, and simulation cockpit effects, including light and sound warnings[8], [9].

Maintenance Interactive Technology. MTD human-computer interaction is non-immersive virtual reality, the system simulates layout of the cockpit and three-dimensional aircraft. It simulates human maintenance behavior through mouse and keyboard in a real maintenance environment, and completes the maintenance process with the corresponding auxiliary service module [10].

Virtual Cockpit. The interface of virtual cockpit (VC) bases on Windows- operating system of a multiple document interface (MDI) style. The interface consists of a menu bar, a toolbar and a display window, shown in Figure 9.

Fig. 9. Virtual Cockpit

The menu bar provides trainers all menu commands, including aircraft setting, trainer initial settings, faulty equipment and view, selection and setting functions about ground service equipment. The toolbar provides selection of shortcuts about commands commonly used menu.

The display window simulates complete cockpit. It implements the zoom and pan shifting functions. Operations, indications and responds of a variety of instruments, control panels consistent with the actual aircraft. The design of cockpit interface basis on Microsoft Visual C ++ 2008 and carried GDI +. GDI + supports a variety of image formats, including JPG, GIF, and PNG choose transparent background images. They effectively solve flicker of the image in the cockpit interface during the image changing process. Meanwhile, the drawing object simply passes to the graphics object as a parameter. It greatly simplifies the development of the process [11].

Virtual Three-Dimensional Aircraft. The Virtual three-dimensional Aircraft (VA) achieves inspection around aircraft, close to the designated area, measurement and removement of parts, the operation program of human-computer interaction. It makes full use of the relations between CAD geometry about aircraft design and assembly relationships. The model needs to be converted according to assembly and disassembly in 3D MAX. While, the excessive streamline model interfaces will affect the visual effects, and too complex model will increase the consumption of the system, so the scene by several block will achieve optimal model interface. It divides the whole aircraft into external aircraft, cockpit, and cabin, rear cargo, engine nacelles, ground equipment and so on several modules, and it changes the current position around/in aircraft depends on the operator. It makes use of photo-textured about real aircraft to render map.The model imports CREATOR, and performs scenes, nodes, and interactive processing, and translation and rotation setting in accordance with the actual aircraft, shown in Figure 10.

Fig10. Simulation scenario

For man interaction in the scene of simulation in VEGA, it assumes that eyes' heights of the man is 150cm in the scene of simulation , the man move forward , backward, sideways pan and 360 ° rotating function. In order to ensure close virtual three-dimensional aircraft components consistent with the real aircraft, it uses the bounding box algorithm for collision detection, so that it avoids penetrating the aircraft components.

Examples of system simulation. For an example, the task No. 28-22-00-1 in "Fault Isolation Manual" shows virtual maintenance process. The aircraft parks on the ground, the cockpit power is on, and the emergency electric fuel pump switches on. The operator selects "Fault Settings" in the virtual cockpit in the menu − "Chapter 28 Fuel System" − "28-1 Emergency electric fuel pump failure", and then the fault is activated. When the engine is started, the left low-pressure fuel light is on in the cockpit. The operator selects "Manual" in the virtual cockpit menu - Fault Isolation Manual. He finds the task No.28-22-00-1, and maintenances aircraft process are as the following:

1) Disconnect the power: Disconnect breaker 201Q in VC;

2) Disconnect wires about the fuel left the emergency electric pump power: disconnect the wires among rib 8 ~ 8a, 1-3 stringers in VA;

3) Power: turn on the circuit breaker 201Q in VC;

4) Test wire: there is 27VDC voltage in VA;

5) Disconnect the power supply: disconnect circuit breaker 201Q in VC;

6) Part receiving: to get the part number NO. RLB-20D in the virtual Air Materiel library for centrifugal booster pump;

7) Replacement: Among the left outer wing ribs 8 ~ 8a, 1-3 stringers in VA, disassembling and assembling;

8) Power: Turn on the circuit breaker 201Q in VA;

9) Test: The fault disappears, and the system is normal;

10) Fill in TLB, the reason for the failure of emergency electric fuel pump is failure, and the troubleshooting completes [12].

Conclusions

Nowadays, the technology about aircraft maintenance and training on virtual simulation is not yet consummate; it is still in the exploratory stage. This paper studies the design and development of maintenance training methods and systems, and has made great progress .The virtual maintenance trainer meets requirements about theoretical training and some hands-on training, and it significantly savings training costs and improves the economic efficiency of training. Since the training equipment and training systems are closely integrated, they are fully adapted the current training system and method. At the same time, the trainer maybe some imperfect in some functions because of the different design of the aircraft itself, such as the central maintenance system function is strong enough and so on, it needs to be further research and improvement.

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