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Development of Jet Training FTD (Flight Training Device) Overhead System

Daeil Jo, Yongjin Kwon*

Department of Industrial Engineering, College of Engineering, Ajou University, Suwon, South Korea
Email: *yk73@ajou.ac.kr

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Abstract

Today, the growth of aerospace industry has led to the development of modular overhead systems that can be applied to a wide variety of aircraft. It actually maximizes training effectiveness by working in a similar way as to the real aircraft maneuverability. Overhead system control device for aircraft simulator is developed as a module and integrated to the flight simulator. The developed system can replace the similar products imported from overseas at a much lower price, about one third of the imports, while maintaining the same level of functionality and the performance with the counterparts. This price advantage is the main motivation of this development, which is expected to enlarge the commercial training simulator market in our country. This development has been also funded by the government, and we invited several commercial airline pilots to test the equipment. The post operation interview revealed that the developed system at least matches or exceeds the performance of the imported products. With the development completed, it is ready for the commercial production and will help promote the expansion of flight training education at various aerospace universities in Korea.

Keywords

Overhead System, Flight Simulator, Interface Board, FTD (Flight Training Device), Aircraft Panel

1. Introduction

The FTD or flight simulator is a flight training device that provides the situation that is very similar to the real environment. In large commercial grade aircraft simulators, such as Boeing 747, the overhead system is one of the main instrument panels, which controls many critical functions. It consists of a function of engine start-up, electricity, hydraulic, fuel, environmental control, oxygen, digestion, pressurization, ice removal, power, bleed air and lighting. From the aircraft start-up to engine stop, the overhead system plays a very important role in aircraft flight. Therefore, the pilots and the student pilots must use the system and become familiar with the various functional control of the panel. Because it controls so many functions of the aircraft, the panel consists of a wide variety of switches, indicator lights, and levers that are interconnected with the light bulbs and electrical boards through the electric wires. All those wires should be connected to and communicate with the simulator main computer that actually flies the simulated aircraft. Due to those complexities in technical issues as well as a small demand in flight simulator market in Korea, the overhead system panel has been imported from foreign countries and installed on the flight simulators that have been domestically manufactured and sold to various flight training agencies and aerospace universities. The typical price (the panel alone) ranges from 30,000 to 50,000 US dollars, while the domestically made Boeing 747 simulator costs around 500,000 US dollars. This is not quite affordable by many small universities. Due to this cost issues as well as the technical development need which is meant to promote domestic products, the development project has been initiated and eventually funded by the government. The project lasted about one year and the successfully developed overhead system has been installed on the Boeing 747 simulator.

Overhead system is typically very difficult to operate, and due to this reason, the training of student pilots using the real aircraft can involve a disastrous accident [1]. In addition, the training using the real aircraft brings so much and economic waste (such as fuel costs, maintenance costs, runway use costs, etc.) and its risks are very high. Therefore, the importance of simulators related to aircraft and simulation control devices are getting higher. We can save a significant portion of the cost and time according to the actual flight as flight training using the simulator. Also we can train to cope with the variety of emergency situations by constituting simulators to artificially being applied to the environment such as weather changes or sudden disorder of the flight devices [2]. Due to many benefits from using the flight simulators, the demand for such devices is expected to increase in the upcoming years from both commercial sectors and the education schools [3].

After the development, we have invited several commercial airline pilots and let them fly the simulator. The post operation interview revealed that the performance level at least matches or exceeds the imported products. With the development completed, it is ready for the commercial production and will help promote the expansion of flight training education at various aerospace universities in Korea. **Figure 1** show the various functions performed by the overhead system which show the importance of the panel in flight training activities.

2. Development of Software and Hardware

In case of hardware development, Boeing 737 overhead system was imported and its internal structures has been analyzed. The Boeing 737 overhead system

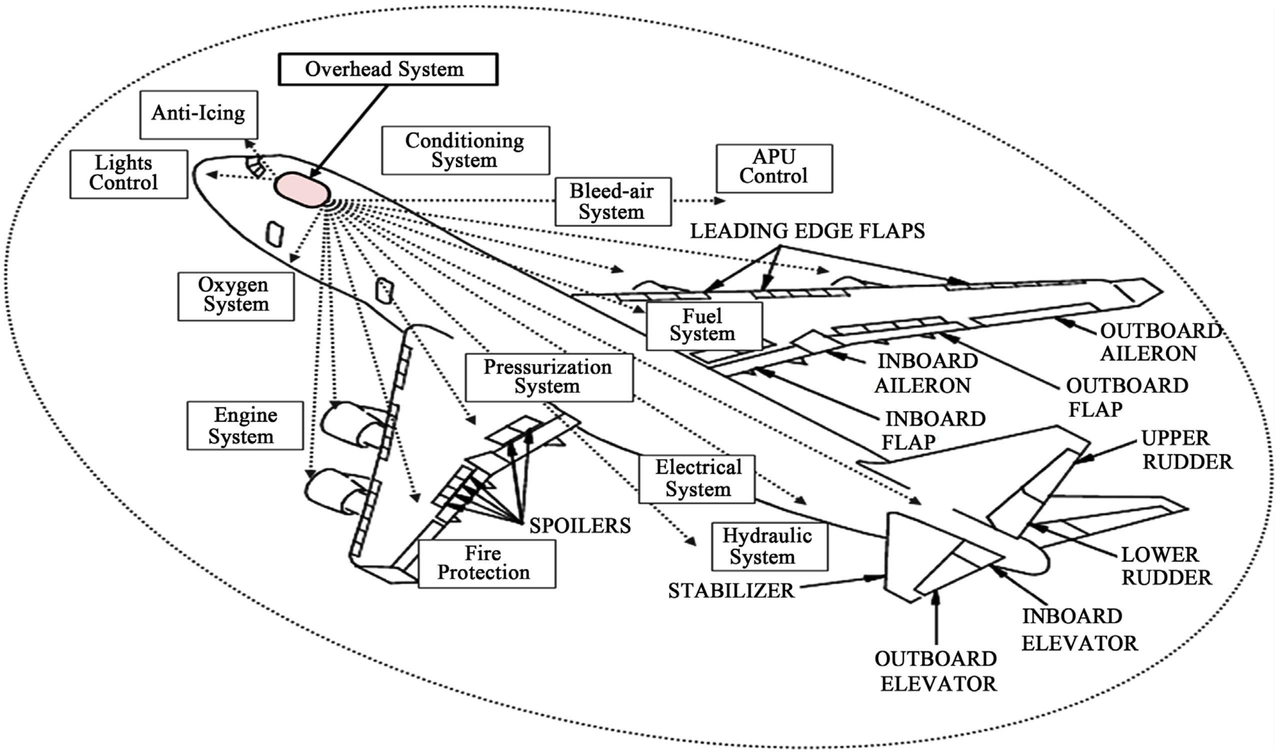

Figure 1. The function of overhead system that controls Boeing 747-400.

was analyzed because it is similar to the model of the product to be developed. Also developed products were designed and developed to maximize training effectiveness. We developed the system using our own domestic technology with the goal of the same level of functionality and performance with the imported products, while the price is about one third of the counterparts. By doing so, we can obtain a competitive advantage in both domestic and overseas markets. We build a system that integrates overhead panel and simulation control software. We also expect to increase exports by applying the overhead system technology to various other types of aircraft simulators. The aircraft simulator determines its function and performance depending on how efficiently it integrates the cutting edge technology that develops rapidly. Development and research of simulator technology that combines elements of electricity, electronics, machinery, and aviation together are expected to promote domestic technology. Figure 2 shows a conceptual diagram of the technology to be developed, and Figure 3 shows the development process of the main organization and participating companies.

2.1. Development Goals and Development Contents

Software development involves extracting flight data from flight simulation software such as Microsoft's Flight Simulator or Prepar 3D from Lockheed Martin, and communicating with hardware through data transmission/reception programs using programs such as FSUIPC, XSUIPC, SIMCONNECT, etc. This

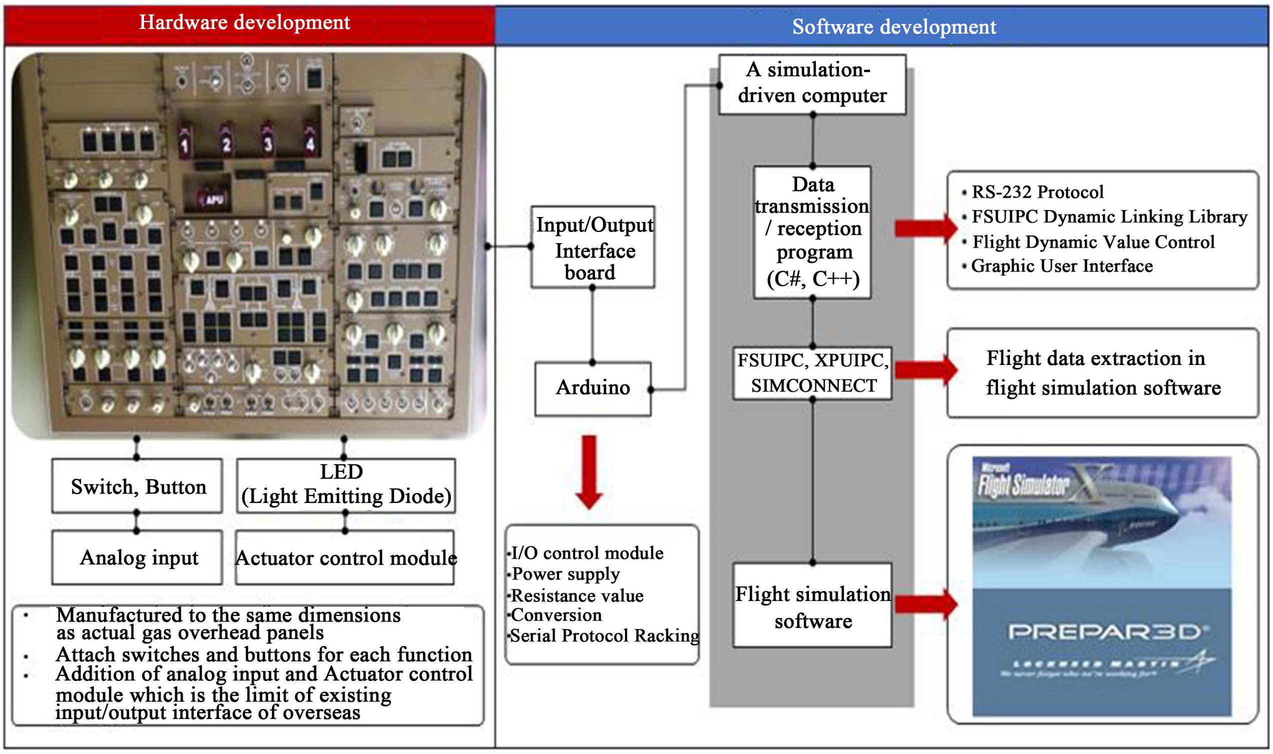

Figure 2. Development target technology concept map.

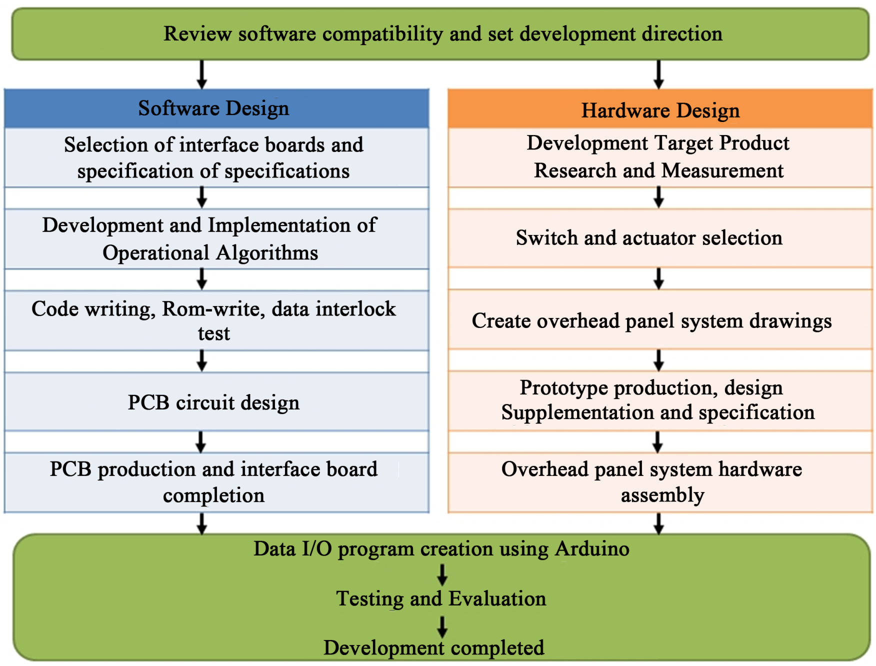

Figure 3. Development process of the project.

is a process of building a path. Each flight data have a categorized and unique data address as shown in Table 1.

The data transmission/reception program was developed by our team in C #. It can send and receive data of each function controlled by overhead system in

Table 1. FSUIPC data offset.

Offset	Size	Explanation
0BE8	4	Gear control: 0 = Up, 16383 = Down
0BEC	4	Gear position (nose): 0 = full up, 16383 = full down
0BF0	4	Gear position (right): 0 = full up, 16383 = full down
0BF4	4	Gear position (left): 0 = full up, 16383 = full down
0D0C	2	Lights (FS2k/CFS2), a switch for each one (bits from lo to hi): 0 Navigation/1 Beacon/2 Landing/3 Taxi/4 Strobes/ 5 Instruments/6 Recognition/7 Wing/8 Logo/9 Cabin

conjunction with flight simulation program through FSUIPC using the above program. Basic flight data can also be loaded. Developed Boeing 747 Overhead System utilizing SW and general purpose interface board.

2.2. Selection of Interface Board

The data communication protocol used in the development of this technology is serial port (RS-232), which is older than USB, but not restricted by the length of the connection line, cheap and the type of exchange information is irrelevant.

On the other hand, the universal interface board used in this technology development project is FDS-SYS1X and has 128 input and 256 output interfacing functions.

Each of the input switches and LEDs of the aircraft simulator operate as shown in Figure 4. After wiring the interface IT SYS card and I / O facilities, we write a code to associate input/output with each of SYS card using the functions of FSUIPC and Project Magenta [5].

2.3. Hardware Design

This is a part of Boeing 747 overhead system installation process. The structure has to be designed and the panel was matched according to the flight simulator internal layout. Overhead system location is measured using Boeing 747 FTD simulator, which is owned by Nuri Air Systems. Figure 5 shows the imported 747 overhead system does not fit with the simulator internal structure. We redesigned the work and created the design drawing, using the actual aircraft data, as in Figure 6 [6]. Figure 7 shows the completed overhead system pictures with all the switches, levers, and indicator lights working correctly.

Figure 8 and Figure 9 show the real-size Boeing 747 simulator made by Nuri Air Systems. The interior of the simulator exactly duplicates that of the real aircraft cockpit. We used the technical data of Boeing Company and every switch and button also replicate the real aircraft.

3. Integration of Hardware and Software

In order to connect the developed data interlocking software with the completed overhead system panel, it is necessary to perform wiring according to the code

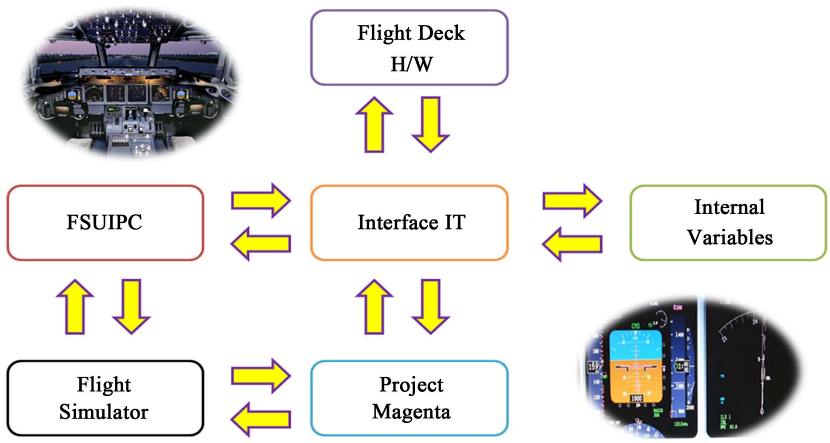

Figure 4. Interface system and structure of interface board.

Figure 5. 747 Overhead panel installtion process.

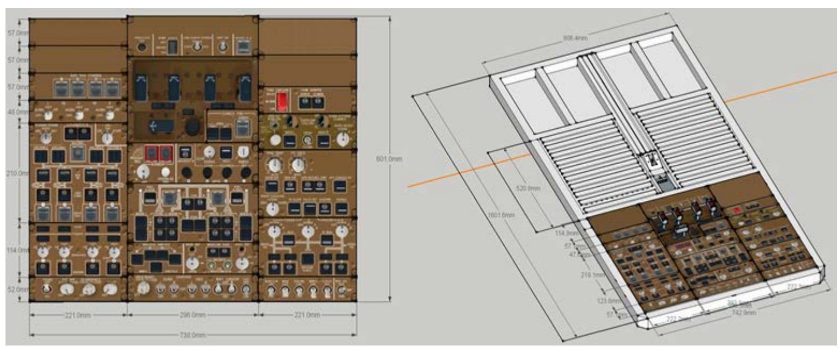

Figure 6. 747 Overhead system design drawings.

Figure 7. Completed work.

Figure 8. The exterior of the Nuri Air Systems Boeing 747 simulator.

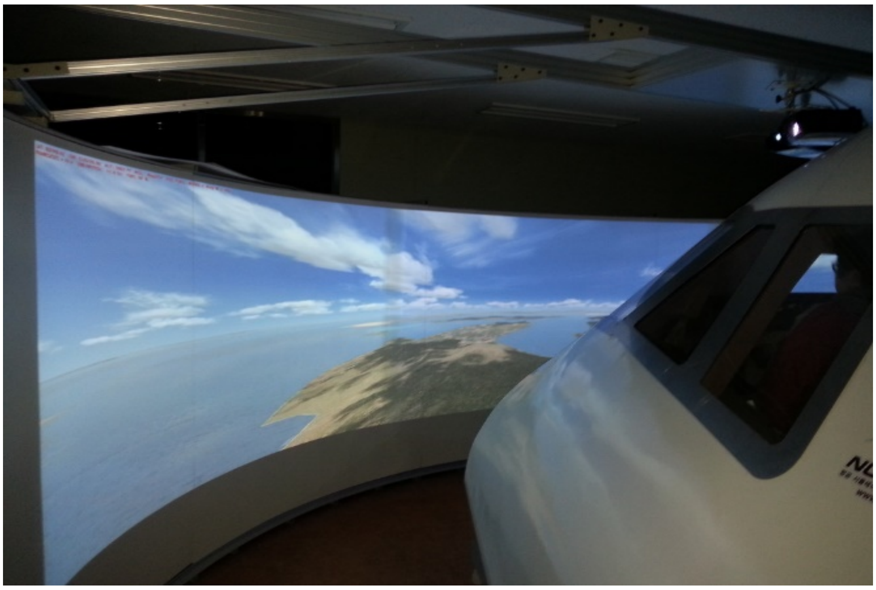

Figure 9. The completion of the Nuri Air Systems 747-400 flight simulator.

inserted in the interface board. The switch and the rotary knob correspond to the input part, so they are connected to the input part of the interface. The LEDs indicating the operation status of each function are connected to the output part, as shown in Figure 10.

Wiring work should be done by using common ground lead in the switch and LED wiring of SYS board. We connect LED toggle switch with FSUIPC's aircraft panel switch, as shown in Figure 11. It shows the wiring for each switch type, while Figure 12 shows the completed assembly that has been tested. Since all kinds of switches are used in this overhead system, we perform the wiring work

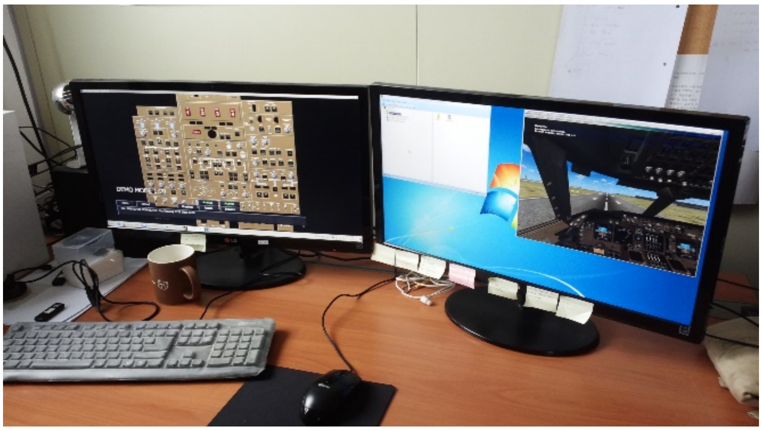

Figure 10. Verification of overhead system wiring and data interlocking.

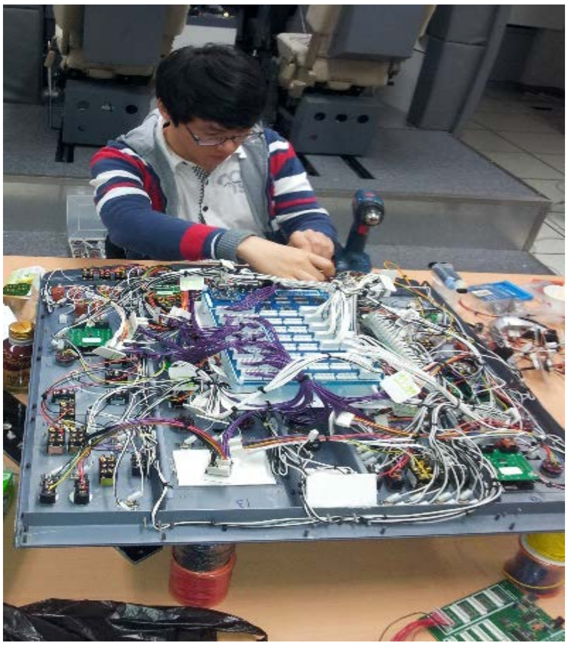

Figure 11. Wiring work.

Figure 12. The backside of the panel shows the completed wiring connections.

refer to the information from the actual aircraft data. The interface connector of each switch and the wiring of the LED output have been carefully constructed according to the design specifications. After checking the cathode and anode of the LED, we connected the 8 cathodes to the common GND and each anode to the pins of the interface board. We followed the procedure to finish the LED wiring and performed the correct operations according to the data interlocking.

4. Final Assembly and Integration

The completed overhead system is installed in the Boeing 747 simulator of participating company (Nuri Air Systems). We did final data interlocking test and operation test. We checked that all functions and found that the backlight functions are working normally. Figure 13 shows the completed assembly, which has been installed in the simulator cockpit.

The completed assembly has been evaluated in accordance with the National Transportation Test and Evaluation Standards [7] [8]. Table 2 shows the detailed evaluation table and the contents. The evaluation results shows the validity of the product.

Figure 14 shows the final installation of the overhead system inside the cockpit of the Boeing 747 simulator.

As shown in Figure 15 and Figure 16, we have invited several commercial airline pilots and let them test fly the Boeing 747 flight simulator, which has

Figure 13. The installed Boeing 747 overhead system.

Figure 14. Completed cockpit interior.

Figure 15. Preflight check of the completed Boeing 747 simulator.

Figure 16. Test flight of the simulator.

Table 2. Evaluation table.

Evaluation (Interlocking)	Unit	(%)	World-class (Italy/Cp flight)	Domestic	Target	Method	Figure	Results
Light control	OFFSET	10%	All functions Normal operation Data Linkage	C	A	Real time (±0.5 sec) Verifictation of Data	+0.2 sec	A
Oxygen System	OFFSET	10%	All functions Normal operation Data Linkage	C	A	Real time (±0.5 sec) Verifictation of Data	+0.1 sec	A
Air control system	OFFSET	10%	All functions Normal operation Data Linkage	C	A	Real time (±0.5 sec) Verifictation of Data	+0.2 sec	A
Electrical control	OFFSET	10%	All functions Normal operation Data Linkage	C	A	Real time (±0.5 sec) Verifictation of Data	+0.2 sec	A
Fuel control	OFFSET	10%	All functions Normal operation Data Linkage	D	A	Real time (±0.5 sec) Verifictation of Data	+0.1 sec	A
Hydraulic system	OFFSET	10%	All functions Normal operation Data Linkage	B	A	Real time (±0.5 sec) Verifictation of Data	+0.1 sec	A
Engine start control	OFFSET	10%	All functions Normal operation Data Linkage	C	A	Real time (±0.5 sec) Verifictation of Data	+0.1 sec	A
Indicator	OFFSET	10%	All functions Normal operation Data Linkage	C	A	Real time (±0.5 sec) Verifictation of Data	+0.1 sec	A
Dimention	mm	10%	-	B	A	(Tolerance ±0.5 mm) Verifictation of Data	±0.2 mm	A

*Evaluation Reference: Level & Target A (Excellent) > B (Good) > C (Fair) > D (Poor) > E (Unstable) > F (Fail). Method: The value (offset) Value between the switch and control board mounted on the overhead panel is connected to the data value (offset) value between S/W and H/W based on 747-400 FCOM (Flight Crew operation manual) and accuracy were evaluated. Signal interblocking time was measured with an interrogate tool.

been installed with the developed overhead system panel. After about one-hour of simulated flight from Seoul to Jeju Island, we asked the pilots about the overhead system [9] [10] [11], as to the: 1) how it feels when operate?; 2) how is the performance of the panel in comparison to the imported counterparts?; and 3) is everything functions normally and smoothly? According to our post-flight interview, the pilots answered that developed system feels and functions just as the same way as the imported products, and in some areas, such as reaction times, it even performs better than the imports [12] [13] [14] [15]. We have therefore concluded that the developed products can be safely installed and used for commercial pilots training purposes, which fits our initial goals.

5. Conclusion

We have domestically developed the flight simulator equipment, which was dependent on imports, through this industry-university cooperation technology development project. We anticipate that the price depreciation of related equipment will open up a new market and the export substitution effect will also occur. We will continue to supplement and revise to export to the world market. After companies and universities participate in technology development, their technology will improve as well as the improvement of personal expertise due to a significant increase in human resource education. It is anticipated to be a substitute for imports through this development project. It is a product that can completely replace imports in terms of product price and performance as to the simulator market.

Acknowledgements

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