6th International Ergonomics Conference
ERGONOMICS 2016 – Focus on Synergy
June 15-18, 2016
Zadar, Croatia

ERGONOMIC ASPECT OF LCD DISPLAY PANELS IN FLIGHT TRAINING DEVICES

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Abstract

Use of liquid crystal display (LCD) in flight training devices can reduce human error during flight simulations. Projected instruments can easily be changed and modified according to pilot needs thus improving human-machine interaction as well as reducing possibility of misreading and wrongly interpreting instrument indication. Also, usage of LCD display in flight training devices allows operator to modify the flight training device for multiple aircraft types and train pilots in situations without the need of major changes in device itself. By replacing mechanical instruments with the ones projected on background LCD display, it is possible to remove parallax error that can happen during mechanical instruments readout. In using LCD display it is required to understand technical and application background before its implementation. By understanding working environment and human-machine interaction it is possible to increase pilot flight accuracy.

Keywords*:* *Human error, human-machine interaction, Flight training device, LCD display*

1. INTRODUCTION

Ergonomics, as defined by the Board of Certification for Professional Ergonomists (BCPE), is a body of knowledge about human abilities, human limitations and human characteristics that are relevant to design. Ergonomic design is the application of this body of knowledge in conceiving tools, machines, systems, tasks, jobs, and environments for safe, comfortable and effective human use [1]. By improving human-machine interaction (hardware ergonomics) it is possible to reduce number of errors made because of misinterpretation in a flight training device, thus reducing stress and increase learning efficiency. The first step is to analyze the ergonomic aspects of LCD display panels in a flight training device.

Flight Training Device (commonly known as Flight Simulator) has a major role in pilot training process because it allows pilots to train difficult procedures that are either dangerous or too complex to be done on actual aircraft. First flight simulators were created in 1920s. According to Koonec and Brambel [2], they were essentially tethered airplanes without the engines. As technology developed, flight simulators started to get more advanced. First full motion simulators were developed before World War II. After the war, flight simulators were commercially used, but only by major training organizations because of its high price. With a rapid development of computer technology, the prices of flight simulators dropped significantly and, currently, most approved training organizations have at least fixed-base flight training device (Flight and Navigation Procedures Trainer - FNPT).

2. FLIGHT TRAINING DEVICES

Today most common aviation training devices used for initial training are Personal computer based aviation training devices and Flight and Navigation Procedures Trainers.

2.1. Personal computer based aviation training devices

Personal computer based aviation training devices (PCATDs), as defined by Reweti [3], are flight simulation devices that are based on desktop computer technology. Besides a personal computer (PC), the main components of PCATDs are software, flight controls and instrument display. The software, such as Flight Simulator or X-Plane, along with fast development of personal computer technology is most worthy for such rapid progress on PCATDs. Even though PCATD is fixed-base and doesn't have as good performance as traditional flight training devices, it still meets required fidelity to be certificated as approved flight training device to specific experience level. Advantage of PCATD over traditional flight training device is that it doesn't require switches for multiple mechanical instruments and its production and maintenance costs are considerably smaller. An example of PCATD is shown in Figure 1.

Figure 1. Example of PCATD [4]

2.2. Flight and Navigation Procedures Trainers

According to EASA [5] Flight and navigation procedures trainer (FNPT) means a training device which represents the flight deck/cockpit environment including the assemblage of equipment and computer programs necessary to represent an aircraft or class of airplane in flight operations to the extent that the systems appear to function as in the aircraft. It is in compliance with the minimum standards for a specific FNPT level of qualification. FNPT is fixed base system that is essentially designed to cross the gap in design complexity between the traditional subjectively created device and the objectively based full flight simulator. It is most commonly used flight simulation device in approved training organizations that educate student pilots. Figure 2. shows an example of FNPT.

Figure 2. Example of FNPT [6]

3. THE INDICATORS AND ERGONOMICS

First airplane indicators were mechanical devices that indicated aircraft parameters and attitude. Accordingly, the first flight simulating devices had mechanical instruments as well. Since approved training organizations that educate student pilots commonly use light aircraft equipped with mostly mechanical instruments, their flight training devices should also have similar instruments. Mechanical instruments for flight training devices are usually more complex than aircraft instruments because they need to convert PC-based electrical information to mechanical dial movements. Moreover, they are commonly customized, which makes them expensive both in purchasing and maintenance. Most contemporary flight training devices have replaced mechanical instruments with Flat Panel Displays (while LCDs – Liquid Crystal Displays being the most common ones) that project desired instrument panel layout.
The advantage of LCD displays over mechanical instruments is the versatility: they can project different instruments and different instrument layouts. That allows pilots to train for multiple aircraft types on a single flight training device.
Another advantage is the lack of parallax error, which causes instrument misreading in off-axis view. In mechanical indicators dial is not at the same plane as the scale due to mechanical constraints, so pilot can misread the indicated value if observing the instrument from incorrect angle of view.

3.1. LCD requirements

Jukes [7] states that the human eye has certain limits so technology needs to be adopted to those restrictions. Following limits of human eye are of the most influence to display performance: the resolution, display scan time and symbol size, shape and color.
The resolution of human eye is typically 1 minute of arc, which means that humans can make difference between two different objects that are divided by less than 1 minute of arc. For LCD display that means that it should have the resolution of around 100 pixels per centimeter if viewed from distance of 54 centimeters. Jukes [7] states that even though 100 pixels per centimeter is maximum resolution of human eye, studies have shown that in flight environments half of that resolution is sufficient.
Typical time for the human eye to fix on an object is 0.3 s. With roughly 20 instruments to scan, it would take 6 seconds just to fix once on every instrument. Therefore, every vital information regarding aircraft should be intuitive and attention-grabbing.
For a common display, an object needs to subtend at least 12 minutes of arc, while for an aircraft environment it is recommended that the object subtend at least 20 minutes of arc [7]. Information is classified by importance: the information of the highest importance will be shown with the largest font and the rest will decline follow accordingly.
The shapes and symbol colors are standardized and each system should match those standards.
Since most of indicators are made for view distance of 54 centimeters, any increase in distance from display will degrade instrument readability and it should be highly avoided.

3.2. Ergonomics

Most common types of indicators used in cockpit are quantitative indicators. As defined by Hendrick [8], quantitative displays are used to give the status of the system with precision. Quantitative displays may be either analog, such as aircraft airspeed indicator, or digital, such as Distance Measuring Equipment (DME) indicator. Quantitative analog indicators are made in two most common designs: round dial instruments and Head Down Displays (HDDs). Practically all mechanical aircraft instruments are round dial instruments. These instruments were commonly monochrome (black background with white dials and scale) and it was easy to misinterpret the readout. Newer versions of particularly essential instruments have multiple colors and vital information is easy to get.
With implementation of Flat Panel Displays in aircraft (and flight simulators), developers started combining multiple instruments on one display. The final result of that is the concept known as Glass Cockpit (shown in Figure 3) which integrates several instruments and indicators on one display. The concept simplifies aircraft operation and navigation and allows pilots to focus on the most pertinent information.

Figure 3. Example of glass cockpit [9]

4. CONCLUSION

With familiarizing with working environment and making it more user-friendly, human error can be reduced to minimum. By using LCD displays in flight simulators, human-machine interaction becomes improved and pilots are expected to make fewer instrument misreading. That could also reduce stress level enabling more focused completing of upcoming tasks. Possible future research would be real-time tests with human-in-the-loop on flight training device with various display setups.

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