Abstract: This paper presents a model for an ergonomic design of an aircraft cockpit with the specification and verification with respect to the new European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA) requirements. The goal is to expressing the concepts on which the aircraft cockpit design is based.

Key words: ergonomic concept, human factors.

1. INTRODUCTION

Aircraft cockpit is the area where an aircraft pilot controls the airplane. Usually this area is located in front of the plane. From the cockpit, the aircraft is controlled on the ground and in the air. Most modern cockpits are enclosed, except on some small aircraft, and cockpits on large airplanes that are physically separated from the cabin. Term cockpit appeared for the first time in 1914. The cockpit of an aircraft contains flight instruments on an instrument panel, and the control, which enable the pilot to fly the aircraft. In nowadays the airlines cockpit are reinforced against bullets, and are fortified against access of hijackers.

2. GENERAL TERMS AND DEFINITIONS

Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

Designing often necessitates considering the aesthetic, functional, economic and sociopolitical dimensions of both the design object and design process. It may involve considerable research, thought, modeling, interactive adjustment, and re-design. Meanwhile, diverse kinds of objects may be designed, including clothing, graphical user interfaces, skyscrapers, corporate identities, business processes and even methods of designing.

In engineering, design is a component of the engineering process. Many overlapping methods and processes can be seen when comparing Product design, Industrial design and Engineering.

Ergonomics is employed to fulfill the two goals of health and productivity. It is relevant in the design of such things as safe furniture and easy-to-use interfaces to machines. Proper ergonomic design is necessary to prevent repetitive strain injuries, which can develop over time and can lead to long-term disability.

Ergonomics is concerned with the ‘fit’ between people and their technological tools and environments. It takes account of the user's capabilities and limitations in seeking to ensure that tasks, equipment, information and the environment suit each user.

According to the International Ergonomics Association:

- Physical ergonomics: is concerned with human anatomical, and some of the anthropometric, physiological and bio mechanical characteristics as they relate to physical activity;
- Cognitive ergonomics: is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system and Human-Computer Interaction design;
- Organizational ergonomics: is concerned with the optimization of socio technical systems, including their organizational structures, policies, and processes. Relevant topics include communication, crew resource management, work design, design of working times, teamwork, participatory design quality management.

Outside of the discipline itself, the term ‘ergonomics’ is generally used to refer to physical ergonomics as it relates to the workplace (as in for example ergonomic chairs and keyboards).

Ergonomics in the workplace has to do largely with the safety of employees, both long and short-term.

Workplaces may either take the reactive or proactive approach when applying ergonomics practices.

Reactive ergonomics is when something needs to be fixed, and corrective action is taken. Proactive ergonomics is the process of seeking areas that could be
improved and fixing the issues before they become a large problem.

Problems may be fixed through equipment design, task design, or environmental design. Equipment design changes the actual, physical devices used by people. Task design changes what people do with the equipment. Environmental design changes the environment in which people work, but not the physical equipment they use.

2.1. Fields of Ergonomics

*Engineering psychology* is an interdisciplinary part of ergonomics and studies the relationships of people to machines, with the intent of improving such relationships. This may involve redesigning equipment, changing the way people use machines, or changing the location in which the work takes place. Often, the work of an engineering psychologist is described as making the relationship more "user-friendly."

Engineering psychology is an applied field of psychology concerned with psychological factors in the design and use of equipment. Human factors are broader than engineering psychology, which is focused specifically on designing systems that accommodate the information-processing capabilities of the brain.

*Macro ergonomics* is an approach to ergonomics that emphasizes a broad system view of design, examining organizational environments, culture, history, and work goals. It deals with the physical design of tools and the environment. It is the study of the society/technology interface and their consequences for relationships, processes, and institutions. It also deals with the optimization of the designs of organizational and work systems through the consideration of personnel, technological, and environmental variables and their interactions.

3. ERGONOMIC COCKPIT DESIGN

The first airplane with an enclosed cabin appeared in 1913 on Igor Sikorsky's airplane The Grand. However, during the 1920s there were many passenger aircraft in which the crew was open to the air while the passengers sat in a cabin. Military biplanes and the first single-engines fighters and attack aircraft also had open cockpits into the Second World War. Early airplanes with closed cockpits were the 1924 Fokker tri-motor, the 1926 Ford Tri-Motor, the 1927 Lockheed Vega, the Spirit of St. Louis, the 1931 Taylor Cub, German Junkers used as military transports, and the passenger aircraft manufactured by the Douglas and Boeing companies during the mid-1930s. Open-cockpit airplanes were almost extinct by the mid-1950s, with the exception of training planes and crop-dusters.

In most cockpits the pilot's control column or joystick is located centrally (centre stick), although in some military fast jets and in some commercial airliners the pilot uses a side-stick (usually located on the outboard side and/or at the left).

Cockpit windows may be equipped with a sun shield. Most cockpits have windows which can be opened when the aircraft is on the ground. Nearly all glass windows in large aircraft have an Anti-reflective coating, and an internal heating element to melt ice. Smaller aircraft may be equipped with a transparent aircraft canopy.

The layout of the cockpit, especially in the military fast jet, has undergone standardization, both within and between aircraft different manufacturers and even different nations. One of the most important developments was the “Basic Six” pattern, later the “Basic T”, developed from 1937 onwards by the Royal Air Force, designed to optimize pilot instrument scanning.
Ergonomics and human factors concerns are important in the design of modern cockpits. The layout and function of cockpit displays controls are designed to increase pilot situation awareness without causing information overload. In the past, many cockpits, especially in fighter aircraft, limited the size of the pilots that could fit into them. Now, cockpits are being designed to accommodate from the 1st percentile female physical size and the 99th percentile male size.

In the design of the cockpit in a military fast jet, the traditional “knobs and dials” associated with the cockpit are mainly absent. Instrument panels are now almost wholly replaced by electronic displays which are themselves often re-configurable to save space. While some hard-wired dedicated switches must still be used for reasons of integrity and safety, many traditional controls are replaced by multi-function re-configurable controls or so-called “soft keys”. Controls are incorporated onto the stick and throttle to enable the pilot to maintain a head-up and eyes-out position – the so-called Hands on Throttle and Stick or HOTAS concept.

The layout of control panels in modern airliners has become largely unified across the industry. The majority of the systems-related controls (such as electrical, fuel, hydraulics and pressurization) for example, are usually located in the ceiling on an overhead panel. Radios are generally placed on a panel between the pilot's seats known as the pedestal. Automatic flight controls such as the autopilot are usually placed just below the windscreen and above the main instrument panel on the glare shield.

Most modern cockpit will also include some kind of integrated warning system.

The best way to reduce pressure in the back is to be in a standing position. However, there are times when you need to sit. When sitting, the main part of the body weight is transferred to the seat. Some weight is also transferred to the floor, back rest, and armrests. Where the weight is transferred is the key to a good seat design. When the proper areas are not supported, sitting in a seat all day can put unwanted pressure on the back causing pain. The seat must be adjustable, because the pilot has to have the best position to look at the instrument panel and also outside on the window. The see should not be blocked. In addition, the seat must be very comfortable, because some pilots must sit many hours.

4. FLIGHT INSTRUMENTS

Flight instruments are cockpit instruments of an aircraft that provide information for the pilot, such as height, speed and attitude. The flight instruments are particular use for instrumental flights, but they are also used for information in visual flights. In a less prominent part of the cockpit, in case of failure of the other instruments, there will be a set of back-up instruments, showing basic flight information such as Speed, Altitude, Heading, and aircraft attitude.

Aircraft design has adopted fully digital “glass cockpit.” In such designs, instruments and gauges, including navigational map displays. Specific Boolean operations are required if ideal or non-ideal features are to be obtained.

<table>
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<th>Table 1. Indicators</th>
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<tr>
<td><strong>1. Airspeed indicator</strong></td>
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<td>The altimeter shows the aircraft's altitude above sea-level by measuring the difference between the pressure in a stack of aneroid capsules inside the altimeter and the atmospheric pressure obtained through the static system.</td>
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<tr>
<td><strong>2. Attitude indicator</strong></td>
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<tr>
<td>The attitude indicator shows the aircraft's attitude relative to the horizon. From this the pilot can tell whether the wings are level and if the aircraft nose is pointing above or below the horizon.</td>
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<tr>
<td><strong>3. Altimeter</strong></td>
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<tr>
<td>The airspeed indicator shows the aircraft's speed relative to the surrounding air. It works by measuring the ram-air pressure in the aircraft's pilot tube.</td>
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### Table 1. Indicators (continuance)

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<tr>
<td>4</td>
<td><strong>Heading indicator</strong>&lt;br&gt;The heading indicator displays the aircraft’s heading with respect to geographical north.</td>
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<tr>
<td>5</td>
<td><strong>Turn indicator</strong>&lt;br&gt;The turn indicator displays direction of turn and rate of turn. Internally mounted inclinometer displays ‘quality’ of turn, i.e. whether the turn is correctly coordinated, as opposed to an uncoordinated turn, wherein the aircraft would be in either a slip or a skid.</td>
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<td>6</td>
<td><strong>Vertical speed indicator</strong>&lt;br&gt;The VSI senses changing air pressure, and displays that information to the pilot as a rate of climb or descent in feet per minute, meters per second or knots.</td>
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<td>7</td>
<td><strong>Magnetic compass</strong>&lt;br&gt;The compass shows the aircraft’s heading relative to magnetic north. While reliable in steady level flight it can give confusing indications when turning, climbing, descending, or accelerating due to the inclination of the Earth’s magnetic field.</td>
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<tr>
<td>8</td>
<td><strong>Course deviation indicator</strong>&lt;br&gt;The CDI is an avionics instrument used in aircraft navigation to determine an aircraft's lateral position in relation to a track, which can be provided by a VOR or an Instrument Landing System.</td>
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<tr>
<td>9</td>
<td><strong>Radio magnetic indicator</strong>&lt;br&gt;An RMI is generally coupled to an automatic direction finder which provides bearing for a tuned Non-directional beacon.</td>
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</table>

A glass cockpit is an aircraft cockpit that features electronic (digital) instrument displays, typically large LCD screens, as opposed to the traditional style of analog dials and gauges. Where a traditional cockpit relies on numerous mechanical gauges to display information, a glass cockpit uses several displays driven by flight management systems that can be adjusted to display flight information as needed. This simplifies aircraft operation and navigation and allows pilots to focus only on the most pertinent information. As aircraft displays have modernized, the sensors that feed them have modernized as well. Traditional gyroscopic flight instruments have been replaced by electronic Attitude and Heading Reference Systems and Air Data Computers.

### 5. CONCLUSION

The future aircrafts cockpit design will have glass cockpit and they will be more ergonomic than today design. They will also have better visibility, inside and outside, and they will be more comfortable.

![Fig. 9 Sketch of a cockpit.](image)

![Fig. 10 Design of a cabin.](image)

### 6. REFERENCES


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