Ergonomics in Design, Vol. 129, 2024, 173–181
https://doi.org/10.54941/ahfe1004822

Five Senses: Integrated Ergonomics/Stylistic Design for Aircraft Interiors

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ABSTRACT

In the reference scenario related to the design development of aircraft interiors defined with the use of new digital technologies, the research activity intended for the application of an innovative operational methodology is direct, functional to achieve the best aesthetic/functional configuration of the final product. Specifically through the application of the methodological and operational action described below, it has been possible to define the development of furnishing complements for the ergonomics and style of seats and PIS (personal Information System) for tourist class of aircraft with low-range mission profiles. The core of the project focused on the "collaborative" use of the Sw (Ergonomic Simulator) tool, characterizing it not only in the context of ergonomic verification of the designed elements, but especially as a tool for functional aesthetic co-design. In this specific case, the application involved the interior furniture with the passenger seats and the upper information panel. The definition and identification of stylistic features and systematization of ergonomic design requirements, was elaborated through a process of integration of factors that converge "synergistically" in "human centered" design. Specifically, the structuring basis necessary to set up the ergonomic design, where the preliminary design was obtained, with the first technical development of the concept and where the first dimensional, technical, functional and material constraints are placed on the design, optimized for maximum stylistic performance of the interior.

Keywords: Virtual ergonomics, Aeronautical design, Human variability modelling, 3D CAS/CAD modelling

INTRODUCTION

In the reference scenario for the design development of aircraft interiors defined with the use of new digital technologies, a functional research and development activity is related to the application of an innovative operational methodology aimed at achieving the best aesthetic/functional configuration of the final product. In the specific case, it was possible to define an innovative application methodological process carried out through the collaborative use of CAS stylistic design modeling software, those of virtual CAD engineering, and those of ergonomic design in a virtual environment. In the specific case, this process was elaborated through a synergistic and equal action of the sw/hw tools functional to achieve the research objectives intended for

a subsequent phase of physical production of finished products. The Scope of Intervention will be developed in order to research innovative and novel solutions for the efficient production of innovative and high-end furniture products (customized aircraft interiors), through the application of new and better performing innovative technologies for production systems with reference to additive manufacturing, industrial design and virtual engineering. The objective of this proposal will be to realize stylistically advanced production, for the "smart factory," creating a set of production systems adapted to current needs, making the best use of available SW and HD resources, simulating new production cycles through the aid of immersive-type virtual reality. The expected results will not only be stylistic and ergonomic but also of technological and applicative derivation, in fact they will be based on the optimization of the aeronautical process/product also during the design/production cycle but especially of the subsequent disposal. Therefore, the most important evaluations and considerations will be analyzed from the moment of product conception. Starting from the concept that "the intelligence of the industrial process/product" is oriented in the ability to interpret what happens around it, and consequently adjusts its behaviors, it will be possible to introduce "new internal concepts" through methodological approaches structured by the coordination of the various production phases, converging in a more overall logic of control of the entire process. Ergonomic design in the virtual environment has defined and structured an innovative operational methodological protocol that provides in the synergy and equal action of CAS/CAD modeling and ergonomics software a perfect functional interaction for project development. In this direction and considering the desirable future interaction between designers, builders and operators of the aircraft, the activity described below required a challenging and careful methodological approach, which was elaborated by focusing on problems and situations with increasing attention especially to the ergonomic aspect, related to the usability and accessibility of the interior of the "Five Senses" project. The methodology used was set on the comprehensive and broader management of anthropometric issues; in fact, the extreme percentiles of the air transport user population were considered, for all types of passengers. Indeed, the increasing presence of women with various limitations of height, weight, and physical strength has defined a more open approach to the design of seats and their interaction controls. The definition of seats and PIS panels defined the dimensional environment through optimizing the interactions between the human body and everything around it, acting as an interface. It means verifying and ensuring the physical spaces required for the movements of different passengers of aircraft interiors (using anthropometric data), evaluating the forces (actions and reactions) exerted on the body and psyche (under normal or higher stress conditions), taking into account the posture of the body during different hours of travel, in order to assess the stresses to which the limbs are subjected (bones, muscles, ligaments, etc.). An additional benefit will be obtained by evaluating the elements (PIS panel - Personal Infor-mation System). From an ergonomic point of view, studies for efficient seating arrangements in the passenger area, located in most aircraft, deserve further investigation in order to make positive contributions to active safety,

which is significantly affected by improved comfort and an arrangement that can reduce the possibility of false movements. Several fields of interest and study have been applied to this research, including:

- seats (comfort, adjustability, breathability characteristics, etc.);
- PIS panels (tilt, position relative to the passenger, etc.);
- PIS dashboard elements, making it easier to read the picture of indicators in it;
- noise and vibration levels to which passengers are subjected.

THE DESIGN METHODOLOGY

The objective of the project proposal "Five Senses" combines the operational path with the study and analysis of the state of the art design methodology currently used by aircraft interior manufacturers, to achieve the highest standards, with a specialized approach developed in multidisciplinary areas. The synthesis of "Five Senses" consists of the development and production of interiors focused on the "centrality" of the passenger, with an ergonomic approach attentive to anthropometric issues; considering the different physical variations of the world's population, which represent the fundamental "dimensional standards" to be taken into account for proper design with the necessary sizing criteria. The update of receiving "in real time" both aesthetic and functional updates, while fully respecting the delicate balance between aesthetics and habitability, is very important. Today, the target market demands increasingly obvious updates with reference to design, construction techniques, perception of comfort and on-board services. In addition, the design activities of the previous points defined the pre-approval requirements functional to the perfect compliance of aircraft interior design standards. The focus was on the seating arrangement and type, considering the following requirements: to keep the number of total seats as high as possible; to manage the modularity of the passenger compartment in order to be able to adapt the vehicle to different types of services; and to keep the habitability space regular, so as to facilitate the passage of users in the aisle. For the design of the PIS paneling, it was appropriate to place the buttons of the different seats at a certain angle and position to allow proper interaction with passengers without leaving the seats unsafe. The dimensions, positions, interface and all other parameters have been unified according to the standards of aeronautical regulations, such as SAE ARP 5765, CS 25.562 certification specifications.

Ergonomic Usability Verification Procedure and Preparation and Setup of the Virtual Model

After completing the ergonomic design of the Five Senses interiors, it was possible to proceed with ergonomic testing in the virtual environment. Within the ergonomic simulator, through the interaction of various software specialized in ergonomic design, the anthropomorphic dummy was implemented in the specially made 3D CAS model with the correct three-dimensional modeling parameters to perform all necessary operations.

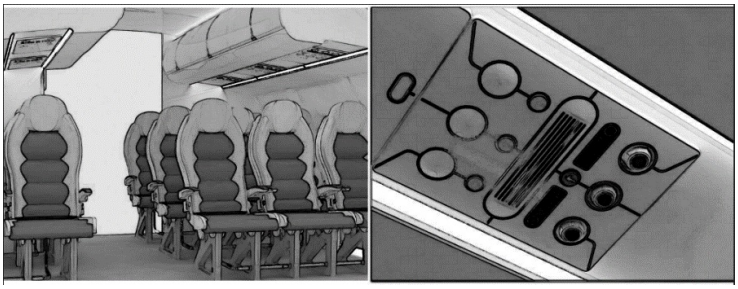

Figure 1: 3D models.

The 3D CAS file was appropriately divided into several layers, each with its own characteristic material, to enable better perception of the Five Sensess concept. Only once the virtual environment was set up with the three-dimensional elaborate was it possible to implement the dummies in the ergonomic database in the agreed percentiles.

Description of Dummies for Ergonomic Testing

As a result of the different reflections and the different analyses, the number and methodologies of ergonomic controls within the aviation interior were agreed upon and established by including 3 types of dummies.

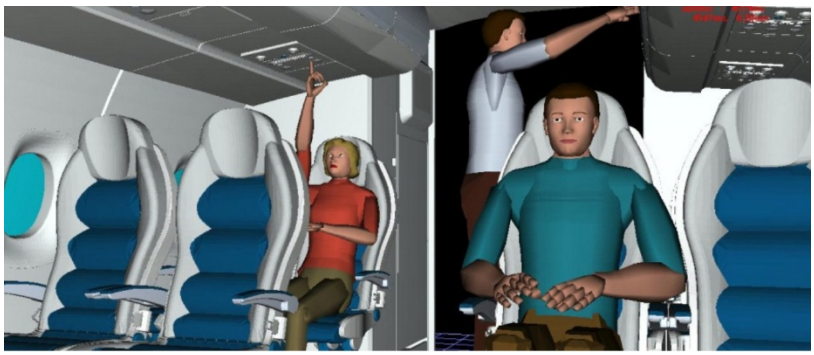

Figure 2: The different percentiles placed in the interior scene.

Specifically, the 3 percentiles identified for testing are as follows:

- 5th percentile female;
- 50th percentile male;
- 95th percentile male.

The choice of the dummies mentioned before, and of the related anthropometric measurements, was dictated by a very specific desire: to verify the degree of postural comfort starting from the minimum size up to the maximum, passing through the average. The following graphs show the anthropometric values for the 3 percentiles, as shown in Table 1.

Table 1. The main 3 percentiles summarized in a table.

5th Percentile Female	50th Percentile Male	95th Percentile Male
Percentile 5°	Percentile 50°	Percentile 95°
Ethnicity European	Ethnicity European	Ethnicity European
Gender female	Gender male	Gender Male
Height (cm) 152,78	Height (cm) 175,49	Height (cm) 186,75
Weight (kg) 49,640	Weight (kg) 77,690	Weight (kg) 98,070

Ergonomic Control of the Passenger Seat and PIS Panel

The virtual model of the interior is now ready to be analyzed. The verification was set up to accommodate the 3 dummies on the above seats assuming a posture true to reality: the torso, buttocks, and legs were placed on the seat, while the hands were placed in the different positions for interaction with the PIS panels.

Figure 3: The percentiles on the session with the different tests of PIS use.

After positioning the dummies in the correct posture, it was possible to check the postural comfort index with a special algorithm then implemented in the specialized comfort assessment software. After this command was executed, the software produced a report for each of the 3 percentiles showing the comfort values of the individual body parts: the farther the value was from 0 (zero), the greater the degree of perceived discomfort.

Figure 4: The different postural interactions in ergonomic testing.

The software, in order to facilitate the reading of these reports, assigns 3 different colors to the values in the graph according to the comfort index: green is assigned to high levels of comfort, yellow to situations of slight discomfort, and finally, red is assigned to clear conditions of postural discomfort (Fig. 5).

Figure 5: The 5th percentile in ergonomic results for women.

The ergonomic comfort of the various percentiles was analyzed. Through the operating protocol, it was found that the interaction is more comfortable for all three percentiles. Again, as can be seen from the image, all values are marked in green.

Figure 6: The 95th percentile in ergonomic results for men.

Summary of Results

This document represents the final summary of intermediate results with reference to the methodological and operational approach for an activity to design an "ergonomic habitat" for the Five Senses project. This activity was configured first as an input and then as an output for the implementation of preliminary design methodologies, restyling, ergonomic design and photorealistic rendering, all functional activities for the best configuration of the aircraft interior. The design process then defined, through a complex analysis, the validated inputs and outputs for the subsequent design correction activity, with careful verification of the aesthetic styles of the manufacturer performed and its interior and seat suppliers. Finally, through 3D CAS-CAD modeling, solutions enhancing the usability of postural comfort were proposed in the design of the new ergonomic profile for passenger seats and PIS. In order to enable their fruition, perception and visualization in a virtual environment

and in photorealism mode, preventive and continuous rendering operations were carried out during the work; these operations are carried out by means of high-definition mode processing. The design process is carried out in operational phases; starting then with the import of the 3D models of the CAS project, which are then introduced into the ergonomic simulator. Ergonomic simulations performed with test reports demonstrate formal-aesthetic consistency with ergonomic consistency. The core of the project definitely focused on the necessary revisiting of the Sw (Ergonomic Simulator) tool by characterizing it for the scope of ergonomic verification of the designed elements, but in the specific functional aesthetic co-design tool for the redesigned furniture and in the specific case the armchairs and the upper information panel. The definition and "identification of stylistic features and systematization of ergonomic design requirements, will take place through a process of integration of the factors that concur in "human centered" design to set up the ergonomic project, where the avamproject that is the first technical development of the concept is obtained and where the first dimensional, technical, functional and material constraints are placed on the project, functional to the maximum stylistic performance of the interiors.

Morphological and Ergonomic Design of Passenger Seats

With the use of virtual dummies, it is possible to analyze a risk assessment of musculoskeletal pathologies caused by the use of the seat system; the system consists of the interaction between the user and the seat, determining the static posture of the user and influencing the user's postural comfort in the next step of verification. Therefore, through the interaction of innovative specialized software for ergonomic checks in a virtual environment, it is also possible to verify the usability in terms of postural comfort in the obtained comfort mode. It is then possible to verify the entire male/female user population characterized by the anthropometric "Gaussian averages" of the users (50th percentile for women and 50th percentile for men).

CONCLUSION

One of the primary Objectives of this work was to verify, through the use of specialized software, the correctness of the design choices made for aircraft interior elements, with an added value of an "ergonomically correct" design. For the ergonomic design-verification of the static posture of this simulation, the results of the studies performed were then implemented in the simulator. Specifically, the work is reworked in its integrity and completeness of information to obtain the potential obtained from the previous activity. The methodological procedure involves the subsequent 3D CAS\CAD modeling and specifically the production of 3D CAD files (model in.igs format of the system). The quality of the proposed morphological design is subject to an ergonomic control according to the methods described above. This activity will also be functional for maximum reliability and performance of the processes of analysis, control, and visualization of the ergonomic simulator. The objective of the subsequent and previous ergonomic design and verification is focused mainly on the design variables that had the greatest influence on

user discomfort in the design, and then develop a real-time design complete with all ergonomic issues, an innovative approach that proves to be of help to the functional and multidisciplinary design processes of the different specialized contexts for the elements involved in the final production of the "Five Senses" project. In conclusion, the key contribution of this approach has been to receive "real-time" design support during the concept design phases, considering both aesthetic and functional canons in full respect of the balance between aesthetics and habitability. Today, the target market demands increasingly evident, and verification activities in the virtual environment have defined functional pre-approval requirements in response of the design aircraft to passenger aircraft habitability standards. At present, performing the ergonomic verifications alone by means of virtual simulations and comparing the results with previous studies and musculoskeletal analyses has helped designers determine the possible cause of discomfort associated with product use, but with methodological optimization of the integrated procedure, optimization of the results obtained can hopefully be achieved. The approach illustrated here elaborated a "scientific and objective" approach, redefining an interiors design by means of a new line of aesthetic/functional adaptation, as an "excellent" stylistic/ergonomic interface between the seat, PIS, and the user, implemented in the finite elements and assembly of the elements of this activity within aircraft and ready for market.

Figure 7: Interior product real model.

REFERENCES

Barone, S., Fittipaldi, F., Lanzotti, A.: Miglioramento del comfort di un nuovo veicolo urbano mediante la progettazione dei parametri in ambiente virtuale. In: Atti della prima conferenza annuale della Rete europea per le statistiche aziendali e industriali, Oslo, 17–18 September (2001).

Fittipaldi F., Ergonomia, progettazione e sperimentazione virtuale, Luciano Editore, Napoli, 2013.

Fittipaldi F., New concepts for rail design, Luciano Editore, Napoli, 2013.
Fittipaldi F., New concepts for urban mobility, Luciano Editore, Napoli, 2013.
Fittipaldi F., Ranzo P., Veneziano R., (2019). IBIS project: the Innovative, sustainable and integrated bus. Designing Sustainability for All The LeNS World distribuited Conference, 3–5 April 2019. ISBN:978-88-95651-26-2.
Fittipaldi F., Ranzo P., Veneziano R., Ergonomics, Design and Comfort for the Automotive Industry Mollafenari Mah., Türkocağı Cad. 3/1, Mahmutpaşa/Istanbul, Turkey, pp. 281–292, ISBN: 978-605-9207-10-6.
Fittipaldi F.: Transportation Design, Nuovi Concetti per la Mobilità Urbana, Luciano Editore, Napoli (2012).
Fittipaldi F.: Transportation Design, Progettazione e Sperimentazione Concettuale, Luciano Editore, Napoli (2012).
Pheasant, S.: Antropometria dello spazio corporeo, ergonomia e progettazione del lavoro, Taylor & Francis, Londra (1996).