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MODELING THE COMFORT OF AIRCRAFT PASSENGERS AS PART OF THE PASSENGER CABIN ENVIRONMENTAL CONTROL SYSTEM (ECS)

Tsahalis, J.[1], Tsahalis, H.-T.[1] Moussas, V. C.[1, 2]

[1]Paragon S.A.
Protopapadaki 19, Galatsi, GR-11147, Athens, Greece
e-mail: info@paragon.gr, web page: http://www.paragon.gr

[2] School of Technological Applications
Technological Educational Institute of Athens
Ag. Spyridonos Str., Egaleo, 12210, Athens, Greece
e-mail: vmouss@teiath.gr, web page: http://www.teiath.gr

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Abstract. *This paper presents the Human Ontology Model for its Environmental Response (HOMER) as it was applied as part of the design of an aircraft passenger cabin and its Environmental Control System (ECS). HOMER was implemented as part of an automated optimization loop of the ModeFRONTIER software, which combined the cabin's CFD model, HOMER, the ECS model and a human thermal response model. Furthermore, HOMER the optimization loop was performed via online collaboration utilizing the internet through online collaboration platforms and purpose-designed automated interfaces.*

1. INTRODUCTION

Current Aircraft industry requires the design of complex engineering systems which interact between multiple disciplines. These kinds of interactions are creating multiple conflicting objectives that are handled by multidisciplinary design optimization (MDO). In such a framework of optimization for the aircraft cabin, human response modeling is an integral part which has a vital role to the assessment of the passenger's comfort.

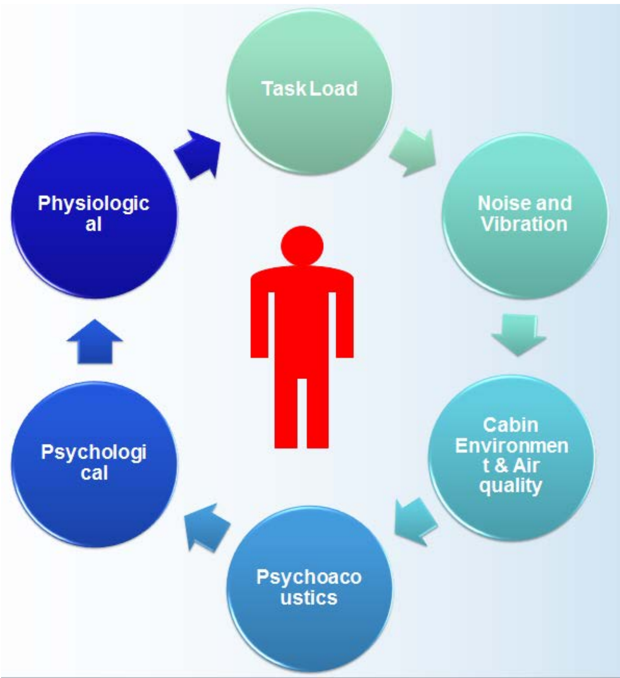

Fig.1: Human Response Model Inputs

2. HUMAN ONTOLOGY MODEL FOR ITS ENVIRONMENTAL RESPONSE (HOMER)

Human response models are complex models that deal with a multitude of parameters (noise, vibration, temperature) that affect a passenger's physiology and psychology. The subject of the Human Ontology Model for its Environmental Response (HOMER) that has been developed is, in a sense, a "pioneering" effort in the field of human passenger responses in aircraft. In a robust collaborative environment like Crescendo, HOMER is integrated to the Environmental Control System (ECS) developed by ALENIA in order to address the passenger's comfort in a global manner.

This paper is focusing to the passenger's comfort in relation to the optimization of ECS distribution architecture. How the aircraft's cabin ECS, developed in CFD, interacts with the human response model, developed by Paragon, is presented here. The inputs to HOMER for this case are aircraft cabin's measurements like temperature, pressure, free stream velocity as simulated by the CFD 3D model. Then an assessment of the passenger's comfort is performed through HOMER, and comfort indices which are the output of the model are provided to ALENIA in order to integrate it to Modefrontier's optimization platform handled by University of Salento.

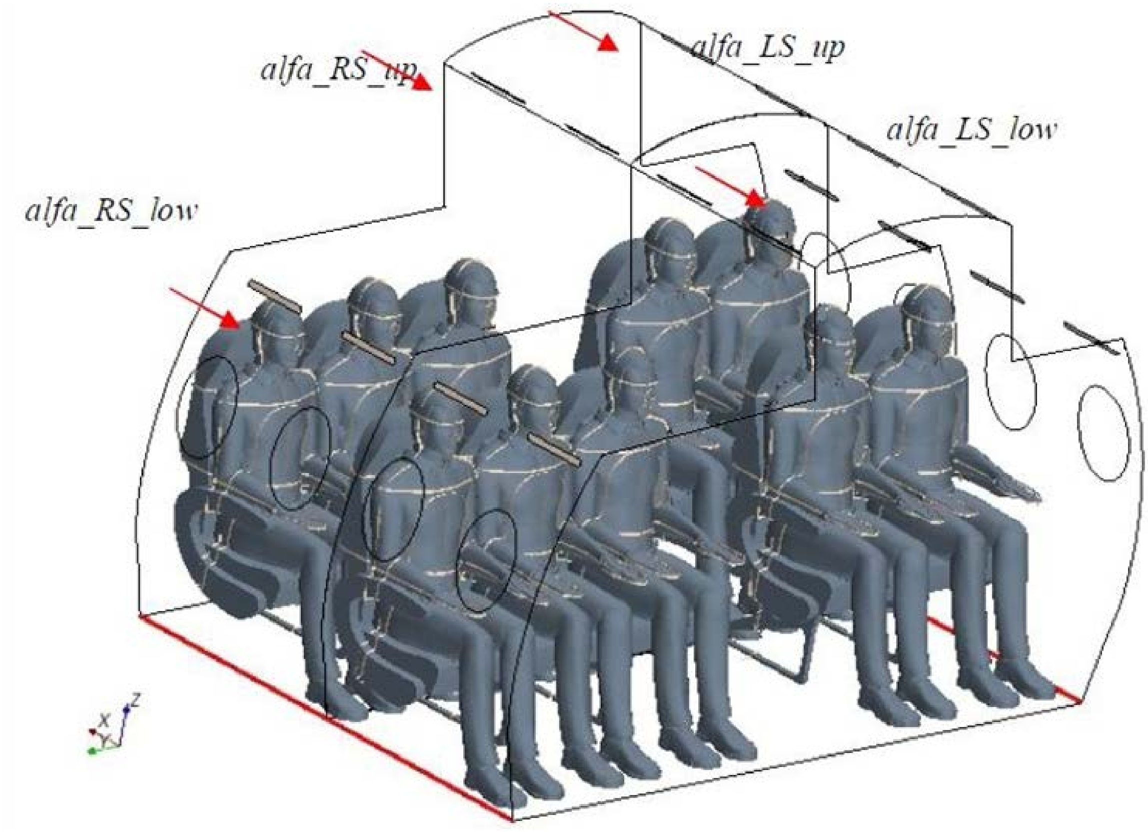

Fig.2: 3D Aircraft Cabin Layout as developed by ALENIA

2.1 Highlights

The multidisciplinary nature of the design and development of an aircraft's ECS.
Industry's drive towards ECS focusing on passenger's comfort needs.

2.2 Technical Challenges

The technical challenges of this study are mainly consisted of the trade-off factors involved in the optimization process, which are:

- Low pressure ECS distribution architecture (in terms of pressure losses vs mass flow);
- Recirculation of fresh flow;

- Air outlets location and shape (in terms of pressure losses and air velocity pattern in passenger cabin);
- Impact of noise/vibration on passenger comfort;
- Impact of environmental condition on passenger comfort;
- Impact of air quality on passenger comfort.

2.3 Key innovations

- Perform the multi-disciplinary design trade-off from equipment, cabin, to aircraft level
- Advanced Human Response Model

2.4 Business benefits

- Providing tools for designing and optimizing the aircraft, from an overall thermal viewpoint, especially in the concept phase, when trade-offs are essential.
- Achieving thermal trade-off, defining thermal architecture and specifying thermal interfaces to system and equipment suppliers in the early phases of aircraft design require an appropriate maturity and efficiency of the thermal simulation framework from equipment, cabin, to aircraft level

2.5 Key messages

- A tool for assessing the passenger's well-being in terms of both physiology and psychology.
- A global optimization framework for the ECS inside an aircraft's cabin.

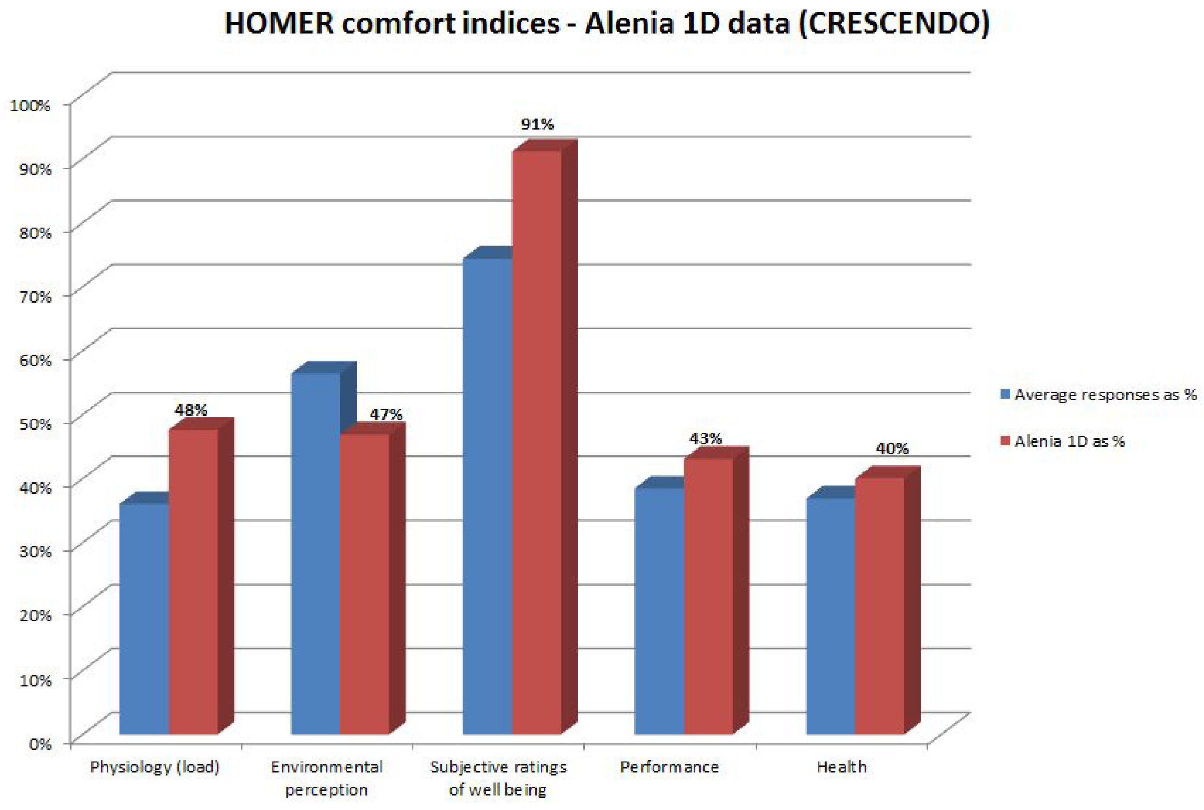

Fig.3: Passenger comfort indices related to ALENIA's 3D CFD data

CONCLUSIONS

The Human Ontology Model for its Environmental Response (HOMER) presented in this paper was developed using ANN. It was enhanced to be able to interface with online collaboration platforms that enable the direct cooperation between manufacturers and third-party suppliers. It was successfully implemented online as part of an optimization loop along with a passenger cabin CFD, an environmental control system (ECS) and a human thermal response model. The end result was the production of several optimal configurations which carried the estimation of the perceived passenger comfort, thus enabling the designers to minimize cost and time while designing for comfort and also to provide a reliable method of comparison between different configurations.

ACKNOWLEDGMENTS

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