THE NEW PRESSURISED FRAUNHOFER FLIGHT TEST FACILITY OFFERED TO THE SCIENTIFIC CABIN ENVIRONMENT NETWORK

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Abstract

The unique Fraunhofer Flight Test Facility (FTF) allows studying the so far unknown integral impacts of the “flying” cabin environment on passengers and crew. This is relevant for the flying society we are evolving into during the current century. Those investigations have to be done by an interdisciplinary research community: a Scientific Cabin Environment Network (SCENE), to which the FTF is offered. SCENE – which is an open network – is already working on two European funded projects: Friendly Aircraft Cabin Environment (FACE) and Ideal Cabin Environment (ICE).

1 The Flight Test Facility (FTF)

1.1 General Description

In 2006 The Fraunhofer-Institut für Bauphysik has finished the construction of a unique flight laboratory (Fig. 1).

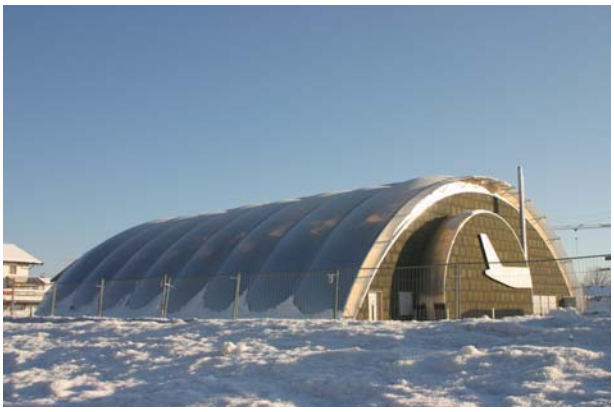

Figure 1: The Fraunhofer Flight Test Facility in Holzkirchen, Germany.

For the first time a huge low-pressure chamber (Fig. 2) was combined with an original front aircraft segment (Airbus A310-200), see Fig. 3.

Figure 2: Low-pressure chamber of the Flight Test Facility. © Fraunhofer/Bernd Müller

Figure 3: Front aircraft segment inside the low-pressure chamber.

Up to 80 test persons can be exposed to realistic typical flight conditions on the ground in a safe, cost effective and environment-friendly way. The basic purpose is to study the impact of flights on the well-being and health of passengers and crew. Moreover components of the cabin environment can be studied and its possible improvement supported.

1.2 Specifications

The low-pressure chamber has a length of 30m and an inner diameter of 9.6m. Its pressure can be lowered to a minimum absolute pressure of less than 180hPa (corresponding to an equivalent altitude of 41,000ft), see Fig. 4.

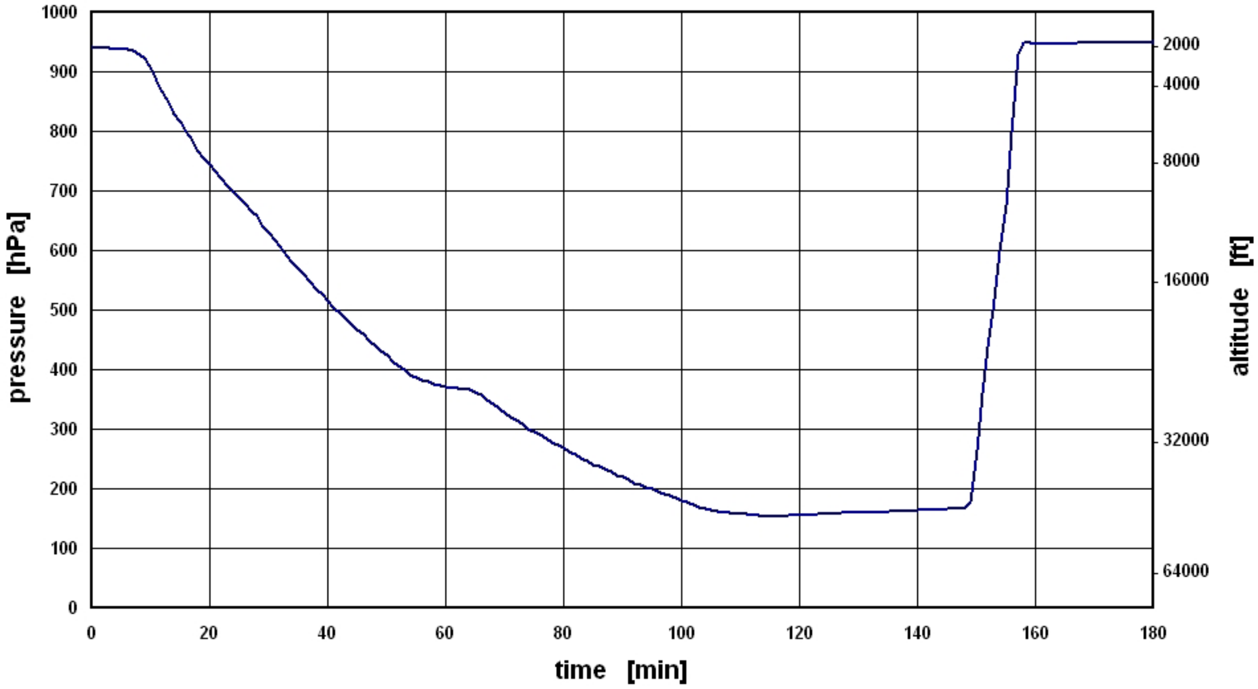

Figure 4: Pressure test of the FTF.

The typical climb situation can be simulated realistically (15min to reach 753hPa, corresponding to an equivalent altitude of 8000ft), see Fig. 5.

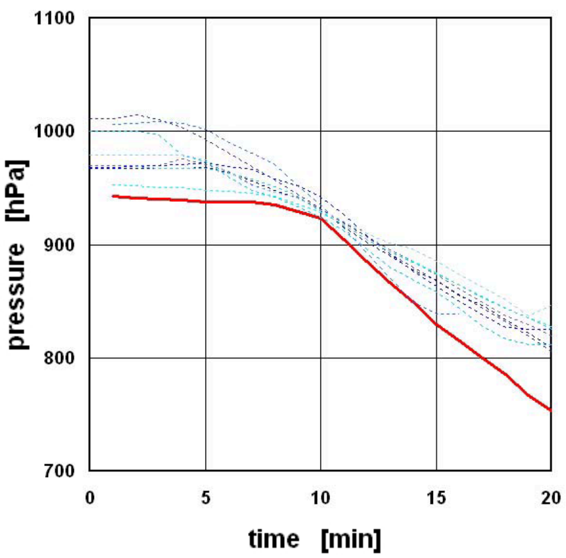

Figure 5: Comparison of a FTF pressurisation (solid line) to real flight measurements (dotted lines).

Inside the aircraft mock-up the air temperature can be varied from -20 to +30°C with a relative humidity of 5% to 65% at 20°C. To achieve realistic temperature profiles inside the cabin the complete outer fuselage can be cooled down to -40°C, with its impact on the surface temperature of side wall panels, floor as well as the condensation of humidity. Air ventilation rates can be varied as well as the air recirculation rates separately for the cabin and the cockpit. Outdoor and recirculation air is cleaned by interchangeable filter systems. Currently installed are HEPA filters class H11/H13 in the recirculation and outdoor air and an additional activated charcoal filter in the outdoor air supply, to avoid odours eventually originating outside the facility. To give the passengers inside the aircraft a most realistic impression of the cabin environment sound and vibrations are simulated with loudspeakers and shakers underneath each seat. The noise spectrum can be varied and calibrated uniformly throughout the cabin to ensure a controlled stressor for the subjects. Environmental parameters can be measured at various locations, within the aircraft. The data are logged by an Ethernet-based system which is controlled outside the cabin. The perception by the subjects can be surveyed via questionnaires and/or physiological measurements.

In addition to the subjective thermal comfort votes the objective physical data of local thermal comfort are collected (Fig. 6).

Figure 6: Subjects voting their perceptions on questionnaires, on the left measurement device DRESSMAN (for a detailed description see [1])
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1.3 Summary of Specifications

aircraft	cockpit and first zone (= 15.5m) of an Airbus A310-200
pressure vessel	length 30m, inner diameter 9.6m
low pressure	180hPa (absolute) Ability to simulate “pressure profiles”, i.e. non-rapid declinations during testing.
cabin air temperature	-20°C to +30°C
fuselage temperature	-40°C to +45°C
relative humidity	5% to 65% at 20°C

realistic simulation of sound and vibration
dynamic control of lighting (intensity as well as colour)

2. The Scientific Cabin Environment Network (SCENE)

Purpose of the FTF is apart from engineering issues (such as development, validation, demonstration) mainly the interdisciplinary scientific work on comfort, health and well-being in the aircraft cabin environment. Therefore the FTF is made available for the interested institutions. The frame for this research is built by the open Scientific Cabin Environment Network (SCENE), in ongoing European projects as well as future research (Fig. 7).

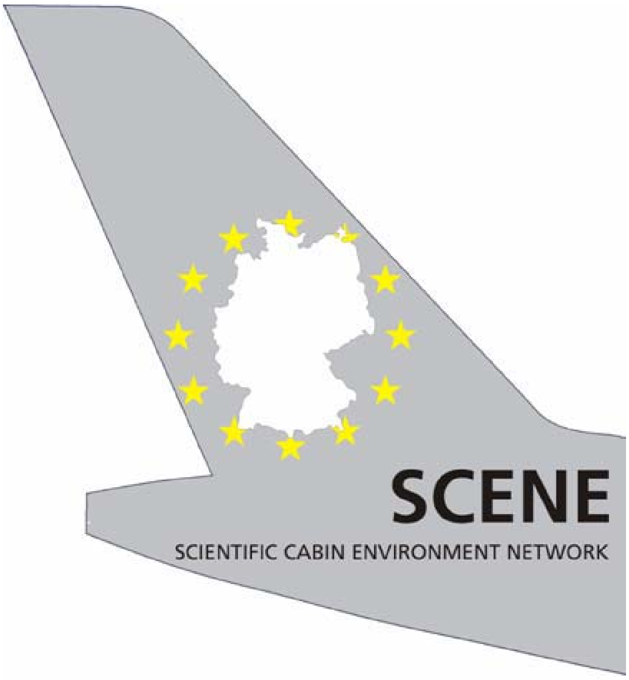

Figure 7: Scientific Cabin Environment Network (SCENE).

2.1 Current Projects

2.1.1 Friendly Aircraft Cabin Environment (FACE) [2]

The FACE project is a European research project, funded under the “5th research Framework” included in the “New perspective for Aeronautic” key action no. 4, focused to improve the know-how related to the aircraft environmental comfort in the aircraft passenger cabin and flight deck area of the future European turbofan aircraft. The project is addressing the main environmental comfort parameters affecting noise, vibration, pressure, air-quality technology, and includes evaluation of comfort effects on/from multimedia utilisation within the limitation of the environmental parameters above indicated. In particular composite fuselage structural acoustic behaviours, considered the most important for future civil turbofan fuselage application, are under analysis within the acoustic tasks. The project consortium is composed by thirty partners spread all along the entire Europe including some of the main airframe industries, research establishments and universities working within the comfort areas at the highest levels.

The effects of multimedia on and from the environmental parameters as affecting the human comfort shall be evaluated. New comfort criteria to evaluate the passenger comfort, an "Environmental Comfort Index", will be developed and validated by an independent team of comfort experts in cooperation with the industrial partners providing aircraft requirements and support into test validation activity.

2.1.2 Ideal Cabin Environment (ICE)

A consortium of 15 organisations from eight European Union countries has started work on a €6 million, three-year research project - ICE (Ideal Cabin Environment) - that aims to bring about a step change in the understanding of the impact of air travel on passenger health and well-being.

While earlier studies have mainly examined the impact of different aspects of the cabin environment (such as air quality and noise) on occupant comfort, the EC funded ICE project takes a different tack, looking at the health and well-being of passengers as they travel on long-haul flights in today's large-scale aircraft. It will give airframers and airlines a hitherto unseen picture of the effects of environmental conditions, including, for the first time, cabin pressure.

The team of researchers, medical experts, and cabin environment specialists will carry out their investigations on large-scale aircraft cabin environment test facilities at BRE's Watford Headquarters, and at Fraunhofer IBP in Holzkirchen. The results will be used to draft Standards and to develop predictive design models, design advice and operational recommendations.

The key objective of ICE is to provide airframers/airlines with step-change knowledge and innovations to address the concerns about the unknown combined effects of cabin environmental parameters, including for the first time cabin pressure, on the health of passengers in commercial aircraft.

ICE addresses the widespread concerns about the impact of flying on the health and well-being of passengers. Changing passenger demographics, the advent of ultra-long-haul services, and specific health issues such as DVT, have all combined to increase concerns. Earlier studies have been fragmented and, significantly, have not determined the health-based optimum levels or studied the synergistic effects of cabin environmental parameters, nor studied cabin pressure, hypoxia (often considered the most serious single physical hazard) and possible links with DVT.

ICE will produce a step change knowledge by investigating impacts of varying levels of parameters on subjects using unique large-scale aircraft cabin environment facilities, and will determine optimum individual and combined levels for human well-being, validated by in-flight monitoring. From these, ICE will develop radical predictive design models for airframers and airlines to provide for the first time a means by which they will be able to determine the health impact of their aircraft on their passengers.

The predictive model will not only consider environmental parameters but also passenger profile, and flight characteristics. If these indicate health risks, the user will be able to vary individual or combined parameters to minimise risks to acceptable levels in a technically feasible and economically viable manner. ICE will also draft relevant standards, including the first scientifically based for cabin pressure, and provide practical design guides and operational recommendations in cooperation with stakeholders.

2.2 Future Projects

There are several cause variables on comfort, health and well-being known from literature (Fig. 8). So far most research concentrates on studying these parameters isolated only. Thus knowledge on possible combined effects on passengers inside the aircraft cabin environment is lacking. One major goal of the FTF is to close these gaps.

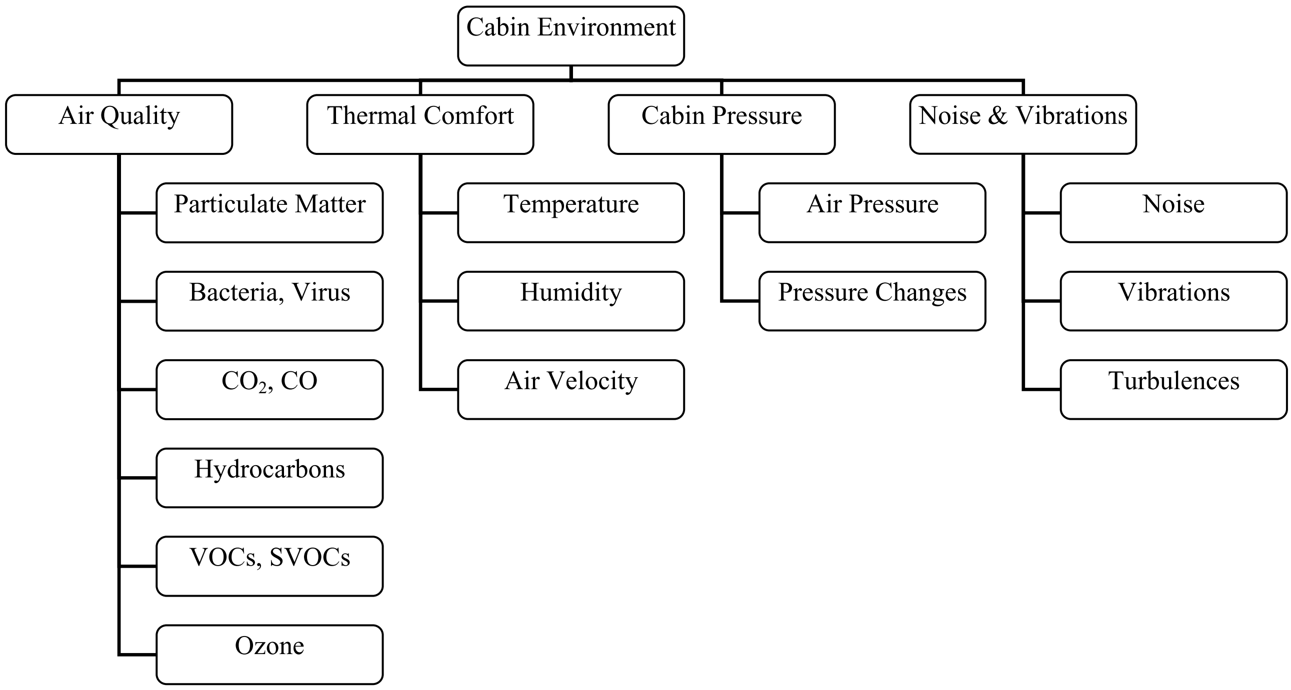

Figure 8: Cause variables on comfort, health and well-being of passengers inside the aircraft cabin environment.

Possible questions for future research include:

- problems in the cardiovascular system, especially for passengers at risk (such as elderly, sick people, children)
- possible risk of deep vein thrombosis
- effect of air contaminations (e.g. cross infections, disinfection procedures)

To get clearance on these issues is of basic interest for both, aviation industry and the general public. To achieve this knowledge the FTF is available for research on ground. On one hand this is an economically feasible way to perform epidemiological studies with subjects (in contrast to in-flight measurements) and on the other hand this research can be done by neutral and publicly accepted institutions.

References

[1] Schwab, R. and Mayer, E.: DRESSMAN – a thermal comfort measurement device for drivers and pilots; International Journal of Vehicle Design 2006 - Vol. 42, No.1/2 pp. 49 – 56

[2] Paonessa A.: Friendly Aircraft Cabin Environment – FACE; euronoise Naples 2003, paper ID: 397