Indoor Environmental Quality in Sustainable Buildings

AIVC International Workshop

Stuttgart, Germany

1-2 April 2025

INIVE EBC Public HEINZ TROX STIFTUNG Fraunhofer IBP

1

Fraunhofer IBP

Indoor Environmental Quality in Sustainable Buildings

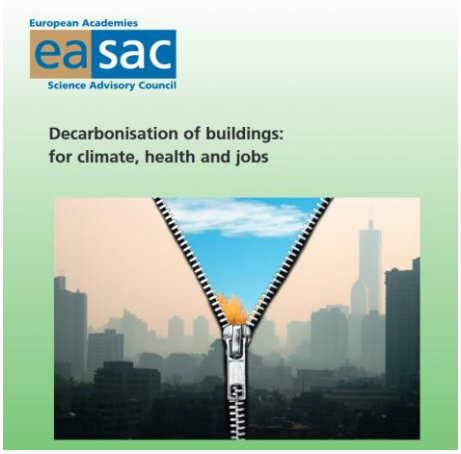
at Fraunhofer IBP

Gunnar Grün

AIVC workshop, Stuttgart, 1.4.2025

2

2021

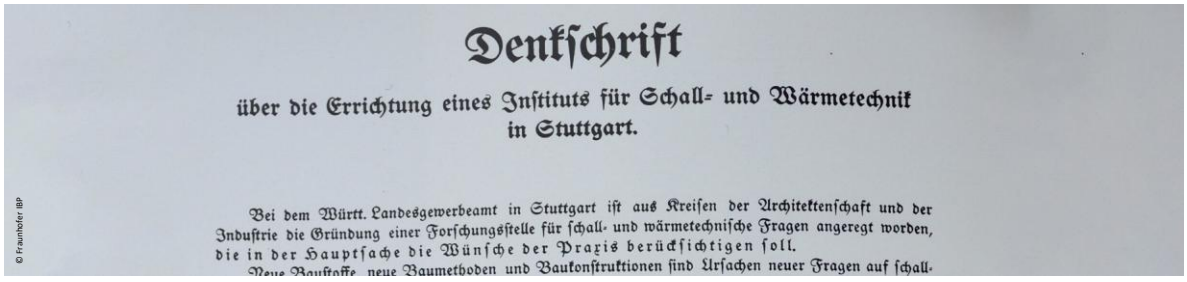


Europeans spend a very large part of their lives in buildings. **So the quality of a building's indoor environment can have a large effect on the health of its occupants.** It can also affect their ability to work and enjoy their activities. A potentially good indoor environment can be created by building designers and builders, but that environment cannot be realised without using energy to provide heating, cooling and ventilation. **Much of that energy today is supplied using fossil fuels, which cause buildings to produce about 25% of the European Union's (EU's) total greenhouse gas (GHG) emissions and so contribute to climate change.**

Action must therefore be taken urgently to reduce the energy that is needed to operate the approximately 250 million existing buildings in the EU as well as all the new buildings that may be built in the future. Existing energy supplies must also be replaced with very low carbon alternatives.

Fraunhofer Institute for Building Physics IBP

Memorandum of 08.12.1928 to the foundation


Denkschrift

über die Errichtung eines Instituts für Schall- und Wärmetechnik in Stuttgart.

Bei dem Württ. Landesgewerbeamt in Stuttgart ist aus Kreisen der Architektenschaft und der Industrie die Gründung einer Forschungsstelle für schall- und wärmetechnische Fragen angeregt worden, die in der Hauptsache die Wünsche der Praxis berücksichtigen soll.

Neue Baustoffe, neue Baumethoden und Baukonstruktionen sind Ursachen neuer Fragen auf schall-

»The constant increase in traffic, especially in large cities, results in noise, sounds and vibrations of all kinds. This is a nuisance to people and is damaging to their health…«

»Inefficient heating and lighting mean that other major assets of the national wealth are lost.«

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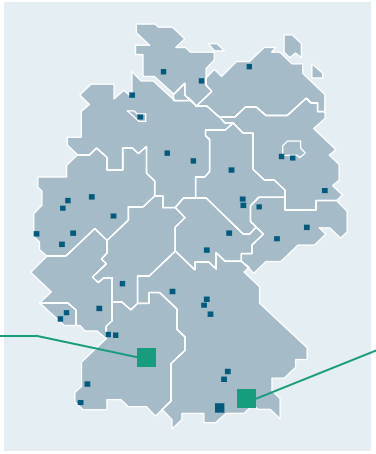

Stuttgart

- founded 1929
- Affiliated to Fraunhofer 1958
- ca. 270 Employees at two sites

Holzkirchen

- External income ca. 22 Mio. Euro
- Industrial contracts ca. 41%

6

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Thematic Areas

Energy

People

Ecology

7

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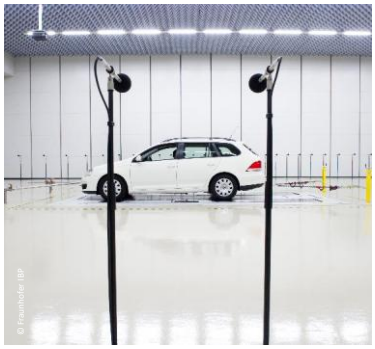
Markets

Construction

Aviation

Automotive



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8

Departments

ACOUSTICS

- Building acoustics
- Room acoustics
- Noise control and vehicle acoustics
- Human-Centered Acoustic Design and User Research
- Musical acoustics / photo acoustics

ENERGIE EFFICIENCY AND INDOOR CLIMATE

- Buildings, Districts, Cities
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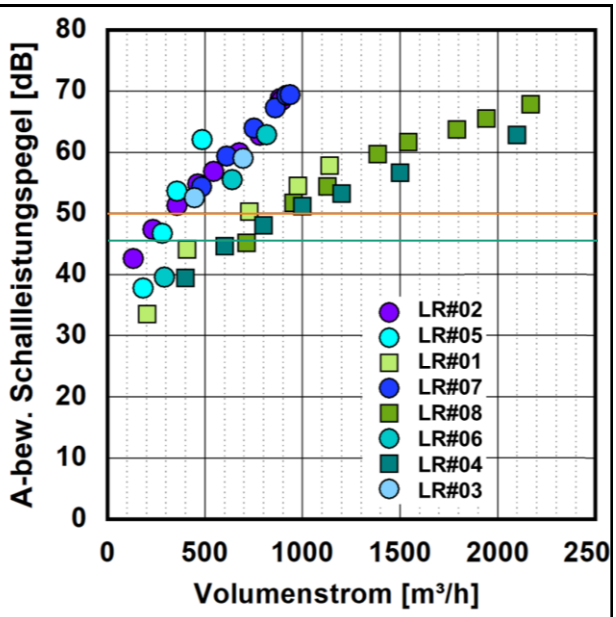
9

Acoustic characterization of ventilation units

- Measurement of the sound power as a function of the different operating levels of the ventilation units.
- Acoustic optimization of the ventilation units, e.g. using an “acoustic camera” or a laser vibrometer.

Acoustic characterization of room air cleaners

- Measurement of the sound power as a function of the different operating levels of the room air cleaners.
  - **Sound power level** for many devices above 55 dB(A)
  - Recommendation of Fraunhofer IBP:
    - $L_w \leq 50$ dB(A) – for open-plan offices, restaurants, sales rooms, environments with correspondingly higher background noise and room volumes > 200 m^3
    - $L_w \leq 45$ dB(A) - for individual offices, classrooms, conference rooms, …



Calculation and evaluation of reverberation times

Web-App https://pro.reverberate.de/

- Web application for **calculating the reverberation time** in rooms **based on the new calculation model** developed at Fraunhofer IBP
- **Flexible room geometry** and arrangement of absorbent surfaces in the room
- Consideration of the **absorption distribution** in the room as well as other advantages in contrast to classic room acoustic calculations according to Sabine
- Classification of frequency-dependent reverberation times according to the acoustic requirements of DIN 18041
- Export of the calculated reverberation times and decay curves as well as the normative evaluation as PDF

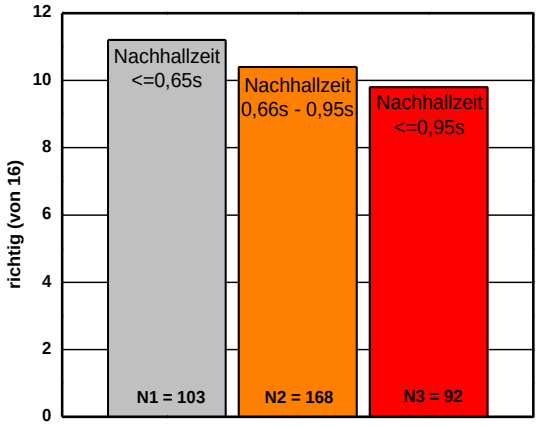
12

Effect of reverberation times in classrooms

Chronic effects of different reverberation times on basic cognitive functions

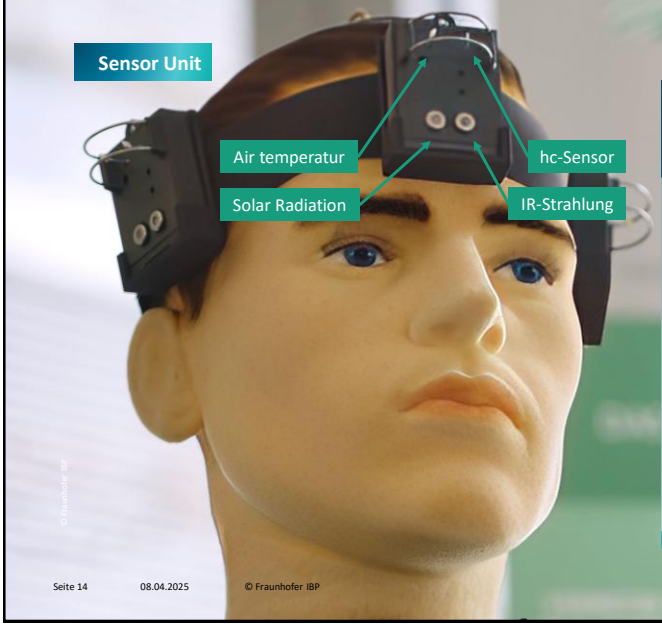
Performance of second graders in categorizing sounds.

(Test under equal reverberation conditions)

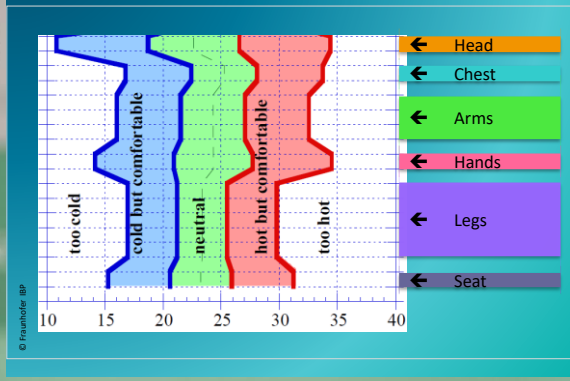


13

Thermal Comfort in Automobiles: DressMAN



Comfort Bands (summer) for different body segments versus equivalent temperature (H. O. Nielsson)



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Zonal Simulation

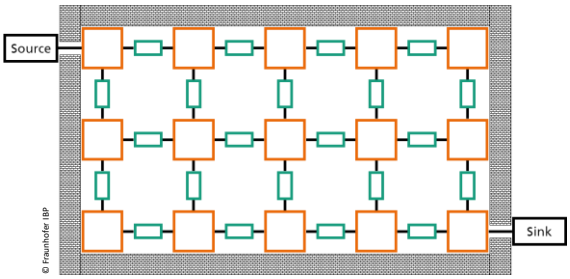
Indoor Environment Simulation Suite

Subdivision of a room into zones (volumes)

Volume model:
- Mass conservation
- Energy conservation
- Species conservation (here: infectious material)

Airflow model:
- Connects two zones
- Calculation of the air mass flow from pressure difference and conservation of momentum

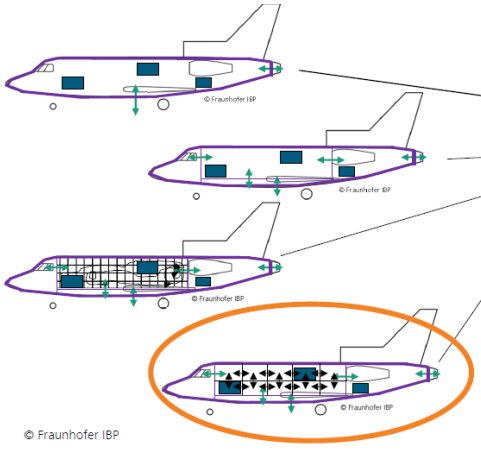
Advantages:
- High local resolution
- Fast simulations
- Parametric studies



16

Zonal Simulation

VEPZO model – Indoor Environment Simulation Suite (IESS) – Best compromise



Modelling Approach	Local Resolution	Speed, Transient
Single-Zone	-	++
Multizone	0	++
CFD	++	--
Zonal	+	+

Optimum between resolution and speed

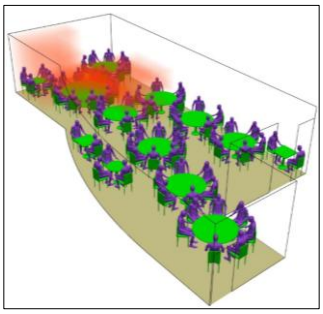
Best compromise

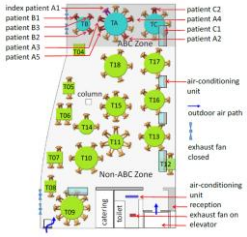
➔ **Fraunhofer IESS**
(Indoor Environment Simulation Suite)

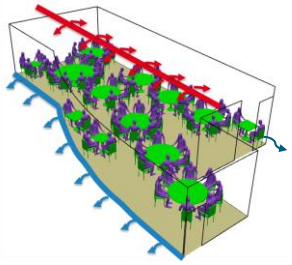
Clean Sky JOINT UNDERTAKING

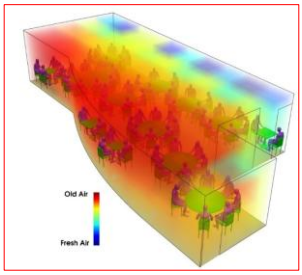
17

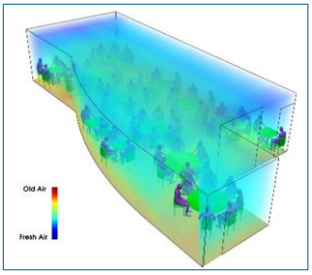
Flow distribution – modeling of dispersion scenarios











Simulation of room air flows with the **Indoor Environment Simulation Suite (IESS)**

IATC – Indoor Air Test Center

Parameters

- 8,2m Length x 5m width x 3,1m height = 127,1 m³, 41 m²
- Modular thermal control of enclosures
- alle parts out of VOC-free or low VOC Materials
- HVAC with supply, exhaust and recirc air up to 1800 m³/h
- Dosing of biological, chemical and particular substances
- Emission tests of whole vehicles

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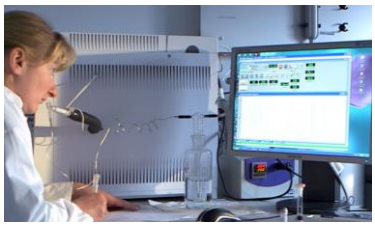
20

Chemical and Biological Laboratories

Facilities

- Emission chambers of different sizes
- Living Database of relevant micro organisms (> 500 Cultures)
- Mould test stand
- GC-MS/FID
- UPLC-MS/MS
- HPLC-DAD
- UV-VIS
- IR-Spektroscopy
- …



21

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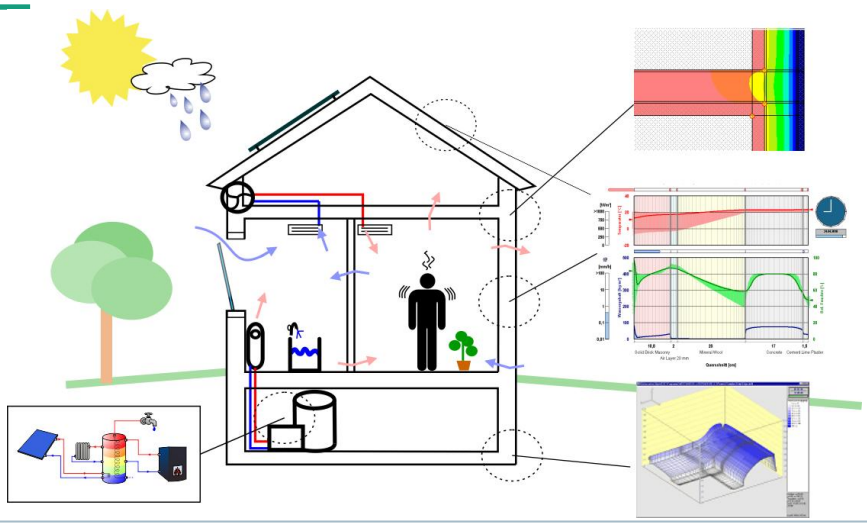
22

Hygrothermal building simulation tools evaluate the combined impacts of heat and moisture transfer



WUFI® 25 Jahre

WUFI Plus® developed by Fraunhofer IBP and used worldwide for hygrothermal building design

23

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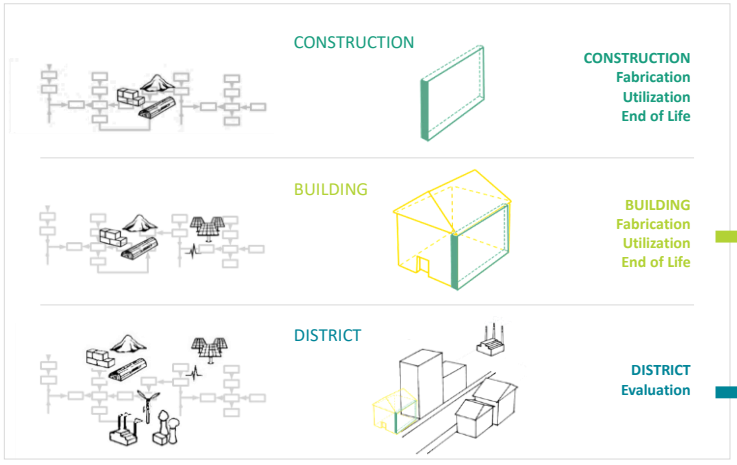
24

Sustainable Buildings

Life cycle assessment of buildings



25

Sustainable Buildings

Life cycle assessment of buildings – with the Websoftware Generis®

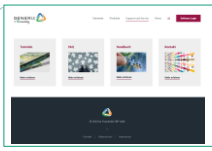
Webtool
generis.live

Constructions

Projects

GENERIS®
Software for life-cycle based planning of buildings

Support-website:
generis-solution.eu



In-App Visualisation
Excel - Analyse

DGNB-conform
Evaluation

Contact

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Opening Session

Chair: Gunnar Grün

09:00	Indoor Environmental Quality in Sustainable Buildings at Fraunhofer IBP	Gunnar Grün, Fraunhofer Institute for Building Physics IBP, Germany
09:20	Overview of AIVC, TightVent & venticool	Arnold Janssens, AIVC Operating Agent/INIVE/UGent, Belgium
09:30	Introduction Heinz Trox Foundation	Christine Roßkothen, Heinz Trox Foundation, Germany
09:40	Impact of indoor air quality on health	Ulrich Zißler, Technische Hochschule Rosenheim, Germany

Status of implementation of EPBD-recast

Chair: Arnold Janssens

10:05	Addressing Indoor Environmental Quality and inspection of ventilation systems: provisions in the EPBD Recast	Marco Morini, European Commission, Directorate-General for Energy (DG ENER), Belgium
10:25	EPBD and Consequences for National Implementation and Relation to other EU-Legislation	Claus Händel, Fachverband Gebäude-Klima e.V., Germany
10:45	Coffee Break	
11:15	Net Zero Energy Codes in Canada	Iain A Macdonald, National Research Council (NRC), Canada
11:30	European Calculation Tools for Energy Efficient Buildings	Simon Wössner, Fraunhofer Institute for Building Physics IBP, Germany
11:45	Discussion	
12:15	Lunch	

IAQ in relation to health

Chair: Christine Roßkothen

13:15	Smart IAQ Management: Enhancing Energy Efficiency in Partially Occupied Office Buildings	Lukas Schmitt, Technische Universität Berlin, Germany
13:30	The harm paradigm for IAQ and IEQ	Benjamin Jones, University of Nottingham, UK
13:45	IEA-EBC Annex 86: a performance based assessment method or a rating ecology?	Jelle Laverge, Ghent University, Belgium
14:00	Smart ventilation performance from an international perspective	Gaëlle Guyot & Jean Paul E. Harrouz, Cerema, France
14:15	Concepts of air purification efficiency tests under realistic conditions with continuous bioaerosol source and evaluation of the test results	Andreas Schmohl, Fraunhofer Institute for Building Physics IBP, Germany
14:30	Discussion	
14:50	Coffee Break	

IEQ in sustainable buildings

Chair: Gunnar Grün

15:20	The TAIL rating schemes for offices and schools are the way to reduce carbon emissions and improve IEQ	Pawel Wargocki, Technical University of Denmark, Denmark
15:35	Solution to Improve IEQ in Classrooms	Dirk Müller, Heinz Trox Wissenschafts gGmbH, Germany
15:50	IEA EBC Annex 97 / IEA CITIES Task 5 - Sustainable Cooling in Cities	Peter Holzer, Institute of Building Research & Innovation, Austria
16:05	Indoor Environmental Quality in Home Offices: A Proof-of-Concept Study on Pleasure and Discomfort	Peiman Pilehchi Ha, RWTH Aachen University, Germany
16:20	Assessment of the impact of climate change on thermal comfort in buildings, taking account of occupant behaviour and the urban context	Bassam Moujalled, Cerema, France
16:35	Noise characteristics and psychoacoustic of outdoor heat pumps	David Goecke, Fraunhofer Institute for Building Physics IBP, Germany
16:50	Environmental impact of heating and ventilation systems in the LCA of a Flemish single-family dwelling	Yanaika Decorte, Ghent University, Belgium
17:05	Indoor Climate in the Spotlight: Between Health Protection and Energy Efficiency	Lukas Siebler, University of Stuttgart, Germany
17:20	Discussion	

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32

Day 2 - Opening

Chair: Gunnar Grün

09:00	IEQ, Ventilation and energy performance of buildings	Thomas Hartmann, *ITG Dresden, Germany*

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Case studies schools and care facilities

Chair: Christine Roßkothen

09:20	Indoor Air Quality in Naturally Ventilated Classrooms and Offices	James A. McGrath, Maynooth University (MU), Ireland
09:35	Improving IAQ in school and Non-residential buildings: case studies	Cécile Caudron, Cerema, France
09:50	A controlled intervention study in two schools: impact and benefits of the air cleaning measures implemented	Iain A Macdonald, National Research Council (NRC), Canada
10:05	Improving air quality in UK schools: SAMHE – Schools' Air quality Monitoring for Health and Education	Henry Burridge, Imperial College London, UK
10:20	Ventilation concepts in classrooms: Results of a long-term study in three elementary schools	Susanna Bordin, Technische Hochschule Nürnberg, Germany
10:35	Discussion	
11:00	Coffee Break	

Demand and personal control, user interaction

Chair: Arnold Janssens

11:30	NudgeFlow: The next generation of residential ventilation - tweaking the natural air flow with distributed components	Hilde Breesch, KU Leuven, Belgium
11:45	Performance of Personalized Ventilation and Chair Fans: Experimental Measurements in a multi-occupied Living Lab	Douaa Al Assaad, KU Leuven, Belgium
12:00	Why is PECS not a mainstream product today?	Bjarne W. Olesen, Technical University of Denmark, Denmark
12:15	Discussion & Closing	
12:45	Lunch	
13:45	End of Workshop	

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