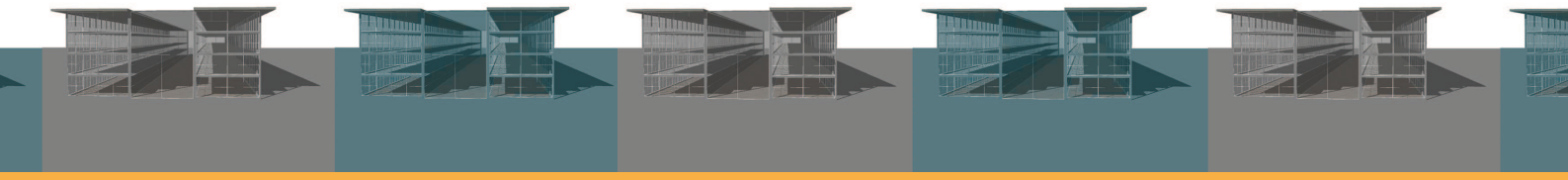
HumanComfort

XRG Simulation GmbH

Modelica-Library

Professional Evaluation and Visualization of Thermal Comfort in Buildings and Vehicles



Description

Modern heating and cooling systems in buildings and industry are designed to optimize operating costs and energy consumption by combining multiple technologies. Such systems typically also incorporate devices for heat reclaim and heat transfer from and to ambience. Thus, control strategies are required in order to provide a reliable and most efficient supply if outside boundary conditions are changing.

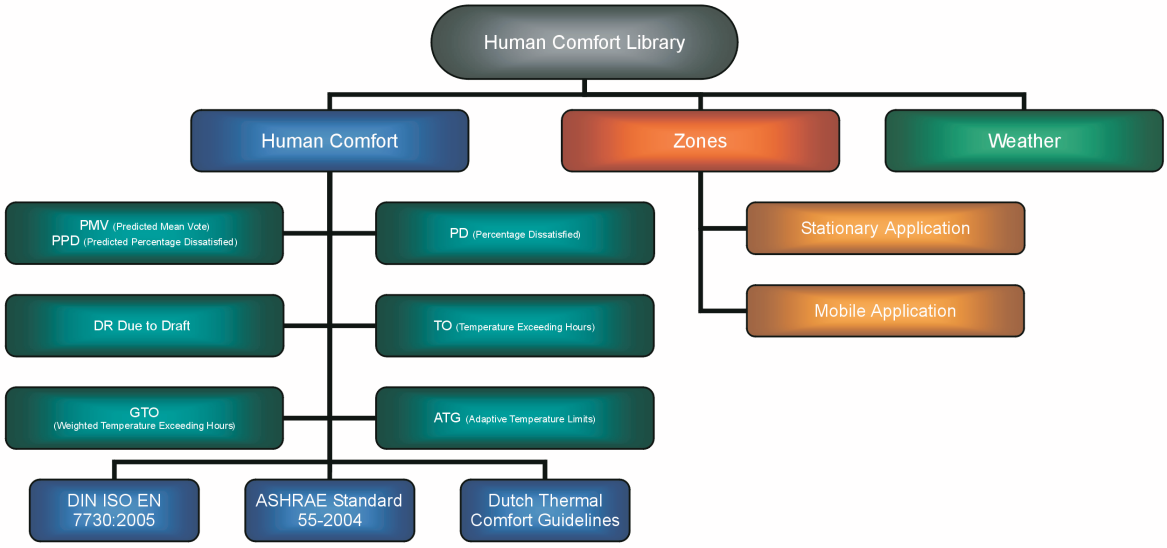
The **HumanComfort Modelica-library** provides basic models for evaluating the human comfort of occupants within an air conditioned zone in form of mathematical criteria and also graphical visualizations.

Integral Approach

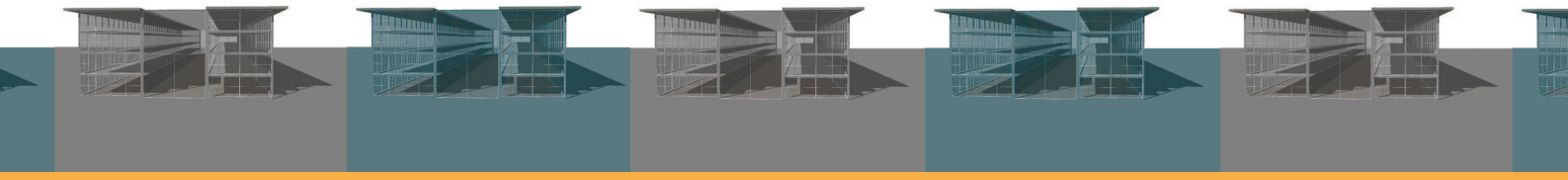
The **HumanComfort Modelica-library** provides an integral approach to simulate the zone (building or cabin model) and the air-conditioning simultaneously under consideration of occupants thermal comfort.

Often the HVAC system will be simulated by using a reference load curve as the boundary conditions instead of the building. This approach assumes that the HVAC system can fulfil the heating and cooling demand at any time. This method neglects however the transient interaction between the building and the HVAC system.

The integral modelling is important for system sizing taken the thermal comfort into account. Integral simulations also allow the user to analyze system configurations where transient effects due to building masses or other inertias cannot be neglected. Hence, realistic control schemes can be developed.



1 HVAC (Heating, Ventilating and Air Conditioning)
2 ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers)



Modular Approach

The **HumanComfort Modelica-library** offers a modular approach and makes use of standardized interfaces (Modelica Fluid connectors) enabling an easy implementation in existing Modelica libraries. Each HumanComfort module is exchangeable. The user may combine an existing building simulation model with the HumanComfort module or the HumanComfort weather module.

The library consists of the following three packages:

HumanComfort Package
(thermal comfort analysis)

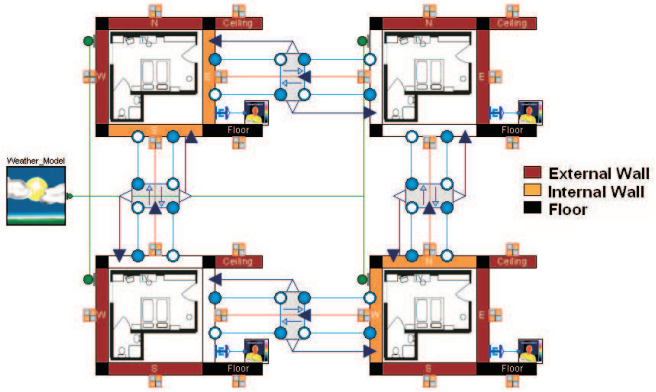
Weather Package
(weather model for annual simulation)

Zone Package

– Mobile Applications (aircraft and automotive cabin models)

– Stationary Applications (building simulation models including simple HVAC systems)

– HVAC



Human Comfort

The **HumanComfort** Package includes mathematical methods and characteristic numbers in order to evaluate the thermal comfort in a building, automotive or aircraft cabin.

The HumanComfort Modelica-library was developed with respect to the following standards and guidelines:

DIN EN ISO 7730

Dutch Thermal Comfort Guideline

ASHRAE Standard 55

Main features:

– Local draft (DR)

– Vertical temperature differences (PD)

– Warm and cold floors, walls and ceiling (PD)

– Asymmetric radiation temperature

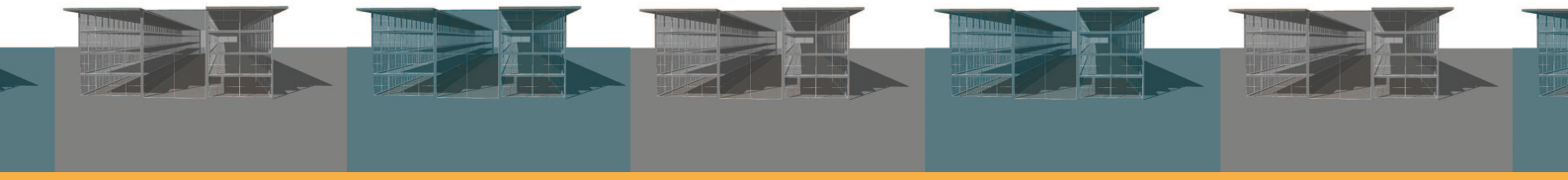
– Dynamic drift and ramps

– Acceptable operative temperature range

– TO - Exceeding temperature hours

– ATG - Adaptive temperature limits

– GTO - Weighted temperature exceeding hours



Library Content

Global Package

Adapter
Interfaces
Icons
Types

HumanComfort Package

Functions and Models

PMV and PMV_DIN
The Predicted Mean Vote (PMV) is an index that predicts the mean value of the votes of a large group of persons on the seven-point thermal sensation scale. The predicted mean vote (PMV) model uses heat balance principles to relate the seven key factors for thermal comfort to the average response of people.

PPD
The Predicted Percentage of Dissatisfied (PPD) is an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people determined from PMV.

GTO
The Weighted Temperature Exceeding Hours (GTO) is the summation of counted and weighted PMV values of every hour of one year. For all hours were the PMV is higher then 0.5 or lower then -0.5 the GTO grows up.

TO 25 and TO 28
The calculation of temperature exceeding hours of the operative temperature. The Temperature Exceeding Hours (TO) method states that:

– during maximally 100 hours a year 25°C may be exceeded

– during maximally 10-20 hours a year 28°C may be exceeded

Library Content

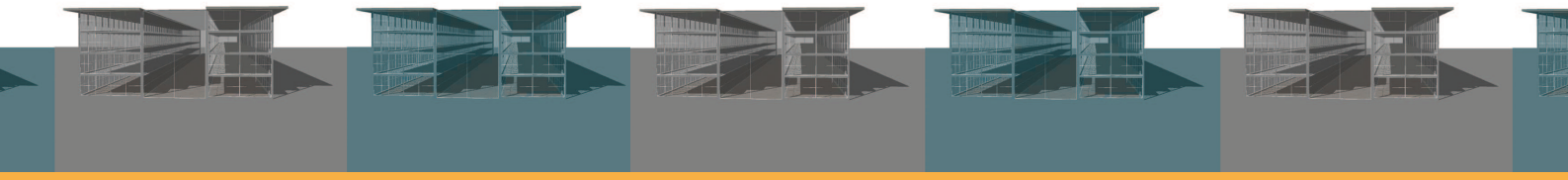
DynamicClothing
The DynamicClothing model enables the coherence between metabolic rate, the air velocity and clothing factor. The insulation effect of clothing depends on the movement of the occupant and the air velocity.

DAR
Limits on operative temperature drifts and ramps. Temperature drifts and ramps are monotonic, non-cyclic changes in operative temperature. Generally, drifts refer to passive temperature changes of the enclosed space, and ramps refer to actively controlled temperature changes.

DR
Draft is unwanted local cooling of the body caused by air movement. Draft sensation depends on the air speed, the air temperature, the turbulence intensity, the activity, and the clothing. Sensitivity to draft is greatest where the skin is not covered by clothing, especially the head region comprising the head, neck, and shoulders and the leg region comprising the ankles, feet, and legs.

PD_Asymmetry
The thermal radiation field about the body may be non-uniform due to hot and cold surfaces and direct sunlight. This asymmetry may cause local discomfort and reduce the thermal acceptability of the space. In general, people are more sensitive to asymmetric radiation caused by a warm ceiling than that caused by hot and cold vertical surfaces.

PD_vdT (Vertical Air Temperature Difference)
Thermal stratification that results in the air temperature at the head level being warmer than at the ankle level may cause thermal discomfort. This section specifies allowable differences between the air temperature at head level and the air temperature at ankle level.



Library Content

Records

Metabolic Rate
The metabolic rate describes the activity of people in conditioned spaces. It's the rate of transformation of chemical energy into heat and mechanical work by metabolic activities within an organism, usually expressed in terms of unit area of the total body surface.

Clothing
The insulation (Clothing) is the resistance to sensible heat transfer provided by a clothing ensemble.

Visualizations
All visualizations are prepared to use them by drag and drop from library. The animations are carried out by moving bars, points or lines of the characteristic numbers at the diagram layer.

Zones Package

– A mixed control volume to describe the internal air

– Air exchange model for the calculation of air mass flow rates between two zones Ambient boundaries models are used to ensure a pressure compensation to ambience

– Ambient air source models are used for controlled air ventilation or for the air exchange to ambience

– Convective heat transfer models

– Conductive heat transfer models

– Models for the calculation of reflection, absorption and transmission effects of solar radiation

– Partition model for walls and windows

Library Content

– Pressure loss models for the pressure compensation between different zones

– Long wave heat radiation model to consider the internal heat exchange between all visible surfaces

– Pre-designed input records for surface roughness, long and short wave absorption, reflection and transmission

– Pre-designed input records to define the layer set up of walls and windows

– Functions to calculate the mean radiant temperature

– Room and automotive models are the main models of the zone package and they are a combination of all base classes of the zone package

Weather Package

– The weather package provides several ambient conditions by reading an external text file. The main weather model provides the transformation of the main ambient values (humidity, temperatures and radiation). The weather data base resolution is hourly to fulfil the standards requirements.

– The absorption model calculates the specific solar radiation to all external surfaces.

Distribution

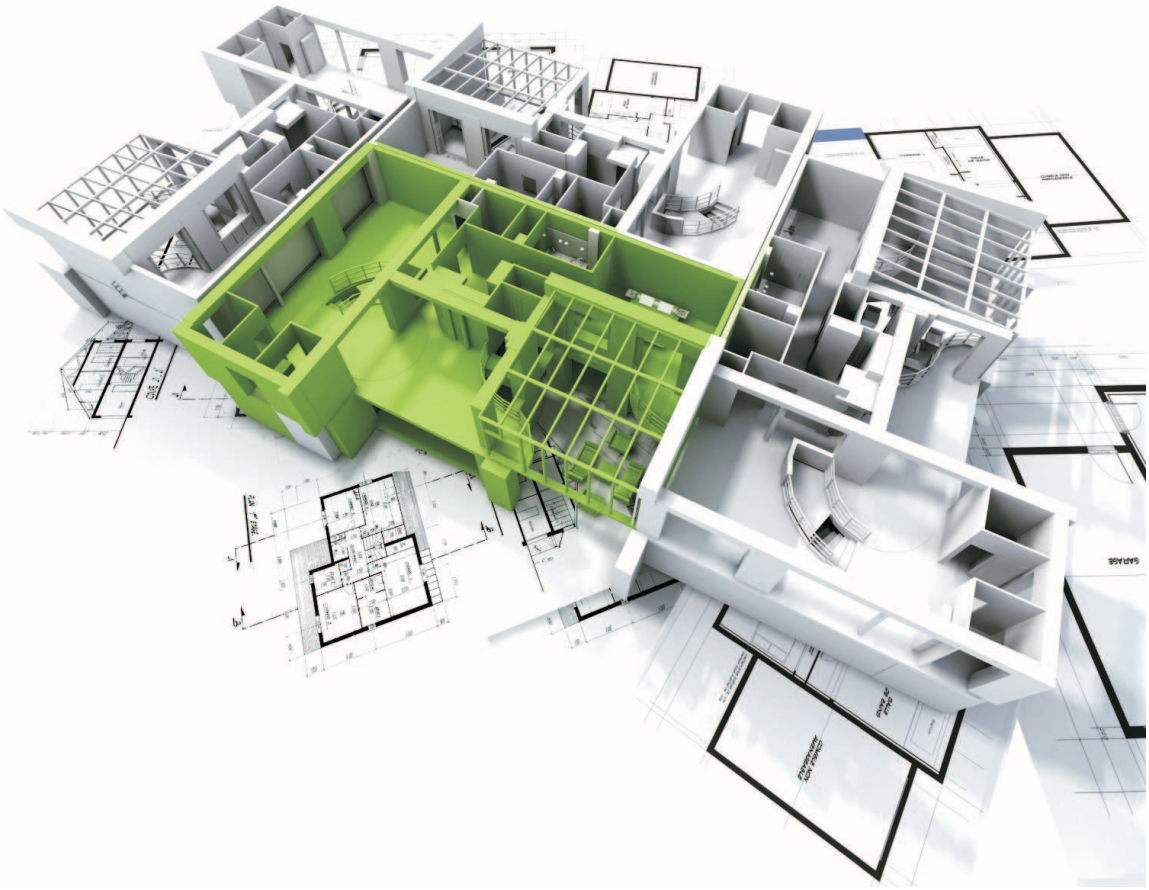
BAUSCH-GALL GmbH
Wohlfartstraße 21 b
80939 München (Germany)

Phone +49 89 32 32 625
Internet www.bausch-gall.de
Email info@bausch-gall.de

Support

XRG Simulation GmbH
Harburger Schlossstraße 6–12
21079 Hamburg (Germany)

Internet www.xrg-simulation.de
Email humancomfort@xrg-simulation.de



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