STAR European Conference 2011

AleniaAeronautica
A Finmeccanica Company

Oggetto: **Aircraft passenger cabin thermal comfort analysis by means of integrated mono dimensional-CFD approach**

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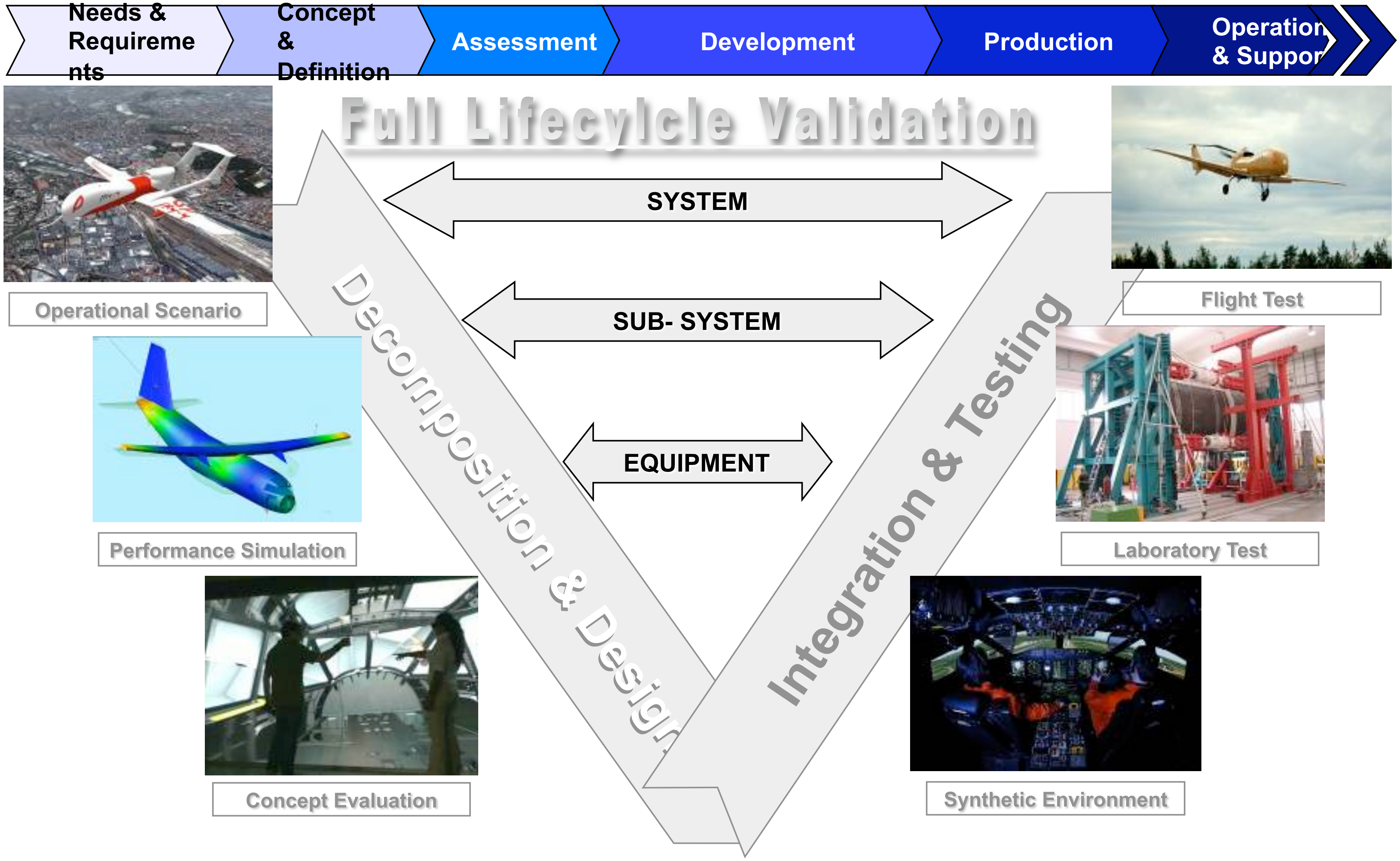
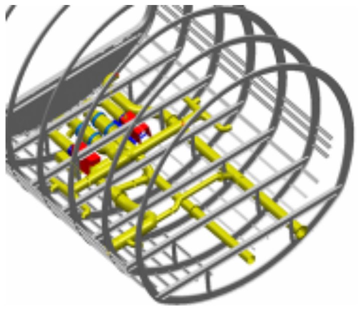
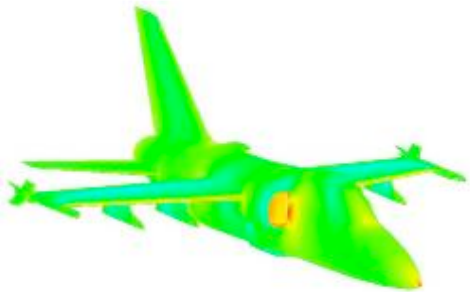
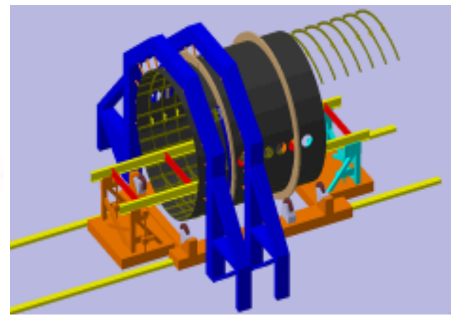
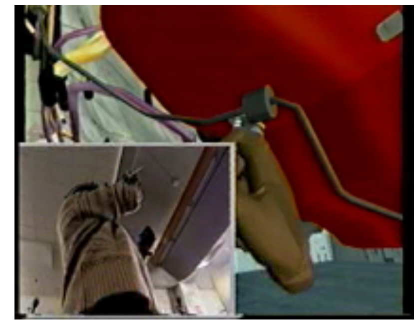
Virtual Prototyping in A&D PLM

Virtual Prototyping covers the full lifecycle development and the validation process

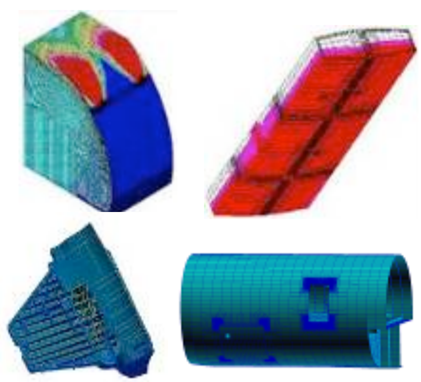


Virtual Prototyping in A&D PLM

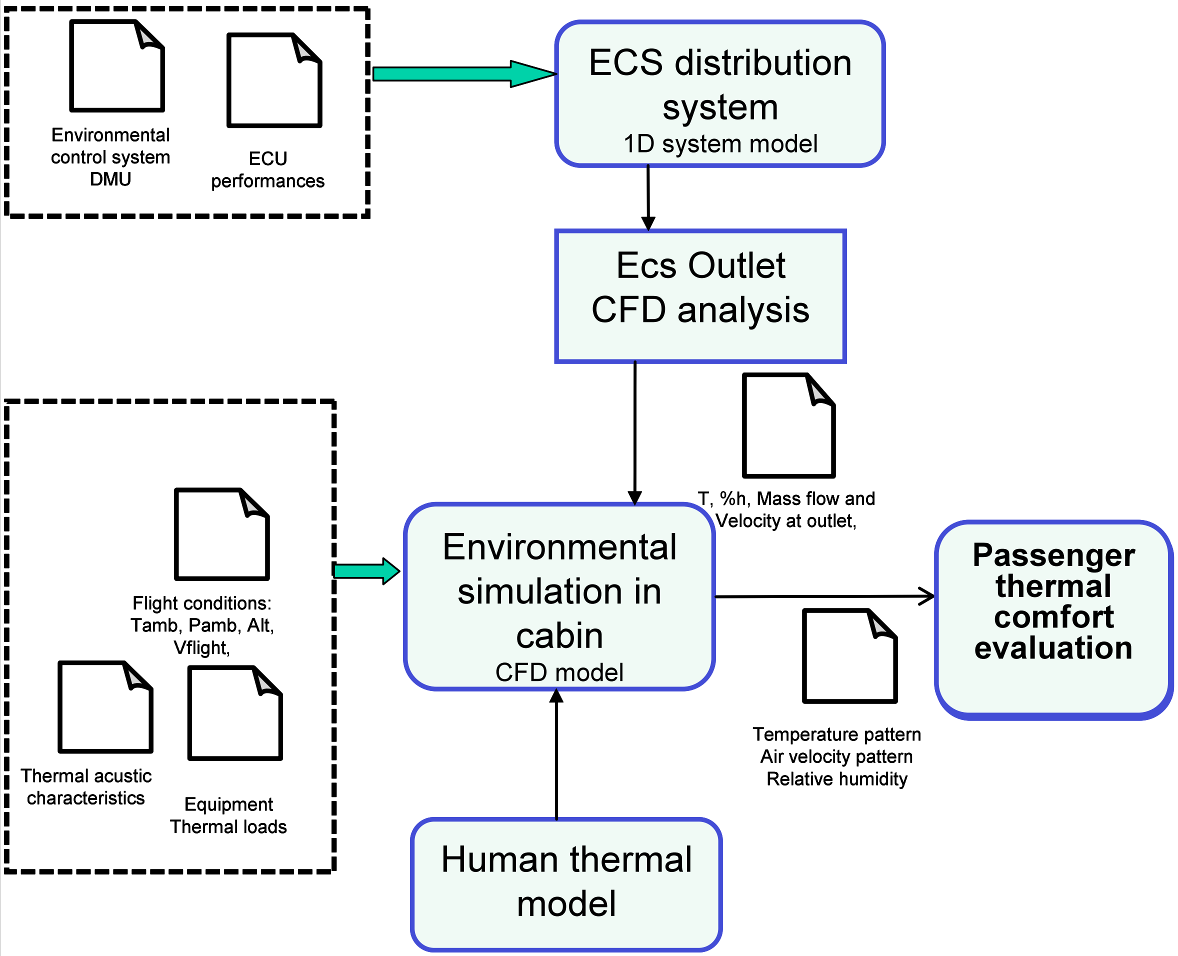
Virtual & Physical Prototyping & Simulation Extension and Coverage

Virtual Product	*Virtual Laboratory*	*Virtual Manufacturing*	*Virtual Utilization*
			
Concept	***Performance***	***Industrialization***	***Operation***

Vision → *Concept* → *Experienc e* → *Definition* → *Synthesis* → *Manufacturing* → *Maintenance* → *Recycling*

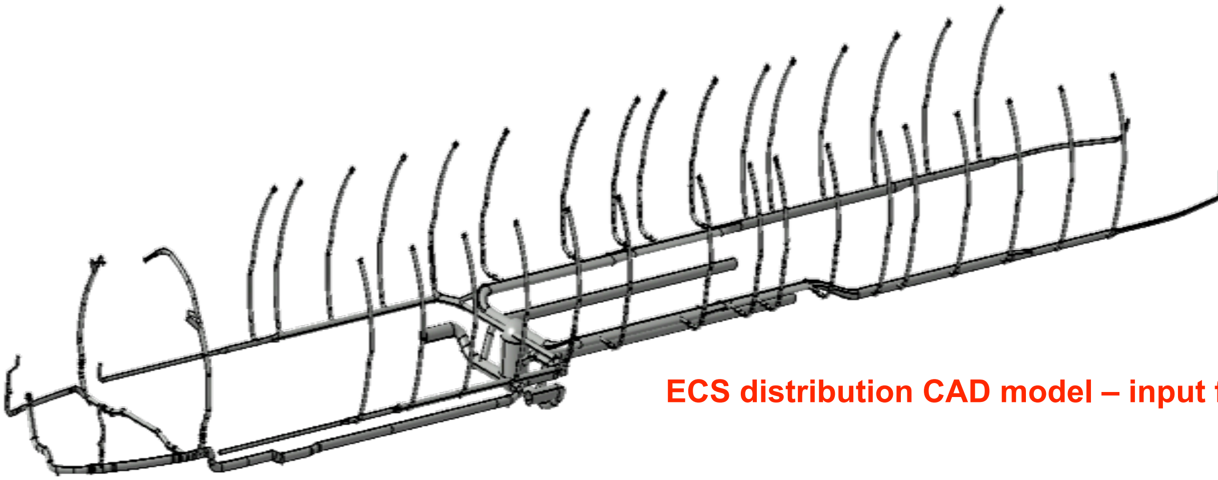
			
High Power Computing	***Multi-disciplinary Simulation***	***Process, Data & Knowledge Management***	***Full Scale Testing***

ECS distribution design and integration – a process view

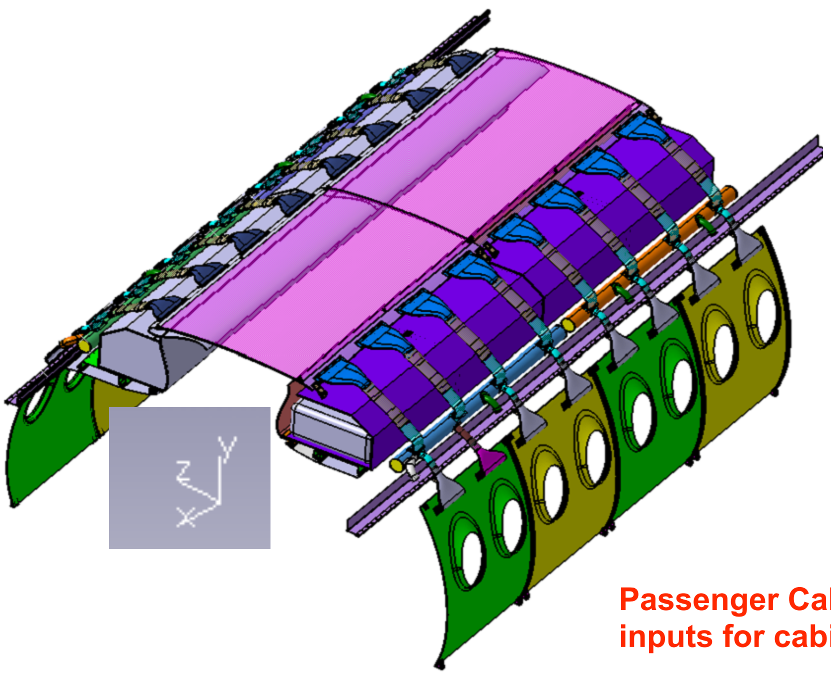


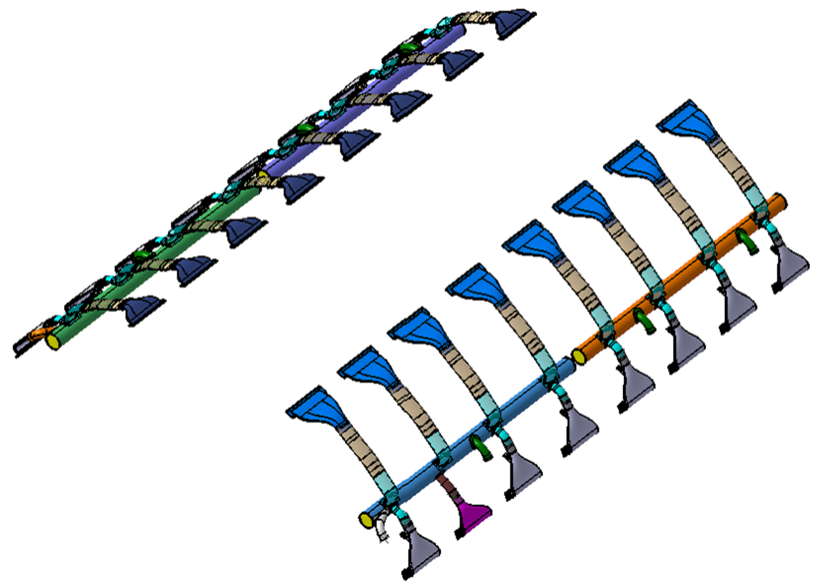
- Integrated 1D – CFD process view for the evaluation of thermal comfort in a passenger cabin environment
- Methodologies integration: taking the advantage of system-level and CFD methods to ensure that the simulation process is Fit For Purpose
- Parameters relevant for passenger thermal comfort:
  - outlets geometry, positioning and orientation (direct impinging air on the passengers);
  - ECS distribution system architecture (airflow splitting);
  - Thermo-acoustic configuration.

CAD models



ECS distribution CAD model – input for ECS distribution system 1D model

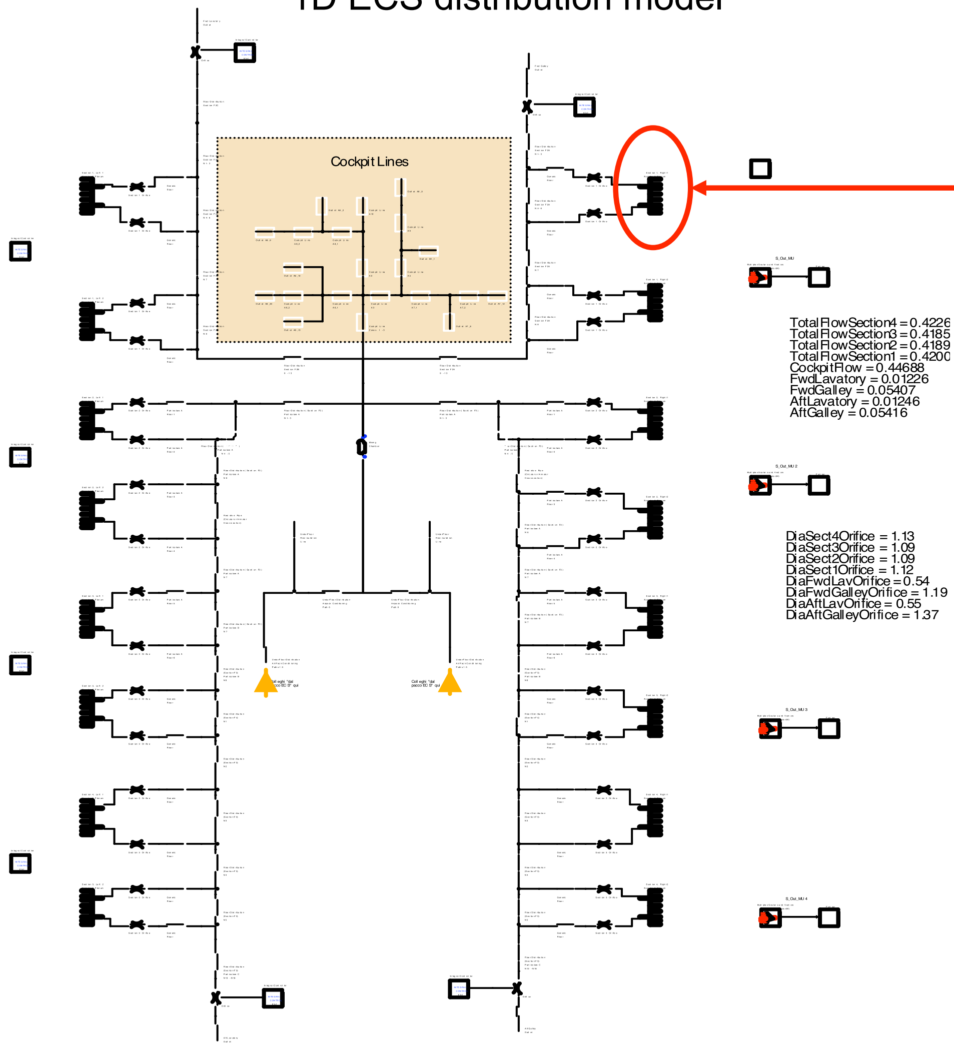




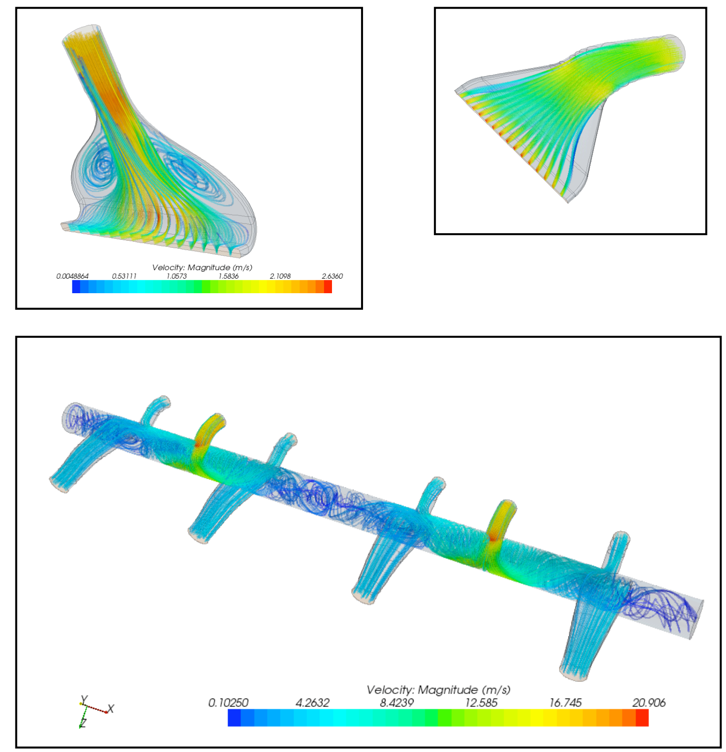
Passenger Cabin interiors and ECS final distribution CAD model inputs for cabin outlets CFD model and cabin CFD model

ECS distribution system and components models

1D ECS distribution model

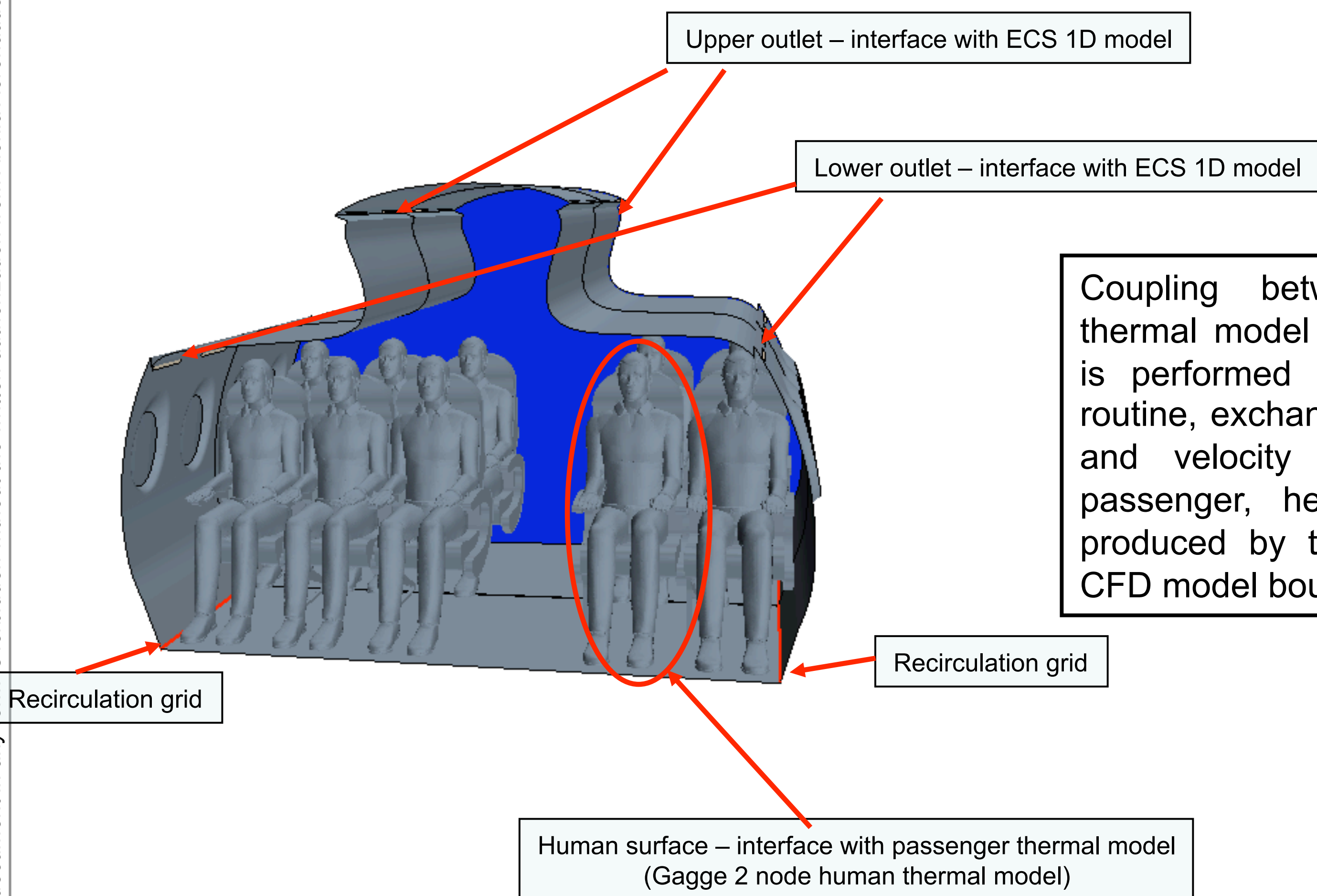


CFD ECS components model



Coupling between 1D ECS distribution system and CFD ECS components by means of components pneumatic characteriazion ($\sigma\Delta P$ – W curves)

Passenger cabin and thermal comfort models



Coupling between 1D passenger thermal model and cabin CFD model is performed by means of a Java routine, exchanging data (temperature and velocity distribution near the passenger, heat flux and humidity produced by the passenger) on the CFD model boundaries

Passenger thermal model – as is

The model considers the control of body temperature to be accomplished by means of skin temperature and central core body temperature.

Inputs to the model:

- Metabolic rate
- Work rate
- Intrinsic clothing insulation
- Velocity of air around body
- Barometric pressure
- Ambient air temperature
- Mean radiant temperature (in first approximation considered equal to ambient air temperature
- Ambient vapour pressure

Other parameters:

- Body weight
- Body surface
- Ratio of body's radiating area to total surface area
- Minimum skin conductance
- Specific heat of blood
- Latent heat of water
- Specific heat of body
- Stefan-Boltzmann Costant
- Lewis Relation at sea level

Model outputs:

- Temperature of skin shell
- Central core temperature
- Total heat power from the human body to the environment
- Respired Convective Heat Loss
- Respired Evaporative Heat Loss
- Heat Loss for skin diffusion
- Total evaporative heat loss
- Ratio of mass skin shell to mass central core
- Skin blood flow
- Unevaporated sweat
- Rate total water evaporated (by respiration, pespiration, sweat)
- ASHRAE Effective Temperature

Inputs from CFD model

Outputs to the CFD model

Passenger thermal model – to be

The model considers the control of body temperature to be accomplished by means of skin temperature and central core body temperature.

Inputs to the model:

- Metabolic rate
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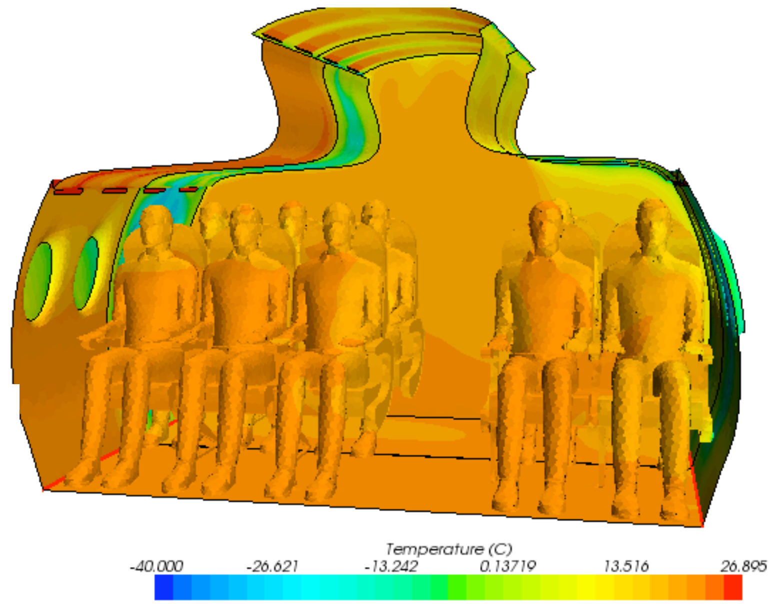
Inputs from CFD model

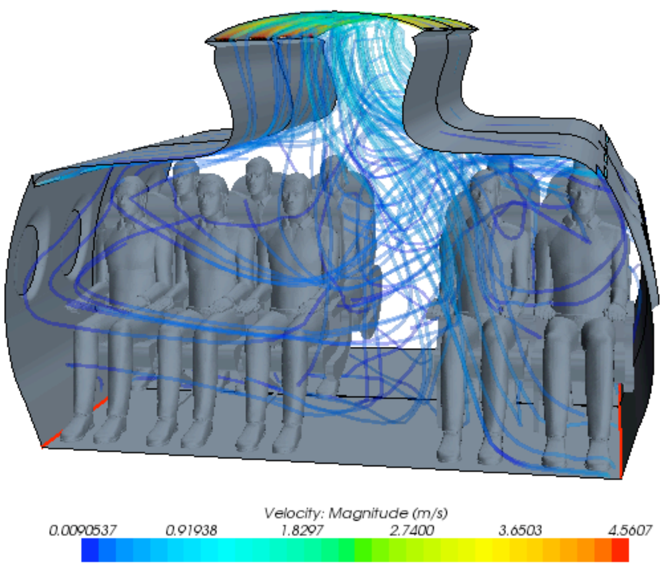
Outputs to the CFD model

ECS distribution design and integration – preliminary results

Mesh model (approx 10^7 cells)



Temperature pattern



Velocity streamlines

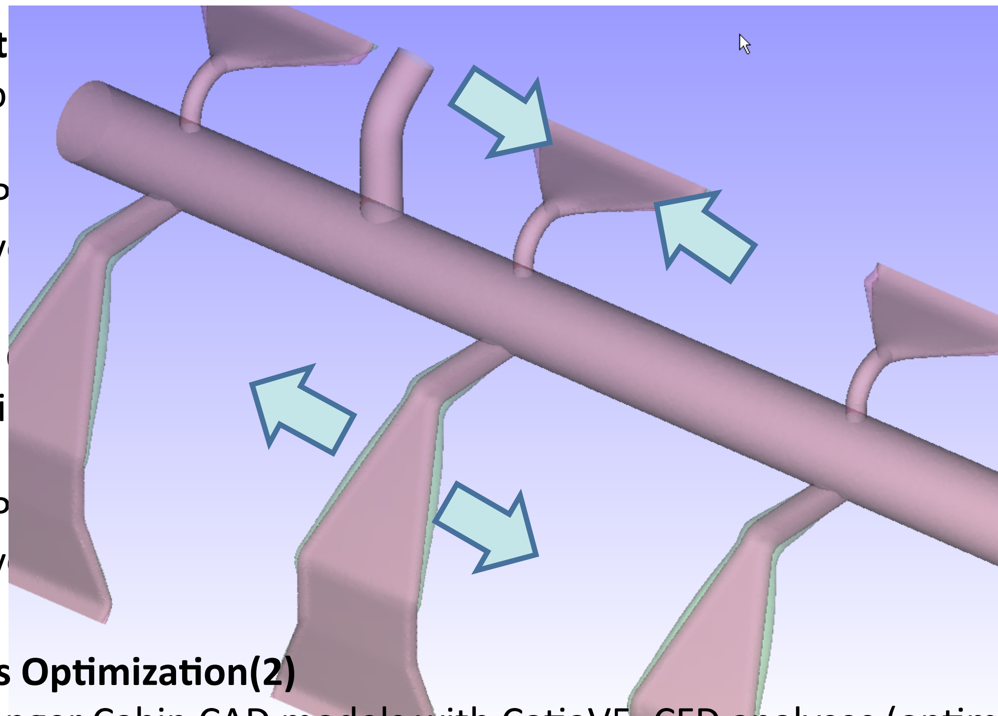
ECS distribution design and integration – next steps

Cabin air distribution system thermo-fluid dynamic and acoustic optimization

Low Pressure Dist

Parametric 1D mo ptimization on parametric models)

1. Design P
2. Objectiv



Cabin Air Outlets

Non parametric ai tion using morphing technique)

1. Design P
2. Objectiv

Cabin Air Outlets Optimization(2)

Parametric Passenger Cabin CAD models with CatiaV5, CFD analyses (optimization on parametric models)

1. Design Parameters: air outlets location and orientation
2. Objectives: air velocity field in the allowed range (max. 70 fpm at head level in seated position, minimum 10 fpm), minimization of the mean velocity differences among each passenger, head-foot temperature difference minimization

Thank you!

** PUBLIC **