Coupling GT-SUITE and TAITherm to Accelerate Cabin Simulations

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Agenda

o Cabin Modeling in CAE/CFD World

o Software Introduction

o Proposed Methodology

o Validation Problem

o Results

o Future Development

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Cabin Modeling in CAE/CFD World

o Common approaches used to model cabins:

Resolution	Speed	Accuracy	
		Fuel Economy	Comfort
Single Volume	+++	++	--
~2- 20 Volumes	++	++	-
CFD (millions of volumes)	---	N/A (too slow)	++

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Cabin Modeling in CAE/CFD World

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Resolution	Speed	Accuracy	
		Fuel Economy	Comfort
Single Volume	+++	++	--
~2- 20 Volumes	++	++	-
20 – 10k Volumes	+	++	+
CFD (millions of volumes)	---	N/A (too slow)	++

Proposed Solution

o Develop capability for TAITherm and GT-SUITE cosimulation to leverage each tool's strength

o Combined solution will offer what is missing in the market today
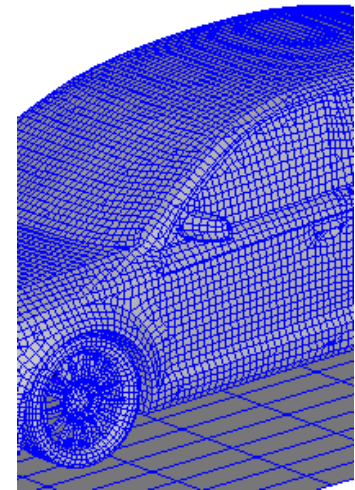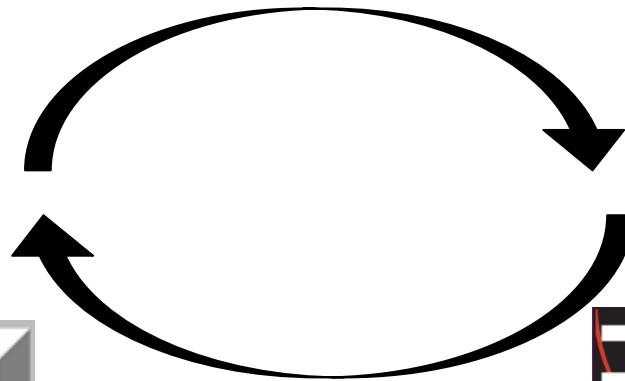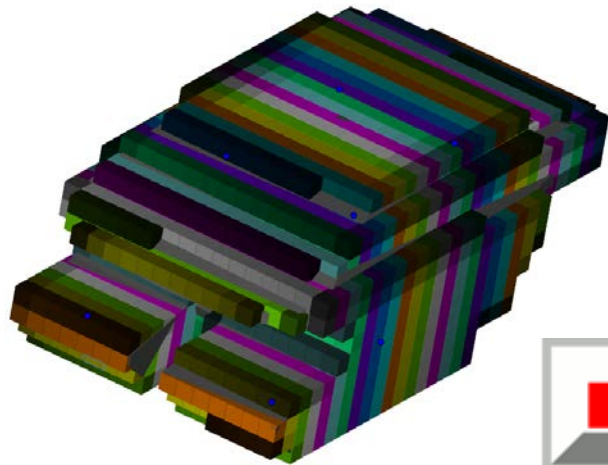
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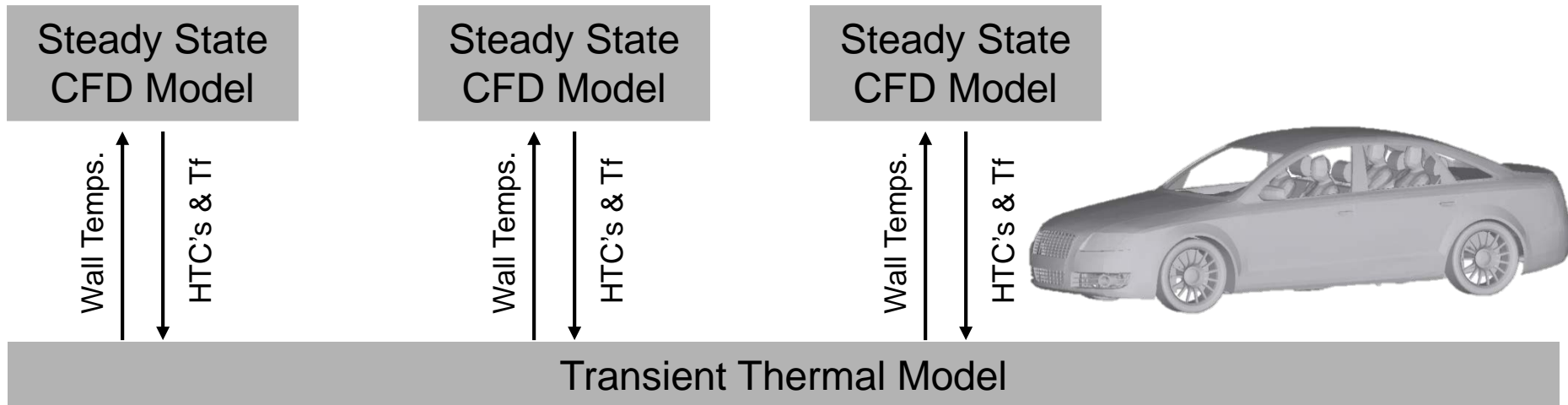o Future Development

Introduction to TAITherm

o TAITherm is a complete 3D thermal simulation tool

   o Can model all 3 modes of heat transfer

      o Conduction

      o Convection

      o Radiation

   o Industry leading natural weather model

      o Considers dynamic solar position and changing environment

o TAITherm is extremely fast for both steady state and transient problems

Current Methodology with TAITherm

o The current methodology calls for coupling steady state CFD solutions to a transient thermal solution

  o This is more generally referred to a Quasi-Transient coupling

    o This helps accelerate the solution since CFD is computationally expensive compared to a thermal

| Steady State CFD Model | Steady State CFD Model | Steady State CFD Model |

Wall Temps. ↑ HTC's & Tf ↓   Wall Temps. ↑ HTC's & Tf ↓   Wall Temps. ↑ HTC's & Tf ↓

Transient Thermal Model

Current Methodology in GT-SUITE

o Spatially resolved flow meshing is available in GT-SUITE via COOL3D

o Provide sufficient flow resolution and speed

o Still lacks full 3D radiation solution
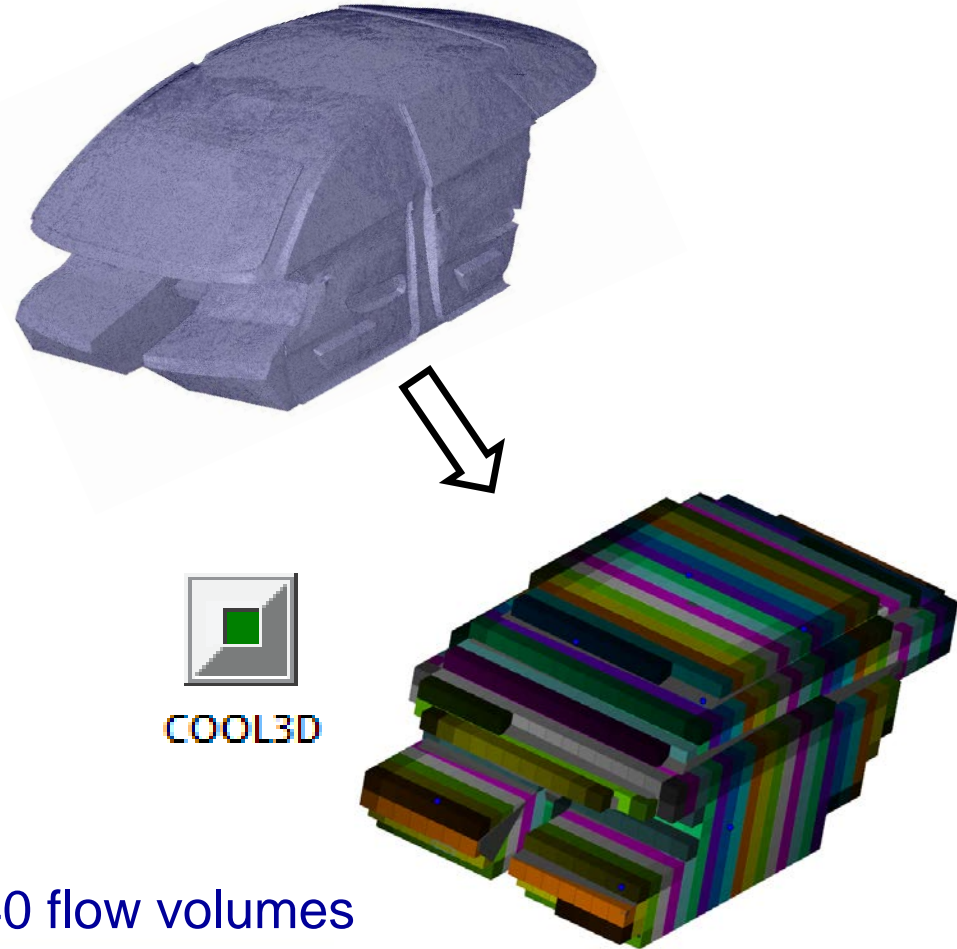
COOL3D

1340 flow volumes

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Coupling Methodology

o Running a coupled simulation incorporates the following tasks:

  o Geometry

  o Model Setup

  o Data Exchange

  o Post-Processing

Geometry

o The same geometry should be used as input for meshing the TAITherm model as well as for meshing the GT-SUITE model
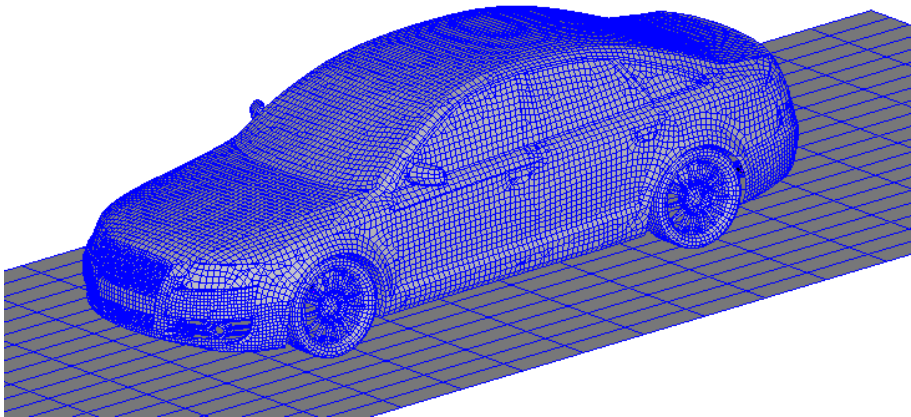

Geometry used in TAITherm
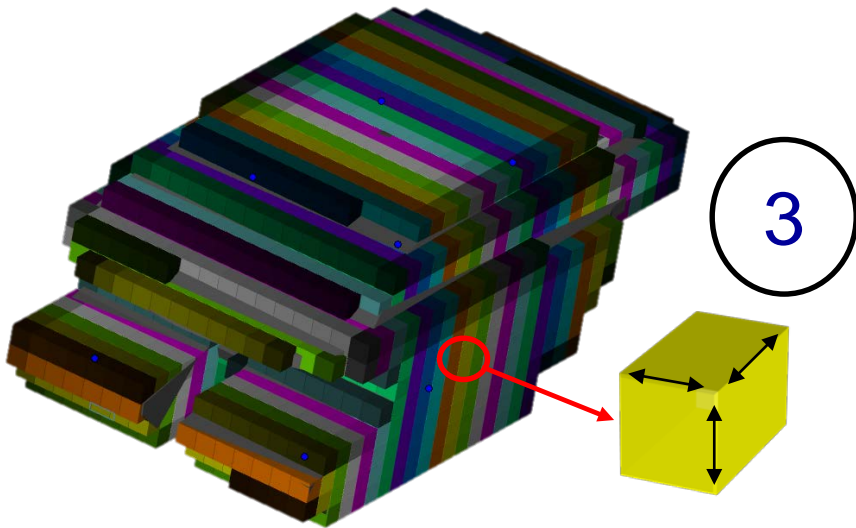

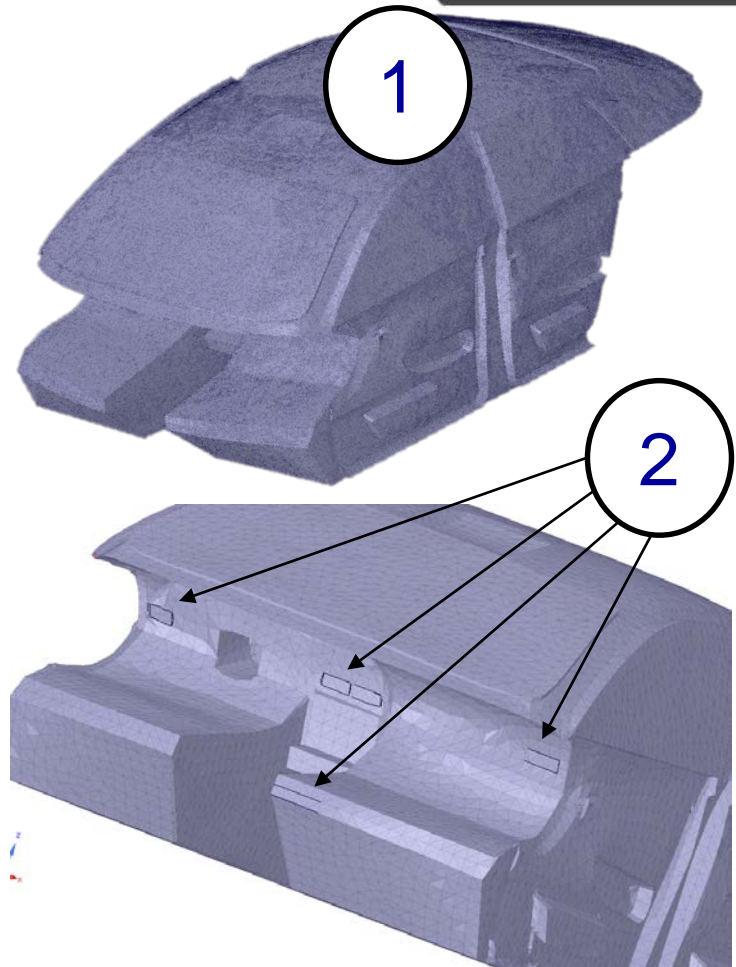
Inner Flow Volume used in GT-SUITE

Model Setup - TAITherm

- 4 Occupants were modeled using the TAITherm Human Thermal Module

  - Occupants act as heat and humidity sources

  - Occupant comfort is the primary drive of the AC system, thus sizing the AC to ensure occupant comfort is paramount

- The TAITherm human thermal model uses 3D segmented human, with specialized physiology models

  - Predicts skin and Core temperatures
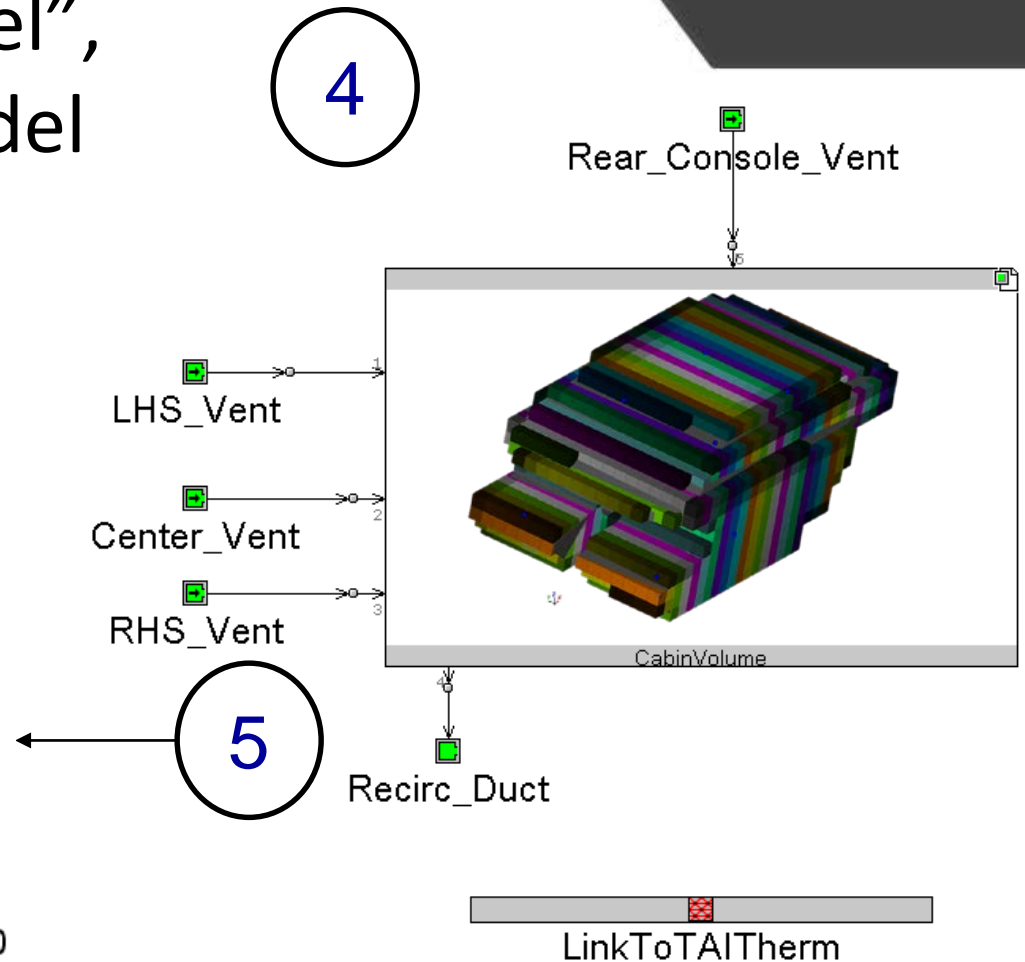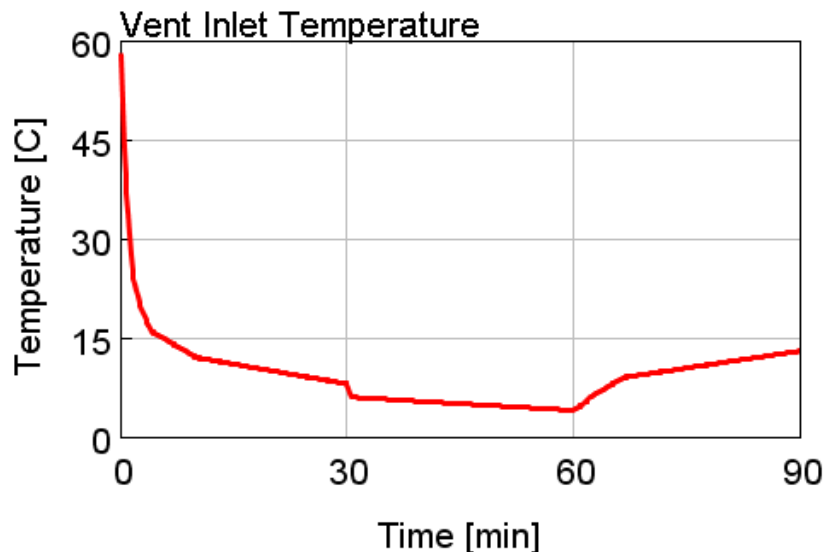
  - Sensation & Comfort metrics

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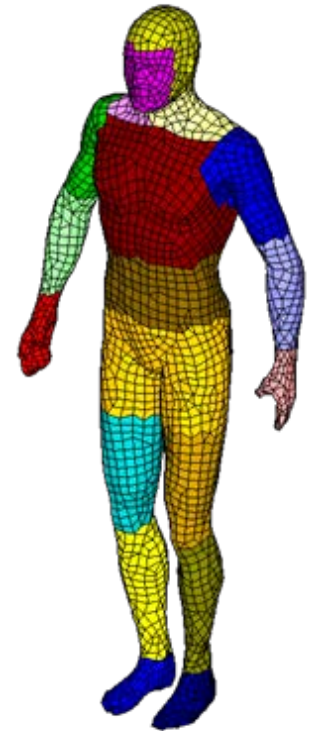
Model Setup – GT-SUITE

1. Inner flow volume is imported into COOL3D

COOL3D

2. Air vents added

3. Discretization size chosen

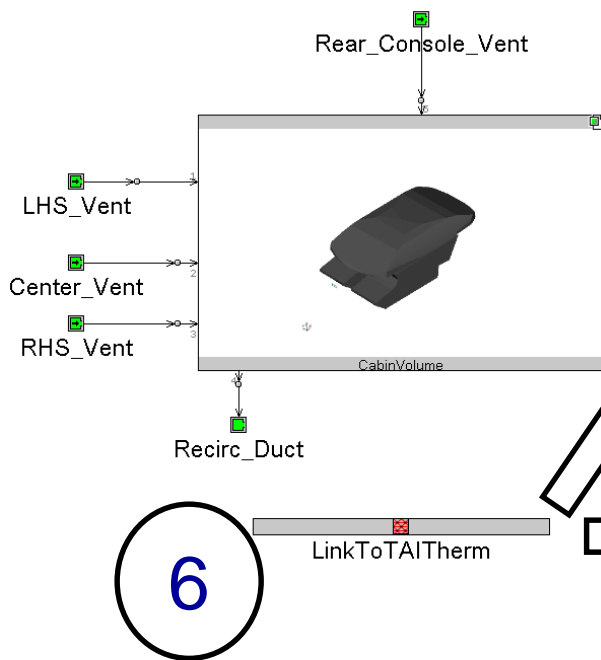# Model Setup – GT-SUITE

o 4. Set up "main model", refer to COOL3D model

o 5. Set up vent flow boundary conditions

4

Rear_Console_Vent

LHS_Vent

Center_Vent

RHS_Vent

CabinVolume

Recirc_Duct

LinkToTAITherm

5

Vent Inlet Temperature

Temperature [C]

Time [min]

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o 6. Set up cosimulation parameters

Mesh File (Nastran or Patran Neutral)		<FullMeshForGT.nas> ...
⊙	Select Single MatrixFlowSplit Part Associated with Mesh	CabinFlowSpace_001 ...
○	Select All MatrixFlowSplit Parts Associated With Mesh	

Attribute	Unit	Object Value
Initial Wall Temperature (Before Cosim)	K ▼	def (=Fluid Temp) ...
Cosim Inputs		
TAITherm Executable		<.../taitherm-12.1.exe> ...
TAITherm Model File		<TAITherm_Model.tdf> ...
Time before First Data Exchange	s ▼	10 ...
Communication Interval (after 1st exchange)	s ▼	10 ...

Rear_Console_Vent

LHS_Vent

Center_Vent

RHS_Vent

CabinVolume

Recirc_Duct

6

LinkToTAITherm

Data Exchange

o Physical domain responsibilities:

   o **Flow**: GT-SUITE

   o **Thermal**: TAITherm

o "Transient-Transient" cosim to exchange data
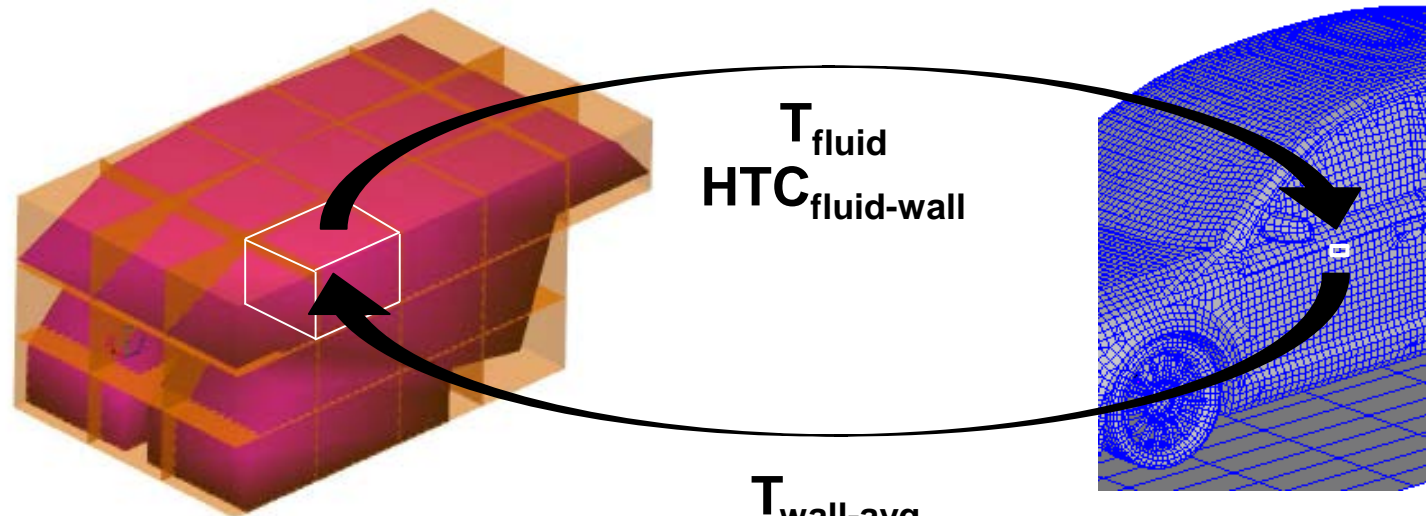
$$T_{fluid}$$
$$HTC_{fluid-wall}$$

$$T_{wall-avg}$$
(over fluid face)

GT "Fluid Cube"
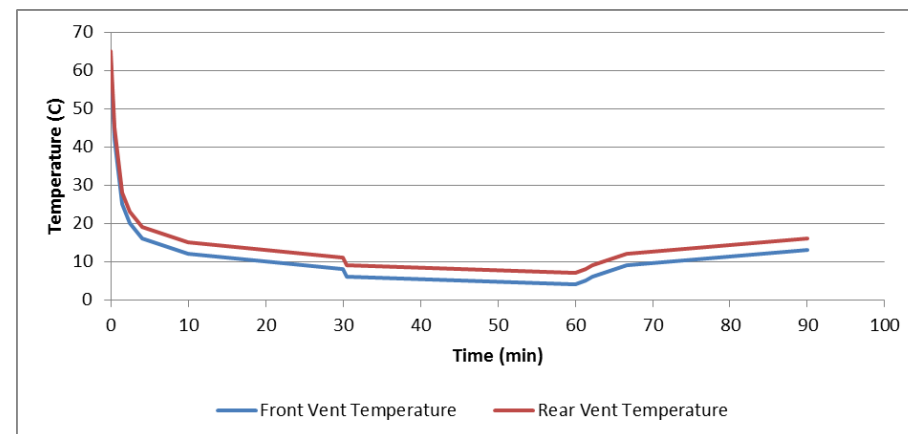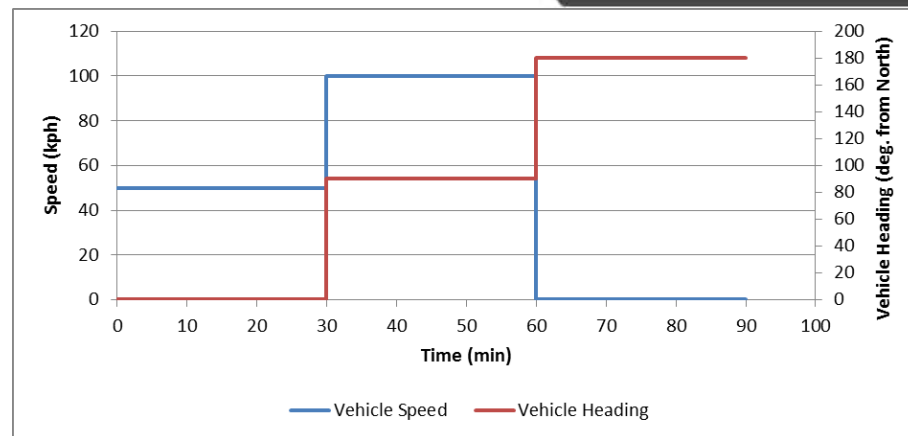
TAITherm "Element"

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Validation Problem

o Long term soak, followed by 60 minutes of driving and a 30 minute idle

   o Two right turns made during the cycle

o Temperature at vent inlets specified over time

o Each vent's mass flow rate was constant throughout the cycle

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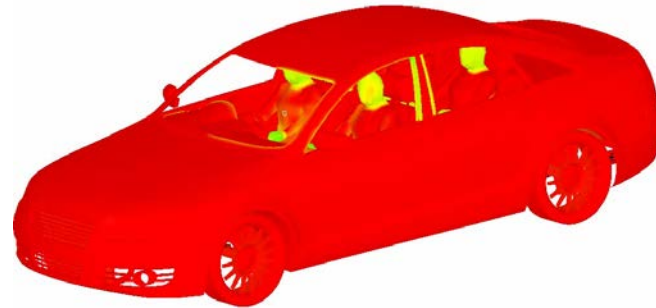# Results – Structure Temperatures

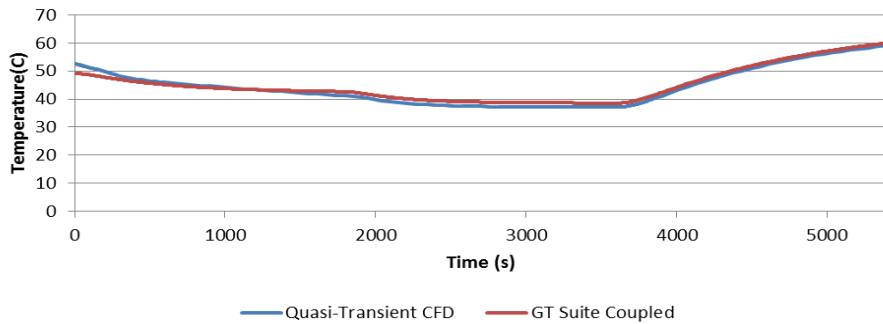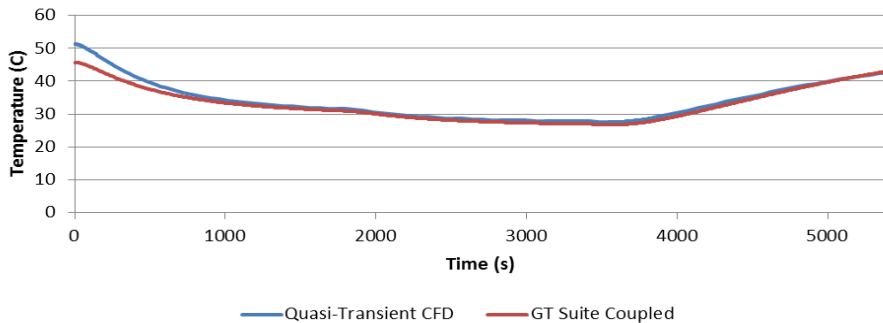|	Coupled with CFD	Coupled with GT-SUITE
Model Run Time	23 hours	1 hour 9 minutes

Coupled With:

Dash Probe Temperature

CFD

Center Console

GT

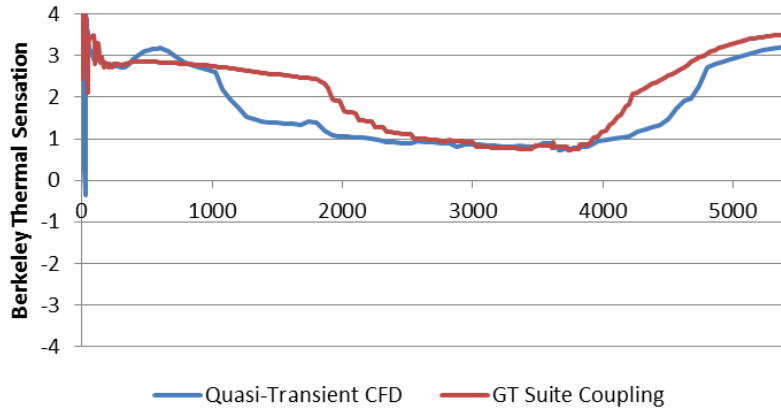# Results – Comfort & Human

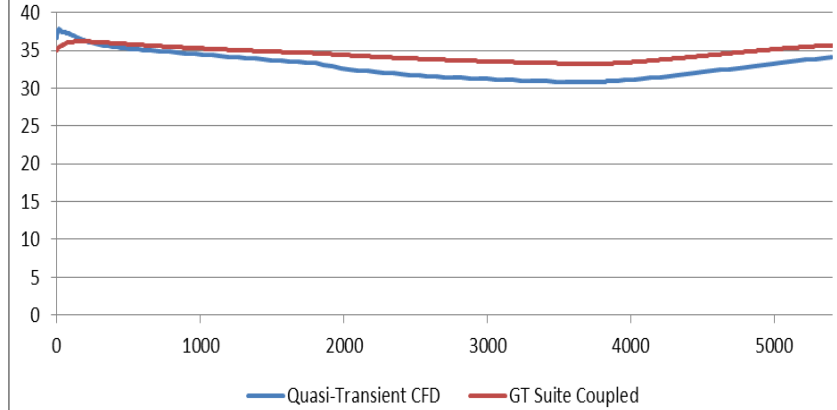|	Coupled with CFD	Coupled with GT-SUITE
Model Run Time	23 hours	1 hour 9 minutes

Overall Sensation

Driver Face Skin Temperature

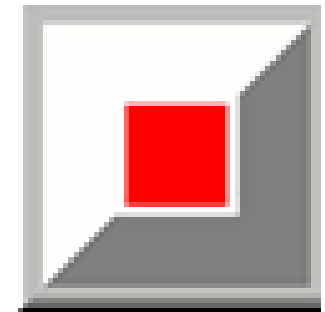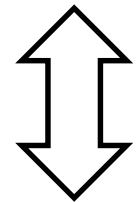GT Gamma Technologies

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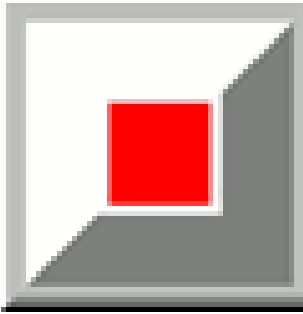- Results
- **Future Development**

Conclusions and Future Development

o New method couples GT-SUITE and TAITherm for cabin simulation, addressing concerns of existing methods

o Compared against CFD; next step is to validate against data with partner OEM

o Faster than Real-Time, great potential for more speed up

o Future work: Apply coupling to...
  o Under-hood and exhaust
  o Braking
  o Engines

Release & Technical Contacts

o Feature to be released in **early 2016**

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