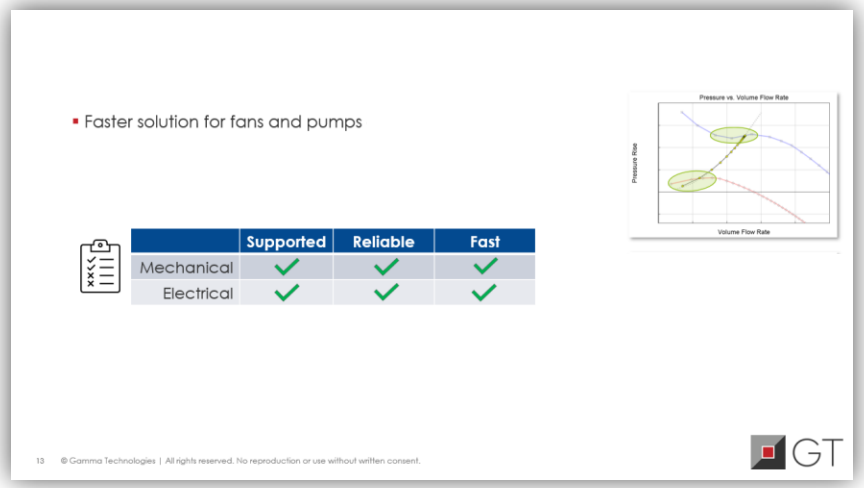
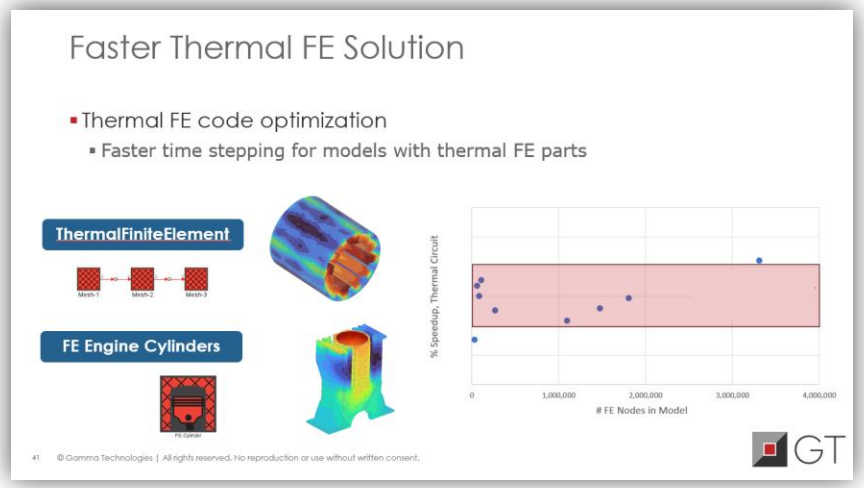
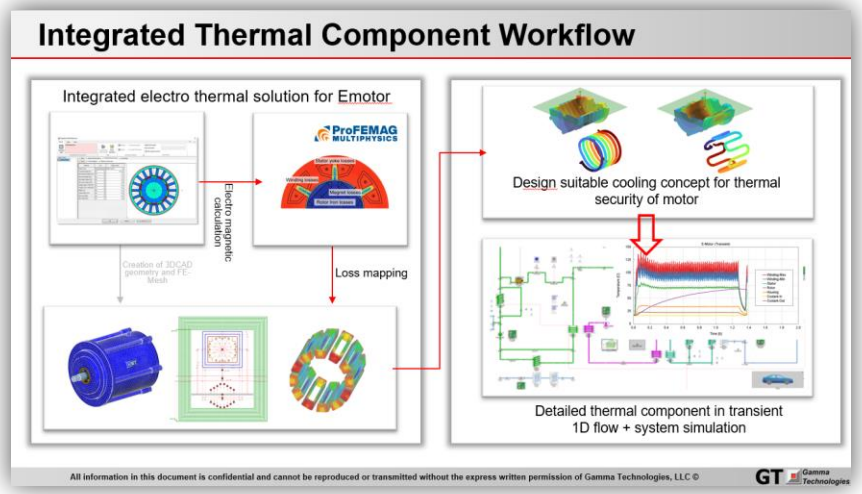
Cool Innovations: Navigating the Future of Thermal Management

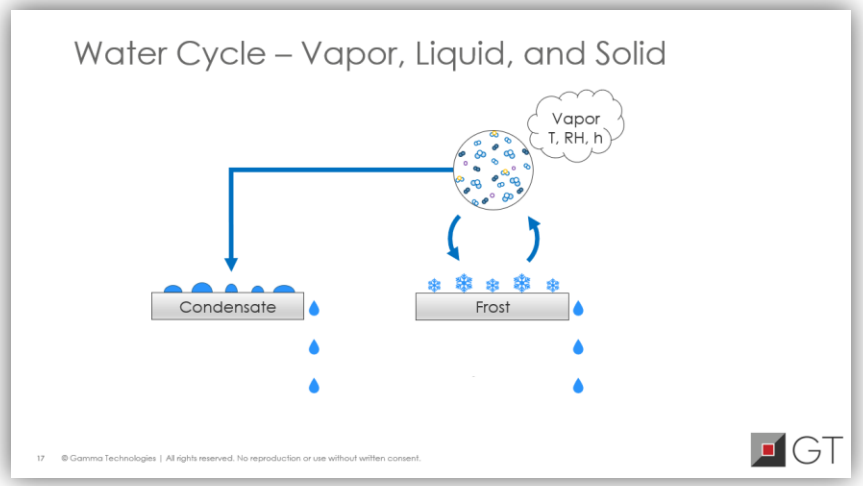
GAMMA TECHNOLOGIES

Leveraging System Agnostic Thermal Simulation

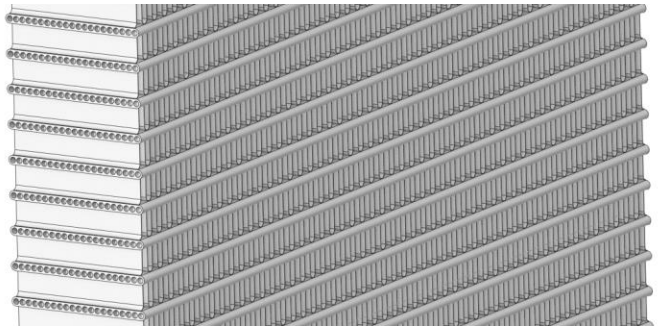




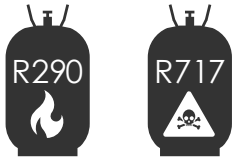




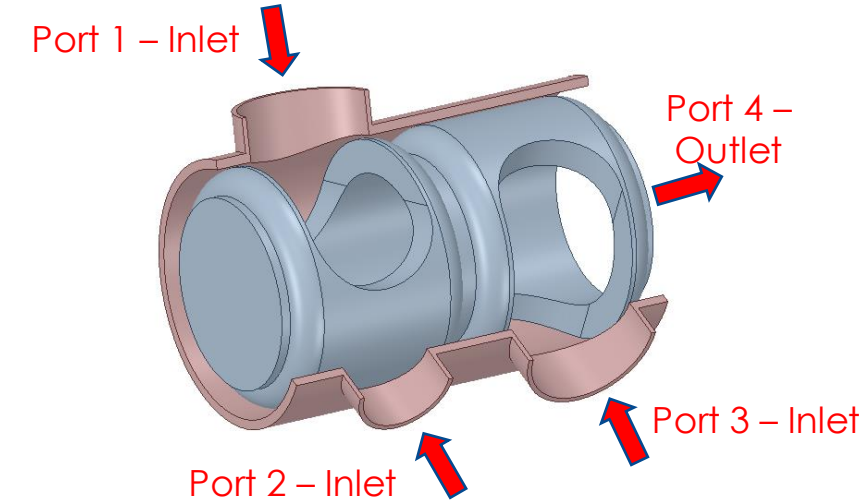
Advanced Cooling Technologies



Micro channel heat exchangers
& other components

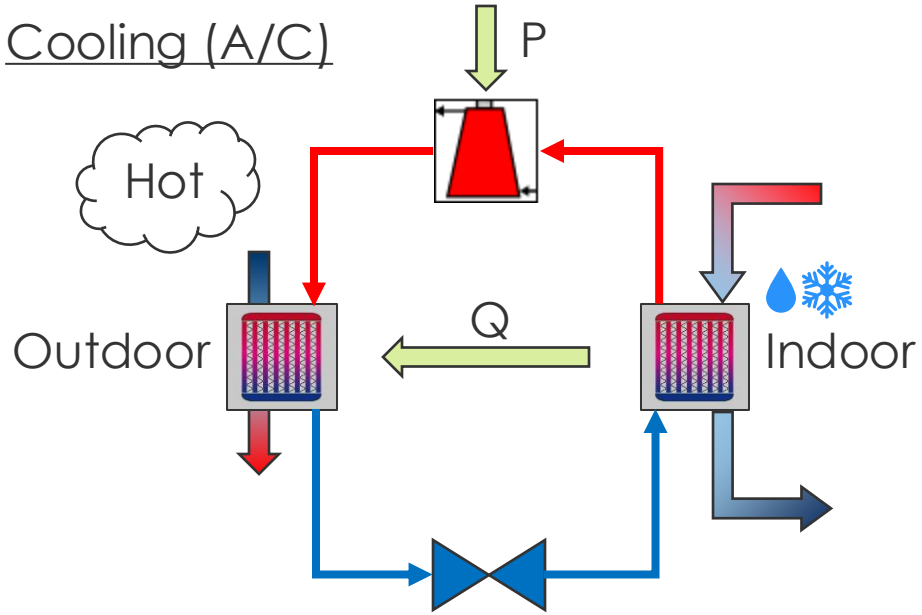


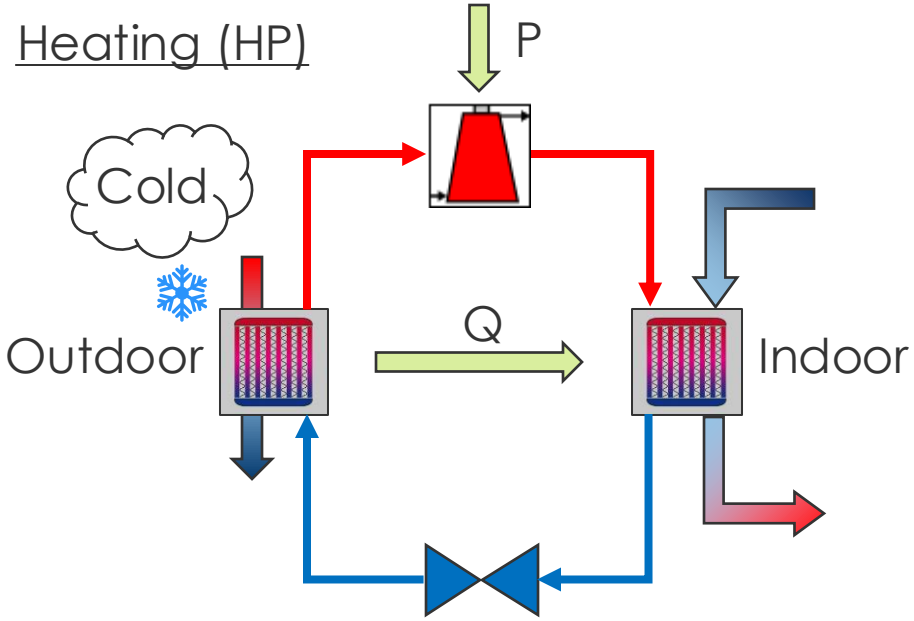
Advanced coolants & refrigerants



Packaging & integration of functions

Heat Pump (HP) Systems

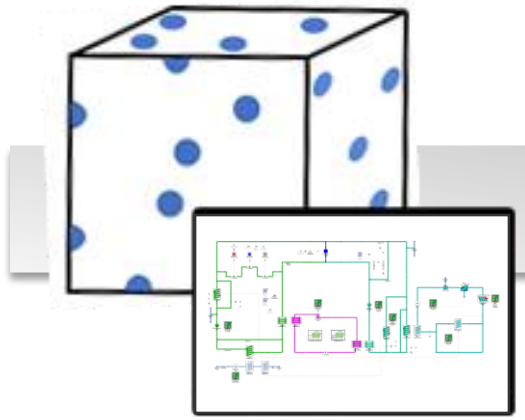




- Advantage:
  - Very efficient – reuse existing HVAC system
  - Positive impact on range
- Challenges:
  - Frost can develop on Indoor (Cooling) or Outdoor (Heating) HX
  - Integration and control
  - Costs

Machine Learning in Solutions

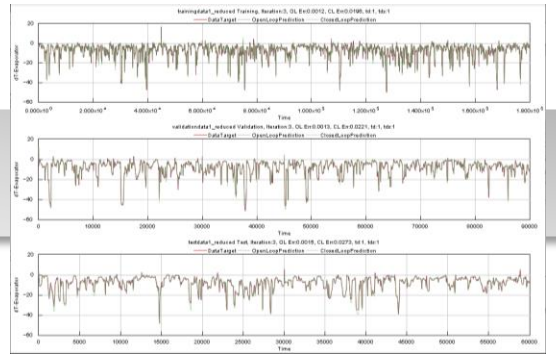
Thermal management model



Design Of Expertiment:

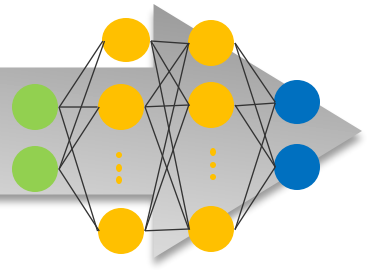
- *5 drive cycle, operating points*
- $T_{amb} = [258,313]\text{K}$

Training



Neural network for prediction of key thermal management model responses

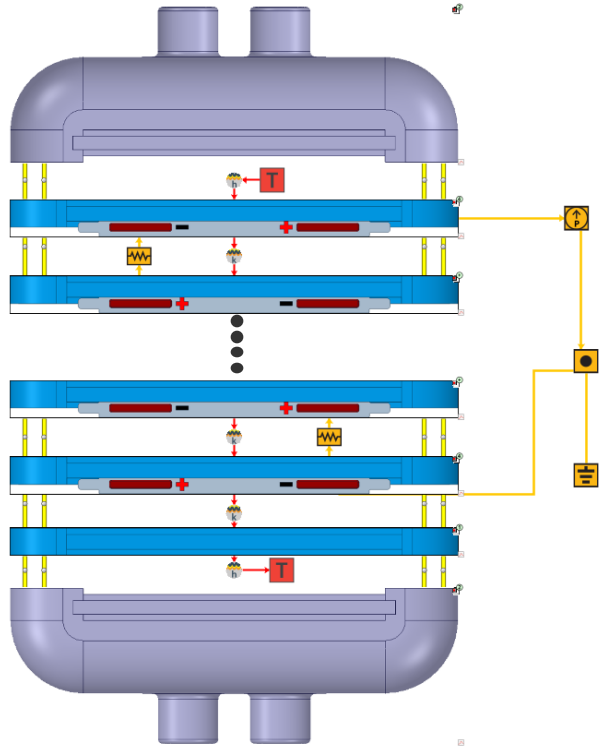
Meta Model



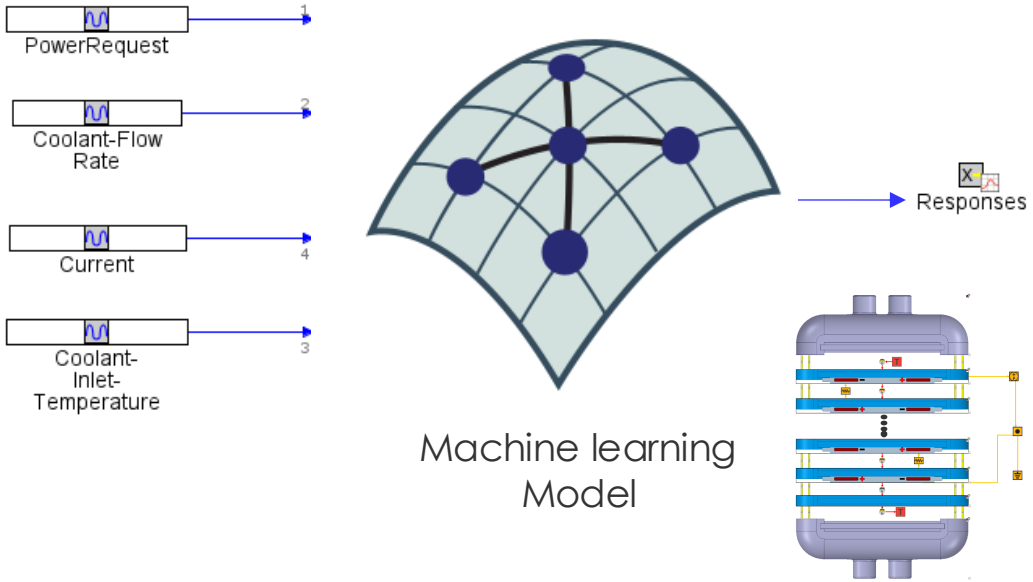
Responses:
$T_{Bat}, P_{VTM,DC}, P_{VTM,AC}$
Factors:
$v_{veh}, P_{total}, T_{amb}, SOC$

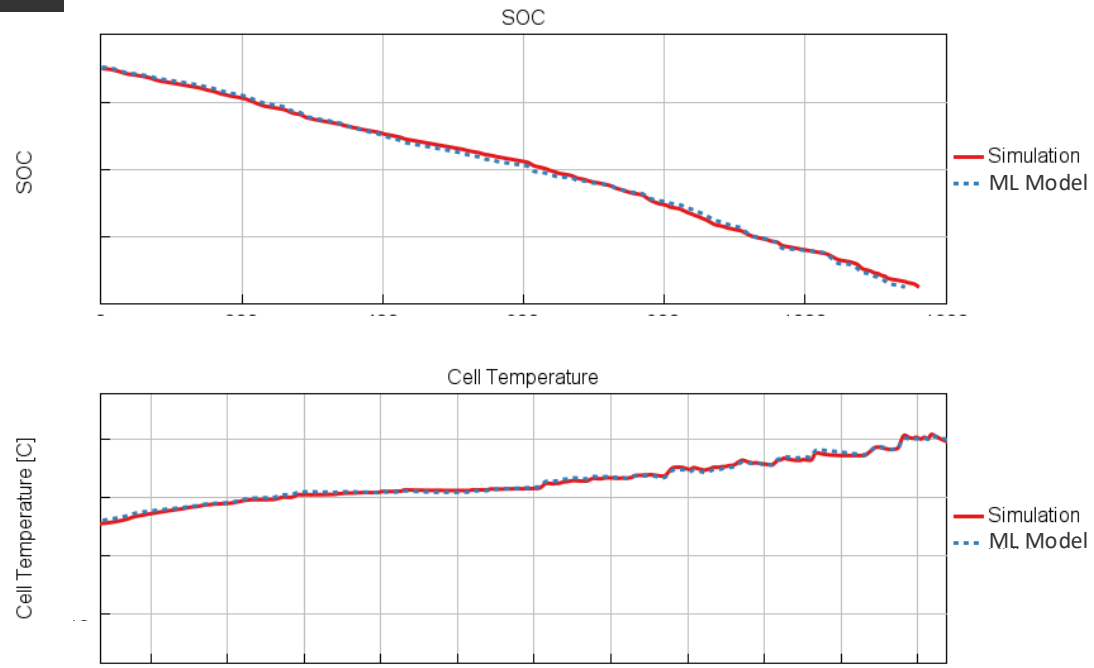
Opportunities when GT Model goes Machine Learning

- In GT-SUITE
  - Component aging and wear
  - Component calibration
  - Using information for testing
  - Using information form higher fidelity
  - …
- With GT-SUITE:
  - Very fast models for embedded systems
  - Virtual sensors
  - Virtual states
  - Detection of faults
  - …

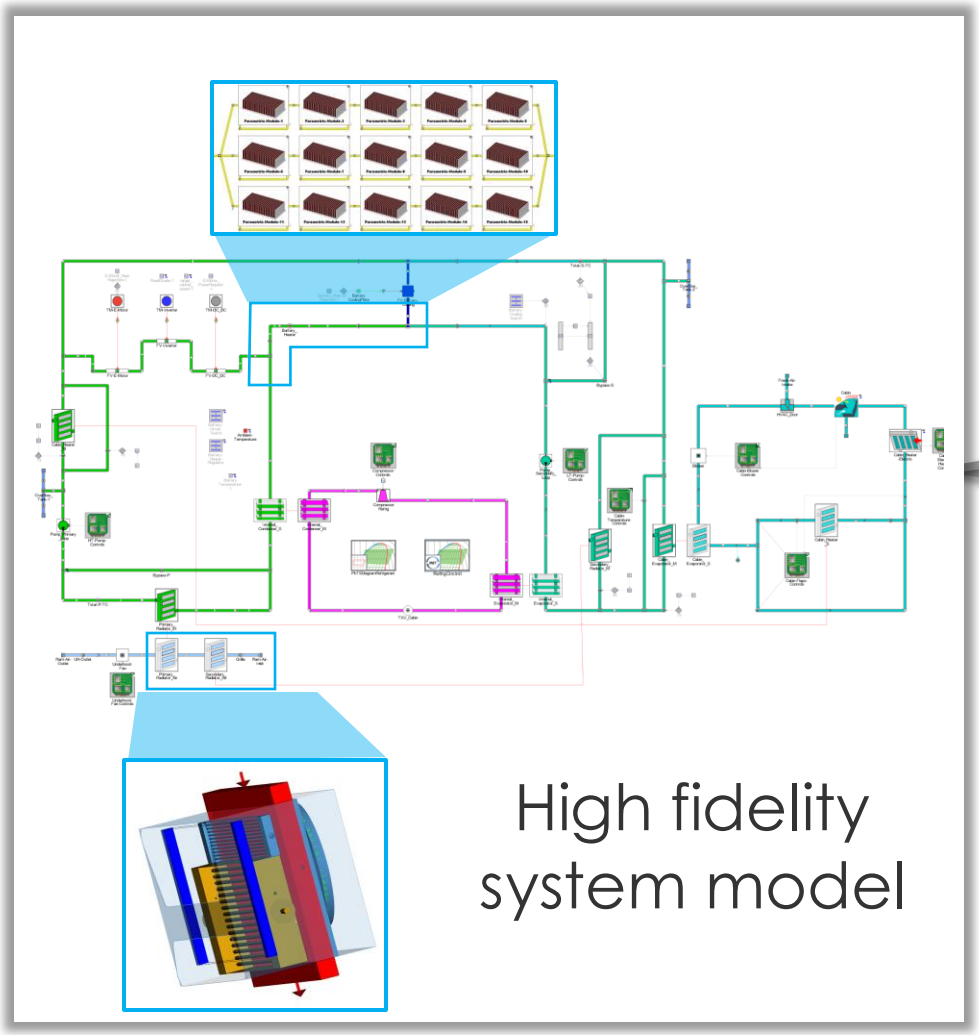


Results





Reduced Order Modeling in GT-SUITE



High fidelity system model

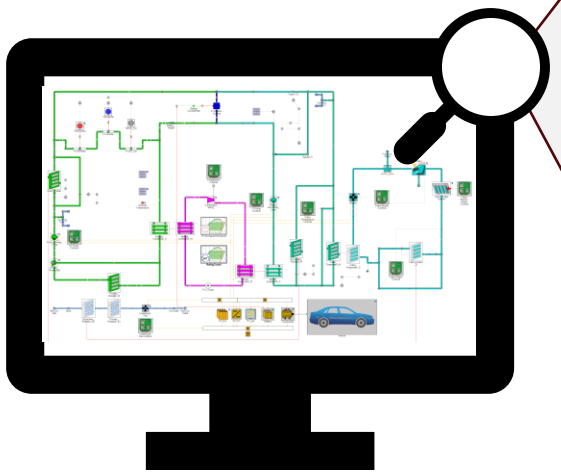
Data driven plant model

- [x] Super fast
- [x] Very easy deployment
- [ ] High upfront costs
- [ ] Change insensitive

Physics based plant model

- [x] Change sensitive
- [x] RT capable
- [ ] Medium upfront cost
- [ ] Deployable

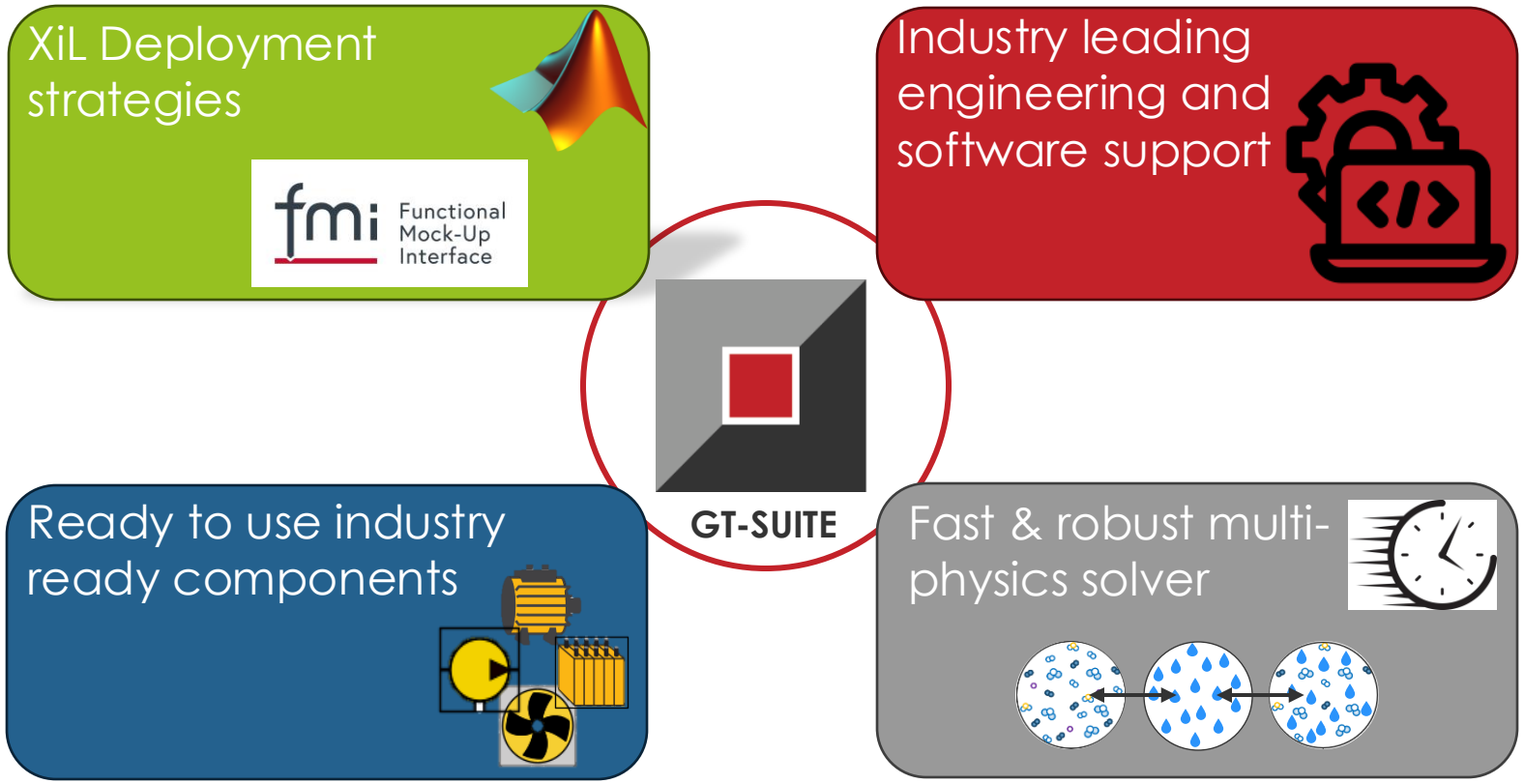
Integration of our work with function development



- Variable components
- connected functions
- Modular layouts
- Advanced controls strategies
- Optimization potential

- Traffic
- Driver
- Environment

GT-SUITE Capabilities for Model Flexibility

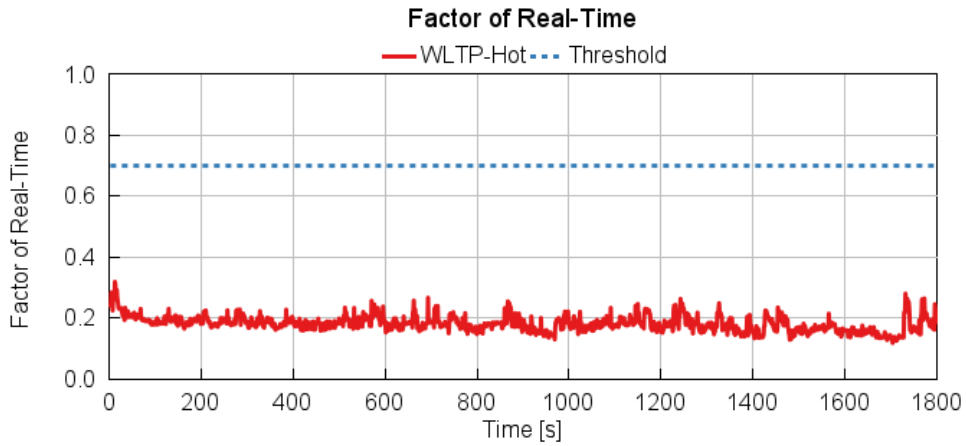


GT-SUITE on a XiL Simulator

Controller

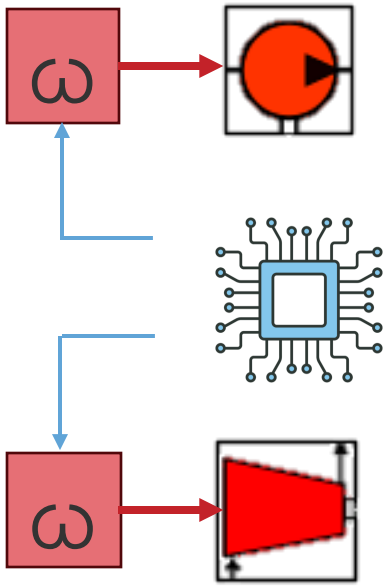
HiL (Hardware in the Loop) Simulator

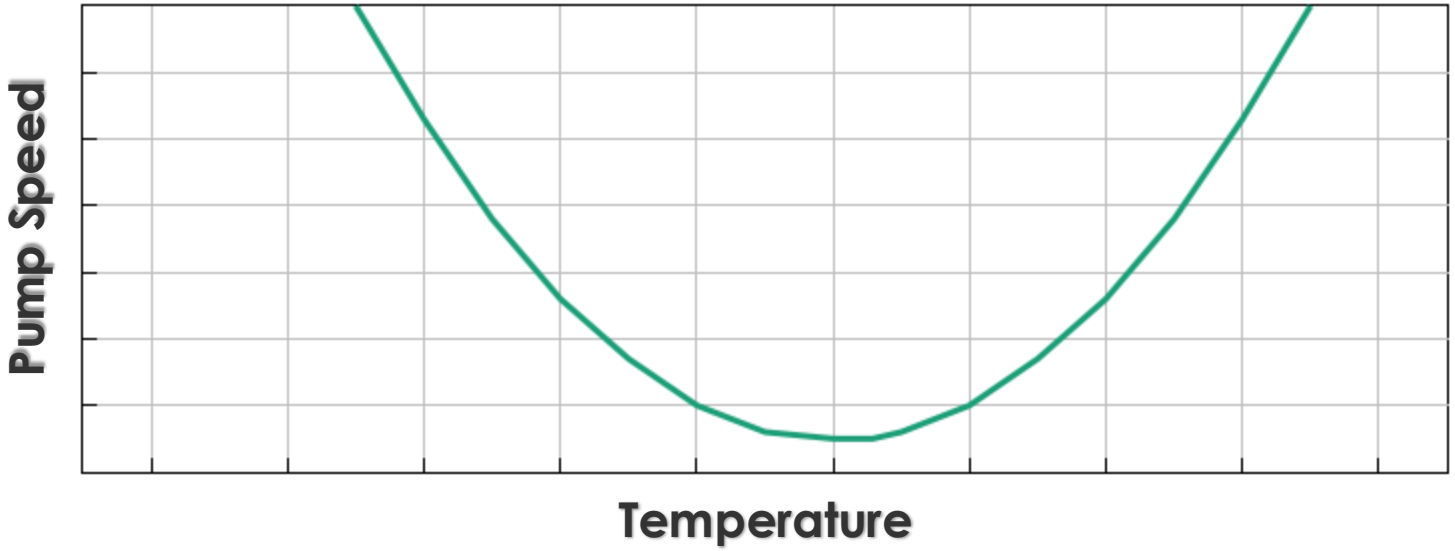
Real Time Plant Model



Control Strategy Test on HiL

Controls Law Validation and Optimization





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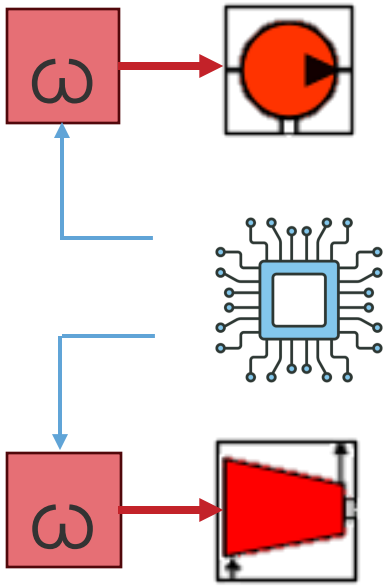

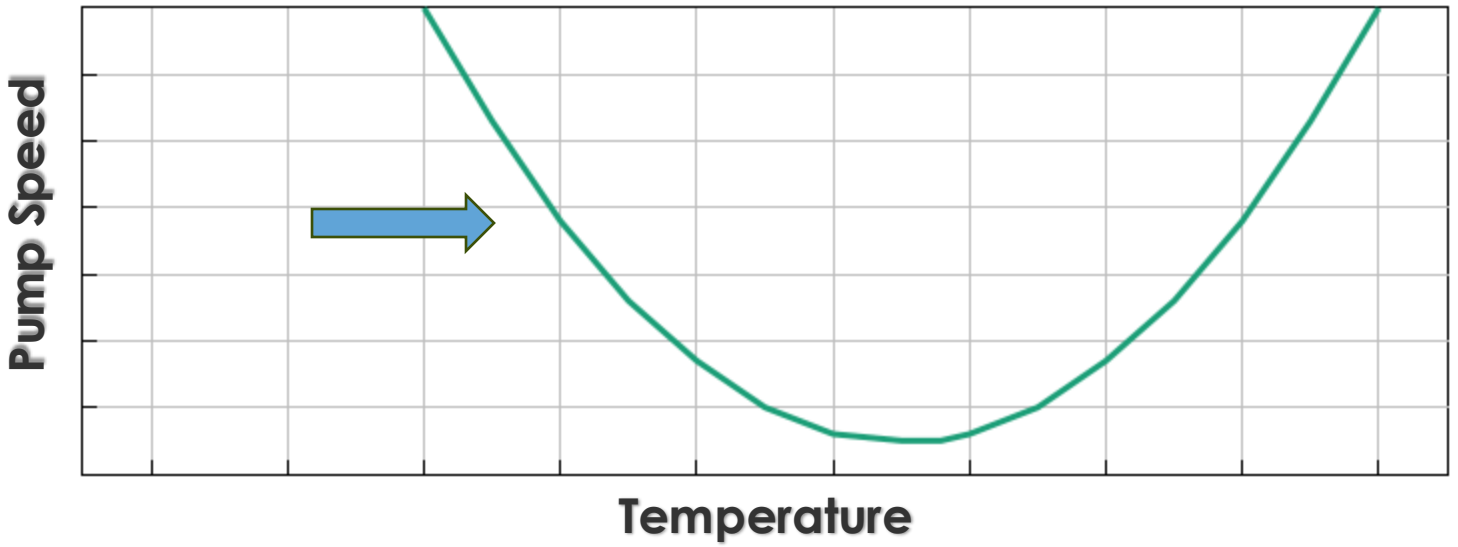

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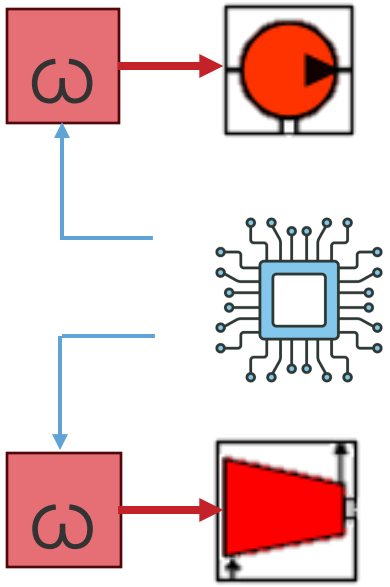
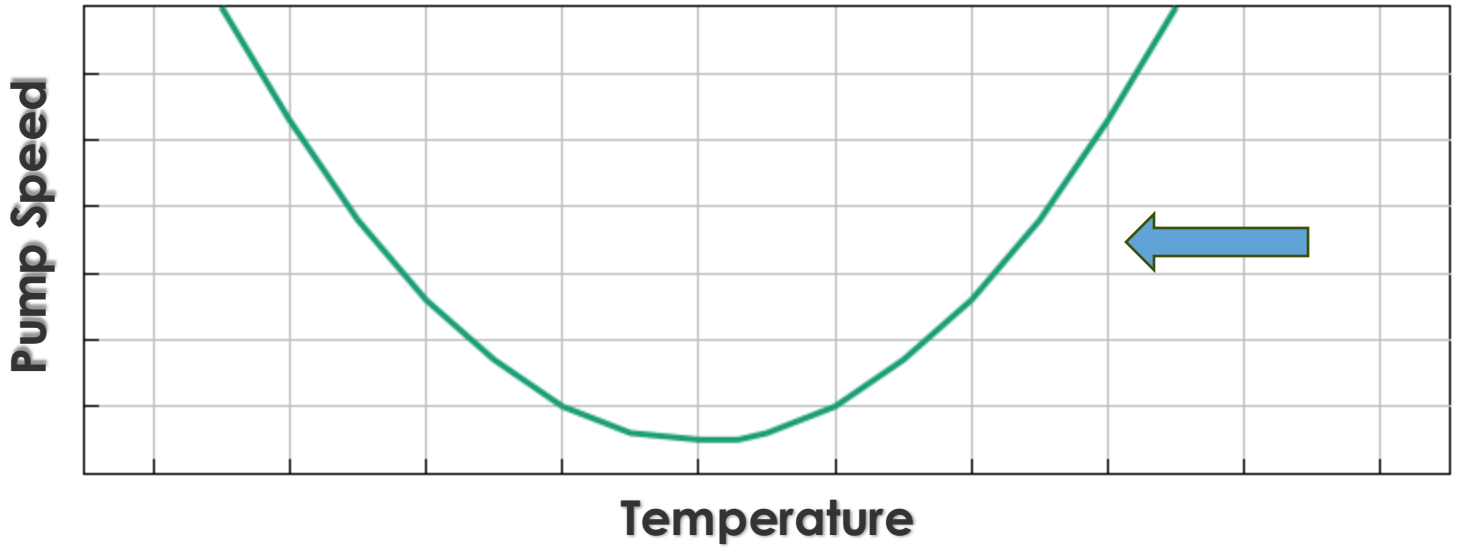
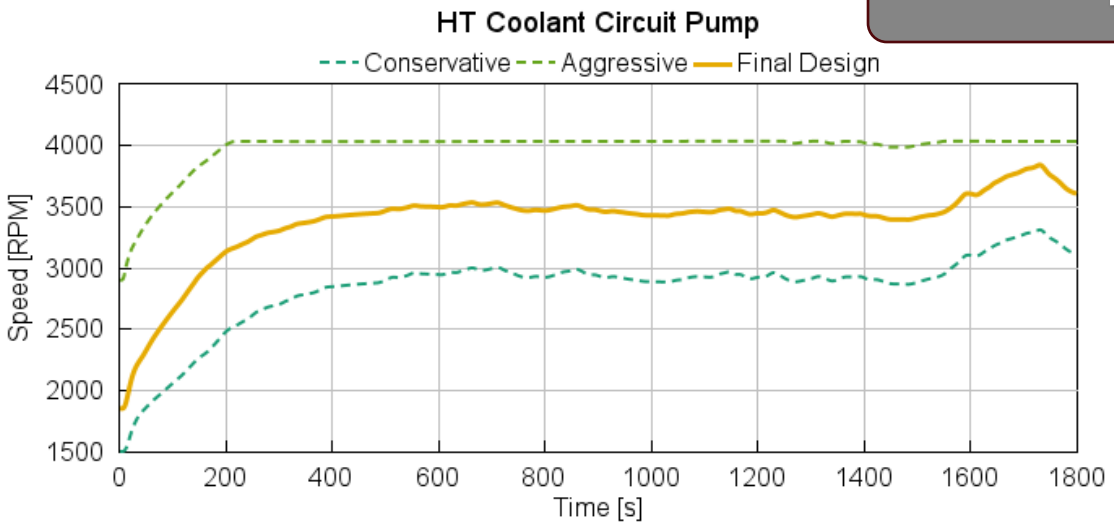
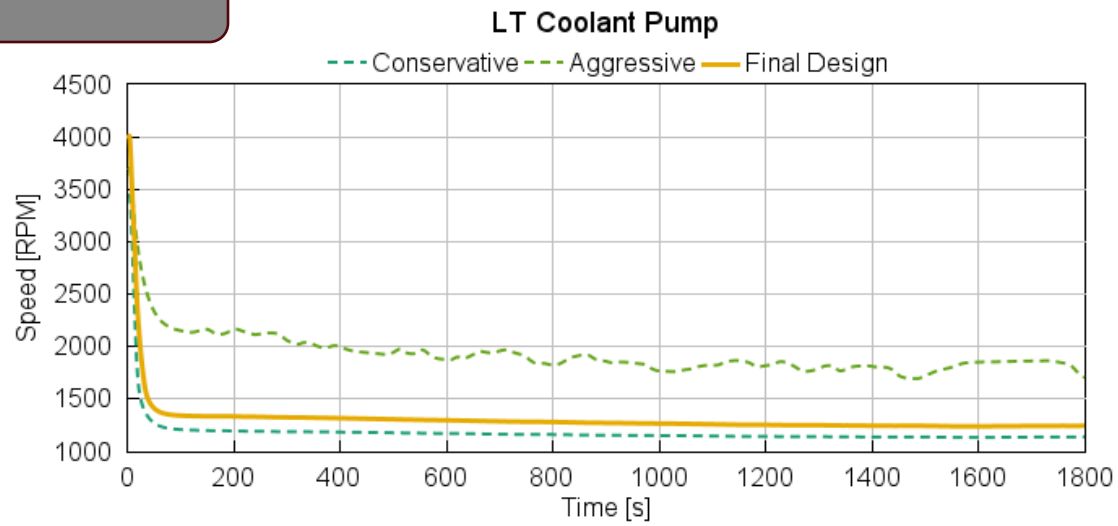


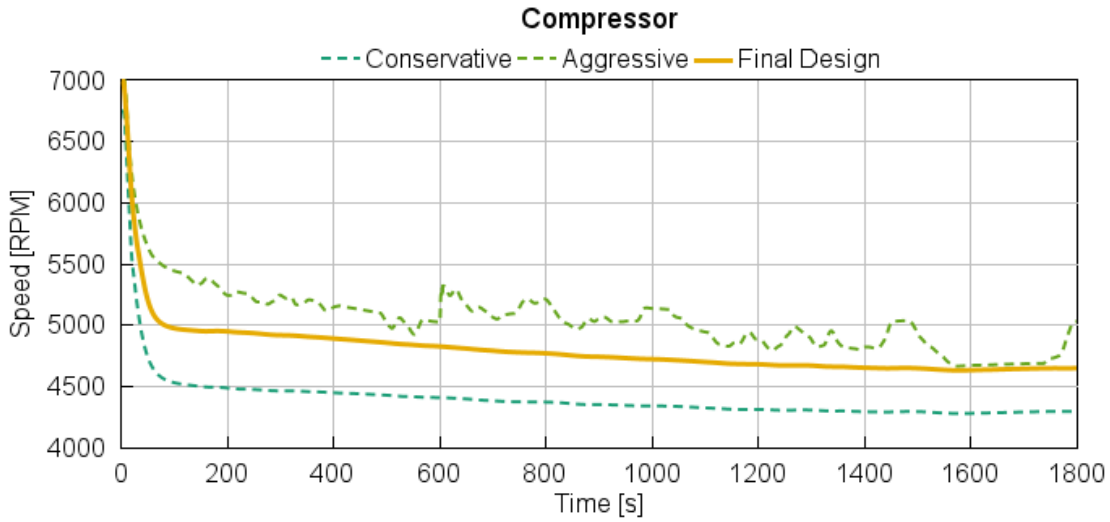


Setpoint Control Optimization

Flow Rate

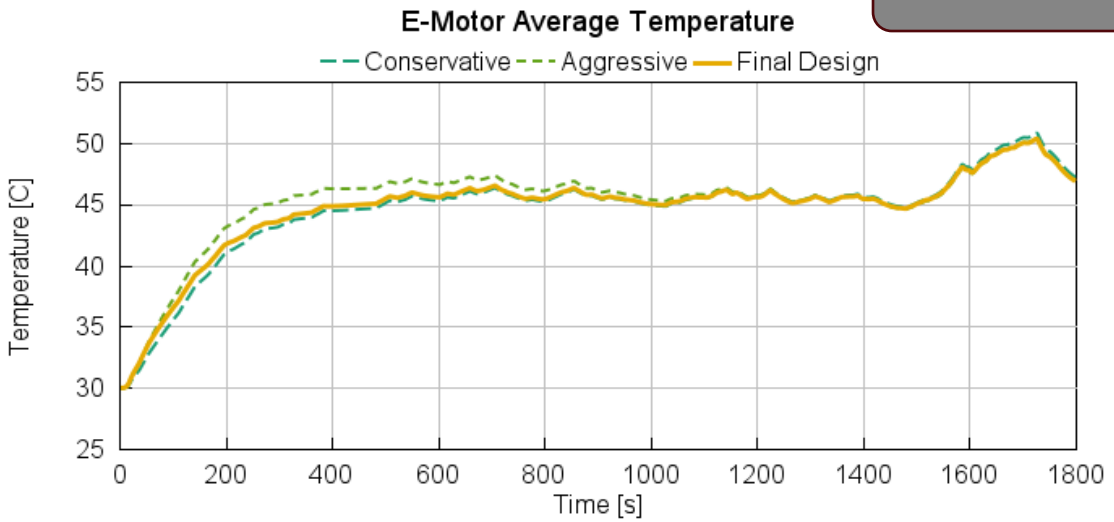


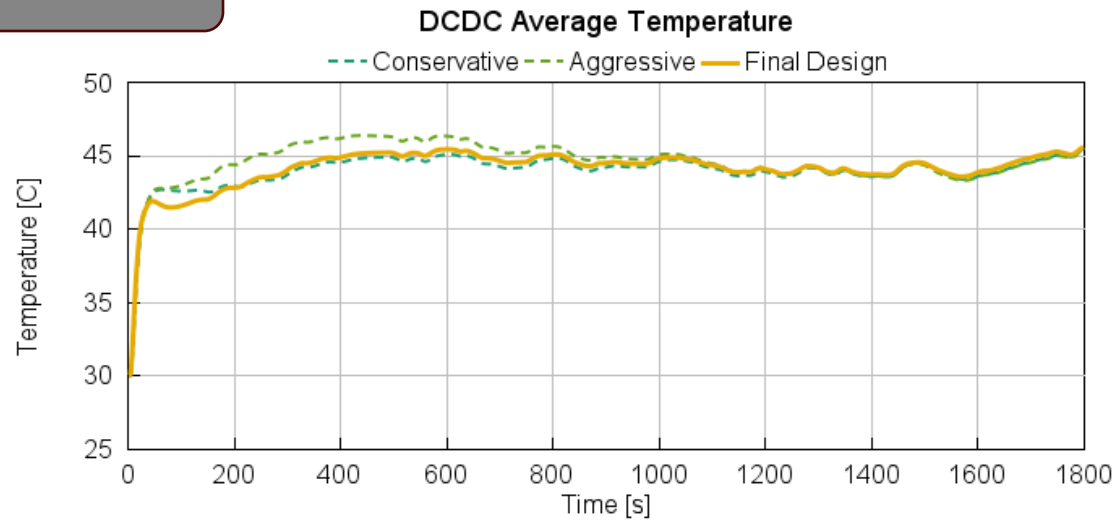


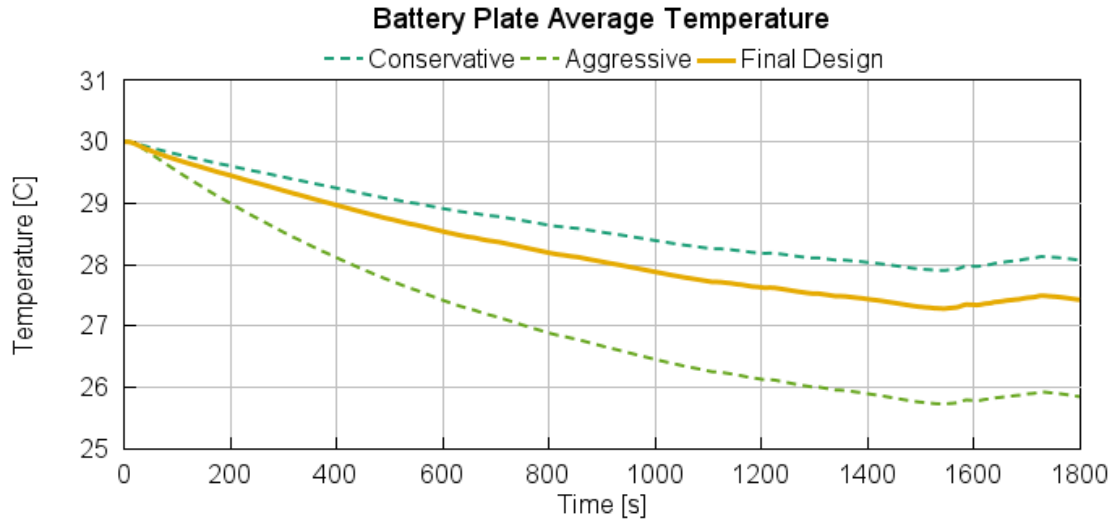


Setpoint Control Optimization

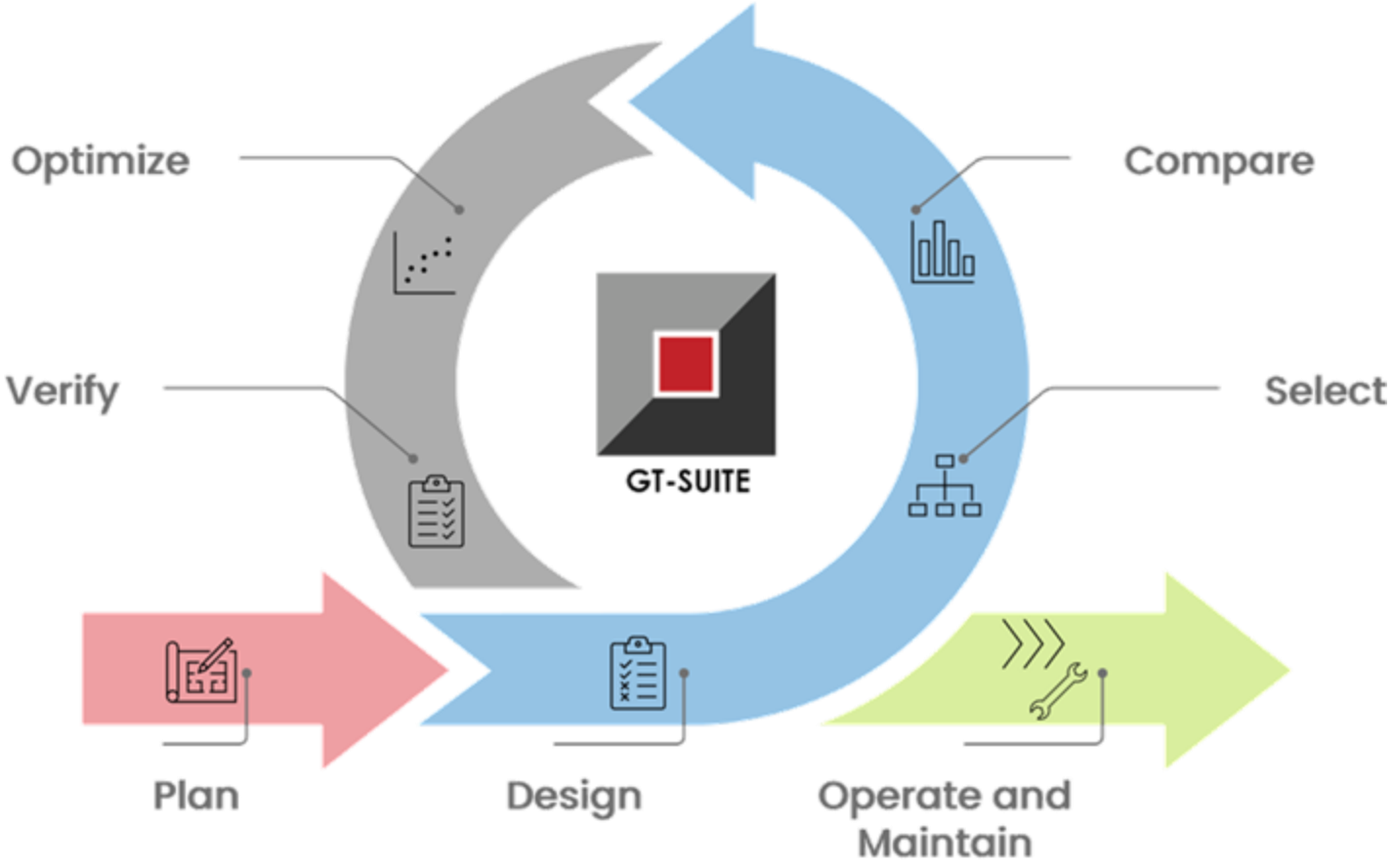
Temperatures

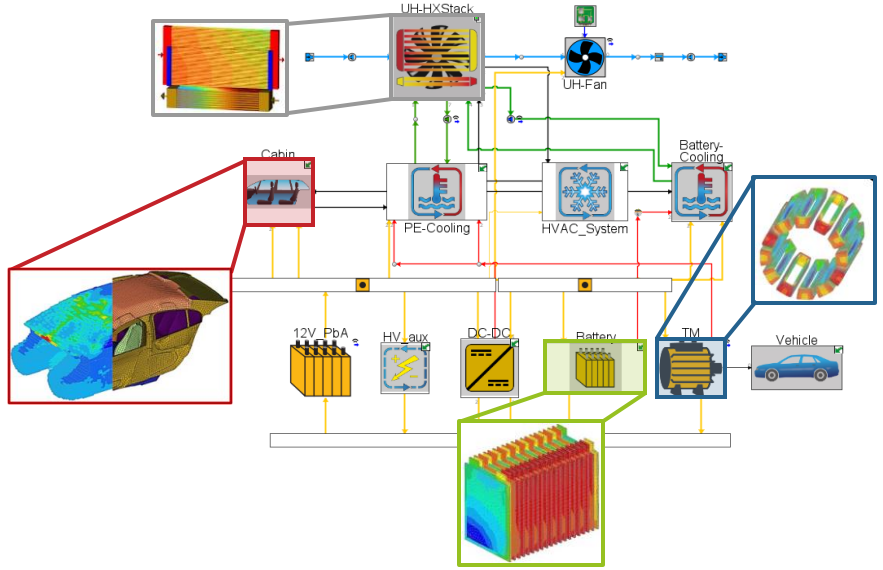




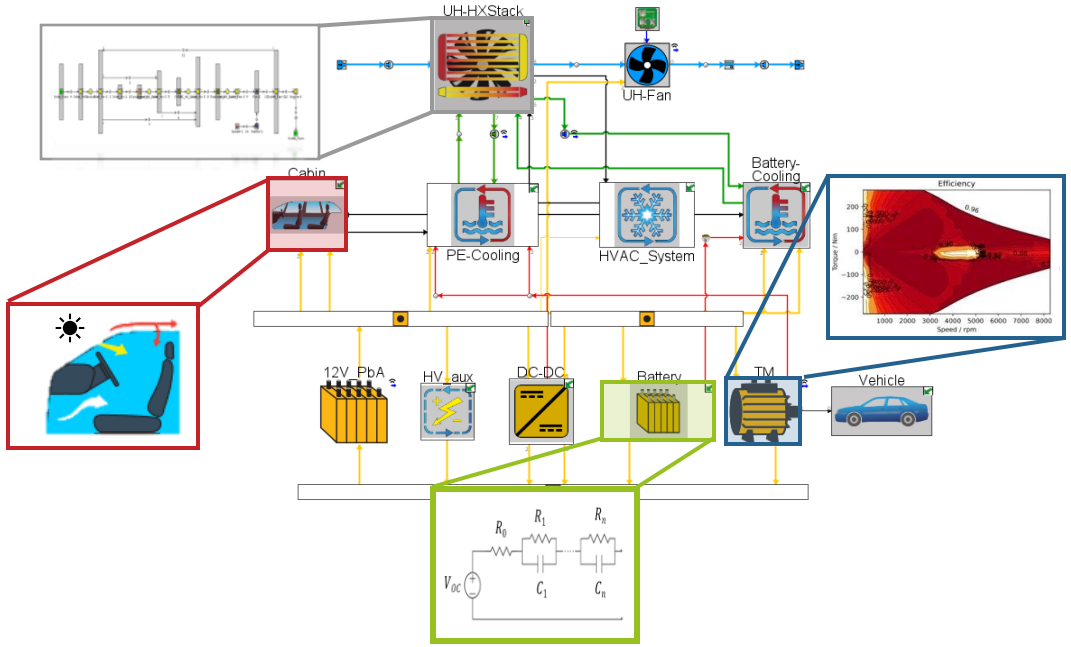


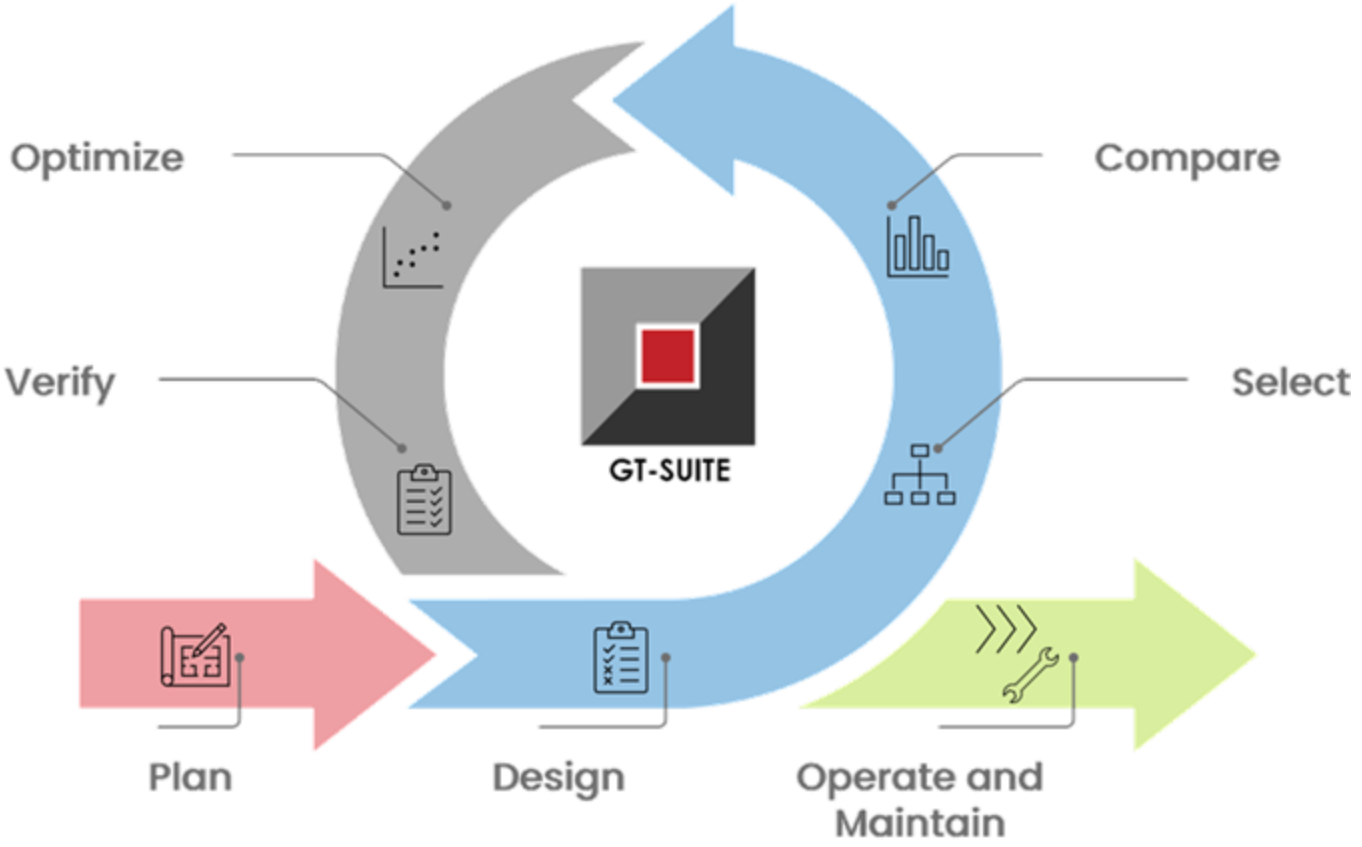
Detailed System Analysis



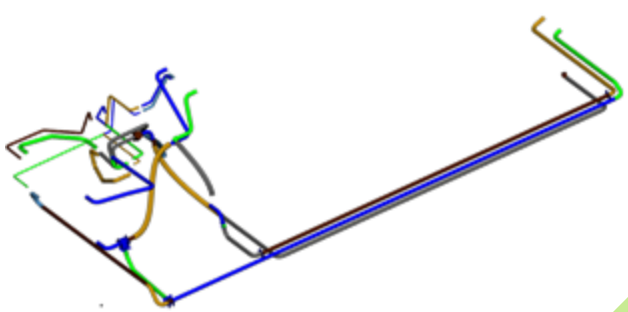


Function Development and Controls





Volume Reduction for Model Speedup



GT-SUITE v2024

Automatic

ADVANCED — Auto Tag (1)

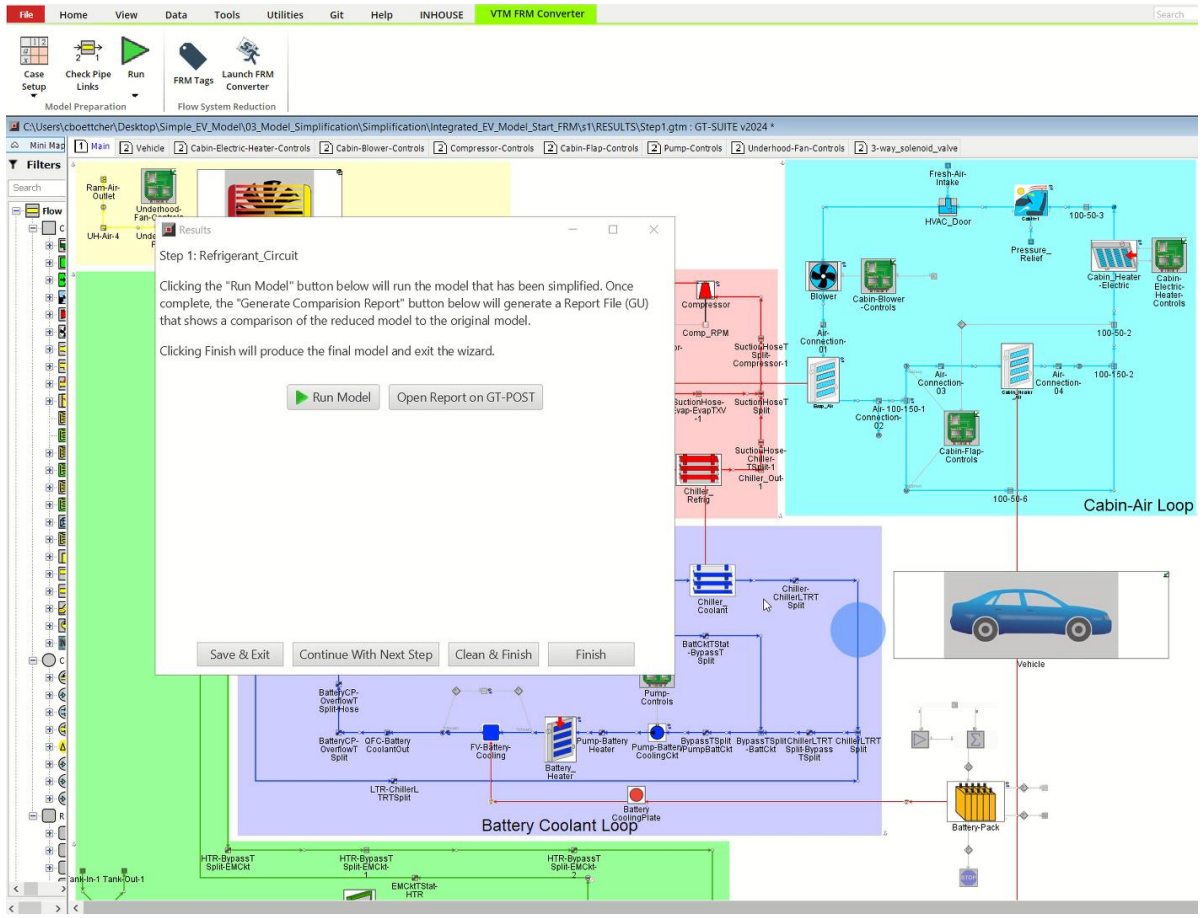
NEW — VTM FRM Wizard (2)

Holistic System Simulation Model for XiL

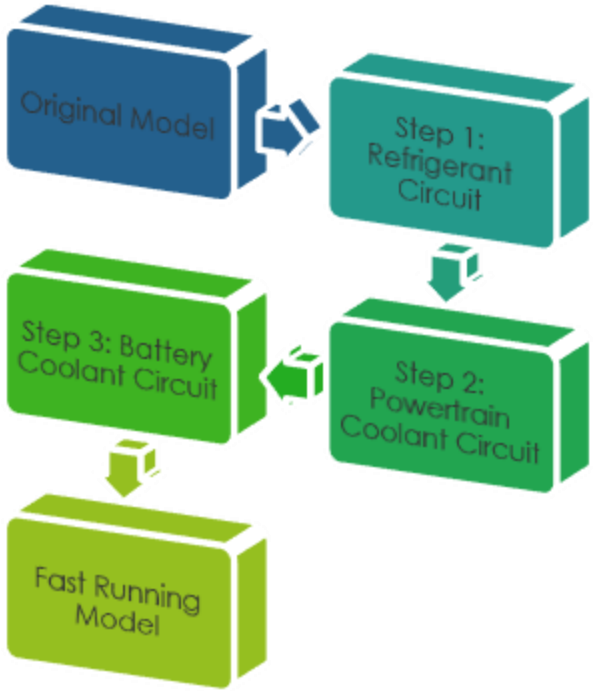
Automatic Identification

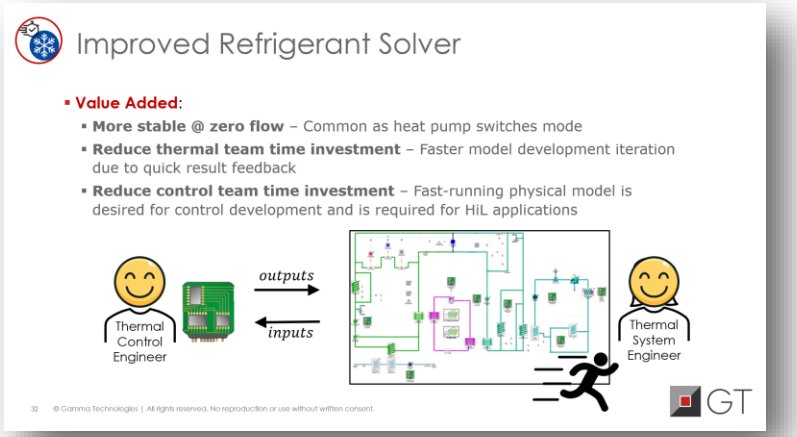
Fast Conversion

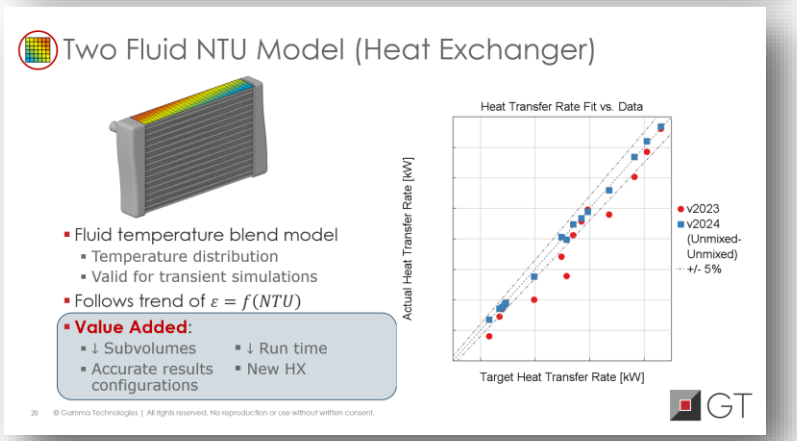
Automatic Comparison



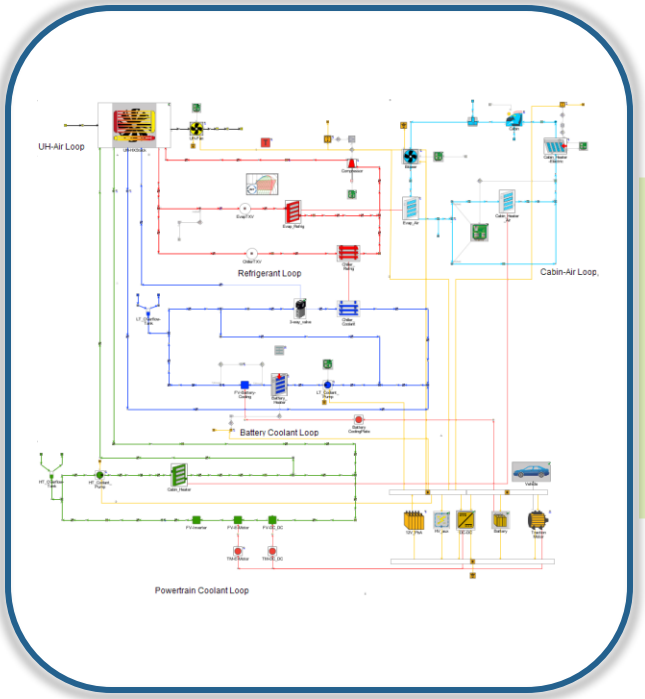
Additional Steps to reduce Model Run Time







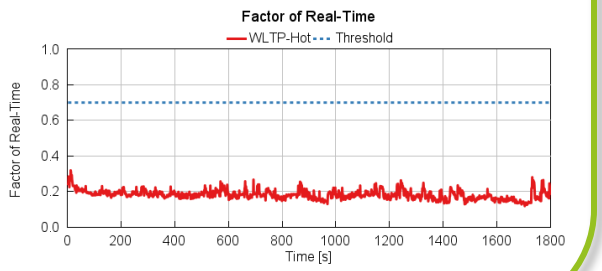
Conclusion



Automatic Identification

Fast Conversion

Automatic Comparison



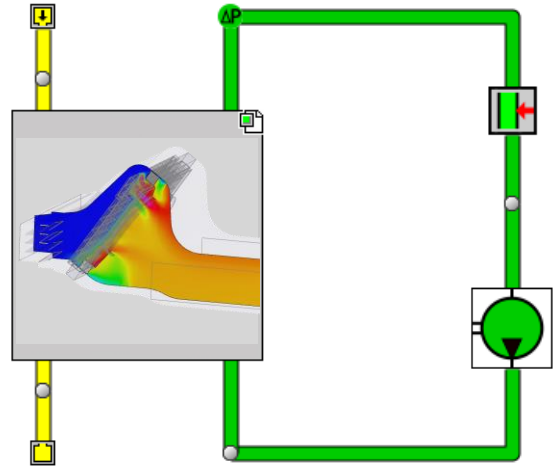
GT-Auto-3DFlow

Fusion of thermal 1D flow with 3D CFD

Higher accuracy for all geometries & modes

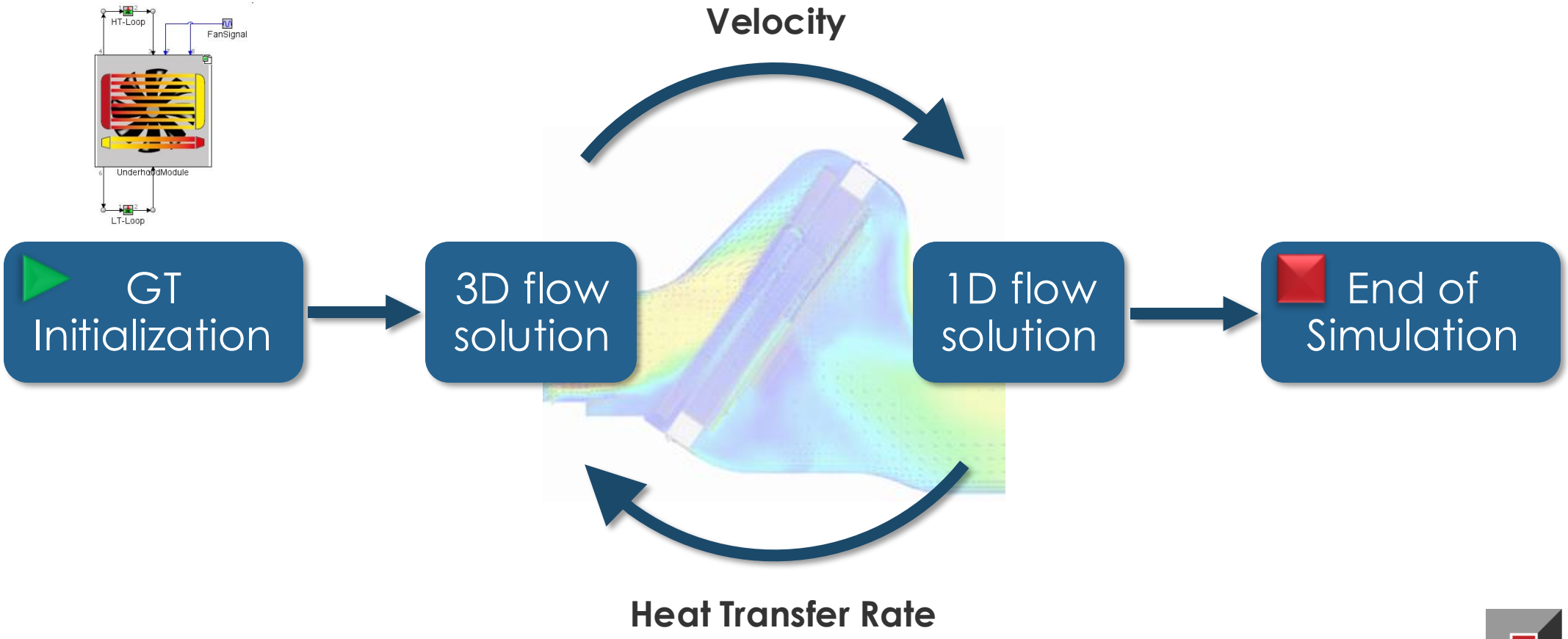
Fast turn-around time using known workflows

Fast, high impact results for your engineering tasks

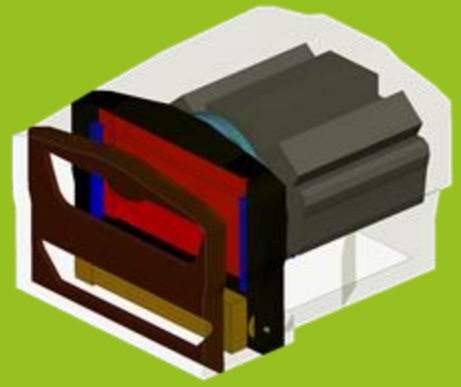


GT-Auto-3DFlow: Coupled 1D-3D Solution

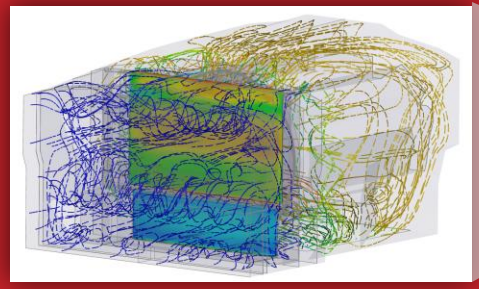
- Integrate with multiple flow domains through GT-SUITE



Optimize Heat Exchanger Sizing and Layout

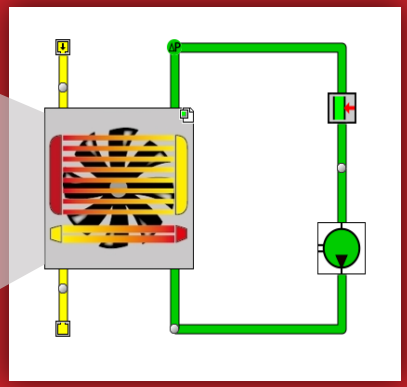


Cool3D
Geometry Domain
Setup & Preparation

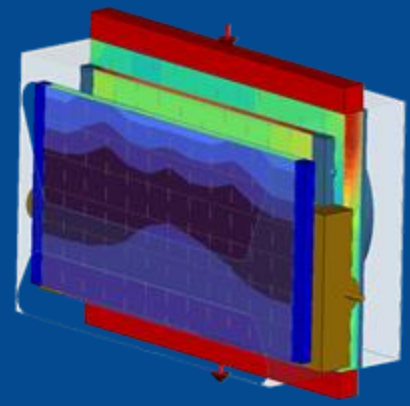


GT-Auto-3DFlow
Powered by Simerics

GT-ISE



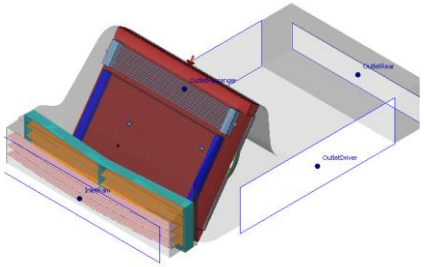
Trusted 1D
GT Flow Solution

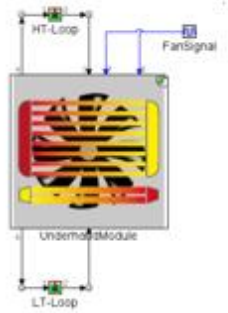


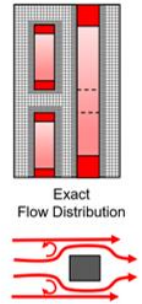
GT-POST
Post-Processing & Analysis

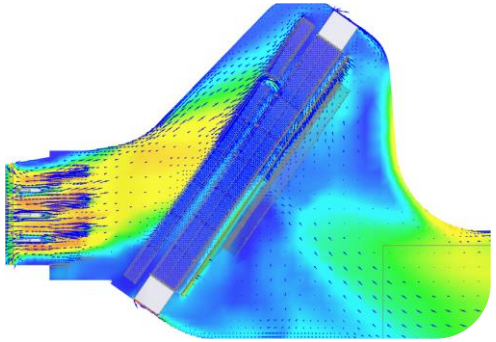
GT 3D SPATIAL FLOW SOLUTION

Streamlined Solution









Fast building of airflow environment → Flexible placement and orientation of components → Multi-domain circuit integration → Automatic co-simulation for an accurate 3D flow solution → Analyze complex flow phenomenon

Summary