Ricardo Software
Powertrain CAE Solutions

WAVE 2017.1 New Features

Delivering Excellence Through Innovation & Technology

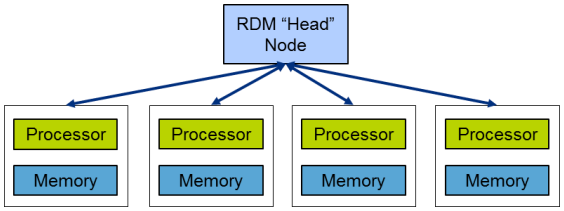
www.ricardo.com

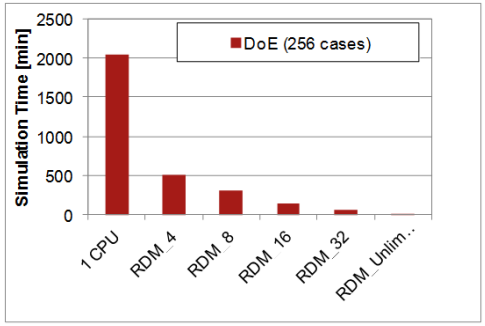
What is WAVE?

WAVE is a one-dimensional gas dynamics program for the design and analysis of internal combustion engines

- Includes tools that can be utilized effectively across an organization by multiple departments to optimize price/performance benefit

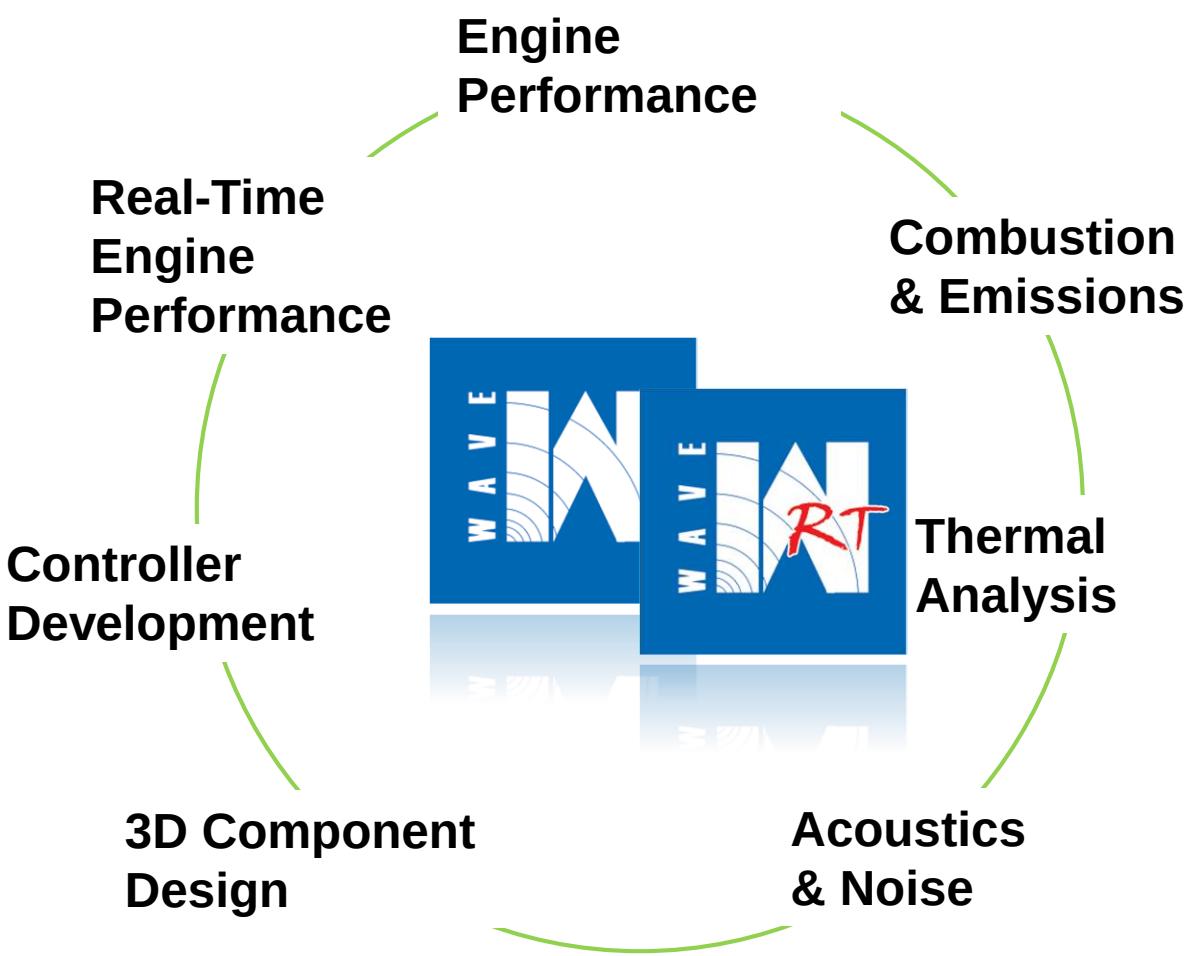
- Run more design points faster than any other tool to make better design decisions, sooner

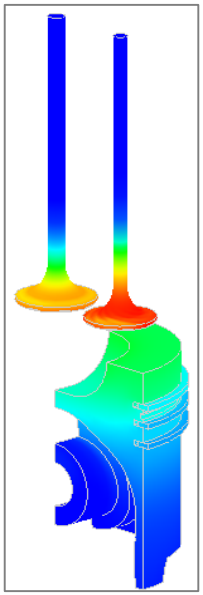


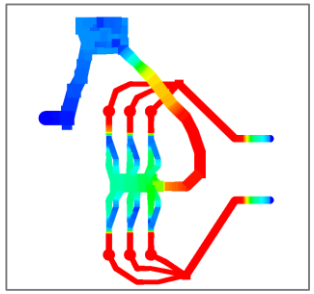


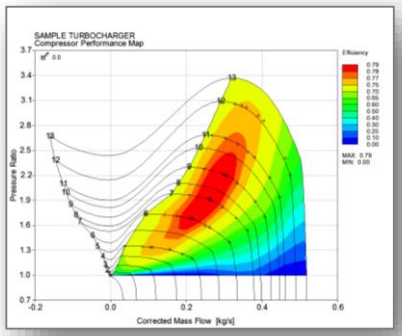
Complete Tool Chain *Speed* *Real-time Technology Like No Other* *Class-leading Acoustics*

WAVE and WAVE-RT are 1D CFD analysis tools supporting engine performance and acoustic/NVH development

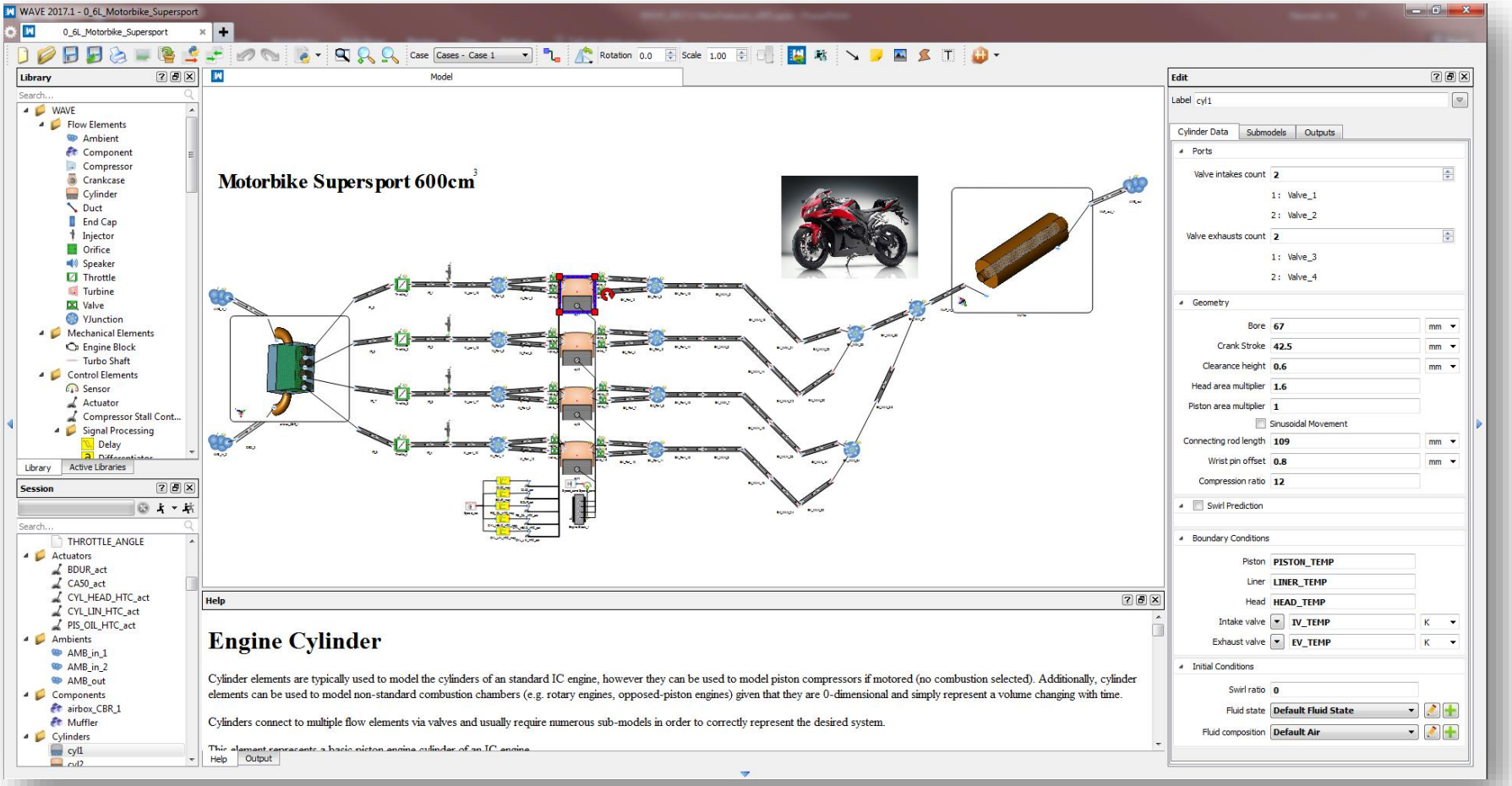






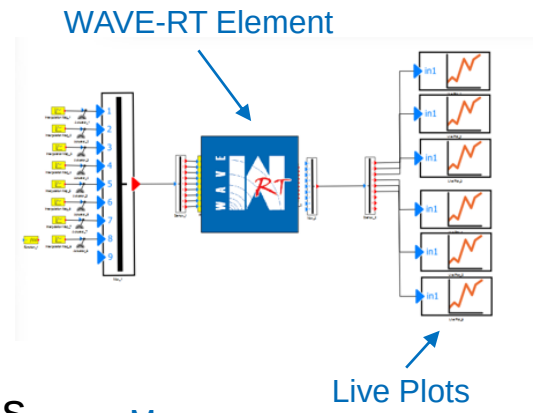


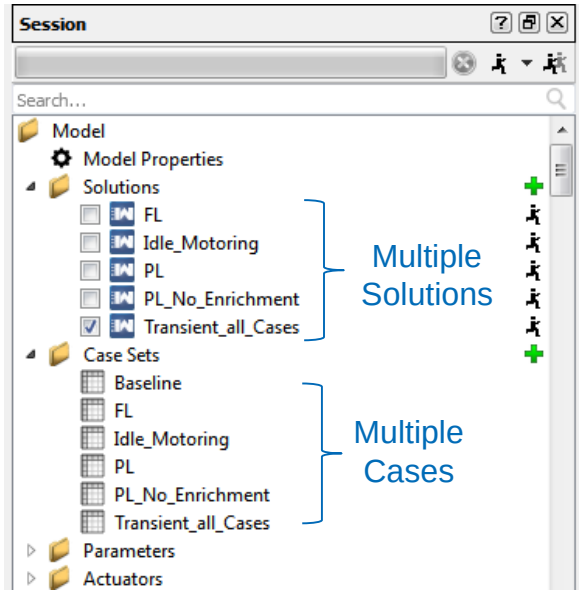
New WAVE Plug in

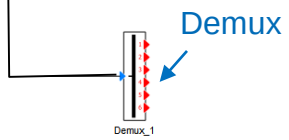


New Key Features

- New Fresh Look
- User Friendly
- 2-Button Mouse Supported
- Multi-Monitor Support
- Multiple Cases and Solutions
- Reference Objects
- Live Plots
- Valve Elements
- New WAVE-RT Export
- WAVE-RT Element
- Direct GT-Power Import
- Seamless IGNITE Element







WAVE-RT Sensor List

WAVE Sensors

	WAVE-RT Name	Units	Sensed Element	Attribute	Export	Filter
1	MAF	kg/s	duct27	duc[19].W_Duct	☑	Instantaneous
2	MAP	Pa	yjun5	cap[29].P_Cap	☑	Instantaneous
3	Cyl1_P	Pa	cyl1	cyl[0].P_Cyl	☑	Instantaneous
4	EngSpd_Sens	rad/s	Engine Block_1	theModel.N_Eng	☑	Instantaneous

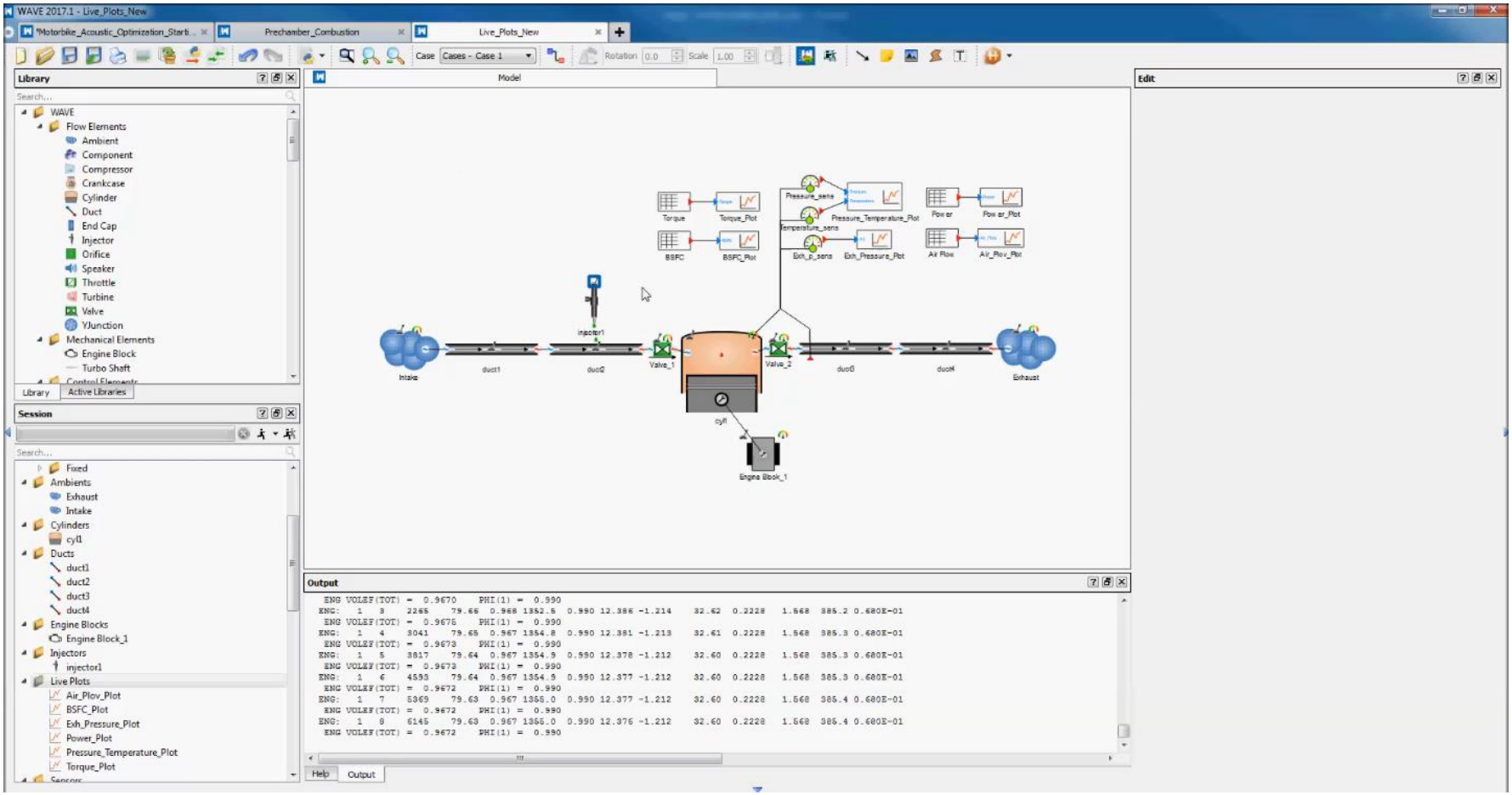
USER Sensors

	WAVE-RT Name	Units	Sensed Element	Attribute	Export
1	**Volumetric Efficiency**			**volef**	☑

Live Plots

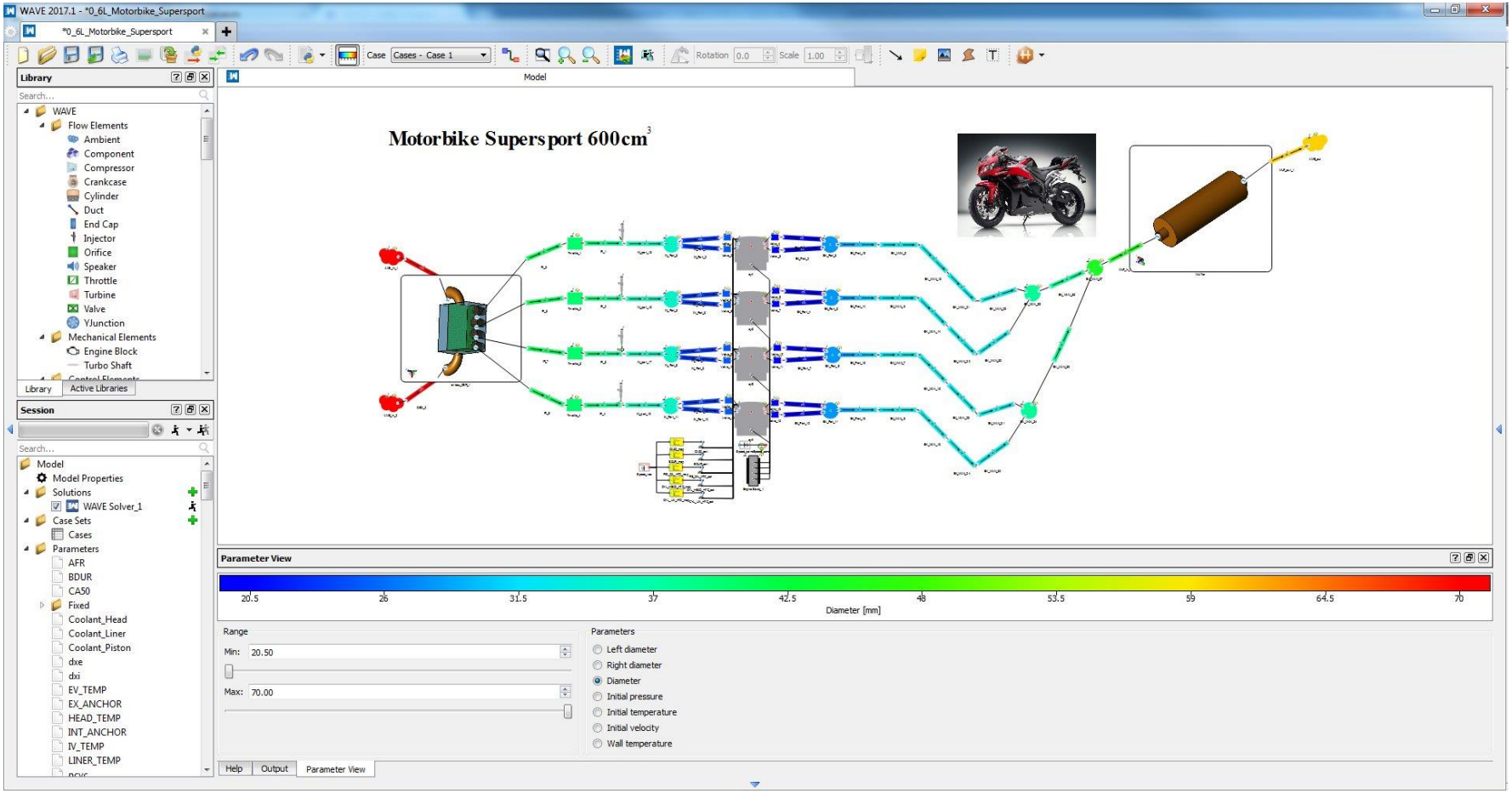
usability

Click on the picture to Play



Parameter View with Gradient Scale

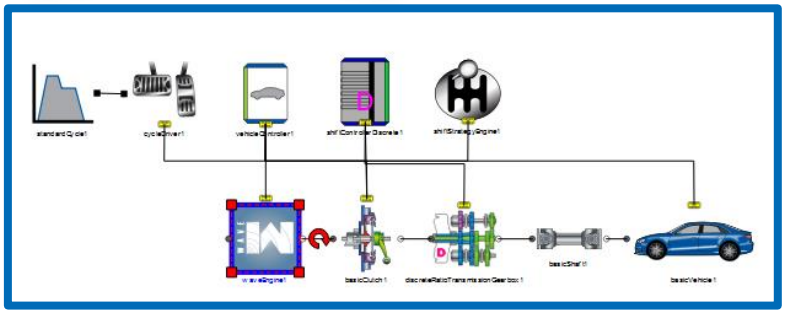
usability

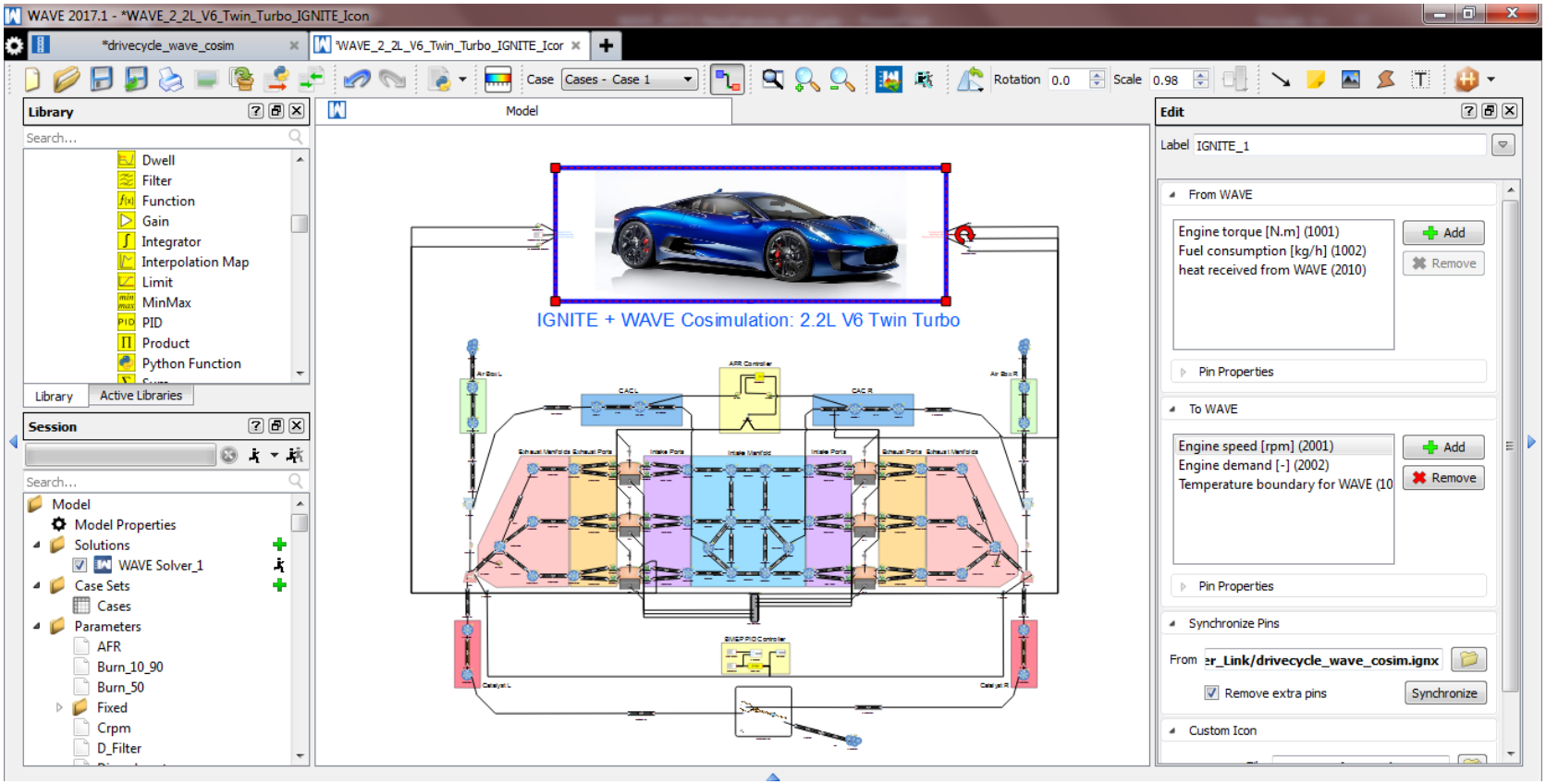


IGNTE Element

usability, flexibility
and capability

- Automatic input and output synchronization
- Both models opened at the same time!



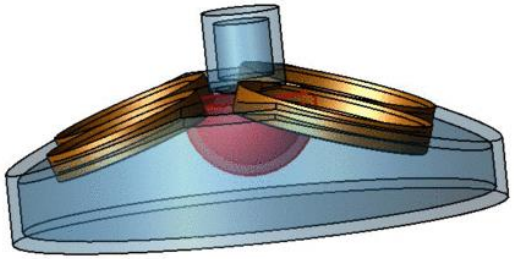


Real-Time SI Predictive Combustion Model

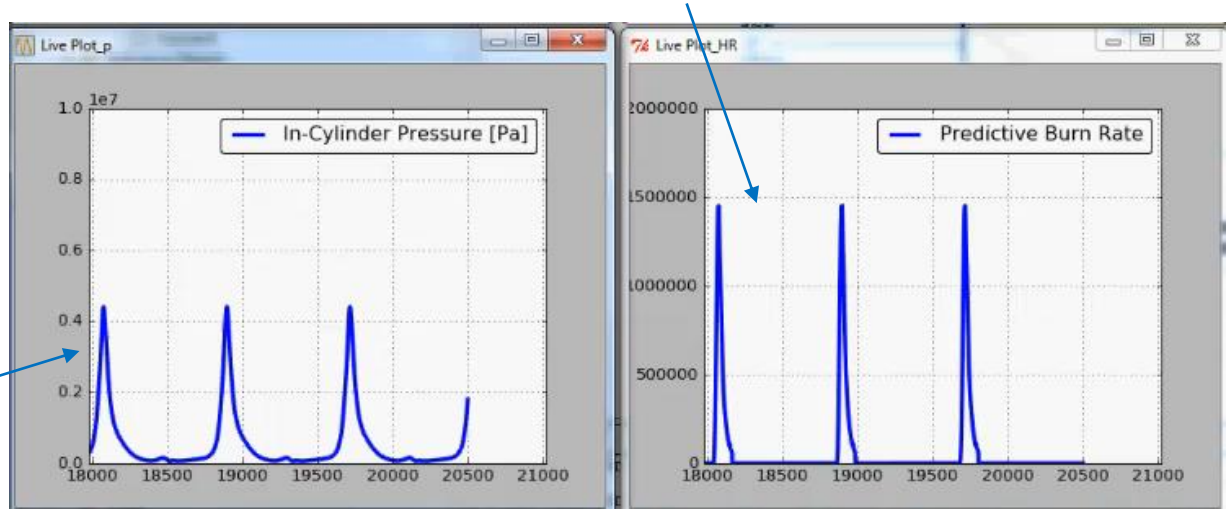
usability and capability

- **Real-Time** SI Predictive Combustion Model in WAVE-RT
  - 2-zone Combustion
  - Laminar and Turbulent flame front propagation
  - Sensitivity to in-cylinder state
    - Pressure, Temperature
    - Lambda
    - Residuals (EGR)
    - Fuel type
- **Knocking Model**
  - Octane Number

Flame Propagation



Predictive Combustion

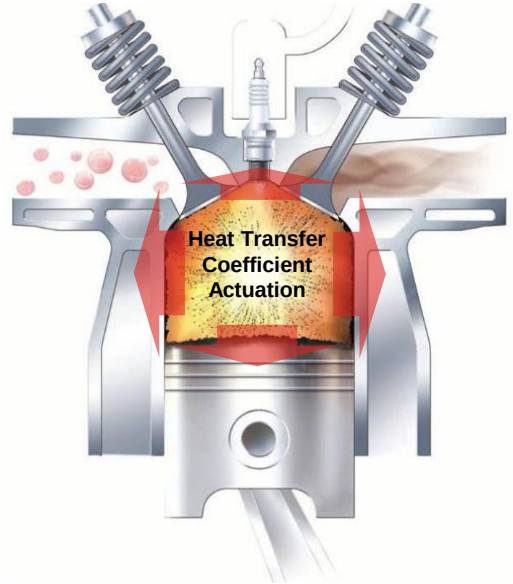


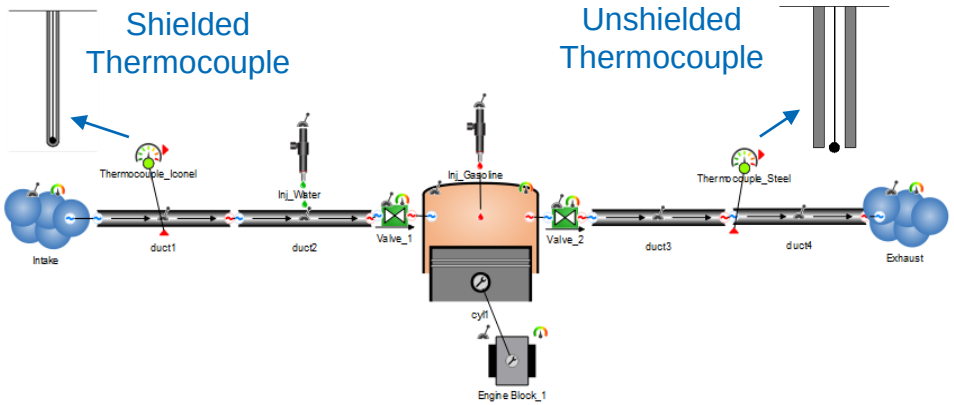
In-Cylinder Pressure

WAVE Enhancements

usability and capability

- Heat Transfer Coefficient Actuator
  - Available for Cylinders and Crankcase



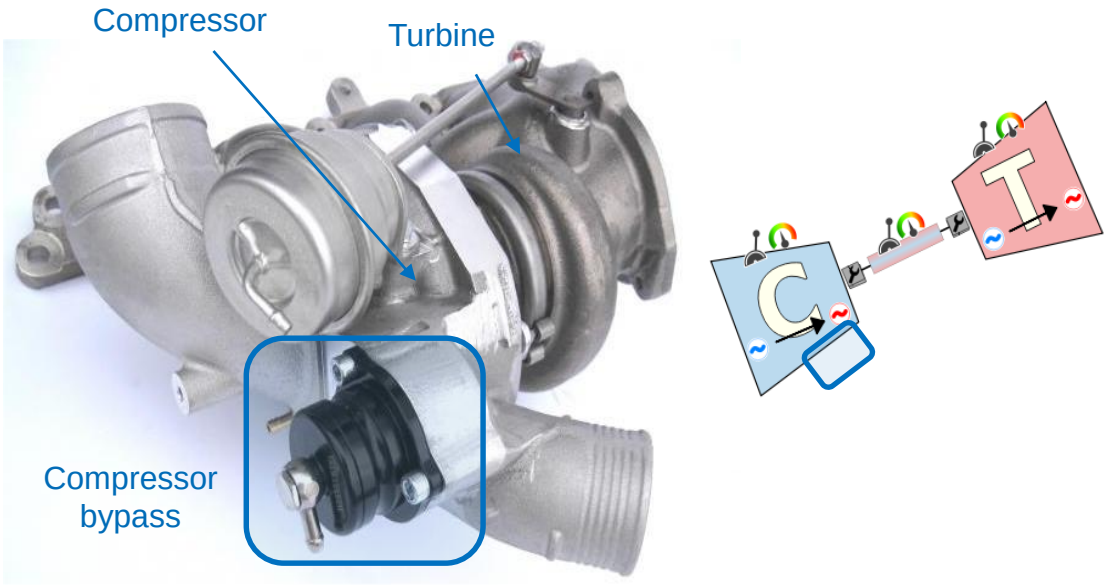


- Multiple Thermocouples Types

WAVE Enhancements

usability and capability

- Integrated Compressor Bypass
  - Both WAVE and WAVE-RT

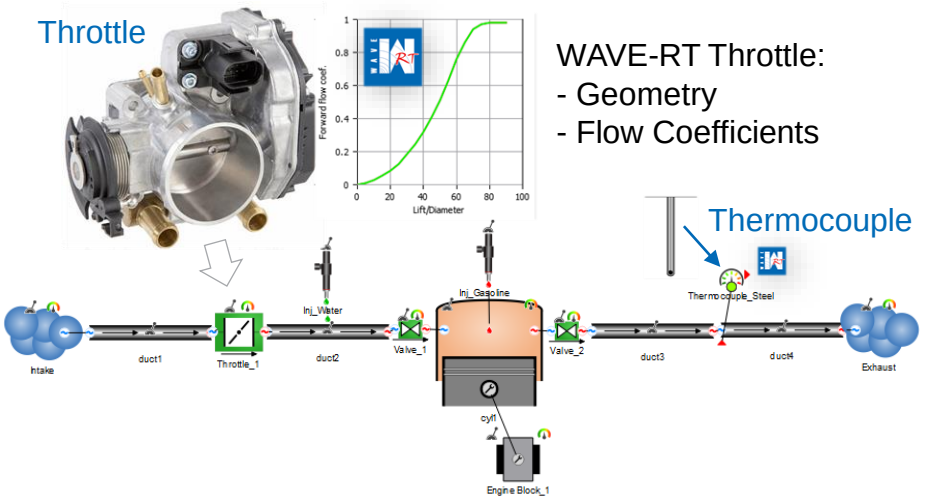


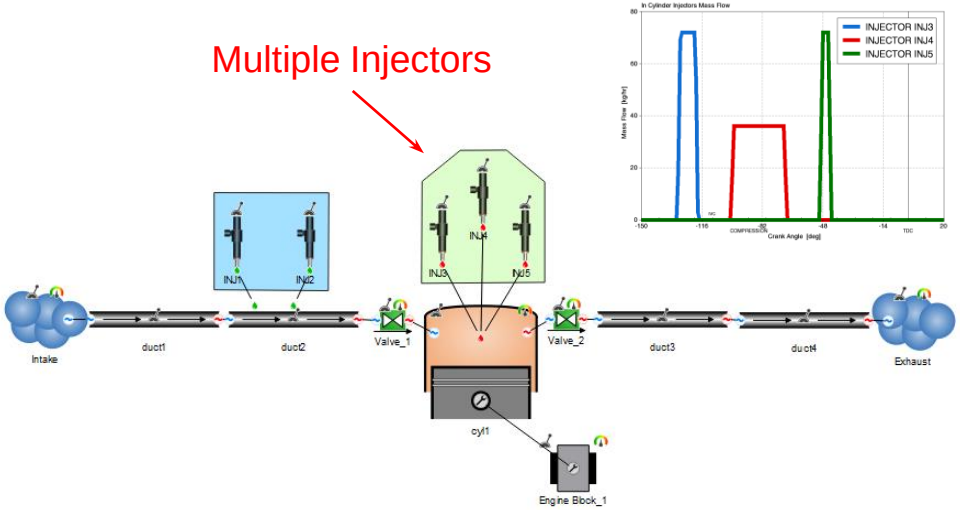
- New Compressor Surge model for Twin Turbochargers

WAVE-RT Enhancements

usability and capability

- Throttle Support
- Multiple Thermocouples Types
- New Sensors and Actuators
  - Instantaneous
  - Summary Sensors



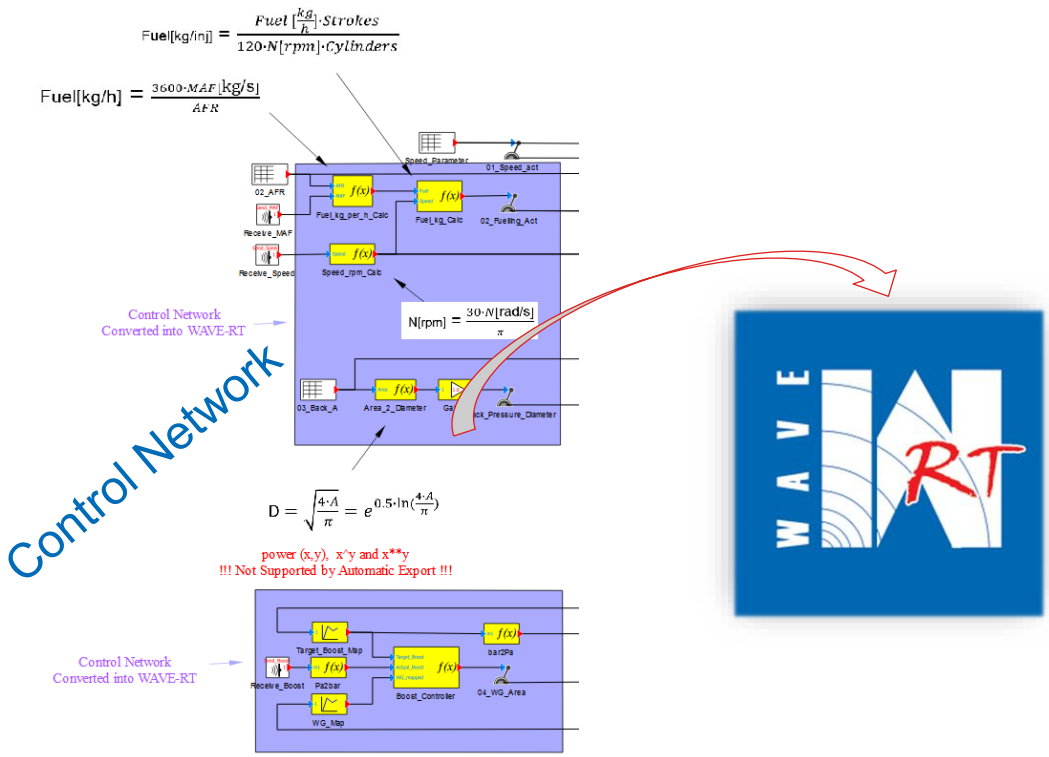


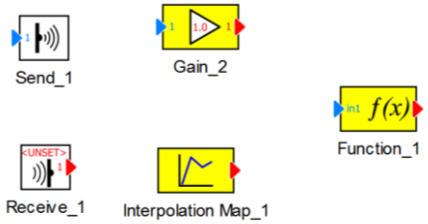
- Multiple Injectors per cylinder
- State of Art Direct Gas Property calculation
- Python script Model Export / Import of models

WAVE-RT Enhancements

usability

- Automatic Control Network Export



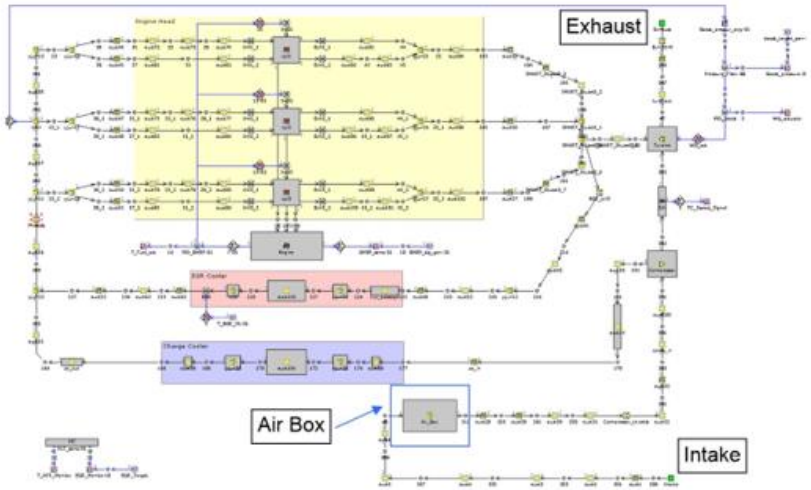


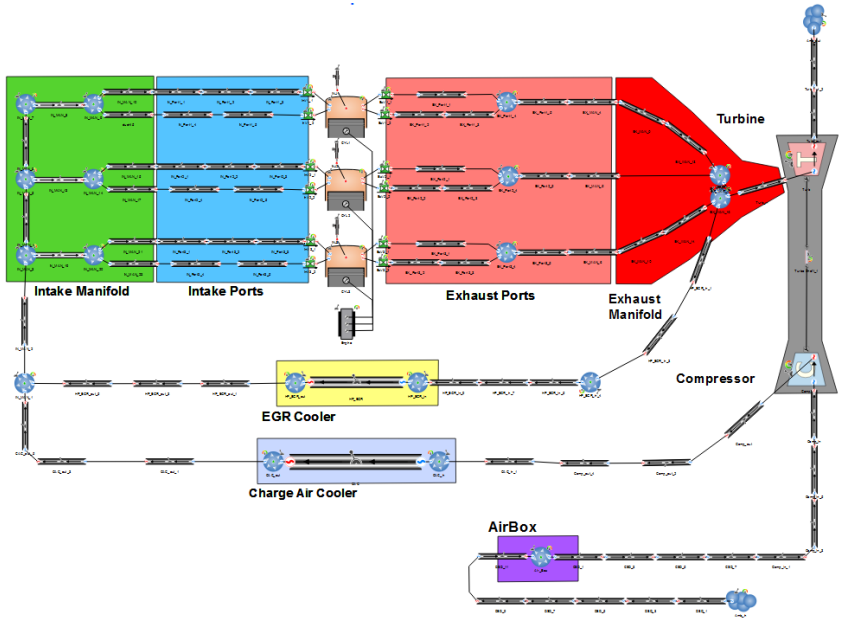
- More Control Elements Exported
  - Function, Gain
  - Interpolation Map
  - Send, Receive

GT-Power Interface

usability and flexibility

- New GT-Power Importer
  - Fuel files
  - TC maps
  - Interpolation maps
  - Structure Conduction
  - Profiles



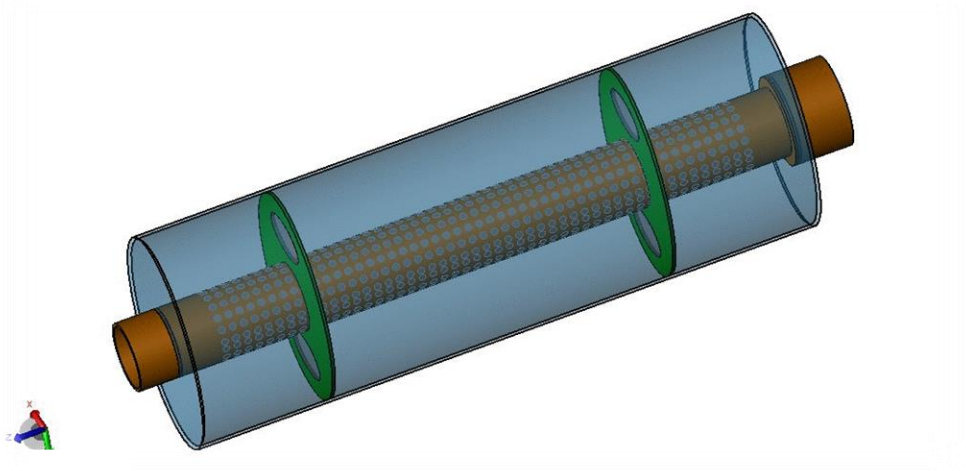


- WavePost reads GTP summary results file

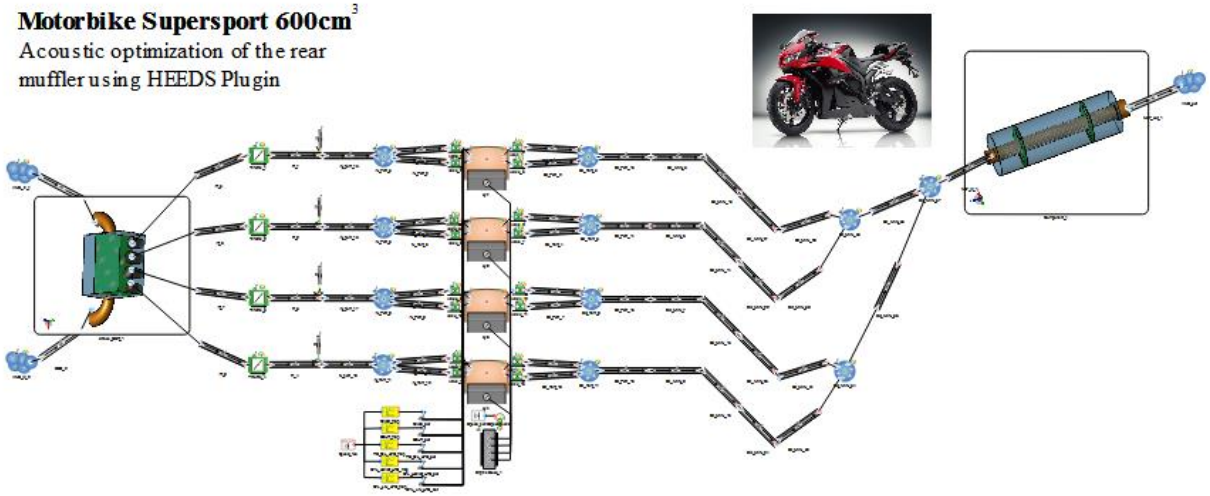
Acoustic Optimization

usability

- WaveBuild3D Components Parameterization
- Automatic Export to HEEDS



Motorbike Supersport 600cm^3
Acoustic optimization of the rear muffler using HEEDS Plugin

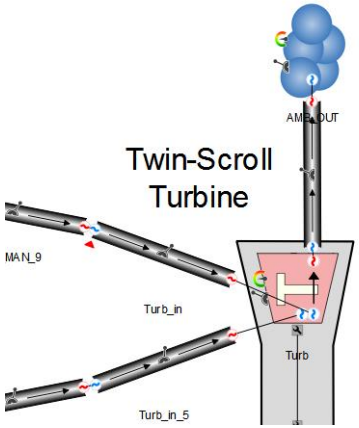


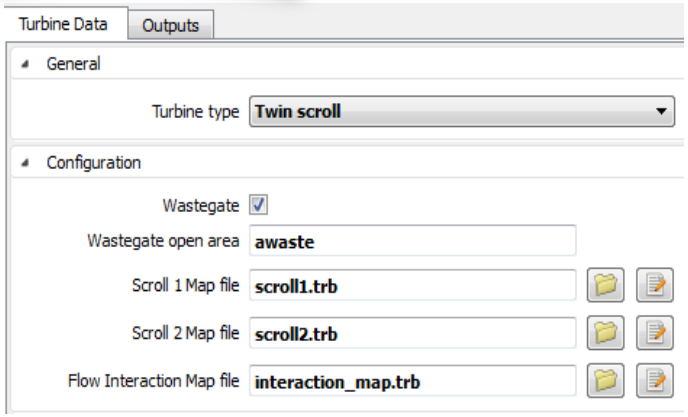
Run Slide Show to perform an animation

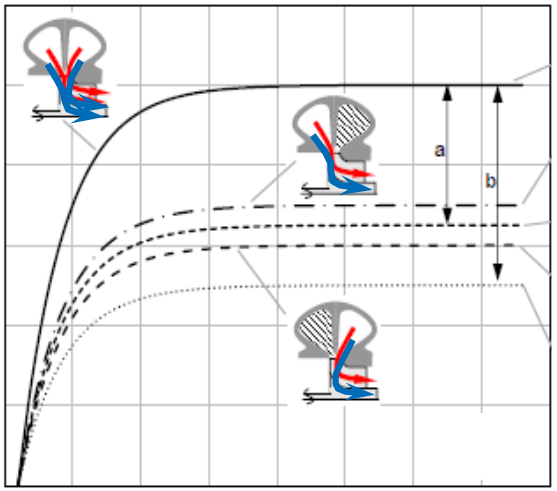
Twin Scroll Turbine

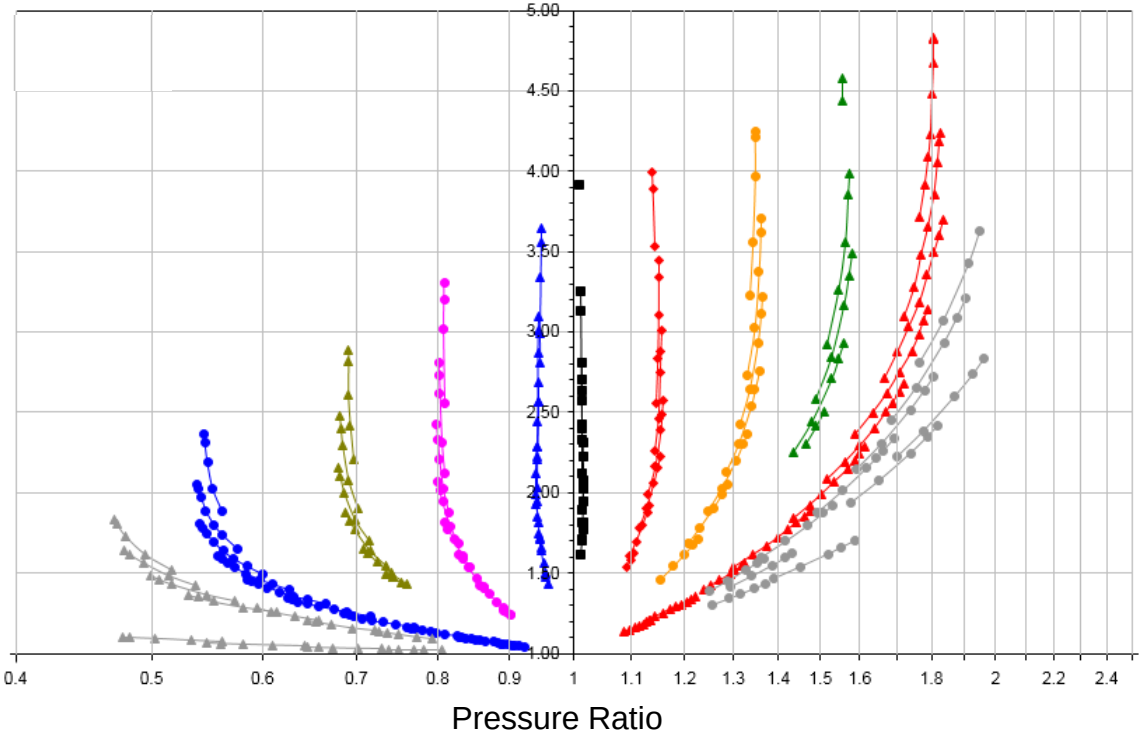
usability

- 3 Maps
  - Scroll 1
  - Scroll 2
  - Cross Flow





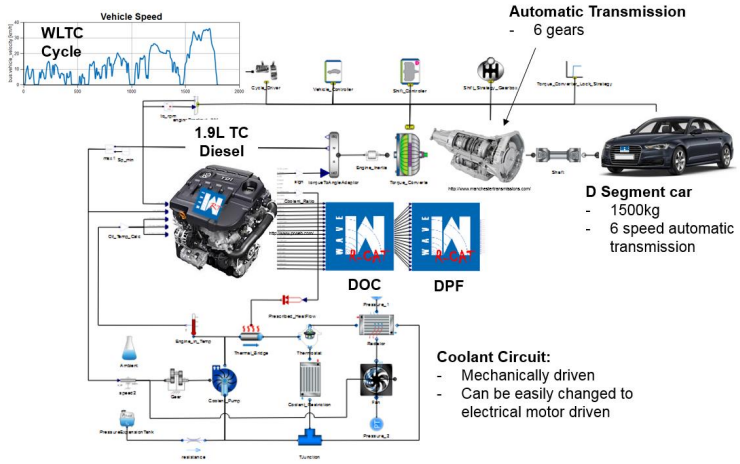




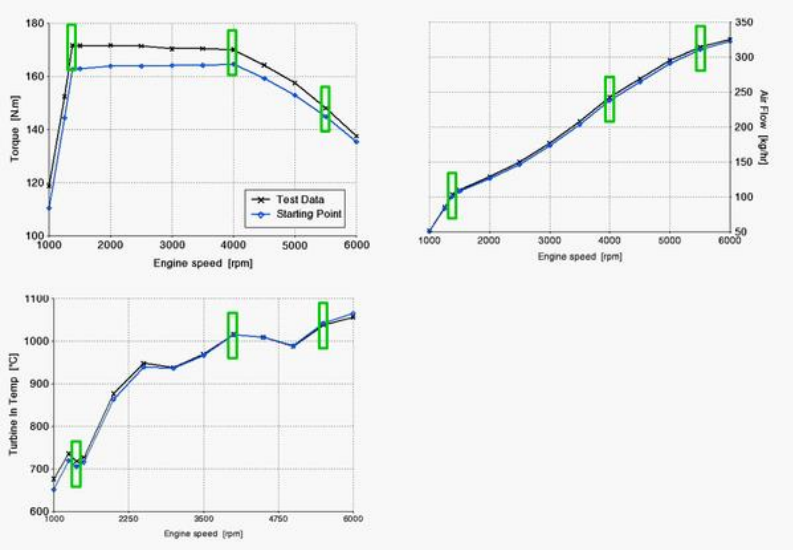
New Tutorials

documentation

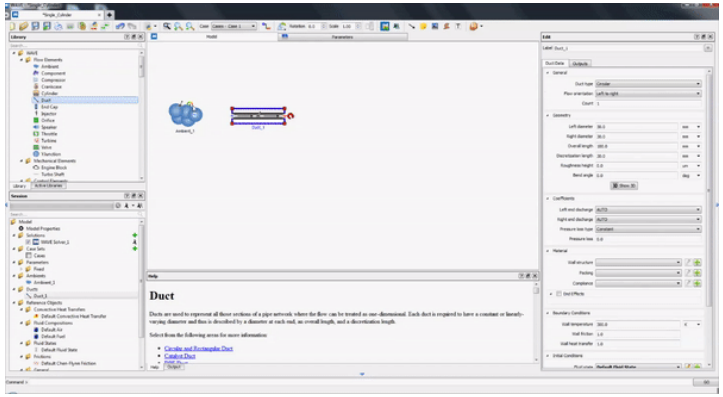
- Acoustic Optimization of WB3D Components
- WAVE-VALDYN stop-start co-simulation
- Python Script Model Export & Import
- Ideal Y-Junctions Connections modelling study



- GT-Power Geometry Model Import



- Model Calibration - Curve Fitting
- Gasoline Engine Model in R-Desk **Video Tutorial**

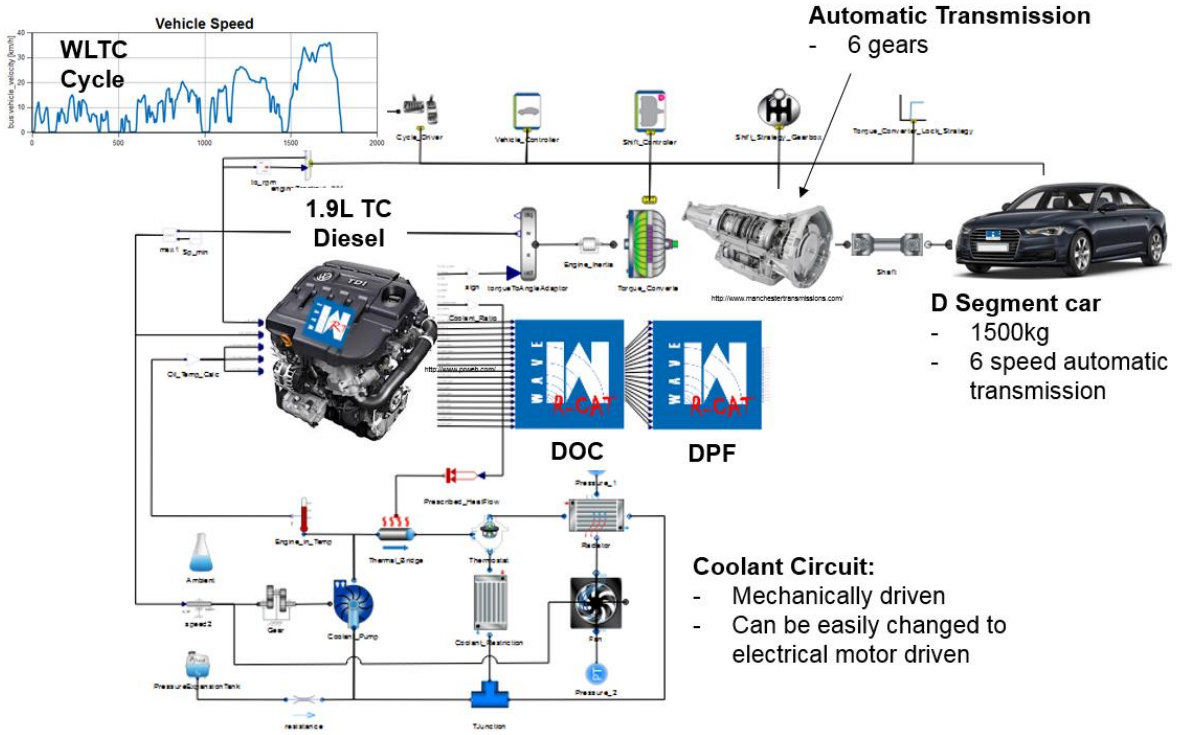


New Tutorials

documentation

- Cold Start Example
  - IGNITE
  - WAVE-RT
  - R-CAT Chemical Kinetics Aftertreatment

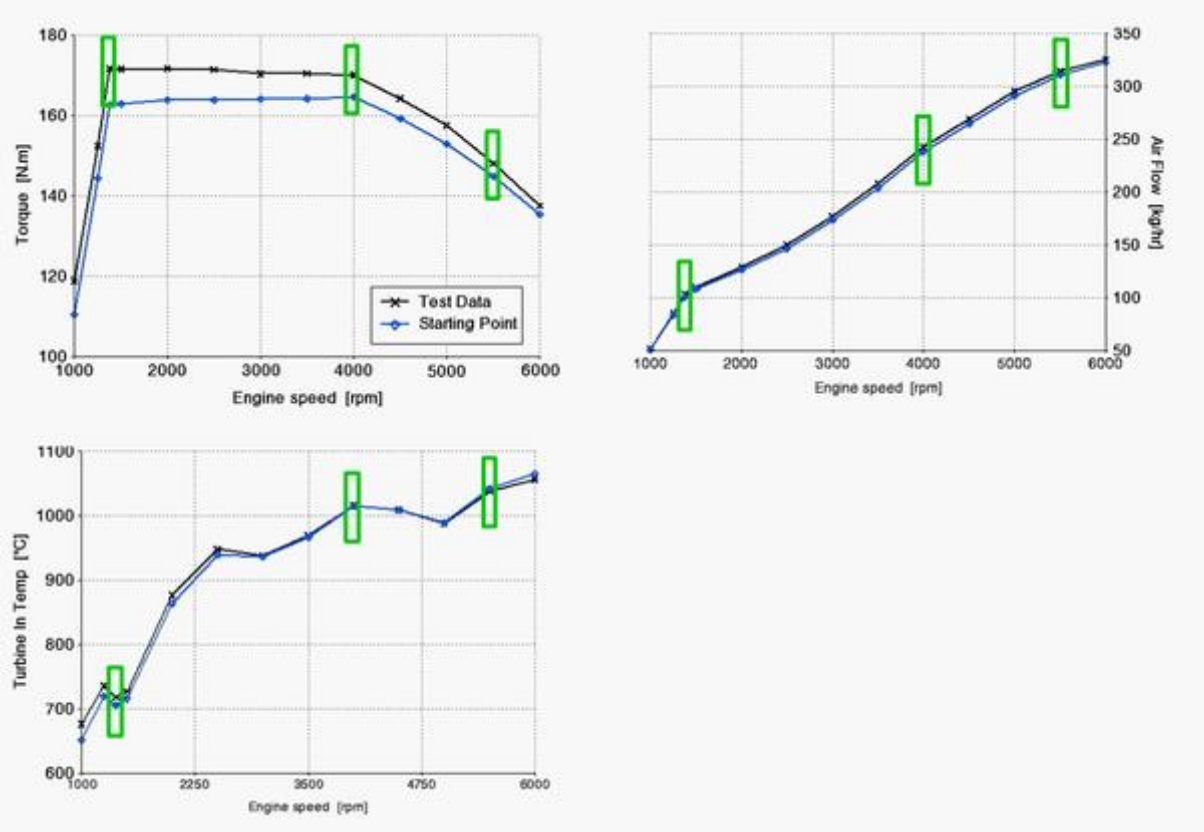
!! Runs Real-Time !!



New Tutorials

documentation

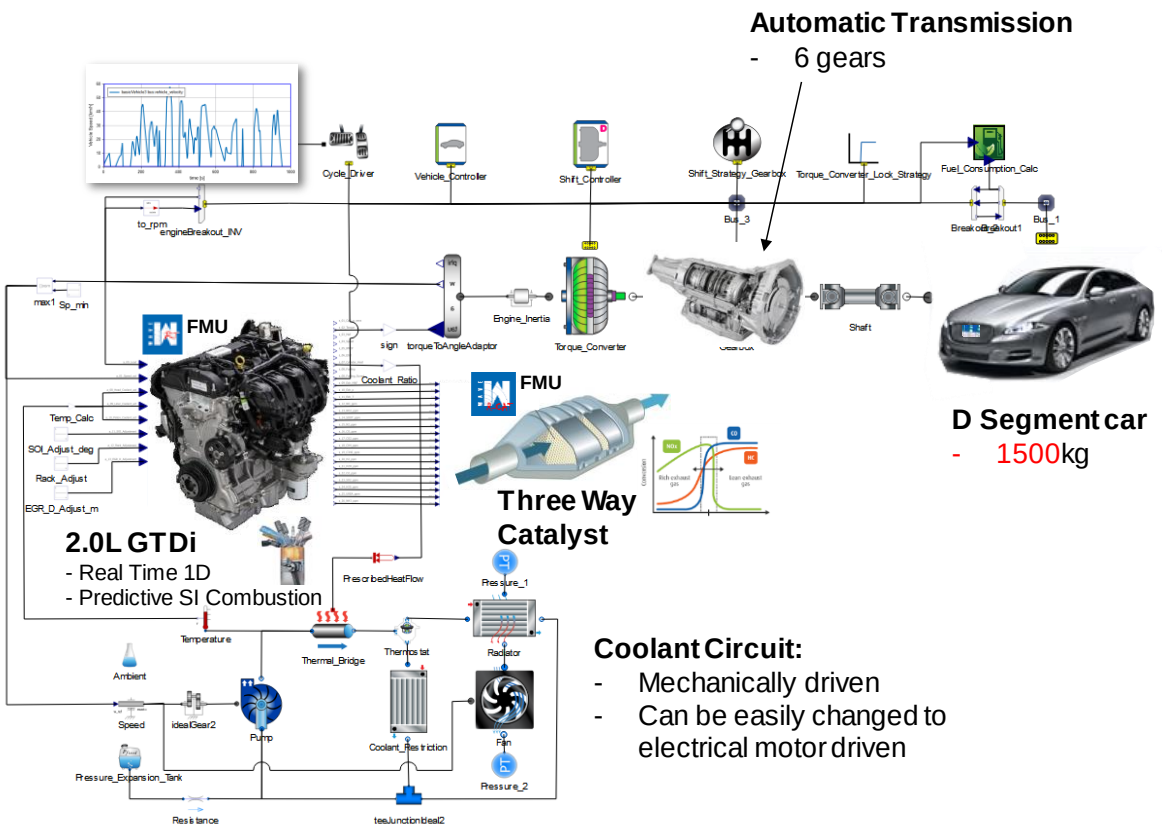
- Model Calibration Example
  - Automatic Curve Fitting
  - Using HEEDS Plugin



WAVE-RT & TWC FMU Example

documentation

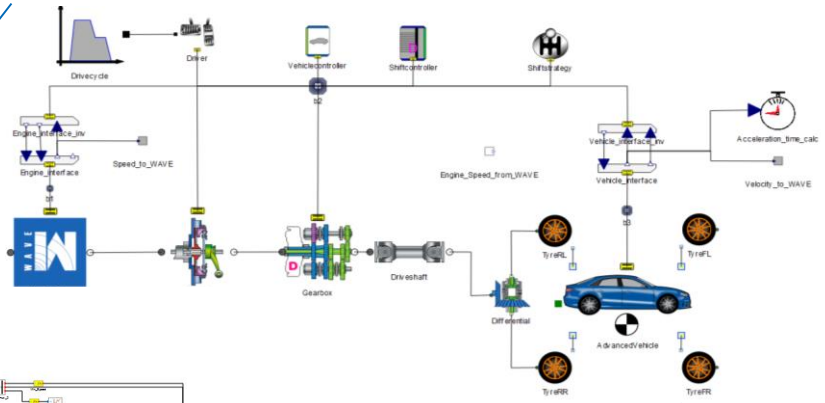
- 1-D Gas Real Time Gasoline Predictive Combustion Cold Start Driveline with TWC Chemical Kinetics Aftertreatment
  - Predictive SI Combustion
  - Knocking
  - Simple Control Strategy
  - Chemical kinetics TWC

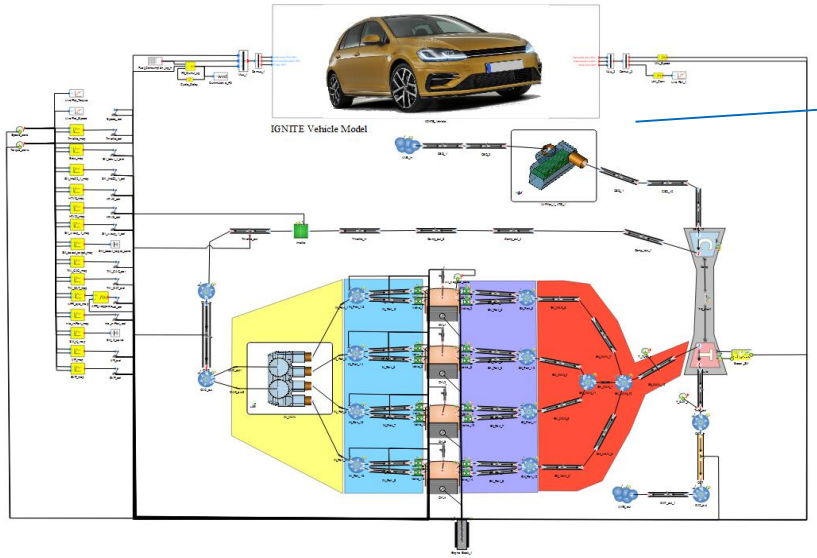


WAVE: Driveline Examples

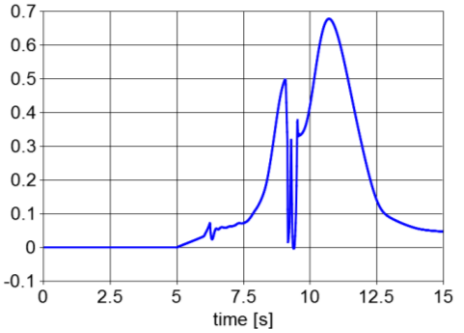
documentation

- WAVE + IGNITE
- Driving cycles
- Acceleration with tire slip





Tire Slip



New Examples

documentation

- WAVE
  - Blow-by with Crank Case Ventilation controlled by PCV Valve
  - Minimum and Maximum sensor value using Python Function
  - Transient acoustic model with Exhaust Speaker allowing to produce user defined sounds within model geometry

- WAVE-RT
  - WAVE-RT & IGNITE Diesel Engine Cold Start with Chemical Kinetics DOC and DPF model
  - WAVE-RT SiL (Software in the Loop) of Diesel and SI with knocking turbocharged engines
  - User Defined EGR Sensor
  - WAVE-RT Duct Length and Volume Actuation
  - Simple Heat Exchanger Model in both WAVE and WAVE-RT
  - Intake Sound Generator model allowing cabin sound prediction and development