



## The Optimization of vehicle interior booming noise based on GT-Power

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# Part 01

## Company Introduction

# Tenneco Product Line



## STRATEGIC IMPERATIVES

### CLEAN AIR

- Global regulatory expertise
- Foundation in core sciences
- Total systems integration
- Cost-effective global market solutions
  - Light vehicle
  - Commercial vehicle
  - Large engines
- China specific solutions
- Large platform lifecycle services



### PROFITABLE GROWTH

### RIDE PERFORMANCE

- Product cost leadership
- Superior functionality
- Advanced technology
- Vehicle dynamics / integrated systems expertise
- NVH solutions provider
- Leading aftermarket brands



*Healthier Lives*

*Superior Driving Experience*

## A COMMON FOUNDATION



### Shared Values

- Accountability
- Health and Safety
- Innovation
- Integrity
- Passion and a Sense of Urgency
- Perseverance
- Results Oriented
- Teamwork
- Transparency
- Trust

### Operational Excellence

- Safety and quality
- Tenneco Manufacturing System
- Global business processes / capabilities
- Optimized global footprint
- Strategic supplier partnerships

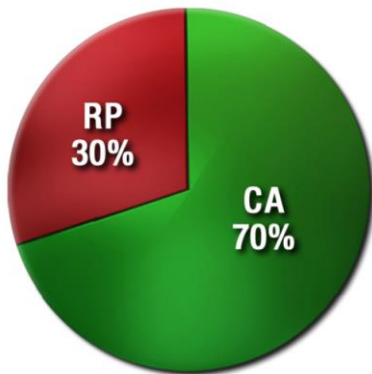
### Financial Strength

- Earnings growth
- Cash flow
- EVA
- Balance sheet strength

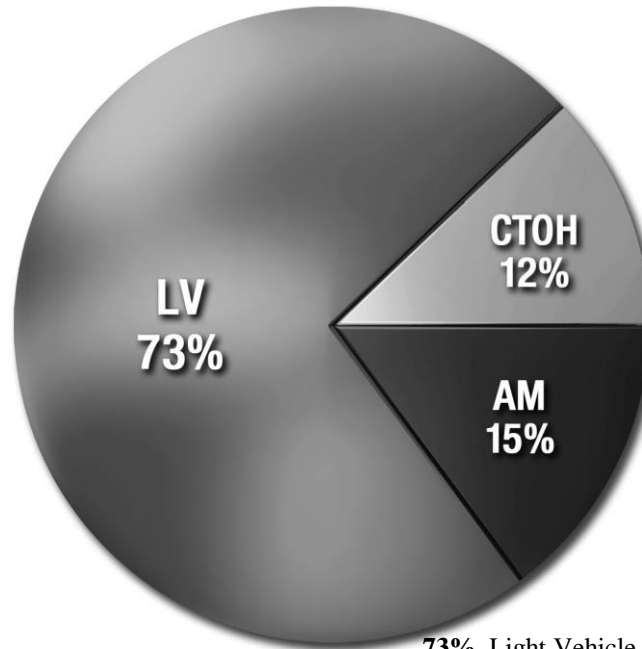
# Tenneco Product Line



## PRODUCT LINES

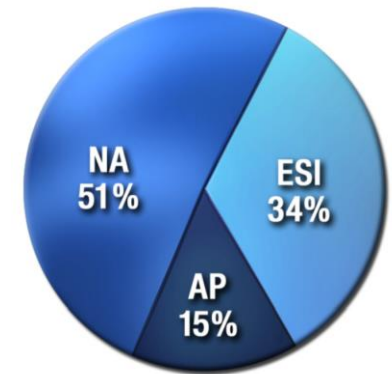


70% Clean Air  
30% Ride Performance



73% Light Vehicle Customers  
12% Commercial Truck, Off-Hwy & Other Customers  
15% Aftermarket

## GEOGRAPHY



51% North America  
34% Europe, South America & India  
15% Asia Pacific

*Partnering with the world's leading OE and aftermarket customers*



# *Global Clean Air Engineering Centers*



# *Clean Air Engineering Center Shanghai, China*



Established 2007

5.000+ square meters

145 Engineers

Focused on light vehicle  
engineering

- Engineering
- Design
- Simulation
- Testing
- Prototyping





# Simulation Capabilities Overview

3D & 2D

Hot End

CFD

Acoustics

FEA

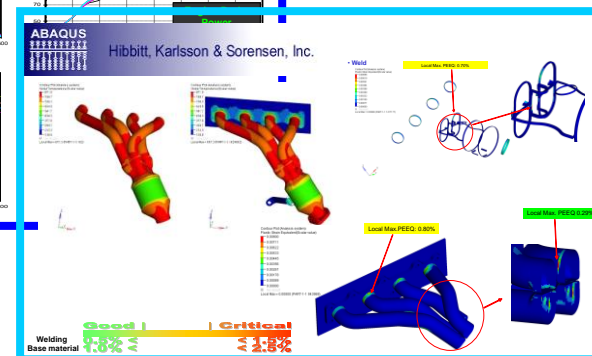
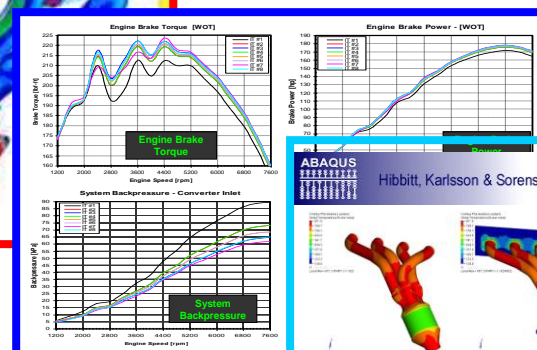
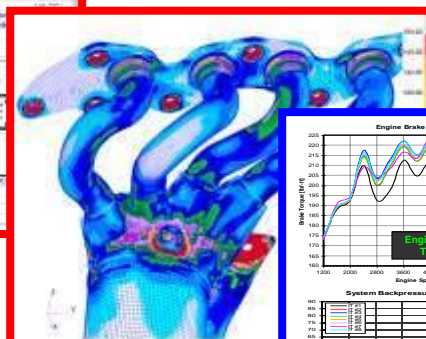
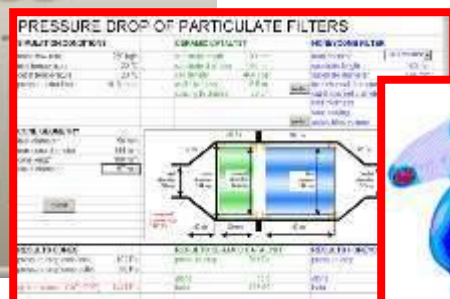
CATIA  
UG  
AutoCAD

P-CAT  
H-CAT  
Mat Layout  
GBD Monte Carlo

StarCD  
FLUENT  
ICEMCFD

GT-Power  
WAVE  
LAMPS

HyperWorks  
ABAQUS  
NASTRAN





# Lab & Prototype Overview



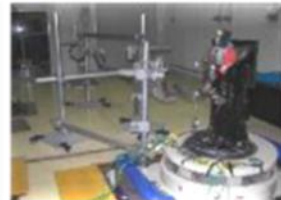
RLDA



Durability Engine Bench



Thermal shock



EVD



Hot Shake



2DOF / RRD



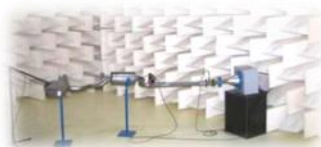
Roller Dyno



NVH Engine Bench



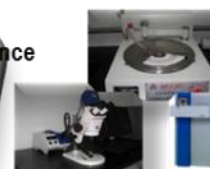
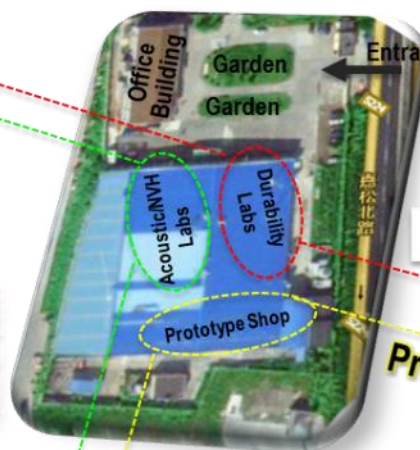
NVH Evaluation



Speaker Bench



Cold flow Bench



Material Analysis



Salt Spray



Fatigue Bench

Prototype Shop

Durability and Material Labs



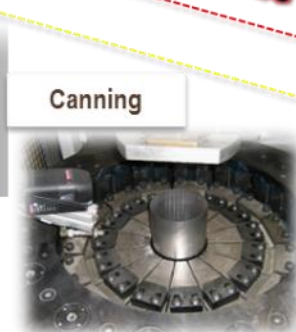
CMM



Weld Robot



Tube Bending

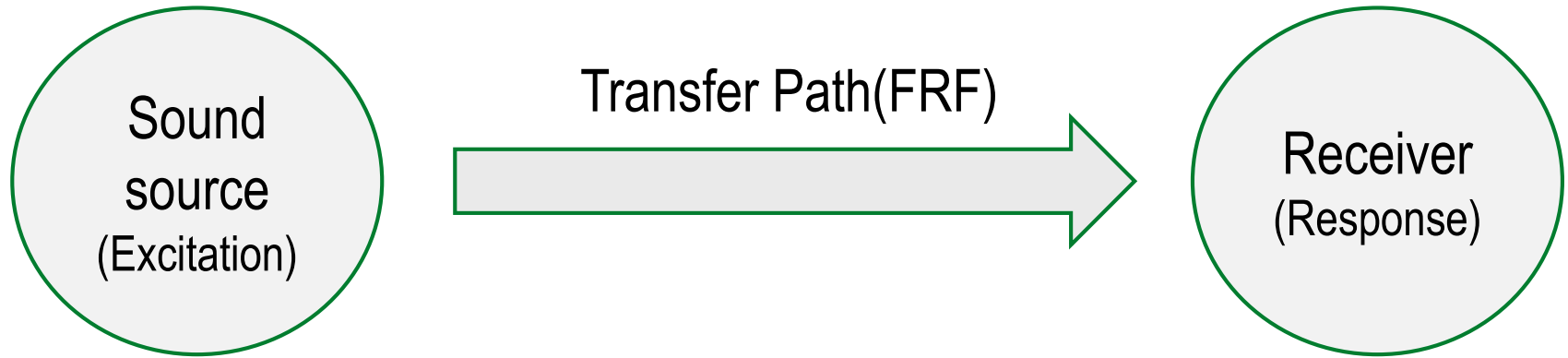


Canning

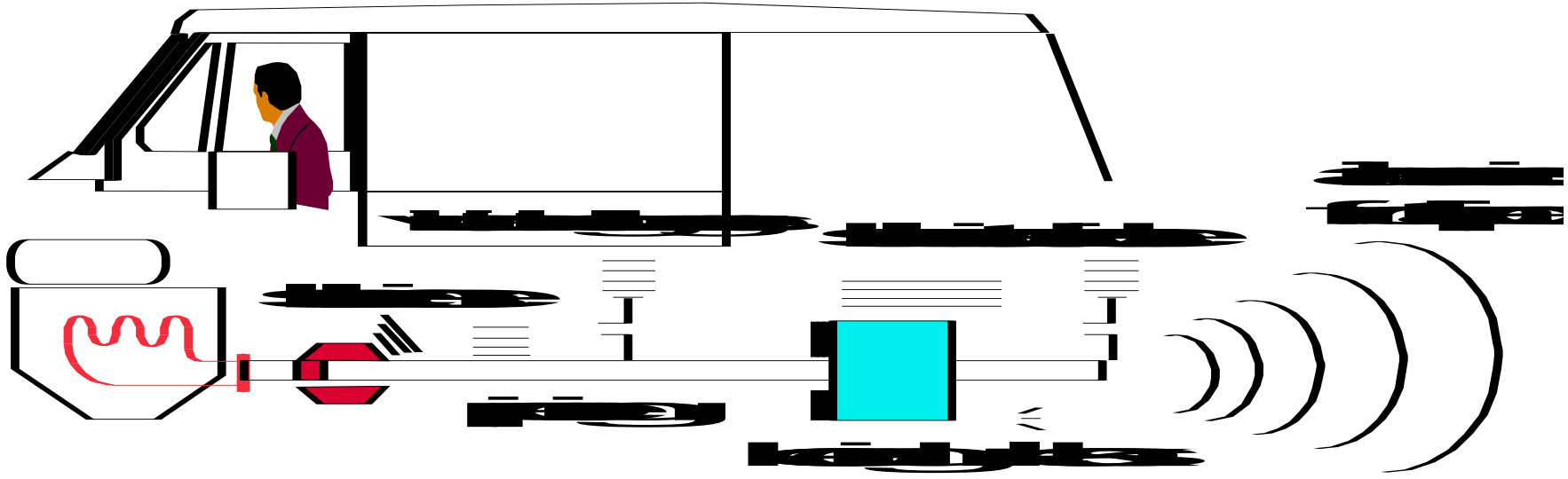
# Part 02

## Problem Description

# Basic elements in NVH



# *Exhaust Source in Car*



- Exhaust source in car including:
  - Airborne noise from tailpipe
  - Airborne shell radiation noise from endplate & shell of converter, muffler
  - Pipe/Head ring
  - Leaks
  - Noise/Vibration through hangers

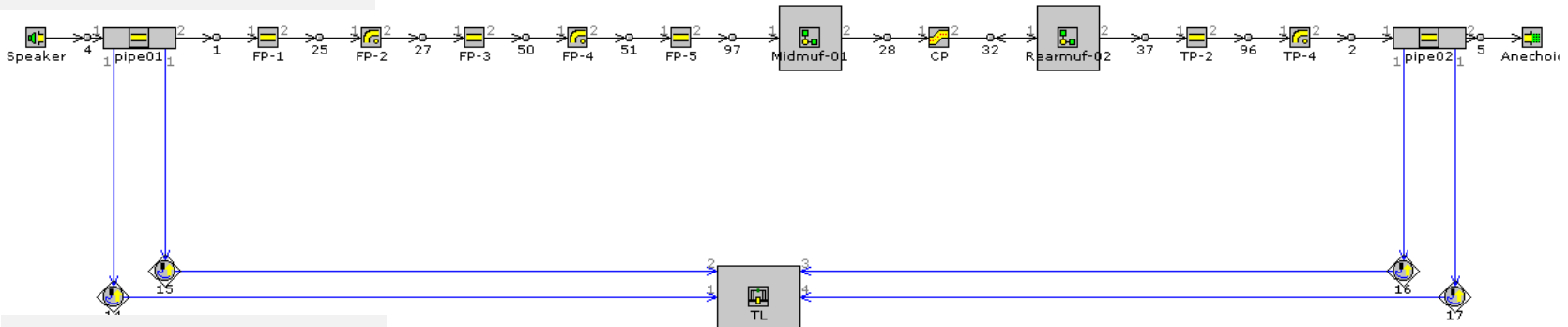
# Part 03

## Simulation Analysis

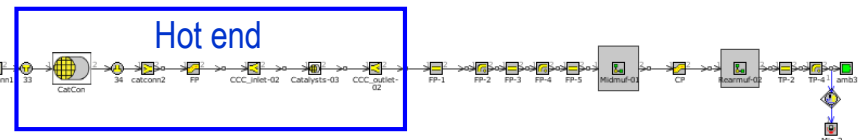
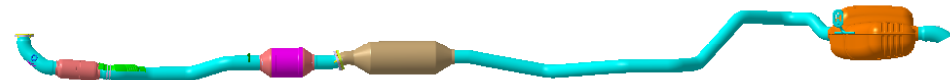
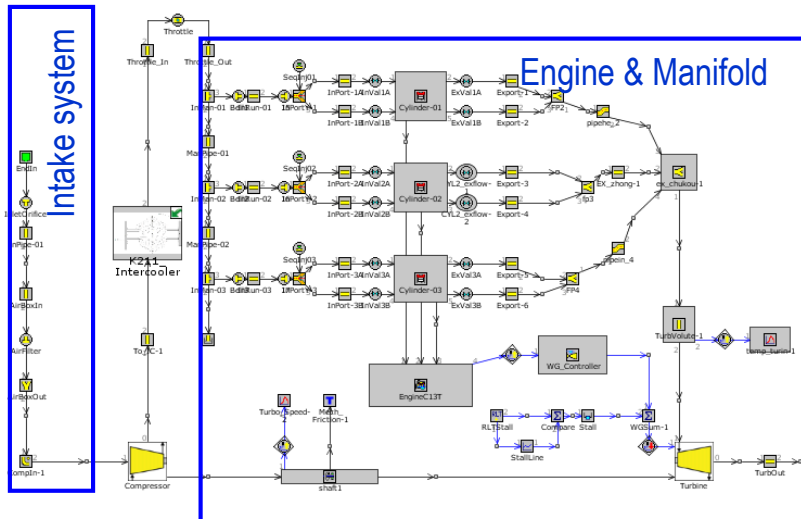
# Simulation Analysis

- Build Transmission Loss and Engine Model**

## Transmission Loss Model

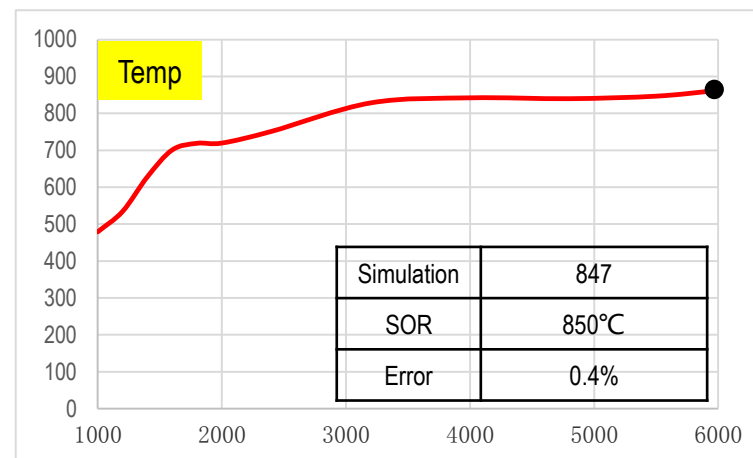
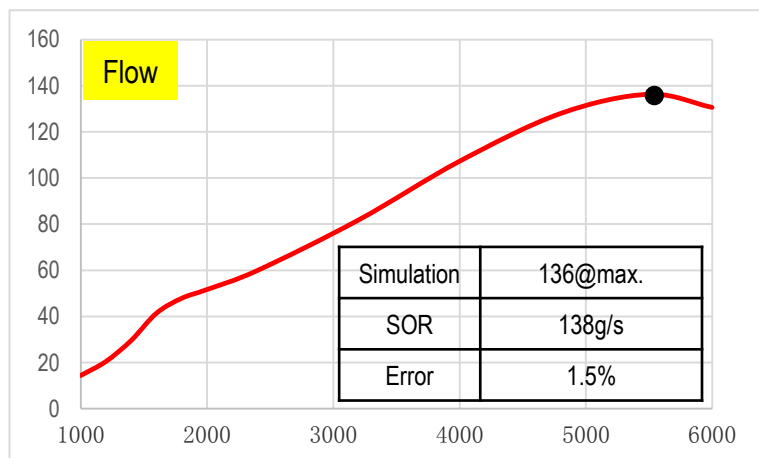
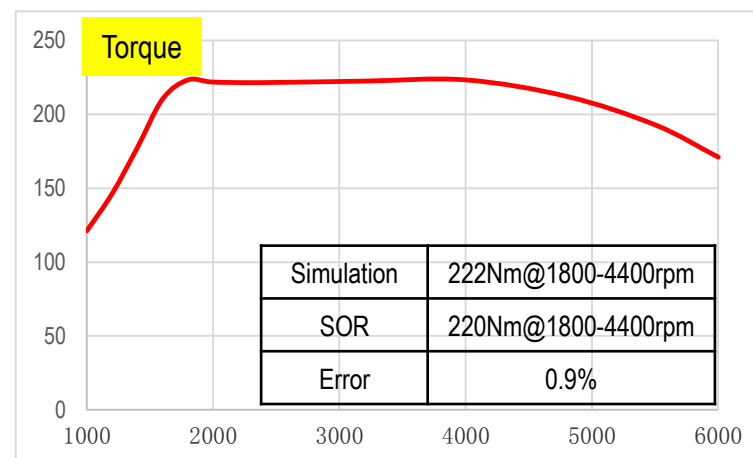
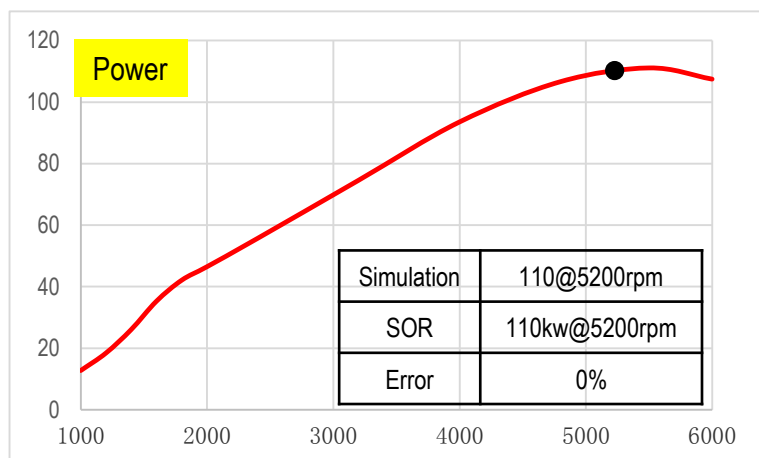


## Engine Model



# Simulation Analysis

- GT-Power Engine Model**





# Part 04

## Validation

# Part 05

## Conclusion

# Conclusion:

➤ The solution for low frequency caused interior booming noise:

- Increase the length of outlet pipe inside rear muffler
- Add Helmholtz tuning chamber
- Decrease the diameter of outlet pipe inside rear muffler, etc.

➤ GT-Power has good prediction performance in low frequency.

➤ Transmission loss is a predictable index for muffler low frequency performance, especially when engine model is unavailable. In this case, the simulation time can be effectively saved.

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Q & A

