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Exhaust System Modeling for Performance and Noise

Dan Agnew
Powertrain Simulation Engineer

AUTOMOTIVE CONSULTING SERVICES

automotivecs.com

Outline

- Purpose
- Engine and Exhaust Model
- Results Summary
  - Power, Torque, and Backpressure
  - Tailpipe Noise

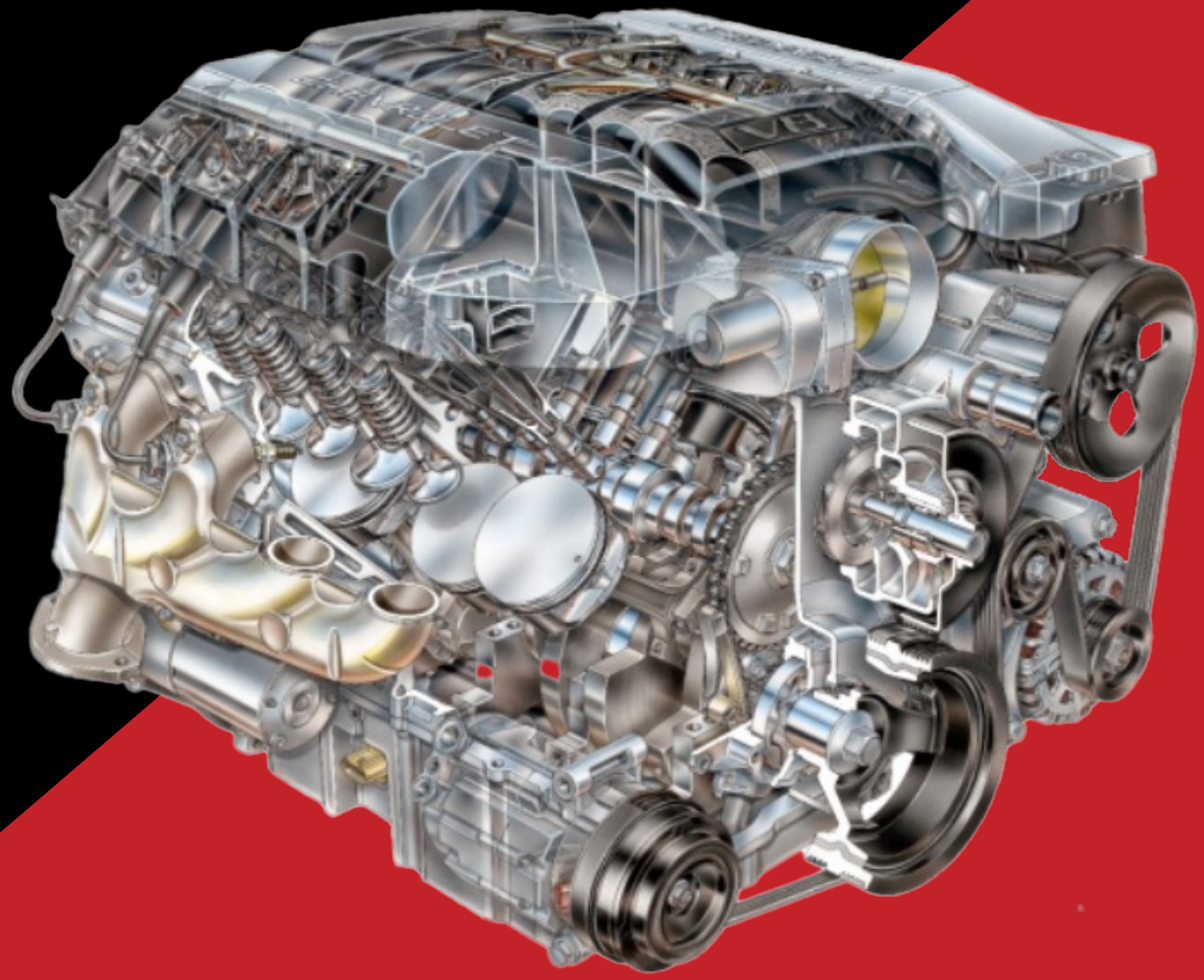
Purpose

Evaluate the performance and noise of two automotive aftermarket exhaust systems.

1. Performance was determined by engine power, torque, and exhaust backpressure.
2. Noise was determined by tail pipe sound power level, order content, and frequency content, and audio WAV recordings.

Engine Model

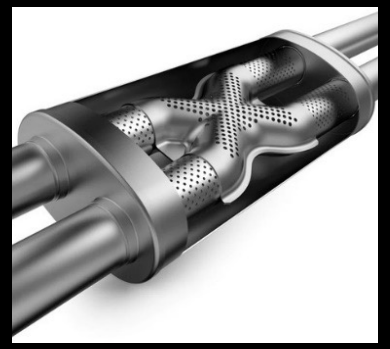
Engine model was based on GM's LS3 general specifications for bore, stroke, valvetrain, intake and exhaust manifolds, etc.



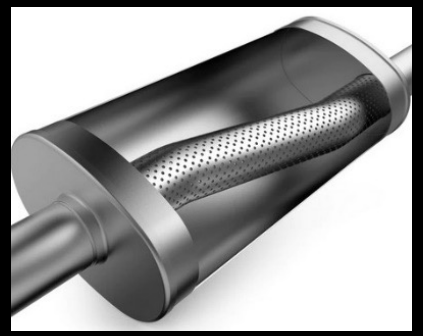
Exhaust System Studied

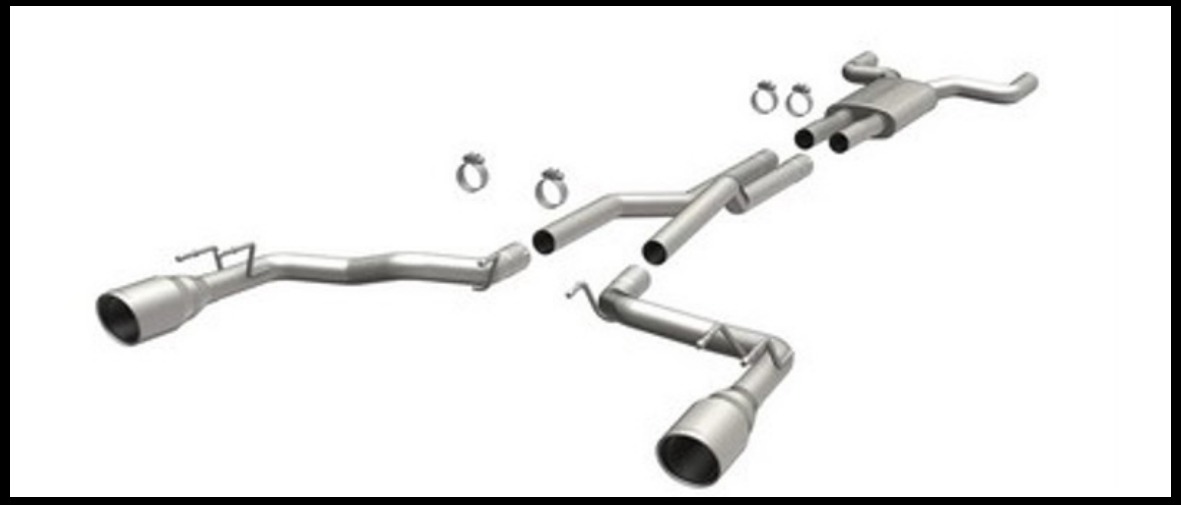
Based on typical aftermarket performance products

Single Muffler Design



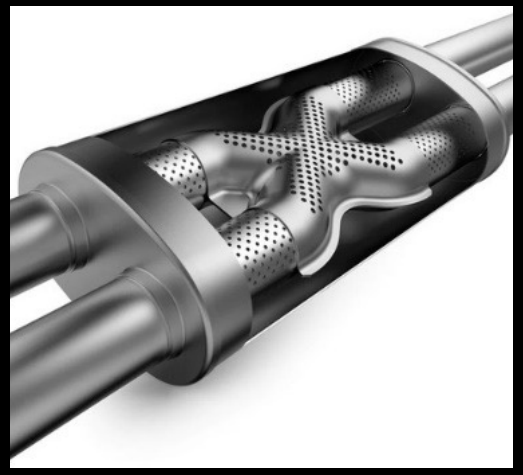
Dual Muffler Design



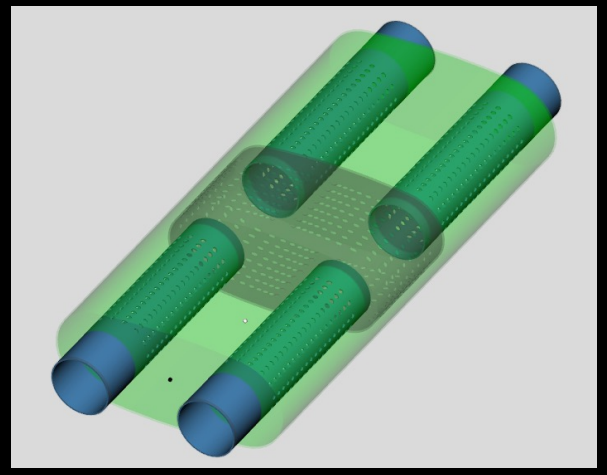


Muffler Model Creation

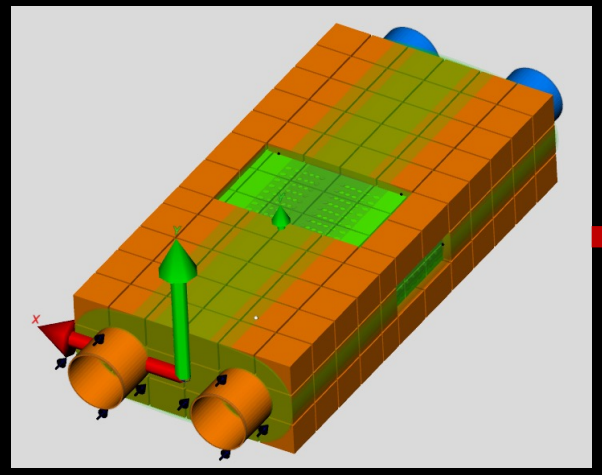
Single Muffler Design



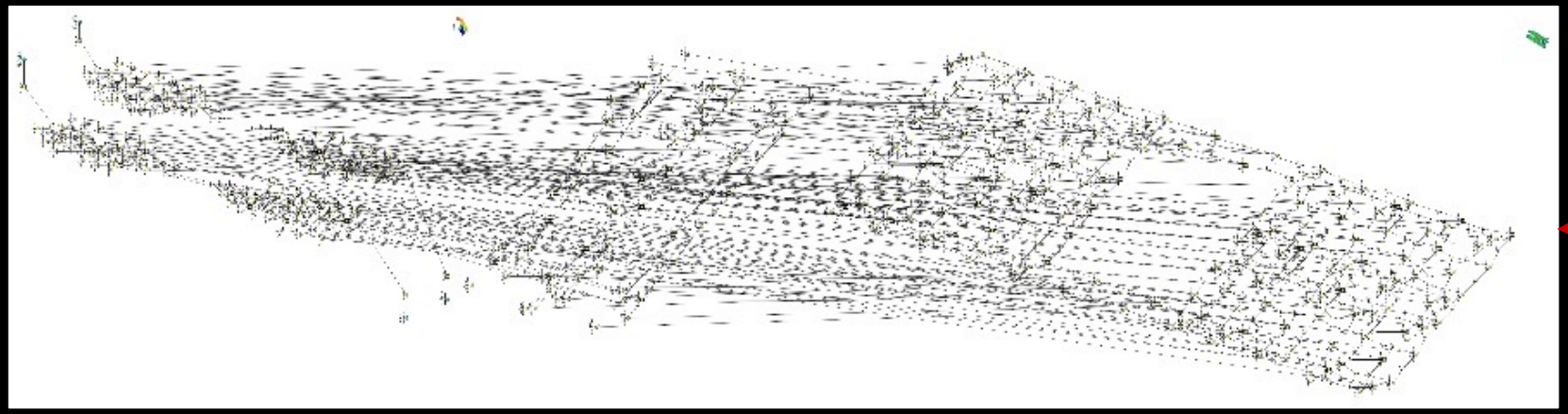
GT-GEM3D Model



GT-GEM3D Discretized Model

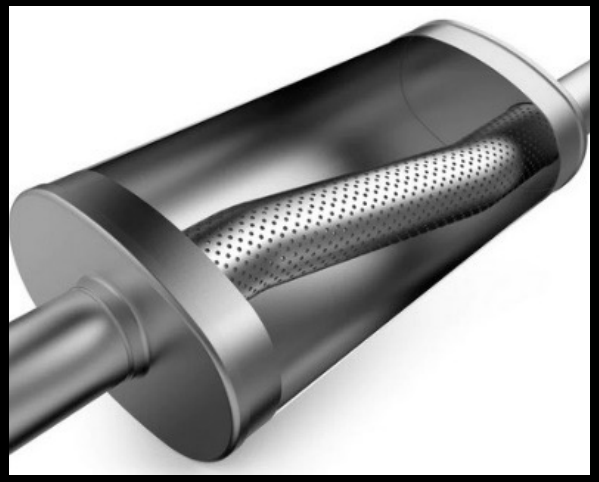


GT-ISE Subassembly Model

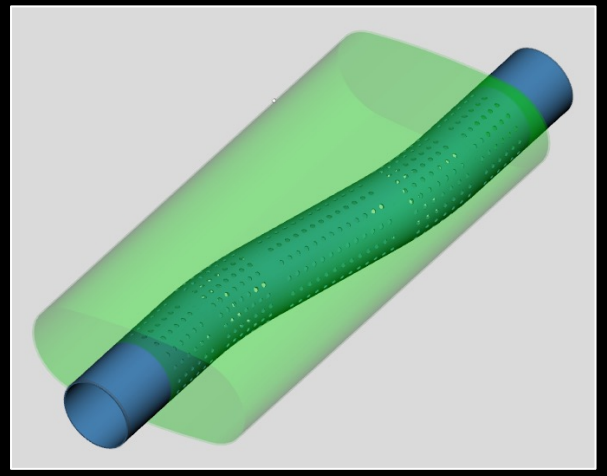


Muffler Model Creation

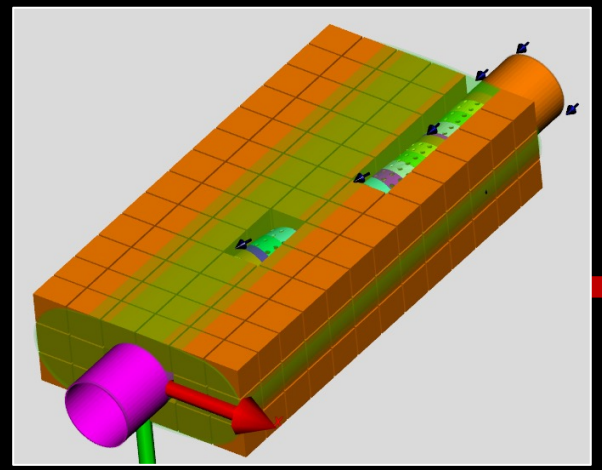
Dual Muffler Design



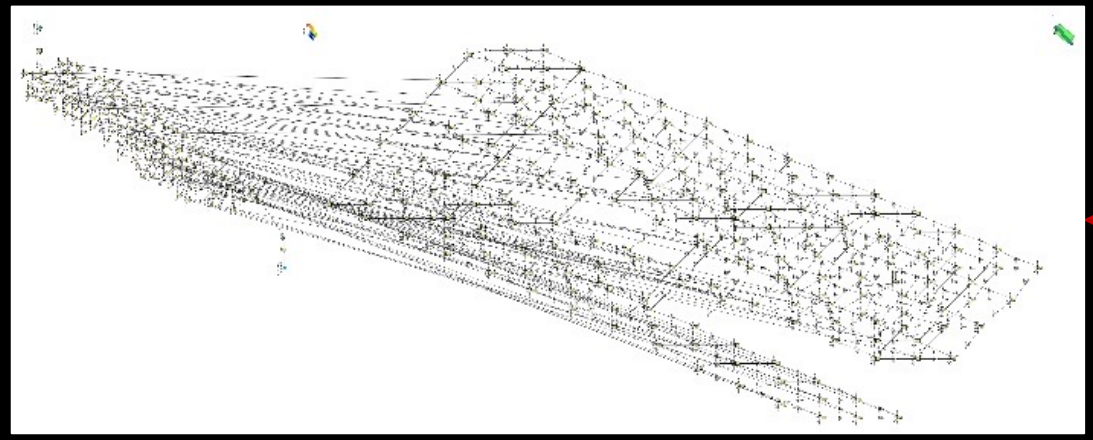
GT-GEM3D Model



GT-GEM3D Discretized Model

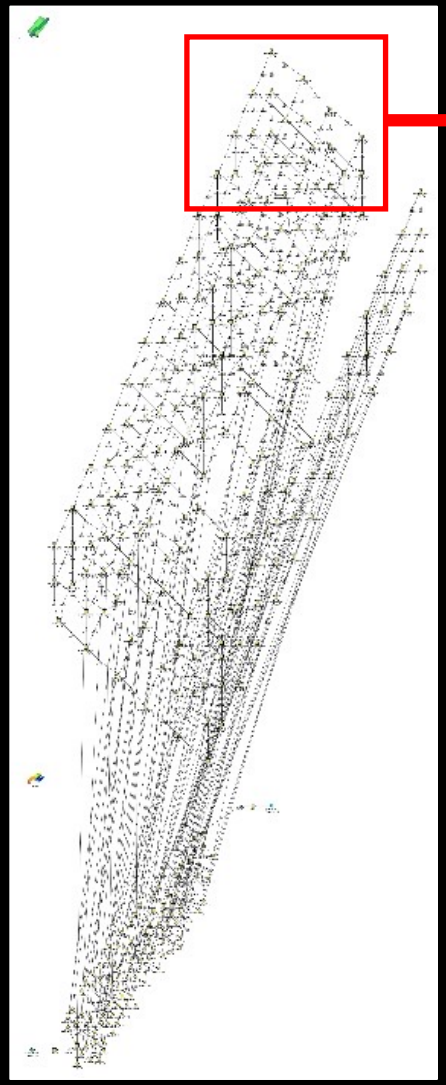


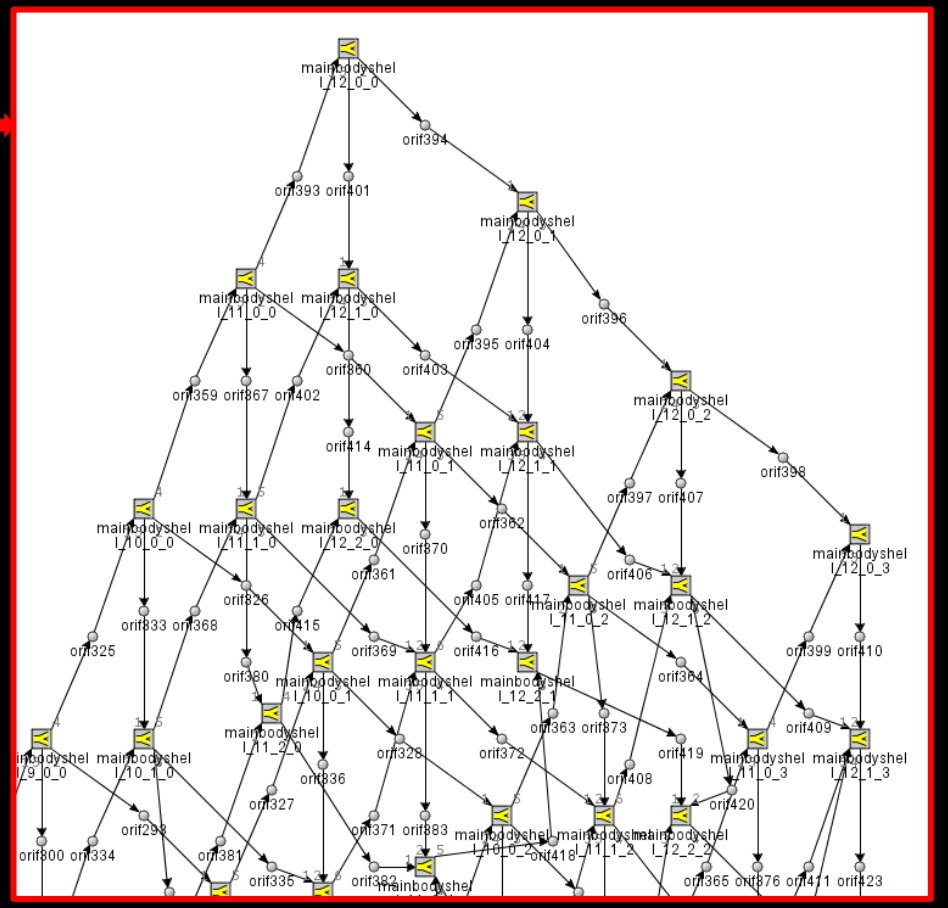
GT-ISE Subassembly Model



Muffler Model Detail

GT-ISE Subassembly Model





Close-up of muffler sub-volumes and connections

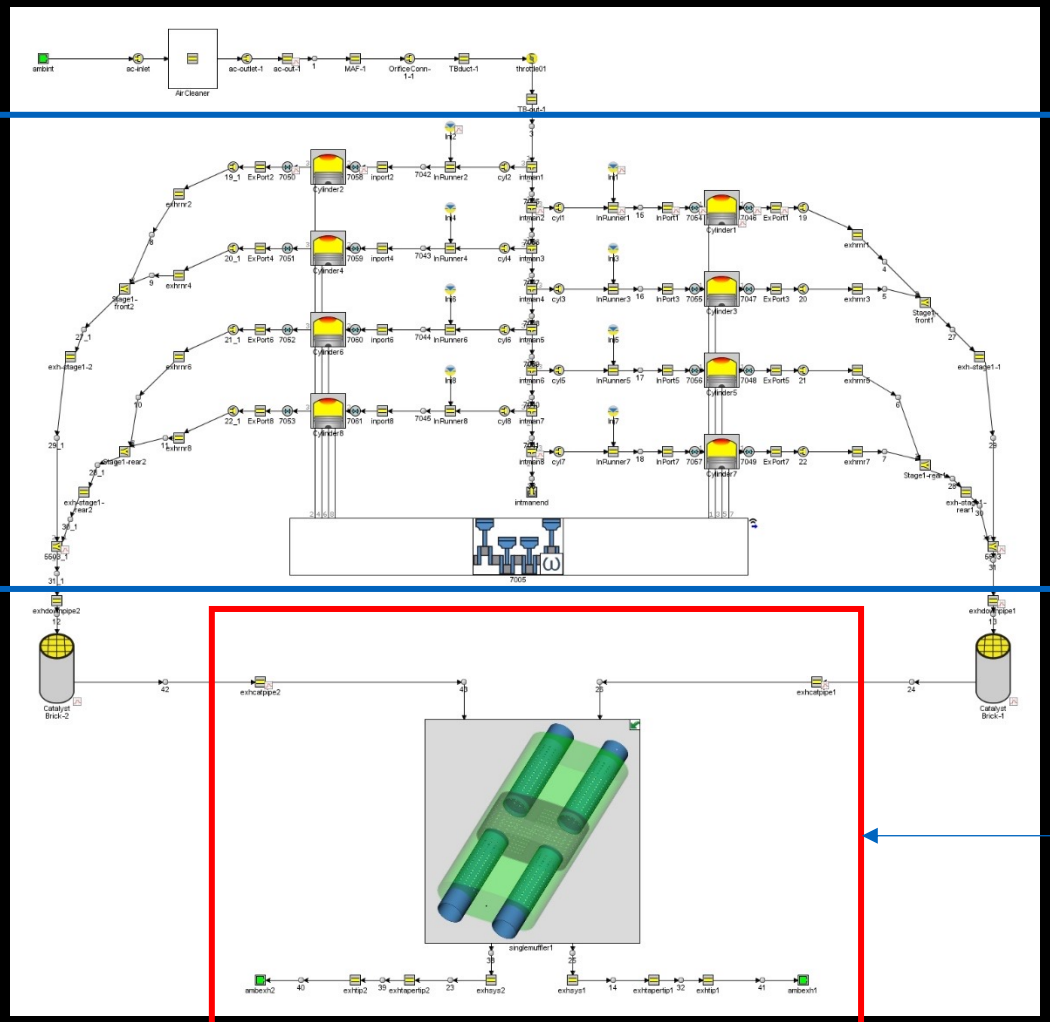
GT-Suite 1-D Engine and Exhaust Model

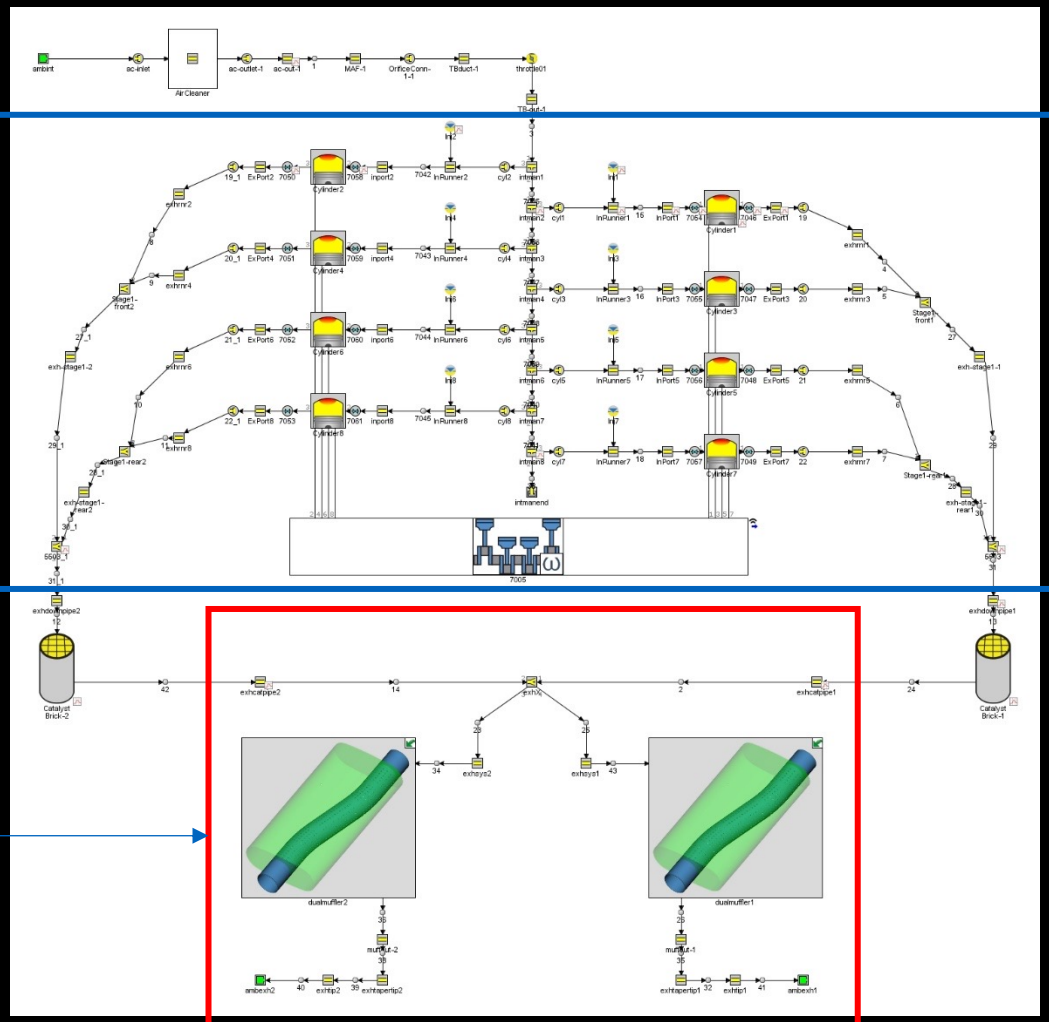
Single Muffler Design

Dual Muffler Design

Engine

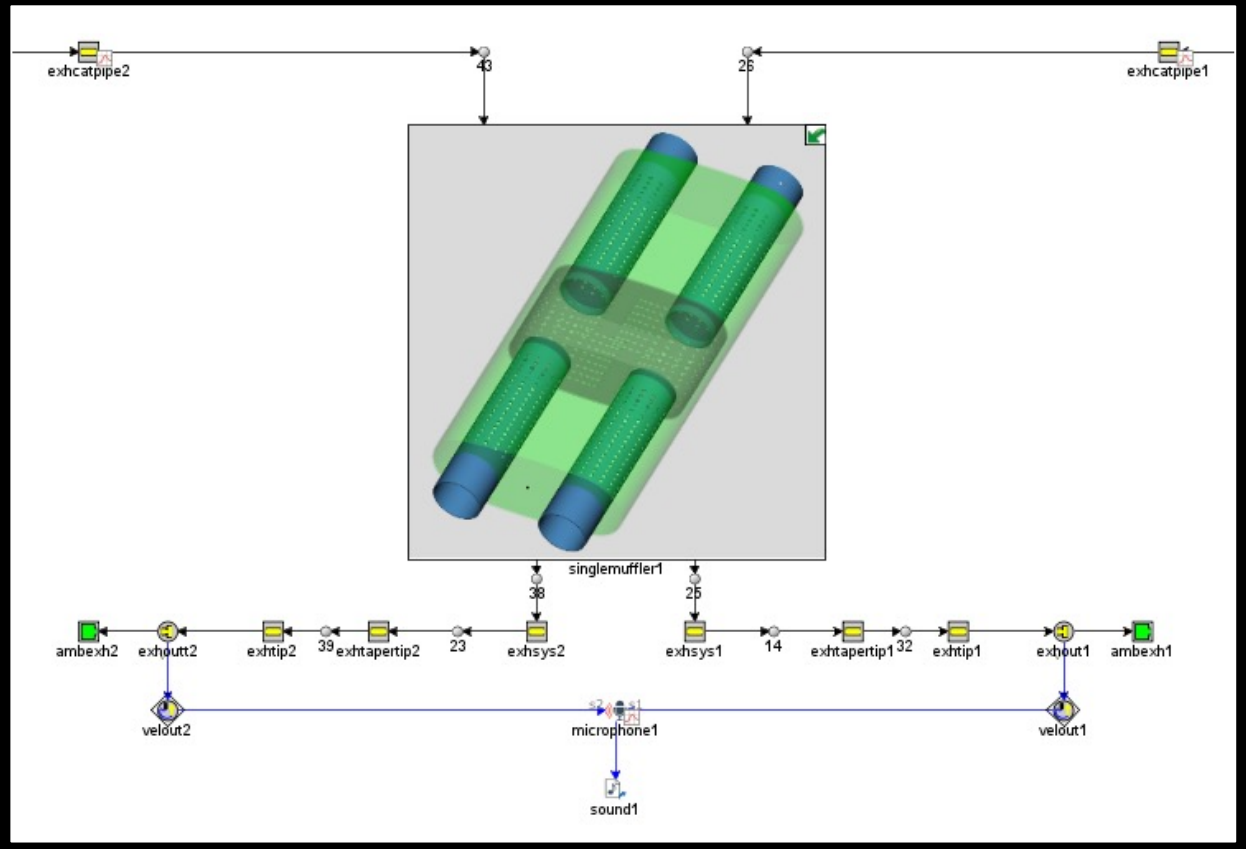
Exhaust System



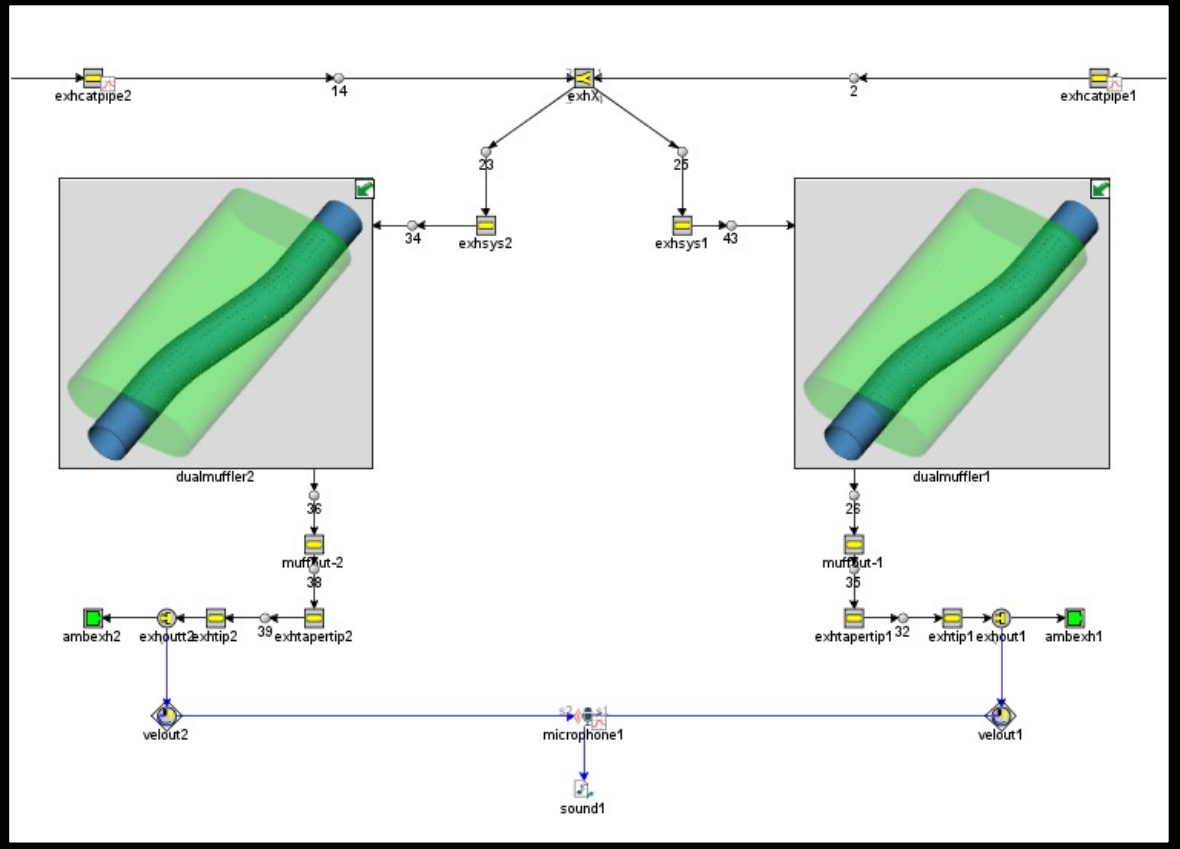


GT-Suite 1-D Engine with Microphones

Single Muffler Design



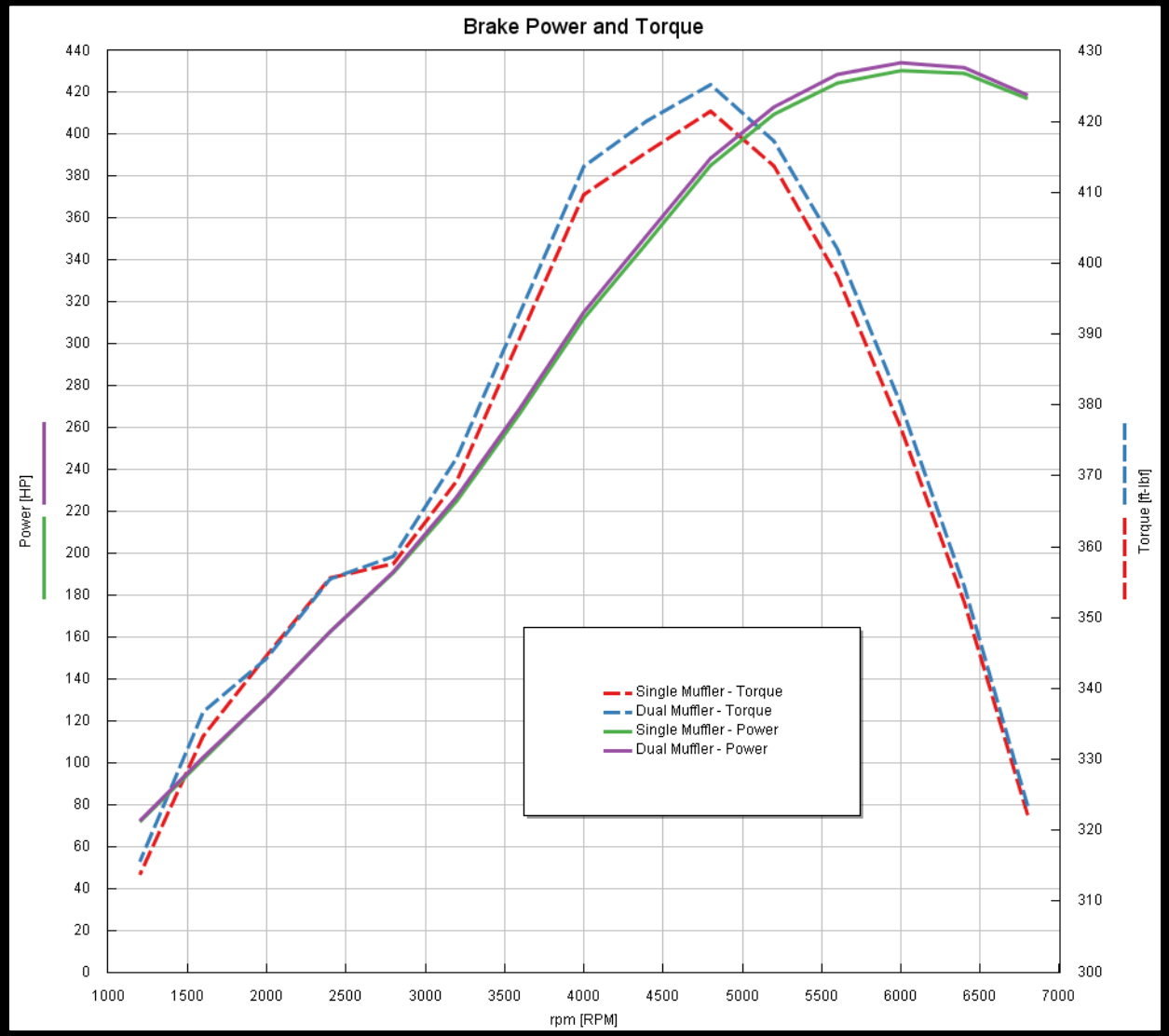
Dual Muffler Design



Microphone model output includes a combined signal from both muffler outlets.

Power and Torque Performance Results

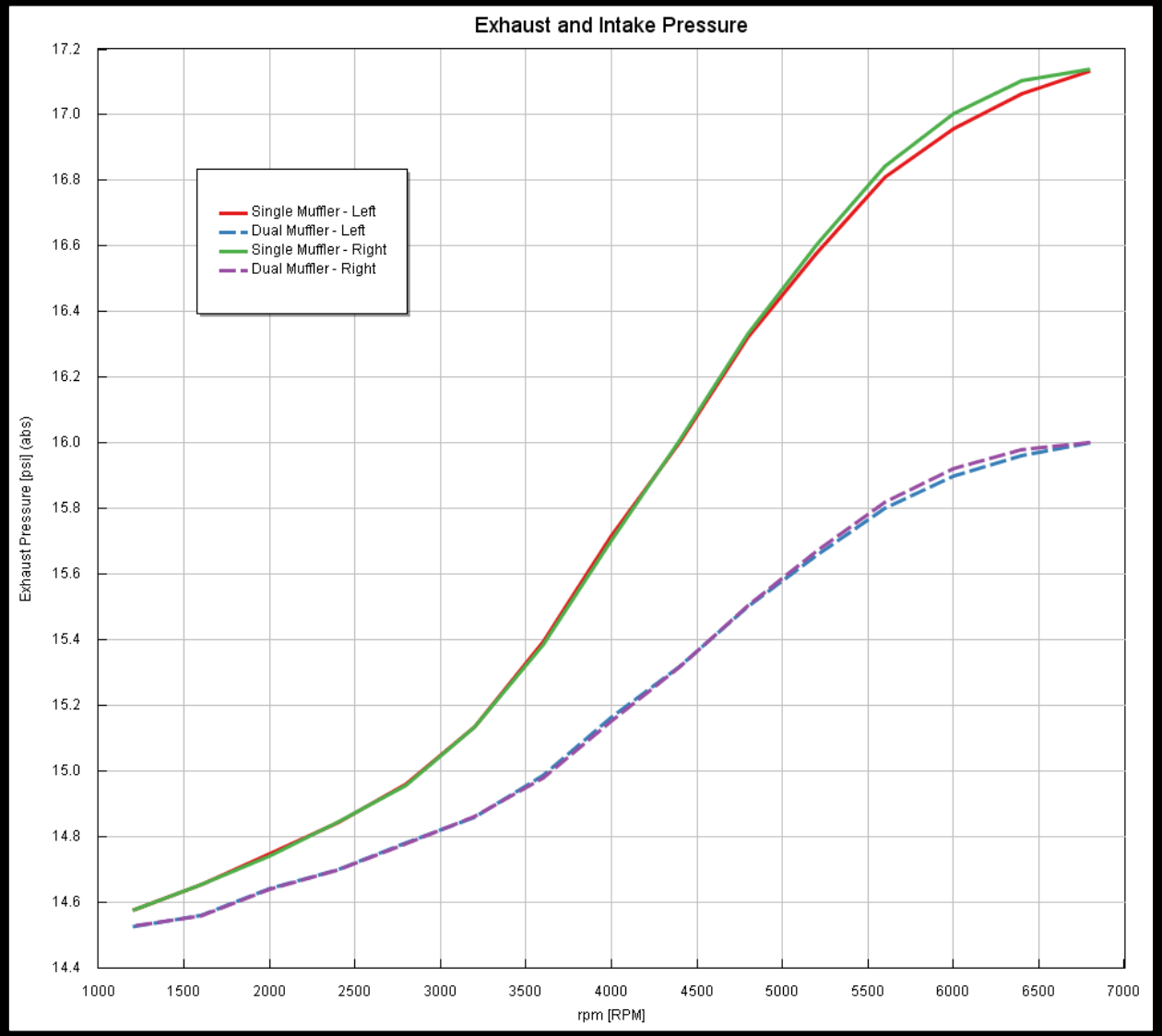
The dual muffler design showed a peak power increase of 4 Hp and torque increase of 4 Ft-Lbs.



Exhaust Backpressure Results

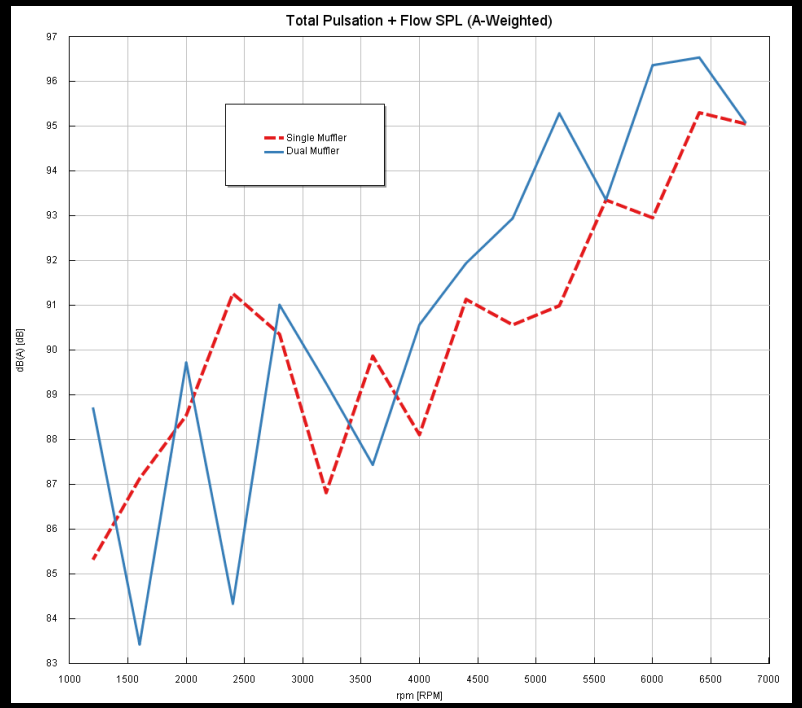
The dual muffler design showed a reduction of exhaust backpressure of 1 psi (abs) at 6000 rpm.

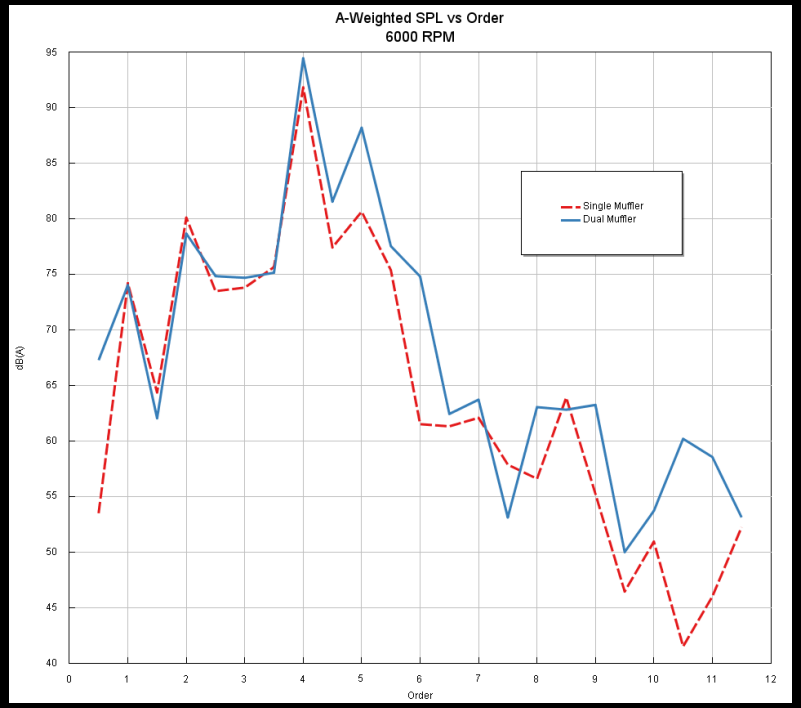
Backpressure calculated just upstream of left and right catalytic converter, respectively.

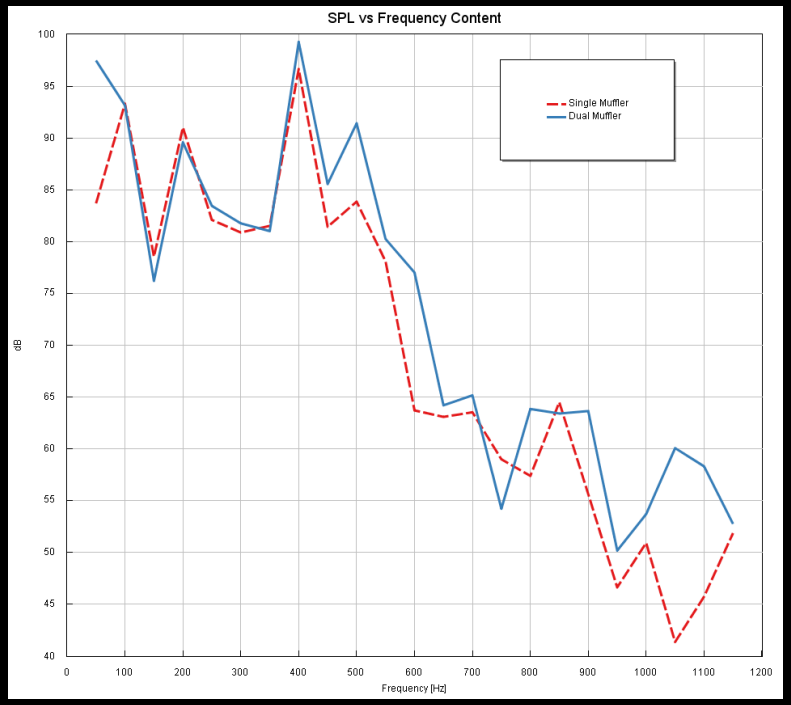


Tailpipe Noise Results – Overall Level and Order Content

- As shown by the overall level, the dual muffler design has higher levels at the higher engine speeds. The difference is subtle but can be heard from the audio recordings at 6000 rpm >>> Click on audio icons below to play sound.
- The lower orders are mostly the same, but above the primary (4^{th}) order, the dual muffler is mostly higher.
- From 450 to 700 Hz, and also above 900 Hz, the dual muffler design, SPL is higher.







Click to Hear Single Muffler vs Dual Muffler Design, 6000 rpm

Summary

- As shown by the models here, exhaust systems performance can be evaluated and compared early in a program's timing to determine the best alternative.
- Granted that tailpipe noise requirements in the performance aftermarket can be quite different than at the OE's, these tools are still quite useful for comparisons.
- For the two typical systems shown in this example, the dual muffler systems would be deemed best as long as the higher noise levels are still acceptable.
- Further studies to determine why there are differences could include pipe sizes (lengths and diameters) and muffler content (volume, baffling, perforations, placement). This study used a common camshaft for the two alternatives, but the effects of exhaust cam timing and duration could be useful also.
- A similar study method can be applied to air intake systems also.

Thank You