

# SEA Optimization

Jian Pan

Rieter Automotive North America



# Outline:

- ❖ **Trivial solutions & misconceptions**

- ❖ **SEA Optimization**

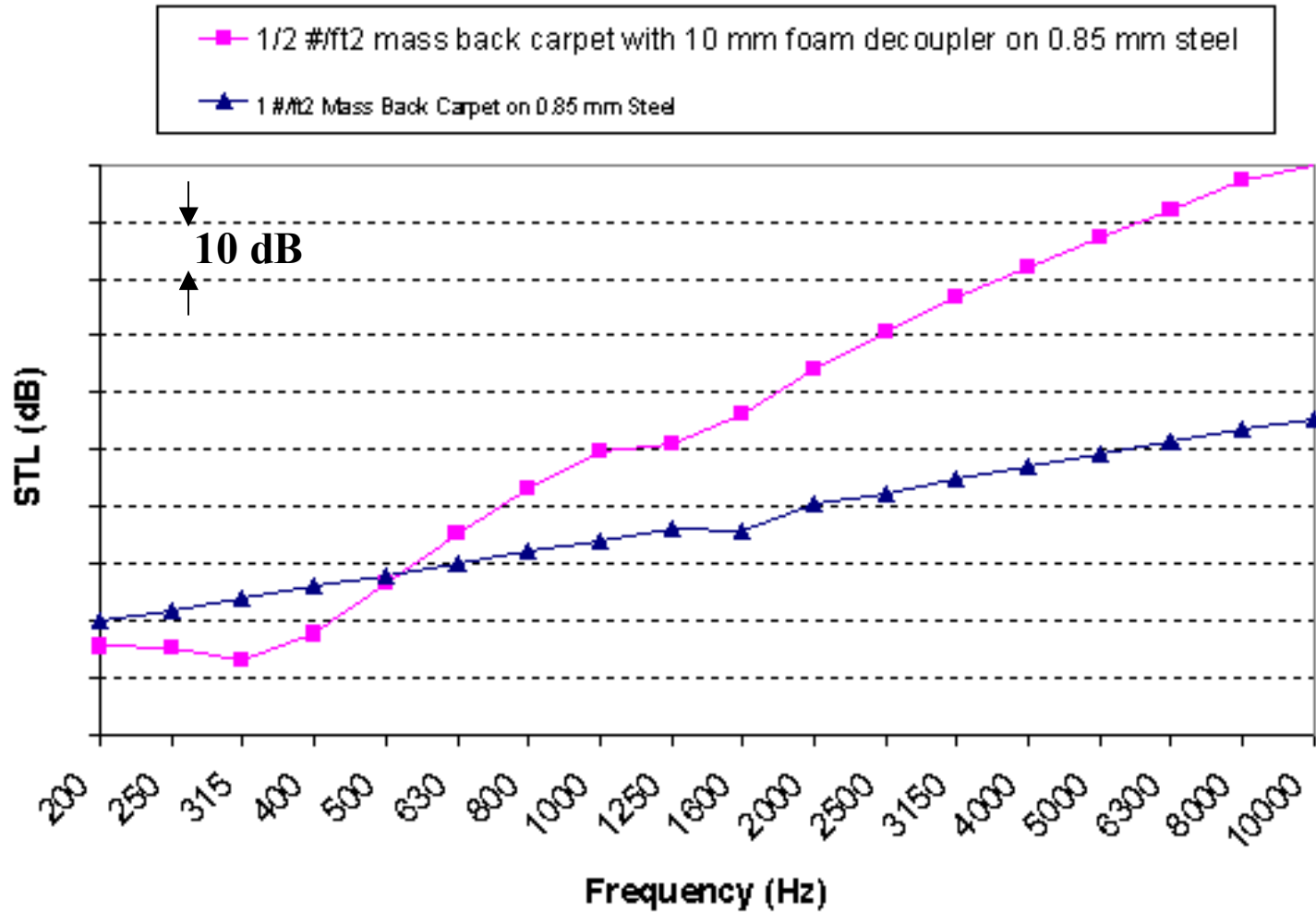
  - ✓ **Problem formulation**

    - **design variables & design space**

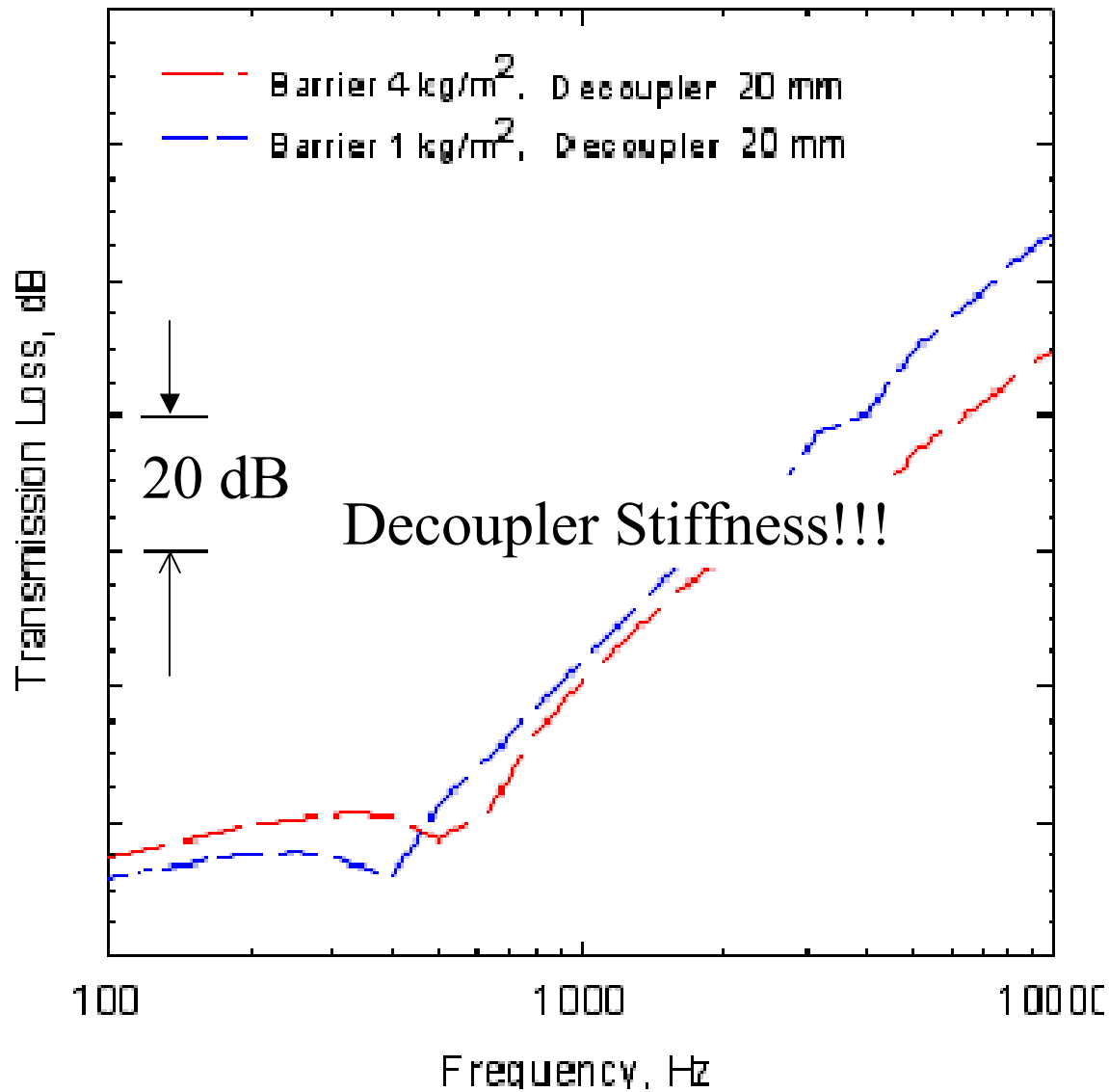
  - ✓ **Applications & cost benefit**



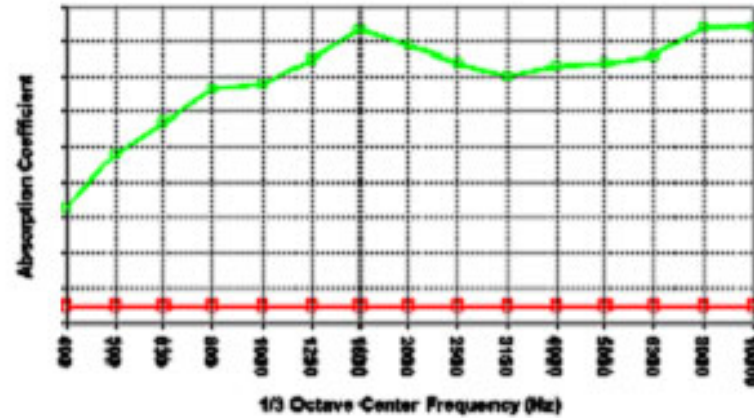
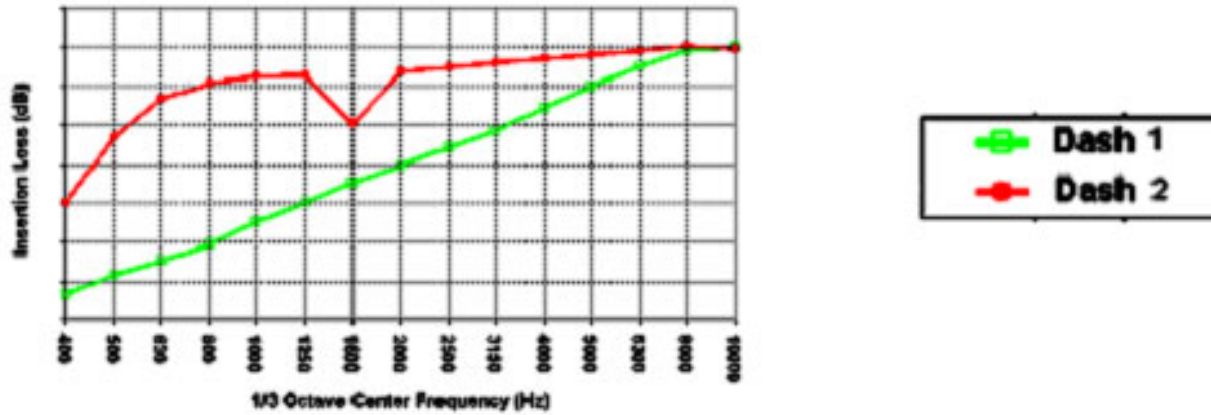
# Misconception #1: Heavier material performs better



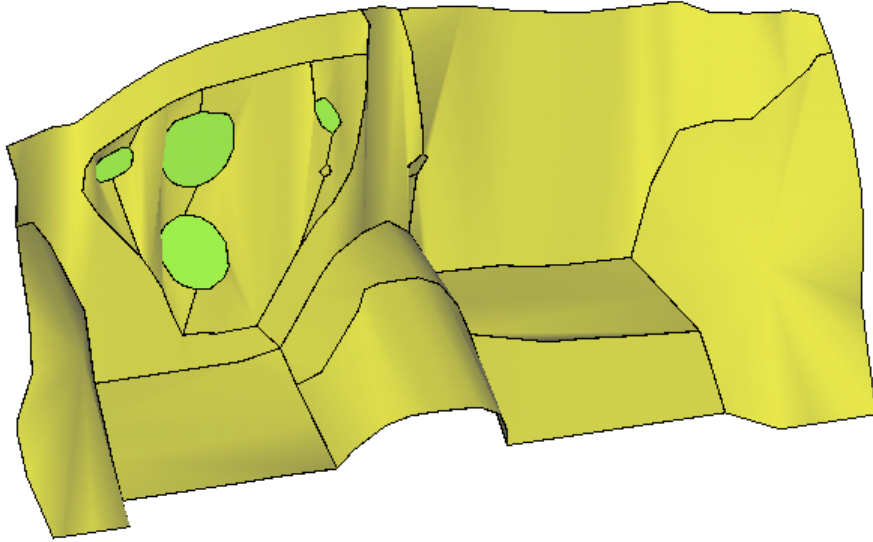
## Misconception #2: Heavier and thicker material performs better



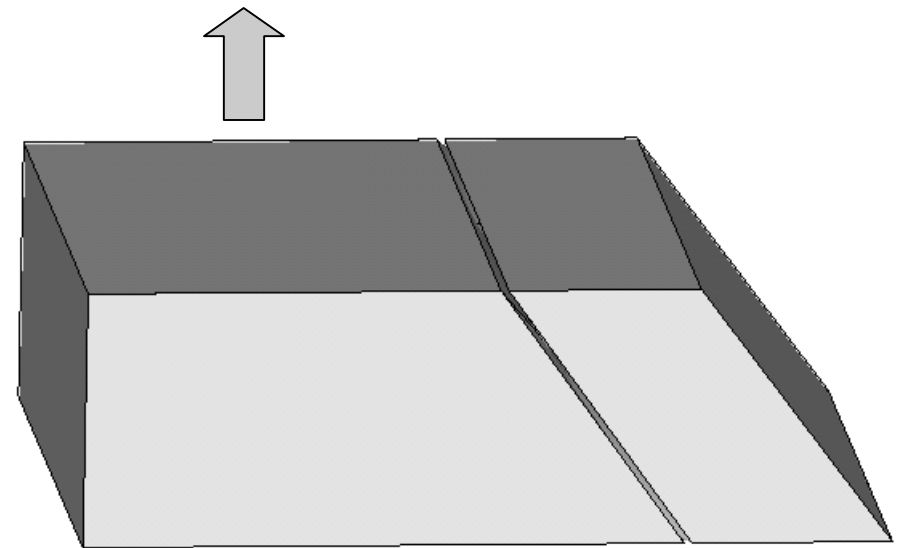
# Misconception #3: Materials with higher STL performs better



# SEA STL Model



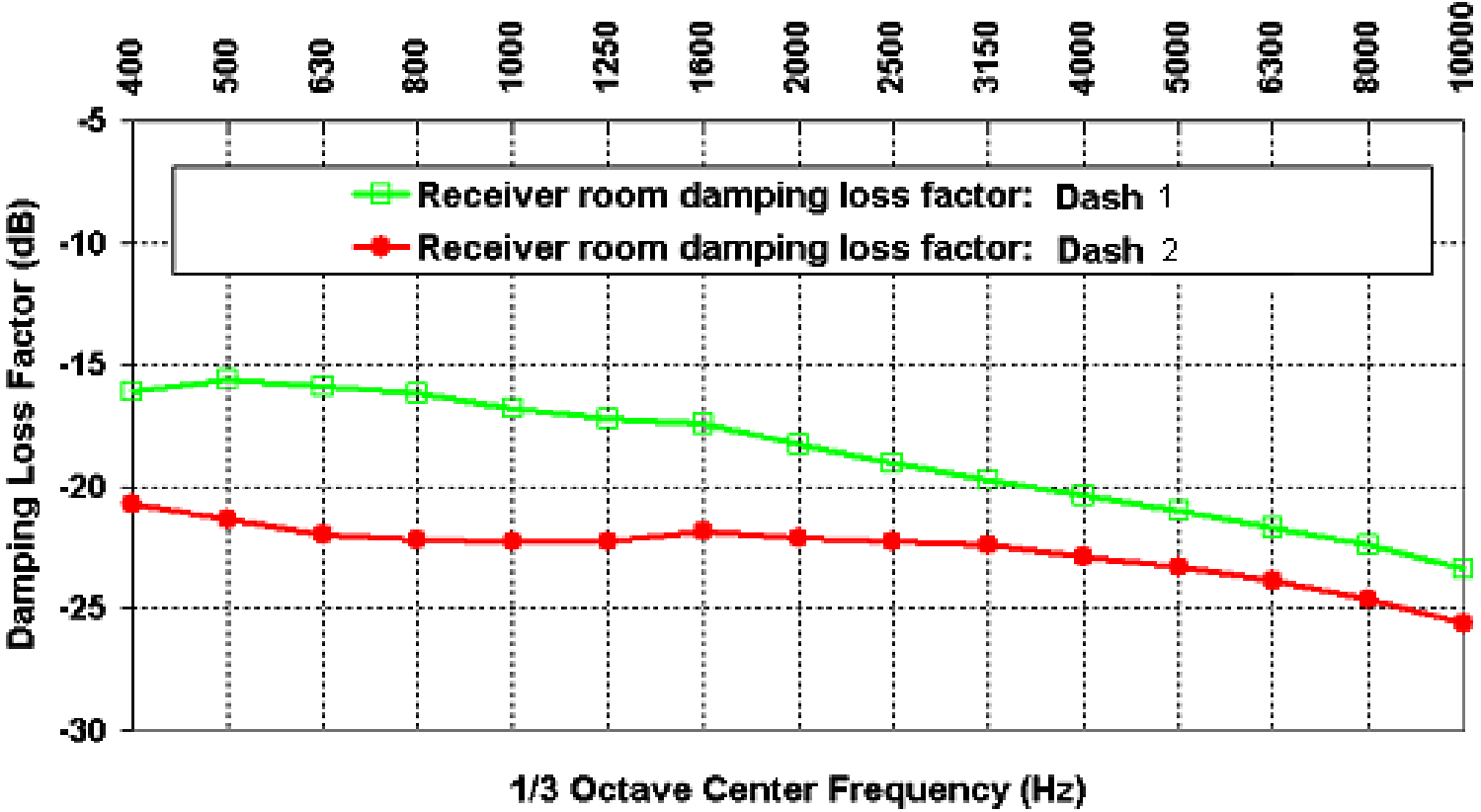
Source Room Input SPL:  
1 Pa, 93.98 dB



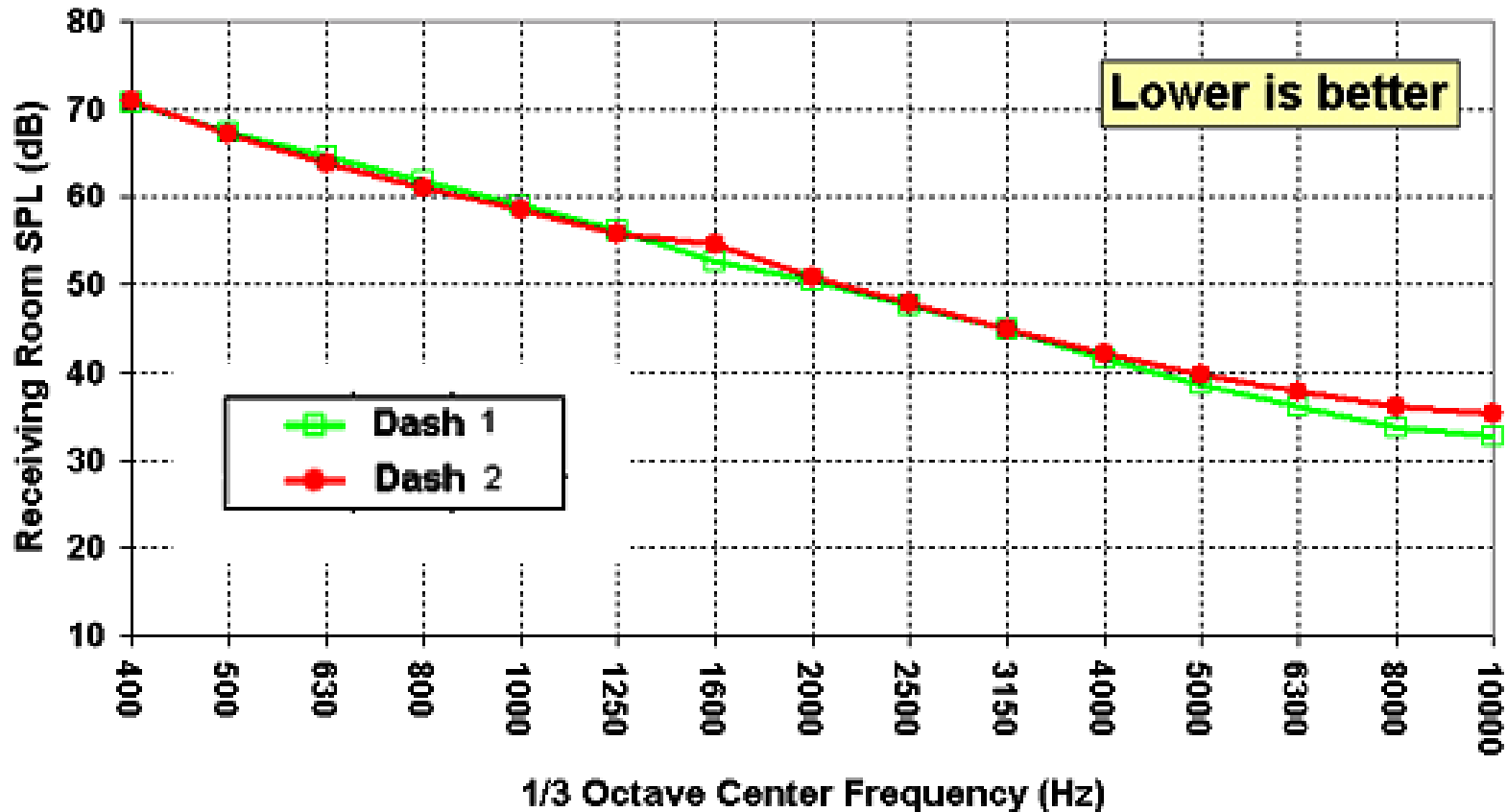
Receiving Room



# Receiving Room Damping Loss Factor



# Receiving Room SPL



# Summary

- ❖ Vehicle acoustic performance is a function of STL, absorption, weight, thickness, and many other material characteristics, e.g., stiffness, constructions, material type (foam vs. fiber) ...
- ❖ Non-trivial optimal solution exists only when all parameters are taken into account!



# Problem Definition

Problem 1: Performance Optimization:

Find optimal sound package design to

Minimize interior SPL subject to cost &/or weight constraints

$$\text{Minimize } f = \sum_i \alpha_i (SPL_i - SPL_i^0)$$



# Problem Definition

Problem 2: Weight or Cost Optimization:

Find optimal sound package design to

Minimize weight or cost subject to performance constraints

$$\text{Minimize } f = \sum_k \omega_k A_k$$





# Design Space

- ❖ Material type,
- ❖ Thickness,
- ❖ Single or multi-layer constructions,
- ❖ Surface weight, ...

Note: the objective functions are complex, discontinuous functions of the design variables, selection of optimization algorithm is important!



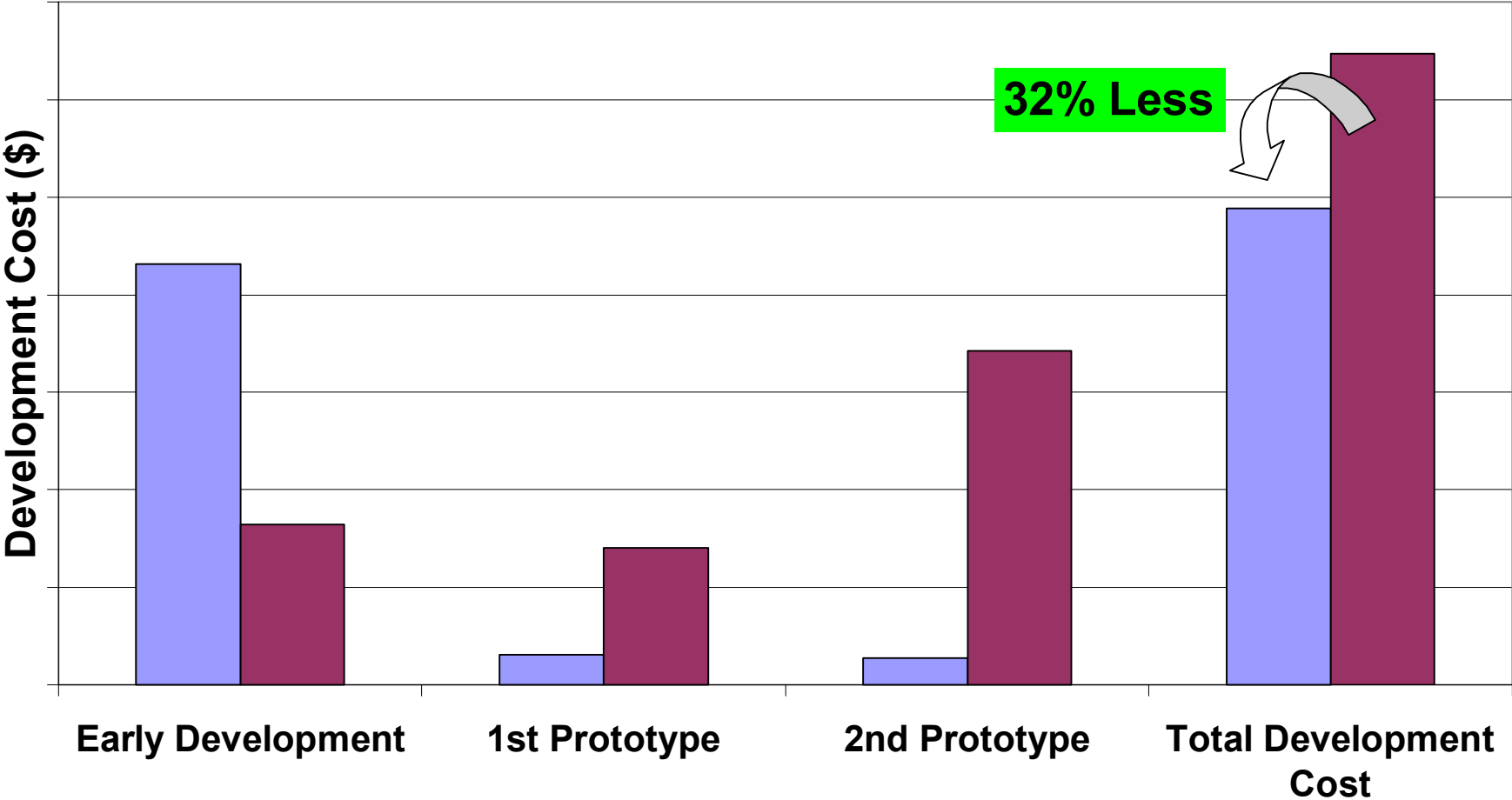
# Applications

- ❖ Early program stage
  - Setting targets w.r.t. performance, cost, weight & packaging space (**targets that make sense!!!**)
  - Determining BOM
- ❖ Design and development stage
  - Trade-off study w.r.t performance, package space & weight



# Development Cost Comparison

- Program 1 - Optimized sound package w.r.t. cost, weight and performance targets
- Program 2 - Sound package pre-determined by cost & weight



# Program Cost Comparison

## ❖ Program 1

- Sound package cost remains the same throughout the program, no new content.

## ❖ Program 2

- 5 new parts were added in production in order to meet acoustic requirements, however, these parts were eliminated 1 year after production.



# Reference

J. Pan, B. Semeniuk, J. Ahlquist, D. Caprioli, "***Optimal Sound Package Design Using Statistical Energy Analysis***", SAE Paper 2003-01-1544, 2003 SAE Noise and Vibration Conference, Traverse City, Michigan.

