

# University of Idaho Two-Stroke Direct Injection Snowmobile



Presented By  
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# Overview

- Design goals & target audience
- Design strategy
- Chassis and engine modifications
- Testing strategies
- Testing results
- Summary
- Questions

# UICSC Design Goals

- Create a National Park certified two-stroke snowmobile
  - E-score >170, J-192 score <74 dBA
- Improve our high-ethanol fuel economy (previously 13mpg on E55 2009)
- Maintain stock power
- Maintain two-stroke riding experience
  - High power density, lightweight
- Deliver OEM level packaging
- Minimize cost by using stock Skidoo components and low cost modifications.

# Target Audiences

## Dealer/Outfitter

- Low maintenance
  - Less scheduled maintenance means less dealer expenses
- High performance
  - Easy to sell
- Environmentally conscious
  - Meets strictest emissions standards

## Rider

- Electronic total loss oil system
  - Comparable to 4-stroke consumption
  - no oil changes
- Fuel economy
  - 18 mpg means more fun between fill-ups
- Lighter than 4-stroke counterparts
- Power
  - Over 100 hp, a top rider priority

# Design Strategy

- Clean & Fuel Efficient
  - E-Tec direct fuel injection
  - Flex fuel E20-E29
  - Electronic oiling
  - 3 way catalyst
- Quiet
  - Reduce noise through sound insulation
  - Block off or re-route vents
  - Thermally activated vents
- Rider Friendly
  - Light weight chassis
  - Factory fit and finish
  - Very low maintenance



# Chassis and Engine

- Chassis

- 2009 Skidoo MXZ REV-XP
  - Performance oriented
  - Proven rider comfort
  - Improved handling

- Engine

- Rotax 593cc H.O. Two-Stroke
  - E-Tec direct injection
  - RAVE 2 variable exhaust with tuned pipe
  - High power-to-weight ratio



# Chassis Modifications

- Larger XR (4-stroke Skidoo) body panels
- Sound deadening material
  - In body panels
  - On tunnel
- Thermally activated vents
  - Hood scoops to force cooling
- Air-box modified to intake from engine compartment

# Thermal Vent Designs



Vents are triggered using a thermal switch typically used for an automotive auxiliary fan

Linear actuator is used to actuate the vents

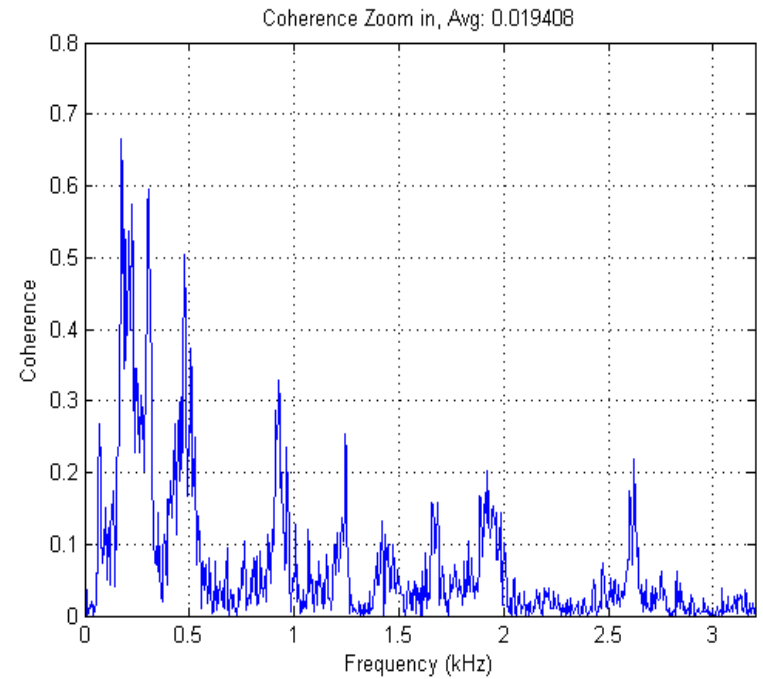
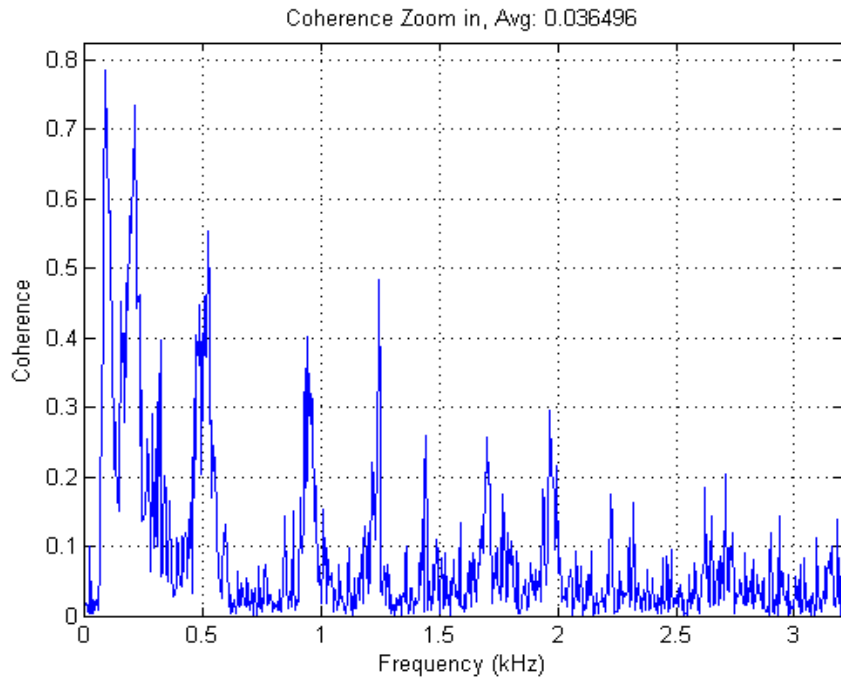


# Coherence Testing

- Percentage of a local contribution to the overall sound measurement.
- Used to test sound insulation materials and modifications.



# Coherence Testing Graphs



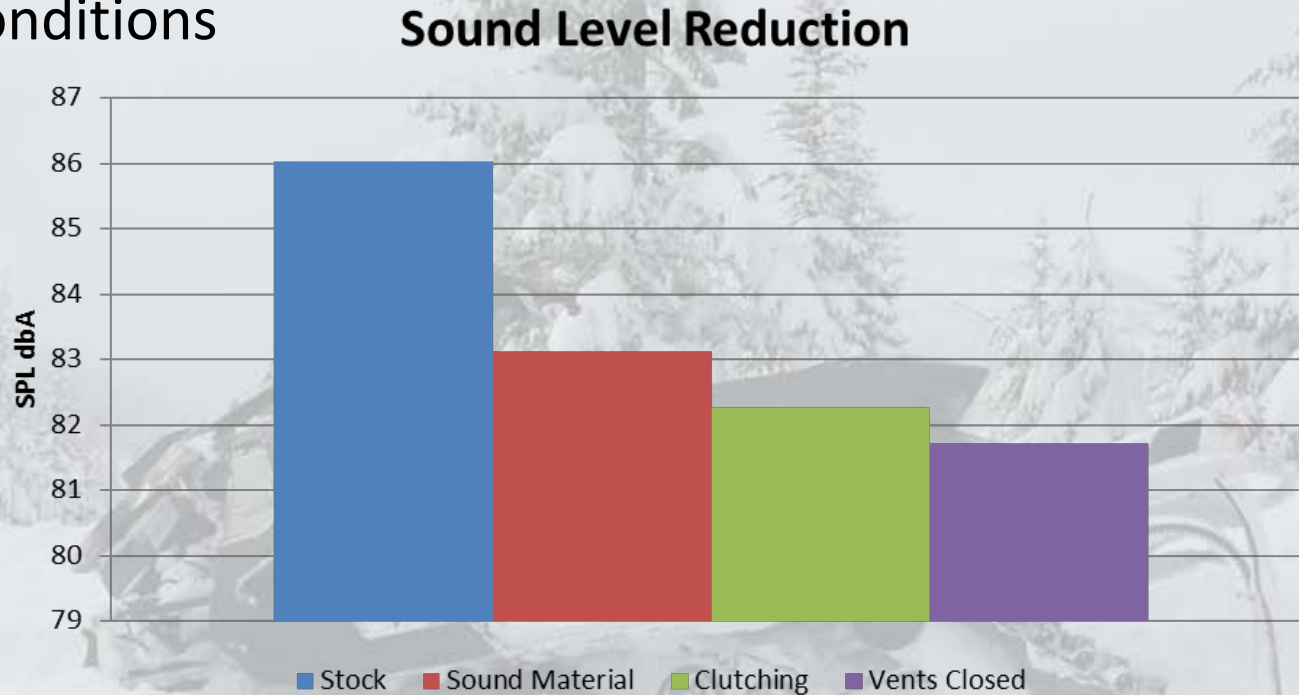
Un-damped Plastic Sample Sheet

Multi-layered foam on plastic sheet



# Sound Level Testing J-192

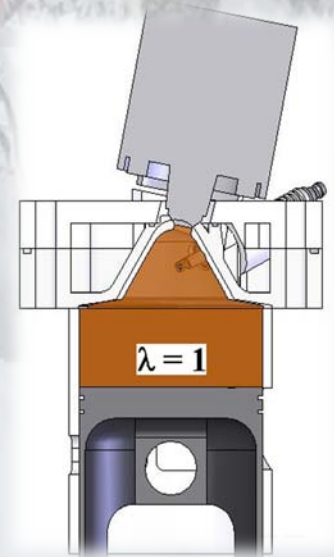
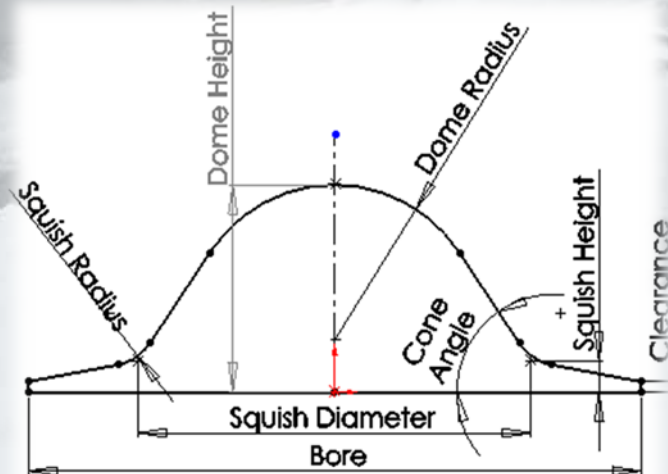
- Control snowmobile was used to normalize for different conditions



- NPS goal of <74dBA not reached
  - Sound meter used reads typically 4dB higher than Head Acoustics

# Engine Modifications

- Cylinder head
  - Improved combustion chamber geometry reduces emissions and improves fuel efficiency
  - Stock compression ratio
- Aristo 3-way catalytic converter



# Engine Tuning and Calibration

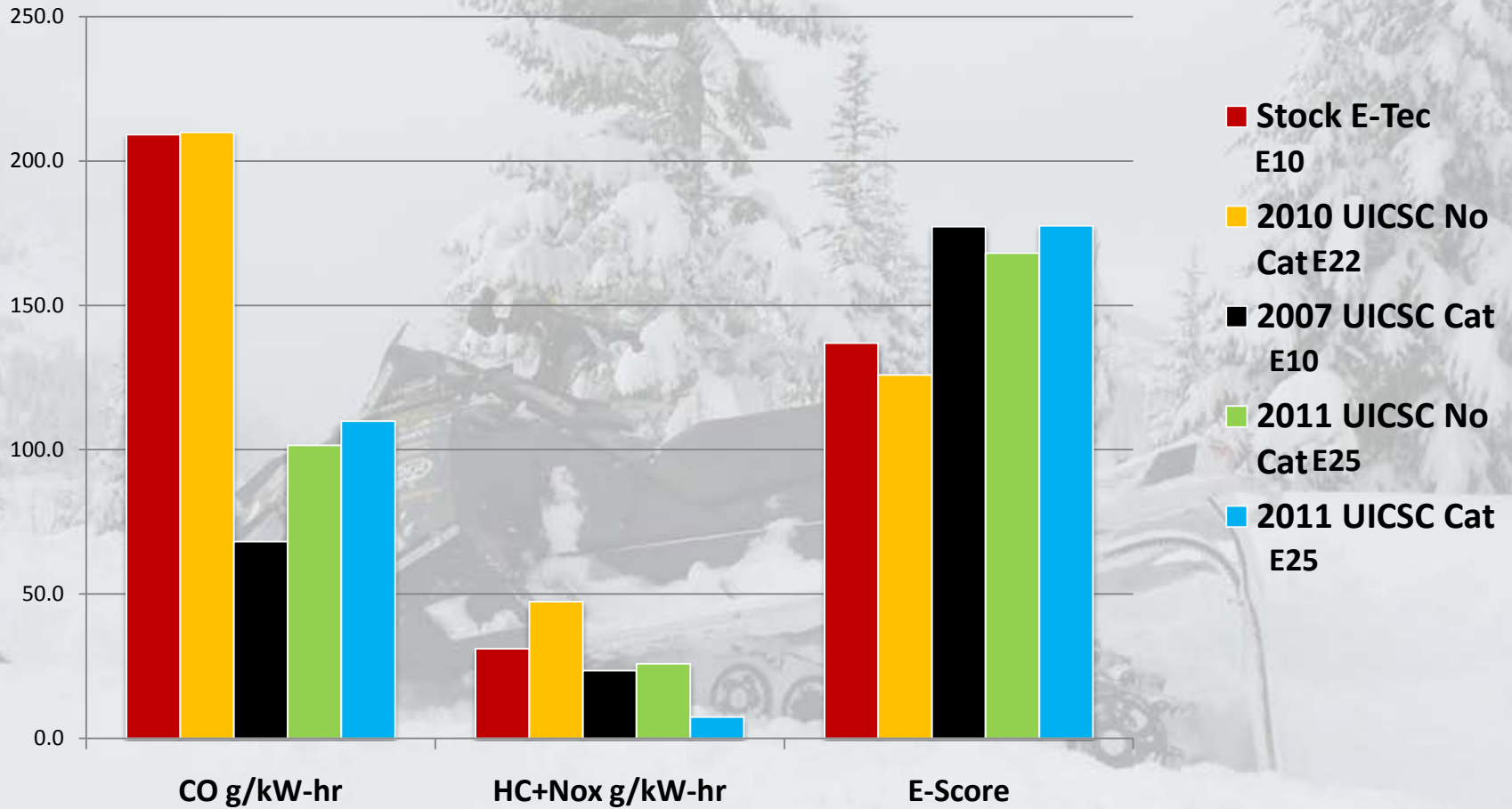
Borghgi & Saveri Eddy Current  
Dyno with Superflow Controller

- Survivability
- Ride-ability
- Fuel Economy
- Power
- Emissions

# Engine Calibration Strategy

- Started with existing calibration for E10
- Overall correction was calculated based on energy content of E25
- Fine tuned mode points and cruise
- Tuned for catalyst back pressure
- Testing with both E20 and E29 showed that the E25 calibration was flexible enough for fuel range

# Emissions Results



# Engine Results

- Average BSFC 355 g/kW-hr
  - 372 g/kW-hr in 2010
- E-Score of 177
  - Goal of 170 (National Park Standard) met
  - Meets requirements for CO and HC+NO<sub>x</sub>
- Achieved an average 105 horsepower during mode 1 emissions



# Summary

- Goals met:
  - Meets NPS exhaust emissions standards
  - Wet weight ~580 lbs
  - 105hp compared to 110hp stock
  - Increased fuel economy from 13 to 18mpg
- Goals not met:
  - NPS sound emissions (EPA standard of 78dBA met)
- Consumers want a powerful, agile, and fuel efficient machine and the UICSC snowmobile is an economical response to this demand

# Thank You

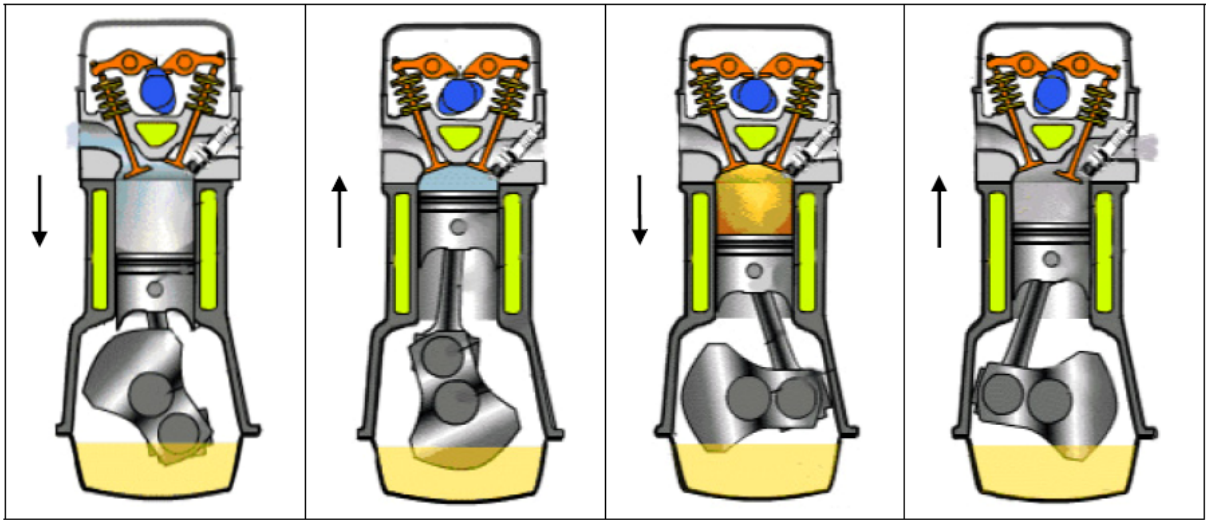
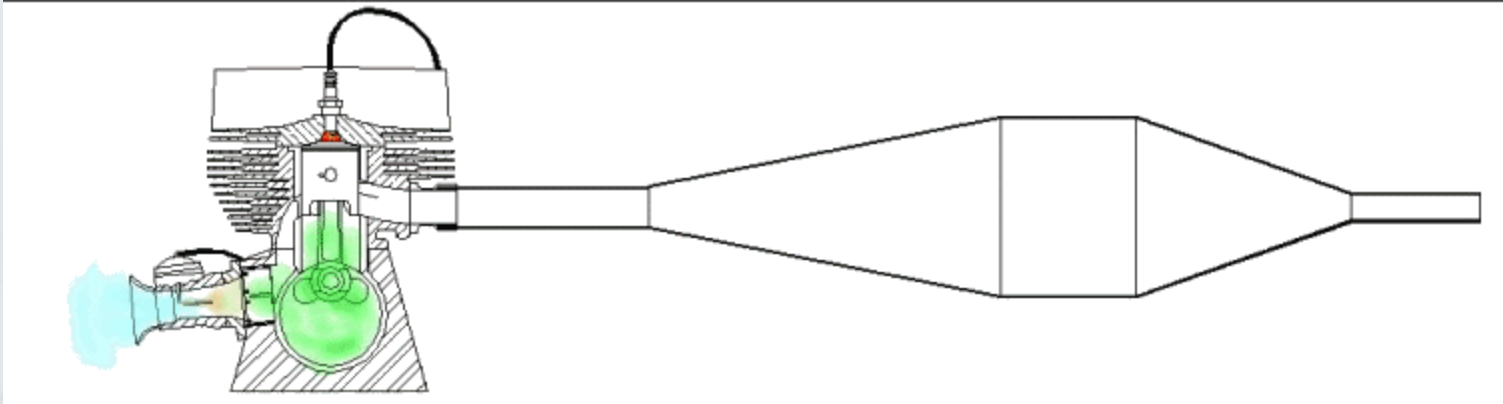


## Questions?

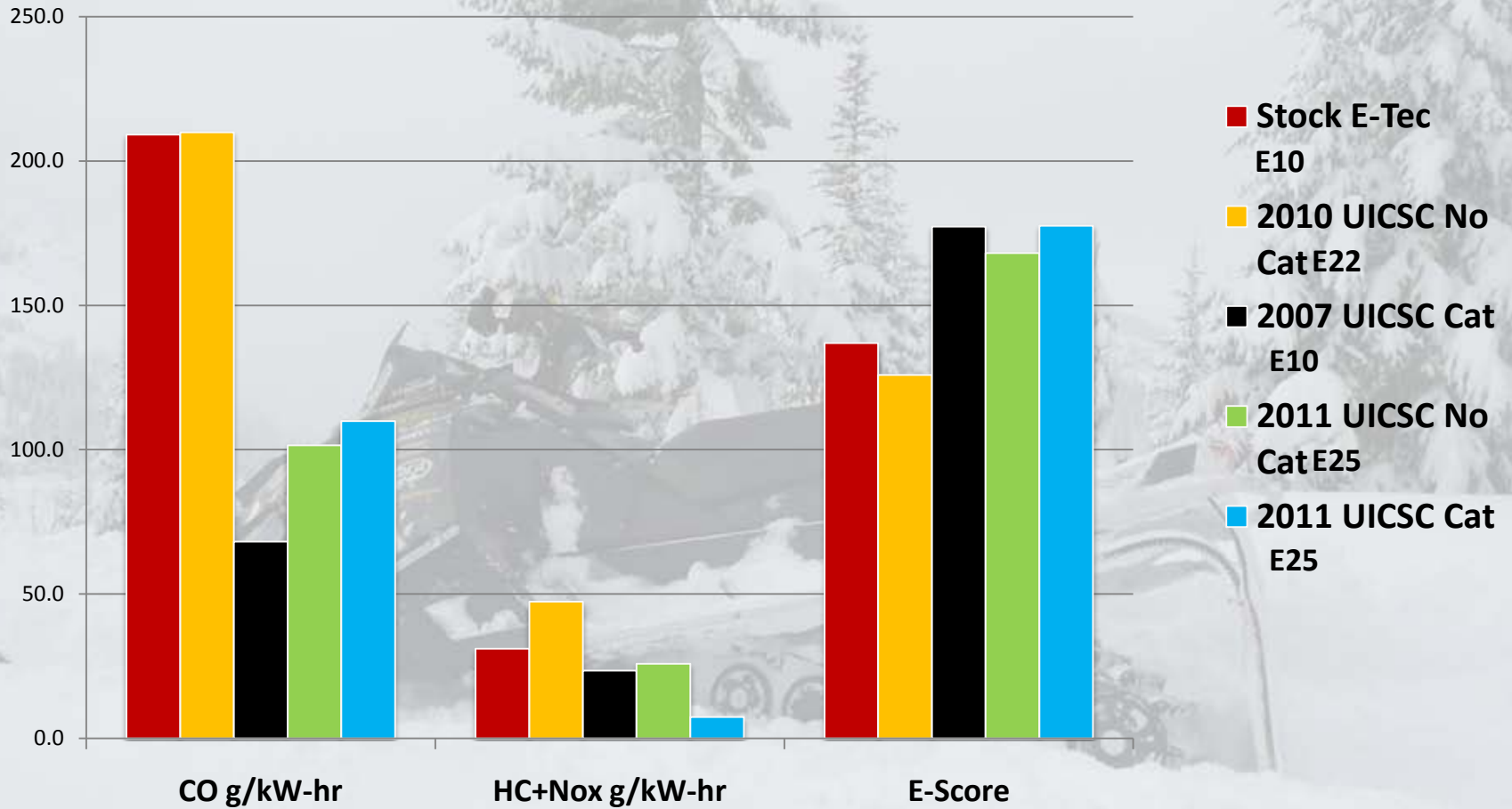
# MSRP Breakdown

- Base sled price \$10099
- UICSC sled price ~\$14000
- Major contributors
  - Ice ripper track  $\$550 * 1.5 = \$850$ 
    - Stock track \$488
  - Skis  $\$244 * 1.5 = \$366$ 
    - Stock skis \$125
  - Head light  $\$195 * 1.5 = \$292$ 
    - Stock lights ~\$100

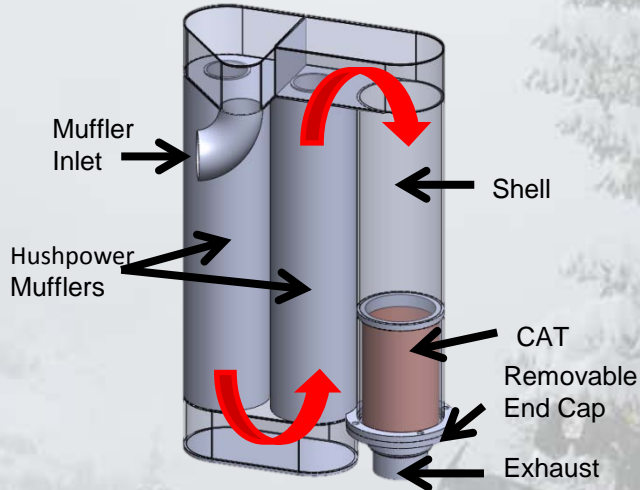
# Two Stroke Verses Four Stroke



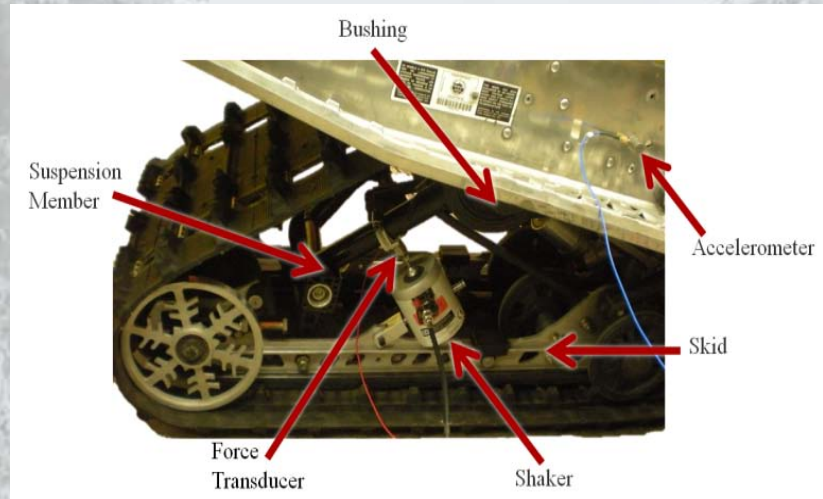
# Emissions Results



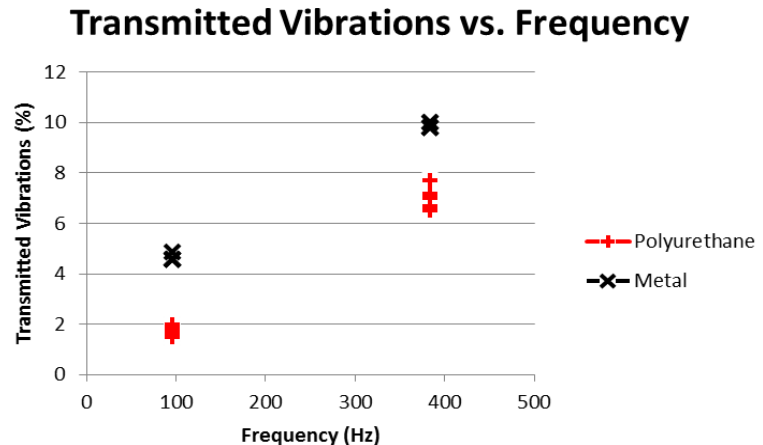
# Experimental Work



Custom muffler designed with two Hushpower mufflers and integrated catalyst.



Skid damper testing



# Experimental Work



Air Injection to improve catalyst performance

Efficiency testing of bogie wheels and

