

# University of Idaho's Clean Snowmobile Design Using a Direct-Injection Two- Stroke Engine



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***The Ultimate Riding Experience***



# Design Goals

- Meet NPS emission standard ( $E > 170$ )
- Pass J-192 sound test
- Fuel economy
- Maintain stock engine power
- Reduce weight
- Improve handling performance
- Maintain two-stroke riding experience

# History

- BMW motorcycle engine in snowmobile chassis
- Multiple wins: 2002 and 2003
- Proved four-stroke can meet NPS requirements
- Quick fix using early 90's technology
- Four-strokes are already a commercially available solution
- Does not meet the needs of many consumers



# 2007 Team Strategy

- **Clean**
  - Gasoline Direct Injection (GDI)
  - Catalyst
- **Quiet**
  - Sound Deadening Materials
  - Hood/Vent Ducting
- **Quick and Agile**
  - Lightweight Components
  - Two-Stroke Power Density

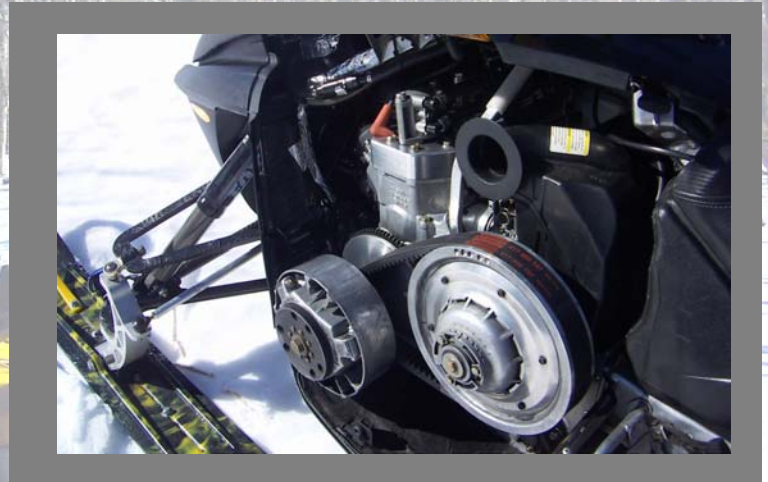


# Chassis & Engine Selection

- **Chassis**

- **Ski-Doo MXZ**

- **Industry Leading Ergonomics and Handling**
    - **Lightest IC Snowmobile at Competition 569 lb**



- **Engine**

- **Rotax 593cc H.O. Two-Stroke**

- **Carbureted, Reed Valve, and Loop Scavenged**
    - **Variable Exhaust with Tuned Pipe**
    - **High Power-to-Weight Ratio**



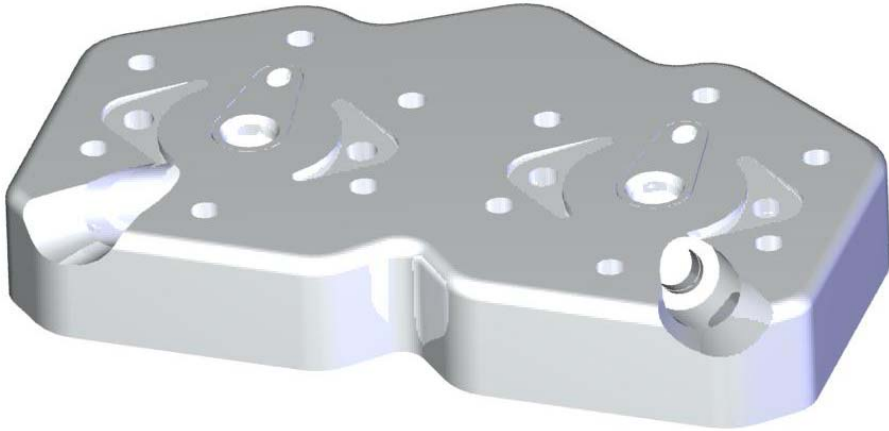
# GDI Design

- Adapts the E-Tec GDI system
- Custom Cylinder Head
- Existing Port and Crankcase Design
- 55 V System with No Battery
- Inductive Ignition
- Uses Mechanical Oil Pump
  - Half the oil consumption of carbureted two-stroke





# Third Generation Cylinder Head

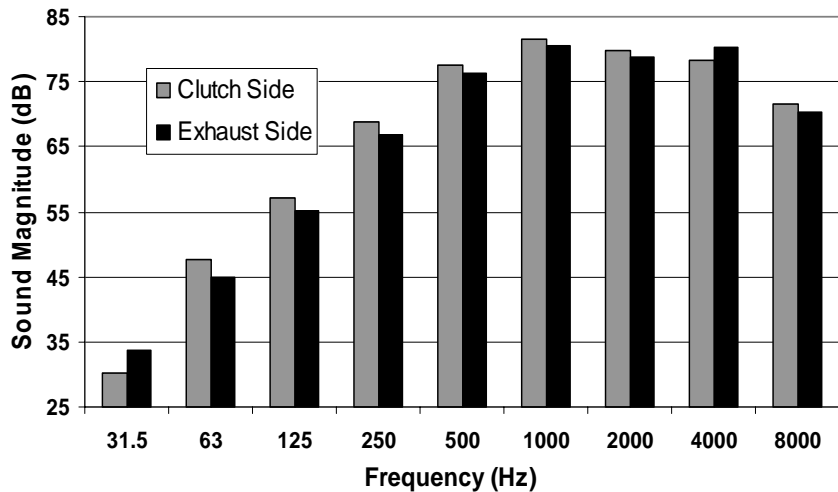


- Student Designed and Manufactured:
  - Solid Modeling using Solidworks
  - CNC code using MasterCam X
  - HAAS 4-axis CNC Mill

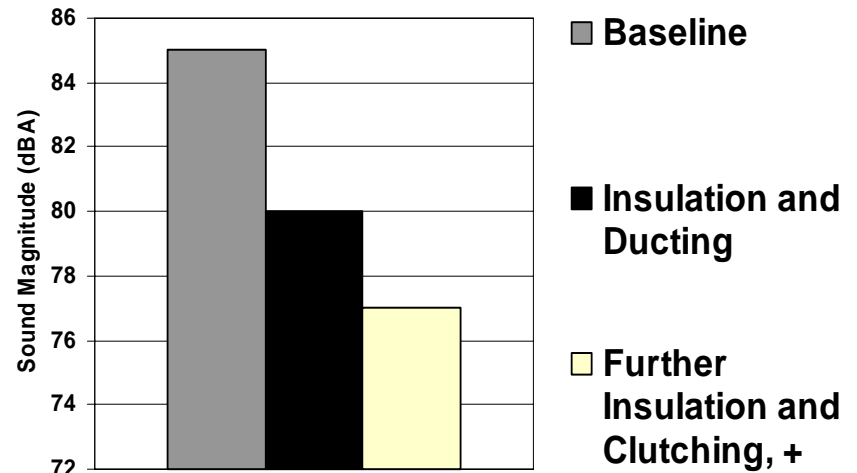


# Noise

Baseline Setup



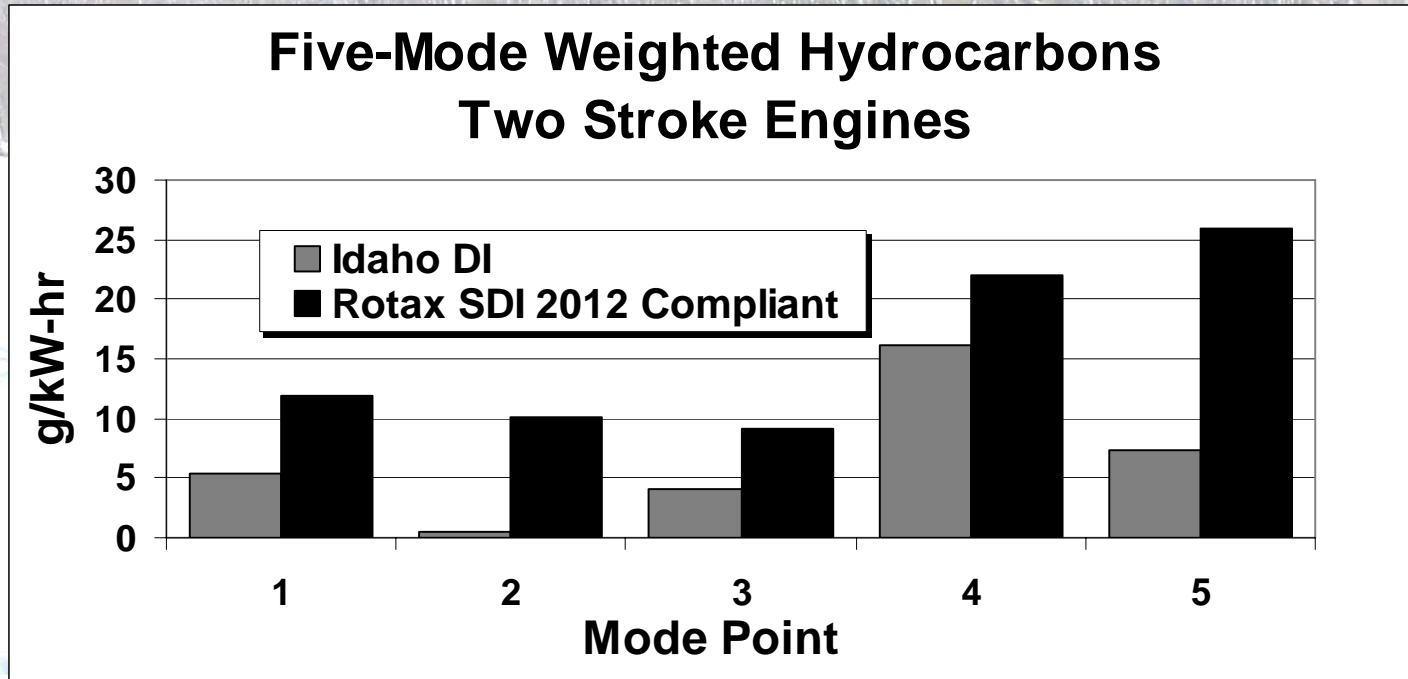
J-192 Sound Testing



Final Level: 77 dBA (8 dBA reduction)



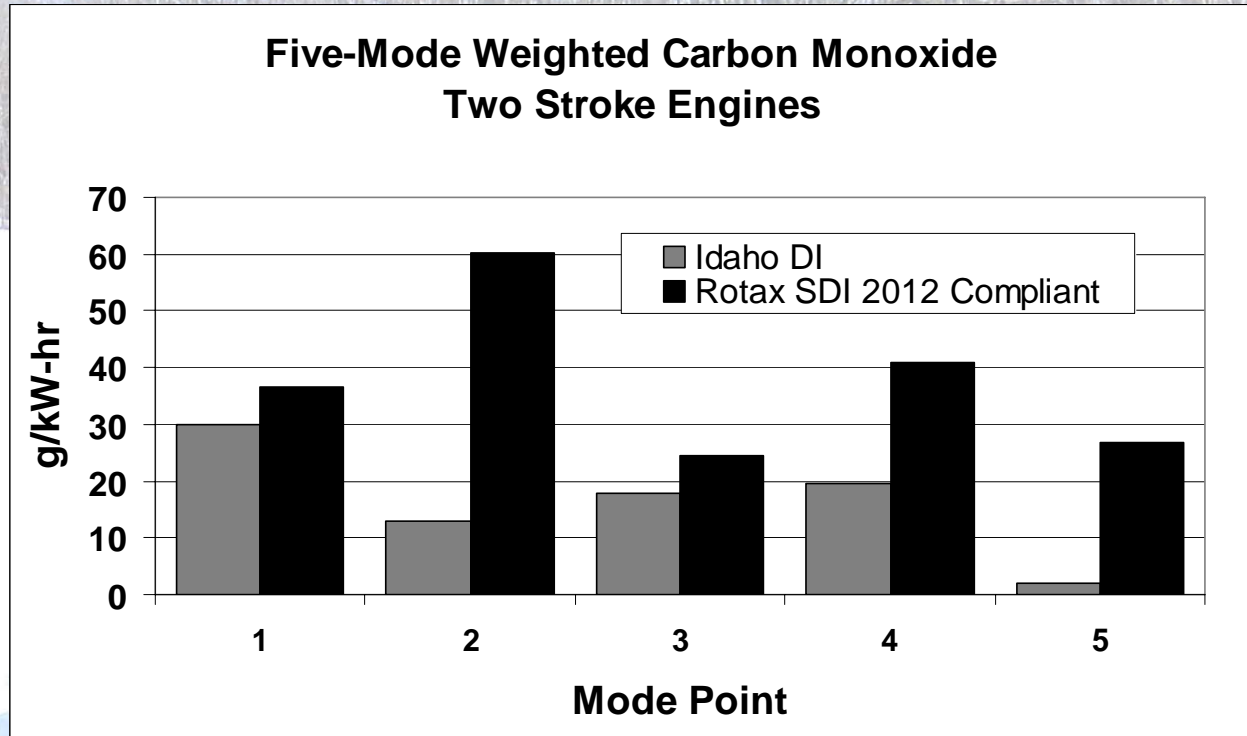
# Emission Results



Five Mode HC: 25 g/kW-hr      E = 158

40% Additional Reduction in Emissions Expected with Catalyst

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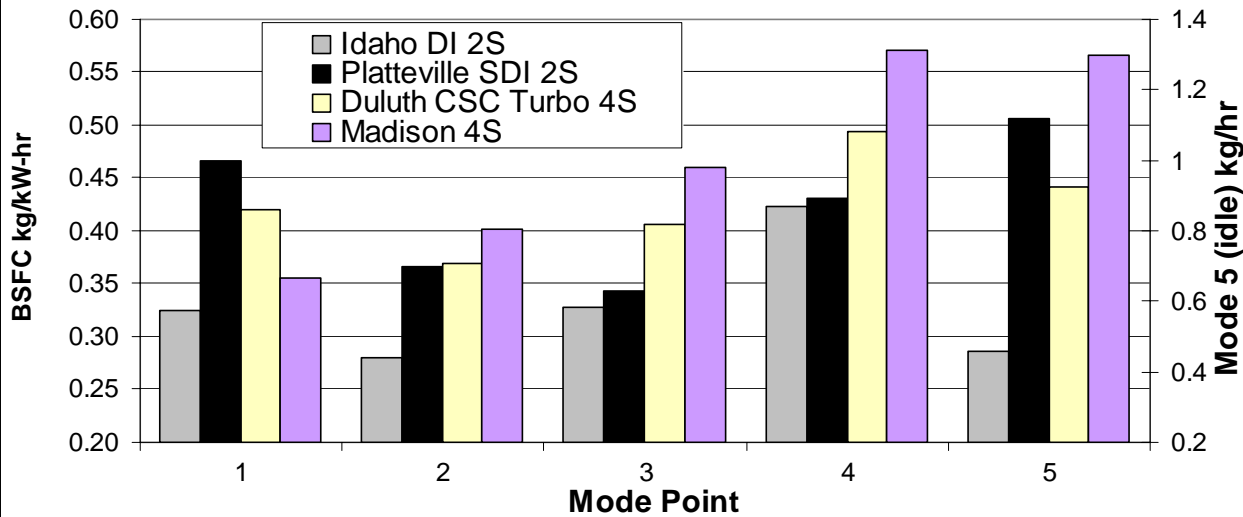


Five Mode CO: 127 g/kW-hr      E = 158

40+% Reduction in Emissions Expected with Catalyst



## BSFC Comparison



## Percent Improvement

Mode	Platteville SDI 2S	Duluth Turbo 4S	Madison 4S
1	30	8	22
2	24	30	24
3	5	29	19
4	2	26	15
5	59	65	50

**18-21 mpg**

# Advantages

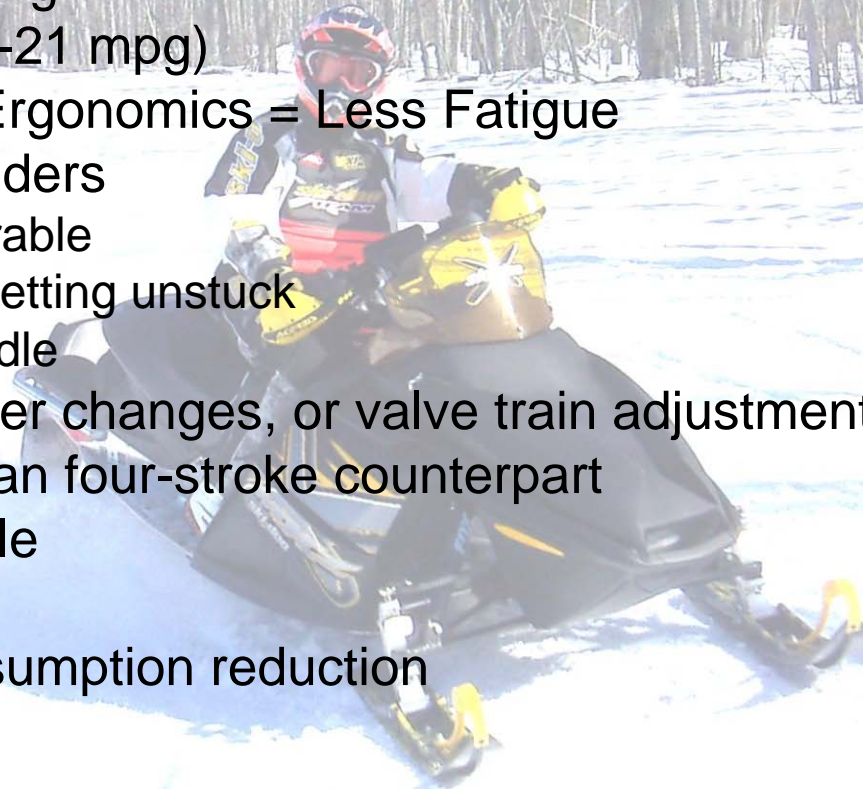
- **Consumer**
  - Fuel Economy
  - Handling and Performance
- **Dealer/Outfitter**
  - Maintenance
  - Reliability
  - Consumer Demand
- **Environmental**
  - CO, HC, and NO<sub>x</sub> Emissions
  - Noise Emission





# Appeal to Outfitters/Riders

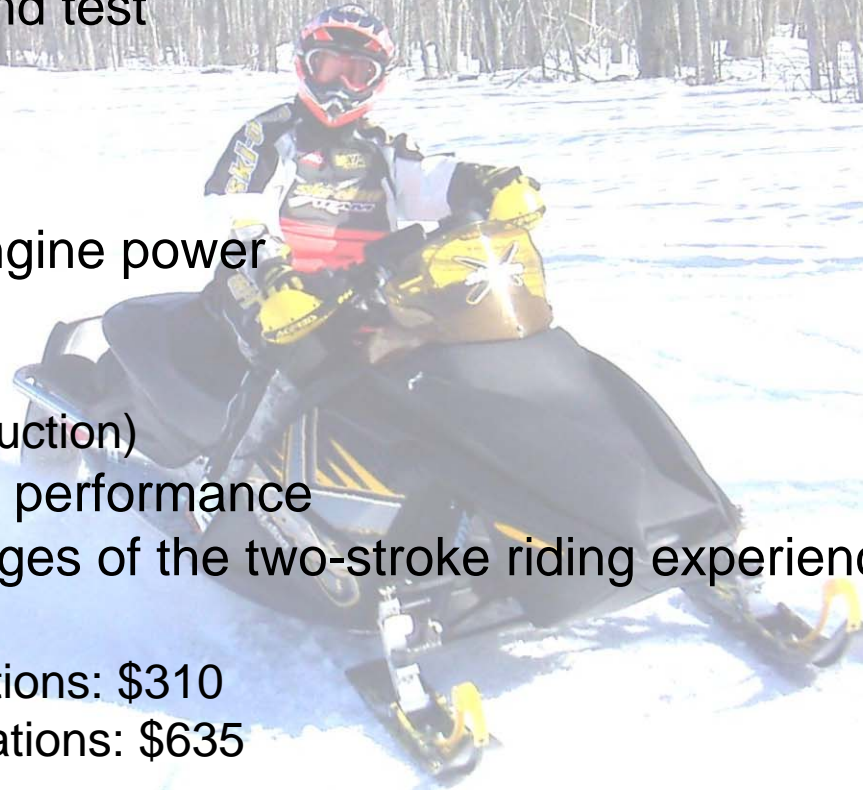
- Weight and Handling
- Fuel Economy (18-21 mpg)
- Industry Leading Ergonomics = Less Fatigue
- Easy for Novice Riders
  - Easily Maneuverable
  - Lightweight for getting unstuck
  - Easy to manhandle
- No oil changes, filter changes, or valve train adjustment
- Less expensive than four-stroke counterpart
- Simple and Reliable
- Clean Packaging
- Significant oil consumption reduction
- No Battery





# Summary

- Meets EPA emission standard
  - 25 gm/kW-hr HC, 120 gm/kW-hr CO (No Catalyst)
- Passes J-192 sound test
  - 77 dBA
- Fuel economy
  - 18-21 mpg
- Maintains stock engine power
  - 108 hp
- Reduces weight
  - 569 lb (45 lb reduction)
- Improves handling performance
- Maintains advantages of the two-stroke riding experience
- MSRP - \$8945
  - Engine Modifications: \$310
  - Chassis Modifications: \$635







# Thank You Questions?



E-Lab

Ralphi

