



University of Wisconsin-Madison

2014 SAE Clean Snowmobile Challenge

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Presented by:

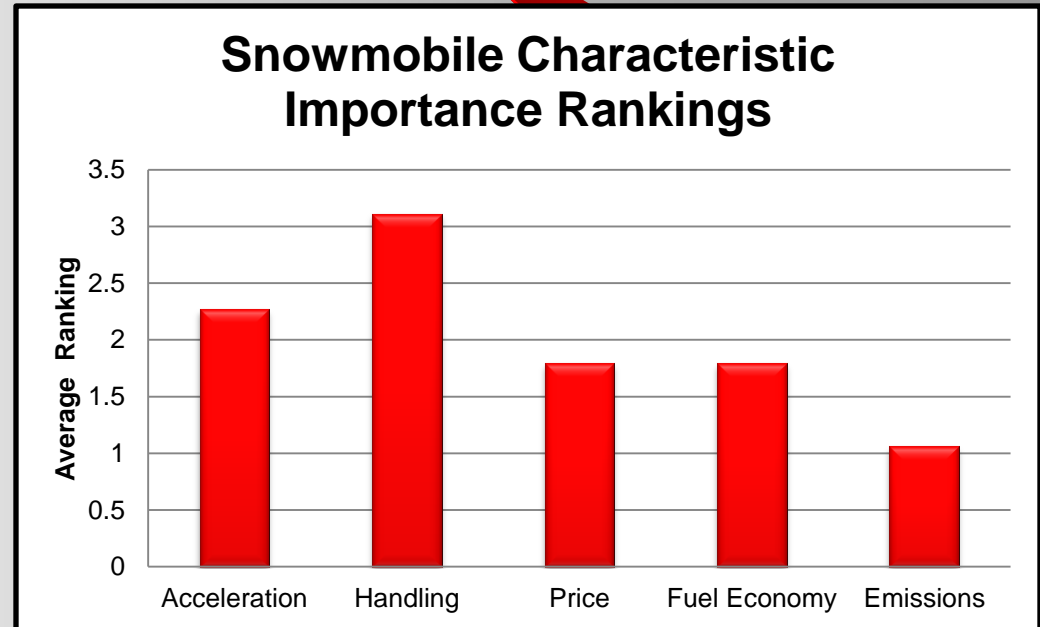
Mike Solger
Jeff Blair



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Design Considerations: Market Survey

- Approximately 120 surveys
- Customers Want:
 - Trail Handling
 - Acceleration
- Historical Best Sellers
 - Ski-Doo Rev XP 600 SDI
 - Polaris Rush 600





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Bucky ACE Turbo

How it Appeals to Snowmobilers

Ultra quiet
Fuel efficient
Powerful
Flex-Fuel capable
Electric start
BAT+ compliant



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Dealer & Outfitter Perspective

- Sales
 - Cleaner/quieter performance model
 - High fuel economy, BAT compliant
- Benefits
 - Integrated catalyst/muffler – Bolt-on Replacement
 - Electronic throttle control, Flex-Fuel Sensor
 - Low maintenance, reliable
- Rider comfort
 - OEM Seat, Handlebars, Suspension, Reduced Noise
- Novice snowmobiler operation
 - OEM Controls



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Chassis Selection

2013 Ski-doo MXZ Sport

- Lightweight
- Rider-forward ergonomics
- SC-5 suspension
- Cost-effective





Clean
Quiet
FAST

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Engine Selection

- Primary: Fuel Economy
- Secondary: Engine-out emissions

	Power (kW)	Weight (kg)	Fuel Economy (km/L)	Emissions (g/kW- hr)		
				HC	CO	NOx
Ski Doo ACE 600	42	40	12.3	8	90	N/A*
Polaris FST	97	62	7.2	6.2	79.9	N/A
Ski Doo ACE 900	67**	55	10	8	90	N/A
Ski Doo 4-Tec 1200	97	64	7.6	9	116	N/A



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Turbocharged Rotax ACE 600



Engine Type	Four Stroke
Cooling	Liquid
Cylinders	2
Displacement	600 cc
Bore x Stroke (mm)	74 x 69.7
Ignition	Custom
Exhaust	Custom 2-into-1
Fueling	EFI
Compression Ratio	12:1

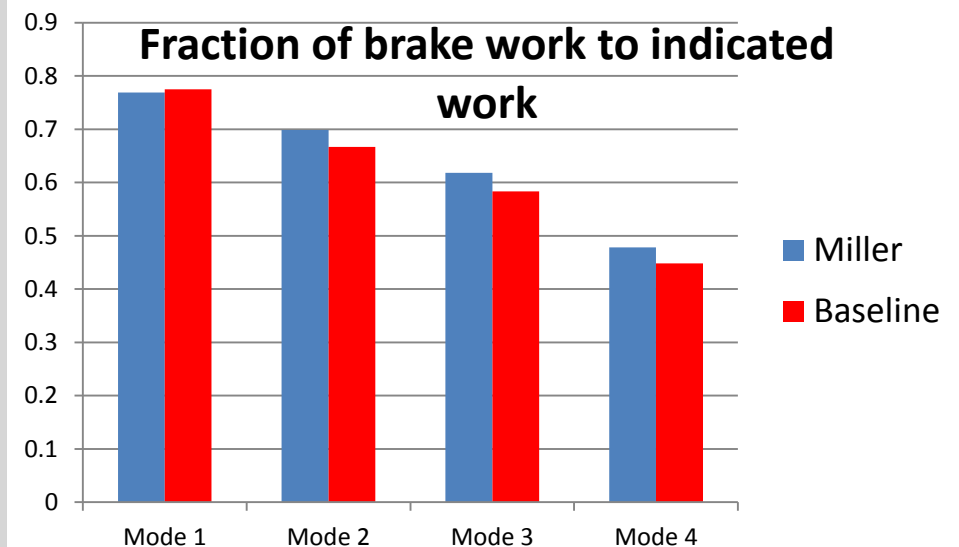
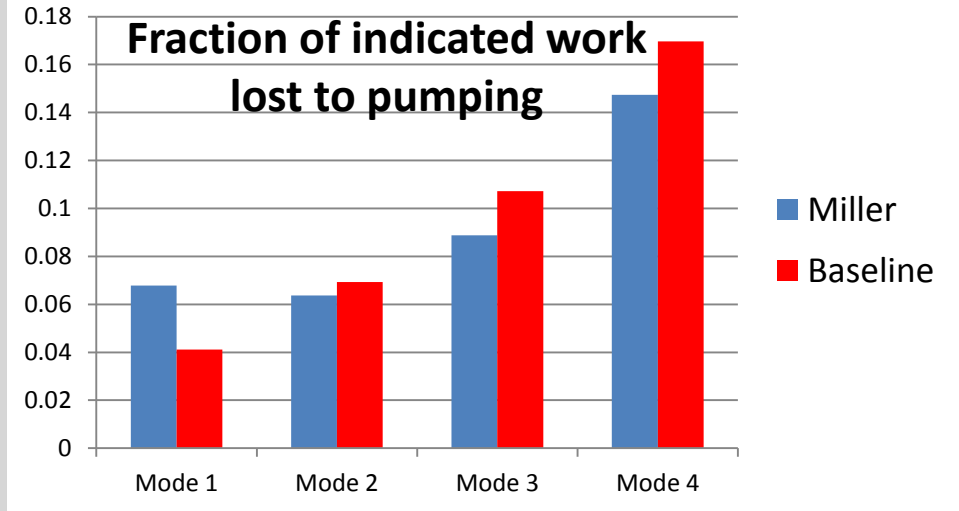


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- Miller cycle operation achieved with late intake valve closing
- Optimized valve timing
- Turbocharger used to compensate for power loss of Miller cycle
- Reduced pumping losses at part load

Miller Cycle





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Turbocharger Choice

Garrett GT1241

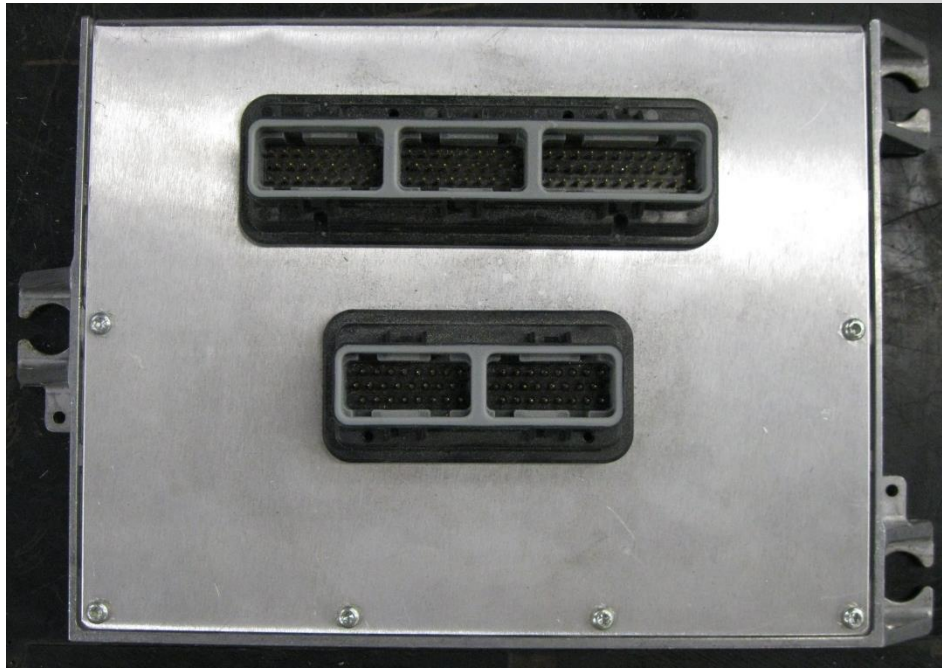
- 37-90 kW applications
- Electronically controlled wastegate with closed loop boost control
- Benefits:
 - Improved efficiency
 - Increased power when needed





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Engine Management



- Woodward/Mototron PCM565
 - Automotive/Marine environments
 - $-40^{\circ} - 130^{\circ} \text{ C}$
 - 18 g Shock Load
 - Up to 3 Meters Underwater
- MATLAB/Simulink engine modeling
- MotoHawk automatic code generation
- Three way switching algorithm



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Engine Calibration

- DYNOMite water brake dyno
- Heated wideband O₂ sensor
- Exhaust thermocouples
- In cylinder pressure transducers

- Calibrated:
 - Spark advance
 - Closed loop fueling
 - Throttle control
 - Boost pressure

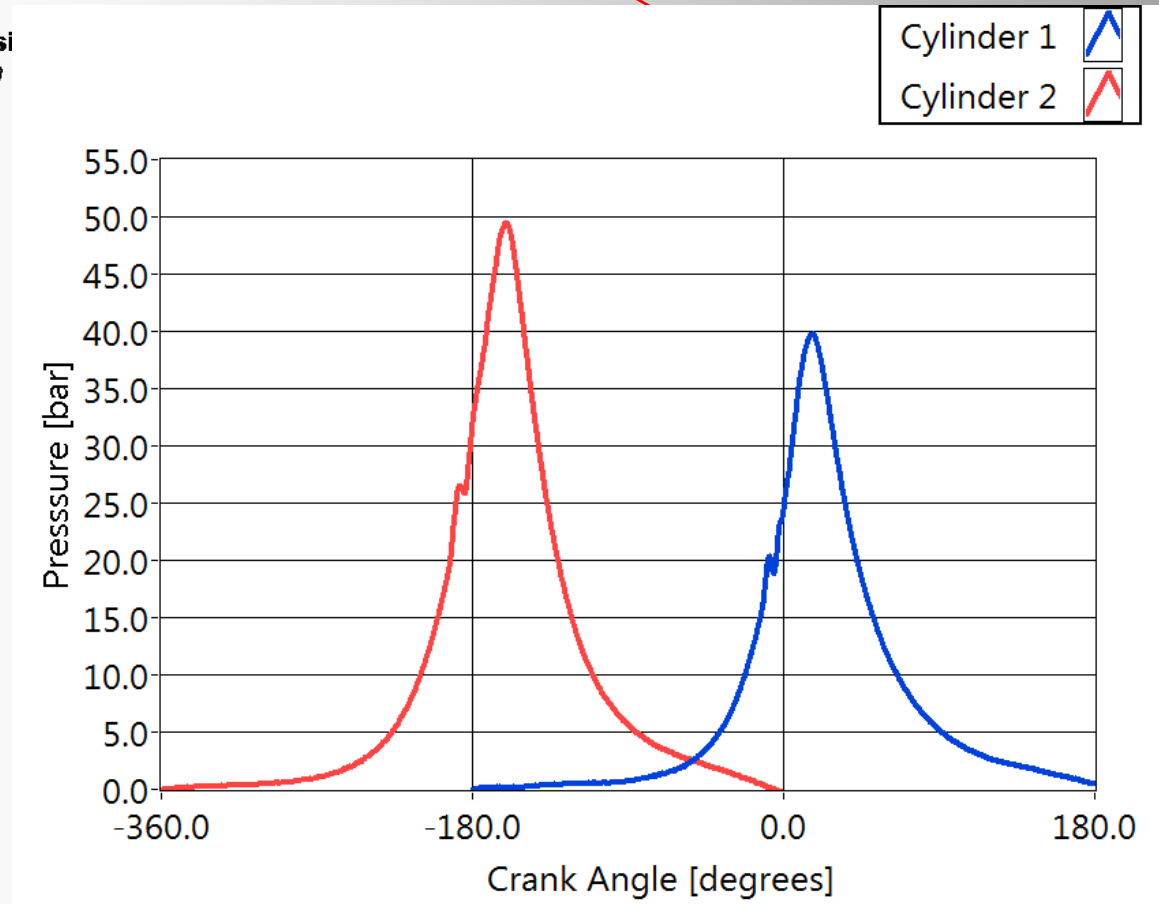




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Cylinder Balance

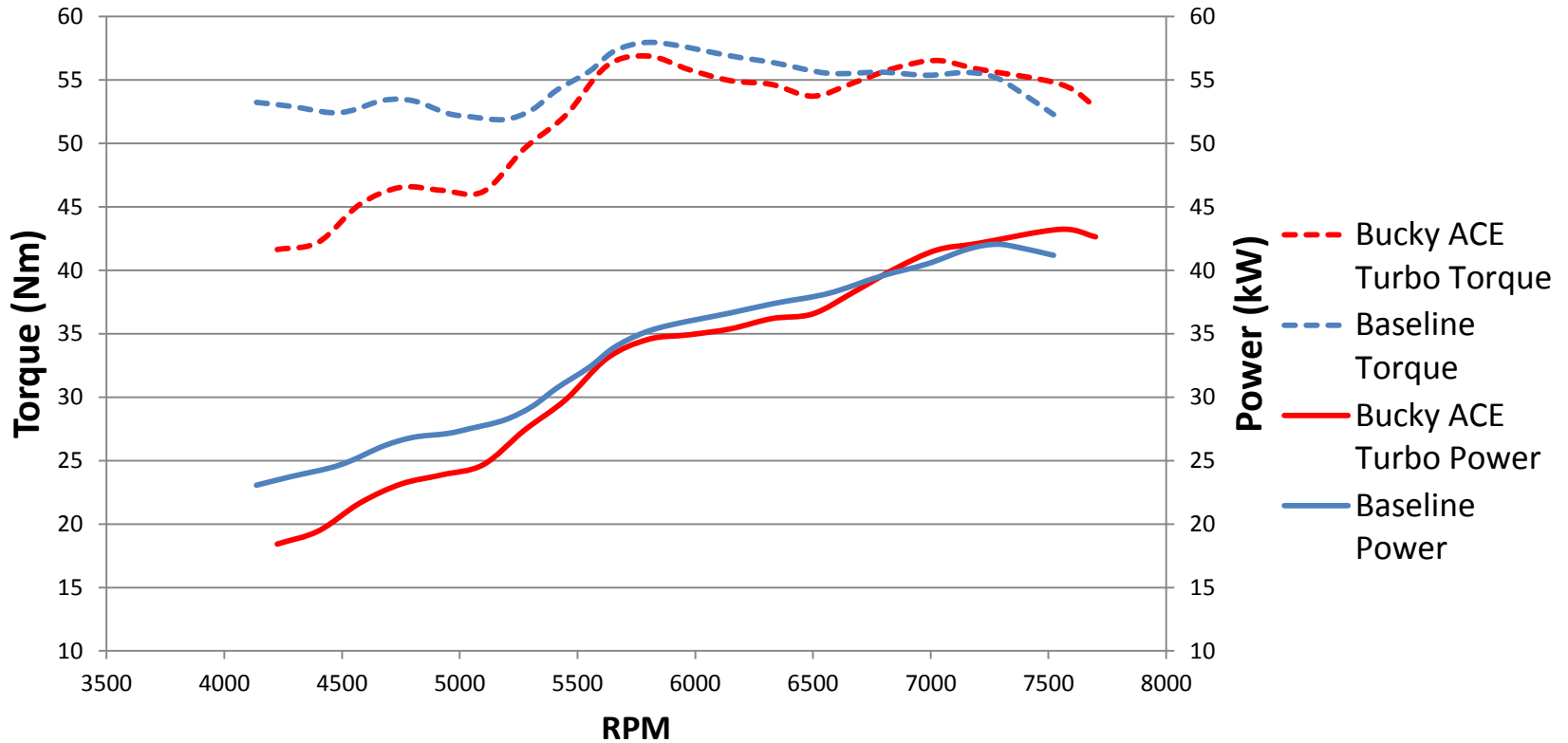


- Mode 3
 - 5600 RPM
 - 18.5 Nm



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Engine Performance



- Power and torque curves closely match baseline
- Maintains production driveability
- Class appropriate 43 kW peak power



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Dynamometer Results (16% isobutanol)

	RPM	Torque (Nm)	Power (kW)	BSFC (g/kW-hr)
Mode 1	7500	54.8	43.0	245
Mode 2	6375	28.6	19.1	260
Mode 3	5625	18.5	10.9	309
Mode 4	4875	10.6	5.4	466
			Total Weighted	294

8% fuel efficiency improvement



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Emissions & Sound Reduction

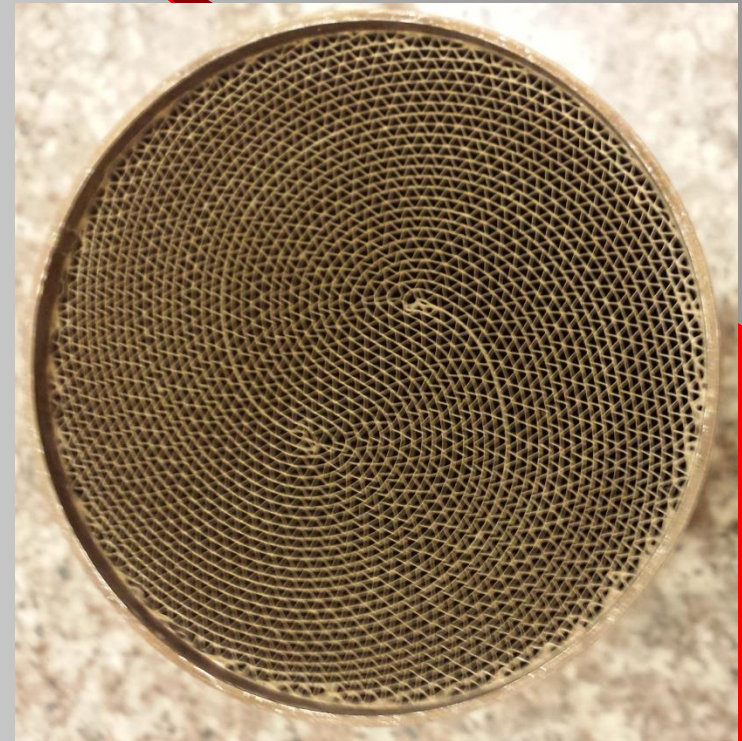


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Emissions Reduction

Manufacturer	Emitec
Coating	Umicore
Diameter	89mm
Length	150mm
Substrate	SuperFoil® Metal Honeycomb
Density	400 cpsi (cells per square inch)
Loading	Palladium 120 g/ft ³ Rhodium 15 g/ft ³





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Sound Reduction

Engine



Chassis





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Cost Summary

Base MSRP: MXZ Sport ACE600		\$7,899.00
Turbocharger	\$657.93	
Electronic Throttle Body	\$325.35	
Fuel Sensor	\$494.00	
Catalyst	\$156.12	
Pre-studded Track	\$563.40	
Sound Attenuation Material	\$39.99	
Others	\$692.85	
Modifications		\$2,929.64
Bucky ACE Turbo MSRP		\$10,596.62



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Questions?

Key Design Points

- Turbocharged
- Lightweight Chassis
- Catalytic exhaust
- Woodward/Mototron control system
- Flex-Fuel Capable
- Studded Track

