

Optimization of Wendigo 2013 for scientists in North and South Poles



Presented by

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March 07, 2013

Main design criteria

- Chassis selection
- Range
- Power & Performance
- Affordability
- Serviceability
- Ergonomics
- User friendliness
- Low environmental impact



Chassis selection

Selection criteria

- Low cost - affordable
- Light weight – better power/weight & handling
- Short track – less drag



Ski Doo MXZ Sport meets all of the criteria

Range

- Primarily depends on battery pack capacity
- LTC's 45Ah cells chosen due to their
 - High durability & ruggedness
 - Large cell size, leading to lesser components in battery pack
- Two battery pack sizes possible in available space:
 - One pack of 20 cells, OR
 - Two packs of total 26 cells

Range

Comparison of two possible battery pack configurations

	72 volts (20 cells)	93.6 volts (26cells)
Range (miles)	10	14
Weight(kg)	30	39
Cells Cost	\$6000	\$7800
Energy	3240 Wh	4214 Wh

Table 1 - Battery pack comparison

Range

Loaded Acceleration		
Drive Ratio	72V	93.6V
2	22.55 s	21.71 s
3	19.7 s	17.85 s
4	19.13 s	17.48 s
5	19.02 s	17.72 s
6	19.27 s	17.95 s
7	19.84 s	18.69 s

Table 2 – Loaded acceleration time simulations

Range

Sled usage in Greenland

based on data from University of Wisconsin, Madison

- Loaded sled average trips: 3.7 miles a day
- Unloaded sled effective average trips: 11.1 miles a day
- Charging capability at the sampling area

Range

20 Cell, 72V battery pack was selected for

- Lower cost
- Lower weight
- Easier maintenance and serviceability

Range

Energy management

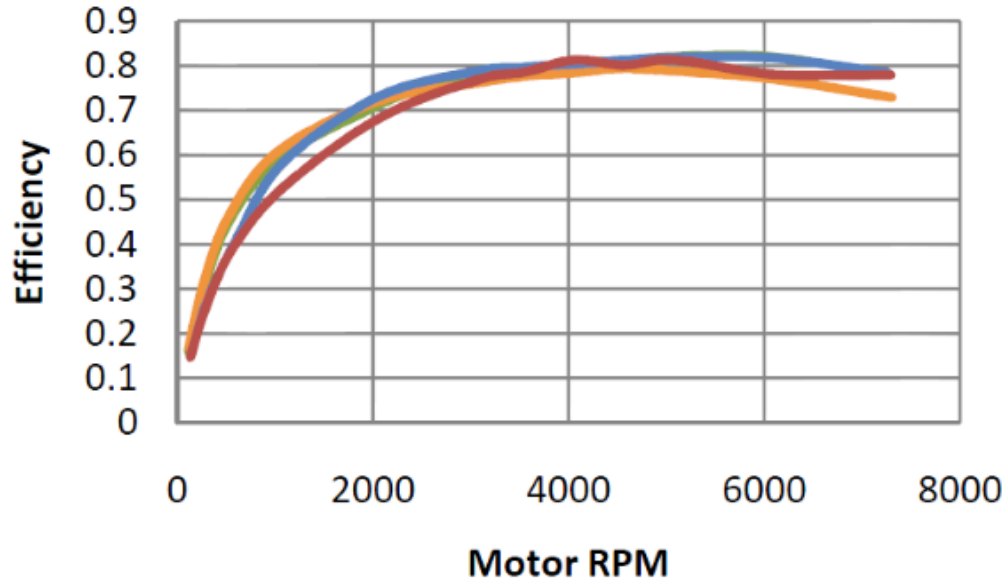
- In order to efficiently use the available energy, the powertrain and auxiliary components selected and/or optimized for maximum efficiency
- E.g., 3 Watt LED headlights were used instead of stock 120 Watt headlights



Power & Performance

- Extensive dynamometer testing to maximize efficiency
 - Acquired data for current, torque, efficiency, slip gain, power, and other parameters
- HPEV AC-15 motors with Curtis 1238 controller produce 28kW & 84Nm peak torque for good towing capacity

Power & Performance



Highest motor efficiency at 3000+ RPM

- 1236- 180A Limit
- 1236- Max Power (=300A)
- 1238- 180A Limit
- 1238- 300A Limit

Graph 1 – Motor efficiency versus RPM

Power & Performance

Powertrain design based on simulation results

PSAT simulations taking into account:

- Snow friction
- Aerodynamic drag
- Traction limits
- 800 lb trailer load over 500 ft
- Validated snowmobile models

Power & Performance

Drive ratio selection

Loaded Acceleration	
Drive Ratio	72V
2	22.55 s
3	19.7 s
4	19.13 s
5	19.02 s
6	19.27 s
7	19.84 s

One step-down ratio
(using stock gearbox)

Two step-down ratios
(using stock gearbox
& belt drive/CVT)

Table 3– Loaded acceleration time simulations

Power & Performance

Drive ratio selection

Loaded Acceleration	
Drive Ratio	72V
2	22.55 s
3	19.7 s
4	19.13 s
5	19.02 s
6	19.27 s
7	19.84 s

One step-down ratio
(using stock gearbox)

- Less number of components – more reliable and cheaper
- Engine bay space available for battery pack – better weight distribution & easier packaging

Table 3 – Loaded acceleration time simulations

Power & Performance

Drivetrain

Fixed gear ratio of 3 to 1 was selected

- Translates to 20mph at approx. 3000 RPM (high powertrain efficiency range)
- Simpler packaging (stock chain case)
- Ease of maintenance
- High reliability
- Lower cost
- Good acceleration

Power & Performance

Depending on snow conditions, short track can reduce the towing capacity, which is compensated by the use of an elevated hitch.

Power & Performance

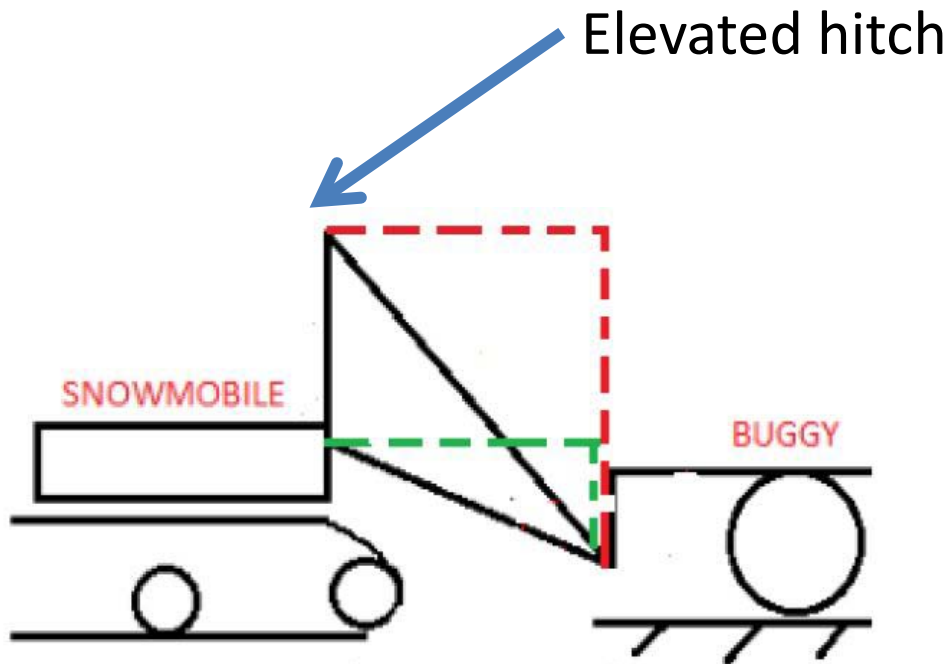
Relation between towing capacity and normal force on track

McGill University				
	Sled's total mass (kg)	Sled's rear mass(kg)	Pull force (N)	Pull force/ Mass on track (N/kg) (With 85kg driver)
Average of past competitions	236	114	2054	10

- Pulling force of approx. 10N/kg of mass on track
- Need to increase normal force on track to get higher towing capacity

Power & Performance

Elevated hitch \Rightarrow More normal load on track \Rightarrow
Higher pulling capacity



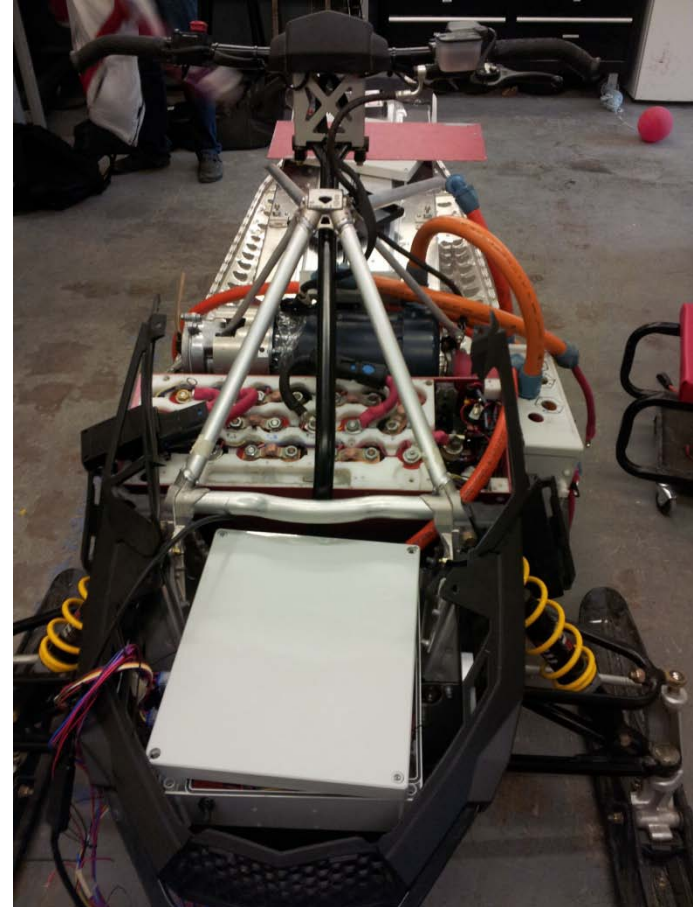
Affordability

- Cost is one of the main driving factor in Wendigo's design – approx. \$15,000
- Examples of cost reductions with minimum compromises:
 - Low cost short track, light weight chassis
 - One battery pack with high capacity large cells to keep number of components low
 - Direct coupling of motor
 - Minimum modifications to the stock chassis

Serviceability

- Modularity
 - Electronics box
 - Controller box
 - Accumulator box
- Easy maintenance
- Readily available spare parts

**Increases Safety &
Saves time**



User friendliness

- Ergonomics
- Display
- Weight distribution
- Cargo Space
- Ignition Sequence
- User switches/inputs same as an IC sled



Low environmental impact

+ Zero Emission!

- Sources of pollution:

- Brake fluids
- Chain case oil
- Bearing Grease
- Dead cells
- Noise

Low environmental impact

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- Sources of pollution:

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- **Dead cells**
- **Noise**



Low environmental impact

Major sources of pollution

Dead cells

- Previous generation of LTC cells lasted 7 years
- Based on dynamometer testing the 7 year old cells were at 70% of their original capacity
- Slightly higher cost of LTC cells is justified due to their durability and reliability

Low environmental impact

Major sources of pollution

Noise

- Track and vibrating chassis components are the main sources of noise in electric sleds
- Damping material is used in between fastened components and on exposed chassis surface to attenuate noise
- Stock studded track can be replaced with a Silentrack without compromising towing capacity thanks to the elevated hitch design

Conclusion

The Wendigo Advantage

- Chassis: light weight, comfortable & affordable
- Range: 10+ miles, reliable energy accumulator
- Performance: low cost, simple and powerful powertrain
- Affordable: approx. \$15,000 MSRP
- Serviceability: modular and simple design, spares readily available
- Ergonomics & User friendliness : minimum modifications during electrical conversion and performs similar to the stock sled
- Low environmental impact: zero emissions & quiet operation

Questions

