



**University Alaska Fairbanks**

**2011 SAE Clean Snowmobile  
Challenge**

**Electric Snow Machine  
Design Presentation**

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# Potential Users

- National Science Foundation in polar regions with extreme sensitivity to pollution
- Rural Villages for transport to work, checking trap lines, substance hunting and fishing.
- National Park Service to preserve the environment.

# UAF Goals for CSC 2011

Category	Challenge Record	UAF Goal	UAF Obtained
Range	29 km (18 mi)	30 km (18.6 mi)	>30 km (18.6 mi)
Weight	226 kg* (498 lb)	227 kg (500 lbs)	<233 kg (514 lbs)
Drawbar Pull	2.56 kN (575 lbf)	2.6 kN (590 lbf)	>2.6 kN (590 lbf)
Noise**	65 dB	64 dB	<64 dB
MSRP	\$14K	\$12K	<\$12K

\*With 2.4 kW·h pack

\*\*With studded track

**Strategy:**  
**“Better,**  
**Faster,**  
**Cheaper”**

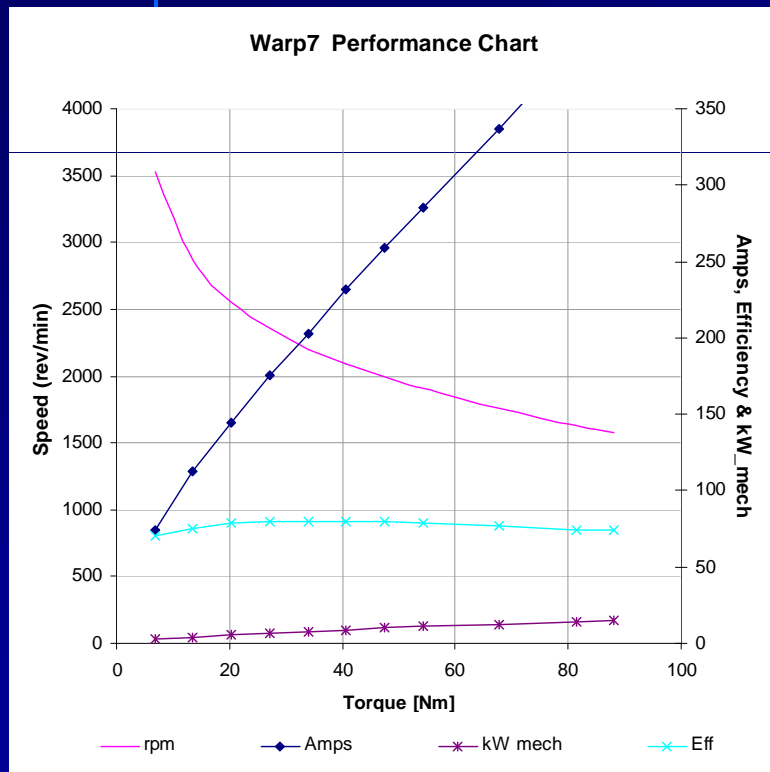
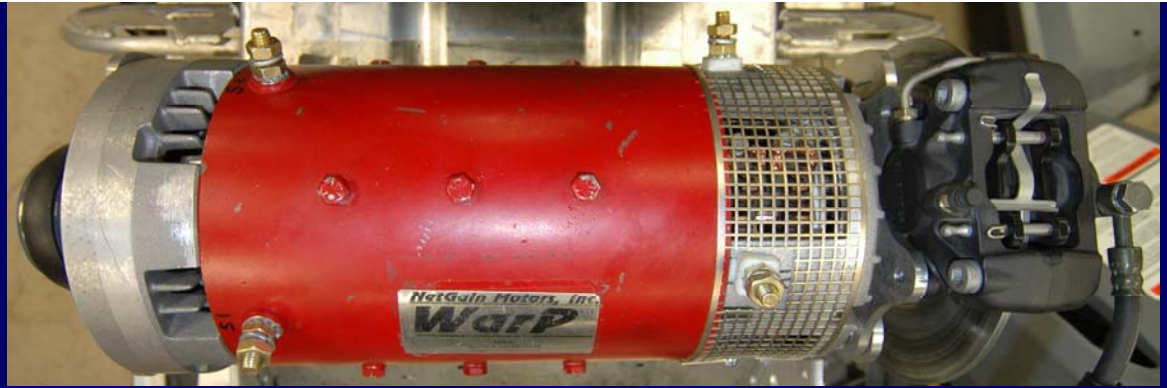
# Priority Design Goals

- Prevent contaminating/polluting samples and environment
- Affordable for villages to reduce necessary quantity of gasoline (~\$10/gal)
- Practicality, Range, and Performance
- Use of renewable energy to recharge reduces emissions from a diesel generator.

# Design Strategy

- KISS (Keep It Simple Stupid)
- 8kWh runs at least 14 miles
- Li-Po batteries for maximum power with minimal weight
- Low Cost yet durable
- Easily repeatable with available components

# Motor



- NetGain WarP7 DC motor
- 181mm (dia.) x 425mm weighs 45.5 kg
- Continuous power of 15.47 kW
- 47 Nm torque @ 32 km/h
- 2,100 rev/min using 48 V & 230 A

# Batteries

- Lithium-ion Polymer (Li-Po) x72
- 22.2 V nominal voltage, 5 Ah
- 9 paralleled strings of 8 batteries each
- 177.6 V total pack size
- Attractive mass energy density, availability, and cost.
- Low resistance (0.003 ohm) allows motor to draw more power
- Protected by Chargery Power BM6 Battery Management System (BMS)



# Battery Chemistry Examined

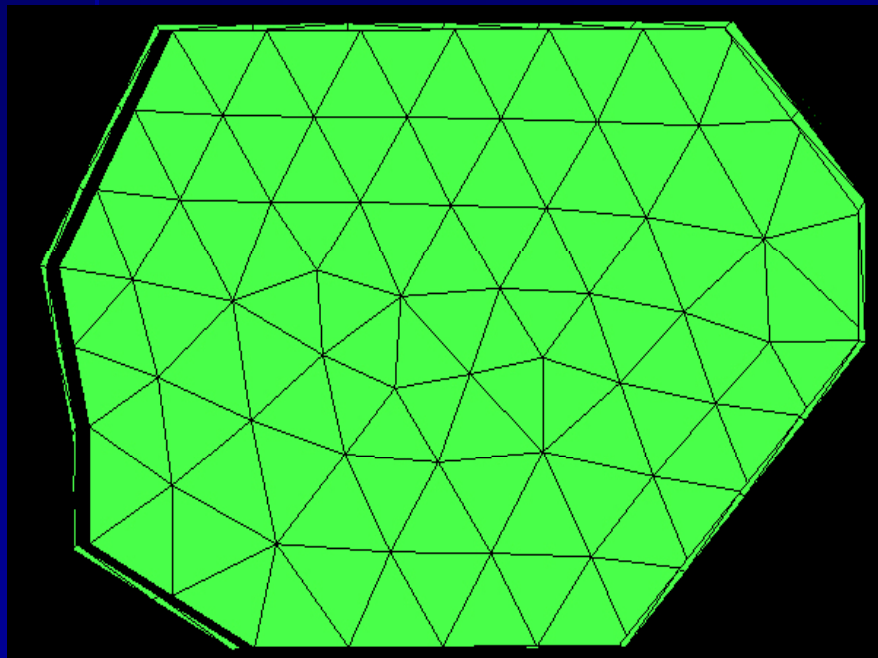
		Nickel		Lithium-ion			
Criteria	Lead Acid	NiCd	NiMH	LiCoO <sub>2</sub>	LiMn <sub>x</sub> Ni <sub>y</sub> Co <sub>z</sub> O <sub>2</sub>	LiFePO <sub>4</sub>	LiPoly Hybrid
Mass Energy Density (W·h/kg)	35	40	75	180	160	110	140
Volume Energy Density (W·h/L)	68	50	200	250	250	220	286
Power Density (W/g )	0.18	0.15	0.7	3	3	3	4.2
Cycle efficiency (% charge/discharge)	70	70	70	95	95	95	95
Self-discharge (%/month)	10	10	30	5	5	5	3
Cycle life (total cycles)	200	1000	500	500	500	2000	1000
Current cost (US Dollar/W·h)	\$0.05	\$0.23	\$0.47	\$0.60	\$0.60	\$0.31	\$0.40
Nominal Voltage	2.1	1.2	1.2	3.7	3.7	3.2	3.7
BMS Required	No	No	No	Yes	Yes	No	Yes
Environmental	Poor	Bad	Good	Average	Average	Good	Good
Cost based on cycle life x W·h of Lead	1	0.7	1.3	1.75	1.75	0.2	.45



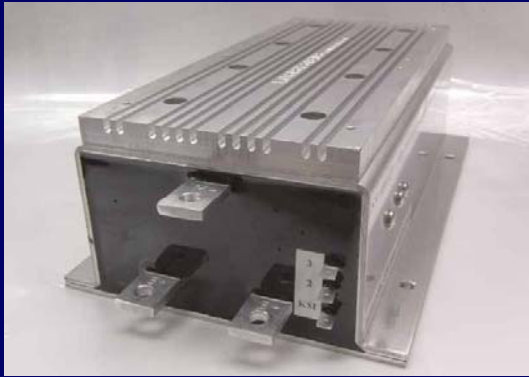
# Battery Box

Used Computer modeling to design a polycarbonate battery box that *Safely* houses our batteries.

Altair HyperMesh Software



- ½ inch Polycarbonate:
- Young's modulus of  $3.2 \times 10^9$  N/m
  - density of 1.20 g/cm
  - Withstand impact @ 20mph with 500 lbs of snowmobile compressing the box



# Controller

- Logsystems Controller 120/196
- Rated for 249 V & 550 A continuously
- Capable of 137 kW continuously
- Rated for -40 degrees Celsius
- 99% efficiency @ >73 degrees Celsius
- High volume Delta fans to ensure proper cooling
- Runs motor with Pulse Width Modulated @ 14 kHz

# Service

- Less moving parts than IC for service
- Only two fluids (brake fluid & bearing grease)
- Longlife batteries (1500 cycles)
- Simple drivetrain with two Gates BX34 V-belts
- Stock hydraulic disk brake system



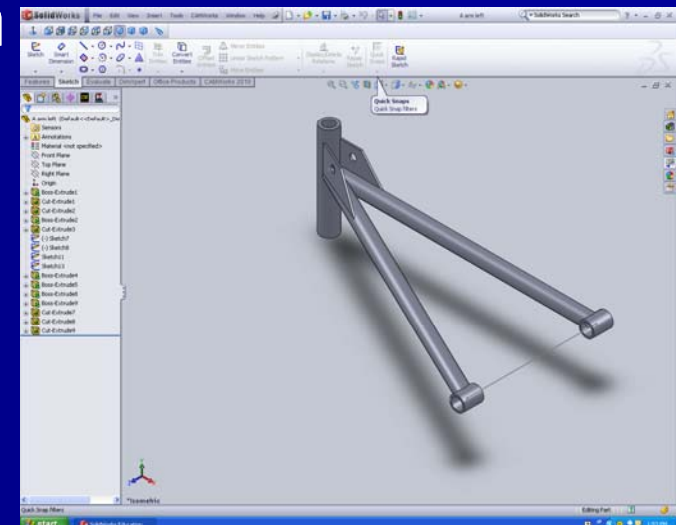
# Cost

- MSRP \$12K
- Potential savings
  - Lower Maintenance Costs
  - Lower energy cost than IC



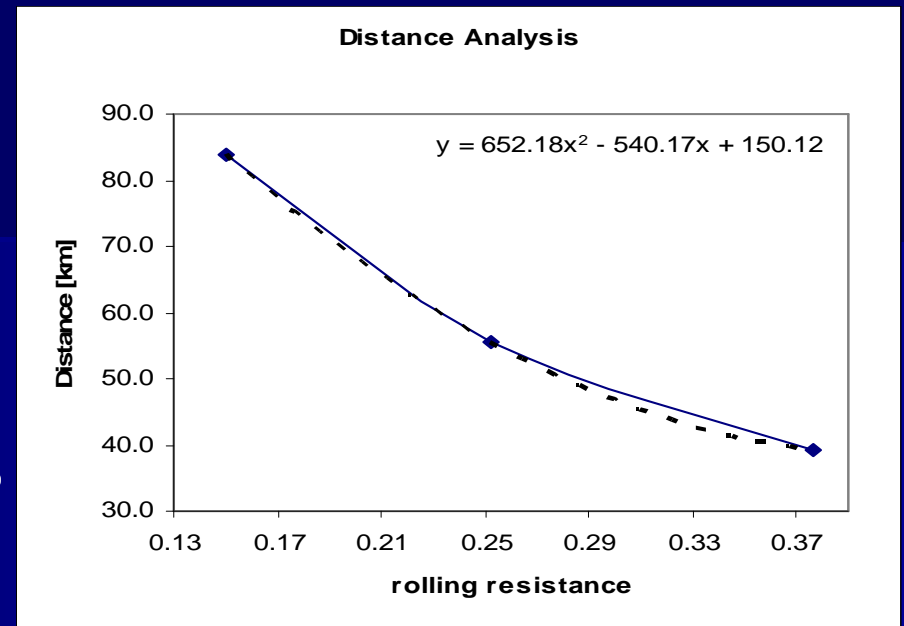
# ZE Tundra Features

- Lighter, total weight 504 lbs
- 18" Fox Airshocks
- Widened ski stance for stability which is safer and easier to drive (for novice)
- Estimated 11% reduction in CO2 emissions & 10% reduction in Greenhouse gases



# Test Results

- Tow force of 590 lbs
- On a 0.83 mi track @ constant speed of 20 mph range is 18.6 miles.
- >65 dB with Kimpex track on light powder snow



# Conclusion



This is our second year in development of the Skidoo Tundra prototype.

We are happy with the DC motor setup because it performs to our expectations and is affordable.

Our hybrid Li-Poly batteries outperform their competition; however we are still searching for batteries with higher mass energy density (semi-conductor, sulfur, LiSnZn, ...)