

Design of Electric Snowmobile



Alaska Style



Introduction: The Appeal

UAF EV3 exceeds criteria set for Scientific Research in the North and South Poles.

1. Successful Zero-Emissions sled will not contaminate fragile environments.
2. Range and Power pack a punch!
3. Comfortable and attractive.
4. Easily maintained and serviced with an 8-piece toolkit.
5. Affordable price makes it obtainable.
6. EV3 is safe, durable, and easy to use.

The Starting Point



- Machine is based on Ski-Doo XP chassis.
- Most efficient chassis available.
- All innovations maintain stock appearance.

Operator Perspective



- Rev-XP chassis was chosen because of its extremely comfortable “rider forward” design and great balance
- Ergonomic modifications from stock are extremely slight
- Weight is balanced perfectly from side to side
- Without rider, center of mass is at drive shaft

Ease of Use

Machine behaves exactly as an electric-start IC:

- -"Run" position on key initializes 12V system, activates BMS display
- Turning key to "crank" starts machine if and only if kill switch, tether, temperature switch, and Bender are positive
- Computer display is available even with HV disabled

Easy-to-use Display

LCD screen displays important info like pack voltage and current draw

Buttons allow access to BMS menus



The LCD screen displays the following data:

Uo1	198.6V	325
H10	1041	4.800
LoU	1251	3.920
Tem	88.5	73.3
amp	+1	Wh/a 882
Soc	100.0	% ChD
Temp	0.1	MPH

LED indicators display status

READY
CRANK
FAULT

Range

- Tests averaged 300 Wh/mile without load
- 8kwh battery pack, 80% depth of discharge
- 6.4kwh useable
- 21.3 mile range



Power

- Pulling power is limited by available traction
- Longer track means best traction is realized on packed snow, and also offers floatation
- Studless design was used for minimum weight and noise, utilizing a BRP “Silenttrack”
- Production machine could use screw-in studs with very little weight or noise penalty

Dealer Perspective

ski-doo®



DEALER LOGIN

DEALER LOGIN // DEALER LOGIN // DEALER LOGIN // DE

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Serviceability-Design Goals

- Serviceability was one of the primary design considerations
- Any component can be removed and serviced or replaced
- All fasteners are easily accessible
- Most fasteners employ “blind nuts,” eliminating the need for a second wrench

Service tool kit

- 10mm combination wrench (should ratchet)
- 7/16" open-end wrench
- 10mm nut driver
- 9/16" x 5/8" box wrench
- 3/16" hex wrench
- 7/64" hex wrench
- Flat screwdriver
- T-25 Torx





Service time



- Drive belt can be tensioned in 15 minutes
- Stripping the chassis down to the motor takes less than 2 hours (removing battery system as a unit)
- Complete removal of the central battery system can be completed in under 4 hours (tested)

Cost

- Our Cost to Build: \$8,000
- Buying in bulk would reduce this cost considerably
- Adjusted MSRP: \$17,600

Durability Enhancements: Carbon Fiber



6 Layer Reinforced Tunnel:

- Increases rigidity
- Decreases weight
- Extra layer for bolt holes

Replaced steering post brace:

- Allows room for battery box
- Maintains strength
- Decreases weight

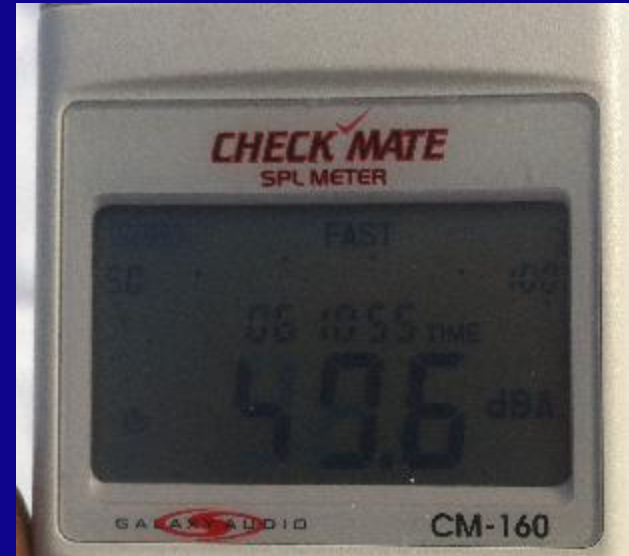


Environmental Perspective

- Noise level was reduced by using a Silentrack
- Idler wheels ride on an extra strip of rubber
- Motor noise is low due to motor placement beneath battery pack
- Environmental pollution has been virtually eliminated by ensuring that all fluid systems are entirely sealed

Environmental Impact Tests

- Only Fluids are brake fluid and bearing grease
- Sound Pressure Level measurements of 49.6 dB were taken in loose snow at 50 feet at 15mph



SPL meter reads 49.6 dB

12 Volt System and Headlights

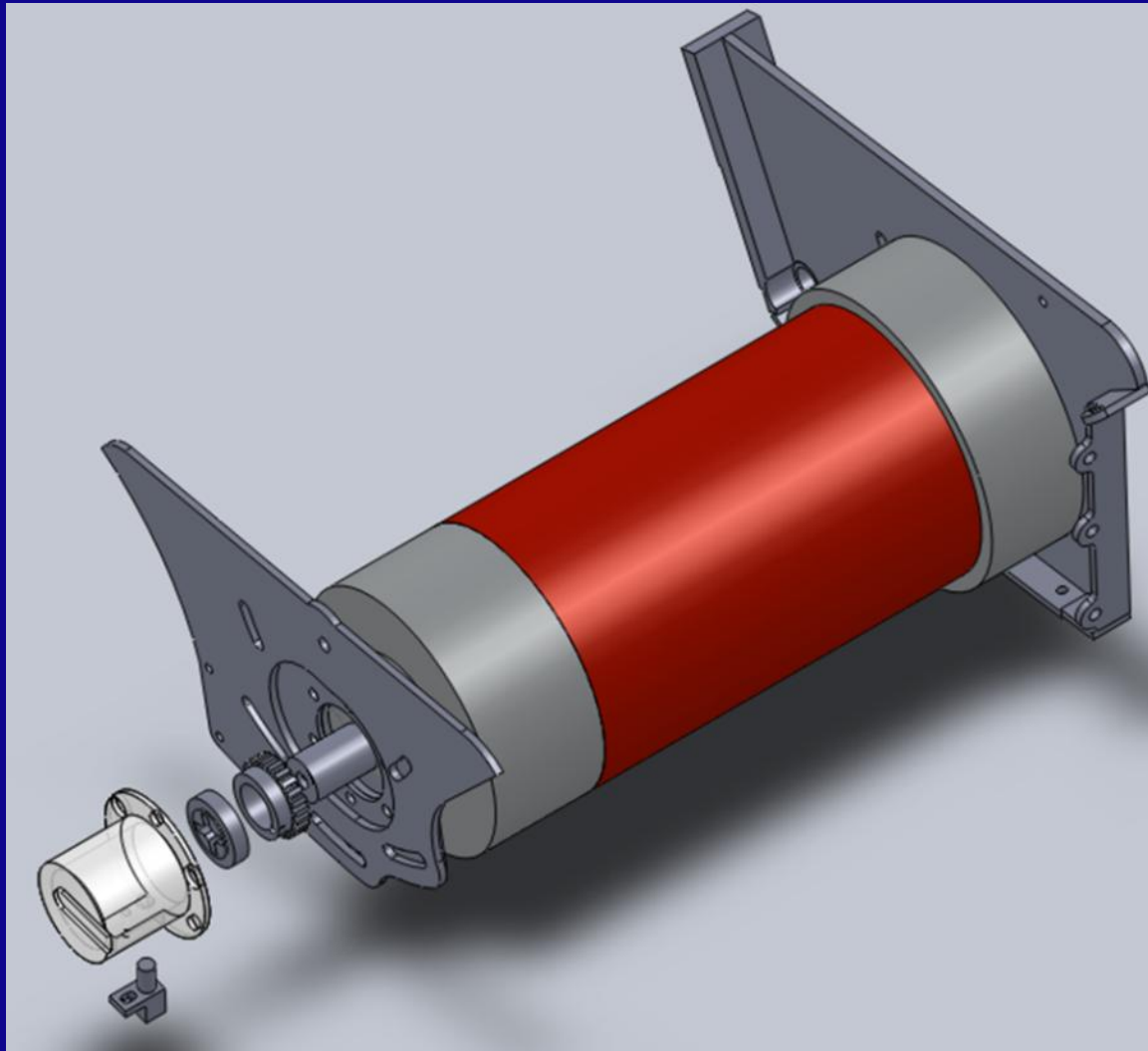
12V system powers motor controller, BMS, dashboard displays, relays, and headlights

Stock headlights replaced with two 10W LEDs.

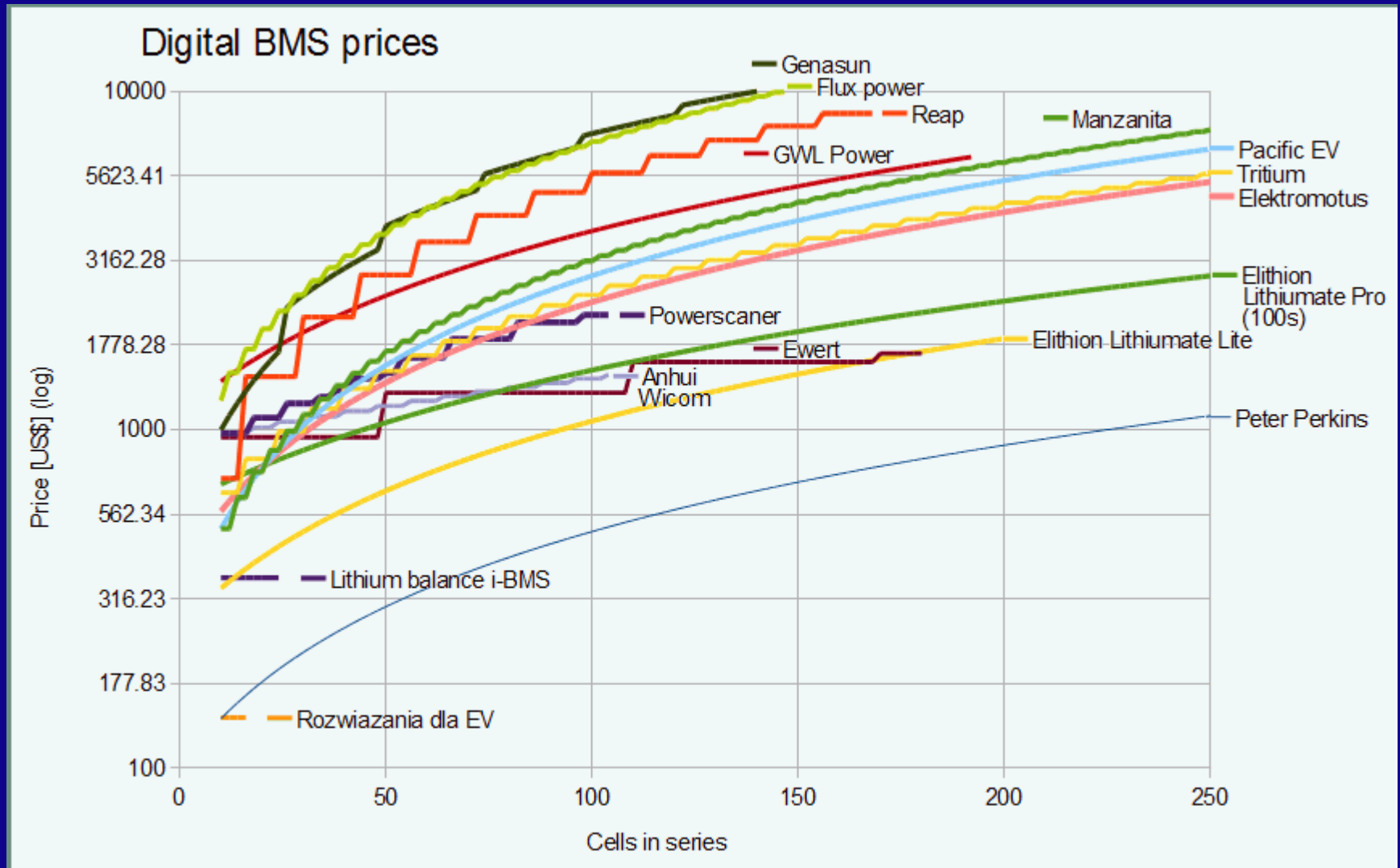


Reduced draw on 12V system by 90%.

Test Results/Science



Battery Management System (BMS)



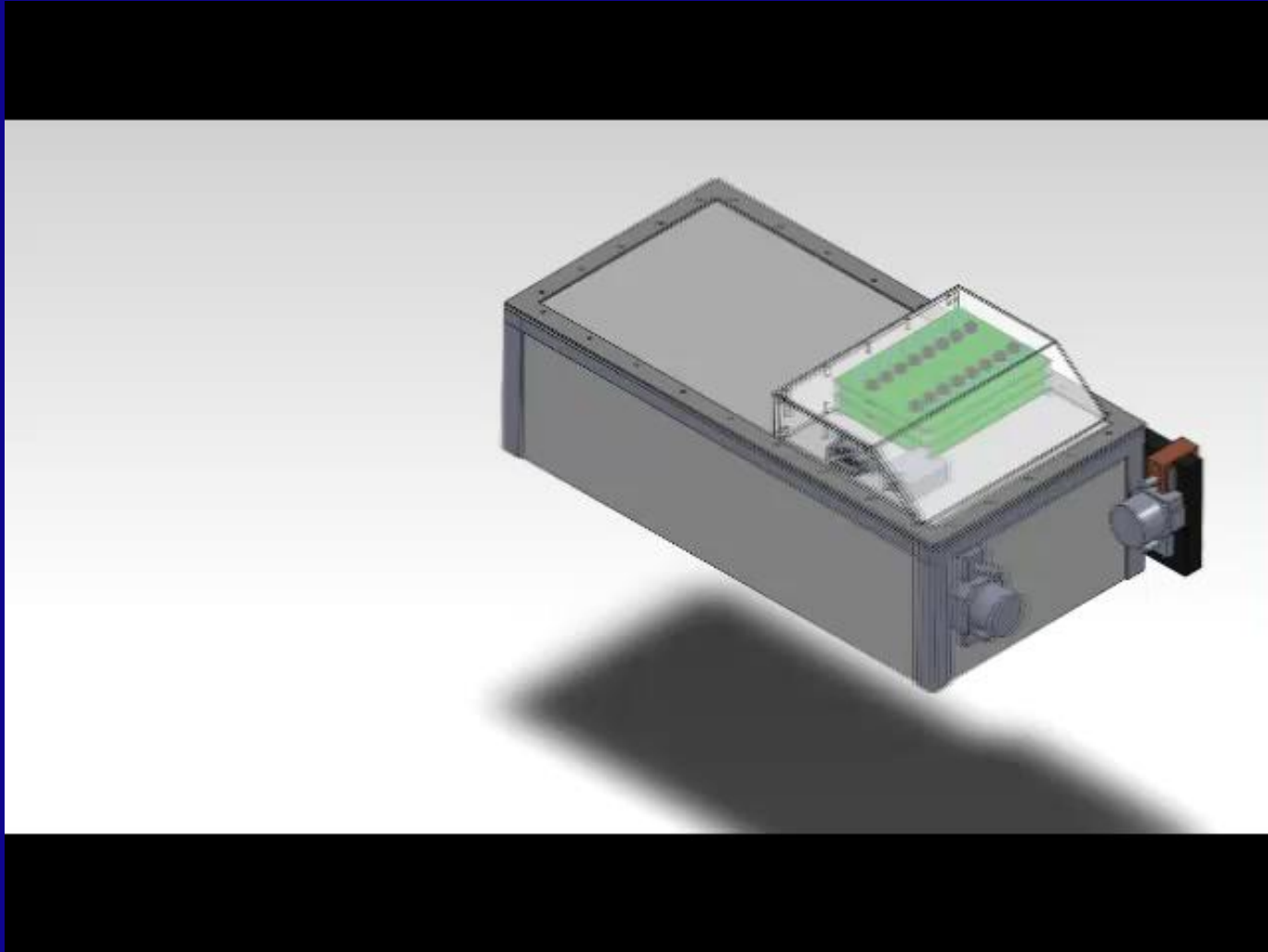


Batteries

Table 2: Battery Chemistry Examined

Criteria	Lead Acid	Nickel		Lithium-ion			
		NiCd	NiMH	LiCoO ₂	LiMn _x Ni _y Co ₂ O ₂	LiFePO ₄	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	0.45

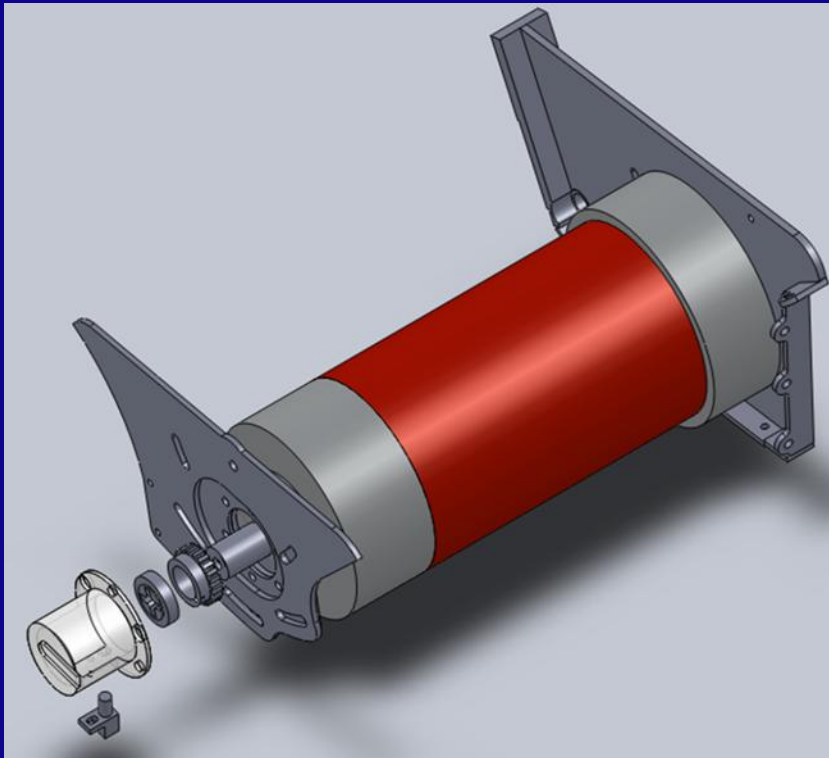
Battery Box modeled in SolidWorks



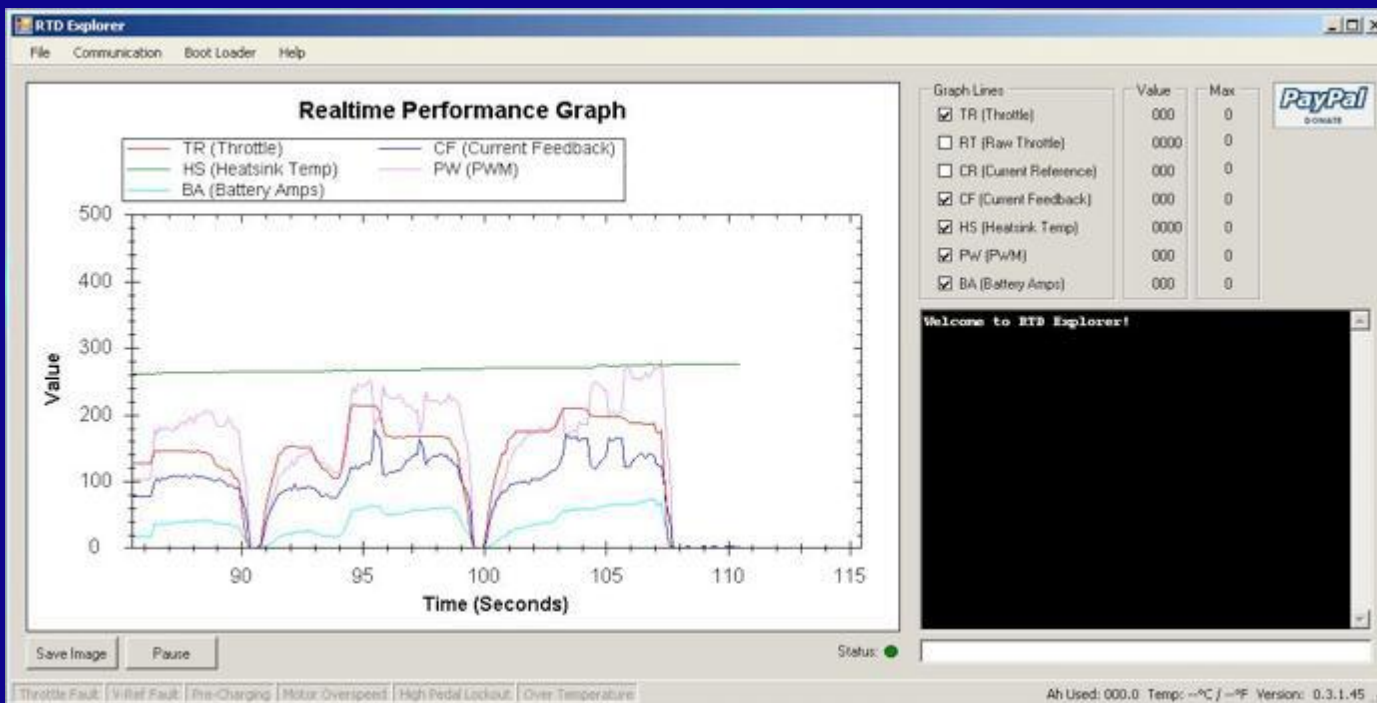
Improved WarP 7 DC Motor

15.47kW
continuous power

1. Replaced Brushes
2. Ceramic Bearings
3. 3% more efficient



ReVolt Open Source Controller



High Performance
Microprocessor Control
Ultimate Customization
Cost effective

SB Electronics Capacitor: “The Heart of the Motor Controller”



- Power Ring Capacitor
- Uses Film Technology
- 600V Rating
- 1000 μ F (microfarad)
- Capable of handling 500A ripple

Conclusions

EV3 exceeds expectations.

It is innovative and well-designed.

We expect great performance from our sled!