EMBRY-RIDDLE AERONAUTICAL UNIVERSITY SAE

FORMULA HYBRID

ignite

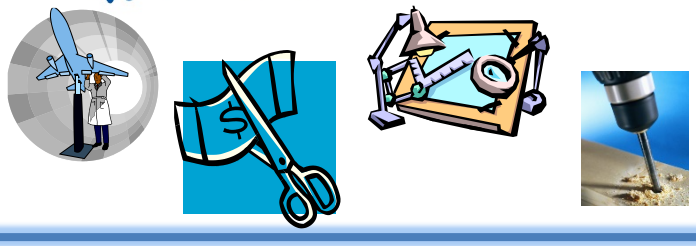
CREATE • RESEARCH • CHANGE

Discovery Day

Formula Hybrid

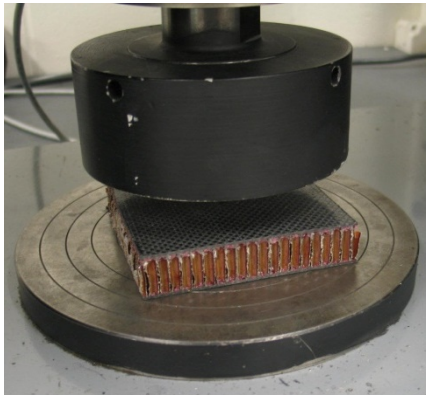
- Teams must design and build an open-wheel, single-seat, electric or plug-in hybrid racecar and compete in a series of static and dynamic events.

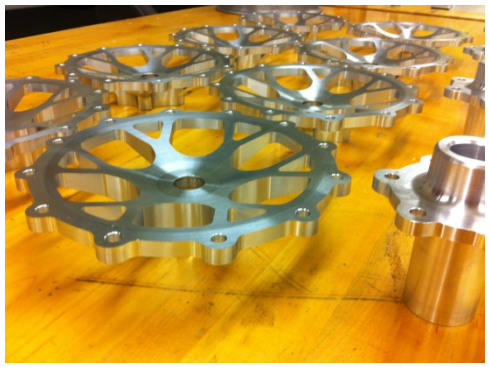
IEEE SAE



Team Goals

- Safety
- Reduce Vehicle Weight to under 500 lbf
- Integration of High Voltage Accumulator
- Serviceability
- Reliability
- Vehicle Dynamics





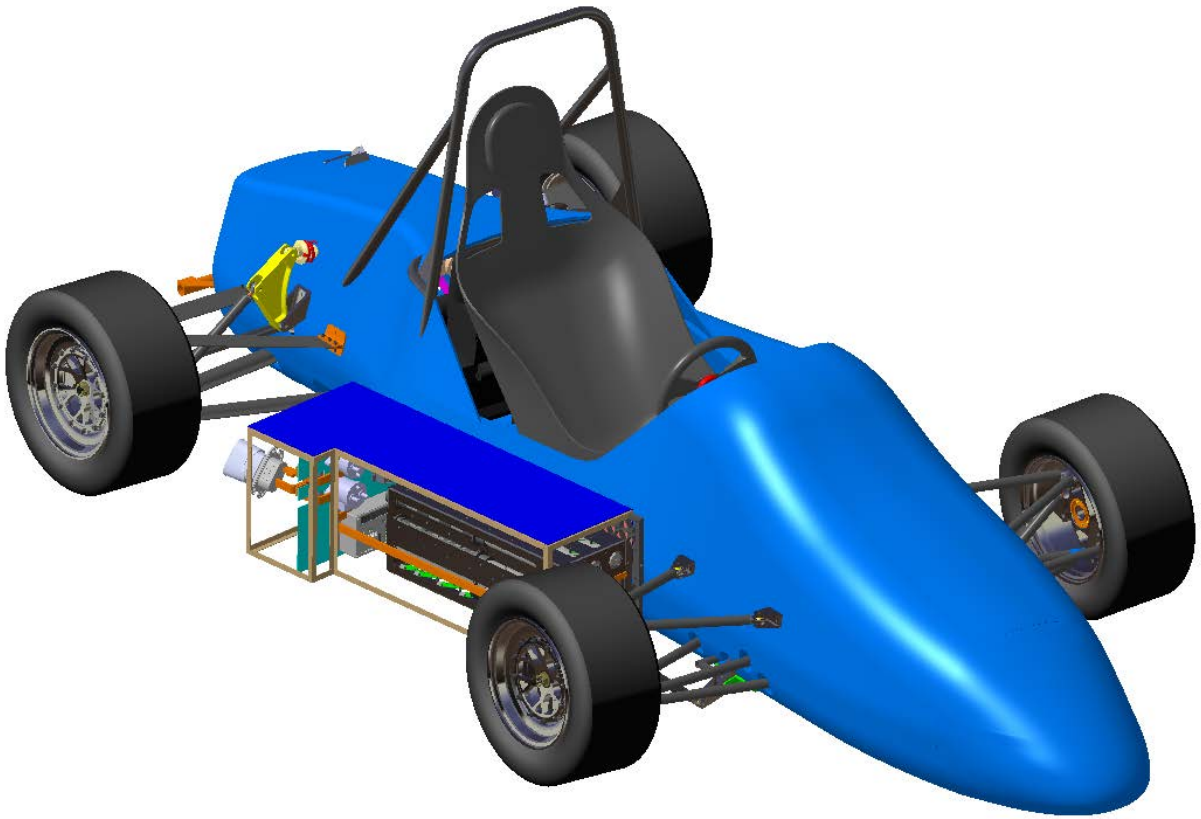
Tractive System Requirements

Completing a 75 meter straight-line course in less than 10 seconds

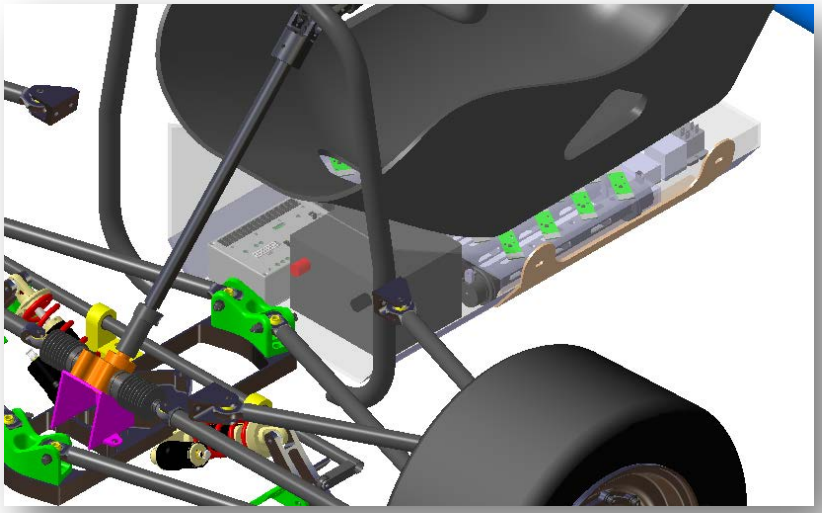
Req. #	Requirement
1	Can withstand 20g loads in the ground plane and 10g vertically
2	Container must be electrically isolated
3	Transparent structure to maintain full visibility of the system's components
4	Pass rain certification
5	Each cell must be individually monitored for voltage and temperature.
6	If enclosure is located outside of the monocoque, it must be able to withstand side and rear impact loads that comply with the minimum material requirement

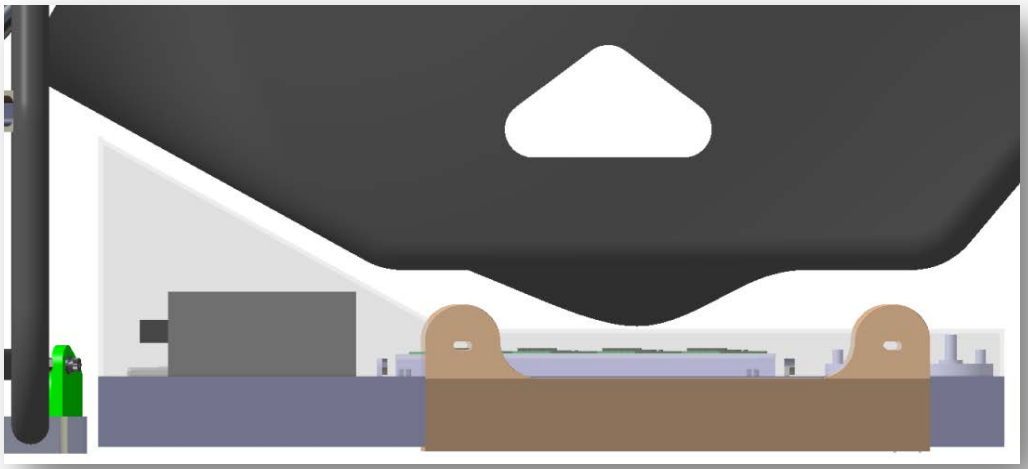
Problems with Last Year's System

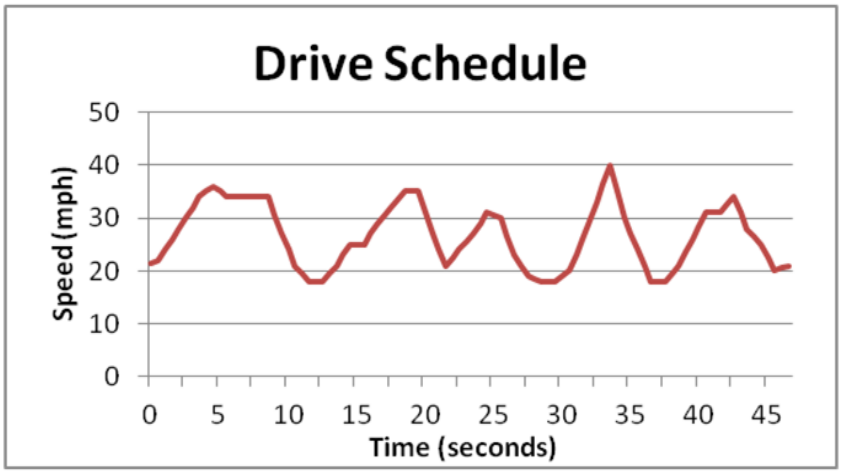
- Lack of serviceability
- Non-symmetric weight distribution leading to poor vehicle dynamics
- Integration
- New SES Requirements for Side/Rear Impact

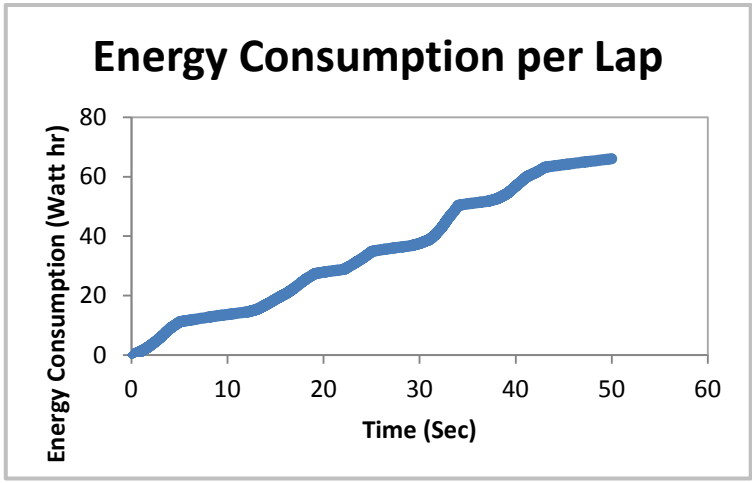


Design and Analysis





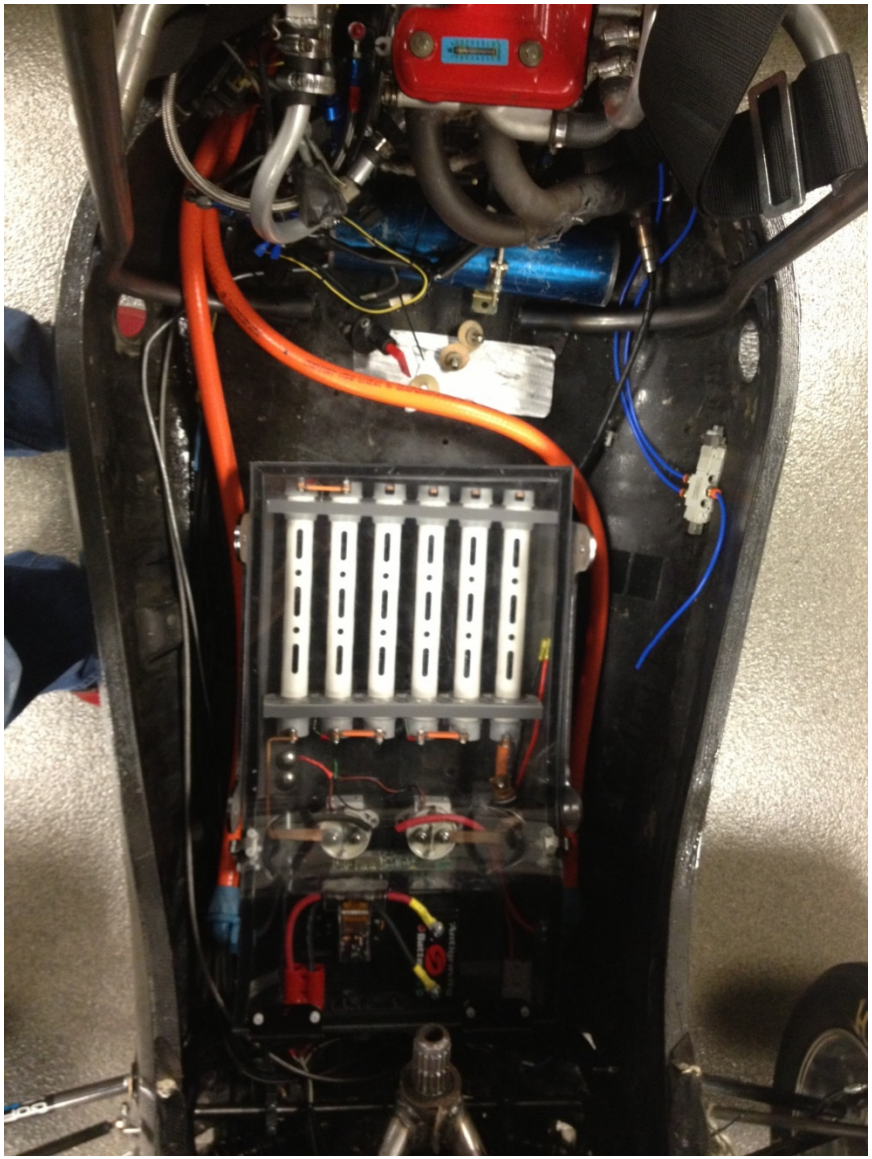




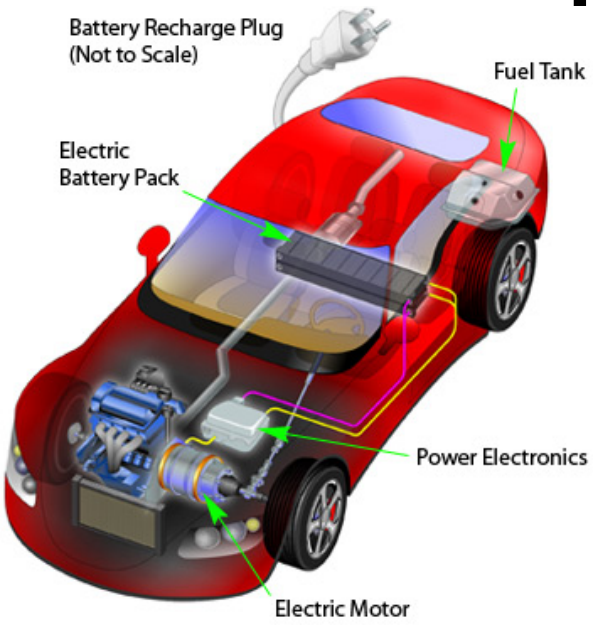
BILL OF MATERIALS

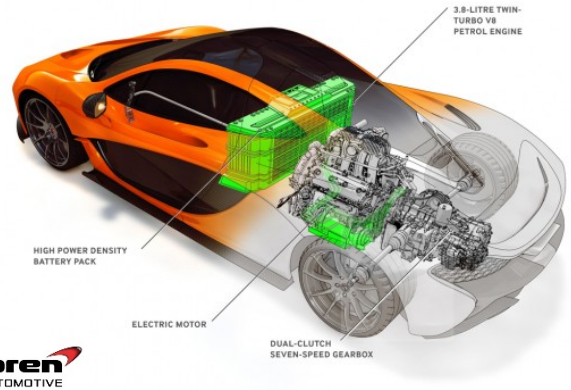
HV SYSTEM AND SUBSIDIARIES

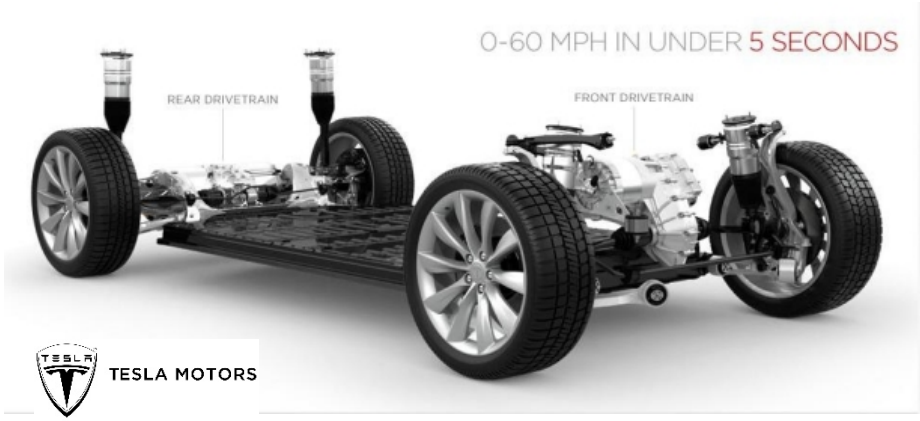
PART DESCRIPTION	PART NUMBER	MATERIAL	SUPPLIER/MFU	QUANTITY REQUIRED	QUANTITY TO ORDER	UNIT PRICE	TOTAL PRICE	LEAD TIME	RESPONSIBLE	STATUS	COMMENTS/MISC.
Enclosure/Tube Mounting											
Overcenter Closing Latch	29-619	Stainless Steel	PROTEX	2	2	$ 7.44	$ 14.88	1 week	Steven Fox	0%	Light duty rigid claw fastner
Latch Catchplates	08-594	Stainless Steel	PROTEX	2	2	$ 1.66	$ 3.32	1 week	Steven Fox	0%	90 degree catchplate
Acrylic Sheet	242084	Acrylic	Optix	2	2	$ 116.00	$ 232.00	1 day	Steven Fox	0%	36X72X.220" Sheet
Case		PC/Acrylic	Cut and Bond	1			$ -		Steven Fox	0%	
Lid		PC/Acrylic	Cut and Bond	1			$ -		Steven Fox	0%	
Top Tube Clamp		PC/Acrylic	CNC Machine	1			$ -		Steven Fox	0%	
Bottom Tube Clamp		PC/Acrylic	CNC Machine	1			$ -		Steven Fox	0%	
Lid Hinge		Stainless Steel	PROTEX	2	2	$ 4.38	$ 8.76		Steven Fox	0%	
Fasteners	92316A628	Steel grade 8	McMASTER-CARR	1	1	$ 7.48	$ 7.48		Steven Fox	0%	
Rubber Spacers	441298	Rubber	The Hillman Group	1	1	$ 17.68	$ 17.68		Steven Fox	0%	
Batteries and Battery Tubes											
Cell Tubes	254977	PVC	Home Depot	3	5	$ 1.72	$ 8.60	1 day	Joshua Drayer	0%	two tubes per and 4 extra
Battery Cells	26650 M1	LiPO	A123	24	0		$ -		Joshua Drayer	0%	
Bus Bars (if needed)	1HLG1	Copper	Grainger	1	0	$ 106.60	$ -	1 week	Joshua Drayer	0%	(2) .25in thick, 1ft long, 6in wide sht
End Cap Nuts		ABS	McMASTER-CARR	12	0		$ -		Joshua Drayer	0%	
End Caps		ABS	McMASTER-CARR	12	0		$ -		Joshua Drayer	0%	
Grommets		Rubber	Grainger	12	0		$ -		Joshua Drayer	0%	
Nickel Plates		Nickel	McMASTER-CARR	18	0		$ -		Joshua Drayer	0%	
Belleville Disc Springs	9712k61	Steel	McMASTER-CARR	24	0	$ 0.32	$ -	1 week	Joshua Drayer	0%	Spring between batteries
12V Battery	AG801	lifepo4	Antigravity	1	1	$ 179.99	$ 179.99	1 week	Joshua Drayer	0%	New low voltage battery
Battery Monitoring											
BMS	Lithiumate Pro	NA	eLithion	1	0		$ -		Jeff Garraud	0%	
Cell Board CENTER	1SC0100X	Cicuit Board	eLithion	12	0		$ -		Jeff Garraud	0%	No connector or dot
Cell Board NEGATIVE	1SC0100X	Cicuit Board	eLithion	6	0		$ -		Jeff Garraud	0%	Has connector and black dot
Cell Board POSITIVE	1SC0100X	Cicuit Board	eLithion	6	0		$ -		Jeff Garraud	0%	Has connector and red dot
Connectors to CB's		ABS	Grainger	12	0		$ -		Jeff Garraud	0%	
Arduino Board		NA	Arduino	1	0		$ -		Jeff Garraud	0%	
Power Distribution											
POSITIVE & NEGATIVE Contacts	686-901	NA	Stancor	2	0		$ -		Roshan Patel	0%	
Bender		NA	Bender	1	0		$ -		Roshan Patel	0%	
HV Relay	686-901	NA	Stancor	1	0		$ -		Roshan Patel	0%	
LV Relay	120-907	NA	Stancor	1	0		$ -		Roshan Patel	0%	
Motor Controller	KDH07601A	NA	Kelly	1	0		$ -		Roshan Patel	0%	
Motor Controller Mount		PC/Acrylic	CNC Machine	1			$ -		Roshan Patel	0%	
4 ga Power Cables		Copper	Soundcrafters	50	50	$ 2.97	$ 148.50	1 day	Roshan Patel	0%	50ft insulated copper wire 4 Gauge
Terminals	Y4-38R-t	Copper	rowbar Electrical Par	1	1	$ 18.95	$ 18.95	1 week	Roshan Patel	0%	(25) Copper Eyelets with 3/8in holes
Ferraz Shawmut	A6T125	Steel	Ferraz Shawmut	1	0		$ -		Roshan Patel	0%	
LED Indicators	WFLS-A6O-BK	LED/Plastic	superbrightleds.com	1	1	$ 23.95	$ 23.95		Roshan Patel	0%	1 m, weatherproof, cuttable, LED strip



Hybrid Vehicles







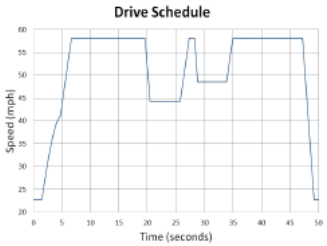
EMBRY-RIDDLE AERONAUTICAL UNIVERSITY SAE
FORMULA HYBRID

2013 Sustainability Report

INTRODUCTION

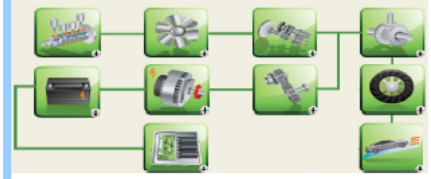
One of the reasons for the growth of hybrid vehicle sales is the reduction in emissions over non-hybrid vehicles. A well-to-tank analysis was done using the Greenhouse, Regulated Emissions, Energy Use in Transportation (GREET) software model created by Argonne National Laboratories. A tank-to-wheel analysis was done using a model made in Simulink and MATLAB. The drive schedule used in the simulation was created in Optimum Lap. The total emissions of the hybrid versus gas vehicles are calculated by looking at the combined analyses (well-to-wheel) of Triton.

MODEL DEVELOPMENT



The calculated drive schedule around the proposed 2013 Formula Hybrid Endurance course.

The drive schedule was drawn out using Optimum Lap and a simulation lap was performed to obtain the optimum drive schedule. A dynamic powertrain model was developed in MATLAB and Simulink using known performance characteristics of Triton (engine fuel map, rolling resistance, aerodynamic drag, etc.) and the selected powertrain configuration, which is a post-transmission parallel hybrid utilizing lithium ion batteries.



Triton's hybrid configuration.

WELL-TO-TANK

The amount of CO_2 generated by the production and delivery of each megajoule (MJ) of gasoline to be used by Triton (often referred to as the well-to-tank emission value) was calculated with GREET. This amount was found to be 24.3 grams of CO_2/MJ of energy. 15.8 grams of CO_2 are emitted per MJ of fuel, while only 8.5 grams of CO_2 are emitted per MJ of electrical energy.

TANK-TO-WHEEL

The average quantity of CO_2 generated by Triton per kilometer of the endurance race (often referred to as tank-to-wheel) was also calculated. This was found to be 122.6 grams of CO_2/km emitted by the engine.

Example Fuel Economy Sticker.

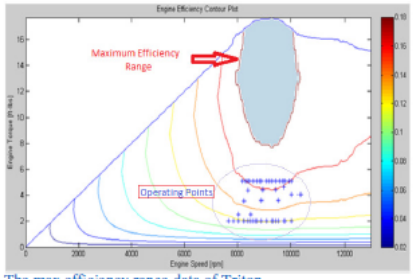
COMPARISON

The well-to-tank and tank-to-wheel results of Triton were compared to a purely gasoline vehicle under the same conditions. If Triton was strictly gasoline powered, the well-to-tank value would be 29.5 grams of CO_2/km of fuel, which is lower than the hybrid system's 39.9 grams of CO_2/km. However, the tank-to-wheel value of the gasoline vehicle, 139.4 g CO_2/km, is higher than Triton's 122.6 grams of CO_2/km. The table below presents the well-to-tank emissions converted to grams of CO_2/km. The combined emissions for the total well-to-wheel analysis are also provided for hybrid and gasoline-only modes of operation. For Triton's application, hybrid vehicles produce fewer emissions than comparable non-hybrids.

Hybrid vs Gas-Only Comparison

Parameters		Hybrid	Gas-Only
Well-to-Tank	(g CO2/km)	39.9	29.5
Tank-to-Wheel	(g CO2/km)	122.6	139.4
Total Emissions	(g CO2/km)	162.5	168.9
MPG		44.7	39.3

Values calculated using Argonne National Laboratories' GREET.



The max efficiency range data of Triton.

Sustainability

12% Increase in Fuel Economy

Future Endeavors

YASA
OXFORD YASA MOTORS

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CREATE • RESEARCH • CHANGE

A123 SYSTEMS