



THE UNIVERSITY of TENNESSEE | UT

Challenge X Program



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Outline

- Challenge X program
- Stock Equinox
- Physics
- Hybrid types
- Tour of Vehicle



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engineering





What is Challenge X



- ❖ Minimize Energy Consumption
- ❖ Reduce Emissions
- ❖ Maintain/Exceed Vehicle Performance

Competition

- ❖ Year 1 – Modeling, Simulation, Powertrain testing
- ❖ Year 2 – Integrate & Develop Powertrain
- ❖ Year 3 – 99% Buy-Off
- ❖ Year 4 – Detroit - DC





Stock Vehicle

- 2005 Chevy Equinox with 3.4 L V6 and AWD



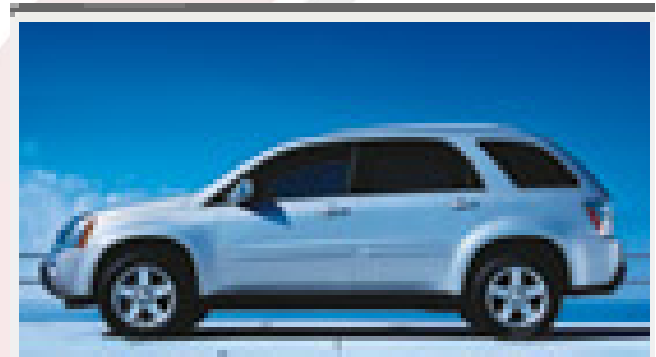
AN AMERICAN REVOLUTION



Stock Specs



- **3.4L V6 Engine**
 - 185 hp and 210 lb.-ft. of torque
- **EPA estimated MPG**
 - 19 city, 26 highway
- **Time for 0-60 mph**
 - 10.94 seconds
- **EPA Emissions Level**
 - LEV



2006 Equinox ▶

Every Equinox FWD has an EPA est.

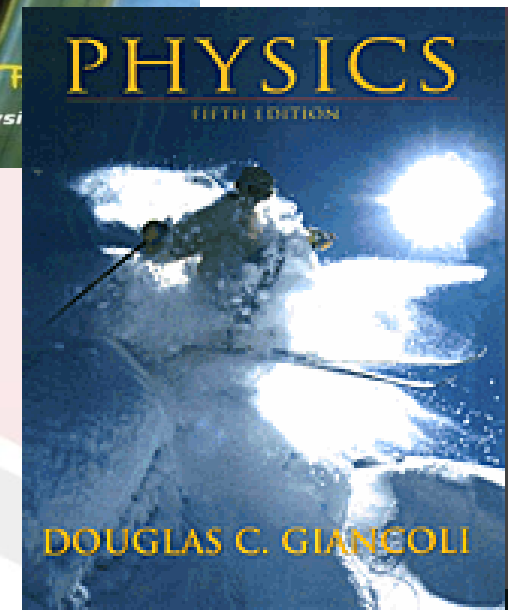
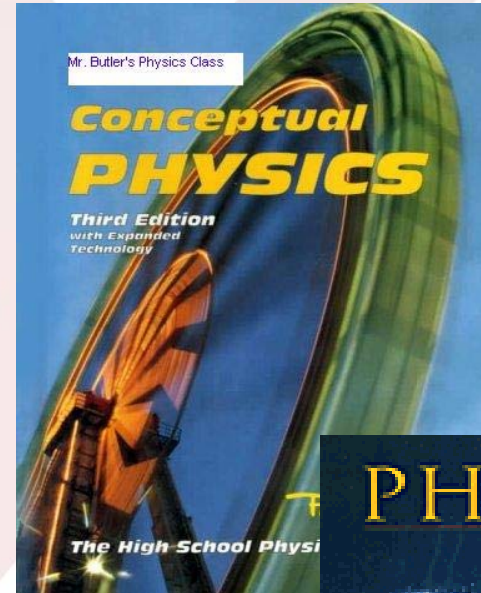
City
19
MPG

Hwy
26
MPG

- **Thermodynamics**
 - Engine Efficiency
 - Combustion

- **Electricity and Magnetism**
 - Electric motors
 - Hi Voltage System
 - Batteries and Energy Storage

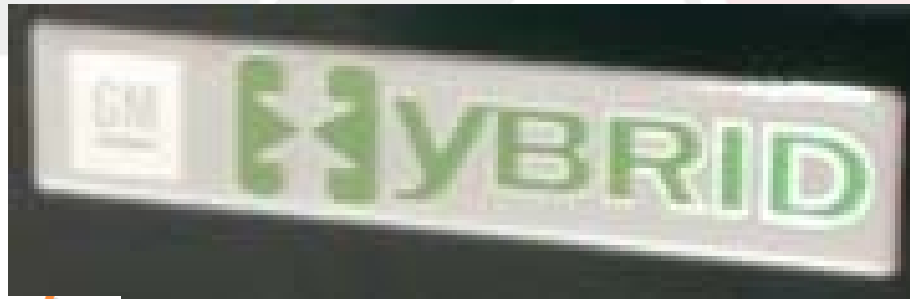
- **Dynamics**
 - Power and Energy
 - Vehicle Handling
 - Newton's Laws



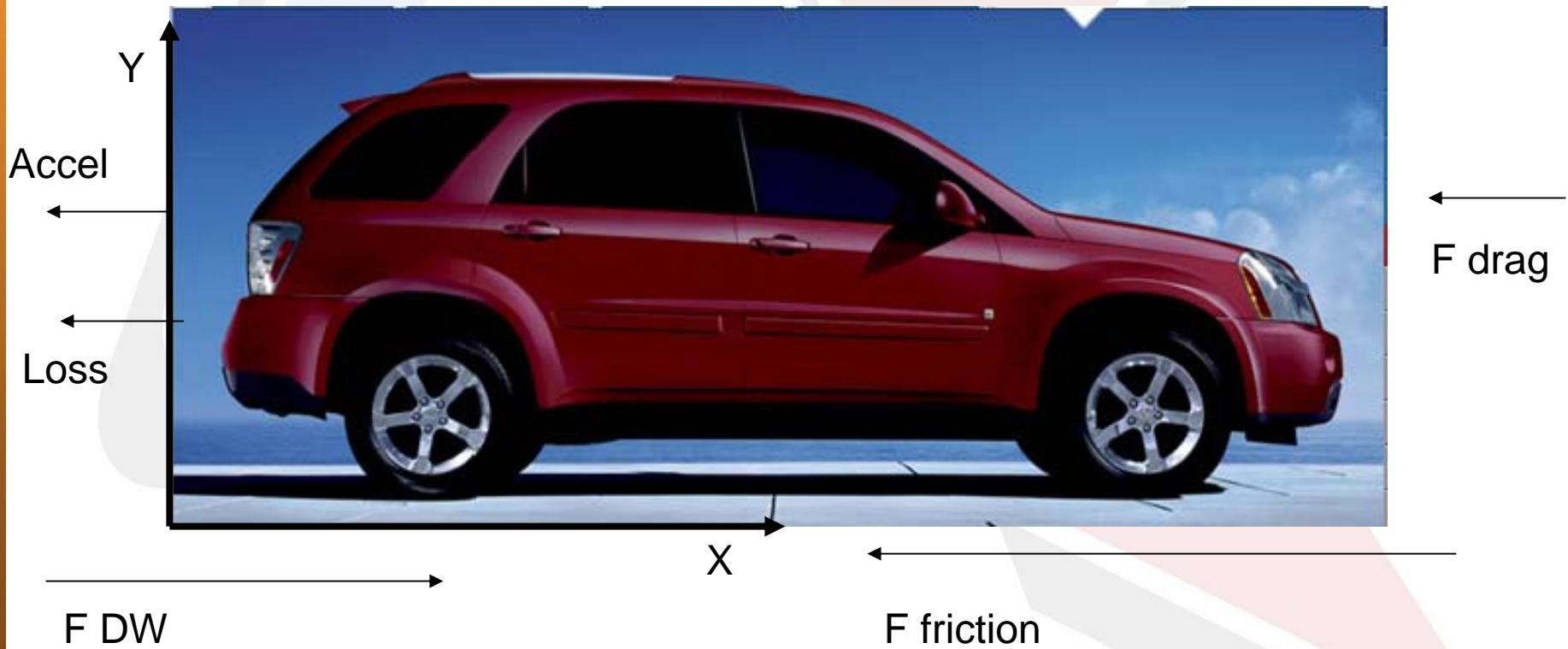


Focus on Hybrids

- Q. Why does a Hybrid get better fuel economy than a regular car?



- Newton's Laws





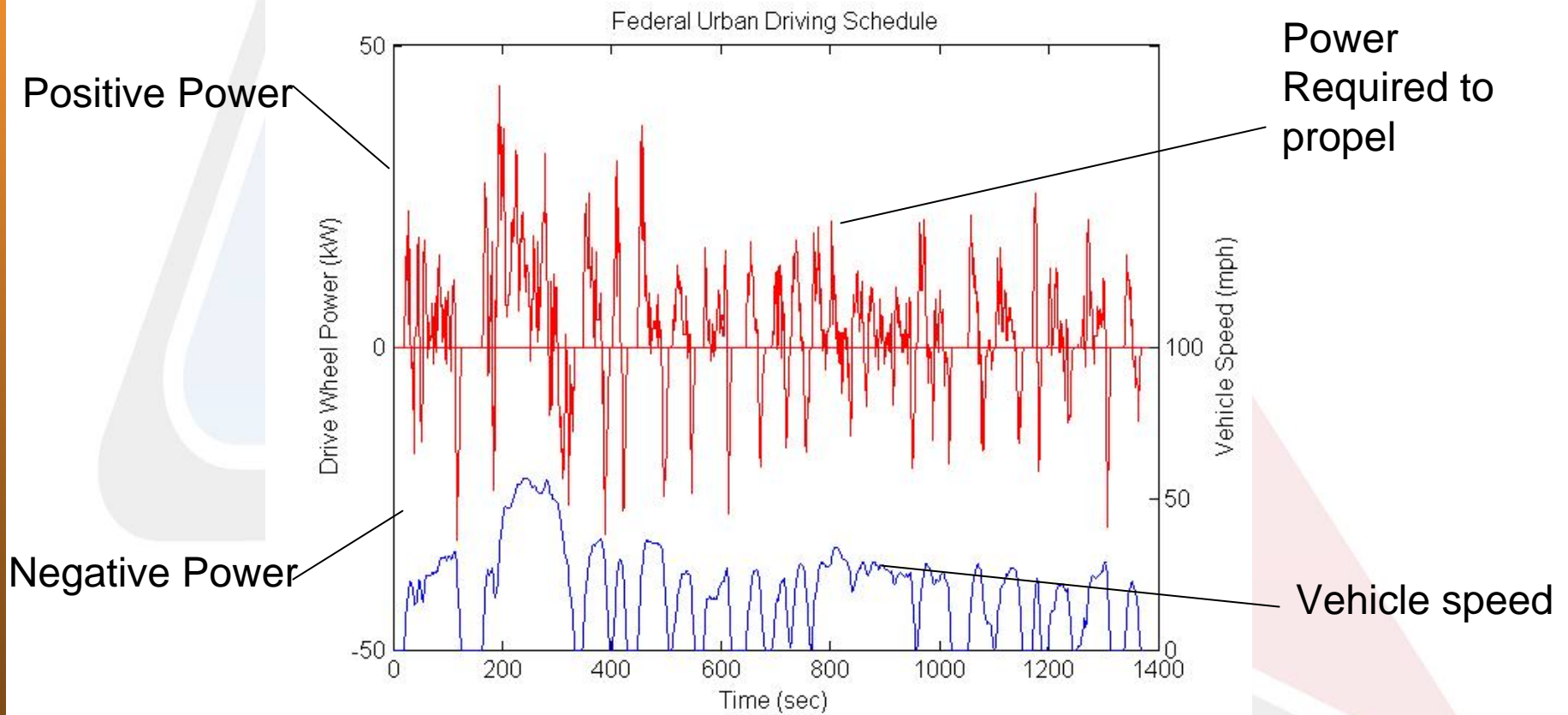
Power





Fuel Mileage

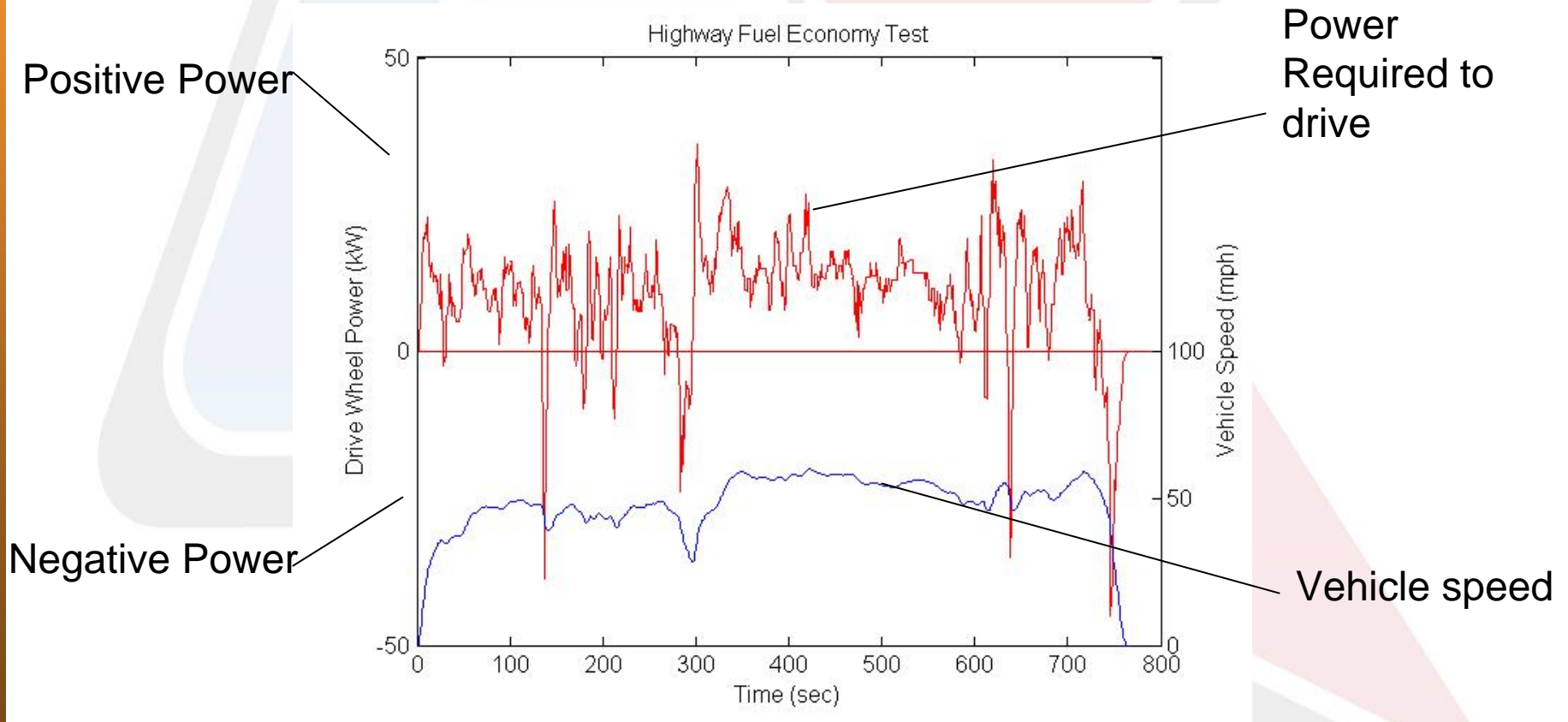
- City Driving - FUDS





Fuel Mileage

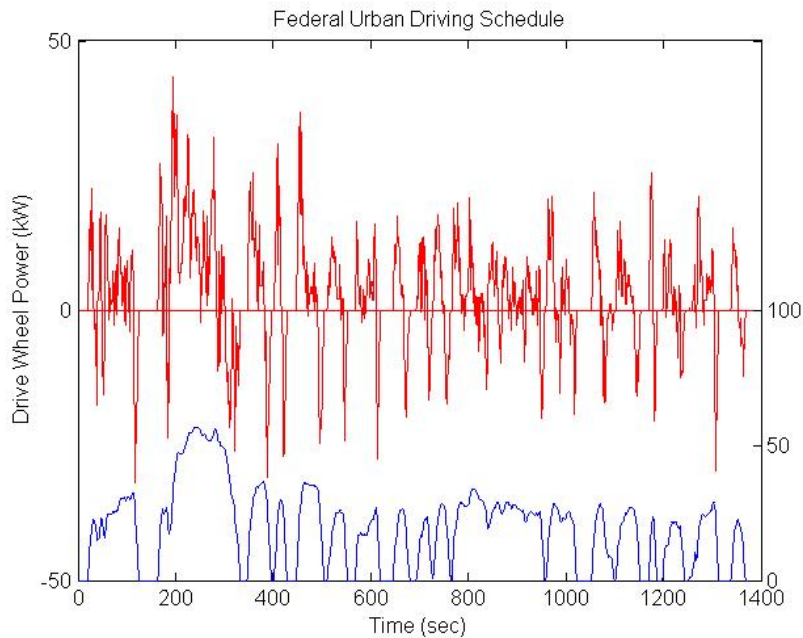
- Highway Driving - HFET



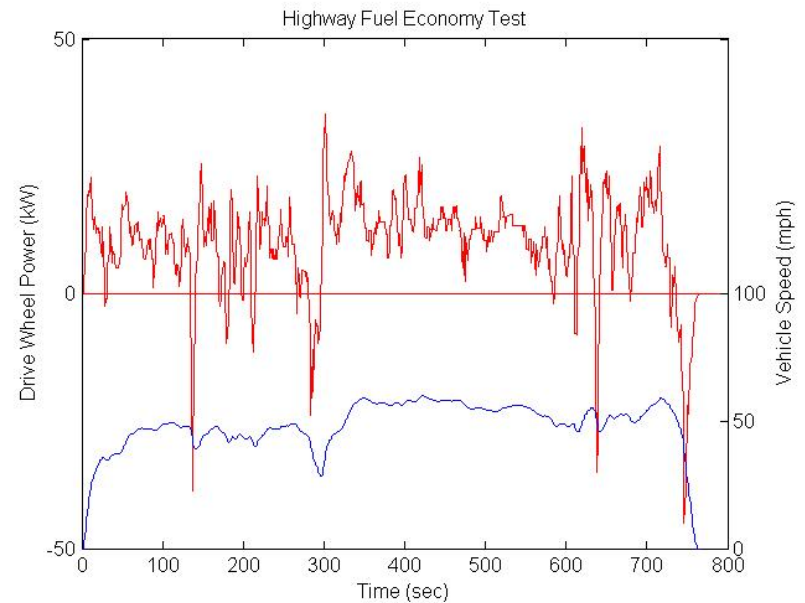


Regenerative Power

- Kinetic Energy = $\frac{1}{2} M \cdot V^2$



City Driving



Highway Driving

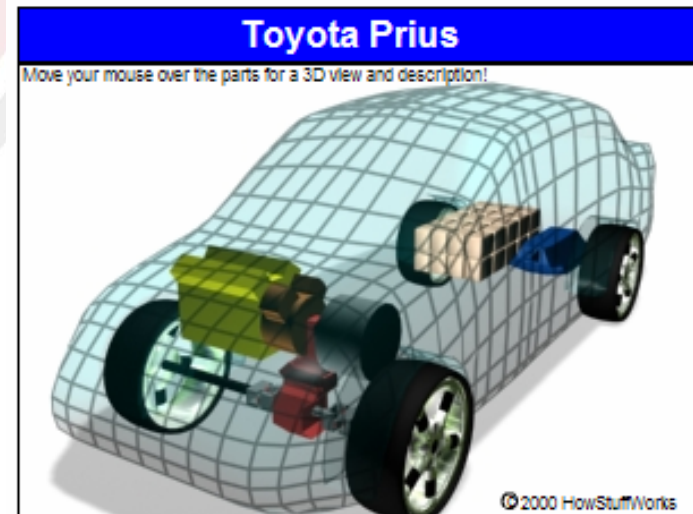


Hybrid Electric Vehicles

- A vehicle that operates using two or more energy sources
- Current marketed vehicles have gasoline engine and electric motor

More information:

www.howstuffworks.com





Energy Sources

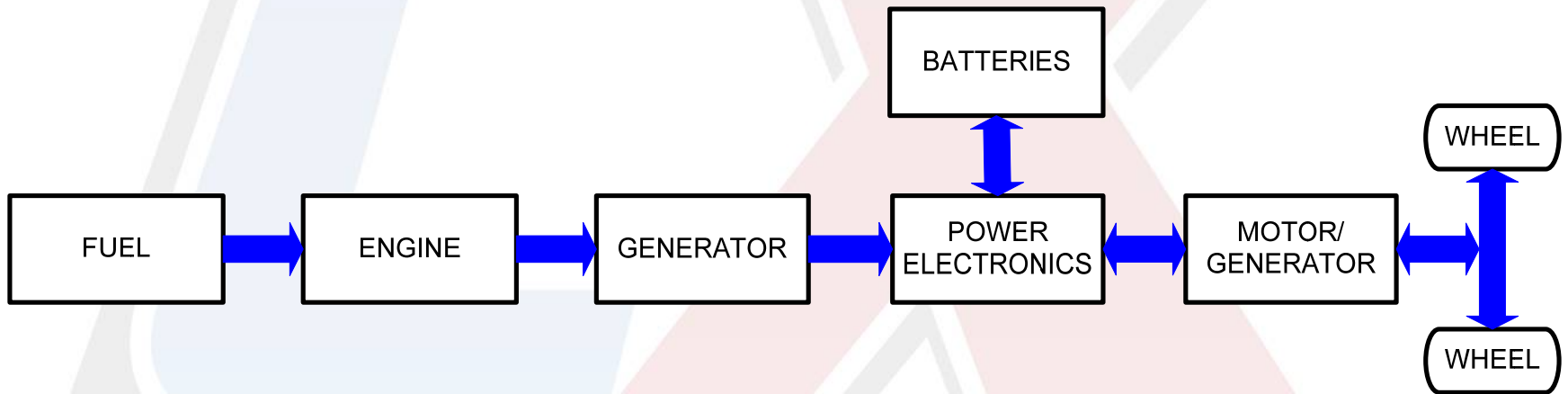
- Engine
- Fuel Cells
- Flywheel
- Ultracapacitors
- Electric Machine
- Fuel Types
 - Gasoline
 - Diesel
 - Biodiesel
 - Ethanol
 - Hydrogen

- Advantages
 - No mechanical coupling between engine and wheels
 - Engine always operates at most efficient point
 - Regenerative braking
- Disadvantages
 - Needs two electric machines
 - Expensive
 - Heavy



Honda Insight

Series



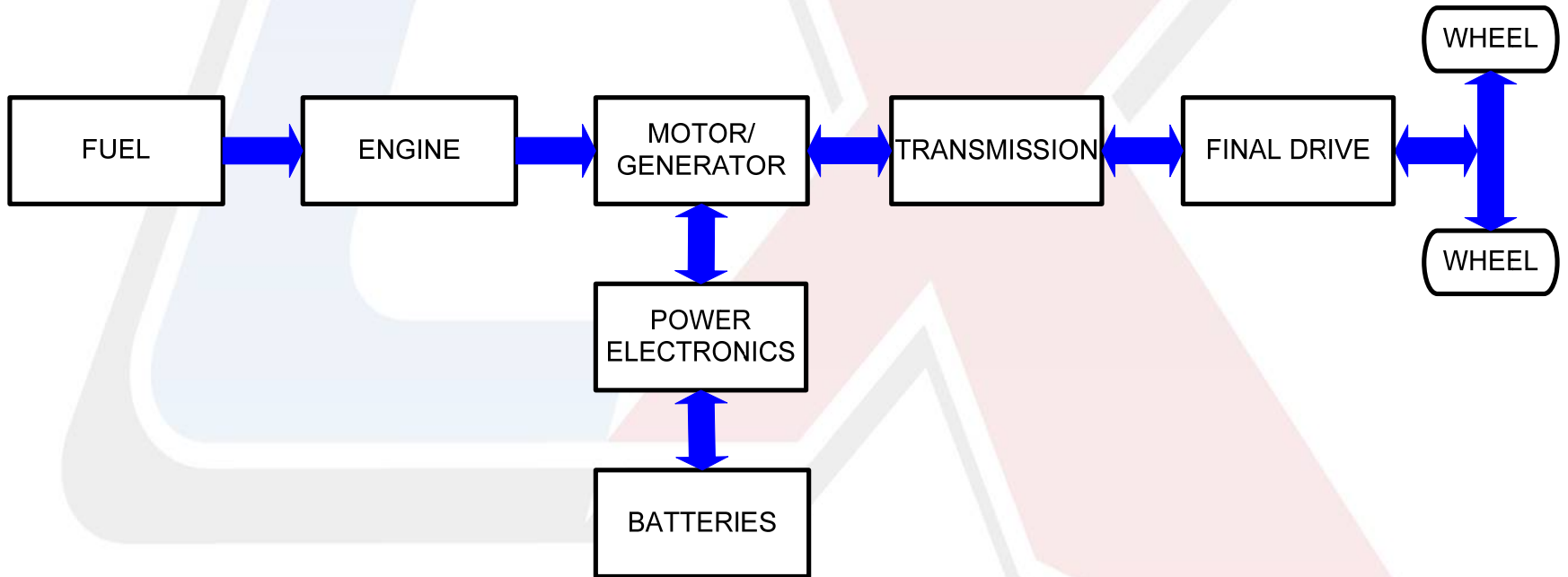
- Advantages
 - Regenerative braking
 - Engine can charge battery
 - Optimize performance of engine and motor
 - Only need one electric machine
- Disadvantages
 - No stationary charging
 - Engine must always be running



Chevrolet Silverado

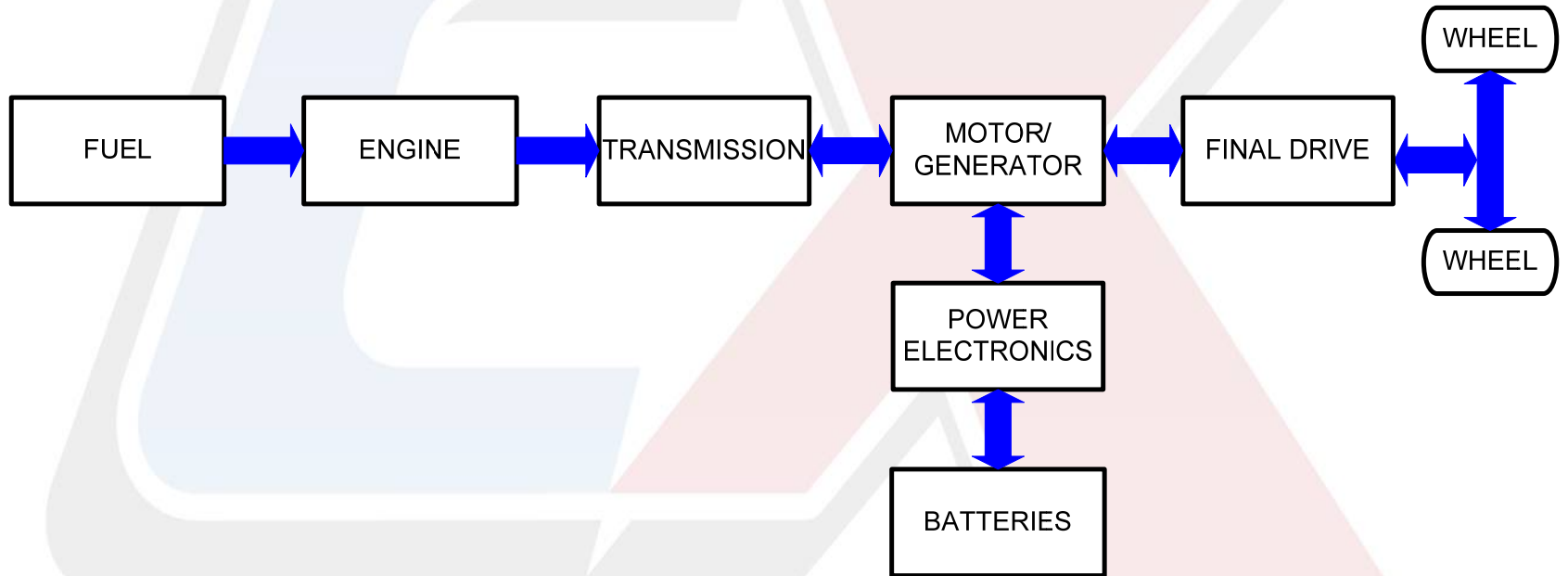


Pre-Transmission Parallel





Post-Transmission Parallel





Thru-the-road Parallel

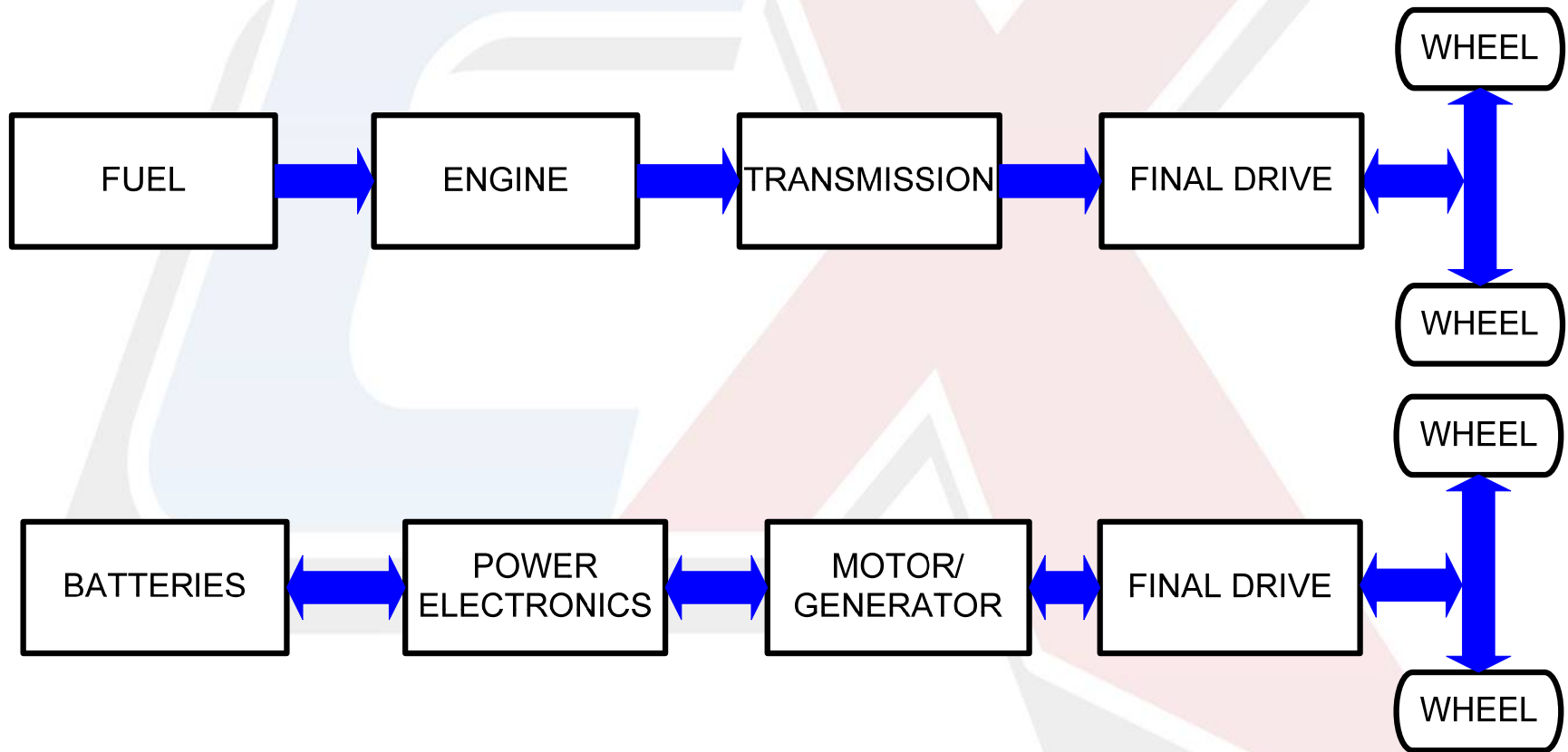
- Advantages
 - Complete redundancy
 - Simple to implement
 - Engine and motor are only connect thru the road
 - Only one electric machine needed
- Disadvantages
 - No stationary charging
 - Engine must always be running



University of Tennessee Equinox



Thru-the-road Parallel



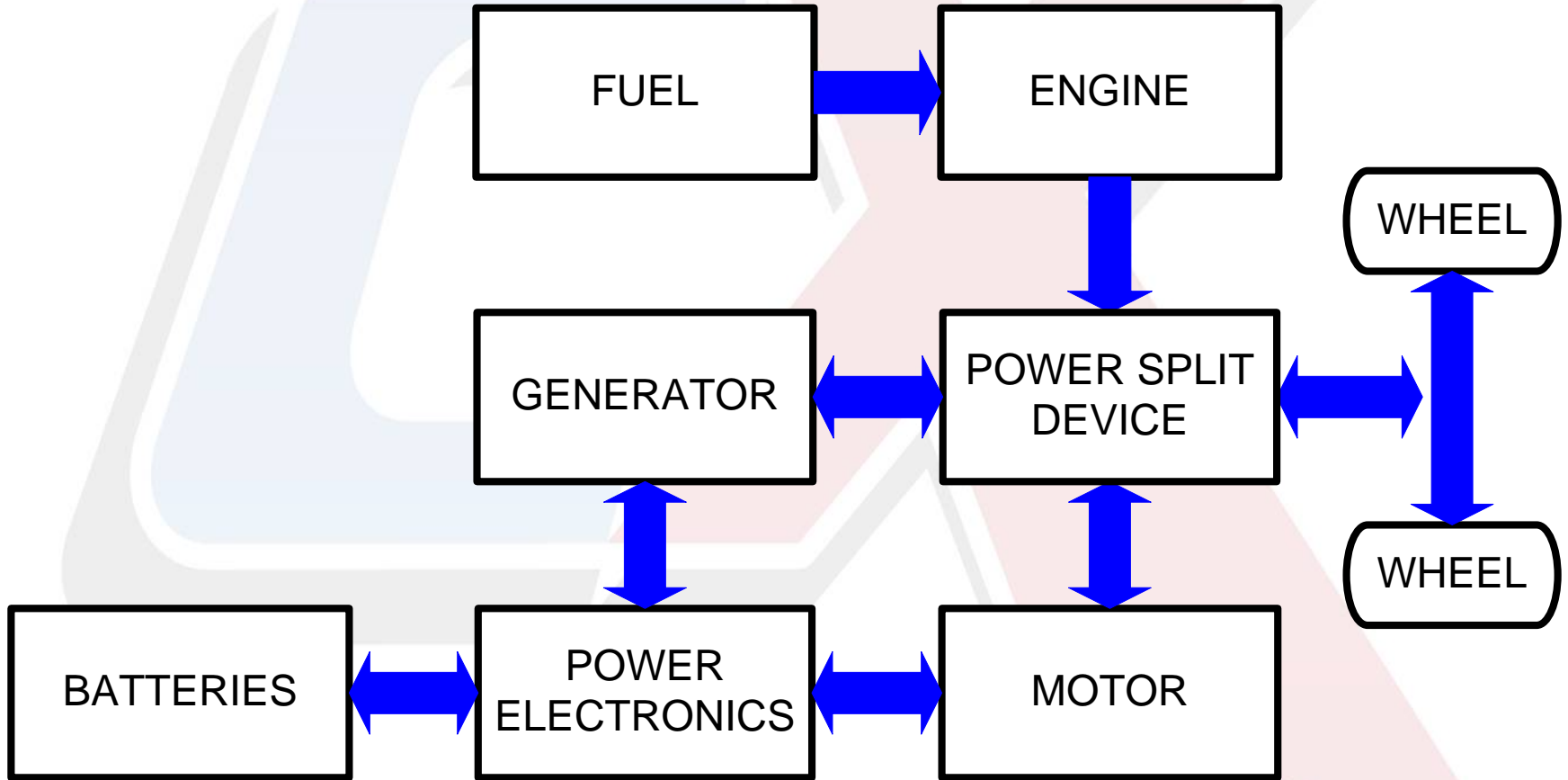
Series-Parallel

- Advantages
 - Can run on pure electric mode
 - Regenerative braking
 - Engine can run more efficiently
- Disadvantages
 - Complex to implement
 - Two electric machines needed



Toyota Prius

Series-Parallel





Not Stock

- Equinox with 1.9 L Turbo Diesel and AWD Parallel HEV



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Through the Road Hybrid

**Internal Combustion
Engine Powered
Front Wheels**



**Electrically Powered
Rear wheels**



Hybrid Components

- 1.9 L Turbo Diesel running biodiesel



- 336 V NiMH Battery Pack



COBASYS



- 60 kW Motor

BALLARD[®]

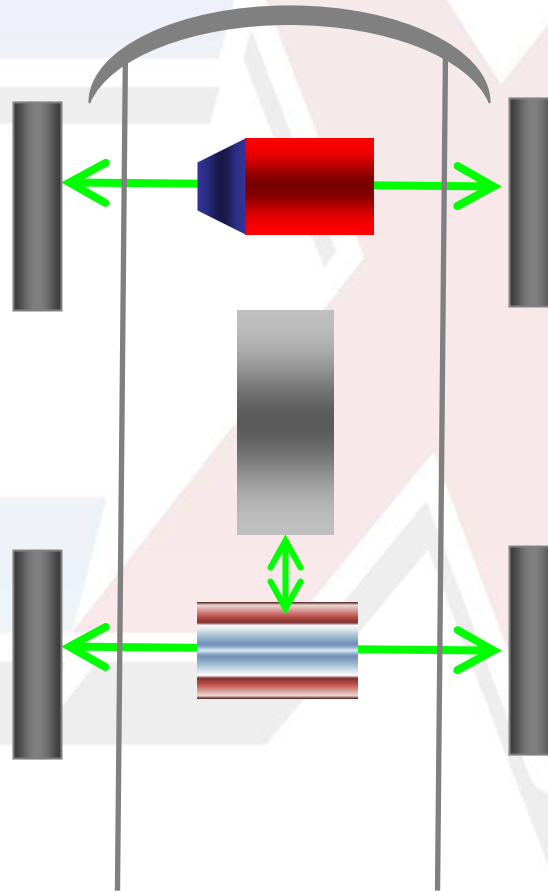
power to change the world[®]



Modes of Operation

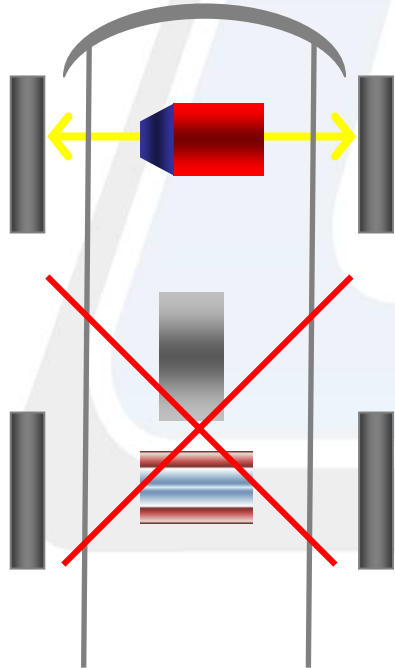
❖ Full Hybrid mode

Both CI engine and IPT provide the traction power for the vehicle

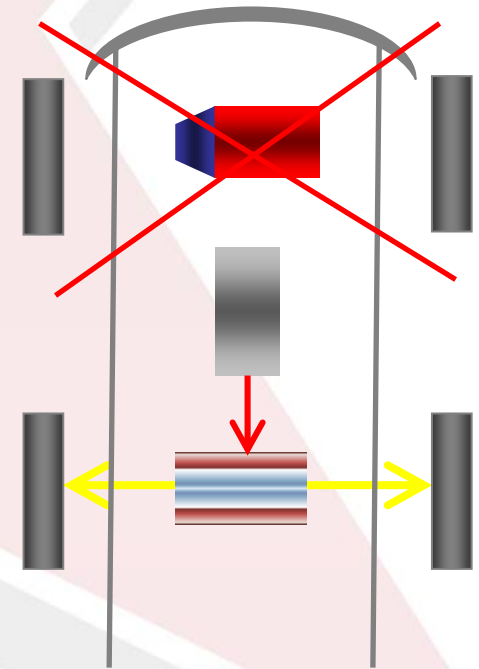


Battery Charging Occurs at Vehicle Cruising speeds when the CI engine can provide excess power to do so.

❖ Limp-Home Mode

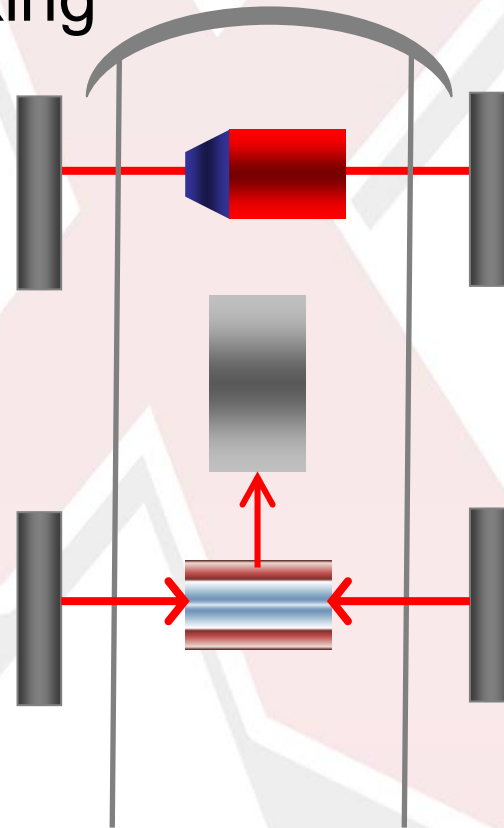


System redundancy & segregation provides the ability for limited vehicle operation should either the CI engine or the High-voltage systems fail



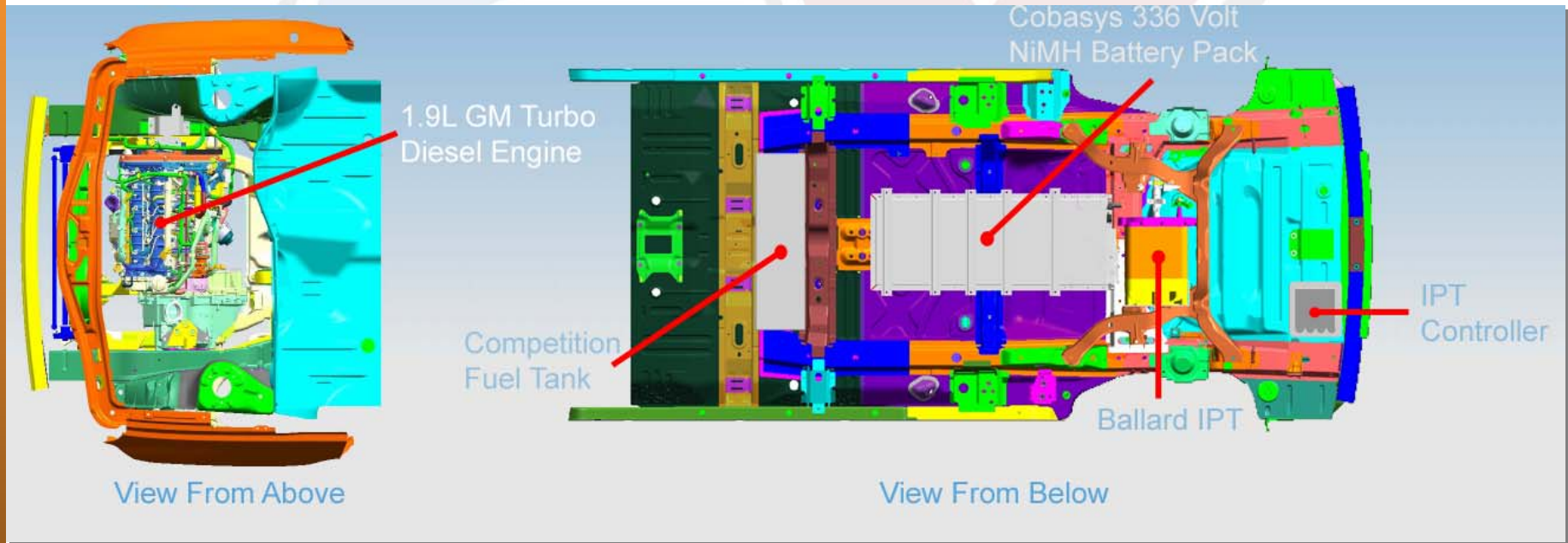
Modes of Operation

❖ Series Regenerative Braking





Component Layout



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COBASYS



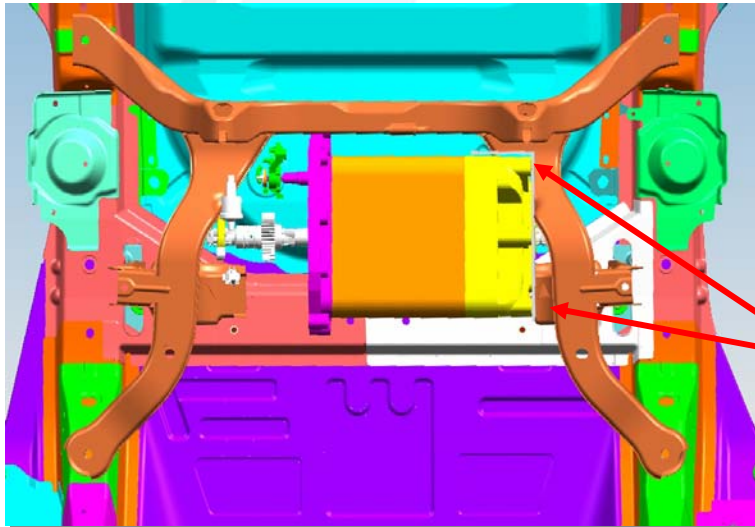
Packaging Continued

Trouble Areas for THRU-the-Road

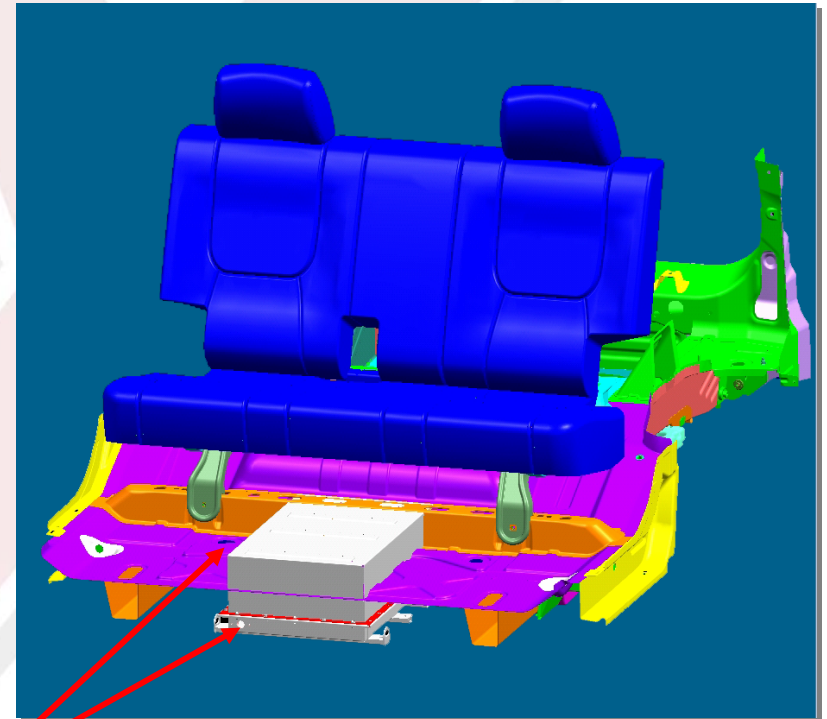
Battery Pack Compartment
Modification

IPT interference with sub-frame

Rear Sub frame



Rear Seat and Floor



Component
to Frame
Interfaces



New Specs



Design Goals

- Increase fuel economy
- Maintain performance and utility
- Reduce emissions
- Noise considerations

Description	Goals	UT Hybrid	Stock Vehicle
0-60 MPH	≤9.5 sec	23.59	10.94
50-70 MPH	≤7.3 sec	23.21	7.49
Vehicle Mass	≤4200 lbs	4312	3791
MPG Combined EPA	≥32.0 mpg	20.39*	15.27*
Highway Range	≥200 mi		
Passenger Capacity	5	5	5
Trailing Capacity	2500 lbs	2500	2500
Cargo Capacity	60 Cu. Ft.	60	60
Starting Time	<5.0 sec	7-8 sec	1.5 sec
Noise Emission	<75 dbA		