

University of Tennessee

Cross-Over to Sustainability



Challenge X at the University of Tennessee

- ❖ Components
- ❖ Modes of Operation
- ❖ Vehicle Design & Packaging
- ❖ Engineering Challenges
- ❖ Changes for the Future

Integrated Vehicle Design

Thru-The-Road Hybrid

Internal Combustion
Engine Powered
Front Wheels



GM

Electrically Powered
Rear wheels

Thru-the-Road
Configuration provides
System Redundancy
by Segregating the
High Voltage System
for the IC engine
components

Integrated Vehicle design - components

- ❖ 1.9 Liter High Pressure Common Rail GM Turbo Diesel Engine Running on Bio-diesel (B20)
- ❖ 67 kW Ballard IPT
- ❖ 336 Volt NiMH Cobasys Battery Pack
- ❖ National Instruments Compact Rio



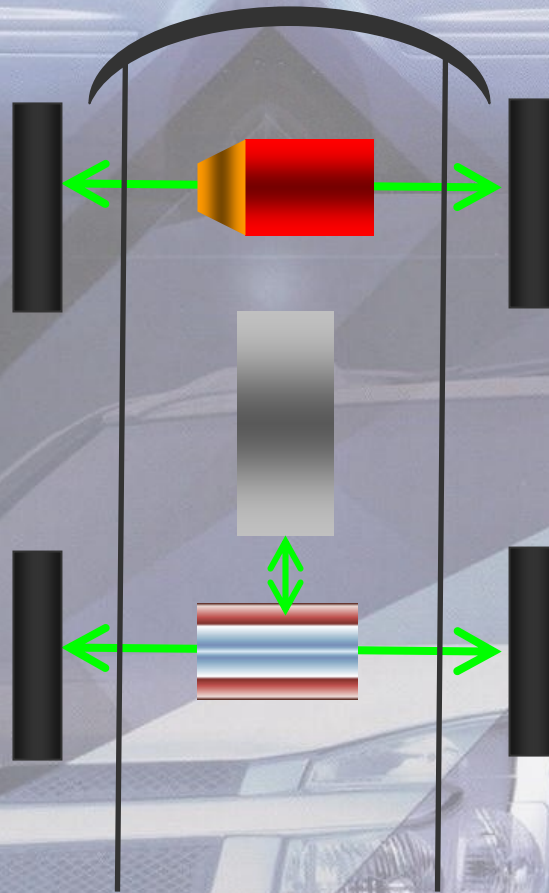
GM



Integrated Vehicle design : Modes of Operation

❖ Full Hybrid mode

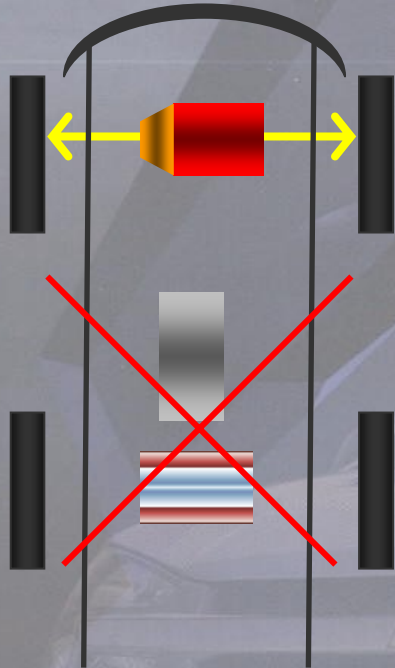
Both CI engine and IPT provide the traction power for the vehicle



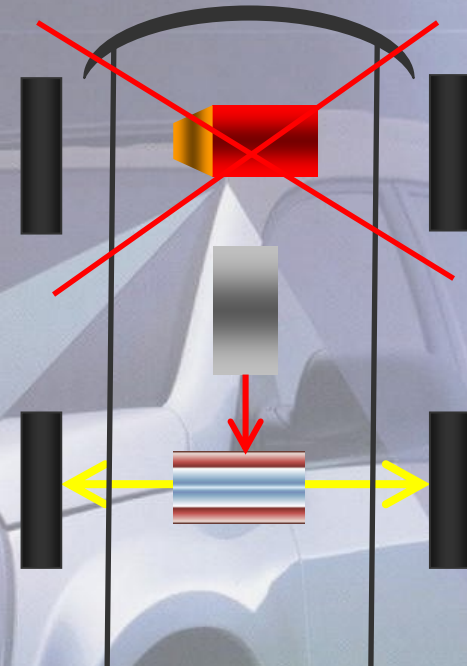
Battery Charging Occurs at Vehicle Cruising speeds when the CI engine can provide excess power to do so.

Integrated Vehicle design : Modes of Operation

❖ Limp-Home Mode

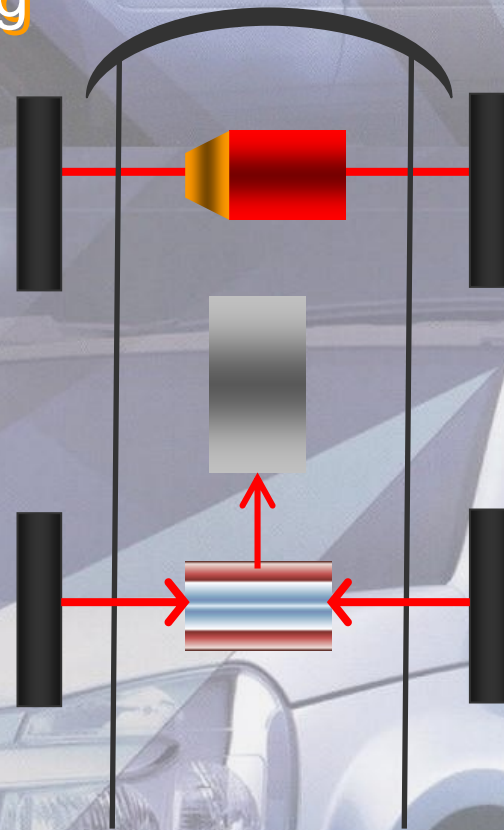


System redundancy & segregation provides the ability for limited vehicle operation should either the CI engine or the High-voltage systems fail



Integrated Vehicle design : Modes of Operation

❖ Series Regenerative Braking



Vehicle Design vs. Construction

■ 1.9L Engine

- ❑ Original design included 1.3 HF engine (100 hp)
- ❑ High Feature engine not available
- ❑ Design revised to include 1.9 engine (150 hp)

■ Energy Storage System

- ❑ Original design included 288V NiMH pack
- ❑ Vendor component substitution
- ❑ Design revised to include 336V NiMH pack

■ Exhaust System

- ❑ Original design included NO_x adsorber
- ❑ Resource constraints shifted implementation to Year 3

Vehicle Technical Specifications

VTS Motivation

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

Description	Test Year	Modeling/Inspection/Testing	VTS (Team Selected)
IVM-60 MPH	1,2,3	M,T	≤9.5 sec
50-70 MPH	1,2,3	M,T	≤7.3 sec
Vehicle Mass	1,2,3	M,T	≤4200 lbs
MPG Combined EPA	1,2,3	M,T	≥32.0 mpg
Highway Range	1,2,3	M,T	≥200 mi
Passenger Capacity	1,2,3	M,T	5 passengers
Emissions Cert Level	2,3	T	Tier 2, Bin 5
Trailing Capacity	2,3	M,T	2500 lbs
Cargo Capacity	2,3	I	60 Cu. Ft. behind front seat
Starting Time	1,2,3	T	<5.0 sec
Noise Emission	1,2,3	T	<75 dbA

Performance Projections

- Fuel Economy (PSAT simulated)
 - Stock - 13.6 mpg
 - Tennessee Hybrid - 17.3 mpg
- How does the vehicle design aid in this effort
 - High efficiency Diesel engine
 - Efficient electric motor
- Well-to-Wheel considerations and trade-offs
 - Bio-fuel
 - B20 is superior to E85 due to Diesel engine's efficiency compared to spark ignition

Powertrain Integration Lessons Learned

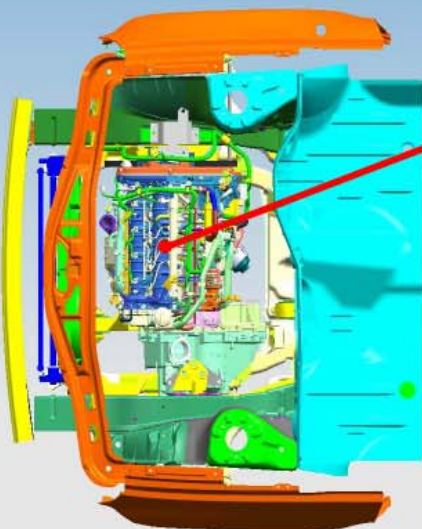
- Simple is *RELIABLE*
- CAN is much better than analog



Engineering Challenges

- Maximizing packaging efficiency
 - ▣ ESS location selected for minimum impact on passenger and cargo compartments
 - ▣ Integrated powertrain incorporated into stock rear subframe
 - ▣ Five passenger capability with full cargo capability
- BFI vehicle integrity preservation
 - ▣ Unmodified rear crush-zone per rules
 - ▣ Modified cross members reinforced structurally
- Sub-system module interfacing and communication
 - ▣ Resource networking
 - ▣ Perseverance
- Schedule impact of component substitutions
 - ▣ Work harder to recover

Packaging Evaluation and Component Layout



1.9L GM Turbo Diesel Engine

View From Above



Cobasys 336 Volt NiMH Battery Pack

Competition Fuel Tank

IPT Controller

Ballard IPT

View From Below

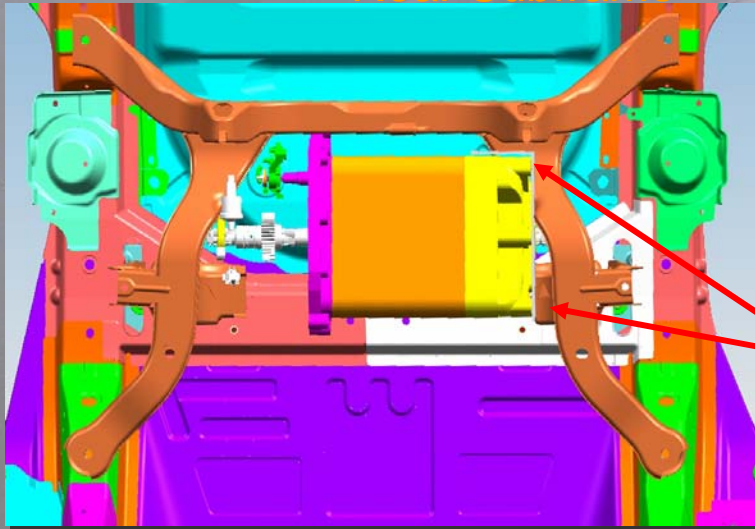
Packaging Continued

Trouble Areas for THRU-the-Road

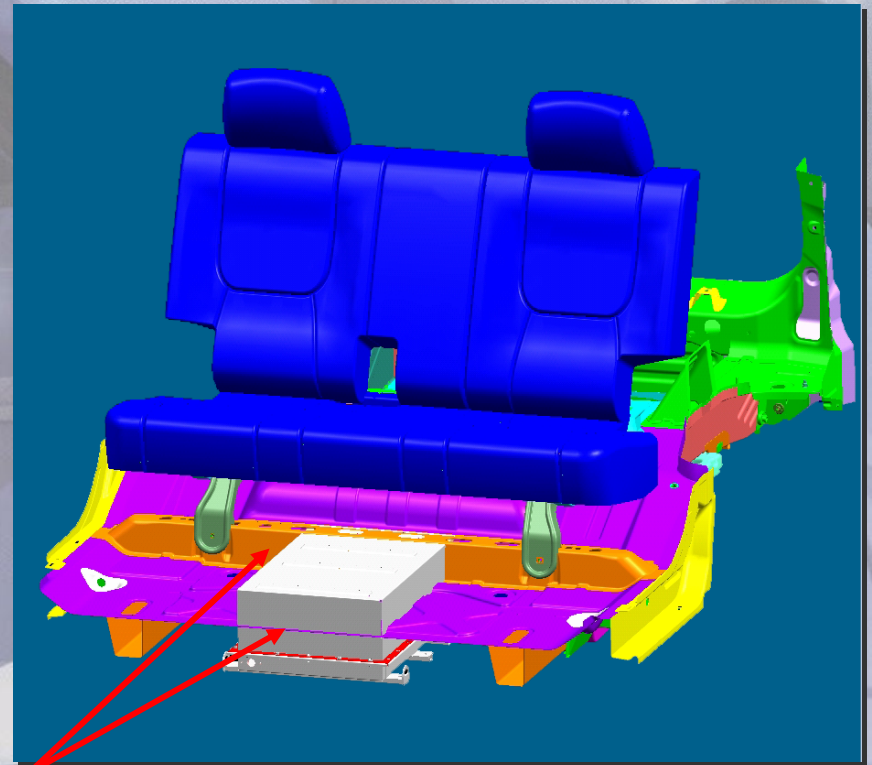
Battery Pack Compartment
Modification

IPT interference with sub-frame

•Rear Subframe



Rear Seat & Floor



Component
to Frame
Interference

Changes for the Future

- Improve emissions control
- High voltage cooling heat exchanger
- Resolve high voltage issues
- Cool paint job

Unique Program Aspects

- Emissions Control Strategies Research
- Rapid Prototyping Environment through the Advanced Powertrain Controls, and System Integration Automotive Lab
- Senior Capstone Design Project
- DOE GATE Center of Excellence

Questions?

