# ECOCAR 3 – YEAR 3

Year Three Overview

Year three of the EcoCAR 3 competition focuses on the application of the vehicle development process (VDP). The Embry-Riddle ESS, in order to place well at springs competition, must achieve the following.

- Complete refined integration of all vehicle components
- Pass safety and tech inspections and On-Road Safety Evaluation at competition.
- Demonstrate that the vehicle can run as intended.
- Participate in all competition dynamic events.

Embry-Riddle Camaro: Parallel-Series Architecture
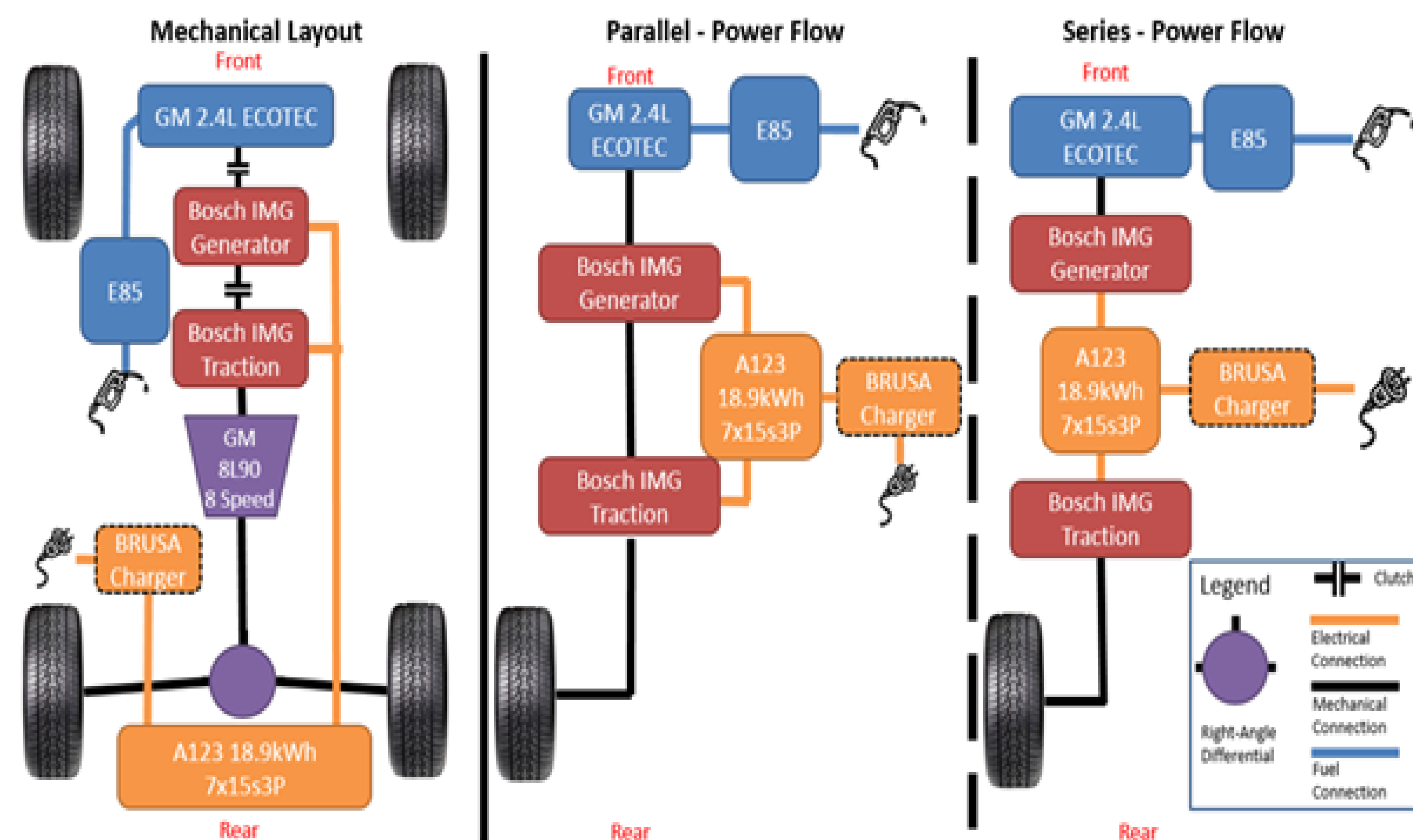
The Camaro EcoSuper Sport is a P2-P2 parallel-series PHEV architecture. The parallel series architecture is unique because it allows for the vehicle to have several modes with the clutches. Including parallel, series, and hyper regenerative braking. This system is a difficult system to control. The clutches need to engage and disengage at proper operating points, while the system synchronizes speeds.

Several unique features and aspects of the vehicle include

- The efficiency of 57 MPGGE and performance of 4.9s IVM-60MPH
- The EcoSuper Sport (ESS) branding and 2 distinct packages
- 7 distinct modes of operation with different power flow strategies

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Abstract

Embry-Riddle Aeronautical University has been accepted into EcoCAR 3 Advanced Vehicle Technical Competition (AVTC). The program is a 4 year program headline sponsored by General Motors and Department of Energy, and managed by Argonne National Lab. This is ERAU's third AVTC competition with previous platforms being a Saturn Vue and Chevrolet Malibu. The new vehicle platform is a Chevrolet Camaro. Sixteen teams internationally compete to create a vehicle that reduces well to wheel emissions, increase fuel efficiency, and maintain consumer acceptability.

## EcoCAR 3 Vehicle Technical Specifications (VTS)

The VTS are a set of design requirements the team needs to meet in order to complete in this spring's competition. The ERAU specific VTS targets were re-evaluated for the fall 2016 Swimlane report. The ESS Camaro is intended to be slotted between the RS and SS versions of the Camaro. This is the last time ERAU's VTS targets could be changed in the four year competition

Specification	Targets	Req's	ERAU
Acceleration, IVM–60 mph (s)	5.9	7.9	4.9
Acceleration, 50–70 mph (Passing) (s)	7.3	9.9	4.2
Braking, 60–0 mph (ft.)	128	135	119
Acceleration Events Torque Split (Front/Rear) (%)	RWD	49%/51%	RWD
Lateral Acceleration, 300 ft. Skid Pad (g)	0.85	0.8	0.95
Double Lane Change (mph)	55	52	59
Highway Gradeability, @ 20 min, 60 mph (%)	6%	6	6%
Cargo Capacity (ft^3)	N/A	2.4	4.0
Passenger Capacity	4	2	4
Curb Mass (kg)	N/A	1938 kg	1899
Starting Time (s)	2	15	5
Total Vehicle Range* (mi)	N/A	150	195
CD Mode Range* (mi)	N/A	N/A	40
CD Mode Total Energy Consumption* (Wh/km)	N/A	N/A	220
CS Mode Fuel Consumption* (Wh/km)	N/A	N/A	568
UF-Weighted Fuel Energy Consumption* (Wh/km)	N/A	N/A	218
UF-Weighted AC Electric Energy Consumption* (Wh/km)	N/A	N/A	151
UF-Weighted Total Energy Consumption* (Wh/km)	700	840	369
(mpgge)	30	25	57
UF-Weighted WTW Petroleum Energy Use* (Wh PE/km)	420	750	65
UF-Weighted WTW Greenhouse Gas Emissions* (g GHG/km)	225	250	127
UF-Weighted WTW Criteria Emissions* (g/km)	N/A	N/A	Tier 2 Bin 4/5

New in Year Three

Phase Change Material

The team is working with phase change material that will promote faster cooling of the energy storage system (ESS) battery pack. The ESS is an 18.9 kWh and 340V A123 lithium ion energy storage system and when charging from regenerative breaking can reach high temperatures very close to limiting operating conditions. The PCM being researched, is combined with high density polyethylene (HDPE) into a composite matrix that can be formed and will retain its shape even when heat is introduced to the system. The PCM can absorb large amounts of heat energy while it changes phases and the HDPE acts as a shape stabilizing matrix, preventing the liquid PCM from leaking out of the compartment beneath the battery.
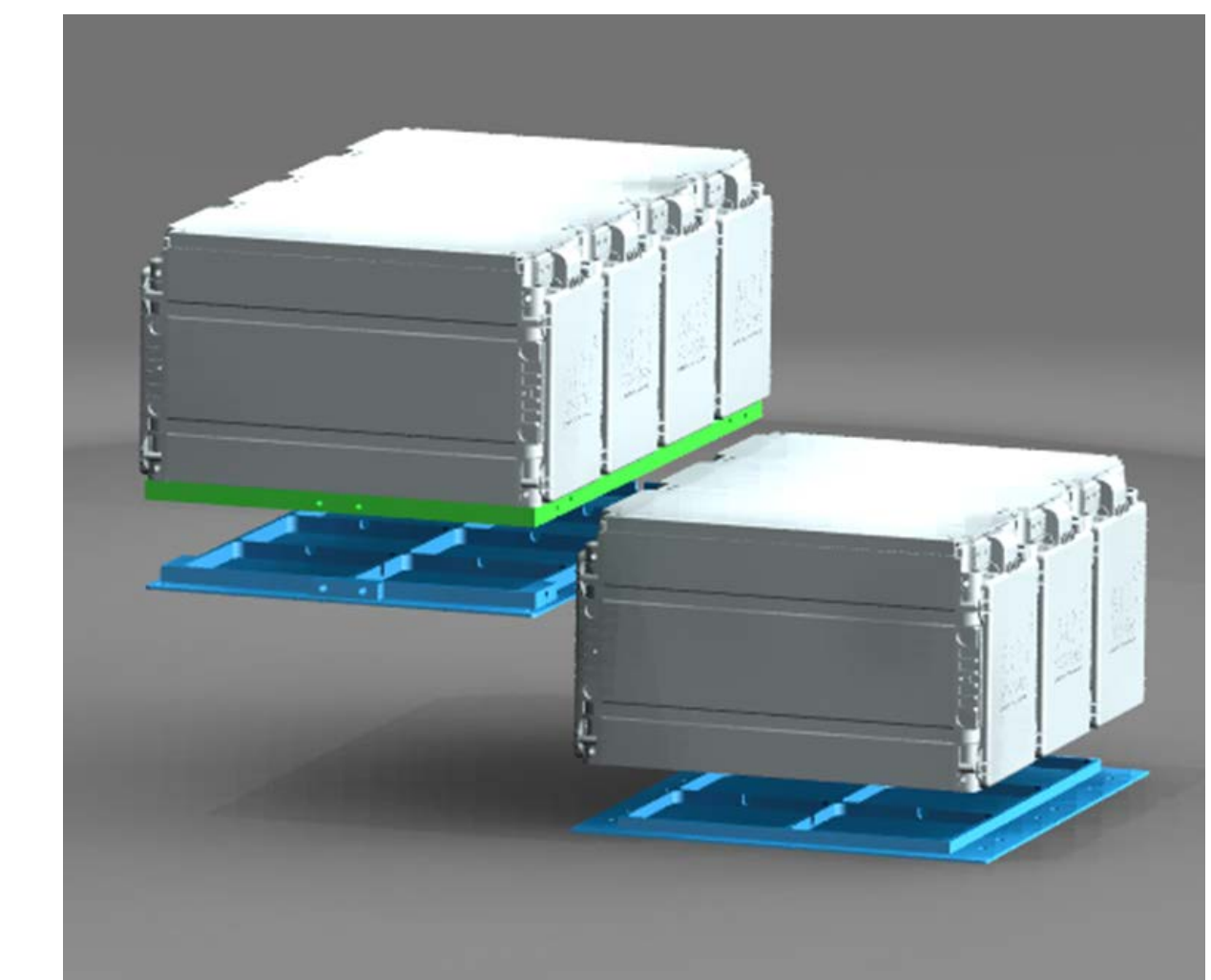
Data Acquisition Module

In order to meet VTS targets the team must insure integrated components in year three can operate optimally. The EcoCAR 3 team replaced the EcoCAR CAN Management System (ECMS) with a general control module (GCM). This unit is used to control the Camaro's radiator fans and the electric motor water pump. The module functionality has also been expanded to gather data from the water pressure and oil sensors to send back through the car's CAN network.

The unit selected was the GCM196 an automotive grade control module for general purpose use. The module was created by New Eagle, a competition sponsor. The module is programmable using customizable blocks created for MATLAB and Simulink. The system has 45 inputs, 45 outputs, and 3 channels for CAN communication.

GCM196
General Purpose Automotive Grade Control Module
P/N: GCM-1793-196-1503