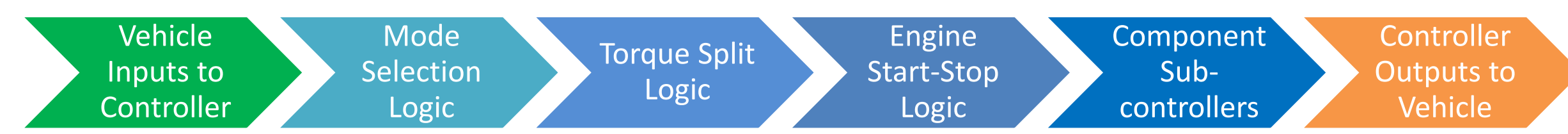


# EcoCAR 3 Active Management Assistance System

### VEHICLE CONTROL SYSTEM DESIGN

#### CONTROL LOGIC FLOW DIAGRAM



The supervisory control unit (SCU) utilizes the above logic flow for allowing torque to be applied by the vehicle powertrain.

#### MODE SELECTION

In year 2 of EcoCAR 3, four primary modes of operation are being utilized. These modes are dual electric motor charge deplete, parallel charge sustain, sport mode, and crawl which is the critical fault mitigation state. The desired mode is selected based on the ESS state of charge, fuel level, mode request buttons, and system faults. Using this information, the desired operational mode is defined.

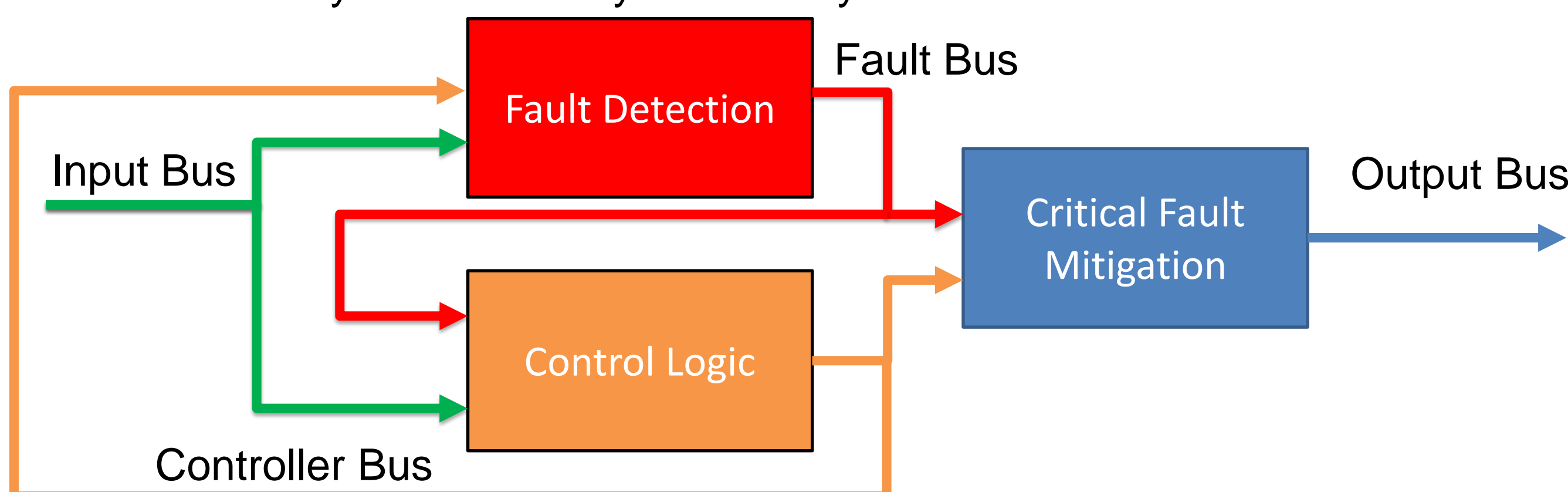
#### TORQUE SPLIT LOGIC

To accomplish proper torque distribution to powertrain components, the team developed a Real-time Energy and Emission Minimization controller (ReTEEM). This controller works by looking at the current status of the vehicle, including speed and transmission gear, and blends powers between the E85 engine and the pair of Bosch electric machines (IMG). In testing, this controller was combined with three different shifting matrices, a predefined speed based shift map (SS), an adaptive transmission optimization logic controller (SL) and a shift map designed to minimize time held in lower gears. The results shown below illustrate the energy efficiency effects for each pairing over the stock vehicle powertrain controller.

Controller Analysis	Basic Controller	ReTEEM-SS	ReTEEM-SS (zero throttle)	ReTEEM-SL
Energy Consumption [Wh/km]	520.1	541.4	488.7	497.7
Delta SOC [%]	0.09	-0.06	-0.20	-0.06
$EC_{\Delta SOC}$ [Wh/km]	-0.9	0.6	1.9	0.6
$EC_{final}$ [Wh/km]	519.1	542.1	490.7	498.3

#### FAULT DETECTION AND MITIGATION

All faults are detected independent of the subsystem controllers, this is to prevent any controller interference in fault detection. Once a fault is detected it is assigned a classification based on a four tier fault identification system that groups faults by severity. Once detected, the controller processes the faults in two separate ways. All non-critical faults are mitigated in individual controller sub-systems while all tier 1 faults are mitigated in the mode selection by switching to crawl mode, and between the control logic and system outputs as shown in the below figure. This is to maximize the controllers ability to maintain system safety.



**Matthew Nelson**  
Primary Investigator  
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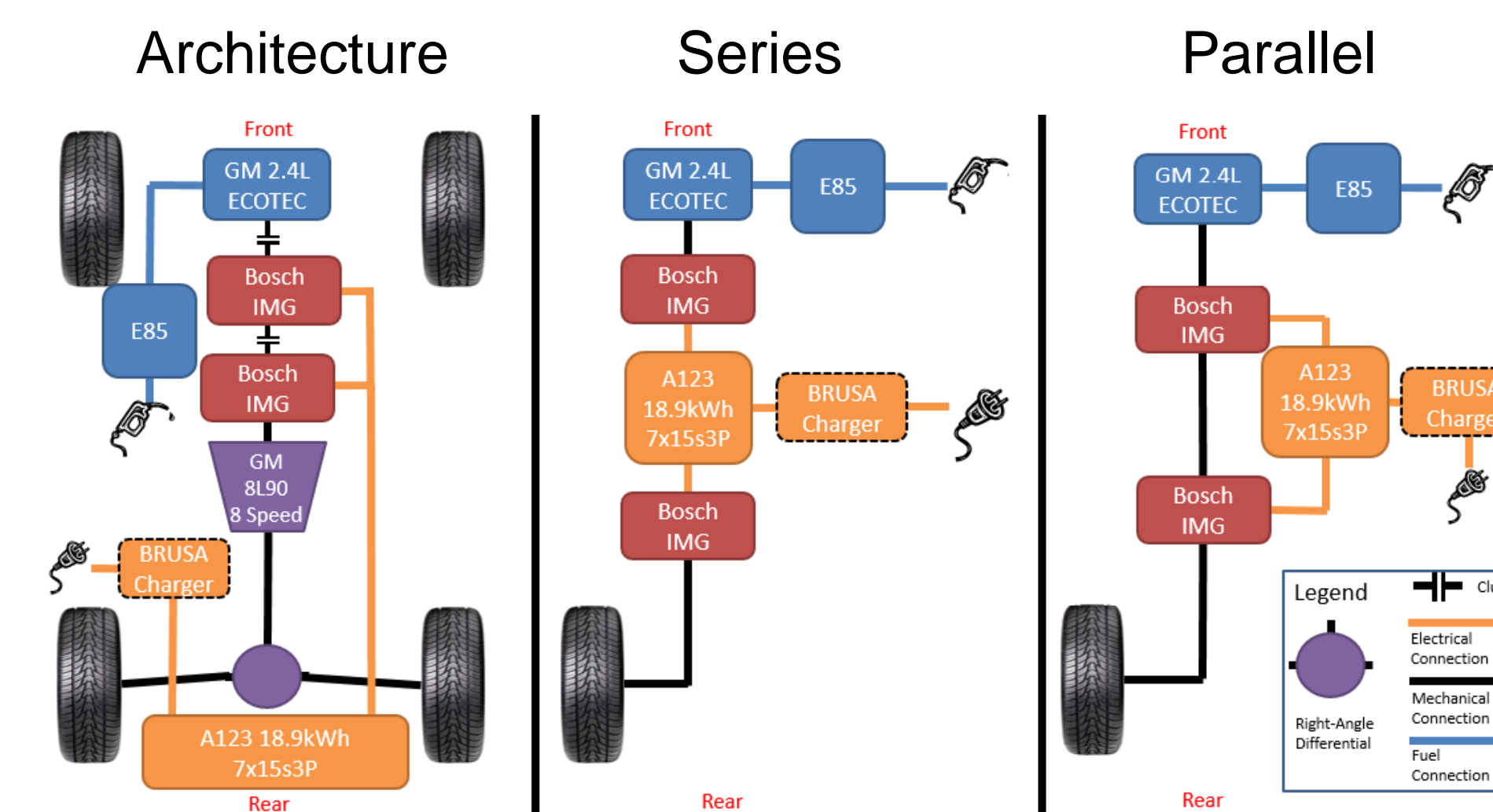
**Blair Cutting**  
*EcoEagles Controls Team Member*

#### ABSTRACT

The Embry-Riddle EcoCAR 3 team is developing a prototype hybrid Chevrolet Camaro utilizing a customized vehicle powertrain controller. This controller is serving to ensure system safety, vehicle operation, and consumer drivability while also incorporating advanced driving aids to achieve both the desired performance levels one expects from a Camaro as well as vehicle efficiency. This vehicle must reach the team set vehicle technical specifications of a 4.9 second 0 to 60 time while maintaining a 53 miles per gallon gasoline equivalence rating.

In order to reach the efficiency goal, the team is developing an Active Management Assistance System utilizing computer vision tools to analyze traffic and road conditions to actively change the vehicle through its seven operational states to achieve the highest levels of energy savings. Currently, this project is in the initial testing phase where baseline functionality of the hybrid powertrain controller is being tested in a hardware-in-the-loop simulation environment to ensure operational safety as well as doing vehicle platform integration of systems. At the end of the spring 2016 term, the hybrid Camaro will be road worthy, and the vision systems will have completed basic functionality testing and be ready for system integration. At the end of the 2017 academic year, the system will be integrated into the vehicle platform and by the end of the 2018 academic year, the system will be fully integrated into the completed hybrid vehicle controller.

#### SERIES-PARALLEL PHEV



Specification	Camaro ESS	2016 Porsche 918 Spyder	2014 Cadillac ELR Coupe
Total Power	370 hp at 2500 rpm	887 hp at 8700 rpm	217 hp
Power-to-Weight Ratio	11.1 lb/hp	4.2 lb/hp	18.5 lb/hp
Engine Displacement	2.4L	4.6L	1.4L
0-60mph time	4.9s	2.2s	8.1s
ESS Capacity	18.9kWh	6.8kWh	16.5 kWh
EV Range	36 miles	18 miles	35 miles
Weighted Fuel Consumption	53mpgge	67mpgge	82mpgge

### VISION PROCESSING SYSTEM DEVELOPMENT



The vision processing system that will be implemented into the 2016 Camaro ESS is currently being produced in a parallel track to vehicle development. This independent path is to ensure that both systems will be functional at the time of integration in year 4 of the EcoCAR 3 competition.

Using the Matlab vision processing toolbox, the team is implementing object detection, object identification algorithms, along with distance estimation functions. These systems are being applied to our real time processing system, the S32V board, which has been provided by NXP Semiconductors.



#### PROJECT DEVELOPMENT TIMELINE

