Software Requirements Specification for Mechatronics: **Formula Electric Vehicle Control System**

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April 7, 2023

Revision History

Date	Version	Notes
Oct 5th, 2022	1.0	Initial Revision
April 5, 2023	2.0	Final Revision: revamped modules, updated requirements, added TA feedback

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1 Project Drivers

1.1 The Purpose of the Project

The purpose of this project will be to design, implement, and test a vehicle control system for McMaster Formula Electric's quarter-scale Formula 1 style electric vehicle. The primary objective of the control system is to send motor commands over CAN to the motor kit (dual-motor & inverter kit supplied by AMK) based on the driver's input and other vehicle state parameters.

Currently, the McMaster Formula Electric team is in the process of preparing their vehicle for the FSAE competition taking place in Michigan during Summer 2023. Some of the vehicle's electronic components have been fabricated, but much of the chassis, mechanical systems and wiring require fabrication and assembly. During the 2020 Fall - 2021 Winter term of the school year, the team went through a full redesign of the electrical and embedded system architecture. The new architecture included a switch from Atmel to STM32F7 microprocessors, enabling the team to develop, test, and integrate in-house vehicle software for their ECUs. This change allows us to implement our own custom vehicle controls software.

1.2 Scope

The control system will be responsible for managing the following vehicle subsystems: vehicle mode selection ("Governor"), tractive motor interface, driver interface, vehicle dynamics, and battery monitoring. See Section 3 for an overview of the environment variables the system monitors and controls.

1.3 Typical Operations Overview

As the user of our system, the McMaster Formula Electric team is able to deploy our control system to their current hardware testing (bench-testing) setups, enabling them to test basic functionality such as throttle pedal input and spinning the motors via speed & torque commands. Members of the team will be able to implement, simulate, and deploy changes to the control system, as new hardware is brought up and requires testing. Once the vehicle is assembled, the control system allows the vehicle to propel itself, and system parameters (eg. pedal mapping, filtering coefficients) can be tweaked through drive testing.

1.4 Users, Clients and Stakeholders of the System

As mentioned above, the sole stakeholder of our system is the McMaster Formula Electric team, who serves to gain or lose from the success of this system in their competition. Users comprise individuals on the embedded software & vehicle controls sub-team, who are be responsible for modifying and integrating the control system once the vehicle is completed.

2 Project Constraints

2.1 Mandated Constraints

The following constraints must be adhered to during the design of the system:

MD1	Total expenses mustn't exceed $750.
Rationale	The project must stay within the budget given by the CAS department.

MD2	Project must be completed before the end of the academic year.
Rationale	Deadline is a project-requirement set by the CAS department.

MD3	The control system must adhere to the 2022 Formula SAE Rules.
Rationale	Rules must be followed to ensure vehicle is eligible for competition.

2.2 Naming Conventions and Definitions

Abbreviations & Acronyms used throughout project documentation:

MFE	Mac Formula Electric
ECU	Electronic Control Unit
BMS	Battery Management System
CAN	Controller Area Network
EV	Electric Vehicle
SAE	Society of Automotive Engineers
PCB	Printed Circuit Board
SoC	State of Charge
TMS	Thermal Monitoring System
AMK	Arnold Müller Kirchheim GmbH; supplier of the vehicle's motor, inverter, controller kit
APPS	Accelerator Pedal Position Sensor
AMS	Accumulator Management System - FSAE lingo, alias for BMS
IMD	Insulation Monitoring Device, installed in the Tractive system.
BSPD	Brake System Plausibility Device, nonprogrammable circuit to check for simultaneous braking and high power output.
PWM	Pulse Width Modulation
G/Gov	Governor module
BM	Battery Monitor module
MI	Motor Interface module
VD	Vehicle Dynamics module

2.3 Relevant Facts and Assumptions

The following are facts relevant to the project:

RF1	The Motors we will be interfacing with, are AMK's "Formula Student Electric" 2 Wheel Drive Racing Kit.
Rationale	This kit contains the necessary motors and motor drivers required to propel the vehicle. Our control system will be interfacing with these through the use of contactors for enable/disable, as well as communication with the motor drivers to send torque requests.

RF2	For battery management, we will be interfacing with an Orion BMS system.
Rationale	This kit has built in functions for things like current & voltage protection, thermal management, cell balancing, and cell health monitoring. The system even has the capability to output digital and analog signals, to control chargers, motor controllers, and other external devices. For our use case, we will be controlling the BMS based on feedback given back to us for things like cell temperature to control our fan curve.

3 Context Diagrams

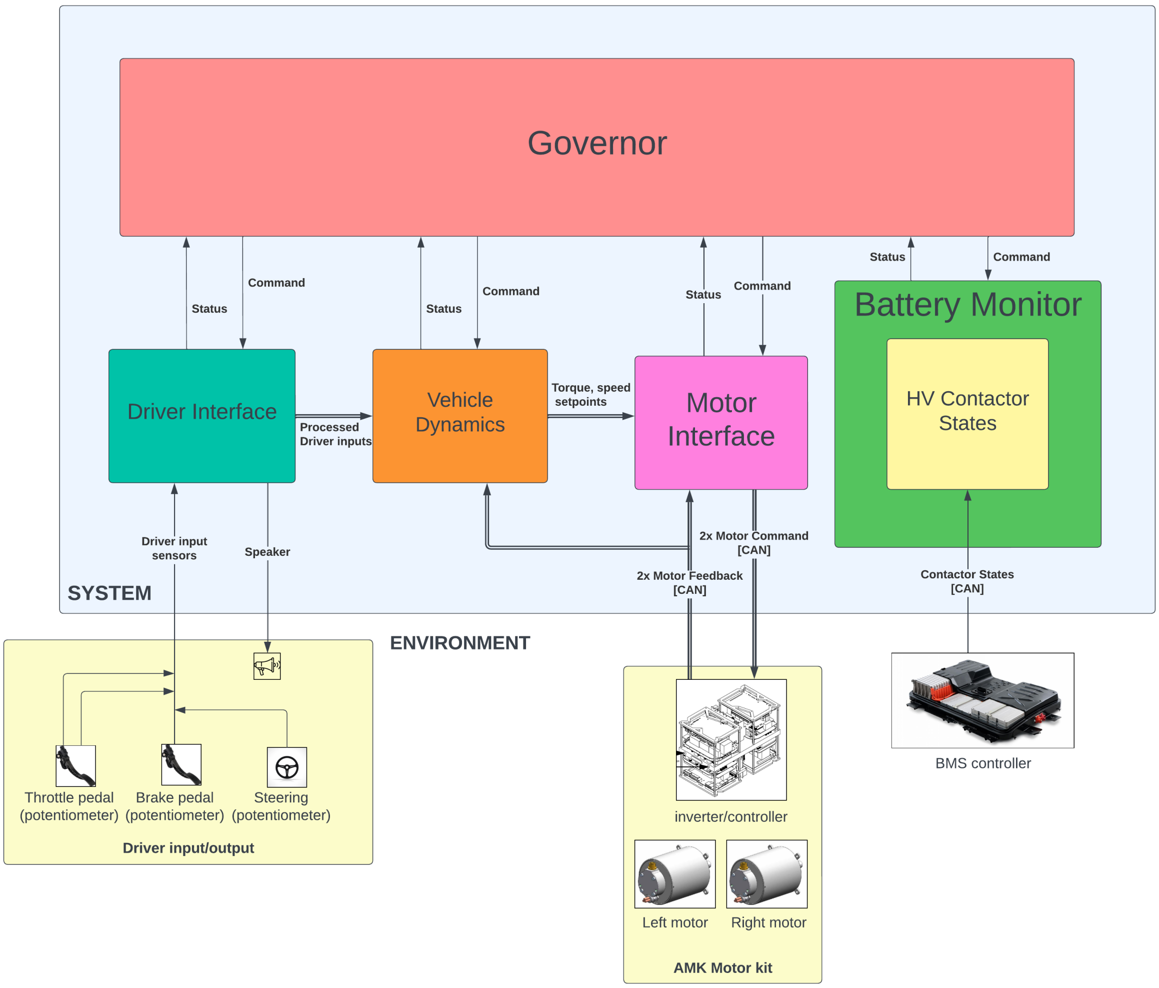

Figure 1: Control System and Environment

Our control system's target hardware is the Front Controller (STM32F7), shown in Figure 2.

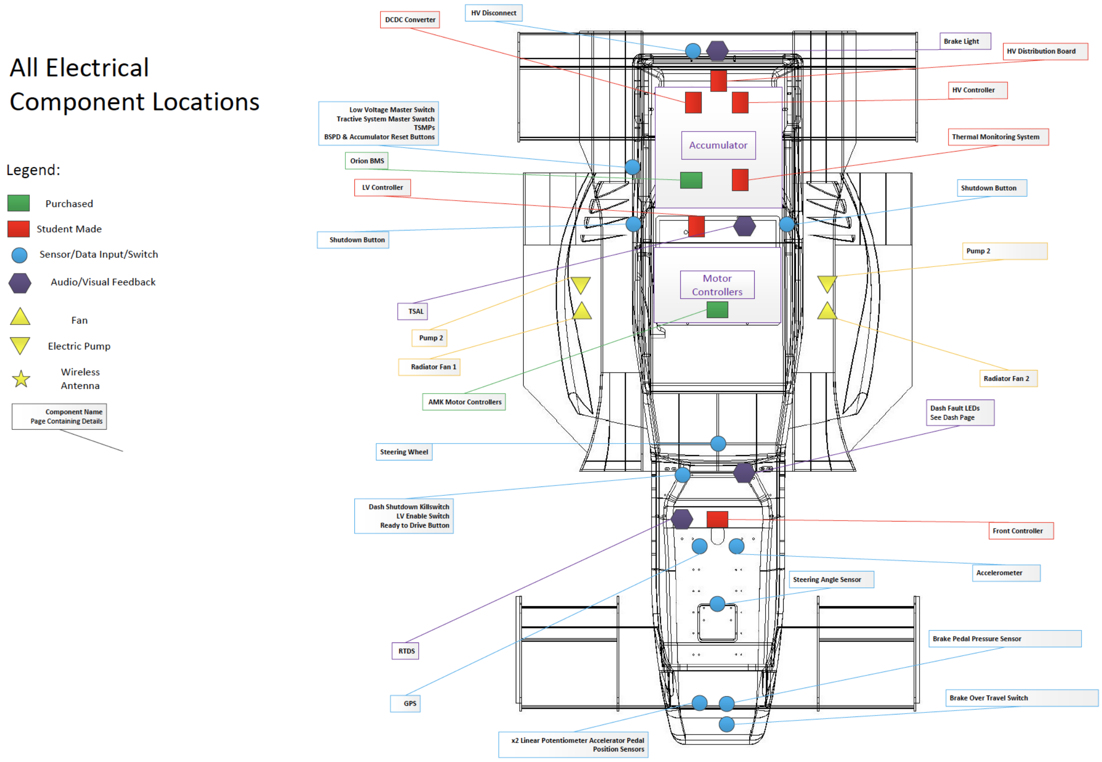

Figure 2: Electrical Component Context Diagram

4 Monitor and Control Variables

4.1 Monitored Variables

Referring to Figure 1, **Monitor variables** comprise signals entering the system from the environment. **Control variables** comprise signals leaving the system to the environment.

Driver Input	APPS1, APPS2, BPPS, Steering angle, driver button.
Battery contactor state	HV positive & negative contactors. precharge contactor.
Motor kit CAN feedback	CAN messages AMK Actual Values 1 and AMK Actual Values 2, for each of the 2 motors. See Figures 9. 10. 11

4.2 Controlled Variables

Motor CAN Commands	CAN messages AMK Setpoints 1 for each of the 2 motors. See Figures 12 & 13
Driver speaker	Indicates to the driver when the vehicle is ready to drive, along with other vehicle states.

5 Functional Decomposition Diagrams

The following diagrams show monitor (input) and control (output) variables for each of the control system's subsystems.

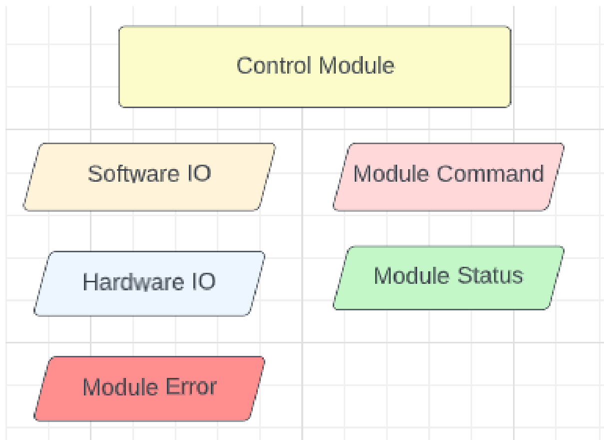

Figure 3: UML Color Coding Legend

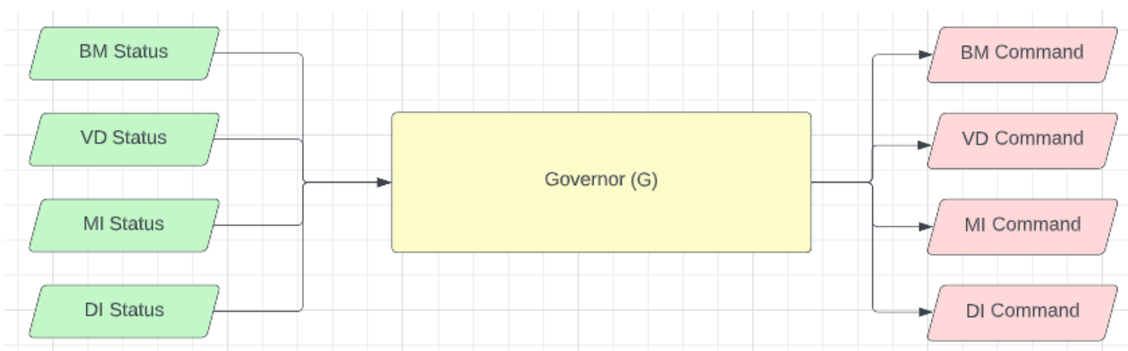

Figure 4: Governor UML

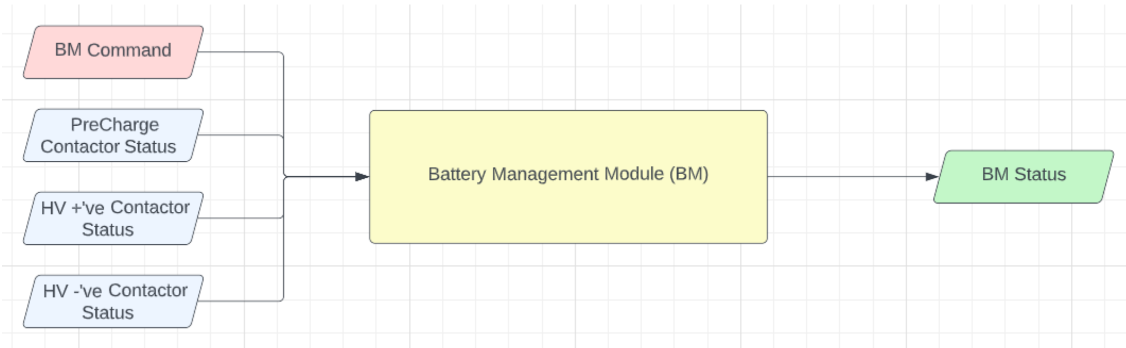

Figure 5: Battery Monitor Module UML

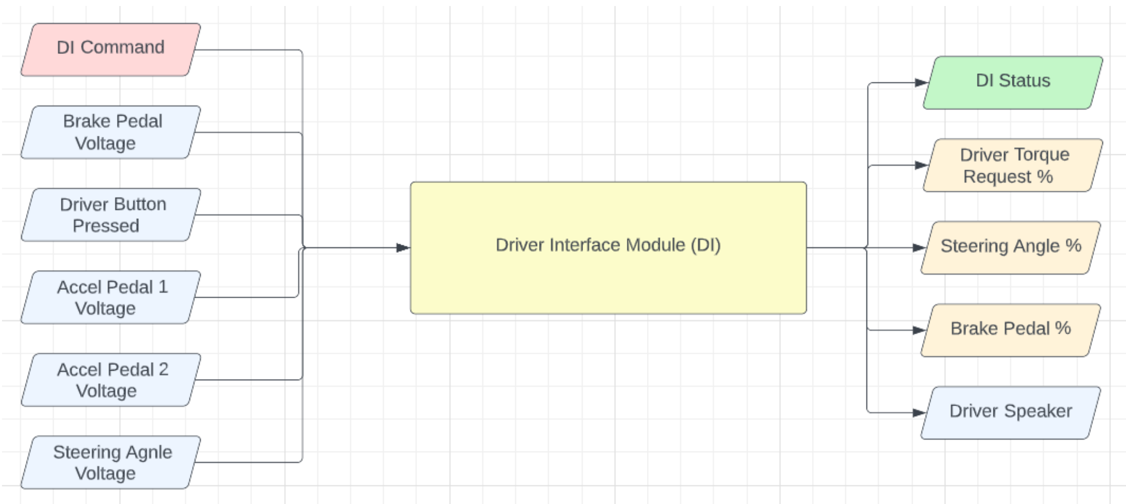

Figure 6: Driver Interface Module UML

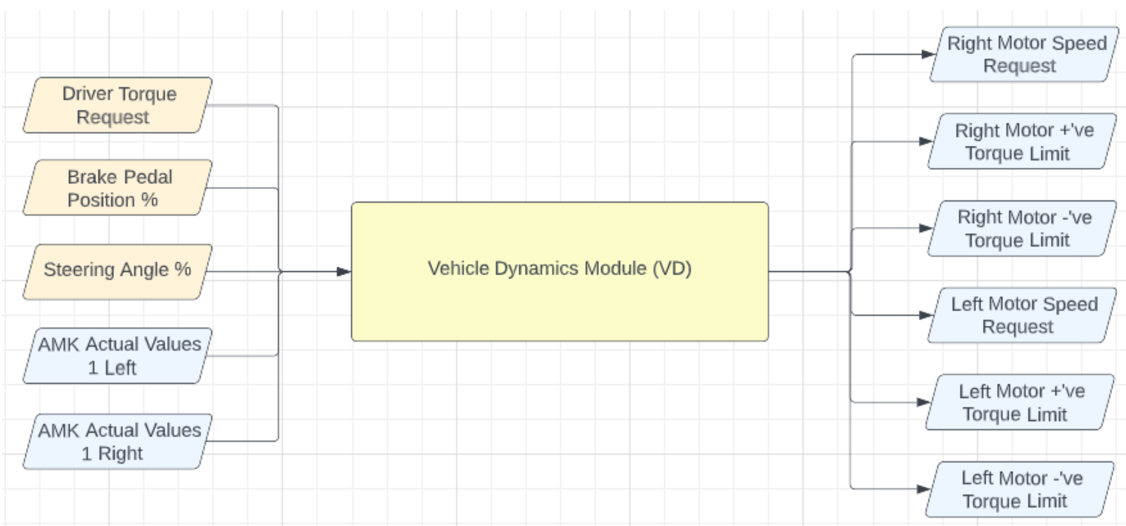

Figure 7: Vehicle Dynamics Module UML

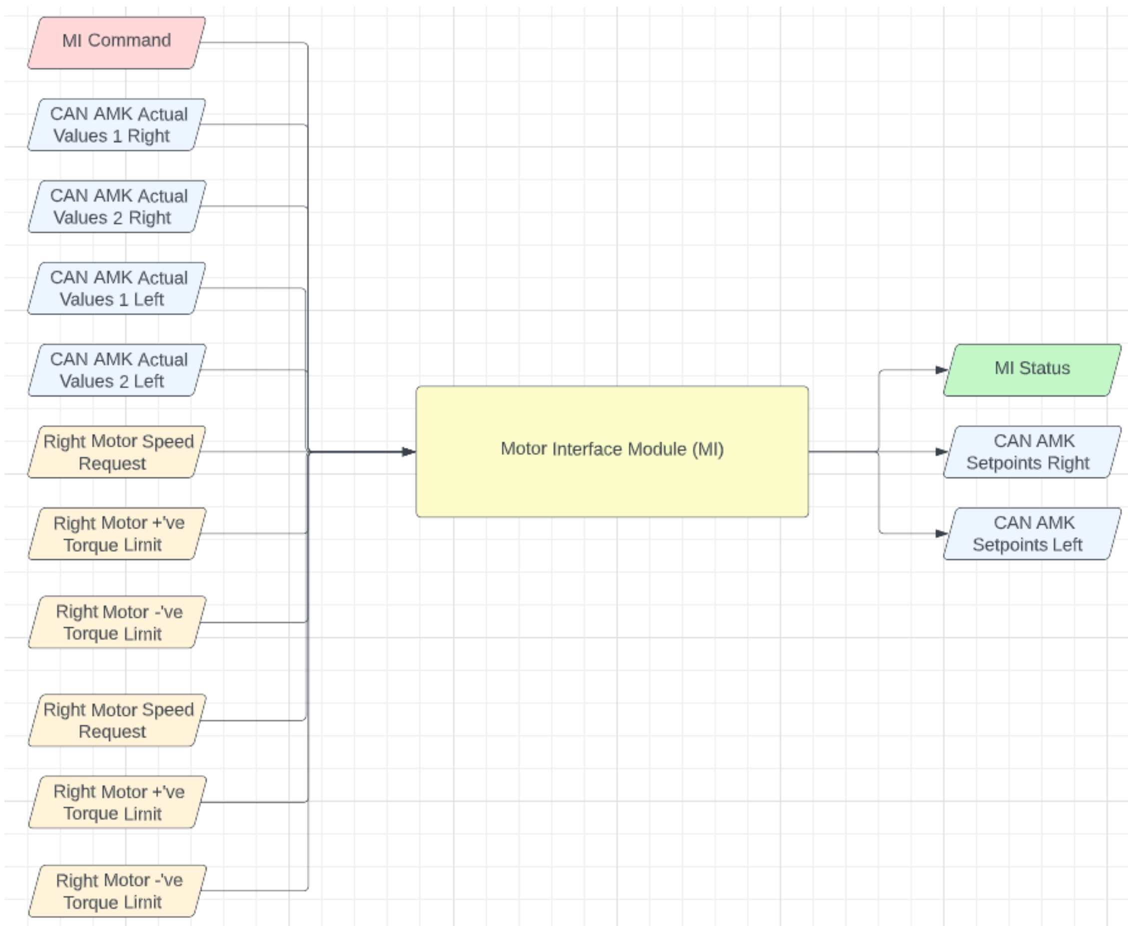

Figure 8: Motor Interface Module UML

6 Functional Requirements

Below are the requirements for each subsystem shown in Sections 3 & 4.

6.1 Governor

G1	Governor shall monitor the following inputs: BM Status, MI Status, VD Status, DI Status
Rationale	Vehicle subsystem states must be known in order to send suitable commands to the rest of the control system.
Likelihood of Change	Unlikely - Would require module architecture change.

G2	Governor shall compute the following output parameters and report them to the control system: BM State command, MI State command, VD State command.
Rationale	Essential command signals to control system's modules.
Likelihood of Change	Unlikely - Would require module architecture change.

G3	Governor shall adhere to Activation Sequence rule FSAE EV.10.4.2 [”Traction System Active”] • Definition – High Voltage is present outside of the Accumulator Container • Tractive System Active must not be possible until both: (1) GLV System is Energized; (2) Shutdown Circuit is Closed
Rationale	Competition rule
Likelihood of Change	Very unlikely - Competition rule

G4	Governor shall adhere to Activation Sequence rule FSAE EV.10.4.3 [”Ready to Drive”] • Definition – the Motor(s) will respond to the input of the APPS • Ready to Drive must not be possible until: (1) Tractive System Active; (2) The brake pedal is pressed and held to engage the mechanical brakes; (3) The driver performs a manual action to initiate Ready to Drive such as pressing a specific button in the cockpit
Rationale	Competition rule
Likelihood of Change	Very unlikely - Competition rule

G5	Governor shall command MI to begin the motor startup sequence once BM reports a ”running” state.
Rationale	The motors should be started only once the batter’s contactors are in the appropriate state.
Likelihood of Change	Very unlikely - Key functionality

G6	Governor shall issue ”Ready to Drive” once BM status is ”running”, MI status is ”running”, and DI status is ”driver start request”
Rationale	Implementation of rule EV10.4.3
Likelihood of Change	Very unlikely - Key functionality

G7	Governor shall report to DI there is a ”system error” when the BM or MI reports an error after ”Ready to Drive” was issued.
Rationale	Driver interface should zero the driver torque request if there is a battery or motor error.
Likelihood of Change	Very unlikely - Key functionality

6.2 Driver Interface

DI1	Driver Interface shall monitor the following sensor inputs from the environment: Brake pedal position, APPS1, APPS2, Driver button, Steering angle
Rationale	Essential driver inputs that will determine the driver’s torque request as well as sensor errors.
Likelihood of Change	Likely - More inputs may be needed as more driver input hardware is brought up.

DI2	Driver Interface shall also monitor the following inputs from the control system: Governor DI command
Rationale	DI will be notified by the control system when there is a vehicle error.
Likelihood of Change	Unlikely - Would require module architecture change.

DI3	Driver Interface shall compute the following output parameters and report them to the control system: Driver interface status, Driver torque request (%), Steering angle (%), Brake pedal position (%)
Rationale	DI is responsible for processing driver inputs and reporting the processed values to the control system
Likelihood of Change	Likely - More inputs may be needed as more driver input hardware is brought up.

DI4	Driver Interface shall compute the following output driver feedback signals and actuate them in the environment: Driver speaker
Rationale	DI is responsible for passing driver feedback to the driver.
Likelihood of Change	Likely - More outputs may be needed as more driver output hardware is brought up.

DI5	Driver Interface shall report a status of ”driver start request” when: Brake pedal position is > 50 %, AND Driver button is ON
Rationale	DI is responsible for converting driver inputs to usable values and reporting these to the control system.
Likelihood of Change	Likely - More outputs may be needed as more driver output hardware is brought up.

DI6	Driver Interface shall monitor each potentiometer signal (all pedals, steering) for out-of-range faults.
Rationale	DI must detect driver sensor faults and report this to the control system.
Likelihood of Change	Likely - More outputs may be needed as more driver output hardware is brought up.

DI7	Driver Interface shall use APPS2 if APPS1 is faulted; and it shall use APPS1 if APPS2 is faulted.
Rationale	Vehicle can still operate with 1 functioning APPS.
Likelihood of Change	Unlikely - Redundancy design

DI8	Driver Interface shall compute percentages (eg. brake pedal position %) corresponding to their potentiometer signals for all sensors (Accelerator pedals 1 & 2, brake pedal, steering)
Rationale	Convert potentiometer signals to usable quantities for the control system.
Likelihood of Change	Unlikely - Redundancy design

DI9	Driver Interface shall report a status of ”error” if any of the following are true: both APPS signals are faulted, BPPS is faulted, steering sensor is faulted.
Rationale	Vehicle can still operate with 1 functioning APPS.
Likelihood of Change	Unlikely - Redundancy design

DI10	Driver Interface shall nullify any driver torque request when the Governor reports a ’system error’
Rationale	Battery or motor errors should zero any torque output.
Likelihood of Change	Unlikely - Key functionality

6.3 Battery Monitor

BM1	Battery Monitor shall monitor the following inputs: PreCharge Contactor Status, HV Positive Contactor Status, HV Negative Contactor Status over CAN from the Orion BMS.
Rationale	These inputs determine the state and control domain of the battery.
Likelihood of Change	Likely - More inputs may be needed as module complexity grows.

BM2	Battery Monitor shall compute and report the following output parameters to the control system: BM Status
Rationale	Battery state reporting to other control system modules.
Likelihood of Change	Likely - More outputs may be needed as module complexity grows.

BM3	Battery Monitor control report "startup", "precharge", "error - precharge" ,"running", "error - running" according to the MFE documented contactor startup sequence.
Rationale	The Battery Monitor must report the functional state of the contactors to the rest of the control system, in order to determine overall vehicle state and running status.
Likelihood of Change	Very unlikely - Key functionality

6.4 Motor Interface

MI1	Motor Interface shall monitor the signals within the following CAN messages from the AMK motor kit for each motor: AMK Actual Values 1, AMK Actual Values 2 (see Figures 9, 10 & 11)
Rationale	The current motor state must be known in order to send startup, shutdown and handle error states of the motors.
Likelihood of Change	Very unlikely - Key functionality

Content of the **'AMK Actual Values 1'** data telegram:

Name	Offset	Length in bits	Value type	Unit	Meaning
AMK_Status	0	16	Unsigned	-	Status word See the table below: Content of the 'AMK_Status' status word
AMK_ActualVelocity	16	16	Signed	rpm	Actual speed value
AMK_TorqueCurrent	32	16	Signed	-	Raw data for calculating 'actual torque current' Iq See 'Units' on page 61.
AMK_MagnetizingCurrent	48	16	Signed	-	Raw data for calculating 'actual magnetizing current' Id See 'Units' on page 1.

Figure 9: AMK Actual Values 1 signals

MI2	Motor Interface shall also monitor the following inputs from the control system: MI State Command, Positive Torque Request, Negative Torque Request, Velocity Request.
Rationale	Key values from the control system that are to be passed through to the motor controller.
Likelihood of Change	Very unlikely - Key functionality

Content of the 'AMK_Status' status word

The system status and the command acknowledgments are displayed via the status word.

Name	Offset	Length in bits	Meaning
AMK_bReserve	0	8	Reserved
AMK_bSystemReady	8	1	System ready (SBM)
AMK_bError	9	1	Error
AMK_bWarn	10	1	Warning
AMK_bQuitDcOn	11	1	HV activation acknowledgment
AMK_bDcOn	12	1	HV activation level
AMK_bQuitInverterOn	13	1	Controller enable acknowledgment
AMK_bInverterOn	14	1	Controller enable level
AMK_bDerating	15	1	Derating (torque limitation active)

Figure 10: Data bits within AMK_Status

Content of the **'AMK Actual Values 2'** data telegram:

Name	Offset	Length in bits	Value type	Unit	Meaning
AMK_TempMotor	0	16	Signed	0.1 °C	Motor temperature
AMK_TempInverter	16	16	Signed	0.1 °C	Cold plate temperature
AMK_ErrorInfo	32	16	Unsigned	-	Diagnostic number
AMK_TempIGBT	48	16	Signed	0.1 °C	IGBT temperature

Figure 11: AMK Actual Values 2 signals

MI3	Motor Interface shall (for each motor) compute signals for the following motor command CAN messages, send them on the same CAN bus as the motors: AMK Setpoints 1 (see Figures 12 & 13)”
Rationale	Essential command signals to startup, shutdown, and operate the motor.
Likelihood of Change	Likely - More outputs may be needed as module complexity grows.

Content of the **'AMK Setpoints 1'** data telegram:

Name	Offset	Length in bits	Value type	Unit	Meaning
AMK_Control	0	16	Unsigned	-	Control word See the table below: Content of the 'AMK_Control' control word
AMK_TargetVelocity	16	16	Signed	rpm	Speed setpoint
AMK_TorqueLimitPositiv	32	16	Signed	0.1% M_N	Positive torque limit (subject to nominal torque)
AMK_TorqueLimitNegativ	48	16	Signed	0.1% M_N	Negative torque limit (subject to nominal torque)

Figure 12: AMK Setpoints 1 signals

Content of the 'AMK_Control' control word

The control word can be used to trigger the following commands in the inverter:

Name	Offset	Length in bits	Meaning
AMK_bReserve	0	8	Reserved
AMK_bInverterOn	8	1	Controller enable
AMK_bDcOn	9	1	HV activation
AMK_bEnable	10	1	Driver enable
AMK_bErrorReset	11	1	Remove error*
AMK_bReserve	12	4	Reserved

Figure 13: AMK_Control bits

MI4	Motor Interface shall execute a motor startup sequence in accordance with procedures outlined in the AMK Documentation.
Rationale	To ensure correct operation of the motor kit.
Likelihood of Change	Very unlikely - Key functionality

MI5	Motor Interface shall execute a motor shutdown sequence in accordance with procedures outlined in the AMK Documentation.
Rationale	To ensure correct operation of the motor kit.
Likelihood of Change	Very unlikely - Key functionality

MI6	Motor Interface shall execute a motor error reset sequence in accordance with procedures outlined in the AMK Documentation.
Rationale	To ensure correct operation of the motor kit.
Likelihood of Change	Very unlikely - Key functionality

MI7	Motor Interface shall report a ”motors running” state only when both motors are running.
Rationale	To ensure correct operation of the motor kit.
Likelihood of Change	Very unlikely - Key functionality

MI8	Motor Interface shall report a ”motor error” state only either of the motors report an error.
Rationale	To ensure correct operation of the motor kit.
Likelihood of Change	Very unlikely - Key functionality

6.5 Vehicle Dynamics

VD1	Vehicle Dynamics shall monitor the following inputs: Driver torque request (%), Accelerator Brake Pedal position (%), AMK motor CAN feedback, AMK Torque, Speed and Current Limits (settings from AMK firmware), Steering Angle
Rationale	These driver and vehicle state variables are required to compute appropriate motor torque commands.
Likelihood of Change	Likely - More inputs may be needed as module complexity grows.

VD2	Vehicle Dynamics shall compute and report the following output parameters to the control system: right motor speed & torque setpoints, left motor speed & torque setpoints"
Rationale	Vehicle Dynamics must compute appropriate motor torque and speed set-points based on driver input and vehicle state.
Likelihood of Change	Likely - More outputs may be needed as module complexity grows.

VD3	Vehicle Dynamics shall adhere to FSAE EV.4.1.3 - "The powertrain must not regenerate energy when vehicle speed is between 0 and 5 km/hr"
Rationale	Competition rule
Likelihood of Change	Very unlikely - Competition rule

VD4	Vehicle Dynamics shall adhere to FSAE EV.4.2.1 - "Supplying power to the motor to drive the vehicle in reverse is prohibited"
Rationale	Competition rule
Likelihood of Change	Very unlikely - Competition rule

VD5	Vehicle Dynamics shall adhere to FSAE EV.4.2.3 - "Any algorithm or electronic control unit that can adjust the requested wheel torque may only lower the total driver requested torque and must not increase it"
Rationale	Competition rule
Likelihood of Change	Very unlikely - Competition rule

VD6	Vehicle Dynamics shall estimate the motor's torque capacity dynamically, based on its current output and available power, according to AMK Documentation."
Rationale	A motor torque request that exceeds the motor's momentary torque capacity may damage the motor.
Likelihood of Change	Very unlikely - Key functionality

VD7	Vehicle Dynamics shall adhere to FSAE EV.5.7.1 - "The power to the Motor(s) must be immediately and completely shut down when the two of these exist at the same time: (1) The mechanical brakes are engaged; (2) The APPS signals more than 25% pedal travel"
Rationale	Competition rule
Likelihood of Change	Very unlikely - Competition rule

VD8	Vehicle Dynamics shall adhere to FSAE EV.5.7.2 - "The Motor shut down must remain active until the APPS signals less than 5% pedal travel, with or without brake operation."
Rationale	Competition rule
Likelihood of Change	Very unlikely - Competition rule

7 Non-Functional Requirements

7.1 Look and Feel Requirements

For our end-user, McMaster Formula Electric, the control system's "front-end" would be the MATLAB/Simulink development environment.

NFR1	The control system Simulink models shall follow a standardized format that facilitates readability, including standard colour schemes, variable naming, and go-to tags where applicable.
Rationale	Future FSAE students should be able to understand control logic while consulting as little documentation as possible.

7.2 Usability Requirements

As our project is a vehicle system for MFE, usability would moreso fall under performance and maintainability requirements.

7.3 Performance Requirements

NFR2	The control system build target shall be the team-selected microcontroller platform, STM32F7
Rationale	Software compatibility with the end-use hardware.

7.4 Maintainability and Support Requirements

NFR3	The control system modules shall incorporate modularity principles, including encapsulation and information hiding.
Rationale	Having modules interact through well-defined inputs/outputs, while hiding their implementation, facilitates maintainability by preventing implementation updates from requiring upstream/downstream changes.

NFR4	The control system shall employ hardware abstraction modules, allowing the control system to be independent of the hardware interface.
Rationale	Future hardware changes can be accommodated within their own encapsulated modules rather than requiring control logic changes.

NFR5	The control system shall include a unit-testing environment for each system module (MI, DI etc.)
Rationale	Each module should be able to have its control logic simulated at the SW level, before reaching hardware.

NFR6	The control system shall include a system-testing environment, including a plant model that simulates the vehicle's response to control system commands.
Rationale	Allow system-level integration testing of control logic at the SW level, before reaching hardware.

7.5 Security Requirements

Code-level security is not within the scope of the project. However, access to source code and high-level control logic is.

NFR7	The control system repository shall be made private upon completion of the project.
Rationale	To prevent our team's work being copied by a rival team, as this can cause issues in terms of plagiarism as per the FSAE rules, while also in practise reducing our competitive advantage.

7.6 Cultural and Political Requirements

As this is a competition-only vehicle with strict guidelines from SAE, there are no relevant requirements reflecting on societal politics and culture.

7.7 Legal Requirements

As this is a competition-only vehicle with strict guidelines from SAE, there are no relevant legal requirements from governing bodies (that would not already been implicitly required with the SAE guidelines).

7.8 Health and Safety Requirements

Health & Safety is comprehensively covered by the FSAE ruleset for which the vehicle must comply, especially at the electrical level (eg. actively-monitored shutdown circuits). If a control system error arises during vehicle operation, the safest state is coasting - motors produce 0 torque, and the driver can use the mechanical steering and brakes to stop the vehicle. This is already reflected in functional requirements, section 6.

8 Project Issues

8.1 Open Issues

Issues that have been raised and do not yet have a conclusion.

- Sourcing and/or development of more sophisticated plant models to use in Model-in-loop testing is an open issue.
- The MFE team lagged behind in delivering test hardware such as brake pedal, steering sensors, and the Orion BMS, and as such we were not able to integrate them immediately.
- The control system is unable to be independently run on the LV test bench, as MFE's custom CAN layer for their LV test bench is still a work in progress.

8.2 Off-the-Shelf Solutions

As this competition follows strict requirements from FSAE, a unique control system must be developed by each team. Systems provided by Mathworks and/or hardware manufacturers cannot be used beyond acting as a broad inspiration or syntax reference. Purchasing vehicle control software from a automotive supplier (eg. Bosch) would still require customization in order to meet FSAE competition requirements.

8.3 Risks

- The FSAE vehicle may not be ready by end-of-project to do vehicle level integration.
- The embedded hardware may not be ready by end-of-project to do hardware-level integration.
- Hardware-level testing introduces some health and safety risk.
- The team-selected microcontroller (STM32F7) may not have computational capacity required for the end-product control system.
- Roadblocks caused by MFE that are out of our team's control

8.4 Costs

Much of the hardware required for our system's development is provided by MFE. Software (MATLAB/Simulink) is available through academic licenses.

Item	Price
NUCLEO-F767ZI Debugger	$25

8.5 Waiting Room

The following are potential additions to the system as permitted by MFE.

- Onboard Diagnostics Module - reporting data over the CAN bus
- Driver Interface - one-pedal driving (regenerative braking)
- Vehicle Dynamics - Stability Control; Torque Vectoring
- Data acquisition & logging during vehicle operation

Appendix — Reflection

This project requires a team-wide understanding of developing embedded software that is functionally complete, robust, maintainable and documented, as well as working within a continuous-improvement framework. Other mechatronics-specific knowledge includes model-based design, signal conditioning, V-model development, requirements-based testing, software-simulation and physical modelling environments and state machine design. Broader technical knowledge will be developed in electric vehicles and automotive standards. Team members will need to be adept with various industry tools including Git, MATLAB/Simulink and LaTeX. Transferable skills are numerous, but notably include experience in compliance-driven design, design communication and collaborative project management.

Team Member	Knowledge/Skills to develop
Dharak	Software simulation & physical system modelling, project management, integration testing, software design documentation
Abhishek	Embedded software development, design communication, model-based design, V-model, control system theory
Jason	Embedded software development, design communication, Simulink algorithms, predictive and intelligent control, real time applications with controls
Laura	Embedded software development, design communication, Simulink, knowledge of electric vehicles and their subsystems
Derek	Embedded software development, design communication, signal conditioning, state machine design, LaTeX, Git

Approaches and rationale are as follows.

Team Member	Knowledge/Skills to develop
Dharak	To acquire knowledge and master the aforementioned skills, I could begin by (1) documenting my work and experience I have gained over my 6 years on MFE in order to easily transfer it down to my team members, (2) consult the expansive catalog of resources provided by decorated FSAE Teams online, and (3) take a leading role in managing both the technical and admin work of the capstone group. Of the listed methods, I will be pursuing method (1) to build my knowledge and skill set. As I have prior experience with embedded software, vehicle controls, and project management due to my past and current involvement with MFE, the best way for me to be able to reinforce the skills I have gained and applied is to reflect back upon them by documenting and teaching others. I strongly believe the best way to test ones knowledge on a topic is by explaining it to someone else, so by explaining the topics related to my goals to my team members, I will be reinforcing my own understanding and be able to find any holes in my own knowledge.
Abhishek	To enhance the skills I've listed above, I can (1) make use of great professors that are available to us, like Professor Lawford, that have a deep understanding of vehicle control systems (2) put into practice what I've learned in multiple courses during my time at McMaster eg. Real Time Applications and Intelligent Control, and finally (3) make use of the great FSAE Formula Electric community to fill any gaps in understanding I may have. Having previous co-ops in the controls space, I will be using what I've learned from practical experience and theoretical experience to become a great asset to this project's development and final outcome.
Jason	Build on course work I have done based around software development and control theory. Additionally, being able to actually develop a control algorithm for on a vehicle is a very unique opportunity and so being able to grasp skills in all areas of it is important to me. Working on simulink for the model driven design pacemaker project provided a great introduction into simulink and I want to build on this skill set through this project. Through conducting research on vehicle controls algorithms, or through consulting professors, I will aim to complete my goal. From the above approaches, I will be pursuing the approach of working with professors, such as Dr. Martin v. Mohrenschildt as he is an expert in the control systems area.

Laura	To ensure that I acquire the skills and knowledge listed above, I will thoroughly review the documentation provided by the MFE team. I will also do research on other electric vehicles, especially ones that are available commercially, to keep up with the ongoing demands and trends of the industry. This will help me to make sure I am on track with my team and that I fully understand the scope of the project and can make meaning contributions to the team. As I have previous experience with software development and design communication, I will be focusing on continuing to learn about electrical vehicles and their subsystems.
Derek	Though I have some experience in state-machine design, formal documentation in LaTeX, and in Git, these have been for smaller-scale projects where I could get by with just the basics. This project provides the opportunity to deepen by knowledge by applying these skills to a larger (in module count) and more complex system. I can enhance these skills by (1) taking advantage of the talent-base of the FSAE team by consulting team members for their knowledge and design advice, and (2) taking advantage of the support from the Capstone instruction team, by consulting with the instructors/TAs for their best-use practices.