QA plan for subsystems

This document describes how subsystems intend to verify that they have met all requirements for their system.

Tractive System Interface

Throttle Plausibility and Brake Light - R005b

Test	Procedure	Results
1.1 Test Pedal Cluster provided by Mechanical Engineering Team	Multimeters will be connected across both potentiometers to ensure they are biased correctly. One should operate between 5-10V and the other from 0-5V.	
1.2 Test Pedal Cluster provided by Mechanical Engineering Team	When pedal is pressed, both potentiometers will react in the same linear scale. This will ensure that we will not have any mistaken faults due to relative measurements.	
1.3 Test Plausibility functioning correctly when operating at normal conditions	Press pedal as in normal use while driving. Output of plausibility circuit will react with expected values. This should be a linear scale coordinating to the percentage of the pedal you are pushing.	
1.4 Test Plausibility functioning correctly when mismatch is forced.	Include a resistor in series with one of the leads from the potentiometers. This will make the system see a mismatch in expected voltages. The system should not deliver any voltage from the output of the plausibility system.	

1.5 Test Plausibility functioning correctly with brake pressed	With the accelerator working correctly under normal conditions, press the brake until the brake light activates. Continue to press both pedals and measure the output that will be connected to the motor controller. This should read 0V. NOTE: this test must be completed after brake functionality is proven.	
1.6 Test Plausibility functioning correctly with brake pressed	After test 1.5 has passed, repeat test. This time, release accelerator pedal fully and then the brake. The accelerator pedals should operate as they did in test 1.3.	
1.8 Brake light turns on when brake is pressed	Press the brake to at least 5% of its travel. The brake light should turn on at this point.	
1.9 Brake light turns on when brake is pressed	Repeat test 1.5 and ensure the brake light turn on.	

TSAL - R005d

Test	Procedure	Result
2.1 Test turn on voltage of TSAL	Connect all high and low voltage connections to their correct ports on the PCB. With 0V on high voltage side, light should not be on.	
2.2 Test turn on voltage of TSAL	With setup of test 2.1, increase high voltage	

	gradually until the light turns on. Record the voltage which should be ~30V.	
2.3 Test turn on voltage of TSAL	While light is turned on from test 2.2, continue to increase the voltage to 96V to test the light remains on for full range of battery power.	
2.4 Test discharging of voltage when IMD faults	With the light on at 96V, turn the output of the power supply off to simulate an IMD fault. The TSAL will shut down as the system will not be active.	

IMD - R005c

Test	Procedure	Result
3.1 Test IMD independently of other parts	Hook up IMD as stated in IMD Memo. Bridge 500 kOhm resistor between high voltage plus and minus. OK_{HS} should read 24V and PWM should be 10 Hz with a Duty Cycle of roughly 23%.	
3.2 Test IMD independently of other parts	Connect IMD the same way as test 3.1 but with 25 kOhm resistor between high voltage plus and minus. The OK_{HS} signal should read 0V and the PWM should be 0 Hz. NOTE: this will take around 10 seconds from when the resistor is connected to when the outputs will change.	

3.3 Test IMD in connection with safety loop relay	Hook up IMD where OK_{HS} signal is controlling the safety loop relay. Under normal conditions, the relay should be closed and the measured voltage out of the relay should be the low voltage applied.	
3.4 Test IMD in connection with safety loop relay	Hook up IMD as in test 3.3. Cause a ground fault as in test 3.2. The relay should open around 10 seconds after the resistor is connected. The measured voltage out of the relay should be 0V.	

TSMP - R005a

Test	Procedure	Result
4.1 Test accurate measurement of voltage	Connect the necessary components for powering the pcb off of controllable power supplies. The voltage on the power supply should be read off a multimeter rated high enough that is attached across the TSV+ and TSV- ports on the TSMP.	
4.2 Test IMD faulting	The test should be setup as in test 4.1. The TSV- will then be connected to the Chassis Ground port to trigger an IMD fault. This should take about 10 seconds. NOTE: Perform this task after successful IMD testing has been completed.	

4.3 Competition IMD faulting	Repeat test 4.2 but with a 50 kilo ohm resistor between the TSV- and Chassis Ground ports as this is the resistance the competition will use to test the faulting across the TSMP.	

RTDS - R005a

Test	Procedure	Result
5.1 Test RTDS decibels	When the drive button is pressed, the RTDS should be heard at 80dBA from 2 meters away.	
5.2 Test RTDS duration	The RTDS should be on for 2 seconds after the drive button is pressed. The rules state this must be on from 1-3 seconds.	

CAN Communication - R005a

Test	Procedure	Result
6.1 Test CAN communication with PC	Connect the CAN bus to a Windows PC and verify that a signal can be sent.	
6.2 Test CAN communication of specific data	Connect with PC as in test 6.1. Then attempt to send the decoded value of the measured resistance by the IMD.	

6.3 Test CAN Communication with SCADA team	Repeat test 6.2 with the SCADA team instead of the PC.	

Precharge Relay - R005a

Test	Procedure	Result
7.1 Test Precharge Relay closing	When TSV is applied to the precharge circuit, the initial current will go through the fuse. The motor controller will then close the relay to deliver full power.	

Cell Phone

Item #	Item Description	Demonstrated Requirements	Successful Test Summary	Type of Verification
1	Cell App talks to SCADA web server	R002d, R002k	Unit Testing and Logging, Cell App values match VSCADA values	Test
2	Cell App is able to run in the background indefinitely	R002d	A week long run for cell app, starts with boot of the phone after installation	Test
3	Cell App provides customizable view generation	R002e, R002f. R002h, R002i, R002j	Proper display of customizable view generation	Inspection
4	Cell App provides editing functionality for views	R002e	● Proper display of drag and drop functionality ● Proper display of zoom in and out functionality	Inspection
5	Cell App contains no exceptions, errors in the code	R002j	Unit Testing and Logging	Test
6	Cell App saves user settings	Maintainability	Destroying the app and launching it back again after creating custom display/settings	Inspection
7	Cell App listens for exceptions/errors from SCADA	R002k	Sending an exception from SCADA and seeing a notification from Cell App, unit testing	Inspection and Test
8	Cell App can implement a new sensor without changing the code	Maintainability	Adding a “fake” sensor to SCADA webserver and observing from Cell App automatically	Test

Cooling System

Requirement #	Type of Prove	Test Method(s)
R007a/f/g	Inspection	Inspect whether the system is running on a 24VDC power, whether the 13x19mm tubing can be used, whether the system can run independently without reusing parts in Dyno room.
R007b	Test	1. Manually set the fluid temperature parameter in Arduino IDE to high (a number above threshold) and see whether Arduino opens the relay, while the cooling system is not connected to the actual safety loop 2. After the previous test is completed, connect the cooling system with the overall safety loop and make fluid temperature above the threshold
R007c/d	Test	1. Display data acquired from different sensors on a LCD display connected to Arduino. 2. After the previous test is completed, show the CAN_HIGH and CAN_LOW signals on oscilloscope.
R007e	Test	1. When the manual control mode and manual override mode is not on, the fan and pump will be automatically controlled by Arduino with pre-specified temperature thresholds 2. When the manual control mode is on, user can use push buttons to manually set the temperature thresholds 3. When manual override mode is on, user will be able to use a knob to control what percentage of full speed of fan is being used

Tractive System Voltage

Requirements Analysis

The following chart details the requirements for the TSV subsystem and their status as of CDR in the spring 2017 semester. Requirements that have been satisfactorily met according to the SOW in previous years are listed; as they are completed we do not elaborate upon them further in this document. However, this does not mean this portion of the accumulator system cannot be improved upon.

R001: TSV Battery Pack Accumulator Requirements			
Req. #	**Description**	**Status**	**P/F**
R001a	Integration	In Progress - See below.	
R001b	Cell Balancing Algorithm	Completed in 2016.	P
R001c	Data Acquisition	Completed in 2016. However, requires reverification with new SCADA system.	
R001d	Displays & Indicators	In Progress - See below.	
R001e	Pack Controls	In Progress - See below.	
R001f	Low Current Output	Completed in 2016.	P
R001g	Safety Shutdown	In Progress - See below.	

R001a - Integration

1. Pass/Fail: Accumulator system and all relevant subsystems (AMS boards, PacMAN, Control Panel) are fully documented, which includes relevant BOMs, wiring diagrams, assembly information, programming guides, software and hardware zip files.
a. This will be conclusively proven when all relevant documents are on the GIT and/or LFEV 2017 website.

Signature(s):___________________________________Date:_____________P/F:_________

2. Pass/Fail: The accumulator system and all relevant subsystems are fully integrated; this means four individual packs have functional displays, controls, and AMS including AMS boards and PacMAN and can be put in series to deliver a complete accumulator system.

a. This will be conclusively proven when:

i. All AMS boards have passed all tests in the AMSVU.

ii. All PacMAN boards can communicate to all 7 AMS boards via I2C as described in R001c ATP 1 below.

iii. All PacMAN boards show relevant information on the display and indicators as described in R001d ATP below.

iv. All pack controls are functional and allow navigation, calibration, and reset to required information.

Signature(s):____________________________________Date:_____________P/F:_________

3. Pass/Fail: The accumulator system has been updated to at minimum (cannot be a lower version) the following versions of firmware/hardware. Any updates beyond these minimums mean that improvements have been performed.

PacMAN Hardware	PacMAN Firmware	AMS Hardware	AMS Firmware
v0.8	v0.15	v1.1	From 2016-10-18

Signature(s):____________________________________Date:_____________P/F:_________

4. Pass/Fail: The accumulator system has been fully tested. This includes the following tests:

a. Individual pack resistance testing to verify the electrical connections inside the pack; without the PacMAN and AMS boards.

b. Individual pack load stress testing to verify the integrity of an individual pack; without the PacMAN and AMS boards.

c. Accumulator load stress testing to verify the integrity of the accumulator system; without the PacMAN and AMS boards.

d. Individual pack load stress testing to verify the integrity of an individual pack; with the PacMAN and AMS boards.

e. Accumulator load stress testing to verify the integrity of the accumulator system; with the PacMAN and AMS boards.

f. Accumulator stress testing with the dynamometer; without all the PacMAN and all AMS boards.

g. Accumulator stress testing with the dynamometer; with all the PacMAN and all AMS boards.

Signature(s):____________________________________Date:_____________P/F:_________

R001c - Data Acquisition

1. Pass/Fail: PacMAN receives cell voltage and temperatures from the AMS boards via I2C.
a. This will be conclusively proven by verifying that all cell temperatures and voltages are correctly and accurately acquired and displayed in the display menus. We will compare this to measured values acquired via thermometer and multimeter.

		Cell 0	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6
Temp	Meausred							
	Displayed							
Voltage	Measured							
	Displayed							

Signature(s):____________________________________Date:_____________P/F:_________

2. Pass/Fail: PacMAN sends all relevant data (pack state, pack voltage, pack current, SOC, cell voltages, cell currents, safety loop status) via CAN.
a. This will be conclusively proven for TSV by utilizing USB2CAN to Windows to monitor the CAN output from the PacMAN. Through this, we can verify that the PacMAN software speaks over CAN and transmits all relevant data in the expected format and order.
b. Relying on the VSCADA subsystem, we will then prove the PacMAN can communicate via CAN to this other subsystem.

PacMAN via CAN to Lab Terminal	PacMAN via CAN to VSCADA

Signature(s):____________________________________Date:_____________P/F:_________

R001d - Displays & Indicators

Here is the quality assurance report from 2016 describing the status of R001d in Spring 2016.

1. Pass/Fail: All desired information displayed on the control panel on the top of each individual pack.

a. Desired is defined at minimum as: pack voltage, current, SOC, cell balancing state, charging state, charging history, discharge history, cell temperatures, cell voltage, safety loop state

b. This will be conclusively proven when all desired information is displayed within the LED display. Photographs will be provided.

Desired Information Not Available Through Menu System

Signature(s):___________________________________Date:_____________P/F:_________

2. Pass/Fail: A “pack-alive” light is illuminated when the AIRs are closed (safety loop closed).

a. This will be conclusively proven when the LED is turned on and held on while the safety loop is closed, as indicated by the display.

Signature(s):___________________________________Date:_____________P/F:_________

R001e - Pack Controls

Here is the quality assurance report from 2016 describing the status of R001e in Spring 2016.

1. Pass/Fail: Through the control panel on each individual pack, a user shall be able to navigate to all desired data as defined in R001d.

a. This will be conclusively proven by providing photographs of the all display menus, which shows that all relevant information can be accessed via the pack controls and appropriately displayed on the LED screen.

Expected Menus Not Available

Signature(s):___________________________________Date:_____________P/F:_________

2. Pass/Fail: Through the control panel on each individual pack, a user shall be able to calibrate or set a range of values.

a. This will be conclusively proven by providing photographs of the display menu to calibrate values and the updated display for newly calibrated values.

Values Not Calibrate-able

Signature(s):___________________________________Date:_____________P/F:_________

3. Pass/Fail: Through the control panel on each individual pack, a user shall be able to reset the PacMAN.

a. This will be conclusively proven when the reset button on the control panel is pushed and the display resets. The PacMAN will turn off while the reset button is held and the board will turn back on when the button is released.

Signature(s):___________________________________Date:_____________P/F:_________

4. Pass/Fail: Through the control panel on each individual pack, a user shall be able to reset each AMS board.

a. This will be conclusively proven when the reset button on the control panel is pushed and the AMS boards active LEDs turn off while the button is held. When the button is released, the AMS boards active LEDs should return to blinking.

Signature(s):___________________________________Date:_____________P/F:_________

R001g - Safety Shutdown

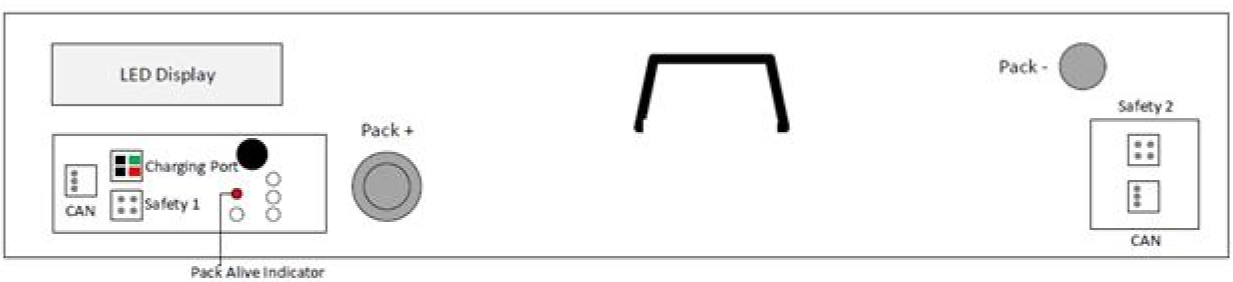

Figure #. Top of Pack for Safety Shutdown

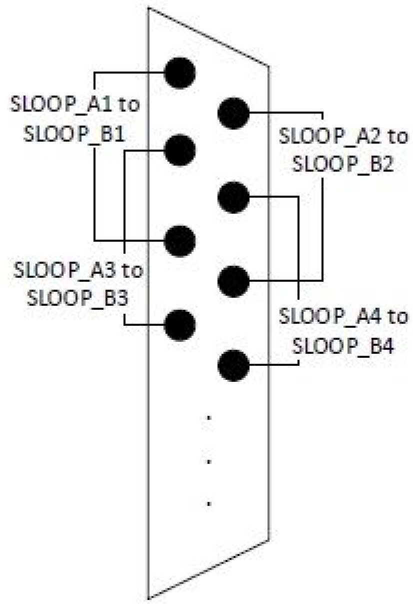

Figure #. Wire jumping diagram for 37-pin connector in pack without a PacMAN.

Procedure - Individual Pack without PacMAN, Control Panel, & AMS boards

This test is run in order to show that the individual pack, in conjunction with the GLV basic safety loop can open and close the AIRs when expected. This test is intended as an incremental test before installing the AMS and control panel.

1. GLV basic safety loop set up in rack with a 24 V power supply in room 400.
2. GLV basic safety loop connected to the 4-pin safety connector near the display (see set-up Figure #) and safety loop jumper plug into the other 4-pin safety connector (see set-up Figure #).
3. Jumper the 37 pin connector in the pack as can be seen in Figure # below; this jumpers the safety loop for this test without the PacMAN board.
4. Power the GLV basic safety loop.
5. Press the E-Stop button to release.
6. Press the GLV basic safety loop master reset button; if functioning correctly, listen to the AIR(s) close.
7. Press the E-Stop button to end the test.

Procedure - Individual Pack with PacMAN, Control Panel & AMS boards

This test is run in order to show that the individual pack, in conjunction with the GLV basic safety loop can open and close the when expected and the displays and indicators are updated as expected. This test requires an assembled pack with properly installed PacMAN, control panel, and AMS boards.

1. GLV basic safety loop set up in rack with a 24 V power supply in room 400.

2. GLV basic safety loop connected to the 4-pin safety connector near the display (see set-up Figure #) and safety loop jumper plug into the other 4-pin safety connector (see set-up Figure #).
3. Verify the pack display indicates the safety loop status is “OPEN.”
4. Power the GLV basic safety loop.
5. Press the E-Stop button to release.
6. Press the GLV basic safety loop master reset button; if functioning correctly, listen to the AIR(s) close, the pack display update the safety loop status from “OPEN” to “CLOSED,” and the pack alive button illuminate.
7. Press the E-Stop button to open the safety loop.
8. Verify the AIR(s) open, the pack display updates the safety loop status from “CLOSED” to “OPEN” and the pack alive button turns off.

Procedure - Accumulator without PacMAN, Control Panel, & AMS boards

This test is run in order to prove that the Accumulator system, in conjunction to the GLV basic safety loop can open and close the AIRS as expected. This test is intended as an incremental test before installing the AMS and control panel in remaining Packs. This test is redundant and unnecessary if the packs are built and tested with the PacMAN/AMS boards/ Control Panel prior to assembly the Accumulator.

1. GLV basic safety loop set up in rack and powered with a 24 V power supply in room 400.
2. GLV basic safety Loop cables connected to the 4 pin connectors in each sequential pack (Pack 1 SL cable leads to Pack2 SL connector etc.)
3. Jumper the 37 pin connector in the pack as can be seen in Figure #. This jumpers the safety loop for this test without the PacMAN boards.
4. Power the GLV basic safety loop.
5. Press the E-stop button to release.
6. Press the GLV basic safety loop master reset button; listen for the AIR(s) closing and the GLV active light to light up.
7. Press the E-stop button on the GLV panel; note the GLV active light turns off.

Procedure - Accumulator with PacMAN, Control Panel & AMS boards

1. GLV basic safety loop set up in rack and powered with a 24 V power supply in room 400.
2. GLV basic safety Loop cables connected to the 4 pin connectors in each sequential pack (Pack 1 SL cable leads to Pack2 SL connector etc.)
3. Ensure PacMAN, AMS boards and Control Panel are all installed properly.
4. Note that on all packs, the current status of the safety loop is closed (on LCD).
5. Power the GLV basic safety loop.
6. Press the E-stop button to release.
7. Press the GLV basic safety loop master reset button; listen for the AIR(s) closing, note the GLV active light is on, and that each pack now displays that the safety loop is closed (on LCD).
8. Press the E-stop button on the GLV panel; note the GLV active light turns off, the packs now display that the safety loop is open (on LCD).

Procedure - Charging Individual Pack & Safety Loop

1. Set up GLV basic safety loop in rack and power with a 24V power supply.
2. GLV basic safety loop connected to the 4-pin safety connector near the display (see set-up Figure #) and safety loop jumper plug into the other 4-pin safety connector (see set-up Figure #).
3. Plug the charging cable into the charging port and begin charging the pack;; ensure that the LCD currently notes that the safety loop is open.
4. Hit the Master Reset button (green button) on the GLV rack. The pack safety loop state should NOT change, the AIRS should NOT audibly turn on, and the GLV active light should NOT turn on.

1. Pass/Fail: The safety loop must be open while an individual pack is being charged.

Signature(s):__________________________________Date:_____________P/F:_________

2. Pass/Fail: The safety loop must be open and remain open while an individual pack is in an unsafe condition.

Signature(s):__________________________________Date:_____________P/F:_________

3. Pass/Fail: All displays, indicators (“pack alive” LED), and computer interfaces (CAN transmission) shall communicate the state of the safety loop.

Signature(s):__________________________________

Vehicle Supervisory Control and Data Acquisition

Item	Description	Test Method	Detailed Test Plan
1	The delivered VSCADA software shall be fully documented with source code, design, and end-user documentation per GPR001.	Code Inspection	All code will be documented and JavaDoc (or a JavaDoc equivalent) will be provided at the time of final submission and will be available as part of the systems API. Approval of such documentation shall be approved by a professor.
2	Simple software installation on new hardware.	Clean Install from GIT Visual inspection of system functionality	A fresh system (one without the SCADA software on it) will perform the following steps. 1. git clone https://github.com/LafayetteFormulaElectricVehicle/VSCADA.git 2. cd VSCADA/ 3. make install 4. ./scada or ./configuration To Pass: System works without additional configuration from the user
3	Simple error and log viewing. Modifiable configuration parameters for error parameters.	Visual Inspection Simulation of SCADA system with sensors surpassing error bounds	The user shall be able to easily view any data logged as well as any errors tracked by the SCADA system. The user shall be able to reconfigure any criteria they deem does not accurately represent a stable system with ease. To Pass: The system shall be run with a set of parameters for determining erroneous levels. The parameters shall

			then be changed and it must be verified that the system now tracks errors based on the new values, not any hard coded values.
4	System Backup	Visual Inspection Transfer of configuration file accurately loads up system state	The system shall have the capabilities of performing automatic backups of data past a certain user input criteria, as edited in the ConfigurationUI. Additionally, the user may export their current configuration to a USB device for use on another SCADA system. To Pass: The user shall conduct standard testing to pass their specified backup criteria and then will verify the new SCADA.db backup file exists in the Backups folder. The user must be able to export the configuration file and load it up on another device. Upon deletion of the configuration file, default presets shall be used to create a new configuration class.
5	Automatic trimming of log files.	Visual Inspection	The SCADA system shall have the capabilities to either automatically trim data or manually based on user configurations. To Pass: The system shall be run for 24 hours continually (or however many hours it takes to surpass the user specified parameters for auto trim). The database shall not grow without bounds during this time. Upon completion of this test, there must be backups as specified in (4) and a more condensed database for rapid querying. To prove data has been trimmed, we will search for data that, by inductive reasoning, should have been trimmed by the system and shall not return such information.

6	Simulation of sensor data	Performance test along with visual inspection	The SCADA system shall have the capability to simulate sensors which cannot be found. To Pass: The SCADA system must be able to function, assuming it is powered on, regardless of the sensors attached to it. At a minimum, the system shall be able to monitor information coming over the CAN line. If there are no signals coming over the CAN line, the system shall not crash. Based on the user defined parameters, the system shall generate results that pass a professor’s approval.
7	Ongoing and reliable operation, maintenance and expansion	Verification through Cell App	The aim of this system is to be one that will last for more than a few years while still being able to expand as the requirements of the project shift. To Pass: The Cell team shall use the API, and the methods provided by the SCADA system to receive information by processing requests. Successful data transmission without the need for additional query logic nor knowledge of the system itself shall prove functionality.
8	Configuration file generation	Clean install and custom configuration loading	The system shall be able to transfer and load up configuration files as mentioned in (4). To Pass: The user shall start with a clean system and verify that a default configuration file is created. If they delete it a new one shall be generated. If they decide they would like to source in a new file then the program shall allow for such actions and refer to the newly sourced in file. The custom file, when deleted, must not cause the

			system to crash; the default configuration file must be created.
9	The developed VSCADA should be useable on the car without recompiling	Repeated reboot process	The SCADA system must be able to run without recompiling. Additionally, on startup the system shall boot without a login prompt. To Pass: The system shall be continually used, shut down and repeated. In the process of use, data label information will be changed. Upon reboot, the system shall automatically load and the changes made in the last session must carry over to the new session.
10	Logs and data must be readily accessible	Cell Team data acquisition Computer application data acquisition	In order for data to be useful and for it to be relevant when conducting scientific experiments, it must be readily available. To Pass: The cell team must be able to request information from, and receive it, the SCADA computer regardless of the system state. The same must be true with the cell app. Neither must require knowledge of SQL or the database structure, merely the API.
11	Dyno Control with VSCADA	Inspection Data acquisition	The SCADA team shall, in addition to logging, have the ability to control the throttle and dyno torque load, as well as acquire torque measurements and dyno RPM through the USB interface to the Huff dynamometer DAQ box. To Pass: The SCADA system shall sweep through the full range of throttle and torque values possible. While controlling the Dyno, it is essential that the system still log data of the dyno, and any other connected systems.

12	Sudden power disconnect	Inspection	The SCADA system shall not crash should there be a sudden and unexpected shutdown in the system. There should not be any user interaction to fix the system post sudden shutdown. To Pass: The power shall be disconnected during normal use and then powered back on. If the system starts back up without interaction on the user’s part then all passes otherwise the test fails.
13	Required Physical Interfaces	Inspection	To Pass: R002a, R002b, R002c and R002d must all be approved by a professor and demonstrate all functionality set forth in the SOW.
14	Mode switching	Inspection	VSCADA hardware and software are required to support operating in and switching between all modes and states independently at all interfaces, and displays. Full functionality shall be available at all of the above interfaces in every mode. To Pass: Tests will be run in the background, during which the user shall switch between every mode. It must be proved that whether all sensors are present, or not, or if errors are present, this functionality persists. The sensors shown in each view will, at a minimum, be the sensors listed in the SOW. This will require demonstration and verification of R002e, R002f, R002g, R002h, R002i, R002j.
15	Log Rate	Inspection of table data	With SCADA it shall be possible to measure individual parameters up to 60 times a minute or at slower rates.

			To Pass: The system must be capable of operating at varying rates, with a maximum rate of 60 times per minute.
16	MTTR	Clean install	In the event of a hardware failure, it is important that the system is able to be fixed within a week. To Pass: Conduct the following tests and prove that the time taken to get a new system up and running (aside from the time it takes to ship parts) is below the required MTTR of 1 week. Start by trimming files that are essential to the system, then delete entire paths, remove the SD card and get a clean one. To pass these tests, a clean and workable system should be possible within the week.
17	Physics Modeling	Data Inspection	It shall be possible for the SCADA team to integrate with physics modeling for closed loop control. To Pass: The SCADA system must demonstrate the physics modeling created by the physics team. The testing requirements must align with their protocol for testing.
18	Data Acquisition	Inspection	The SCADA system must be able to record data from a non finite set of sensors over CAN, regardless of their data type. To Pass: At a minimum the SCADA system must be able to record data over CAN for all sensors set forth in the SOW.

Grounded Low Voltage

Requirement Description	Test Method	Condition to Pass
R003a-1: GLV 24 VDC supply provides sufficient current to supply all the power needs the all GLV subsystems.	Test- Each of the GLV powered systems will be powered individually, and the current drawn by each subsystem will be measured.	The amperage rating of the 24 VDC GLV battery is greater than the sum of the current drawn by each GLV powered subsystem.
R003a-2: GLV power negative terminal is connected to chassis ground at only one point in the subsystem.	Test- The current will be measured between the chassis connection and the negative terminal when the GLV system is powered on.	No current flow from the chassis to the negative terminal of the GLV system.
R003a-3: The GLV power battery must be able to run the car GLV systems for at least three hours.	Analysis- The total current drawn by each individual subsystem will be compared to the amount of Amp/hours which the GLV battery can provide.	The amount of amp/hours in the GLV battery greater than three times that of the summation nominal current drawn by each of the GLV subsystems.
R003a-4: The GLV power battery can be recharged by means of a UL listed charging device that plugs into 120 VAC mains with *plug and forget* functionality.	Inspection- The purchased UL approved GLV battery charger includes a charging algorithm that disables charger when battery is fully charged.	The GLV battery demonstrates *plug and forget* functionality.
R003a-5: The GLV Battery is protected from full discharge, overcharge,	Inspection- The GLV battery is advertised to include built in over	The GLV Battery is monitored by the specified

overcurrent, and overvoltage.	charge, discharge, and overcurrent protection.	regulatory features.
R003a-6: The GLV system can safely sit idle without fear of over-discharge or damage.	Inspection- The GLV battery advertises that discharging the battery completed will not damage the battery.	The GLV Battery does not suffer damage due to over-discharge.
R003a-7: The GLV battery can be fully charged without disassembly or special actions.	Inspection- The GLV Battery can be charged by simply plugging in the charger.	No special actions are needed to recharge the GLV battery.
R003a-8: GLV voltage, current, temperature, and SOC shall be displayed by VSCADA.	Test- Required battery monitoring information will be relayed to VSCADA using I^2C. These values will be viewed on the VSCADA display. The voltage, current, and temperature are measured using external tools and measured with the VSCADA reading.	VSCADA and the externally measured signals are reasonable similar.
R003b-1: The safety loop can drive the 24VDC AIRs in the accumulator.	Test- The Safety Loop will energized. The end of the safety loop (post car dashboard) will be measured for voltage output.	The system will supply a 24 VDC output to the AIRs when the safety loop is functioning properly.
R003b-2: The packaging of the safety loop system complies with all Formula EV rules including shock, vibration, temperature, and humidity (rain).		
R003b-3: The safety loop interfaces with VSCADA so that the	Test- The safety loop will be triggered in every possible location with one fault at a time.	VSCADA as well as Dashboard LEDs correctly indicate where the

state of the safety loop can be logged.		safety loop fault occurred.
R003b-4: VSCADA can trip the safety loop if there is a fatal VSCADA error.	Test- The Raspberry Pi will initiate a safety loop fault.	The safety loop will deenergized, as shown by a lack of a final 24V output as well as by fault LEDs.
R003b-5: The safety loop does not rely on VSCADA for any functions aside from R003b-4 and R003b-3.	Test- The safety loop will be powered with a shorted VSCADA fault section.	The safety loop provides a 24 VDC output to the AIRs without VSCADA intervention.
R003c: Vehicle user interface panel designs must meet all relevant requirements.		
R004d: GLV hardware allows SCADA to provide full diagnostic display of all car and dyno data and full maintenance mode control of the car and dyno parameters.	Inspection: The GLV system includes a display which VSCADA can interface with via HDMI.	VSCADA has the capability to display desired information.