VSCADA Acceptance Test Plan

ECE 492 - Spring 2015

Abstract

The Acceptance Test Report will examine and varify how the Lafayette Formula Electric Vehicle (LFEV) system will comply with requirements. Specifically, this document focuses on how the Vehicle Supervisory Control and Data Acquisition (VSCADA) completes the Acceptance Test Plan (ATP). Requirements may be met by analysis, test or inspection.

Revision 7.0.0
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Executive Summary

The Lafayette Formula Electric Vehicle (LFEV) is a complex, multi-year project and as such is subject to many requirements, both competition-wide Formula EV requirements as well as LFEV-specific ones. The Vehicle Supervisory Control and Data Acquisition (VSCADA) subsystem must be shown to be in full compliance with many of these requirements, since VSCADA is the brains of the overall LFEV system and controls the system states in addition to monitoring and logging data from other subsystems. It is therefore critical that all performance and safety requirements and specifications which are relevant to VSCADA are met.

It is of utmost importance that the tests detailed below are carried out while adhering to the project-wide Safety Plan. All general safety procedures described in the Safety Plan as well as test-specific procedures must be in place before any tests are carried out. In addition to safety precautions, preconditions listed for each test must be carried out before the test is performed.

Deliverables

The following items shall be delivered as part of the VSCADA subsystem of the LFEV-Y3-2015 project.

Item	Description	P/F	Date	Signature
Deliverables listed in LFEV-Y3-2015 SOW				
D000	PDR Materials	P	2/19/2015	
D001	CDR Materials	P		
D002	Users Manual	P	2/28/2015	
D003	Final Report and Maintenance Manual			
D004	Acceptance Test Plan			
D005	Acceptance Test Report			
D006	QA Audit Report			
D007	Project Web Site			
D008	LFEV-Y3-2015 Integrated System and Presentation			
D009	Conference Paper, Presentation, and Video	Waived	4/15/2015	
D010	Project Poster			
D011	Calibration and Accuracy Analysis			
D012	Maintainability Plan	P	3/9/2015	
D013	Individual Research Report(s)			
D014	Project Management and Status Letters			
D015	Project Interface Control Document			
Additional VSCADA team deliverables				
D016	Reliability Report			
D017	Maintainability Report			
D018	System Bill of Materials			

Test Procedures

T000 - DYNO Maintenance App Operation

This test shows that the DYNO Maintenance App allows the user to monitor all aspects of the DYNO system. It also shows that all DYNO measurands are logged and stored.

Test Procedures:

1. Start the computer on which the DYNO Maintenance App is installed and verify that the program opens automatically.
2. Open up a DYNO parameter's graph with a sampling rate of once every second and verify that the parameter is being logged at a rate of once every second.
3. Change the sampling rate of a DYNO parameter from once every second to once every two seconds.
4. Verify that the parameter is being logged at a rate of once every two seconds.
5. Save a DYNO parameter's data to a CSV file and verify that the data within the file is accurate based on the currently shown parameter's graph.
6. Verify that all other DYNO parameters are being logged and that all GUI components function in an expected manner.
7. Shutdown the system and verify that it does so correctly, safely, and leaves the system in a quiescent state.

T001 - Maintainability Test

This test shows that the VSCADA software can be installed on a different Linux computer with a simple make/install operation without the need for editing files.

Test Procedure:

1. Power on a separate computer with a vanilla Linux installation.
2. Make/install the VSCADA software on this computer following instructions in the maintenance manual.
3. VSCADA software should be successfully installed on the vanilla Linux distribution.

Appendix A: Traceability Matrix

Key:

I = Inspection
Txxx = Test number xxx
Dxxx = Analysis provided in deliverable number xxx
X = NOT MET

Note: Upon analysis, it was determined that none of the Formula EV rules apply directly to the VSCADA subsystem of the LFEV. However, they still apply to the LFEV system as a whole.

Requirement	Description	Met by
R002	**VSCADA**	
R002-1	VSCADA computer hardware shall be provided as required to handle the VSCADA user interface and processing requirements. This includes on-car and off-car functions.	I
	VSCADA software is implemented on a Windows computer used by the DYNO team to program their motor controller. The software runs in a Virtualbox virtualized system.	See Appendix B
R002-2	VSCADA software shall be a suite of applications built to a unified API with common data formats, protocols, look and feel. To the greatest extent possible, the same core system must run on various hardware platforms in and around the LFEV components.	D003
	The API is not unified but the data formats and protocols used are common and widely supported (.csv as data format, CAN and Serial as protocols)	
R002-3	The VSCADA software must start automatically, reaching a sane, operational state without human interaction.	X

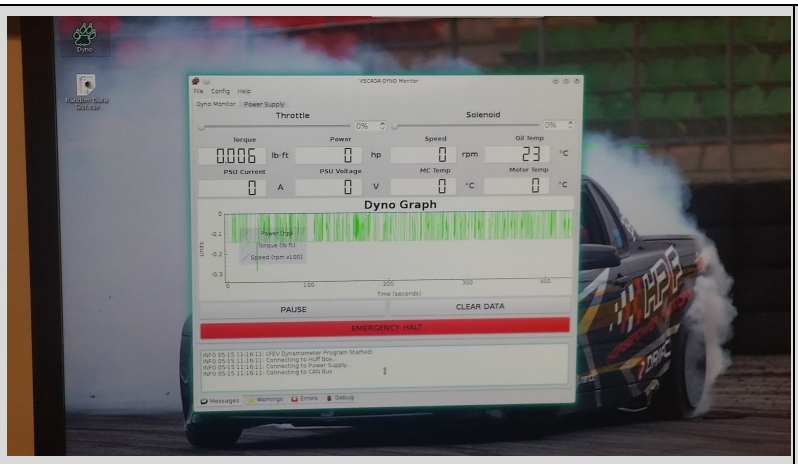
	In the current setup we need to manually start the virtual machine. In the virtual machine itself the software starts automatically after clicking the icon.	
R002-4	Performing a sudden, unexpected shutdown of the VSCADA software shall not cause failure or significant data corruption.	T000
	The only time we are writing to a file is when we manually choose to output data to a csv file, and having an unexpected shutdown should not cause any failure in the software operating system; when it comes to data corruption, if the user does not choose to overwrite the old csv file, then old data will not be lost. The data stored in the memory (that is, the data not yet stored in a csv file) will be lost, but it could matter less if the user saves the data regularly during a single run or if enough data is collected over a long enough period of time that a single missing run is not missed.	
R002-5	VSCADA shall communicate with accumulator by means of the protocol established in 2014, with extensions as required.	X
	The only communication link established is with DYNO. VSCADA did not intend to communicate with the accumulators directly either, as that should be done by TSV's ucontroller and VSCADA was to talk to the ucontroller over CAN.	
R002-6	A backup system or recovery strategy must be developed to allow the VSCADA system to be promptly repaired after a hardware failure (e.g. bad hard disk, accidental disk formatting, broken CPU, etc…) in less time than the MTTR given in GPR007.	T001
	If a user follows the instructions on the sites linked to our wiki page on bitbucket.org, he/she should be able to reinstall the system in one week. All the data collected in the previous corrupted system is stored in a folder the user chose and is portable to the newly reinstalled software.	

R002-7	Several different physical user interfaces and displays are required. Required Physical Interfaces: • Car Dashboard Display *(VCI)* • *Cell Phone App Interface (Out of Scope)* • Remote PC Interface (not met) These interfaces must support different operational modes (not met). To the maximum extent reasonably possible, VSCADA hardware and software are required to support operating in and switching between all modes independently at all interfaces, and displays. Full functionality shall be available at all three of the above interfaces.	T000 (partially)
	VSCADA software should be able to work on most Linux distributions with Linux kernel 3.0 or higher. However, it is suggested to use kernel 3.4 or higher as a lower distribution may cause buffer overflow problems when VSCADA talks to the motor controller.	
R002-8A	From the Maintenance mode, VSCADA shall allow a trained human technician to easily control, alter, and monitor all the processes, parameters, and internal workings of the car systems at the lowest possible level.	T000 (DYNO only)
	As shown in T000, VSCADA system can record data from the DYNO huff box and motor controller, which currently are all the processes and parameters VSCADA has access to.	
R002-8B	When operating in this mode, it shall be possible to alter, enable, or disable the various safety checks and interlocks that constrain functionality and state transitions in other modes.	X
R002-8C	Security features must be provided to protect this mode from unauthorized or accidental access.	T000
	Root access (password needed) is required to run the software, which can be seen as a protection from unauthorized access.	

R002-9	In Drive mode a minimal display and interaction with extensive automation and safety checking is provided to the driver to support and optimize his or her operation of the vehicle in all its operational states, without undue distraction. Note that drive mode does not imply the vehicle is physically moving, or that the safety system is in an active state.	X
R002-10	A Drive mode demo shall be provided (selectable and parameterized from maintenance mode) that allows all functions of driver mode to be realistically and safely exercised, tested, and demonstrated, including motor operation, vehicle sensors and AMS interaction without modification of VSCADA, even if these other subsystems are not available. The drive mode demo display must be identical to the normal drive mode display except that a clear indication on the display must distinguish this demo mode from actual drive mode.	X
R002-11	Plug and forget charging of the accumulator must be possible with an appropriate display. The operation begins, operates, and ends automatically with virtually no user interaction other than plugging in the charger cable. It is critical that Charger/Discharger operation be completely automated to the same level that is seen in typical rechargeable electronics (cell phones, laptops, etc…). The active charge cable can be left plugged in indefinitely without causing any damage.	X
	No Drive Demo or Drive mode is implemented; no communication with accumulator is established and the plug and forget charging is out of scope for VSCADA.	
R002-12	A long term shutdown mode shall be supported. This mode shall configure all hardware in a safe, quiescent state to permit long-term storage without draining batteries.	X
R002-13A	Except during shutdown, or as modified by maintenance mode, at all times monitoring and data acquisition by VSCADA continuously collects data for	T000 (DYNO only)

	real-time and forensic analysis. It shall be possible to transfer data easily from VSCADA to other computers either by removable media or network file transfer.	
	Shown in T000. Data will be constantly received as long as the communication links are not broken. Data can be transferred since the user chooses where to save the data.	
R002-13B	Access to this data must be possible at all interfaces.	T000
	Currently VSCADA only has one interface and it is accessible by the current VSCADA interface.	
R002-14	Simultaneous operational modes shall be supported to the largest extent possible. At a minimum the dashboard must provide a ~~*driver mode*~~ display *(display present but not driver-viewable, driver still has VCI LEDs to view)* at the same time as VSCADA performs monitoring and data acquisition along with possible maintenance and experimentation through the PC *or cell phone (Out of Scope)* interface. Charging the battery in plug and forget mode shall be possible simultaneous with maintenance, monitoring and data acquisition. Except when overridden in maintenance mode, safety rules and limits shall prevent conflicting or unsafe operation.	X
R002-15	*A wireless link shall be provided for communication between the car VSCADA and the off-car interfaces.*	*N/A (Out of Scope)*
R002-16A	At a minimum, the following measurands shall be monitored and stored by the VSCADA. • Overall voltage, current, and power delivered to the load. • Individual cell voltages, aggregate pack voltage, and total TSV • Tractive System DC current, and motor phase currents. • *Sensor outputs required to diagnose failure in the pack fuse and the AIRs. (Out of Scope)*	X

	• Rate of charge or discharge of the aggregate accumulator and individual cells and estimate of their state of charge • Temperatures of ambient, all subsystems, individual cells in the accumulator, and significant fuses or other devices that may heat up normally or as a result of an anticipated fault. • Data available from the motor controller. • Vehicle Speed and distance travelled • *Data available from a GPS or INS located on-car. (Out of Scope)*	
R002-16B	• Data available from the Dyno Test Stand, including torque and RPM	T000 (hard-coded)
	Shown in T000 and DYNO's ATR.	
R002-17	Uncertainty of these measurands shall be analyzed and specified in D011.	X
R002-18	It shall be possible to measure individual parameters up to 60 times a minute or at slower rates. All parameters shall have their values logged electronically along with a timestamp at some minimum rate. Sampling rates shall be individually programmable for each measurand.	T000 (DYNO only)
	It is currently hard-coded, and therefore is programmable but not configurable.	
R002-19	Plots of measurands versus time shall be generated.	T000 (DYNO only)

		
R002-20	Fuel gauge displays of State of Charge (SoC) shall be generated.	X
R002-21	In addition, the VSCADA system shall log any events, exceptions, faults, or changes in operational state of the LFEV, including safety interface events.	T000
	Logging can be seen in the picture above. However, the safety interface is not implemented.	
R002-22	The VSCADA data storage shall have sufficient capacity for retaining data records over the lifetime of the system.	D017
	If the user operates according to D017 (saving data regularly) then the data will be stored and no data will be lost.	
R002-23	Auto-detecting hardware, rather than static configuration, is encouraged. It is critical that the system adapt automatically and safely to different numbers of cells and packs. It shall not be necessary to explicitly configure VSCADA with the cell or pack counts.	X
R002-24	The LFEV system shall use a commercial motor controller with a computer interface already installed. VSCADA shall use this interface to access, record, and display all available motor controller data in a form that is integrated with the overall LFEV data display.	T000

R002-25	The LFEV system shall use a commercial dynamometer with a data acquisition sensor hardware already installed. VSCADA shall use the data acquisition hardware interface to access, record, and display all available dynamometer data in a form that is integrated with the overall LFEV data display.	T000
	As seen in T000 and DYNO's ATR.	
R002-26	*VSCADA shall be capable of closed loop control and "scripting" of Motor Controller System (MCS) Test Stand operation. Specifically, it shall be possible to set motor RPM and torque through closed loop control as a function of time. Various dynamic scenarios such as trapezoidal profiles simulating actual car dynamics on the competition racecourse shall be programmable.*	*N/A (Out of Scope)*
R002-27	The VSCADA system shall be expandable to allow the incorporation of additional sensors, measurands, and control functions. Expansion shall be accomplished in a way that does not require recompiling software to make configuration changes.	X
R002-28	Data storage shall be accumulated in a portable, non-proprietary format readily usable by commonly available data analysis tools.	I
	Csv file is used and DYNO team uses EXCEL to analyze data, as seen in DYNO's ATR and QA audit.	
R002-29	All VSCADA software should automatically initialize when car GLV is powered up. It should not be necessary to manually run various programs and edit files to get the system going after a reboot or power outage.	X
R002-30A	The capability to set alarms and shutdown rules shall be provided. At a minimum it shall be possible to have the VSCADA system automatically log an event, enable an alarm, or declare a fault to shut down the LFEV should a monitored parameter cross some predefined threshold or leave some range. It shall be possible to add and alter alarm rules without	X

	recompiling the system. Rule definitions shall be flexibly programmable.	
R002-30B	Rules shall be capable of defining arithmetic, logical, or algorithmic (script calculated) combinations of measured parameters or conditions.	X
R003	**VSCADA API, SDK and Applications**	
R003-1	The LFEV-Y3-2015 shall provide a fully documented software VSCADA Applications Programming Interface (API) and a System Development Kit (SDK) that an applications programmer can use to write software applications that control and monitor all interfaces and functions supported by the VSCADA.	X
R003-2	The scope of the API must be sufficient to maintainably support both low level debugging applications and high-level automated applications on all the hardware platforms in use. The exact same API must be used for all applications running on or offcar.	X
R003-3	The SDK must include a complete tool chain, with compilers, linkers, libraries, include files, utilities, compilers, as well as developer level documentation. All tools shall be actively supported and mature.	D003
	The SDK installation steps are put on a wiki page on VSCADA's bitbucket.org, which is linked to the LFEV 2015 site.	
R003-4	All sources must be maintained under configuration control.	I
R003-5	The complete SDK, including API documentation and application source under configuration control shall be delivered to or linked by the project web site.	I
R003-6	The API, SDK, and applications shall be copyrighted using open source practices. The team shall identify and GPL all software written by the team.	X
R003-7	Maintainability of the API/SDK and associated applications is critical. This aspect shall be reviewed in D012.	D012

R006	**GLV**	
R006-1	GLV voltage, *current (Out of Scope),* temperature*, and SOC (Out of Scope)* shall be measured by VSCADA.	X
GPR	**General Project Requirements**	
GPR001	Documentation	I
GPR005	Safety and Good Practice	I
GPR006	Reliability	X
GPR007	Maintainability	T002, D012
GPR008	Manufacturability	D018
GPR011	Project Video and Final Demonstration	I
GPR012	Final Disposal of Projects	I

Appendix B: Inspection Guide

Requirement	Description	P / F	Date
R002-1	VSCADA computer hardware shall be provided as required to handle the VSCADA user interface and processing requirements. This includes on-car and off-car functions.	F	5/15/2015
R002-28	Data storage shall be accumulated in a portable, non-proprietary format readily useable by commonly available data analysis tools.	P	5/15/2015
R003-4	All sources must be maintained under configuration control.	P	5/15/2015 (see repository bitbucket.org)
R003-5	The complete SDK, including API documentation and application source under configuration control shall be delivered to or linked by the project web site.	P	5/15/2015 (see sites)

GPR001	Documentation		
GPR005	Safety and Good Practice	P	5/15/2015 (we remain safe throughout the semester)
GPR011	Project Video and Final Demonstration	P	5/15/2015
GPR012	Final Disposal of Projects		

Inspection

_____ _____

Examiner Signature **Date**

Appendix C: Analysis Requirements

Requirement	Description	P / F
D003	**Maintenance Manual**	
R002-2	VSCADA software shall be a suite of applications built to a unified API with common data formats, protocols, look and feel. To the greatest extent possible, the same core system must run on various hardware platforms in and around the LFEV components.	F
R003-1	The LFEV-Y3-2015 shall provide a fully documented software VSCADA Applications Programming Interface (API) and a System Development Kit (SDK) that an applications programmer can use to write software	P (API is not unified but should be sufficient

	applications that control and monitor all interfaces and functions supported by the VSCADA.	for future developers)
R003-2	The scope of the API must be sufficient to maintainably support both low level debugging applications and high-level automated applications on all the hardware platforms in use. The exact same API must be used for all applications running on or offcar.	F
R003-3	The SDK must include a complete tool chain, with compilers, linkers, libraries, include files, utilities, compilers, as well as developer level documentation. All tools shall be actively supported and mature.	P
R003-6	The API, SDK, and applications shall be copyrighted using open source practices. The team shall identify and GPL all software written by the team.	
D011	**Calibration and Accuracy Analysis**	
R002-17	Uncertainty of these measurands shall be analyzed and specified in D011.	P (see DYNO QA audit)
D012	**Maintainability Plan**	
R003-7	Maintainability of the API/SDK and associated applications is critical. This aspect shall be reviewed in D012.	
GPR007	Maintainability	
D016	**Reliability Report**	
GPR006	Reliability	
D017	**Maintainability Report**	
R002-6	A backup system or recovery strategy must be developed to allow the VSCADA system to be promptly repaired after a hardware failure (e.g. bad hard disk, accidental disk formatting, broken CPU, etc…) in less time than the MTTR given in GPR007.	P
R002-22	The VSCADA data storage shall have sufficient capacity for retaining data records over the lifetime of the system.	P
D018	**System Bill of Materials**	

GPR008	Manufacturability	

Analysis

Examiner Signature **Date**

Appendix D: Test Results Form

T000 - DYNO Maintenance App Operation

Date of Test: _____ Time of Test: _____
Person(s) Performing Test(s): _____
ECE Professor(s) Witnessing Test(s): _____
(This test is based on the test ran by DYNO team, as they recorded in their ATR. VSCADA team did not run any of these tests.)

Test	Passing Criteria	Results (if any)	P / F
T000-1	DYNO parameter is being logged at rate of 1 sample every second.	The graph is changing and updating at about once every second.	P
T000-2	DYNO parameter is being logged at rate of 1 sample every two seconds.	The graph is changing and updating at about once every second.	P
T000-3	DYNO parameter data is properly saved to CSV file.	After click the save button a window pops up asking for directory.	P
T000-4	All DYNO GUI components are usable and operate in an expected manner.	The whole test runs without software failures.	P
T000-5	Safe system shutdown occurs.	The Emergency shutdown button which was implemented works.	P

_____ _____
Examiner Signature Date

T001 - Maintainability Test

Date of Test: 5/15/2015 **Time of Test:** _____
Person(s) Performing Test(s): _Bikram Shrestha_____
ECE Professor(s) Witnessing Test(s): _None_____

Test	Passing Criteria	Results (if any)	P / F
T001-1	VSCADA software is successfully installed on the vanilla Linux distribution.	This can be done either by downloading source codes from the site and install them or simply by mirroring one of the working Linux virtual.	P

_____ _____
Examiner Signature **Date**