System Test Plan

For

Portable Ultrasound Device for Coda-Wave Interferometry

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v1.0 Kisellus, Baker, Foxworthy, Fox, and Coppedge	Draft from 1st semester	21Feb2024
V1.1 Kisellus	Formatting and editing all pages	22Feb2024
V1.2 Baker	Updated cooling system testing.	10Mar2024
V1.3 Baker	Feedback from TA, removal of unnecessary cases	21Mar2024
V1.4 Baker	Combined two cases testing the same thing, corrected missing inputs for tests	4Apr2024

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1.   Introduction

Bridges are vital transportation infrastructure that are used daily by millions of people. Like any constructed work, the material used has a finite lifespan and will degrade as both the effects of nature and its designed purpose act on the bridge. Being able to determine locations of failure points, subsurface cracks, and voids in building materials such as concrete can greatly increase the ability for an engineering team to predict future issues and plan remedial work for a bridge. To assist those engineers, the Portable Ultrasound Device (PUD) was designed. This device can be used in conjunction with ultrasonic transducers to detect anomalies within concrete. The data collected can be used to make future engineering decisions.

1.1 Purpose

This document is a test plan for the Portable Ultrasound Device (PUD) Testing, produced by the System Testing team. It describes the testing strategy and approach to testing the team will use to verify that the application meets the established requirements of the client prior to release.

1.2 Objectives

- Meets the requirements, specifications, and Client rules.
- Supports the intended clients' functions and achieves the required standards.
- Satisfies the Entrance Criteria for User Acceptance Testing.
- Complies with electrical safety requirements to ensure operator safety.

2.   Functional Scope

The scope of the PUD is to utilize an internal electrical system to control and generate high voltage pulses through a piezoelectric transducer to push ultrasound waves through a sample of concrete, capture the resultant sound waves, process them through an internal oscilloscope, and capture the processed signals for analysis by an off-site lab. The PUD will also have an internal cooling system to maintain safe operating conditions for the components, a control system to maintain the testing for 48-72 hours, a software system to produce, capture, and record the pulses created by the system, and a hardware system to allow the engineer to do this with a portable unit that can be carried in one hand and left on-site unattended.

3.   Overall Strategy and Approach

3.1 Testing Strategy

Portable Ultrasound Device System Testing will include testing of all functionalities that are in scope (Section 2) identified. System testing activities will include the testing of new functionalities, modified functionalities, screen level validations, work flows, functionality access, testing of internal & external interfaces.

The following 3.1 sections describe overall how the testing types will be evaluated.

3.1.1 Electrical subsystem testing

Test objective: The PUD's Electrical subsystem works according to the listed requirements presented on the SRS.

Technique: Apply normal operating voltage to parts of the system and verify proper operation using test equipment.

Completion criteria: When all tested components match expected value range from the test case list below in section 4. All failed tests are troubleshot, repaired, and pass retest.

Special considerations: Some tests will involve 500V and require proper electrical safety precautions to test.

3.1.2 Cooling subsystem testing

Test objective: The PUD's Cooling subsystem works according to the listed requirements presented on the SRS.

Technique: After connecting the fan to the controller and the controller to the pico, we assign the fan speed lookup table IAW the controller's documentation and then expose the controller to controlled temperature changes of approximately ±10C and observe the output fan speed accordingly via a visual inspection and tactile increase in the amount of airflow.

Completion criteria: The fan's RPMs increase and decrease with exposure to higher and lower ambient temperatures IAW SRS and the EMC2101 specifications.

Special considerations: N/A

3.1.3 Data processing subsystem testing

Test objective: The PUD's Data processing subsystem works according to the listed requirements presented on the SRS.

Technique: Once the receiver section is assembled, a power on and function test will be performed. A test sine wave will be applied to the input and the data will be collected and stored.

Completion criteria: A complete sine wave will be reconstructed from the data collected.

Special considerations: This test should be completed before total assembly. This test should show a complete sine wave with no gaps and with consistent sampling.

3.1.4 Transmission/ Reception subsystem testing

Test objective: The PUD's Transmission/ Reception subsystem works according to the listed requirements presented on the SRS.

Technique: The transmitter will be switched on, powered, and triggered. The receiver will be switched on, powered, and triggered.

Completion criteria: For the TX the transmitter must supply a full 500V signal with a

ramp time of under 50ns, and a 2us pulse. RX must receive a signal between 0V and 1V, the signal must be complete in nature.

Special considerations: N/A

3.1.5   Control subsystem testing

Test objective: The PUD's Control subsystem works according to the listed requirements presented on the SRS.

Technique: Apply inputs via the control switches.

Completion criteria: Microcontroller registers the input and can produce the correct, corresponding output.

Special considerations: N/A

3.1.6   Exterior casing/mounting subsystem testing

Test objective: The PUD's Exterior casing/mounting works according to the listed requirements presented on the SRS.

Technique: Apply gradually stronger forces to mounted components. This will build up to a drop test.

Completion criteria: Components do not move, do not disconnect, and are not damaged by the focus applied to them.

3.1.7   Overall system functionality testing

Test objective: The PUD system as a whole works according to the listed requirements presented on the SRS.

Technique: Operate the PUD system to verify the unit works as expected for normal operating conditions.

Completion criteria: When all tests are passed from the test case list below in section 4. All failed tests are troubleshot, repaired, and pass retest.

Special considerations: The system is expected to operate outside for the duration of normal testing. But must be monitored to prevent theft or unexpected error.

3.2 System Testing Entrance Criteria

To start system testing, certain requirements must be met for testing readiness.
The system must be completely constructed or for the case of subsystems that sub system is complete. For electrical wiring the system is inspected with a fluke/multimeter prior to initial use. Tests may also be performed to verify individual components operate properly prior to system completion.

3.3 Testing Types

3.3.1   Electrical subsystem testing

This testing encompasses the requirements for testing related to the operation of the electrical system for the PUD system. The goal of Electrical subsystem testing is to produce a safe, reliable, and requirement satisfying electrical distribution system.

System Requirements Specification, 5.2.3: "The safety lock shall be electrically isolated from any of the high voltage components to prevent shock."

System Requirements Specification, 5.1.1: "The system shall operate for 48 to 72 hours without recharging the internal battery."

System Requirements Specification, 6.3: "The electrical distribution system shall not exceed a component's rated limits, as shown in its related datasheet."

System Requirements Specification, 6.4: "The electrical system shall have no faulty components."

System Requirements Specification, 6.8: "The electrical system shall have no unintended paths to ground."

3.3.2   Cooling subsystem testing

This testing encompasses the requirements for testing related to the operation of the cooling system for the PUD system. The goal of cooling subsystem testing is to produce a safe, reliable, and requirement satisfying cooling and heat dispersion system.

System Requirements Specification, 4.2.3.1: "The system shall be able to monitor internal temperatures within the unit."

System Requirements Specification, 4.2.3.2: "The system shall run the cooling fan via pulse-width modulation in accordance with a pre-programmed hysteresis curve"

System Requirements Specification, 4.2.3.3: "The system shall shut down in the event that temperatures cannot be reduced below the danger level."

3.3.3   Data processing subsystem testing

This testing encompasses the requirements for testing related to the operation of the data processing system for the PUD system. The goal of data processing testing is to produce a reliable and requirement satisfying data processing system.

System Requirements Specification, 3.2.6: "The Computer shall send commands to the SD card to record the received signal."

System Requirements Specification, 3.2.7: "The SD card will store data and be kept in a computer and MATLAB readable format."

System Requirements Specification, 3.3.2: "Raw data from the receiving transducer shall be sent to SD card by the oscilloscope using .mat format"

System Requirements Specification, 3.4.1: "The Raspberry Pi Pico will use the SPI bus to move data between internal components."

System Requirements Specification, 4.1.3.4: "The system shall convert the analog signal received from the receiver transducer into a digital signal which can be recorded."

System Requirements Specification, 4.1.3.5: "The system shall be able to save the data received from the receiving transducer to a SD card."

System Requirements Specification, 4.1.3.6: "The system shall have greater than or equal to 35 GB of storage space to store test data."

3.3.4 Transmission/ Reception subsystem testing

This testing encompasses the requirements for testing related to the operation of the Transmission/ Reception system for the PUD system. The goal of Transmission/ Reception subsystem testing is to produce a safe, reliable, and requirement satisfying Transmission/ Reception distribution system.

System Requirements Specification, 3.2.5: "The ADC or oscilloscope shall receive inputs from the transducer receiver."

System Requirements Specification, 3.2.6: "The TX will have a ramp time of under 50ns"

System Requirements Specification, 4.1.3.1: "The electrical system shall produce 500 V 2μsec test pulse."

3.3.5 Control subsystem testing

This testing encompasses the requirements for testing related to the operation of the Control system for the PUD system. The goal of Control subsystem testing is to produce a safe, reliable, and requirement satisfying Control system.

System Requirements Specification, 3.2.1: "The push buttons shall input commands to the Raspberry Pi Pico"

System Requirements Specification, 3.2.2: "The Raspberry Pi Pico shall send a switching signal to the MOSFET to gate the 500v input on and off."

System Requirements Specification, 3.2.3: "The Raspberry Pi Pico shall send PWM or digital switching signals to the cooling fan to control its speed and on/off status."

System Requirements Specification, 3.2.4: "The Raspberry Pi Pico shall send commands to the status and alarm LEDs to turn on or off"

System Requirements Specification, 4.1.3.2: "The control system shall be able to gate the test signal on and off within 2μsec"

System Requirements Specification, 4.1.3.3: "The system shall be able to produce 50 test signals with 100μsec interval between the test pulses."

System Requirements Specification, 4.3.3.2: "The system shall turn power on for the overheated LED on the alarm panel if temperature exceeds or is equal to 125°F for more than 1 min."

System Requirements Specification, 4.3.3.3: "The system shall shut down if temperature exceeds or is equal to 130°F for more than 30 seconds."

System Requirements Specification, 4.3.3.4: "The system shall be able to monitor SD card status."

System Requirements Specification, 4.3.3.4.1: "The system shall power on if no SD card is inserted and flash the "SD Card Full" and "Power" LEDs if the card is not present."

System Requirements Specification, 4.3.3.4.2: "If no SD card is present, the machine shall not perform the test phase."

System Requirements Specification, 4.3.3.5: "The system shall turn power on for the SD card full LED on the alarm panel if the SD card is 95% of max storage capacity."

System Requirements Specification, 4.3.3.6: "The system shall record over the oldest data on the SD card if the error is not corrected."

System Requirements Specification, 4.3.3.7: "The system shall be able to monitor battery voltage."

System Requirements Specification, 4.3.3.8: "The system shall turn power on for the low battery LED on the alarm panel if the battery voltage drops to or below 10.5."

System Requirements Specification, 4.3.3.9: "The system shall turn off the system if battery voltage is below 10V for greater than 1 min."

3.3.6   Exterior casing/mounting subsystem testing

This testing encompasses the requirements for testing related to the Exterior casing/mounting system for the PUD system. The goal of Exterior casing/mounting subsystem testing is to produce a safe, reliable, and requirement satisfying Exterior casing/mounting distribution system.

System Requirements Specification, 4.4.3.1: "SD Card slot shall be protected by an external cover that requires external action to open."

System Requirements Specification, 4.4.3.2: "SD Card shall contain a locking latch mechanism."

System Requirements Specification, 4.4.3.3: "SD Card slot shall present an alignment guide to ensure proper insertion."

System Requirements Specification, 5.2.1: "The system shall have an external safety lock to protect the user from high voltages present within."

System Requirements Specification, 5.2.2: "The system shall have a warning posted on the outside to alert the user to secure power and wait 5 minutes prior to opening due to risk of shock from high voltage supply and capacitor bank."

System Requirements Specification, 6.1: "The case shall be able to withstand a fall from 1 ft and protect the contents of the case"

System Requirements Specification, 6.2: "The case shall be water resistant and be able to protect the contents from water penetration from rain"

System Requirements Specification, 6.7: "The electrical system components shall be securely mounted to the casing."

3.3.7 Overall system functionality/PUD testing

This testing encompasses the requirements for testing related to the operation of the PUD system that is not covered by the subsystems. The goal of PUD testing is to produce a safe, reliable, and requirement satisfying system for the client.
Note: This section also contains requirements for any remaining tests

System Requirements Specification, 3.2.8: "A laptop separate from the PUD shall run the MATLAB software required to analyze the raw data."

System Requirements Specification, 3.3.3: "Laptop using MATLAB shall retrieve data from SD card."

System Requirements Specification, 3.3.4: "Laptop shall be running Windows 10 or later."

System Requirements Specification, 3.3.5: "Laptop shall have Thonny and MATLAB installed."

System Requirements Specification, 5.4.1: "All system components shall be tested prior to installation"

System Requirements Specification, 5.4.2: "The system when fully constructed shall be tested using a test plan."

System Requirements Specification, 5.4.3: "A parts list shall be provided along with the finished product to the user."

System Requirements Specification, 5.5.1: "Only personnel who have read the operating manual should operate the equipment."

3.4 Suspension Criteria and Resumption Requirements

This section will specify the criteria that will be used to suspend all or a portion of the testing activities on the items associated with this test plan.

3.4.1 Suspension Criteria

Testing will be suspended for a sub system or the whole system if a component within the sub

system breaks or is damaged.

Testing will also stop if any team member expresses a concern with safety or believes the system to be unsafe in the testing condition used.

3.4.2   Resumption Requirements

After the system is restored to a fully functional and safe state.

Permission to resume testing will be authorized by the team leader.

4.   Execution Plan

4.1 Execution Plan

The execution plan will detail the test cases to be executed. The Execution plan will be put together to ensure that all the requirements are covered. The execution plan will be designed to accommodate some changes, if necessary, if testing is incomplete on any day. All the test cases of the projects under test in this release are arranged in a logical order depending upon their inter dependency.

The test plan for the PUD system is as follows:

4.1.1   Electrical subsystem testing (3.1.1)

4.1.2   Cooling subsystem testing (3.1.2)

4.1.3   Control subsystem testing (3.1.5)

4.1.4   Data processing subsystem testing (3.1.3)

4.1.5   Exterior casing/mounting subsystem testing (3.3.6)

4.1.6   Transmission/ Reception subsystem testing (3.1.4)

4.1.7   Overall system functionality testing (3.1.7)

Requirement (From SRS)	Test Case Identifier	Input	Expected Behavior	Pass / Fail
Electrical subsystem testing				
5.2.3: The safety lock shall be electrically isolated from any of the high voltage components to prevent shock.	1.1	Engineer attempts to open the case.	Lock prohibits non forceful entry to the interior of the device without a key.	Pass
5.1.1: The system shall operate for 48 to 72 hours without	2.1	Activate system for 72-hour test	Battery shall be above 10 V by end of test	

recharging the internal battery.				
6.3: The electrical distribution system shall not exceed a component's rated limits, as shown in its related datasheet.	3.1	12.8v from battery, 5v from converter 500v from converter	All electrical components listed below are operating within the data sheet specified voltage, current, and power limits: (apply a required voltage or measure a resistance and get an expected result from the component/ not a faulty part and operate as intended.) Mosfet rated for 20v has less than 1 ohm resistance at 3.3v control signal as specified in the data sheet. Mosfet rated for 500v has less than 1 ohm resistance at 12v control signal as specified in data sheet resistor rated for 390, 2.5k, 27k, match expected resistance value plus or minus tolerance range specified in data sheet. LED's illuminates and does not exceed current limits specified in data sheet battery voltage matches expected value 10v to 14.5 v specified in the data sheet. dc to dc, 5v, 20v, 500v converters produce 5v, 20v, or 500v depending upon the data sheet specified value. wire has no damage to insulation and has resistance exceeding 1 mega ohm Fuse's rated for 5A and 6.5A have resistance less than 1 ohm Switches are over 1M ohm when open and less than 1 ohm when shut. operational at required 12 or 500v (2 different switches).	Pass
6.4: The electrical system shall be tested for faulty components.	4.1	Variable DC source (A variable DC source uses a rheostat to change its output voltage. Hence the voltage is	All electrical components operate per data sheet requirements prior to instillation: (apply a required voltage or measure a resistance and get an expected result from the	Pass

		variable and changes according to the user's needs.) 0 to 100 vDC as required by the tester.	component/ not a faulty part and operate as intended.) Mosfet rated for 20v has less than 1 ohm resistance at 3.3v control signal as specified in the data sheet. Mosfet rated for 500v has less than 1 ohm resistance at 5v control signal as specified in data sheet resistor rated for 390, 2.5k, and 27k, match expected resistance value plus or minus tolerance range specified in data sheet. No burnt-out resistors. LED's illuminate when 3.3v applied. battery voltage matches expected value 10 v to 14.5v specified in the data sheet. dc to dc, 5v, 20v, 500v converters produce 5v, 20v, or 500v depending upon the data sheet specified value. wire has no damage to insulation and has resistance exceeding 1,000,000 ohms. No shorts to ground. Fuse's rated for 5A and 6.5A have resistance less than 1 ohm Switches are over 1M ohm when open and less than 1 ohm when shut. Switch operates from open to shut and shut to open.	
6.5: The electrical system shall produce 5,12, and 500V DC. Within 5%	5.1	12.8v from battery, 5v from converter 20v from converter 500v from converter	All electrical sources produce power per data sheet specifications. Battery produces 10 to 14.5v 5v converter produces 5 v 20 v converter produces 20v 500v converter produces 500v plus, or minus data sheet specified tolerance bands	Pass
6.8: The electrical system shall have no unintended paths to ground.	7.1	12.8v from battery, 5v from converter 20 v from converter	System has no unintended grounds and operates as intended. No resistance less than 1 M ohm to the casing.	Pass

		500v from converter		
Cooling subsystem testing				
4.2.3.1: The system shall be able to monitor internal temperatures within the unit.	8.1	Ambient air temperature	Thermal sensors accurately output the temperature of the air around it.	Pass
4.2.3.2: The system shall run the cooling fan via pulse-width modulation in accordance with a pre-programmed hysteresis curve	9.1	5V from Battery TACH & FAN from fan Ambient Temperature	As temperature rises, fan speed increases and as temperature falls, fan speed decreases IAW hysteresis curve.	Fail, due to lack of FAN lead
Control subsystem testing				
3.2.1: The push buttons shall input commands to the Raspberry Pi Pico	12.1	Push button controls	Input controls shall have the desired effect on the control of the system.	
3.2.2: The Raspberry Pi Pico shall send a switching signal to the MOSFET to gate the 500v input on and off.	13.1	Switching signal from Pico	The Raspberry Pi controller shall gate the MOSFET on and off to create the desired waveform.	
3.2.3: The Raspberry Pi Pico shall send PWM or digital switching signals to the cooling fan to control its speed and on/off status.	14.1	Most likely a temp sensor	The Raspberry Pi shall monitor internal temperatures of the box constantly and gate the fans on and off according to design specs of cooling system.	
3.2.4: The Raspberry Pi Pico shall send commands to the status and alarm LEDs to turn on or off	15.1	Signal from Pico	The Raspberry Pi shall send signals to the LEDs that accurately depict system status.	
4.1.3.2: The control system shall be able to gate the test signal on and off within 2μsec	18.1	Test signal	The MOSFET shall be turned on within 2μsec	
4.1.3.3: Signal testing for duration and quantity	19.1	Control software directive	The system shall be able to produce 50 test signals with 100μsec interval between the test pulses.	
4.3.3.2: Overheat alarm test	20.1	Temperature sensor forced to max	The system shall turn power on for the overheated LED on the alarm panel if temperature exceeds or is equal to 125°F for more than 1 min	
4.2.3.3, 4.3.3.3: Overheat shutdown Test	21.1	Temperature sensor forced to max	The system shall shut down if temperature exceeds or is equal to 130°F for more than 30 seconds.	
4.3.3.4: The system shall be able to monitor SD card status.	22.1	SD card data	The system shall have a way to show monitor SD card storage used and remaining, alerting the user if there is an issue	

4.3.3.4.1: SD card missing test	23.1	SD Card removed	The system shall power on if no SD card is inserted and flash the "SD Card Full" and "Power" LEDs if the card is not present.	
4.3.3.4.2: SD card missing redundancy test	24.1	SD Card removed	If no SD card is present, the machine shall not perform the test phase.	
4.3.3.5: The system shall turn power on for the SD card full LED on the alarm panel if the SD card is 95% of max storage capacity.	25.1	Data on SD card	The Raspberry Pi shall read the amount of data currently on the SD card. If data on card is equal to 95% or more of total storage capacity the Raspberry Pi shall turn on the SD Card Full LED.	
4.3.3.6: The system shall record over the oldest data on the SD card if the error is not corrected.	26.1	Full SD Card	Instead of throwing away new data the system shall overwrite data starting with the oldest collected.	
4.3.3.7: The system shall be able to monitor battery voltage.	27.1	Voltage from battery	The Raspberry Pi should have access to the voltage coming off the battery	
4.3.3.8: The system shall turn power on for the low battery LED on the alarm panel if the battery voltage drops to or below 10.5.	28.1	Voltage from battery	The Raspberry Pi shall turn on the low Battery LED if voltage coming off of battery drops below 10.5	
4.3.3.9: The system shall turn off the system if battery voltage is below 10V for greater than 1 min.	29.1	Voltage from battery	The Raspberry Pi shall start an internal timer every time the battery drops below 10V. If this state remains constant for 60 seconds or longer the Raspberry Pi shall power down the system.	
Data processing subsystem testing				
3.2.6: The computer shall send commands to the SD card to record the received signal.	30.1	Data from computer	There is stored data on the SD card	
3.2.7: The SD card will store data and be kept in a computer and MATLAB readable format.	31.1	Data from computer	The data on the SD card is readable, non-corrupted, and in a .mat format	
3.3.2: Raw data from the receiving transducer shall be sent to SD card using .mat format	32.1	Data from computer Received transducer signal	The data on the SD card is readable, non-corrupted, and in a .mat format	
3.4.1: The Raspberry Pi Pico will use the SPI bus to move data between internal components.	33.1	Data from component	The SPI bus is communicating with other components	
4.1.3.4: The system shall convert the analog signal received from the receiver transducer into a digital signal which can be recorded.	34.1	Signal from transducer	The oscilloscope will receive the signal and record it.	

4.1.3.5: The system shall be able to save the data received from the receiving transducer to a SD card.	35.1	Data from oscilloscope	The data on the SD card is readable, non-corrupted, and in a .mat format	
4.1.3.6: The system shall have greater than or equal to 35 GB of storage space to store test data.	36.1	Specifications of Computer and SD Card	A SD card will be greater than 31GB and the computer will have storage greater than 5GB	
Exterior casing/mounting subsystem testing				
4.4.3.1: SD Card slot shall be protected by an external cover that requires external action to open.	37.1	N/A	Outside dust, debris, and water should not be able to easily enter the SD card slot.	
4.4.3.2: SD Card shall contain a locking latch mechanism.	38.1			
4.4.3.3: SD Card slot shall present an alignment guide to ensure proper insertion.	39.1	Insert an SD card to ensure alignment allows for operation.	SD card can be inserted easily.	
5.2.1: The system shall have an external safety lock to protect the user from high voltages present within.	40.1	Give locked system to an unauthorized user.	Unauthorized user should not be able to open the case of the system.	Pass
5.2.2: The system shall have a warning posted on the outside to alert the user to secure power and wait 5 minutes prior to opening due to risk of shock from high voltage supply and capacitor bank.	41.1	N/A	A user should be able to clearly see the warning posted on the case of the system.	
6.1: The case shall be able to withstand a fall from 1 ft and protect the contents of the case	42.1	Allow case to fall from 1 ft.	No components shall move, become disconnected, or damaged in any way, shape, or form.	
6.2: The case shall be water resistant and be able to protect the contents from water penetration from rain	43.1	Simulated water ingress with spray bottle		
6.7: The electrical system components shall be securely mounted to the casing.	44.1	The case will be shaken with moderate force.	No component shall become loose or be damaged.	Pass
Transmission/ Reception subsystem testing				
3.2.5: The ADC chip shall receive inputs from the transducer receiver.	45.1	1V Sine wave	A complete sine wave with consistent sampling	
4.1.3.1: The electrical system shall produce 500 V 2μsec test pulse.	46.1	12.8v from battery 5v from converter 3.3v control signal from control system	3.3v signal triggers MOSFET to allow 5v to trigger another MOSFET. Which allows 500v to be applied to the transducer port.	

Overall system functionality testing				
3.2.8: A laptop separate from the PUD shall run the MATLAB software required to analyze the raw data.	47.1	Data collected from tests	A user readable output will be displayed of the results of the ultrasound test	
3.3.3: Laptop using MATLAB shall retrieve data from SD card.	48.1	SD card containing test data from 72 hours of testing	Data from SD card shall be accessible and downloadable on the laptop	
3.3.4: Laptop shall be running Windows 10 or later. ■	49.1			
3.3.5: Laptop shall have Thonny and MATLAB installed.	50.1			
5.4.1: All system components shall be tested prior to installation	51.1			
5.4.2: The system when fully constructed shall be tested using a test plan.	52.1			
5.4.3: A parts list shall be provided along with the finished product to the user.	53.1	N/A		
5.5.1: Only personnel who have read the operating manual should operate the equipment.	54.1	N/A	Only authorized users will be given the code to open the system container.	

5. Traceability Matrix & Defect Tracking

5.1 Traceability Matrix

REQ ID	Criticality	Test Case IDs
4.1.3.1	Critical	46.1
5.2.3	Low	1.1
5.1.1	Medium	2.1
6.3	Critical	3.1
6.4	Critical	4.1
6.5	Critical	5.1
6.8	Critical	7.1
5.1.2	Critical	11.1
4.2.3.2	Medium	9.1

List of requirements, corresponding test cases

5.2 Defect Severity Definitions

Critical	The defect causes a catastrophic or severe error that results in major problems and the functionality rendered is unavailable to the user. A manual procedure cannot be either implemented or a high effort is required to remedy the defect. Examples of a critical defect are as follows: ● System abends ● Data cannot flow through a business function/lifecycle ● Data is corrupted or cannot post to the database
Medium	The defect does not seriously impair system function can be categorized as a medium Defect. A manual procedure requiring medium effort can be implemented to remedy the defect. Examples of a medium defect are as follows: ● Form navigation is incorrect ● Field labels are not consistent with global terminology
Low	The defect is cosmetic or has little to no impact on system functionality. A manual procedure requiring low effort can be implemented to remedy the defect. Examples of a low defect are as follows: ● Repositioning of fields on screens ● Text font on reports is incorrect

6.   Environment

6.1 Environment

The System Testing Environment will be used for System Testing.

Most testing will occur indoors in a controlled environment. The final test will be an outdoor test for 72 hours.

7.   Assumptions

Define test plan assumptions.

● The battery is fully charged prior to testing and the battery is in peak condition.

● The user does not open the outer casing without taking proper electrical safety precautions.

● The testing area is dry with mild to no weather interference.

● The user has read the operating procedure.

8. Risks and Contingencies

Define risks and contingencies.

Risk #	Risk	Impact	Contingency Plan
1	Electrical shock	High	Perform proper electrical safety procedures
2	Explosion	High	Distance requirement prior to initial startup or first-time operation.
3	Hand laceration/bruising	Medium	Ensure fans have external mesh to prevent physical ingress.

9. Appendices

Reference

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