**System Test Plan**

**For**

**Optical Communications System (OCS)**

Team Members: Jarrod Siglin, Sean Huber, Dominic Steiner, Dylan Koch, Cameron Martinez

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# Introduction

## Purpose

This document is a test plan for the Low-Cost Optical (Laser) Communication System 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 business prior to release.

## Objectives

* Meets the requirements, specifications and the Business rules.
* Supports the intended business functions and achieves the required standards.
* Satisfies the Entrance Criteria for User Acceptance Testing.

# Functional Scope

The Modules in the scope of testing for the Low-Cost Optical (Laser) Communication System Testing are mentioned in the System Requirements Specification document (SRS), attached to this document.

# Overall Strategy and Approach

## Testing Strategy

Low-Cost Optical (Laser) Communication System Testing will include testing of all functionalities that are in scope (Refer Functional Scope Section) identified. System testing activities will include the testing of new functionalities, modified functionalities, screen level validations, workflows, functionality access, testing of internal & external interfaces.

## System Testing Entrance Criteria

In order to start system testing, certain requirements must be met for testing readiness. The readiness can be classified into:

* + *Safety* – At risk individuals must be wearing the appropriate laser goggles. The laser must be harnessed properly so that it is not pointed towards any person accidentally. All connections must be secured so there is no risk of electrical damage or fires.
  + *Laser diode and sensor operability* – The laser diode, driver and sensor must be functioning under nominal conditions to ensure capability with other systems. This is to simplify functionality testing by eliminating their operability as the cause of the problem.

## Testing Types

### 3.3.1 Usability Testing

User interface attributes, cosmetic presentation and content will be tested for accuracy and general usability. The goal of Usability Testing is to ensure that the User Interface is comfortable to use and provides the user with consistent and appropriate access and navigation through the functions of the application (e.g., access keys, consistent tab order, readable fonts etc.)

3.3.1.1 The user shall be able to view the video stream through a web browser.

3.3.1.1.a: Testable through powering on the system, waiting for initialization, opening the static IP for the local webpage.

3.3.1.2 The user shall be able to view the video stream through a physical monitor connected to the Raspberry Pi.

3.3.1.2.a: Testable through powering on the system, waiting for initialization, viewing the stream on the receiver module.

3.3.1.3 The user shall be able to retrieve a copy of the video stream from the SD card installed on the Raspberry Pi.

3.3.1.3.a: Testable through removing the SD card in the Raspberry Pi receiver, navigating to /pirx/stream to find the local .mp4 files.

3.3.1.4 The user shall be able to start the system with a power switch.

3.3.1.4.a: Testable through plugging in the receiver system, the transmitter system battery and starting each system.

3.3.1.5 The user shall be able to access and modify the starting parameters of the system through a Secure Shell.

3.3.1.5.a: Testable through connecting the Raspberry Pi to either a local network or a physical display and accessing the terminal.

3.3.1.6 The user shall be able to take out and put back in the rechargeable batteries.

3.3.1.6a: Testable by having the user attempt this action. It should be easily accessible.

### 3.3.2 Functional Testing

The objective of this test is to ensure that each element of the component meets the functional requirements of the business as outlined in the:

* Business / Functional Requirements
* Other functional documents produced during the course of the project i.e. resolution to issues/change requests/feedback

3.3.2.1 The laser driver shall transmit a minimum of 4 mW of power.

3.3.2.2 The receiver and transmitter shall be properly aligned to ensure maximum power transfer.

3.3.2.3 The receiver shall produce a sinusoidal wave, to be displayed by oscilloscope, when the diode transmits an unmodulated signal.

3.3.2.4 The Raspberry Pi shall use On-Off-Keying (OOK) techniques to modulate the signal in accordance with information from the camera.

3.3.2.5 The receiver shall demodulate the signal to display the video.

3.3.2.6 The receiver shall be powered by a portable power supply.

3.3.2.7 The system shall be in a fixed and controlled environment with all stationary components for testing purposes.

3.3.2.8 All components for transmission and receiving end shall respectively fit in a 1ft x 1ft x 1ft volume space.

### 3.3.2.9 Transmission should occur through free space.

3.3.3.0 The system shall transmit up to a 250 KHz square wave signal.

### 3.3.3.1 The system shall receive up to a 250 KHz square wave signal and display via oscilloscope with limited distortion.

3.3.3.2 The system shall be able to transmit and receive an OOK scheme signal with limited distortion.

### 3.3.3 System Requirements Specification

System requirements Specification, 3.2.1: "The system shall communicate between a transmitter and receiver through an optical form.”

System requirements Specification, 3.2.2: " The system shall output a maximum of 5mW from laser diode.”

System requirements Specification, 3.3.1: “The system shall utilize a Raspberry Pi camera for video capture.”

System requirements Specification, 3.4.1: “The system shall utilize a Raspberry Pi 3 for encoding signal, using UART transmission standard, to the laser driver.”

System requirements Specification, 3.4.2: “The system shall use a Raspberry Pi 4 to decode the received data into MJPEG video. “

System requirements Specification, 3.5.1: “The system shall be powered by battery power while in an independent state (moveable).”

System requirements Specification, 3.6.1: “The system receiver shall utilize an amplifier to boost incoming signals from optical source.”

System requirements specification 3.7.1: “The system throughput shall be a 1 frame per second.”

System requirements specifications 3.8.1: “The system shall transmit and receive up to 250 kHz frequency.”

System requirements specification 3.8.2: “The system shall be capable of receiving an OOK modulated signal with limited bit error rate (BER). “

System requirements specification 3.9.1: “They system shall store and display the information from the sensor.”

## 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.

### Suspension Criteria

Testing will be suspended if the incidents found will not allow further testing of the system/application under-test. If testing is halted, and changes are made to the hardware, software or database, it is up to the Testing Manager to determine whether the test plan will be re-executed or part of the plan will be re-executed.

Incidents which would require suspension include:

* + Diode fails to transmit 5 mW of power.
  + Sensor is unable to detect signal from transmitter.
  + Raspberry Pi is unable to produce valid OOK modulated signal obtained from signal.
  + The signal is not properly modulated by Raspberry Pi.
  + The receiver is unable to demodulate signal and display video.
  + The receiver is unable to be powered by portable power supply.
  + Heat dissipation reaches above 110 degrees Fahrenheit.

### Resumption Requirements

Resumption of testing will be possible when the functionality that caused the suspension of testing has been retested successfully. Safety standards must also be addressed to ensure they are in line with entrance criteria.

# Execution Plan

## 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.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Requirement | Test Case Identifier | Input | Expected Behavior | Pass / Fail |
| 3.2.1 "The system shall communicate between a transmitter and receiver through optical form.” | 1.1.a | Laser diode sends and photodiode receives data | Laser diode sends data that photodiode can read | Pass |
| 3.2.1 "The system shall communicate between a transmitter and receiver through optical form.” | 1.1.b | Laser diode sends and photodiode receives data | Expect 1.1 V at the laser diode | Pass |
| 3.2.2 “The system shall output minimum 5mW at 3V from laser diode.” | 1.2 | Laser driver calibrated for 5mW transmission. | ThorLabs laser detector reads 5mW directly at diode. | Pass |
| 3.3.1 “The system shall utilize a Raspberry Pi camera for video capture.” | 2.1 | User provides input for camera | Camera can capture inputs |  |
| 3.4.1 “The system shall utilize a Raspberry Pi for encoding signal, using UART transmission standard, to the laser driver” | 3.1 | Camera video feed ported into Raspberry Pi | Video feed is encoded and fed to laser driver | Pass |
| 3.4.2 “The system shall use a Raspberry Pi to decode the received data into MJPEG video.” | 4.1 | Optical (laser) data into receiver | Camera feed from transmitter side in MJPEG video | Pass |
| 3.5.1 “The system shall be powered by battery power while in an independent state (moveable).” | 5.1 | 3300 mAH rechargeable lithium-ion battery | All components power off a single power source. |  |
| 3.6.1 “The system receiver shall utilize an amplifier to boost incoming signals from optical source.” | 6.1 | Data received at receiver from optical transmitter | Signal power boosted for better reading on display |  |
| 3.7.1 “The system shall be stationary and in a controlled environment for testing” | 7.1 | Access to the lab | Placement remains unchanged in between manipulation by group members | Pass |
| 3.8.1 “The transmission system shall fit within a 1ft x1ft x 1ft area” | 8.1a | Laser driver, power source, raspberry pi and laser diode with mount | All elements fit within the given area | Pass |
| 3.8.2 “The receiver system shall fit within a 1ft x1ft x 1ft area” | 8.1b | Receiver and receiver mount, raspberry pi, | All elements fit within the given area | Pass |
| 3.4.3 “The system shall utilize a 1550 nanometer laser diode for transmission” | 4.2 | Laser driver, raspberry pi | Laser diode sends light waves within the expected wavelength | Pass |
| 3.6.2 “The system shall transmit and receive non-video (text) data over wired serial connection for testing” | 9.1 | Raspberry pi TX and RX, network connection | Confirmation of ability to perform UART transmission of videos | Pass |
| 3.4.4 “The system photodetector shall detect in a range encompassing 1550 nanometers.” | 4.3 | Photodetector, laser diode | Photodetector displays readings upon receiving power from laser diode | Pass |
| 3.4.5 “The system shall save all data transmitted for ability to confirm proper transmission occurred." | 4.4 | Raspberry Pi, network connection | Data transmitted through the raspberry pi is uploaded |  |
| 3.7.2 “The system laser diode shall transmit at more than 2.5 milliwatts when separated by 6 inches.” | 9.2 | Laser diode, optical power meter | Power level measured is greater than or equal to 2.5 mW prior to transmitting | Pass |
| 3.9.1 “The system shall transmit a 1 KHz square wave.” | 10.1 | Laser driver, diode, photodetector, reciever | Expected peak to peak value of 20 V with a frequency of 1 KHz. | Pass |
| 3.9.2 “The system shall transmit a square wave at frequency 5 KHz.” | 10.2 | Laser driver, diode, photodetector, reciever | Expected peak to peak value of 20 V with a frequency of 5 KHz. | Pass |
| 3.9.3 “The system shall transmit a square wave at frequency 100 KHz.” | 10.3 | Laser driver, diode, photodetector, reciever | Expected peak to peak value of 20 V with a frequency of 10 KHz. | Pass |
| 4.0.1 “The system shall have a 230 kHz frequency throughput signal.” | 11.1 | Photodiode, receiver | Expected 1 frame per second throughput of video received. |  |

# Traceability Matrix & Defect Tracking

## Traceability Matrix

List of requirements, corresponding test cases

***Requirement* CRITICAL:** System requirements Specification, 3.2.1: "The system shall communicate between a transmitter and receiver through an optical form.”  
Test Case: Check the oscilloscope to observe the signal sent and compare to expected result.

***Requirement* CRITICAL:** System requirements Specification, 3.2.2: " The system shall output minimum 5mW from laser diode.”  
Test Case: Check the power level directly at laser diode using ThorLabs PM400 power meter.

***Requirement* CRITICAL:** System requirements Specification, 3.3.1: “The system shall utilize a Raspberry Pi camera for video capture.”

**Test Case:** Check for voltage and current being sent to Laser driver.

***Requirement* CRITICAL:** System requirements Specification, 3.4.1: “The system shall utilize a Raspberry Pi for encoding signal, using UART transmission standard, to the laser driver.”

**Test Case:** Check the signal being used for OOK modulation using oscilloscope.

***Requirement CRITICAL*:** System requirements Specification, 3.4.2: “The system shall use a Raspberry Pi to decode the received data into MJPEG video. “

**Test Cases:** Check signal with Oscilloscope to view serial data, Check reconstructed video stream on display.

***Requirement CRITICAL*:** System requirements Specification, 3.8.1: “The system shall transmit and receive up to 250 kHz frequency.

**Test Cases:** Check signal with Oscilloscope to view signal and check distortion and frequency.

***Requirement* MEDIUM:** System requirements Specification, 3.5.1: “The system shall be powered by battery power while in an independent state (moveable).”

**Test Case:** Check power usage for all system components does not exceed available power, Check voltage levels at valid locations along sub-systems.

***Requirement* MEDIUM:** System requirements Specification, 3.6.1: “The system receiver shall utilize an amplifier to boost incoming signals from optical source.”

**Test Case:** Check a boosted and non-boosted signal using oscilloscope to ensure proper amplification.

## 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 |

# Environment

## Environment

* The System Testing Environment will be used for System Testing.
  + Software
    - Python ver. 3.10.7 September 6, 2022
    - Raspberry Pi OS Lite ver. September 22, 2022
    - PL011 SoC UART ver. Nov 1, 2005
    - NumPy ver. 1.23.4 Oct 12, 2022
    - OpenCV ver. 4.6.0.66 June 8, 2022
    - Flask ver. August 8, 2022
  + Hardware
    - Raspberry Pi 0 W
    - USB-C Power Supply, 5.1V, 3.0A
    - 1550 nm, 5 mW Laser Diode
    - Thor Labs PBA20C2 Detector
    - ThorLabs Laser Power Meter PM400
    - Oscilloscope
    - LD2.5CHA Laser Driver
* All testing will be conducted in the MicaPlex lab (224), ensuring proper safety practices.

# Assumptions

This section outlines assumptions specific to this project:

* The system is tested in an enclosed space with proper safety equipment in place.
* The user understands how to correctly establish Line of Sight (LOS) between receiver and transmitter.
* The user understands how to properly set up the laser driver for operation.
* All sub-systems are properly connected.

# Risks and Contingencies

Define risks and contingencies.

|  |  |  |  |
| --- | --- | --- | --- |
| Risk # | Risk | Impact | Contingency |
| 1 | Damage to the receiver | High Impact  We will not be able to proceed and must purchase a new receiver to complete most tasks | The receiver should be turned off when not in use and changing the setup will be done with careful handling of equipment |
| 2 | Damage to the diode or driver | High Impact  We will not be able to produce a signal with a damaged diode or driver and may have to change the entire configuration for new components | The driver should not push past 3V and no more than 5mW will be put through the laser at any point in time |
| 3 | Damage to group members' eyes | High Impact  Permanant damage to eyes from concentrated infrared exposure | The laser output shall not go above 5 mW and if it does eye protection will be worn |
| 4 | Laser sensor cannot operate at specified baud rate. | Medium Impact  Video is unable to display properly. | New sensors may need to be considered depending on issues with display. |
| 5 | System power consumption exceeds 20 W. | Medium-High Impact  Excessive heat, which may become a hazard or may damage components. | Systems may need to be reconsidered or redesigned to lessen these harmful effects. |
| 6 | Damage to portable power source. | Medium Impact  Presents chance of chemical or heat burns to members or equipment. | Power source will be fixed to the system and will not be stored in harsh environments. |

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