| **Group** 13 | *Spring 2024 Design Challenge* |
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**Test and Evaluation Master Plan**

***Requirement Test Plan***

| ***Req No.*** | ***Test Method*** | ***Evaluation Method*** | ***Threshold*** | ***Objective*** |
| --- | --- | --- | --- | --- |
| ***10*** | *Add up the cost of all components and compare them to the budget.* | *Verify the cost of all components complies with the listed budget.* | *The cost of all components must be less than $300.* | *The cost should be as low as possible while meeting all other requirements.* |
| ***10.1*** | *Check the data transmission system.* | *Verify that the data transmission system utilizes a VLC system, specifically Li-Fi.* | *See visual output and have data be equal hex value post-transmission.* | *The system utilizes visible light to transmit and receive data.* |
| ***10.2*** | *Verify the md5sum data of the transmitted images matches the md5sum of the original images.* | *Code analysis in conjunction with a built-in test to verify that the hashes match.* | *All hashes of transmitted data and untransmitted data match.* | *Each hash should match with per image.* |
| ***10.3*** | *Check if there are 2 Raspberry Pi computers.* | *Visual confirmation that there are 2 Raspberry Pi devices.* | *2 Raspberry Pi computers give I/O responses.* | *Raspberry Pis can run test code to prove operational.* |
| ***10.4*** | *Check if both Raspberry Pis can transmit and receive data.* | *Visual confirmation that both Raspberry Pis have both laser and solar cells to send and receive data.* | *Both Raspberry Pi systems have a laser transmitter and solar cell receiver.* | *Each Raspberry Pi should have the ability to send and receive data.* |
| ***10.5*** | *Check coding language to ensure that either C, C++, or Python is used.* | *Visual confirmation that the transceiver system is coded in either C, C++, or Python.* | *No obscure language is used to code the transceiver application.* | *Code can compile with no errors.* |
| ***10.6*** | *Check if Empire Pi can download files from a USB drive.* | *Download sample files from a USB drive onto the Empire Pi.* | *files download successfully from USB without corruption.* | *Verify all files from the USB exist on the Raspberry Pi.* |
| ***10.7*** | *Check if each image format is the same after transmission.* | *Visual confirmation that each image format is the same for each image* | *Image formats are the same before and after transmission* | *Each image should show image format when opened in a text editor.* |
| ***10.8*** | *Check if there are obstructions between the transmitter and receiver during transmission.* | *Visual confirmation that there are no obstructions.* | *Transmitter and receiver can communicate efficiently with each other.* | *Transmitter and receiver should be able to communicate with each other with little to no obstruction.* |
| ***10.9*** | *Check that the transceiving system is powered by 10 volts or less.* | *Verify that the transceiving system can be powered by 10 volts or less using voltage readings.* | *Transceiving system is powered by 10 volts or less.* | *The power drawn should be as low as possible while meeting all other requirements.* |
| ***10.10*** | *Check if both Empire and Rebel transceiving systems take in 5V from their respective Raspberry Pi.* | *Verify that both Empire and Rebel transceiving systems can be powered by 5V from their respective Raspberry Pi using voltage readings.* | *Empire and Rebel transceiving systems take in* 5V±5% *from respective Raspberry Pis.* | *Empire and Rebel transceiving systems can take in 5V from their respective Raspberry Pis.* |
| ***20*** | *Look at the encrypted file to visually check the ciphertext in hex.* | *Visual confirmation of ciphertext and plaintext to ensure data is encrypted and decrypted.* | *Text should be encrypted and decrypted utilizing AES-256.* | *Transmission should be encrypted and decrypted using AES-256.* |
| ***20.1*** | *Check if data binaries are the same before and after transmission.* | *Verify data binaries are the same before and after transmission.* | *Data binaries are the same before and after transmission.* | *Data binaries should be the same before and after transmission.* |
| ***20.2*** | *Check if password is required for encryption and decryption.* | *Visual confirmation of password request for encryption and decryption functions* | *Password required to implement encryption and decryption of data.* | *Entered password encrypts or decrypts transmitted data.* |
| ***20.3*** | *Check that all group members know the password.* | *Verify all group members know the password key.* | *All group members know the password key.* | *Each group member enters the correct password to encrypt and decrypt the data.* |
| ***20.4*** | *Check that Rebel Raspberry Pi can decrypt encrypted messages from the Empire Raspberry Pi.* | *Verify that Rebel Raspberry Pi can decrypt encrypted messages from the Empire Raspberry Pi.* | *Rebel Raspberry Pi must decrypt encrypted messages from the Empire Raspberry Pi.* | *Rebel Raspberry Pi must decrypt encrypted messages from the Empire Raspberry Pi.* |
| ***30*** | *Verify an image processing application is on the device.* | *Verify an uploaded picture can be processed via the application.* | *Image evaluation must occur using PNG images.* | *The image evaluation application is able to process images for specific data points.* |
| ***30.1*** | *Verify the image evaluation application can identify 10 Death Star images out of 100.* | *Verify image evaluation software can correctly identify 10 images out of 100.* | *The image evaluation process must be able to identify the correct 10 images containing red circles out of 100 possible images.* | *The image evaluation program must be able to scan, process, and identify 10 images out of 100 that contain red circles.* |
| ***30.2*** | *Verify that the 100 images from the USB are successfully loaded onto the Empire Raspberry Pi.* | *Verify that all 100 images from the USB are copied onto the Empire Raspberry Pi.* | *All 100 images must be accessed and uploaded onto the Empire Raspberry Pi for image evaluation.* | *Confirm that all 100 images are accessed, copied, and prepared for image evaluation.* |
| ***30.3*** | *Visually confirm that the Empire Raspberry Pi has the image evaluation program installed and can be executed.* | *Verify that the image evaluation program is installed and can only be executed on the Empire Raspberry Pi.* | *Verify the image evaluation program is installed and can only be executed on the Empire Raspberry Pi.* | *The image evaluation program is used on the Empire Raspberry Pi to process the 100 images for the Death Star plans.* |
| ***40*** | *Check that it is a Linux script that converts data to md5 sums.* | *Verify that the Linux script converts data to md5 sums.* | *Data must be converted to md5 sums.* | *Create a Linux script that must be able to convert data to md5 sums.* |
| ***40.1*** | *Check that md5 sums are compared using a Linux data verification script.* | *Verify that there is accurate data transmission confirmation of md5 sums that were compared using a Linux data verification script.* | *Confirmation of accurately transmitted data must be done by comparing md5 sums using a Linux data verification script.* | *Create a Linux data verification script that compares md5 sums for accurate data transmission confirmation.* |
| ***40.2*** | *Check that the comparison of md5 sums is done on the Empire Raspberry Pi after one image is transmitted* | *Observe comparison of md5 sums is performed on the Empire Raspberry Pi using an instance of one image in a debug instance* | *Comparison of md5 sums must be performed on the Empire Raspberry Pi before another image is transmitted.* | *Comparison of md5 sums must be done after transmission is completed for all images on the Empire Raspberry Pi.* |
| ***40.3*** | *Check that the md5 sum of transmitted image is sent to the Empire Raspberry Pi by the Rebel Raspberry Pi for one image* | *Observe that the md5 sum of transmitted data is sent to the Empire Raspberry Pi by the Rebel Raspberry Pi using one image in a debug instance* | *The md5 sum of transmitted data is sent to the Empire Raspberry Pi by the Rebel Server and the system is ready to send the next image.* | *The md5 sum of transmitted data must be sent to the Empire Raspberry Pi by the Rebel Server.* |
| ***50*** | *Check the mobile device has a program to evaluate the weaknesses of the Death Star plans.* | *Verify the mobile device has an application to evaluate the weaknesses of the Death Star plans.* | *The mobile application must be able to evaluate the weaknesses of the Death Star plans.* | *The mobile application must be able to evaluate each image for the weaknesses depicted within the red circles.* |
| ***50.1*** | *Verify that the table created by the weakness evaluation application is scrollable.* | *Ensure that the evaluation program creates a scrollable table to display the evaluated weaknesses.* | *Confirm the evaluation program creates a scrollable table to display the evaluated weaknesses.* | *The mobile weakness evaluation application needs to create a scrollable table and display the weaknesses.* |
| ***50.2*** | *Check if mobile weakness evaluation software applications can recognize the weaknesses depicted as separate red circles for each image*. | *Verify that the mobile weakness evaluation software application can recognize the weaknesses depicted as separate red circles for each image*. | *The application finds all possible weaknesses in the 10 images.* | *Make sure that all the weaknesses are found in the 10 images by the mobile weakness evaluation software application.* |
| ***50.3*** | *Verify that each evaluated weakness is depicted once in the table.* | *Ensure that each weakness the red circles depicts is shown only once on the scrollable table.* | *Verify that each depicted weakness is shown only once on the scrollable table.* | *The scrollable table shows each depicted weakness only once.* |
| ***50.4*** | *Check the website has been created and is online via the Rebel Server.* | *Verify the website is online and able to be connected during the downloading via the mobile device.* | *Verify the website is online via the Rebel Server and able to be connected to and downloaded from via the mobile device.* | *The website hosted on the Rebel server needs to be created, online, and able to be connected to during the mobile device download.* |
| ***50.5*** | *Check the Rebel Server website can be connected to by anyone and the contents can be downloaded.* | *Verify the Rebel Server website is publicly available and the content can be downloaded.* | *Verify the Rebel Server website is available to the public and the contents can be downloaded.* | *The website hosted on the Rebel Server must be available for anyone to access and download the images from.* |
| ***50.6*** | *Verify Rebel Server can send Youtube url data to any user logged into a public website.* | *Verify a user logs in and can access the saved url link.* | *The user can view the Youtube url no matter the authentification.* | *The user can view the Youtube url before logging in and a secondary video after logging in.* |
| ***50.7*** | *Verify that a user with the correct ssh key pair can log into public website* | *ssh keypair is generated and shared with a test user. That user can login to the public website.* | *Any user with correct keypair can access the second video url and download images.* | *The mobile application can log into the public website and access the download images and second video.* |
| ***50.8*** | *Verify correct authentication to Rebel Server shows the second video.* | *A user with the correct key pair logs into the public website. Verify authenticated login plays second video.* | *Correctly authenticated user can access the second video.* | *The user Obiwan can view the second video and download images via the website.* |

***Constraint Test Plan***

| *Const No.* | *Test Method* | *Evaluation Method* | *Threshold* | *Objective* |
| --- | --- | --- | --- | --- |
| ***10*** | *Verify that no component of our transmission system uses Wi-Fi, Bluetooth, or Cellular Data* | *List all forms of data transmission and verify that Wi-Fi, Bluetooth, and Cellular Data are not included.* | *Wi-Fi, Bluetooth, and Cellular Data are not used for data transmission in any form.* | *Li-Fi system is used for all data transmission going out of the Empire Lab.* |
| ***20*** | *Verify that the total cost of all combined materials must be 300 USD or less.* | *Add up the total cost of all materials and ensure that the cost comes in at or below 300 USD.* | *Verify the cost of all materials is 300 USD or less.* | *The system can be fully assembled with the materials costing 300 USD or less.* |
| ***30*** | *Verify no electrical tethers are connected to the Empire Raspberry Pi.* | *Check that all external ports on the Empire Raspberry Pi are not connected to an external device.* | *No ports are connected to an external device.* | *The Empire Raspberry Pi transmits without any electrical tethers using Li-Fi.* |
| ***40*** | *Project is demonstrated in the last week of Fall 2024 semester.* | *The project is demonstrated by witnessing with a professor.* | *The demonstration takes place in the allotted time with a professor.* | *The project was successful during the last week of the Fall 2024 semester.* |
| ***50*** | *Verify that the measured distance between the Rebel Server and the Empire Pi is less than 5 meters.* | *Measure the distance between the Rebel Server and the Empire Raspberry Pi.* | *Measured distance must be more than 5 meters.* | *System is fully operational with the Rebel Server from at least 5 meters from the Empire Raspberry Pi.* |
| ***60*** | *Verify that the final demonstration is performed in the Russ basement.* | *Verify the room number where the demonstration takes place is in the basement of Russ.* | *Room number of the demonstration area is in the basement of Russ.* | *The project is performed successfully in the Russ basement.* |
| ***70*** | *Verify that the final demonstration components do not take more space than what is possible to be performed in the Russ basement.* | *Verify that the final demonstration components are operational and can be performed in the Russ basement.* | *Room number of the demonstration area is in the basement of Russ.* | *The project is performed successfully in the Russ basement.* |
| ***80*** | *Verify that the final group consists of 4+ members of different degree paths.* | *Count the number of members in the group and record each member's major.* | *The number of members must be greater than 3 and at least 4 different majors are included.* | *Group has 5 members of at least 4 different majors.* |
| ***90*** | *Verify that the ambient temperature does not limit the operational values of the system.* | *Verify the ambient room temperature does not prohibit the devices from operation.* | *The final system performs as specified in ambient temperatures of the basement of the Russ building.* | *The final system operates normally in the Russ building’s basement at ambient temperature.* |
| ***100*** | *Place each device on a scale to verify that it does not weigh more than 10 lbs.* | *Visually verify that the displayed weight on the scale does not exceed 10 lbs for each device.* | *Each device must not weigh more than 10 lbs as weighed by the scale.* | *Each device must weigh less than 10 lbs as measured by the provided scale.* |
| ***110*** | *Verify that all electrical devices can use the standard 120 VAC 60 Hz power supply.* | *Check that all electrical devices can use standard wall outlets for power.* | *All electrical devices are to use the standard 120 VAC 60 HZ wall outlets.* | *All electrical devices can be fully powered by the standard 120 VAC 60 Hz wall outlets.* |

**Standard Test Plan**

| *Standard* | *Test Method* | *Evaluation Method* | *Threshold* | *Objective* |
| --- | --- | --- | --- | --- |
| ***10*** | *Compare VLC system to* IEEE 802.11bb-23/0277rl |  |  | *System is functional while in compliance.* |
| ***20*** | *Comparison of group-created code to* Python PEP: 8. |  |  | *Code is functional while in compliance.* |
| ***30*** | *Verify OpenSSL encryption/decryption adheres to* Federal Inf. Process. Stds. (NIST FIPS) - 197-upd1 |  |  | *encryption/decryption is functional while in compliance.* |
| ***40*** | *Comparison of group-created code to* ISO/IEC 9899:2024 |  |  | *Code is functional while in compliance.* |
| ***50*** | *Verify that all of the group hashes follow the* FIPS PUB 180-4: Secure hash standard |  |  | *Hashes are correct while complying.* |
| ***60*** | *Verify all wireless traffic adheres to HTTPS* | *Evaluate the contents of a sent packet and verify data follows HTTPS* | *Packet is organized using HTTPS* | *packets can be sent and received successfully by Rebel server* |
| ***70*** | *Verify the transmitted images adhere to the* ISO/IEC 15948:2003 (E) | *Check the metadata of an image to ensure it retains PNG standard compliance after transmission.* | *Image metadata is compliant with the PNG standard.* | *All 10 transmitted images in our system retain PNG metadata.* |
| ***80*** | *Ensure laser diode usage falls within the* ANSI Z136 standards. |  |  | *Don’t shine lasers in people’s eyes, or look directly into the laser.* |
| ***90*** | IETF RFC8017 RSA Cryptography Specifications | *Verify that the created RSA keys follow specifications* | *The RSA keys can be assigned for authentication* | *The RSA keys successfully authenticate* |

***Requirement 10*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: A spreadsheet will be maintained of all parts bought by the team and added together in said sheet. The total gathered from this sheet will then be subtracted from the $300 maximum budget. The threshold is the bought items being less than $300 and the objective is as low as possible with all system functions.*

***Requirement 10.1*** *will be tested in Russ Basement, where we will implement the Li-Fi system. The test method is as follows: Two Li-Fi transceivers will be set up 5 meters across from each other. A test set of data will be used to observe light being used for transmission as well as receiving accurate data post-transmission. The threshold for this test is for the data being sent to be the same hex value as the data received using a VLC system. The objective for this test is for the transmission speed to be greater than 1Gb/s.*

***Requirement 10.2*** *will be tested in Russ Basement which is where we will be verifying that no data was lost during the transmission process. The test method is as follows: Before and after the transmission process the md5sum hash will be taken and then after the transmission is complete the two hashes will be compared. They should then match verifying that the data was successfully sent losslessly. The threshold for this test is it should be completed with no lost data and the objective is also no lost data during transmission.*

***Requirement 10.3*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Two Raspberry Pi’s connected to 5V power will be turned on. The threshold for this test is for both Pi’s will show visual stimuli to show operational. The objective for this test is for both Raspberry Pi’s to be able to run test code to prove fully operational.*

***Requirement 10.4*** *will be tested in Russ Basement, where the system will be assembled for testing. The test method is as follows: Two Raspberry Pi’s will be configured each with a laser and a solar cell to send and receive data. They each should have the capability to send and receive data independently. The threshold for this system is for both Pi’s to be able to both send and receive data. The objective of this system is for both Raspberry Pi’s to be able to independently send and receive data losslessly.*

***Requirement 10.5*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: All code relating to the transceiver system will be analyzed for the approved coding languages. The threshold for this test is for all code to be used to be either Python, C, or C++. The objective for this test is for all of this code to compile with no errors before being implemented.*

***Requirement 10.6*** *will be tested in Russ Basement which is where the system will be assembled for testing. The test method is as follows: The Empire Raspberry Pi will have a directly attached USB and it can successfully download the files from the USB to the Empire Raspberry Pi. The threshold for this test is for the Empire Raspberry Pi to successfully download files from the USB. The objective of this test is for the Empire Raspberry Pi to losslessly download all files from the USB drive to the Empire Raspberry Pi.*

***Requirement 10.7*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: Two Raspberry Pi’s will be set up for Li-Fi transmission. Each Raspberry Pi will send one image and receiver one image. The image that is received from each Raspberry Pi will be opened in the Raspberry Pi operating system. The threshold for this test is for the post-transmission image on both Raspberry Pis to have the same file format as the image pre-transmission. The objective for this test is for all of each post-transmission image to show the file format at the beginning of its text representation.*

***Requirement 10.8*** *will be tested in Russ Basement which is where the system will be assembled for testing. The test method is as follows: The two Raspberry Pi’s can successfully communicate using the laser and solar cell configuration without any obstructions blocking the path of the laser. The threshold for this test is for the laser to successfully send a beam of light to the receiving Raspberry Pi’s solar cell. The objective for this test is for all of the data to be transmitted between the two Raspberry Pis without the laser path being obstructed.*

***Requirement 10.9*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: The Li-Fi transceiving system will be set up for operational use in the Russ Basement. During transmission, the voltage readings from the Raspberry Pi’s, to their respective Li-Fi system, will be recorded. The threshold for this test is for the voltage readings recorded to be within 5% of the 5V goal. The objective for this test is for all voltage readings to be as close to 5V as possible.*

***Requirement 10.10*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: Both transceiving systems take in 5V from their respective Raspberry Pi. The voltages will be measured during the test and monitored throughout to ensure proper power to complete the processes. The threshold for this test is that the Empire and Rebel transceiving systems take in* 5V±5% *from respective Raspberry Pi’s. The objective for this test is that the Empire and Rebel transceiving systems can take in 5V from their respective Raspberry Pis.*

***Requirement 20*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: The Li-Fi transceiving system will be set up for operational use in the Russ Basement. Before data is transmitted it will be encrypted using symmetric key AES-256 encryption. After transmission, the data will be decrypted using the same key and AES-256. The threshold for this test is for the data to change after being encrypted and for the post-decryption text to be binary equal to the pre-encryption text. The objective of this test is for all transmitted data to be successfully encrypted and decrypted.*

***Requirement 20.1*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: The data binaries will be compared to ensure that they are the same before and after transmission. The threshold for this test is for the data binaries to be the same before and after transmission. The objective for this test is for the data binaries to be the same before and after all transmissions.*

***Requirement 20.2*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: A test text file will be created with a random string. This file will then be encrypted using AES-256 with a given key. The same file will then be decrypted with the same key. The threshold for this test is for the data to change after being encrypted and for the post-decryption text to be binary equal to the pre-encryption text if the same key is passed to the algorithm. The objective for this test is for all transmitted data to be successfully encrypted and decrypted using this same key.*

***Requirement 20.3*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows:* A password will be shared with only group members for encryption and decryption verification and *all group members know the password key. The threshold for this test is that all group members know the password key. The objective of this test is for each group member to enter the correct password to encrypt and decrypt the data.*

***Requirement 20.4*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: The Empire Raspberry Pi will encrypt a test message and transmit the message to the Rebel Raspberry Pi. This message will then be decrypted by the Rebel Raspberry Pi. The plaintext of the decrypted message must be binary equal to the plaintext of the pre-encryption message on the Empire Raspberry Pi. The threshold for this test is for the message data of the decryption text to be binary equal to the pre-encryption text after being transmitted. The objective for this test is for all transmitted data to be equal to the pre-encryption plaintext and be decrypted.*

***Requirement 30*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Verify an uploaded picture can be processed via the application. The threshold for this test is for the image evaluation to occur using PNG images. The objective of this test is for the image evaluation application to be able to process images for specific data points.*

***Requirement 30.1*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Verify image evaluation software can correctly identify 10 Death Star images out of 100. The threshold for this test is for the image evaluation process to be able to identify the correct 10 images containing red circles out of 100 possible images. The objective of this test is for the image evaluation program to be able to scan, process, and identify 10 images out of 100 that contain red circles.*

***Requirement 30.2*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Verify that all 100 images from the USB are copied onto the Empire Raspberry Pi. The threshold for this test is for all 100 images to be accessed and uploaded onto the Empire Raspberry Pi for image evaluation. The objective of this test is to confirm that all 100 images are accessed, copied, and prepared for image evaluation.*

***Requirement 30.3*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Both Raspberry Pi’s storage will be analyzed to verify that only the Empire Raspberry Pi can execute the image evaluation application. The application will then be executed on the Empire Raspberry Pi using 100 test .png images. The threshold for this test is for all 100 images utilized by the Empire Raspberry Pi image evaluation application. The objective for this test is for all 100 images to be accessed by only the Empire Raspberry Pi image evaluation application when executed.*

***Requirement 40*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: A hash will be generated for a set of 10 test .png images. A script will then be created to generate hashes of the same images. The hashes generated from both the script, and hashing the images directly, must be binary equal. The threshold for this test is for the two techniques of generated hashes to be binary equal. The objective for this test is for all 10 images being transmitted can have their hashes generated by this script.*

***Requirement 40.1*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Verify that there is accurate data transmission confirmation of md5 sums that were compared using a Linux data verification script. The threshold for this test is for the confirmation of accurately transmitted data to be done by comparing md5 sums using a Linux data verification script. The objective of this test is to create a Linux data verification script that compares md5 sums for accurate data transmission confirmation.*

***Requirement 40.2*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: Verify that the comparison of the md5sums is done on the Empire Raspberry Pi, only after the transmission is completed. The threshold for this test is for the comparison of md5sums to be performed on the Empire Raspberry Pi after the transmission is completed. The objective for this test is for a matching comparison of the md5sums after transmission is completed, on the Empire Raspberry Pi.*

***Requirement 40.3*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: 10 test .png images will be transmitted by the Empire Raspberry Pi, to the Rebel Raspberry Pi. Each transmitted image will have its md5sum hash values generated and saved. These md5sum values will then be transmitted back to the Empire Raspberry Pi. The threshold for this test is for all 10 md5sums transmitted by the Rebel Raspberry Pi to get back to the Empire Raspberry Pi. The objective for this test is for all 10 images being transmitted can have their hashes returned to the Empire Raspberry Pi for comparison.*

***Requirement 50*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: Verify the mobile device has an application to evaluate the weaknesses of the Death Star plans. The threshold for this test is for the mobile application to be able to evaluate the weaknesses of the Death Star plans. The objective of this test is for the mobile application to be able to evaluate each image for the weaknesses depicted within the red circles.*

***Requirement 50.1*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Ensure that the evaluation program creates a scrollable table to display the evaluated weaknesses. The threshold for this test is to confirm that the evaluation program creates a scrollable table to display the evaluated weaknesses. The objective of this test is for the mobile weakness evaluation application to create a scrollable table and display all of the weaknesses.*

***Requirement 50.2*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: The mobile application will use 10 test .png images with various red circles to depict potential weaknesses. The mobile application will then be run on these test images. The threshold for this test is to verify that the mobile application saves the data of each red circle for all of the 10 images. The objective of this test is for the mobile weakness evaluation application to evaluate the weaknesses of all of the transmitted Death Star images when downloaded from the Rebel Server.*

***Requirement 50.3*** *will be tested in the Russ Basement which is where the system will be assembled for testing. The test method is as follows: Ensure that each weakness depicted by the red circles is shown only once on the scrollable table. The threshold for this test is to verify that each depicted weakness is shown only once on the scrollable table. The objective of this test is for the scrollable table to show all depicted weaknesses only once.*

***Requirement 50.4*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Verify the website is online and able to be connected during the downloading via the mobile device. The threshold for this test is to verify the website is online via the Rebel Server and able to be connected to and downloaded from via the mobile device. The objective for this test is for the website hosted on the Rebel server to be created, online, and able to be connected to during the mobile device download.*

***Requirement 50.5*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Verify that the Rebel Server website is publicly available and the content can be downloaded. A test user with the correct ssh keypair is created and logged onto the public website. The threshold for this test is to verify the Rebel Server website is available to the public and the contents can be downloaded. The objective for this test is for the website hosted on the Rebel Server must be available for anyone to access and download the images from.*

***Requirement 50.6*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Verify that the Rebel Server website is publicly available and access the site via a test user. The threshold for this test is for the user to be sent the url for the first Youtube video with no access to the secondary video. The objective for this test is for the website hosted on the Rebel Server to send the video to the mobile application user.*

***Requirement 50.7*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Verify that the Rebel Server website is publicly available and the content can be downloaded. A ssh keypair will be generated on the Rebel Server and the public key will be shared with a test user. This user will then log in to the website. The threshold for this test is to verify the Rebel Server website is available to the public, the contents can be downloaded, and the user is sent the url for the secondary Youtube video. The objective for this test is for the website hosted on the Rebel Server to authenticate the mobile application user and allow the user to download images and access the second video url.*

***Requirement 50.8*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: A test user logs into the public website with correct keypair. The website allows the user to show the second video. The threshold for this test is to verify that the correctly authenticated user can view the second video and download the images from the Rebel Server. The objective for this test is for the website hosted on the Rebel Server must be available for only the authenticated user, Obiwan Kenobi, to access the second full video and images from the Rebel Server and download the images.*

***Constraint 10:*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: List all forms of data transmission and verify that Wi-Fi, Bluetooth, and Cellular Data are not included. The threshold for this test is for Wi-Fi, Bluetooth, and Cellular Data to not be used for data transmission in any form. The objective of this test is to use the Li-Fi system for all data transmission going out of the Empire Lab.*

***Constraint 20:*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Add up the total cost of all materials and ensure that the cost comes in at or below 300 USD. The threshold for this test is to verify the cost of all materials is 300 USD or less. The objective for this test is for the system to be fully assembled with the materials costing 300 USD or less.*

***Constraint 30:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Check that all external ports on the Empire Raspberry Pi are not connected to an external device. The threshold for this test is for no ports to be connected to an external device. The objective of this test is for the Empire Raspberry Pi to transmit without any electrical tethers using Li-Fi.*

***Constraint 40:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: The project is demonstrated by witnessing with a professor. The threshold for this test is for the demonstration to take place during the allotted time with a professor. The objective for this test is for the project to be successful during the last week of the Fall 2024 semester.*

***Constraint 50:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Measure the distance between the Rebel Server and the Empire Raspberry Pi. The threshold for this test Measured distance must be more than 5 meters. The objective for this test is for the system to be fully operational with the Rebel Server at least 5 meters from the Empire Raspberry Pi.*

***Constraint 60:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Verify the room number where the demonstration takes place is in the basement of Russ. The threshold for this test is for the Room number of the demonstration area in the basement of Russ to be correct. The objective for this test is for the project to be performed successfully in the Russ basement.*

***Constraint 70:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method follows: Verify that the final demonstration components are operational and can be performed in the Russ basement. The threshold for this test is for the Room number of the demonstration area to be in the basement of Russ. The objective of this test is for the project to be performed successfully in the Russ basement.*

***Constraint 80:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Count the number of members in the group and record each member's major. The threshold for this test is for the number of members must be greater than 3 and at least 4 different majors are included. The objective of this test is for the Group to have 5 members of at least 4 different majors.*

***Constraint 90:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Verify the ambient room temperature does not prohibit the devices from operating. The threshold for this test is for the final system to perform as specified in ambient temperatures of the basement of the Russ building. The objective for this test is for the final system to operate normally in the Russ building’s basement at ambient temperature.*

***Constraint 100:*** *will be tested in Room SC 007 which is where we will be planning and documenting next semester. The test method is as follows: Visually verify that the displayed weight on the scale does not exceed 10 lbs for each device. The threshold for this test is that each device must not weigh more than 10 lbs as weighed by the scale. The objective of this test is that each device must weigh less than 10 lbs as measured by the provided scale.*

***Constraint 110:*** *will be tested in the Russ Basement, where the system will be assembled for testing. The test method is as follows: Check that all electrical devices can use standard wall outlets for power. The threshold for this test is for all electrical devices to use the standard 120 VAC 60 HZ wall outlets. The objective for this test is for all electrical devices to be fully powered by the standard 120 VAC 60 Hz wall outlets.*

***Standard 10:*** *will be verified under* IEEE 802.11bb-23/0277rl and will be tested in room SC 007. The test method is as follows: *Compare the VLC system to* IEEE 802.11bb-23/0277rl and ensure that all of the requirements are valid. The threshold for this test is that all components of the VLC systems fall within these standards. The objective for this test is for the VLC system to be fully functional while staying within the standards.

***Standard 20:*** *will be verified under Python PEP: 8 and will be tested in room SC 007. The test method is as follows: Gather all Python code created for this system and compare it with the requirements specified in the PEP: 8. The threshold for this test is that all code falls within these standards. The objective for this test is for the code to be functional while within said standard.*

***Standard 30:*** *will be verified under (NIST FIPS) - 197-upd1 and will be tested in room SC 007. The test method is as follows: Verify that the OpenSSL instance of AES is compliant with this standard through observation. The threshold for this test is that all implementation of AES falls within these standards. The objective for this test is for encryption/decryption to be functional while within said standard.*

***Standard 40:*** *will be verified under ISO/IEC 9899:2024 and will be tested in room SC 007. The test method is as follows: Gather all C/C++ code created for this system and compare it with the requirements specified in the ISO/IEC 9899:2024. The threshold for this test is that all code falls within these standards. The objective for this test is for the code to be functional while within said standard.*

***Standard 50:*** *will be verified under FIPS PUB 180-4 and will be tested in room SC 007. The test method is as follows: Verify that the groups hashes that are sent between both Raspberry Pis follow the secure hash standard FIPS PUB 180-4. The threshold for this test is that all hashes fall within these standards, The objective for this test is for all hashes to be correct and functional while falling within the standard.*

***Standard 60:*** *will be verified under HTTPS and will be tested in the Russ Basement. The test method is as follows: Use Scapy to analyze the hex contents of a packet going to the Rebel Server. Verify that this packet is organized to what is specified in HTTPS. The threshold for this test is that all packets received and sent follow this standard. The objective for this test is for all packets to follow HTTPS going to and from the Rebel Server.*

***Standard 70:*** *will be verified under ISO/IEC 15948:2003 (E) and will be tested in the Russ Basement. The test method is as follows: Use the tested Li-Fi transceiver system to transmit a single test .png image. Take the hex value of this image and verify the data is organized in accordance with the standard. The threshold for this test is that the image transmitted follows this standard. The objective for this test is for all 10 images transmitted in the system to follow the standard.*

***Standard 80:*** *will be verified under ANSI Z136 and will be tested in the Russ Basement. The test method is as follows: Observe the Fi-Fi transceiver system and verify its compliance with all specifications of the standard. The objective of this test is to verify all safety specifications are followed at all times.*

***Standard 90:*** *will be verified under IETF RFC8017 and will be tested in Russ Basement. The test method is as follows: Observe and verify that the created RSA keys follow specifications. The threshold for this test is that the RSA keys can be assigned for authentication. The objective for this test is for the RSA keys to successfully authenticate the user.*