Test Instruction & Report

OKAA Solutions (Team 5)

HotSeat

Carmel High School

Engineering Design & Development

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04/24/2025

V4

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Chapter 1: Scope

1.1: Application

The design specification should be applied as a standard for all other documents to reference. All dimensional, performance, and construction constraints should be listed in the specification. The specification should be applied in documents such as the test instruction, build and assembly instruction, and in deliverables such as the critical design review, by providing performance guidelines, dimension constraints, and a record of progress. The system should be designed to assist patrons with locating open seating in a public space. Due to this criteria, the system should be applied in a library setting. Its crowd control and open seating regulation capabilities lend themselves to use in an indoor, public setting with non assigned seating, such as a library.

1.2: Limitation

The system will be limited by the budget of the project, the schedule and limited time of the project, and the method with which it collects and processes data. The budget for the project is 300 dollars total, with a limitation of 150 dollars allocated for each semester. The project was limited to a time frame of the standard academic year of 36 weeks, with 18 weeks per semester. The Raspberry Pi camera should be limited by its range and focal length. Onboard local processing may produce excess heat.

Chapter 2: Applicable Documents

2.1: Government Documents

2.1.1 40 CFR 761.20 Code of Federal Regulations, PART 761—Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution In Commerce, And Use Prohibitions.

https://www.ecfr.gov/current/title-40/section-761.20

2.1.2 CDC - Safe 3D Printing

https://blogs.cdc.gov/niosh-science-blog/2024/07/29/safe-3d-printing/

2.2: Specifications, Standards, and Handbooks

2.2.1. ISO 18434-1:2008: Condition monitoring and diagnostics of machines — Thermography

https://www.iso.org/standard/41648.html

2.2.2. ISO 10878:2013: Non-destructive testing — Infrared thermography

https://www.iso.org/standard/46265.html

2.3: Other government documents, drawings, and publications

2.3.1 National Vulnerability Database CVE-2021-38759 Raspberry Pi Software Weaknesses and Solutions

https://nvd.nist.gov/vuln/detail/CVE-2021-38759

2.4: Non-government publications

2.4.1: Raspberry Pi Ltd Rasberry Pi 5 8Gb Product Brief

https://cdn-shop.adafruit.com/product-files/5813/raspberry-pi-5-product-brief.pdf

2.4.2 Raspberry Pi Ltd Official Raspberry Pi 5 Active Cooler Product Description

https://www.adafruit.com/product/5815#description

2.4.3 Raspberry Pi Ltd Brass M2.5 Standoffs for Pi HATs - Black Plated Technical Details

https://www.adafruit.com/product/2336#technical-details

2.4.4 Raspberry Pi Ltd Raspberry Pi Camera Module 3 NoIR - 12MP 75 Degree Infrared Lens

2.4.4.1 Camera Module 3 Product Brief

https://cdn-shop.adafruit.com/product-files/5659/camera-module-3-product-brief.pdf

2.4.4.2 Mechanical Drawing

https://cdn-shop.adafruit.com/product-files/5659/camera-module-3-standard-mechanical-drawing.pdf

2.4.5 Raspberry Pi Ltd Raspberry Pi 5 FPC Camera Cable - 22-pin 0.5mm to 15-pin 1mm - 200mm long Technical Details

https://www.adafruit.com/product/5818#technical-details

2.4.6 Is PETG Food Safe? Inplex Custom Extruders

https://www.inplexllc.com/blog/is-petg-food-safe/#:~:text=As%20just%20discussed%20PETG%20material,food%20containers%20and%20beverage%20bottles

2.4.7 PETS University of Maryland Terrapin Works

https://terrapinworks.umd.edu/materials/petg#:~:text=PETG%20is%20an%20industrial%2Dgrade,and%20immune%20to%20UV%20light

2.4.8. What Is Infrared Thermography? NORIFT

https://www.reliableplant.com/infrared-thermography-31572

Chapter 3: Safety Precautions

3.1 Danger

3.1.1 Electrocution – Do not touch the raspberry pi while it is in operation, the current will cause electrocution which will result in serious injury or death.

3.2 Warning

3.2.1 Possible electrocution - Touching the device or tampering/opening the device while it is in operation could result in electrocution, which will result in serious injury or death.

3.2.2 Small parts - During assembly, account for all magnets and keep away from children. Swallowing magnets could result in serious injury or death.

3.3 Caution

3.3.1 Pinching hazard - While closing the lid on the system, keep fingers outside the box to avoid pinching, which could cause minor injury.

3.3.2 Sharp edges - The system is 3D printed, so the edges of the device may have sharp fragments that can cause minor injury.

3.4 Notice

3.4.1 This device is not suitable for anyone under the age of eighteen.

3.4.2 A drill should not be used for installation of the tapping screws, as it could cause the casing to break.

3.4.3 Water should not come in contact with any electrical component of the device as it could subject it to breakage.

Chapter 4: Supporting and Test Equipment/Tools/Fixtures

4.1: Supporting Equipment

4.1.1 Screwdriver - A screwdriver must be used to insert the tapping screws that will attach the Raspberry Pi to the casing.

4.2: Test Equipment

4.2.1 Ruler - A ruler must be used to take dimensions of the 3D printed model and confirm the tolerances were followed.

4.2.2 Computer - A computer must be used to run all of the software diagnostics.

4.2.3 Scale - A scale must be used to weigh the assembly and confirm the 3D printed model is correct.

Chapter 5: Test Procedures

5.1: Preparing the Testing Area

5.1.1 Find a stable, flat surface to serve as a testing area with a power source and accessible computer.

5.1.2 Clear the testing area of all food, electrical, or other hazardous items.

5.2: Prepare Testing Equipment

5.2.1 Install the appropriate software on the nearby computer.

5.2.2 Assume that all supporting tools are in a usable condition.

5.2.3 Turn on device with the power supply unit and open software.

5.2.4 Set up chairs in view of the device's camera.

5.3 Test the Device

5.3.1 Click "Analyze Image" on the user interface.

5.3.2 If results are accurate, add a success to the testing log.

Chapter 6: Test Log with Pass/Fail Criteria

Feature	Pass/Fail Criteria	Status	Validation
3.1.1	SYSTEM HOUSING should be printed with PETG filament	PASS	Certified with CCPL and compared with PETG filament.
3.1.2	Hardware should not exceed 200 grams.	PASS	Dependent upon different versions of the case. Case iterations are still in progress.
3.1.3	System should be contained in a 3d printed housing 97mm±3mm x 67mm±3mm x 59mm±3mm (Length x Width x Height)	PASS	Measured casing with ruler.
3.2.1	The range of the seats must be at least 15 ft away from the camera assembly.	PASS	Measured distance from camera to points of detection. Distance was 18 feet.
3.2.2	The SYSTEM should detect chair data upon USER request with a maximum response time of 10000 ms.	PASS	Watch console logs for latency/response time. Average response time was 5346 ms.
3.2.3	The SYSTEM should be able to detect at least 2 OCCUPANTS with an accuracy of ± 1 individuals.	PASS	HotSeat was able to accurately analyze up to 3 chairs and their occupancy.
3.2.4	The SYSTEM should be powered via wired 5.1V 5A power.	PASS	The system and its peripherals are sufficiently powered by a single 5.1V 5A power supply.

3.3.1	The SYSTEM should remain mounted for at least 30 days without physical maintenance.	PASS	SYSTEM remained mounted to treated pine (to simulate a wall stud) for a 30 day test period.
3.3.2	The SYSTEM should remain mounted stationary to a wall for at least 3 years.	PASS	Strong force was used to simulate extended wear.
4.1.1	The SYSTEM should function at room temperature (68–72 °F), with low humidity (between 30% and 50%).	PASS	During testing, ensured that system functioned at room temperature
4.1.2	The SYSTEM does not need to function under high vibration or stress conditions	PASS	No test required, No test performed.
4.1.3	The SYSTEM should remain mounted stationary to a wall for at least 3 years.	PASS	See 3.3.2
4.2.1	SYSTEM should have a mean time between failure of at least one week.	PASS	During trails SYSTEM failed in intervals of more than one week
4.3.1	Camera Module: Low power camera SYSTEMs do not pose a health risk (Adafruit industries, 2021).	PASS	Certified by manufacturer
4.3.2	PETG 3D Printer Filament: Fumes are non toxic, very limited off-gassing (INPLEX LLC, 2024).	PASS	Certified by manufacturer

4.4.1	The SOFTWARE should be able to receive updates for the entirety of the lifespan of the SYSTEM.	PASS	SOFTWARE updates were successful for the entirety of testing and development
4.4.2	Camera Module Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021).	PASS	Verified in Adafruit camera module specifications
4.4.3	PETG 3D Printer Filament Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021).	PASS	Verified by Adafruit PETG 3D specifications
4.4.4	Raspberry Pi board Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021)	PASS	Verified by Adafruit Raspberry Pi Specifications
4.4.5	Raspberry Pi 5 Active Cooler Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021)	PASS	Verified by Adafruit Raspberry Pi 5 Active Cooler Specifications
4.5.1	SOFTWARE: Server error logging should be comprehensive with NextJS and Python debugging tools.	PASS	Follow code documentation for setting up and using error analysis tools.
4.6.1	The WEBSITE should have an easily navigable user interface.	PASS	Certified by customer trials

4.6.2	The SYSTEM should be attached semi-permanently to a surface and will not be handled by USERS.	PASS	SYSTEM was secured semi-permanently to a wooden beam with self tapping screws
4.7.1	The HOUSING should be 3D printed at a local printing location with well stocked filament.	PASS	Confirmed at retrieval.
4.7.2	The processor and camera should be connected with manufacturer recommended and unmodified wiring and mounting.	PASS	Certified with manufacturer and observation of the connection.
4.8.1	Updates to the WEBSITE and Raspberry Pi should take place instantaneously given that they are both connected to WiFi.	PASS	Was able to SSH into the Raspberry Linux environment and push code from laptop.
4.8.2	Maintenance to the HARDWARE should be achievable by removing the HOUSING and accessing the components.	PASS	Housing was removed and it was determined that all hardware could be appropriately accessed.
4.9.1	All parts are available from multiple online vendors and they use the same interface with the Raspberry Pi.	PASS	This was certified to be true by finding the parts from multiple vendors.
4.10.1	SYSTEM should not have any impact on the environment aside	PASS	Energy usage was verified in Raspberry Pi specification and

	from their energy use of less than 2 kilowatt-hours per month.		observed in the energy bill.
4.11.1	The HOUSING should have filleted edges and be rectangular in shape.	PASS	Rounded edges were observed and quantified with a protractor.
4.11.2	The WEBSITE should have a minimalist design containing no features that are unnecessary to the functionality.	PASS	Website was observed by a sample population to validate minimalist qualities.
4.12.1	The SYSTEM should be stored at margins slightly extended from room temperature (58-62 °F) with humidity (0-50%).	PASS	See 4.1.1
4.13.1	The HOUSING should be 3D printed out of PETG 3D printing filament.	PASS	See 3.1.1
4.13.2	The material used for the HOUSING should be non-toxic, UV resistant, and waterproof.	PASS	Validated by PETG specification and water and sun testing.

Chapter 7: Testing Procedures

Feature	Procedures
3.1.1	Inspect the label on the bottom surface of the system and verify that it reads PETG filament.
3.1.2	Obtain a scale, setting the units to grams, and weigh the system. Verify that the reading is within 5g of 200g.
3.1.3	Obtain a ruler with millimeter units, and verify that the length of the system is 97mm, the width is 67mm, and the height is 59mm. Note that if these dimensions are within 3mm of the target values it is still considered a pass due to tolerance.
3.2.1	Obtain a tape measure using Imperial units and position a test occupant 15 ft away from the system and run a trail analysis.
3.2.2	Run a test detection with a single occupant, use the inbuilt software delay timer to ensure that the delay is less than 1 second.
3.2.3	Run a test detection using two separate occupants in separate seating arrangements.
3.2.4	Connect the system to a power supply producing 5.1V and 5A and ensure that all processes function properly by testing procedures 3.2.1-3.2.3
3.3.1	Use a screwdriver or electric drill to secure the system to the wall using included self tapping screws of the proper size. Apply tension to the attachment and ensure that the fastening will not release
3.3.2	Apply constant, strong, tension to the attachment point to simulate at least 3 years of regular wear (supporting the weight of the system).
4.1.1	Using a thermostat and a humidity monitor,

	ensure that the system is functioning at multiple points along the suggested temperature range.
4.1.2	The system is statically installed and will not be exposed to vibrations or high stress conditions.
4.1.3	Apply constant, strong, tension to the attachment point to simulate at least 3 years of regular wear (supporting the weight of the system).
4.2.1	Run continuous detections at a higher rate than typical to simulate one week of use, ensure that only one failure occurred.
4.3.1	This has been verified by the manufacturer and therefore does not require a testing procedure.
4.3.2	This has been verified by the manufacturer and therefore does not require a testing procedure.
4.4.1	Ensure that the system lag time does not increase drastically over the lifespan of the system to verify that it is receiving updates.
4.4.2	This has been verified by the manufacturer and therefore does not require a testing procedure.
4.4.3	This has been verified by the manufacturer and therefore does not require a testing procedure.
4.4.4	This has been verified by the manufacturer and therefore does not require a testing procedure.
4.4.5	This has been verified by the manufacturer and therefore does not require a testing procedure.
4.5.1	Should an error occur, cross-reference the error message with NextJS and Python debugging tools using the internet or an IDE

	and compiler.
4.6.1	Navigate through the user interface before and after setup and determine if the user components match their functions with no unnecessary features.
4.6.2	After mounting the system, ensure that it remains in place without any human assistance.
4.7.1	Verify using the label that the system was 3D printed at a local location.
4.7.2	Inspect the wiring and mounting components and visually verify that they match those on the parts list and do not switch them out or remove them.
4.8.1	When the manufacturer releases a system update, ensure there is no lag time in the processing of the system by beginning or continuing usage.
4.8.2	Remove the housing by carefully lifting up the lid from the magnets to ensure the accessibility of the internal components.
4.9.1	Verify using the internet that the components are available from multiple vendors and use the same interface as the Raspberry Pi.
4.10.1	At the end of the lifetime of the product, be sure to recycle the system at a local electronics drive to ensure no environmental impact other than the energy usage takes place.
4.11.1	Certify that the edges of the casing are filleted and the system is rectangular in shape by visually inspecting each edge.
4.11.2	Inspect the website to ensure that the minimalist design language is maintained, eg. Each element serves an obvious purpose with no excess.
4.12.1	Using a thermostat, verify that the

	temperature and humidity of the storage location is within the specified ranges.
4.13.1	Material used should be certified by the printing lab prior to delivery.
4.13.2	Material used should be certified as non-toxic, UV resistant, and waterproof by the printing lab prior to printing.

References

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