Design Specification

OKAA Solutions (Team 5)

HotSeat

Carmel High School

Engineering Design & Development

Kelly Fulk, Olivia Hart, Ahmed Secen, Abram Weller

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V8

Table of contents

Chapter 1: Scope

1.1: Problem Statement

In today's modern society, public establishments are flourishing with an abundance of people using their resources. A commonality is that many of these places run out of seats to host all users. This is the problem we face. In 2023, an average of 1,649 people visited the Carmel Library each day (CCPL Annual Report, 2023). In further research, we conducted a poll by posting surveys around the school questioning students about their experience at the public library. After 59 responses, 66% of people said that the library is always at least somewhat busy, with 73% saying it's difficult to find adequate seating. Afterwards, we interviewed two Carmel Clay Public Library Workers. Many mentioned the same issues:"Especially in the mornings and between 4-6 pm afterschool, every seat is filled with students. I see many people walking around looking for study space" (CCPL Adult Services Employee). In essence, the occupancy of the public library often poses a common problem for students looking for study space, causing many people to walk circles around the building in search of an empty seat.

1.2: Design Statement

A **SYSTEM** that collects occupancy data and displays the information to the user in an accessible manner. The **SYSTEM** should help individuals determine the best time to go to the library when chairs and/or tables are occupied. The **SYSTEM** should be discrete and should not interfere with library patrons' experience.

1.3: 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.

1.4: 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 Raspberry Pi Camera Module 3 NoIR - 12MP 75 Degree Infrared Lens Mechanical Drawing

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

2.4.2 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

2.4.3 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

2.4.4 PETS University of Maryland Terrapin Works

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

2.4.5 What Is Infrared Thermography? NORIFT

https://www.reliableplant.com/infrared-thermography-315

Chapter 3: Requirements

3.1: Form

3.1.1 **SYSTEM HOUSING** should be printed with PETG filament

3.1.2 **SYSTEM** should not exceed 200 grams

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)

3.2: Function

3.2.1 **SYSTEM** should detect an **OCCUPANT** in a chair from 15 ft away

3.2.2 **SYSTEM** should detect chair data upon **USER** request with a maximum latency of 10000 ms.

3.2.3 **SYSTEM** should be able to detect 2 **OCCUPANTS** with an accuracy of ± 1

3.2.4 **SYSTEM** should be powered via wired 5.1V 5A power.

3.3: Fit

3.3.1 **SYSTEM** should be mounted semi-permanently to the wall via self tapping screws.

3.3.2 **SYSTEM** should remain mounted for at least 3 years.

Chapter 4: Performance

4.1: Qualification

4.1.1 The **SYSTEM** should function at room temperature with an extended range (30-130 °F), with low humidity (between 0% and 50%).

4.1.2 The **SYSTEM** does not need to function under high vibration or stress conditions

4.1.3 The **SYSTEM** should remain mounted stationary to a wall for at least 3 years.

4.2: Reliability

4.2.1 **SYSTEM** should have a mean time between failure of at least one week.

4.3: Safety

4.3.1 Camera Module: Low power camera **SYSTEMs** do not pose a health risk (Adafruit industries, 2021).

4.3.2 PETG 3D Printer Filament: Fumes are non toxic, very limited off-gassing (INPLEX LLC, 2024).

4.4: Durability

4.4.1 The **SOFTWARE** should be able to receive updates for the entirety of the lifespan of the **SYSTEM.**

4.4.2 Camera Module Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021).

4.4.3 PETG 3D Printer Filament Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021).

4.4.4 Raspberry Pi board Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021)

4.4.5 Raspberry Pi 5 Active Cooler Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021)

4.5: Testability

4.5.1 **SOFTWARE:** Server error logging should be comprehensive with NextJS and Python debugging tools.

4.6: Operability

4.6.1 The **WEBSITE** should have an easily navigable user interface.

4.6.2 The **SYSTEM** should be attached semi-permanently to a surface and will not be handled by **USERS.**

4.7: Manufacturability

4.7.1 The **HOUSING** should be 3D printed at a local printing location with well stocked filament.

4.7.2 The processor and camera should be connected with manufacturer recommended and unmodified wiring and mounting.

4.8: Maintainability

4.8.1 Updates to the **WEBSITE** and Raspberry Pi should take place instantaneously given that they are both connected to WiFi.

4.8.2 Maintenance to the **HARDWARE** should be achievable by removing the **HOUSING** and accessing the components.

4.9: Interchangeability

4.9.1 All parts are available from multiple online vendors and they use the same interface with the Raspberry Pi.

4.10: Sustainability

4.10.1 The **SYSTEM** does not have any impact on the environment aside from its energy use of less than 2 kilowatt-hours per month.

4.11: Aesthetics

4.11.1 The **HOUSING** should have filleted edges and be rectangular in shape.

4.11.2 The **WEBSITE** should have a minimalist design containing no features that are unnecessary to the functionality.

4.12: Storage

4.12.1 The **SYSTEM** should be stored at margins slightly extended from room temperature (30-130 °F) with humidity (0-50%).

4.13: Material

4.13.1 The **HOUSING** should be 3D printed out of PETG 3D printing filament.

4.13.2 The material used for the **HOUSING** should be non-toxic, UV resistant, and waterproof.

Chapter 5: Verification & Validation

SYSTEM - The completed **SYSTEM** of the **HOUSING**, motherboard, and camera.

OCCUPANT - Person or object that the **SYSTEM** should detect.

HOUSING - 3D printed enclosure that the **SYSTEM** should be installed in.

SOFTWARE - OCCUPANT detection software that should be running on the **SYSTEM.**

WEBSITE - Collection of linked web pages that share a unique domain name.

HARDWARE - Physical components of the **SYSTEM**, including motherboard, camera, and wiring.

USER - An individual that interacts with the **SYSTEM** and **SOFTWARE.**

Paragraph	Requirement	Method	Representative
3.1.1	**SYSTEM HOUSING** should be printed with PETG filament	Inspection	Ahmed S.
3.1.2	**SYSTEM** should not exceed 200 grams	Test	Olivia H.
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)	Test	Ahmed S.

3.2.1	**SYSTEM** should detect an **OCCUPANT** in a chair from at least 15 ft away	Test	Kelly F.
3.2.2	**SYSTEM** should detect chair data upon **USER** request with a maximum latency of 1 second.	Test	Ahmed S.
3.2.3	**SYSTEM** should be able to detect at least 10 **OCCUPANTS** with an accuracy of ± 3	Test	Abram W.
3.2.4	**SYSTEM** should be powered via wired 5.1V 5A power.	Inspection	Kelly F.
3.3.1	**SYSTEM** should be mounted semi-permanently to the wall via self tapping screws	Inspection	Olivia H.
3.3.2	**SYSTEM** should remain mounted for over 3 years without physical maintenance.	Certification	Kelly F.

4.1.1	The **SYSTEM** should function at room temperature with an extended range (30–130 °F), with low humidity (between 0% and 50%)	Test	Abram W.
4.1.2	The **SYSTEM** does not need to function under high vibration or stress conditions.	Inspection	Ahmed S.
4.1.3	The **SYSTEM** should remain mounted stationary to a wall for at least 3 years.	Test	Olivia H.
4.2.1	**SYSTEM** should have a mean time between failure of at least one week	Test	Ahmed S.
4.3.1	Camera Module: Low power camera **SYSTEM**s do not pose a health risk (Adafruit industries, 2021)	Inspection	Kelly F.
4.3.2.	PETG 3D Printer Filament: Fumes are non toxic, very	Inspection	Abram W.

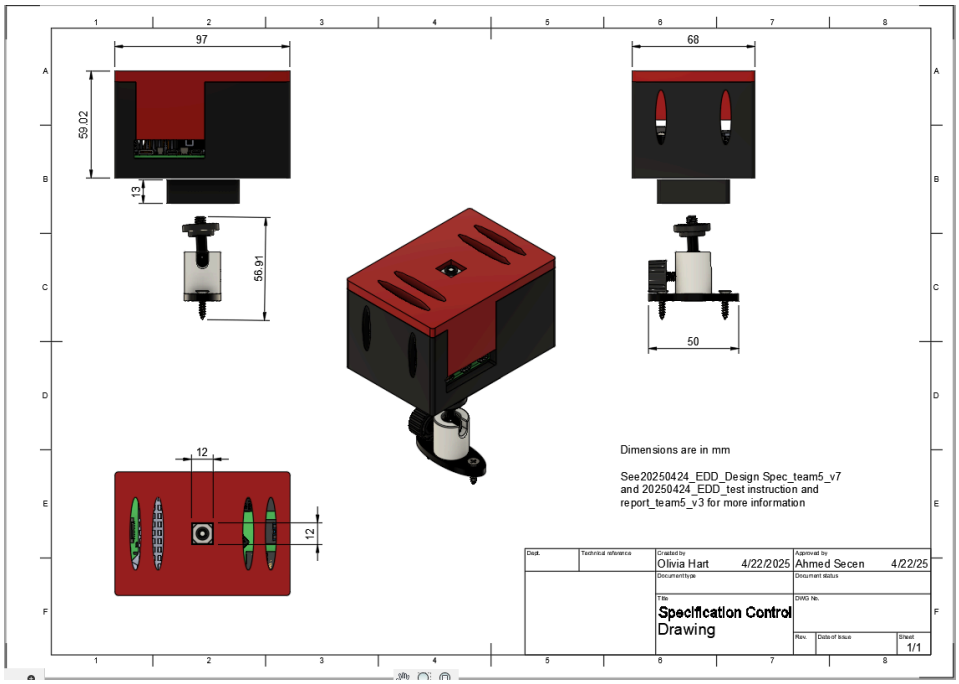
	limited off-gassing (INPLEX LLC, 2024)		
4.4.1	The **SOFTWARE** should be able to receive updates for the entirety of the lifespan of the **SYSTEM.**	Inspection	Ahmed S.
4.4.2	Camera Module Lifespan: greater than three (3) years [under ideal conditions] (Adafruit industries, 2021).	Certification	Kelly F.
4.4.3	PETG 3D Printer Filament Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021).	Certification	Abram W.
4.4.4	Raspberry Pi 5 Lifespan: greater than three years [under ideal conditions] (Adafruit industries, 2021)	Certification	Ahmed S.
4.4.5	Raspberry Pi 5 Active Cooler Lifespan: greater than three	Certification	Olivia H.

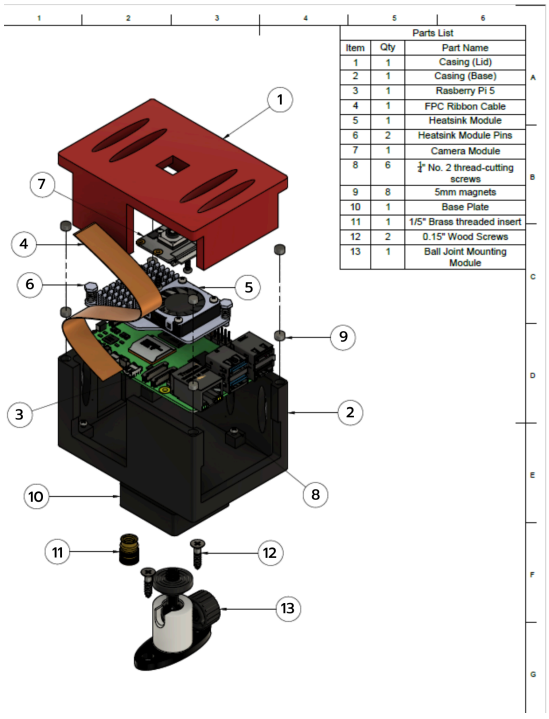
	years [under ideal conditions] (Adafruit industries, 2021)		
4.5.1	**SOFTWARE**: Server error logging should be comprehensive with NextJS and Python debugging tools.	Inspection	Kelly F.
4.6.1	The **WEBSITE** should have an easily navigable user interface.	Inspection	Ahmed S.
4.6.2	The **SYSTEM** should be attached semi-permanently to a surface and will not be handled by **USERS.**	Inspection	Olivia H.
4.7.1	The **HOUSING** should be 3D printed at a local printing location with well stocked filament.	Certification	Kelly F.
4.7.2	The processor and camera should be connected with manufacturer recommended	Inspection	Abram W.

	and unmodified wiring and mounting.		
4.8.1	Updates to the **WEBSITE** and Raspberry Pi should take place instantaneously given that they are both connected to WiFi.	Inspection	Ahmed S.
4.8.2	Maintenance to the **HARDWARE** should be achievable by removing the **HOUSING** and accessing the components.	Demonstration	Olivia H.
4.9.1	All parts are available from multiple online vendors and they use the same interface with the Raspberry Pi.	Inspection	Abram W.
4.10.1	**SYSTEM** does not have any impact on the environment aside from its energy use of less than 2 kilowatt-hours per month.	Test	Ahmed S.

4.11.1	The **HOUSING** should have filleted edges and be rectangular in shape.	Inspection	Kelly F.
4.11.2	The **WEBSITE** should have a minimalist design containing no features that are unnecessary to the functionality.	Inspection	Abram W.
4.12.1	The **SYSTEM** should be stored at margins slightly extended from room temperature (30-130 °F) with humidity (0-50%).	Certification	Ahmed S.
4.13.1	The **HOUSING** should be 3D printed out of PETG 3D printing filament.	Certification	Kelly F.
4.13.2	The material used for the **HOUSING** should be non-toxic, UV resistant, and waterproof.	Certification	Kelly F.

Chapter 6: Specification Control Drawing





Parts List

Item	Qty	Part Name
1	1	Casing (Lid)
2	1	Casing (Base)
3	1	Rasberry Pi 5
4	1	FPC Ribbon Cable
5	1	Heatsink Module
6	2	Heatsink Module Pins
7	1	Camera Module
8	6	¼" No. 2 thread-cutting screws
9	8	5mm magnets
10	1	Base Plate
11	1	1/5" Brass threaded insert
12	2	0.15" Wood Screws
13	1	Ball Joint Mounting Module

Chapter 7: References

40 CFR 761.20 -- Prohibitions and exceptions. (n.d.). eCFR :. https://www.ecfr.gov/current/title-40/section-761.20

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

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Is PETG food safe? Find out with Inplex custom extruders, LLC. (2023, January 25). Inplex Custom Extruders, LLC. https://www.inplexllc.com/blog/is-petg-food-safe/#:~:text=As%20just%20discussed%20PETG%20material,food%20containers%20and%20beverage%20bottles

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Safe 3D printing is for everyone, everywhere. (2024, November 25). CDC Blogs | Blogs | CDC. https://blogs.cdc.gov/niosh-science-blog/2024/07/29/safe-3d-printing/