SoundFire Systems

ESC204 Design Debrief

Team 0110D
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Introduction

Summary from Design Concept

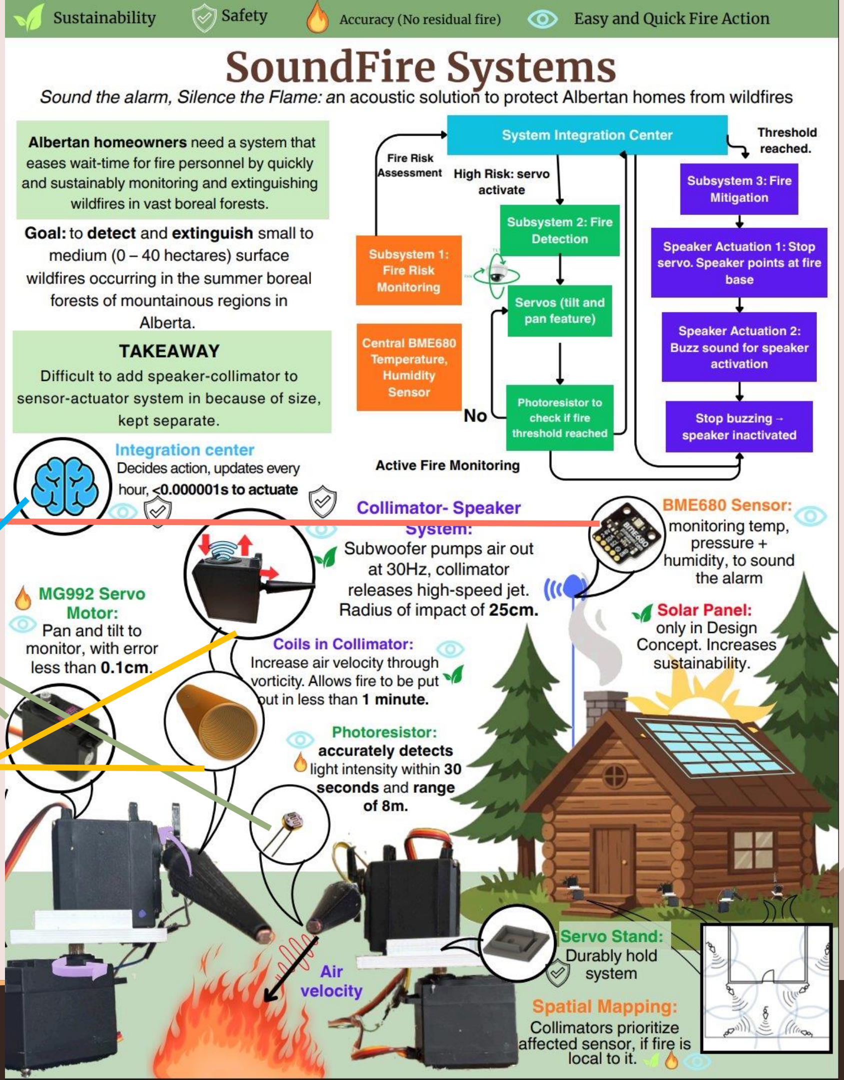
Detecting and Putting out small to medium (0 – 40 hectares) surface wildfires occurring during the summers (May – August) in the boreal forests of mountainous regions in Alberta to help its community members.

SoundFire: Acoustic Wildfire Protection System

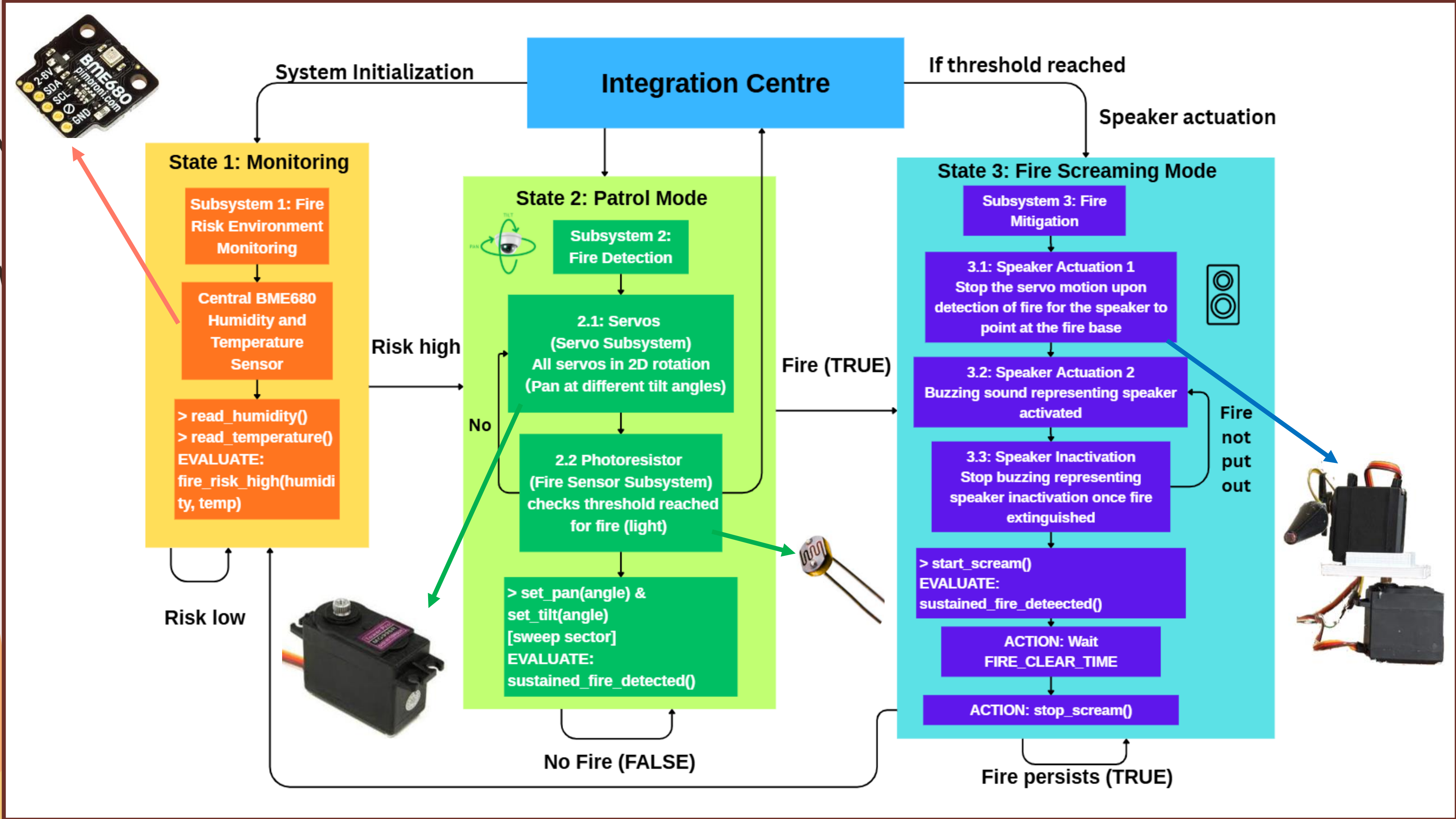
Monitor Risk
(BME680: temp, humidity, pressure)

Detect + Target
(Photoresistor + MG992 Servo system)

Suppress Fire
(Subwoofer at 30 Hz + Collimator-Speaker)

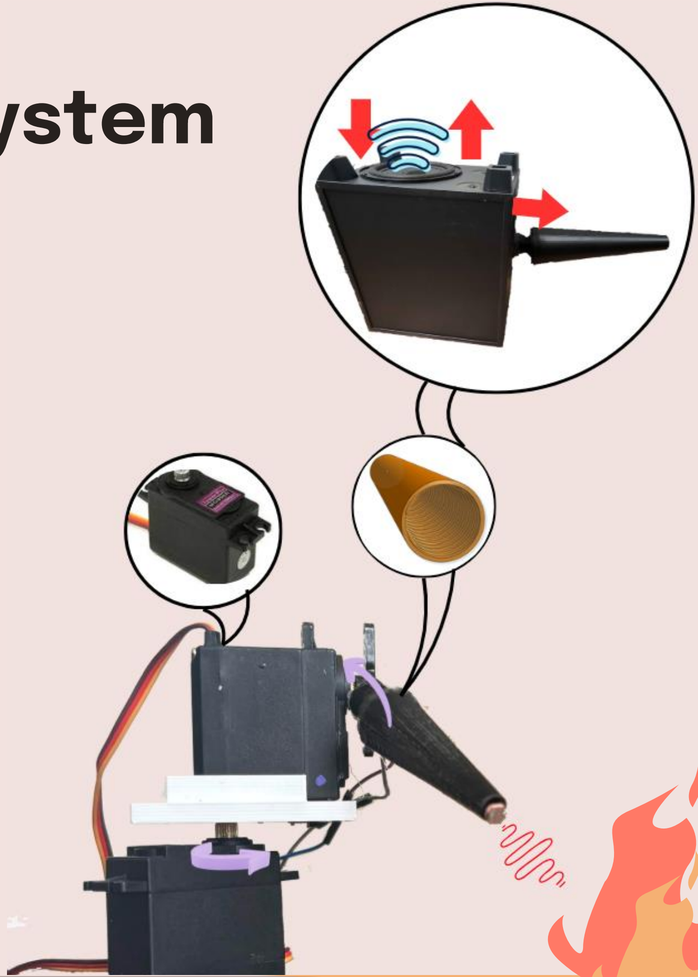


02
System Architecture



2-6V
SDA
SCL
GND
BME680
pimoroni.com
Integration Centre
System Initialization
If threshold reached
Speaker actuation
State 1: Monitoring
Subsystem 1: Fire Risk Environment Monitoring
Central BME680 Humidity and Temperature Sensor
> read_humidity()
> read_temperature()
EVALUATE:
fire_risk_high(humidity, temp)
Risk high
Risk low
State 2: Patrol Mode
Subsystem 2: Fire Detection
2.1: Servos
(Servo Subsystem)
All servos in 2D rotation
(Pan at different tilt angles)
No
2.2 Photoresistor
(Fire Sensor Subsystem)
checks threshold reached for fire (light)
> set_pan(angle) &
set_tilt(angle)
[sweep sector]
EVALUATE:
sustained_fire_detected()
No Fire (FALSE)
Fire (TRUE)
State 3: Fire Screaming Mode
Subsystem 3: Fire Mitigation
3.1: Speaker Actuation 1
Stop the servo motion upon detection of fire for the speaker to point at the fire base
3.2: Speaker Actuation 2
Buzzing sound representing speaker activated
3.3: Speaker Inactivation
Stop buzzing representing speaker inactivation once fire extinguished
Fire not put out
> start_scream()
EVALUATE:
sustained_fire_deteected()
ACTION: Wait
FIRE_CLEAR_TIME
ACTION: stop_scream()
Fire persists (TRUE)

Subwoofer System



03

System Utility

NGOs to Specifications

Identified Need (Statement)	Value Proposition + Approach	Associated Goals		Objectives #	Description	Metric	Justification
There is a need to support communities (particularly those living in remote regions at the Wildland-Urban Interface (WUI)) in implementing prevention and mitigation measures to improve resilience to Wildland Fire in Canada.	Wildland fire is essential in the renewal of Canada's forest landscapes; however, it has the potential to cause significant damage to structures and other community assets at the Wildland-Urban Interface (WUI). Empowering communities to improve the resilience of both community and privately owned structures to the eventuality of wildland fires can support thriving of these communities in the long term. One approach to provide value is to enable monitoring of an ongoing wildland fire event, to help make informed decisions about protection and/or mitigation actions.	G-1	Collect actionable data regarding an ongoing wildland fire event.	O-1.1	Observe key indicators of fire behaviour, including at a minimum the local windspeed and rate of spread [1].	Wind speed and wild fire spread rate shall be measured.	~10% of the average 10m open wind speed. As Alberta is one of the windiest and driest provinces in Canada, it makes it more important to assess wildfire spread from the wind
				O-1.2	Provide fire detection and extinguishing information regarding a large coverage area, with a minimum area of **100** acres [1].	Coverage area 100 acres over which accurate information is provided.	wildfires are larger than 200 hectares, many of these wildfires starting off as medium, more controllable wildfires. Thus, to address our framing of extinguishing
				O-1.3	Collect data regarding key indicators of local wildland fire risk, at minimum temperature and precipitation.	Collection of data relevant to assessing fire risk in a local area including temperature, wind speed and humidity, such that the Fire Weather Index (FWI) can be assessed.	precipitation play a primary role in determining the spread of wildfires, so it is important to use and maintain a system widely used by the Government of Alberta.
				O-1.4	Provide information regarding a large coverage area, with a minimum area of 5027 km sq.	Coverage area 5027 km sq. over which accurate information is provided.	identified in Alberta is by employing fire lookouts. 127 look outs are able to cumulatively detect 30% of wildfires starting annually and reporting wildfires
				O-1.5	Provide data at a sufficient rate to enable understanding of fire behaviour, and not less than once per second [1].	Data collection rate shall be at least once per second.	pressure and temperature sensors that can collect data quickly operates at 1Hz. All other commonly available sensors like motion, sound, and vibration
		G-2	Enhance existing protection and/or mitigation measures based on improved understanding of local fire behaviour.	O-2.1	The fire extinguisher should be able to operate for a minimum amount of time	The fire extinguisher shall be able to last for at least 13s per cycle before completion/refill according to NFPA-10.	NFPA-10 requires a minimum discharge time of 13 seconds for portable fire extinguishers. For this specific design, the metric is adopted such that the acoustic fire extinguisher shall operate for a minimum of 13 seconds per activation for fire to be efficiently extinguished. [22]
				O-2.2	Improve effectiveness of protection and/or mitigation actions based on data, with larger change in effectiveness (see metrics) preferred.	and/or mitigation actions based on collected data [various metrics, including reduction in Structure and Site Hazard Rating [3], increased	Hazard Rating are the most popular nationwide websites and tools for collecting as much wildfire data, providing consistency and credentiality for users
		G-3	Withstand environmental stresses due to	O-3.1	surface floor for a duration of at least 1 minute [1,4] or be able to handle the fire from an area that has a temperature of 300°C for 20 minutes	Maintenance of regular operation at these temperatures for at least one minute.	design space, there are reference designs and innovations of devices like drones that are able to effectively clear a fire without resisting those

NGOs

Specifications

Specification ID	Statement of Related Specification for the Prototype System	Justification (how does this specification relate to the top-level or subsystem objective(s), translated in Prototyping space?)
S-1.2.1	Minimum Monitoring Coverage shall be at least 12m and 180 degrees in 2 directions	In Canada, average living area of a single detached house is around 1400 square feet, whic about 130 m^2. Therefore a range of 12m would be sufficient to cover the entire house.[1]
S-1.2.2	Fire Detection Sensitivity Minimum detectable flame area of less than 1m^2	Average burned area follows a t^2 expression of relationship, growing rapidly. Thus detecti at a small size enables intervention early (1m^2). 1m^2 is also the typical size of testing fo [2]
S-1.2.3	Detection Time shall be less than 60s, for fire within its range	Civilian GNSS specify horizontal accuracy typically within 5-10m under open sky condition chosen for our prototype due to its small dimension.[5] Early detection significantly limits spread of wildfire and reduces the final burned area. [3] The detection time is set to have a maximum of 1min due according to the reference design by Ramadan et al. [4]
S-1.2.4	Location Accuracy shall have a position error radius of less than 5m	Civilian GNSS specify horizontal accuracy typically within 5-10m under open sky condition chosen for our prototype due to its small dimension.[5]
S-1.3.1	Temperature Measurement Accuracy shall have an error amount of less than ±0.5°C	This accuracy is needed for surface air temperature measurements in operational weather stations. An accurate temperature measurement allows for a more precise assessment of according to Canadian government FWI. [7]
S-1.3.2	Relative Humidity Accuracy shall have an error percent of ≤ ±3% RH	WMO specifies 2-3% RH accuracy for standard humidity sensors used in fire weather netw
S-1.3.3	Fire Risk Update Frequency shall have a computation rate of at least once per hour	Canadian Forest Fire Danger Rating System supports sub-daily computation of FWI compo when higher frequency meteorological inputs are available. [7] The 1h requirement was set taking the Canadian Wildfire Smoke PM2.5 72hour map as a reference, where the map updates every hour.
S-1.4.1	Minimum area that the system must provide data over (0.5m)	The system's sensing range was verified by evaluating measurement accuracy within a 0.5 radius under controlled environmental variation. Temperature readings from the BME680 environmental sensor were compared to a reference thermometer at spatially distributed assess representativeness of the local environment. This approach aligns with ISO 7726, w specifies that environmental measurements should be conducted in situ and be represent surrounding conditions.

Specifications to Verifications

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S-1.5.1	Temperature sensor shall have a data collection rate of at least 1Hz	behavior. Sensors like the BME680 support continuous real-time monitoring, making 1 Hz

Objective 1.2 - Provide Fire Detection and Extinguishing Information Over a half spherical region of radius 12m

Spec ID	Statement of related specification for prototyping system	Verification Method (i.e., Test, Inspection, Analysis, Demo)	Verification Procedure (including metrics if applicable)	Justification
S-1.2.1	Minimum Monitoring Area	Test	1. Perform this test during the day with sufficient sunlight or lighting (~80 lumens per square feet multiplied by the number of square feet in the room). Record the resistance of the photoresistor. 2. Shine a phone flashlight on top of the photoresistor and record the change in resistor value. Allow 30 readings of the resistance before proceeding. 3. Mark a 12-meter radius around the sensor. 4. Step back 1 meter and repeat step 2. until reaching 12 meters. If the photoresistor resistance setting matches the calibrated resistor value within an error of 10Kohms and plateaus, then the prototype does not pass. The value at which	The test needs to replicate the sensor being able to detect the fire outside. Light intensity operates differently outside near sunlight compared to in a dark room. It is a modification from the test. 80 lumens per square feet is the average recommended amount of luminescence necessary in a highly illuminated bathroom, where bathrooms are required to have the highest illumination in a house, and thus being closest to the high intensity of the Sun. [1] [2] 2. The distance of 12 meters is taken from 04.4/Prototype_Specifications The reason that the test requires you to step 1 meter is to see the range the photoresistor accuracy with distance and because photoresistors fluctuate a lot and are inaccurate, and a sample size of 30 will allow for

Specifications

Verification Methods

This spreadsheet is adapted from an example Verification and Validation Plan provided by NASA at https://www.nasa.gov/reference/appendix-d-requirements-verification-matrix/

Legend	Pass	Fail

Specification ID	Statement of Related Specification	Verification Method (i.e., Inspection, Analysis, Demonstration, Test)	Verification Procedure (including metrics, if applicable)	Results	Notes	Artifact Location	Link 1 to Artifact	Link 2 to Artifact	Link 3 t
S-1.2.1	Minimum Monitoring Area	Test	1. Perform this test during the day with sufficient sunlight or lighting (~80 lumens per square feet multiplied by the number of square feet in the room). Record the resistance of the photoresistor using a voltmeter or by printing the LDR values in your code terminal. 2. Shine a phone flashlight on top of the photoresistor and record the change in resistor value. Allow 30 readings of the resistance before proceeding. 3. Mark a 12-meter radius around the sensor. 4. Step back 1 meter and repeat step 2 until reaching 12 meters or until the photoresistor resistance setting matches the calibrated resistor value within an error of 10Kohms.	FAIL: The photoresistor was only able to get a change in value until the 8 meter mark, then began to plateau before that, making it fall 4 metres short of the 12 metre range.	The room this was tested in was 120 square feet, therefore the lumens were 9600 at the base level. The lux of the room was verified to be 9671 lux from the overhead light, by the photoresistor itself.	The code, data and graphs for this verification can be found in **04.4/Verification_Artifacts/1.2.1 . Video was removed due to dossier size, but link is still accessible.**	1.2.1.mp4	1.2.1_DATA	1_2_1p
S-1.2.2	Fire Detection Sensitivity	Test	1. Stand at the edge of the photoresistor's range (from S - 1.2.1). 2. Shine an object with surface area of lighting less than or equal to 1 m2 with light that has 200 lumens of luminescence in room (preferably a bedroom). 3. Record changes in the resistance value of the photoresistor upon shining the light. Passes if the change is more than or equal to 10 Kohms.	PASS: The area was detectable up to around 10 times more than the 10Kohm threshold.	The maximum range was 8 meters from 1.2.1. The opening of the door was calculated to be around 1.5m^2, which exceeds the minimum, validating the system further.	The code, data and graphs, and video for this verification can be found in **04.4/Verification_Artifacts/1.2.2**			

Key Specifications

G1 - Collect actionable data regarding an ongoing wildland fire event.

O1.2 - Provide fire detection and extinguishing information regarding a large coverage area, with a minimum area of 100 acres [1].

Ref #	Specification Title	Metric	Value (Target)	Justification
S-1.2.1	Minimum Monitoring Coverage	Area monitored	≥ 100 acres (≈0.405 km^2)	In Alberta, >90% of wildfires are contained under 4 hectares (~10 acres); 100 acres provides coverage beyond initial containment size for small-to-medium fires.

Prototype Concept S-1.2.1: Minimum Monitoring Coverage shall be at least 12m and 180 degrees in 2 directions

Key Specifications - Prototype

S-1.2.1	Minimum Monitoring Coverage shall be ≥ 12m radius around the head
S-2.2.2	Reliable fire detection without nuisance activation (≤ 1 false activation per 24 hours)
S-6.1.1	System should be able to suppress the fire in less than 60s

S-1.2.1: Monitoring

S-1.2.1	Minimum Monitoring Area	Test	1. Perform this test during the day with sufficient sunlight or lighting (~80 lumens per square feet multiplied by the number of square feet in the room). Record the resistance of the photoresistor. 2. Shine a phone flashlight on top of the photoresistor and record the change in resistor value. Allow 30 readings of the resistance before proceeding. 3. Mark a 12-meter radius around the sensor. 4. Step back 1 meter and repeat step 2. until reaching 12 meters. If the photoresistor resistance setting matches the calibrated resistor value within an error of 10Kohms	The test needs to replicate the sensor being able to detect the fire outside. Light intensity operates differently outside near sunlight compared to in a dark room. It is a modification from the test. 80 lumens per square feet is the average recommended amount of luminescence necessary in a highly illuminated bathroom, where bathrooms are required to have the highest illumination in a house, and thus being closest to the high intensity of the Sun. [1] [2] 2. The distance of 12 meters is taken from 04.4/Prototype_Specifications The reason that the test requires you to step 1 meter is to see the range the photoresistor accuracy with distance and because photoresistors fluctuate a lot and are

Results	Notes	Artifact Location	Link 1 to Artifact
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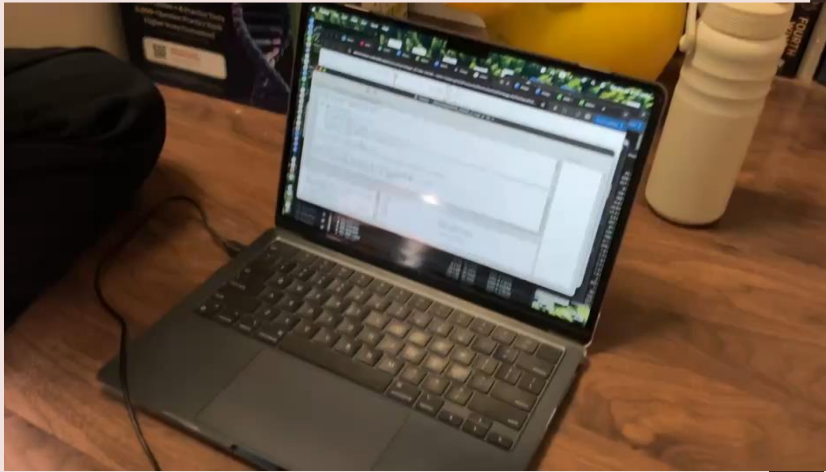


S-2.2.2: False Alarms

S-2.2.2	The detection shall be liable with minimized false alarm.	Test	1. The system shall be run over a period of 10 minutes 2. Lights will arbitrarily be placed inside the sensor's detection zone and removed 3. Over the 10 minutes interval, no false positive or false negative shall be detected	According to NFPA-72, the number of false alarms, including malicious, unintentional, nuisance, and unknown alarms shall be minimized [23]. Given the time constraint for this project, a 10-minute testing period with 0 false alarm. The 10-minute interval of intense testing would give an 85% confidence for a maximum of 1 false alarm per 24 hour, which is the common design limitation for home use fire alarms.

Results	Notes	Artifact Location	Link 1 to Artifact
PASS: Any instance of head-on light placement, including at the edge of the 10ft radius outlined in **04.1/Photoresistor_Calculations.**	The entirety of the ten minutes was not recorded due to dossier size issues. As well, in the video, due to the unsteadiness of holding a camera with one hand, some instances may have seemed like "false negatives", because the light was angled away from the photoresistor. However, when done with two hands and the light facing the photoresistors, they are all true positives.	Video was removed due to dossier size, however, the link is still attached.	2.2.2.MOV

S-6.1.1: Putting Out a Flame

S-6.1.1	System should be able to suppress the fire in less than 60s	Inspection	1. Ignite a small controlled flame on a candle 2. Activate the system 3. Measure the amount of time from activation to completely extinguish the fire using a stop watch 4. Repeat for at least 3 trials 5. verify that all trials took less than 60s	Experiments such as those conducted by George Mason University demonstrate the acoustic suppression's ability to extinguish small flames in seconds. A 60s threshold is a conservative upper bound accounting for system delays and variability. [25]

Results	**Notes**	**Artifact Location**	**Link 1 to Artifact**
directly exposed to the collimator. The flame was extinguished in less than 5 seconds. Trial 2, the flame was contained inside a small container with walls that were roughly 1 cm above the flame. The collimator was still able to penetrate through the wall and extinguish the flame within 15 seconds. Trial 3: the same procedure as Trial 2 was conducted. The flame was extinguished in 18 seconds. All tests were run 25 seconds away from the collimator outlet		Video in **04.4/Verification_Artifacts/6.1.1_ALLTRIALS**	6.1.1.mp4

Demonstration

04

Relationship to ESC204

Our Iteration Process

1

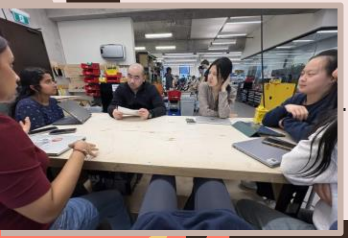
Testing our Design Concept

- Porous membrane collimator
- Testing servo motors + PIR sensors
- BME680 sensors

2

Expectation VS. Reality

- Collimator --> Not enough air
- PIR ineffective for needs --> MYFAB constraints
- BME680 sensors worked well
- Cannot integrate collimator + sensors



3

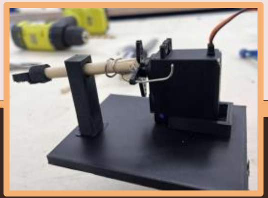
Reframing

- Advice from TAs, research, MYFAB and professors
- Finding speaker from MYFAB
- PIR --> photoresistor
- Two systems

4

Re-Building

- Putting a collimator inside a speaker instead of speaker inside collimator.
- **Simplifying**

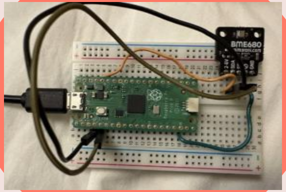


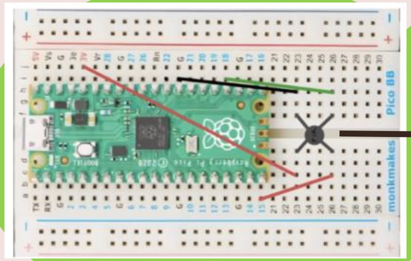
5

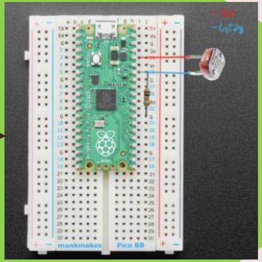
Verification

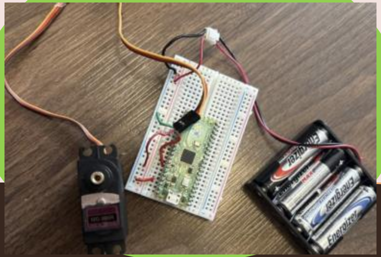
Testing using verification methods drafted for our context.

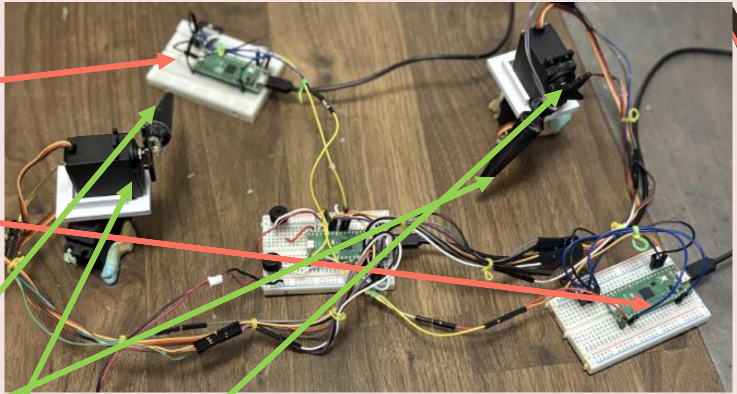
Our Iteration Process

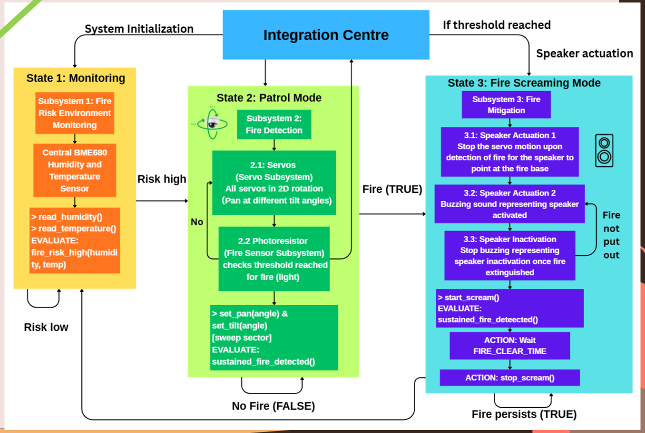




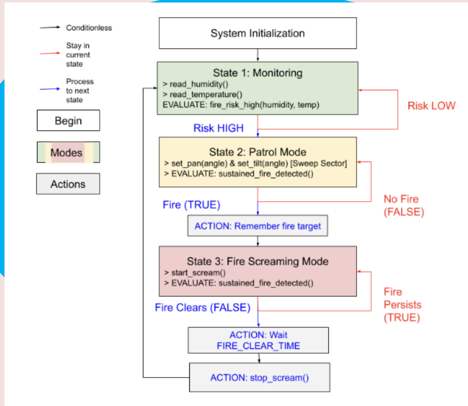


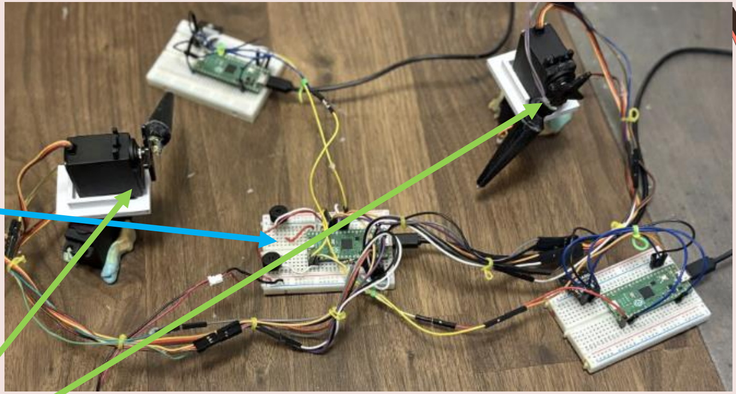


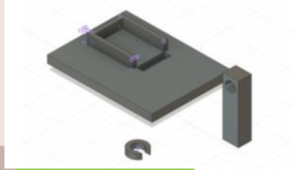


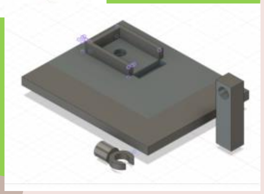


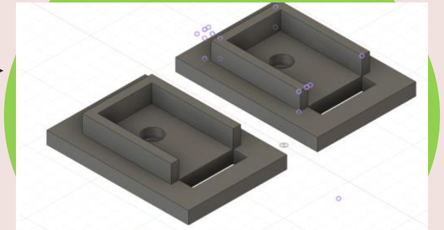
Our Iteration Process

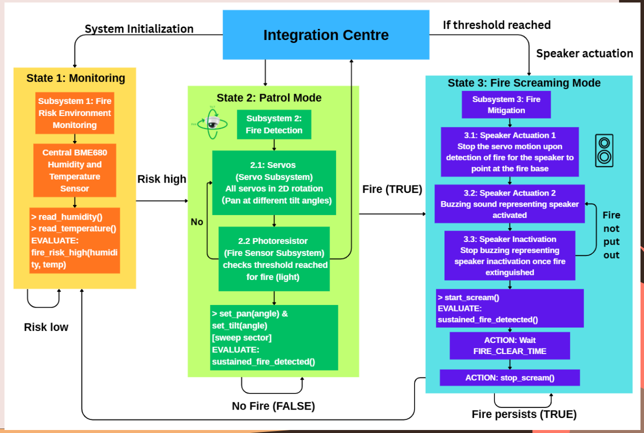












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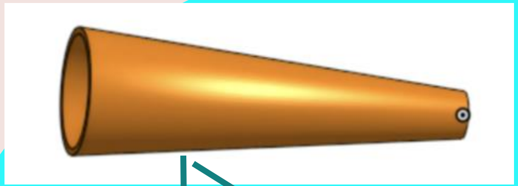
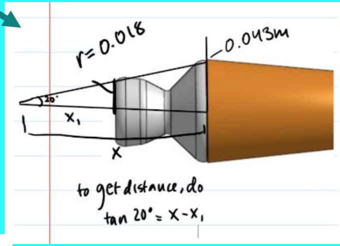
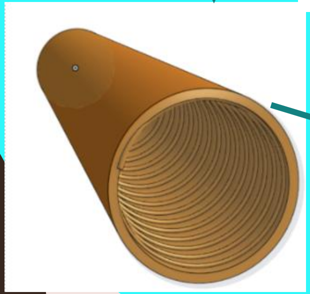
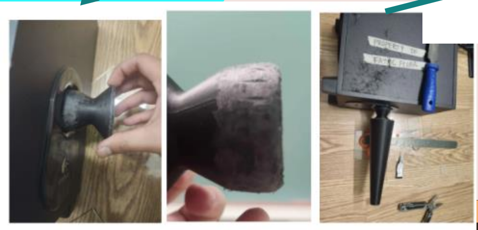
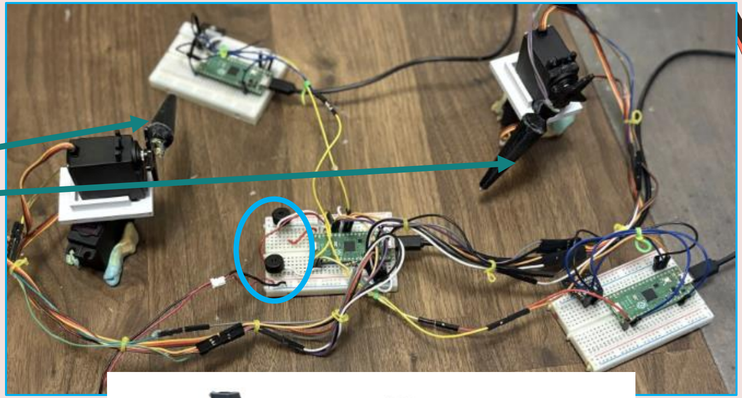
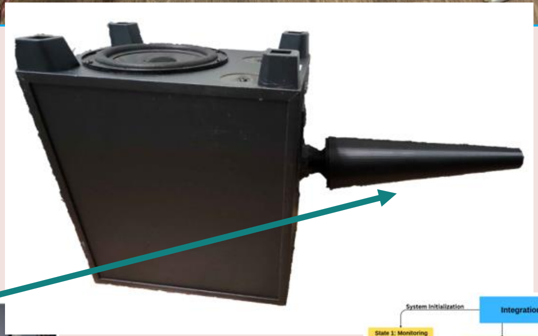


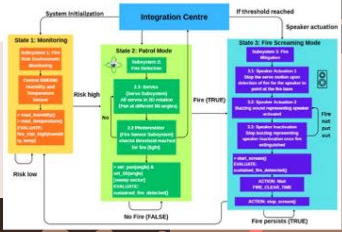












18 out of 19 specifications passed!

Able to detect fires within 12m radius (S-1.2.1: **FAIL (range was 8m)**

Able to detect fire within 60s, and extinguish fire in 60 seconds (S-1.2.3 and S-6.1.1): **PASS both**

Post-charge cleanup and discharge is zero **(S- 5.1.1):** **PASS by both subsystems)**

SENSOR-ACTUATOR: Detection to actuation latency less than 2 seconds (S-2.2.1): PASS

SPEAKER-COLLIMATOR: System generates an acoustic output of at least 20-60Pa to disrupt combustion: **PASS up to a distance of 22.5cm**

Challenges and Takeaways

Challenges

GROUP: Too many components in system architecture
Struggled to be realistic in design process and while making engineering models. .

GROUP: Time-management in completion of certain projects. Delays were inevitable.

INDIVIDUAL: For CAD, so many iterations needed to be made because of small errors in calculation, or forgetting to account tolerances.

Takeaways

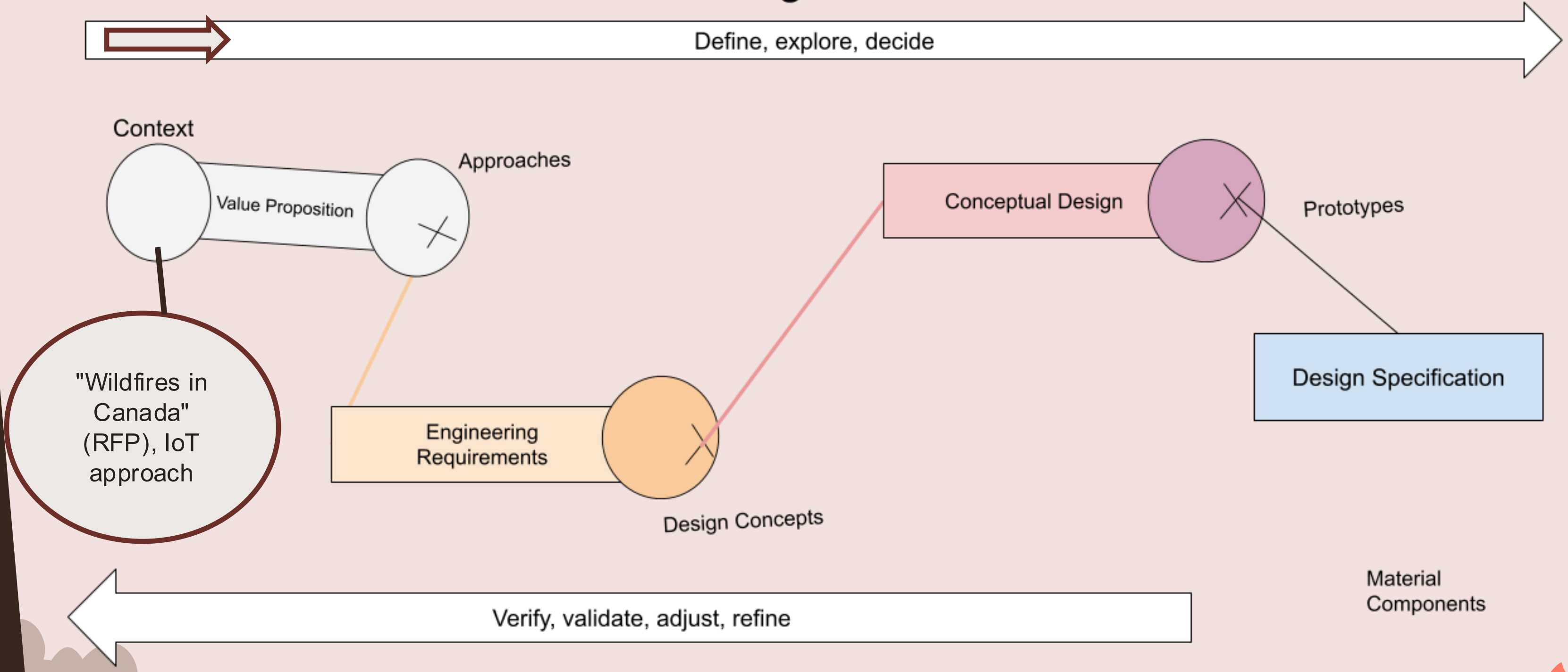
Simplest Solution is the Best Solution
Integration of two systems is hard

Make engineering assumptions on research

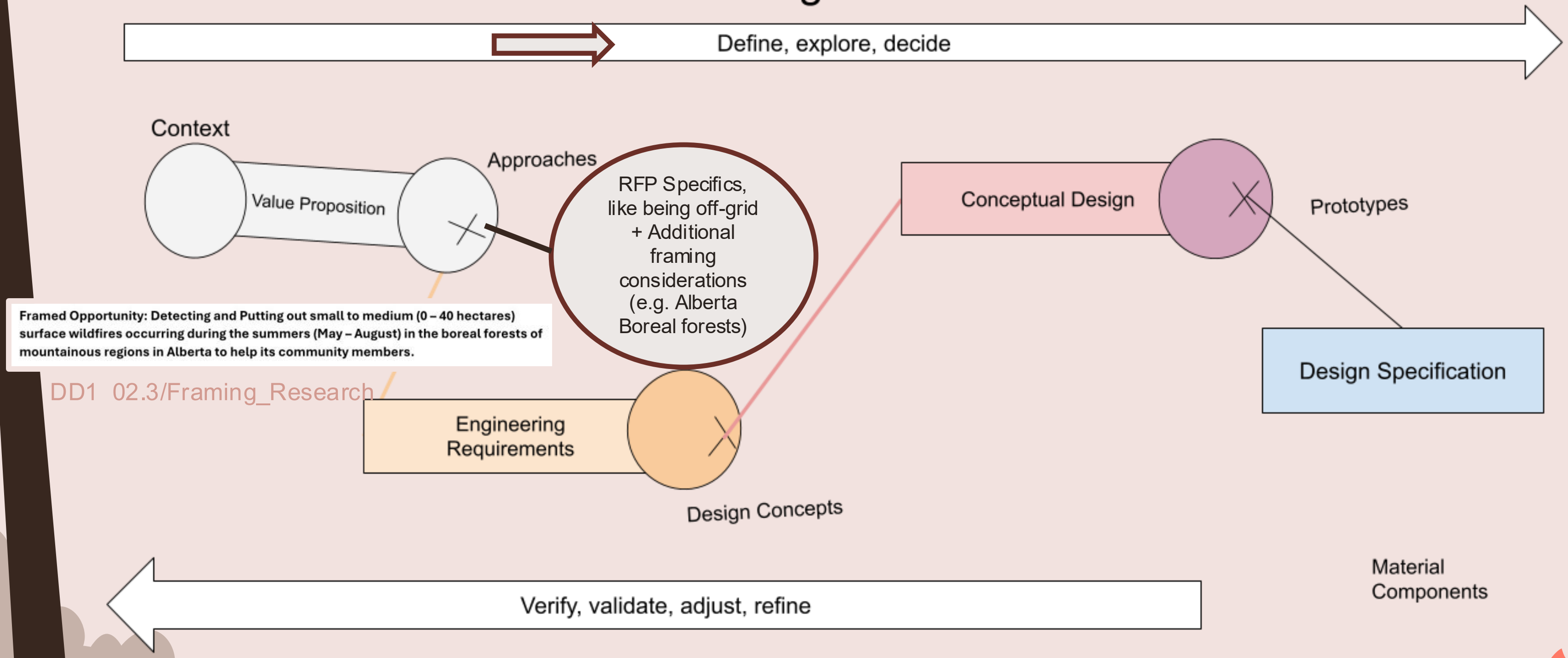
Sometimes, revisiting old ideas has benefits
Collimator challenge of air displacement

05
Design Chain Integration

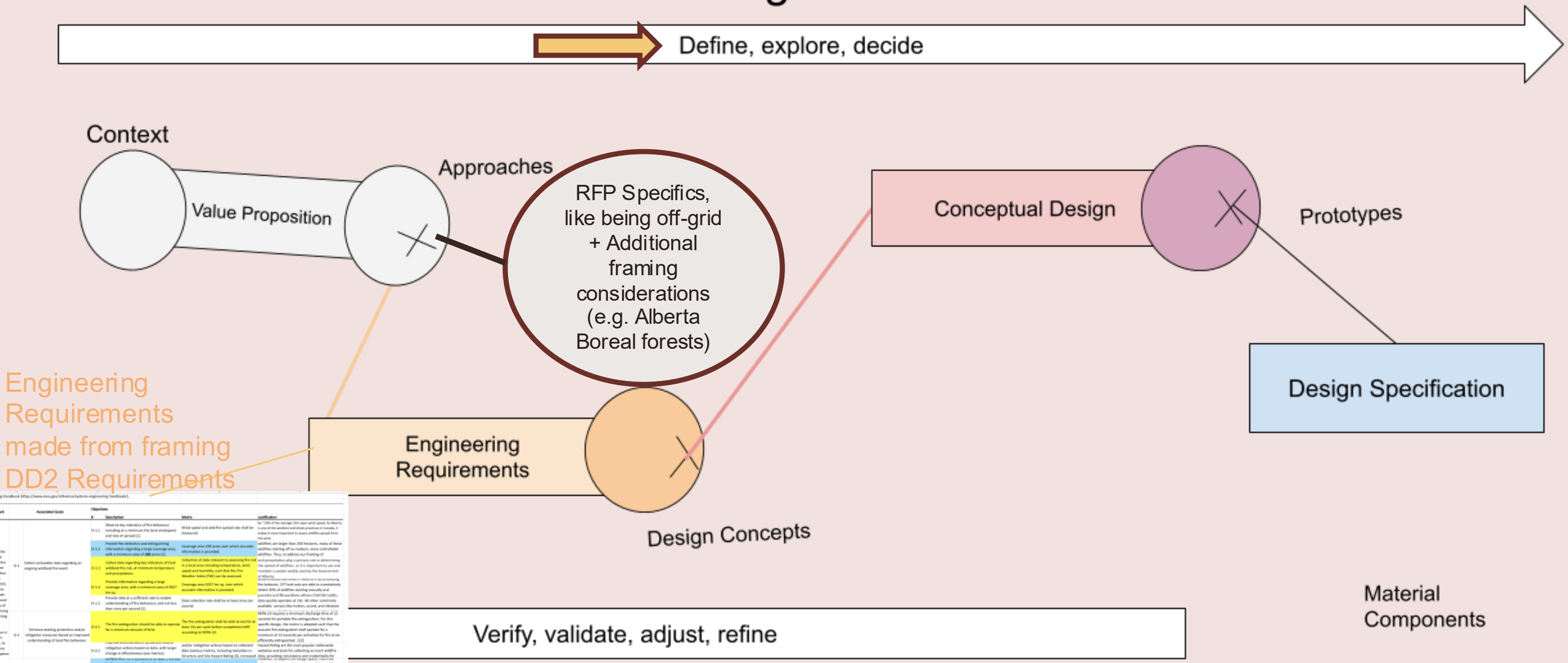
Design Chain

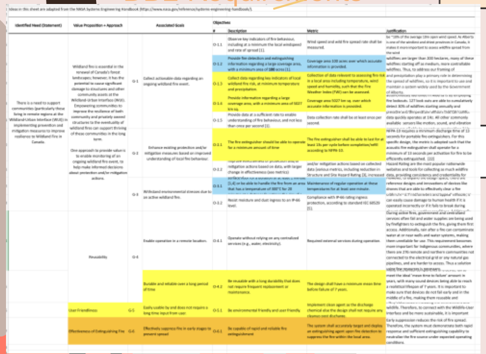


Design Chain



Design Chain





Design Chain

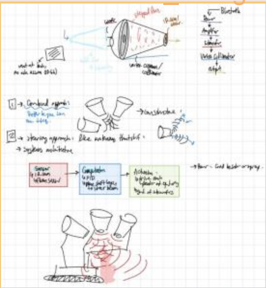
Define, explore, decide

Context

Value Proposition

Approaches

DD1_03.1/Sound_Design



Conceptual Design

Prototypes

Design Specification

Table 1- Reasoning for why each requirement was considered with greater emphasis in the Pugh Chart in Figure 2.

Objective Number	Objective Summary	Justification for Emphasis on Requirement
O1.2	Provide information regarding a large coverage area.	Protection systems at the WUI must address the Extended Zone (up to 30m) to be effective. We emphasized this because any solution is only valuable to a community if it can protect a significant perimeter of the HIZ rather than a single point.
O2.2	Improve effectiveness of protection and/or mitigation actions based on data.	Wildfire behaviour is highly unpredictable due to shifting winds and fuel types, as mentioned in the RFP. We prioritized data-driven effectiveness to ensure our chosen system could dynamically adapt its response based on real-time fire status, reducing wasted resources, and improving the probability of structure survival. Not to mention, we believe the focus of our design should be that it *actually works*, so we want to emphasize the effectiveness of the design itself to put out fires.
O4.1	Withstand high temperatures.	Equipment used for active fire protection must be able to maintain functionality while directly exposed to the heat flux of an approaching front. We prioritized this requirement to ensure that no candidate design would suffer immediate mechanical failure before it had a chance to perform its primary function.
O4.2	Allow for multiple usages (reusability).	Remote and rural communities often have limited access to emergency infrastructure and supply chains, as mentioned in the RFP. We emphasized reusability as a key differentiator to ensure a system could provide continuous protection throughout a fire season without requiring immediate refilling or replacement of parts in an isolated setting.
O5.1	Be convenient for stakeholder use.	Stakeholders at the WUI are often community members who may need to evacuate quickly. We emphasized convenience to ensure that any protection measure would not create secondary hazards, such as toxic runoff into local water sources or excessive cleanup burdens, which disproportionately affect remote populations

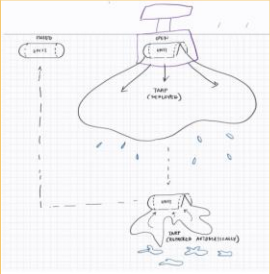
Engineering Requirements

Design Concepts

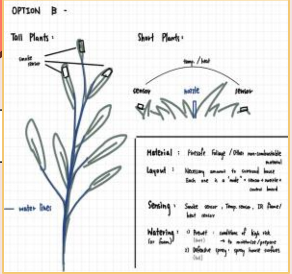
Brainstormed in DD1, all of which were designs to place around houses (as per framing)

Verify, validate, adjust, refine

Prioritized objectives from requirements, based on framing DD1 Design Concept



DD1_03.1/Tarp&Explosion_Design



DD1_03.1/Sprinkler&Border_Design

Material Components

Design Chain

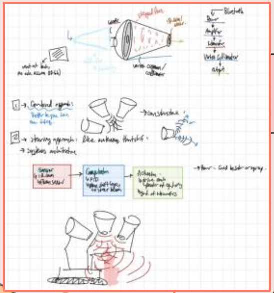
Define, explore, decide

Context

Value Proposition

Approaches

DD1 03.1/Sound_Design

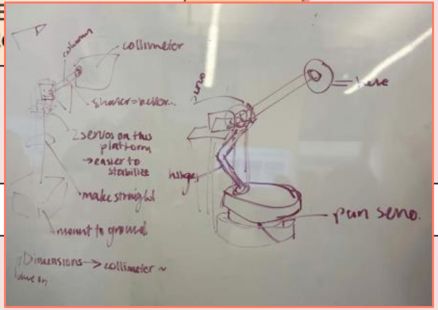


Conceptual Design

Prototypes

Chose the go-forward conceptual design based on prioritized requirements, context

Design Specification

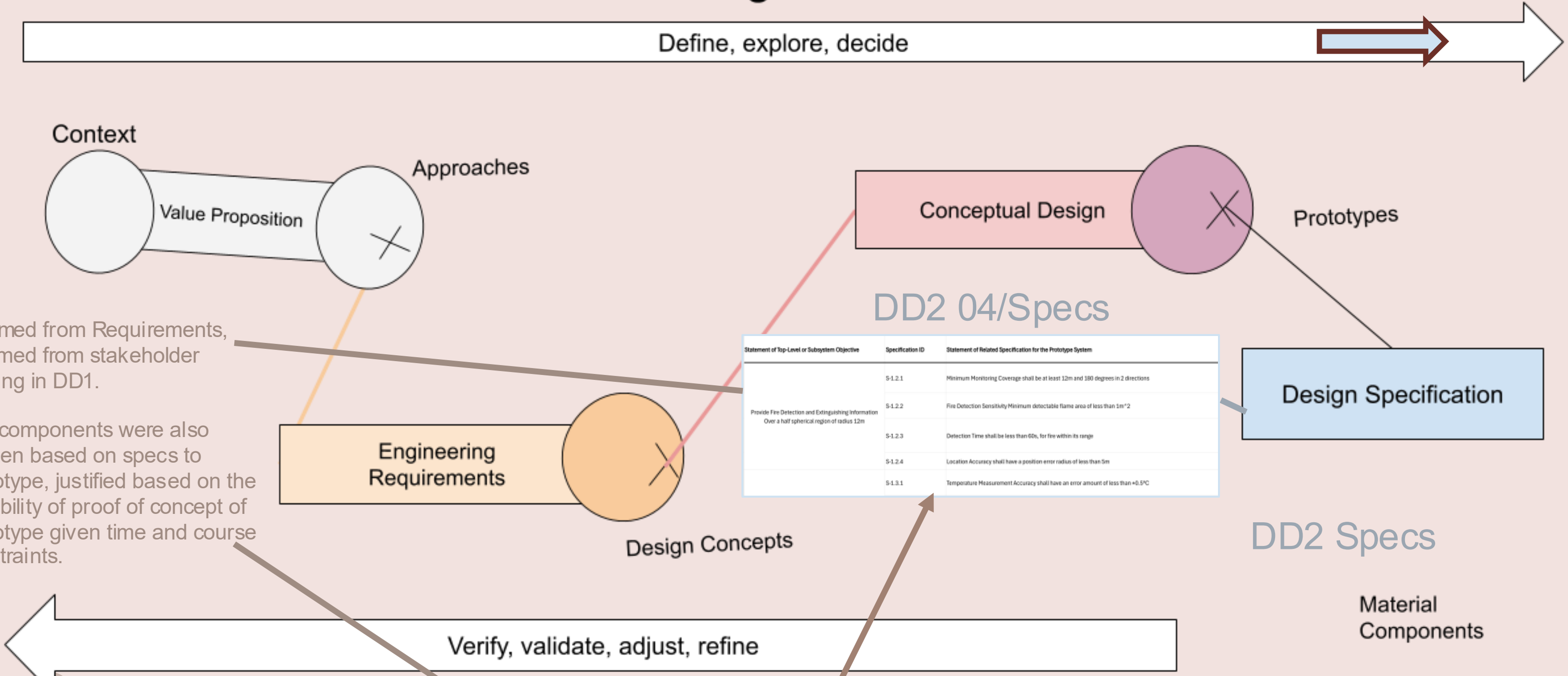


DD1 03.2/Converge

DD1 03/PrototypeConcept

Material Components

Design Chain



Informed from Requirements, informed from stakeholder framing in DD1.

The components were also chosen based on specs to prototype, justified based on the feasibility of proof of concept of prototype given time and course constraints.

DD2 04/Specs

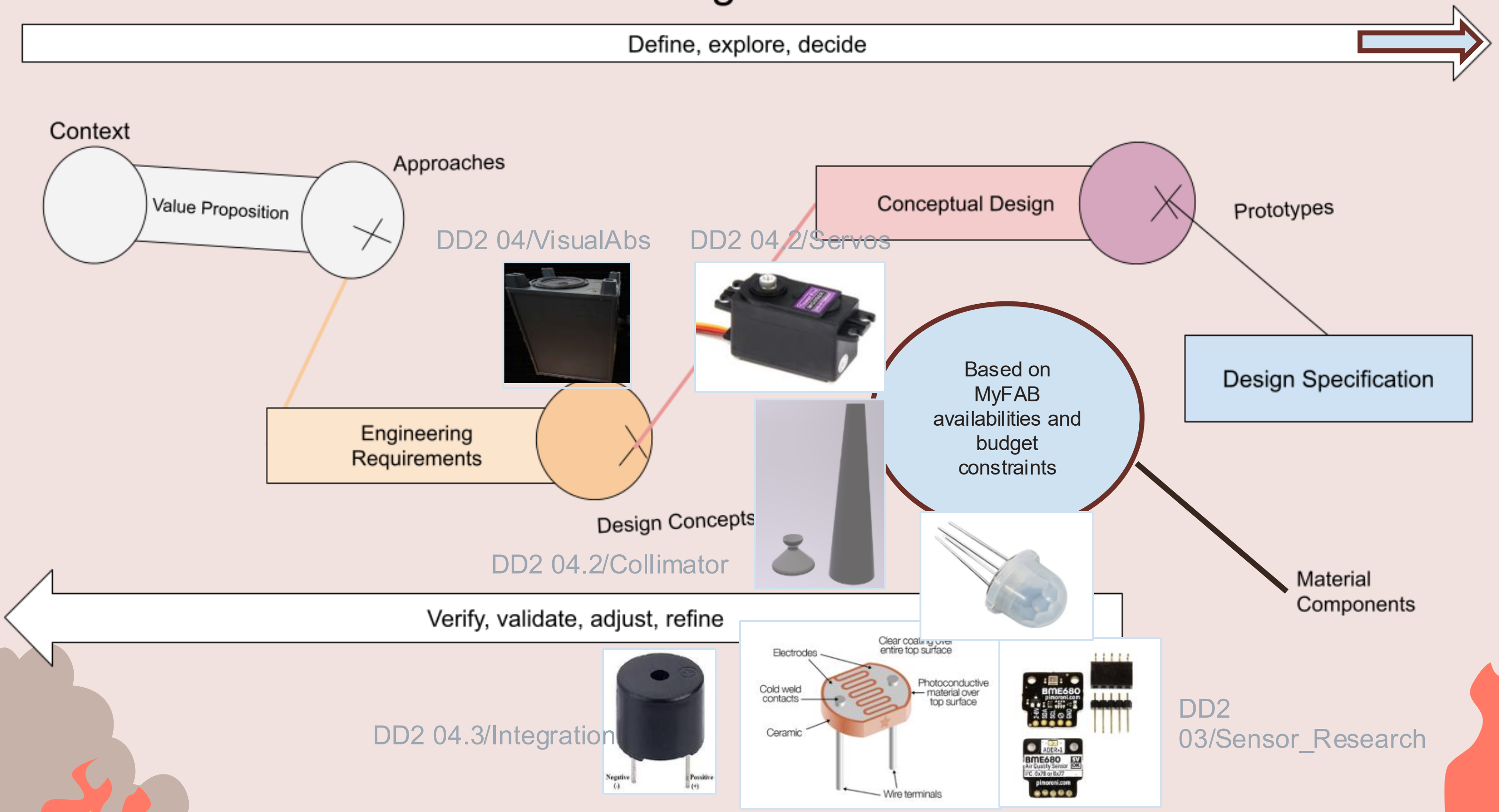
Statement of Top-Level or Subsystem Objective	Specification ID	Statement of Related Specification for the Prototype System
Provide Fire Detection and Extinguishing Information Over a half spherical region of radius 12m	S-1.2.1	Minimum Monitoring Coverage shall be at least 12m and 180 degrees in 2 directions
	S-1.2.2	Fire Detection Sensitivity Minimum detectable flame area of less than 1m^2
	S-1.2.3	Detection Time shall be less than 60s, for fire within its range
	S-1.2.4	Location Accuracy shall have a position error radius of less than 5m
	S-1.3.1	Temperature Measurement Accuracy shall have an error amount of less than ±0.5°C

DD2 Specs

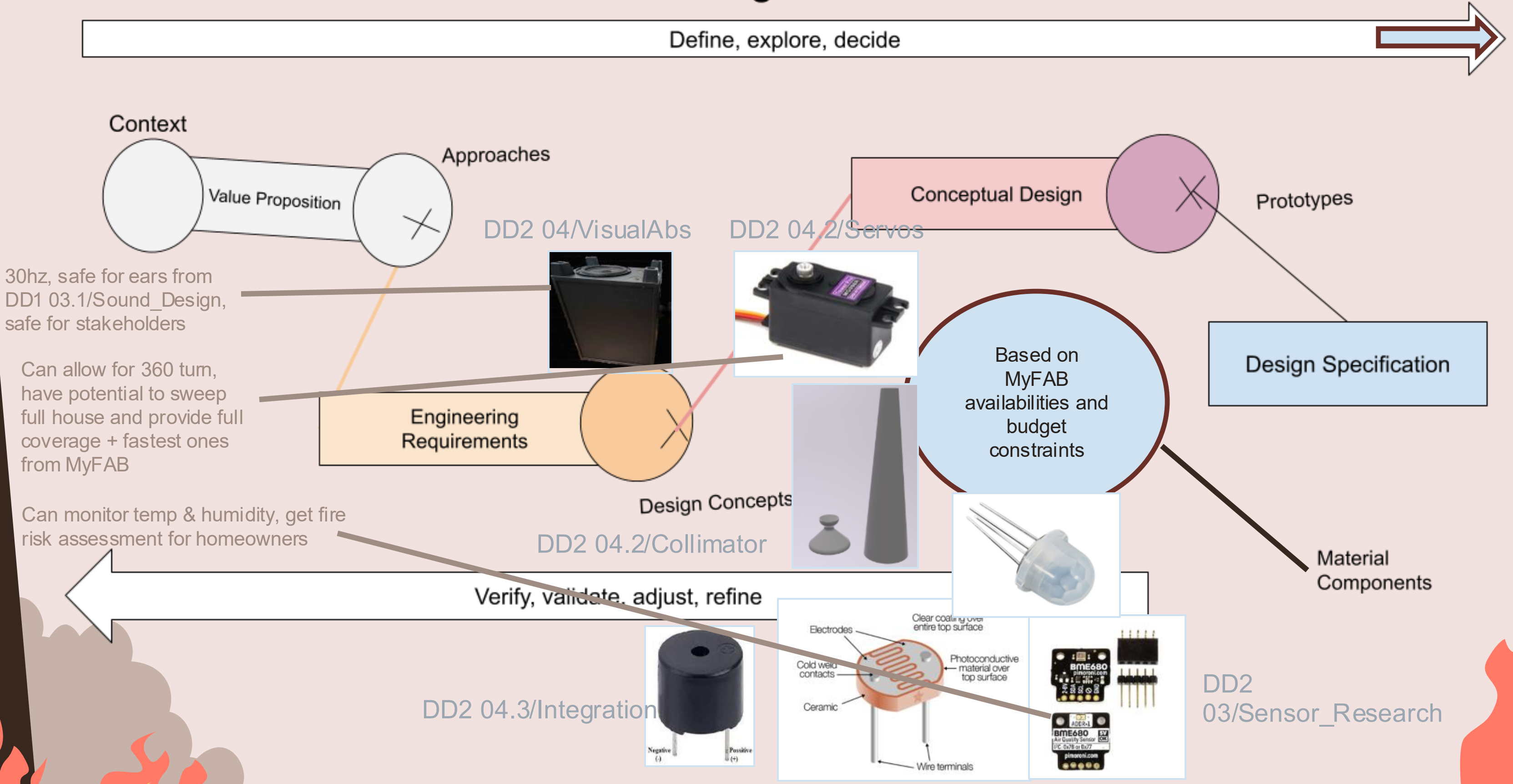
Subsystem	Category	What to verify	Specification
1	Fire risk	Humidity sensor detects data appropriately	S-1.3.2; S-1.5.2
		Temperature sensor detects data appropriately	S-1.3.1; S-1.5.1
2.1	Servo	Servo pan at different tilt angles	S-1.2.1; S-1.5.3
		Servo tilt to desired direction	S-1.2.1; S-1.5.3
2.2	Photoresistor	Photoresistor detects fire correctly	S-1.3.3; S-2.2.2; S-1.2.2; S-1.2.3
3.1	Speaker acutation	Find direction to turn for all speakers	S-1.2.4
3.2	Speaker actuation	Start all speakers once fire detected	S-2.2.1; S-2.1.2; S-2.1.1
3.3	Speaker stop	Stop all speakers once fire stops	S-2.2.1; S-2.1.2; S-2.1.1; S-5.1.1
	Putting out Fire	The amount of time it takes the system to reach the desired pressure	S-6.1.1, 6.1.2
integration centre	Fire risk	Fire risk can be assessed	S-1.3.3
	Servo actuation	All servo in action once threshold for fwi reached	S-2.2.1
	IR monitor	Determine if fire is out	S-2.1.2; S-1.2.2

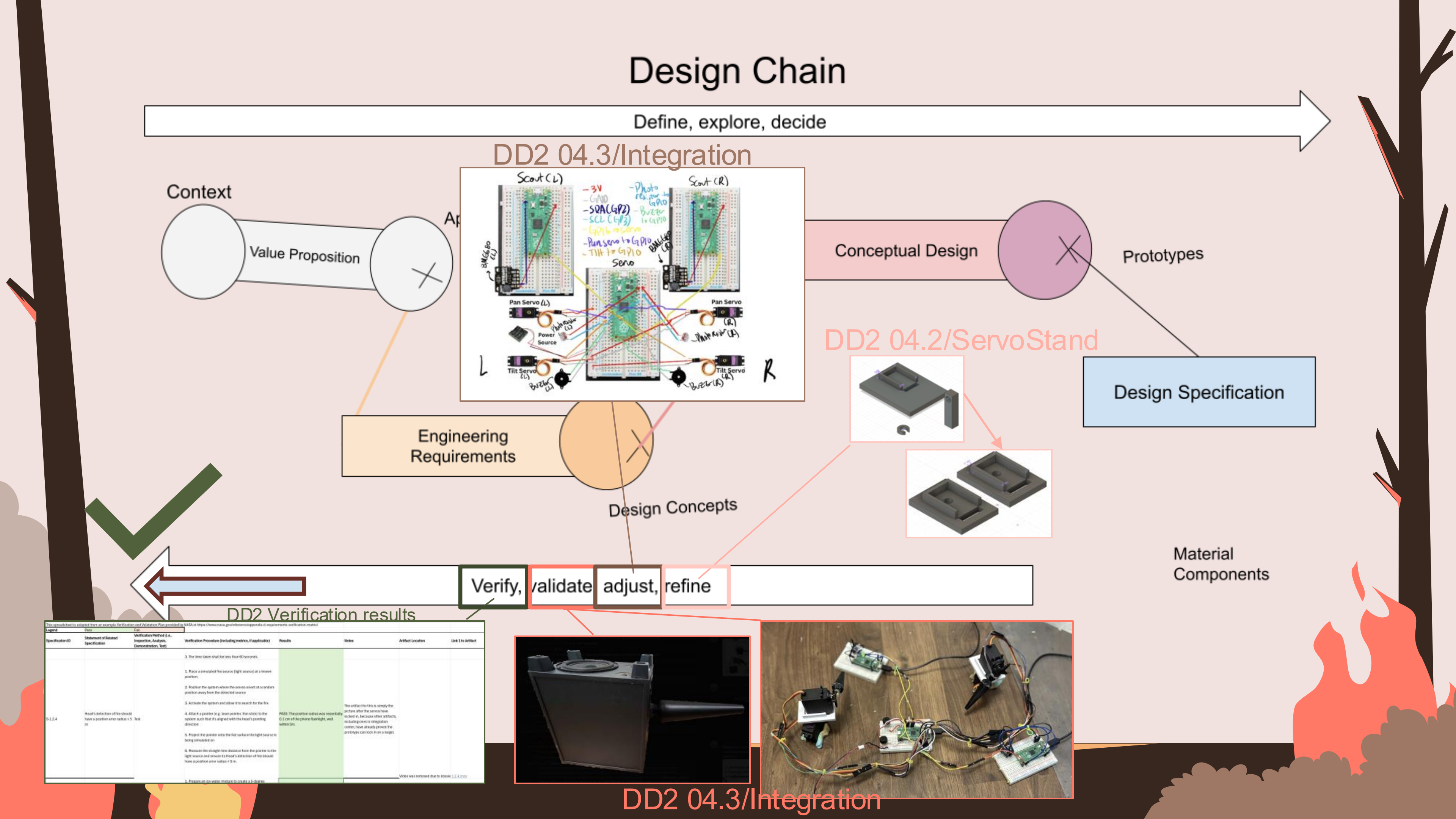
DD2 04/SpecsToPrototype, from DD2 04/ConceptSpecs

Design Chain



Design Chain





Design Chain
Define, explore, decide
DD2 04.3/Integration
Scout (L)
Scout (R)
Servo
Pan Servo (L)
Pan Servo
Power Source
Tilt Servo (L)
Tilt Servo
L
R
Context
Value Proposition
Conceptual Design
Prototypes
DD2 04.2/ServoStand
Design Specification
Engineering Requirements
Design Concepts
Material Components
Verify,
validate
adjust,
refine
DD2 Verification results
DD2 04.3/Integration

06

Teamwork

Moving from Phase 2

Post-Phase 2 Reflection

Ground Rules Moving Forward

- Being more realistic (which we have been trying to do with scaling down)
- Find ways to incorporate ideas more elegantly
- Integrate ideas instead of discarding
- Use research-backed decisions

Strengths Identified from feedback

- Jessica: creative ideas
- Yiran: strong ideation
- Aarya: communication + interaction
- Victoria: creativity + positivity
- Sara: team coordination/check-ins
- Srishti: out-of-box ideas + high expectations

Key Improvements for Phase 3

- More frequent check-ins (big picture focus)
- Reduce:
  - Side conversations
  - Misalignment during discussions
- Improve:
  - Idea integration (SCAMPER method)
  - Realistic prototyping
- Maintain / Improve:
  - Psychological safety
  - Having fun! (as stated in 04/0110D_DD1_TeamCharter.pdf)

Team Goals for Prototyping

- Being realistic
- Aiming simple, yet innovative and novel ideas.
- Prioritizing low cost and sustainability whenever possible, especially because our "stakeholders" value sustainability as well

- Individual reflection on feedbacks received (strength and constructive)
- Key improvements to be made:
  - Less side conversation
  - More check-ins
- Team goals:
  - Foster psychologically safe learning environment
  - Realistic
  - Have fun!
- Decision to assign tasks based on strength and interests

SMART Goal

- Zone of proximal development (praxis 1)
- Social event for bonding
- Cross collaboration for learning and innovation

Aarya: Yiran (CAD for collimator), Sara (for verification procedure and results, speaker idea, BME680), Srishti (creating the visual abstract, calculations and creating the speaker idea), Victoria (understanding the verification justification).

Jessica: Yiran (working on the CAD stand), Srishti (working on the prototype overview), Victoria (integration center), Sara (for the servos and the speaker idea),

Yiran: Jessica (CAD stand), Aarya (collimator CAD and designing), Sara (integration center)

Sara: Yiran (integration center), Jessica (servo and integration center), Srishti (sensors and actuators), Victoria (integration Center)

Victoria: Aarya (verification justification and editing of citations), Jessica (integration center), Sara (integration center for the code)

Role Delegation and Project Management

Assignment of tasks based on strength and interested area to improve

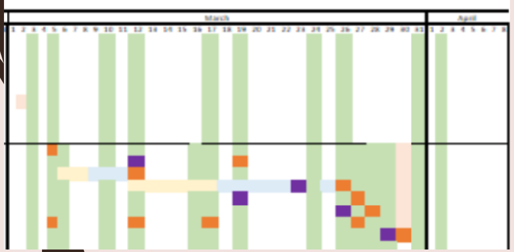
- Aarya has a heavy finance background based on her experiences and the icebreakers we conducted. Thus, we put her in charge of procurement and budgeting activities, along with tracking and purchasing the majority of orders.
- Srishti and Aarya are both heavily interested in the aerospace industry and work, and they wanted to perform calculations regarding air displacement amounts through a collimator using concepts like fluid mechanics. Thus, they oversaw that particular analytical verification procedure.
- Yiran mentioned her interest in improving her CAD skills, so she took the lead on developing CAD models, while also collaborating with other team members during Phase 3 prototyping to refine and iterate designs.
- Sara was consistently recognized in team feedback as being strong in coordinating check-ins and assigning tasks. Because of this, she was responsible for overseeing the integration center, where all subsystems come together, ensuring smooth communication and coordination across different parts of the project.
- Jessica has prior experience with circuit building from previous design team work. Therefore, she was responsible for the servo system design in our prototype, which is one of the key components of our overall system.
- Victoria has less prior experience with hands-on building, so she was assigned responsibilities such as the team charter, meeting minutes, and verification documentation. This role allowed her to stay involved with all subsystems, interact with different team members, and build a better understanding of the overall project by documenting and learning from others' work.

Westeria	Mechanical	Servos	Week 1 (3/9/2026 - 3/15/2026)	50	Complete
Persian Lilac	Documentation	System Architecture	Week 1 (3/9/2026 - 3/15/2026)	60	Complete
Bowtruckle	Documentation	System Architecture	Week 1 (3/9/2026 - 3/15/2026)	60	Complete
Foxglove	Documentation	Specifications	Week 1 (3/9/2026 - 3/15/2026)	60	Complete
Westeria	Documentation	Specification	Week 3 (3/23/2026 - 3/29/2026)	150	Complete
Nightshade	Documentation	Specifications	Week 1 (3/9/2026 - 3/15/2026)	45	Complete
Westeria	Documentation	Weight limit for small collimator based	Week 2 (3/16/2026 - 3/22/2026)	50	Complete
Bowtruckle	Mechanical	Big Collimator Amplifier	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Persian Lilac	Mechanical	Big Collimator Amplifier	Week 2 (3/16/2026 - 3/22/2026)	20	Complete
Bowtruckle	Mechanical	CAD for servo stand	Week 2 (3/16/2026 - 3/22/2026)	20	Complete
Bowtruckle	Testing	Test Collimator with flame	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Persian Lilac	Testing	Test Collimator with flame	Week 2 (3/16/2026 - 3/22/2026)	20	Complete
Nightshade	Testing	Test PIR with flame	Week 2 (3/16/2026 - 3/22/2026)	30	Complete
Foxglove	Electrical	Photoresistor	Week 2 (3/16/2026 - 3/22/2026)	20	Complete
Lilly of the Valley	Testing	Input fake values for temp, humidity	Week 2 (3/16/2026 - 3/22/2026)	30	Complete
Foxglove	Electrical	BME680 sensor for temp, humidity, pre	Week 2 (3/16/2026 - 3/22/2026)	90	Complete
Lilly of the Valley	Electrical	Integrate all sensors with servo	Week 2 (3/16/2026 - 3/22/2026)	120	Complete
All	Electrical	Integrate all sensors with servo	Week 2 (3/16/2026 - 3/22/2026)	120	Complete
Westeria	Electrical	Integrate all sensors with servo	Week 2 (3/16/2026 - 3/22/2026)	120	Complete
Westeria	Documentation	Remove and justify unnecessary specifi	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Bowtruckle	Documentation	Add specifications for prototype	Week 2 (3/16/2026 - 3/22/2026)	30	Complete
Bowtruckle	Documentation	Edit specifications for prototype	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Lilly of the Valley	Documentation	Verification Methods Draft	Week 2 (3/16/2026 - 3/22/2026)	30	Complete
Foxglove	Software	Prototype system map	Week 2 (3/16/2026 - 3/22/2026)	20	Complete
Foglove	Software	POI calculations	Week 2 (3/16/2026 - 3/22/2026)	20	Complete
Persian Lilac	Documentation	Verification Methods Draft	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Bowtruckle	Documentation	Verification Methods Draft	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Westeria	Documentation	Verification Methods Draft	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Nightshade	Documentation	Clean + update responsibility tracker	Week 2 (3/16/2026 - 3/22/2026)	60	Complete
Persian Lilac	Documentation	Verifying with Verification Methods	Week 3 (3/23/2026 - 3/29/2026)	60	Complete
Bowtruckle	Documentation	Verifying with Verification Methods	Week 3 (3/23/2026 - 3/29/2026)	45	Complete
Foxglove	Documentation	Verifying with Verification Methods	Week 3 (3/23/2026 - 3/29/2026)	45	Complete
Newt's Bowtruckle	Documentation	EngineeringRequirements	Week 3 (3/23/2026 - 3/29/2026)	20	Complete
Foxglove	Documentation	ReadMes for each folder	Week 3 (3/23/2026 - 3/29/2026)	15	Complete

Project Management Strategies

Agile Framework

- Creating deliverables
- Flexible timelines
- Small tasks



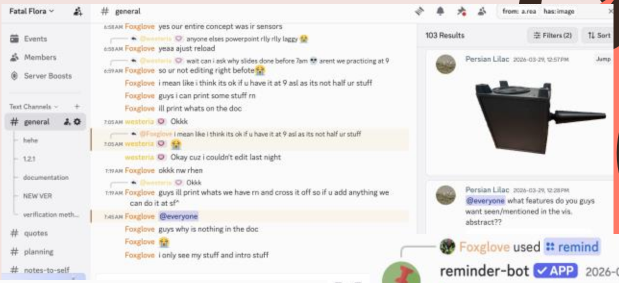
SMART Goals

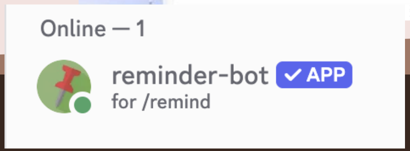
- Assessing personal and group goals.
- Meeting minutes to assess progress + delegating tasks based on individual and group goals.

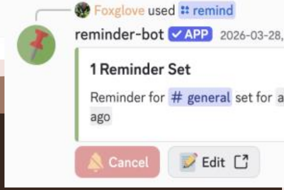
Westeria	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	45	Complete
Newt's Bowtruckle	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	50	Complete
Lily of the Valley	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	60	Complete
Nightshade	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	20	Complete
Lily of the Valley	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	20	Complete
Westeria	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	150	Complete
Foxglove	Documentation	Verification Artifacts (Collimator+Pressu	Week 3 (3/23/2026 - 3/29/2026)	15	Complete
Persian Lilac	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	15	Complete
Newt's Bowtruckle	Documentation	Verification Artifacts (Sensor+Actuator !	Week 3 (3/23/2026 - 3/29/2026)	60	Complete
Lily of the Valley	Documentation	TeamCharter	Week 3 (3/23/2026 - 3/29/2026)	60	Complete
Westeria	Documentation	ProjectSchedule (Intend + Actual Timeli	Week 3 (3/23/2026 - 3/29/2026)	30	Complete
Nightshade	Documentation	ResponsibilityTracker	Week 3 (3/23/2026 - 3/29/2026)	20	Complete
Persian Lilac	Documentation	ProcurementTracker	Week 3 (3/23/2026 - 3/29/2026)	60	Complete
Lily of the Valley	Documentation	Engineering Notebook (Meeting Minute	Week 3 (3/23/2026 - 3/29/2026)	120	Complete
Newt's Bowtruckle	Documentation	Engineering Notebook (Work Log + pict	Week 3 (3/23/2026 - 3/29/2026)	30	Complete

Communication Organizing

- DISCORD threads and channels
- Project schedule includes personal timelines/goals.
- Reminder-bot







Strengths

- More frequent check-ins online or in person
- Psychological safety and collaboration
- Personal growth and skill build up

- **Aarya** had little experience with electric circuits and was initially very intimidated by using them. In phase 3, as she oversaw the speaker-collimator system, she had to conduct a verification test that involved configuring and testing the BME680 sensor. While she did not know what she was doing initially, she watched many videos and conducted research. When she faced small obstacles, she asked her peers for mentorship and was successfully able to complete this task.
- **Srishti** had very little experience with using PIR sensors and how many sensors and actuators worked. She was assigned this role because she was open to doing any task and she conducted a lot of initial research in sensors and actuators. She was however able to get the PIR sensor working with the knowledge of the ESC204 lab handouts. She faced the issue of the PIR sensor being too sensitive, especially while mounted on the servo stand. She asked the TAs and peers for advice and was open about her concerns.
- **Jessica** has little to no experience in CAD and initially asked **Yiran and Aarya** to create the stand instead. However, it was difficult to timely communicate how she wanted the stand to look like, and they were already working on a lot of CAD work already. She took the initiative to complete the CAD stand on her own. She consulted a lot of videos and asked **Aarya and Yiran** for advice on how the CAD should look like and later collaborated with **Yiran** on this initiative. They took a few iterations to ensure the stand was how they imagined it.
- **Yiran,** alongside learning CAD, had little to no experience in 3D printing and running simulations. As we initially tried to conduct a calculation and test using simulations on Ansys, **Yiran** was encouraged to learn it. She completed training and onboarding tasks on Ansys Fluent to become more familiar with the software and asked for help in both 3D printing and Ansys from her peers, as well as individuals from MYFAB.
- **Sara** faced numerous challenges in trying to conduct research and implement the algorithm for spatial mapping. They took on this task with enthusiasm but quickly realized that there were a lot of challenges in coding (their code kept breaking) and

conducting research for the algorithm that would be specific to our context may be difficult to implement. Sara expressed concerns with an open mind of when their code would not go as planned. They ended up taking a break from the map because there were other, more pertinent tasks piling up. Taking a break allowed them to revisit with a fresher mind, and with persistent effort, they were able to solve their challenges.

- **Victoria** had a challenge where they were initially a little lost with the framing and research that was conducted during Phase 2 (creating DD1). Thus, when she had to draft the verification justification, she found it hard because she forgot a lot of the initial framing that was done because she was not in charge of it. This task allowed

March 10, 2026

Members Present: Sara, Srishti, Jessica, Yiran, Victoria, Aarya

Members Not Present:

External Attendees: Max (MYFAB), Mohammad

Agenda

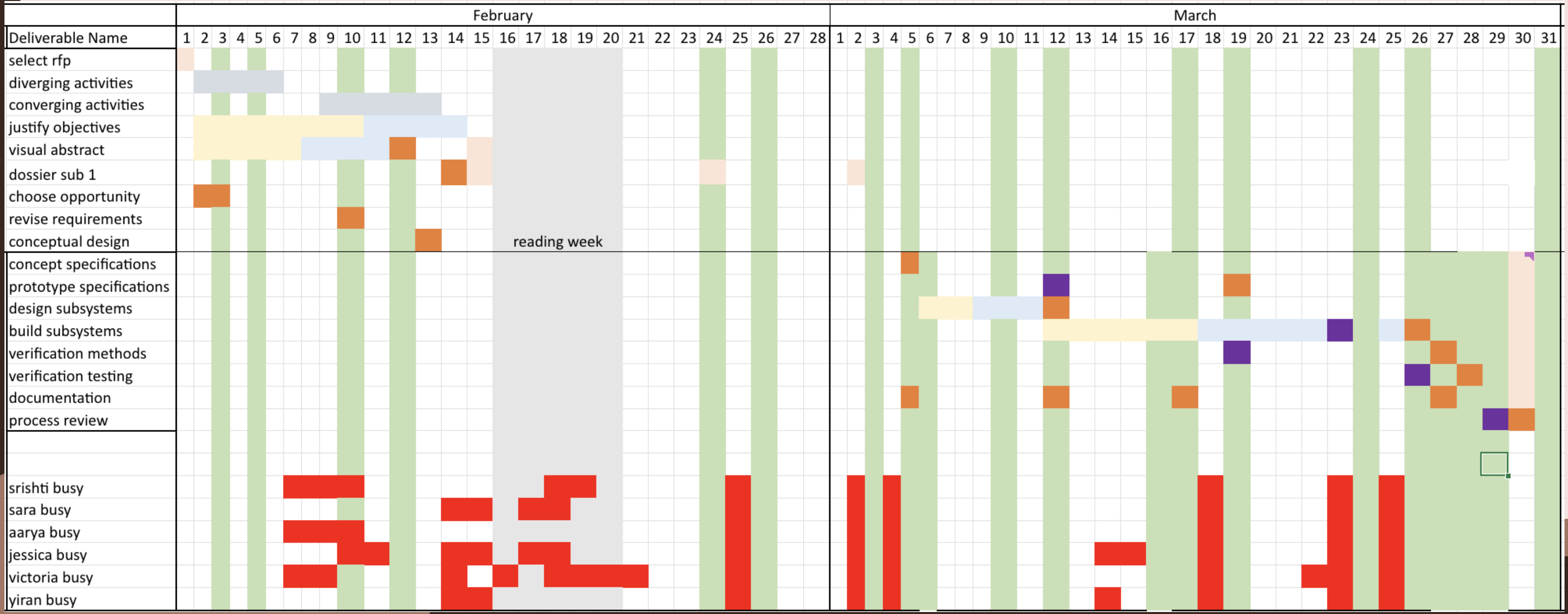
- Go over everyone's completed, discuss to do for next week

Notes

- Victoria has reviewed sensor documents, will try to finish integration centre by Thursday
- Aarya has collaborated with Yiran on and mostly finished the CAD for the subwoofer and collimator system. They just need to adjust a few things in the dimensions. Will get done by end of studio.
- Aarya and Yiran have also finished the system architecture and have shared them to the team.
- Jessica has finished preliminary testing with sensors and being able to move them, designed possible ways of placing the servos to pan and tilt the heads properly, next step is to physically implement it
- Sara has created a greedy algo to place the acutal system (sensors NOT used in prototype, used IRL) around a house, using the 10m radius for intermediate range recommended for house safety.
- Srishti has worked on using a PIR sensor, sees that it takes too long to set back, pretty buggy. Thinking of using noir cameras
  - Can also put a film/window for PIR input to limit the amount of detected IR
- Would have to get a diff raspberry pi for the camera

Challenges

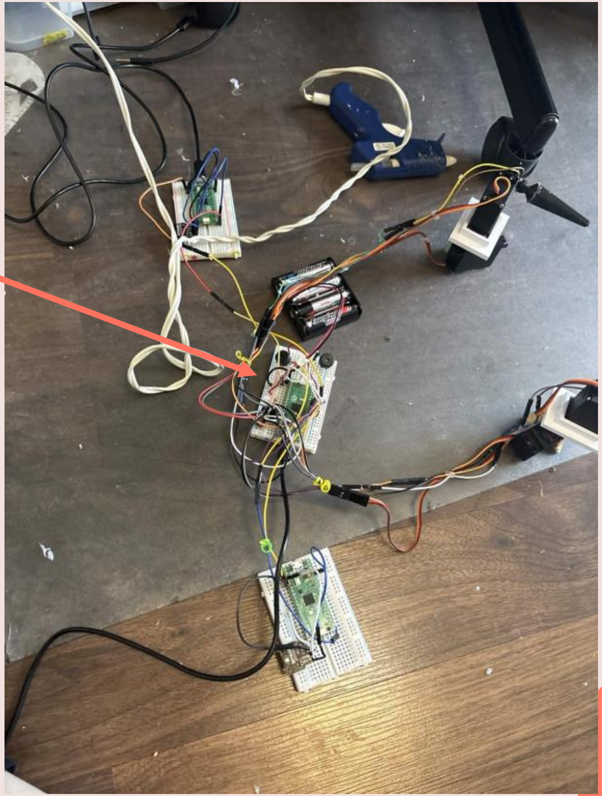
- Late integration → time pressure
- Misalignment in discussions
- Project schedule not consistently followed
- Collaboration inefficiency in some tasks



07

Future Steps

1. Enclosure for subsystems (wires)
2. Base for servos
3. Location tracking and activation in proximity
4. Start early on tasks (Dossier was a lot)
5. Clearer communication (Updating people is hard)



Thanks!

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How long does a head need to put out fire?

- Exponential increase in time taken to extinguish fire.

How Quickly a Fire Spreads

Understanding fire behavior highlights why **response time is critical**:

- 🔥 **First 30 seconds** – A small flame ignites, often unnoticed.
- 🔥 **1 minute** – The fire begins spreading to nearby materials.
- 🔥 **2 minutes** – Smoke thickens, temperatures rise, and toxic gases increase.
- 🔥 **3-5 minutes** – Flashover occurs; everything in the room ignites at once, making survival nearly impossible.
- 🔥 **Beyond 5 minutes** – The fire spreads beyond the initial room and can consume an entire structure.

This timeline emphasizes why **fire departments must be equipped with the best apparatus, technology, and training** to minimize delays.

NJ Fire Department : https://www.watchungfd.org/the-science-of-fire-spread-and-response-time/#:~:text=Several%20key%20elements%20impact%20how,%E2%9C%85%20Check%20smoke%20alarms%20regularly

While future step can be to test how long a head takes to put out a fire because of size differences.

Candle takes less than 1 minute.

Satellites can detect fires within 4m^2 whereas our requirement and prototype can detect within 1m^2.

Our prototype performs better --> we have more temperature sensors.

How many heads do you need to put out a fire?

- One head meets minimum pascal and jet velocity at 25cm (limitation factor in detection).
- Use optimization to see how we many heads required at a distance given that 20-60 Pascal acoustic pressure is necessary.
- Constructive jet velocity and how it depends on the angle at which the collimator is oriented in relation to the fire (from test we realized that you needed the sensor to be at a certain location and be accurate for you so be able to achieve the threshold pressure).
- This was complex for our prototype system because we only have one subwoofer (commercial), material constraints from MYFAB.