Assignment 8 – End of Project Report

Monday May 2

Autonomous Home Protection against Infernos

Team 12

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Elevator Pitch - ‘Home fires involving electrical failure or malfunction caused an estimated average of 440 civilian deaths and 1,250 civilian injuries each year in 2012-2016, as well as an estimated $1.3 billion in direct property damage a year’ [1, p. 1]. A semi-autonomous fire suppression robot can help minimize the destruction by providing a rapid initial response and faster suppression time than the standard fire engine can respond. Mitigating this danger would help keep people's homes, and offices safe and prevent injuries and lives from being lost. These fires can be started from a variety of different sources, such as electrical shorts, chemical spills, or arson. Additionally, they can happen when no one is present or physically capable of fighting the fire. First responders' response times can vary greatly and there are times when fires run rampant, destroying homes and important belongings before any suppression efforts may be made towards the fire, therefore, a quick response semi-autonomous fire suppression robot may be the right solution.

EXECUTIVE SUMMARY

Posed with our societal problem we brainstormed a design solution to the dynamic response of emergency services which is the rapid suppression response of a firefighting robot. Total loss of residential properties due to fires will be outdated as our firefighting robot will take on the initial fire suppression. The information gathered from our research points to a heightened danger of life for all ages, during critical times of the day which enriches the need for a quick response fire suppression robot.

To battle home fires, an autonomous firefighting robot would be the perfect solution. This robot would be capable of mobilizing to the location of an ignition/fire based on a mesh system of a fire alarm with the robot following a predefined trail to the room of a fire based on line following. Then it aims at the fire with its fire suppressant equipped to put out the danger while no verbal stop commands are asserted. Our idea provides a solution to the time propagation that it takes emergency services to arrive at a house fire. The robot will, at a minimum, prevent a fire from spreading further across the home, and at best extinguish said fire. The robot will alleviate first responders by providing more time for occupants to seek safety.

Our Project can be broken down into sub tasks or defined features which makes up the entire autonomous firefighting robot. A hierarchical graph is created to help envision tasks that must be done for this project. So far, we have four main sub tasks which are: the fire suppression system, detection system, voice commands system and mobility. These sub tasks have lower-level features that split to help make up the complete system.

The Project Timeline is a tool meant to give the team a visual representation of what parts of the project are to be completed at what times, it also serves to determine what parts of the project depend on others to be completed first. The project timeline continues to be dynamically written as the propagation of systems are continuously worked on during the semester.

All projects have a risk factor to them. They may be caused by numerous reasons such as systematic, human error, or a hardware malfunction. The purpose of this section of the report is to look at possible risk factors that would cause the project to fail and avoid them by coming up with possible solutions. Pinpointing the critical path of the project will help the team identify potential risks. Risk matrices are one tool used to assign a risk value to a probable decision that a team would make and would tell them what the impact of that decision is.

The problem statement revision shows how the team better understands the societal problem. The team confirms the original design idea or modifies it based on a better understanding of the first-semester interpretation of the societal problem. A detailed plan is created, and the design idea contract is reviewed if changes have to be made. The verification process is to ensure that all the features specified in the original design idea are implemented. The goal is to help decrease the impact of the societal problem.

The device test plan proves that our prototype works as expected using a range of quantitative data such as voltage, temperature, gas concentration, motor speed, and current. Each function of our robot has been tested individually and with integration: robot moves 1ft/sec, carries at least 1.5Ibs of water, line following works, sees fire at a certain temperature, voice commands, battery life, and smoke alarm system. This step will help us see progress and where debugging needs to take place.

The market review details who is going to use and buy the team's final product. The price and place where it will be used are also specified. The market review establishes the team's understanding of the environment in which the product will operate. The price will also vary depending on the amount of funds to create the prototype and its competitors. We will look at fire suppressions systems in homes and determine how our project is one of a kind and will perform better than other systems.

The testing results of our subsystems provided for a continual improvement of efficiency and exceeding the measurable metrics. Each subsystem is tested for its success rate and modified to achieve the best rate where errors may be prone to happening. Each individual feature set of the project has met its measurable metric with ease.

ABSTRACT

To introduce the issue of injury and fatalities during residential fires in part due to the uncertain response time of emergency services, rapid initial response against the fire is critical to lower the probability of injury, death, and destruction.

A proposed robot capable of mobilizing to a location of an ignition/fire based on a fire alarm. No product in the market currently works autonomously to fight fire within a residential dueling.

A work breaks down structure is required to finish the A.P.H.I. robot. This is the estimated amount of work needed to produce the final product.

The Project Timeline tracks what the status of completion for the robot should be over the weeks.

The goal of our risk assessment is to identify possible risks and brainstorm mitigation processes utilizing a risk matrix.

Our problem statement revision proves our understanding of the societal problem over the course by researching peer reviewed articles to make changes to our project.

The Device test plan will be done for all our systems as to undergo testing to ensure they meet engineering requirement and specification of our complete system.

Our prototype would interest consumers who own houses or maybe even a large "office-like" environment who doesn't want to lose important items. There are many competitors our protype must compete against and prove that it is better.

Our testing results stem from the continued tweaking of our subsystems to continual improve the efficiency for the overall system to make sure each feature set is completed.

KEYWORD INDEX

Robot, fire suppression, Autonomous, initial response, point and shoot, firefighting robot, line following, voice activation

I. INTRODUCTION

A. Societal Problem

House fires present a very serious and real danger to homes and people across the nation. Many people will have to deal with the loss of their home and perhaps even their loved ones through a variety of incidents that can spark a fire inside of a home. The when and where of each cause of fire can be unpredictable. Therefore, having a system that can respond to the start of fires before they engulf the entire house would be incredibly beneficial for a vast majority of people and their homes.

B. Design Idea

The design idea will guide the team in our senior design course for fall 2021 and spring 2022. For the fall portion, our team will discuss the proposal overview to figure out the spec of the build and the team's budget for the project. This semester, we will focus on designing our robot and determining what functions are needed. Such functions are: speed, voice commands, fire detection, aim & shoot, and line following. For the spring portion of the project, we will have a built prototype that the team will improve. Since our project is not sponsored, parts and necessary equipment will have to be provided by the team members.

C. Work Breakdown Structure

The work breakdown schedule helps the team to organize the project down to key components. From this basic level, each member is assigned an essential part to complete over a specific period to ensure its completion and reach the project's goals. The structure serves team members to create goals in terms of how long it will take and minimizes room for error once the project begins.

D. Project Timeline

The project timeline introduces a visual representation of the course assignments and the work packages shared amongst the team across the two semesters. The current timeline was created by the team utilizing an online platform called diagrams.io. This timeline is an addition to the Work Breakdown Structure. The timeline is included for the entirety of the two semesters which make up the Senior Design course along with milestones at their respective dates. Summarized into a few blocks, we will have researched and began building our systems in this first semester and the tweaking and deployment phases will occur in the Spring Semester.

E. Risk Assessment

The Risk assessment section of this paper dwells into the possible scenarios that may lead to our team struggling or failing to complete the project. For this we brainstormed potential scenarios that are bound around our work packages that pose a risk to our project. With the help of a risk matrix, we assigned each case a risk value, a value from 0.1 through 4.5, with the latter being a high risk and the former a low rating on how detrimental the risk actually is.

F. Problem Statement Revision

The inferno scenarios that led us to build our end of the fall semester prototype continues to pave the way for developing a solution to the problem of residential fire fatalities and injuries. Said infernos present serious and real danger to those faced with the true consequence of attempting to fight the fire rather than fleeing or calling for help. Many people will have to deal with the loss of their home, lives and perhaps even their loved ones through a variety of incidents that can spark a fire where the lack of preparation or experience firefighting may occur. Therefore, having a system that can respond to the start of fires before they engulf the entire house and step in as rapid suppression response would be incredibly beneficial to the lives of those residing in home endangered by fires.

G. Device Test Plan

The Device Test Plan places the prototype's subsystems through a series of planned trials in order to verify their successful operation and fulfillment of specifications before becoming a final product. The Device Test Plan for A.H.P.I. tests five major systems. Those major systems being: Fire suppression, Fire Detection, Mobility, Smoke Alarm Activation, and Battery Life.

H. Market Review

Our prototype tries to solve, prevent, or slow the societal issue: house fires. The consumers who would be interested in our product would be home owners and companies who own single-floor buildings. When a house fire does happen, our client loses many of their valuable items and even lives. Our main target would mainly be families who have children in the house or important items they cannot afford to lose in the house. An alternative client would be companies who run an "office-like" environment who needs important document or servers to be saved.

I. Testing Results

Our prototype has been through many various testing plans and detailed analysis to determine that each subsystem works independently and through integration with the whole system. We have derived from our initial plan at the start of the semester with the data we collected with testing to make new test plans that work.

II. *SOCIETAL PROBLEM*

A. *First Semester Interpretation of the Societal Problem*

House fires present a genuine danger to people and property. From 2012-2016 house fires have caused an estimated 440 deaths and 1,250 injuries each year, along with an estimated $1.3 billion in direct property damage [1, p. 1]. In an attempt to lessen this impact, the team brainstormed to design a solution and create a semi-autonomous house fire suppression robot. This robot would help minimize or prevent a fire by providing a quick response and suppression time.

B. Second Semester Improved Interpretation of the Societal Problem

Our prototype, A.H.P.I., focuses on attacking fires that are started within the home. A.H.P.I. would not only be saving the residents of the home it lives in, but also has the potential to prevent one of California's largest societal issues. This issue is the wildfires that ignite all along with the state and spike during the summer months. A house fire in a rural setting is a recipe for disaster in the dry, hot months of the summer. 'The extent of flame damage that residential structures sustain is worse in rural areas than in non-rural areas. This is likely due to two factors. Emergency response times are longer in rural areas due to longer travel distances. Additionally, fires may burn longer before being noticed in rural areas due to lower population densities,' [11, p. 6]. In other words, house fires in rural areas have more opportunities to grow and spread to not only the entirety of the house but to the land around it as well. A.H.P.I. is designed to fight the residential fire immediately to either completely put the fire out or allow firefighters more time to respond before it can develop into a wildfire.

There are thousands of homes that are destroyed every year due to fires. The National Fire Protection Association (NFPA) researched that 'In 2003-2007, 92% of all fire deaths occurred in the home, resulting in an estimated 2,850 civilian deaths' [2, p. 1]. These fires can be started from a variety of different sources such as electrical shorts, chemical spills, or arson. Cooking equipment is the number one leading cause of fire injuries [2, p. 37]. 'Smoking materials have historically caused the largest share of civilian deaths in home structure fires even though they account for 5% of the home structure fires' [2, p. V]. Additionally, they can happen when no one is home or to those who are not physically capable of handling the fire. 'Based on 2003-2007 experience data, children under age 5 are almost one and a half times as likely to die in a home fire as the general public. Older adults age 75 or over are nearly three times as likely to die as the general public' [2, p. V]. First responders' response times can vary greatly therefore, there are times when fires run rampant, destroying homes and important belongings before any sort of action is taken towards it. First responders could also be too late to the scene, potentially resulting in injury or death to the occupants.

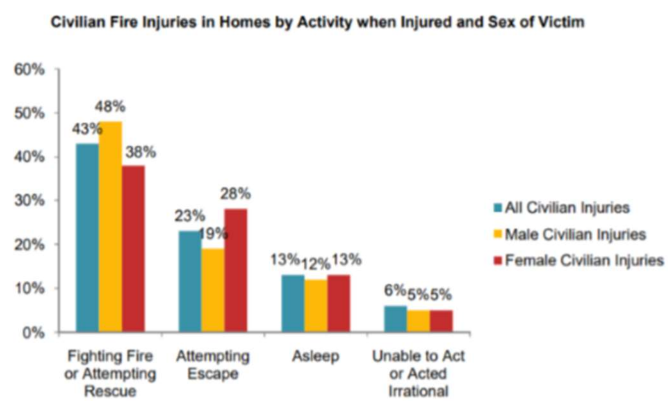


Figure 1 - Civilian Fire Injures in home by activity by sex [2, p. Viii].

The majority of U.S. home fatal and non-fatal fire victims were in the area of fire origin when the fire began. Because of this, 'Males are more likely than females to be attacking the risk (by fighting the fire or trying to rescue others from it) when injured, while females are more likely than males to be escaping the fire when injured' [2, p. Vii].

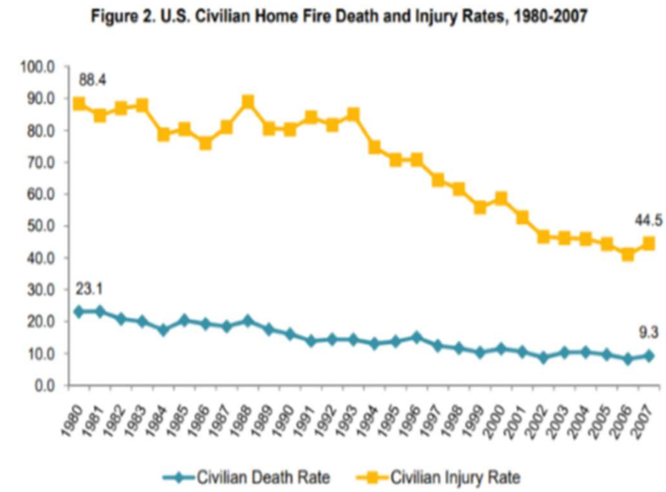


Figure 2 - U.S Civilian Home Fire Death and Injury Rates [2, p. 2].

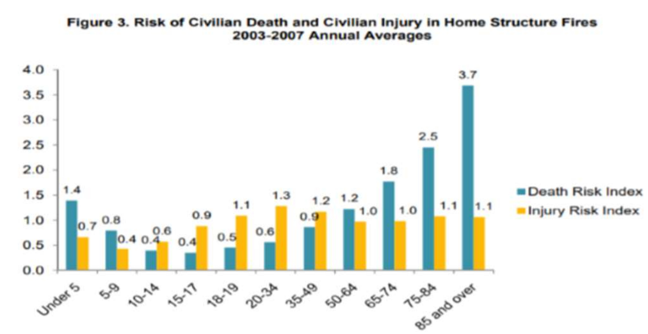
Table 21.
Activity at Time of Victim's Fatal Injury by Smoke Alarm Presence and Operation in Non-Confined Home Structure Fire Deaths
Excluding Fires Too Small to Activate the Smoke Alarm
2003-2006 Annual Averages

Activity	Present and Operated		Present but Did Not Operate		None Present	
Escaping	310	(30%)	200	(31%)	420	(37%)
Sleeping	310	(30%)	290	(45%)	460	(41%)
Unable to act	150	(14%)	50	(8%)	90	(8%)
Unclassified activity	70	(7%)	30	(5%)	40	(4%)
Fire control	70	(6%)	20	(3%)	20	(2%)
Returning to vicinity of fire before control	50	(5%)	10	(2%)	30	(3%)
Irrational act	50	(5%)	20	(4%)	30	(2%)
Rescue attempt	20	(2%)	20	(3%)	40	(3%)
Total	1,030	(100%)	640	(100%)	1,140	(100%)

Note: Fire deaths resulting from fires too small to activate the smoke alarm are not included in these tables. Sums may not equal totals due to rounding errors.

Figure 4 - Activity at time of victim fatal Injury [2, p. 66].

Looking at the graph of Figure 2, about 50% of the people in home fires result in an injury. Around 10% of the people lose their lives in the fire. We can see a downtrend in injuries and a constant but slightly down trend for death rates.



Source: NFIRS 5.0 and NFPA survey, population figures from U.S. Census Bureau.

*The risk index for an age group is the ratio of that age group's civilian fire deaths per million population to the civilian fire injury rate per million population for all age groups combined. The risk index for all age groups combined is 1.00. A risk index higher than 1.00 for a specific age group means that age group is at higher risk of death than the general public.

Figure 3 - Risk of Civilian Death and Civilian Injury in Home Structure Fires [2, p. 3].

The youngest and oldest have the highest risk of home fires. Even if they are aware of the fire, they cannot act by themselves to put it out. 'Children under age 5 are almost one and a half times as likely to die in a home fire as the average person, but their relative risk has been declining over time. Adults over the age of 65 are more than twice as likely to die in home fires as the average person. Alcohol or other drugs, disabilities and age-related limitations are all factors in the risk of home fire death' [2, p. Abstract].

Regardless of having a smoke detection system, sleeping and unable to act is the 2nd and 3rd highest action performed and not performed.

Statistics:

1. 'Local fire departments responded to an estimated average of 44,880 home fires involving electrical failure or malfunction annually between the years of 2012-2016' [1, p. 1].

2. 'Electrical distribution, lighting, and power transfer equipment accounted for half (50%) of home fires involving electrical failure or malfunction, followed by cooking equipment (15%), heating equipment (9%), fans (6%), air conditioners (3%), and clothes dryers (3%)' [1, p. 1].

Figure 5 below displays how the age of individuals directly correlates with the rate of injuries caused by house fires in a target area in Texas.

From *The New England Journal of Medicine*

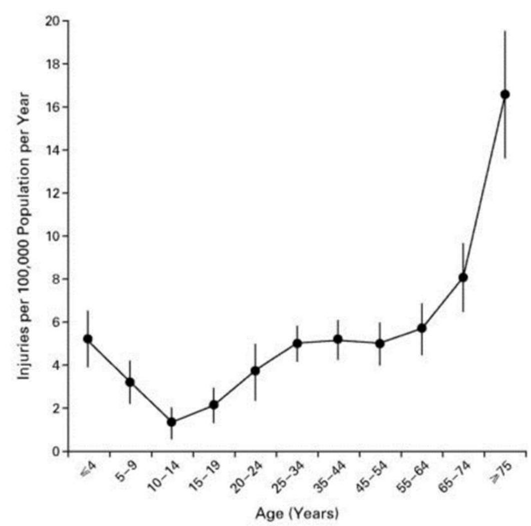


Figure 5 - Average Annual Rate of Injuries Related to House Fires in Dallas from 1991 to 1997, According to Age of Injured Person.

[6]

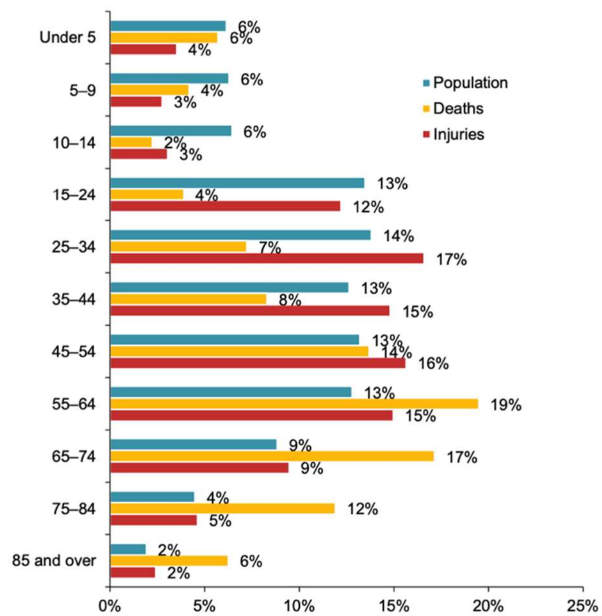


Figure 6 - Home fire deaths and injuries by age group: 2014–2018 [3, p. 3]

Figure 6 ‘shows that more than half of the fatal home fire victims were 55 and over (55 percent), while more than one-third were at least 65 years old (35 percent). One of every five fatal home fire victims was between 55 and 64 years of age (19 percent)’ [3, p. 3]. Maheshwari’s[3] report states that most commonly home structure fires happen in the cooler months when people are spending more time inside homes. ‘In 2014–2018, 47 percent of home structure fires and 56 percent of home structure fire deaths occurred in the five-month span of November through March. Reported home fires peaked from 5:00 to 8:00 p.m., when many people are coming home from work, preparing dinner, or engaging in other household activities’ [4, p. 4].

The purpose of a smoke alarm is to alert people when there is a fire presence but failure sometimes occurs. ‘During 2014–2018, local fire departments responded to an estimated average of 24,300 home fires per year in which smoke alarms should have operated but failed to do so. These fires cause an average of 410 deaths and 1,310 injuries annually’ [4, p. 4].

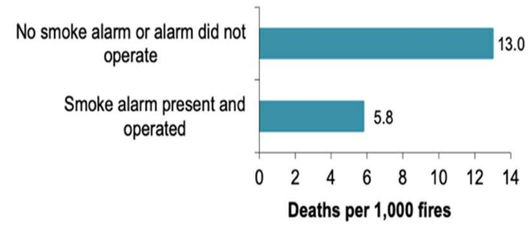


Figure 7 - Death Rate per 1,000 Reported Home Fires by Smoke Alarm Status: 2014–2018 [4, p. 3].

National Fire Protection Association Response time standard

Demand Zone[a]	Demographics	Minimum Staff to Respond[b]	Response Time (minutes)[c]	Meets Objective (%)
Urban area	>1000 people/mi2	15	9	90
Suburban area	500–1000 people/mi^2	10	10	80
Rural area	<500 people/mi^2	6	14	80
Remote area	Travel distance ≥ 8 mi	4	Directly dependent on travel distance	90
Special risks	Determined by AHJ	Determined by AHJ based on risk	Determined by AHJ	90

Table 1 - Response time in minutes for different zones NFPA: Residential Structures [5]

[5]

The mixture of knowledge along with the ingenuity within our group members make us suitable to tackle this societal problem with our CPE/EEE engineering skillset to provides a partial solution to the problem of uncontained house fires and the dependance of firefighters to put out a fire. With object and fire/heat detection technology along with line following the aspect of putting out a fire semi-autonomously is within our grasp today. Our group skillset consists of research, electrical engineering fundamentals, computer engineering fundamentals, and teamwork, all which will allow our group to design and implement a design approach suitable for the partial solution to that which this document states.

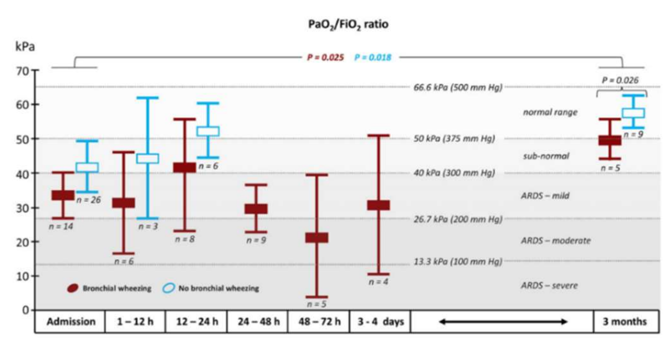


Figure 8 - Respiratory failure in fire smoke victims [9, p.1148]

Air quality is important to people's respiratory system as well as the heart. Reducing or preventing the number of house fire occurrences helps maintain the air from reaching dangerous levels. Fire smoke has microscopic particles that are dangerous to inhale for a prolonged period resulting in higher rates of respiratory and heart problems. [9] 'Acute fire smoke inhalation injury is a serious condition, accounting for nearly 80% of all fire- related deaths.1–3 In Europe, approximately 70,000 patients are hospitalized and more than 4,000 die from smoke-related injuries every year.4 Estimates from the United States suggest 2,600 fatalities and 12,500 injuries annually.' [9, p.1143]

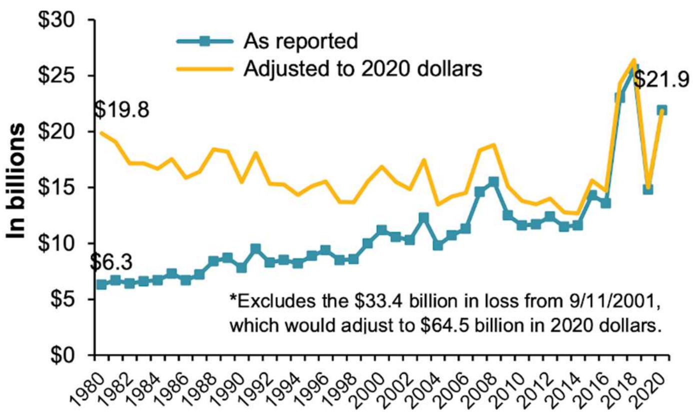


Figure 9 - Estimated fire property loss by year [10, p.3]

Reducing the amount of property damage would be a great start in tackling the group's societal problem. The National Fire Protection Association Reported that home structure fires rose 5 percent and home fire property damage rose 8 percent from 2019 to 2020. [10, p.7] Covid forced people to quarantine and spend more time in homes. As a result, people used equipment that increased the risk of a fire. 'The 356,500 home structure fires in 2020 (26 percent) caused 2,580 civilian fire deaths (74 percent); 11,500 civilian injuries (76 percent), and $8.4 billion in direct property damage (38 percent). On average, a home structure fire was reported every 89 seconds, a home fire death occurred every three hours and 24 minutes, and a home fire injury occurred every 46 minutes.' [10, p.7]

III. DESIGN IDEA

A. Design Philosophy

A semi-autonomous machine that will be triggered by a fire alarm to provide an immediate response to combating the fire. This robot is meant to be able to put out the fire before it can get out of control and give first responders more time to arrive and handle it themselves when necessary. The robot will be activated by a fire detection system and will identify the fire through temperature readings and flame detection and spray fire suppressant to keep the fire from growing and attempt to put it out completely.

Features	Measurable Metric
Fire Suppression Spray can shoot at an effective distance to put out the fire while keeping the robot out of reach of the fire.	Fire suppressant can be sprayed for an effective range of 2 feet
Battery Life of the robot to last long enough to reach the fire and be able to have a positive effect on the fire	Battery life can last at least 20 min
Sensors on robot able to identify fire through temperature readings	Identification of fire for temperatures over 200 degrees
Most optimized speed to preserve battery life while being able to reach the fire in a timely manner.	Robot is able to reach a speed of 1 ft/s
Ability to carry a payload of liquid feasible to put out fires.	A minimum of 1.5 Ibs, 680ml, of liquid feasible for fire suppression
Smoke Alarm mesh system to determine which room is on fire and activates robot	Robot is able to communicate with at least 2 devices in separate locations
The robot's movement will follow a predetermined path (line-following)	Able to turn left and right to follow the predefined path.
Voice Commands	Able to hear "stop" and stop current function

Table 2- Team 12 Punch List

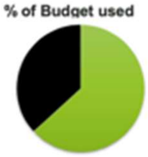
B. Specific Design Components

The project will incorporate designs components such as a, fire suppressant tank, fire suppressant hose, IR sensor, thermal sensor, camera, metal chassis, water pump, water tank and a microphone for voice commands. The robot would have the fire suppressant hose and an IR sensor attached to it in such a way that the nozzle of the hose would be at the end. The fire suppressant hose would be connected to the tank holding the suppressant. At the connection of the tank and hose, this will be a water pump to give the spray pressure to be able to reach the fire from a distance. There will be additional IR sensors on the chassis of the robot to allow for line following. The chassis of the robot would be comprised of metal and be the foundation of the overall system. The treads would allow the robot to pivot on a singular point and avoid having the arm rotate on the chassis and complicate the wiring and suppressant hose set up. The majority of the electronics and power setup will sit on top of the chassis and to the rear while the fire suppressant tank will be positioned below the chassis and between the treads.

IV. FUNDING

Budget

% of Budget used



37%

Summary

Total Budget
$1,800
Total Parts expense
$662

Team Member Contribution pledge

Item	amount up to:
Andy	$400.00
Michael	$400.00
Francisco	$500.00
Gabe	$500.00

Parts Expenses

Item	Amount	Where	Availability		Internal Team parts
Arduino Mega 2560 Rev3	$17.23	Amazon (purchased by Francisco)	Purchased		Raspberry pi(francisco)
Frame	$86.99	Amazon (purchased by Gabriel)	Purchased		Arduino UN
Velcro Straps	$3.96	Home Depot(Purchased by Francisco)	Purchased		Rasberry P
Plastic Sheet Cuter	$6.68	Home Depot(Purchased by Francisco)	Purchased		2 Lipo batterys
Acrylic Glass	$5.98	Home Depot(Purchased by Francisco)	Purchased		360 degree
Grove line finder	$16.27	Amazon (purchased by Gabriel)	Purchased		IR Distance se
Grove air quality sensor	$0.00	Arduino/$11.50	Available		Ultrasonic ser
Rasoberrv Pi Camera Module 2 N	$0.00	Raspberry Pi website/$25	Available		Logitech Web
Lipo battery charger	$40.00	Amazon (purchased by Francisco)	purchased		
12V water pump	$17.38	Amazon(Purchased by Andy)	Purchased		purcha
Resistor pack	$0.00	Amazon /ebay/$12	Available		Resitor pac
4 Waterproof Sensors	$0.00	Amazon (purchased by Gabriel)	Purchase	Returned	Purcha
2 Bread board	$0.00	Amazon /ebay/$20	Available		(Franci
Bread board jumper wires	$0.00	Amazon /ebay/$6	Available		Bread board jump
BreadBoard wires 120 pcs	$6.08	Amazon (purchased by Andy)	purchased		wires(Gabri
Small BreadBoard	$10.86	Amazon (purchased by Andy)	purchased		solder gun (F
Water Nozzle	$21.68	Purchased by Andy	Purchased		solder wire(F
Water tanks	$15.49	Amazon (purchased by Andy)	Available		Purcha
USB Microphone	$13.99	Purchased by Andy	Purchased		Heat shrink(F
H-Bridge	$11.09	Amazon (purchased by Francisco)	Purchased		
Voltage Checker alarm for lipo	$11.84	Amazon (purchased by Francisco)	Purchased		
2 12V Motors	$30.36	Amazon(Purchased by Gabriel)	Purchased		
Spacer standoffs	$14.00	Amazon (purchased by Francisco)	Purchased		
Infrafred raspberry pie camera	$108.74	Amazon (purchased by Gabriel)	Purchased		
keeyees development board	$32.78	Amazon (purchased by Andy)	Purchased		
Relay module	$6.19	Amazon (purchased by Andy)	Purchased		
2 Flat Aluminum Bar	$5.80	Home Deopt (Purchased by Michael	Purchased		
3 Threaded Zinc Rods	$5.94	Home Deopt (Purchased by Michael	Purchased		
2 Aluminum Angle Gauge	$21.96	Home Deopt (Purchased by Michael	Purchased		
Flint Striker	$5.27	Home Deopt (Purchased by Michael	Purchased		
140ZMAP Gas Bernzomatic	$11.97	Home Deopt (Purchased by Michael	Purchased		
Bernzomatic MAP-PRO Cylinder	$10.47	Home Deopt (Purchased by Michael	Purchased		
Bernzomatic acid solder kit	$31.97	Home Deopt (Purchased by Michael	Purchased		
4 Bronze Flux Brazing Rod	$19.92	Home Deopt (Purchased by Michael	Purchased		
Steel Brush	$3.14	Home Deopt (Purchased by Michael	Purchased		
flat washers	$1.28	Home Deopt (Purchased by Michael	Purchased		
2 Aluminum Angle Gauge Small	$5.30	Home Deopt (Purchased by Michael	Purchased		
2 Flat Aluminum Bar	$10.72	Home Deopt (Purchased by Michael	Purchased		
Flat Aluminum Bar Small	$3.11	Home Deopt (Purchased by Michael	Purchased		
5 Aluminum Brazing Rods	$20.40	Lowes (Purchased by Michael)	Purchased		
Gas and smoke Analog Sensor	$10.99	Amazon (purchased by Andy)	Purchased		
8 channel LLC	$6.86	Amazon (purchased by Gabriel)	Purchased		
4 Channel LLC	$9.12	Amazon (purchased by Gabriel)	Purchased		
	$661.81				

[7] Team 12 Budget breakdown of parts and contribution pledges, contributions by Gabriel Marquez and Francisco Torres.

V. WORK BREAKDOWN STRUCTURE

Task	Estimate hours	Hours for each team member	Work package
Point and shoot suppression	20 hours	Andy Cha, Gabriel Marquez:	Work Package[1.0]
Battery life longevity over 20 minutes	10 hours	Francisco Torres, Michael Buhman	Work Package [5.0]
Effective fire detection	20 hours	Gabriel Marquez:	Work Package [2.0]
Mobility speed of 1ft/s	12 hours	Francisco Torres, Gabriel Marquez, Michael Buhman	Work Package [3.0]
Payload of .239 gallons for fire suppression	12 hours	Andy Cha, Michael Buhman, Francisco Torres	Work Package [1.2]
Voice Commands	20 Hour	Andy Cha	Work Package [2.2]
Mesh system of smoke alarm	35 hours	Andy Cha, Michael Buhman, Gabriel Marquez, Francisco Torres	Work Package [4.0]

Table 3-Work Break Down by Work Package

VI. PROJECT MILESTONES AND TIMELINE

Our project has five features that make up the semi-autonomous firefighting tank. The first feature is the fire suppression system which is made up of two smaller subtasks which are the point and shoot system and a liquid tank. This system will be made to shoot a suppressant liquid at a range of two feet. The second feature is the detection system made up of the flame and heat detection subtasks. This system will use sensors to identify fire through temperature readings of over 200 degrees. The third feature is mobility which has line following to reach the location of the room in fire. The tank must be able to operate for a minimum of twenty minutes, carry at least 2 pounds, 0.2397 gallons, of liquid, and reach a speed of 1 ft/s.. All the sub-tasks have lower-level features that split to break down the project to help make up the tank.

VII. RISK ASSESSMENT

The project to construct the firefighting robot, A.H.P.I., carries a considerable number of risks that are labeled critical to the project. In other words, there is a series of risks that could hurt the team and the progress of the project. These are risks that can set back the project and take team members out of the class and the building of the robot for medical reasons. Below is the risk assessment matrix used to determine the severity of the risks facing the team by assigning numerical values to the impact, probability, and overall risk. We can then use this quantified data to see which risks pose the biggest threat to the project and team and therefore be able to coordinate different plan of actions and prevention methods to keep anything from getting crippled in the process.

Risk Matrix						
Probability	5	0.9	1.8	2.7	3.6	4.5
	4	0.7	1.4	2.1	2.8	3.5
	3	0.5	1	1.5	2	2.5
	2	0.3	0.6	0.9	1.2	1.5
	1	0.1	0.2	0.3	0.4	0.5
	0	1	2	3	4	5
	Impact					

Table 4-Risk Assessment Matrix

One of the biggest issues to prevent is what occurs when a member of our group leaves the team. These are a type of critical points in the project path that need to be covered to prevent single points of failure. A "single point of failure" is where the project would depend on the success of a singular aspect of the project. Our team consists of four members, two of which are electrical engineering focused, and the other two are computer engineering focused. The electrical engineers focus on the physical aspects of the construction for A.H.P.I. while computer engineers will focus on the software side of the project. Having two of each in the team sets up redundancies so that if worst case scenario occurs and member of the team has to leave, the other electrical or computer engineer can resume their work to carry on the project. All four members may have their specialties within their discipline; however they are generalized enough that outside sources can be sought after for consultation if not figured on our own. This is the case since both the two types of engineers in the group have similar spheres of knowledge. For instance, the beginning construction of the project the computer engineers have been looking into the fire detection and fire suppressant system. The electrical engineers have been focusing on the movement and arm extension systems. All members have the ability to confer with one another and any outside sources such as professors, mechanical engineers, fabricators, and programmers for continued progress. Our team's ability to share similar knowledge and confer one another and even with other sources allows for an interdependence with each other. Ultimately, single point of failures is avoided.

In the table below a variety of potential events, or risks, are identified as possible critical points for the project or areas that require caution for personnel. In other words, these are the quantified risks that either pose a threat to the project or to the people themselves. Along with the defined risks are their associated mitigations. In order to ensure continued success of the project, these courses of actions address each of the anticipated risks accordingly.

		R = f(P, I) = P * I	
Case:	**Risk**	**Risk Calculations**	**Possible Mitigation Strategies**
arc welder electric shock	4.5	R=(0.9)(5) = 4.5	use welder's gloves, never weld alone, use welder's clamps
Burns/fire from blow torch	4	R=(0.8)(5) = 4	Keep flammable material away, be extremely concsious of direction of flame, have a fire extringuisher nearby
eye damage from arc welder	4	R=(0.8)(5) = 4	Use welder's helmet to protect against arc strikes
Miter Saw harm	3	R=(0.6)(5) = 3	Use safety goggles, wooden jig for stability of cuts
Drill Press harm	3	R=(0.6)(5) = 3	Use safety goggles, wooden jig for stability of drills
Hot metal burns (2,000 F +)	2.7	R=(0.9)(3) = 2.7	Use tongs, heat gloves/welding gloves, water for cooling
Grinder harm	2.7	R=(0.9)(3) = 2.7	Use safety gloves, eye protection
Covid	2.5	R = (0.50)(5) = 2.5	practice safety precautions in public areas
depressurization of compressed flammable gas	2.5	R=(0.5)(5) = 2.5	work in a well ventilated area away from open flames
Team runs out of money	2	R=(.5)(4) = 2.0	Credit card debt :((choose cheaper components)
Fire/flame detection fails	1.8	R=(.45)(4) = 1.8	Heat sensor use
Motor failure	1.8	R=(.45)(4) = 1.8	Have back up motors for just in case
matel shavings splinter/shavings in eye	1.8	(0.9)(2) = 1.8	Use Safety gloves, eye protection
fire caused by sparks from grinding	1.2	R=(0.3)(4) = 1.2	keep flammable material away, eliminate loose clothing, direct sparks in safe direction
compressed flammable gas tank combustion	1	R=(0.2)(5) = 1	Keep tanks away from any open flames/heat sources
Raspberry Pi short circuited	0.6	R=(.30)(2) = .6	We can always buy another one
Water damage	0.6	R = (0.2)(3) = 0.6	build containers to keep circuit safe
sensor failure, collision	0.5	R = (0.25)(2) = 0.5	use more sensors

Table 5-Classifiactions of Possible Risks

One of the largest risks facing us all today is the COVID-19 virus. There are specific guidelines that are required for all students and faculty to adhere to. These are guidelines mandated by Sacramento State, the State government, and Federal—in that hierarchical order. Students and faculty are required to be fully vaccinated in order to be allowed on campus and use campus facilities with a few exceptions such as medical or religious. To be fully vaccinated, individuals must have taken both shots from the Pfizer or Moderna vaccine plus two weeks, or two weeks after the single shot Johnson & Johnson Janssen Vaccine [8]. Even with the vaccine, all personnel are required to wear face coverings when indoors. Faculty members working within their own workspace may be allowed to remove their face mask if indoors. Even if you are vaccinated, you are recommended to get tested in 5-7 days if exposed to the virus in any capacity [8]. Those who do test positive for COVID are required to isolate for 10 days and retest. Those who cannot provide a negative COVID test are not allowed to return to in-person operations [8].

VIII. DEPLOYABLE PROTOTYPE STATUS

"Quantifiable data that demonstrates the utility, effectiveness, and execution of our integrated system. Our goal of how and what the robot moves and data to show how we are successful in meeting the punch list items we have targeted." The effective mobilization of AHPI consists of a smoke sensor detecting smoke in a room to fire off an alarm sent wirelessly to the robot at a range within 40 feet, providing AHPI with the trigger to line follow toward the indicated room value. At every junction, or stop, AHPI check against its indicated room value on fire and either continues forward, or turns to pivot in the direction of the room on fire.

REFERENCE ONENOTE FOR ID SCHEME

MASTER Device Test Plan

Performer of test	TESTID	Test Description	Expected Results	Actual Results	Pass/Fail	Date perfromed
Andy (CPE)	1.1.2	Servo movement	The servo moves the nozzle up and down in a 30-degree motion	The servo moves the nozzle upwards and back down in a 30-degree motion.	Pass	
Andy (CPE)	1.1.3	Water pump distance	The water pump sprays up to 2ft at 12V and 1A	The water pump sprays up to 9ft with 12V and 1A	Pass	
Gabriel (CPE)	2.1.1	MLX90640 IR Array Thermal Imaging Camera Voltage Reading	3.3V	3.29V	Pass	
Gabriel (CPE)	2.1.1.2	MLX90640 IR Array Thermal Imaging Camera Running code current	UNK mA	.2mA	Pass	
Gabriel (CPE)	2.1.1.2	MLX90640 IR Array Thermal Imaging Camera Running Code current	UNK mA	2.mA		
Gabriel (CPE)	2.1.1.3	Logitech Webcam read/detect flame at an effective distance of over 6 inches away while webcam sits at a height of 10 inches	Webacm is triggered	Webcam detects the flame and triggers output LINE	Pass	
Gabriel (CPE)	2.1.1.4	Logitech Webcam read/detect flame at an effective distance of over 12 inches away while webcam sits at a height of 10 inches	Webacm is triggered	Webcam detects the flame and triggers output LINE	Pass	
Gabriel (CPE)	2.1.2	Arduino MEGA 2560 Engagement upon ESP8266 Trigger	Less than 5 seconds	UNK		
Andy (CPE)	2.1.3	Voice commands	LED is HIGH if mic hears "stop"	Error. Turns out raspberry pi needs wifi to use Google's voice recognition	Fail	
Gabriel (CPE) /Michael (EE	3.1.2.1	Grove - Line Finder v1.1 sensor IDLE voltage(RIGHT)	3.3V	3.19	Pass	
Gabriel (CPE) /Michael (EE	3.1.2.2	Grove - Line Finder v1.1 sensor IDLE Current (RIGHT)	UNK mA	.21mA		
Gabriel (CPE) /Michael (EE	3.1.2.3	Grove - Line Finder v1.1 sensor Trigger (RIGHT) on BLACK	Signal Line (HIGH)	SIG LINE HIGH	Pass	
Gabriel (CPE) /Michael (EE	3.1.3.1	Grove - Line Finder v1.1 sensor IDLE voltage (LEFT)	5 V	4.82V	Pass	
Gabriel (CPE) /Michael (EE	3.1.3.2	Grove - Line Finder v1.1 sensor IDLE Current (LEFT)	UNK mA	.21mA		
Gabriel (CPE) /Michael (EE	3.1.3.3	Grove - Line Finder v1.1 sensor (LEFT) on BLACK	Signal Line (HIGH)	SIG LINE HIGH	Pass	
Andy (CPE)	4.0.0	ESP8266 mesh system	two ESP8266 with 5V and 80mA. Baud rate of 9600. Send a message.	Send/receive "hello" with location "A" or "B". Connection takes around 3 seconds. Send a message every 2 seconds.	pass	
Andy (CPE)	4.1.1	two ESP8266 with 5V and 80mA. Baud rate of 9600. Send a message.	Three ESP8266 ith 5V and 80mA. Baud rate of 9600. LED lights up with Q2 sensor reading over 1000PPM	Two ESP send "A" and "B" to main ESP if Q2 sensor go beyond 1000PPM to identify location	pass	
Andy (CPE)	4.1.2	ESP82 mesh system distance	See how far ESP can communicate, estimate around 20 ft. 5V and 80mA. Baud rate of 9600.	ESP82 could communicate up to 40 ft	pass	
Francisco (EEE)	5.1.0	Motors can carry more than 2lbs	10 Lbs carrying weight	10lbs + chasis weight	PASS	10/16/2021
Francisco (EEE)	5.1.1	Roboto on lipo 3000mAh 20 min test	Last at least 30 minutes	1 hour 30 minutes	Pass	10/15/2021
Francisco (EEE)	5.1.2	Robot on LIPO 2200mAh (20 Minute test)	Last at least 20 minutes	in progress testing with new system	N/A	
Francisco (EEE)	5.1.3	Robot on 20,000 mAh (minute test)	Last at least 20 minutes	Powere the pi 3 for 2 hours and 45 minutes with an estimated 90 percent charge left on the battery. The pi was put under strain by running retro pi emulation	Pass	Feb 5 2022
Francisco (EEE)	5.1.4	Robot on 10,000 mAh (20 minute test)	Last at least 20 minutes	powered arduino and the line following sensors for 2 hours and 45minutes with an estimated 90 percent battery charge remaining	Pass	Feb 5 2022
Francisco (EEE)	6.1.0	Speed test must meet feature set of 1 ft per second on version 1 motors (Non-Line following)	I expect the motors to move the robot faster than 1 ft/s	1.02667 foot per second was the max speed the robot reached with 10lbs weight + frame	pass	10/15/2021
Francisco (EEE)/Andy (CPE	6.1.1	Speed test must meet feature set of 1 ft per second on new motors applying a voltage of 5 volts	I expect the motors to move the robot faster than 1 ft per second	Failed. Motors did not move the robot.	Fail	
Francisco (EEE)/Andy (CPE	6.1.2	Speed test must meet feature set of 1 ft per second on new motors	Reach at least 1 foot in less than 1.5 seconds	Covered 1 foot each 1.5 seconds	Pass	2/6/2022
Francisco (EEE)/Andy (CPE	6.1.2	V.2 motor speed test. Apply 7.1V to the motors and record speed test. Lay out 12 in line and record time it takes to cross from one point to another.	Reach at least 1 foot each 2 seconds	Covered 1 foot each 1.8 seconds	Pass	2/6/2022
Francisco (EEE)/Andy (CPE	6.1.3	V.2 motor speed test. Apply 11.2V to the motors and record speed test. Lay out 12 in line and record time it takes to cross from one point to another.	Reach at least 1 foot each 1.8 seconds	Covered 1 foot each 1.3 seconds	Pass	2/6/2022
Francisco (EEE)	7.1.0	Tank must carry 1.5 lbs of liquid used for fire suppression/water	Tank is able to carry 1.5 lbs. The The 10lbs weight was testing the boundaries of how much weight it could carry.	Was able to carry 1.5lbs of	Pass	12/1/2021
Francisco (EEE)/Andy (CPE	7.1.1	Container can carry at least 680ml of water	Container should carry at least 900ml of water based on the volume calculated	Container is able to carry 1039ml of water	Pass	12/1/2021
Francisco (EEE)/Andy (CPE	7.1.2	Container size and able to hold 1.5lbs of water	Container needs to hold at least 1.5lbs of water and fit under the tank (3.5in x 5.66in x 5.2in). Container volume is (3.75 x 3.75 x 5.25)	Container fits perfectly under the tank with a gap of 1.91 inch on the left. Enough space to fit the Lipo battery.	Pass	11/28/2021
Gabriel (CPE)	8.1.0	Logic Level Converter PI->Arduino communication via one channel: LLC requires Two power sources, One 3.3V(RBPI4) and One 5V (Arduino)	Raspberry Pi 4 GPIO Pin (3.3V) HIGH Logic effectively triggers Arduino (5V) HIGH logic pin	Arduino Input Pin triggers LED to turn on based on Raspberrry Pi 4 condition through LLC	Pass	
Gabriel (CPE)	8.1.1	Logic Level Converter PI->Arduino communication via two channel: LLC requires Two power sources, One 3.3V(RBPI4) and One 5V (Arduino)	Raspberry Pi 4, two GPIO Pins (3.3V) HIGH Logic effectively triggers two Arduino (5V) HIGH logic pin	Two LEDs effectively triggered based on Raspberry Pi 4 condition through LLC	Pass	
Andy (CPE)	9.0	MQ2 gas sensor	Running at 5V and 88mA. If value over 1000PPM is read, send signal	Idle state for Q2 is 600PPM at 5V and 88mA. When gas is read goes to 1024PPM	Pass	
Francisco (EEE)	10.0.0	Strain on the old motors using 5lb weight+frame for 5 minutes	The motors will operate normally without overheating	Motors operated as predicted with minimal heat due to normal operation	Pass	10/15/2021

Francisco (EEE)	10.1.0	Strain on the old motors using 10lb weight+frame 5 minutes	The motors will operate normally without overheating	Motors did not overheat	Pass	10/15/2021
Francisco (EEE)	10.1.1	Strain on version 1 motors using 10lb weight+frame for 1 hour and 30 minutes. Will be checking each 5 minutes unless motor don't over heat each 10 minutes	Motors will over heat due to the continuous testing of the motors.	Motors did not overheat	Pass	10/16/2021
Francisco (EEE)/Andy (CPE	11.0.0	Testing water pump and container working together.	We may need to turn down the voltage from 12V to 9V so we can control the amount of water released.	The water pump ended u	Fail	
Francisco (EEE)/Andy (CPE	11.1.1	Testing the voltage boundaries that can work with the water pump without damaging the container/tank. We are goig to start with 9V.	We expect that the water pump will not damage the container by turning down the voltage.	Once the water pump fin	Fail	
Francisco (EEE)/Andy (CPE	11.1.2	Test of water tank/container by filling the tank to full and let water pump run until tank is emty with some modification that Michael made to the container.	We expect that the modifications that Michael made to the container will not damage the container by sucking all the air	It was a success. The water pump did not damage the container by suction of air.	Pass	

IX. MARKETABILITY FORECAST

The major consumer that we are targeting is the homeowners, primarily of single story dwellings, and commercial office owners who own simple floorplans with long straight hallways. Our product excels in structures, homes, office buildings, schools, with simple floorplans consisting of long hallways and where doors may not be present. Office buildings that implement a sprinkler system for fire protection is an area effect where areas that are not yet affected by the fire, and may not be by the time the fire is put out, is then subject to water damage. A.H.P.I. offers precision fire suppression by targeting the fire directly.

A.H.P.I. is currently projecting to be at $1000 or below in market retail pricing to be implemented in single family housing and single floor office plans. The competing fire suppression system for offices and even some homes is the sprinkler system. The expected present value net benefits (PVNB) in 2005 dollars is estimated as $2,967 for the colonial-style house, $3,099 for the townhouse, and $4,166 for the ranch-style house. [17, p. abstract]. Sprinkler systems are anticipated to be installed into the infrastructure of the house through the walls and ceiling. A.H.P.I. is a system with easy setup that does not require modifications to the house, offers precision fire suppression instead of area effect, and at a cheaper price. Sprinkler systems in office complexes are estimated to be more costly in order to cover greater area of square feet depending on the size of the office.

X. TESTING RESULTS

Our prototype testing is nearly completed. Mostly all systems are fully functional. The voice detection is fully functional and has been tested with the whole system. At the start of the semester, we were using Google's voice recognition database through Wi-Fi and found that it is not viable. Having the robot connected through Wi-Fi is not efficient and the word transcribing was not 100% reliable. It would also keep transcribing words as long as there is a sound so the raspberry pi would not transcribe anything until it was quiet or "end of the sentence". With this in mind, we switched to downloading an entire word transcribing database provided by PicoVoice. This way we can do voice detection offline and it only listens for keywords such as "power off". Every other noise is disregarded. Through testing, it has shown at least a 90% success rate. As for our smoke alarm mesh system with the ESP8266s we have completed the entire system with integration and it is working 100%. We have 3 ESPs in different locations with MQ-2 gas sensors that have the room locations saved and one ESP on the robot to capture data. Once the ESP on the robot receives data of a fire location, it will send to the Arduino that does the line following through UART communication.

A feature that the team is currently working to improve is the water pump system. A wider spread of retardant at a higher psi would prove the most efficient to mitigate a starting fire. Therefore, the team purchased a more capable dc motor and is working to incorporate a system for water to flow through and attain the desired results. A prototype version has been created for water flow but is currently in the initial stages. A lot of adjustments need to be made to make the ongoing system work. Presently, the prototype water system lacks suction which the team will address by repositioning the height of the cap that encloses the blades. Adjusting the height of the blades and changing their direction of them will serve to regulate the flow rate of water.

XI. CONCLUSION

A. *Societal Problem*

The values at risk are too high for dependency on one single source of rescue for fire suppression, as circumstances per case differ, so does the response time of emergency services. It is crucial to the life of the occupants and the residential property that a source of fire be located and suppressed within the first 90 seconds of detection in order to prevent the further destruction caused by a loose ravaging fire within a residential property. The standard set forth by the National Fire Protection Association is a metric that spares too much time for a fire to spread more than it should.

B. *Design Idea*

Our team's ingenuity and preliminary solution design utilizes multiple technologies like object detection, autonomous technology, and efficient use of treads for quick mobility and pivoting feasibility. The payload of the machine will be dependent on factors that affect the consumption of energy from the onboard batteries to meet the punch list specifications. Our unique idea defines a semi-autonomous firefighting robot while existing solutions to our societal problem require human interference or alternatively stationary sprinklers. As a system, the input to trigger our robot's engagement with the fire will consist primarily of a wireless communication system and our output will be that of a successful fire being extinguished.

C. *Work Breakdown Structure*

We have created a hierarchical graph to help determine the tasks that our robot must be able to do. We broke down the entire system into four sub tasks which have lower-level tasks that create these sub tasks to help us determine what we must complete and what we have already completed. So far, the breakdown structure has shown us our progress with the system and what we could be missing from the system. We have chosen to split our work between individual team members to work on these sub tasks such as mobility, detection, and arm movement.

D. *Project Timeline*

The team has created a project timeline to help track the status completion of the project. The timeline works as a visual guide to see what parts of the project must be completed and at what time. It serves as a checklist of things the team needs to complete before proceeding forward. It is a way of determining what parts of the project depend on others to be completed in order to proceed to the next.

E. *Risk Assessment*

Risk Assessment table will help us determine what risk is present within our project. This will allow us to mitigate or be cautious of the problem so that no team members or audience members are injured due to the lack of safety. Some of the major risks presented with this project are fire damage, water damage, and system failures. There are systematic risks that we cannot control that might hinder our progress as well. Having identified these risks, we can push forward with a better understanding of what we are dealing with.

F. *Problem Statement Revision*

House fires present a very real threat to all residents and will force them to either evacuate immediately or attempt to extinguish it themselves. An attempt to extinguish the fire individually has a high risk of suffering severe injuries or death, especially if they are not trained. In the best-case scenario, residents would rather evacuate and risk the loss of their home instead while preserving their own lives. House fires can occur for a variety of reasons and without warning. Therefore, the implementation of a system that can respond to the fire immediately will save the residents of the home the dire task of tackling the fire and giving them more time to evacuate.

G. *Device Test Plan*

The device test plan is where the team members execute an extensive range of tests to assess the system reliability and operability of the project at hand. The design idea is evaluated based on these extreme situations conducted by each team member to make improvements. The report documents the date from start to finish, who performed the test, place of testing, equipment used, and other relevant information.

H. *Market Review*

A.H.P.I. is an autonomous robot that will seek and put out fires at the indication of smoke alarms. A.H.P.I. works best in single floor dwellings with open space or long hallways that are unobscured by doors. Therefore, it works ideal in office buildings and homes with simplistic floor plans. A.H.P.I. is meant to give people a second chance at saving their family, home, important documents, servers, or any other valuable belongings. A.H.P.I. offers precision fire suppression in comparison to sprinkler systems that implement an area effect style of fire suppression. A.H.P.I. comes at a cheaper cost, nearly $2,000 cheaper, and easier installation than the competing sprinkler fire suppression systems for homes and offices.

I. *Testing Results*

Our Robot, A.H.P.I, is able to be deployed via remote wireless smoke sensor and deliver a payload of fire suppressing liquid to the location of the detected smoke room. Line following a designated tape path by various testing scenarios has led us to improve the code where necessary. We run multiple line following tests over and over again to achieve the highest success rate of reaching the desired room and where hiccups occurred, we tweaked the code.

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GLOSSARY

Societal Problem: *A condition or behavior that affects a large number of people and can be said to have negative consequences.*
Abrogate: *To abolish or do away with.*
Technical risks: *the possible impact changes could have on the project when an implementation does not work as anticipated*
Systematic risks: *Changes that impact the project by factors beyond the control of a specific company or individual*

PVNB: *present value net benefits*

Inferno: *a large fire out of control*
Fatality: *an occurrence of death by accident, war, or disease*
Autonomous: *Having the freedom to govern itself or control its own affairs*
Mesh System: *Group of devices that act as a single Wi-Fi network to communicate with each other*

APPENDIX D. WORK BREAKDOWN STRUCTURE

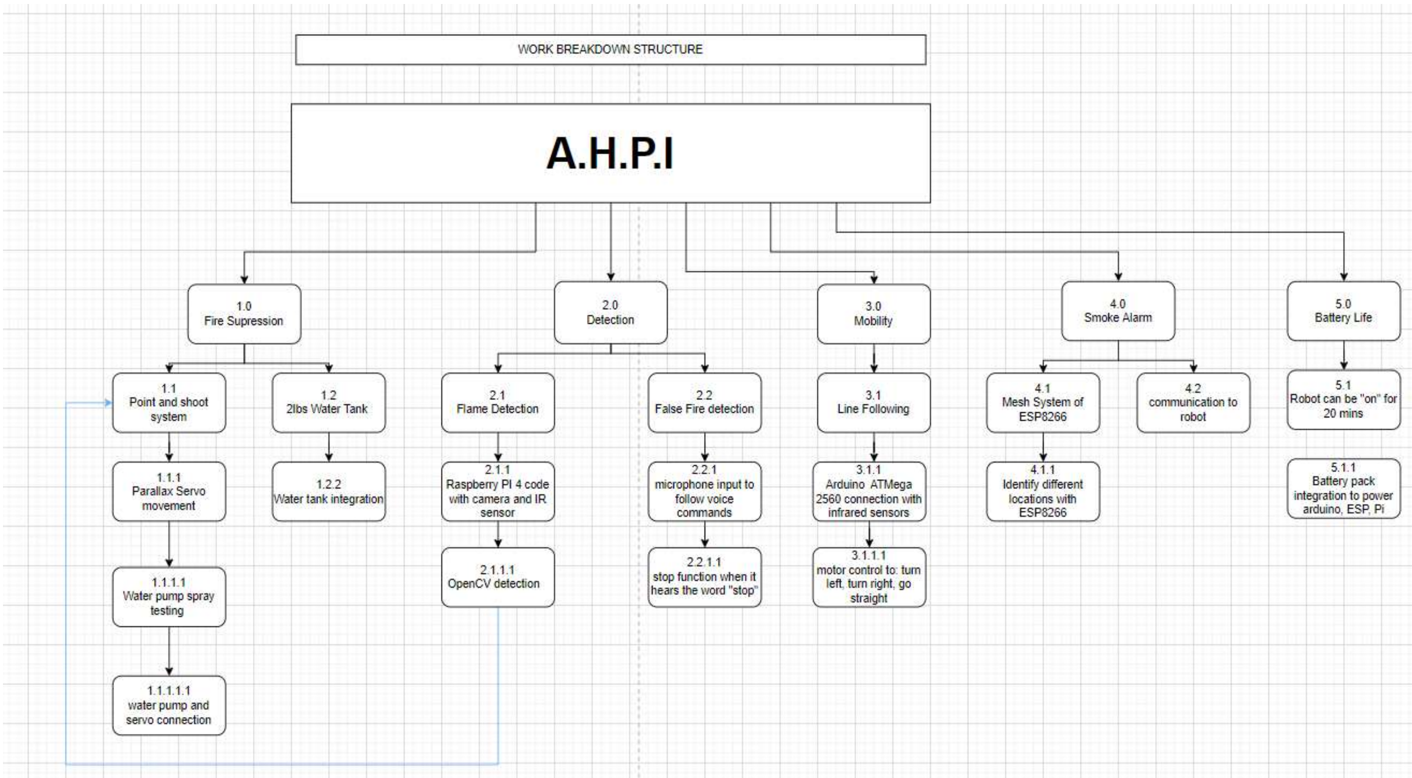

Figure 10 - Work Breakdown Structure

APPENDIX D-1 WORK BREAKDOWN STRUCTURE TABLE

Level 1	Level 2	Level 3	Level 4	Level 5
[1.0] Fire Suppression				
	[1.1] Point and Shoot System			
		[1.1.1] Parallax Servo movement		
			[1.1.1.1] Water pump spray testing	
				[1.1.1.1] Water pump and servo connection
	[1.2] 1.5lbs water tank			
		[1.2.2] Water tank integration		
[2.0] Detection				
	[2.1] Flame Detection			
		[2.1.1] Raspberry Pi 4 code with camera & IR sensor		
			[2.1.1.1] OpenCV Detection	
	[2.2] False fire detection			
		[2.2.1] microphone input to follow voice commands		
			[2.2.1.1] stop function when it hears the word “stop”	
[3.0] Mobility				
	[3.1] Line following			
		[3.1.1] Arduino ATMega 2560 connection with infrared sensors		
			[3.1.1.1] motor control to: turn left, turn right, go straight, go backwards	
[4.0] Smoke Alarm				
	[4.1] Mesh System of ESP8266			
		[4.1.1] Identify different locations with ESP8266		
	[4.2] communication to robot			
[5.0] Battery life				
	[5.1] Robot can be “on” for 20 mins			
		[5.1.1] Battery pack integration to power Arduino, ESP, Pi		

Table 4 - Work Breakdown Structure table

APPENDIX E. TIMELINE CHARTS AND PERT DIAGRAM

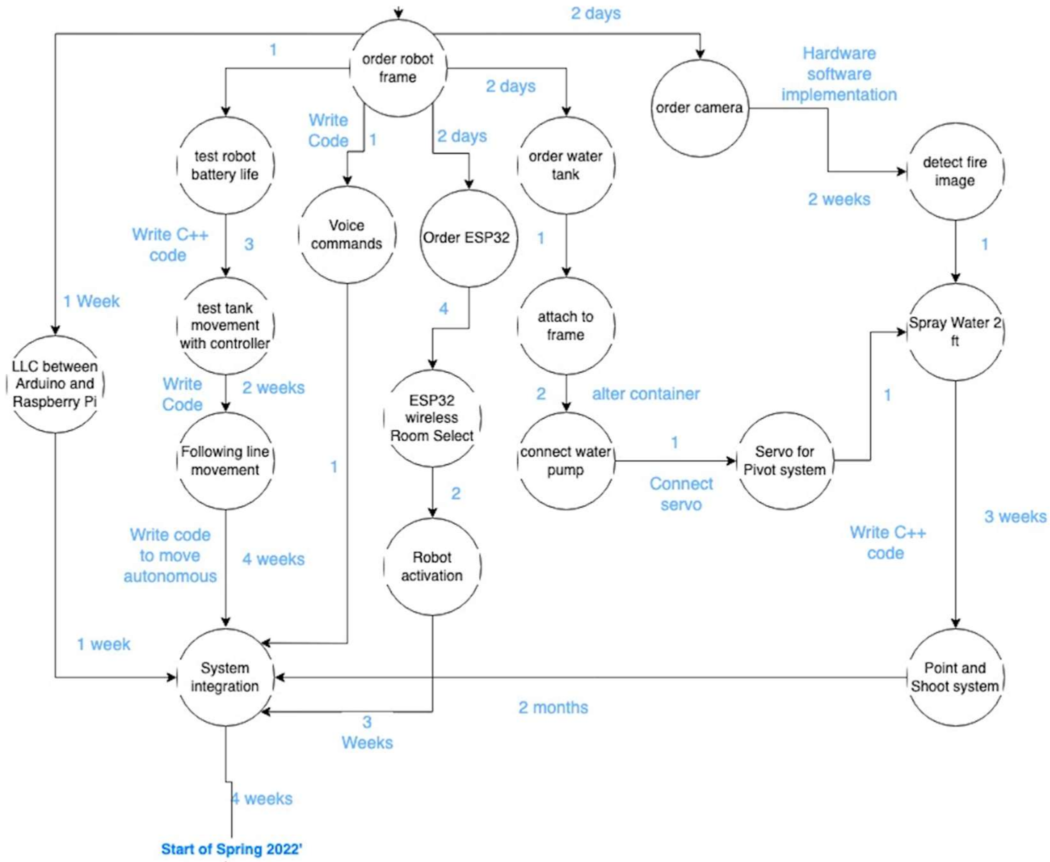

Figure 11 - PERT Diagram

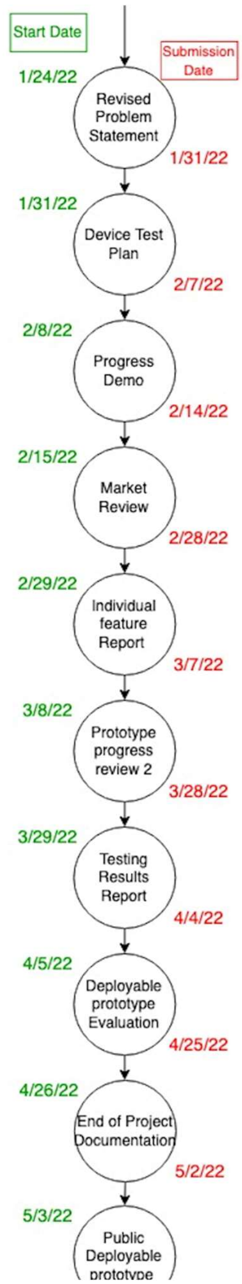

Figure 12 - Assignment Timeline

Andy Cha

EDUCATION

Computer Engineering Expected Graduation Date: May 2022
CSU Sacramento, CA

SKILLS

Java, C#/C++ Programming, Assembly, Python, Git, Microsoft Office, HTML, JavaScript, Verilog, VHDL, Instruction set architecture (ISA)

EXPERIENCE AND PROJECTS

- Movie Database Website
- Garage Door Remote simulation with microcontrollers
- Verilog design of LFSR (linear-feedback shift register)
- Autonomous firefighting robot

WORK EXPERIENCE

Sacramento State: SSIS ITC shop *June 2021 – Present*

- Assist in setup, maintaining, deploying and restoring systems
- Assist in maintaining and updating computer labs
- Responsible, punctual, detail oriented with excellent troubleshooting and customer service skills

Network Sound *March 2021 – June 2021*

- Help create/code Win32 GUI application in C programming for board level testing (BLT)
- Test each hardware component to make sure that they are working correctly before being shipped out

Amazon *June 2020 – August 2020*

- Maintain the workstation for five to six people
- Supply and clean stations, track each individual output, and boost team morale

California Sandwich Co. *July 2018 – August 2019*

- Prepare lunch meals for firefighters combating a current disaster
- Work as a team to push out large numbers of orders with great accuracy within a time frame

Round Table *October 2017 – May 2018*

- Interact and assist with customer's needs, maintain dining area standards, and prep food with team members for customer orders

Francisco Torres

<u>EDUCATION</u>

Electrical Engineering and Electronics — Expected Graduation Date: May 2022
CSU Sacramento, CA

Associates of Science, Major Computer Engineering — Spring 2018
Napa Valley College, Napa, CA

<u>SKILLS</u>

SOLIDWORKS, C & C ++, X86 Assembly language, Leader, MATLAB for Engineers, (x86) Assembly Language

<u>EXPERIENCE AND PROJECTS</u>

DWIGHT D. EISENHOWER FELLOWSHIP

- Researched how to decrease traffic congestion using intelligent transportation systems
- Quadcopter
- Remote control car

<u>LEADERSHIP</u>

THE SOCIETY OF HISPANIC PROFESSIONAL ENGINEERS
Napa Valley College/Sacramento State, Napa, CA/Aug 2018-present

- Coordinated event as part of the "Breakfast with Engineers" committee of over 20 people
- Volunteered at the Latino Engineering Day in SF Exploratorium, helped run the workshops by building scribble bots and performed magic tricks

ROBOTICS CLUB (MEMBER/PRESIDENT)
Napa Valley College Napa, CA/Aug 2016-Dec 2018

- Organized and coordinated weekly workshops by helping colleagues build their first drone and remote-control car
- Handled secretary obligations and assisted with setting up and cleaning with club rush events

ENTERTAINMENT CLUB
Napa Valley College Napa, CA/Aug 2014-Dec 2014

- Learned to play guitar by composing a song and applied what was learned to a live performance
- Assisted with the coordination of live performances held at NVC

ROTORACT CLUB (MEMBER/VICE PRESIDENT)
Napa Valley College Napa, CA/Aug 2013-Dec 2014

- Organized and coordinated events, participated in multiple community service events logging over 50 hours
- Assisted with the creative process of designing club shirts and promoted club activity on local table television

Gabriel Marquez

EDUCATION

Computer Engineering Expected Graduation Date: May 2022
CSU Sacramento, CA

SKILLS

HTML,CSS, JAVA, LINUX/UNIX, C, Soldering, Team work (x86) Assembly Language, Python, TCP/IP

PROJECTS

- **Semi-Autonomous Fire-Fighting Robot**
- **Digital Bike Speedometer**

WORK EXPERIENCE

Information Technology Specialist -Desktop Support - DOI *Nov 2021 – current*

- Providing advice and guidance on a wide range and variety of IT issues
- Installing, configuring, integrating, troubleshooting, optimizing and maintaining customer hardware and software to maximize system availability
- Diagnose and resolve hardware related issues in person, or remotely via various communication outlets including, telephone, email and or remote access to their pc.

Information Technology (FIRE IT) - USDA *Oct 1st 2017 – Nov 2021*

- Providing advice and guidance on a wide range and variety of IT issues
- Managed multiple projects/tasks on a daily and weekly basis independently without direct supervision in order to maintain a forward moving agenda.
- Involved in setting up small networks, LAN in remote locations while on Fire Assignments in non-typical office environments.
- Created and maintained documents of computer inventory, printers, account information and classified information.

Front Desk - Country Inn & Suites *Dec 1st 2014 – Jun 2016*

- Provided exceptional customer service by active listening and understanding the root of the issue in order to reach a resolution
- Ability to identify and handle customer issues, concerns, and questions leading to a positive resolution in various situations

LEADERSHIP

Autonomous Home Protection against Infernos (A.H.P.I)
Team Leader *August 2021 - October 2021*

- Piloted the jump start of a team of four engineers to organize the build of a semi-autonomous fire-fighting robot.
- Organized and coordinated weekly meetings by setting meeting agendas and taking notes while setting deadlines and expectations for the team.
- Brainstorming the adoption of solutions to evolving problems.

Michael Buhman

EDUCATION

Electrical Engineering and Electronics Expected Graduation Date: May 2022
CSU Sacramento, CA

Associates of Science, Mathematics Spring 2019
Folsom Lake College, Folsom, CA

Associates of Science for Transfer, Mathematics Spring 2019
Folsom Lake College, Folsom, CA

Associates of Arts, Interdisciplinary Studies Math and Science Spring 2019
Folsom Lake College, Folsom, CA

SKILLS

Auto Cad, Python & C ++, Soldering, Leader/Project Manager, MATLAB, Problem Solver, Welding, public speaker

PROJECTS

- **Electric Skateboard**
- **Automatic Catapult**

WORK EXPERIENCE

Folsom Lake College Tutor *August 2020 – Present*

- Help a wide range of students in the scopes of math, chemistry, and physics
- Group tutoring of 10+ students simultaneously

Folsom Lake College IT *January 2020 – August 2020*

- Fix or replace computers on campus
- Troubleshoot various electronics
- Server Maintenace for the school

LEADERSHIP

Air Force Reserve Officer Training Corps *August 2019 – Present*
Expected Date of Commission June 2022

- Training in the Professional Officer Course to become a commissioned officer in the Air Force.
- Held three different command positions including Cadet Group Commander on Senior Staff
- Delegation of tasks
- Administering Discipline
- Mentoring subordinates

Electric Skateboard
Team Lead *Fall 2019*

- Oversaw the development of an electronic skateboard with wireless connection to a remote
- Managed timeline, project files and assigning of tasks
- Developed serial wireless connection between raspberry pi and remote for user input to skateboard