Deployable Prototype Documentation

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Skid Safe

Team 6

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

EXECUTIVE SUMMARY

Everyday thousands of tire blowouts occur putting drivers, and those surrounding, in immediate risk. There are currently no measures taken as a means of reducing the likelihood or the risk drivers are put in these events. From Fall 2018 to Spring 2019, our team developed a reactive system that in the event of a tire blowout, or wheel detachment, will deploy a support system that will allow drivers to maintain stability and safely maneuver off of the road.

Over the past year we put in the due diligence in order to look deep and research the topic. We created a system that covered all necessary measures required for a consistent and reliable system. Haley created a single sensor method that monitors the speed of the vehicle based off of tire circumference and rotations of the wheel with respect to time. Nick implemented a two sensor system that monitors the pressure of the tire based off of distance from the bottom of the car to the ground and position of the wheel with respect to the wheel well of the vehicle. Andrew created a system that interprets the data and sends a signal to deploy the sled. Derek built a device that deploys the support system using pressurized air. This system is intended to be placed on the frame within the wheel for each wheel and tire of the vehicle, however for prototype purposes we chose the driver side's wheel. In our research we found that a blowout to the front left wheel puts the driver at the highest level of risk due to additional weight on the left side of the vehicle, losing one of the wheels that manipulates the direction of the vehicle, and the likelihood of being pulled into oncoming traffic.

We calculated in the event of a tire blowout, based on the average height of the tire from the rim, that there is approximately 0.3 seconds from when a tire blows out to when the rim hits the ground, stripping control from the driver. That means Skid Safe would have to deploy within 0.3 seconds for either a tire failure or wheel detachment case. With these calculations we created our features and metrics in a fashion that would allow the system to collect data, interpret that data, send a signal, and then deploy the system all within this timeframe. We allotted a tenth of a second for the system to collect the data and send the signal, and then two tenths of a second to deploy the mechanical system that would support the car. The sled used in the support system had to meet a strict criteria. This sled needed to be an appropriate length, compose of a sturdy material, be able to withstand friction resistance, and not create heat or sparks when sliding on the road.

The composition of this design had a structured plan for completion. Our team put emphasis into the necessity for a safety feature for tire protection, backed it with factual information, and constructed a design idea to follow. The process of design led the team through many methods that either were successful or failed. Acknowledging the failures and having secondary ideas helped our team manage time well and complete the task at hand. Fall semester paved the foundation for the idea of Skid Safe. Within Spring semester our hard work, ideas, and teamwork led to a successful design. Skid Safe at the moment is constructed for a smaller scaled car, but has the potential to be applicable to life sized vehicles. This design has the potential to make it the market and could potentially save many lives in the future.

Abstract - Skid Safe is the first safety feature to provide total protection to tires in the event of a tire blowout or displacement. Using the force from a pressurized air system, a sled will deploy when tire failure occurs and allow the driver to maintain stability of the vehicle. Over the course of this project, team six has been innovative, problem solved, and completed the features necessary for the design of Skid Safe. Beginning with a societal problem, the team put careful consideration into how the build would begin, alternative methods that can be used, risks that may arise, and finished with a successful deployable prototype. Skid Safe's intentions to save lives and decrease collisions is recognizable. Even if Skid Safe does not become manufactured, the lack of tire safety is now brought to attention.

Keyword Index- ABS, Accelerometer, Gyroscope, IMU, IR, mph, OEM, Pneumatic, PSI, PWM, Ultrasonic, RTOS

I. INTRODUCTION

At the beginning of the Fall semester, our team was given the task of deciding on a societal problem that needed attention. Based on the skill set of each of our team members, we would design a system that would solve a small portion of a said societal problem. The societal problem that we decided on was traffic safety. Every day, thousands of car accidents occur throughout our nation. Many accidents are driver error, whether it is lack of attention to the road or driving recklessly, however not all accidents can be avoided. Being long-time drivers and daily commuters on California highways, it is very clear that the condition of the roads are sub par. Our roads are full of potholes, debris, and other dangerous materials. Due to these harsh road conditions it very common to see shredded tires on the roadside along with drivers whose cars are hopefully still intact. As a result of this common problem, we chose to focus on creating a system that would help drivers in the event of tire failure.

For our project, we realized that creating a preventive system to either reinforce tires or reduce the likelihood of a tire blowout was out of our reach due to lack of knowledge on the topic, as well as, lack of time to develop knowledge. We decided that it would be best to create a reactive system that would assist drivers in maintaining the stability of their vehicles in either the event of a tire blowout or wheel detachment. In our research, we discovered that it is very common for drivers to lose the stability of their vehicle in the event of a tire blowout. This loss of stability yields fatal accidents daily, whether it be the driver being pulled off of the road into dangerous terrain or drivers being pulled into other vehicles. As a means for prevention, this design we decided to look into would create a system that would create stability before a loss of control occurred for the driver, we call this system Skid Safe.

Skid Safe is an integrated system that monitors the condition of the tire, the position of the wheel, and the speed of the car. Under the basis that these conditions are unsafe, a signal will be sent that deploys a sled as a means of supporting the weight of the vehicle and allowing the driver to maintain stability. After discussing the interests of each team member at the beginning of the fall semester, we were able to split the project into four main features that each individual would focus the majority of their time and efforts towards.

Haley took the reins on vehicle speed evaluation. Vehicle speed evaluation seems irrelevant to the idea towards the project, however, it plays a key role in the design. If a vehicle is not moving or is moving slowly, and a tire blowout occurs, the driver will have control of the vehicle and there will be no necessity for the sled to deploy. Through in-depth research, Haley determined that in a full sized vehicle, drivers were not at serious risk until about 35 mph. 35 mph is approximately 35% of the maximum speed of the average passenger sized vehicle. Since our project is scaled down onto a child-sized car, we used 35% the test car's maximum speed as a means of setting a condition that mimics a dangerous vehicle speed. After the speed is evaluated it is time for the system to check the condition of the tire and wheel.

For tire quality monitoring, Nick implemented a two sensor system to monitor both the diameter of the tire, as well as the position of the wheel with respect to the frame of the car. For the tire diameter, as a tire deflates, the tire on the underside becomes less firm and yields a smaller diameter. This then results in the frame, near where the failing tire is placed, to get in closer proximity to the ground. In order to monitor this diameter Skid Safe uses a distance sensor under the frame of the car to acknowledge this Change. When the distance is too small or the rate of change of the sensor becomes too large, it will recognize the tire has failed and send a signal to prepare deployment. For monitoring the wheel position, Skid Safe has an additional distance sensor that is placed on the frame of the wheel well and faces outward towards the inside of the wheel. If the sensor reads a distance beyond the set value the system assumes that the wheel has been detached from the vehicle. Both of these readings are monitored by a microcontroller that we call 'the brain' in this design.

Andrew coded 'the brain' of our system to interpret the data from each sensor, compare that data against unsafe conditions, and they will send a signal to deploy the system in the case of unsafe conditions. The two conditions that must be met for Skid Safe to deploy are the speed must inhibit maneuverability, in addition to either tire failure or wheel detachment occurring. If the undesired conditions occur, 'the brain' sends a signal to deploy the mechanical system.

For deployment, Derek designed a pneumatic system that deploys a rod using pressurized air when signaled. Through various trials of what to use for the support system, Derek decided on using a ski type material, similar to that of a snowmobile. Using 3D prints to fasten the sled to the rod he created a method that would deploy a low friction device just next to the wheel to support the weight of the vehicle without damaging roads and allowing stable maneuverability of the vehicle.

The creation of Skid Safe had many thoughts and ideas put into the design. The initial societal problem on the amount of collisions and injuries that occur from tire failure was brought to attention. Countless hours were spent researching the necessity for a safety measure for this circumstance and was validated from many articles, news reports, and car studies. After addressing the problem our team devised a design idea, which was altered in both the Fall and the Spring semester. In the process of the construction of the design idea, we used many engineering techniques to organize the procedure to make this mechanism. We assigned tasks for each designated feature, created a timeline for structure, acknowledged all possible risks and failures, and thought of secondary options to combat any interferences in the project. All of these skills helped our team reach those important milestones that were necessary for the project. Each failure we encountered was corrected in little time. Overall the entirety of the project was on time as planned, each team member put around the same amount of hours into producing Skid Safe, and was manageable in costs. With a great deal of effort and hard work, our team created a successful safety mechanism that we'd like to call Skid Safe.

II. SOCIETAL PROBLEM

Safety features in vehicles have been saving many lives over the course of time. The introduction of safety features to vehicles has provided extra protection and security to passengers and drivers of many cars. The evolution of safety precautions administered to vehicles has made an influential impact on the amount of injuries and deaths from collisions. The creation of seat belts, air bags, anti-lock brakes, and automatic braking systems have successfully reduced this number. According to the Center for Disease Control and Prevention the United States has saved more than 250,000 lives because of seatbelts from 1975-2008 [1]. An estimated 2,756 lives were saved by frontal airbags in 2016 [2]. With these results, the underlying question is if there is still components of a vehicle that are unsafe or unprotected. The remaining uncertainty lies with the reliability of tires and the consequences that arise from tire failure. According to the US Department of Transportation, about 11,000 collisions and 200 fatalities occur per year from tire blowouts and other tire-related issues [3]. With this amount, it is understood that tire failure still occurs and that there is a lack of protection. This is the fuel to the creation of Skid Safe.

A study was done to analyze the reasons that contribute to crashes in vehicles. In this study, each component was evaluated and the likeliness for malfunction was documented. These malfunctions increased the possibility of a crash and intensified the end result of collisions. Below in Fig. 1 the main reason for resulting crashes was by tire failure. Tire failure still occurs and is a heavily weighted cause for car crashes.

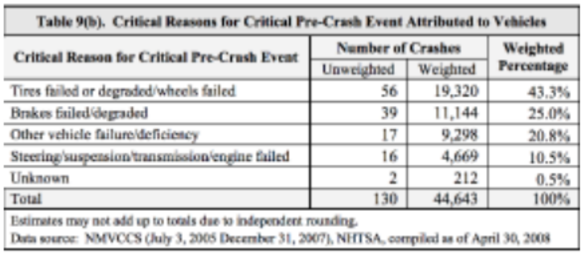


Table 9(b). Critical Reasons for Critical Pre-Crash Event Attributed to Vehicles

Critical Reason for Critical Pre-Crash Event	Number of Crashes		Weighted Percentage
	Unweighted	Weighted	
Tires failed or degraded/wheels failed	56	19,320	43.3%
Brakes failed/degraded	39	11,144	25.0%
Other vehicle failure/deficiency	17	9,298	20.8%
Steering/suspension/transmission/engine failed	16	4,669	10.5%
Unknown	2	212	0.5%
Total	130	44,643	100%

Estimates may not add up to totals due to independent rounding.
Data source: NMVCCS (July 3, 2005 December 31, 2007), NHTSA, compiled as of April 30, 2008

Fig. 1. Table of reasons for crashes from malfunction of car parts [4]

It is evident that a safety feature is necessary to protect tires and improve reliability in them. In addition to analyzing the main malfunction that occurs in vehicles, our team looked into which body type has tire-related malfunctions. The most frequent body type of vehicles that are in tire-related crashes were passenger vehicles. In Fig. 2 passenger vehicles were more than around 50% in tire-related collisions than other vehicles. With that being said, Skid Safe's design will focus on tire protection and be geared for passenger vehicles.

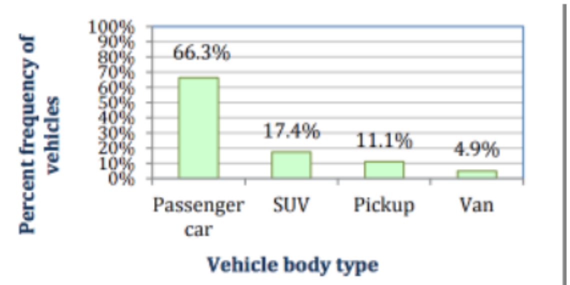


Figure 2(b). Percentage distribution of tire-related crash vehicles over vehicle body type

Fig. 2. Percentage of vehicle body types that are in tire-related collisions [4]

Speed is the most common factor in fatal road accidents, accounting for more than half of all road deaths each year [4]. Speed's influence on the maneuverability of a vehicle can result in a more catastrophic collision. The average speed at which a car has difficulty being controlled when tire failure occurs is 35 mph [5][1]. As the speed increases the maneuverability decreases. The average maximum speed of passenger vehicles used for normal street traveling is 100 mph [6]. Using this value in comparison to the inhibiting speed, at speeds of above 35% of the maximum speed of the prototype will be considered for necessity to deploy the sled.

III. DESIGN IDEA

Our design idea needed to address the societal problem that a tire failure at high speeds can have catastrophic consequences. This goal led us to create a system, Skid Safe, to allow the driver to maintain control of the vehicle in high-speed tire failure scenarios. Currently, in the event of a tire failure, the driver needs to be very aware of their actions in order to maintain control of the vehicle. Braking in the wrong manner could cause the vehicle to lose control and maybe even cause the vehicle imbalance. We looked at other automobile safety technologies that also address low probability, high risk events and determined that Skid Safe has a place in today's automobile safety market. The Skid Safe design addresses the problem similar to how ABS prevent accidents by preventing the brakes from locking up. ABS is designed to remove specialized braking technique from rapid brake scenarios. By automatically performing the pump-and-release braking technique to prevent the tires from locking up, ABS allows the driver to focus on maneuvering the vehicle while not having to simultaneously apply the proper braking technique. In the event of tire failure, the driver needs to take specific action to prevent loss of control. Like in ABS, Skid Safe will remove the actions needed to maintain control from the responsibilities of the driver and allow the driver to focus on maneuvering to safety.

The design idea we've committed to Skid Safe was developing an automotive safety technology that will deploy a skid upon tire failure at high speed, allowing the driver to maintain control of the vehicle while maneuvering to safety. Starting from there, we developed a feature set to achieve Skid Safe's purpose. The design was divided up into four features: vehicle speed evaluation, tire quality monitoring, emergency activation system and time-critical emergency vehicle support deployment. The vehicle speed evaluation feature measures the speed of the vehicle to determine if sled deployment is necessary. The tire quality monitoring feature determines if the tire has ruptured or fallen off. The emergency activation system analyzes incoming data from the preceding two features and actuates the final feature. The final feature is the time-critical emergency vehicle support system which must deploy the sled and support the car safely. Development of the vehicles speed evaluation, tire quality monitoring, emergency activation system and time-critical emergency vehicle support deployment features were appointed to Haley, Nick, Andrew, and Derek, respectively. This was based on their skill set and knowledge. Due to fiscal, mechanical, and liability constraints, our design idea was developed for a small scale, child sized car.

A. Vehicle Speed Evaluation Design

The speed of the vehicle plays a major role in maneuverability in the instance of a tire blowout. At a stop and at low speeds, a tire blowout or detachment does not present danger to the occupants. However, as speed increases, the danger greatly increases. At higher speeds and especially freeway speeds, a vehicle's maneuverability decreases significantly. If tire failure occurs at a high speed, the vehicle is much less likely to come to a safe, controlled stop. This information was used to determine which speed at which Skid Safe should unlock and deploy. In a regular vehicle, this speed would be about 35 mph. In our small scale vehicle with a max speed of 5 mph, this danger speed comes out to around 1.75 mph which is used in our system.

After determining the targeted speed for deployment, we had to come up with a way to allow Skid Safe to read the current speed of the vehicle. On an actual vehicle, Skid Safe could access the onboard computer of car which would provide data from the speedometer to our system. We did not have the capability to use the onboard computer method in the laboratory and deployable prototype so we had to develop other ways to measure speed. The measurable metric that was developed was to measure speed of vehicle to the ±0.1 ft/sec in a forward accelerating direction while traveling on a straight paved street.

In the laboratory and deployable prototype, this feature was implemented with a wheel encoder using an IR sensor. The original goal in Fall was to implement two different sensors that would provide data on the speed and sled orientation. The first sensor, a triple-axis accelerometer gyroscope sensor, was to be used to adjust the orientation of the sled when meeting the ground. Originally we thought that for a smooth response of the sled with the ground, the sled needed to descend at an angle. So once the sled made contact with the ground, the angle of the sled would need to gradually decrease to a position that was in total contact with the ground. The triple-axis accelerometer gyroscope sensor would use its features to measure tilt and orient at that time. A gyroscope would measure angular rotational velocity while an accelerometer sensor would measure linear acceleration of movement. This would allow us to measure the most suitable initial angle of the sled and the angle difference that would need to occur when correcting itself. This would also create an environment with less friction and stress on the sled. In this case an accelerometer sensor was appropriate to use on the sled because it would be in a 2 dimensional orientation with the ground. Although, an accelerometer sometimes can provide either noisy output that is quick or a clean output that is sluggish [7]. With this, it is best to have a combination of the two sensors. Ideally, using a triple-axis accelerometer and triple-axis gyroscope in combination would've given us an output that is both clean and responsive.

Unfortunately, in development and testing, we discovered that was not the case.

The data outputted was neither responsive nor clean enough. Any small error would propagate into the next calculation, and thus creating worse error. Since, on an actual vehicle, Skid Safe would have access to the onboard computer for speed information, we opted to move forward with an IR wheel encoder to gather speed information. This proved much easier to work with while sufficiently meeting the specifications laid out in the feature set.

B. *Tire Quality Monitoring Design*

There are multiple ways a tire could fail including a rapid tire deflation, complete tire blowout, and entire wheel detachment. Nearly all of possible tire failure methods we came up with could be detected by gathering two metrics on the tire status. The tire quality monitoring feature was developed to provide data on these two tire metrics, tire material detection and tire pressure monitoring. Our tire quality monitoring system is a two sensor system that will be tasked with retrieving different sets of data that will represent the current condition of the tire.

Tire material detection is used in the case of complete tire blowouts or detachments. For detection of the presence of a tire, a sensor inside the wheel well will be facing the tire and detecting its material. Another sensor will be facing the ground under the axle to measure deflation. A complete tire blowout is sensed when the sensor detects no material and the car's frame is approaching to the ground. A tire detachment is acknowledged when the sensor reads the tire has moved a certain distance off the axle. While tire detachment provides a longer time to react than a complete tire blowout, the system still needs to respond within a fraction of a second.

Tire deflation at high speed also presents a danger to vehicles. A completely deflated tire could drive on the rim of the wheel causing damage, loss of control, or pulling in the direction of the failed tire.The tire pressure monitor sub-feature of the tire quality monitoring feature gathers data on tire pressure with the goal of recognizing when a deflation is occurring. For our implementation, rate of tire deflation will not matter because safety procedures will only be activated at tire failure pressure levels. This feature is geared towards the severely deflated cases.

Early in the Fall, we pursued monitoring tire pressure with wireless Bluetooth valve stem pressure monitors. Originally were going to receive tire pressure data over Bluetooth with a Raspberry Pi and send tire pressure status to a microcontroller. However, we discovered that the wireless valve stem pressure monitors were too slow for the strict time constraints that Skid Safe requires. In researching alternatives to measure tire pressure we found that the feature can take advantage of the relationship between tire pressure and vehicle height. At the scale we are presenting Skid Safe, this relationship is a reliable method of determining tire pressure. A drop in tire pressure could be measured by how the distance between the ground and frame changes. From there, the measurable metric developed for this feature is that tire quality monitoring will measure tire diameter to assess inflation levels with accuracy down to 1 centimeter.

The tire quality monitoring feature met its requirements in both the laboratory and deployable prototypes. A time of flight distance ranging sensor registers tire detachment once the tire has moved past a certain distance away. An ultrasonic sensor is used to measure the height of the vehicle and from there derives the tire pressure reading. The ultrasonic sensor reads with accuracy down to 1 centimeter.

C. *Emergency Activation System Design*

The main role of the emergency activation system is to act as the brain of the system by using near real-time data analysis. The emergency activation system will analyze the sensor data coming in, determine if a tire failure has occurred, and if so, will send the signal to begin sled deployment procedures. The other features are connected directly to the microcontroller. From the beginning we knew that there was a possibility of the use of a sensor that requires I^{2}C protocols. Originally, the signal for the tire pressure monitor was going to be provided by a separate onboard computer to take advantage of the sensor's wireless capabilities. Because we moved away from the wireless valve stem pressure monitors, we no longer needed the separate onboard computer. This streamlined programming the software because we only had to develop software for one board, the microcontroller.

The configurations found in microcontrollers can vary in programmability, reprogrammability, memory size, memory organization, CPU performance, CPU cores, and peripherals such as ethernet, USB, serial ports, communication protocol controllers, pulse width modulation controllers and more. They are very popular in electronics projects because many of them are programmable, have the ability to provide outputs, and can read in inputs. Arduino is a popular open-source electronics platform for easy and rapid prototyping. The simple and accessible user experience Arduino provides allows programmers of all levels to pick up an Arduino and quickly get it running. The Arduino platform fit the requirements for the emergency activation system so we decided to develop Skid Safe on the Arduino Mega 2560 Rev3.

We had planned on developing the software on the Arduino in the Fall and porting over to STM32 Arm Cortex microcontroller in the Spring. However, it was determined that porting the software to the STM32 Arm Cortex board presented too much risk so we continued using Arduino throughout the project. The risk was possibly having to rewrite drivers and libraries to use our sensors. Also, since the Arduino performed well enough, the amount of work required to port the software was not worth the marginal, if any, increase in performance of the software.

Three measurable metrics were developed for this feature: it must analyze data from sensors and develop current status of tire within 0.2 seconds, when at 35% of average maximum speed the deployment of the skid will be unlocked, it must determine if tire failure has occurred, and begin deployment procedures within 0.1 seconds. The emergency activation system was developed with FreeRTOS to meet these metrics.

D. *Time-Critical Emergency Vehicle Support Deployment Design*

The purpose of the time-critical emergency vehicle support deployment feature is to deploy the sled as quick as possible to provide support for the wheel that just failed. It needed to be quick, strong, and reliable. From early on, the decision was made that pneumatics would provide the best support for Skid Safe. Thus, this feature was to consist of pneumatic hardware, appropriate circuitry assembled, and a sled attached for the car to slide on. In the Fall the components were gathered and tested. In the Spring, the components were mounted on the small scale car.

The measurable metrics developed for the time-critical emergency vehicle support deployment feature will eject the sled to meet the ground in 0.3 seconds and will support the weight carried by the tire that failed. This metric was met by timing the sled deployment and successfully held up the car.

IV. FUNDING

For Skid Safe, we had no intention of getting a sponsor. The production of this design was fulfilling towards our creativity, but was difficult to construct to a full scale model. Our skill sets and budgets were unable to meet the necessary parts for a full scaled mechanism. Thus, we were able to afford all of the components in the construction of Skid Safe. Each team member kept balance of what they paid for. At the end of the year, all of us compensated one another and split the cost for everything. This scale of the project did not cost a great amount and was manageable to afford. The project costs are shown in Table I.

TABLE I.
PROJECT EXPENSES [8]

Item	Total
TMPS	50
Raspberry Pi	35
Arduino Mega 3x	35
Small Scale Car	280
Time of Flight Distance Sensors	30
Pneumatics	196
HC-SR04 ultrasonic sensor	14
URM37 Ultrasonic Sensor	26
MPU6050 Gyroscope Accelerometer Sensor	16
Other Supplies (super glue, velcro strips, tape, etc)	20
Tools	60
Wheel Stuff	40
3D Printing Stuff	20
Jumper Wires	6
Digital IR sensor	2
Heat Shrink	9
String for Testing	3
1/2" grommets	4
1 1/2" grommets	3
Black Spray Paint	5
Legos for robotic car	10
9 volt battery source	8
L298N H Bridge	7
DC Motors with wheels	24
Arduino Uno	17
Arduino Mega Shield	20
Battery Source for deployable prototype	20
Total	960

V. MILESTONES

There were definitely milestones when it came to our project. These milestones go from the Fall to the Spring semester, which was the duration of the project. We determined as a group that there are the six major milestones that we couldn't have finished the project without.

A. Societal Problem

We could not have done this project in the first place without having a strong societal problem with a clear solution. Having a concrete problem and a possible solution made it easier for us to come together and create an idea to make this solution come to life. We believe this is a great milestone. The research put forth to diving into this societal problem gave us a better understanding of its commonness and validated our approach towards a solution. A vast amount of hours were spent researching this societal issue and brought even more attention to the lack of tire protection safety features.

B. Design Idea Contract

After creating a finalized design it was a great milestone for us. We had created a feature list that our design had to meet at the end of the spring semester. We also had a good idea on the materials we were using for meeting these requirements. Having such a good head start in the fall gave us a lot of time to do research and make sure that we are well versed in the topics that we need to create our solution. After creating our feature list, we split up the work equally for us to work effectively.

C. Work-Breakdown Structure

We created the Work Breakdown Structure to keep ourselves and our teammates on schedule. We believe this is a milestone because this is where we assigned each other jobs. The only way that we were able to finish within the two-semester time frame was because we split up the work and all worked on something different. This involved and created trust within our group. Creating deadlines for ourselves and trusting our team to meet the deadlines as well. This is a great milestone because kept us on track for the laboratory prototype and deployable prototype.

D. Laboratory Prototype

We were tasked to create a laboratory prototype by the beginning of December. This was a milestone because this was the first time that our system was operating as a whole. Almost the entire first semester we worked apart on our features getting them to achieve our feature set individually. Compiling all of our features together was a great accomplishment for us because it gave us a basis for our code. Since we already knew how our sensors and actuators were working together all we had to do was adjust our code and test to increase reliability as well as response time.

E. Testing

Being able to actively test was a great milestone for our group. This testing meant that we were done with the physical aspects of our project. Everything was affixed onto our testing car and all testing was to improve the software of the system to support our measurable metrics. Proving our metrics would show that this would be an actual solution to the societal problem that we have brought to the public's attention. After completing our testing we were able to simplify our wiring and permanently affix our components to our test car. These were the final steps to completing our deployable prototype.

F. Deployable Prototype

Completing our deployable prototype was a great milestone and achievement for the whole team. It was a whole two semesters of planning coming together into one uniform thing. Our deployable prototype came with everything that was mentioned in our feature set and exceeded our metrics that measured if our feature was met. This is our completion milestone, which reminded us that we are almost done with this project.

All of these milestones were great for us. Every milestone guided us to the next one and made it easier to complete. Without our research on our societal problem, we would not have created our project. Without having a good understanding of our design, we wouldn't have known how to correctly assign the work. Having such linear milestones and having assignments aligned with these milestones made creating this project a lot more organized than it would have been. Along with improving the organization, it also eased all of our nerves reminding us that we are on track to finishing on time.

VI. WORK BREAKDOWN STRUCTURE

Skid Safe consists of four major features: vehicle speed evaluation, tire quality monitoring, deployment activation system, and the support system. In the beginning of the Fall semester we spoke about the strengths and interests of each member of our team. Based off of our initial thoughts on our design, we were able to break up the tasks strictly by the features at hand. Each member took the reins on his/her feature developing a method that seemed sufficient for the task. As we moved through the project we bounced ideas off of one another and assisted each other when necessary.

Outside of the projects main features, we worked cohesively through the written and oral assignments throughout both semesters. Work was split as evenly as possible. This was based off of our working pace and was adjusted as the project progressed to assist any teammate that struggled. The total amount of hours each team member spent was around the same amount. Each team member managed their time to their best ability and put forth great effort into completing all of the assigned tasks. The hour distribution is shown in Table II.

TABLE II.
TIME BREAKDOWN [9]

Activity	Total Hours	Derek	Nick	Andrew	Haley
Research Individual Societal Issues	40	7	10	15	8
Problem Statement	44	7	12	10	15
Design Idea Contract	41	12	12	8	9
Work Breakdown Structure	38	8	13	8	9
Timeline	21	10	3	3	5
Risk Assessment	27	6	9	6	6
Problem Statement Revision	27	5	5	10	7
Device Test Plan	22	7	6	6	3
Market Review	34	7	10	8	9
Feature Report	27	7	7	8	5
Mid Term Progress	32	6	6	10	10
Team Meetings	222	49	59	59	55
Pneumatic Deployment System	60	60	0	0	0
Tire Speed Evaluation	104	0	0	1	103
Tire Quality Monitoring	69	0	55	4	10
Activation System	91	0	0	91	0
Integrated System	189	64	41	44	40
Summed Hours	1088	255	248	291	294

VII. RISK ASSESSMENT AND MITIGATION

After constructing the work breakdown structure, each team member had a specific feature to focus on. Within each of these features, the materials that would be used posed some potential for risk in their application. From an engineering standpoint, there are five sources of failure in a project; hardware, software, human, organizational, and external. Each of these five categories must be taken into consideration when a team means to begin preparing a project. It was our responsibility to acknowledge those potential risks, how they would affect the design, and have a secondary plan in mind.

Haley's focus was on the vehicle speed evaluation feature. In this feature, Haley acknowledged risk in the method used to measure speed and the effect of collecting inaccurate speed data would have on the deployment of the sled. Nick's focus was on the tire condition monitoring feature. This feature posed for more risks due to the hardware used, importance of acknowledging the tire blowing out or falling off, location of hardware, and the testing tire's material. Derek worked on the time-critical emergency vehicle support feature. In this feature, Derek needed to construct a pneumatic system that would deploy in the desired time and would also hold the weight of the car. Andrew was assigned to work on the emergency activation system feature. Andrew's responsibility was to configure the emergency system by finding an adequate controller that could translate the data efficiently and rapidly.

Each team member began a risk assessment for their feature in the Fall semester and discovered which predicted faults occurred as they progressed through the project.

A. Vehicle Speed Evaluation Risk Assessment

The speed of the vehicle is crucial to acknowledge in this project. Higher speeds administer more dangerous effects if a negative alteration to the vehicle occurs while in motion. The control of a vehicle diminishes as the speed increases. That being said, it is important for the team to find an accurate method in obtaining the speed.

1. Method Used for Measuring Speed

Configuring a method for measuring the speed went through two processes through the semester. The two possible options posed risks. Using an IMU had a potential of not being connected properly, giving false readings, or providing error when the acceleration was integrated. The IR sensors used for the rotary encoder had the potential of having the potentiometer turning as the car was being tested. If this happened the readings would not be accurate or consistent.

2. Inaccuracy of Speed Data

Once the sensor was connected for testing, the method towards measuring speed was put to the test. The accuracy of the data obtained for speed is crucial towards the design of Skid Safe. The speed allows the system to know if the car has maneuverability in the case of the tire rupturing or falling off. Inaccurate data can occur from the incorrect way of wiring the sensor, sensor failure, or applying a code that does not receive accurate data.

B. Tire Condition Monitor Risk Assessment

Monitoring the condition of the tire is a complicated feature due to reliance on the data of tire failure being transmitted at the desired time. The severity of the tire rupturing or falling off of the axle is huge in regards to the purpose of this mechanism. The acknowledgement of tire failure needs to have a well constructed method, rapid data transmitted, and be set to the metrics of the testing tire used.

1. Hardware

The hardware used to retrieve the tire's condition will need to be meticulous. The tire rupturing or falling off can happen in a fraction of a second and the hardware used will need to be able to recognize that in that given time. The tire pressure monitoring sensors had the risk of not transferring data quick enough when using bluetooth. The other two sensors, the ultrasonic and time of flight, had other risks. The wiring of them could result in unresponsiveness or inaccurate data. Depending on the range of proximity the sensors can read, the distance of the tire or ground could surpass that and affect the data.

2. Tire Monitoring Data

The data collected for the tire's condition had great importance towards the severity of the situation. Recognizing the tire rupturing or leaving the axle was crucial when deploying the sled. The risk that remained in this portion of the tire monitoring system resided in the code constructed or the sensors used. If the code had flaws when monitoring the tire's condition this could leave to false readings.

3. Tire Thickness and Size

The thickness of the tire material and its size had a major impact on the tire monitoring system's setup. The tires needed to be appropriately fitted to the vehicle and be flexible enough to show deflation occurring. The prototype's intended size was at maximum a child's size car, but would be vacant of weight from a passenger. Thus, the weight of the child's size car would be the only force acting on the tire that ruptures or falls off. The tire used for testing and for the prototype needed to be a thinner rubber to show quicker deflation. The thicker the rubber of the tire the more difficult it would be to demonstrate deflation and have it visible for observation. The risk arising from this situation was to find a tire that would have a thickness useful for testing purposes and fit the size of the child sized car.

4. Location of Hardware

Initially, the exact size of the prototype was undecided and making sure there was room to attach the hardware was at question. The risk in attaching the tire monitoring hardware was if there was no available space. Also the components needed to sit under the car, but could not touch the ground. If the components were to touch the ground deterioration would occur, wires would come loose, and the components would no longer be protected for longevity.

C. Time-Critical Emergency Vehicle Support Risk Assessment

This feature of the Skid Safe's design focused most on the mechanical construction of the pneumatic system and the sled. This feature includes an air driven system that deploys the sled nearly instantly to assist the car in maneuvering to a safe area. To do so we had to create a pneumatic system, as well as the sled. Both of these essential parts to the feature has some amount of risk assigned to it. These risks were larger scaled in the hardware aspect versus the software

1. Pneumatics

For the Pneumatic System the main risk was the force administered to the piston from the air tank reservoir. The PSI in the reservoir needed to be at a high enough rate to eject the piston at less than 0.3 seconds. The system needed to also be sturdy enough to hold the weight administered to the failed tire. Along with the system being up to par, the connection of the tubing for the air to passed through the solenoid needed to be air tight and have no risk. The leak of air would pose a huge risk in the sled deploying with enough force and in a quick enough time.

2. Sled

The Sled is the object that will be sliding on the ground when the sled deploys during the tire blowout. A possible material to use would thermoplastic because is very mendable at very high temperatures. The metrics of the prototype are a smaller scale so the type of plastic used in the project will not pose a huge risk. The risk for the sled would be using material other than plastic that may send sparks and cause a fire when having friction with the ground. Another risk would be the size and the thickness of the sled. The sled needed to fit the size of the wheel well and be a thick plastic. Many tests occurred over the year so the sled needed to be a certain size or wear from the test deployments would ultimately affect the end result of the project.

D. Emergency Activation System Risk Assessment

The goal of the emergency activation system is to process inputs from sensors and analyze the current system status. If the data indicates a tire failure has occurred the emergency activation system will trigger the deployment signal if the conditions are right. The emergency activation system will be implemented in a microcontroller. Due to the critical role the microcontroller plays in this design, implementation presents some risks. In summary the work packages of the emergency activation system are to research and purchase microcontroller, wire sensors to interface with microcontroller, determine state of tire based on data, RTOS implementation, code microcontroller to analyze sensor data, and deploy sled. Each one of these tasks presents risks of varying degrees.

1. Adequate Controller

Having a specialized board presents the most risk in the emergency activation system. The board in this case is referring to the microcontroller. The microcontroller for the emergency activation system needed to have a rapid enough clock speed to translate data. The risk was not only in the board used in this project, but also the changes that could occur from changing boards. The initial constructed code was compiled on the Arduino platform and uploaded to the Arduino Mega. The risk that was able to occur in this instance was changing to a comparable board such as the STM32 Arm Cortex. The risk in changing to a different board was the potential to have missing libraries and have to rewrite drivers. This would set back the team tremendously if that were to occur. Another risk that could occur would be blowing out the microcontroller from too much power being inputted into the board. If that were the case, our team would have to order another controller and extend our progress on the project.

2. Wiring Sensors

Wiring the sensors is a relatively small task but comes with risks of damaging components and even the microcontroller. If a sensor or microcontroller is damaged a new one will be required as soon as possible. The cost to get a new component will depend on the part price and shipping costs. Closer to deadlines, shipping costs could be exorbitant. The microcontrollers and most of the sensors are under $20 so the risk is mostly set in wait times for shipping.

3. RTOS Implementation

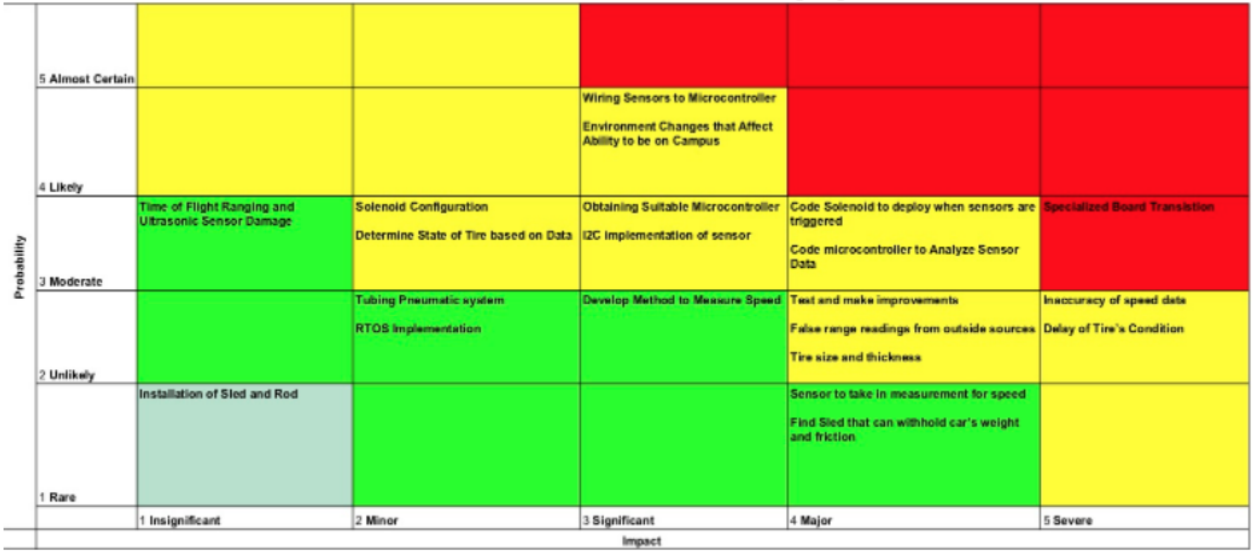
Due to the timing requirements this project presents, the microcontroller needs to process data as fast as possible. A Real Time Operating System (RTOS) will be implemented on the microcontroller to reduce buffer delays and speed up processing to get the sled out in a quick manner. As with the code for the sensors, this is low risk for the Arduino platform because of libraries, drivers, and documentation. If another platform were to be used there would be an increase in risk and a necessity for mitigation to quickly forward.

E. Additional Risks

The main risk outside of the components used and the construction of Skid Safe, was maintaining a valid location to work on the project. Problems that would interfere with this would be possible theft or environmental conditions. Poor environmental conditions had the ability to decrease class time for assistance and affect our ability to come to campus to work.

All of these risks were recognized by each team member and ranked in Table III. In the table you are able to see the severity each potential risk would have on the project. We also ranked the probability of each risk. This allowed us to acknowledge the risks that may occur, what to expect, and how to correct them. It also showed the importance in every task needed to be completed to assemble the features.

TABLE III.
RISK ASSESSMENT [10]



Probability	5 Almost Certain					
	4 Likely			Wiring Sensors to Microcontroller Environment Changes that Affect Ability to be on Campus		
	3 Moderate	Time of Flight Ranging and Ultrasonic Sensor Damage	Solenoid Configuration Determine State of Tire based on Data	Obtaining Suitable Microcontroller I2C implementation of sensor	Code Solenoid to deploy when sensors are triggered Code microcontroller to Analyze Sensor Data	Specialized Board Transistion
	2 Unlikely		Tubing Pneumatic system RTOS Implementation	Develop Method to Measure Speed	Test and make improvements False range readings from outside sources Tire size and thickness	Inaccuracy of speed data Delay of Tire's Condition
	1 Rare	Installation of Sled and Rod			Sensor to take in measurement for speed Find Sled that can withhold car's weight and friction	
		1 Insignificant	2 Minor	3 Significant	4 Major	5 Severe
				Impact		

F. Risk Mitigation Plan

As each team member put time into analyzing all the potential risks for the components used for each feature, each team member devised a back up plan. For the speed evaluation feature, Haley found another method for measuring speed. The IMU had potential to provide inconclusive and noisy data. The information received from the IMU was for acceleration in the x-axis and when that was integrated for speed there was an excessive amount of error. The error from the sensor was able to be decreased by the application of filters, but that was still not a solution. Since this was the case, Haley found a rotary encoder wheel design online to use. Using this 3D print of the wheel allowed for speed measurement to be done in an incremental process using a digital IR sensor. Haley portioned her attention on the IMU for only the Fall semester and quickly changed to the rotary wheel encoder method within a month of the Spring semester.

For the tire pressure monitoring sensors, they were sufficient when collecting data but had other complications. These sensors used bluetooth to transfer data which took longer than the time our design needed for acknowledgment of a tire blowout. The secondary option for monitoring the condition of the tire was to be from outside of the wheel. The tire pressure monitoring sensors were inadequate and within a month Nick moved to another method of monitoring the tire's condition. Nick used the axle of the prototype and attached an ultrasonic sensor to measured the distance the axle was from the ground. This was an alternative to showing deflation occurring and mimicked the case of the tire rupturing.

The other two features resulted in no mitigation and used the same components from the Fall semester into the Spring. Derek's pneumatic support system obtained enough PSI to deploy the sled in less than 0.3 seconds. Derek's option for mitigation of this feature would have been to purchase a pneumatic air tank that could obtain a higher PSI for a more forceful deployment of the sled. Andrew's mitigation for the emergency activation system relied heavily on the clock speed of the microcontroller used. The Arduino Mega's clock speed was comparable to the STM32 Arm Cortex board. Andrew had options in the mitigation for the potential risk in using the Arduino Mega. He could've used the STM32 Arm Cortex and see how it interacts with the code assembled from the Fall semester. He also had the option to alter his code or use a different method than RTOS.

When the Camp Fire occurred it did take away our ability to go to campus and consult with the professors about progress. This was a small step back for our group. Although, due to us keeping possession of our project at Haley's home we were able to continue working on the design. We mitigated this risk by keeping the project with our team until it was necessary to be on campus. Any problem that occurred was quickly solved by persistent work and research. We lucked out with only two features resulting in mitigation, but our plan for mitigation to these risks allowed our team to move quickly from any failed component and work with another method. This was proven to be successful with the end result of Skid Safe.

VIII. DESIGN OVERVIEW

Within the overview of this design, we will talk about the hardware and the software components comprising this project. After walking through all of the components we will go over some instances where Skid Safe would and would not deploy.

A. Hardware

The first thing on our hardware list is the child sized car. This car was the perfect size for us to put Skid Safe on. It was perfect because it was remote controlled as well as big enough for us to have a tire with tubing on the axle. The tires that came with the car were small and very durable plastic. We then added our own tires to control the internal pressure to simulate a displacement or a flat tire.

Fig. 3. Child Size Car [11]

After figuring out the car we were using, we attached the sensors to watch the following: tire quality, tire displacement, and car speed. For measuring the tire quality we used the HC-SR04 Ultrasonic Sensor. This sensor is affixed onto the axle of the vehicle and continually measures the distance from the axle to the ground. Once the axle reaches a certain distance from the ground the system acknowledges that a flat tire has occurred.

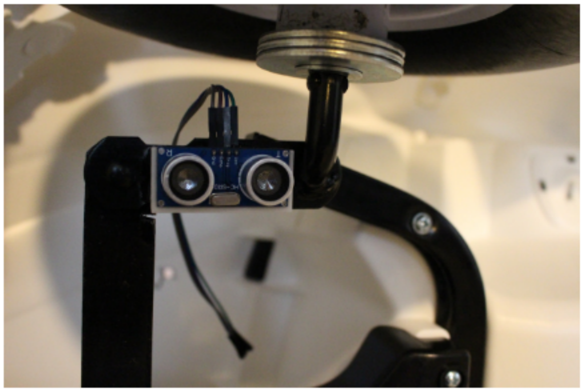


Fig. 4. Mounted Ultrasonic Sensor [11]

Fig. 4. is a picture of the ultrasonic sensor on the car and shows the orientation to the ground. As you can see it is pointing directly down, constantly measuring to see if

the pressure of the tire has gone down. The next sensor on our system is the VL6180X time of flight distance ranging sensor. This sensor measures tire displacement occurring on the car. This is for the situation when your tire comes completely off your car with no other tell signs to pull off the road. We placed it within the wheel well of the car and pointed it outward towards the tire.

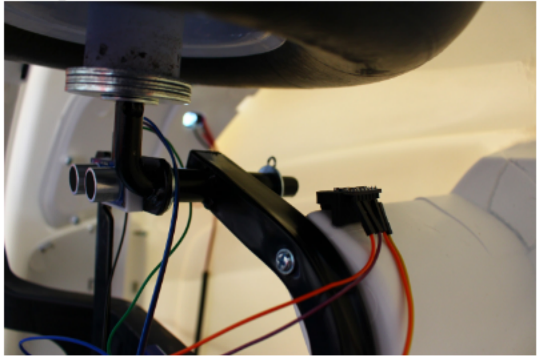


Fig. 5. Time of Flight Sensors [11]

After using these sensors to measure the quality of the tire, the system has to know whether or not the car is moving. For this, we put a rotary encoder on the tire not being used for testing and used an IR sensor to measure the rotations per minute of the wheel and translate that to measure down to the 0.1 ft/sec.

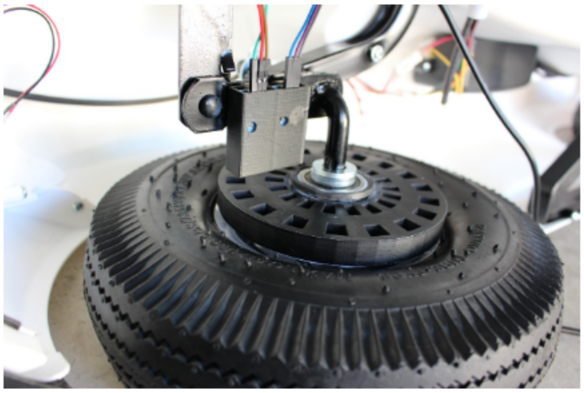


Fig. 6. IR Sensor/Rotary Encoder [11]

All of these sensors transfer the data to the Arduino Mega for analyzation. When the certain conditions are met, the Arduino Mega sends a signal to the solenoid for the pneumatic piston to deploy the sled.

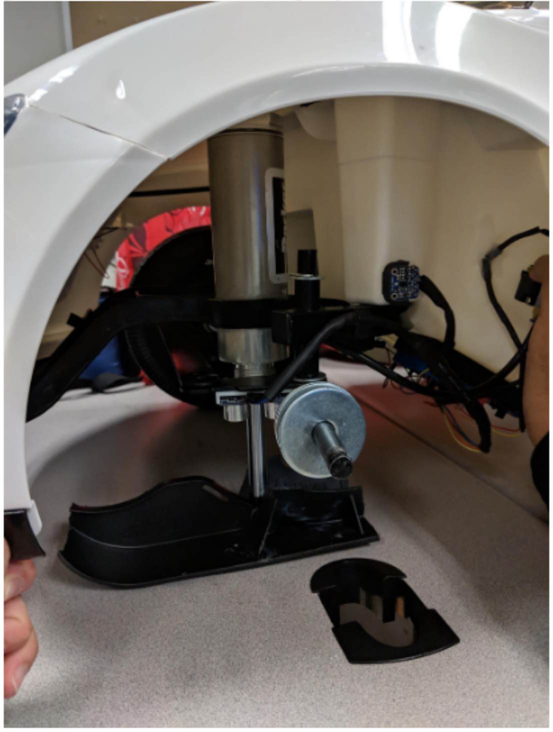


Fig. 7. Pneumatic Piston fully extended [11]

In Fig. 7, it is shown that the sled and piston are able to support the weight of the car. Before the piston is able to deploy we have to make sure the whole system is compressed with air. For doing this, we use an air compressor. We charge the system to the maximum psi our compressor can go which is 100 PSI. The more PSI the system has, the more weight it can hold as well as a faster deployment. The piston is mounted in a way such that when it is fully extended, it pushes the car back up to where the tire is supposed to be. This provides balance and support to the car.

Throughout the whole process of converting the laboratory prototype to our deployable we created mounts for the sensors for the transition to be easier. All of these mounts were created with a 3D printer created by one of our team members. All the mounts you can see within the pictures helped make this project happen. In the beginning we had a 3D printed piece for the sled. We soon realized that we would need a slightly more durable plastic, so we converted a sled that was used for biking in the snow into the desired sled for the deployable prototype.

We also have an external 12V battery source that powers both the solenoid and the arduino. This eliminated a constant connection of the laptop to the Arduino and completed the system to work continuously on its own. After the hardware was successfully implemented, the software's impact on the entire system was put to the test.

B. Software

Our goal for Skid Safe is to create a rapid and accurate system that responds in the desired time to save lives. Our research for a method of software approaches led us to Real-Time Operating Systems. Many embedded systems use RTOS implementations because of their quick and deterministic qualities. In Skid Safe, the deterministic qualities of an RTOS are extremely valuable. In a general purpose operating system the scheduler, which decides what to process to run next, is unpredictable. An RTOS is built around its own kind of scheduler which provides a predictable, deterministic execution pattern [12]. Skid Safe benefits from an RTOS implementation because the pneumatic sled needs to deploy in 0.3 seconds. The RTOS solution we pursued was FreeRTOS because of the abundant support and documentation. FreeRTOS capabilities have been optimized for Arduino AVR Devices so this was the natural choice for our design [13]. Using the FreeRTOS scheduler for Arduino, we wrote various functions to receive data from the sensors and monitor the status of the tire. The functions were derived from code other team members wrote for the other features. There were several code scripts initially written for the isolated testing of each of the components and meeting their feature's expectation. This was then translated into an RTOS implementation and integrated into a cohesive system. By taking advantage of the deterministic qualities, we can make sure that the high priority task of deploying the sled always takes precedence over getting another sensor reading. The software will also be very important for testing due to the difficulty testing Skid Safe presents. With the tire blowout and sled deployment happening in such a small time frame, making exact timings on data sensing and system actuation is difficult. As a result, the microcontroller may also be required to log data to make sure we meet the measurable metrics.

C. Instances

There are few instances where the Skid Safe should deploy and instances where it shouldn't. For example, if the vehicle is parked somewhere and realizes there is a flat, the system does not need to deploy. This could be a quick fix by replacing the tire immediately with a spare. Even at low speeds, the vehicle is able to be slowed down to a controlled stop to change a ruptured tire. Skid Safe is for when the vehicle is moving at a high enough speed that inhibits control. For example, if the car has the tire rupture while on a highway, the speed when traveling on the highway would be high enough for the sled to need to deploy. Another instance is if the tire comes the axle while driving. The severity of this case has a heavier impact on the stability of the car. This would instantly create friction to the metal components of the vehicle, shift balance of the drive, and have no object to fill in the void of that missing tire. This is where Skid Safe's necessity is apparent and valuable. This mechanism has the potential to lower the amount of tire related collisions on the road and save many lives.

IX. DEPLOYABLE PROTOTYPE STATUS

At the end of the Spring term, the deployable prototype has achieved all the requirements we set for it for a small scale demonstration. All of the components for Skid Safe were designed, tested, and installed on a small scale vehicle that travels at a maximum speed of about 5 mph. Thus, Skid Safe is operating at about a 1:15 to 1:20 scaling with a common car. Skid Safe was successfully tested at this scale so as a proof of concept, Skid Safe has validity to increase scaling.

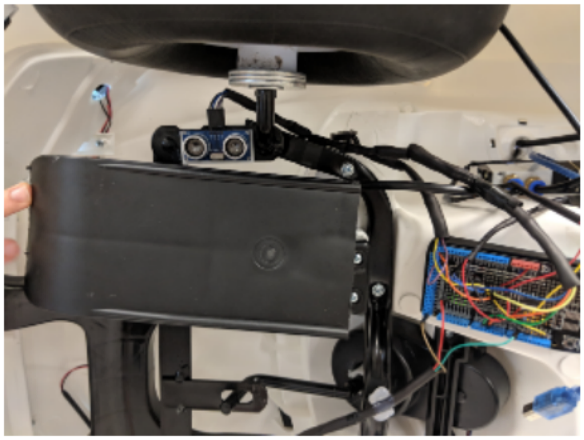


Fig. 8. Skid Safe System Installed [11]

The small scale installation of Skid Safe Fig. 8 shows the sled, tire quality monitoring sensors, and the emergency activation system microcontroller. 3D printed mounts were attached to the small car with super glue, then the sensors were glued to the mounts with more super glue. After testing, wirings were bundled with heat shrink tubing and soldered to a prototyping shield on the Arduino Mega. On the shield is a transistor that allows the microcontroller to control the pneumatics solenoid to operate the cylinder, to which the sled is fastened at the end. An air compressor sits in the seat of the car as a reservoir for compressed air for the pneumatics system. A battery powers both the microcontroller with a 5V USB port and the pneumatic system with 12V. Fig. 9 is the model of 3D printed mount designed for the Tire Quality Monitoring time of flight sensor.

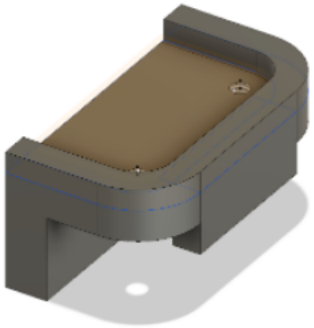


Fig. 9. Time of Flight Mount 3D Model[14]

Each of the features meets the measurable metrics developed. These are based on the test results that are given in the Appendix. For the vehicle speed evaluation feature, The measurable metric was achieved that it would measure speed of vehicle to the ±0.1 ft/sec on the small scale vehicle traveling on a straight paved street in forward accelerating direction. The deployable prototype uses an IR sensor to gather speed data. On a real vehicle, this speed data would be provided by the vehicle's onboard computer. The small scale vehicle's maximum speed is around 5 mph so the speed evaluation system was adjusted for that speed. The tire quality monitoring feature successfully met its requirements in the deployable prototypes. A time of flight sensor is used to detect the state of the tire material. Tire detachment is sensed when the sensor reads the tire has moved past a certain distance away. An ultrasonic sensor is used to measure the height of the vehicle and derives the tire pressure reading. The ultrasonic sensor reads with accuracy down to 1 centimeter. The three measurable metrics were developed for the emergency activation system were also achieved. It successfully analyzed data from sensors and develop current status of tire within 0.2 seconds. It also unlocked sled deployment at a specified, dangerous speed and finally, it determined if tire failure has occurred and begins deployment procedures within 0.1 seconds. The emergency activation system performance was enabled by software developed with FreeRTOS. The measurable metric developed for the time-critical emergency vehicle support deployment feature was met in that the support will extend in 0.3 seconds and will support the weight carried by the tire that failed. In its current status, the deployable prototype meets all the metrics we developed for the features. More work could be completed to further increase performance but that is beyond the scope of project.

X. MARKETABILITY STATUS

There is definite potential for Skid Safe to make it to the market and be administered on vehicles of all sizes. This product would be intended for car manufacturing companies and would be applicable in OEM vehicles. There is a possibility to attach Skid Safe to previously design vehicles, but the problems that would arise would be the amount of available space for the sled, the fitting of all of the components, and the vehicle would need to have a digital speedometer to interact with the controller. It would be more reasonable to add Skid Safe to OEM vehicles.

The current features on today's vehicles that could be used would be the speedometer and tire pressure monitoring system. The speedometer would eliminate the rotary encoder used in the prototype and would be a more efficient method of measuring speed. This wouldn't be difficult to connect to the controller as well. The other feature that could be used would be the tire pressure monitoring system. This would eliminate the use of the ultrasonic sensor on the bottom of the axle. Instead of measuring the distance the axle is from the ground, this would provide a more precise measurement of the amount of inflation the tire has. If these two features were to be used, the cost of applying Skid Safe would be less and the accuracy of the speed measurement and tire's condition would increase.

Skid Safe would need to be applied to all of the vehicle's wheels. This would provide the intended protection to each of the tires if a tire blowout or displacement occurs. To minimize equipment and space used, all of the solenoids for the support system would share one reservoir of compressed air. Another option towards increasing the force administered to the piston with the sled would be the use of dielectrics. The repulsion of dielectrics depends on the material, but can be greater than using pneumatics. Hydraulic systems use dielectrics for a more forceful reaction. If the vehicle is large in size using hydraulics may be ideal. Hydraulics use anywhere from 1,500 to 10,000 PSI which would be more efficient if the sled was holding the weight of a semi-truck [15].

The sled will need to also be altered for administration to a vehicle. The thickness of the material, length, and type of material will need to be matched to the size of the vehicle. The current sled on the prototype is made of a sturdy plastic and if this was to be used on a vehicle, plastic would still remain a good choice. Plastic materials work well in situations where friction resistance is important [16]. This resistance will occur when the sled slides against the road. Roads have a high friction coefficient [17]. An ideal material for the sled would be a high-temperature polymer sled. This type of plastic material would be able to withstand the friction and heat caused by friction with little wear [16]. The sled's cost will depend on the length and thickness, but the material used would not be too costly.

The last two components that would need to be provided for the administration of Skid Safe on vehicles would be a sensor for acknowledging tire displacement and an adequate controller for the system's interactions. For tire displacement any sensor that recognizes change in distance could be used. The time of flight distance ranging sensor could still be used or an ultrasonic could be used as well. It would be more efficient to use the time of flight distance ranging sensor due to the use of a narrow beam of light for readings. This would decrease the possibility of outside disturbances occurring and affecting the data. Lastly, the controller used for Skid Safe would need to have a clock speed that is the same or greater than the Arduino Mega our team used. This is crucial for the data that is being received and transmitted. The microcontroller would need to be able to consistently take in data, translate the data from the tire rupturing or displacing in 0.2 seconds, and send the signal for the sled to deploy in 0.1 seconds.

Skid Safe's cost would depend mostly on the pressurized system and material for sled used. These two components will range in cost due to type of vehicle Skid Safe is applied to. Using the tire pressure monitoring system and speedometer will cost nothing, and the microcontroller and distance sensor will cost very little. Overall, Skid Safe will not be overpriced and the result of saving lives will be worth its consideration.

XI. CONCLUSION

Skid Safe was conceptualized as an automotive safety technology that would that would prevent accidents caused by tire blowouts. Further research uncovered that while generally safe, modern tires still have a chance of failure and consequences in those events can be catastrophic. Roads are often full of potholes, debris, and other dangerous materials. Due to these harsh road conditions, it very common to see shredded tires on the roadside along with drivers whose cars are hopefully still intact. As a result of this common problem we chose to focus on creating a system that would help drivers in the event of tire failure.

Skid Safe addresses the societal problem that a tire failure at high speeds can have catastrophic consequences. This goal led us to developing an active safety system that would allow the driver to maintain control of the vehicle in high speed tire failure scenarios. Currently, in the event of a tire failure the driver needs to be very aware of their actions in order to maintain control of the vehicle. Braking in the wrong manner could cause the vehicle to lose control and maybe even cause the vehicle to start rolling. We looked at other automobile safety technologies that also address low probability, high risk events and determined that Skid Safe has a place in today's automobile safety market. The Skid Safe design addresses the problem similar to how ABS prevent accidents by preventing the brakes from locking up. ABS is designed to remove specialized braking technique from rapid brake scenarios. By automatically performing the pump-and-release braking technique to prevent the tires from locking up, ABS allows the driver to focus on maneuvering the vehicle while not having to simultaneously apply the proper braking technique. In the event of tire failure, the driver needs to take specific action to prevent loss of control. Like in ABS, the Skid Safe removes the actions needed to maintain control from the responsibilities of the driver and allow the driver to focusing on maneuvering to safety.

Andrew, Derek, Haley, and Nick worked together to develop Skid Safe is an integrated system that monitors the condition of the tire, the position of the wheel, the speed of the car, and under the basis that a tire failure is detected, will send a signal that deploys a sled to support the weight of the vehicle and allow the driver to maintain control of the vehicle.

As the person who originally came up with the idea, Haley constantly provided her vision in Skid Safe. She used here mechanical skills to develop the Speed Evaluation feature. Haley took the reins on vehicle speed evaluation. Vehicle speed evaluation seems irrelevant to the project, however plays a key role in our design. If a vehicle is not moving, or is moving slowly, and a tire blowout occurs, the driver will be put at little to no risk. Through in depth research Haley determined that in a full sized vehicle, drivers were not at serious risk until a certain speed. Since our project is scaled down onto a child sized car, we scaled down the speed for our test car's maximum speed as a means of measuring a dangerous vehicle speed. After the speed is evaluated it is time for the system to check the condition of the tire and wheel.

For tire quality monitoring, Nick implemented a two sensor system to monitor both the diameter of the tire, as well as the position of the wheel with respect to the frame of the car. For the tire diameter, as a tire deflates, the tire on the underside becomes less firm and yield a smaller diameter. As the diameter gets smaller the frame of the car nearest to the tire will get closer to the ground. In order to monitor this diameter Skid Safe uses a distance sensor, and under the basis that the distance is too small or the rate of change of the sensor becomes too large, it recognizes that the tire failed and send a signal to prepare deployment. For monitoring the wheel position, Skid Safe has an additional distance sensor that is placed on the frame of the vehicle and faces outward towards the inside of the wheel. If the sensor reads a distance beyond the set value the system assumes that the wheel has been detached from the vehicle. Both of these readings our monitored by a microcontroller.

Andrew developed the software of our system to interpret the data from each sensor, compare that data against unsafe conditions, and then in the case of unsafe conditions will send a signal to deploy the system. The two conditions that must be met for Skid Safe to deploy are dangerous speed, in addition to either tire failure or wheel detachment. If either event occurs, the system sends a signal to deploy mechanical system. To meet the strict time constraints laid out in the feature set, the software was developed as a real-time operating system using FreeRTOS.

For deployment, Derek designed a pneumatic system that deploys a rod using pressurized air when signaled. Through various trials of what to use for the support system Derek decided on using a ski type material, similar to that of a snowmobile. Using 3D prints to fasten the sled to the rod he created a method that would deploy a low friction device just next to the wheel to support the weight of the vehicle without damaging roads, and allowing stable maneuverability of the vehicle.

After each component was designed and tested individually, Skid Safe was integrated and mounted onto the car for testing. Initially there were various issues which caused for false deployments, or did not deploy in the instance of unsafe conditions. Each time a new problem arose we would brainstorm implementation methods that would take this error out of the question. We did several tests in various environments and on various terrains and each and the system has deployed when expected. Even though our design is a small-scale proof of concept, with additional time and resources, it could be scaled to full size.

Outside of the projects main features, our team worked cohesively through the written and oral assignments throughout both semesters. The total amount of hours each team member spent was around the same amount. Each team member managed their time well and put forth great effort into completing all of the assigned tasks and helping each other when needed.

As a team, we determined sources of risk and mitigating them. Each team member put time into analyzing all the potential risks for the components used for each feature, each team member devised a mitigation plan. Some of the mitigation plans were put to use in the cases of the dealing with unusably noisy IMU, slow Bluetooth valve stem pressure monitors, software porting issues with the STM32 Arm Cortex, and no class access during the Camp Fires. While not all risks were predictable, our team adapted and persevered through the events.

At the end of the Spring term, the deployable prototype has achieved all the requirements we set for it for a small scale demonstration. All of the components for Skid Safe were designed, tested, and installed on a small scale vehicle that travels at a maximum speed of about 5 mph. Thus, Skid Safe is operating at about a 1:15 to 1:20 scaling with a common car. Skid Safe was successfully tested at this scale so as a proof of concept, Skid Safe has validity to increase scaling.

If there is continued development there is great potential for Skid Safe to make it to the market and be administered on vehicles of all sizes. This product could be adopted by car manufacturing companies and would be applicable through OEM in vehicles. There is a possibility to attach Skid Safe to previously design vehicles, but the problems that would arise would be the amount of available space for the sled, the fitting of all of the components, and the calibration it would require. It would be more reasonable to add Skid Safe to OEM vehicles.

We believe that Skid Safe is a promising design that will improve automotive safety. This will not only help the users with Skid Safe installed but also other vehicles and people on the road. Every day, thousands of car accidents occur throughout the nation. If we are able to assist in anyway by reducing these accidents, we would be performing our civic duty as engineers.

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[10] H. Lawrence - Table III “Risk Assessment”

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[24] A. Encinas - “Tire Material Range Subroutine"
[25] A. Encinas - “Tire Pressure Monitoring Subroutine Flow Diagram"
[26] A. Encinas - “Tire Pressure Monitoring Subroutine Flow Diagram"
[27] A. Encinas - “Vehicle Speed Evaluation Subroutine Flow Diagram"
[28] A. Encinas - “Deployment Test”
[29] H. Lawrence - “Isolated Pneumatics System”
[30] A. Encinas - “Pneumatics Tests”

GLOSSARY

ABS- anti-lock braking system

Accelerometer- an instrument for measuring acceleration

Gyroscope- device used for measuring or maintaining orientation and angular velocity

mph- miles per hour

OEM- original equipment manufacturer

I^{2}C- Inter-integrated circuit protocol that allows multiple digital integrated circuits to communicate with one of more “master” chips

IMU- An inertial measurement unit is an electronic device that measures and reports a body's specific force, angular rate, and sometimes the magnetic field surroundings the body, using a combination of accelerometers and gyroscopes, sometimes also magnetometers.

IR- Infrared sensor that emits in order to sense some aspects of the surroundings.

Pneumatics- a system that uses compressed air to transmit and control energy.

PSI- Pounds per square inch

PWM- Pulse width modulation

Ultrasonic- sensor that measure distances based on transmitting and receiving ultrasonic signals

RTOS- Real-Time Operating System which is any operating system intended to serve real-time applications that process data as it comes in, typically without buffer delays.

Appendix A
User Manual

1. Have the code preloaded to the controller and check that all connections are secure
2. Hook up hose to air compressor and pump until it reaches to 100 PSI
3. Turn on the external power source that is powering the controller and the solenoid
4. Turn on Car for driving

Tire Displacement Test

5. Take off the locking mechanism of the front left tire to the axle, put tire back on
6. Pump front left tire until you can see the tubing 1 cm from the wheel well
7. Drive the car and have a friend take off the front left tire quickly
8. Once sled deploys drive somewhere "safely" simulating getting off highway

<u>OR</u>

Flat Tire Test

5. Pump front left tire until you can see the tubing 1 cm from the wheel well
6. Place the tire deflator on the valve stem of the front left tire
7. Go to a place where you can test instantly
8. Pull the valve stem out of the tire, the tire should instantly start deflating
9. Start driving and wait until the sled deploys
10. Once sled deploys drive somewhere "safely" simulating getting off highway

- This is just for testing that your system WORKS, after testing all you have to do is make sure your batteries are charged for the microcontroller and solenoid as well as the air compressor at 95-100 PSI(1-4). This is a reactive system to something that is unpredictable, so we don't encourage more than one test a month just to see the system is still working properly.

Appendix B
Hardware

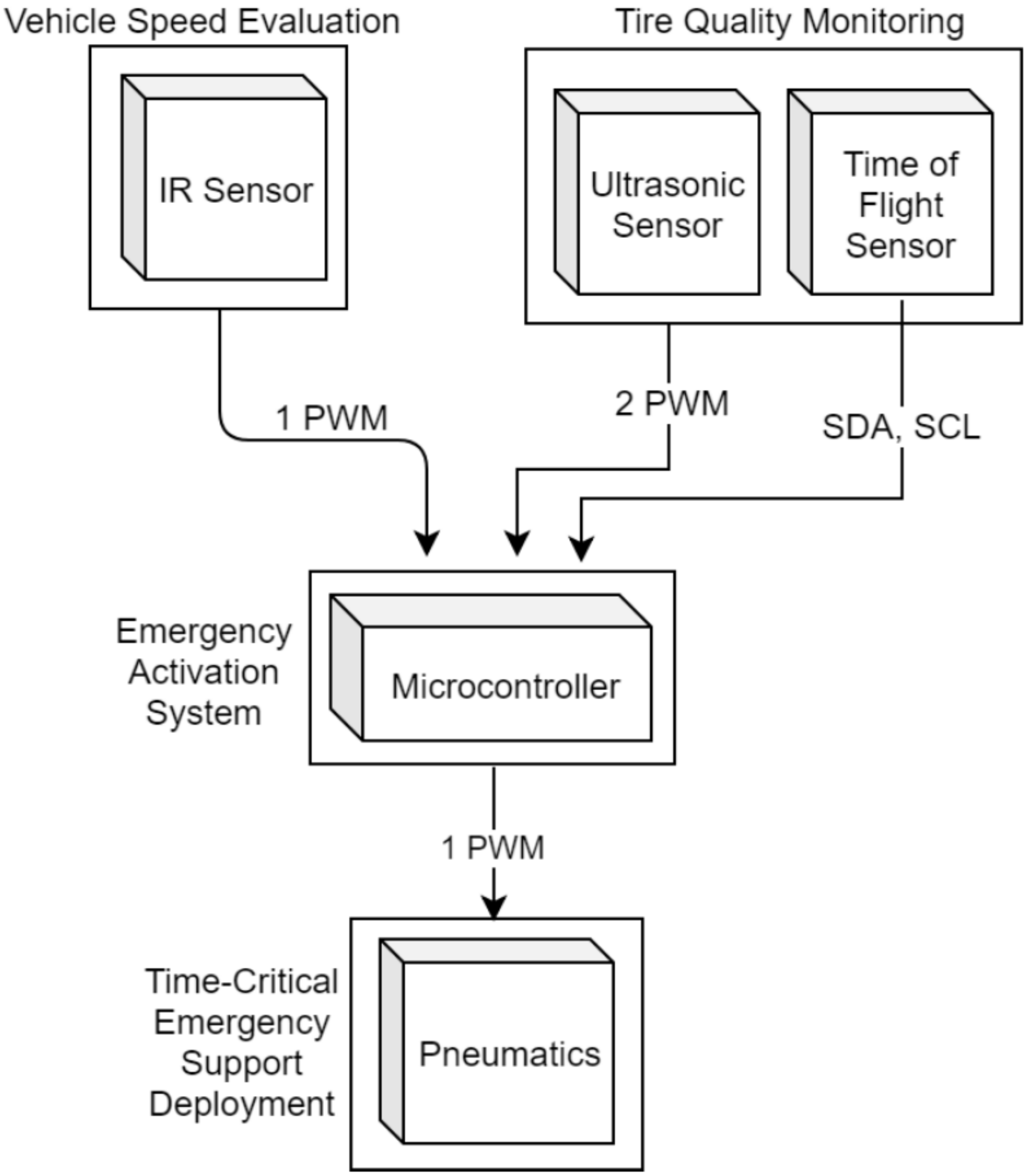


Fig. B-1. Skid Safe Hardware Diagram [18]

The hardware is summarized in a flowchart in Fig. B-1. The vehicle speed evaluation feature gathers data from an IR sensor that transmits signal to the emergency activation system's microcontroller through a PWM pin. The IR sensor uses a rotary encoder wheel that transmits both light and dark signals to translate the amount of rotations the wheel makes. This is how the speed is measured and analyzed in the microcontroller. This is shown in Fig. B-2.

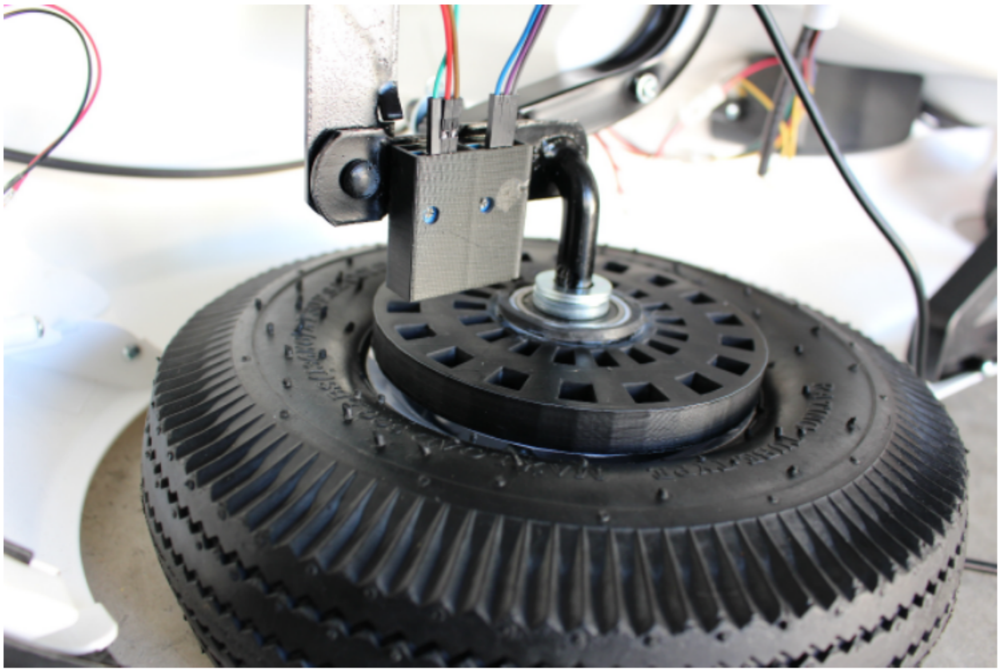


Fig. B-2. Rotary Encoder with Digital IR sensor[19]

The tire quality monitoring feature is made up of two sensors. The first sensor is the HC-SR04 ultrasonic sensor and is depicted in Fig. B-3. This sensor uses an 8 cycle burst of ultrasound at 40 kHz and pulses in an echo signal to determine distance. This sensor is tasked with keeping track of a distance from the bottom of the wheel's axle to the ground. The echo and trig pins on the HC-SR04 are connected to the microcontroller with two PWM pins. The other sensor is an Adafruit VL6180X Time of Flight micro-LIDAR Distance Breakout which is Fig. B-4. This sensor determines distance by measuring how long a narrow beam of light sent from the sensor takes to be received back to the sensor. It communicates using IC2 thus connects to the microcontrollers I^2C logic pins, SCL and SDA. All of the listed sensors connect to 5V and ground on the Arduino Mega 2560.

Fig. B-3. HC-SR04 Ultrasonic Sensor[20]

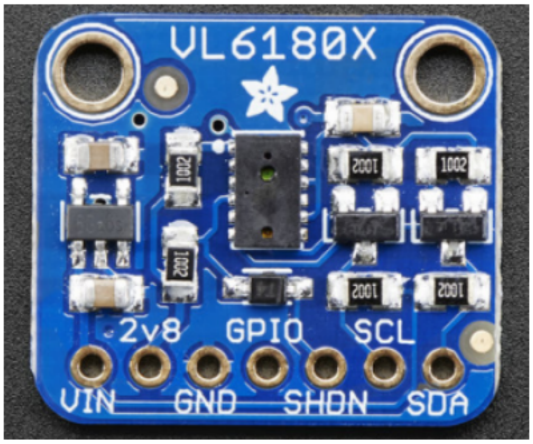
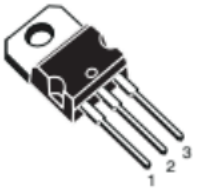


Fig. B-4. VL6180X Time of Flight Sensor[21]

If a tire failure is sensed, the emergency activation system microcontroller sends the signal to deploy to the pneumatics circuitry. Because 12V is required to actuate the solenoid, a separate power source is used to power it and a TIP32C power transistor, in Fig B-5., is used as a switch. Signal to deploy from the microcontroller is inputted into the base of the transistor and powers the solenoid which activates the pneumatics.



TO-220

Fig. B-5. Power Transistor[22]

Appendix C
Software

Skid Safe software was developed using FreeRTOS to meet the strict time requirements this project presents. The flow of the software is seen in Fig. C-1. Data acquisition is split into three separate tasks and once data is collected, it is analyzed and deployment is determined. If a tire failure has occurred at a dangerous speed, the signal is sent to actuate the pneumatics. The system spends the majority of time in the data acquisition-analysis loop because of the rare nature of tire failures.

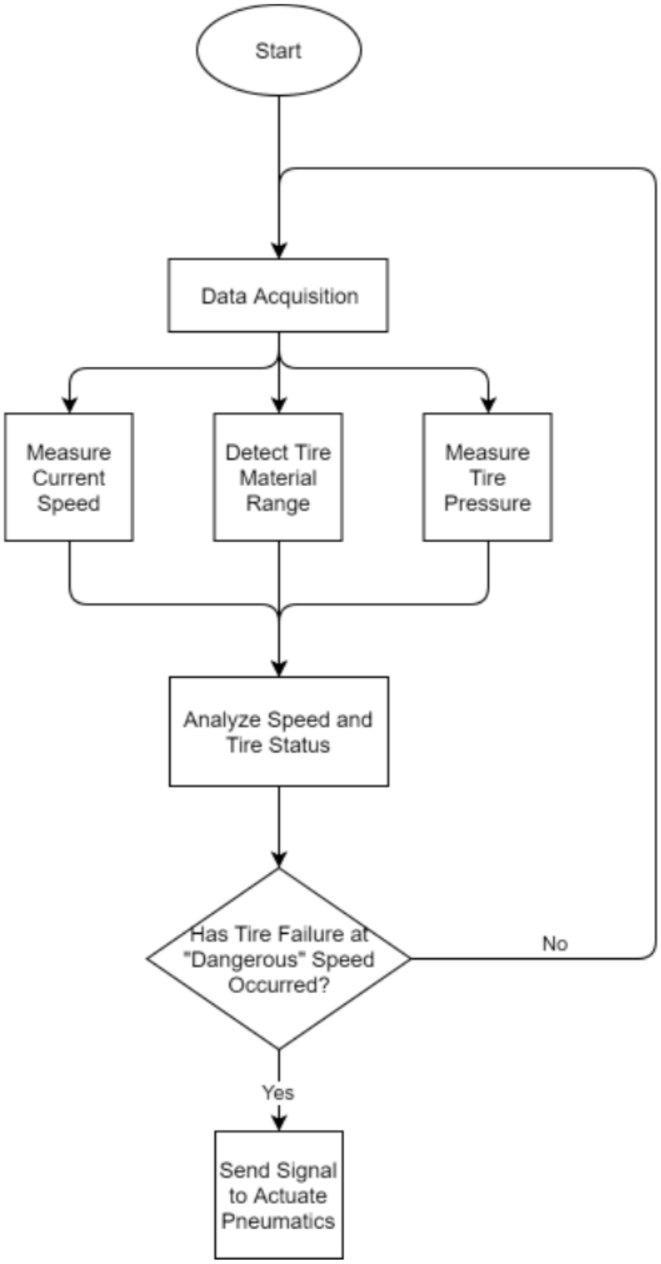


Fig. C-1. Skid Safe Software Flow Diagram [23]

The four main subroutines that make up the software are the Deployment Probe Subroutine, Tire Material Range Subroutine, Tire Pressure Monitoring Subroutine, and Vehicle Speed Evaluation Subroutine which are summarized in flow diagrams in Fig. C-2, Fig. C-3, Fig. C-4, and Fig. C-5, respectively. The RTOS implementation takes advantage of priority by putting the Deployment Probe Subroutine at the highest priority. Thus, it will never be interrupted by another subroutine and cause delays.

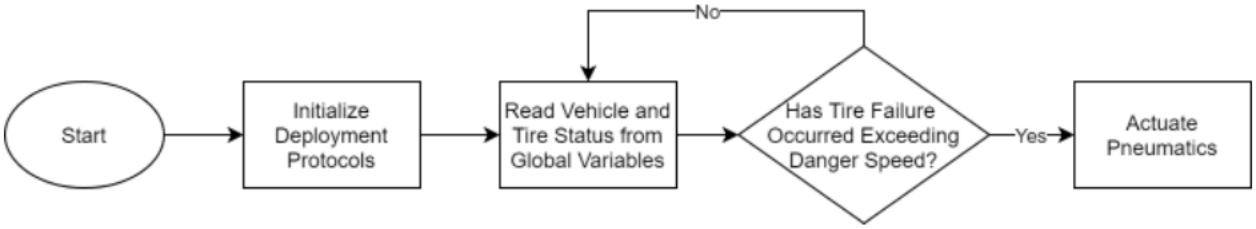


Fig. C-2. Deployment Probe Subroutine Flow Diagram [24]

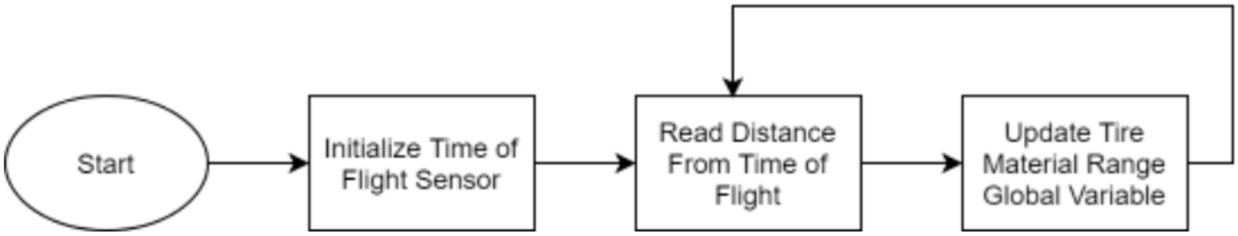


Fig. C-3.Tire Material Range Subroutine Flow Diagram[25]

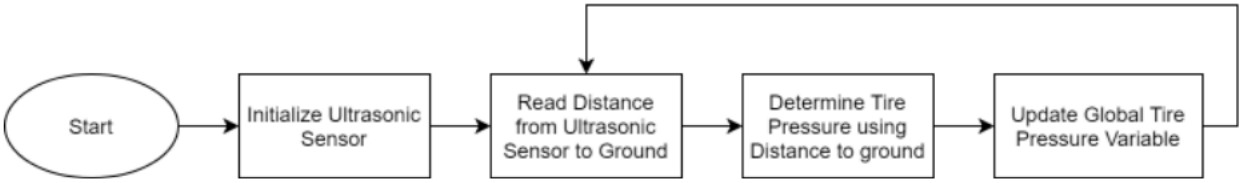


Fig. C-4. Tire Pressure Monitoring Subroutine Flow Diagram [26]

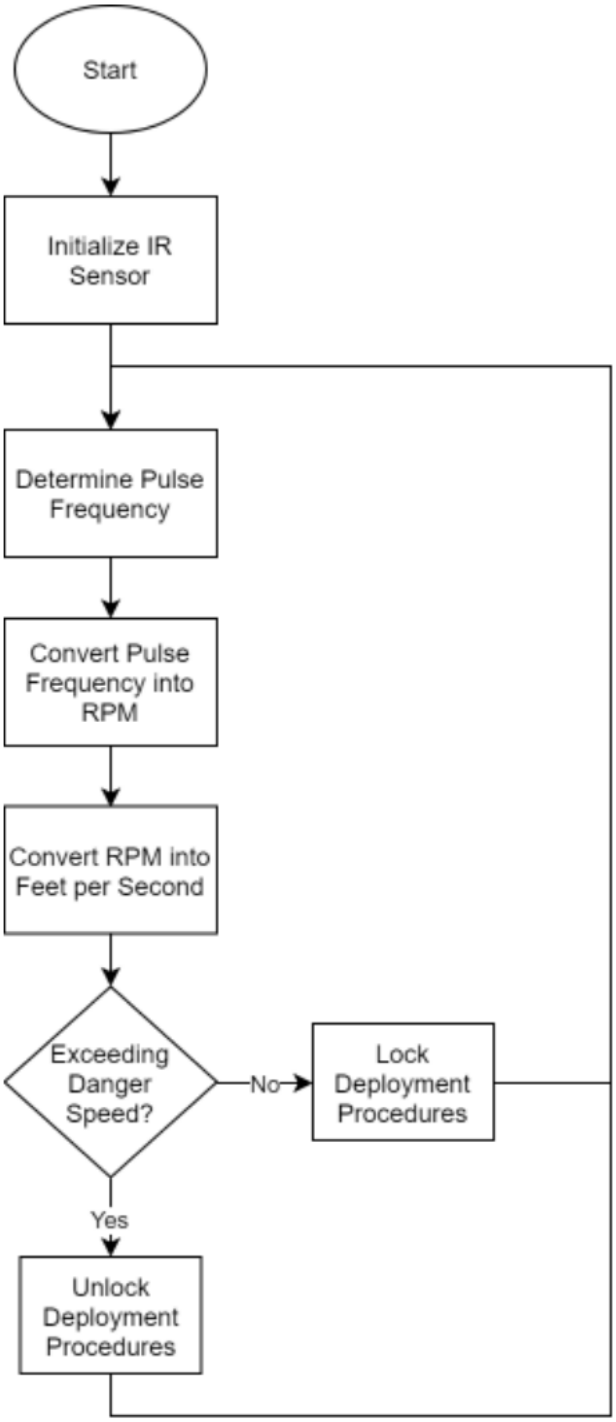
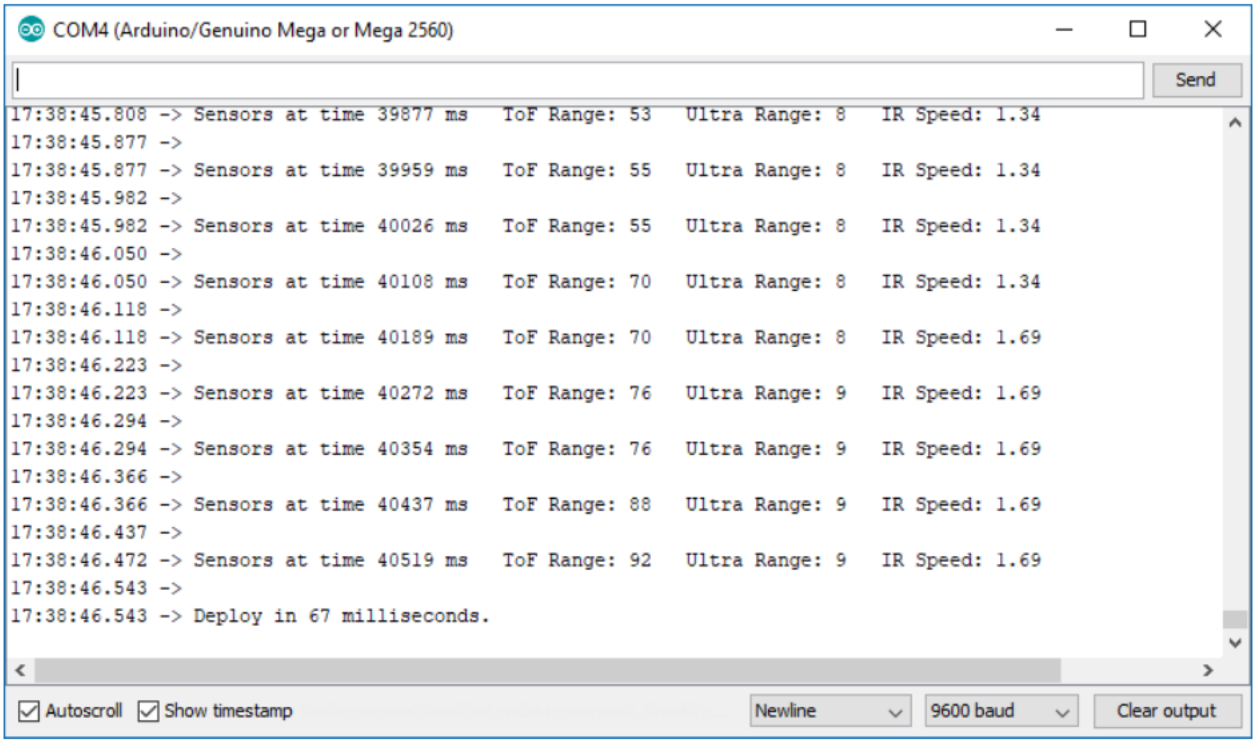


Fig. C-5. Vehicle Speed Evaluation Subroutine Flow Diagram [27]

Integrating all the features to test the software had to be carefully done because any small time defects could greatly impact performance. The main method of software testing was performed by tracking the timings for subroutines and actuations in the software. Results were outputted with timestamps that showed if the data analysis was happening within the metric time frame. In both the laboratory and deployable prototype, data analysis and actuation output was printed on the serial monitor. Fig. C-6. shows an example of a Skid Safe deployment test that was performed many times to assure test quality. Each line of printed output represents the Deployment Probe running its analysis which runs at an average of 13 times per second. The other subroutines are happening constantly in the background. In Fig. C-6, when the ToF Range is read prior to time 40519 ms, analysis determines the tire has detached (is greater than 90) and the signal to deploy is sent. A time stamp analysis shows that the deployment occurred in 67 ms as read by serial outputs and 71 ms as read by separate serial monitor timestamps. The 4 ms discrepancy was considered negligible.



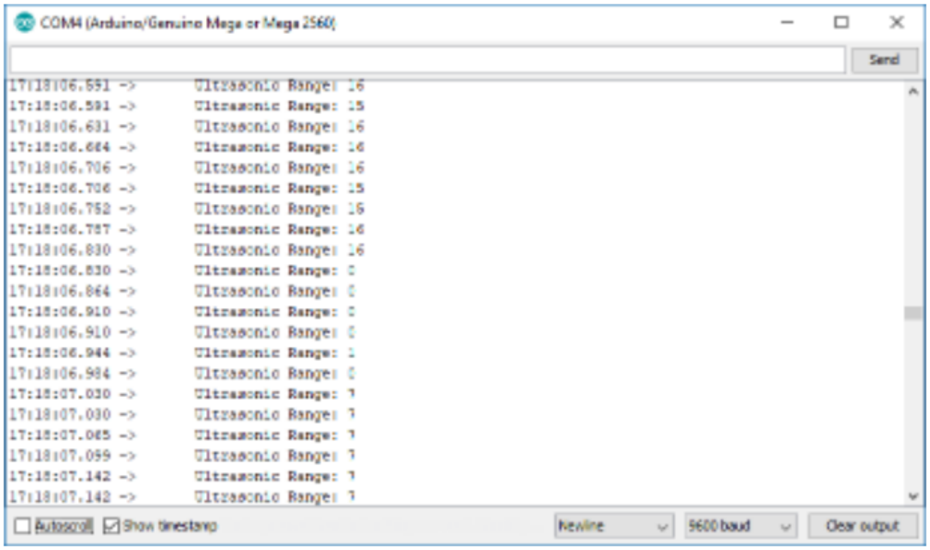
```
17:38:45.808 -> Sensors at time 39877 ms   ToF Range: 53   Ultra Range: 8   IR Speed: 1.34
17:38:45.877 ->
17:38:45.877 -> Sensors at time 39959 ms   ToF Range: 55   Ultra Range: 8   IR Speed: 1.34
17:38:45.982 ->
17:38:45.982 -> Sensors at time 40026 ms   ToF Range: 55   Ultra Range: 8   IR Speed: 1.34
17:38:46.050 ->
17:38:46.050 -> Sensors at time 40108 ms   ToF Range: 70   Ultra Range: 8   IR Speed: 1.34
17:38:46.118 ->
17:38:46.118 -> Sensors at time 40189 ms   ToF Range: 70   Ultra Range: 8   IR Speed: 1.69
17:38:46.223 ->
17:38:46.223 -> Sensors at time 40272 ms   ToF Range: 76   Ultra Range: 9   IR Speed: 1.69
17:38:46.294 ->
17:38:46.294 -> Sensors at time 40354 ms   ToF Range: 76   Ultra Range: 9   IR Speed: 1.69
17:38:46.366 ->
17:38:46.366 -> Sensors at time 40437 ms   ToF Range: 88   Ultra Range: 9   IR Speed: 1.69
17:38:46.437 ->
17:38:46.472 -> Sensors at time 40519 ms   ToF Range: 92   Ultra Range: 9   IR Speed: 1.69
17:38:46.543 ->
17:38:46.543 -> Deploy in 67 milliseconds.
```

Fig. C-6. Deployment Test [28]

An important note is that Fig. C-6 meets the requirements and is the slowest the software will run. Since serial outputs are considered “slow” processes, their removal will further increase performance.

Appendix D
Mechanical

Fig. D-1. Isolated Pneumatics System [29]



```
17:18:06.551 ->        Ultrasonic Range: 16
17:18:06.591 ->        Ultrasonic Range: 15
17:18:06.631 ->        Ultrasonic Range: 16
17:18:06.664 ->        Ultrasonic Range: 16
17:18:06.706 ->        Ultrasonic Range: 16
17:18:06.706 ->        Ultrasonic Range: 15
17:18:06.752 ->        Ultrasonic Range: 16
17:18:06.787 ->        Ultrasonic Range: 16
17:18:06.830 ->        Ultrasonic Range: 16
17:18:06.830 ->        Ultrasonic Range: 0
17:18:06.864 ->        Ultrasonic Range: 0
17:18:06.910 ->        Ultrasonic Range: 0
17:18:06.910 ->        Ultrasonic Range: 0
17:18:06.944 ->        Ultrasonic Range: 1
17:18:06.984 ->        Ultrasonic Range: 0
17:18:07.030 ->        Ultrasonic Range: 7
17:18:07.030 ->        Ultrasonic Range: 7
17:18:07.065 ->        Ultrasonic Range: 7
17:18:07.099 ->        Ultrasonic Range: 7
17:18:07.142 ->        Ultrasonic Range: 7
17:18:07.142 ->        Ultrasonic Range: 7
```

Fig. D-2.Pneumatics Tests [30]

Fig. D-2 test was to prove the sled deploys in under .25 seconds, as you can see at 100 PSI it take .2 seconds to deploy.

Appendix E

Vendor Contacts

Skid Safe currently has no vendor contracts. The validity of the idea of Skid Safe and it's application has been approved by a representative at CalTrans and Chevrolet. Also two associates at Mercury Insurance and AAA agreed on the importance towards protection during tire blowouts or displacement. Our team was told the design has good intentions and has potential if we pursue it further.

Appendix F
Resumes

Haley Lawrence

EDUCATION

California State University, Sacramento, CA | Expected: May 2019
Bachelor of Science | Electrical Engineering | Control Systems | GPA: 3.5

Sierra College, Rocklin, CA | December 2016
Associate of Science | Natural Science

RELATED COURSEWORK:

- Robotics
- Circuit Analysis
- Microprocessor
- Signal Acquisition & Control
- Digital Controls
- RF Engineering
- Feedback Systems
- Power Electronics
- Electronics I and II
- PLC
- Applied Electromagnetics
- Project Design
- Renewable Energy
- Communication Systems

TECHNICAL SKILLS

Hardware: Microcontrollers, electrical components, semiconductors, amplifiers, oscilloscopes
Programming: C, Matlab, JavaScript, Python
Software: Pspice, Multisim, Visio, AutoCAD Advanced Design System, FreeCAD, MS Office
Platforms: macOS, Linux, Windows
Additional: Project management, risk mitigation, instrumentation and electrical measurements, circuit debugging, 3D design and printing, soldering, PLC programming

RELATED PROJECTS

Skid Safe (Team of 4)
Leader, Skid Safe Project Team, Sacramento State, August 2018 - November 2018

- Senior design project that is a vehicle safety feature design that uses pneumatics to deploy a support system implemented behind the wheel in the occurrence of tire failure or displacement
- Measure instantaneous speed using an incremental rotary encoder attached to one wheel
- Translate the RPM of the wheel to feet per second due to metrics of prototype
- Set condition in system that would mimic a high enough speed to inhibit control of a car in the event of tire failure and dignify necessity for support system to deploy

Robot Vehicle

- Created a Lego model for the body of the vehicle and attached two DC motors, two analog line tracking sensors, and an ultrasonic sensor to increase complexity of robot
- Applied PID control to the wheel encoders on the motors to match speed and improve response time
- Used a H bridge dual motor driver to control speed and direction of motors

Smart Home (Team of 4)

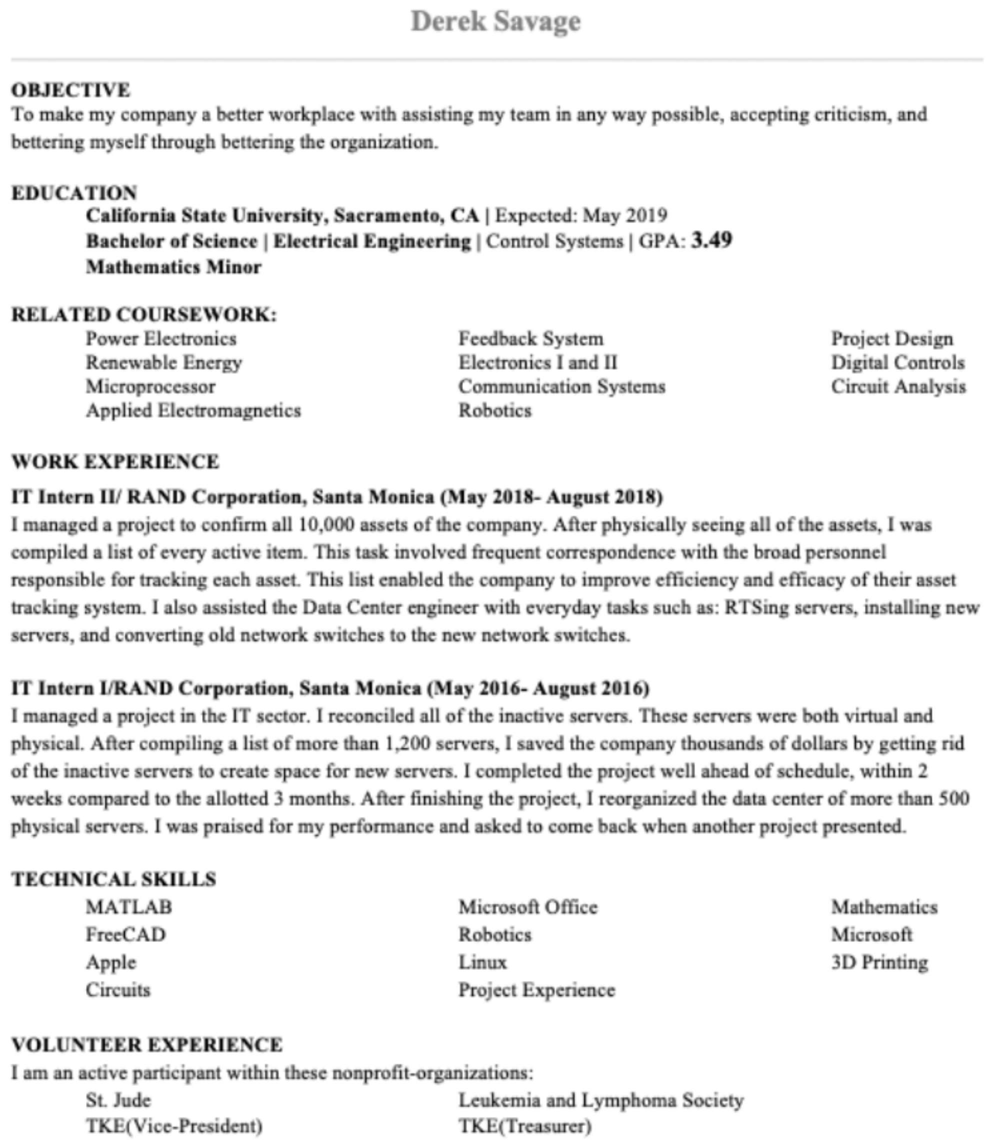
- Voice control system using a Raspberry Pi 3 B+ that interacted with multiple peripherals
- Measured temperature of room and transferred data wirelessly using MQTT from the NodeMCU to Raspberry Pi 3 B+
- Integrated an IR remote that would turn on a nearby fan if temperature was above desired value

WORK EXPERIENCE

Lego Robotics Instructor, Intellibricks, Rocklin, CA, August 2017 - September 2018

- Internship involved with working with 10-20 children from ages 6-13
- Delivered instruction on construction of models with Legos and operation of computers
- Taught concepts such as kinetic and potential energy, types of gears, gear ratios, rotational inertia, linear speed, speed modifications, circuit board assembly, and RGB LED control
- Assisted children in writing in JavaScript and uploading code to Arduino microcontrollers

Appendix F-2



Derek Savage

OBJECTIVE

To make my company a better workplace with assisting my team in any way possible, accepting criticism, and bettering myself through bettering the organization.

EDUCATION

California State University, Sacramento, CA | Expected: May 2019
Bachelor of Science | **Electrical Engineering** | Control Systems | GPA: **3.49**
Mathematics Minor

RELATED COURSEWORK:

- Power Electronics
- Renewable Energy
- Microprocessor
- Applied Electromagnetics
- Feedback System
- Electronics I and II
- Communication Systems
- Robotics
- Project Design
- Digital Controls
- Circuit Analysis

WORK EXPERIENCE

IT Intern II/ RAND Corporation, Santa Monica (May 2018- August 2018)

I managed a project to confirm all 10,000 assets of the company. After physically seeing all of the assets, I was compiled a list of every active item. This task involved frequent correspondence with the broad personnel responsible for tracking each asset. This list enabled the company to improve efficiency and efficacy of their asset tracking system. I also assisted the Data Center engineer with everyday tasks such as: RTSing servers, installing new servers, and converting old network switches to the new network switches.

IT Intern I/RAND Corporation, Santa Monica (May 2016- August 2016)

I managed a project in the IT sector. I reconciled all of the inactive servers. These servers were both virtual and physical. After compiling a list of more than 1,200 servers, I saved the company thousands of dollars by getting rid of the inactive servers to create space for new servers. I completed the project well ahead of schedule, within 2 weeks compared to the allotted 3 months. After finishing the project, I reorganized the data center of more than 500 physical servers. I was praised for my performance and asked to come back when another project presented.

TECHNICAL SKILLS

- MATLAB
- FreeCAD
- Apple
- Circuits
- Microsoft Office
- Robotics
- Linux
- Project Experience
- Mathematics
- Microsoft
- 3D Printing

VOLUNTEER EXPERIENCE

I am an active participant within these nonprofit-organizations:

- St. Jude
- TKE(Vice-President)
- Leukemia and Lymphoma Society
- TKE(Treasurer)

Appendix F-3

Andrew Encinas

STRENGTHS

- Strong problem-solving and analytical skills gained from hardware and software projects
- Eager to learn new technologies and methodologies
- Excellent Organization and Communication Skills
- Self-motivated and dependable

EDUCATION

BS, Computer Engineering, California State University Sacramento, GPA 3.57. Graduating May 2019.

Related Coursework:

Senior Design
Advanced Computer Organization
Advanced Logic Design
CMOS and VLSI Design
Computer Interfacing
Electronics 1
Computer Hardware Design
Computer Network and Internet
Network Analysis
Operating Systems Pragmatics

KNOWLEDGE & SKILLS

Computer Languages:
Python, SQL, C++, C, Java, Natural Adabas, Verilog, VHDL

Computer Applications:
Multisim, MS Office Suite, MS Visio, G Suite, SQL Server Management Studio

EXPERIENCE

Intern **Obra Art & Tech** 9/18 to Present

Create 3D digital models in Autodesk Fusion 360 for use on a CNC mill. Wire and test electric motorbike components based on technical documentation to develop a deployable prototype. Aided in programming microcontrollers and wiring for custom LED signage. Design and fabricate PCB boards for projects.

Student Assistant **California Department of Taxes and Fees** 9/14 to present

Work on an application development team to assist in development and maintenance of system applications. Create and maintained application clear and concise documentation of programs and workflow. Perform data analysis in the Integrated Revenue Information system using various methods including Natural Adabas and SQL queries. Bring webpages up to date on current accessibility standards and laws.

Math Center Tutor **Cosumnes River College Math Center** 8/15 to 7/16

Worked with students to develop their math skills. Asked questions to promote memorization, reasoning, evaluation, and creative thinking. Approached new and sometimes difficult situations with an optimistic and open mind. Developed the self-confidence and improved study skills of students being tutored. Managed math center facility when supervisors were not present.

ACTIVITIES & ACCOMPLISHMENTS

- Winner of CSU Sacramento Fall 2017 Micromouse Tournament
- Member - Institute of Electrical and Electronics Engineers
- Member - Toastmasters

Appendix F-4

Nicklaus Ryan Rentschler

OBJECTIVE:

Part-time Internship for Spring 2019 Semester, or full time position following the Spring Semester

EDUCATION:

BS, Computer Engineering, CSU Sacramento, GPA 3.525

Courses:

Computer Hardware Design
Computer Interfacing
Advanced Computer Organization
CMOS and VLSI *
Electronics I
Network Analysis

** In progress as of Fall 2018*

PROJECT EXPERIENCE:

Micromouse Competition(1st place winner) Dec. 2017

+ Built an autonomous robot that would traverse a randomly generated 16x16 grid maze using a C program that implemented a variation of Dijkstra's algorithm.

+ Worked with controlling PWM values in order to have the robot navigate the maze efficiently.

Safe Skid (Senior Project)

+ Developed python scripts in order to communicate with and decode tire pressure sensors

+ Designed a Circuit between Microprocessor and Pneumatic device in order to deploy hardware

KNOWLEDGE AND SKILLS:

Hardware/Software:

Object Oriented Programming, Data Structures and Algorithm Analysis, Linked Lists, Stacks, Queues, Trees, Recursion, Searching, Sorting, Basic System Calls, Operating System Principles, basic Networking protocols, Embedded Systems, Circuit Analysis, Transistors, Diodes, Op Amps.

Software Applications:

Multisim, Microsoft Office applications (i.e Excel), Cadence VLSI

Languages:

C, Verilog, Python (in development), HTML, UNIX/Linux, Assembly (x86)

WORK EXPERIENCE:

Courtesy Clerk ***Safeway*** 8/15- 8/16

ACTIVITIES AND ACCOMPLISHMENTS:

- Dean's List