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PROJECT PLAN

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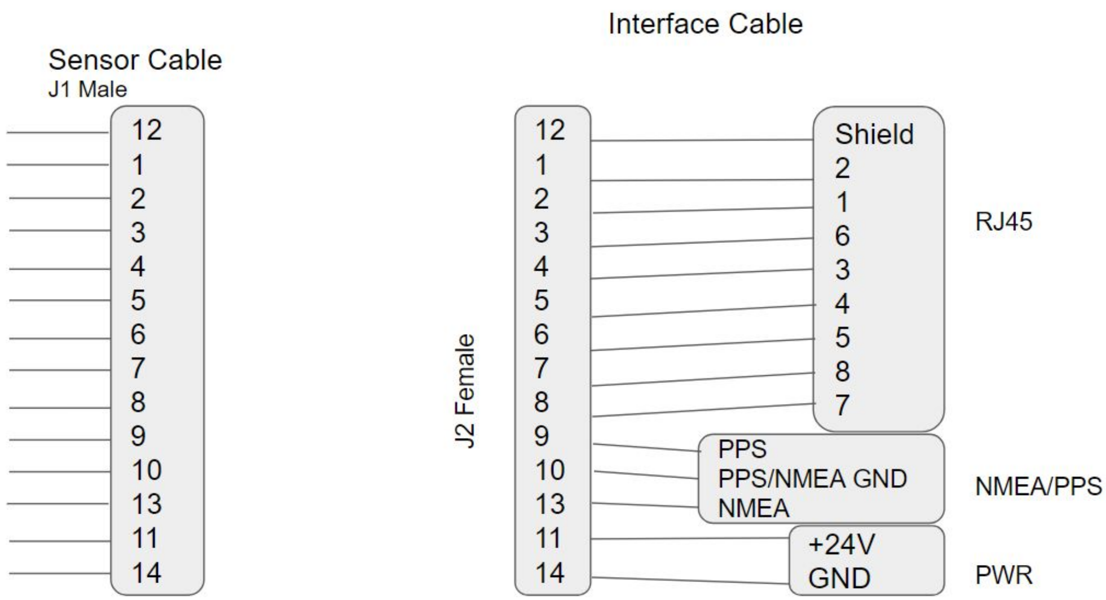
Color	Pin	Line	Function	Description
Green	1	3	Power/Input	12V DC camera Power/Non-insolated input
Black	2	0	Opto Input 1	Opto-isolated input
Red	3	2	NC/+3.3V/GPIO	3.3V output.Current 120mA(nominal)
White	4	1	Opto Output 1	Opto-isolated output
Blue	5	N/A	Opto GND	Ground for opto-isolated I/O
Brown	6	N/A	GND	DC camera power ground

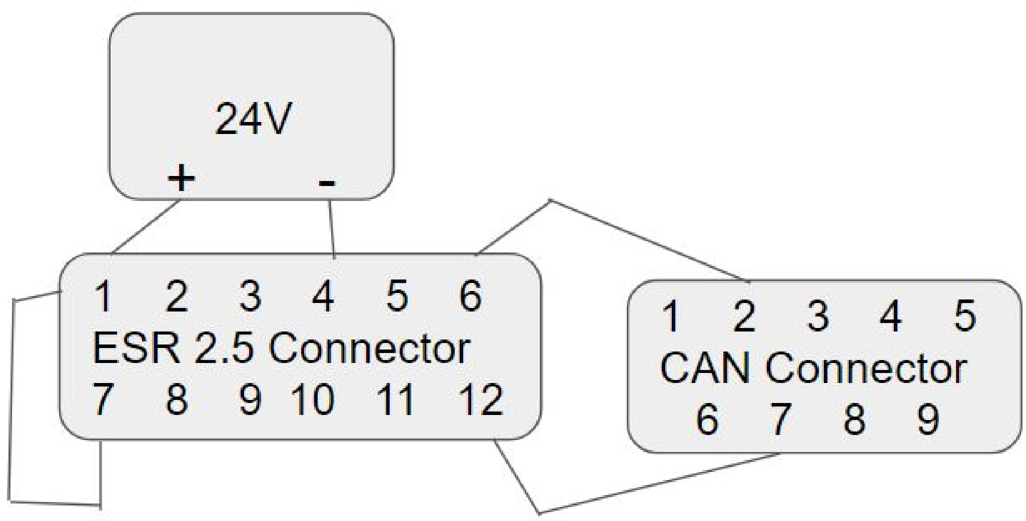


1	2	3	4	5	6	7	8	9	10	11	12	13	14
Orange	White	Green	Yellow	Blue	Clear	Brown	Light Blue	Violet	Tan or Pink	Red	Bare	Gray	Black

Power supply	24VDC/1.5A(max)
Protection	Short Circuit/Over Current/Over Voltage
Ripple	1-2%Vpp

Pin Number	Singal	Port Color
1	**Battery (+24V)**	**Red**
2	**USB D+ (Green Wire)**	**Green (USB)**

3	**USB D- (White Wire)**	**White (USB)**
4	**Ground**	**Black**
5	**USB Ground (Black Wire)**	**Black (USB)**
6	**PRVCANL**	**Green**
7	**Ignition (+24V)**	**White**
8	**USB +5V (Red Wire)**	**Red (USB)**
9	**VEHCAN L**	**Blue**
10	**VEHCAN H**	**Brown**
11	**VEHCAN Shield**	
12	**PRVCANH**	**Orange**



ESR Features

The ESR has features that will allow it to be integrated with other devices. Such features that we must keep in mind are the following:

- Enhances the ease for driving and gives information of general surrounding
- Reduces the chance of a potential collision which can cause an accident or injury and helps avoid property damage if such occur
- Brake support allows the previous mishaps which will come in use when it needs to come to an abrupt stop
- Gives information of distance between obstacles and other on-road vehicles and also notifies the driver is such situations occur.
- Has two modes: medium 60 feet with 90 degree vision and 175 feet with 10 degree vision.

List of Definitions

Power supply
- 24VDC
- 1.5A(max)
- Protection
  - Short Circuit
  - Over Current
  - Over Voltage
- Ripple
  - 1-2%Vpp

Use Quanergy Processing Unit (QPU)
-pre configured at the factory as a complete solution that includes necessary source code, library, and third party applications.

We need also(to make it work)
Power Source
    To power the sensor, we need to do this efficiently and take the other sensors into account.(mobile battery required for all the sensors)
Mouse+keyboard+Monitor
    Support computing environment.
Mounting surface
    Affix the sensor(I believe the Mechanical team will probably handle this)
Ethernet switch + Power adaptor
    To handle multiple sensors, Netgear ProSafe GS108 recommended

GPS/IMU module

Report position and supply the NMEA/PPS timing signals(OXTS RT3003 and VectorNav200 are supported by Quanergy)

Lidar has multiple returns(3)

Maximum, Second Strongest, and Last

Need to connect sensor to Ubunta Host computer

Page 26 really talks about the process in how to connect it

Laser Firing:

Sensor spins at 10Hz

Lasers fire at 53,828Hz

They fire at 8 different angles

(+3.2 to -18.25 degrees)

1 Introductory Material

1.1 Acknowledgement

We would like to appreciate Vishaal Mahulkar and his company for sponsoring our senior design team and providing the data information and equipment for the project. We also want to thank Professor Chinmay Hegde for being our faculty advisor. We would also like to thank Iowa State's robotics and control's team for corporation to make the final product.

1.2 problem Statement

GPS is one of most important component in sensor system of our project. Recent couple weeks, we are focus on data transmission of GPS, which include data of latitude and longitude. The GPS itself could not transmit data, thus we need find tool to help send and receive information. The problem really is getting the safest way to transmit the information efficiently as well as powering all the components.

We have considered several methods, like DSRC and Xbee. However, DSRC is expensive and overkill. Finally, we select Xbee which is small size, easy to use but satisfy our requirement. It will transmit over the right amount of length and fast. We also plan on using cellular communication later on to transmit location when the vehicles are farther apart from each other.

1.3 Operating Environment

There is range requirement of data transmission, 100m inside and 1 mile outside. Xbee fits the requirement after we test. Between the buildings of the library and durham it was able to transmit a signal over 120 meters without getting disrupted, this included a couple walls.

For the other sensors we are using to make the vehicle autonomous there is many road weather considerations. Just like any vehicle we are expecting it to travel to all kinds of climates.

1.4 Intended Users and Intended uses (two paragraph +)

The final product should be open to any driver in the world. The vehicle will be used on actual road for actual driving. It can be used for both personal purposes and commercial. The users may want to take control if necessary but have the luxury of not having to worry about their car working. Should be able to be implemented on several vehicles to be able to transport large amounts of goods if the client so wishes.

1.5 Assumptions and Limitations

Assumptions

- The two cars will be within 300 feet from each other the majority of the time.
- We will have users in and outside the U.S.
- There will be traffic signs and road signs that we won't be able to recognize.

Limitations

- There is a limit to the distance of detectable objects.
- We only have a 12V battery supply to power all the hardware.
- We will have a limit of how far away the lead car can get to.
- There should be a speed limit for the safety of the driver.

1.6 Expected End Product and other Deliverables

At end of project, our product should has following function:

– The follow car could drive completely automatically. The car could operate the gas, brake and steering wheel by its system.

– The follow car can receive the exact location data in from the lead car. The follow car will drive with same track of lead car.

– The follow car could detect and recognize the pedestrian, car, truck and curb by the sensor of lidar, radar and camera.

– The system can process all the data from GPS and sensors. According to the data, the car can judge the drive environment and determine how to operate the car by the system.

-The hardware will be powered completely with a 12 volt battery.

2 Proposed Approach and Statement of Work

2.1 Functional requirements

The requirements for our project are:

1. To be able to send the location of a lead vehicle to a following vehicle. This means that we need to come up with a way to let the following vehicle know where it needs to get to.
2. To be able to communicate sensor information to ROS. For this part we need to be able to receive data from all the sensors and have it packaged in a way that the controls and robotics team can use.

3. To be able to communicate this information to the other teams and required destinations. This means to be able to receive and send the data we get in the right format.

2.2 Constraints considerations

Some of the constraints that we will need to take into account when going about this project include making sure our transceivers can transmit over at least 100 meters. This includes with having trees and buildings in between. We are also constrained with having a GPS that transmits in 16 bit serial. We will either use transceivers that transmit in the serial code in 16 bit or create a transforming code

2.3 Technology considerations

For the method of communicating between a lead and following vehicle we have the ability to choose any way we choose to. This can be a great strength as we have some ideas. We do have several sensors from which to work from. We are constrained to working with the radar, gps, Lidar, and camera we are given. We are also constrained to using Ubuntu and the ROS for our project. We use ROS since it is a great widely used system for autonomous vehicles. The other aforementioned technologies are constraints put by the client.

For the communication between the two vehicles we have had many options. There has been thoughts on doing DSRC communication. There has also been thought on using Cellular Communication to fulfill this requirement. We are opting with an Xbee as our source of communication. They work in the wifi range of 2.4GHz. We could possibly go back to some other form of communication if the distance requirements are not met with this option. We are choosing to work with the Xbee due to us only having to communicate between two points and our required range of communication is 300 feet. We plan on implementing the 4G Cellular implementation later on for when we are having the vehicles getting apart from each other in longer distances.

2.4 Safety considerations

Since we will be working with two large golf carts in this project we need to test many times before actually testing on the cars in a driveway. We will have to make sure first that all the information is going where it needs to go and guarantee almost no chance for errors. There is little risk in testing before the actual use of the golf cars.

2.5 Previous Work and Literature

We looked at an article that talks about how there has been implementation of DSRC and 4G LTE to communicate between a lead and following vehicle. They implemented the DSRC exclusively to send the location of the leading vehicle to the following vehicle. Meanwhile they used the 4G LTE other forms of data transfer as well as location when the cars are far from each other. The reason they did it this way was to send the most immediate location via DSRC specially when the cars were very close to each other. DSRC would be straight forward communication. Meanwhile 4G LTE was chosen to for other information such as entertainment due to being a slower less reliable method. It was used for communicating the location of the lead vehicle once the lead vehicle was too far ahead. We definitely plan on using 4G LTE for the long distance communication once we manage to get the short distance communication flowing. The following is the link to the information.

https://www.digikey.com/en/articles/techzone/2016/dec/radio-links-for-driverless-cars

We also found several other articles talking about the implementation of autonomous vehicles in other parts of life. Whether it's them talking to each other or to the infrastructure around them. These gave us ideas of what is possible. The following are links to these kind of articles.

http://www.autonews.com/article/20161226/OEM06/312269996/v2v-finally-on-its-way-but-is-it-too-late%3F

https://blog.caranddriver.com/vehicle-to-vehicle-communications-are-the-next-big-thing-in-auto-safety/

2.6 Possible Risks and risk management

We are doing this project with four other groups. Each one is emphasizing on a specific role. Some of the things that may slow down our work is communication between all the groups. We need to specify all the safety details, as well as the hardware necessities to make sure all the equipment works when put together. We are sharing all our work with the other groups online. This should allow all the groups to be on the same page and allow smoother roads to a completion of the project. All possible risks can be managed in our project by making sure everything works before we test with an actual moving car.

2.7 Project Proposed Milestones and evaluation criteria

The following are our Project Milestones

Milestone 1: 2~3 weeks (Early October)

- Know how each component works
- Figure out all necessary hardware
- Understand the hardware and begin getting data for both the hardware and software
- Understand ROS
- Install on top of Ubuntu
- Look into possible options for the vehicle to vehicle communication

Not Much testing during this phase. Will mostly consist of research.

Milestone 2: 1 month (Early November)

- Have communication between the teams (Robotics + Controls)
- Be able to receive data from the vehicle
- Know how to format the raw data through ROS
- Format received input data
- Use the received data to control the car
- Start Planning for powering the whole vehicle. Using the 12 volt battery provided.

Testing will consist of receiving data from the car itself using our designed circuit and components. There will be a lot of testing during this phase.

Milestone 3: Before Dead Week (12/1/17)

- Test all inputs and see if they are functioning properly
- Do some corner case testing
- Have a well planned circuit for the power to the vehicle.

There will be on car testing at this point.

Testing will be done throughout each milestone before we can move on to the following objectives.

2.8 Project tracking procedures

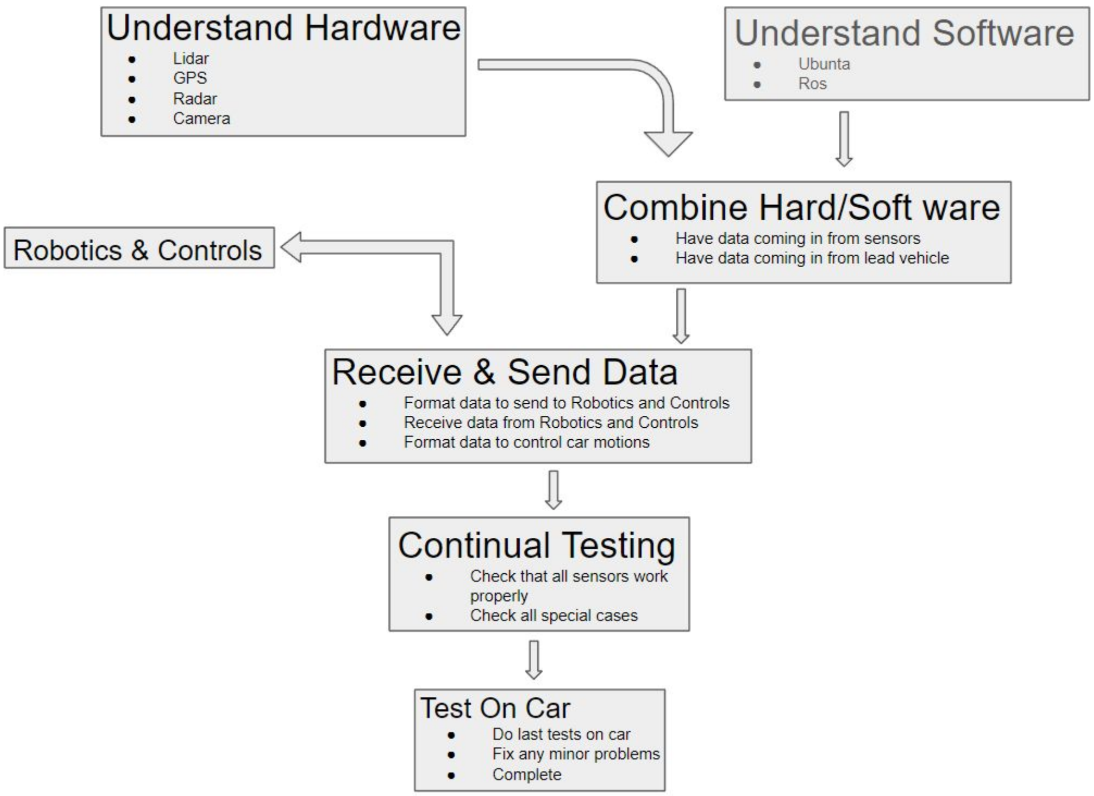
In order to track progress we will have at least one general group meeting with our client on wednesdays each week. There, we talk about all the progress we have made as a group. We will also show the individual work we have done to the whole group. This will all be compiled into a report which will specify all the progress that we have made in that week.

2.9 Objective of the task

Our overall objective is to have a working autonomous vehicle. This autonomous vehicle should be able to avoid obstacles on the road. It must also be able to receive the location of another vehicle and be able to drive to/ follow the said vehicle. However, for senior design project plan prospect of view, we will just focus on the wireless communications part because this is what our client expects us to accomplish as a senior design group. Our objective is to setup wireless communication between a leading vehicle and a following vehicle to allow data exchange for the big project which is to have an autonomous driven vehicle. Our primary goal is to pack the GPS data from the leading car and send them back to the following vehicle for computation. We need to make sure the data we received has uniform format, size, accuracy, and integrity with what is being sent.

2.10 Task approach

We plan on understanding the hardware and software. The hardware includes the XSENS MTi-G GPS, Lidar, Radar, and Xbee transceivers, etc. Software includes ROS, C in Arduino, etc. We will then transmit the data from those sensors to ROS and compute them later now. Our primary focus is to set up wireless communication of GPS data between leading vehicle and following vehicle. Our approach is to have an Xbee transceiver on the leading vehicle to transmit the GPS data and also have an Xbee transceiver on the following vehicle to receive the GPS information. From the power supply point of view, we plan on rewiring the power pins on Xbee and power everything else with the standard USB cable from PCs for testing. Once we have a well tested product we will use a 12 volt battery to power all the sensors and other hardware.



The diagram above represents the process we hope to use to approach our problem. In reality it will be very dynamic and will have hidden arrows jumping back and forth several times.

2.11 Expected Results and Validation

The desired outcome is a totally autonomous vehicle with collision avoidance. However, this will be our very final stage. For the final outcome to be fully functional, it requires validations from all other groups(Controls, Robotics, and mechanical). For our group's project plan aspect of view, we will just make validations to make sure our wireless communications between the two vehicles are stable and reliable. We would be mocking situations where two vehicles are away under different ranges, possibly 50, 100, 200, 300 and 400 meters, since our client just wants the transmission range to operate within 300 meters. We will monitor the received GPS data on the following vehicle and verify the integrity and format of what we receive with what is being sent on the leading side. Meanwhile, we will also monitor our backup cellular network method and make sure GPS information is always being updated to the cloud and the following vehicle is able to access the GPS info in cloud. By verifying both of our solutions would significantly reduce the risk of losing communication between the two vehicles. It's possible to have both routes being malfunctional simultaneously when something unexpected such as a tornado comes and destroy the cellular network, but the chances are very low and we can't really do anything to avoid them. Overall, if there isn't an expected disaster occurring, we shouldn't have a problem and our verification would almost guarantee that the GPS information communication between the two vehicle to work.

3 Estimated Resources and Project Timeline

3.1 Personnel effort requirements

Task	Team	Time to Complete	Effort & Task
ROS & Ubuntu	Software	Will require time at the beginning and at the middle of the project.	Must be able to know the system front and back. Will implement it to convert information coming into the proper format.
Communication V2V	Software & Hardware	Will be the main part and be a focus during the majority of the project.	Must find proper transmission method. Be able to communicate properly over long distances and effectively.
Power Components	Hardware	Will be a priority near the later part of the project.	Will have to make sure every component gets the required amount of power.
Lidar / GPS / Radar	Hardware & Software	Will need to have everyone very well knowledgeable throughout the project.	Will require that proper knowledge of all components. The other teams will be implementing these hardwares but we will be aiding as well.

3.2 Other resource requirements

Working on this project without the actual hardware requires Ubuntu 16.04 to be installed on our personal computers. Without each team member having a personal computer, our performance will be impacted. Without Ubuntu 16.04, we would be unable to work with ROS.

We will also need access to the GPS system that we will be using as well as the other pieces of hardware. Many of the multimeters and power sources in the lab are great resources to get the project moving.

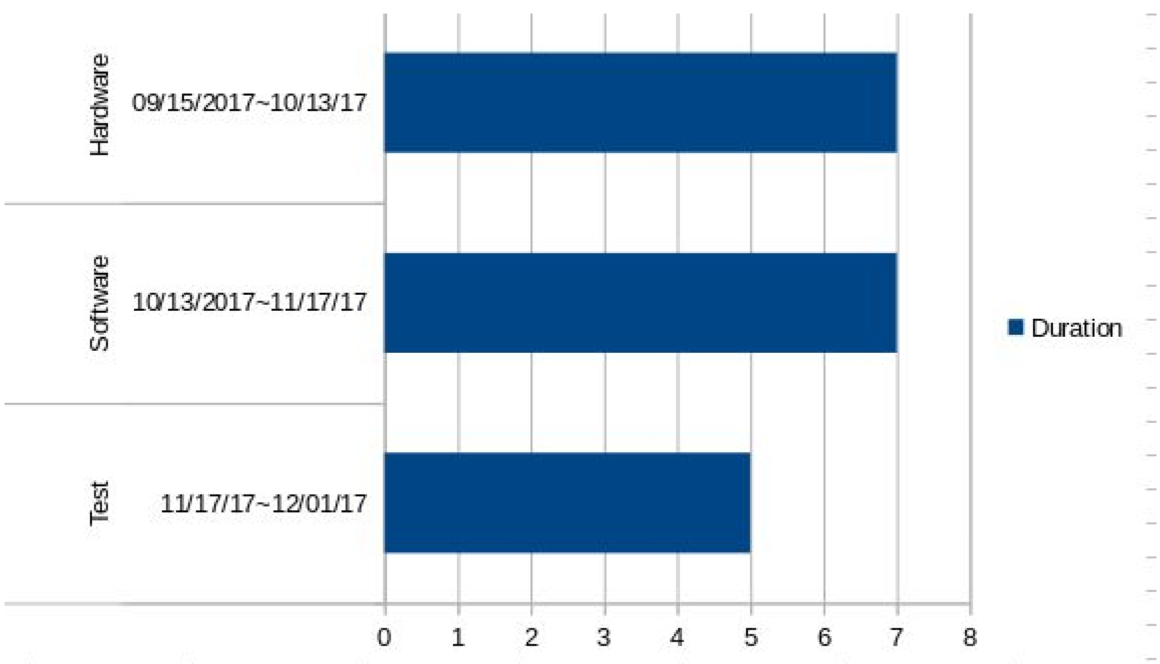
3.3 Financial requirements

We have had to get several Xbees to achieve our communication between the vehicles these have amounted to roughly $120. We have the majority of the sensors that we need so much of the rest of the financial requirements are covered. If there are any more that pop up we will add them here.

3.4 Project Timeline

Before we start to manage a planned schedule, we have already set up three milestones to come up with our project`s result. Thus, we will make a schedule by following each milestone as a step by step.

The chart is a simple timeline of our project by this semester. The date that is represented in a chart might be changed flexibly but we are going to keep this schedule as well as there is no specific schedule error.



• A detailed schedule is needed as a part of the plan:

Task	Expected Schedule
Hardware	
Figure out all necessary hardware sensors such as Lidar, Radar, Camera, and GPS	
Figure out how to use ROS on Ubuntu	
Start to collect receiving data from sensors by using ROS and QPU	~ 10/13/17
Software	
Communicate between Robotics and Controls team	
Format data is given through ROS	
Control a vehicle by using data	
Figure out what errors might be	~11/17/17
Testing	
Test all parts are working as expected	
Test if it detects something in front of vehicle by sensor	
Test if it detects corner case	~12/01/17

4 Closure Materials

4.1 CONCLUSION

Overall for the project, our milestones had many alterations as we progressed with the project and had clearer objectives. Since we were responsible for transmission of data and making sure that collected data was accurate, our agenda of progress shifted considerable along with our original milestones. Our design for transmission does depend significantly with our hardware equipment along with our ability to power the electrical components. Our senior design project overall impacted other groups which would need to utilize the transmitted data to run in through the ROS (Robot Operating System). If we were to list the significant factors that affected our ability to have a reliable system of transmission it would be these:

1) Hardware Limitations: The GPS that is attached to the car uses a baud rate of 115200 and transmits data in 16 bits. The hardware that we utilized had a data limitation of 8 bits so had to find a way to work around that. Also, each hardware had different operating current thresholds, therefore we could not power all of the devices using one power source. To work around this, we had to find a different way to power each component separately.
2) Testing Limitations: Our primary way of testing the transmission is by sending dummy serial data over to observe is the data sent matches the data received. To actually test the reliability, we must have constant access to the actual carts used which is located at INTRANS. We have limited access as the building with the carts require access from the staff which only our project director, Vishal, has. The makes us have to thoroughly mock test our equipment before we go actually test it.

Our project is a part in the process of making an autonomous car. In the future there is much talk of creating autonomous vehicles that will be in every corner of the world. As future engineers we must understand how these vehicles work and be able to make them as safe for the public as possible. It is important that we as future engineers experiment with this type of engineering now to be ready tomorrow. Who knows we might stumble unto the discovery that finally makes these cars mainstream.

4.2 References

- https://iowastate.sharepoint.com/sites/followme/_layouts/15/guestaccess.aspx?guestaccesstoken=2r78LZdQdlEBxtbRZtiIOMEm9KbOjpWrGogUOSo4cgo%3d&docid=2_1d17f93c98c7f4f9b8ce85de091e412a5&rev=1
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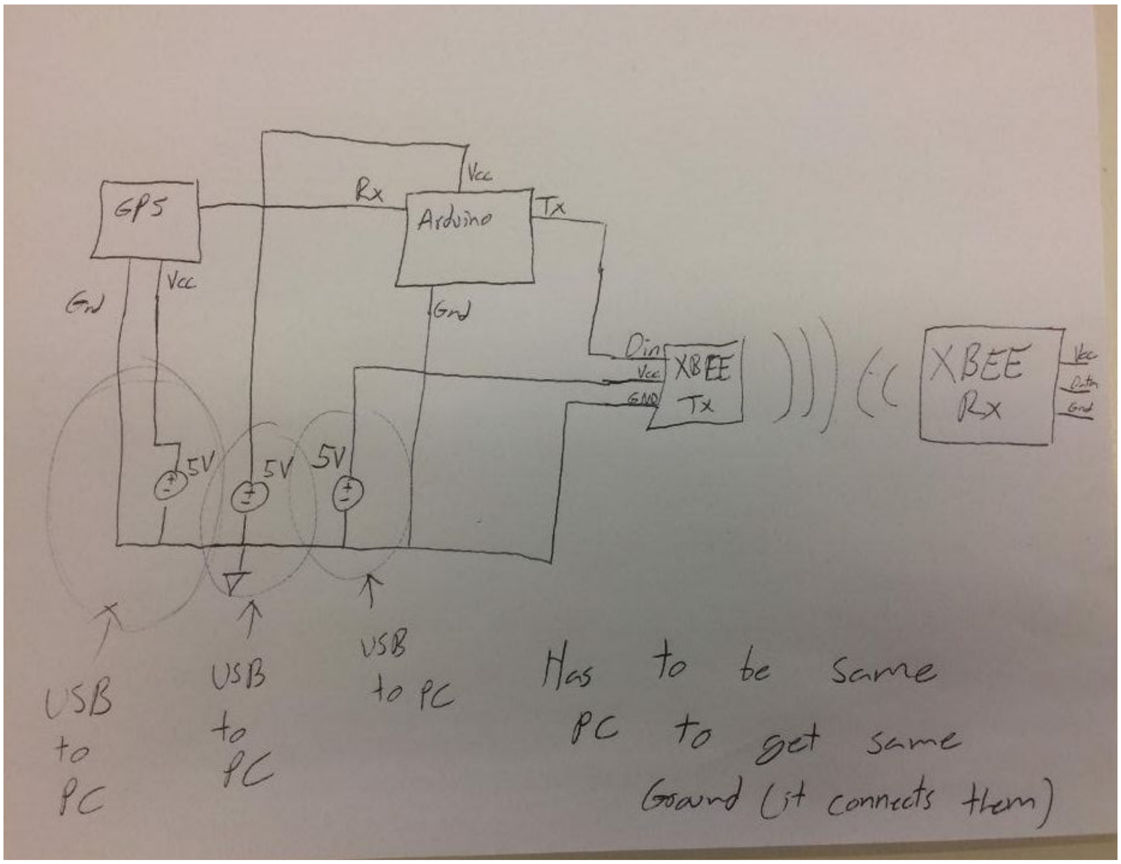
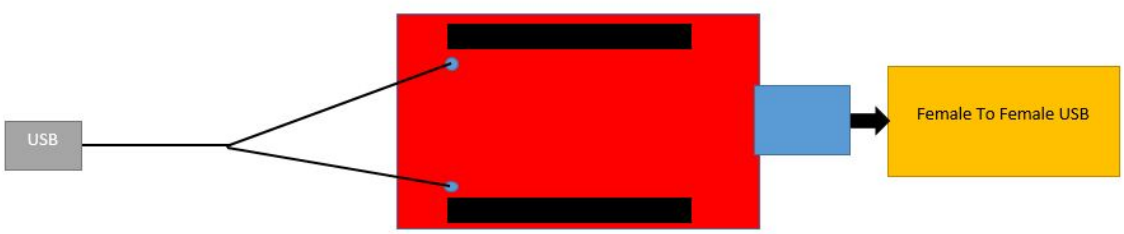
- http://www.mathworks.com/matlabcentral/fileexchange/45550-wireless-control-and-monitoring-of-an-led-using-xbee
- http://forum.arduino.cc/index.php?topic=22324.0
- https://www.engineersgarage.com/embedded/arduino/how-to-transmit-gps-data-from-arduino-using-xbee

4.3 Appendices





Specification	XBee	Xbee-PRO
Performance		
Indoor/Urban	100ft	300ft

Line of sight range	300ft	1 mile
Data Rate	250k bps	250k bps
Serial Interface Data Rate	1200bps-250kbps	1200bps-250kbps
Receiver Sensitivity	-92 dBm	-100 dBm
Power Requirements		
Supply Voltage	2.8-3.4V	2.8-3.4V
Transmit Current(@3.3V)	45mA	250mA
Idle Current	50mA	55mA
Power Down Current	<10uA	<10uA
Our Choice	NO	YES