Project Closeout

Mobile Package Delivery Robot

Group #37

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Design Impact Statement

1.0 Public Health, Safety, and Welfare Impacts

During the time of the COVID-19 Pandemic the availability of the package delivery robot to the OSU community will allow for a safer method of package delivery. Covid has taken control over the way in which humans interact. There is a large push for no unnecessary human interaction to avoid the spread of covid. By having a mobile package delivery robot on the Oregon State campus we will be able to reduce the amount of unnecessary human interactions. The Oregon State campus has already licensed 20 Starship food delivery robots [1]. Kerry Paterson stated "We'd been considering contactless delivery for a while. This service is yet another way we can facilitate COVID protocols regulating restaurants" [1]. Since Oregon State University is already on board with implementing new ways to limit unnecessary human interaction, the deployment of a campus wide mobile package delivery robot will allow the University to further progress their Covid-19 measures. A potential negative of this would be that those living in poor communities might not have access to such accommodations for a while.

2.0 Cultural and Social Impacts

The deployment of the package delivery robots city wide would reduce the need for large package delivery vehicles that operate on roads and highways. By reducing the number of large package delivery trucks and vehicles, it's expected to potentially reduce the number of road injuries by 348,000 [2]. By replacing the current package delivery system with a system that will reduce the number of injuries in car accidents, many lives will be saved as on average 3,700 people die a day globally due to car crashes [3]. A negative impact of deploying autonomous package delivery robots would be that the need for human delivery workers would be reduced and many people would be at risk for losing their jobs.

3.0 Environmental Impacts

By setting up an incentivized program for customers to recycle their electric wheelchairs, the autonomous package delivery robot system could be deployed on a city scale. Deploying this project on a city scale would alleviate the need for gas powered package delivery vehicles and the package delivery workers themselves. This would reduce carbon emissions and potentially reduce the production of gas powered delivery trucks. With many companies offering one or two day delivery to customers, the number of gas powered package delivery vehicles has been increasing, in large cities it's expected to increase by 36% over the next decade [4]. The increase in gas powered package delivery vehicles is expected to add an additional six million tons of carbon dioxide emissions which will contribute to the rise of global warming [4]. If small battery powered package delivery robots, created from recycled wheelchairs, were able to replace these gas powered vehicles, then the amount of carbon dioxide emissions would be significantly reduced.

4.0 Economic Factors

The market for manual and electric wheelchairs has been on an upward trend and will continue to do so for years to come, as seen in figure 1 [5]. Electric wheelchairs' have a short lifespan and only last users who care well for their machine approximately five years. With this information, it can be concluded that there will be an increased amount of electric wheelchairs that will be recycled for years to come. If all these wheelchairs were able to be recycled and turned into package delivery robots, then the need for package delivery workers would significantly decrease as the package delivery robots are completely autonomous. A negative economic impact of this would be raising unemployment from package delivery workers losing their jobs.

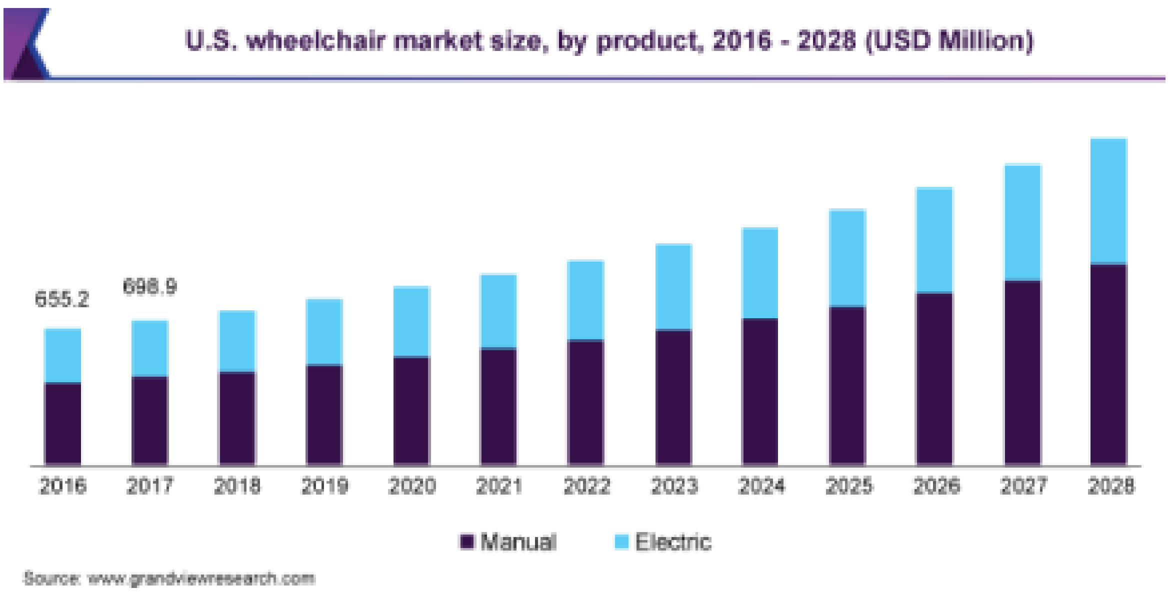
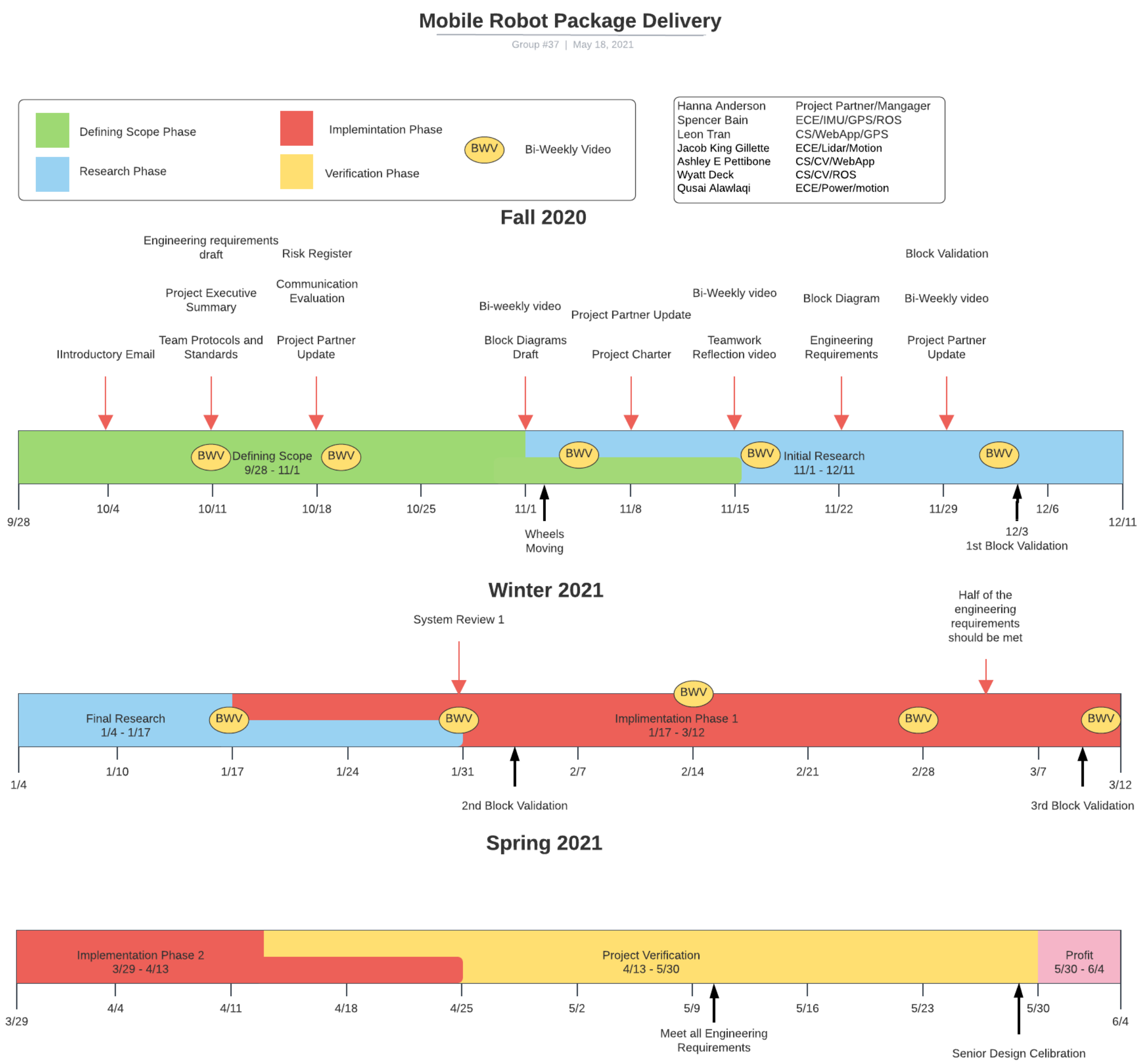


Figure 1: Graph displays exponential growth in wheelchair market for years to come [5]

Project Timeline



Scope and engineering requirements summary

Name	CR	ER
Emergency stop (bump sensor)	The system will stop if it collides with something as a backup safety measure	The system stops within 0.1 seconds if its bump sensor is impacted.
Global and Local Positional Information	The location of the robot should be updated on the webpage.	The system will have a gps, accelerometer, magnetometer, and gyroscope to update its location to the webpage/database every 30 seconds. It will be accurate up to 10 meters.
Local display on system	The system will support a display that outputs system information and takes in user input.	The system will have a local touch screen display that allows the user to interact with our mobile app. From the display the user will be able to login in and submit delivery orders. Also switch between manual mode and delivery mode.
Manual Controls	The system must be able to be moved remotely. For debugging purposes.	The system will move forward, back, left, and right when supplied with the appropriate wireless commands.
Object Reaction	The system will not run into any objects	The system will navigate around a stationary object of (25dx25wx45h)cm placed in front of it while traveling.
Operation Time	The system must be able to execute cross campus deliveries with max payload.	The system will operate for 10 minutes while carrying a load of at least 50 pounds.
Path Following	The system must be able to deliver packages across campus, on preplanned routes.	The system will follow pre-planned routes of at least 150M with at least 1 intentional turn.
Speed	The system will always operate at a safe speed.	The system will travel at a speed of 3 mph (+- .2mph) while operating when no obstacles are present.

Risk register

Risk ID	Risk description	Risk category	Risk probability	Risk impact	Performance indicator	Respons ible party	Action plan
Sickness	Teammates find themselves ill and unable to complete all expected work.	Timeline	30%	M	Check communication platforms for team updates.	Jacob	Reduce
Vendor delay	Items needed for the project get delayed by shipping or shortages.	Timeline	20%	M	Constantly check the status of placed orders.	Jacob	Retain
Broken part	A component of the project is damaged, broken, or lost.	Timeline & Cost	20%	M	If a part breaks, it should be reported to the group immediately .	Jacob	Reduce
Incompa tible interface	Interfaces between two blocks end up not being compatible.	Technical	10%	H	Keep the interface definitions up to date.	Qusai	Reduce
Standards	Team members are not performing to set standards.	Personal	20%	H	When reviewing the group's work, everything is up to quality.	Jacob	Reduce
Incompl ete work	Team members are not completing work they committed to do.	Timeline	25%	M	Over a two-week span, a team member has the same task to complete.	Qusai	Reduce

Sabotage	Team members are intentionally y wasting resources.	Personal	2%	H	Need to keep an up to date project inventory.	Jacob	Reduce
Interpersonal conflict	Team members have personal conflict outside of the project.	Personal	10%	M	Outbursts from team members, and dividing comments towards others.	Spencer	Reduce

Future Recommendations

Enclosure The electronics on the project right now are stringed about the top of the project for ease of access when developing. This does make them take up valuable real estate that could be used by the application of the project rather than developing it. Recommendation The system is more functional than aesthetic at the moment. Building an enclosure for the system, one that has development in mind. Think about how someone is going to take apart the electronics to test, work on, and add to them.
Package Dock Currently, the package delivery robot doesn’t have a designated spot for a package to be loaded. For our operation time testing we had to use rope to strap weight to the robot because we did not design a specific place for a package to be loaded. Recommendation Design and implement a package loading dock that is aesthetically pleasing and intuitive to use. Utilize the square tubing that was meant for the post of the chair.
Recharge station Currently there is no quick and easy way to recharge the batteries on the robot. Assuming in the future all components of the robot are running on the two core batteries, then there

should be an easy method to recharge the batteries on the robot. Once the robot is implemented for real world use it will need an easy perhaps autonomous recharge station. Recommendation Design and implement a wired or wireless recharging dock which recharges the two batteries on the robot.
Setup placing delivery system Our partner Computer Science team created a webpage that connects to the robot. We originally intended for users to be able to input sender and receiver information on the webpage which would generate a cost map that the robot would use to make the delivery. Recommendation Finish developing the webpage function so that a user can place a delivery which will then generate a cost map for the robot.
Move to C++ The system is somewhat simple when it comes to robots at the moment. We have capitalized on that by writing almost the whole thing in python. Python made it easy for us to learn and quickly develop in ROS for we didn't have to worry about Cmake, catkin_make, or any of the Cmake rules files. Recommendation To get a better understanding of the project and what we have written, rewrite our code in C/C++. Not only will this give a better understanding of the project at the beginning, this will also give some understanding of what ROS is and what it is not.
Integrate edge detection Providing more data to the navigation stack will make the robot navigate perfectly. Since we are using a GPS coordinate system it's really hard to make sure that the robot is moving exactly in the middle of a sidewalk or crosswalk. Recommendation Incorporating visual navigation like edge detection is not something that is easy to do. This should be a big chunk of your work level, if you choose to do it.

Rear bump stops One of the main requirements we have is having an emergency stop system that will detect any collisions happening to the robot body, to avoid both damaging people and the robot body. For the requirement we just created 2 front bump sensors since our navigation system will try to not move backward. Recommendation To have a better navigation system you may need the robot to move backward. In this case, adding two rear bump sensors will be useful and it will add more safety to the robot.
Power Supply Our goal was to make a power supply to supply all the devices we have attached on the robot with their specified voltage, current, and power. However, since it's not one of our engineering requirements we used rechargeable batteries that powers only the raspberry pies and sensors we have for testing. Recommendation After making sure about all the attached components such as raspberry pies, sensors, motors, etc. Start designing your power supply, which is going to be supplied from either a separate battery or the same battery that you are using for your motors, to supply all other devices attached in your robot.

References

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[4] M. Joselow, “Delivery Vehicles Increasingly Choke Cities with Pollution,” Scientific American, 11-Jan-2020. [Online]. Available: https://www.scientificamerican.com/article/delivery-vehicles-increasingly-choke-cities-with-pollut i on/. [Accessed: 16-Apr-2021].

[5] “Wheelchair Market Size: Industry Analysis Report, 2021-2028,” Wheelchair Market Size | Industry Analysis Report, 2021-2028. [Online]. Available: https://www.grandviewresearch.com/industry-analysis/wheelchair-market. [Accessed: 16-Apr-2021].