Product: TransportED
Team: AutomatEd

Abstract

TransportED is a mobile robot whose main functionality will be to pick up boxes from shelves and to bring them to a target location while coordinating with other robots to avoid congestion and collisions. With it, we want to present an affordable but efficient solution for small and medium-sized warehouses.
The first major milestone is to design a working robot in Webots that fits our needs. The second one is to deliver the pick up mechanism, such that the robot can retrieve an item from a shelf and put it onto its platform. After that, we want our robot to be able to navigate from any shelf to any other location in the warehouse while carrying an item. The final big milestone is to develop the multi-agent algorithm, so multiple robots can pick up items in the same warehouse while avoiding each other.

1. Goal description

Most medium to small sized warehouses operate manually. This is due to the high cost of entry to automation. Our solution, TransportED integrates with the pre-existing warehouse environment, greatly reducing the setup costs and providing a affordable solution to small and medium enterprises (SME).

1.1. Relevance of the system

With an increase in demand of goods, warehouse owners need to deliver faster order fulfillment. However, the costs of staff are rising and finding good quality, reliable workers is becoming a difficult task in most parts of UK[1] (Walker, 2020). Hence, warehouse owners are actively seeking different ways to address these issues, specially through automation.

From goods-to-person technologies to mobile autonomous robots, warehouse automation solutions improve the operational speed and productivity. However, most of these solutions are often intended for large warehouses. They require large upfront costs in new shelves, a customized navigation layout, organisation of goods, and training of the staff. This means for small to medium scale warehouses the return on investment is expected to be 6-10 years.

TransportED will reduce these upfront costs by providing robots that can be integrated with the pre-existing shelves/ warehouse environment. This will allow a much faster return on investment, making it practical for SME to start automating their warehouses.

Another overlooked barrier to entry to automation is warehouse owner's scepticism in the benefits of automation (Veridian, 2019). With our simple to integrate set up, warehouse owner's could transform their warehouse gradually, by only investing in few robots at a time.

A typical warehouse with manual picking loses up to 400,000 US-Dollars annually to picking errors due to human error. (Works, 2018)

Our robots will be able to safely and reliably pick up objects from the shelves and deliver the items to a drop off point, like a customer or conveyor belt. This will be achieved by our robot's ability to raise platforms to the shelf's height, and use a simple robotic arm with suction cups to pull the target object onto our robot. This is illustrated in Figure 1. Our robots will be able to work together in a swarm like manner to coordinate, and plan the most efficient routes, allowing for increased productivity and speed.

Figure 8 investigates the logistics of automating picking processes in small-medium scale warehouses [2]. Their findings show that such warehouses could save up to 300000€ a year in labour costs, and start having return on investment (ROI) within just two years! This minimizes the risks linked to the uncertainty. This study encourages a need for a solution like ours, and a clear demand in the market.

Our suction cup based arm was inspired by Ocado's automated packing robots. These robots follow a rail system to a specific bin, then use a suction pump to pick up the items. By implementing a similar suction pump based system we cut down on the moving parts of the robot, making it more reliable and robust as compared to a claw/ gripper style arm. Ocado's warehouse is custom built with automation in mind. Although the rail system increases efficiency, such a warehouse requires investments of more than 225 million pounds in upfront costs, making it infeasible for small warehouse owners. (Dowdy)

Other implementations which minimize disruption to pre-existing warehouse operations are thereby more suited for SME. Squid by BionicHIVE attempts to solve this issue. It is an autonomous robot that can climb the shelves by attaching itself to a rail, which is attached to the shelf, to reach the desired item. Then, using a suction cup, it slowly picks up the object and starts descending using the rails.

[1] Since Britain's withdrawal from EU, people predict reduction in the number of people available to work in distribution and fulfillment centres.

[2] Considering the robot can be integrated into the pre-existing environment, like ours.

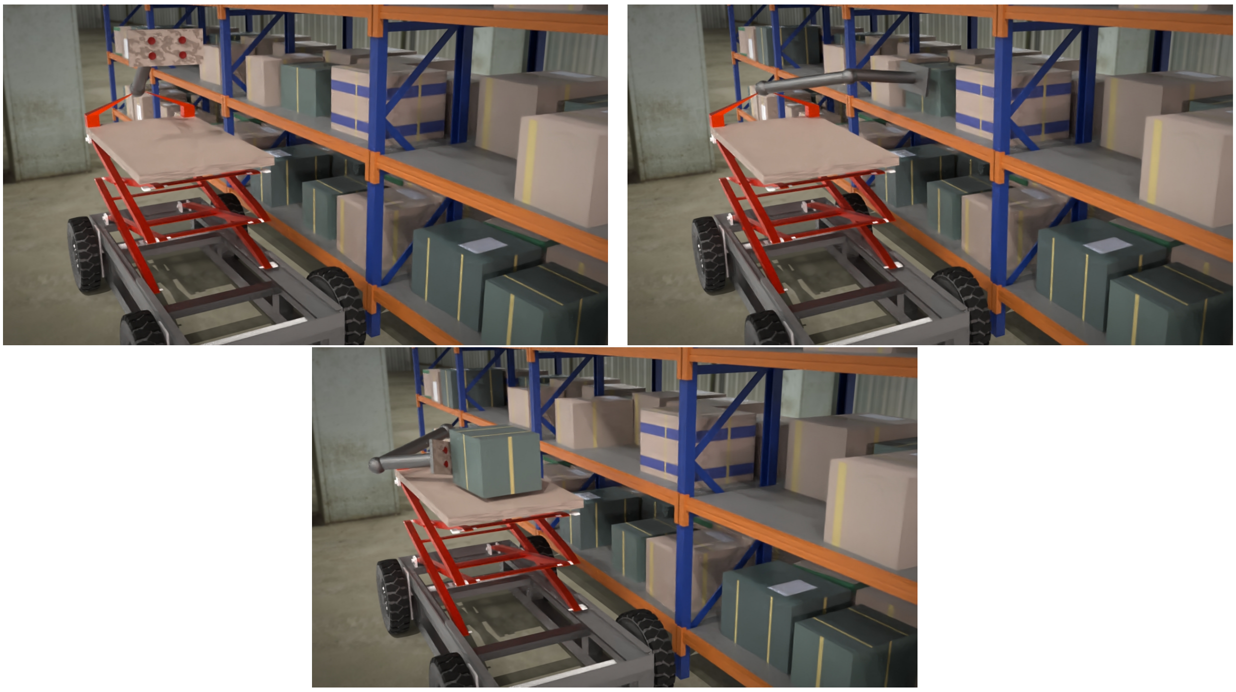

Figure 1. A very preliminary robot design for our project, made by us. The three pictures demonstrate the suction mechanism of robot being used to grab an item off the shelf the robot's platform. A scissor like structure to reach different shelf heights.

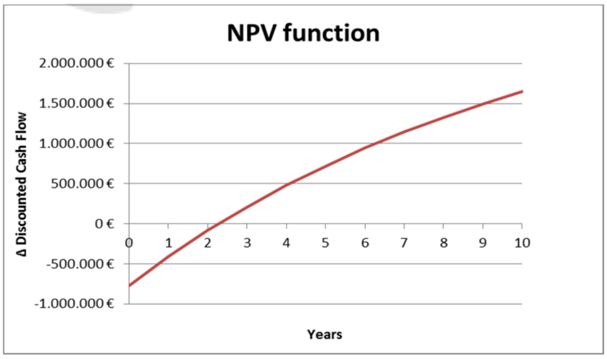

Figure 2. Cash flow vs time. Net present value of the investment made by SME warehouses, according to (Bonini et al., 2016)

Moreover, apart from the rails, it only requires QR codes placed on the ground for navigation. This is a very cheap system to install. However, this system is only ideal for warehouses dealing with light weight goods with very high and compact shelves (Raizer, 2019). We were inspired by ease of use offered by the suction cup, and are trying to create a robot that fits well for small warehouse owners.

Our rising platform is inspired by the scissor lift. Scissor lifts make for a good solution in this system as their compact "accordion" like structure allow for the platform to be able to rise very high in comparison to the space it takes up when contracted.

This combination is modelled in Figure 1.

1.2. High-level description

We wanted to understand the needs of SME's warehouses so that we could develop solutions to help them.

> "I wish to spend less time focusing on repetitive tasks, like finding and picking up items, and focus my time on more complex tasks." - A warehouse worker.

With our solution, workers would no longer have to walk long distances in warehouses, finding items. Moreover, this will help with inventory management and boost worker productivity.

> "I wish the costs of automation were cheaper so that I too could increase the productivity and match the customer's demands." - A small-scale warehouse owner.

Being able to just purchase our robots to work with preexisting warehouses, the cost of automation will be significantly decreased for SME.

> "I want to get my order as quickly as possible so that there is less waiting time." - A customer purchasing from a SME.

Our multi agent system and planning algorithms will allow for finding the most efficient routes, reducing the time for object retrieval.

To validate our product, and truly understand the warehouse business, we interviewed the Amazon UK Operations - Regional Director. The full interview can be found in Appendix, section A.1.

The interview has shown us what the biggest issues are with warehouse management and automation. We learnt that the cost of capital is a huge problem for warehouse automation. (Appendix A.1 Q1). With our solution, we want to reduce that burden by requiring minimal adaptions to the current warehouse environment.

We also found out that picking and stowing items is by far the most time-consuming task. (Appendix A.1, Q3) TransportED provides a way to automate both.

2. Task planning

2.1. Milestones

Our system can be split up into four sub tasks: Environment and robot design, robot movement and localisation, item retrieval, and multi-agent coordination. We use these sub tasks as our basis to generate milestones:

1. Initial robot design (Target Date: 27/01/21)
2. A working prototype of our simulation (Target Date: 29/01/21)
3. Item retrieval mechanism (Target Date: 19/02/21)
4. Robot navigation (Target Date: 25/02/21)
5. A working simulation with a single robot (Target Date: 01/03/21)
6. Multi-agent simulation (Target Date: 15/03/21)
7. Testing (Target Date: 29/03/21)

We decided to split the above tasks into three categories, namely: Environment design, software development, and market research to allow for an efficient delegation of tasks between groups by reducing the dependency between them. Despite market research consisting of only a few tasks, we understand its importance. Therefore to avoid neglecting it, a mistake made by multiple past SDP groups, we decide to categorise it separately.

We aim to develop a working prototype of our simulation during milestones 1 and 2, and finalize our simulation design by milestone 4. Similarly, we starting working on our software since milestone, and heavily focus our attention on it for milestones 4,5,6,7. Market research will be an ongoing process to best understand SME warehouse owner's needs. Milestone 7 also includes a big Market Research task regarding the user guide.

2nd, 5th, 6th, and 7th Milestones line up with the four demo days. These milestones exactly mark functionality we hope to be able to create and display in our demos. These also serve the function of externally monitoring our progress.

Whereas 1st, 3rd, and 4th milestones help us internally monitor our progress. These will help us keep ourselves on track and achieve the big functionalities our project needs in time. We hope all these milestones will help us improve our productivity, and work better as a team.

We hope to achieve the following by each milestone:

1. Have a working robot design in WeBots. This includes a robotic arm, raisable platform, locomotion and a chassis.
2. Have the initial warehouse design and layout implemented within WeBots. These includes shelves, drop off points and items. Also finalize the robot design and implementation and specified drop-off points.
3. The robot can pick up a specified item from a shelf using its arm mechanism. Items need not be of different sizes.
4. The robot is able to navigate from a shelf to another specified location in the warehouse.
5. The navigation is fully integrated with the robotic arm control - the robot can retrieve a specified item and bring it to any location.
6. Multiple robots like designed in milestone 5 can work together to efficiently retrieve multiple items.
7. Testing our robots. Generating a final user guide, a website and our individual reports.

2.2. Task Decomposition

The gantt chart can be found below in figure 7. Furthermore, we have created a table containing all the items in the gantt chart with a description of them in table A.3. We tried to split tasks such that no task takes more than 20 hours. Despite our best efforts, some challenging tasks need longer. Moreover, over the weeks as our knowledge of our tasks increases we might be able to further divide them.

2.3. Resource distribution

The pie charts below details how each group member will spend their time in order to achieve our goals. There are 8 non-hardware related workshops, and we expect to attend those with two persons each. Furthermore, there are 5 hardware workshops. As we do not plan to build any hardware, we will ignore them in our time allocation chart. This would lead to roughly 3.5 hours spent on workshops per person. Furthermore, we will have a weekly meeting with the whole group, leading to 12 hours of meetings throughout the semester. The trade fair is planned to take around eight hours, but we will estimate that 10 hours are spent overall when including the time spent setting everything up. There are four demos overall, with the last one being the biggest. We estimate that the first three demos take up 1.5 hours for each group member, whereas the last will take around five hours, leading to 9.5 hours in total. Furthermore, we are planning to do an hour of testing before each demo, which would make 4 hours overall. We expect that most of the report-writing will be done by project and team managers, as they have the most knowledge about the whole system. We also think that it will prove very valuable to get feedback from the whole team. Therefore, we allocate five hours of designated report writing and feedback time. The rest of the time is devoted towards development and testing. We decided not to split up development and testing, as we believe that those tasks come hand in hand. As shown in figure 3.

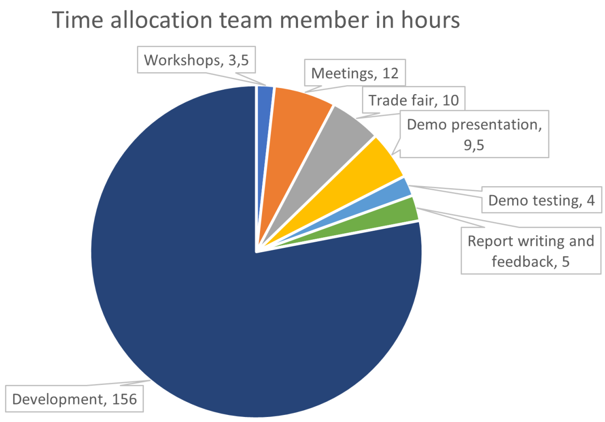

Figure 3.

For team managers, we expect them to spend a bit more time on organizing meetings and ensuring their team is heading towards the right direction. Given the skills of our team managers, we think this organizational overhead can be kept at a minimum, and assume that they will spend further 10 hours doing just that. Additionally, we expect them to do most of the report writing, and assume they will spend 30 hours on it. As shown in figure 4.

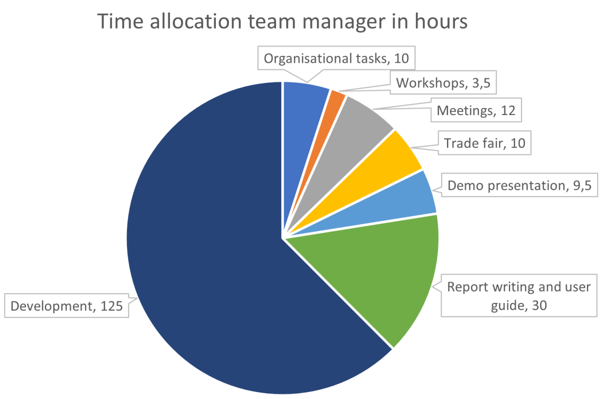

Figure 4.

Team leads, similar to mangers will spend more time on organisational tasks. We also assume that this will be roughly equal to about 10 hours over the course of three months. Furthermore, we assume that another 20 hours will be devoted towards market research, to position our product optimally and to search for any other ideas we might have missed. This time should also be used to address any ethical concerns that might arise from our product. Furthermore, team leads will also be heavily involved in report writing, totalling 45 hours, as shown in figure 5.

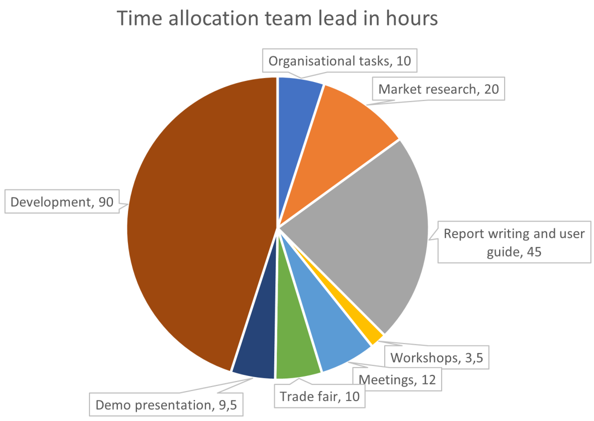

Figure 5.

As we want to develop our robot fully in simulation, we do not expect to spend much money. Depending on how we host the item database and the central server for the swarm algorithm, we expect to be spending at most £20 in hosting fees.

2.4. Risk assessment

We have decided on a very ambitious project, with many hurdles to overcome to achieve our final goal of developing a swarm-based autonomous warehouse system. To achieve our goal, we would need to find a simple and robust pickup and localisation mechanism and would need to develop an algorithm that enables our robots to interact with each other. Thankfully though, the problems we need to tackle are not interrelated, allowing us to solve them one at a time, leaving room to reduce our project scope if needed.

The complexity of all our algorithms heavily depends on the environment they are in. The range of products we need to pick up determines the complexity of the pickup mechanism, more robots in the same factory will increase the complexity of the navigation. If humans need to work side by side with our robots, we would need to fit and integrate additional sensors to not hurt any of them.

Fortunately, being the designers of the simulation, we can add and remove the complexity of our project depending on our progress. During the initial development of our robot, we will make many assumptions to get a working prototype ready as fast as possible.

2.4.1. Pickup algorithm

For the pickup algorithm, the following assumptions are made. We assume that all items are placed in boxes of similar size. There will only be one box per compartment, allowing us to find the right box by just knowing the compartment position. All shelves are similar in size. Depending on our progress, we will gradually increase the

RISK	LIKELIHOOD
COLLISIONS	HIGH
LOCALISATION MIGHT PROVE DIFFICULT	HIGH
MULTI-AGENT ALGORITHM DIFFICULT TO IMPLEMENT	HIGH
PICKUP ALGORITHM TOO COMPLICATED	MEDIUM
BUILDING OWN ROBOT	LOW
GROUP CONFLICTS	LOW

Table 1. Possible risks and likelihood

complexity by handling boxes of different sizes, boxes at different positions, and shelves of different sizes. We expect differently-sized shelves to be challenging, and there is a chance that we need to reduce the scope of this algorithm.

2.4.2. Localisation and navigation

For localisation and navigation, we will aim to use the simplest localisation mechanisms available. These would include NFC tags, QR codes or lane markings that are placed on the ground. Furthermore, we will assume that only robots operate in the warehouse, reducing the need for many safety measures and sensors needed for safe interaction with humans. There will only be one robot operating at the time, allowing us not to worry about possible congestion and collisions. No objects will block paths. As we progress, we will introduce multiple robots and might lift some of the other assumptions.

2.4.3. Multi-agent algorithm

The multi-agent algorithm will first focus on resolving any congestion or conflicts. For that, we might only declare one-way streets that have to be followed. If this works, we will optimize the pickup process by choosing the optimal robot to pick up an item and will use two-way streets.

2.4.4. Prioritization

If it turns out that the individual problems are very difficult even with all of the simplifications, we have a prioritization list in place that we will follow through. By the end of the project, we want to have at least a working pick up mechanism. If we realize during development that we are on track to achieve that, we will shift some of our resources towards basic navigation with a single robot. Only if those two mechanisms are achieve by the third demo, we will start the development of our multiagent algorithm that will allow us to unleash the full potential of our system.

2.4.5. WeBots

Currently, we have little to no experience with WeBots. To truly succeed, we need to develop our own robot. We do not think that this should be too challenging, as WeBots is easy to learn. In the case that still happens, we will switch to a premade design, e.g. a Turtlebot.

2.4.6. Team risks

Concerning the group organisation, there is a risk of disputes and disagreements during development, especially with a group of our size. If a conflict arises we will have a vote in the subteam to reach consensus. The team managers have the final say in the case if there is no clear majority.

3. Group organisation

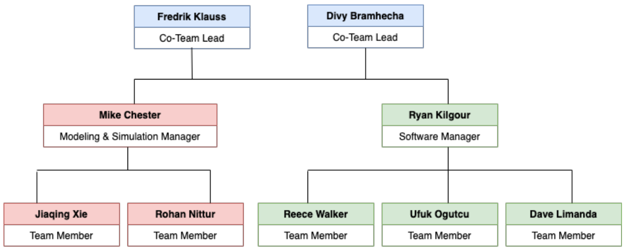

Figure 6. Our group organisational structure

Our group is divided into two: 'Modelling & Simulation' and 'Software', each with their own responsibilities. We decided to follow a matrix organizational structure, where each division has a manager/leader. This will ensure that we have a smoother interdepartmental communication and collaboration.

The assignment of team members to each division is done based on their strengths and weaknesses (see Figure 8):

The project managers are Fredrik and Divy. They will be responsible for ensuring that the group works together, and they work at a synchronized pace such that one division is not waiting for the other division to finish a task they are dependent on. We have decided on two team leaders so that in cases where one leader is unable to perform his duties (i.e. ill), we still have another team leader to back him up.

The modelling team consists of Mike, Jiaqing and Rohan. This team is formed based on their skill level on design and modelling, robotics, simulation and C++. All of the members have some experiences in CAD designs. In addition, Jiaqing has good knowledge in simulation and C++ and Mike has experiences in robotics. We have decided on Mike as the team manager as he has project management experiences.

The software team consists of Ryan, Dave, Reece and Ufuk. This team is formed based on their skill level in programming, networks and databases. All of the members have good programming knowledge in Python and Java and we have a good mix of members who are good in databases and networks. We have decided Ryan as the team manager as he has project management experiences.

Market research is another important aspect for our project and this will be carried out mainly by the project managers and the division leaders. We also have decided that each of the members should carry out their own market research at the start of the project to help gather ideas on how to position our product in the market.

3.1. Meetings & Progress Tracking

Our group will follow Agile practices where every evening, each member in their own division will update each other on the progress they have done and the problems they have encountered. This will ensure that each team is on track and any difficulties can be worked on by the whole division. A meeting may also be scheduled within the division whenever needed, which allows a flexible structure that aligns with the division's schedule and needs.

Every Friday, we will have a weekly progress update meeting with members from all the divisions. Each division manager will update their respective progress to the project managers. The aim of this is to discuss if we have met the agenda laid out for that week, and depending on this outcome, we will discuss the agenda for the following week. For every meeting, there will be one person responsible to make sure that the meeting achieves its predefined goal and does not take much longer than anticipated.

Every Monday, we will have a meeting with our mentor. This is used to update our progress and ask advices for challenges we encountered during the week.

3.2. Tools (Communication and Code-Sharing)

For communication, we have chosen Microsoft Teams as it allows us to divide the channel into divisions. This will ensure that members of one division are not distracted by communication of the other division that does not concern them. We have decided to only use one channel of communication to prevent miscommunications.

Our Agile team structure is maintained using Asana. This project management tool allows the assignment of tasks to each team members. Each task will have one or more team members assigned to it and has a strict deadline. Assigned members are expected to add comments to the task whenever they make progress. This enables us to track the work done by the individual members and enables us to address issues as needed. Division leaders will aim to assign detailed tasks using the SMART template from the project management workshop.

For version control system, we have chosen Github as most of our members are acquainted with it, which should reduce adaptation time. For each feature and bugfix we develop, there will be a branch encompassing it. For each merge request, the division manager is responsible to do a code review, ensuring clean, efficient and reliable code.

For cloud storage, we decided to use OneDrive as it is integrated nicely with MS Teams. This enables us to store all information related to our project in a central space. It allows us to upload a vast amount of files and can be accessed anywhere in the world, allowing our team to collaborate efficiently as we operate on two different continents.

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A. Interview and tables

A.1. Interview with Amazon UK operations' Regional director Graham Allison.

Q1: Amazon already fully/partially automated warehouses. What is holding you back to implement this automation technology in all warehouses?
R: Cost/benefit of capital outlay, humans are still better at a large group of tasks. Think solving bin packing problem of different objects to pack a box.

Q2: What are some challenges that management face with interactions between workers and robots?
R: It's reasonably straightforward but designing safety in mind is forefront of the mind.

Q3: What is the most time-consuming task when fulfilling an order?
R: Picking and stowing an item on a shelf.

Q4: How do you go about optimizing the logistics of the robots/workers to maximise efficiency and avoid congestion?
R: Pick an NP complete problem and apply every solution

method you know.

Q5: What is the most challenging part of running a warehouse?
R: Leading thousands of people is always more tricky than any complex software or robotics. Super tricky to keep that many people happy, fed, warm and behaving well.

Q6: Which areas in the warehouse have been automated? Which areas have not? What challenges are preventing these areas from being automated?
R: We move boxes around a big room. Most of this is automated in some way (conveyance or robotically). Physically picking the item from a location and packing into a box is manual. Loading sorted pallets onto a trailer is manual. Moving inventory to a location is a mixture of manual/robotic depending on the building. We run a competition for teams to solve the "physical" pick aspect. https://arc.cs.princeton.edu/ shows some entries.

Q7: What is the upfront investment needed to automate an Amazon warehouse? How long does it take?
R: Probably high eight or low nine figures. Can build one in a year.

Q8: How do the robots know where they are in the environment(localization)?
R: Basically a series of 2D barcodes on the floor.

Q9: How are the robots managed? Is there room for improvement in the system management interface? Are there any features that could be added to the interface to improve the management of the robots?
R: Always! But we have the best computer scientists and AI brains working on it.

Q10: Where is Amazon currently trying to push innovation in warehouse automation?
R: Pretty much everywhere. It's harder to innovate on the connections with other companies/organisations and where there are existing standards. So pallet sizes are standard, trailers are standard and we have external drivers/carriers/vendors who deliver items in a standard way. These are constraints on what we can change (or what we would want to change). One limitation is "attention span" when you are growing very quickly as a company. You need to prioritise where people spend their time. In our case picking and sorting packages in more granular levels for last mile deliveries are areas of focus.

Q11: Do you feel there are any other areas we should know about in the day to day operations of a warehouse that we may not have considered?
R: Will be difficult to simulate but you need to spend way more time thinking about people than robots. How do they interact, where do they not, who fixes things when they go wrong. Where do they go get lunch, how do they travel to work, how do you train them quickly.

A.2. Gantt chart

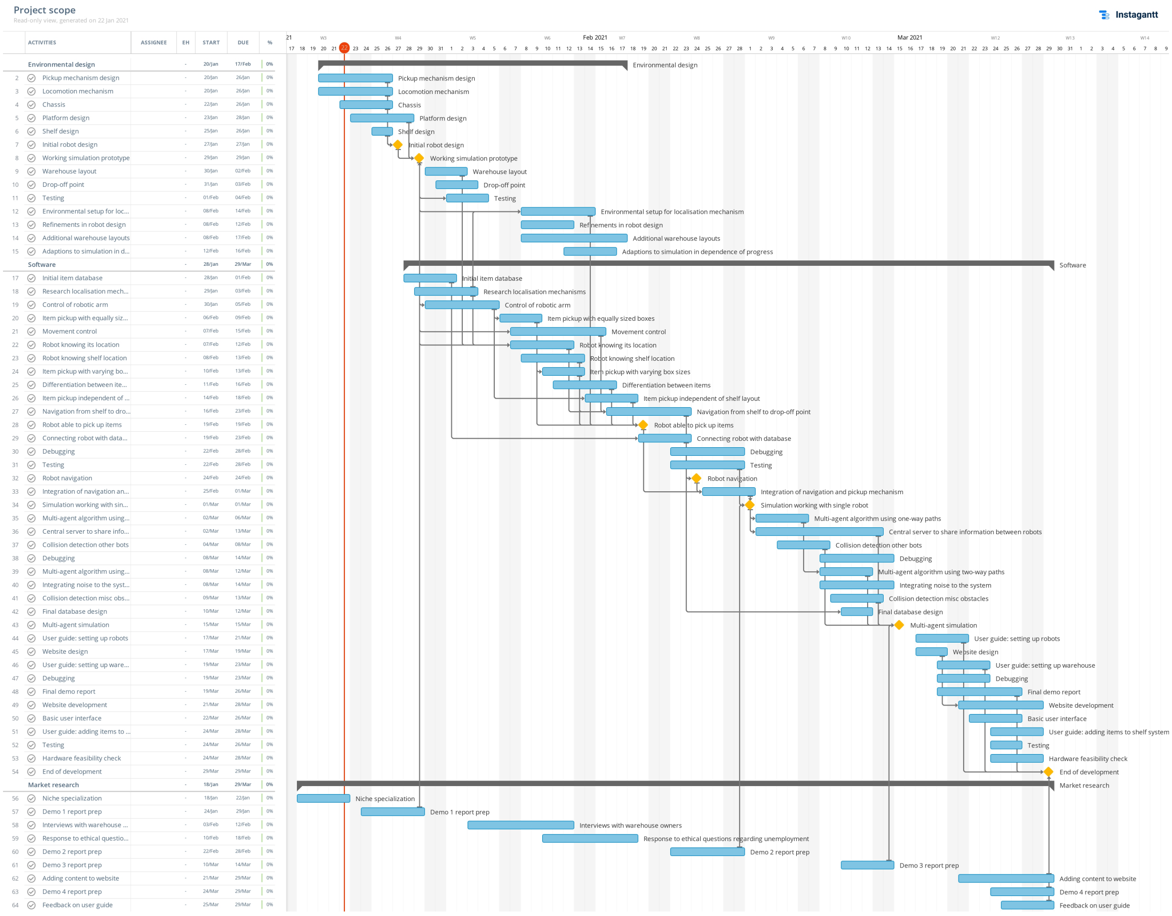

Figure 7. Gantt chart

A.3. Task decomposition

Table 2: Task decomposition table (MS stands for Milestone)

Task Name	MS	Hrs	Dependency	Rough description
1. Pickup mechanism design	1	20	-	Design of robotic arm in WeBots
2. Locomotion mechanism	1	15	-	Design of the locomotion mechanism in WeBots
3. Chassis	1	20	Task 2	Design of the chassis of the robot in WeBots
4. Platform design	1	10	-	Design of the platform on which the robot carries objects
5. Shelf design	2	10	-	Initial shelf design used to test the pickup functionality
6. Warehouse layout	2	20	-	Used to assess effectiveness of robot
7. Drop-off point	2	5	-	Point where robot drops off picked up objects.
8. Testing	2	15	MS–2	Testing of simple robot controls
9. Debugging	2	20	MS–2	Debugging of simple robot controls
10. Demo 1 report preparation	2	26.5	-	Prepare report for demo 1 as specified on Learn
11. Control of robotic arm	3	25	MS-2	Development for advanced control of the robotic arm.
12. Item pickup with equally sized boxes	3	20	Task 11	The robot should be able to pull an object onto its platform
13. Item pickup with varying box sizes	3	20	Task 12	Ability to pull items of varying sizes onto platform
14. Item pickup independent of shelf layout	3	30	Task 13	Robot should be able to pickup an item from any shelf independent the compartment size or height.
15. Differentiation between items	3	20	-	Robot must be able to pickup a particular item/box.
16. Research localisation mechanisms	4	10	-	Dive into possible localisation mechanism and there advantages and disadvantages.
17. Robot knowing its location	4	25	MS-2, Tasks 6,16	Enabling robot localisation
18. Robot knowing shelf location	4	15	MS-2	Modifying robot so it knows location of shelf
19. Environmental setup for localisation mechanism	4	20	MS-2, Task 16	Adding any sensors or adding landmarks needed for localisation.
20. Movement control	4	25	MS-2	Robot can move into any compass direction for a certain duration.
21. Navigation from shelf to drop-off point	4	30	Tasks 17,18, 20	Robot should be able to find the path from any location to any other in the warehouse and navigate to it.
22. Integration of navigation and pickup mechanism	5	40	MS-4	Able to pickup any item from any shelf and deliver it to the drop-off point
23. Demo 2 report preparation	5	26.5	-	Prepare report for demo 2 as specified on Learn
24. Testing	5	20	Task 22	Tests on a variety of shelf sizes and heights.
25. Debugging	5	20	Tasks 22, 24	Debugging bugs that have arisen from tests.
26. Refinements in robot design	5	20	-	If any flaws in the initial robot, this will be the time to adapt the design in order to overcome these.
27. Additional warehouse layouts	5	20	Task 6	Different warehouse layouts, enabling further testing of our robots.
28. Adaptions to simulation in dependence of progress	5	20	-	Depending on the progress, we might add more constraints or add further obstacles.
29. Central server to share information between robots	6	20	MS-5	Central server so robots can share location data and other useful information in order to avoid congestion.
30. Multi-agent algorithm using one-way paths	6	20	MS-5	Assuming paths that only lead into one direction should enable us to quickly develop a first algorithm
31. Multi-agent algorithm using two-way paths	6	20	Task 30	Lifting the assumption above, assumed to be more complex but should increase efficiency
32. Collision detection other bots	6	20	MS-5	Possible collision detection with other robots
33. Collision detection misc obstacles	6	30	Task 32	Possible collision detection with misc obstacles
34. Integrating noise to the system	6	20	MS-5	Final step to integrate sensor and movement inaccuracies.

35. Demo 3 report preparation	6	26.5	-	Prepare report for demo 3 as specified on Learn
36. Initial item database	3	15	-	Item database that stores the location of various items
37. Connecting robot with database	4	15	Task 36	Should allow robot to find location of an item without human interference
38. Final database design	5	10	Task 37	Finalizing database design
39. User guide: Setting up robots	7	20	MS-5	Prepare setting up robots of user guide
40. User guide: Setting up warehouse	7	20	-	Prepare setting up warehouse system of user guide
41. User guide: Adding items to shelf system	7	20	Task 38	Prepare setting up of shelf system as specified on Learn
42. Website design	7	18	-	Nice website layout fitting to our project and the possible content
43. Website development	7	20	Task 42	Actual development of the website. Might use website builder to reduce time spent.
44. Adding content to website	7	40	Task 43	Main content generation for website
45. Basic user interface	7	10	-	Simple user interface so somebody can add/remove items from the database, order robot to pickup an item.
46. Hardware feasibility justification	7	8	-	Justification of why our robot would work in the real world
47. Testing	7	20	-	Final testing so we can have a successful demo
48. Debugging	7	20	Task 47	Final debugging 49 we can have a successful demo
50. Final demo report	7	30	-	Prepare final demo report as specified on Learn
51. Feedback on user guide	7	20	Tasks 39, 40, 41	Improve based on feedback
52. Niche specialization	1	20	-	Focus on finding a right market fit where we can create value
53. Interviews with warehouse owners	3	4	-	Conducting and preparing for interviews with warehouse, feedback on product
54. Response to ethical questions regarding unemployment	5	15	-	If our product is a success, it might cause unemployment. We need to take position on that and propose possible solutions.

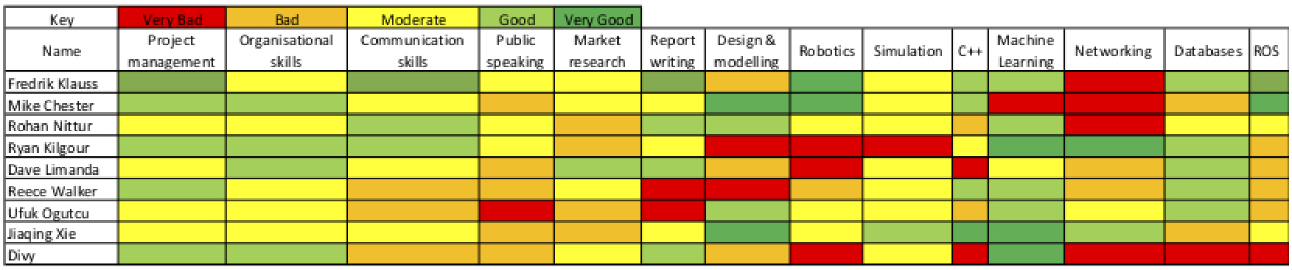

Figure 8. Strength and weaknesses chart