SYSTEM DESIGN PROJECT:
PROJECT PLAN

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DispensED - Group 17

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Purpose of this Document

This document is prepared as part of the project for the System Design Project course at the University of Edinburgh. The goal of the project is to build an assistive robot with appropriate software interface. Our project is to create a system that automates delivery of medicines to patients in care homes. This project plan will highlight the goals we have set as a team, as well as how we will achieve them, and includes a breakdown of our resources and an overview of our organisational structure.

1 Introduction and Goals

There is a large shortage of nursing staff across the UK. The NHS reported in 2017 that nurses account for 38% of overall vacancies in England [NHS17]. The *Care Home Use of Medication Study* has found that care home staff, specifically, spend about 40-50% of their time with drug related activities. The study also found that administration errors occur 8.4% of the time [BAR+09], meaning that if a patient receives medication three times a day, there is a 1 in 4 chance that an error will occur[1].

DispensED is aiming to develop a solution to the problems created by manual drug administration by creating a robot to do the bulk of the work. Our product will move around care homes to different residents' rooms. The residents can then scan their identification and the appropriate drugs and vitamins will be dispensed. The system will also have a wide range of administrative functions available to staff, such as setting alerts on low stock levels or non-admittance of drugs.

[1] This can be viewed as Bernoulli experiment with 3 trials where the successive event is the correct administration of drugs. It follows that $\mathbb{P}(\textit{an error occurs}) = 1 - \mathbb{P}(\textit{no error occurs}) = \binom{3}{0} * 0.916^3 * 0.084^0 \approx 0.23$

1.1 Technical Subgoals

The system can roughly be divided into 4 parts, which will be desribed in this chapter, with different milestones set for each. The milestones are to be presented at each demonstration, with the final demonstration being for the entire system.

1.1.1 Movement and Physical Frame

The robot needs to be able to move around the facility in which it is deployed, using motors mounted on a frame. The frame will also have to accommodate the other physical parts of the system, and handle communication to the central system. The navigation will happen along predefined routes using marks on the floor. These marks are made using coloured tape.
The different milestones for these can be set as follows:

1. Initial control of simple frame with pre-programmed movement
2. Full frame with pre-programmed movement
3. Full frame with movement that is controlled by a remote computer

1.1.2 Dispensing of Medication

The robot will support giving out medication that does not require a special environment (for example requiring temperature control). It does this in two different ways:

- **Pre Packed Sets of Medication** Most care homes get pharmaceutical drugs pre-packed from the pharmacy, sorted by patient. In this case, the robot must give out the container with the pre-packaged drugs to the correct patient. There needs to be support for storing drugs for several different people who may not collect their drugs in any predefined order.
- **Single Pills (Vitamins)** For pills that do not come pre-packed (such as vitamins), a different kind of dispenser is needed. This dispenser must be able to hold a collection of a type of pill and give out single pills, one at a time.

Based on these two aspects, the following milestones can be set:

1. Dispensing of individual (vitamin) pills
2. Dispensing of pre-packaged pills for specific patients
3. Recognising when the pills have been taken from the robot by the patient (dispensing tray empty)

1.1.3 Vision

Several vision systems are needed in order for the robot to accomplish its objective:

- **Orientation** The robot must be able to recognise and process the markings on the floor that are used for navigation. Additionally, the system must know the location of the rooms that it is trying to service - separate floor markings or an alternative kind of internal representation of the environment may be used for this.
- **Barcode Scanning** Medication is dispensed to the patient after they have authorised themselves. The main form of authorisation will be barcodes (these could be affixed to the patients' wristbands). The system must be able to read these barcodes

This leads to the following milestones:

1. Detecting target line and door markers
2. Scanning barcodes and using them to report the ID of the patient
3. Generating directions for actual movement: Using the lines to steer the robot along the lines.

1.1.4 Software Back- and Front-end

To support the robot in getting the appropriate medication to patients, there will be a back-end system in place, running on a central computer. This will hold a database of patients, medication, and what should be dispensed at which times. This, in turn, will be accompanied by a user interface, which nursing staff can use to manage patients and monitor what medication has been delivered.
This leads to the following milestones:

1. A design plan of how the software will be structured. The current idea is to have a modular design to maximise flexibility. This stage will also define the contents of the different modules and how they will be approached.
2. Implementation of database and software interface (API) to modify the database.
3. Working user interface that inter-operates with the back-end

2 Resource Allocation

We first went and analysed particularly strong skills of our group members and how they might translate into out project. We have determined four core skills for each member (Table 2.1). Next, we broke down our project into smaller parts, each of which developed into a sub-team. We then assigned each team member to the sub-teams they were most interested in and where their strenghts would be most useful. For a full list of the sub-teams, please refer to Table 3.1 in Section 3.1.

Team Member	Strengths
Stefani	Databases, Python, Machine Learning
Tizzy	Object Oriented Programming, Java, Database Management
Glen	Databases, Robot Construction, Java, Python
Alexander	Project Management, LaTeX, Python, Software Engineering
Jasper	Vision, Program Design, Object Oriented Programming Robotics Experience
Philip	Lego Mindstorm experience, Java, Python, Language Processing
Boyan	Electrical & Mechanical Engineering, Robot Construction, Physics

Figure 2.1: Team Strengths

2.1 Time Planning

The Gantt chart (Appendix 1) shows what should be done when, and who is responsible. While we believe that Gantt charts are incredibly useful as tools to set goals and track progress, we don't think this should dictate the entire project flow, especially considering the highly flexible nature of the sub-teams. The focus will be on meeting the deadlines set in the Gantt chart and analysing what resources should be dedicated to certain tasks based on progress.
The deadlines for the milestones laid out previously are at the times of the client demonstrations (Milestone 1 = First client demonstration, ..). The final client demonstration does not have an explicit deadline, but will involve further polishing of the system as catching up on any milestones that may have not been fulfilled. This means there will be plenty demonstrable material for every demonstration. Additionally, after every demonstration, time has been scheduled to process any client feedback before the next period of development starts.
We specifically left the period leading up to the final demonstration generic. As this is a complex system with many parts, plenty of time is necessary to integrate them. If there is time left over, then it will be used to expand functionality and polish up the final product.

In terms of the total time to be spent on the project, the pie chart (Figure 2.2) shows roughly how much time per person is allocated to actual development of the system. This equates to

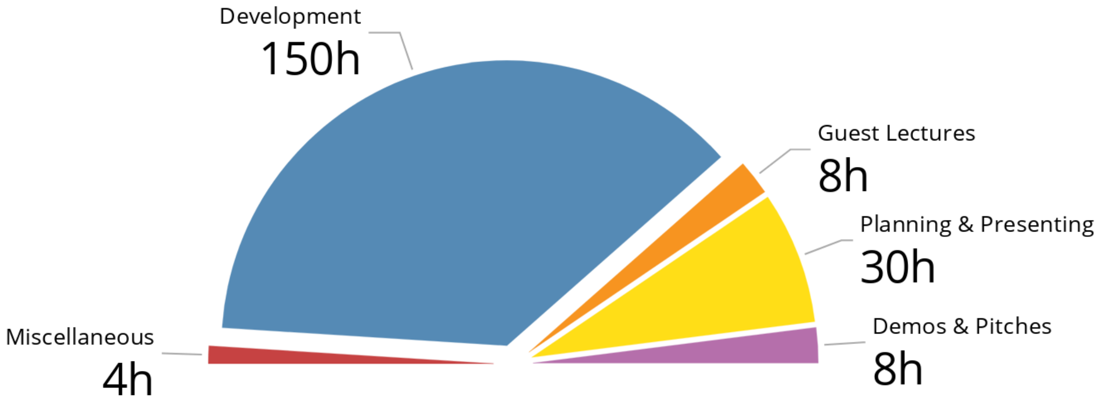

Figure 2.2: Planned Individual Time Deployment

around 14 hours per person per week. These can roughly be allocated to tasks. Every team member can then compare their own contributions against those of others on the team, discussing any problems in the regular meetings.

2.2 Equipment and Physical Resources

The robot will consist mainly of Lego while being controlled by the provided EV3 and Arduino kits. The only obvious thing that would have to be added to this is two cameras (for line detection and barcode scanning), and possibly 3D printed parts for medication dispensing. This should fit into the budget while leaving some room for additional parts where needed. The software will run entirely on the provided DICE machine, meaning there is no need for additional resources.

2.3 Risks and Contingency Planning

The most apparent risk that would hinder project progress is absence of team members. As will be discussed in the next chapter, we split our team into multiple sub-teams. Every sub-team has multiple members and the project management ensures that no one team member has knowledge that no other team member possesses. This way, the impact of any one team member being ill or otherwise unable to work is minimised.
Other risks arise from needing to integrate the smaller parts of the system into one robot. We plan to use the time leading up to the final demonstration for this purpose, which should be adequate. It is still essential for the sub-teams to maintain regular communication with each other to make this process as straightforward as possible. These and other identified risks have been combined into the risk matrix 2.1 below.

3 Organisational Structure

3.1 Team Structure

The team structure loosely follows a Functional Matrix structure with Alexander assigned as the key contact and team manager. As previously mentioned, we split our team up into multiple sub-teams, (Table 3.1) each working towards the sub-goals of their area. The person marked in bold assigned as the "owner" of the groups work, meaning they are the first point of contact.

The teams were created based on a combination of preference and competence, meaning each member will get to work on aspects they find interesting and are most competent in. To ensure

Risk	Likelyhood	Severity	Mitigation
Team Members may be absent due to illness, etc	High	Low	Division into sub-teams. Multiple members in sub-teams create redundancy. No one team member has unique knowledge about the product.
Integration of sub-systems may be delayed if sub-systems are delayed	Medium	High	Regular communication between sub-teams ensures that they can maintain a similar level of progress.
Acquisition of critical items may be delayed	Low	High	Critical items must be ordered as soon as possible.
Support Staff may be unavailable (Garry, Mentor, ..)	Medium	Medium	Maintaining good progress towards our milestones should minimise any last-minute support needs.
Unrealistic Schedules	Medium	Low	SCRUMBAN will enable us to re-plan to meet deadlines accordingly
Software compatibility issues	Low	High	Software is to be vigorously tested on DICE
User Interface unusable	Low	Low	Test UX with client prior to demo.

Table 2.1: Identified Risks and their Mitigation

Medication Dispensing	Software Back & Front End	Movement (physical)	Vision
Glen	**Alex**	**Philip**	**Jasper**
Tizzy	Bobby	Jasper	Stefani
Philip	Glen	Bobby	
Stefani	Tizzy	Alex	

Table 3.1: Sub Teams - Key Contacts marked in **bold**.

that the teams communicate effectively, each member is assigned to two different teams, to create as much overlap between the teams as possible. This has the added benefit of ensuring that each team has an understanding of the other parts of the system.
While the teams are inherently flexible, since members are on two teams simultaneously, there is also room for movements between sub-teams. This could be due to unexpected workload, or if it turns out someone has valuable ideas for other aspects of the system. Any such shifts this would be discussed with the entire team.

3.2 Meetings

Every morning an informal stand-up is held so that everyone is able to be up to date with the current state of the system. These catch-ups usually just include any progress from the previous day as well as any potential new issues or roadblocks that may have emerged.
The whole team meets with our mentor during a one hour fixed meeting slot on Thursdays at noon - everyone is expected to attend these meetings. Quick meetings will also happen directly after client demonstrations in order to identify any issues that arose during the demo and plan to mitigate these in future. Additional meetings follow a drop-in approach and are conducted as needed. We will also meet after each demnstration to reflect on how it went and to plan what needs to be improved before the next milestone.

3.3 Communication and Tools

The main vector of communication is the team Slack, while Notion is used as a platform for notes, drafts and project management. Specific tasks are allocated via trello-like boards in the To-Do section on Notion. We decided to use Notion instead of Trello as it offers additional functionality. The way we manage both task allocation and progress tracking follows SCRUMBAN management system, a mix between SCRUM and KANBAN. This system picks out the most useful agile parts from KANBAN while maintaining clearly defined roles. This will aid our team with more steady progress whilst not locking ourselves into an engineering process that requires planning very far ahead.
A private GitHub repository for code version control has been set up for the project. We have used GitHub as it was the most accessible since everyone already had an account.

Table 3.2: Tool Overview

Tool	Purpose	Link
Slack	Main Communications HUB, Chat	`https://sdpgroup17.slack.com/`
Notion	Meeting Notes, Project Management	`https://www.notion.so/dispensed/`
GitHub	Code Version Control	`https://github.com/xMythycle/DispensED/`

Bibliography

[BAR+09] Barber, N D. ; Alldred, D P. ; Raynor, D K. ; Dickinson, R ; Garfield, S ; Jesson, B ; Lim, R ; Savage, I ; Standage, C ; Buckle, P ; al. et: *Care homes' use of medicines study: prevalence, causes and potential harm of medication errors in care homes for older people.* `http://qualitysafety.bmj.com/content/18/5/341`. Version: Oct 2009

[NHS17] *NHS Vacancy Statistics England.* `http://digital.nhs.uk/catalogue/PUB30033`. Version: Jul 2017

teamgantt
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