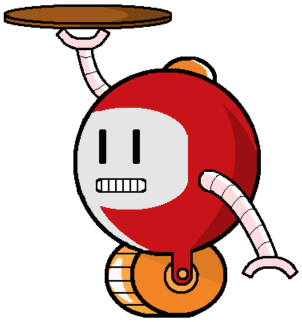

LazyBots

McMaster University

Hazard Analysis

SE 4GA6 & TRON 4TB6

Group 9

Karim Guirguis	001307668
David Hemms	001309228
Marko Laban	001300989
Curtis Milo	001305877
Keyur Patel	001311559
Alexandra Rahman	001305735

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1 Revisions

Table 1: LazyBots Table of Revisions

Date	Revision Number	Authors	Comments
November 24th, 2017	Revision 0	Karim Guirguis David Hemms Marko Laban Curtis Milo Keyur Patel Alexandra Rahman	-
March 6th, 2018	Revision 1	Karim Guirguis David Hemms Marko Laban Curtis Milo Keyur Patel Alexandra Rahman	Added the section to include the scope of the project as well as edited the FMEA table to include hazards that have been previously overlooked.

2 Introduction

2.1 Document Purpose

The purpose of this document is to identify the components of Alfred which could potentially have hazardous consequences, and either eliminate them or reduce its risk to an acceptable level. Hazard analysis should be performed for all the major phases of the software development lifecycle, including requirements, architectural design, detailed design, and actual code. In particular, this document will look at the hazardous potential when the system works correctly, as well as when the system works incorrectly.

Hazards will be identified based on hazards from similar systems, as well as any hazards that occur during development/lifecycle of the system.

For this report we will analyze the hazards which can be affected by our mechanical and software systems.

2.2 Scope

The system implemented is one that is meant to automate the dispensing of beverages to customers within a restaurant at the respective customers' table. The customer will be able to order a drink from their table which will be followed by Alfred arriving at their table and dispensing the requested drinks. The staff will be able to request Alfred to return to a Home Base for charging and refilling when desired.

2.3 Definitions

System Hazard	The system is in a condition/state from which an accident can occur.
Accident	Unplanned event which can lead to unacceptable consequences.
Risk	A measure that combines the likelihood that a system hazard will happen, the likelihood that an accident will happen, and the severity of the worst potential accident.
Critical System	System whose failure can lead to unacceptable consequences.
Safety Critical System	A critical system whose failure can lead to injury, death, or environmental damage.

3 Component Overview

The components can be divided into the following ten components:

3.1 Drink Ordering System

An android application that allows customers and consumers to order drinks. The order is then relayed to Alfred.

3.2 Login System

A web application that allows users such as administrators or servers to login into the system and modify the restaurant map or close orders.

3.3 Administrative Map System

An android application that allows an administrator to change the layout of the restaurant. This map is then relayed to Alfred.

3.4 Error Management System

An application that allows users and administrators to view and track ongoing issues with Alfred. Users can also close issues once they have been resolved.

3.5 Backend Server System

The backend server serves as a method of communication between Alfred and other applications and components.

3.6 Alfred Manager System

This system serves as Alfred's drink order manager. The system will place the orders in a queue and assign them to the corresponding table number so that Alfred may complete the drink order.

3.7 Drivetrain Subsystem

This is the basic mechanical and electrical components of Alfred that allow motion and movement.

3.8 Alfred Pumping System

The system that deals with the fluid dynamics. Receives necessary information from Alfred Manager System to dispense correct type of drink, with the correct amount for the corresponding table.

3.9 Image Processing Subsystem

Alfred will be utilizing this subsystem to assure that all pathways are clear and to relay better error reports in case on an accident.

4 Safety Considerations

4.1 Drink Ordering System

Software Issues:

- An order is not sent within the desired time

Hardware Issues:

- None

4.2 Login System

Software Issues:

- The ability to perform attacks the server software to prevent access to the system
- The ability to perform attacks the server software to pose as store manager
- The ability to snoop information in order to obtain information about clients
- The ability to attack the system by injecting code

Hardware Issues:

- Server is not able to perform functionality to properly verify users due to internet issues or component failure

4.3 Administrative Map System

Software Issues:

- The ability to inject false information while data is being transferred to the server

Hardware Issues:

- Computer is not able to perform functionality due to internet issues or component failure

4.4 Error Management System

Software Issues:

- Errors are injected into the communication to be able to provide incorrect information to the manager's system
- Errors are not received within the desired time

Hardware Issues:

- Computer is not able to perform functionality due to internet issues or component failure

4.5 Backend Server System

Software Issues:

- The ability to perform attacks the server to prevent access to the system
- The ability to perform attacks the server system to pose as a manager or administrator
- The ability to snoop information in order to obtain information about clients
- The ability to attack the system by injecting code
- Issues with response and processing time of the subsystem

Hardware Issues:

- Server is not able to perform functionality to properly verify users due to internet issues or component failure

4.6 Alfred Manager System

Software Issues:

- Attacks where incorrect drink orders are sent to Alfred

Hardware Issues:

- Issues within micro-controller that would prevent computation functionality
- Issues such as faulty wiring or noise would prevent proper communication to the drink subsystem

4.7 Drivetrain Subsystem

Software Issues:

- Correct command to the motor is obtained and is regulated for things such as slew rates and max capacities
- The system is within a stable control state of operation and if not the ensuring that there is no motion
- Detection of obstacles blocking Alfred's path of motion

Hardware Issues:

- Encoders are operating within the normal suggested operating range
- Motors are performing the correct path of motion based on the control systems specifications
- Motors are performing within the recommended operating range
- Ultrasonic sensors are providing information within the recommended operating range
- Electrical components being leaked on by liquid storage devices
- Insufficient power is supplied from the battery to the drive system

4.8 Alfred Pumping System

Software Issues:

- The software system is not able to validate command from the Alfred manager system

Hardware Issues:

- There is a leak within the pumping system
- There is a leak within the storage of the liquids
- Alfred is not able to pump liquid using the pump
- Micro-controller is not able to receive information due to broken communication lines
- Micro-controller components fail and is not able to process drink request

4.9 Image Processing Subsystem

Software Issues:

- The software image processing Library is not able to properly process the image due to poor lighting conditions

Hardware Issues:

- The image is not able to be captures properly due to a broken or blocked camera
- Micro-controller processor is broken and not able to perform functionality

5 Correlation Between Hazard Functions and Requirements

Hazard Function	Functional and Non-Functional Requirement
F1: Movement of Alfred	Alfred Functional Requirement 3 Alfred Functional Requirement 10 Alfred Functional Requirement 11 Alfred Functional Requirement 12 Non-Functional Requirement 11 Non-Functional Requirement 13 Non-Functional Requirement 16 Non-Functional Requirement 18 Non-Functional Requirement 20

Table 3: Correlation between Hazard Function 1 and Requirements

Hazard Function	Functional and Non-Functional Requirement
F2: Correlates drink order to correct table	Alfred Functional Requirement 1 Alfred Functional Requirement 2 Alfred Functional Requirement 4 Alfred Functional Requirement 8 Alfred Functional Requirement 14 Table Ordering Functional Requirement 2 Non-Functional Requirement 14 Non-Functional Requirement 15

Table 4: Correlation between Hazard Function 2 and Requirements

Hazard Function	Functional and Non-Functional Requirement
F3: Navigates to table successfully	Alfred Functional Requirement 3 Alfred Functional Requirement 10 Non-Functional Requirement 11 Non-Functional Requirement 13 Non-Functional Requirement 16 Non-Functional Requirement 20

Table 5: Correlation between Hazard Function 3 and Requirements

Hazard Function	Functional and Non-Functional Requirement
F4: Dispense correct drink for the order	Alfred Functional Requirement 1 Alfred Functional Requirement 2 Alfred Functional Requirement 4 Alfred Functional Requirement 6 Alfred Functional Requirement 9 Non-Functional Requirement 14 Non-Functional Requirement 17 Non-Functional Requirement 21 Non-Functional Requirement 26 Non-Functional Requirement 31 Non-Functional Requirement 33

Table 6: Correlation between Hazard Function 4 and Requirements

Hazard Function	**Functional and Non-Functional Requirement**
F5: Dispense correct amount	Alfred Functional Requirement 1 Alfred Functional Requirement 2 Alfred Functional Requirement 4 Alfred Functional Requirement 5 Alfred Functional Requirement 8 Alfred Functional Requirement 9 Non-Functional Requirement 12 Non-Functional Requirement 19 Non-Functional Requirement 21

Table 7: Correlation between Hazard Function 5 and Requirements

Hazard Function	**Functional and Non-Functional Requirement**
F6: Determine when liquids are not the correct temperature	Alfred Functional Requirement 6 Alfred Functional Requirement 7 Administration Functional Requirements 5 Non-Functional Requirement 17 Non-Functional Requirement 25 Non-Functional Requirement 34 Non-Functional Requirement 35

Table 8: Correlation between Hazard Function 6 and Requirements

Hazard Function	**Functional and Non-Functional Requirement**
F7: Notify staff when errors or warnings occur	Alfred Functional Requirement 6 Alfred Functional Requirement 7 Alfred Functional Requirement 8 Alfred Functional Requirement 10 Alfred Functional Requirement 11 Administration Functional Requirement 4 Non-Functional Requirement 26 Non-Functional Requirement 27 Non-Functional Requirement 31 Non-Functional Requirement 33

Table 9: Correlation between Hazard Function 7 and Requirements

Hazard Function	**Functional and Non-Functional Requirement**
F8: Determine when liquid supply is lower than desired level	Alfred Functional Requirement 7 Alfred Functional Requirement 8 Alfred Functional Requirement 9 Administration Functional Requirement 5 Non-Functional Requirement 22

Table 10: Correlation between Hazard Function 8 and Requirements

Hazard Function	Functional and Non-Functional Requirement
F9: Moving the liquid storage containers	Alfred Functional Requirement 10 Non-Functional Requirement 1 Non-Functional Requirement 13 Non-Functional Requirement 18 Non-Functional Requirement 22

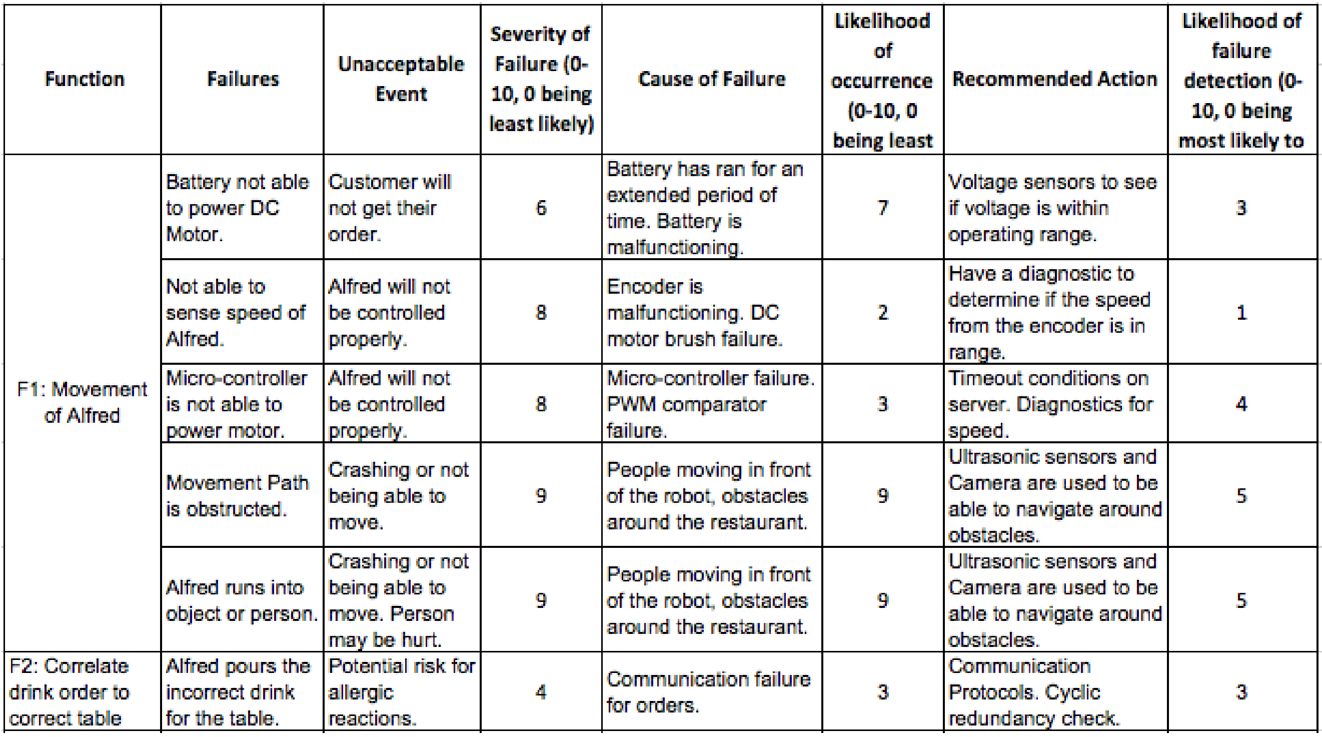
Table 11: Correlation between Hazard Function 9 and Requirements

Hazard Function	Functional and Non-Functional Requirement
F10: Dispense drink for the customer	Alfred Functional Requirement 1 Alfred Functional Requirement 2 Alfred Functional Requirement 3 Alfred Functional Requirement 4 Alfred Functional Requirement 6 Alfred Functional Requirement 8 Alfred Functional Requirement 9 Alfred Functional Requirement 10 Table Ordering Functional Requirement 2 Non-Functional Requirement 11 Non-Functional Requirement 12 Non-Functional Requirement 13 Non-Functional Requirement 14 Non-Functional Requirement 16 Non-Functional Requirement 17 Non-Functional Requirement 19 Non-Functional Requirement 20 Non-Functional Requirement 21 Non-Functional Requirement 26 Non-Functional Requirement 31 Non-Functional Requirement 33

Table 12: Correlation between Hazard Function 10 and Requirements

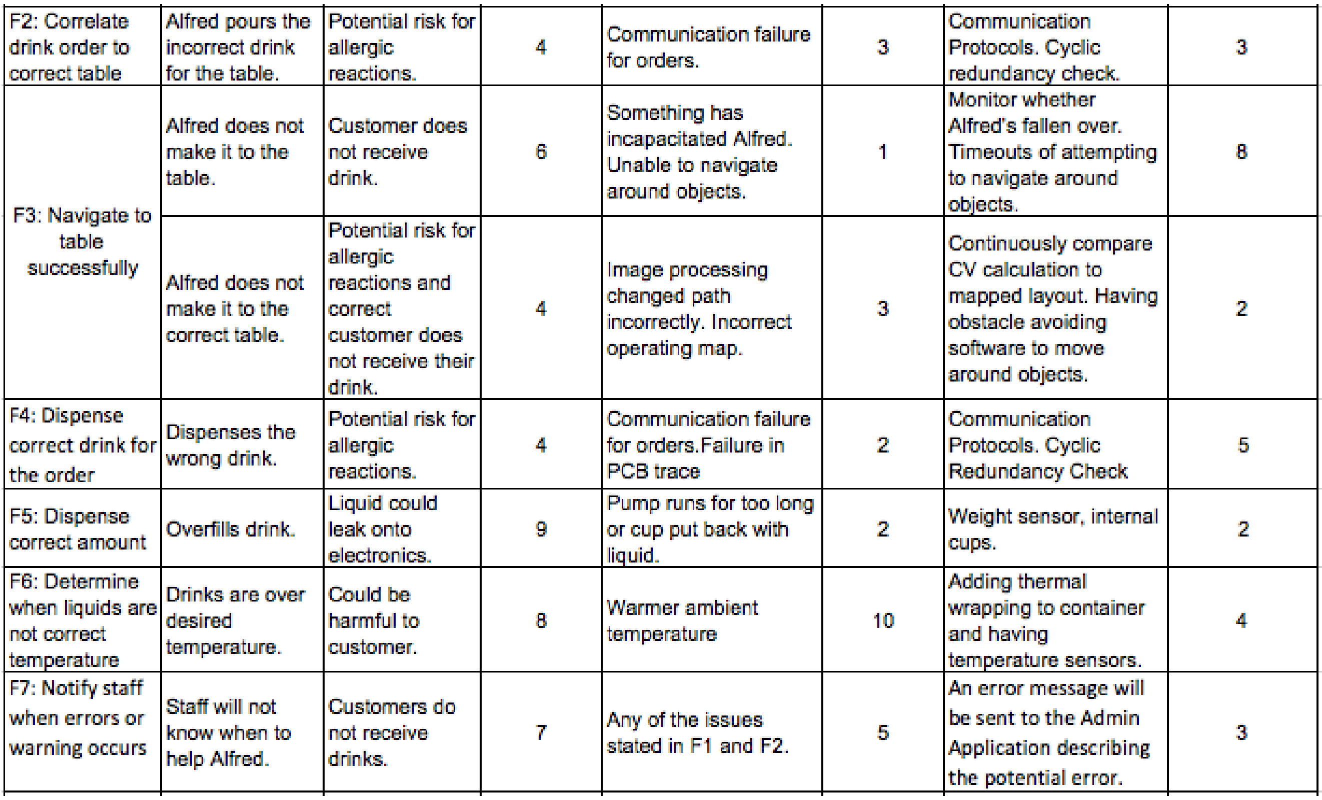
6 FMEA Worksheet

The following is a breakdown of the failure modes and effects analysis, or FMEA table. A hazard function will be presented with the possible failures, the unacceptable events that could occur should said failure occur, the severity of the failure, the possible cause of said failure, the likelihood of the failure, recommended action and the likelihood of failure detection.



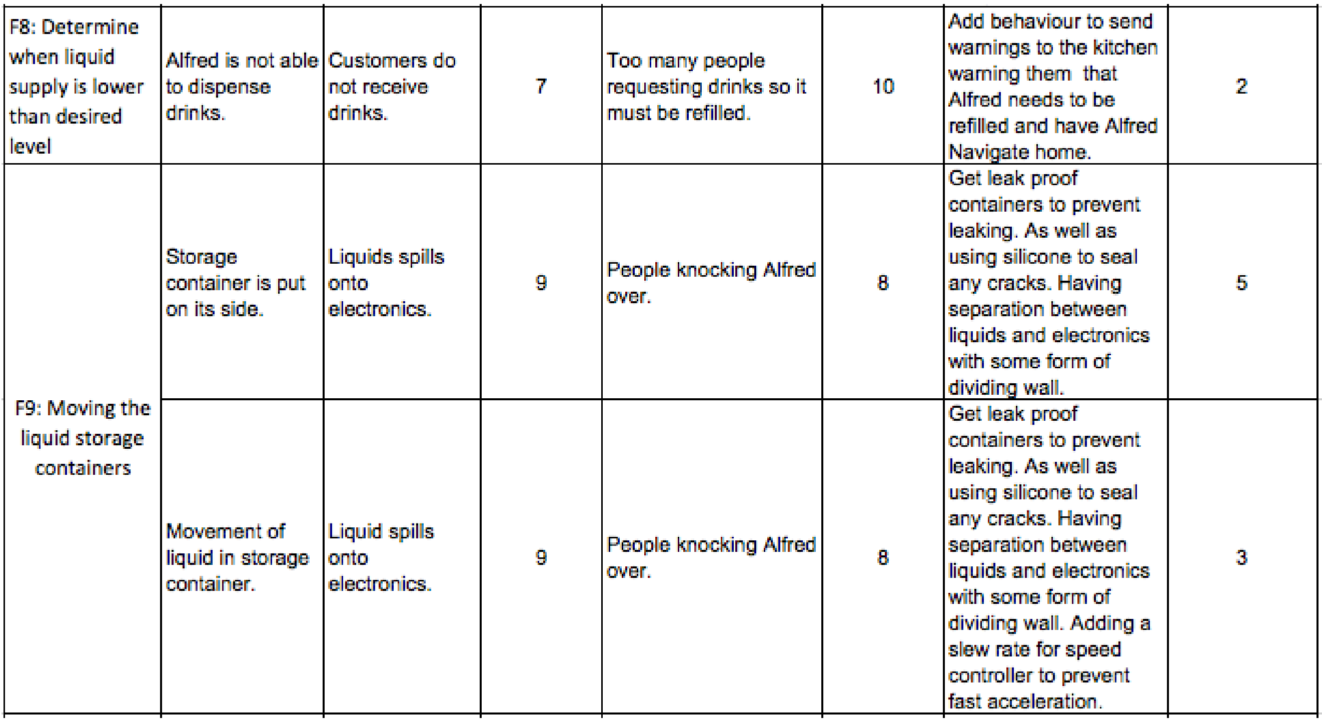
Function	Failures	Unacceptable Event	Severity of Failure (0-10, 0 being least likely)	Cause of Failure	Likelihood of occurrence (0-10, 0 being least	Recommended Action	Likelihood of failure detection (0-10, 0 being most likely to
F1: Movement of Alfred	Battery not able to power DC Motor.	Customer will not get their order.	6	Battery has ran for an extended period of time. Battery is malfunctioning.	7	Voltage sensors to see if voltage is within operating range.	3
	Not able to sense speed of Alfred.	Alfred will not be controlled properly.	8	Encoder is malfunctioning. DC motor brush failure.	2	Have a diagnostic to determine if the speed from the encoder is in range.	1
	Micro-controller is not able to power motor.	Alfred will not be controlled properly.	8	Micro-controller failure. PWM comparator failure.	3	Timeout conditions on server. Diagnostics for speed.	4
	Movement Path is obstructed.	Crashing or not being able to move.	9	People moving in front of the robot, obstacles around the restaurant.	9	Ultrasonic sensors and Camera are used to be able to navigate around obstacles.	5
	Alfred runs into object or person.	Crashing or not being able to move. Person may be hurt.	9	People moving in front of the robot, obstacles around the restaurant.	9	Ultrasonic sensors and Camera are used to be able to navigate around obstacles.	5
F2: Correlate drink order to correct table	Alfred pours the incorrect drink for the table.	Potential risk for allergic reactions.	4	Communication failure for orders.	3	Communication Protocols. Cyclic redundancy check.	3

Figure 1: FMEA Table Part 1



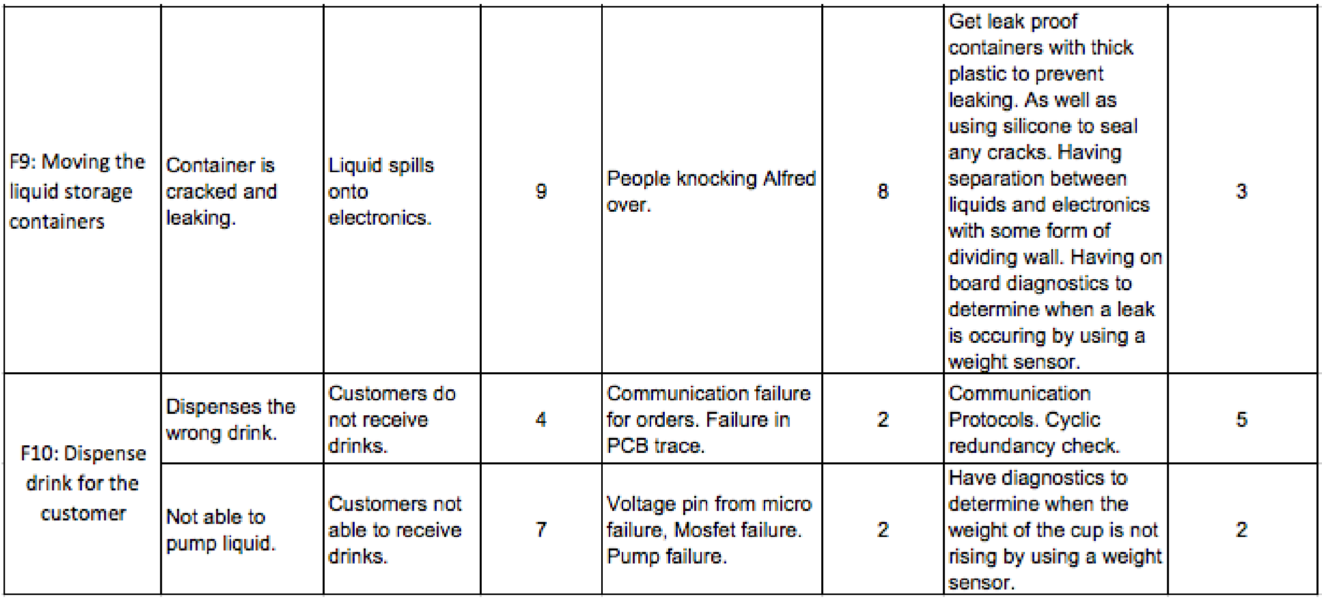
F2: Correlate drink order to correct table	Alfred pours the incorrect drink for the table.	Potential risk for allergic reactions.	4	Communication failure for orders.	3	Communication Protocols. Cyclic redundancy check.	3
F3: Navigate to table successfully	Alfred does not make it to the table.	Customer does not receive drink.	6	Something has incapacitated Alfred. Unable to navigate around objects.	1	Monitor whether Alfred's fallen over. Timeouts of attempting to navigate around objects.	8
	Alfred does not make it to the correct table.	Potential risk for allergic reactions and correct customer does not receive their drink.	4	Image processing changed path incorrectly. Incorrect operating map.	3	Continuously compare CV calculation to mapped layout. Having obstacle avoiding software to move around objects.	2
F4: Dispense correct drink for the order	Dispenses the wrong drink.	Potential risk for allergic reactions.	4	Communication failure for orders.Failure in PCB trace	2	Communication Protocols. Cyclic Redundancy Check	5
F5: Dispense correct amount	Overfills drink.	Liquid could leak onto electronics.	9	Pump runs for too long or cup put back with liquid.	2	Weight sensor, internal cups.	2
F6: Determine when liquids are not correct temperature	Drinks are over desired temperature.	Could be harmful to customer.	8	Warmer ambient temperature	10	Adding thermal wrapping to container and having temperature sensors.	4
F7: Notify staff when errors or warning occurs	Staff will not know when to help Alfred.	Customers do not receive drinks.	7	Any of the issues stated in F1 and F2.	5	An error message will be sent to the Admin Application describing the potential error.	3

Figure 2: FMEA Table Part 2



F8: Determine when liquid supply is lower than desired level	Alfred is not able to dispense drinks.	Customers do not receive drinks.	7	Too many people requesting drinks so it must be refilled.	10	Add behaviour to send warnings to the kitchen warning them that Alfred needs to be refilled and have Alfred Navigate home.	2
F9: Moving the liquid storage containers	Storage container is put on its side.	Liquids spills onto electronics.	9	People knocking Alfred over.	8	Get leak proof containers to prevent leaking. As well as using silicone to seal any cracks. Having separation between liquids and electronics with some form of dividing wall.	5
	Movement of liquid in storage container.	Liquid spills onto electronics.	9	People knocking Alfred over.	8	Get leak proof containers to prevent leaking. As well as using silicone to seal any cracks. Having separation between liquids and electronics with some form of dividing wall. Adding a slew rate for speed controller to prevent fast acceleration.	3

Figure 3: FMEA Table Part 3



F9: Moving the liquid storage containers	Container is cracked and leaking.	Liquid spills onto electronics.	9	People knocking Alfred over.	8	Get leak proof containers with thick plastic to prevent leaking. As well as using silicone to seal any cracks. Having separation between liquids and electronics with some form of dividing wall. Having on board diagnostics to determine when a leak is occuring by using a weight sensor.	3
F10: Dispense drink for the customer	Dispenses the wrong drink.	Customers do not receive drinks.	4	Communication failure for orders. Failure in PCB trace.	2	Communication Protocols. Cyclic redundancy check.	5
	Not able to pump liquid.	Customers not able to receive drinks.	7	Voltage pin from micro failure, Mosfet failure. Pump failure.	2	Have diagnostics to determine when the weight of the cup is not rising by using a weight sensor.	2

Figure 4: FMEA Table Part 4