Alpha Vending Solutions

B39VS Systems Project 2017

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1 Introduction

The aim of this project was to build an autonomous system for the sorting and dispensing of coloured blocks, representing snacks, to enter into a bid for a production contract from “Snack-o-Mat”, a company producing intelligent solutions for sensor-based snack delivery systems. The fundamental requirement of the system was to read in a card indicating what colour of block the user is “allergic” to, and to dispense a requested number of blocks excluding the designated allergen colour.

The team producing this product was comprised of members from multiple nationalities and experience levels, none of whom had encountered one another prior to developing the product. The team was also a mixture of students from different courses, other Heriot-Watt campuses, and direct entrants into 3rd year at the university. From these disparate backgrounds, with no team members having an initial understanding of one another’s skills or working practices, the formation of a team with clearly defined roles, working in multiple languages to successfully deliver the product, is one of the key achievements of this project.

Team members were presented with engineering challenges not directly related to previous technical/ theoretical course content, and acquisition of the knowledge required to overcome these challenges was left to the individual. As a result, over the life cycle of the project, the skills of team members in areas such as problem solving, planning, and designing were greatly expanded via working to deliverables and self-set goals and deadlines. The technical skills of the team in areas such as software/digital programming, analogue electronics, and mechanical construction were also developed via the problem-based learning involved in meeting the spec.

2 Mechanical Design

2.1 Initial design

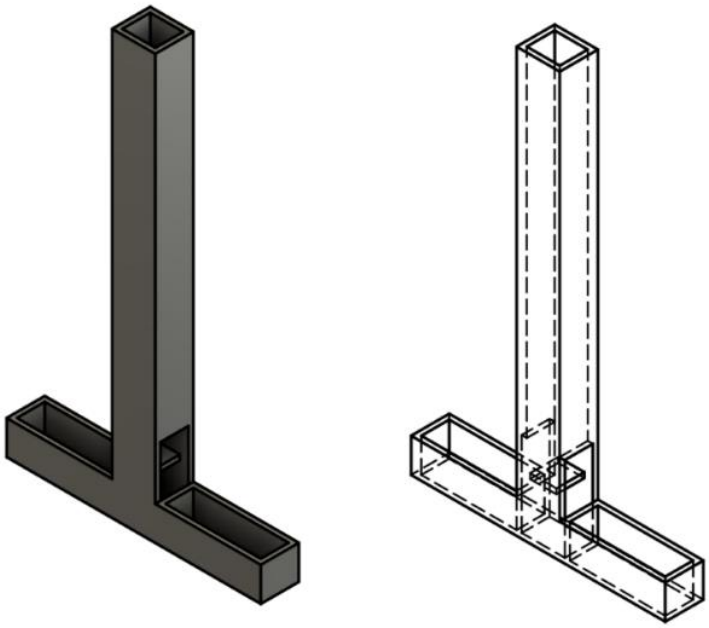

Figure 2-1: Initial Design Isometric View

Fig. 2-1 shows the initial design of the project, intended to be the simplest and easiest to construct, as well as the lowest-cost design if funding were considered. It has only three main sections, the storage tower, sorting platform and accept/reject trays. The upside-down "T" design requires only one servo to sort the bricks into either the accept or reject tray. Attention was paid to the diameter of the storage tower to ensure blocks could travel through it and not become jammed.

See *Appendix 9-1* for the full design.

2.1.1 Initial build

For the first session in the workshop, the aim was to build an initial prototype using wood. No servos or sensors were put into this prototype as it was purely used to determine the suitability of the design. It was discovered that one sorting platform was not able to sort the accepted or rejected bricks quickly enough. The initial design also intended for the colour senor to be placed at the top of the machine and read the blocks as they fell past it under gravity. However, testing of the sensor found that it was not able to accurately read the colour of a block traveling past it at speed. It was concluded that although the basic design allowed for flow of blocks through the machine, changes were required for the machine to give stable and fully functional results.

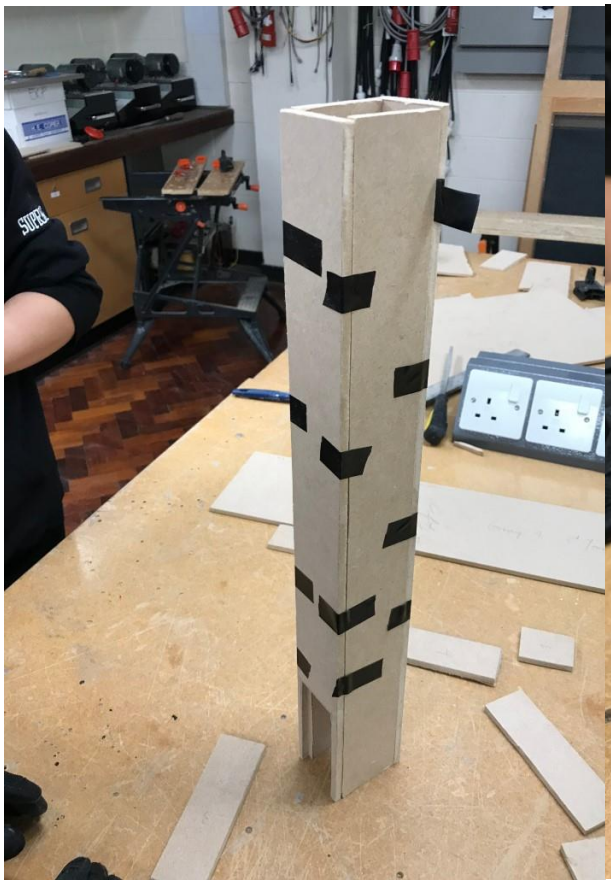

Figure 2-2: Initial Design Build

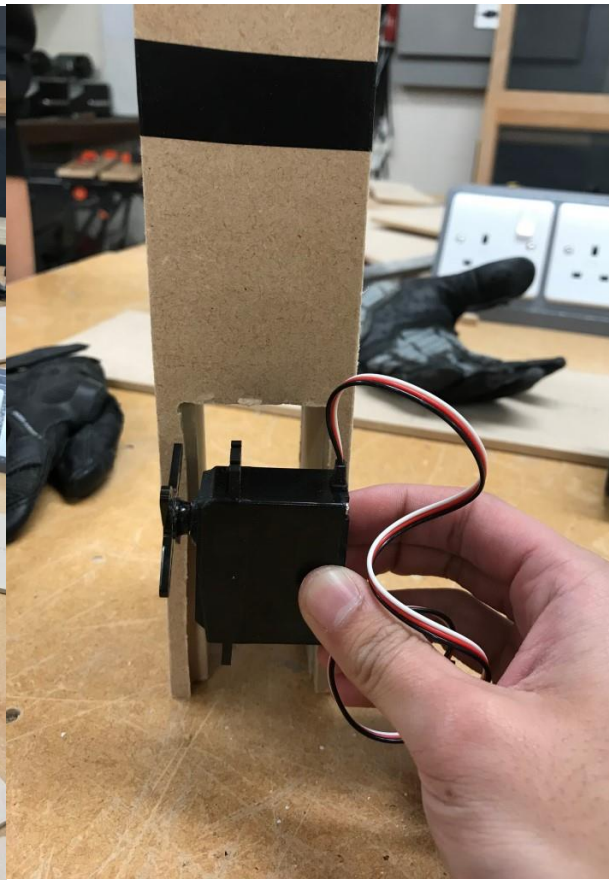

Figure 2-3: Initial Design Servo Placement

2.1.2 Changing design

The first prototype assisted in finding the flaws in the initial design. For increased efficiency, a second storage tower was added, and a block sorting platform was placed above them, able to tilt left or right under servo control to feed blocks into the two towers. Another design flaw was that the storage towers did not channel the blocks correctly as it was not fit to size, allowing them to spin and change position as they fell into it. The tower design had to be narrowed to resolve this issue. A third change was to design a dispensing platform at the bottom of each tower with a rod or “kicker” moving to push the blocks into either the accept or reject trays.

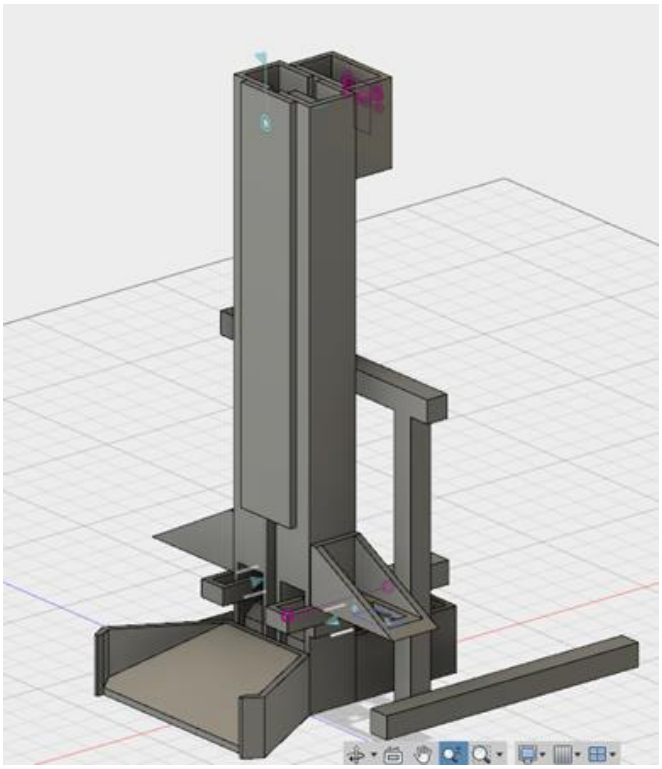

Figure 2-4: Final Design Isometric

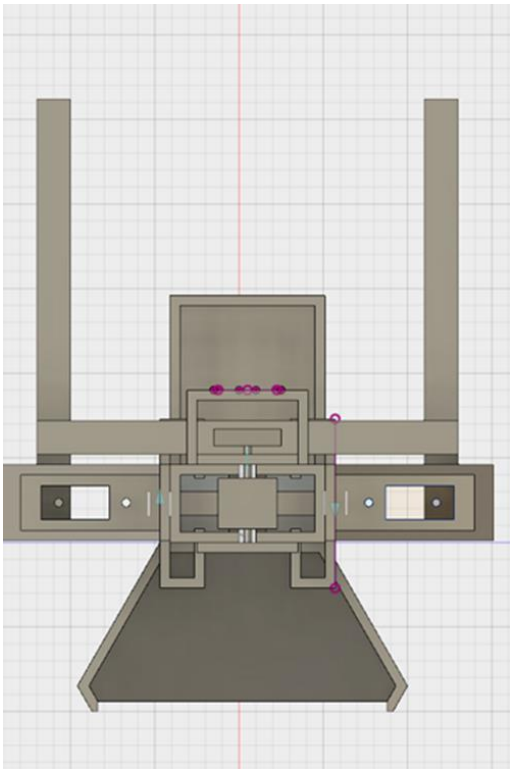

Figure 2-5: Final Design Plan View

2.1.3 Changing build

The second prototype included the new colour sorting platform and dispensing kickers. During testing of this prototype, the kickers were found to be unreliable in dispensing the blocks and for keeping the blocks in position after falling into the storage tower and into the dispensing position. The first kicker design involved them pivoting around a fixed point, but this was not adequate for reliable dispensing and, so they were changed to laterally-moving rods.

2.2 Final design

A shell frame for mounting of the FPGA and MBED boards was also constructed at the back of the device, and the kicker design was modified to move parallel to the ground. The part of the kicker that meets the blocks was changed to a triangular shape, which assisted in positioning the blocks as they fell through the tower onto the dispensing platform. See *Appendix 9-2* for the full design.

2.2.1 Final build

Based on the final design, the machine was added the base platform and metal brackets to make sure the entire machine can sit on a flat surface. The metal brackets also created the spaces for the MBED, FPGA and power supply. The new lateral kickers were built using a rack-and-pinion system to transfer power from the rotating servos, and fitted beside the towers on the metal brackets. In the final build, three servos were used - one in the colour sorting platform and two powering the kickers. The Colour sensor was also fitted above the colour sorting platform. After we made sure the machine was fully functional, we built the case to cover the machine to improve its appearance. The card reader was set up on the right-hand side of the case (as seen by the user) and no lid was included to ease loading of blocks on demonstration day.

Figure 2-6: New Design Kicker Back

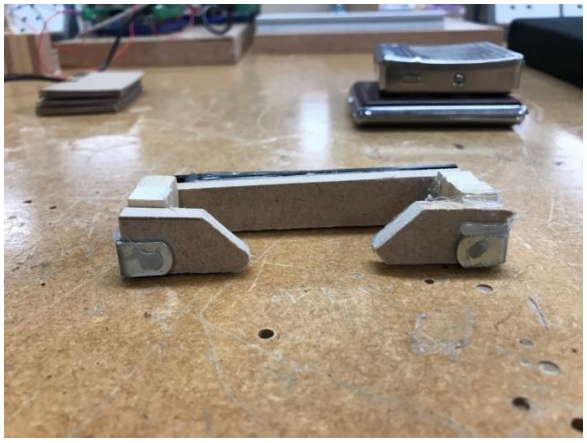

Figure 2-7: New Design Kicker Front

Figure 2-8: Final Design Assembly

Figure 2-9: Final Design Rear Support Arms

Figure 2-10: Final Design Servo and Kicker Placement

Figure 2-11: Final Design Upper Servo and Sorting Platform Placement

Figure 2-12: Final Design Enclosure

2.3 Conclusion

To summarise the mechanical design and workshop building, it was an informative process to learn about designs not directly translating into working models and requiring modification. Sticking too closely to the initial plan can run the risk of blinding the team to design changes during implementation. However, the design was just a way to express ideas and was not necessarily expected to work first time. Our method for designing and building the product was to keep an open mind about changes to the design and continually update it as required.

For this project, we also had a principle about using less materials to build an efficient machine. For this vending machine, we mainly used wood as a construction material. Hot glues and metal brackets were the materials to mount the main body on the platform and make it stable. Four gears and two servos helped the kickers work, colour sensor and one servo make the colour sorting platform work in the expected way.

3 Digital Design

The Verilog system designed for the Field Programmable Gate Array (FPGA) must be able to accomplish two main features;

1. Receive Commands from the MBED Development Board
2. Operate Servos Biased on those commands

The FPGA will need to operate under in two modes, Maintenance and Operational modes. The maintenance mode will allow the FPGA to receive commands to directly drive the servos. The operate mode will have the FPGA running a state machine to dispense the required snacks.

The commands will be sent from the MBED by a Serial UART (Universal Asynchronous Receiver and Transmitter), commands will be decoded and sent to the module expecting those commands. The commands will be sent as a Hexadecimal byte to the FPGA.

Command	Description
XX	Servo Command: Value Between 11 to DD
EE	All Servo to Maximum Position
00	All Servo to Minimum Position
AA	Enter Sort Mode
BB	Enter Dispense Mode
Sort Commands	**Description**
AA	Home Sort Servo
FF	Sort Complete
1F	Sort into Tower 1
F1	Sort into Tower 2
Dispense Commands	**Description**
99	Dispense Complete
BB	Home Tower Servos
FF	Dispense Both Towers
F8	Dispense Tower 1
08	Recycle Tower 1
8F	Dispense Tower 2
80	Recycle Tower 2
00	Recycle Both Towers

Table 3-1: FPGA Serial Commands

When there is no serial data received the FPGA will wait in an Idle State until data is received

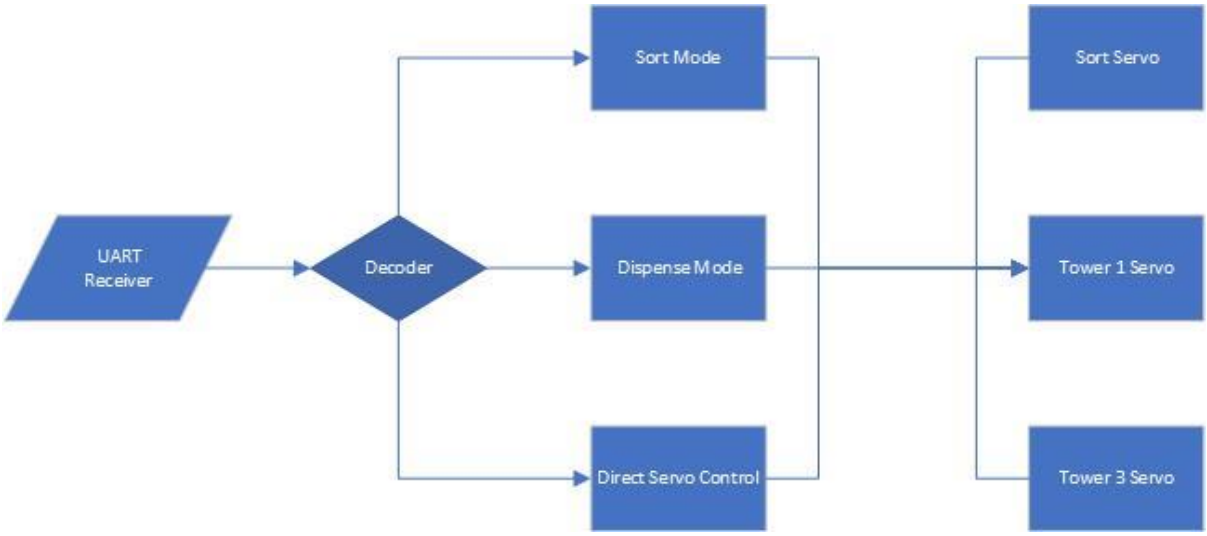

Figure 3-1: FPGA Flowchart

The decoder will decide where the signals from the UART Receiver are to be sent, for sort and Dispense modes the decoder will lock in the path allowing further commands from the UART Receiver to pass directly through to the required module until the relevant stop commands are received for the modules.

The Direct Servo Control Module disassembles the incoming serial data as two hexadecimal nibbles, half a byte, for the servo number and servo position. The servo driver modules take a 8-bit input, so the nibble has four zero bits added onto the end to convert it into eight bit, or byte.

```
1.  begin
2.      en <= 0;
3.      sv_no  = rx_data[7:4];
4.      sv_pos = rx_data[3:0];
5.
6.      case(sv_no)
7.          4'b0001:
8.          begin
9.              sv1_pos = {sv_pos, 4'b0000}; //Servo1 Data Recieved
10.             state_c = IDLE;
11.         end
```

Source Code 3-1: Verilog Servo Direct Controller

The case is repeated for all six available servo drivers, and with two special cases for all maximum and minimum. Once the servo position has been set, the systems returns into the idle state waiting on another instruction from the UART Receiver. The nibble available for driving the servo position results in an increased step angle from the byte driver.

$$\frac{Range\ of\ Motion}{Steps} = \frac{180}{255} = 0.7°\ per\ step$$

$$\frac{Range\ of\ Motion}{Steps} = \frac{180}{240} = 0.75°\ per\ step$$

This increased angle per step did not have any noticeable effect on the operation of the system.

3.1 Servo Driver Module

The Servo Driver takes an eight-bit value to determine the position of the servo. For 180-degree motion servos require a pulse between 0.5ms and 2.5ms at a frequency of 50MHz.

To derive the output, a second clock signal need to be generated which has a period of the change in output pulse divided by the steps used.

$$\frac{Change\ in\ Pulse}{Steps} = \frac{2ms}{256} = 7.8\mu s$$

To generate this clock from the existing 50MHz clock a counter is created to roll over to zero every $7.8\mu s$. the value of this counter is determined by dividing the period of the new clock by the period of the existing clock.

$$\frac{New\ Clock\ Period}{Existing\ Clock\ Period} = \frac{7.8\mu s}{20ns} \approx 390$$

This counter is incremented at every existing clock rising edge, therefore after 390 rising clock edges $7.8\mu s$ will have passed. When this counter reaches 390 a register is set high for one existing clock pulse, this is the new clock which will be used to determine the servo pulse output.

The servo output pulse has a period of 20ms, the pulses must start at intervals of 20ms. A second counter is used and will increment on the new clock pulse, the size of this counter is the servo period by the new clock period.

$$\frac{Servo\ Period}{New\ Clock\ Period} = \frac{20ms}{7.8\mu s} \approx 2564$$

This counter will provide the timings for the output signal, as the counter increments every $7.8\mu s$. This is done by setting the servo pulse as high for when below a certain value of the counter and low for the rest of the counter. The values for which the signal output is lower than the counter is given as;

$$\frac{Pulse\ Width\ Minumum}{New\ Clock\ Period} = \frac{0.5ms}{7.8\mu s} \approx 64$$

$$\frac{Pulse\ Width\ Maximum}{New\ Clock\ Period} = \frac{2.5ms}{7.8\mu s} \approx 320$$

As the values for maximum and minimum are separated by 256 steps, the value for driving the servo signal output is 64 added to the input byte. During testing 64 was found to be to large a value for the maximum value of the servo and caused overturning, the value was reduced to 50. This was most likely due to approximating timings during calculations

The Servo Output pulse can then be expressed as;

$$Servo\ Pulse\ Period = (50 + Input\ Byte) \times 7.8\mu s$$

Which gives us the range of

Input Byte (Decimal)	Output Pulse Period
0	0.5ms
128	1.5ms
255	2.5ms

Table 3-2: Servo Pulse Timings

4 Software Design

4.1 Visual C# PC Graphical User Interface

The Maintenance software will be required to send and receive commands for the MBED, or FPGA during testing, and will be designed using Visual Studio and Visual C#. For ease of additional functionality, the main form was designed to be a Multiple Document Interface (MDI) which allows for additional forms to be added to the software to increase the functionality, whilst being contained within the main form. Communication with the embedded system will be handled by the Serial Port object within the C# environment

4.2 Maintenance Mode Design and Implementation

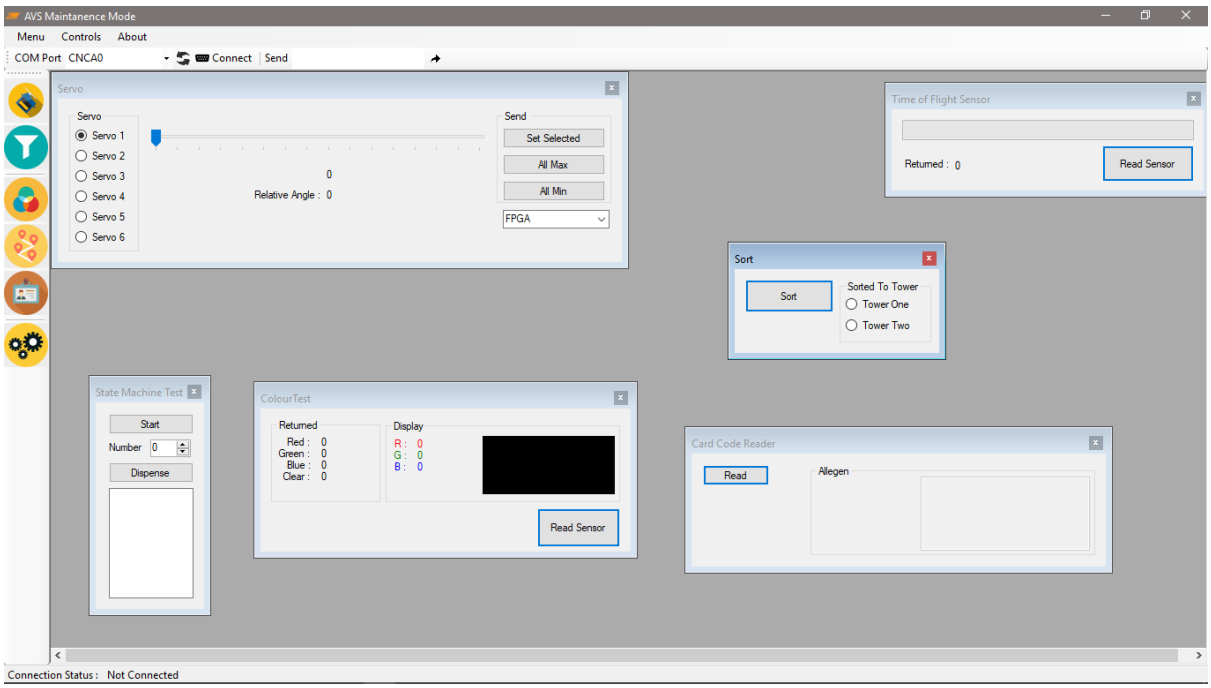

Figure 4-1: Main Form Design, Showing Child Forms

The main form consists of simple design elements including a Menu, Icon and Status Toolstrips. The main operation to be performed on the main form is to open to serial port, this is done through a Combo Box item which is updated with the active serial ports at the Form Load event and can be manually refreshed using the Refresh Button. The Icon Toolstrip has the functionality to send a text sting to the serial port, this was included for testing purposes of the Application. The status toolstrip is used to monitor the status of the serial port, and displays a label showing the open port number, or if the port was unable to be open; will display an error message.

For ease of use the main control forms can be opened from the icons on the left of the main form, along with two buttons for purging the two towers and homing all the servos.

To allow opening the other forms for sending formatted commands to the system a Menu Toolstrip tab was added with the buttons to open the forms. To allow the other forms to be able to communicate using the same serial port as is open within the main form the serial port as created in the main form, is passed to the additional forms as an argument. When the form is created it will have `MDI.parent` method set to be the main form, this creates an instance of the form within the

main form. To open the forms as single instance, a function is created to view the currently open forms and return a true if a form with the same name is open and a false if not.

```
1.  private bool IsOpen(String name)
2.          {
3.              foreach(Form frm in Application.OpenForms)
4.              {
5.                  if(frm.Name == name)
6.                  {
7.                      return true;
8.                  }
9.              }
10.             return false;
11.         }
12.         //Servo Control Window
13.         private void servoToolStripMenuItem_Click(object sender, EventArgs e)
14.         {
15.             Servo SVR = new Servo(sp)
16.             {
17.                 MdiParent = this,
18.                 Name = "servo"
19.             };
20.
21.             if (IsOpen("servo") == false)
22.             {
23.                 SVR.Show();
24.             }
25.
26.         }
```

Source Code 4-1: Single Instance Child Form

To allow the new form to be able to control the Serial Port which is passed to it from the main form, a new instance of a Serial Port Object must be created in the New form and set to the Serial Port which was passed to in.

```
1.  private SerialPort serial;
2.          public Servo(SerialPort port)
3.          {
4.              InitializeComponent();
5.              serial = port;
6.          }
```

Source Code 4-2: Passing Serial Port to Child Form

This allows all the child forms to be able to communicate over the same open serial port, without having to close the port and reopen within the newly open child form.

The majority of the functionality of the main form is with the Com Selection options. To be able to display available serial ports a method is created to scan the serial ports on the device and display them as items in a Combo Box, this is called when the form is loaded and when the manual refresh button is clicked.

To have the ability to connect to serial ports and be able to switch between them the event when the connect button is clicked must look at the currently selected item in the Combo Box and set the Serial Port Instances `PortName` property to it. The event will also set some other properties of the serial port. To allow the form to switch between serial ports the method looks to see if the serial port object is open and what `PortName` is currently set. Should the port be open

and the selected item in the Combo Box is not the current Port Name it will close the port and change the settings. If the port is not open it sets the `PortName` to the Combo Box selection.

```
1.  //Connect to serial port
2.  private void TS_BTN_ComCon_Click(object sender, EventArgs e)
3.  {
4.      string COMPort = TS_CMB_ComPort.Text.ToString();
5.      string cur_com = sp.PortName;
6.
7.      //If com port is close and new com port selected
8.      if (!sp.IsOpen && cur_com != COMPort)
9.      {
10.         //set the com port
11.         sp.PortName = COMPort;
12.     }
13.     //if teh com port is open and new com port selected
14.     else if (sp.IsOpen && cur_com != COMPort)
15.     {
16.         //close the port and set new port name
17.         sp.Close();
18.         sp.PortName = COMPort;
19.     }
20.
21.     //set serial port properties
22.     sp.ReadTimeout = READ_TIMEOUT;
23.     sp.BaudRate = Baud_rate;
24.
25.     //try to open serial port
26.     try
27.     {
28.         sp.Open();
29.     }
30.     catch
31.     {
32.         //if unable to open serial port display in status bar
33.         TS_LBL_Con.Text = "Unable to Open " + COMPort;
34.         TS_LBL_Con.ForeColor = Color.Red;
35.     }
36.
37.     //Display open com port and baud rate in status bar
38.     TS_LBL_Con.Text = COMPort + " @ " + Baud_rate.ToString() + " Open";
39.     TS_LBL_Con.ForeColor = Color.Green;
40. }
```

Source Code 4-3: Connecting to Serial Port

The functionality of the maintenance mode comes from the individual child forms which can be opened into the main form. They will be sending out commands to the MBED.

Command	Description	Expected Response
`S:n&p`	Servo Command	No Response
`G`	Sort	[0/1/2/3] Tower Sort and Error
`?`	System Query	[0/1] System State
`B`	Read Barcode	[X] Barcode Value
`?D`	Snack Query	[X] Number of Snacks Available in System
`D&n`	Dispense Snacks	[0/1] Dispense Error
`C`	Read Colour Sensor	[R&G&B&C] Sensor Reading from Colour Sensor
`T`	Read Time of Flight	[X] Time of Flight Sensor Value

Table 4-1: C# Serial Commands

4.2.1 Child Forms

4.2.1.1 Servo Controller

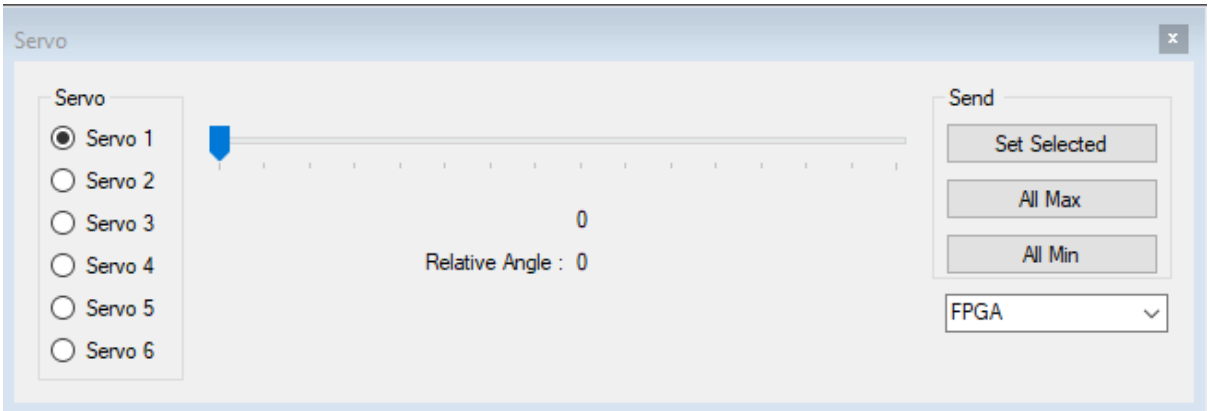

Figure 4-2: Servo Controller From

The Servo Control form uses a track bar to select the position of the servo and six radio buttons to select which servo is being controlled. There are three buttons for setting the selected servo with the value of the track bar, setting all the servos to their maximum position, and for setting all servos to their minimum position. To allow the FPGA to be directly connected to the computer an option for sending out the servo commands in a format required for the FPGA, or to send them out in the format required by the MBED.

4.2.1.2 Colour Sensor Test

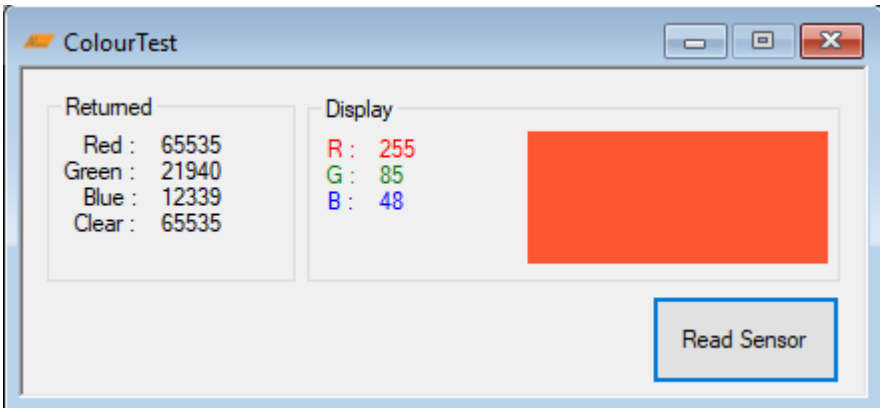

Figure 4-3: Colour Sensor Test Form

The Colour Sensor Test Form will send a command to the MBED to return the current reading from the colour sensor. The raw values from the colour sensor are decoded into RGB colour values and displayed on the form. The decoding is done using the clear value returned form the colour sensor.

$$RGB_{red} = \left[\frac{RAW_{red}}{RAW_{clear}}\right] \times 255$$

4.2.1.3 Barcode Reader

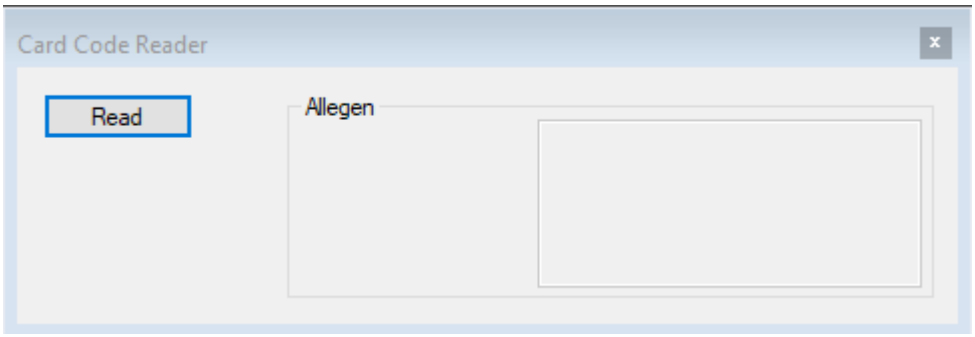

Figure 4-4: Barcode Reader From

The Barcode Reader form send a command to the MBED to read the value of the barcode inserted. The form will display the value of the barcode as the colour it represents.

4.2.1.4 Sort Controller

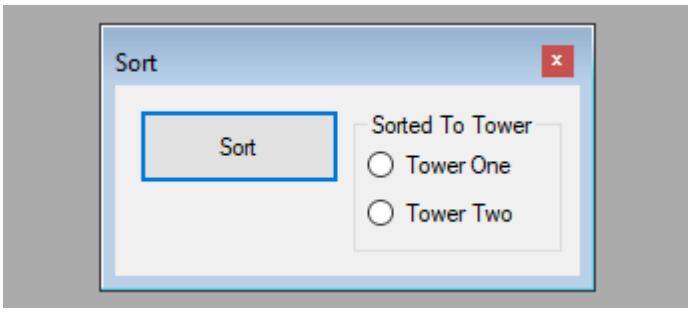

Figure 4-5: Sort Controller Form

The Sort Controller send the command to the MBED to sort the block currently in place, the Form displays which tower the block has been sorted into. Should there be an error in reading the colour of the block, an appropriate error message will be displayed and prompting the user to retry sorting the block.

4.2.1.5 Other Modules

Functionality for reading the value of the time of flight sensor was added, this form displays the current reading from the time of flight sensor and converts it to a physical distance in millimetres.

To simulate the functionality and process of the main application, a Machine Test form was added. This form would allow the user to operate the system in the same way as the main application, giving a readout of the serial commands send and responses from then to allow for debugging of the system.

4.3 Main Vending Application

The Main Vending application is used by the customer to select the number of snacks that thy want. The interface is designed for used on a touch screen device. There are two languages to select from, English and Spanish, this will change the language of both the text and the speech synthesizer.

Figure 4-6: Language Selection

To ensure that no user interaction is required upon starting the application, it will automatically connect to the seral port with the MBED connected. This is done by querying all the available comports with the Query Command for the MBED, "?". If the application finds the serial port which returns a value for this query it will automatically connect to that serial port.

```
1.  foreach(string p in SerialPort.GetPortNames())
2.              {
3.                  serial.ReadTimeout = 50;
4.                  try
5.                  {
6.                      serial.PortName = p;
7.                      serial.Open();
8.                      Thread.Sleep(20);
9.
10.                     Console.WriteLine("Trying Port " + p);
11.                     serial.WriteLine("?");
12.
13.                     string test_return = serial.ReadLine();
14.                     int t_return = int.Parse(test_return);
15.                     if (t_return == 0)
16.                     {
17.                         Console.WriteLine("MBED Connected To " + p);
18.                         break;
19.                     }
20.                     else
21.                     {
22.                         Console.WriteLine("MBED Not Connected to " + p);
23.                         serial.Close();
24.                     }
25.                 }
```

Source Code 4-4: Automatic Connection to Serial Port

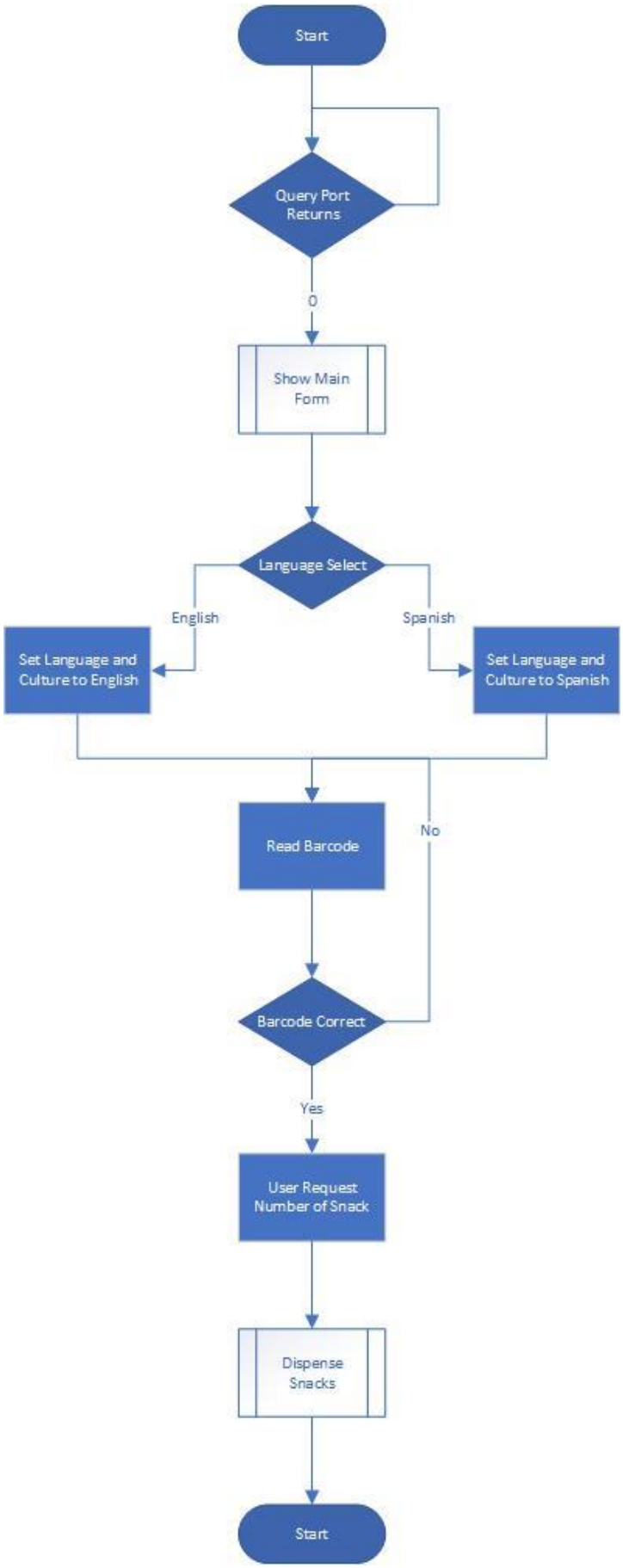

Figure 4-7: Operate Mode State Diagram

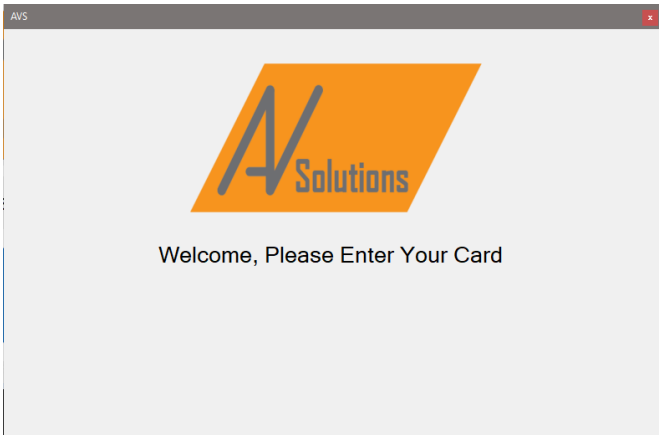

Figure 4-8: Welcome Screen

Once the user has selected their preferred language, the application will request for the use to enter their allergen card. At this point the application will send the Barcode command, "B", to the MBED and await the response.

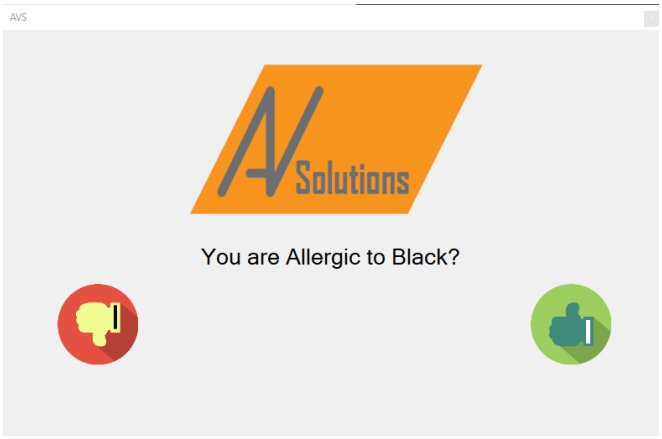

Figure 4-9: Allergy Confirmation

When the application has received a response from the MBED it will decode the value into it respective allergen colour. The user will then have to option to confirm that the displayed value is correct or not.

After the user has confirmed the card value is correct the application will ask the MBED how may snacks are available in the system which are not the value of the allergen. This value is used to set the value of the number-up-down box used for selecting the number snacks.

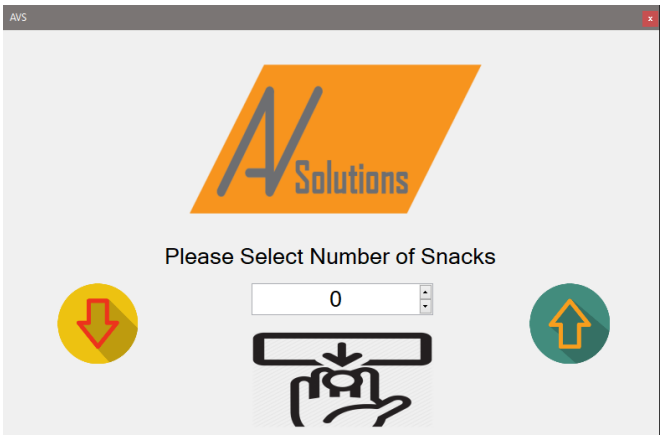

Figure 4-10: Snack Number Selection

The user can select up to the maximum value of snacks returned by the MBED. Once the user has selected the number of snacks and clicked dispense the application will request the MBED to dispense the required number of snacks.

If the MBED can dispense the number of snacks, the system will return to the start form ready for the next user.

4.3.1 Language Selection

To be able to change language for the whole application, a separate class was made to hold the languages. It makes use of a private variable and the Get a Set functions available in the C# Library. For this instead of defining the text for a label of speech synthesizer it is declared as the method of this class.

```
1.  class lang
2.  {
3.      private int lang_code;
4.      //Set Language
5.      public int Set_lang
6.      {
7.          get
8.          {
9.              return this.lang_code;
10.         }
11.         set
12.         {
13.             lang_code = value;
14.         }
15.     }
16.
17.
18.     //Greeting
19.     public string Greeting()
20.     {
21.         if(lang_code == 1)
22.         {
23.             return "Bienvenido, por favor ingrese su tarjeta";
24.         }
25.         return "Welcome, Please Enter Your Card";
26.     }
```

Source Code 4-5: Language Selection

4.4 MBED C++

The MBED processes data coming from the sensors and the visual interface. It then relays the system status back to the user interface and also sends the appropriate commands to the FPGA which drives the servos.

|

The MBED code was broken down into several functions that perform specific tasks such as detect colour, and a main function which calls upon these functions to perform sequences of tasks to achieve a goal. This section will describe the task specific functions first, then the main function.

4.4.1 ColAvg function

This function takes in the RGB and Clear values coming from the Colour Sensor. The RGB values are then converted from their raw values into value of the range 0 - 255. They were converted using the formula below, where colour can be Red, Green or Blue:

*rgb normalised colour value = (raw rgb colour value / raw_clear value) * 255*

$$RGB_{red} = \left[\frac{RAW_{red}}{RAW_{clear}}\right] \times 255$$

The new Red, Green and Blue values are checked against a set of ranges to determine what colour they represent. These ranges were calculated as described in Section 6. Sensor Systems.

Using these ranges the function will return one of the following:

Red, Green, Yellow, White, Black, Blue, Orange or Cannot Detect.

Cannot detect will be returned for RBG values that do not fall into one of the calibrated ranges.

4.4.2 Store function

This function stores the blocks into the towers. It takes a colour name as an argument. It fills up Tower 1 first with 12 blocks, then fills up tower 2 with 12 blocks. If both towers are full then it will return Max-Capacity Reached. As the blocks are stored into the two towers, they are stored in two string arrays called tower1array and tower2array, this allows us to keep track of the order and number of the blocks in the towers.

Function algorithm:

1. Set sorting platform to neutral position (0xAA command to FPGA)
    a. If tower 1 array contains less than 12 blocks
        i. Add block to tower1array
        ii. Sorting platform tips the block into tower1 (0x1F command to FPGA)
        iii. Wait 0.5 seconds, for sorting action to finish
        iv. Set sorting platform back to neutral position
    b. Else If tower 2 array contains less than 12 blocks and tower 1 is full
        i. Add block to tower2array
        ii. Sorting platform tips the block into tower2 (0xF1 command to FPGA)
        iii. Wait 0.5 seconds, for sorting action to finish
        iv. Set sorting platform back to neutral position
    c. Else If both towers are full
        i. Send 0xFF command to FPGA, to indicate both towers are full

4.4.3 Request Manageable function

This function is used to check if the number of snacks requested by the user can be fulfilled by the system. It takes into account the user's allergy as well.

First the function goes through tower1array (contents of tower 1) and checks how many allergic blocks it contains. Then the same is done for tower2array.

If the total number blocks in the system minus the number of blocks the user is allergic to is equal to or greater than the number of blocks the user requested, then the function returns true to indicate the request can be fulfilled. If the requested number of snacks cannot be fulfilled, then the function returns false.

4.4.4 Manageable Snacks function

This function counts the number of snacks the system can dispense to the user. It does not count the blocks the user is allergic to as they cannot be dispensed to the user.

It goes through tower 1 blocks first, and adds 1 to the count if it sees a block the user isn't allergic to. Then the same is done for tower 2. After all the blocks have been processed, the function returns an integer that represents the total number of snacks the system can currently dispense to the user.

4.4.5 Main

The main function sets the FPGA baud rate at 115200 as per the requirements of the FPGA in the system. Then the rest of the contents of the main function are enclosed in a while(1) loop, so it is always true. The main function consists of several case statements which invoke particular actions. These case statements are invoked by commands from the PC serial port.

Since the case statements are enclosed in an always true while loop, this means that the program is always listening to the PC serial port and waiting for commands form the PC. A summary of the commands is shown in the table below.

PC Command	Action
?	Sends out a 0 to the PC
D&{X}	Dispense X snacks - A smart adaptive algorithm, that minimizes the number of snacks recycled
C	Read and print out RGB values from colour sensor
G	Sort 1 block into the system
F	Sends out "communication works" to the PC
X	Prints out the output of the manageable_snacks function
Z	Prints out the contents of the towers
S	Moves the servos to a particular position
B	Activate card sensor

The rest if this section will describe in detail what each case statement in the main function does.

Case '?':

This case was made for testing purposes, when the MBED receives this command then the program sends a 0 through the PC serial port. We used the terminal on the PC to see this output coming from the MBED.

Case 'D&'{X}:

The "0xbb" command is sent to the FPGA to enter dispense mode.

The X is a placeholder for an integer, which is the number of snacks the user requested.

The towers have been given names Tower 1 and Tower 2 randomly, but each tower's naming is consistent throughout the program.

There a variable called dispensed which keeps track of the number of snacks dispensed, this is set to 0 initially. Then a check is made, to see if the requested snacks can be delivered by the system by calling the **request_ manageable** function. If the request_ manageable returns true, then a while(dispensed < requested) loop is entered (else "1" is sent to the PC serial port to indicate that the request is not possible). This will loop through the dispensing code until the requested number of snacks have been dispensed to the user. The dispensing loop is shown below:

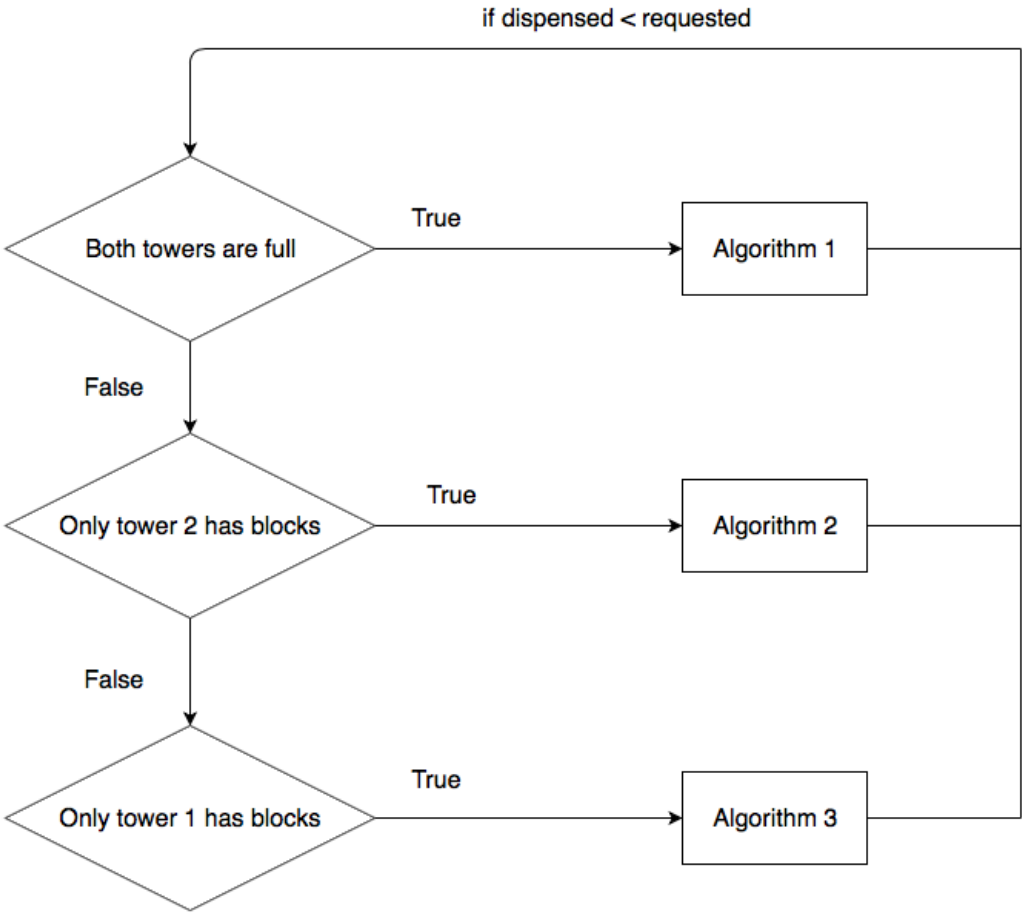

Figure 4-11: Dispensing Loop

Each time an algorithm is executed 1 block is dispensed to the user (2 blocks can be dispensed at the same time in Algorithm 1 in a special case, see description below), then the loop continues to check the new status of the towers and a new algorithm is selected. This loop continues until the requested number of snacks are dispensed.

Algorithm 1: This algorithm is chosen when both towers contain blocks. The algorithm works as follows:

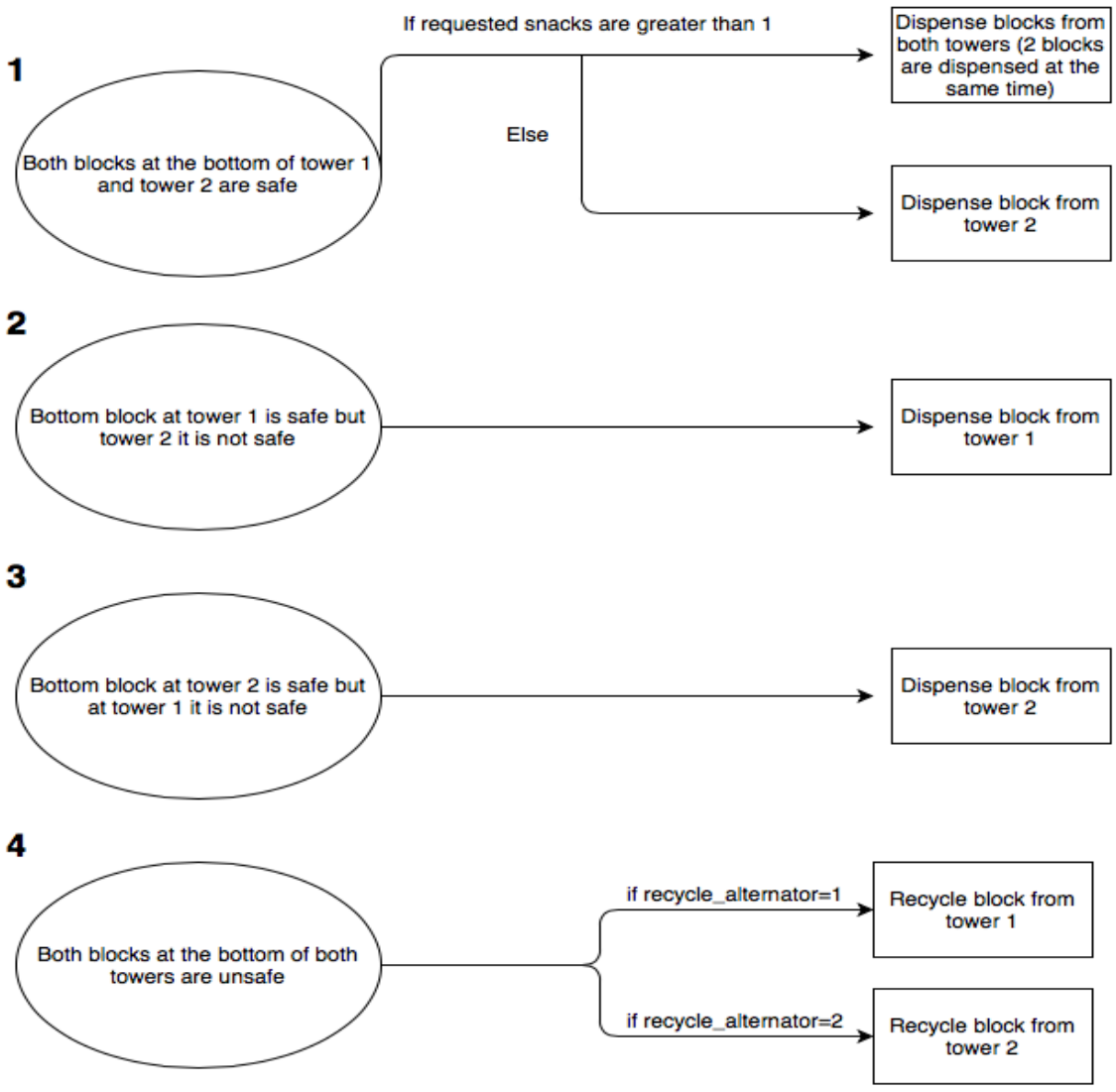

Figure 4-12: Algorithm 1

When the program enters this algorithm, it checks the status of the bottom blocks of each tower - block is safe if the user is not allergic to the block and unsafe if the user is allergic to the block. The actions that are taken are based on the 4 possible conditions the statuses of the blocks can be in.

1. When both the bottom blocks on both towers are safe, the program dispenses both the blocks from tower 1 and tower 2, if the requested number of blocks is greater than 1. We choose to dispense both blocks at the same time to **increase the dispensing speed**.

   If the requested number of blocks is just 1, it is not suitable to dispense two blocks, so we choose to dispense one block from tower 2. Tower 2 was chosen randomly, we could easily change it to dispense from Tower 1 on this condition.

2. When only tower 1 has a safe block, we dispense from tower 1 only.

3. When only tower 2 has a safe block, we dispense from tower 2 only.
4. When tower 1 and tower 2 have unsafe blocks, the program will alternate between recycling from tower 1 and tower 2 - i.e. on the first instance of this condition being activated the program recycles from tower one, then on the next instance tower 2 block is recycled and so on. We alternate to **reduce the number of blocks that are recycled** as we want to preserve as many blocks within the system without the need for reloading, to increase the chances of the system serving future customers without the need for reloading.

Algorithm 2: This algorithm is chosen only tower 2 contains blocks. The algorithm works as follows:

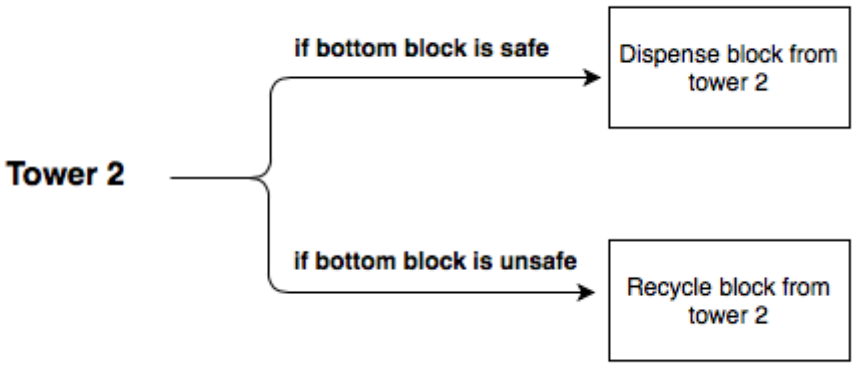

Figure 4-13: Algorithm 2

If tower 2 contains a safe block, then the block is dispensed else the block is recycled.

Algorithm 3: This algorithm is chosen when only tower 1 contain blocks. The algorithm works as follows:

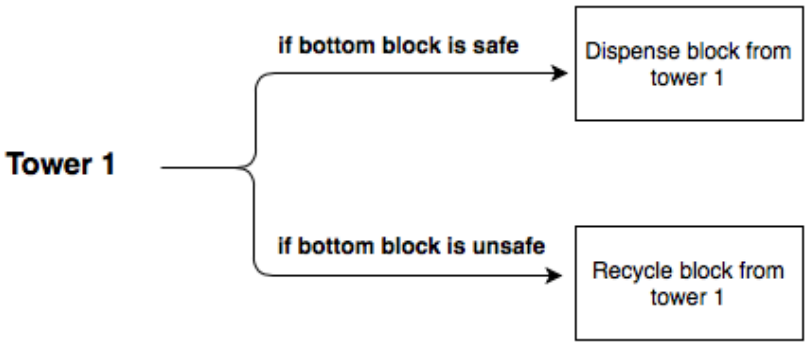

Figure 4-14: Algorithm 3

If tower 2 contains a safe block, then the block is dispensed else the block is recycled.

The program keeps dispensing, and choosing one of these 3 algorithms until the requested number of blocks by the customer is dispensed.

Case '`C`'**:**

This case returns the RGB values the colour sensor is currently detecting. This was used for testing and calibrating purposes. The function takes the raw colour values from the sensor, then converts them to a 0 – 255 range as described in 5.4.1. Then these values are sent to the PC port, which we can see via the PC terminal.

Case '`G`'**:**

This command reads the colour value of block on the sorting platform using `ColAvg` (4.4.1) then sorts it by calling the `Sort()` function (4.4.2).

Case '`F`'**:**

This was used to test if the communication ports are running, when this command is received the program sends a message "Communication Works" via the PC serial port. We can use a PC terminal connected to the port to see this message.

Case '`X`'**:**

This command calls the `manageable_snacks` function (see 5.4.4), this will send the output of that function to the PC serial port.

Case '`Z`'**:**

The sends out the contents of `tower1array` and `tower2array` to the PC serial port, this command can be used to see what blocks are currently in the system and in which tower and which order they are in.

Case '`S`'**:**

This case is used in maintenance mode. Immediately following the the S the program looks for a string ":`n&p`". n stands for the servo number (there are 3 servos in our system, servo 1 is the sorting platform and 2 &3 are the dispensing/recycling actuators) and p stands for the servo position /angle such as 78. This command will move this servo to particular angle, this case was used in maintenance to test if all servos were working fine.

Case '`B`'**:**

This case activates the IR card reader. Upon this case being called, the program waits for the user to insert the card in the card reader. The card reader has 4 bits to read `B0, B1, B2, B3` which are all voltage values from the IR receiver. If the voltage in the IR receiver is above 0.3V then it is deemed as 1 else it is a 0.

When the user puts the card in, the card passes through the IR receiver B0 first, so after this is crossed the program waits 2 seconds for the card to be set in place., After 2 seconds the values from the 4 IR receivers are measured.

These values are interpreted as a 4 bit binary code, and converted into the colour that they represent. The colour they represent is the colour the user is allergic to. Once this is done the allergic block value is saved in memory and also sent to the PC serial port.

5 Sensor Systems

5.1 Sensor System Setup

The product makes use of an RGB colour sensor and an array of four infra-red emitter/receivers acting as a card reader for the 4-bit card input, all feeding data into the MBED microcontroller.

5.2 Colour Sensor

The colour sensor, a TAOS TSC34725, is mounted next to the loading platform at the top of the product. In this position, it is used to read the colour of blocks placed on the loading platform and store the colours in an internal register on the MBED.

5.2.1 Operation

The colour sensor is physically located at the top of the product next to the loading platform and driven via the MBED. Blocks to be stored in the machine are placed on the loading platform one at a time. On receiving a 'G' character via the serial terminal, the MBED stores the `'rgb_readings'` values of Red, Green, Blue and Clear for the block in front of the sensor. These are then processed by the function `'ColAvg()'` which takes the raw values used by the sensor and converts them into standard 0-255 RGB values.

Ranges are then used for Red, Green, Blue and Clear that define the expected RGB value of each block. If a block falls within all the desired ranges for one colour, it is stored in either the `'tower1array'` or `'tower2array'` string as that colour. The loading platform tilts and the block physically falls into its assigned tower, and the platform returns to the start position to await the next block for colour data read-in. If a block does not fit any of the defined colour ranges, a `"Cannot Detect"` is returned.

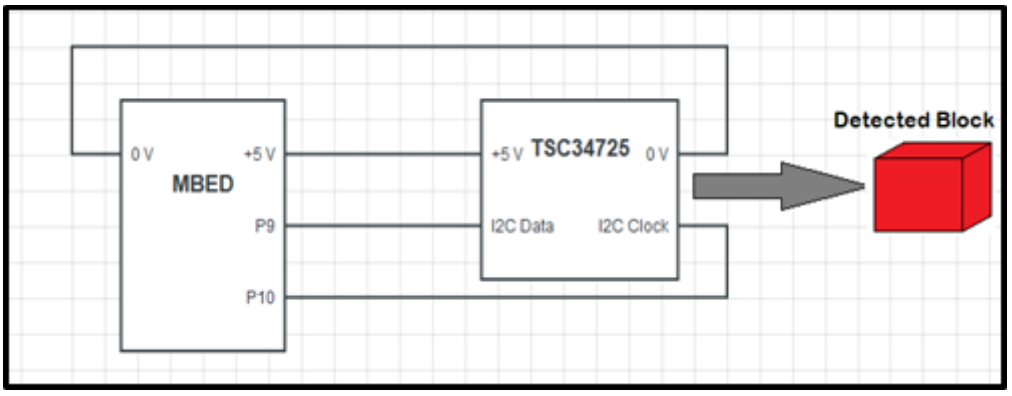

Figure 5-1: Colour Sensor Schematic Diagram

5.2.2 C++ Code

```
1.  string ColAvg(){
2.
3.      rgb_sensor.getAllColors(rgb_readings);
4.  //Read in colour values and convert to RGB 0-255 range
5.      raw_red = rgb_readings[1];
6.      raw_green = rgb_readings[2];
7.      raw_blue = rgb_readings[3];
8.      raw_clr = rgb_readings[0];
9.      rgb_red = (raw_red/raw_clr) * 255;
10.     rgb_green = (raw_green/raw_clr) * 255;
11.     rgb_blue = (raw_blue/raw_clr) * 255;
12.     rgb_clr = raw_clr;
13.
14.     bool detected = false;
15.
16.  if ((rgb_red > 175) && (rgb_red < 205) && (rgb_green > 35) && (rgb_green < 55) &
    & (rgb_blue > 35) && (rgb_blue < 60)){
17. //Define a range for each colour to identify blocks
18.                                     detected = true;
19.                 return "Red";
20.                                   }
21.          else if ((rgb_red > 35) && (rgb_red < 75) && (rgb_green > 115) && (rgb_g
    reen < 145) && (rgb_blue > 45) && (rgb_blue < 70)){
22.                                       detected = true;
23.                 return "Green";
24.                                   }
25.          else if ((rgb_red > 80) && (rgb_red < 95) && (rgb_green > 110) && (rgb_g
    reen < 130) && (rgb_blue > 30) && (rgb_blue < 50)){
26.                                       detected = true;
27.                 return "Green";
28.                                   }
29.          else if ((rgb_red > 115) && (rgb_red < 210) && (rgb_green > 100) && (rgb
    _green < 190) && (rgb_blue > 35) && (rgb_blue < 70) && (rgb_clr > 50000) && (rgb_
    clr < 65537)){
30.                                     detected = true;
31.                 return "Yellow";
32.                                   }
33.
34.          else if ((rgb_red > 95) && (rgb_red < 240) && (rgb_green > 85) && (rgb_g
    reen < 275) && (rgb_blue > 95) && (rgb_blue < 125) && (rgb_clr > 65000) && (rgb_c
    lr < 65537)){
35.                                     detected = true;
36.                 return "White";
37.                                   }
38.          else if ((rgb_red > 50) && (rgb_red < 115) && (rgb_green > 80) && (rgb_g
    reen < 115) && (rgb_blue > 50) && (rgb_blue < 105) && (rgb_clr > 4000) && (rgb_cl
    r < 9000)){
39.                                     detected = true;
40.                 return "Black";
41.                                   }
42.          else if ((rgb_red > 25) && (rgb_red < 55) && (rgb_green > 75) && (rgb_gr
    een < 95) && (rgb_blue > 115) && (rgb_blue < 140)){
43.                                     detected = true;
44.                 return "Blue";
45.                                   }
46.          else if ((rgb_red > 150) && (rgb_red < 175) && (rgb_green > 55) && (rgb_
    green < 75) && (rgb_blue > 30) && (rgb_blue < 45)){
47.                                       detected = true;
48.                 return "Orange";
49.                                   }
50.
51.
```

```
52.                                     if (detected == false){
53.         return "Cannot Detect";
54.         }
55.
56.     }
```

Source Code 5-1: Colour Sample

5.2.3 Positioning and Calibration

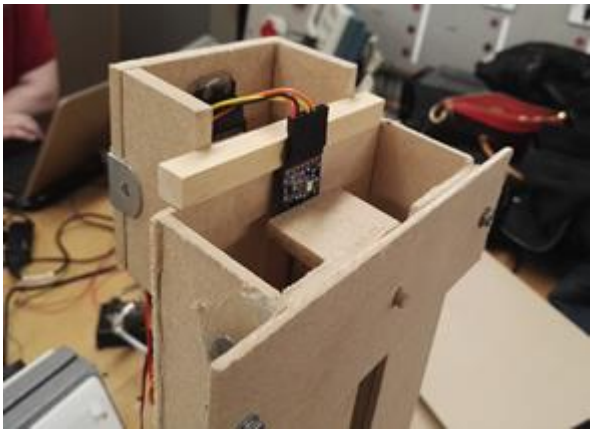

Figure 5-2: Colour Sensor Positioning

The colour sensor is positioned at the top of the device, to be used during the initial loading of blocks into the machine. Blocks are placed on the loading platform in front of the sensor and scanned using the Maintenance Mode GUI to send the 'G' case to the microprocessor.

There was a small amount of room on the loading platform for blocks to move around, which meant further calibration was required for colour ranges to factor in the small increase in distance and angle of block.

Calibration was undertaken by repeatedly scanning in coloured blocks, and using the highest and lowest values seen to define a unique RGB range for each block. As the colour sensor was exposed to any ambient light in the environment, additional calibration checks were performed at each design phase and on the morning of the final exhibition to ensure the changes in ambient light did not affect the RGB ranges for block detection. For new or unexpected block colours, the sensor will initially return "`Cannot Detect`", however the new colour range can be defined by capturing multiple scans of that block using the Maintenance mode GUI and writing a new line that defines the colour ranges for it. Thus, the program can continually accept new block colours and shades. This can be seen from the above code, where two ranges for "Green" are defined, as there were two known and expected shades of green for the sensor to process.

For the raw data used to calibrate the sensor, see *Appendix 9-3.*

5.3 Card Reader

The card reader is constructed from an array of four Sharp IS471F IR receivers, each driving one Vishay TSAL7200 IR emitter. The components were arranged so the default operating state is an unbroken line of sight between emitter and receiver, producing an active low (0V) output. Breaking the line of sight between the two components produces a high (5V) output.

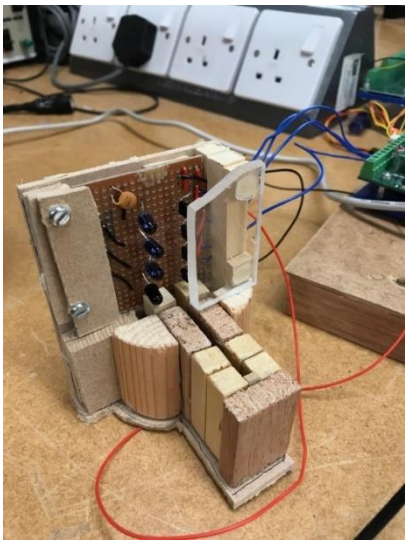

Figure 5-3: Card Reader Final Build

The emitter/receiver array is soldered onto Veroboard and physically arranged with a 5mm spacing between devices to match the shape of allergy card specified by the customer. This creates a sensor circuit that can read physical four-bit codes cut from the allergy cards and feed the logic outputs to the MBED. To counteract noisy voltage coming from the supply, a 100nF decoupling capacitor is connected between supply and ground to provide a path to earth for high-frequency AC noise pulses and stabilise the logic outputs.

The allergy cards themselves are manufactured from aluminium foil glued between two strengthening layers of standard craft card. This creates an IR-blocking laminate that was thinner than other readily available solutions (wood, foam board) and can still be shaped easily with scissors. A physical body was also constructed around the circuit from wood to ensure the cards could be inserted in the correct position, and so the card reader could be handled safely and mounted onto the product.

5.3.1 Operation

The card reader is driven by the MBED. On receiving a '`B`' character via the serial terminal, the MBED enters a loop which waits for a change in voltage at the first IR emitter/receiver pair of the array. On seeing this state change (i.e, a card has been entered) the system waits for two seconds for the user to position the card correctly. It then stores the value of V_o of each emitter/receiver pair – a '0' if there is line-of-sight between the pair, and a '`1`' if there is not. (The four output bits V_o are connected to MBED Digital I/O pins 15-18.) The binary sequence of the four bits are then analysed to determine the allergy. The value of the string '`allergy`' is then set to the correct colour, e.g "`Red`", and stored for use during the dispense sequence. The raw binary sequence is also sent through the serial terminal to be interpreted by the Operation Mode GUI to visually display the allergy to the user. This allows for visual confirmation that the correct card has been inserted, and that it was positioned and read correctly. If the read is not successful, it can be repeated by initiating the sequence again.

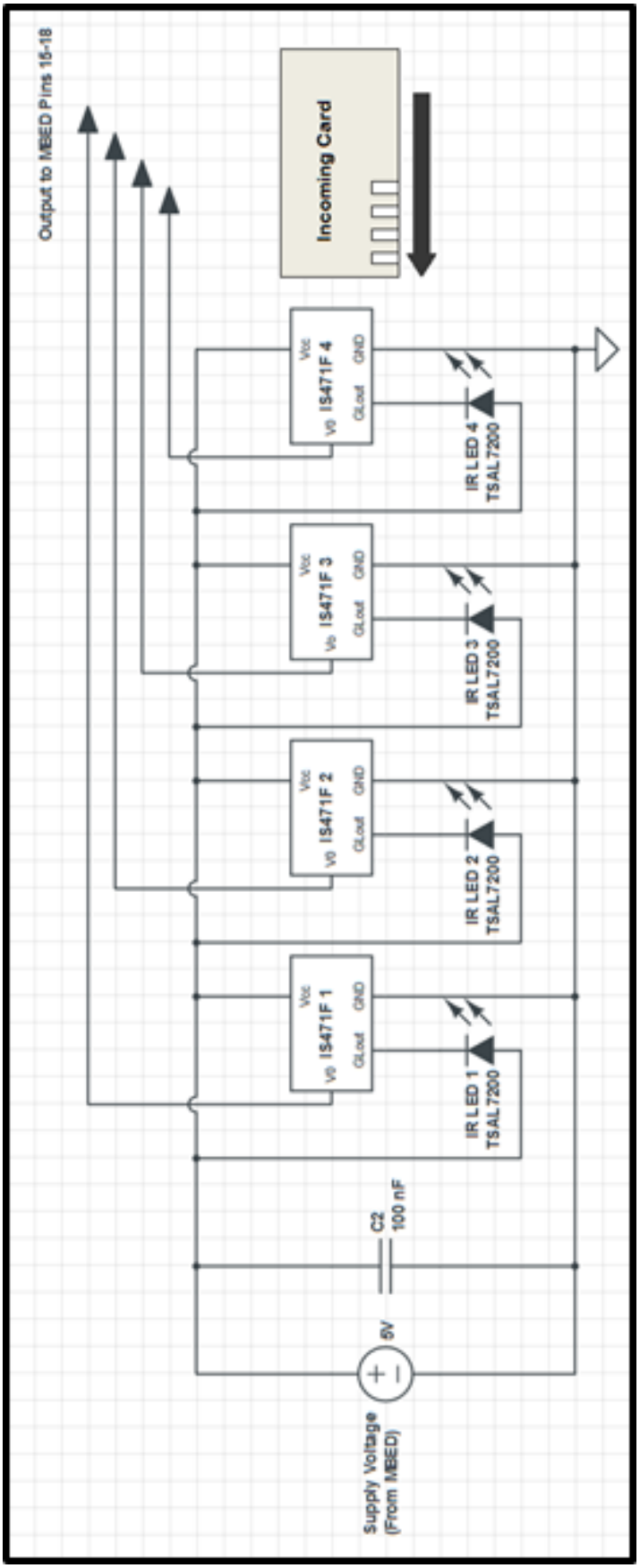

Figure 5-4: Card Reader Circuit Diagram

5.3.2 C++ Code

```
 {case 'B':
    while(1){
        if(B0 > 0.3f) {
// Await state change on first bit (card inserted)
            wait(2);
// Wait two seconds for card positioning
        if(B0 > 0.3f) {
// Set value of Code1 - Code4 according to voltage values at MBED pins 15-18
            Code1 = 1;
        }
        else {
            Code1 = 0;
        }
        if(B1 > 0.3f) {
            Code2 = 1;
        }
        else {
            Code2 = 0;
        }
        if(B2 > 0.3f) {
            Code3 = 1;
        }
        else {
            Code3 = 0;
        }
        if(B3 > 0.3f) {
            Code4 = 1;
        }
        else {
            Code4 = 0;
        }
        pc.printf("%d%d%d%d\n",Code1, Code2, Code3, Code4);
//Send raw sequence for interpretation by Visual C#
        if (Code1 == 0 && Code2 == 0 && Code3 == 0 && Code4 == 0)
//Set string 'allergy' to correct value
            {allergy = "None";}
        else if (Code1 == 0 && Code2 == 0 && Code3 == 0 && Code4 == 1)
            {allergy = "Red";}
        else if (Code1 == 0 && Code2 == 0 && Code3 == 1 && Code4 == 0)
            {allergy = "Green";}
        else if (Code1 == 0 && Code2 == 1 && Code3 == 0 && Code4 == 0)
            {allergy = "Blue";}
        else if (Code1 == 1 && Code2 == 0 && Code3 == 0 && Code4 == 0)
            {allergy = "Yellow";}
        else if (Code1 == 0 && Code2 == 0 && Code3 == 1 && Code4 == 1)
            {allergy = "Orange";}
        else if (Code1 == 0 && Code2 == 1 && Code3 == 0 && Code4 == 1)
            {allergy = "White";}
        else if (Code1 == 1 && Code2 == 0 && Code3 == 0 && Code4 == 1)
            {allergy = "Black";}
            break;
        }
    break;
}
```

Source Code 5-2: Barcode Reader

Figure 5-6: Sensor Locations on Finished Product

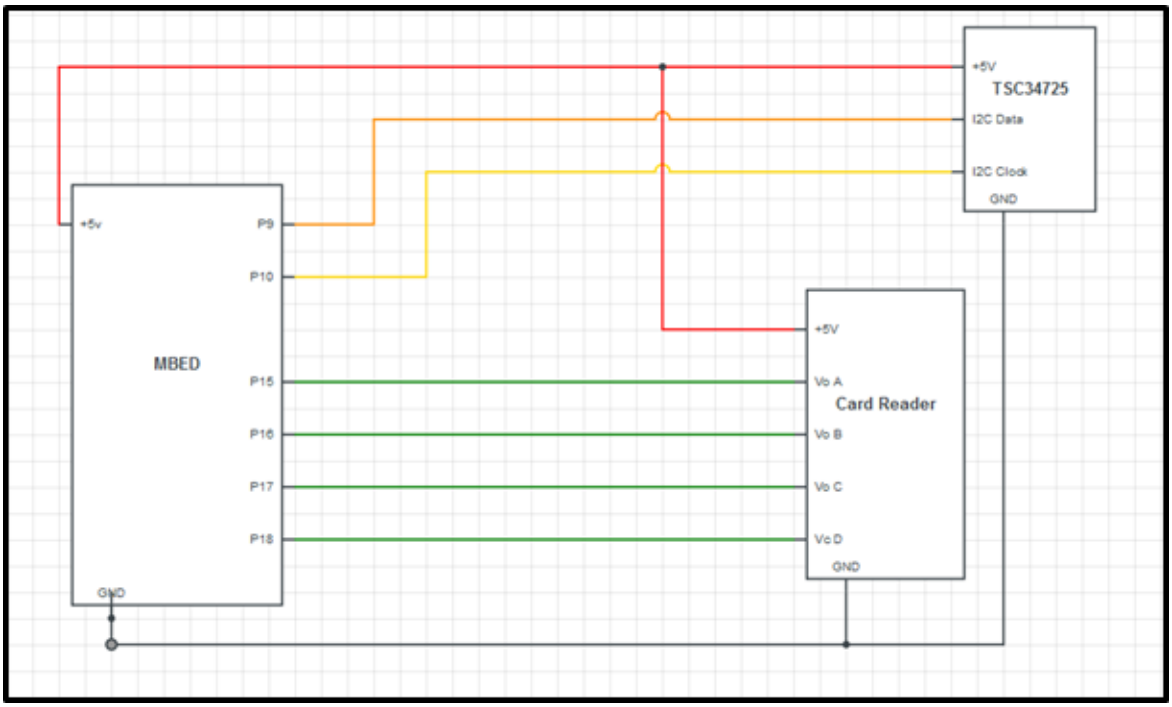

Figure 5-5: Sensors Full Schematic Diagram

6 Marketing and Web

6.1 Business plan

Snacks these days are made up of several ingredients a lot of which in turn consists of other foods. Hence people allergic to certain foods can't use vending machines for a quick snack. The vending machine industry is saturated with wide array of offerings ranging from low cost machines to high end complex ones.

Alpha vending solutions aims to tackle this problem with are newest vending machine. Our latest vending machine can dispense snacks based on what the consumer is allergic to. Once a pre-programmed card is inserted into the machine it can very quickly dispense snacks based on your dietary requirements and/or personal preference. The design too is highly modular enabling us to with ease increase or decrease the size based on the institutions requirements. While some other products exist that too can sort products based on allergy most are restricted by the number of allergies they can account for by hardware limitations requiring them to provide a machine for places where the consumer has a wider range of allergies, whereas a small software patch is all that's required for us.

Strengths	Weaknesses
• Large Storage allows for product to last without requiring maintenance interaction. • Design allows for customization for customer orders.	• No functionality for people with multiple allergens.
• Can expand into other forms of dispensing for other items, other than snacks. • Optimize existing design and expand on features within design.	• It may be difficult to compete with established companies, and existing products. • Product aimed at facilities who may already have a vending solution in-place
Opportunities	**Threats**

Table 6-1: SWOT Analysis

The consumers we feel who would benefit most from our products are for those whose might not be aware of or remember what they're allergic to as with young children or old people and those whose dietary restrictions change due to surgery and/or medication as with hospitals. Hence our target markets are primarily sensitive environments such as preschools, hospitals and old age homes. This enables them to conveniently get snacks of any kind (with appropriate hardware adjustments) without worry.

To reach our target market, we will have a sales team reach out to institutions all around the globe both over the phone and via email. Congruently taking out ad spaces in magazines and newspapers are consumers read based on market research, such as in medical journals for doctors, to raise product awareness. In turn we set up temporary vending machine sites for potential high value locations that are on the fence about investing in our product. Instructional videos will be made to show how to use our product though not necessary in both Spanish and English adding more languages once our product supports them.

Market Development Strategy	Diversification Strategy
• To develop growth, new markets can be introduced within other industries. • Different types of customer can be attracted by advertising new products. • For example, Larger machines, either physically or more allergen capacity.	• Produce more control systems within the company. • Which will reduce outsourcing and help to lower prices
• The company brand can be promoted further through the internet to better compete with rival businesses. • This can be achieved by introducing deals, such as discounts to new customers or a standard warranty.	• Having Automated updates to software for both Maintenance and Vending Applications, to ensure smooth operation. • Inform customers via newsletters and other media of new and upcoming products.
Marketing Penetration	**Product Development**

Table 6-2: Growth Strategy Matrix

Pamphlets will be mailed to institutions all around the globe advertising our product, giving eager customers a chance to reach us even before our sales team contacts them. The pamphlet will include sample pictures of our products, its unique selling point and our website and contact details. Pre-Schools, Retirement homes and hospitals each will receive its own pamphlet each which markets our products specifically to them making it more appealing.

We believe in a more flexible approach to pricing our machines than other companies. Since we aim to have a global presence we need to tailor our products to the needs of the region. Hence from the machines maximum capacity to its durability can be changed to fit our customer's needs. We plan on running our business as one that makes its money out of the volume of sales rather than individual high prices machines.

Market Growth / Cash Use	Market Share / Cash Generation	
	Stars	Question Marks
	• Defines Businesses with a Large Market share and Growth Rate • For Example; online Retailers such as eBay Alibaba.com	• High Growth Prospects but low market share • Alpha Vending Solutions will begin within this business group
	Cash Cows	Dogs
	• Businesses that are market leaders but have low growth prospects.	• Low Market Share and low Growth Rates. • Effective Customer Targeting and Product Advertising can prevent Alpha Vending Solutions from Falling into this Category.

Table 6-3: BCG Matrix

6.1.1 Marketing Poster

(See *Appendix 9-4)*

6.2 Company website

As part of our marketing strategy, we developed a website to advertise our product to potential customers. The website has the following pages:

1. Home – contains a presentation about AV Solutions
2. About Us – describes AV Solutions' mission
3. Our Product – describes our vending machine and all its components
4. The Team – pictures and biographies of our team members
5. Blog – a development blog showing major milestones

6. Contact Us – contains the group email address

The rest of this section will describe the design and contents of each page in more detail.

The link to the website is: https://zc5014.wixsite.com/avsolutions

A blue colour theme was maintained throughout the website, to match with our groups agreed company colour theme.

A menu bar to navigate to any page of the website, is at the top of every page. The background picture is a live picture with subtle shifting patterns, this was chosen as a plain background would make the website dull and a live picture might captivate a visitor's interest.

6.2.1 Homepage

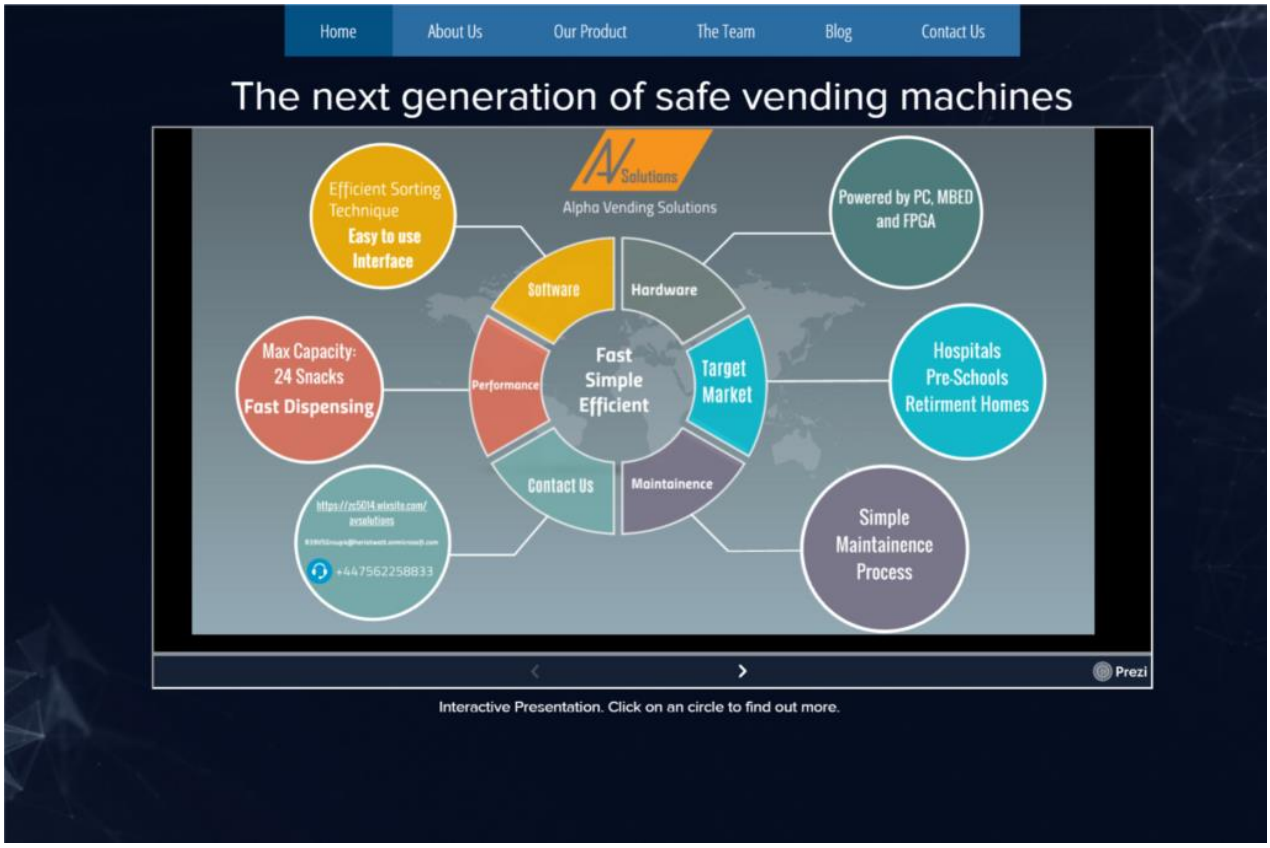

Figure 6-1: Website Homepage

The homepage contains our company slogan: "The next generation of vending machines". Underneath is an embedded Prezi presentation. This is an interactive presentation where people can click on each circle (sub-section), which will then expand to show further detail.

The initial homepage was made interactive to spark the visitors interest, as it is the initial page a visitor sees when they come on the website. A quick presentation will give an overview of AV Solutions and our vending machine.

6.2.2 About Us

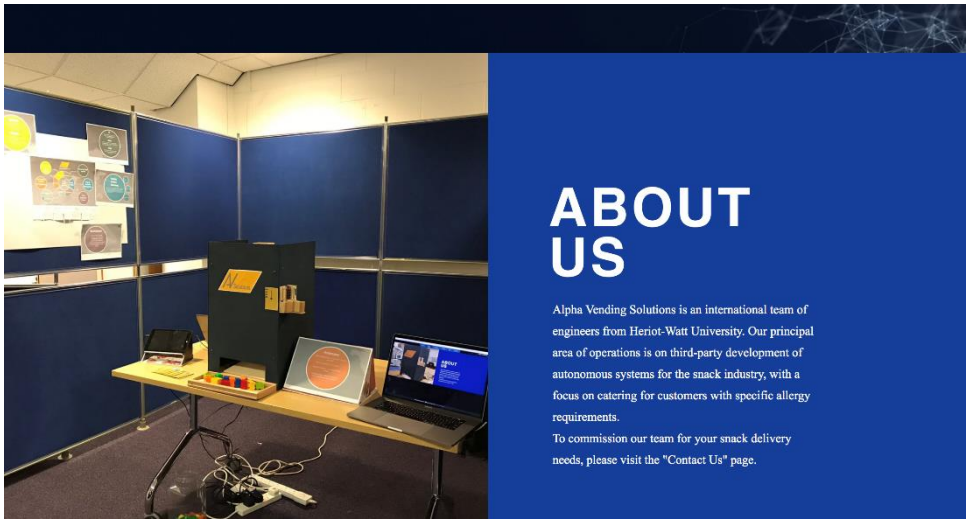

Figure 6-2: About Us Page

This page describes what AV Solutions is and its mission statement. A picture of our presentation stand is shown on the left-hand side.

6.2.3 Our Product

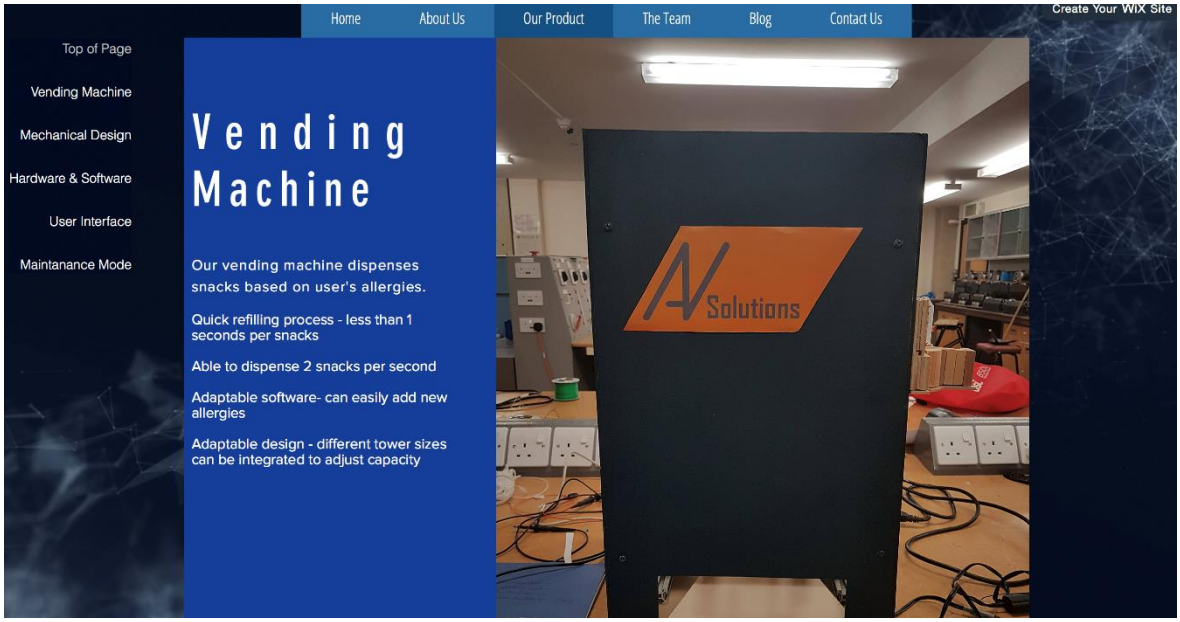

Figure 6-3: Product Page

This page describes the vending machine. Initially an overview of the system is given, then each component of the system is described in the other sections: Mechanical Design, Hardware & Software, User Interface and Maintenance mode.

The descriptions of the components are simple descriptions, which are not very technical. The descriptions are done in this way, as we expect majority of our customers to be coming from a non-technical background so the language used is very simple so that even a non-technical person can understand.

The menu to select each sub-section moves along as the user scrolls down the page, this was done so that the user has ease of navigability and can easily access the menu form any point in the page to navigate to a particular sub-section

6.2.4 The Team

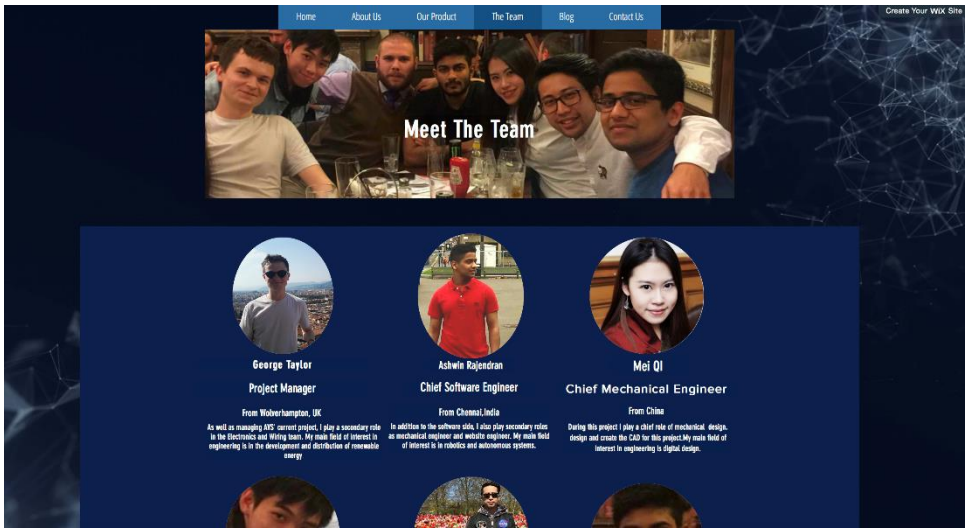

Figure 6-4: Team Biography Page

This page contains the biographies of our team members. Our group picture from a group dinner was put at the top.

We added pictures of our team members, in the biographies we described our roles within the team and our academic interests.

We also highlighted the countries we were from, to highlight the fact that we are an international team with members coming from different countries.

Our biographies are given in table form below:

Team Member	Roles	About
George Taylor	Project Manager	Third Year Direct Entry Electrical and Electronics Engineering Student. As well as managing Alpha Vending Solutions, I play a secondary role in Electronics and Wiring. My main field of interest is the development and distribution of renewable energy.
Ashwin Rajendran	Chief Software Engineer	Third Year Direct Entry Computer and Electronics Engineering Student. In addition to the software side, I also play secondary roles as mechanical engineer and website engineer. My main field of interest is in robotics and autonomous systems.
Mei 'Fiona' Qi	Chief Mechanical Engineer	Third Year Continuing Electrical and Electronic Engineering Student. During this project I play a role as Chief Mechanical Designer and create the Computer Aided Design for the project. My main field of interest in engineering is digital design.

Zhepin Choong	Chief Website Designer	Third Year Transfer Electrical and Electronics Engineering Student from Malaysia Campus. I oversee Website Design for Alpha Vending Solutions, and I have a secondary role as a workshop engineer. My main field of interest is digital design.
Chi Wai 'Leo' Kong	Electronics and Wiring / Workshop Engineer	Third Year Computing and Electronic Engineering Student I am the Electronic and wiring engineer and the workshop engineer. I am really enjoying the ability to work in the lab. My main interest in engineering is building small and useful gadgets for helping people and making their life easier.
Rohit	Public Relations Officer / Workshop Engineer	Third Year Transfer Electrical and Electronic Engineering Student from Dubai Campus. Aside from being part of the mechanical team, I am also involved in the public relations within the company. Making something useful has always been a passion of mine I chose to be a mechanical design engineer to help build our product and in the public relations to help grow our company.
Duncan Fraser	Secretary / Chief Digital Design Engineer	Third Year Continuing Electrical and Electronics Engineering Student, Heriot Watt IEEE Student Branch Chair. Throughout the project my main responsibilities were Digital Design and Graphical User Interface Design and implementation. My main interests are in Hobbies Electronics design, implementation and development.

6.2.5 Development Blog

To keep customers updated on the progress of the project, a development blog was included into the website. This blog was updated by all team members on their progress towards completion of the project.

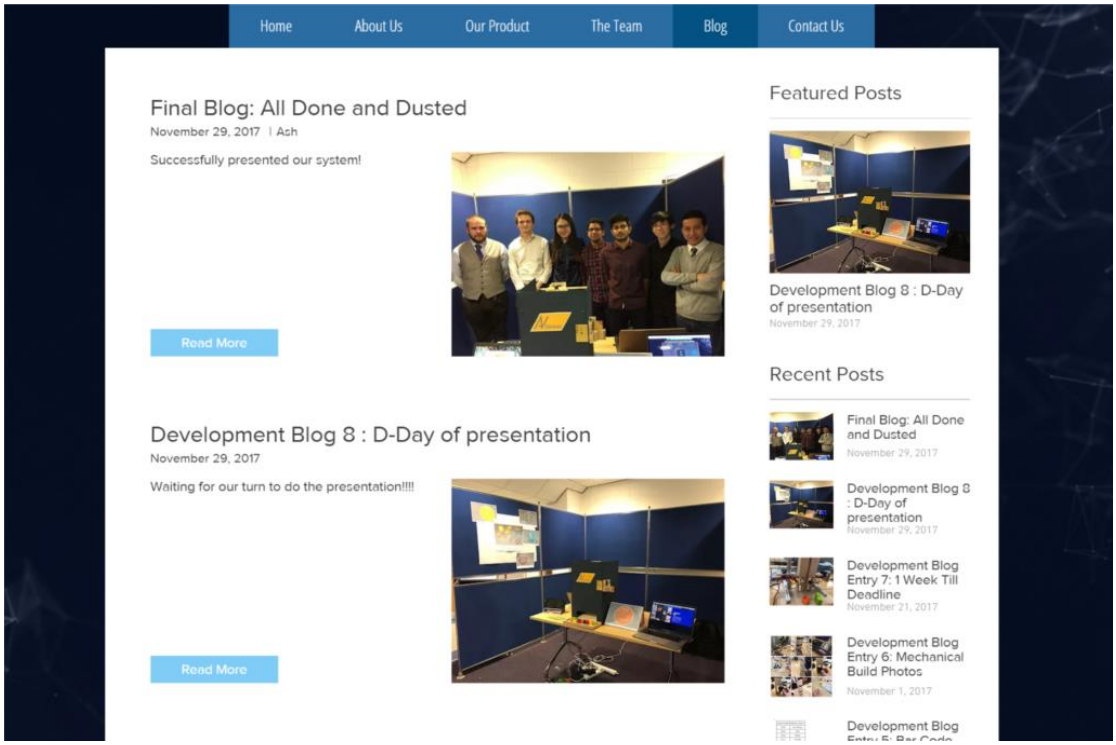

Figure 6-5: Development Blog

6.2.6 Contact Us

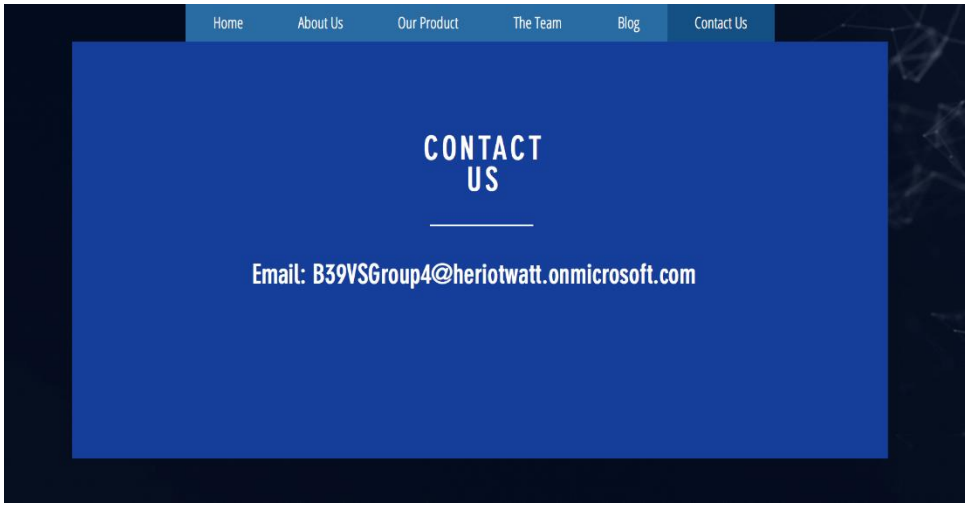

Figure 6-6: Contact Us Page

We also have a contact us page with our group email, so anyone interested in our product or team can contact us.

7 Project Management

Management of the project was broken down into five separate areas: outlining the project scope, producing a work breakdown structure (WBS), using the scope and WBS to generate a project plan to track progression, making a substantial assessment of expected risks, and finally by drawing up a contract that laid down the expected working dynamic of the team. This section details each of these areas and how they evolved over the development cycle.

7.1 Project Scope

The scope statement was one of the first important tasks to be completed in the project life cycle. It was used to structure and define the overall goals of the project and break key tasks down into milestones, and provide the first layout of timetabling for these milestones.

The scope evolved in multiple ways throughout the development of the product. Each milestone was achieved by its intended target date, but after discussion during the weekly team meetings the team could collectively analyse the scope and make decisions on tasks to be brought forward. Details of these specific tasks will be given in the project plan section.

The team was initially formed of seven members who had not previously encountered one another and were unaware of each other's skills. Roles were discussed and initially assigned based on each member's estimation of the area of the project they considered themselves able to make the greatest contribution towards. The assigned roles became more fluid as the project developed, with team members moving naturally into roles more suited to them than given at the start of the development. This generated an element of unforeseen risk, in that the chance arose for a team member's initial role to be neglected after they moved onto a different work area. However, close track of each member's current area of responsibility was taken by the project manager and recorded in the weekly minutes to ensure each role remained filled despite this fluidity. The change in team member roles was also influenced by extracurricular commitments of team members, such as work outside of university and family business.

(See *Appendix 9-6*)

The scope outlines the requirement for weekly "workshop reports", for members working on the physical assembly of the product to bring updates of their progress to the rest of the group. Generation of these reports was not adhered to, primarily because every member of the team eventually had a role in the workshop development, so all members were continually aware of the workshop progress from encountering it frequently. The formal reports were therefore replaced by informal verbal communication to maintain the awareness of all team members of the workshop progress.

The scope does not account for any additional costs, as none were predicted at the start of the project development. The workshop space was well-stocked with a variety of building materials, and additional requirements were not predicted. There were some small costs incurred during project development, for purchase of consumable materials such as paint and craft card. Individual team members also made use of resources already owned by themselves such as additional development boards, to aid with software and digital design.

(See Appendix 9-6)

7.2 Work Breakdown Structure (WBS)

The WBS was produced from the development of the project scope. The key tasks were given a priority order, and prerequisites were identified to produce a visual left-to-right task progression. There was no change to the WBS during product development.

(See Appendix 9-7)

7.3 Project Plan

The plan was produced using the Scope and WBS, and took the form of a Gantt chart. The chart provided a visual reference of the complete project life cycle, including all the identified project areas and tasks within those areas, and expected completion dates. This document was the main reference for guiding the project throughout its development and was referred to in each team meeting. All team members were kept aware of the project progression via this method.

The development timetable of the project was based on a given list of “deliverables”. These deliverables are intended to demonstrate the skills of individual team members were progressing at the required rate for successful completion of the full project. The deliverables had set dates for completion and assessment by the project supervisor, and were therefore used as a framework to construct a timetable for the overall project development. However, there were goals specific to the project that were not directly linked to any given deliverables, and were not factored into the initial timetabling.

As mentioned in the scope section, some tasks were brought forward when possible to aid faster completion. In reference to the project plan Gantt chart, Task 1.3.1.3 – “Website” was brought forward by 14 days from 24/10/17 to 10/10/17 and separated into two tasks, “Initial Website” and “Website Maintenance”. This allowed for construction and near-completion of the website to happen early, and for it to evolve and track the changes in the project via a development blog rather than purely serving as a promotional tool during the final marketing stage.

Similarly, Tasks 1.4.1 – “Marketing Poster” and 1.4.2 – “Exhibition Display” were both brought forward by 21 days, as it was decided that doing so would allow for more early completion of project goals without causing any additional loss of productivity in the other development areas ongoing at that time.

(See Appendix 9-8)

7.4 Risk Management

Initial risk management was conducted by identifying ten initially expected risks and ranking them on a probability/impact severity scale. From the initial list of ten, there were two predicted risk events that can be said to have occurred in some form. The following section details these events and demonstrates how planning for risk ahead of time and the working practises of the team minimised their impact on the project progress.

Risk Code 1 – Injuries from the Workshop.

One team member assigned as a workshop engineer sustained a minor injury to his right hand. This injury occurred outside of the workshop environment and was not related to the project in any way. However, it is included in this report as relevant because the temporary loss of use of the engineer's hand (while bandaged) had a negative impact on his ability to perform in the workshop. No delays resulted from this, however, due to the integration of all team members into the workshop activities.

Expected Impact – High

Actual Impact – Low

Risk Code 4 – Initial Mechanical Prototype Might Not Work

This is the most significant risk that occurred during product development. The initial mechanical design did not operate as designed and was not sufficient to fulfil the specification. This was assessed as resulting from the lack of mechanical experience in the team. The Mitigation Strategy prepared for this risk came into effect – 15 days were given for testing and modification of the prototype design. This gave a large enough time window that eventually, through redesigns and trial-and-error testing, a working model was produced that was a vast improvement on the original design, with no overall delay to the delivery of the completed project.

Expected Impact – Medium

Actual Impact – Low

(See Appendix 9-9)

7.5 Team Contract

The expected working dynamics and behaviours of the team were outlined in this document, as well as decision-making policy and record-keeping practises. It was also used for contingency planning and to provide accountability in the event of issues and infractions. The team contract was not altered during the project life cycle, and no infractions occurred.

(See Appendix 9-10)

7.6 Meeting Minutes

(See Appendix 9-11)

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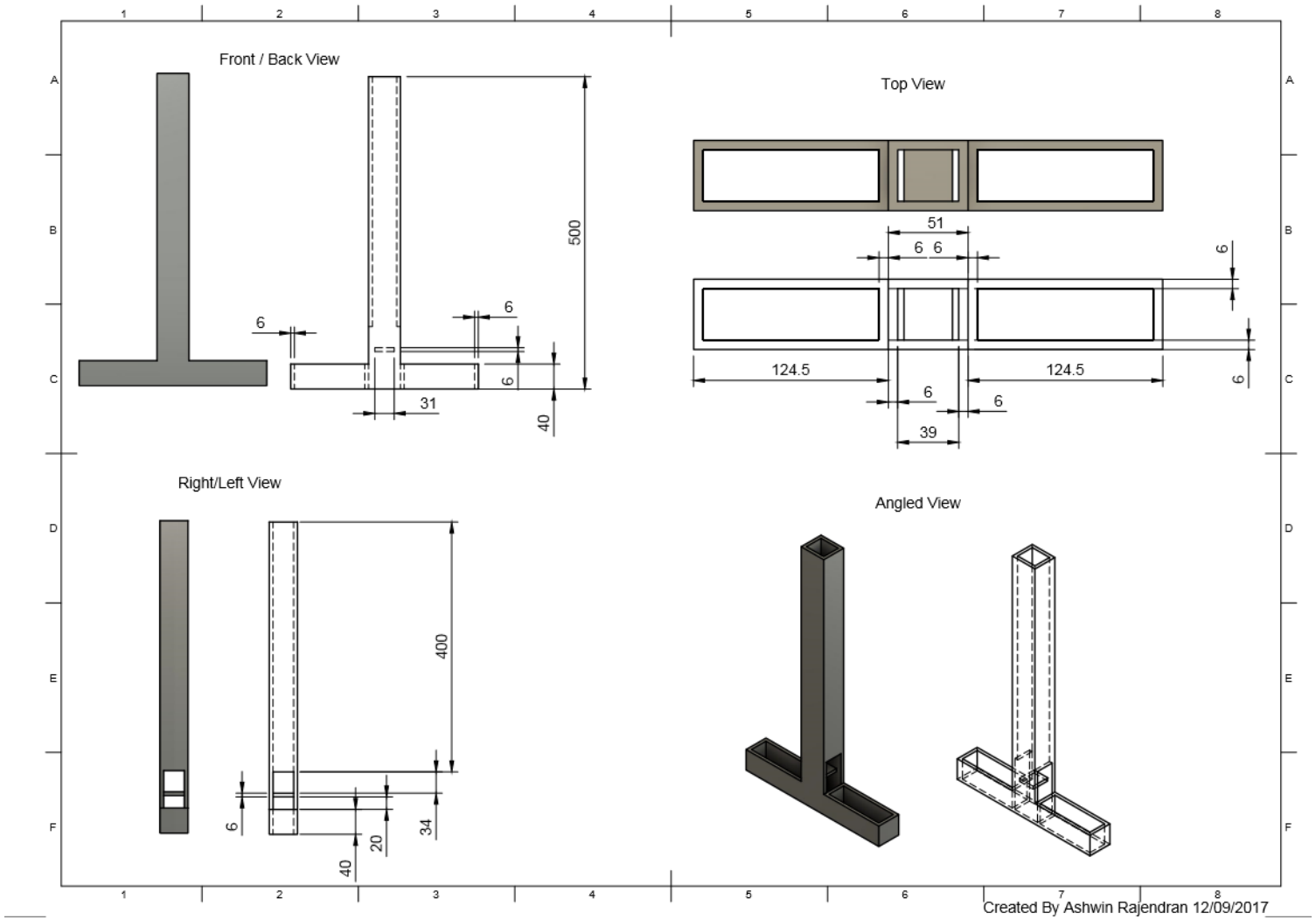
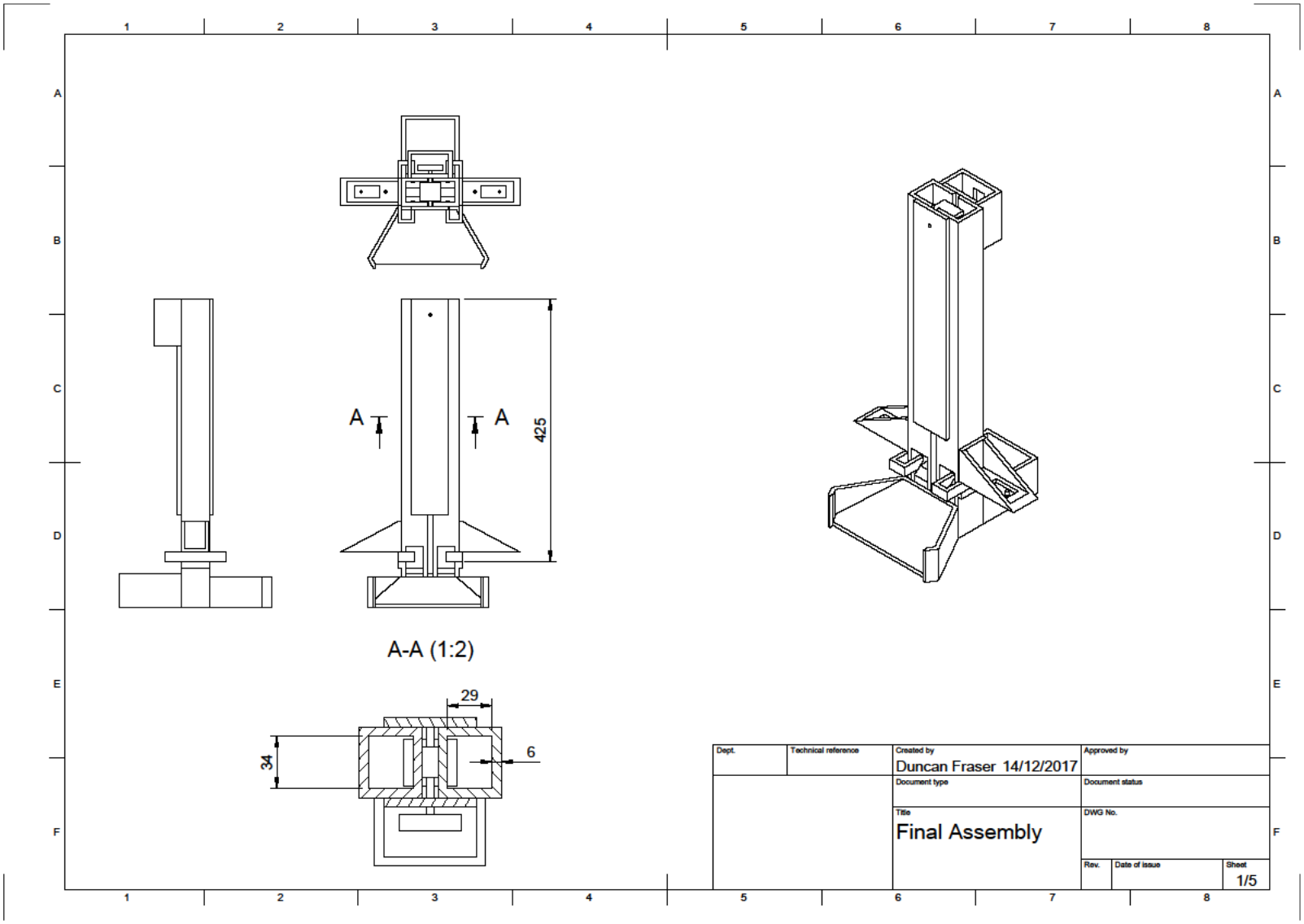
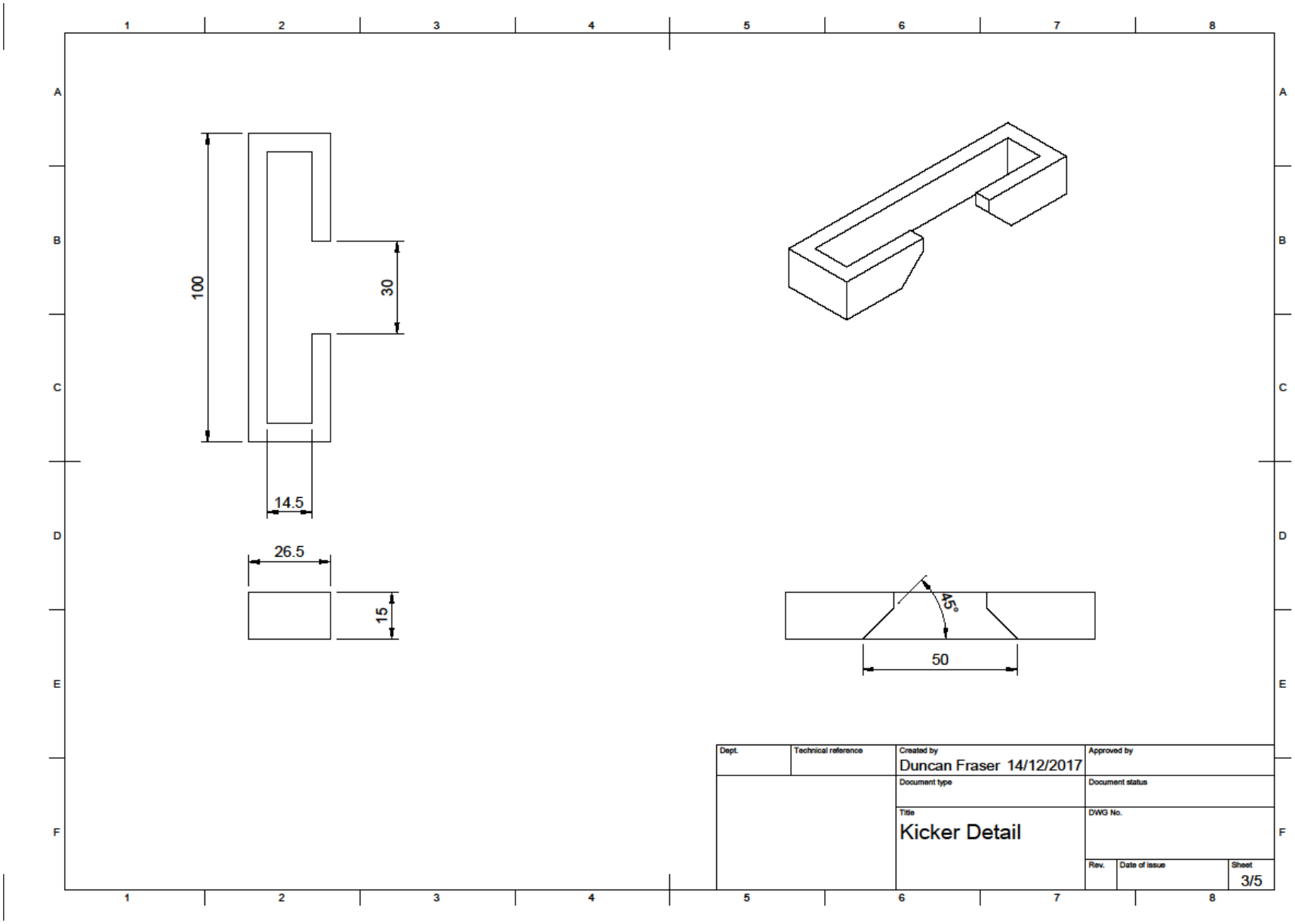
9 Appendices

9.1 Full Initial Mechanical Design



9.2 Full Final Mechanical Design

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Approved by
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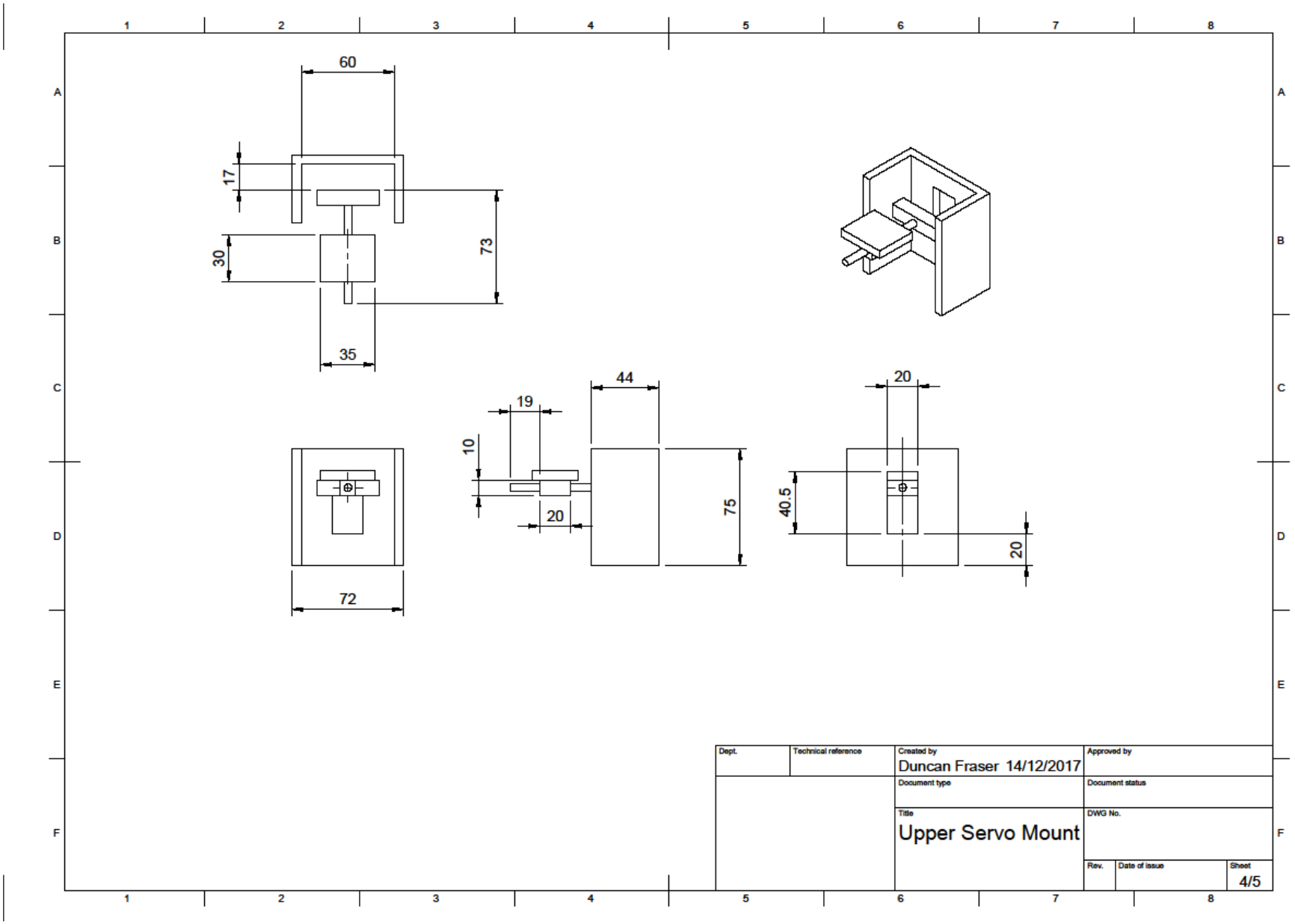
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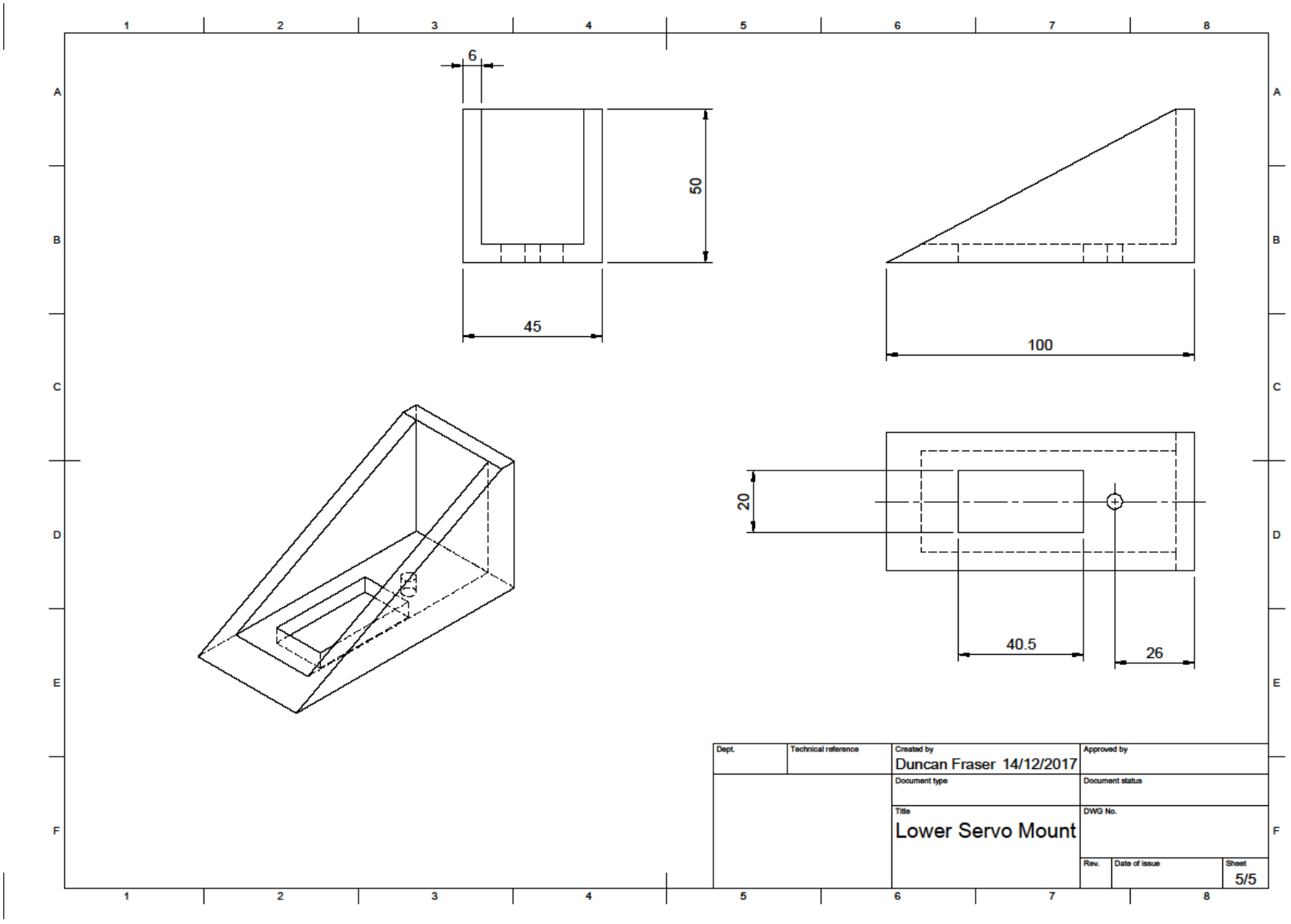
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Duncan Fraser 14/12/2017
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Title
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9.3 Colour Sensor Data Capture

	Test No.	R	G	B	C
RED	1	181	46	38	21422
	2	185	47	38	23462
	3	186	50	50	19434
	4	198	46	50	15266
	5	183	48	39	23436
	6	182	50	40	28370
	7	183	49	39	26373
	8	182	48	39	20655
	9	180	52	43	26440
	10	184	51	48	23126

	Test No.	R	G	B	C
WHITE	1	177	185	120	65535
	2	118	96	56	65535
	3	196	213	137	65535
	4	145	148	96	65535
	5	193	207	134	65535
	6	182	193	125	65535
	7	223	255	165	65535
	8	204	219	141	65535
	9	161	166	108	65535
	10	223	255	164	65535

	Test No.	R	G	B	C
BLACK	1	96	93	65	6940
	2	73	99	80	6072
	3	68	95	90	4444
	4	80	103	70	7715
	5	101	91	63	6182
	6	99	91	64	6724
	7	67	98	87	5340
	8	98	92	65	6829
	9	81	101	69	7860
	10	89	96	67	8158

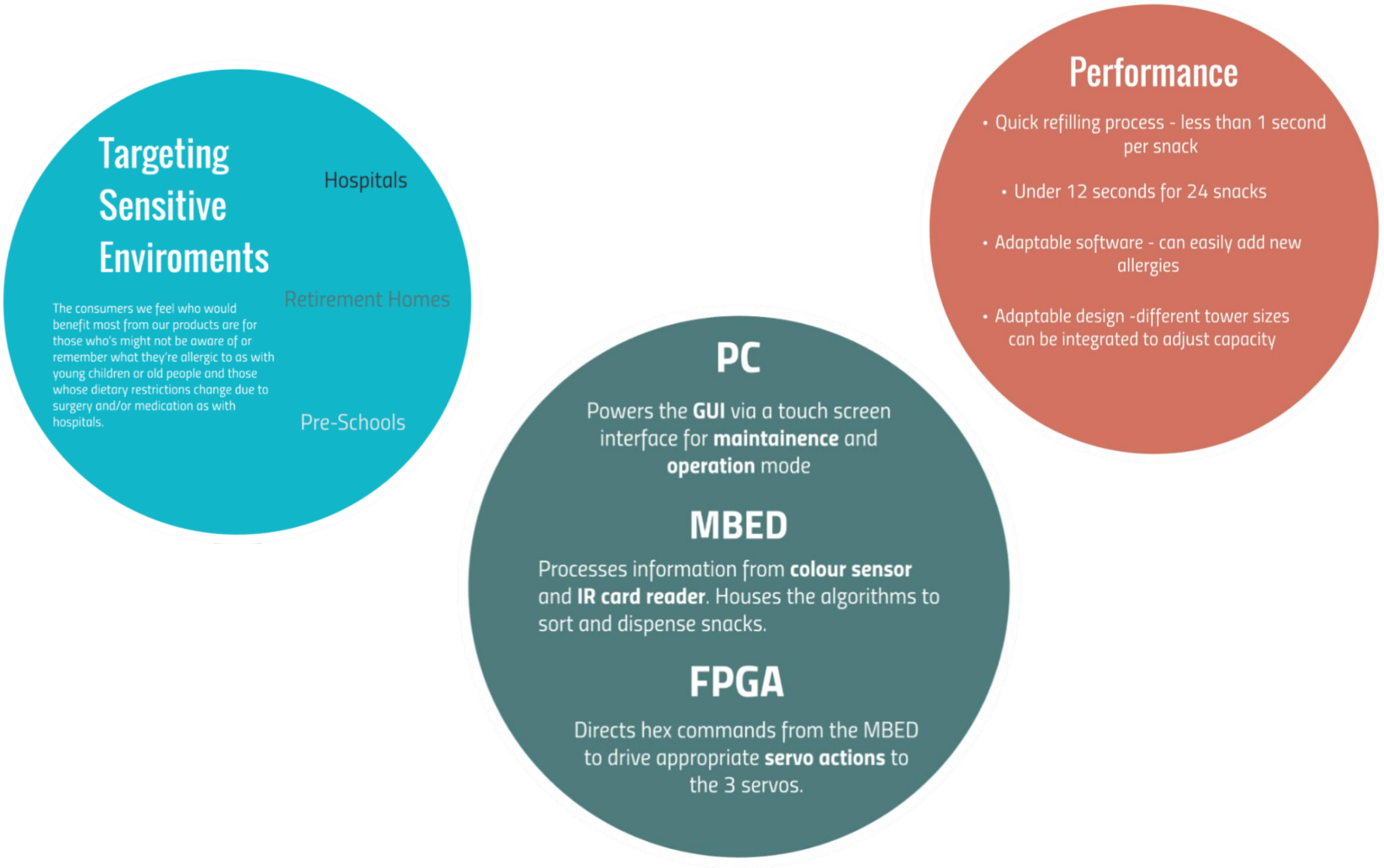
	Test No.	R	G	B	C
ORANGE	1	158	65	31	52837
	2	169	58	37	40010
	3	156	66	34	60004
	4	158	65	31	54385
	5	157	67	31	65535
	6	163	61	37	48692
	7	158	65	31	57007
	8	158	65	31	54709
	9	158	66	31	65535
	10	167	72	34	65535

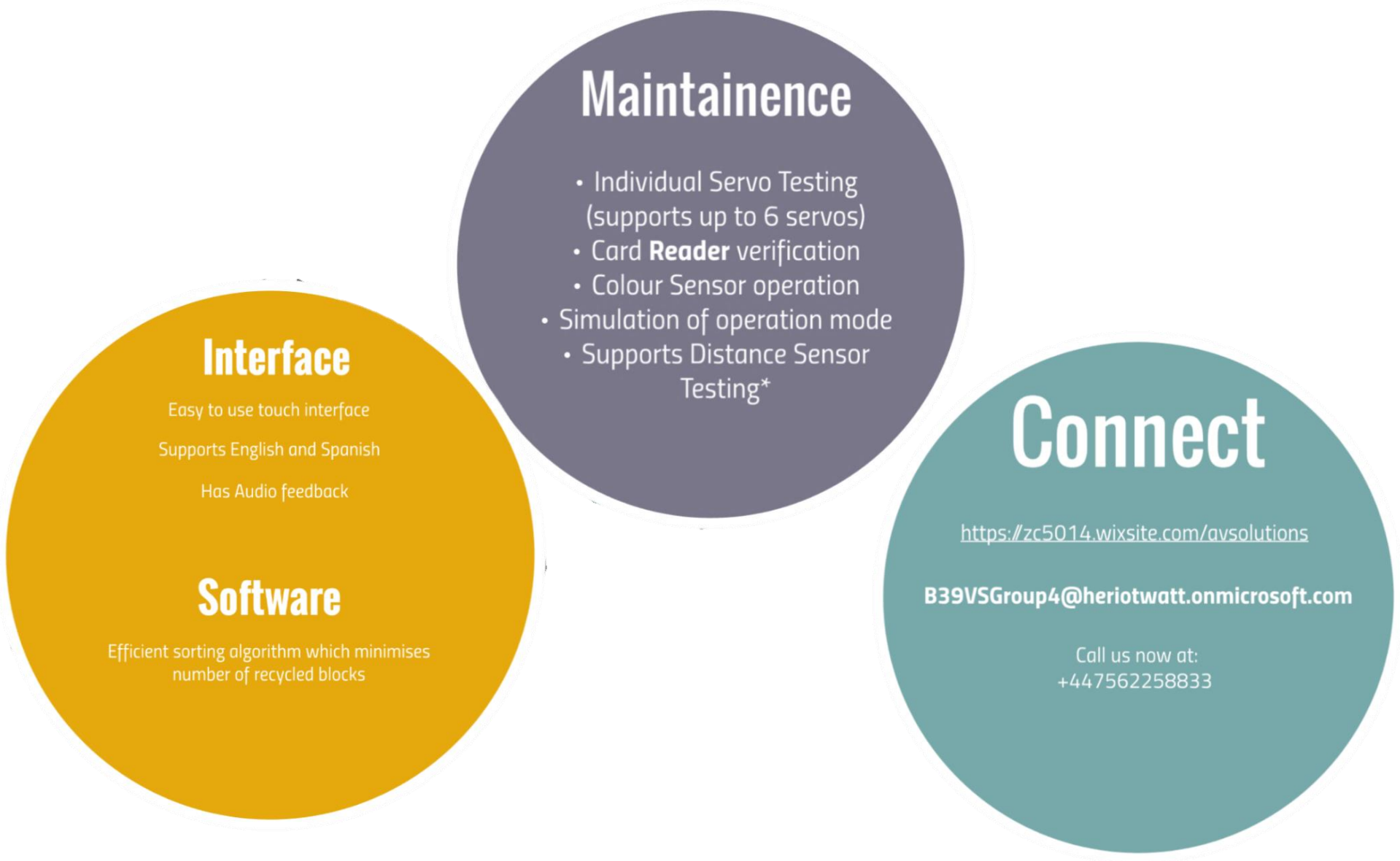
	Test No.	R	G	B	C
YELLOW	1	152	119	42	65535
	2	117	96	33	56098
	3	196	165	55	65535
	4	168	134	46	65535
	5	196	167	55	65535
	6	196	166	55	65535
	7	180	145	49	65535
	8	168	135	46	65535
	9	157	123	43	65535
	10	134	102	36	65535

	Test No.	R	G	B	C
GREEN	1	52	139	52	44186
	2	63	132	53	31611
	3	60	135	52	36512
	4	61	134	52	33600
	5	63	132	52	25965
	6	61	134	52	36509
	7	52	127	59	13115
	8	62	133	52	33907
	9	56	137	52	42244
	10	57	136	52	39256

	Test No.	R	G	B	C
BLUE	1	43	88	125	23368
	2	42	87	126	21537
	3	36	84	128	14078
	4	38	88	128	23983
	5	36	85	128	14888
	6	29	88	131	25329
	7	44	87	124	22821
	8	29	88	131	28079
	9	38	88	128	30246
	10	39	88	128	25862

9.4 Marketing Poster Material




Maintainence
• Individual Servo Testing (supports up to 6 servos)
• Card **Reader** verification
• Colour Sensor operation
• Simulation of operation mode
• Supports Distance Sensor Testing*
Interface
Easy to use touch interface
Supports English and Spanish
Has Audio feedback
Software
Efficient sorting algorithm which minimises number of recycled blocks
Connect
https://zc5014.wixsite.com/avsolutions
B39VSGroup4@heriotwatt.onmicrosoft.com
Call us now at:
+447562258833

9.5 Roles and Responsibilities Evolution

Team Member	Initial Roles	Actual Roles
George	Managing Director	Managing Director
	Electronics and Wiring	Electronics and Wiring
		Software Engineer
Rohit	Public Relations	Public Relations
	Workshop Engineer	Workshop Engineer
Ashwin	Software Engineer	Software Engineer
	Mechanical Engineer	Mechanical Engineer
		Website Engineer
Leo	Electronics and Wiring	Mechanical Engineer
	Software Engineer	Workshop Engineer
	Workshop Engineer	Electronics and Wiring
ZhePin	Digital Engineer	Web Designer
	Public Relations	Workshop Engineer
Fiona	Company Secretary	Mechanical Engineer
	Mechanical Engineer	Workshop Engineer
	Workshop Engineer	
Duncan	Company Secretary	Company Secretary
	Digital Engineer	Digital Engineer
		Workshop Engineer
		Software Engineer

9.6 Project Scope

PROJECT SCOPE STATEMENT

Note: Any work not explicitly <u>included</u> in the *Project Scope Statement* is implicitly <u>excluded</u> from the project.

Project Name:	Group 4
Course Code:	**B39VS**
Prepared by (Project Team):	George Taylor, Duncan Fraser, Mei Qi, Zhepin Choong, Rohit, Chi Kong, Ashwin Rajendran
Date (MM/DD/YYYY):	24/09/17
Project Manager Signature	
Team signatures	
Sponsor Signature	

Version History (insert rows as needed):

Version	Date (MM/DD/YYYY)	Comments
0.01	24/09/17	Initial Project Scope Statement
1.0	26/09/2017	Initial Scope Statement Finalized – added Contents to section 2.2, revision of scheduled meetings, finalized roles.

1. Executive Summary

Provide below a brief overview of this project (e.g., project purpose and justification):

Design and manufacture a system to supply snacks to a user based on the allergies of the user and the number of snacks requested.

Provide a brief project summary in the space below. This information may be available in the Project Charter. Also provide a link to the *Project Charter* for reference.	**Link To Project Charter**

Note: **In any instance where there is a discrepancy between the *Project Charter* and the *Project Scope Statement*, the latter is considered authoritative.**

2. Business Objectives

2.1 Product Description (Solution):

An autonomous snack supply system to make use of digital, mechanical and eMBEDded systems to analyze and dispense snacks, based on user input (a card to indicate known allergies) and to automatically dispense the requested number of snacks. An automated analysis system is required to sort out which snacks contain allergens. The analysis will be done similar to spectroscopy, by looking at the different colors present in the presented sample.

2.2 Course Objectives:

- To design and deliver an automated snack system as a 3rd party contracted company
- To adhere to the specification given by the client
- To build and demonstrate a proof-of-concept unit to bid for the contract.

3. Project Description

For each area below, provide sufficient detail to define this project adequately:

3.1 Project Scope

Includes (list Deliverables):

- Mechanical Designs via a CAD package
- Read sensors via MBED driven by visual C# program
- Demonstration of Mechanical Prototype
- Produce System State Machine and ASM Charts
- A Graphical User Interface to interact with the system
- A website for marketing the system
- Demonstrate ability to integrate PC, MBED and FPGA systems to manipulate physical hardware

Does Not Include:

- Any elements outside of scope not cleared by project sponsor

3.2 Project Completion Criteria:

Demonstration of working prototype to staff and industry.

3.3 External Dependencies:

3. Project Description
• Access to Windows machines that have Altera Quartus and Visual C# software • Common construction materials, e.g. metal plates, strips, rod, wires etc. • Construction facilities with hand-held tools • Security of the locker facilities
3.4 Assumptions:
Each user has only one allergy – combinations of two or more allergies not possible User is able to read and comprehend one of the two display languages
3.5 Constraints:
Time – Due in Week 12 (29th November 2017), Manpower, No additional costs, Resources, Limited contact with project sponsor (once a week),

4. Project Milestones

Estimated Schedules – List key project milestones relative to project start. (Insert rows as needed)

Project Milestone	Target Date (MM/DD/YYYY)
Project Start	19/09/17
First Set of Mechanical Drawings	16/10/2017
Read a Sensor via MBED	20/10/2017
Demonstration of Mechanical Prototype	26/10/2017
State Machines and ASM Charts	26/10/2017
Demonstration of GUI	2/11/2017
Demonstration of Web Page	2/11/2017
PC to MBED to FPGA Demonstration	9/11/2017
Demonstration of sorter to industry under control of PC program	9/11/2017
Project Complete	29/11/17

5. Project Approach

5.1 Primary Plans - Will the project have formal written plans – i.e., project schedule, budget, quality, risk, etc.? Describe briefly in the space below:

5.2 Scheduled Status Meetings (Insert rows as needed):

Meeting	Purpose	Frequency
Team Meetings		Weekly
Sponsor Meetings	Update Sponsor on Progress of Project	Weekly
Mechanical Labs	Work on Physical Prototype and Electronics	Weekly
Section Meeting	Individual Section meet to work on section completion	As Needed

5. Project Approach

5.3 Scheduled Status Reports (Insert rows as needed):

Report	Purpose	Frequency
Informal-Section Reports	Formal updates on completion on sections of project.	Bi-Monthly
Meeting Minutes	Report on Team meetings to be submitted to project sponsor weekly.	Weekly
Workshop Reports	Updates on current completion of physical prototype, any addition resource request	Weekly

Briefly describe how each of the following will be handled. Provide links to relevant documents as appropriate. Modify example text provided or enter your own.

5.4 Issue Management:	▪ Project-related issues will be tracked, prioritized, assigned, resolved, and communicated in accordance with the *Project Management Methodology*. ▪ Issues will be reported using an Issue Report Form. Issue descriptions, owners, resolution and status will be maintained in an Issues Log in a standard format. ▪ Issues will be addressed with the project owner and communicated in the project weekly status report.
5.5 Change Management:	**This will not apply to you and your assessment as this project will be excluded and delivered in a control environment**
5.6 Communication Management:	The following strategies have been established to promote effective communication within and about this project. Specific Communication policies will be documented in the <Project> Communication Plan. • The Project Manager will present project status to the project Sponsors on a weekly basis; however, *ad hoc* meetings will be established at the Project Manager's discretion as issues or change control items arise. ▪ The Project Manager will provide a written status report to the project Sponsors monthly and distribute the Project Team meeting minutes. ▪ The project Sponsors will be notified via e-mail of all urgent issues. Issue notification will include time constraints, and impacts, which will identify the urgency of the request for service. ▪ The Project Team will have weekly update/status meetings to review completed tasks and determine current work priorities. Minutes will be produced from all meetings. ▪ All electronic Project Documents will be maintained in central storage accessible by all project stakeholders.
5.7 Procurement Management:	▪ **This Will not apply to you and your assessment as the material and resources are available and there is no need to purchase.**

5. Project Approach	
5.8 Resource Management:	The project team will produce a Resource Management Plan that will document the following: • Lists all major goods and services required in the project along with cost estimates and quality information. • Indicates which goods and services will be obtained from sources outside the Organization • Indicates who is assigned to the project and when.

6. Authorizations (Modify lists as needed)
The Scope Statement, WBS, Project Schedule, Risk Management Plan and Project Budget are approved by the:
• **Keith Brown** • **George Taylor**
Project performance baseline changes will be approved by the:
• **Keith Brown** • **George Taylor**
Project deliverables will be approved/accepted by the:
• **Keith Brown** • **Reza Mohammadi**
Specific task responsibilities of project resources will be defined in the *Responsibility Assignment Matrix*.

7. Project Scope Statement Approval / Signatures	
Project Name:	Group 4
Project Manager:	George Taylor

The purpose of this document is to provide a vehicle for documenting the initial planning efforts for the project. It is used to reach a satisfactory level of mutual agreement among the Project Manager, Project Sponsors and Stakeholders with respect to the objectives and scope of the project before significant resources are committed and expenses incurred.

I have reviewed the information contained in this* Project Scope Statement *and agree:

Name	Role	Signature	Date (MM/DD/YYYY)
George Taylor	Project Manager		
Duncan Fraser	Company Secretary		
Rohit	Public Relations Officer		
Ashwin Rajendran	Chief Software Engineer		
Chi Wai Kong	Chief Electronics and Wiring Engineer		

7. Project Scope Statement Approval / Signatures			
Mei Qi	Chief Mechanical Engineer		
Zhepin Choong	Chief Digital Systems Engineer		

The signatures above indicate an understanding of the purpose and content of this document by those signing it. By signing this document, they agree to this as the formal* Project Scope Statement *document.

9.7 Work Breakdown Structure

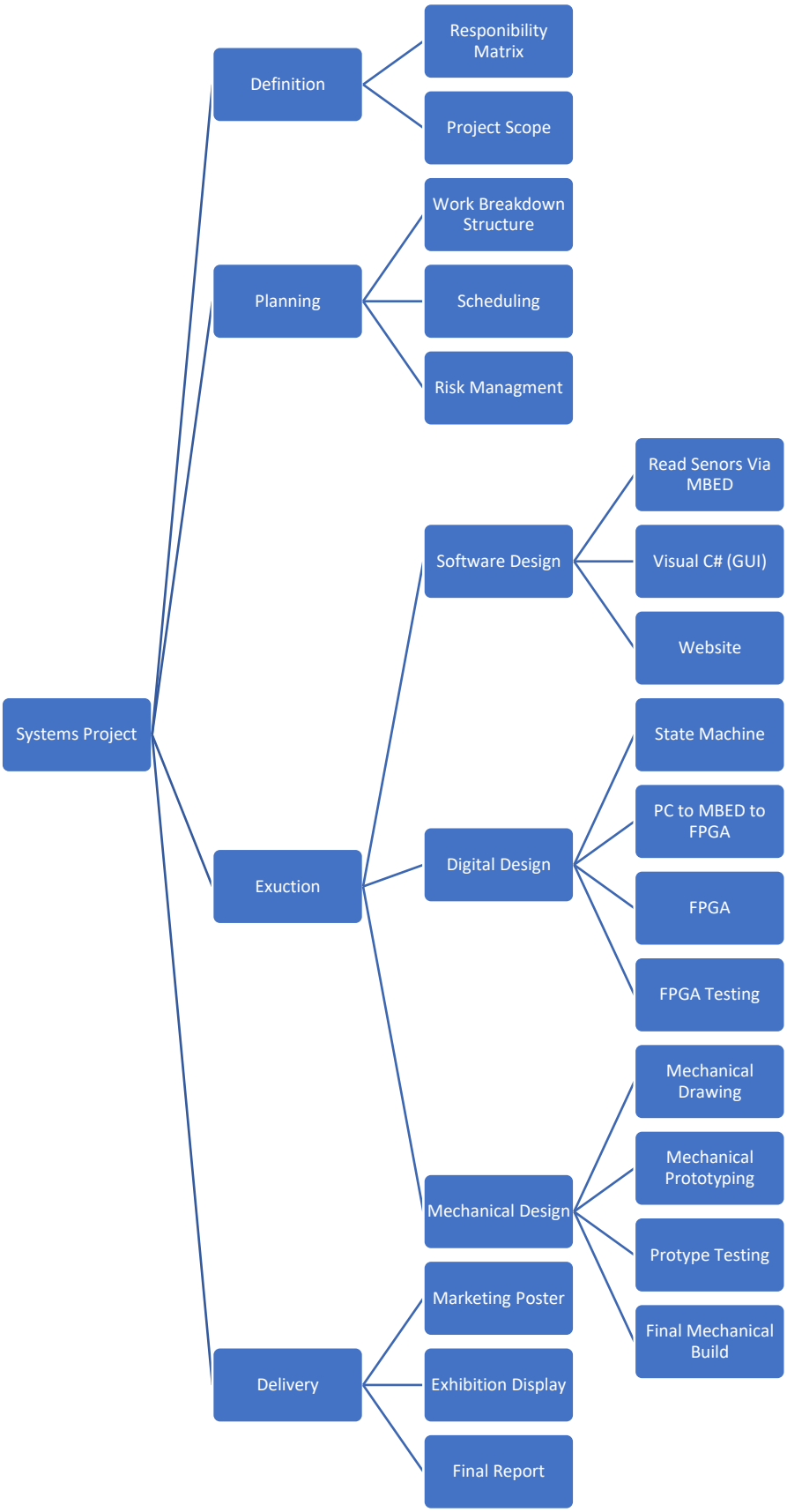
Work Breakdown Structure

Project Name:	Alpha Vending Solutions
Course Code:	**B39VS**
Prepared by (Project Team):	George Taylor Mei Qi Zhepin Choong Chi Kong Ashwin Rajendran Rohit Duncan Fraser
Date (MM/DD/YYYY):	
Project Manager Signature	
Team signatures	
Sponsor Signature	

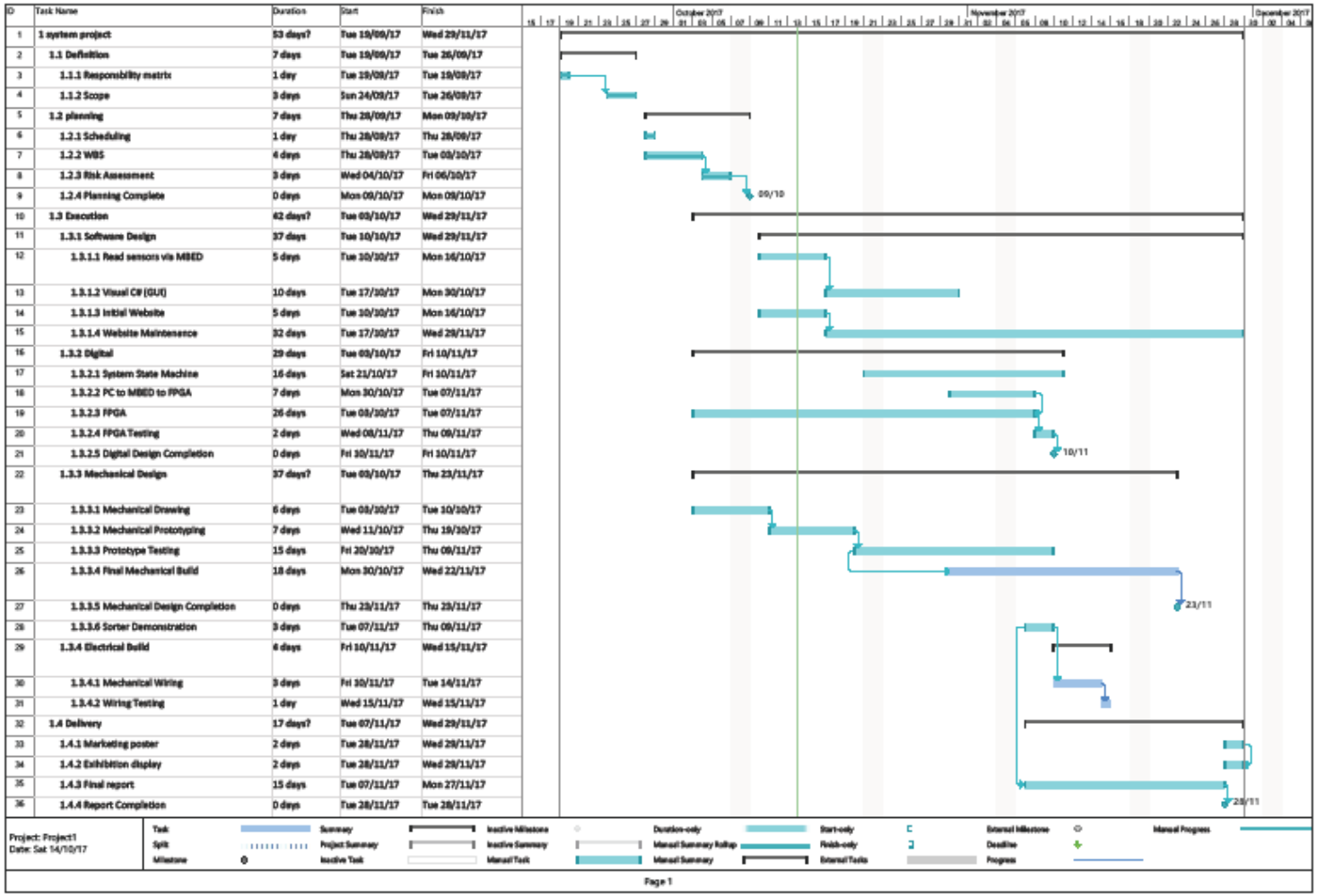
Version History (insert rows as needed):		
Version	**Date (MM/DD/YYYY)**	**Comments**
1.0	06/10/17	Initial WBS document

1. Work Breakdown

Task Name
1. System project
1.1. Definition
1.1.1. Responsibility matrix
1.1.2. Scope
1.2. Planning
1.2.1. Scheduling
1.2.2. WBS
1.2.3. Risk Assessment
1.2.4. Planning Complete
1.3. Execution
1.3.1. Software Design
1.3.1.1. Read sensors via MBED
1.3.1.2. Visual C# (GUI)
1.3.1.3. Website
1.3.2. Digital
1.3.2.1. System State Machine
1.3.2.2. PC to MBED to FPGA
1.3.2.3. FPGA
1.3.2.4. FPGA Testing
1.3.2.5. Digital Design Completion
1.3.3. Mechanical Design
1.3.3.1. Mechanical Drawing
1.3.3.2. Mechanical Prototyping
1.3.3.3. Prototype Testing
1.3.3.4. Final Mechanical Build
1.3.3.5. Mechanical Design Completion
1.3.3.6. Sorter Demonstration
1.3.4. Electrical Build
1.3.4.1. Mechanical Wiring
1.3.4.2. Wiring Testing
1.4. Delivery
1.4.1. Marketing poster
1.4.2. Exhibition display
1.4.3. Final report
1.4.4. Report Completion


Systems Project
Definition
Responibility Matrix
Project Scope
Planning
Work Breakdown Structure
Scheduling
Risk Managment
Exuction
Software Design
Read Senors Via MBED
Visual C# (GUI)
Website
Digital Design
State Machine
PC to MBED to FPGA
FPGA
FPGA Testing
Mechanical Design
Mechanical Drawing
Mechanical Prototyping
Protype Testing
Final Mechanical Build
Delivery
Marketing Poster
Exhibition Display
Final Report

9.8 Project Plan



ID	Task Name	Duration	Start	Finish
1	1 system project	53 days?	Tue 19/09/17	Wed 29/11/17
2	1.1 Definition	7 days	Tue 19/09/17	Tue 26/09/17
3	1.1.1 Responsibility matrix	1 day	Tue 19/09/17	Tue 19/09/17
4	1.1.2 Scope	3 days	Sun 24/09/17	Tue 26/09/17
5	1.2 planning	7 days	Thu 28/09/17	Mon 09/10/17
6	1.2.1 Scheduling	1 day	Thu 28/09/17	Thu 28/09/17
7	1.2.2 WBS	4 days	Thu 28/09/17	Tue 03/10/17
8	1.2.3 Risk Assessment	3 days	Wed 04/10/17	Fri 06/10/17
9	1.2.4 Planning Complete	0 days	Mon 09/10/17	Mon 09/10/17
10	1.3 Execution	42 days?	Tue 03/10/17	Wed 29/11/17
11	1.3.1 Software Design	37 days	Tue 10/10/17	Wed 29/11/17
12	1.3.1.1 Read sensors via MBED	5 days	Tue 10/10/17	Mon 16/10/17
13	1.3.1.2 Visual C# (GUI)	10 days	Tue 17/10/17	Mon 30/10/17
14	1.3.1.3 Initial Website	5 days	Tue 10/10/17	Mon 16/10/17
15	1.3.1.4 Website Maintenence	32 days	Tue 17/10/17	Wed 29/11/17
16	1.3.2 Digital	29 days	Tue 03/10/17	Fri 10/11/17
17	1.3.2.1 System State Machine	16 days	Sat 21/10/17	Fri 10/11/17
18	1.3.2.2 PC to MBED to FPGA	7 days	Mon 30/10/17	Tue 07/11/17
19	1.3.2.3 FPGA	26 days	Tue 03/10/17	Tue 07/11/17
20	1.3.2.4 FPGA Testing	2 days	Wed 08/11/17	Thu 09/11/17
21	1.3.2.5 Digital Design Completion	0 days	Fri 10/11/17	Fri 10/11/17
22	1.3.3 Mechanical Design	37 days?	Tue 03/10/17	Thu 23/11/17
23	1.3.3.1 Mechanical Drawing	6 days	Tue 03/10/17	Tue 10/10/17
24	1.3.3.2 Mechanical Prototyping	7 days	Wed 11/10/17	Thu 19/10/17
25	1.3.3.3 Prototype Testing	15 days	Fri 20/10/17	Thu 09/11/17
26	1.3.3.4 Final Mechanical Build	18 days	Mon 30/10/17	Wed 22/11/17
27	1.3.3.5 Mechanical Design Completion	0 days	Thu 23/11/17	Thu 23/11/17
28	1.3.3.6 Sorter Demonstration	3 days	Tue 07/11/17	Thu 09/11/17
29	1.3.4 Electrical Build	4 days	Fri 10/11/17	Wed 15/11/17
30	1.3.4.1 Mechanical Wiring	3 days	Fri 10/11/17	Tue 14/11/17
31	1.3.4.2 Wiring Testing	1 day	Wed 15/11/17	Wed 15/11/17
32	1.4 Delivery	17 days?	Tue 07/11/17	Wed 29/11/17
33	1.4.1 Marketing poster	2 days	Tue 28/11/17	Wed 29/11/17
34	1.4.2 Exhibition display	2 days	Tue 28/11/17	Wed 29/11/17
35	1.4.3 Final report	15 days	Tue 07/11/17	Mon 27/11/17
36	1.4.4 Report Completion	0 days	Tue 28/11/17	Tue 28/11/17

9.9 Risk Management

Risk Management

Project Name:	Alpha Vending Solutions
Course Code:	**B39VS**
Prepared by (Project Team):	George Taylor Zhepin Choong Chi Kong Mei Qi Ashwin Rajendran Rohit Duncan Fraser
Date (MM/DD/YYYY):	06/10/17
Project Manager Signature	
Team signatures	
Sponsor Signature	

Version History (insert rows as needed):

Version	Date (MM/DD/YYYY)	Comments
1.0	27/09/2017	Initial Template. To be Filled in upon completion of WBS
2.0	06/10/2017	First Complete Plan (WIP)

1 Project Risk Register

Project Name	Alpha Vending Solutions				
Prepared by		**Date**		**Revision**	**1.0**
Project Manager	George Taylor	**Project Sponsor**		Keith Brown	
Risk Code	**Risk Event**	**Probability**	**Impact**	**Response**	
1	Injuries from the workshop	Medium	High		
2	Not enough people/ no one attends workshop	Medium	High		
3	Losing files and data	Low	High		
4	Initial Mechanical Prototype might not work	Medium	Medium		
5	Delay in Tasks completion	Low	High		
6	Lack of Team Attendance during Sorter Demonstration	Low	Medium		
7	Overwork of Team Members	Medium	High		
8	Damage to Wiring Loom	Medium	Medium		
9	Poor communication among team members	Low	High		
10	Team member Leaving project	Low	Medium		

2 Risk Probability / Impact Matrix

		Impact		
		Low	Medium	High
Probability	Low		06 10	03 05 09
	Medium		04 08	01 02 07
	High			

3 Severity Scale

Provided for reference

		Impact				
Probability	1.00	0.20	0.40	0.60	0.80	1.00
	0.80	0.16	0.32	0.48	0.64	0.80
	0.60	0.12	0.24	0.36	0.48	0.60
	0.40	0.80	0.16	0.24	0.32	0.40
	0.20	0.40	0.08	0.12	0.16	0.20
		0.20	0.40	0.60	0.80	1.00

4.1 Project Risk Information

Duplicate as Necessary

Code	01	**Revision**	1.0	**Date Identified**	5th Oct, 2017
Risk Title	Injuries from the workshop				
Probability	Medium		**Risk Owner**	Chi Wai Kong	
Impact	High		**Source**	WBS 1.3.0.0	
Severity	0.6		**Time Frame**	11/10/2017 - 22/11/2017	

Risk Description	In electronic and wire engineering/ workshop engineering is very easy to get injured. For example, people are easily getting hurt when using soldering iron and saw wrongly or without safety consciousness.
Mitigation Strategy	Following the rules of the lab and do not work alone.
Contingency Plan and Trigger	Rearranging the duty of everyone.
Risk Status	Electronic and wire engineering/ workshop engineering has not started yet.

4.2 Project Risk Information

Duplicate as Necessary

Code	02	**Revision**	1.0	**Date Identified**	5th Oct, 2017
Risk Title	Not enough people/ no one attend workshop				
Probability	Medium		**Risk Owner**	Chi Wai Kong	
Impact	High		**Source**	WBS 1.3.0.0	
Severity	0.48		**Time Frame**	11/10/2017 - 22/11/2017	

Risk Description	If not enough people or no one attend workshop, tasks will be delayed or cause heavier workloads for other team members.
Mitigation Strategy	People who will absent the workshop should inform project manager and the department engineer at least 12 hours before the workshop starts. Otherwise, there will be a warning letter.
Contingency Plan and Trigger	Setting up a Rota for every teammate to be the substitute on the workshop day. Teammate who is on duty for the substitute position should be able to on call and gives help if needed during the working hours.
Risk Status	Workshops have not started yet.

4.3 Project Risk Information

Code	03	**Revision**	1.0	**Date Identified**	5th October 2017
Risk Title	Losing Our Files and Data				
Probability	Low		**Risk Owner**	All Team Members	
Impact	High		**Source**	WBS 1.0.0.0	
Severity	0.20		**Time Frame**	19/09/17 - 16/12/17	

Risk Description	All our work is currently being saved in our group SharePoint, via our university Office 365 Accounts. Should the servers crash, or someone accidently deletes any files, we may lose our work.
Mitigation Strategy	All of us agreed to synchronize our personal computers with the SharePoint, so we all have a copy of the documents which is updated regularly. We all will also have the responsibility to keep back-ups of each our individual work in our own personal computers and/or via our student accounts on university computers.
Contingency Plan and Trigger	Should anyone notice any missing documents, they should email the group immediately. Then upon review by the rest of the team, we can decide to restore the document using one of our back-ups.
Risk Status	Currently no risk as all files are up-to date on SharePoint.

4.4 Project Risk Information

Duplicate as Necessary

Code	04	**Revision**	1.0	**Date Identified**	5th October 2017
Risk Title	Initial Mechanical Prototype might not work				
Probability	Medium		**Risk Owner**	Fiona and Ashwin	
Impact	Medium		**Source**		
Severity	Medium		**Time Frame**		

Risk Description	Our initial mechanical design might not work, so we will need to redesign as we find faults, either from other team members reviewing the design or after making the initial prototype
Mitigation Strategy	We have allocated plenty of time – 15 days, for prototype testing. This gives us some leeway, to make modifications to the design and the physical prototype.
Contingency Plan and Trigger	Should the mechanical prototype not be in a working state within 3 days of the scheduled sorter demonstration on 9/11/17, the mechanical engineers will need to inform the project manager and additional team members will be requested to assist.
Risk Status	The initial designs are being worked on, and are due on 10/10/17 during the weekly meeting.

4.5 Project Risk Information

Duplicate as Necessary

Code	05	**Revision**	1	**Date Identified**	5/10/17
Risk Title	Delay in Tasks completion				
Probability	low		**Risk Owner**	All team members	
Impact	High		**Source**	WBS 1.0.0.0	
Severity	High		**Time Frame**		

Risk Description	Inability to complete set tasks on time will result in our project being delayed and work that might be rushed and/or incorrect.
Mitigation Strategy	Allow a buffer time for each task to recover if not completed on time. Through communication with the entire team so that team members may assist one another to overcome the various reasons one might not be able to complete a given task.
Contingency Plan and Trigger	The task heads will ensure the smooth progress and completion of the task and will report to the team leader if additional assistance in required. In turn, the team leader will keep up with the progress of each task to ensure its timely completion.
Risk Status	Each of the group members are keeping up the daily progress of the project and thus far the tasks are being completed smoothly. Continuous monitoring during the life span of the project will be necessary to ensure this holds true.

4.6 Project Risk Information

Duplicate as Necessary

Code	06	**Revision**	1.0	**Date Identified**	06/10/17
Risk Title	Lack of Team Attendance during Sorter Demonstration				
Probability	Low		**Risk Owner**	Team	
Impact	Medium		**Source**	WBS 1.3.3.6	
Severity	0.08		**Time Frame**	27/11/17 – 1/12/17	

Risk Description	Team members unable to attend sorter demonstration to customer
Mitigation Strategy	All Team members will be informed prior to event. With reminders during the week of the demonstration.
Contingency Plan and Trigger	All team members will have required knowledge to attend the sorter demonstration and operate the system effectively
Risk Status	No Effect until towards end of project.

4.7 Project Risk Information

Duplicate as Necessary

Code	07	**Revision**	1.0	**Date Identified**	06/10/17
Risk Title	Overwork of Team Members				
Probability	Medium		**Risk Owner**	Team	
Impact	High		**Source**	WBS – All Sections	
Severity	0.6		**Time Frame**	19/09/17 - 16/12/17	

Risk Description	This risk may occur during normal task progression, or develop as time goes on if other risks begin to stack up. If project delivery is delayed by too much, report-writing will overlap with end-of-semester exams, leading to further overwork.
Mitigation Strategy	For each team member to stick to project plan and to continually take into consideration the wellbeing and workload of other team members
Contingency Plan and Trigger	As with risk code 05, task heads will take responsibility for specific delivery areas and team leader will ensure task progression is followed as per the project plan.
Risk Status	No indication of risk as yet.

4.8 Project Risk Information

Duplicate as Necessary

Code	08	**Revision**	1	**Date Identified**	06/10/17
Risk Title	Damage to wiring Loom				
Probability	Medium		**Risk Owner**	George Taylor	
Impact	Medium		**Source**	WBS 1.3.41	
Severity	0.36		**Time Frame**	10/11/17 – 27/11/17	

Risk Description	Damage to wiring loom resulting in loss of functionality or loss of power to system.
Mitigation Strategy	Correct routing of wiring loom. Ensure wiring loom is clear of any moving part of the system. Protection of the wiring by insertion into T section of frame.
Contingency Plan and Trigger	construct a new wiring loom, or reroute existing wiring loom to prevent damage. Identify cause and rectify.
Risk Status	No risk Present at time of writing.

4.9 Project Risk Information

Duplicate as Necessary

Code	09	**Revision**	1.0	**Date Identified**	6/10/17
Risk Title	Poor communication among team members				
Probability	Low		**Risk Owner**	Team	
Impact	High		**Source**	WBS-All Sections	
Severity	0.20		**Time Frame**	19/09/17 - 16/12/17	

Risk Description	This risk can occur if one of the members did not update their progression on the work they are working on. This can cause the other members to not be able to proceed on their work.
Mitigation Strategy	Have all members to send an informal report to the team once they are done working on each of the allocated tasks.
Contingency Plan and Trigger	The team leader or anyone from the group shall constantly remind other members to send their informal report.
Risk Status	No indication of risks yet.

4.10 Project Risk Information

Duplicate as Necessary

Code	10	**Revision**	1	**Date Identified**	06/10/17
Risk Title	Team Member Leaving Project				
Probability	Low		**Risk Owner**	George Taylor	
Impact	Medium		**Source**	WBS 1.0.0.0	
Severity	0.80		**Time Frame**	19/09/17 – 27/11/17	

Risk Description	Team Member leaving Project/University Course.
Mitigation Strategy	maintain internal working practices and relationships, to ensure there is no internal stimulus to provoke a team member leaving. External factors cannot be accounted for.
Contingency Plan and Trigger	All team members will have a basic knowledge of each section, should a team member leave. Another team member can be assigned their roles and responsibilities.
Risk Status	Unable to determine.

9.10 Team Contract

Team Contract

Project Name:	Group 4
Course Code:	**B39VS**
Prepared by (Project Team):	George Taylor Duncan Fraser Mei Qi Zhepin Choong Rohit Chi Kong Ashwin Rajendran
Date (MM/DD/YYYY):	24/09/2017
Project Manager Signature	

Version History (insert rows as needed):		
Version	**Date (MM/DD/YYYY)**	**Comments**
1.0	24/09/17	Initial Team Contract, To Be Approved by Team Members

1. Team Procedures	
1.1 Team Meetings	Weekly Team meeting will be held Tuesday mornings before 10:15, these meetings will have minutes recorded. Sponsor meetings will be held Tuesday afternoon between 13:15 and 16:15, at a time set by the project sponsor. Any additional meeting can be arranged between team members, these meeting do not require minutes to be taken.
1.2 Communication	Communication will primarily be through university provided emails. Any communication to the entire group should be addressed to the SharePoint email address [B39VSGroup4@heriotwatt.onmicrosoft.com]. For any non-essential communication and instant messaging capability WhatsApp mobile application will be used, with a group provided for the team. Any documents relevant to the project will be saved in the SharePoint Formal team meeting will be announced on SharePoint, with team members required to RSVP to all formal team meetings. All team members will keep a back-up by syncing to the SharePoint folder.
1.3 Decision Making Policy	Primary decision making is done by consensus, and for contentious issues we switch to majority vote. For minor decisions, they are to be brought up as other business during the weekly team meeting. For major decisions, they are to be brought to the project manager to be included into the agenda for the weekly team meeting for a more comprehensive discussion between team members.
1.4 Meeting Agendas	Agendas will be produced by the Project Manager, or Project Secretary is Project Manager is unable to complete agenda. Any group member may suggest agenda points in an open informal document on SharePoint prior to the meeting. The suggested points will be considered and included in the formal Agenda on a priority and time basis. Agenda for meetings will be included in the SharePoint and the meeting event, no later than one day before the team meeting.
1.5 Record Keeping	Meeting minutes will be the responsibility of the Project Secretary, should they not be able to attend meetings, they will be responsible for requesting another team member to complete the minutes during the meeting. Meeting minutes will be formally written up and sent to the Project Sponsor prior to Noon Friday on the week of the meeting. Written up notes will be published to the SharePoint group prior to Noon Friday on the week of the meeting.

2. Team Expectations	
2.1 Work Quality	
2.11 Project Standards	Every aspect of the project should be completed with to the highest possible standard which you can personally achieve. The solutions found to tasks should be efficient using only the appropriate resources. The finished prototype should meet the entirety of the supplied specification, along with properly functioning upon every use of the system. Initial draft of final report will be collated by the group, each member contributing to their own assigned section. The final document will then be reviewed by the Project Manager, Secretary, or designated person, in order to combine all contributed sections into one complete written piece.
2.12 Strategies	To accomplish the highest possible project standards, each aspect of the project will be assessed by the fellow team members. Where upon all team members can contribute to assessing the aspect of the project. Any member who requests additional help and/or resources to help assist in obtaining the expected standard, will be given such. So long as the request for help and/or resources is within reason.
2.2 Team Participation	
2.21 Team Maintenance	All Team Member will have an input on the duration of any task given to them, so long as this does not have an adverse effect upon Project Sponsor deadlines or upon other Team Members tasks. During Team Meeting all Team Members are encouraged to voice their inputs on all agenda topics. No topics with effect on the whole project should be made without the input from the majority of Team Members. Although topics within set assignments can be decide by those working on said assignment.
2.22 Task Maintenance	Tasks will be reported on at every Team Meeting to ensure that deadline are being upheld to, should any Team Member not be able to meet said deadline due to time constraints by other assignments or fellow Team Members the deadline will be adjusted so long as any adjustment does not have any adverse effect on any other assignment or deadline by Project Sponsor. Responsibility for remaining on task for any assignment will be on the Team Member in charge of the assignment, with the Project Manager maintaining contact with the Team Member to ensure that the assignment is able to be completed within the deadline. Team Members may request additional personnel to assist with completion of an assignment. Should no fellow Team Members volunteer to assist in completion of the assignment the Project Manager has the ability to request a Team Member to assist in the completion of the assignment, this is completely at the discretion of the Project Manager.
2.3 Personal Accountability	

2. Team Expectations	
2.31 Punctuality	All team members are expected and required to attend formal team meetings at the time and location specified. Should any member have a reason for being unable to attend team meetings, they should contact the team an email prior to 18:00 the night before the meeting. Should there be a mitigating circumstance under which a team member cannot attend the meeting and are unable to inform the team, they should endeavor to inform the team after the fact with the mitigating circumstance. Should you not wish to disclose the mitigating circumstance, it will be allowed for one off incidents. Should it begin happening frequently it will be investigated.
2.32 Assignments	Once as task has been assigned to a team member they will have a say on the duration of time that they will require to complete the task. This should be a reasonable request that should not adversely affect any other deadlines, either team member deadlines or those set by Project Sponsor. All team members are responsible for completion of all task assigned by the Project Manager within the deadline assigned. Should team members require extensions on deadlines they should make a request during a team meeting. If the request is reasonable and does not have an adverse effect upon fellow team task or assignment deadlines set by the Project Sponsor, it will be considered.
2.33 Communication	Team members are expected to communicate progress of their task at team meeting. Team members should respond to all email communications which require responses from all team members [Meeting Events] and to respond to any email directly sent to them from any other team member which regards to progress within the project. Team members should also be present within the group chat, using the WhatsApp messaging service, although they are not required to respond to all messages, unless directed at you personally or the section/task you are working on.
2.34 Commitment	Should any team member have an issue with decisions made as a team has the right to question the decision and to propose a different solution until all team members agree. Team member are expected to show a noticeable level of commitment to the Project and the tasks they are requested to complete. Should any team member does not show this level of commitment, this will be investigated

3. Infractions	
3.1 Initial Infractions	
3.11 Infraction Definitions	Infractions include, but not limited to; • Routine failure to attend Team Meetings. • Failure to produce work in adherence to Project Plan • Be involved in a conflict which is affecting the ability for fellow Team Members to complete their section/task • Have any adversely negative effect upon any Team Members, Project or Meetings.
3.12 Issue Reporting	Should you believe a Team Member is suspect of committing an infraction. You should contact the Project Manager or Project Secretary. You can also submit an issue using the Issue Report Form, this form is anonymous.
3.13 Infraction Resolution	Infractions regarding Tasks/Assignments will be handled by the group as a whole. The team member suspected of committing an infraction will be required to give an explanation to the team during the weekly meetings. Should they keep repeating the infraction, the team will inform the project Sponsor. The team member suspected of the infraction will be presented with the information that has culminated in the suspicion being levied against them. They will be allowed to query the accusations levied against them. The group will then decide upon the action to take against the Team Member suspected of committing the Infraction and a resolution will be attempted. Should there be no resolution to be found from within the Team further action will be taken.
3.2 Multiple or Severe Infractions	
3.21 Failure to Produce or Attend	The Team Member suspected will be interview with the team. [See Section 3.13]. Should there be no resolution from this interview the information that has culminated in the suspicion will be passed onto the Project Sponsor along with the Minutes from the interview. The Project Sponsor will decide what action should be taken against the Team Member suspected.
3.22 Unresolved Interpersonal Conflict	The Project Manager, or an impartial member of the team will interview all parties involved in the conflict to resolve the issue to resolve any issues. Should there be no resolution following the meeting the Project Sponsor will be informed and the decision on resolving the issue will be solely by the Project Sponsor.
3.23 Discrimination or Hate Crimes	For any suspected incident of Discrimination or Hate Crimes with circumstantial evidence will receive a written warning, which will be copied to the Project Sponsor. Should there be any proof, or sufficient evidence of Discrimination or Hate Crimes committed by Team Member. This proof/evidence will be immediately submitted to the Project Sponsor and University Staff.

7. Project Scope Statement Approval / Signatures	
Project Name:	Group 4
Project Manager:	George Taylor
The purpose of this document is to provide a vehicle for documenting the expectations for the project. It is used to reach a satisfactory level of agreement among the Project Manager, Project Sponsors and Stakeholders with respect to the expectations for successful completion of the outlined project scope and specification.	
I have reviewed the information contained in this Team Contract and agree:	

Name	Role	Signature	Date (MM/DD/YYYY)
George Taylor	Project Manager		
Duncan Fraser	Secretary		
Mei Qi	Chief Mechanical Engineer		
Zhepin Choong	Chief Digital Designer		
Rohit	Public Relations Officer, Workshop Engineer		
Chi Kong	Chief Electronics and Wiring Engineer, Workshop Engineer		
Ashwin Rajendran	Chief Software Engineer, Web Designer		

The signatures above indicate an understanding of the purpose and content of this document by those signing it. By signing this document, they agree to this as the formal Team Contract

9.11 Meeting Minutes

Meeting Minutes				
Group Name:	Alpha Vending Solutions		**Group Number:**	04
Week:	Week 2			
Date:	26/09/17	**Time:**	08:30 – 09:30	
Place:	Learning Commons Room 1			
Present:	Duncan Fraser George Taylor Ashwin Rajendran Chi W Kong Mei Qi Zhepin Choong			
Apologies:	Rohit			
Agenda:	1- Finalize Project Scope 2- Finalize Team Contract 3- Review individual timetables to improve scheduling meetings 4- Begin Brainstorming WBS 5- Decide on team name			
Review of previous actions:	Non-Applicable			
Main business:			**Action**	
	1) George Taylor Reviews initial Project Scope as drafted by George Taylor, Ashwin Rajendran and Duncan Fraser. Addition to Section 2.2 of Project Scope; Business objective as outline under Background Section of third year Systems Project Webpage. Modifications to Roles as displayed in Project Scope. All actions where approved by present team members. 2) Change to Section 2.2 of Team Contract to remove Password from Important Documents, approved by all present team members. Section 1.3 was altered to make decision making via consensus. An open Document will be made available for team members to add Agenda points for next meeting. Section 2.31 Reworded to be more concise. Apologies made more formal. Sections 3.13 altered to change infraction handling to a group process rather than individual.			

	All actions approved by present team members. 3) All team members agreed upon Tuesday mornings prior to 10:15 for formal team meetings. 4) WBS Brainstorm postponed to a later date during this week. Proposed time Thursday post-Lecture hours, or via Skype Meeting during Weekend. Proposed time yet to be accepted by all team members. 5) Rohit submitted several team names via proxy. After discussion 'Alpha Vending Solutions' was accepted by all present team members.
AOB:	
	Next Meeting to be held Tuesday 3rd October, Time and Location to be determined.

Meeting Minutes			
Group Name:	Alpha Vending Solutions	**Group Number:**	04
Week:	Week 4		
Time:	09:15 – 10:15		
Place:	Learning Commons Room 1		
Present:	George Taylor Mei Qi Duncan Fraser Ashwin Rajendran Rohit Zhepin Choong		
Apologies:	N/A		
Agenda:	1. Review Project Plan and Finalize Task Scheduling 2. Discuss Points to raise during Customer Meeting 3. Begin Risk Management		
Review of previous actions:	Project plan accepted by team members not present during WBS plan meeting.		
Main business:		**Action**	

	1. Review of Project Plan Feasibility Study Removed from WBS, as non-applicable within current project. Dates set for Gantt Chart. Agreed upon by all team members. Duncan Fraser to organize Gantt Chart for end of week to allow for submission with rest of Project Plan. 2. Customer Meeting Points No immediate points to be discussed during Customer Meeting. 3. Risk Management Each member will add a risk to the Risk Register and complete Risk Information by end of day Thursday. George Taylor and Duncan Fraser will collate Risk Management Document and submit with rest of project plan at end of week to Project Sponsor.
AOB:	
	No other business to be discussed

Meeting Minutes			
Group Name:	Alpha Vending Solutions	**Group Number:**	04
Week:	Week 6 Meeting 4		
Time:	17/10/17 0900 – 1015		
Place:	Learning Commons Room 2		
Present:	Duncan Fraser George Taylor Leo Kong Rohit Zhepin Choong Ashwin Rajendran Mei Qi		
Apologies:	N/A		
Agenda:	Review of Previous Actions: Software and Electronics team to report back on status of Task 1.3.1.1 (Read Sensor via MBED) Mechanical Team to report on status of task 1.3.2.2 – Prototyping Web Design Team to report on status of task 1.3.1.3 - Website Agenda: Project Plan to be analysed to view upcoming tasks		

	Discussion of questions for Keith at Team Meeting in the afternoon Any Other Business	
Review of previous actions:	George Taylor and Ashwin Rajendran report Colour sensor and Time of Flight Sensor working on MBED development board. Rohit Reports that Mechanical design requires reworking, Ashwin Rajendran, Leo Kong confirm and elaborate. Duncan Fraser reports that Servo has been confirmed working on Altera DE1 board, and that board was replaced due to original board having damaged input/output buffers. Duncan Fraser reports that the Maintenance Mode Software is now functional and integration to the MBED can begin. Zhepin Choong reports that website shell has been designed, placeholder text and images currently used.	
Main business:		**Action**
	Mechanical design needs redesigned to hold more blocks and make room to sit servo in the slot, ask during Project QnA if system should find out how many of each colour block are in system or if it can be inputted at start-up. Dependent on answer Mechanical design me need more changes. Ashwin Rajendran will complete CAD drawing for any updated mechanical design. George Taylor, Ashwin Rajendran and Duncan Fraser will integrate Maintenance Mode Software and MBED to read the colour sensor. Asynchronous State Machine Diagram will be completed by Digital Design Team (Duncan Fraser, Zhepin Choong) and Mechanical Design Team (Ashwin Rajendran, Mei Qi). Meeting time to be confirmed.	
AOB:		
	N/A	

Meeting Minutes			
Group Name:	Alpha Vending Solutions	**Group Number:**	04
Week:	Week 7 Meeting Number 5		
Time:	24/10/17 12:15 – 13:15		
Place:	Earl Mountbatten Room G85		
Present:	George Taylor Duncan Fraser Ashwin Rajendran Zhepin Choong Mei Qi		

Apologies:	Leo Kong Rohit	
Agenda:	Arrange meeting for State Machine Design. Project Plan to view upcoming tasks. Discussion of meeting points for Keith.	
Review of previous actions:	Mechanical Prototype: Mechanical majority complete. Top platform and servo integration required. Mechanical design team to arrange meeting for finishing the mechanical prototype. MBED: Initial source compiled and function with Time of Flight sensor and Colour Sensor operational. FPGA: UART Module compiled and testing required and integration within main Verilog Source.	
Main business:		**Action**
	Team Brainstorm on mechanical design. Discussion regarding holding the storage towers, top loading platform design. Ashwin Rajendran and Duncan Fraser to meet to design State Machine Diagram/ ASM.	
AOB:		
	N/A	

Meeting Minutes			
Group Name:	Alpha Vending Solutions	**Group Number:**	04
Week:	Week 8 Meeting Number 6		
Time:	0900 – 1100		
Place:	Learning Commons Room 2		
Present:	Duncan Fraser George Taylor Mei Qi Ashwin Rajendran Leo Kong Zhepin Choong Rohit		
Apologies:			

Agenda:	PC to MBED to FPGA task assignment Web Design Brainstorm and feedback Decide on Company Logo Visual C# Interface Feedback Final Mechanical Build	
Review of previous actions:	Duncan Fraser and Ashwin Rajendran report; State Machine Diagram Completed and Delivered to Project Sponsor. Zhepin Choong reports; Website Shell Majority Complete, brainstorm being held latter half of meeting. Duncan Fraser reports; FPGA Serial Module Transmitter Working, was unable to test Receiver Module due to not having correct logic level usb-serial device. Basic functionality added to Visual C# GUI. Although design needs improving. Basics of working card scanner working, for a swipe movement. Ashwin Rajendran, Leo Kong, Rohit, Mei Qi report; Mechanical design needs to be built into a housing/mooring for support of the towers. Bottom Platform/Bins need designed and implemented	
Main business:		**Action**
	Work to be carried out on PC-MBED-FPGA, Duncan Fraser will get the serial interface with the FPGA working during the first half of next week (week 9). George Taylor and Ashwin Rajendran will meet with Duncan Fraser to test full functionality of system prior to deliverable. Team Vote on Company logo, Duncan Fraser submitted one design, Rohit Submitted three designs. Team decided on Duncan Frasers Logo. Website Brainstorm, all team members to submit a suitable photograph and description for use on the website. Duncan Fraser suggests holding a brainstorming meeting to design Visual C# GUI. Team Agrees on meeting being held Wednesday 1315-1615. Duncan Fraser requests that George Taylor and Ashwin Rajendran, assume responsibility for the further design and implementation of the card scanner. Both Ashwin Rajendran and George Taylor Accept the change. Mechanical design team (Leo Kong, Mei Qi, Rohit, Ashwin Rajendran) to further build the Mechanical design.	
AOB:		
	Questions for Team Feedback Meeting; “What state of function is requested for deliverable?”	

Meeting Minutes			
Group Name:	Alpha Vending Solutions	**Group Number:**	04
Week:	Week 9 7/11/17		
Time:	1315 - 1415		
Place:	WA Crush		
Present:	Duncan Fraser George Taylor Ashwin Rajendran Leo Kong Zhepin Choong Rohit Mei Qi		
Apologies:			
Agenda:	Task 1.3.3.6 – Demonstration of sorter under control of PC Program Review Task 1.3.3.4 and any required changes to mechanical design from the prototype. Potential Early Task Assignment 1.4.1 and 1.4.2 – Marketing and Poster Task Assignment 1.4.3 Final Report		
Review of previous actions:	PC – MBED -Fpga integration Duncan Fraser reports Serial interface running on Fpga and control of servos through serial communication functional. George Taylor, Ashwin Rajendran and Duncan Fraser Report MBED Control of FPGA Functional. Visual C# GUI Duncan Fraser reports Visual C# Brainstorm produced a successful design. Only functionality to be added is multiple languages		
Main business:		**Action**	
	Demonstration of sorter under PC control George Taylor and Ashwin Rajendran to meet with Duncan Fraser to finish integrating MBED software with C# Software and FPGA Design Marketing and Poster Rohit asked to design Poster for presentation and begin on marketing strategy. Final Report Team requested to begin on writing up their section of the final report. Mechanical Design		

	Duncan Fraser and Mei Qi will design CAD for final mechanical design. All Team members will attend Workshop on Friday to work on building final mechanical design.
AOB:	
	N/A