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**Project Title** Retrofit Fridge Cam

**Revision History**

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision** | **Description of Change** | **Effective Date** | **Updated by** |
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Table of Contents

[1.0 Block Diagram of the Complete System 5](#_Toc507778316)

[2.0 Block Diagram Description 5](#_Toc507778317)

[2.1.1 Display 5](#_Toc507778318)

[2.1.2 Microcontroller 5](#_Toc507778319)

[2.1.3 PC 5](#_Toc507778320)

[2.1.4 HMI 5](#_Toc507778321)

[2.1.5 Wireless 6](#_Toc507778322)

[2.1.6 Image Processing 6](#_Toc507778323)

[2.1.7 Database 6](#_Toc507778324)

[2.1.8 Connector 6](#_Toc507778325)

[2.1.9 Signal Conditioning 6](#_Toc507778326)

[2.1.10 Camera 6](#_Toc507778327)

[2.1.11 Sensor 6](#_Toc507778328)

[3.0 Off-the-shelf Components 7](#_Toc507778329)

[4.0 Design Components 7](#_Toc507778330)

[5.0 Risks and Risk Management Plan 7](#_Toc507778331)

[6.0 Design Task 1: Display (Anas) 8](#_Toc507778332)

[6.1 Display Design Specification (effort of rating is high) 8](#_Toc507778333)

[6.2 Requirements of New Skills 9](#_Toc507778334)

[6.3 Tools and Resources 9](#_Toc507778335)

[6.4 Assessment 1 9](#_Toc507778336)

[6.5 Assessment 2 9](#_Toc507778337)

[6.6 Risks and Risks Management Plan 9](#_Toc507778338)

[7.0 Design Task 2: Connector (Anas) 10](#_Toc507778339)

[7.1 Connector Design Specification (effort of rating is medium) 10](#_Toc507778340)

[7.2 Tools and Resources 10](#_Toc507778341)

[7.3 Assessment 1 10](#_Toc507778342)

[7.4 Assessment 2 10](#_Toc507778343)

[7.5 Risks and Risks Management Plan 10](#_Toc507778344)

[8.0 Design Task 3: Sensor (Mike) 11](#_Toc507778345)

[8.1 Sensor Design Specification (low) 11](#_Toc507778346)

[8.2 Requirements of New Skills 11](#_Toc507778347)

[8.3 Tools and Resources 11](#_Toc507778348)

[8.4 Assessment 1 11](#_Toc507778349)

[8.5 Assessment 2 11](#_Toc507778350)

[8.6 Risks and Risks Management Plan 12](#_Toc507778351)

[9.0 Design Task 4: Database Architecture (Mike) 12](#_Toc507778352)

[9.1 Database Architecture Design Specification (effort of rating is medium) 12](#_Toc507778353)

[9.2 Requirements of New Skills 12](#_Toc507778354)

[9.3 Tools and Resources 12](#_Toc507778355)

[9.4 Assessment 1 12](#_Toc507778356)

[9.5 Assessment 2 12](#_Toc507778357)

[9.6 Risks and Risks Management Plan 13](#_Toc507778358)

[10.0 Design Task 5: Camera (Mike) 13](#_Toc507778359)

[10.1 Camera Design Specification (effort of rating is high) 13](#_Toc507778360)

[10.2 Requirements of New Skills 13](#_Toc507778361)

[10.3 Tools and Resources 13](#_Toc507778362)

[10.4 Assessment 1 13](#_Toc507778363)

[10.5 Assessment 2 14](#_Toc507778364)

[10.6 Risks and Risks Management Plan 14](#_Toc507778365)

[11.0 Design Task 5: Microcontroller (Dinkar) 14](#_Toc507778366)

[11.1 Microcontroller Specifications (effort rating is high) 14](#_Toc507778367)

[11.2 Requirement for new skills 14](#_Toc507778368)

[11.3 Tools and Resources 14](#_Toc507778369)

[11.4 Assessment 1 14](#_Toc507778370)

[11.5 Assessment 2 15](#_Toc507778371)

[11.6 Risks and Risks Management Plan 15](#_Toc507778372)

[12.0 Design Task 6: Signal Conditioning (Mike) 15](#_Toc507778373)

[12.1 Signal Conditioning Specifications (effort of rating is low) 15](#_Toc507778374)

[12.2 Requirements of New Skills 15](#_Toc507778375)

[12.3 Tools and Resources 15](#_Toc507778376)

[12.4 Assessment 1 15](#_Toc507778377)

[12.5 Assessment 2 15](#_Toc507778378)

[12.6 Risks and Risk Management Plan 16](#_Toc507778379)

[13.0 Design Task 7: Object Detection (Dinkar) 16](#_Toc507778380)

[13.1 Object detection specifications (effort rating is high) 16](#_Toc507778381)

[13.2 Requirements of New Skills 16](#_Toc507778382)

[13.3 Tools and Resources 16](#_Toc507778383)

[13.4 Assessment 1 16](#_Toc507778384)

[13.5 Assessment 2 16](#_Toc507778385)

[13.6 Risks and Risk Management Plan 16](#_Toc507778386)

[14.0 Design Task 8: Image Enhancement (Anas) 17](#_Toc507778387)

[14.1 Image Enhancement Specifications (effort of rating is high) 17](#_Toc507778388)

[14.2 Requirements of New Skills 17](#_Toc507778389)

[14.3 Tools and Resources 17](#_Toc507778390)

[14.4 Assessment 1 17](#_Toc507778391)

[14.5 Assessment 2 17](#_Toc507778392)

[14.6 Risks and Risk Management Plan 17](#_Toc507778393)

[15.0 Project Schedule 18](#_Toc507778394)

[15.1 Gantt chart 19](#_Toc507778395)

# Block Diagram of the Complete System

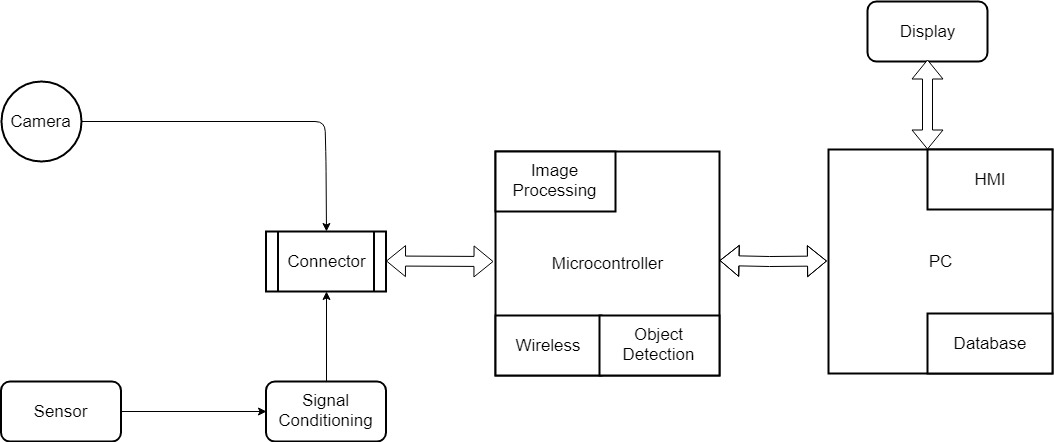


Figure 1. Retrofit Fridge Cam system diagram

# Block Diagram Description

### Display

To present the items inside the fridge, a display will be used. This will be the only way that the user will be able to interact with the whole project. It will always be updated by the microcontroller displaying the new picture taken once the door is closed. Therefore, the purpose of the display is to show the UI application to the end user.

### Microcontroller

The microcontroller will be the core of the system. It is responsible for interfaces with the display, camera, and the sensor. The main task is to run image processing on the received pictures from the camera. The original picture may not be clear due to vibrations, blockage, or viewing angle. Therefore, the microcontroller will provide image enhancements or select the best quality image for the display. Alongside image enhancement, the microcontroller will contain open source object detection software that will identify items inside the fridge. Lastly, the microcontroller will communicate with an external database to send or to retrieve information such as metadata, pictures, or system information.

### PC

The external PC will host the database and the HMI component of the UI. The PC will act as a mediator between the database and the microcontroller. Once the data has been sent and entered into the database, the information can be offered to the HMI to display to the user.

### HMI

The human machine interface (HMI) component will contain the UI design, interface to display, and process interactions with the user.

### Wireless

The microcontroller will require a wireless means of communication with the external database or the display.

### Image Processing

Digital image processing will be used to enhance the quality of the image captured from the camera. Alternatively, it will be used to remove noise from the picture and to select the best quality image to be displayed.

### Database

As part of the project there will be a database to store some information, for example store a list of the objects inside the fridge. The database would reside on a PC (with wireless capabilities), this would give the option of being able store the images of the contents and work on them.

### Connector

A wired approach is chosen to connect the camera and sensor to the microcontroller instead of the wireless one. This is due to many problems that can come up from using a wireless technology from inside of the fridge. In the block diagram, the connector represents the state where the camera and sensor are connected to the microcontroller using the wired approach. The connector will be a thin wire attached to the camera and sensor to transfer the signals coming from both devices to the microcontroller.

### Signal Conditioning

The main purpose of the signal conditioning circuit will be to remove noise from the sensor output and to amplify the output for the ADC.

### Camera

The will be placed inside of the fridge. It will need to have as wide of an angle lens as possible to be able to cover as much as possible of the shelves inside. As mentioned above the camera will be connected by a wire to the microcontroller. Using this wire approach will also allow the camera to be powered from the microcontroller, instead of battery power.

### Sensor

The sensor will have to determine the state of the fridge door. This will be needed to when the camera should take a picture. If the door is closed there will not be any sufficient light to take a picture, also there would be no reason to take a picture since it would be known that no one had put in any items in the fridge. Once the door is open, the sensor, will be able to detect it and tell the microcontroller of the event to trigger a photo.

# 

# Off-the-shelf Components

* Camera
* Sensor
* Microcontroller
* Display
* PC

# Design Components

* Signal Conditioning
* Object Detection
* Image Enhancement
* Picture Selection
* Connector
* Database Architecture

# Risks and Risk Management Plan

|  |  |  |  |
| --- | --- | --- | --- |
| Potential Risk | Description of the Risk | Level of the Risk | Risk Management Plan |
| Object detection | If there is more than one item in the camera's view, the camera might have difficulties detecting all the items in one picture. | High | More investigation required |
| Do not have experience in object detection. | High | Will use open source software which have prebuilt neural networks. |
| Picture selection | After taking pictures of the items, there will be a process where multiple pictures will be analyzed and select the best picture to the next task. At this process, the microcontroller might have issues trying to know which picture the best is compared to the others. | High | Since the camera is constantly taking pictures until the door closes, then the microcontroller should consider the second or third last picture taken. |
| Image Enhancement | After selecting the best picture, it must undergo through a process such as brightening the picture and noise is being removed which will be an issue since no one has an experience at this area. | High | May get help and support by the professors. |
| Moisture | When the project is eventually placed inside the fridge, it may have some moisture issues due to temperature difference when opening and closing the door. | High | Might isolate the entire project by encasing it with a box that prevents the development board and the other parts from moisturizing. |
| Project code backup | The project code will require source code versioning such as GitHub. | Medium | Use of USB or external drives to backup source code regularly. |
| Processing power | The embedded board may not have enough processing power to run multiple software. | Medium | Offload processes to an external PC. |

# Design Task 1: Display (Anas)

## Display Design Specification (effort of rating is high)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reasons |
| Size | * 10-inch touch screen * 5 mm in depth | * The display must be big enough to clearly present all the items in the picture. * Reasonable price around $80 |
| Configuration | * Configurable by the microcontroller | * The display must be configurable by the same development board |
| Interface | * Touchscreen interface | * With respect to the size requirement, the display must be touchscreen |
| Power | * Powered by microcontroller * Power needed will need more investigation | * Easier to power it by the microcontroller; otherwise, an extension wire needed from outside the fridge or a battery |

## Requirements of New Skills

* Configuring the display and interact with it
* Presenting pictures on the display

## Tools and Resources

* Display source
* Power to turn on the display

## Assessment 1

Some investigation needed to support the proposed design specifications of size, design and power.

## Assessment 2

Some investigation needed to support the proposed design specifications of configurations and interface.

## Risks and Risks Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| Lack of experience at configuring the touchscreen | May switch to simple screen with buttons instead since some projects have been done using the buttons in the past |
| Not able to power the display | Use an external battery as an alternative |

# Design Task 2: Connector (Anas)

## Connector Design Specification (effort of rating is medium)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reasons |
| Temperature Tolerance | * Must tolerate low temperatures 0°C to 5°C | * Avoid noises as well as frequency differences since it will carry signals from devices to microcontroller |
| Wire Length | * 100cm - 500cm | * Will be cut and used to make connections where needed |
| Jumpers | * Female and male wires | * Will be needed to make connections from sensor and camera to microcontroller |
| Wire Thickness | * As thin as possible * Will do more investigation about it | * Easier in integration and takes less space |

## Tools and Resources

* Jumpers (female and male wires)
* Cutter
* Wire strippers
* Electric tape

## Assessment 1

Some investigation needed to support the proposed design specifications of wire length and thickness.

## Assessment 2

Some investigation needed to support the proposed design specifications of temperature tolerance.

## Risks and Risks Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| Issues with temperature difference | May put the wires inside an isolator that prevents the temperature of making any mismatch between both ends |

# Design Task 3: Sensor (Mike)

## Sensor Design Specification (low)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reasons |
| Size | * Must not exceed size of 3 cm x 3 cm x 1 cm | * Compact to not take space away from fridge user |
| Temperature Tolerance | * Must be able to withstand temperatures between 0°C to 5°C | * The sensor will be inside of the fridge |
| Configuration | * Connect to microcontroller through designed connector | * Only one wire to come out from the inside of the fridge |
| Power | * Low power consumption, less than 1 W | * Need to make power consumption as low as possible. |
| Cost | * Less than $10 | * Project is under cost budget |

## 

## Requirements of New Skills

* None

## Tools and Resources

* Hardware tools
* Breadboard
* Multi-meter
* Oscilloscope

## Assessment 1

Must have selection made for which sensor will be used for project and purchase it.

## Assessment 2

Interfacing with the sensor and begin testing.

## Risks and Risks Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| Size requirement not met | Possibly designing our own sensor, for example – IR sensor, or limit sensor |
| Temperature | Build insulating fixture |

# Design Task 4: Database Architecture (Mike)

## Database Architecture Design Specification (effort of rating is medium)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reasons |
| Design | * Running on a web server (or PC with internet connect) | * This gives the flexibility of being able to connect wirelessly to see the data |
| Configuration | * Use MariaDB | * Team has prior knowledge and experience with using MariaDB |

## Requirements of New Skills

* How to store picture into a database or have some connection between the pictures and label of an item

## Tools and Resources

* MariaDB Software
* PC

## Assessment 1

Build test environment and fill it with dummy data. Use the test environment to learn how to integrate the database with the information from camera and sensor.

## Assessment 2

Have some tables created and test integration with information coming from other components.

## Risks and Risks Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| Losing data | May switch to simple screen with buttons instead since some projects have been done using the buttons in the past |
| Inconsistent connection | Use a wired method of connecting |

# Design Task 5: Camera (Mike)

## Camera Design Specification (effort of rating is high)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reasons |
| Speed | * Must have be able to take picture quickly (within a few seconds) | * Might have little time when the door is open |
| Temperature Tolerance | * Must be able to withstand temperatures between 0°C to 5°C | * The camera will be inside of the fridge |
| Resolution | * Minimum 5 Megapixel | * The better the resolution of the camera is the easier the image enhancement job will be |
| Size | * Must be small around 5 cm x 5 cm x 1 cm | * Compact to not take space away from fridge user |

## Requirements of New Skills

* How to interface and use the camera and camera API

## Tools and Resources

* Development Board
* Camera API

## Assessment 1

Select a camera that meets the requirements

## Assessment 2

Interface with camera and connector

## Risks and Risks Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| Pictures not fast enough. | Find ways in software to make the camera faster. There will be more researched required. |
| Temperature difference between opening and closing the door may cause the camera lens to be covered with fog. | Spray the lens with anti-fog solution. |
| The camera may not capture all the items inside the fridge. | Add more than one camera to cover all the items. |

# Design Task 5: Microcontroller (Dinkar)

## Microcontroller Specifications (effort rating is high)

|  |  |  |
| --- | --- | --- |
| Feature | Requirement | Reason(s) |
| RAM | Minimum of 1GB | Image processing and object detection software will require memory intensive processes. |
| Power | Must not exceed 10W | The project is constrained to an overall power limit. |
| Storage | Minimum of 1GB | Pictures will need to be temporarily stored. |
| Wireless module | Requires investigation | Need to communicate with the external PC. |
| GPIO | Minimum of 2 GPIO pins | Need to interface with the signal condition circuit. |
| Female USB port | Minimum of 1 USB 2.0 port | May need to interface with the camera system. |
| Cost | Maximum cost of $50 | Project is under budget constraint. |

## Requirement for new skills

* N/A

## Tools and Resources

* Power supply

## Assessment 1

Ongoing investigation into finding a microcontroller suitable for the project.

## Assessment 2

Choose a microcontroller based on the requirements.

## Risks and Risks Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| GPIO power limitations | Build a separate circuit compensate for the low power levels. |
| Processing power may not be enough | Can offload processing power to an external PC. |

# Design Task 6: Signal Conditioning (Mike)

## Signal Conditioning Specifications (effort of rating is low)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reason(s) |
| Analog to digital convertor (ADC) | * Minimum of an 8-bit ADC | * Doesn’t require a lot of memory * It will take shorter time to digitalize the 8-bit |
| Input signal | * Sample and hold circuit | * To stabilize the input signal during the time when the conversion happens |

## 

## Requirements of New Skills

None

## Tools and Resources

* Breadboard
* ADC chip
* Resistors
* Wires
* Power
* Oscilloscope

## Assessment 1

Investigate the parts needed to complete circuitry and the prices of the parts.

## Assessment 2

Purchase and gather the parts. Create schematic for signal conditioning.

## Risks and Risk Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| Crosstalk which may cause some measurements errors. | Connect the input signal to an isolation amplifier to minimize the error. |

# Design Task 7: Object Detection (Dinkar)

## Object detection specifications (effort rating is high)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reason |
| Food detection | Detect minimum of 3 food items. | To satisfy the main purpose of the project. |
| Architecture | Must be able to run on the chosen embedded board. | Prevents offloading work to an external PC. |
| Processing power | Requires investigation | The software is running on limited resources. |
| Speed of detection | Must be able to detect food items under 5 seconds. | To provide *near* real time updates. |

## Requirements of New Skills

* Understanding the key parameters that control the neural networks and methods to improve accuracy of the object detection
* Understanding different neural networks
* Interface with the neural networks

## Tools and Resources

* Accessible, open source software
* Camera
* PC/microcontroller

## Assessment 1

Investigate different object detection software and neural networks.

## Assessment 2

Investigate processing power required to run the software.

## Risks and Risk Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| If there is more than one item in the camera's view, the camera might have difficulties detecting all the items in one picture. | More investigation required |
| Do not have experience in object detection. | Will use open source software which have prebuilt neural networks. |

# Design Task 8: Image Enhancement (Anas)

## Image Enhancement Specifications (effort of rating is high)

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Reason(s) |
| Brightness | * Still under investigation | * If light is not enough |
| Image clarity | * Still under investigation | * Adjust the resolution of the picture if needed |
| Noise reduction | * Still under investigation | * To filter out the noises from the picture * If picture is grainy |

## Requirements of New Skills

* Filtering images from noises
* Dealing with image brightness and resolution

## Tools and Resources

Still under investigation.

## Assessment 1

Investigate how to filter out noises and brightness improvement.

## Assessment 2

Run preliminary tests on image enhancement after investigation.

## Risks and Risk Management Plan

|  |  |
| --- | --- |
| Risk | Risk Management Plan |
| Lack of experience in image enhancement | Get help from professors and knowledgeable resources |

# Project Schedule



## Gantt chart

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Task Name | Duration | Start | Finish | Predecessors | Resource Names |
| **Retrofit Fridge Cam** | **145 days** | **Mon 1/15/18** | **Fri 8/3/18** |  |  |
| **Semester 7** | **70 days** | **Mon 1/15/18** | **Fri 4/20/18** |  |  |
| Outline Document | 5 days | Mon 1/15/18 | Fri 1/19/18 |  | All |
| Proposal Document | 15 days | Mon 1/22/18 | Fri 2/9/18 | 3 | All |
| Proposal Presentation | 15 days | Mon 1/22/18 | Fri 2/9/18 | 3 | All |
| Specification and Plan Document | 10 days | Mon 2/12/18 | Fri 2/23/18 | 4,5 | All |
| **Assessment # 1** | **20 days** | **Mon 2/26/18** | **Fri 3/23/18** |  |  |
| Display - Investigate about size, design, and power | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Anas |
| Connector - Investigate wire length and thickness | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Anas |
| Sensor - Selection made and bought | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Anas |
| Database - Build test environment | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Mike |
| Signal Conditioning - Investigate the parts needed | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Mike |
| Camera - Select a camera | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Mike |
| Microcontroller - Ongoing investigation into finding a suitable microcontroller | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Dinkar |
| Object Detection - Investigate different object detection software and neural networks | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Dinkar |
| Image Enhancement - Investigate how to filter out noise and brightness | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Anas |
| **Assessment # 2** | **20 days** | **Mon 2/26/18** | **Fri 3/23/18** |  |  |
| Display - Investigate configuration and interface | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Anas |
| Connector - Investigate temperature tolerance | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Anas |
| Sensor - Interface with sensor and test | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Mike |
| Database - Create table and test integration | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Mike |
| Signal Conditioning - Purchase the parts needed | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Mike |
| Camera - Interface with camera and connector | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Mike |
| Microcontroller - Choose a microcontroller | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Dinkar |
| Object Detection - Investigate processing power required | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Dinkar |
| Image Enhancement - Run preliminary tests | 20 days | Mon 2/26/18 | Fri 3/23/18 |  | Anas |
| Final Presentation and Demonstration | 5 days | Mon 4/16/18 | Fri 4/20/18 |  | All |
| **Semester 8** | **65 days** | **Mon 5/7/18** | **Fri 8/3/18** |  |  |
| Update Specifications and Plan Document | 5 days | Mon 5/7/18 | Fri 5/11/18 |  | All |
| Assessment # 1 | 16 days | Fri 5/11/18 | Fri 6/1/18 |  | All |
| Assessment #2 | 15 days | Mon 6/4/18 | Fri 6/22/18 |  | All |
| Detail Design and Test Plan Document | 10 days | Mon 6/25/18 | Fri 7/6/18 |  | All |
| Assessment # 3 | 10 days | Mon 7/9/18 | Fri 7/20/18 |  | All |
| Final Presentation and Demonstration | 5 days | Mon 7/23/18 | Fri 7/27/18 |  | All |
| Final Report | 5 days | Mon 7/30/18 | Fri 8/3/18 |  | All |