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Senior Design I: EML4551

TEAM 14

Wireless Infrared Monitoring System

PROJECT PLANS & PRODUCT SPECIFICATION

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SIEMENS

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Abstract

The purpose of this paper is to baseline our project sponsored by Siemens Energy[1] in what will be called a Project Plans and Product Specification Report. This report will introduce our project, a Wireless Infrared Monitoring System. It will cover the project background, existing technologies, and market gaps in a Background Research Section. There then will be a Needs and Goal Statement describing why our Sponsor initiated this project and what they want to get out of it. The constraints and objectives of the project will also be detailed, along with design and performance specifications. The Design Specification will detail what components our system will need in order to meet the goal statement while the performance specification section will explain how these components will need to perform. Methodology of the project will be discussed lastly. This section will have the project schedule, composed in Microsoft Project, and Resource Allocation. The outcome of this report should deliver a full understanding of the project background, goals, and constraints with an insight into a preliminary system specification and project execution schedule.

1. Introduction

As the Age of Information progresses, there is an increasing development in electronics and electrical systems and consequentially and increased interest in application. This can be attributed to the potential of reduced cost, increased reliability, and adaptability that are characteristic of most electronic systems. This project is along this line of interest in its investigative nature into the optimization of dated methods of monitoring for predictive maintenance. The term predictive maintains refers to direct observation of a system's properties and is commonly accomplished by the use of imaging equipment.[2]

The objective of this project is to design a system that better monitors subsystems of interest at power plants for preventative maintenance. Currently, power plants utilize a large network of thermocouples or small vibration monitoring devices to do this. All of which have to be wired to a power source and tapped individually. Siemens Energy, as the project sponsor, is interested in eliminating cost and auxiliary plant loads with a wireless system that can monitor several problematic areas at a time. Specifically they are interested in exploring the use of Infrared technology.[1] Thermal imaging cameras can see things the human eye cannot by sensing electromagnetic radiation in the infrared range of 9–14 μm.[3] These cameras can be utilized to monitor the temperature of operating equipment, enabling it to diagnose potential problems long before other traditional systems. The cameras are also nondestructive and do not require equipment interference. Siemens Energy has initiated this project to explore incorporating this technology in a conceptual design of a Wireless Monitoring System to improve their preventative maintenance service.[1]

2. Project Definition

2.1 Background research

Background Research was completed on this project in order to assess existing technologies and market gaps. It was found that there are monitoring systems that have been designed for applications close to ours. These systems seemed to have similar subsystem components in common which gave us a good idea of the potential scope of our project. The following images are examples of systems by Helios[4], Panasonic[5], and A to Z Security[6]. Solarvision[7] is also a solar/battery company that combines their products with Netvision's Security Cameras to produce integrated Solar Powered Wireless Security Systems as well. These systems seem to vary around the cost of $5,000-$10,000. It should be noted however that most of the cameras used in these existing systems are high definition security cameras with limited infrared capability. Also, almost all are for security applications. Our particular application requires an Infrared Camera of much higher caliber for specific temperature monitoring.

Figure 1. Solar Powered Wireless Security Systems: Helios, Panasonic, and A to Z.[4567]

FLIR has emerged as the top of the line provider for Infrared Cameras for substation monitoring. They also sell packages to go with their camera that can be used to help integrate the camera into certain applications. For example, FLIR offers a line of pan-tilt packages[8] and universal mounts for their cameras. Also, FLIRs cameras come with the software for IP Configuration and network detection. There is also a built in web server that allows for camera control and image viewing. Finally any SDK software for camera control and image grabbing can be purchased separately.[2]

Due to the fact that this project has existing technologies and market competition in place already, the focus will be on component selection, integration, and specification towards our sponsors specific needs and goals. Close attention will have to be paid towards subsystem interface to ensure that a cohesive system is ultimately produced.

2.2 Need Statement

There is a need for an improved method of monitoring critical equipment under operation in power plants.[1]

Siemens, as an Engineering Procurement Construction and Service provider in the Energy Industry, is highly involved in all aspects of projects. In this particular case, this project has risen out of a demand for improved preventative maintenance in its Service sector for commissioned fossil fuel power plants. The current state of temperature monitoring at their power plants beckons for consolidation, simplification, and improvement.

2.3 Goal Statement & Objectives

The intended goal of this project, communicated by the sponsor in the Kickoff Meeting that was held on September 23rd, is as follows,[1]

Design a proposed complete system that can monitor a wide range of equipment for problematic operation.

Some objectives of this project were dictated as follows:

- Design a stand-alone system that does not consume any auxiliary power
- Decrease equipment interference on operating systems
- Decrease manual work needed for preventative maintenance
- Create cost savings through the elimination of need for numerous existing systems

In order to accomplish these objectives, a complete system was conceptualized and broken up into the following five major subsystems:

- Infrared Camera
- Pan Tilt Module
- Wireless Communication Module
- Solar Array & Battery System
- Mount & Weather Enclosure

The Infrared Camera will survey the selected target(s) thoroughly, precisely, and without interfering with the equipment. The Pan Tilt Module will control the camera's position allowing it to target a wide range and ultimately eliminating the need for numerous systems. The wireless network will monitor and communicate the data back to a control room, reducing the need for manual local monitoring. The Solar/Battery System will harvest the Sun's radiation converting it into electric power to be stored in the batteries, which will discharge power to the system when needed. Finally, the Mount will support and house all the components. Each of these five major subsystems have an explicit goal that will contribute to the final system goal statement.

3. Constraints

The following table, Table 1, captures design constraints provided by the sponsor. [1]

Table 1. System Design Parameters and Constraints.

Subject	Descriptor	Constraint
Location	Exclusively	Fossil Fuel Power Plants
Lifetime	At least	30 years
Monitoring	Type	Thermal Imaging
Power	Source	Solar Harvesting
Battery Storage	At least	3 days
Communication	Wireless	100m
Communication	Protocol	HART
Compliance	Code	NERC, IBC2006
Weatherproofing	Rating	IP55
Movement	Range	360° in horizontal, 90° in vertical
System Cost	Maximum	$20,000
Prototyping Budget	Maximum	$2,000

3.1 Design Specifications

3.1.1 Infrared Camera

The infrared camera selected for this project must be able to withstand the following conditions of IBC 2006 Code. [1]

Table 2. Infrared Camera IBC 2006 Code

Wind Loading	Occupancy Category III
	V_{3s} = 100 mph
	Exposure C
Rainfall	5”/hr for 1 hr in a day
Ambient Temp.	0 F – 110 F

This will most likely be accomplished through a built in weather enclosure with an International Protection rating of at least IP55. The camera must not weigh an excessive amount in order to reduce stress on the pan tilt motors and the mount. The camera shall be chosen with power conservation in mind in order to keep the total system load as small as possible. Most of the infrared cameras that were found draw 25 to 35 W with the smallest being 2.5 W. [9] The camera, if not containing a built in pan-tilt system, must be able to be attached securely to the pan tilt module via bolt holes or brackets. The infrared camera must also come with built in software to transmit temperature data (at least the maximum and minimum temperature of the system). The camera must also include an Ethernet or USB output in order to transmit data to the microcomputer.

3.1.2 Pan Tilt Module

When sizing and selecting our pan-tilt module, the payload will be of high consideration because the servomotors will have a specified range of torque for nominal performance. In this case our payload is the camera, so camera selection is critical path for the design of this module. The motors of this module will need to be powered and controlled through the integration of a microcomputer through a RS 232, 422, or 485 serial connections or Ethernet connection[10]. The microcomputer must have pan-tilt drivers so that it can control the hardware functions of the motors and any other hardware that it is integrated with. The microcomputer must also be able to support the language interface and compile the code in one language, i.e. C programming[11]. Visual Studio, MATLAB and Simulink can be used to develop an algorithm with proven API's, protocols, and SDK's. The microcomputer will act as the onboard computer, executing programs and functions, and processing data. This component will be the most tailored component of our project and will have to seamlessly interface with every other component in the system or else the system, as a whole, will not function.

3.1.3 Wireless Communication Module

The wireless module must be able to communicate the Infrared camera data to the control room. The IR cameras of interest mainly have two connections that can be used for data communication; a USB port and an Ethernet port. [2] The Ethernet standard of the cameras of choice are IEE802.3. [9] The processing and converting of the Infrared data will be done with a microcomputer as mentioned in the earlier section. The microcomputer must have the appropriate video processing packages to process the infrared data and package it to be sent to the transceiver of choice.

The infrared data must be transmitted over a distance of up to 100 m. [1] To facilitate a wireless communication of this range, a wireless router or similar wireless module will have to be installed on the system. The data from the camera must be able to be processed and communicated via HART Protocol in order to eventually be integrated into the 'Control Room'. [1] Hart Protocol is an open communication protocol that will interface the 'control room' with our system in the field.

3.1.4 Solar Array & Battery System

Our solar system cannot be sized until the selection of our camera, pan-tilt module, microcomputer, and wireless transceiver are completed. These are all the power consuming devices in our system and thus will dictate our load that needs to be met. Once these components are selected, a power consumption study will be conducted in order to size the appropriate array for our system. The local insolation of the theoretical application site, RJ Midulla, will be used as our design case. However, we will factor in a margin for the insolation of other areas in the Continental US. This will give our system the ability to be installed anywhere and still generate the necessary amount of power.

In order to minimize weight and cost, we want to minimize the size of our solar panel. In order to do this, power consumption must be a highly considered constraint in the selection of each of our components. The PV Array chassis will also be selected in order to withstand the IBC2006 code. A static substrate will be chosen in order to stand up to the constraints of this code. [1]

In addition to a PV Array, we will need a charge controller in order to charge our battery appropriately so as to not deplete their lifetime. A highly efficient charge controller will be selected in order to prevent from peripheral power loss. An appropriate charge control must be selected based on the charge cycle characteristics of our selected batteries.

The batteries should be robust and able to withstand a wide range of ambient temperatures (0-110F) even though they will be housed in a weather enclosure (to be discussed below). Our batteries will have to have potential for long life cycles due to the inconsistency of solar power. Also, a high level dischargeable battery would be an advantage, reducing the necessity for more units to meet the required Amp-hours.

Finally, an inverter will be required in order to convert the DC power to AC for our powered components. The wireless transmitter currently is the only component that might need AC power but if an equivalent component that takes DC can be found, then the elimination of the inverter is possible.

3.1.5Mount & Weather Enclosure

The mounting system utilized for this project must be sturdy and withstand the following design conditions of IBC 2006 as dictated in the constraints section.

Table 3. Mount IBC 2006 Code

Seismic Loading	Occupancy Category III
	Site Class D
	Mapped Spectral Response: S_s = 0.41g, S_1 = 0.19g
Wind Loading	Occupancy Category III
	V3s = 100 mph
	Exposure C
Rainfall	5”/hr for one hour in a 24 hour period
Ambient Temp.	0 F – 110 F

All necessary equipment must be easily and firmly attached to the mounting structure. The mount must be located in a centralized location where it can effectively monitor the largest amount of equipment possible. Weight and cost must be minimized without sacrificing safety and performance.

The weather enclosure must be designed in order to fit all electronic components appropriately in as small of a package as possible. The weather enclosure must provide cooling in order to prevent the overheating of the electrical components during hotter temperature days. The weatherproof enclosure must at least provide IP55 protection and preferably comply with NEMA standards. [12]

3.2 Performance Specification

3.2.1 Infrared Camera

The selected infrared camera should ultimately be able to capture and output a good resolution MPEG-4 or JPEG with temperature data of the target. It must also be able to capture the targets temperature with ±5% accuracy. The camera must also transmit its data with open protocols that are accessible to outside parties. Any closed off software or data transmission will prevent system integration and therefore will be unacceptable for this project. Below are performance specifications on infrared cameras that will be considered for this project.

Table 4. A310f and A310pt Specifications[9]

Subject	FLIR A310f	FLIR A310pt
Weight	11 lb	40 lb
Dimensions	460x140x159 mm	460x467x326 mm
Operating Temp	5 to 122 F	-13 to122F
Temp Measurment	-4 to 248 F, 32 to 662F	-4 to 248 F, 32 to 662F
Encapsulation	IP66	IP66
Accuracy	±2%	±2%
Power	25 W max w/heater	65 max w/0 heater 185 max w/ heaters
Output	MPEG-4 over Ethernet	MPEG-4 or MJPEG over Ethernet
Resolution	320 x 240	320 x 240
Pan Tilt	n/a	360° pan: .1 to 60°/sec ±45° tilt: .1 to 30°/sec

Table 5. FLIR A5 and PELCO Sarix TI Comparison.

Subject	FLIR A5[9]	PELCO Sarix TI[13]
Weight	0.44 lb	7.2 lb.
Dimensions	460 x 140 x 159 mm	376 x 126 x 128 mm
Operating Temp	-15C to 50C	-40°C to 50°C
Temp Measurement	-25C to 135C -40C to 550C	7.5 to 13.5 µm spectral response
Encapsulation	IP40	IP66
Accuracy	±5%	unknown
Power	2.5 W max	35 W max w/heater
Output	MPEG-4 Ethernet	MPEG-4 Ethernet
Resolution	80 x 64 pixels	640 x 480 pixels

Figure 2. Infrared Camera Selections. [9213]

3.2.2Pan Tilt Module

The pan/tilt module is expected to operate in an auto scan mode that will cycle through fixed positions. It should have the ability to have a continuous pan of 360° and have 90° of tilt motion. The pan tilt module should be able to also give feedback of its specific position to the microcomputer. One of the important performance characteristics is the precision and accuracy in displacement of the pan/tilt module.[10] When an analog encoder is used for positional feedback, the signal must be digitized to communicate with the microcomputer. This can limit the accuracy of the measurements taken by the encoder.[10] To ensure precision and accuracy of the pan/tilt module from position to position, it will be ideal to prevent zero drift and sensitivity drift. High Resolution digital encoders provide an absolute count of position, which allows it to provide more stable readings over time and temperature.[10]

3.2.3Wireless Communication Module

The wireless module is expected to transmit the images and data from the camera to the 'control room' up to 100m away. The wireless system should send a picture and associated data every 5 minutes at the least, however higher rates or real time video is optimal. The communicated data should be sufficient enough to be able to detect abnormal or extreme temperatures of monitored equipment.

It should be mentioned that a graphical user interface (GUI) will need to be created in order to view, analyze, and ideally monitor the data. This is an optional scope of the project, but would be required in a real life application. [1]

3.2.4Solar Array & Battery System

In general, Solar panels are typically rated under the following standard conditions; 1000 W/m2 irradiance, module temperature of 25°C, and Air Mass 1.5, and tested for open circuit voltage, short circuit current, and max power output. Therefore the listed specifications of solar panels must be considered a theoretical maximum. The selection and purchase of our solar panel will have to take into account our specific insolation, and system load with a 5-10% margin in order to account for supporting component inefficiencies and particulate build up over time.

The photovoltaic array should efficiently solar harvest the available insolation to keep the batteries charged. The charge controller should efficiently and appropriately charge the battery to prevent burn out without consuming too much extraneous energy of its own. The batteries should be adequately sized to provide system power for 3 days without sun. The system as a whole should be low maintenance.

3.2.5 Mount & Weather Enclosure

All electrical devices must be protected from high heat, moisture, and fouling particulate by the weather enclosure to a rating of at least IP55. It must house all electronics appropriately and at manageable operating temperatures. The mount must be capable of withstanding all environmental conditions including intense and prolonged sunshine, rain, and snow without deteriorating or necessitating frequent maintenance. It also must fully support and integrate all subsystems into one rigid package while allowing for dynamic camera movement. The system as a whole must have a life of 30 years. [1]

4. Methodology

4.1 Schedule

Figure 1 below is the outlined timeline of our project that was created in Microsoft Project. The timeline shows major milestones throughout the lifetime of the project such as team and faculty meetings, deliverables, and presentations. This timeline is a good snapshot of the work and pace of the project that will take place this semester. The current date is marked in orange.

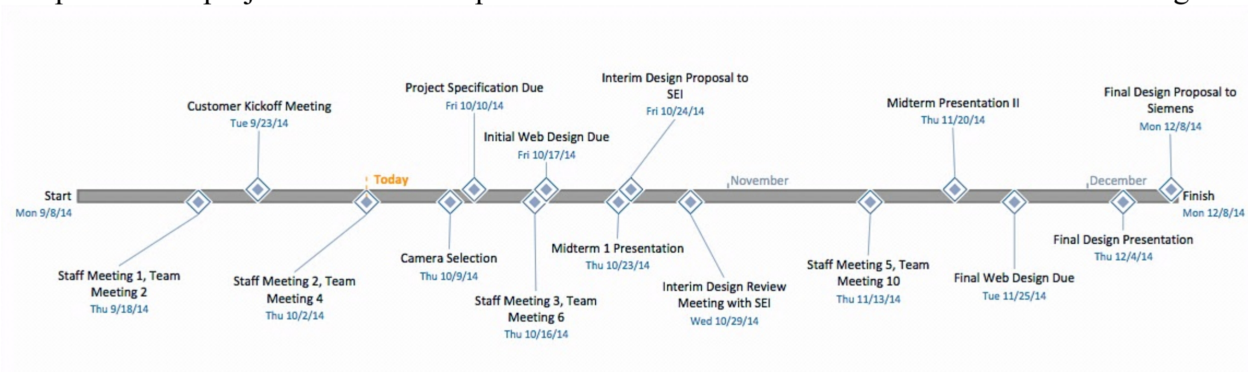
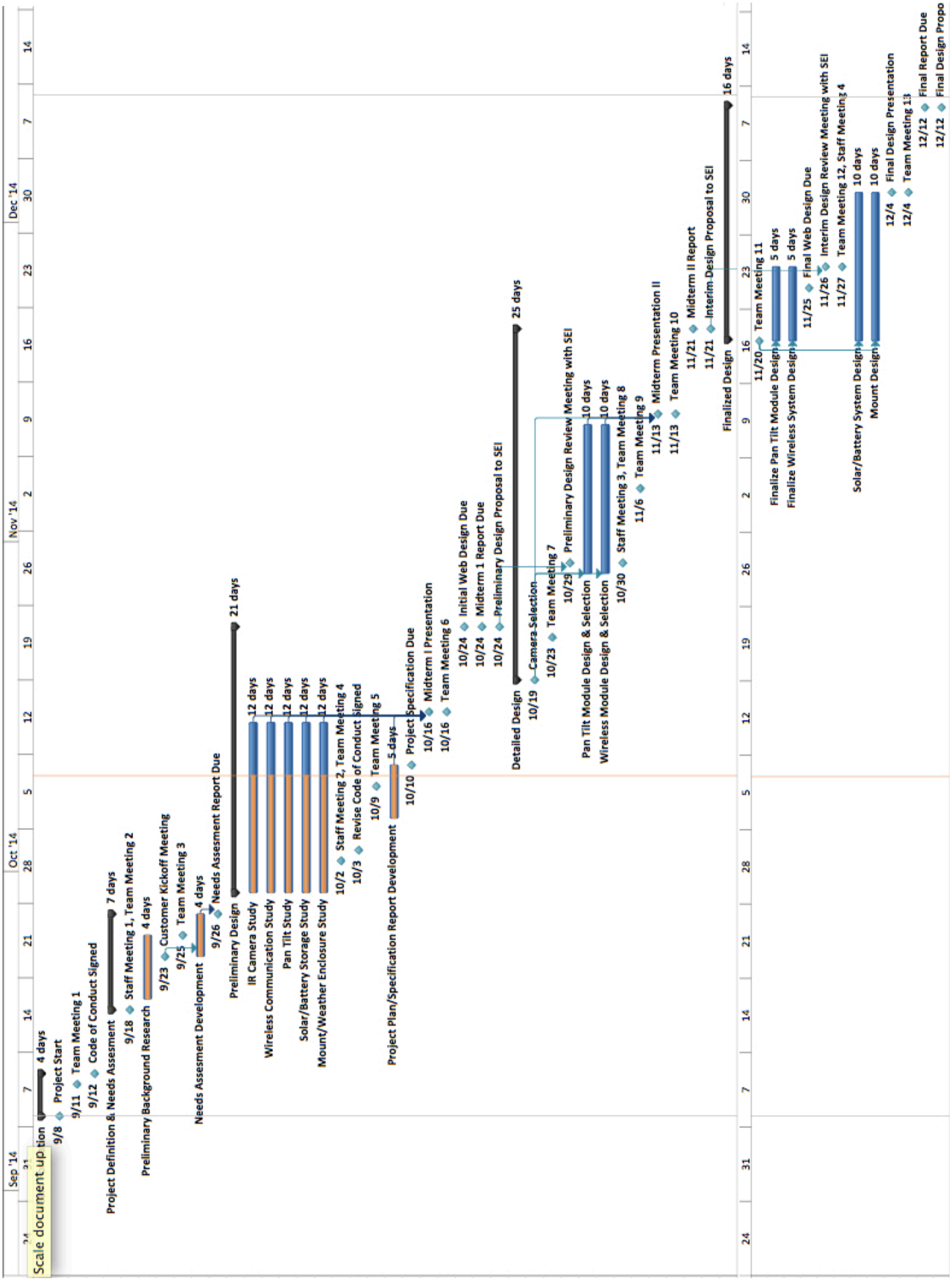


Figure 3. Project Timeline.

The pages to follow are the detailed project Gantt Chart which was also created in Microsoft Project. The project start date was marked as the date the full team was assigned to the project, Monday September 8th. The project end is marked as Monday December 8th. This is a full 3 months schedule which is broken down into four summary phases; Team Formation, Project Definition and Needs Assessment, Preliminary Design, Detailed Design, and Finalized Design. Within these phases are scheduled meetings, deliverable developments, milestones, and ongoing design processes. This schedule was planned accordingly based on the goal statement and major deliverables required by the class and sponsor. The first midterm presentation is planned to be an overview of the preliminary conceptual design. After this presentation, a preliminary design report will be submitted to the sponsor, for review and comment. Pending authorization to proceed at the Preliminary Design Review Meeting, the second phase, Detailed Design, will commence and culminate in the Midterm II Presentation that will consist of a more down-selected detailed design. Concluding this presentation, another report, the Interim Design Report, will be submitted to the sponsor and another Design Review Meeting will be held. The last phase of the project, Finalized Design, will entail the optimization of the agreed upon design which will be presented in its entirety in the Final Presentation. A final complete Conceptual Design Report and System Specification will be submitted, concluding the project for the semester. This schedule, which can be seen below, is also attached in Appendix 1 for reference.


Sep '14
Oct '14
Nov '14
Dec '14
Scale document up
Project Definition & Needs Assesment
9/8 Project Start
9/11 Team Meeting 1
9/12 Code of Conduct Signed
4 days
7 days
9/18 Staff Meeting 1, Team Meeting 2
Preliminary Background Research
4 days
9/23 Customer Kickoff Meeting
9/25 Team Meeting 3
Needs Assesment Development
4 days
9/26 Needs Assesment Report Due
Preliminary Design
21 days
IR Camera Study
Wireless Communication Study
Pan Tilt Study
Solar/Battery Storage Study
Mount/Weather Enclosure Study
12 days
10/2 Staff Meeting 2, Team Meeting 4
10/3 Revise Code of Conduct Signed
10/9 Team Meeting 5
Project Plan/Specification Report Development
5 days
10/10 Project Specification Due
10/16 Midterm I Presentation
10/16 Team Meeting 6
10/24 Initial Web Design Due
10/24 Midterm 1 Report Due
10/24 Preliminary Design Proposal to SEI
Detailed Design
25 days
10/19 Camera Selection
10/23 Team Meeting 7
10/29 Preliminary Design Review Meeting with SEI
Pan Tilt Module Design & Selection
Wireless Module Design & Selection
10 days
10/30 Staff Meeting 3, Team Meeting 8
11/6 Team Meeting 9
11/13 Midterm Presentation II
11/13 Team Meeting 10
11/21 Midterm II Report
11/21 Interim Design Proposal to SEI
Finalized Design
16 days
11/20 Team Meeting 11
Finalize Pan Tilt Module Design
Finalize Wireless System Design
5 days
11/25 Final Web Design Due
11/26 Interim Design Review Meeting with SEI
11/27 Team Meeting 12, Staff Meeting 4
Solar/Battery System Design
Mount Design
10 days
12/4 Final Design Presentation
12/4 Team Meeting 13
12/12 Final Report Due
12/12 Final Design Propo

Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
	Team Formation	**4 days**	**Mon 9/8/14**	**Fri 9/12/14**		
	Project Start	0 days	Mon 9/8/14	Mon 9/8/14		
	Team Meeting 1	0 days	Thu 9/11/14	Thu 9/11/14		
	Code of Conduct Signed	0 days	Fri 9/12/14	Fri 9/12/14		
	Project Definition & Needs Assesment	**7 days**	**Thu 9/18/14**	**Fri 9/26/14**		
	Staff Meeting 1, Team Meeting 2	0 days	Thu 9/18/14	Thu 9/18/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
	Preliminary Background Research	4 days	Fri 9/19/14	Wed 9/24/14		
	Customer Kickoff Meeting	0 days	Tue 9/23/14	Tue 9/23/14		
	Team Meeting 3	0 days	Thu 9/25/14	Thu 9/25/14		
	Needs Assesment Development	4 days	Tue 9/23/14	Fri 9/26/14	8	Alex Hull
	Needs Assesment Report Due	0 days	Fri 9/26/14	Fri 9/26/14	10	
	Preliminary Design	**21 days**	**Mon 9/29/14**	**Fri 10/24/14**		
	IR Camera Study	12 days	Mon 9/29/14	Tue 10/14/14		Joseph Besler
	Wireless Communication Study	12 days	Mon 9/29/14	Tue 10/14/14		Alex Hull
	Pan Tilt Study	12 days	Mon 9/29/14	Tue 10/14/14		Nixon Lormand
	Solar/Battery Storage Study	12 days	Mon 9/29/14	Tue 10/14/14		Kenny Becerra
	Mount/Weather Enclosure Study	12 days	Mon 9/29/14	Tue 10/14/14		Jonathan Jennings
	Staff Meeting 2, Team Meeting 4	0 days	Thu 10/2/14	Thu 10/2/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
	Revise Code of Conduct Signed	0 days	Fri 10/3/14	Fri 10/3/14		
	Team Meeting 5	0 days	Thu 10/9/14	Thu 10/9/14		
	Project Plan/Specification Report Development	5 days	Mon 10/6/14	Fri 10/10/14		
	Project Specification Due	0 days	Fri 10/10/14	Fri 10/10/14		Michelle Hopkins
	Midterm I Presentation	0 days	Thu 10/16/14	Thu 10/16/14	13,21,14,15,16,17	Michelle Hopkins,Joseph Besler,Nixon Lormand
	Team Meeting 6	0 hrs	Thu 10/16/14	Thu 10/16/14		
	Initial Web Design Due	0 days	Fri 10/24/14	Fri 10/24/14		Alex Hull
	Midterm 1 Report Due	0 days	Fri 10/24/14	Fri 10/24/14		Michelle Hopkins
	Preliminary Design Proposal to SEI	0 days	Fri 10/24/14	Fri 10/24/14		Michelle Hopkins
	Detailed Design	**25 days**	**Sun 10/19/14**	**Fri 11/21/14**		
	Camera Selection	0 days	Sun 10/19/14	Sun 10/19/14		
	Team Meeting 7	0 hrs	Thu 10/23/14	Thu 10/23/14		
	Preliminary Design Review Meeting with SEI	0 days	Wed 10/29/14	Wed 10/29/14	27FS+4 days	James Sharp
	Pan Tilt Module Design & Selection	10 days	Wed 10/29/14	Tue 11/11/14	29	Nixon Lormand
	Wireless Module Design & Selection	10 days	Wed 10/29/14	Tue 11/11/14	29	Alex Hull
	Staff Meeting 3, Team Meeting 8	0 days	Thu 10/30/14	Thu 10/30/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
	Team Meeting 9	0 days	Thu 11/6/14	Thu 11/6/14		
	Midterm Presentation II	0 days	Thu 11/13/14	Thu 11/13/14	29,32,33	Jonathan Jennings,Kenny Becerra,Michelle Hopkins,
	Team Meeting 10	0 days	Thu 11/13/14	Thu 11/13/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
	Midterm II Report	0 days	Fri 11/21/14	Fri 11/21/14		
	Interim Design Proposal to SEI	0 days	Fri 11/21/14	Fri 11/21/14		
	Finalized Design	**16 days**	**Thu 11/20/14**	**Fri 12/12/14**		
	Team Meeting 11	0 days	Thu 11/20/14	Thu 11/20/14		
	Finalize Pan Tilt Module Design	5 days	Thu 11/20/14	Wed 11/26/14	41SS	Nixon Lormand
	Finalize Wireless System Design	5 days	Thu 11/20/14	Wed 11/26/14	41SS	Alex Hull
	Final Web Design Due	0 days	Tue 11/25/14	Tue 11/25/14		Alex Hull
	Interim Design Review Meeting with SEI	0 days	Wed 11/26/14	Wed 11/26/14	39FS+4 days	James Sharp
	Team Meeting 12, Staff Meeting 4	0 days	Thu 11/27/14	Thu 11/27/14		
	Solar/Battery System Design	10 days	Thu 11/20/14	Wed 12/3/14	41SS	Kenny Becerra
	Mount Design	10 days	Thu 11/20/14	Wed 12/3/14	41SS	Jonathan Jennings
	Final Design Presentation	0 days	Thu 12/4/14	Thu 12/4/14		
	Team Meeting 13	0 days	Thu 12/4/14	Thu 12/4/14		
	Final Report Due	0 days	Fri 12/12/14	Fri 12/12/14		
	Final Design Proposal to Siemens	0 days	Fri 12/12/14	Fri 12/12/14		

4.2 Resource Allocation

With every deliverable development, there must be design work being done and so, a responsible party assigned. This is necessary in order to assure that all facets of the project are accomplished at an appropriate pace that will allow for cohesive integration and optimization. Our system, as described above, was broken up into five major subsystems. Those five major subsystems were assigned an individual team member, and associated team member(s). The individual team member will be responsible for the majority of the design of their respective subsystems. Associated team members are members who have inputs/outputs into that subsystem and are responsible for aiding in the development and design. Figure 3 is a schematic of the subsystems and their design engineers. Each design engineer will work on their subsystem according to the above project schedule in order to ensure on-time deliverables. With this even division of design work and appropriate integrated support, a cohesive final product should be achievable.

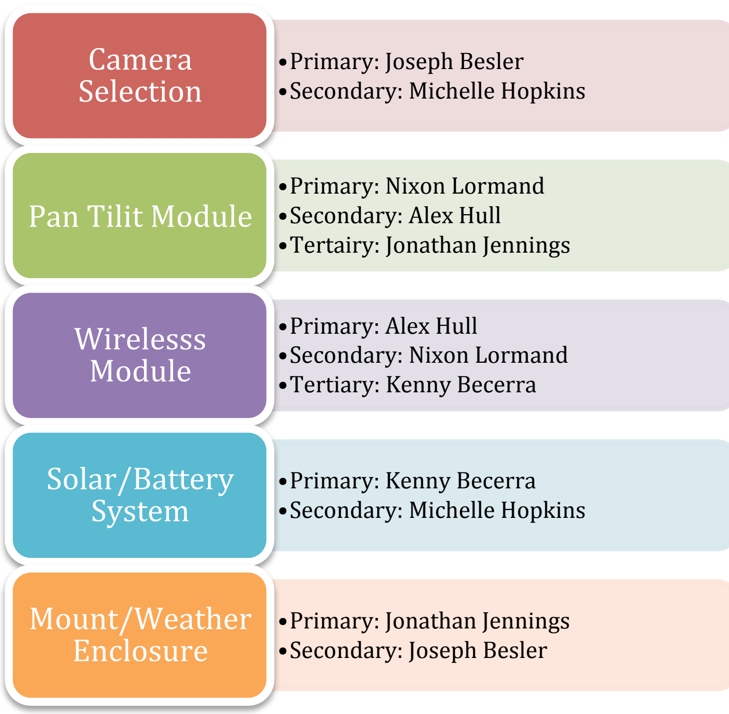


Figure 4. Subsystem Division of Responsibility.

5. Conclusion

In conclusion, our project is to design a Solar Powered Wireless Infrared Monitoring System that can monitor a wide range of equipment for problematic operation in order to reduce auxiliary plant loads, manual labor, extraneous local systems, and total cost of preventative maintenance. This will be accomplished in five phases; Needs Assessment and Product Specification, Preliminary Design, Detailed Design, and Final Design. We have also split the system up into five sub systems and appropriately assigned team members to each sub system. The respective team member(s) will be responsible for the design and/or prototype of their sub system along with whatever interfaces it has with other subsystems. This structure and division of responsibility was created to cater to a productive work environment in hopes to ultimately produce a viable system. The project schedule will be used to pace work, track progress, and mark milestones. The schedule shall be adhered to but will cause for updating throughout the project if there is scope or deliverable date change.

Looking forward in the coming weeks the following will take place; Camera Selection, Subsystem Design Concepts and Comparison, Midterm I Presentation and Report, Initial Website Design and delivery of Preliminary Design Proposal to the Sponsor.

6. References

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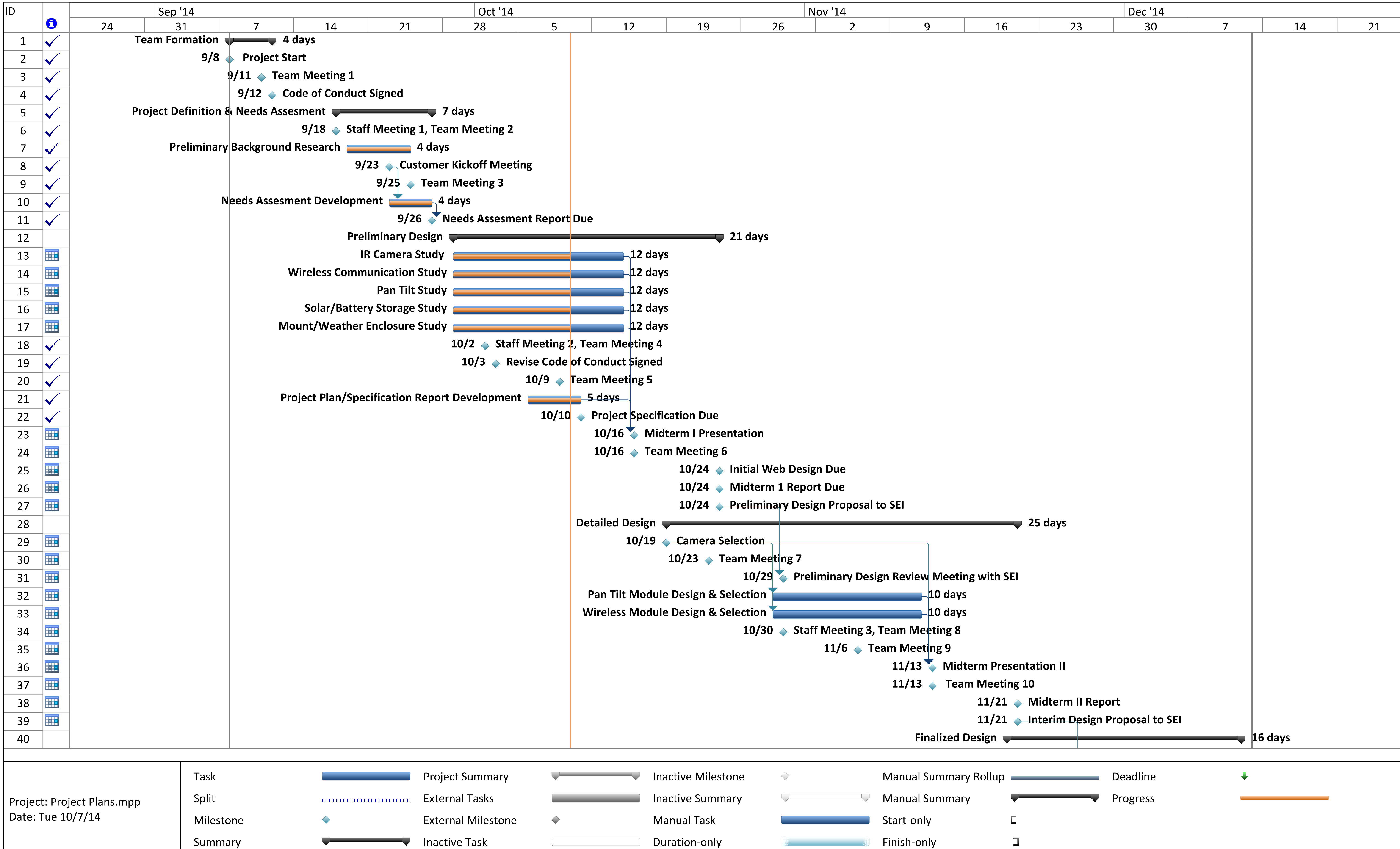
Appendix 1:Microsoft Project Gantt Chart & Data

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	✓		**Team Formation**	**4 days**	**Mon 9/8/14**	**Fri 9/12/14**		
2	✓		Project Start	0 days	Mon 9/8/14	Mon 9/8/14		
3	✓		Team Meeting 1	0 days	Thu 9/11/14	Thu 9/11/14		
4	✓		Code of Conduct Signed	0 days	Fri 9/12/14	Fri 9/12/14		
5	✓		**Project Definition & Needs Assesment**	**7 days**	**Thu 9/18/14**	**Fri 9/26/14**		
6	✓		Staff Meeting 1, Team Meeting 2	0 days	Thu 9/18/14	Thu 9/18/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
7	✓		Preliminary Background Research	4 days	Fri 9/19/14	Wed 9/24/14		
8	✓		Customer Kickoff Meeting	0 days	Tue 9/23/14	Tue 9/23/14		
9	✓		Team Meeting 3	0 days	Thu 9/25/14	Thu 9/25/14		
10	✓		Needs Assesment Development	4 days	Tue 9/23/14	Fri 9/26/14	8	Alex Hull
11	✓		Needs Assesment Report Due	0 days	Fri 9/26/14	Fri 9/26/14	10	
12			**Preliminary Design**	**21 days**	**Mon 9/29/14**	**Fri 10/24/14**		
13			IR Camera Study	12 days	Mon 9/29/14	Tue 10/14/14		Joseph Besler
14			Wireless Communication Study	12 days	Mon 9/29/14	Tue 10/14/14		Alex Hull
15			Pan Tilt Study	12 days	Mon 9/29/14	Tue 10/14/14		Nixon Lormand
16			Solar/Battery Storage Study	12 days	Mon 9/29/14	Tue 10/14/14		Kenny Becerra
17			Mount/Weather Enclosure Study	12 days	Mon 9/29/14	Tue 10/14/14		Jonathan Jennings
18	✓		Staff Meeting 2, Team Meeting 4	0 days	Thu 10/2/14	Thu 10/2/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
19	✓		Revise Code of Conduct Signed	0 days	Fri 10/3/14	Fri 10/3/14		
20	✓		Team Meeting 5	0 days	Thu 10/9/14	Thu 10/9/14		
21	✓		Project Plan/Specification Report Development	5 days	Mon 10/6/14	Fri 10/10/14		
22	✓		Project Specification Due	0 days	Fri 10/10/14	Fri 10/10/14		Michelle Hopkins
23			Midterm I Presentation	0 days	Thu 10/16/14	Thu 10/16/14	13,21,14,15,16,17	Michelle Hopkins,Joseph Besler,Nixon Lormand
24			Team Meeting 6	0 hrs	Thu 10/16/14	Thu 10/16/14		
25			Initial Web Design Due	0 days	Fri 10/24/14	Fri 10/24/14		Alex Hull
26			Midterm 1 Report Due	0 days	Fri 10/24/14	Fri 10/24/14		Michelle Hopkins
27			Preliminary Design Proposal to SEI	0 days	Fri 10/24/14	Fri 10/24/14		Michelle Hopkins
28			**Detailed Design**	**25 days**	**Sun 10/19/14**	**Fri 11/21/14**		
29			Camera Selection	0 days	Sun 10/19/14	Sun 10/19/14		
30			Team Meeting 7	0 hrs	Thu 10/23/14	Thu 10/23/14		
31			Preliminary Design Review Meeting with SEI	0 days	Wed 10/29/14	Wed 10/29/14	27FS+4 days	James Sharp
32			Pan Tilt Module Design & Selection	10 days	Wed 10/29/14	Tue 11/11/14	29	Nixon Lormand
33			Wireless Module Design & Selection	10 days	Wed 10/29/14	Tue 11/11/14	29	Alex Hull
34			Staff Meeting 3, Team Meeting 8	0 days	Thu 10/30/14	Thu 10/30/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
35			Team Meeting 9	0 days	Thu 11/6/14	Thu 11/6/14		
36			Midterm Presentation II	0 days	Thu 11/13/14	Thu 11/13/14	29,32,33	Jonathan Jennings,Kenny Becerra,Michelle Hopkins,A
37			Team Meeting 10	0 days	Thu 11/13/14	Thu 11/13/14		Dr. Helzer,Dr. Frank,Dr. Gupta,Dr. Shih
38			Midterm II Report	0 days	Fri 11/21/14	Fri 11/21/14		
39			Interim Design Proposal to SEI	0 days	Fri 11/21/14	Fri 11/21/14		
40			**Finalized Design**	**16 days**	**Thu 11/20/14**	**Fri 12/12/14**		
41			Team Meeting 11	0 days	Thu 11/20/14	Thu 11/20/14		
42			Finalize Pan Tilt Module Design	5 days	Thu 11/20/14	Wed 11/26/14	41SS	Nixon Lormand
43			Finalize Wireless System Design	5 days	Thu 11/20/14	Wed 11/26/14	41SS	Alex Hull
44			Final Web Design Due	0 days	Tue 11/25/14	Tue 11/25/14		Alex Hull
45			Interim Design Review Meeting with SEI	0 days	Wed 11/26/14	Wed 11/26/14	39FS+4 days	James Sharp
46			Team Meeting 12, Staff Meeting 4	0 days	Thu 11/27/14	Thu 11/27/14		

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
47			Solar/Battery System Design	10 days	Thu 11/20/14	Wed 12/3/14	41SS	Kenny Becerra
48			Mount Design	10 days	Thu 11/20/14	Wed 12/3/14	41SS	Jonathan Jennings
49			Final Design Presentation	0 days	Thu 12/4/14	Thu 12/4/14		
50			Team Meeting 13	0 days	Thu 12/4/14	Thu 12/4/14		
51			Final Report Due	0 days	Fri 12/12/14	Fri 12/12/14		
52			Final Design Proposal to Siemens	0 days	Fri 12/12/14	Fri 12/12/14		


ID
Sep '14
Oct '14
Nov '14
Dec '14
24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21
1 Team Formation 4 days
2 9/8 Project Start
3 9/11 Team Meeting 1
4 9/12 Code of Conduct Signed
5 Project Definition & Needs Assesment 7 days
6 9/18 Staff Meeting 1, Team Meeting 2
7 Preliminary Background Research 4 days
8 9/23 Customer Kickoff Meeting
9 9/25 Team Meeting 3
10 Needs Assesment Development 4 days
11 9/26 Needs Assesment Report Due
12 Preliminary Design 21 days
13 IR Camera Study 12 days
14 Wireless Communication Study 12 days
15 Pan Tilt Study 12 days
16 Solar/Battery Storage Study 12 days
17 Mount/Weather Enclosure Study 12 days
18 10/2 Staff Meeting 2, Team Meeting 4
19 10/3 Revise Code of Conduct Signed
20 10/9 Team Meeting 5
21 Project Plan/Specification Report Development 5 days
22 10/10 Project Specification Due
23 10/16 Midterm I Presentation
24 10/16 Team Meeting 6
25 10/24 Initial Web Design Due
26 10/24 Midterm 1 Report Due
27 10/24 Preliminary Design Proposal to SEI
28 Detailed Design 25 days
29 10/19 Camera Selection
30 10/23 Team Meeting 7
31 10/29 Preliminary Design Review Meeting with SEI
32 Pan Tilt Module Design & Selection 10 days
33 Wireless Module Design & Selection 10 days
34 10/30 Staff Meeting 3, Team Meeting 8
35 11/6 Team Meeting 9
36 11/13 Midterm Presentation II
37 11/13 Team Meeting 10
38 11/21 Midterm II Report
39 11/21 Interim Design Proposal to SEI
40 Finalized Design 16 days
Project: Project Plans.mpp
Date: Tue 10/7/14
Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress

ID	Task	Date / Duration
41	Team Meeting 11	11/20
42	Finalize Pan Tilt Module Design	5 days
43	Finalize Wireless System Design	5 days
44	Final Web Design Due	11/25
45	Interim Design Review Meeting with SEI	11/26
46	Team Meeting 12, Staff Meeting 4	11/27
47	Solar/Battery System Design	10 days
48	Mount Design	10 days
49	Final Design Presentation	12/4
50	Team Meeting 13	12/4
51	Final Report Due	12/12
52	Final Design Proposal to Siemer	12/12

Timescale: Sep '14, Oct '14, Nov '14, Dec '14 — 24, 31, 7, 14, 21, 28, 5, 12, 19, 26, 2, 9, 16, 23, 30, 7, 14, 21

Project: Project Plans.mpp
Date: Tue 10/7/14

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone		External Milestone		Manual Task		Start-only			
Summary		Inactive Task		Duration-only		Finish-only			