Hazardous Environmental Monitoring System Proposal

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E 122

Section S
Group 8

We pledge our honor that we have abided by the Stevens Honor System

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Introduction

This proposal shall be presented to the Homeland Security Initiative by Group 8 of Section S for Engineering Design II (E-122). The group members include, Kyle Gensheimer, Ranjeet George, and Chloe Quinto. The group has chosen to design a hazardous environmental monitoring system (HEMS) that, in short, is an early warning and detection system to report the accidental or intentional release of a toxic gas into the atmosphere. The design shall be configured to house several sensors to provide detection and alerting capabilities, and to take environmental measurements of parameters that would predict the direction and the speed of a contamination cloud.

Requirements Analysis

Stakeholders (Direct/Indirect) and their requirements

Stakeholders	**Direct/Indirect**	**Requirements**
Emergency Operations Center (EOC)	Direct	-supply enough product to meet the demand -reliable -size -meets budget -should meet schedule
City	Indirect	-reliable -aesthetically pleasing
Citizens	Indirect	-reliable
3rd Party Vendors	Direct	-profitable
Manufacturers	Direct	-manufacturability -producible
Intellectual Property Rights Holders	Direct	-licensing
Federal Government	Direct	-reliable -should meet schedule -meets budget

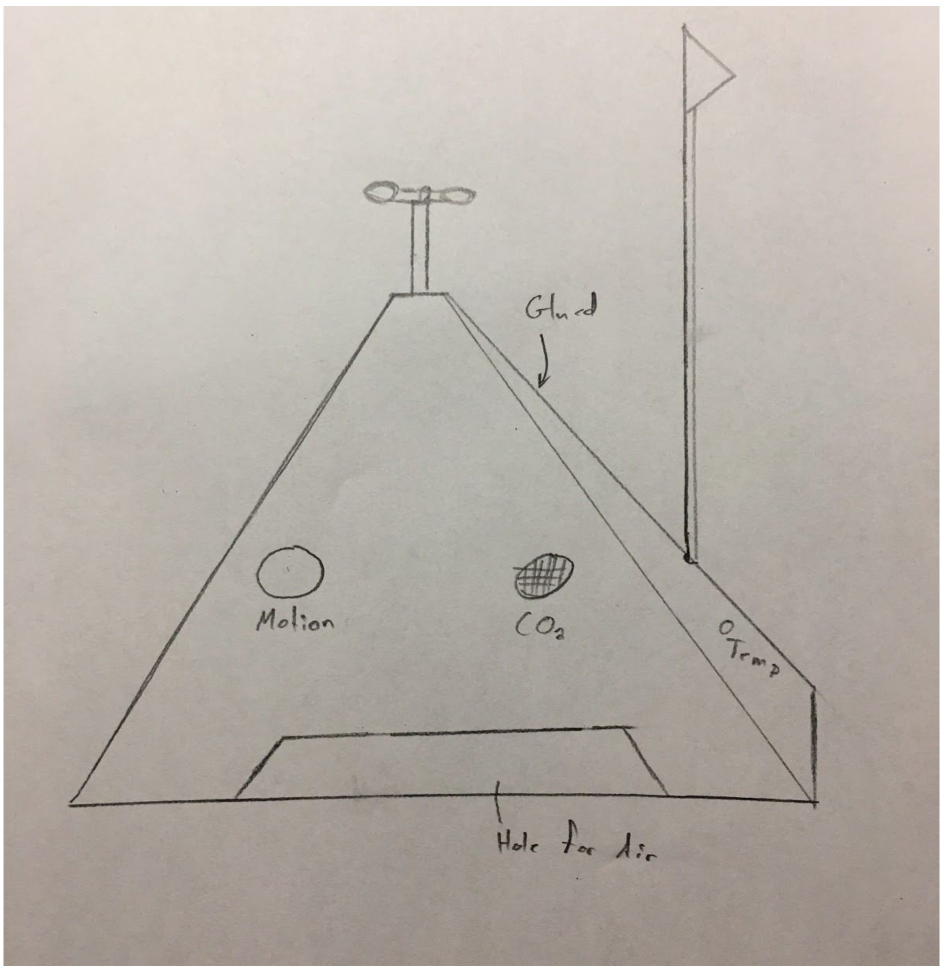
Technical Requirements

1. The MS shall be controlled by a computer connected to a Data Acquisition (DAQ) module.The computer shall configure the DAQ and control data access from the DAQ. The computer shall also format and disseminate collected data.
2. For proof of concept, the MS shall only be required to operate in the "local" mode. In the local mode all collected sensor data shall be displayed on a co-located computer.
3. The sensor used to detect the presence of harmful contaminants, the Gas Sensor (GS),shall connect to a standard interface. Input power to the GS shall be 5VDC at 100 mA max and the GS shall output a conditioned analog voltage in the range of 0-5 volts DC proportional to the level of contamination detected. The sensor shall be modular and easily interchangeable with a variety of gas detection sensors as long as the standard input and output interfaces are maintained.
4. Upon detection of the gas, a local audible and visual alarm shall sound. The audible alarm shall be capable of being silenced.
5. To support the EOS in its mission of alerting neighboring areas of impending evacuations,the MS shall provide environmental data to help predict the direction and time of gas arrival. Several additional sensors are required to support this function.
    a. Wind Speed Sensor - A sensor shall provide wind speed data. The sensor shall report wind speeds of up to 50 miles per hour
    b. Wind Direction Sensor - A sensor shall provide originating wind direction data. The sensor shall report direction in degrees with North being 0 degrees, east being 90 degrees, south being 180 degrees and west being 270 degrees. The sensor shall provide data accurate to within 22 ½ degrees from the actual wind direction.
    c. Temperature - A sensor shall provide local temperature in degrees Fahrenheit.Temperature shall cover the range of 32 - 100 degrees F.
6. The MS shall be capable of providing a tamper warning signal using a motion detection sensor. A local audible and visual alarm shall sound if an object approaches within 10 feet of the MS. The audible alarm shall be capable of being silenced.

Technical Design Considered

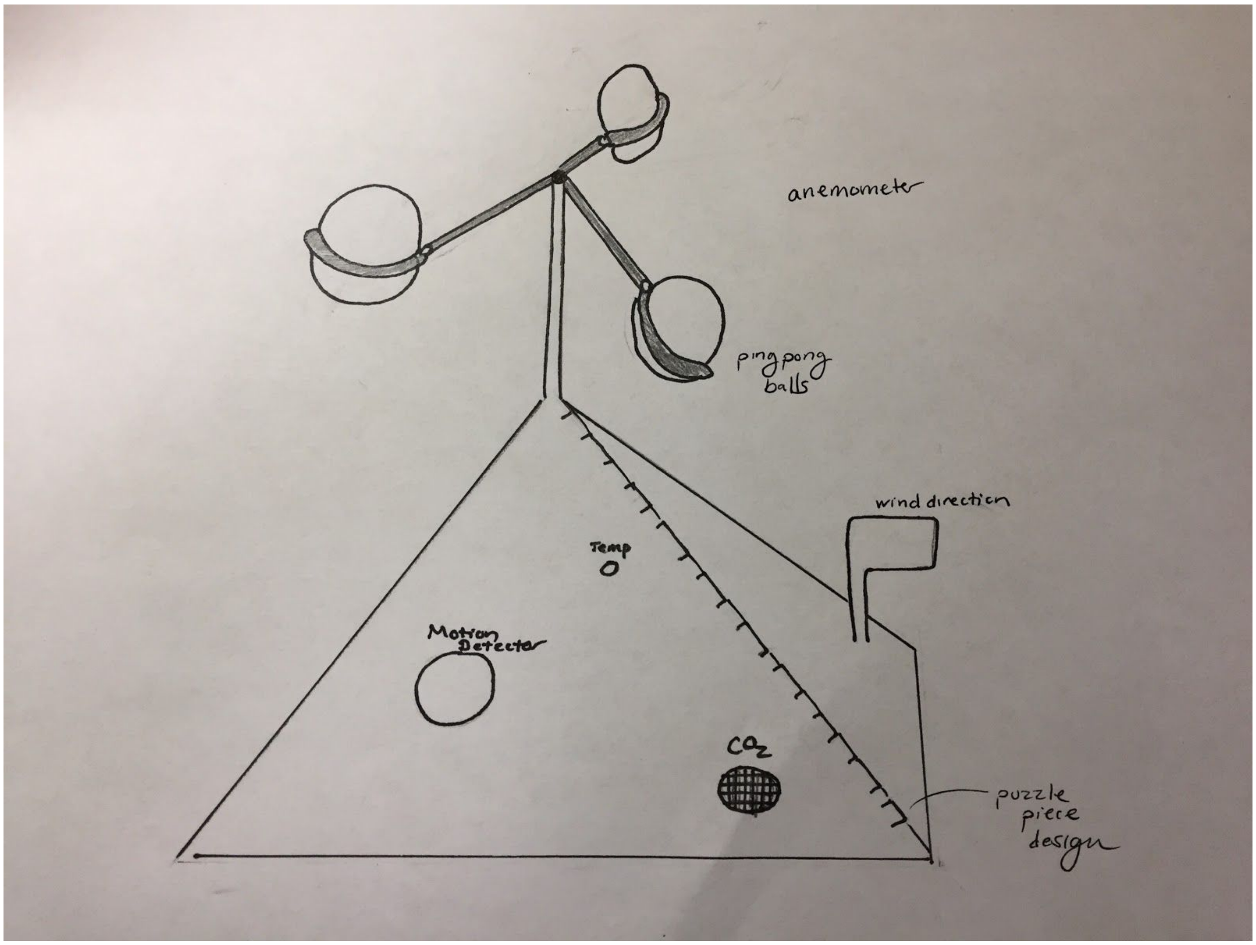
1. **Pyramid Design:** The Pyramid Design is a square pyramid that is 6"x 6"x 5.19". The pyramid will have the tip cut to allow for the pole on which the anemometer rests to pass through. In addition, there will three holes cut into the side to allow for the wind direction detector, there temperature sensor and the motion sensor to have access to the outside environment and still be wired into the DAQ that is located inside. Also, there will be wide, thin rectangular holes to allow the air containing the potentially toxic gas molecules contact with the gas detection sensor. This design has the benefit of being the most economically feasible because it uses the least amount of material while also maintaining an easy assembly process and a sturdy design.

Drawing of Pyramid Design:



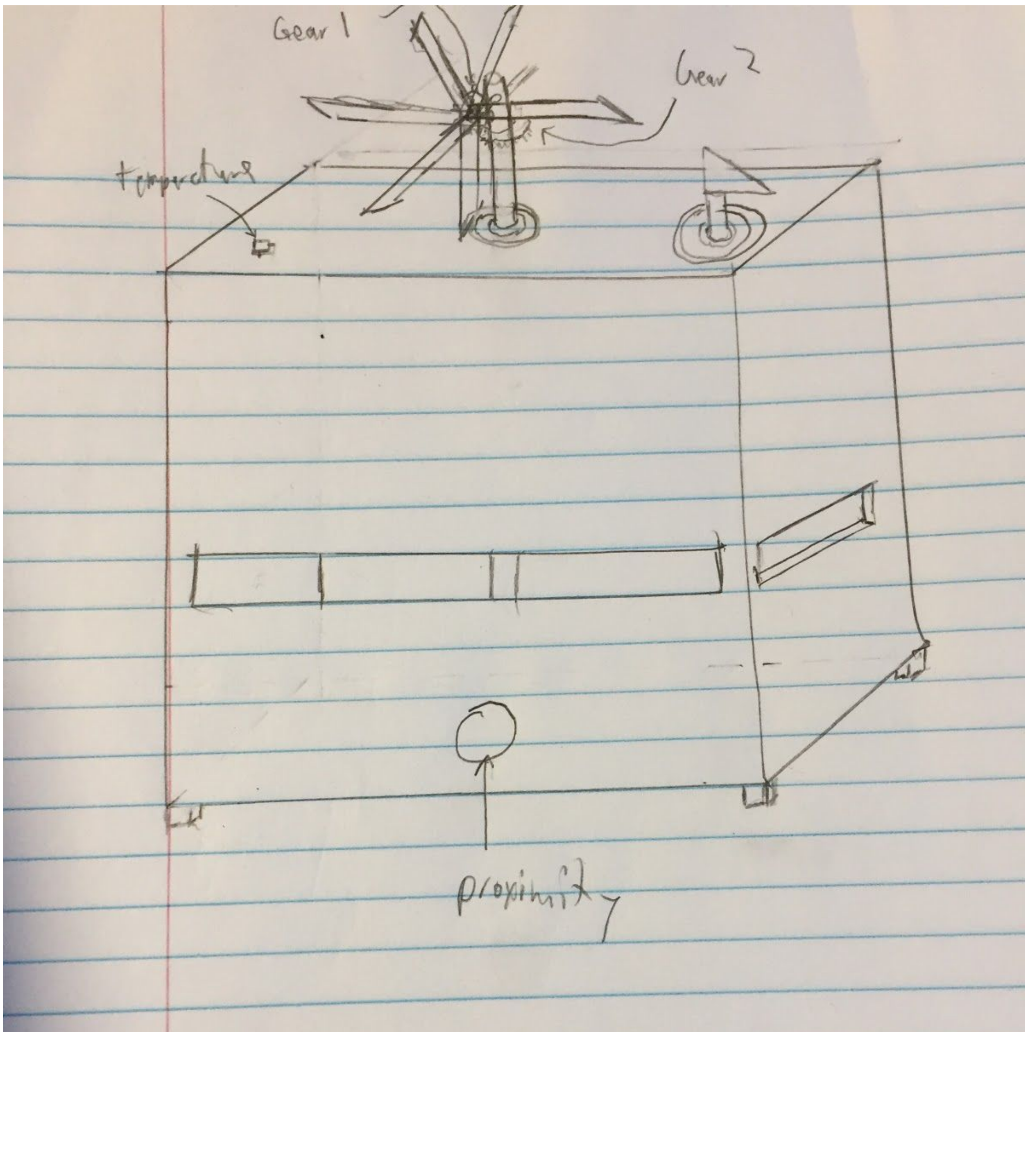
2. **Pyramid Puzzle Design:** This design is very similar to the normal Pyramid Design but, the ends have puzzle spokes. This will allow for easy assembly and disassembly during the construction process. However, this will be substantially more difficult because it will require cuts made are precise angles. This is prohibitive because the equipment for doing so is not readily available.

Drawing of Pyramid Puzzle Design:



3. **Cubic Windmill Design:** This design is a cube raised on stilts with a vertically rotating "windmill" for the anemometer. The windmill will then use gears to translate vertical rotation to horizontal rotation to allow the encoder wheel to spin properly. The other parts of the design will be very similar to the pyramid design with the exception of the motion sensor, which will be wired through the bottom of the cube. The windmill has the benefit having lower resistance to rotation. However, this design does face concerns with regard to longevity because the "windmill" can be more easily broken than the horizontally spinning design, due to greater amount of stress on the rotating.

Drawing of Cubic



Tradeoffs

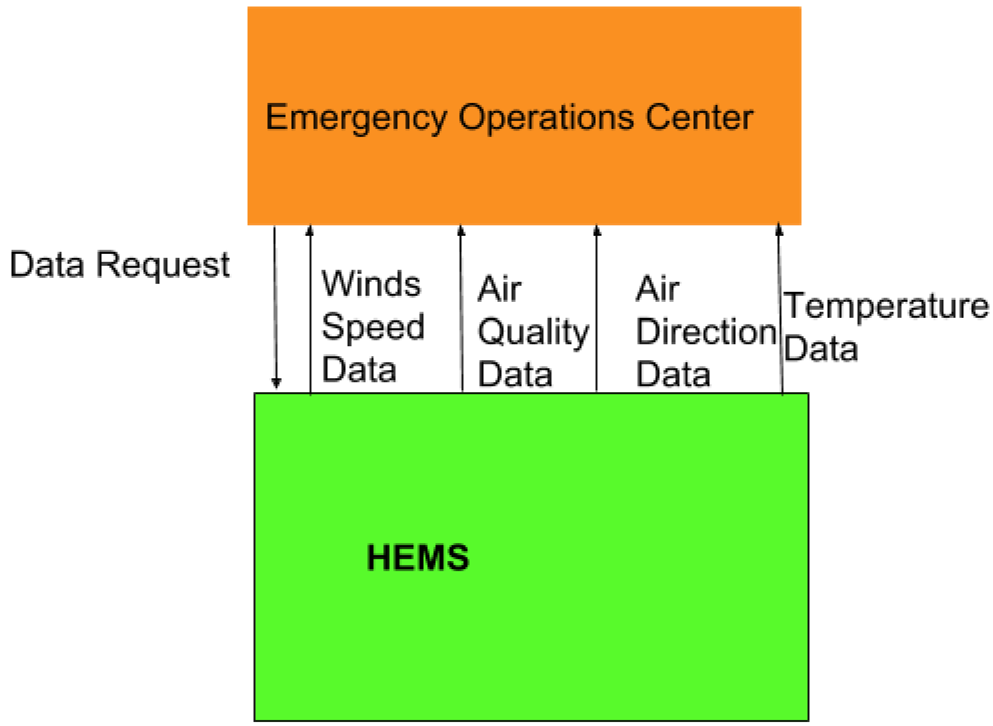
	Designs	Pyramid	Pyramid Puzzle	Cubic Windmill
Aspects				
Complexity		+1	-1	0
Material Used		1	1	0
Longevity		1	1	0
Function		0	0	1
Disassembly		0	1	0
Software		0	0	0
Total		**3**	**2**	**1**

Proposed Technical Design

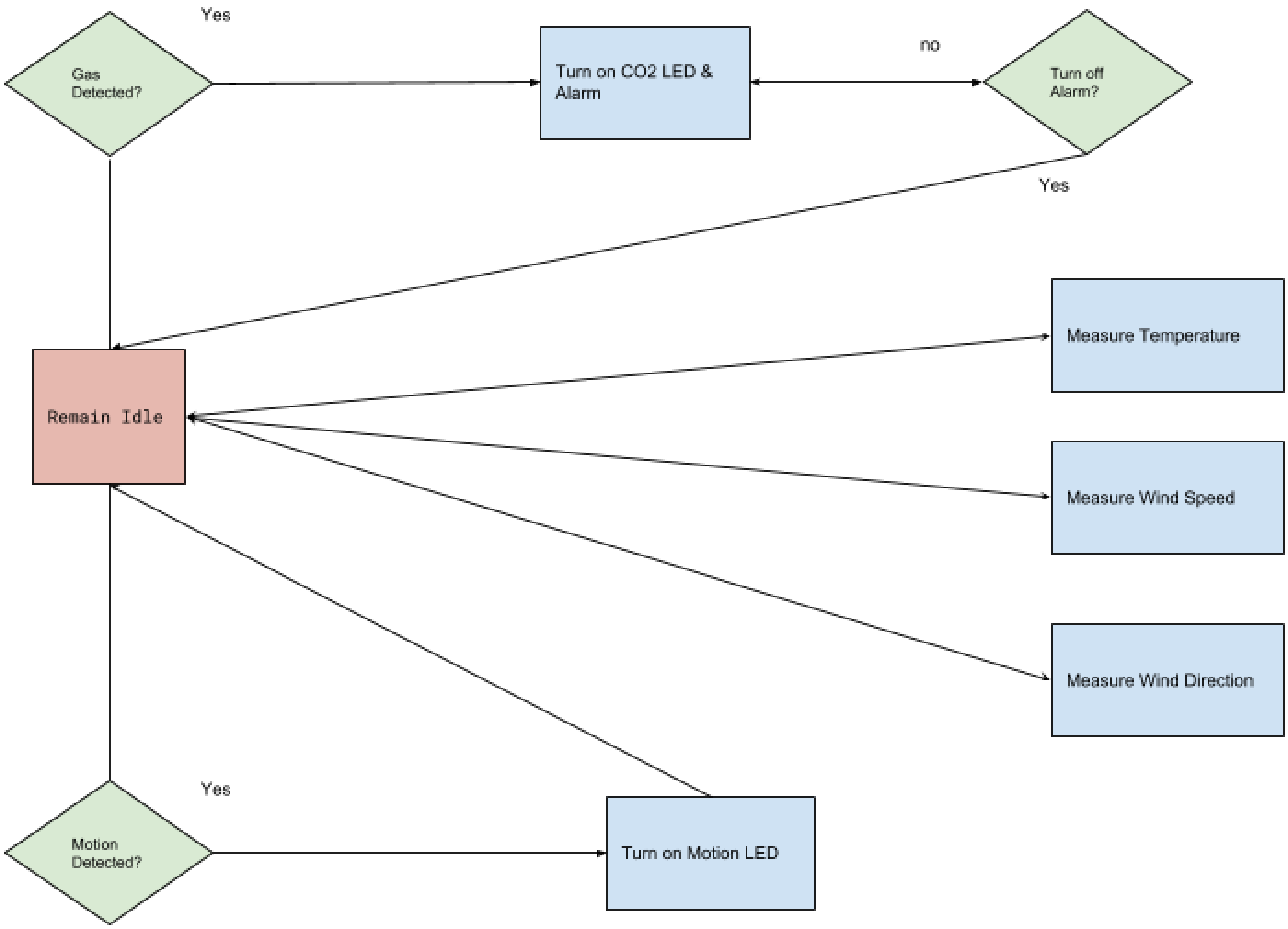
The main body of our HEMS will be a raised square pyramid and will be constructed out of __ plastic. The pyramid sides will have holes cut in the side of it to allow the air to flow in. It will have puzzle spokes to allow for easy assembly and disassembly. The wind speed measurement will be taken by a horizontal windmill with spokes in the shape of cone to prevent backwards rotation. The windmill will be mounted on a ball bearing to minimize friction during rotation and maximize precision of recordings. It will also have an encoder wheel attached to it which will rotate through an optical interrupt which will then calculate the wind speed. We will also have a flag also mounted on a ball bearing next to the windmill. It will attached to potentiometer, which will be used to determine wind direction. On the opposite side of the pyramid, there will be a temperature sensor that will be wired through the wall of the pyramid, which will be used to collect temperature data. Underneath the pyramid, there will be a motion sensor wired through the floor of the pyramid,which will trigger an alarm when people get too close, in order to prevent tampering.Inside the pyramid there will be a CO_2 sensor, to detect levels of CO_2, and a DAQ to collect and transmit the data from the Potentiometer, the Optical Interrupt, the CO_2 sensor, the Temperature sensor and the motion sensor.

Project Plan

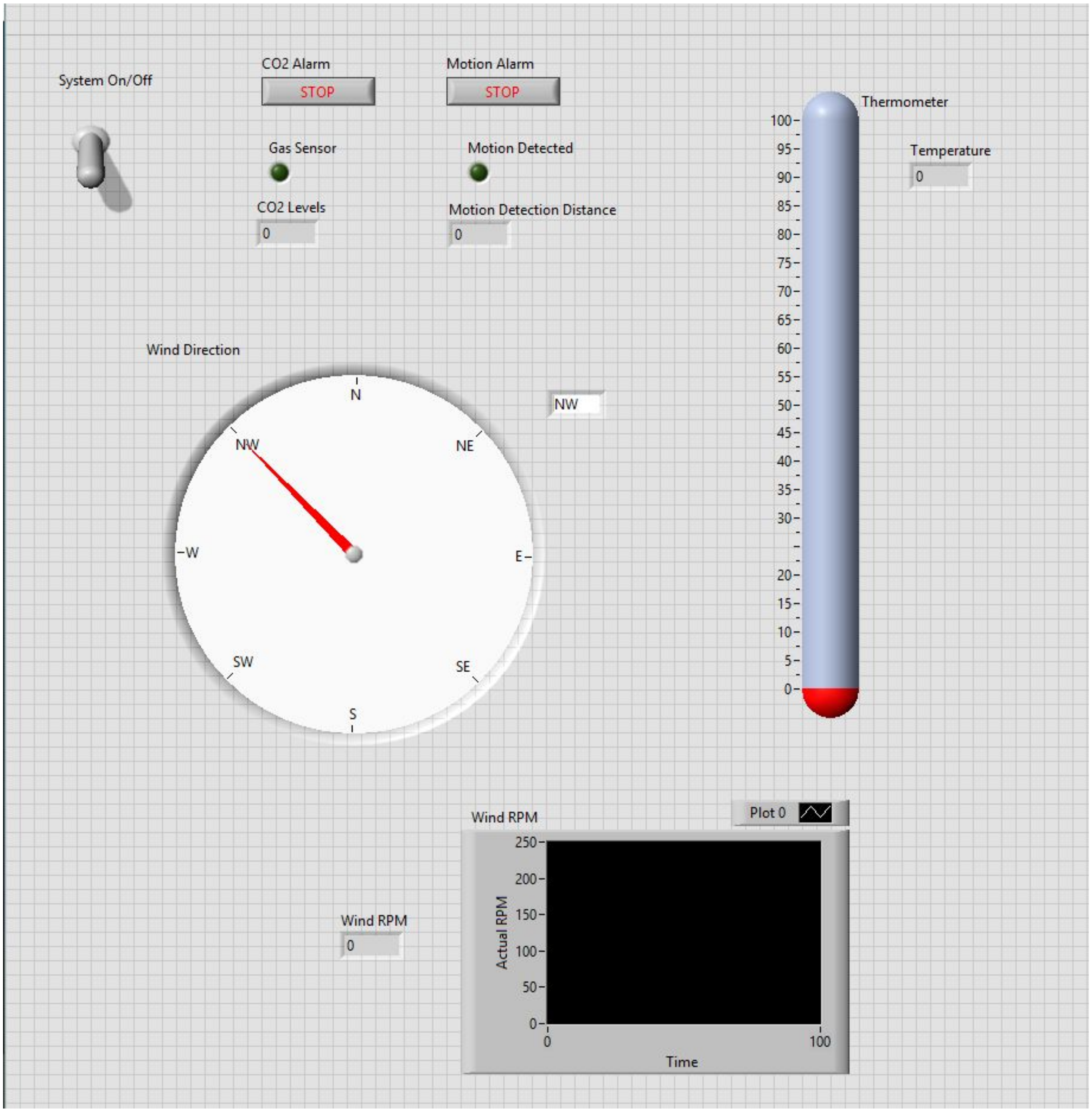
Context Diagrams



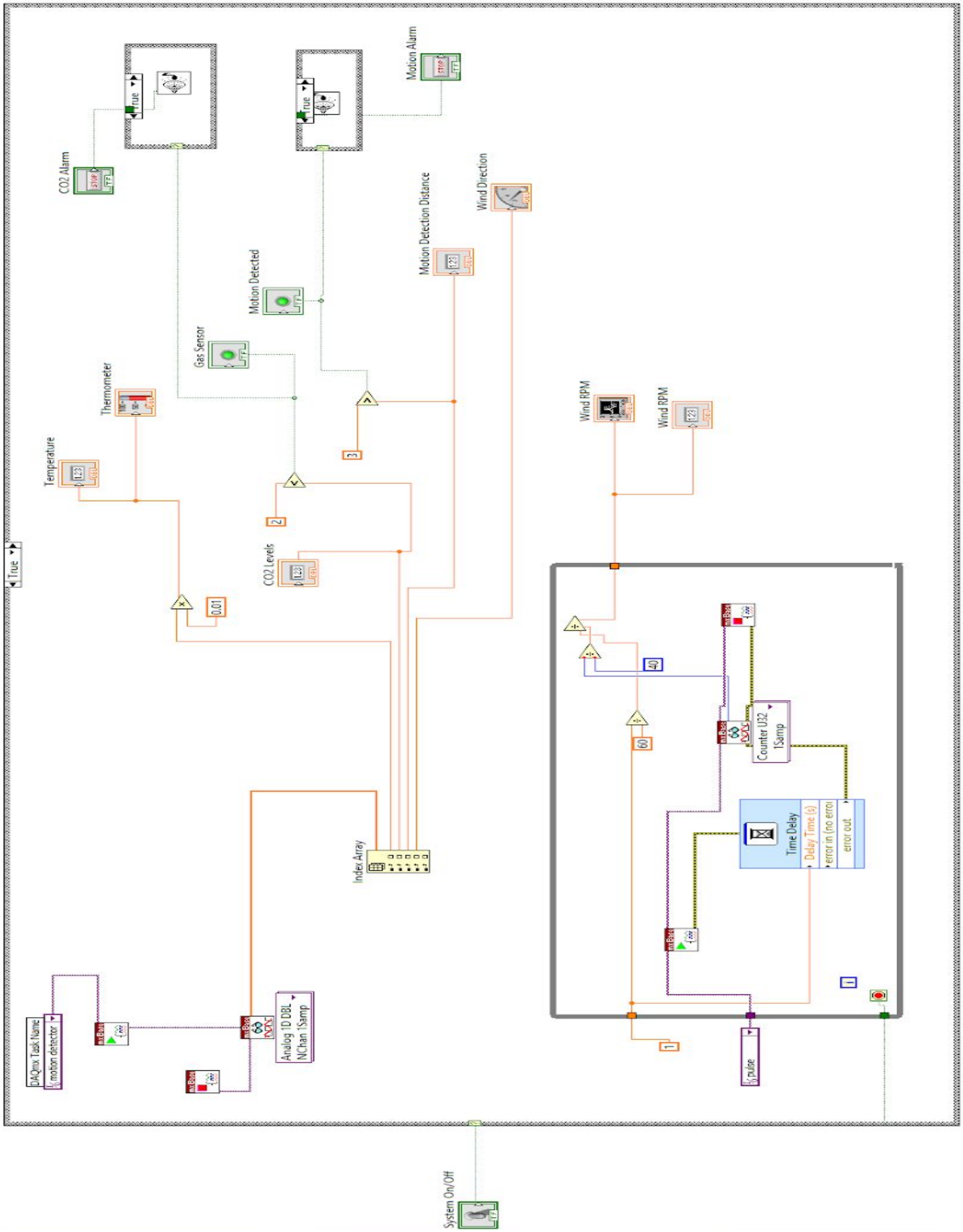
Software Flow Chart



LabView Front Panel



LabView Block Diagram



Explanation of the Block Diagram:

To detect any accidental or intentional releases of toxic gases into the atmosphere, the group used several sensors connected to a national instruments data acquisition device DAQ and programmed through LabView. This specific device was used instead of the arduino because DAQ is far more delicate instrument that is intended for acquiring or provide a low level signal information.

The block diagram begins with a “System On/Off” button that is an input for a case structure that encompases all of the program. A case structure has a similar functionality to an if/else statement, thereby pressing the “System On” button, the program runs. Two activities run simultaneously for the analog and digital sensors.

Analog Sensors:

This program begins with the DAQmx Task Activity. This enables the programmer to use a specific task activity. Subsequently, the DAQmx Task Activity begins and reads the analog channels. This follows through to an index array, where multiple sensors can be connected. The values obtained from these sensors are then presented/compared with their respective sensors. Since each sensor value requires different outputs, they will be explained individually.

Temperature: The values taken from the DAQ will be multiplied by a value of 0.01. This is because the sensor outputs 10 millivolts for each degree F it senses. After this conversion, the temperature will be presented through a thermometer graphic and a plain numeric value.

CO2: The values taken from the DAQ will be presented in a numeric value. The values obtained are actual level of CO2 in the atmosphere and therefore do not need to be converted. Stemming from the wire of the values from the DAQ, the value will be compared if it is less than 2. If this is true, the “Gas Sensor” LED will illuminate and an audible alarm will turn on. This alarm is placed within a case structure and will turn off when the “CO2 Alarm” button is pressed.

Motion: The values taken from the DAQ will be compared. If the value is greater than 3, motion is detected and an LED will be turned on as well as an audible alarm. This value is taken from the fact that a voltage of 3.3 means that the sensor detected movement while a voltage of 0 means that the sensor has not detected anything. The alarm is placed within a case structure and will turn off when the “Motion Alarm” button is pressed.

Wind Direction: The values taken from the DAQ will be presented in a compass.

Digital Sensors Program:

Measuring the wind speed requires a different case. Since the optical interrupt sensor is a digital sensor, it cannot be wired the same way. The program begins with a DAQmx Task Activity that will then follow into a case structure where task starts, reads the values, and begins a time delay. Since the DAQ does not directly measure frequency, it does have the capability to count pulses. Since our sensor disk had 40 slots, we measured RPMs by:

$$\left(\frac{\#\ of\ pulse\ counts}{40}\right)*\left(\frac{60}{Sample\ Time}\right) = \#\ of\ pulse\ counts\ /sample\ time\ in\ seconds$$

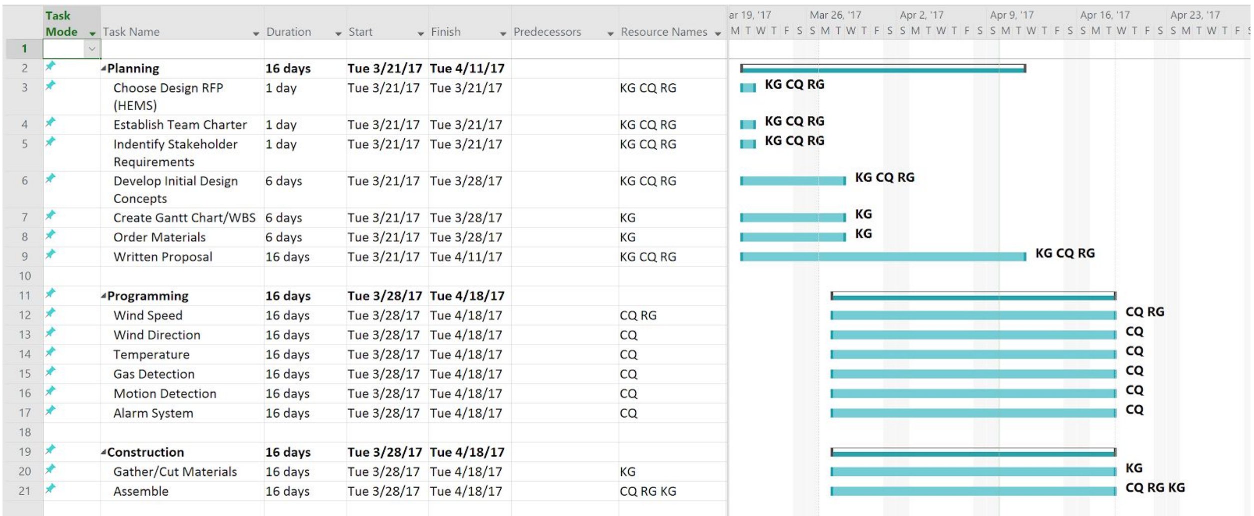
The group programmed this accordingly. The output of the RPMs will de displayed through a waveform chart and a numeric value.

Evidence/Testing of Concepts:

Previous experiments done by group 9 helped in testing and designing their concept. In a side experiment, the group dealt with working with the temperature sensor. The group thereby understood, that the values taken from the DAQ needed to be multiplied by 0.01 to get the correct temperature values. In experiment two, the group learned about the optical interrupter sensor, that when programmed correctly, measured the RPMs of the sensor disk correctly. These two experiments allowed the group to not only have a better knowledge of these sensors beforehand, but also to have an easier time programming it in labview. The group also tested each sensor individually to make sure that they worked accordingly to the program.

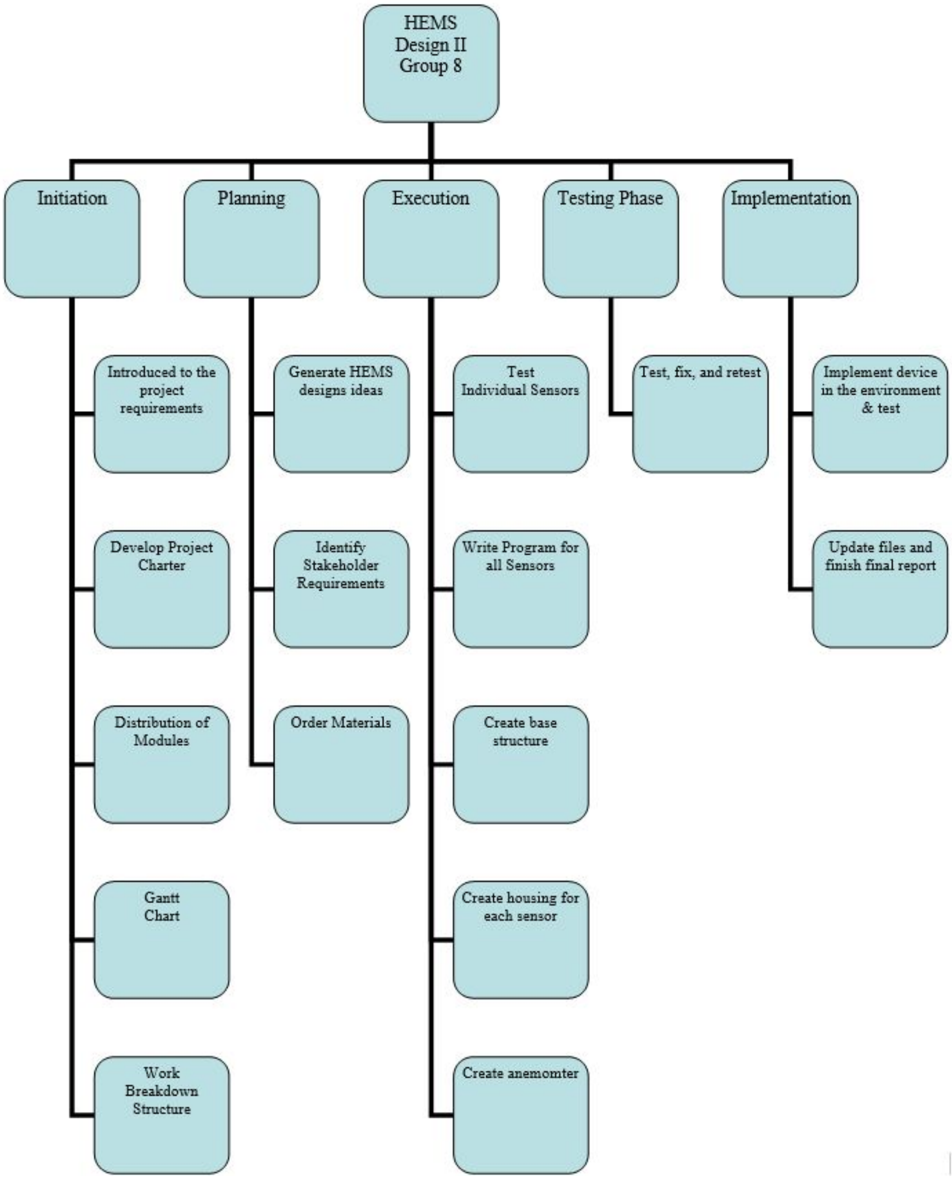
Project Plan

Gantt Chart



	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1							
2		**Planning**	**16 days**	**Tue 3/21/17**	**Tue 4/11/17**		
3		Choose Design RFP (HEMS)	1 day	Tue 3/21/17	Tue 3/21/17		KG CQ RG
4		Establish Team Charter	1 day	Tue 3/21/17	Tue 3/21/17		KG CQ RG
5		Indentify Stakeholder Requirements	1 day	Tue 3/21/17	Tue 3/21/17		KG CQ RG
6		Develop Initial Design Concepts	6 days	Tue 3/21/17	Tue 3/28/17		KG CQ RG
7		Create Gantt Chart/WBS	6 days	Tue 3/21/17	Tue 3/28/17		KG
8		Order Materials	6 days	Tue 3/21/17	Tue 3/28/17		KG
9		Written Proposal	16 days	Tue 3/21/17	Tue 4/11/17		KG CQ RG
10							
11		**Programming**	**16 days**	**Tue 3/28/17**	**Tue 4/18/17**		
12		Wind Speed	16 days	Tue 3/28/17	Tue 4/18/17		CQ RG
13		Wind Direction	16 days	Tue 3/28/17	Tue 4/18/17		CQ
14		Temperature	16 days	Tue 3/28/17	Tue 4/18/17		CQ
15		Gas Detection	16 days	Tue 3/28/17	Tue 4/18/17		CQ
16		Motion Detection	16 days	Tue 3/28/17	Tue 4/18/17		CQ
17		Alarm System	16 days	Tue 3/28/17	Tue 4/18/17		CQ
18							
19		**Construction**	**16 days**	**Tue 3/28/17**	**Tue 4/18/17**		
20		Gather/Cut Materials	16 days	Tue 3/28/17	Tue 4/18/17		KG
21		Assemble	16 days	Tue 3/28/17	Tue 4/18/17		CQ RG KG

Work Breakdown Structure



Financials

List of Materials Given:

- CO2 Sensor Assembly
- Motion Detector
- Optical Interrupt Sensor Assembly
- Plywood 1’ x 1’
- Temperature Sensor
- Potentiometer

Materials	Estimated Costs
Optical Interrupt Sensor	$ 8.00
Passive Motion Sensor	$ 8.00
CO2 Gas Sensor	$ 8.00
Temperature Sensor	$ 1.00
Infrared Sensor	$ 1.89
Proximity Sensor	$ 11.00
Wooden Dowels	$ 3.89
Bearings	$ 5.10
Super Glue	$ 6.79
DAQmx National Instruments	$ 200.00
Total Cost	$ 253.67