Project Plan and Product Specification

Solar Sausage for Water Desalination

Team 7

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Submitted to:

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Abstract

The topic of this senior design project is applying the Solar Sausage to the need of potable water in developing countries. The goal is to incorporate a desalination system with the Solar Sausage. The project must continue on the idea that the Solar Sausage is a cost-efficient way to concentrate solar energy. The design must be easily operated and maintained, transported and stored, and meet the budget requirement of $5,000 while attempting to remain as cost effective as possible. Performance specifications must be met such as reaching the liquid's phase shift temperature, desalinating water to less than 1,000 ppm, and maintaining a pressure differential of 0.001 psi between Solar Sausage chambers. Thus far, the group has visited the facility and met with Mr. Ian Winger in order to further their knowledge of the background of this invention. The group has been informed on many specifications about the Solar Sausage and its operating conditions. Research has been conducted on different desalinization techniques as well as location characteristics such as weather and potable water scarcity. In the future, the group plans to finalize decisions on the desalination technique, product specifications, and overall design of the apparatus. In order to reach this, the group will continue to meet with all the advisors and mentors and construct a prototype from this assistance. This will ensure that the group will continue to work on a steady path.

1 Introduction

This senior design project involves using a Solar Sausage to desalinate saline water. This is an entrepreneurial project expanding on the work of Mr. Ian Winger, FSU scientific research specialist. The objective behind this project is to research different thermal desalination techniques and incorporate one into the solar sausage converting saline water into potable drinking water. Desalination is a technique most heavily used in Middle Eastern Countries. It is a very energy intensive process that relies on existing and reliable energy sources. Madagascar is the preferred location of choice based on the country's scarcity to clean drinking water sources as well as poor conditions related to this issue. Madagascar is also preferred based on its relative weather conditions similar to Tallahassee where the testing will be conducted. The end design and prototype will hopefully be applicable to other regions in need meeting similar standards and deficiencies as Madagascar.

Mr. Ian Winger will provide the materials for the Solar Sausage. The team will complete the construction, as well as the distillation apparatus. Temperatures reached by the collector must be around 100^0C to be sufficient for evaporation to take place as well as vapor condensation to occur at a satisfactory rate. There are a lot of technical specifications that need to be determined by the group. The temperature to reach phase change must be determined as well as the geometric parameters that will provide a sufficient water supply for a single household.

2 Project Definition

2.1 Background Research

Desalination as a practice has been in use a long time, it just happens to be a very energy intensive. Osmotic Drives, the act of driving saline water through a small membrane, at its most efficient requires about 1.5 $kWh/kgal$ [1]. Middle Eastern countries are the world leaders in producing clean drinking water through desalination; countries include Saudi Arabia, United Arab Emirates and Israel. Due to the Middle East involvement there is an abundance of literature available on desalination. Their largest facilities use multi-flash desalination, where the saline water is reheated multiple times at lower pressure [2]. Multi-Flash desalination plants are often built in conjunction with power plants in order to utilize the waste heat, else it becomes a very energy intensive process [2].

While large scale desalination plants require electricity or the waste heat from a power, low cost desalination devices utilizing solar thermal energy only produce enough water for personal use [3]. These methods for using solar thermal energy at a small scale can be applied with Mr. Winger's invention to desalinate water at a much larger scale.

Mr. Ian Winger invented an inflatable parabolic trough referred to as Solar Sausage. The Solar Sausage, a long 50ft cylinder, made of Mylar Polyester with a reflective membrane in the

along the middle, is more efficient than traditional mirrors at concentrating sun light [4]. At 1/20th of the cost and 1/50th of the weight of traditional parabolic mirrors, Solar Sausage can be used to create low cost solar concentration system capable of reaching $400℃$ within a few minutes of exposure to direct Sunlight [5]. This device heats around 50 gallons per day of fluids to high temperatures that can be used for power generation and water heating.

2.2 Need Statement

Partnering with the College of Engineering our team has been tasked with creating a desalination system. In the developing world, access to clean drinking water is not often available or available on a consistent basis. Unclean water leads to sick children whose education suffers as they miss school. Economic opportunities are lost if a parent is sick from unclean water or spends most their day in search of clean water [6]. This leads to a cycle of poverty that only access to clean drinking water can break. This drives the need for a cheap and low tech system capable of desalinating water and supporting the potable water needs of a small village family. Thermal desalination devices currently exist but with small capacities, with current technology invented by Mr. Winger a large scale thermal desalination device is possible.

"Much of the under developed world still lacks access to clean drinking water."

2.3 Goal Statement & Objectives

The need of this clean water is hoped to be resolved through the senior design project encompassed around the Solar Sausage which provides heat in a cheap fashion. This leads to the goal of desalinating water with the Solar Sausage's assistance.

"The goal of this project is to create a solar desalination system using the Solar Sausage."

As stated in the goal statement Team 7's goal is to create a desalination system using the solar sausage, the system must be easily transported to a small African village. The project becoming more defined, Team's 7 objectives became clearer

- Must provide a sufficient amount of potable water for a small community located in Madagascar
- Must stay within allowable budget
- Must simplistic in nature so that locals could easily be trained to operate and maintain
- Solar Sausage must be easily transported and installed

3 Constraints

Team 7 was given two constraints by the instructors and mentors on this project; to use the solar sausage and a budget of $5,000. The other constraints where developed by the team based on the operating environment and the local villagers using the desalination system. As the project continues to develop the constraints listed below will be subject to change

- Budget of $5000
- The system must be durable and able to withstand moderate weather conditions
- The system must have low to no emissions
- The system must be simple and easy to operate for locals
- Measurements must be precise and consistent
- The group only consists of four members so the workload for each person will be greater
- Project must be conducted in a timely fashion, and completed by the end of the school year
- Maximum temperature is reached during primary sunlight hours from 10 AM to 3 PM
- Must have a means to store fresh water after desalination
- Must have materials capable of operating with saline water as the working fluid

3.1 Design Specifications

As mentioned the Desalination System will be used by a village in a developing nation. The limitations by the sociological factors greatly influence how the system can be design and implemented. Having to take into account the resources available to the villagers and the vocational skills of the villagers themselves. These factors along with the initial project requirements lead to the following design characteristics

- Local villagers must be able to easily install and maintain the desalination system. System must be low-tech
- The desalination system must be easily operated by one villager
- Must utilize sunlight as the primary energy source. Operated independently of any electrical power
- Finished product should cost $5,000 or less. The given budget
- System must be able to be easily stored and transported
- Desalinated water must be stored in sanitary tank easily accessible to local villagers

3.2 Performance Specification

The process of Desalination has a couple of approaches, one uses membranes to force either sodium or water across the membrane the other uses distillation. As the team has chosen distillation as the means to desalinate the water, this leads to a certain set of performance specifications. The

Solar Sausage must heat the saline water to a temperature for evaporation to occur, while maintaining the integrity of the structure. This leads to the following performance characteristics

- Initial Filtering stage must remove dirt and large particles from the saline water
- Saline water must be heated to a minimum of 100℃, or right to the point where a phase shift occurs
    - $T_{min} = 100℃$
- Desalinated water must have a Saline content of less than 1000ppm
    - $S \leq 1000ppm$
- Must be a device in place to maintain and regulate the pressure difference between the top and bottom Solar Sausage compartment
    - $P_{diff} = .001psi$

4 Methodology

The group will produce a cost efficient solar sausage desalination system with respect to the budget, time frame, and resources given. There are many vital steps that must be taken for early stages of design. The group will need to research concepts of desalination, fluid pumping mechanisms, fluid storage systems, and filtration systems. A review of thermal fluid properties, along with a consistent measuring system, will be necessary in order to combine these concepts. Obtaining information on past project designs will further assist the incorporation of these concepts. Since Madagascar is the prime location of clean water scarcity, a better understanding of the geography and climate will be necessary. The group will remain conscious of environmental standards and regulations while taking into account for climate change.

Once the primary steps are completed and a sufficient amount of research has been obtained the group must choose the most practical design techniques, establish equations needed to solve for variables, use MathCAD to solve for these variables, and then finally use software to perform tests on the design.

The final steps in order to complete the solar sausage desalination system will be a final simulation of the design, compiling all results, and then checking for any mistakes or errors in the experiment.

4.1 Schedule

Located in the appendix is the Gantt Chart for the fall semester that ends on December 5th, 2014. The chart is broken down into four phases, system constraints, concepts development, design finalization, and materials research and selection. The schedule, if followed, has all design work including CAD drawings, calculations and dimensions completed by November 25th, 2014. As the project develops the schedule is subject to change as more resources get added or removed, making these dates tentative. This leaves over a week for the team to prepare for the next semester that begins in January.

The first phase is determining the system constraints, the design and performance specifications were developed and are listed above in the constraints section. The concept development phase is the longest of 21 days, early during this phase the preliminary designs are analyzed for their validity and the best one is selected. The best design's measurable quantities needed to meet the performance specifications such as phase change energy, compressor analysis and many more are calculated. These measurable quantities will allow the values such as the receiving tube diameter and Solar Sausage length to be determined. In the design finalization phase the team meets to discuss the specifics of the design and vote on whether or not we are satisfied with the design. Upon approval the CAD drawings, which will be used for construction in the spring semester, will be completed with appropriate dimensions by November 25th, 2014. In the final stage (material research and selection), the team prepares for spring semester. The team will research vendors, necessary equipment for construction and machinist; this should allow the team to begin the construction process as soon as the spring semester begins.

4.2 Resource Allocation

There are four team members in the design group that will be responsible for completing the required task. The task allocated to each team member is displayed in the table for each member. The labor hours for task not yet completed and will be updated with the actual labor hours as the project progresses.

Table 1 Resource Allocated to Alex Filardo

Resource	Resource Type	Labor Hours	Expected Completion Date
Design Specifications	Intellectual	4	Oct. 8, 2014
Saline Water Corrosiveness	Research	3	Oct. 15, 2014
Evaporation Input Energy	Intellectual	2	Oct. 21, 2014
Solar Sausage Length Analysis	Intellectual	5	Oct. 29, 2014
Condensing Techniques	Research	4	Oct. 31, 2014
CAD Drawings	Intellectual	10	Nov. 24, 2014
Pipe Selection	Material/Fiscal	2	Dec. 5, 2014
Total Labor Hours		**30**	

Table 2 Resources Allocated To Joseph Hamel

Resource	Resource Type	Labor Hours	Expected Completion Date
Performance Specifications	Intellectual	4	Oct. 8, 2014
Heat Enchanger	Research	5	Oct. 15, 2014
Condensation Energy	Intellectual	2	Oct. 21, 2014
Head Loss Calculations	Intellectual	3	Nov. 2, 2014
Condension System Requirements	Intellectual	7	Nov. 2, 2014
Cad Drawings	Intellectual	10	Nov. 24, 2014
Total Labor Hours		**31**	

Table 3 Resources Allocated To Alex Stringer

Resource	Resource Type	Labor Hours	Expected Completion Date
Design Specifications	Intellectual	5	Oct. 8, 2014
Conduction Research	Research	3	Oct. 15, 2014
Solar Intensity Research	Research	4	Oct. 15, 2014
Solar Concentration Analysis	Intellectual	5	Oct. 24, 2014
Temperature Regulations	Research/Material	2	Nov. 4, 2014
CAD Drawings	Intellectual	10	Nov. 24, 2014
Storage Tank Selection	Material/Fiscal	2	Dec. 5, 2014
Total Labor Hours		**31**	

Table 4 Resources Allocated To Crystal Wells

Resource	Resource Type	Labor Hours	Expected Completion Date
Performance Specifications	Intellectual	4	Oct. 8, 2014
Madagascar Demographics	Research	2	Oct. 12 , 2014
Heat Transfer Fluids	Research	3	Oct. 15, 2014
Receiving Tube Material	Material	5	Oct. 21, 2014
Minimum Diameter Calc.	Intellectual	1	Oct. 31,2014
Water Storage	Material	3	Nov. 4, 2014
CAD Drawings	Intellectual	10	Nov. 24, 2014
Structural Material	Research	2	Dec. 5, 2014
Total Labor Hours		**30**	

5 Conclusion

The conclusion of this senior design project at the end of the first semester is hopefully a final design concept that has been conceptually and numerically proven successful in absorbing sunlight through the Solar Sausage, desalinating water through our desalination apparatus, and moving and storing the water in an efficient manner. The distillate water flow output should be vast enough to provide sufficient water for a family of four to five in a village in Madagascar and clean enough that the family has consistent potable water and sustainability. Engineering detailed sketches should be made of the idea providing these features.

6 References

[1] Seawater Desalination Power Consumption." *Sustainable Solutions for a Thirsty Planet*. WateReuse Association, 1 Nov. 2011. Web. 23 Sept. 2014. <WateReuse Association>.

[2] Aintablian, Xanthe. "Desalination Expands as Technology Becomes More Affordable." *Water Desalination*. AboutEducation. Web. 23 Sept. 2014.

[3] West, Tyler. "Low - Energy Desalination Units for Developing Countries." Web. 23 Sept. 2014. <http://www.pitt.edu/~tew32/WA3.pdf>.

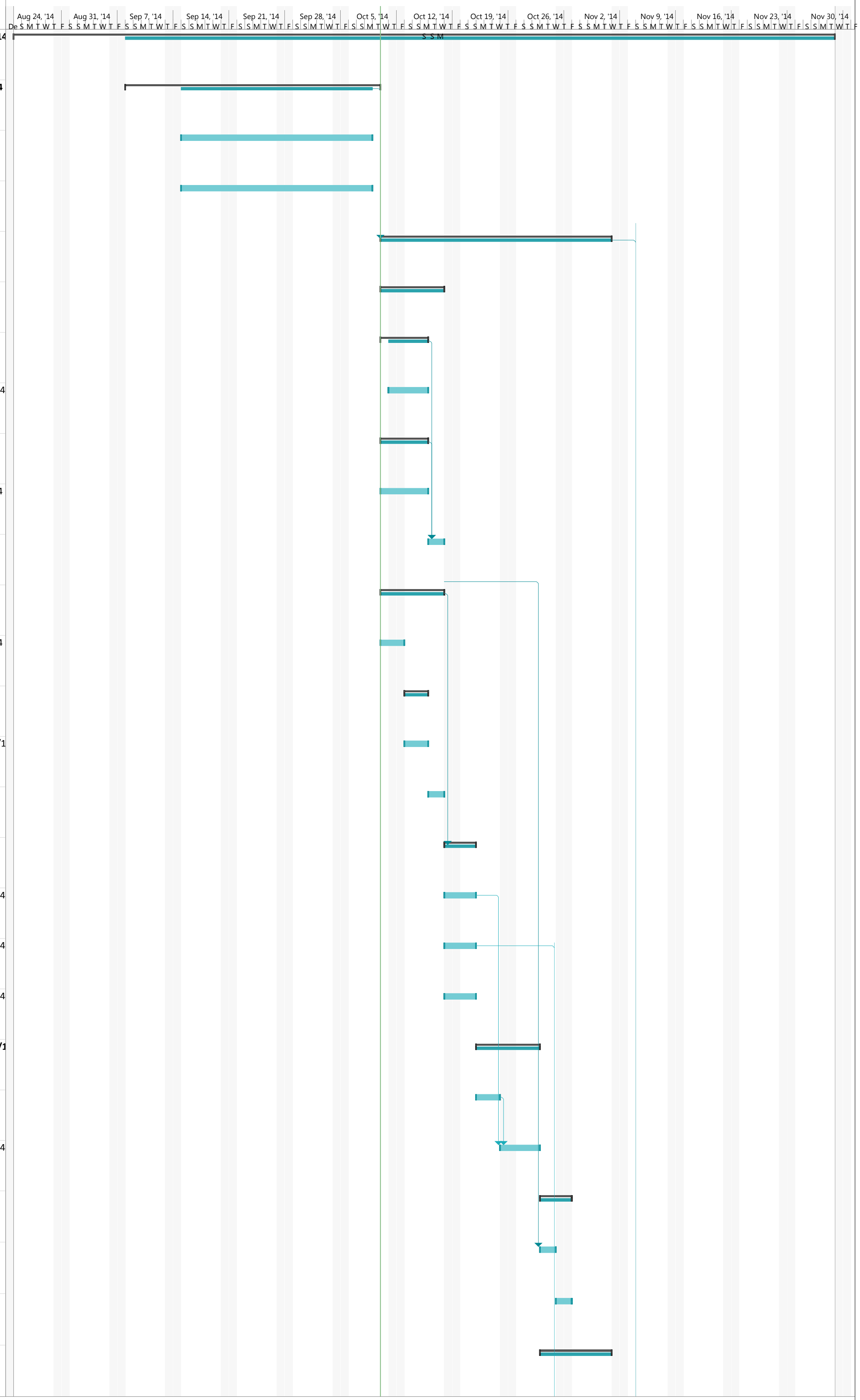
[4] Group Seven, Ian . Personal interview. 8 Sept. 2014. FAMU-FSU College Of Engineering Building A Atrium.

[5] Sams, Jack. "Inflatable Solar Energy Collector (the "Solar Sausage")." *Technology Opportunity*. Florida State University Office of IP Development and Commercialization. Web. 21 Sept. 2014. http://www.research.fsu.edu/techtransfer/technologyopportunity/documents/energy/winger2.pdf

[6] "Safe Drinking Water Is Essential: Why Is Safe Water Essential?" *Safe Drinking Water Is Essential*. National Academy of Science, 1 Jan. 2008. Web. 21 Sept. 2014. <http://www.drinking-water.org/html/en/Overview/Why-is-Safe-Water-Essential.html>.

Appendix

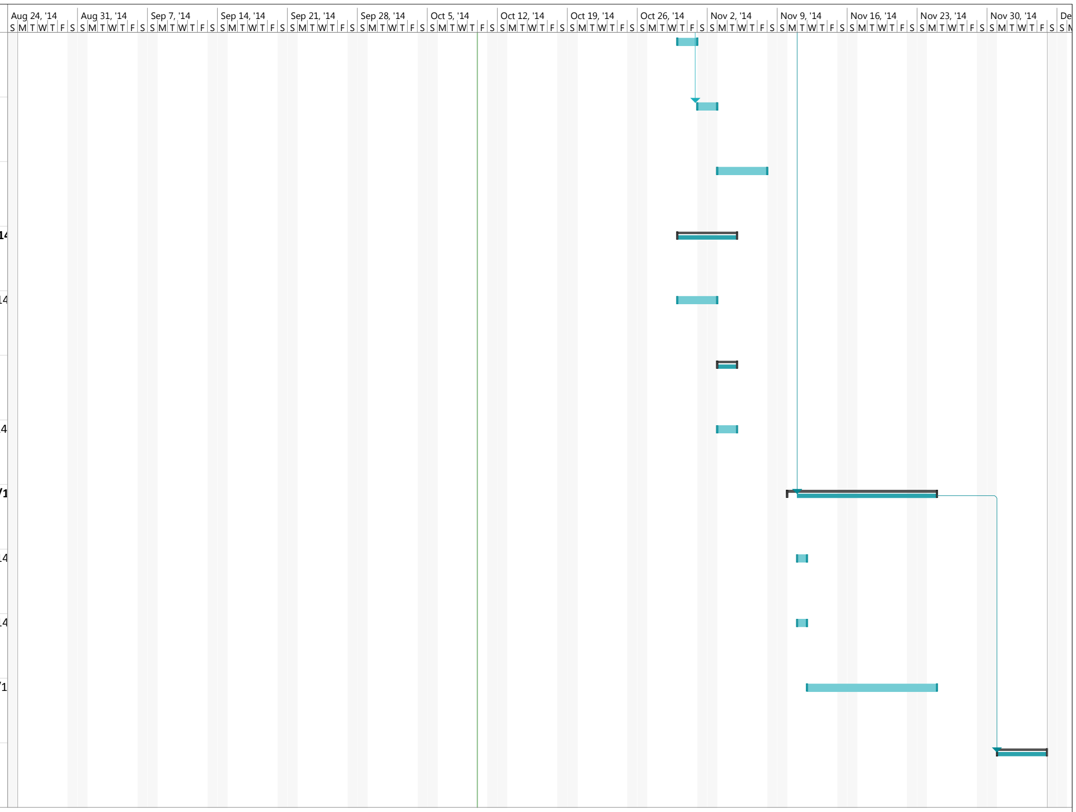
ID	Task Name	Duration	Start
1	**Senior Design Fall Semester**	**75 days**	**Mon 8/25/14**
2	**System Constraints**	**24 days**	**Mon 9/8/14**
3	Design Specifications	18 days	Mon 9/15/14
4	Performance Specifications	18 days	Mon 9/15/14
5	**Concept Development**	**21 days**	**Fri 10/10/14**
6	**Heat Transfer Method**	**6 days**	**Fri 10/10/14**
7	**Heat Exchanger Research**	**4 days**	**Fri 10/10/14**
8	Heat Transfer Fluids Research	4 days	Sat 10/11/14
9	**Conduction Research**	**4 days**	**Fri 10/10/14**
10	Saline Water Research Corrosivenes	4 days	Fri 10/10/14
11	Heat Transfer Method Selection	2 days	Thu 10/16/14
12	**System Capacity Selection**	**6 days**	**Fri 10/10/14**
13	Madagascar Research Demographic	2 days	Fri 10/10/14
14	**Madagascar Research Geographic**	**3 days**	**Mon 10/13/14**
15	Solar Intensity Research	3 days	Mon 10/13/1
16	Set Capacity	2 days	Thu 10/16/14
17	**Phase Change Energy Analysis**	**3 days**	**Sat 10/18/14**
18	Evaporation Energy Input	3 days	Sat 10/18/14
19	Condensation Energy	3 days	Sat 10/18/14
20	Receiving Tude Material Selection	3 days	Sat 10/18/14
21	**Solar Sausage Analysis**	**6 days**	**Wed 10/22/1**
22	Solar Concentration Analysis	3 days	Wed 10/22/1
23	Solar Sausage Length Analyisis	4 days	Sat 10/25/14
24	**Pipe Flow Analysis**	**3 days**	**Thu 10/30/14**
25	Minimum Diameter Calculations	2 days	Thu 10/30/14
26	Head Loss Calcualtion	2 days	Sat 11/1/14
27	**Condensor Analysis**	**7 days**	**Thu 10/30/14**



Project: Senior Design

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

ID	Task Name	Duration	Start
28	Condensing Techniques Research	2 days	Thu 10/30/14
29	Condensing System Requirements	2 days	Sat 11/1/14
30	Condensor Selection and Design	5 days	Mon 11/3/14
31	**Water Storage**	**4 days**	**Thu 10/30/1**
32	Saline Water Storage	3 days	Thu 10/30/14
33	**Desalinated Water Storage**	**2 days**	**Mon 11/3/14**
34	Temperature Regulation	2 days	Mon 11/3/14
35	**Design Finalization**	**11 days**	**Mon 11/10/1**
36	Design Validation Meeting	1 day	Tue 11/11/14
37	Final Design Vote	1 day	Tue 11/11/14
38	CAD Drawings	9 days	Wed 11/12/1
39	**Material Research and Selection**	**5 days**	**Mon 12/1/14**



Project: Senior Design

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