Quick Change Electrical Connection

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Team 09

Concept Generation

Document

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1.0 Introduction:

This project works with Raytheon, a defense company, to design a self-aligning quick change nose assembly for a weapon. Our job is to create a design that self-aligns the electrical connector and provides a secure contact of that connection. Our design must operate under the normal weapon operating conditions successfully.

This report analyzes how the given criteria will affect the concept generation and selection process. This report will also describe the concepts that are being analyzed. It will then discuss the various parameters used in the concept selection and what the initial selection is before further review, designing and testing to verify that the first selection is the best option.

2.0 Problem Statement:

Goal:

Design an improved electrical connection alignment using the constraints given by Raytheon. The constraints and how they affect the design choice will be further analyzed later in the report.

Constraints:

- Must fit in a 1.5'' x 4'' x 2'' zone
- Connection must be maintained for a mating tolerance of ±0.020''
- Resistance to captive carriage vibration standards
- **Transportation Loads**: Must resist 30 Gs of shock in all directions
- **Temperature Range**: -54^{o} to 80^{o} C
- **Sand**: The connector shall be able to operate after exposure to blowing sand with protective covers at particle concentration of 1.06 gram (gm)/m3 with a wind velocity of 40 mph (59 ft/sec, 17.9 m/s) and a corresponding particle size from 74 to 1000 micrometers.
- **Dust**: The connector should be able to be exposed to dust at a particle concentration of 10.6 ± 7 grams (gm)/m^3 with a wind velocity of 20 mph (29 ft/sec, 8.95 m/s) and a corresponding particle size less than 150 micrometers.
- **Water and Ice**: The nose assembly should be able to be operated under exposure to 1 inch/hr (25.4 mm/hr) with an average droplet size of 0.07 inch diameter for a duration of 5 min at a velocity of 862 ft/sec.
- **Bomb Rack Ejection Shock**: Must be able to resist loads from a 50G acceleration from ejection of an aircraft.
- **Corrosion Resistance**: Must be able to resist exposure to 5% salt solution
- Must be compatible with JP-10 Jet Fuel.

3.0 Concept Generation:

Solid Guided Connection:

The first concept of the six unique designs created in our team is the Solid Guided Connection, shown in Figure 1. This design worked off a similar concept to the docking mechanism on the International Space Station where a conical guide guides a docking spacecraft into the port and allows movement of people or things from the spacecraft and the Space Station. This design allows for both self-alignment of the connection and a secure mating of the two halves of the electrical connection.

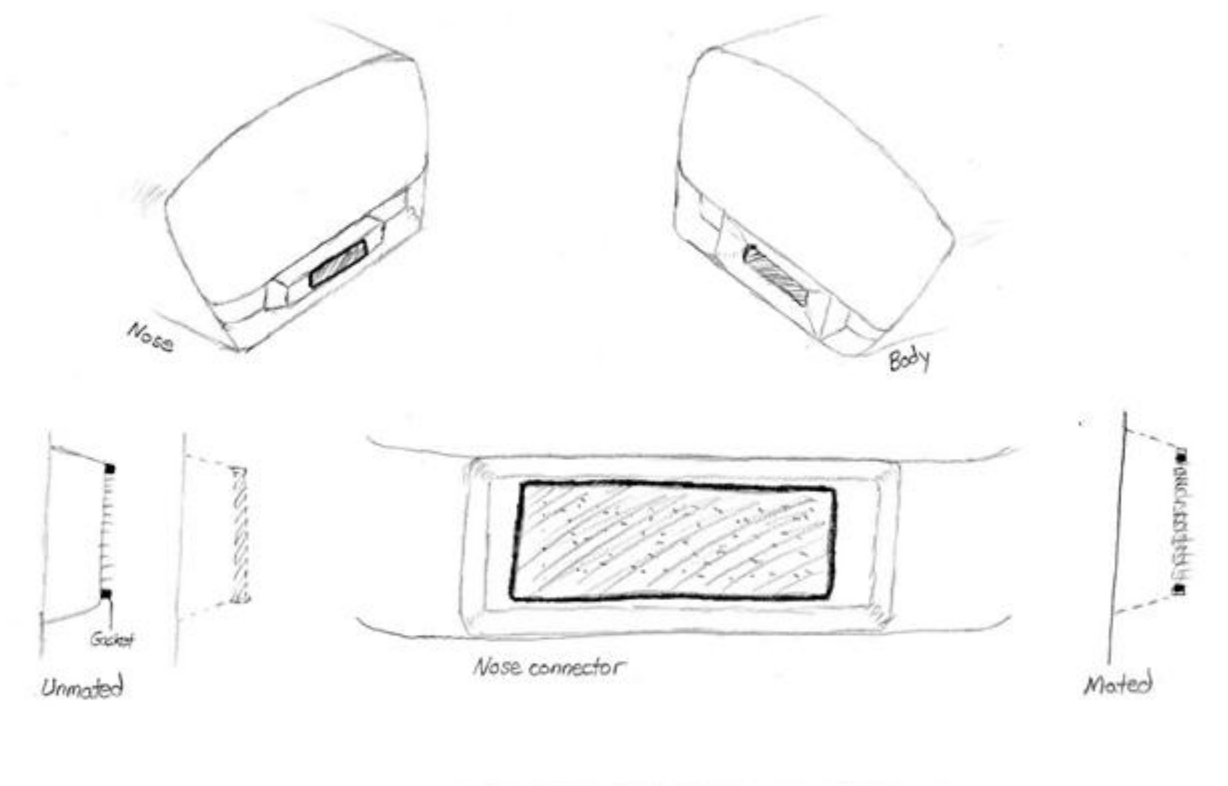


Figure 1 – The Solid Guided Connection

The biggest part of this design is the self-aligning slant that the connection has, which would allow the chosen port connection to slide into the other half of the connection effectively and automatically. This meets the requirement by Raytheon to have a self-aligning electrical connection and alleviates any issues associated with the electrical connection to not mate up properly. No matter how far off the aligning of the nose to the body of the unit is, the connection is sure to always align and connect. Additionally, with a gasket or similar material around the outer edge of the connector, as the two parts are mated, the gasket is pushed against the opposing face, making a tight seal immediately next to the connector to avoid contamination by moisture or dust.

Indented Guided Connection:

The second concept generated by the team includes the Indented Guided Connection, as shown in Figure 2. This design is very similar to the Solid Guided Connection listed above, but instead of integrating the connection into the alignment guides as in that design, the connection is isolated and the alignment guides are to either side of it.

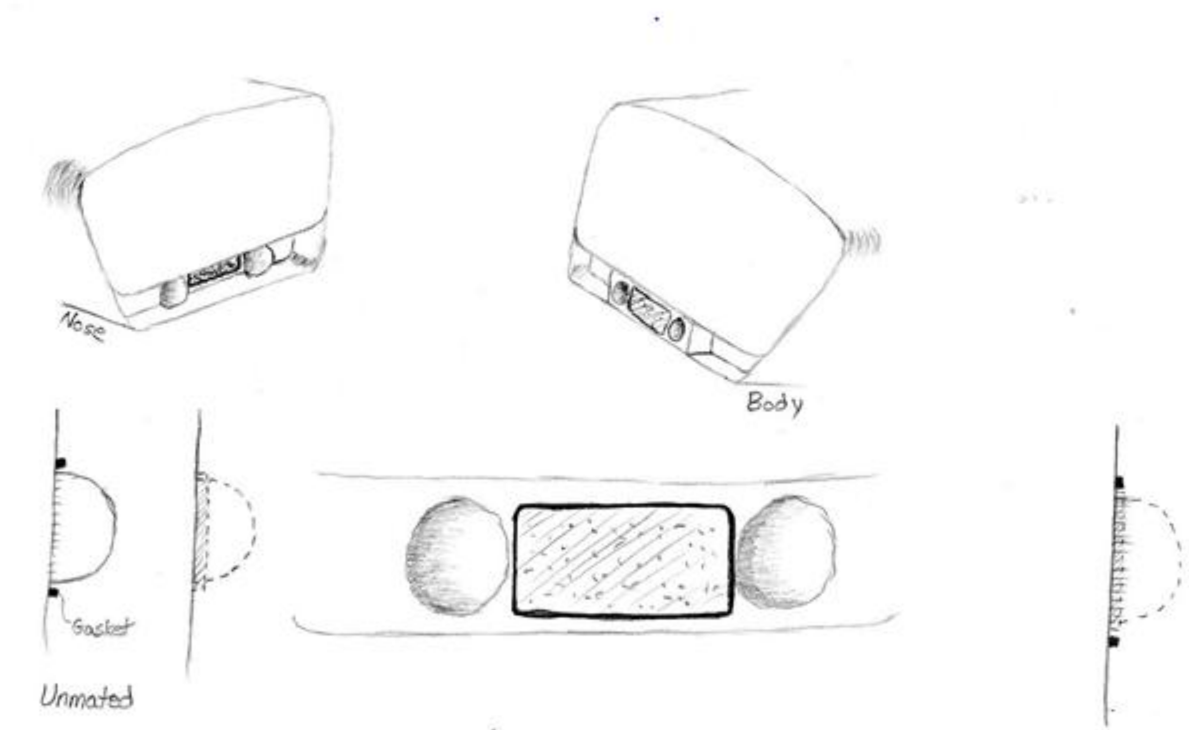


Figure 2 – The Indented Guided Connection

In this design, there are two half-spheres mounted to the nose part of the unit and two indents on the body side of the unit. The use of two spheres to align the connection puts less stress on the parts, including the threat of damaging the electrical connector, due to the mounting of the connections mostly on the body and not on an added part that could break off. Additionally, field repair of this connection is much easier than the first concept due to the usability of the unit if one or both of the half-spheres break off and easy substitution of another similar part (half-sphere) to use the guides. However, this connection is not as secure as the Solid Guided Connection and does not provide a solid seal between the two sides of the connection to keep out any stray dust or moisture, despite the use of a gasket.

Alignment Flange:

This design incorporates a flange that attaches to the back of the electrical connector and the bottom of the connector keep in zones. This design is relatively cheap however, it may deform under high stress situations. Although this design keeps the electrical connector within mating tolerance, it does not ensure perfect alignment if the nose and body were of center. The aspects of the design are in figures 3 and 4:

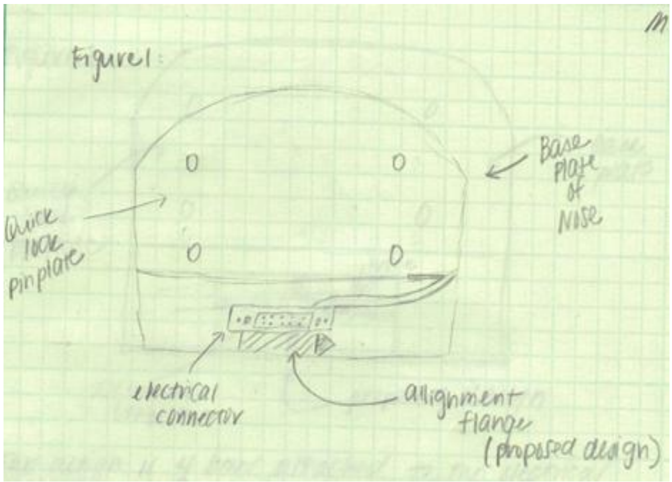


Figure 3 - Alignment Flange Assembly

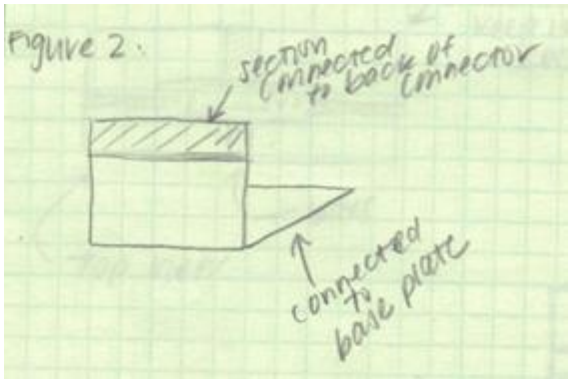


Figure 4 - Alignment Flange

Stabilizing Bars:

This design is optimum for securing alignment in all coordinate directions. However, just like the design before, it does not guide the electrical connector in place, and therefore the nose and body alignment must be perfect. The four bars will be connected to the keep in zone by screws or adhesive, and will be connected to the electrical connector by some form of adhesive as well. This design however, does not do a great job of shielding the wires from any debris that could potential harm the system. The details of the design are shown below in figures 5 and 6:

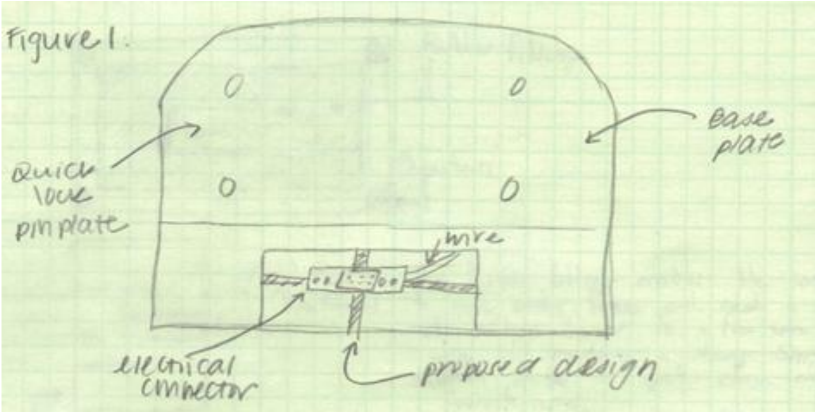


Figure 5 - Stabilizing Bars Assembly

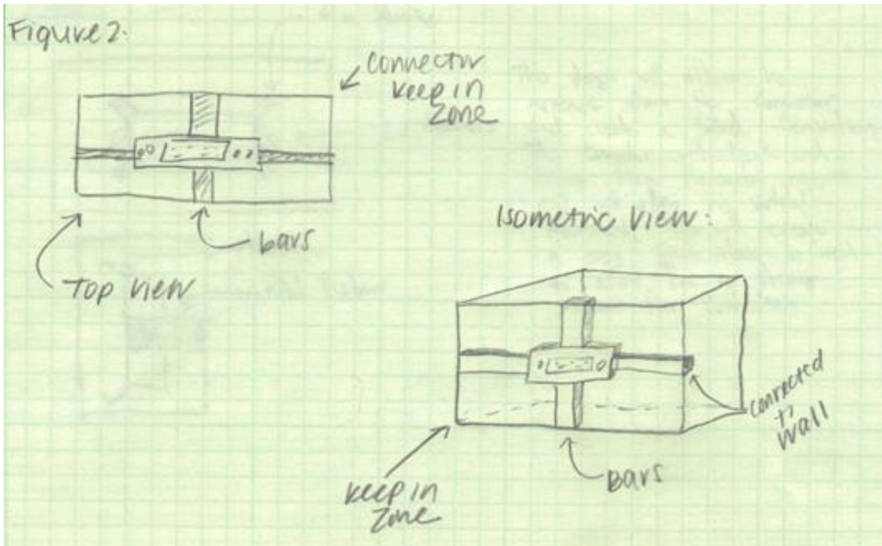


Figure 6 - Stabilizing Bars

<u>Flexible Material:</u>

This design conceals the wiring with a flexible material like rubber to capture any debris that may occupy the system. The material will be held in place by fasteners into the keep in zone, and will prevent any movement from the electrical connector. This allows for maximum mating tolerance.

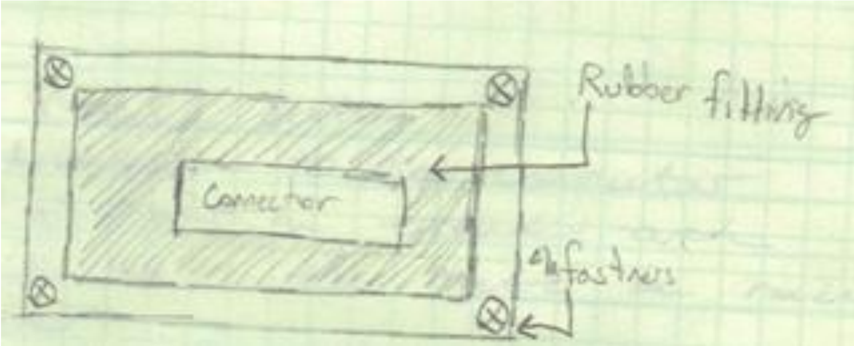


Figure 7 - Flexible Material Front View

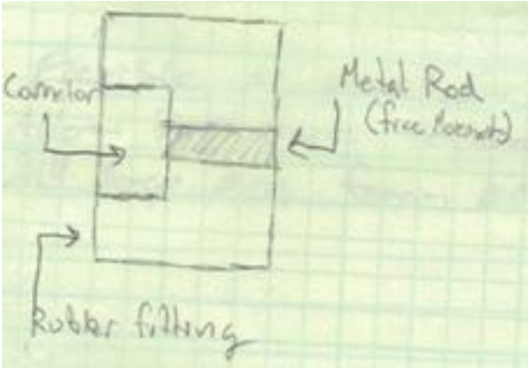


Figure 8 - Flexible Material Side View

<u>Hooks and Fasteners:</u>

The final design was developed around the idea to keep the electrical connector in place. The hooks in this design will latch onto the opposing electrical connector securing the mate. This will prevent any separation due to missile movement. The details of this design is shown in figures 9 and 10 below:

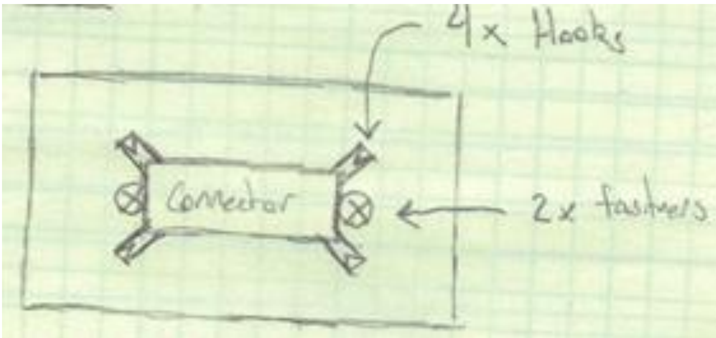


Figure 9 - Hooks and Fasteners Front View

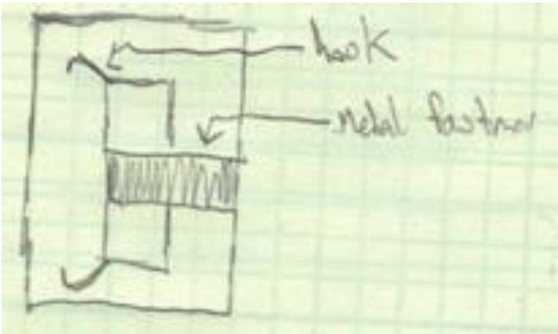


Figure 10 - Hooks and Fasteners Side View

4.0 Concept Selection:

The tables below represent or initial concept selection process. The first step in the process is to define the weights for each of our main categories. The main categories for our project are operating conditions, power loads, cost and maintenance. Table 1 is an arbitrary numerical system that rates the criteria based on relative importance. These numbers where then tabulated in Table 2 to get the pair wise comparison matrix. By using the values in the pair wise comparison matrix, we were able to calculate the normalized values for each of the four categories. The weights are shown in the green column of Table 3 where highest weight value is the operating conditions criteria at 44.5%

Table 1 - Numerical Ratings

Judgment of Importance	Numerical Rating
Extremely more important	9
	8
Very strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

Table 2 - Pair Wise Comparison Matrix

Criteria	Power Loads	Cost	Maintenance	Operating Conditions
Power Loads	1	7	5	1
Cost	0.143	1	0.333	0.143
Maintenance	0.2	3	1	0.143
Operating Conditions	1	7	7	1
Totals	**2.343**	**18**	**13.333**	**2.286**

Table 3 - Normalized Values and Overall Importance

Criteria	Power Loads	Cost	Maintenance	Operating Conditions	Overall Importance
Power Loads	0.427	0.389	0.375	0.438	**0.407**
Cost	0.061	0.056	0.025	0.063	**0.051**
Maintenance	0.085	0.167	0.075	0.063	**0.097**
Operating Conditions	0.427	0.389	0.525	0.438	**0.445**

<u>Weighted Criteria Tree:</u>

Our criteria tree located below shows the relative weights for each of our main criteria. Starting with the left side our second rated criteria, Power Loads, has a weighting of 40% because we believe that the forces impacted on our alignment devise are crucial to how successful our design will be. Between the two sub categories, Transportation Loads, and Bomb Rack Ejection, Transportation Loads is ranked higher because these loads are throughout any given flight path of the missile, where the loads associated with bomb rack ejection are only once in the missiles lifetime. The next category, cost, is ranked the lowest. Although cost is important, a significantly better design would be worth the cost. Next operating conditions were broken down into five sub categories, temperature, sand/dust, water/ice, corrosion, and fuel. All of these conditions must be met and therefore have a high importance but the same relative weight. Lastly, maintenance is broken down into three subcategories: field replaceable, reparability, and life. The life time of the design is weighted the most out of the three sub criteria because our designs must be able to withstand the life of the missile.

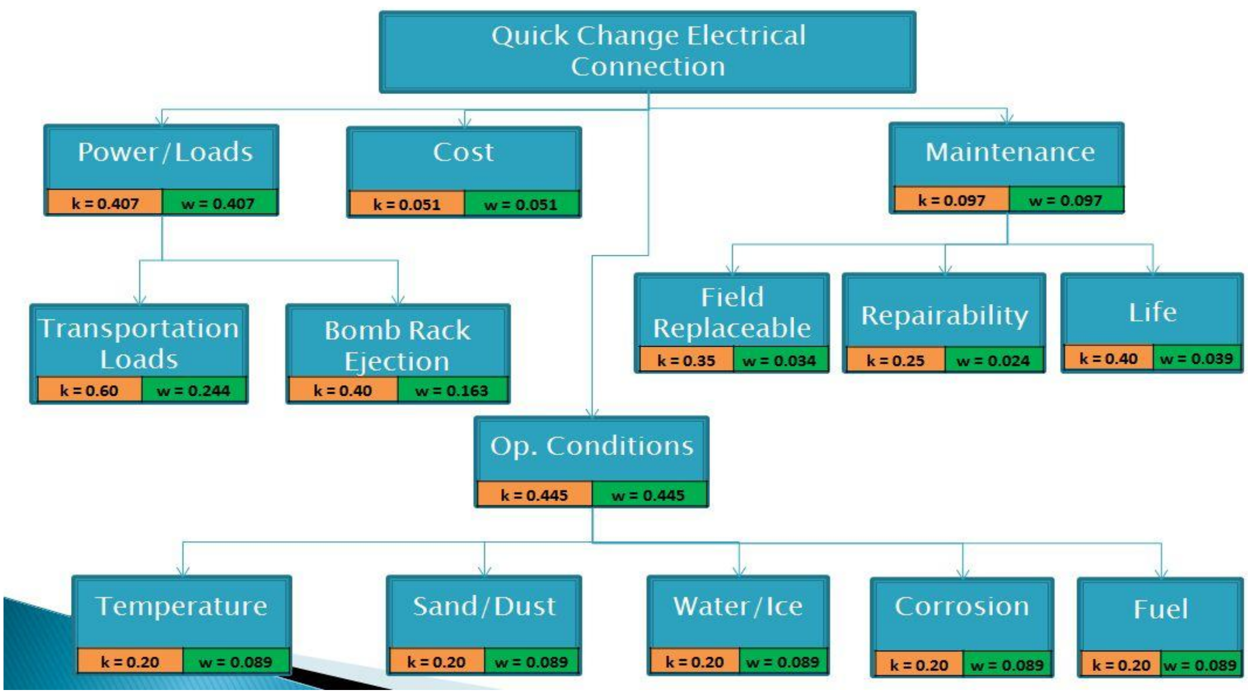


Figure 11 - Weighted Criteria Tree

Decision Matrix:

As for our concept selection, the use of a decision matrix allowed the team to match the four major features of the connection versus the six designs mentioned earlier in this report. Power Loads, Cost, Maintenance, and Operating Conditions match against the six designs, with given weights of each category of interest calculated from the calculations in the Concept Tree. Using a rating scale of 1 to 6, with one being the least favorable design for the given category and six being the most, the four categories scaled against the six designs as shown in Table 4 below.

Table 4 - Decision Matrix of the six concepts vs. the four categories.

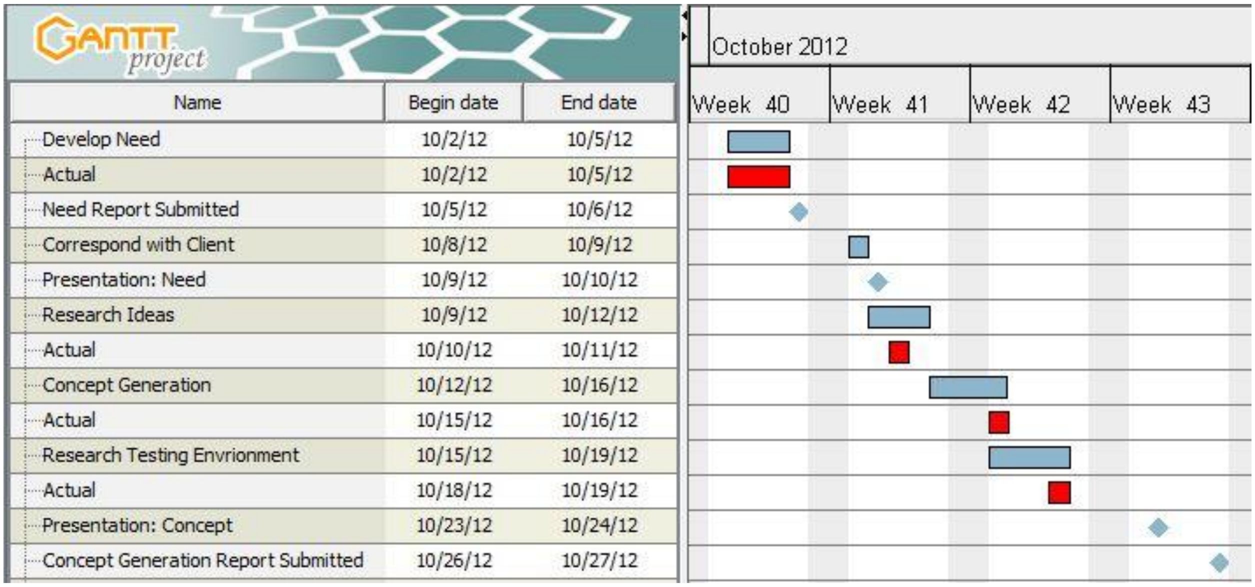
	Power Loads		Cost		Maintenance		Operating Conditions		Totals
	0.407		0.051		0.097		0.445		
Solid Guided Connection	4	1.628	4	0.204	6	0.582	6	2.67	**5.084**
Indented Guided Connection	1	0.407	6	0.306	5	0.485	3	1.335	**2.533**
Alignment Flange	2	0.814	5	0.255	3	0.291	2	0.89	**2.25**
Stabilizing Bars	5	2.035	2	0.102	2	0.194	4	1.78	**4.111**
Flexible Material	3	1.221	3	0.153	4	0.388	5	2.225	**3.987**
Hooks and Fasteners	6	2.442	1	0.051	1	0.097	1	0.445	**3.035**

Upon scoring each of the six designs, each score was weighted based on the category weight listed above. For example, for the Solid Guided Connection, the score of 4 assigned to the Power Loads category was multiplied by 0.407 to get the weighted score of 1.628 for that category. These weighted values were then added in the far right column labeled “Totals” to achieve a final score for each of the six concepts.

Analyzing the total score for all the concepts, the Solid Guided Connection came out far ahead of the other five designs with a final score of 5.084. Following nearly one whole point behind, the second best concept was the Stabilizing Bars with a score of 4.111. The Flexible Material concept came in third best with a score of 3.987. After that, the Hooks and Fasteners design was our fourth-best design, the Indented Guided Connection was our fifth-best design, and lastly the Alignment Flange was our sixth-best design. From the top three designs we will choose a final design after more analysis.

5.0 Gantt Chart

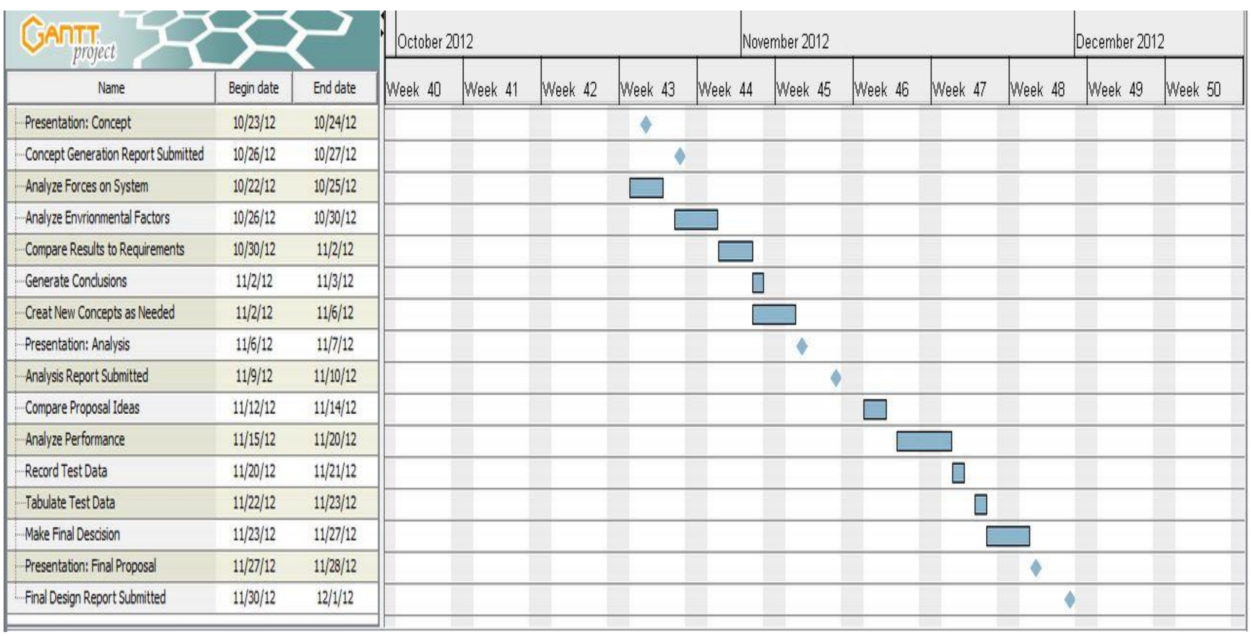
Shown below, in figure 12, is our team’s completed timeline. Shown in blue, is the time that we allotted to complete each task and milestone. While in red is what actually took place over the past few weeks. The only item on our timeline that was not completed as expected was corresponding with our client. Contact was not made during this expected time but there was correspondence shortly after the projected date.



Name	Begin date	End date
Develop Need	10/2/12	10/5/12
Actual	10/2/12	10/5/12
Need Report Submitted	10/5/12	10/6/12
Correspond with Client	10/8/12	10/9/12
Presentation: Need	10/9/12	10/10/12
Research Ideas	10/9/12	10/12/12
Actual	10/10/12	10/11/12
Concept Generation	10/12/12	10/16/12
Actual	10/15/12	10/16/12
Research Testing Envrionment	10/15/12	10/19/12
Actual	10/18/12	10/19/12
Presentation: Concept	10/23/12	10/24/12
Concept Generation Report Submitted	10/26/12	10/27/12

Figure 12 - Completed Timeline

Above is our completed timeline for the past few weeks and below, in figure #, is our projected timeline for the remainder of the semester. There are some dates on this timeline that are permanently set, such as presentation and report dates, but all others are subject to change if the deems it necessary.



Name	Begin date	End date
Presentation: Concept	10/23/12	10/24/12
Concept Generation Report Submitted	10/26/12	10/27/12
Analyze Forces on System	10/22/12	10/25/12
Analyze Envrionmental Factors	10/26/12	10/30/12
Compare Results to Requirements	10/30/12	11/2/12
Generate Conclusions	11/2/12	11/3/12
Creat New Concepts as Needed	11/2/12	11/6/12
Presentation: Analysis	11/6/12	11/7/12
Analysis Report Submitted	11/9/12	11/10/12
Compare Proposal Ideas	11/12/12	11/14/12
Analyze Performance	11/15/12	11/20/12
Record Test Data	11/20/12	11/21/12
Tabulate Test Data	11/22/12	11/23/12
Make Final Descision	11/23/12	11/27/12
Presentation: Final Proposal	11/27/12	11/28/12
Final Design Report Submitted	11/30/12	12/1/12

Figure 13 - Future Timeline

The team hopes that adhering to the dates on the timeline above will be beneficial to complete the tasks on time and in an efficient manner. Our next step will be to analyze our chosen design in various ways to determine if the design will help the team accomplish our goals.

6.0 Conclusion

For our project the team came up with 6 unique designs and through various processes was able to determine that our ‘Solid Guided Connection’ would be the best one to complete our task. This was done through things such as an analytical hierarchy process, weighting factors, and a decision matrix. After further discussion with our client the team will be able to determine if this is truly an acceptable design or if any changes need to be made. Something that will also be discusses is if it would be possible to combine any of our other concepts with the ‘Solid Guided Connection’ to be able to further meet our goals. These determinations will need to be done swiftly so that the team can stay on track with the projected timeline.

7.0 References

- Project document from Raytheon Company.