Separation Connector

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Concept Generation and Selection

Document

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ABSTRACT

By request of Mary Rogers and Orbital Sciences Corporation, our team has generated new design ideas for a separation connector. The process started with brainstorming one hundred design ideas and eliminating all but fifteen of those ideas. Our team analyzed these fifteen ideas in depth in order to determine which ideas fit our client's needs the most. At the end of this phase, we were left with four ideas that satisfied both the needs of the client as well as our own requirements. This report will show the decision making tools that we used to analyze which of the four design ideas is the best fit for our client. It will also give our recommendation of the design we believe is the best solution to our client's problem.

PROBLEM STATEMENT

The goal for this project is to design and prototype a perfectly reliable, inexpensive, and easily manufacturable separation connector.

CONCEPT GENERATION

We started our concept generation phase by brainstorming design ideas that we thought had the potential to solve the problem. Throughout the brainstorming sessions, we generated one hundred different ideas that could solve the problem. Although some of the ideas were not feasible, it allowed us to become more creative in the ways we approached the problem. Our team was able to eliminate the impractical ideas and narrow it down to four concepts that we believe best solved the problem presented by our client. These four ideas are listed below:

1. Ball Bearing Design
    - This design is inspired by ball bearings. It utilizes 6 evenly spaced balls on the male end of the connector. The balls are implanted into the male piece with springs directly behind them. The springs allow for the balls to retract so that the male end of the connector can mate/de-mate with the female end of the connector easily. The springs will be stiff enough to hold until dynamic mating is needed and will compress when a force of 200lbf acts on them; thus causing it de-mate. The female end of the connectors is simply a sleeve with a groove cut into it. The groove will be big enough to allow the ball bearings to slide into but small enough to allow them to be pulled out. Figure 1 below shows a CAD drawing of the conceptual "Ball Bearing" design.

Figure 1: Ball Bearing Design Concept

2. Spring-Button Design
   - This design is inspired by a door's handle. When you push a door handle down the locking mechanism retracts. This is how our design is supposed to work. There are two buttons at the top of the male end that control to locking mechanisms at the bottom of the piece. The female end will be a shell with a groove cut into it that will receive the locking mechanism. The locking mechanism will be spring loaded and will compress when the buttons are pressed and release when the buttons are released. Figure 1 below shows a CAD drawing of the conceptual "Spring-Button" design.

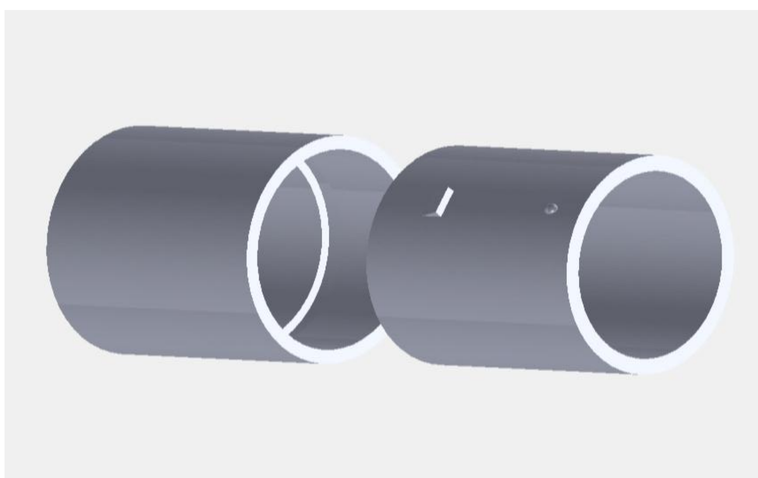

Figure 2: Spring-Button Design Concept

3. Spring Hammer Design
   - The spring hammer design uses a spring loaded "hammer" or cylindrical ring locked on the inside of the outermost collar. When the release cord is pulled the outer most collar is pulled down and unlocks the guided springs forcing the cylindrical hammer ring to strike the mated surfaces. This causes the two ends of the connector to de-mate. To reset the connector, simply twist the male and female connectors together. The overall idea is to de-mate using the stored force provided from the springs' potential energy. Figure 1 below shows a CAD drawing of the conceptual "Spring Hammer" design.

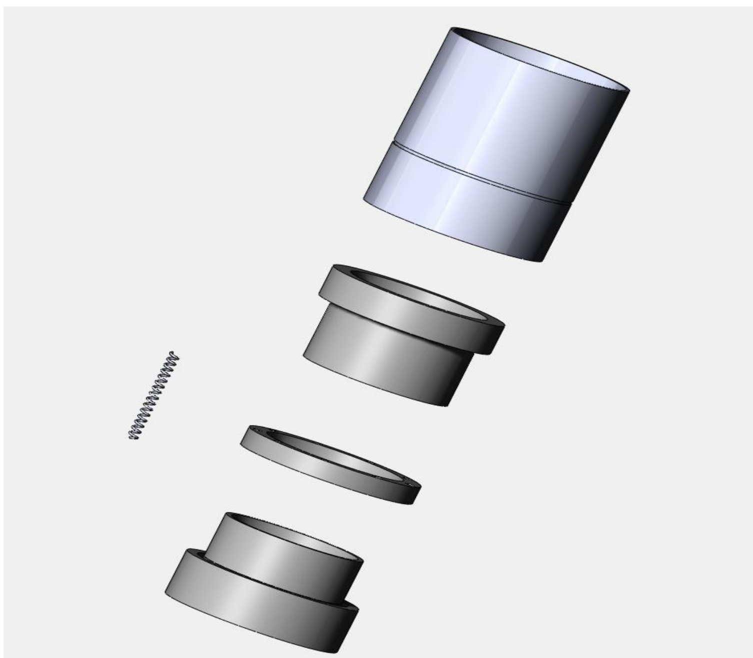

Figure 3: Spring Hammer Design Concept

4. Lever-Action Design
   - During the mating process, the three levers are exposed on outside of the connector. Once the wires are mated, the levers are placed flush with the collar which locks the two ends together. One pull cord is connected to each lever and then connected to each other to form one lanyard. When the lanyard is pulled, the three levers will be pulled down into the unlock position and the connector will de-mate. Figure 1 below shows a CAD drawing of the conceptual "Lever-Action" design.

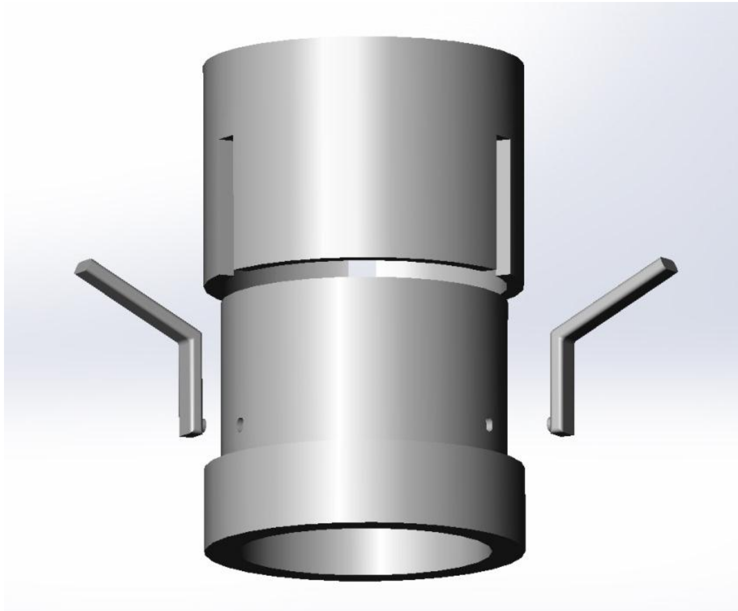

Figure 4: Lever-Action Design Concept

CONCEPT SELECTION

By using a multiple criteria table, a pairwise comparison, and a decision matrix concluded that “Spring-Hammer” design was the best decision. However, this decision is not final. We will present our evidence and arguments to Mary Rogers and allow her to make the final decision on which design is best suited for her needs. The tables below show the data that we calculated in order to decide on a design.

Table 1: Multiple Criteria Table

Performance Level	Value	Cost ($)	Manufactura bility (hrs)	Damage Resistant (inches)	Reliabilit y (%)	Weight (lb.)	Pull Angle (angle)	Size (inches)
Perfect	9	200	4	0.01	100	>1.5	>25	>2
	8	<225	>5	>.02	>99.75	>1.75	>22.5	>2.1
Excellent	7	<250	>6	>.03	>99.5	>2	>20	>2.2
	6	<275	>7	>.04	>99.25	>2.25	>17.5	>2.3
Good	5	<300	>8	>.05	>99	>2.5	>15	>2.4
	4	<325	>9	>.06	>98.75	>2.75	>12.5	>2.5
Fair	3	<350	>10	>.07	>98.5	>3	>10	>2.6
	2	<375	>11	>.08	>98.25	>3.25	>7.5	>2.7
Inadequate	1	400	>12	>.09	>98	3.5	>5	2.8

The function of this criteria table is to make the decision matrix more impartial by placing values on the criteria. These values range from one (inadequate) to nine (perfect). They are used in the decision matrix to rank the designs based on the given criteria. The values are gathered from research and are ranked according to what we consider to be an inadequate or perfect design. For example, the average cost of a separation connector is $400 and we would like it to be $200 or less. So, the $400 separation connector receives a ranking of 1, or inadequate, and the $200 separation connector receives a ranking of 9, or perfect.

Table 2: Pairwise Comparison Table

	Cost	Size ↓	Weight	Manufacturability	Reliability	Pull Angle	Damage Resistant	Total	Normalized weights
Cost	**X** →	0	0	0	0	1	0	1	0.04761
Size	1	**X**	0	0	0	1	0	2	0.09523
Weight	1	1	**X**	0	0	1	0	3	0.14285
Manufacturability	1	1	1	**X**	0	0	1	4	0.19047
Reliability	1	1	1	1	**X**	1	1	6	0.28571
Pull Angle	0	0	0	1	0	**X**	1	2	0.09523
Damage Resistant	1	1	1	0	0	0	**X**	3	0.14285

The pairwise comparison table allows us to assign higher importance to certain criterion, defined as the normalized weight. The normalized weights are determined through a comparison of any two criteria. Each criterion is given a rating of “1” meaning more important or a “0” meaning less important. For example, the arrows on the chart are pointing at a “0” relating cost to size. Since cost is less important than size, it receives a zero. If the table has an “X”, it is a criteria being related to itself and needs no rating. The values are totaled horizontally and placed in the “Total” column. Then each of the “Total” values are divided by the sum of the “Total” column to get the normalized weights.

Table 3: Un-weighted Decision Matrix

		Spring Hammer Design		Ball-Bearing Design		Lever-Action Release Design		Spring Button Design	
Criteria	Units	Raw Score	Value on Scale	Raw Score	Value on Scale	Raw Score	Value on Scale	Raw Score	Value on Scale
Cost	$	300	5	275	6	325	4	300	5
Manufacturability	hrs	6	7	5	8	8	5	7	6
Damage Resistant	inches	0.04	6	0.02	8	0.04	6	0.02	8
Reliability	percent	99.75	8	98.75	4	99.25	6	99.25	6
Weight	lb.	2.25	6	2	7	2.25	6	1.75	8
Pull Angle	angle	15	5	12.5	4	15	5	15	5
Size	inches	2.4	5	2.2	7	2.5	4	2.3	6
Total			42		44		36		44

The un-weighted decision matrix assigns rankings to each design idea. Each design is given raw scores based on how well we thought it met each criterion. The raw scores are then converted into values based on the criteria scale above in table 1. The design with the highest total score is rated as the best design on an un-weighted scale. The weighted decision matrix below will help choose the best design based on the customer's highest priorities.

Table 4: Weighted Decision Matrix

		Spring Hammer Design		Ball-Bearing Design		Lever-Action Release Design		Spring Button Design	
Criteria	Weights	Value on Scale	Raw Score	Value on Scale	Raw Score	Value on Scale	Raw Score	Value on Scale	Raw Score
Cost	0.04761	5	0.23809	6	0.28571	4	0.19047	5	0.238095
Manufacturability	0.19047	7	1.33333	8	1.52380	5	0.95238	6	1.14285
Damage Resistant	0.14285	6	0.85714	8	1.14285	6	0.85714	8	1.14285
Reliability	0.28571	8	2.28571	4	1.14285	6	1.71428	6	1.71428
Weight	0.14285	6	0.85714	7	1.00000	6	0.85714	8	1.14285
Pull Angle	0.09523	5	0.47619	4	0.38095	5	0.47619	5	0.47619
Size	0.09523	5	0.47619	7	0.66666	4	0.38095	6	0.57142
Total			6.52380		6.14285		5.42857		6.42857

This weighted decision matrix multiplies the values obtained from the un-weighted decision matrix by the normalized weight of the corresponding criteria. Taking the sum of the new weighted values yields the weighted total of each design. The design with the highest total value is the best design choice; in this case our recommendation would be the "Spring-Hammer" design.

UPDATED GANTT CHART

This section contains our updated Gantt chart. The Gantt chart shows the deadlines we need to meet as well as deliverables that have already been completed. This schedule is tentative and is subject to change. See figure 5 below for updated Gantt chart. (Updated 10/23/2012)

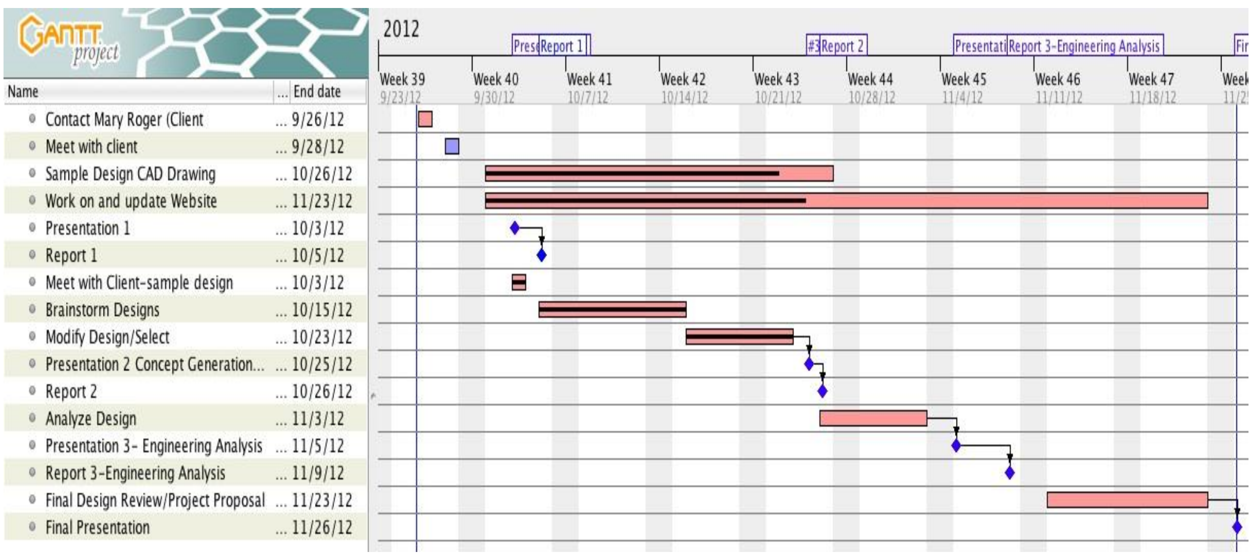

Figure 5: Updated Gantt Chart

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