Concept Selection

Following the determination of our high-fidelity concepts and medium fidelity concepts, selection tools were used to quantify and rank each concept's ability to fulfill project goals. The selection tools used include the binary pairwise comparison, house of quality, Pugh charts, and the analytical hierarchy process. Having quantifiable characteristics allows for easier design comparison and final design selection.

1.1 Binary Pairwise Comparison

Binary pairwise comparison is a method that compares each customer need against one another. The customer needs are put into rows and columns and if the need on the row is more important than the need of the column it receives a "1", but if the need on the row is not more important than the need of the column it receives a "0". After the completion of the comparison table the importance weight factor is obtained from the far-right column that adds the total number each row receives. This weight factor is then used in the House of Quality.

Table 6: *Binary Pairwise Comparison Matrix*

Customer Needs	Life-span	Fluid Loss	Active Seal	Material Resilience	Resusability	Maintains Pressure	Effective Coupling	Heat Transfer	Particulate Mitigation	Channel Sizing Parameters	Cost	Total
Life-span		0	0	0	1	0	0	0	1	0	1	3
Fluid Loss	1		1	1	1	0	0	1	1	1	1	8
Active Seal	1	0		1	1	0	1	1	1	1	1	8
Material Resilience	1	0	0		1	0	0	0	0	0	0	2
Resusability	0	0	0	0		0	0	0	0	0	0	0
Maintains Pressure	1	1	1	1	1		1	0	0	1	1	8
Effective Coupling	1	1	0	1	1	0		1	1	1	1	8
Heat Transfer	1	0	0	1	1	0	0		1	1	1	6
Particulate Mitigation	0	0	0	1	1	0	0	1		1	1	5
Channel Sizing Parameters	1	0	0	1	1	0	0	0	0		0	3
Cost	0	0	0	1	1	0	0	0	0	1		3
Raw Total	7	2	2	8	10	0	2	4	5	7	7	n-1=9
Relative Weight	6%	15%	15%	4%	0%	15%	15%	11%	9%	6%	6%	100%
Weight Factor	0.389	0.296	0.296	0.296	0.000	0.000	0.296	0.444	0.463	0.389	0.389	

Key	
0	Not as important
1	Important

1.2 House of Quality

The House of Quality is a table that compares the engineering characteristics in the columns of the table and customer requirements as the rows. The matrix allows the group to identify the critical engineering characteristics that satisfy the project according to customer requirements. A ranking/score from row to column of 0,1,3, and 9 were given for final rankings of each engineering characteristic. If a “0” was given that meant the requirement had no significance on the requirement and if a “9” was given that meant it had a very significant impact on the characteristic. A raw score was calculated from the sum of the importance weight factor multiplied by each ranking for each requirement. From these raw scores the top three engineering characteristics were found to be: leakage, boil off, and temperature.

Table 7: *House of Quality*

House of Quality	*Engineering Characteristics*								
	Improvement Direction	↑	-	↑	↓	↓	↑	↓	
	Units	cm	K	SCIM	SCIM	SCIM	MPa	$	
Customer Requirements	**Importance Weight Factor**	**Diameter**	**Temp.**	**Flow Rate**	**Leakage**	**Boil Off**	**Tensile Strength**	**Price**	
Life-span	3	0	1	0	3	1	9	1	
Fluid Loss	8	0	3	3	9	9	1	3	
Active Seal	8	3	1	1	3	1	0	1	
Material Resilience	2	-	3	1	1	1	9	3	
Reusability	0	1	1	0	0	0	3	3	
Maintanis Pressure	8	1	3	1	9	1	3	1	
Effective Coupling	8	3	1	1	3	0	1	0	
Heat Transfer	6	3	9	1	1	9	0	1	
Particulate Mitigation	5	0	0	0	0	0	0	1	
Channel Sizing Parameters	3	9	1	9	0	1	0	1	
Cost	3	3	1	0	1	1	3	9	
Raw Score:	875	110	133	83	212	153	94	90	Average Weight Percentage
Total: 875	**Weight (%)**	12.57	15.20	9.49	24.23	17.49	10.74	10.29	14.29
	Rank order	4	3	7	1	2	5	6	

Key
0 - Not Significant
1 - Moderately Significant
3 - Very Significant
9- Extremely Significant

1.3 Pugh Charts

Two Pugh charts are implemented in our selection analysis. The first allows us to compare seven concepts to the market datum, the NASA Low Separation Force Quick Disconnect. We assigned scores in the form of better (+), worse (-), and satisfactory (S) in the following categories: leakage, lifetime, seal, resilience, size, and cost. Our goal is to improve upon the current market datum in the six chosen categories. This ensures that we will select a design that will be better than the existing cryogenic coupler chosen as a reference. The scores are then summed, so that “better” has a value of +1 and “worse” has a value of -1.

Table 8: *Pugh Chart- Concept*

Pugh Chart- Concept

Selection Criteria	Concept Datum	Concept #48	Concept #50	Concept #49
Leakage	Concept #33	S	-	-
Lifetime		-	S	-
Seal		S	-	-
Resilience		-	-	-
Size		+	S	+
Cost		+	+	+
	Pluses	2	1	2
	Satisfactory	2	2	0
	Minus	2	3	4
	Decision	**0**	**-2**	**-2**

Key	
-	Worse
+	Better
S	Satisfactory

Fidelity	Concept #	Description
High	33	Force held lock with double poppet valve, encapsulated o-ring seals, double vacuum wall and MLI
High	48	Force held lock with double poppet valve, encapsulated o-ring seals, double vacuum wall and SOFI
High	50	Force held lock with double poppet valve, Teflon seals, double vacuum wall and MLI
Medium	49	Force held lock with double poppet valve, Teflon seals, double vacuum wall and SOFI

The second Pugh chart is in the same configuration as the first, but the reference for comparison is a design from the market datum Pugh Chart. This table compares the top designs to this new reference. The purpose of this is to compare the designs to each other and get an idea of which concepts perform well in the chosen categories in reference to each other. These two charts allow us to choose a design that is both better than the market datum and outperforms the other top concepts.

Table 9: *Pugh Chart- Market*

Pugh Chart - Market

Selection Criteria	Market Datum	Concept #33	Concept #48	Concept #50	Concept #49	Concept #31	Concept #32	Concept #30
Leakage	NASA Low Seperation Force Quick Disonnect	+	+	+	+	-	-	-
Lifetime		+	+	+	+	+	+	+
Seal		+	+	+	+	-	-	-
Resilience		S	S	S	S	+	+	+
Size		-	-	-	-	-	-	-
Cost		-	-	-	-	-	-	-
	Pluses	3	3	3	3	2	2	2
	Satisfactory	1	1	1	1	0	0	0
	Minus	2	2	2	2	4	4	4
	Decision	**1**	**1**	**1**	**1**	**-2**	**-2**	**-2**

Key	
-	Worse
+	Better
S	Satisfactory

Fidelity	Concept #	Description
High	33	Force held lock with double poppet valve, encapsulated o-ring seals, double vacuum wall and MLI
High	48	Force held lock with double poppet valve, encapsulated o-ring seals, double vacuum wall and SOFI
High	50	Force held lock with double poppet valve, Teflon seals, double vacuum wall and MLI
Medium	49	Force held lock with double poppet valve, Teflon seals, double vacuum wall and SOFI
Medium	32	Collet lock with double poppet valve, encapsulated seals, double vacuum and MLI
Medium	31	Collet lock with double poppet valve, encapsulated seals, double vacuum and SOFI
Medium	30	Collet lock with double poppet valve, Teflon seals, double vacuum and MLI

1.4 Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a table that compares the targets against each other to determine the weight it has in our consideration of the top design. In each cell, we assigned a value using the following key: equal (1), slightly more important (3), strongly more important (5), demonstrated dominance (7), and highly evident dominance (9). The sum and average for each column was calculated. The normalized matrix was also implemented, where the scores in the first chart are interpolated to a range between 0 and 1 such that the vertical summation is 1.

Table 10: *Analytical Hierarchy Process (Normalized)*

Normalized Comparison Matrix [NormC]

Criteria	1. Fuel Leakage	2. Sealability	3. Heat Transfer	4. Durability	5. Weight	6. Cost	Critical Weight
1. Fuel Leakage	0.03	0.01	0.02	0.04	0.05	0.03	0.03
2. Sealability	0.10	0.04	0.02	0.04	0.05	0.03	0.048
3. Heat Transfer	0.17	0.18	0.08	0.06	0.11	0.06	0.12
4. Durability	0.23	0.26	0.40	0.29	0.34	0.18	0.304
5. Weight	0.23	0.26	0.24	0.29	0.34	0.53	0.271
6. Cost	1.40	1.54	1.45	1.72	0.68	1.07	1.357
Sum	0.767	0.744	0.758	0.713	0.887	0.822	0.774

From the normalized chart the relative weights that were found were then used to calculate the alternative values from matrix multiplication.

Table 11: *Final Alternate Values for Design Selection*

Concept	Alternative Value
#33	1.032268981
#48	0.466251315
#50	0.632534386

This finally led to the teams selection of Concept #33 which involves a force held lock and double poppet valve configuration, insulated by a double vacuum wall and MLI blanket and using encapsulated seals.