Concept Selection – RoboBoat (516)

Boat

- **Pairwise**

When determining the Pairwise table for the boat, we took into consideration all the events and parameters that would award or deduct points from the competition. This led to a heavy weight on parameters that could lead to disqualification if failed. Such as Weight/Size, as well as Thrust and Autonomous Navigation. Since all of these concepts have to function properly before any of the other events could be completed.

Concept Selection For Boat													
Pair-wise													
	1	2	3	4	5	6	7	8	9	10	11	12	Total
1. Weight/size	-	1	1	1	1	1	1	1	1	1	1	1	11
2. Thrust	0	-	1	1	1	1	1	1	1	1	1	1	10
3. Circumnavigation	0	0	-	1	1	0	1	1	1	0	1	1	7
4. Maintain Heading	0	0	0	-	0	0	1	0	0	1	1	1	4
5. Slalom Maneuver	0	0	0	1	-	0	1	1	0	0	1	0	4
6. Autonomous Navigati	0	0	1	1	1	-	1	1	1	1	1	1	9
7. Speed Challenge	0	0	0	0	0	0	-	0	0	0	0	0	0
8. Automated Docking	0	0	0	1	0	0	1	-	0	0	1	0	3
9. Raise the Flag	0	0	0	1	1	0	1	1	-	1	1	1	7
10. Find the Path	0	0	1	0	1	0	1	1	0	-	0	1	5
11. Follow the Leader	0	0	0	0	0	0	1	0	0	1	-	0	2
12. Return to Dock	0	0	0	0	1	0	1	1	0	0	1	-	4
Total	0	1	4	7	7	2	11	8	4	6	9	7	n-1 = 11

- **HOQ**

When doing the House of Quality for the boat, we determined that Autonomy, Propulsion, and Visual Feedback were the most important Engineering Characteristics of the boat. Most of the high weighted items were influenced by the competition rules. For example, if your boat isn't completely autonomous, then you are disqualified. So therefore, high weightings were given to autonomy. Propulsion is also a critical element to our design. Without propulsion, the boat cannot navigate the obstacle courses and cannot compete.

Engineering Characterisitcs Boat																		
Impovement Direction			↑			↓			↑			↓				↓	↑	
Units		y/n	Newtons	y/n	y/n	Voltage	y/n	y/n	ft/lbs	y/n		ft		y/n		lbs	lbs	
Customer Requirements	Weight Facto	Autonomy	Buoyancy	Communicatio	Deployable	Energy Source	Kill Switch	E-Kill Switc	Propulsion	Remote-Controlable	Safety	Size	Surface	Towable	Visual Feedback	Weight	Payload	
1. Weight/size	11		3		9	3			9		3	9	3	9		9		
2. Thrust	10					9			9		3	9	3			9		
3. Circumnavigation	7	9	9	9		3			9		3				3		3	
4. Maintain Heading	4	9	9	3		3			9		3				9		3	
5. Slalom Maneuver	4	9	9	3		3			3			3			9			
6. Autonomous Navigati	9	9		9		3			3		3				9			
7. Speed Challenge		3	9	3		3			9			3			3	3	3	
8. Automated Docking	3	9	9	3		3			3		3	3			9		3	
9. Raise the Flag	7	9		9		3			3						3		3	
10. Find the Path	5	9		9		3			3		3				9		9	
11. Follow the Leader	2	9		9		3			3		3				9		9	
12. Return to Dock	4	9		9		3			3						9		9	TOTAL
Raw Score (2883)		405	195	339	99	258	0	0	390	0	153	210	63	99	321	189	162	2883
Relative Weight %		14.0%	6.8%	11.8%	3.4%	8.9%	0.0%	0.0%	13.5%	0.0%	5.3%	7.3%	2.2%	3.4%	11.1%	6.6%	5.6%	100.0%
Rank Order		1	6	3	10	4	12	12	2	12	9	5	11	10	3	7	8	

- **Pugh Chart**

Using a decision matrix, we decided that there are five possible additions that could be added to improve upon the current design. Taking the same selection criteria from the above charts, each of the concepts were compared to the criteria to determine whether it would improve or decrease the overall design. Using the + and – symbols to depict positive or negative effect, they were then tallied which is how we were able to determine that the addition of a lydar detector would be the best addition. Due to the lack of documented previous designs, the datum used was the current design without any additions.

Concepts Boat						
Selection Criteria	Datum: current design	1. lydar detector	2. side cameras	3. infared sensor	4. sonar sensor	5. rotating motors
1. Weight/size	/	-	-	-	-	-
2. Thrust	/					+
3. Circumnavigation	/	+	+	+		+
4. Maintain Heading	/					+
5. Slalom Maneuver	/	+			+	+
6. Autonomous Navigation	/	+	+	+	+	
7. Speed Challenge	/	+				+
8. Automated Docking	/	+	+	+	+	
9. Raise the Flag	/	+	+	+		
10. Find the Path	/	+	+	+	+	
11. Follow the Leader	/	+	+	+		+
12. Return to Dock	/	+	+	+	+	+
# of Pluses	**/**	**9**	**7**	**7**	**5**	**7**
# of Minuses	**/**	**1**	**1**	**1**	**1**	**1**

- **AHP**

	Material Cost	Manufactoring Cost	Reparability	Durability	Reliability	Time to Produce
Material Cost	-	0.11	1	3	1	1
Manufactoring Cos	9	-	0.33	3	1	3
Reparability	1	3	-	9	3	0.33
Durability	0.33	0.33	0.11	-	1	0.11
Reliability	1	1	0.33	1	-	0.11
Time to Produce	1	1	3	9	9	-
SUM column	12.33	5.44	4.77	25	15	4.55

	Material Cost	Manufactoring Cost	Reparability	Durability	Reliability	Time to Produce	AVG row
Material Cost		0.020220588	0.209643606	0.12	0.066666667	0.21978022	0.127262
Manufactoring Cos	0.72992701		0.06918239	0.12	0.066666667	0.659340659	0.329023
Reparability	0.081103	0.551470588		0.36	0.2	0.072527473	0.25302
Durability	0.02676399	0.060661765	0.023060797		0.066666667	0.024175824	0.040266
Reliability	0.081103	0.183823529	0.06918239	0.04		0.024175824	0.079657
Time to Produce	0.081103	0.183823529	0.628930818	0.36	0.6		0.370771
SUM column	1	1	1	1	1	1	1

The tables above show the work corresponding to the analytical hierarchy process. The first table shows the work related to the evaluation criteria of our project. Each aspect (rows) was evaluated in order of importance and compared to the same aspects (columns). This is a mathematical way of helping us to better decide what to do in order to meet the requirements of the competition. The second table corresponds to the normalization of the first table. Each element was divided by the total sum of each column and a number was obtained. The sum of each column should give a total of 1 as it is shown above. The whole process helps us to calculate the weighted value of each aspect, so we can work on the project more efficiently, thus saving time and money.

The AHP is continued below. Using the weights found earlier, the concepts were analyzed, summed and weighted, normalized, and then ranked. Based on this, the Lydar Detector is the best option for the boat implantation.

Boat						
	weight	1. lydar detector	2. side	3. infared	4. sonar	5. rotating
Material Cost	0.12726222	9	1	3	1	9
Manufactoring Cos	0.32902334	9	9	9	9	9
Reparability	0.25302021	0	1	1	0	3
Durability	0.04026581	3	9	3	3	3
Reliability	0.07965695	3	9	3	1	3
Time to Produce	0.37077147	9	1	1	1	1
SUM		7.803281545	4.791568816	4.326556704	3.659698162	5.596170425
normalized		0.298093723	0.183043067	0.165279105	0.139804394	0.213779711
Rank		1	3	4	5	2

Drone

- **Pairwise**

  When it came to the drone's pairwise comparison there were less requirements set by the competition. Since it was only one event in which the drone is used. This made it so that the autonomous navigation of the drone as well as its physical characteristics carried much greater importance.

Concept Selection For Drone					
Pair-wise					
	1	2	3	4	Total
1. Weight/size	-	1	0	1	2
2. Thrust	0	-	0	0	0
3. Autonomous Navigation	1	1	-	1	3
4. Raise the Flag	0	1	0	-	1
Total	1	3	0	2	n-1 = 3

- **HOQ**

  The house of quality was done for the drone and is pictured below. This was done in the same way as the house of quality for the boat.

Engineering Characterisitcs Drone															
Impovement Direction					↓			↑			↓		↓	↑	
Units		y/n	y/n	y/n	Voltage	y/n	y/n	ft/lbs	y/n		ft		lbs	lbs	
Customer Requirements	Weight Facto	Autonomy	Communicat	Deployable	Energy Sour	Kill Switch	E-Kill Switc	Propulsion	Remote-Controlabl	Safety	Size	Visual Feedbac	Weight	Payload	
1. Weight/size	11			9	3			9		3	9		9	9	
2. Thrust	10	1		9	3			9	3	9	9		9	9	
3. Autonomous Navigati	9	9	9					3		9		3			
4. Raise the Flag	7	9	9	9	1	1	1	9		9	1	9			
5. Return to Boat	4	9	3	3	1	1	1	9		9	3		3		TOTAL
Raw Score (2883)		190	156	264	74	11	11	315	30	303	208	90	201	189	2042
Relative Weight %		9.3%	7.6%	12.9%	3.6%	0.5%	0.5%	15.4%	1.5%	14.8%	10.2%	4.4%	9.8%	9.3%	100.0%
Rank Order		6	8	3	10	12	12	1	11	2	4	9	5	7	

- **Pugh Chart**

  Just as for the boat above, we created another decision matrix to find ways of improving the functionality of the drone. Since it is very difficult to add to the current design without having to buy a new different drone, two design concepts were weighted against the criteria specifically directed to the drone's abilities. As shown below, the addition of a new camera with live stream possibility as well as easily being able to link up to the CPU would be the best addition that can be made.

Concepts Drone			
Selection Criteria	Datum: current design	1. New Camera	2. infared sensor
1. Weight/size	/	-	-
2. Thrust	/		
3. Circumnavigation	/	+	
4. Maintain Heading	/	+	+
5. Autonomous Navigation	/	+	+
6. Raise the Flag	/	+	+
7. Find the Path	/	+	+
8. Follow the Leader	/	+	+
# of Pluses	/	**6**	**5**
# of Minuses	/	**1**	**1**

Drone			
	weight	New Camera	Infared Sensor
Material Cost	0.12726222	9	3
Manufactoring Cos	0.32902334	9	9
Reparability	0.25302021	3	0
Durability	0.04026581	3	0
Reliability	0.07965695	9	3
Time to Produce	0.37077147	1	1
Sum		6.074112119	3.952739066
Normalized		0.605784608	0.394215392
Rank		1	2

Using the weights found in the boat AHP, the drone was calculated in the same manner using the two concepts selected before. A new camera was found to be a better option in both this and then pugh chart.

Final Decision

We have decided to implement Lidar on the boat to assist in object detection. We have also decided to add an additional camera to the drone so we the Zotac can analyze the live stream coming from the drone. We would save a significant amount of money by altering the drone to add a camera instead of buying a completely new drone.