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Standoff Project

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Project Description (1)

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- Many standoffs are bonded to motor domes using adhesive
- Adhesive is applied and bracket is taped to help cure adhesive
- Taping is unreliable and costs money and man hours when it fails
- Analyze and build a prototype that will hold standoff brackets while adhesive cures

- The mounting arm shall:
  a. Support brackets bonded 4-36 inches inboard from the motor ring
  b. Have 6 degrees of freedom
  c. Be mountable to several rocket motors
     i. Orion 38
     ii. Orion 50XL
     iii. Castor 30XL
  d. Be ESD (electrostatic discharge) compliant

Figure 1: Castor 50XL [1]

Project Description (3)

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d. Be adaptable to several mounting bracket templates
e. Hold a bracket to up to 10 lbs
f. Lock in place and apply a force of 20 lbs
g. Have a Factor of Safety of 3.0 based on maximum expected loads
h. Be easily manipulated by hand
i. Perform a pull test of 50 lbs at 45 degrees of freedom

Figure 2: Castor 30XL [1]

Background & Benchmarking (1)

Current “state-of-the-art” process:

Tape is used to hold the bracket, to the motor dome, in place while the adhesive cures.

Issues:

- ~5% failure rate
- Weather constraints
- Costly

Background & Benchmarking (3)

Benchmark (1): 6 DOF Robot Arm [2]

Features:

- 6 degrees of freedom
- maneuverability

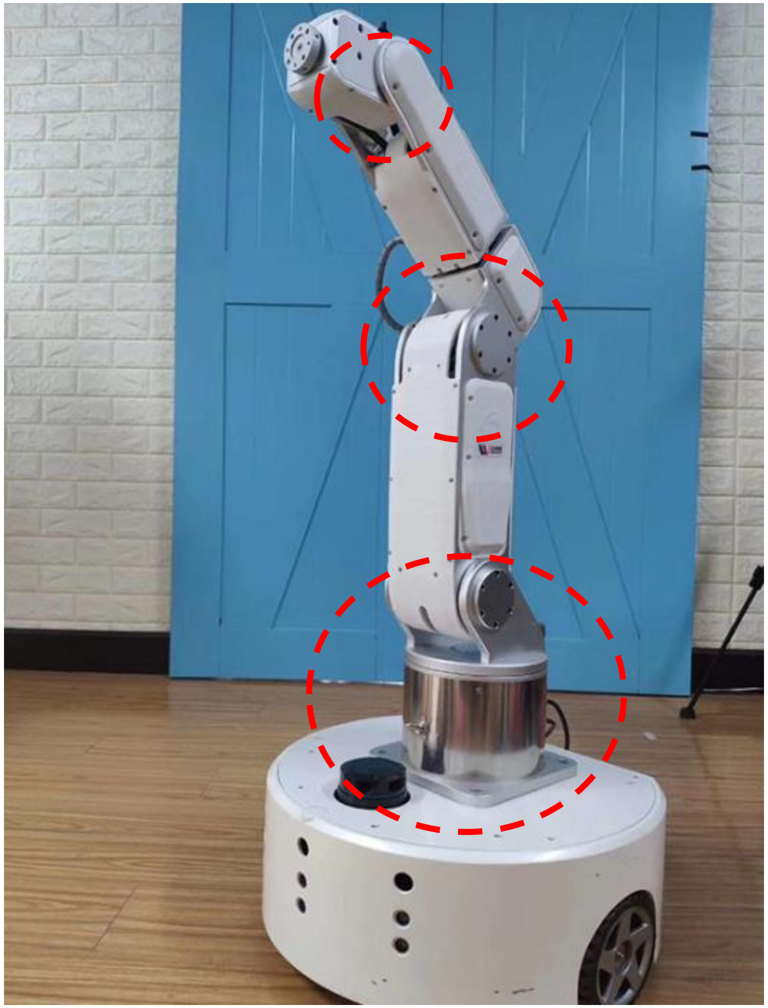

Figure 3: 6 DOF Robot Arm [2]

Background & Benchmarking (3)

Benchmark (2): Kant Twist Stainless Steel Clamp [3]

Features:

- load capacity: 1500lb
- item depth: 2-¼ inches
- adjusts to the curve of the ring

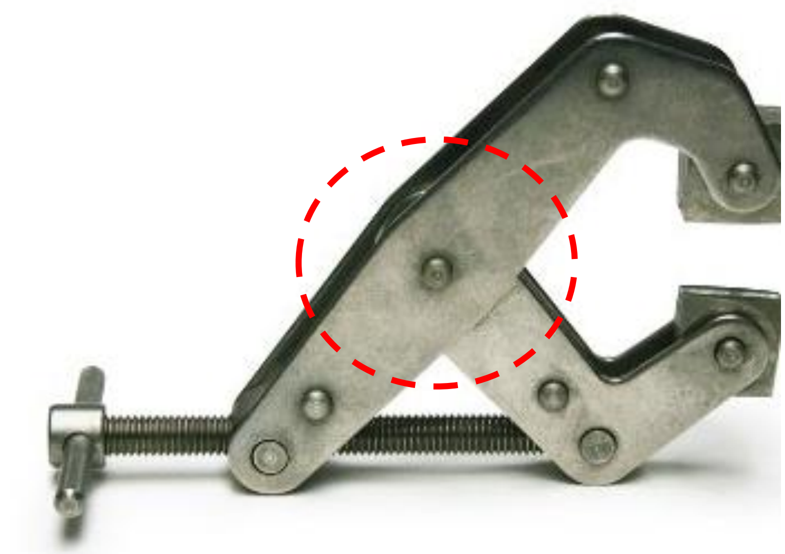

Figure 4: Kant Twist Stainless Steel Clamp [3]

Background & Benchmarking (4)

Benchmark (3): Dual Arm [4]

Features:

- dexterity
- use of joints
- maneuverability
- use of two arms
- lifts over 110lb

Figure 5: Dual Arm [4]

Literature Review

- The sources that we collected are intended to provide insight and possible solutions into the problems we are tasked with for the project.

- The subject matter relevant to the problems proposed in the project included:
    - Electrostatic Discharge Protection [5]
    - Rocket Structure and Functionality [1,6]
    - Human Driven 6-DOF Articulated Arm [7,8]
    - Pull Test Procedure and Setup [9]

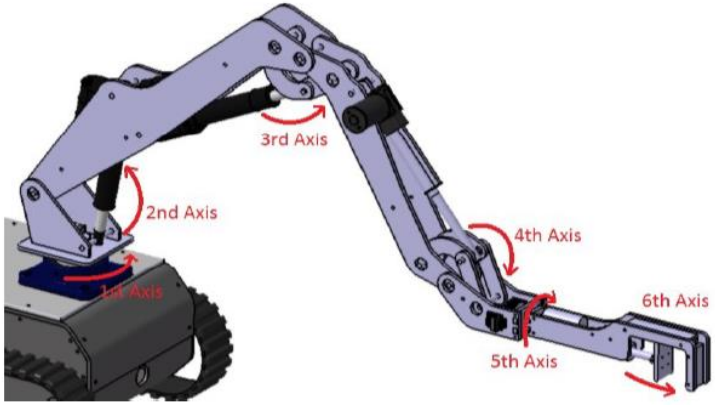

Figure 6: Six-Axis Articulated Arm [7]

- The references were gathered to help the individual team members in their specialized tasks but can also be used by the team as a whole.

Customer and Engineering Requirements: Customer Needs

1. ESD compliance
2. Apply axial forces
3. Six degrees of freedom in movement
4. Usable 4" - 36" inboard of ring
5. Transportability
6. Ease of operation
7. Durability
8. Reliability
9. Adjustable Interfaces
10. Support 10lbs in locked position
11. Minimum 3.0 Factor of Safety

Figure 7: Castor 38 [1]

Customer and Engineering Requirements: Engineering Requirements

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- Electrically Conductive (Y or N)
- Mass (slugs)
- Principal Dimensions (in)
- Working Length (in)
- Working Angle (Degrees)
- Modulus of Elasticity (lbf/in^2)

Customer and Engineering Requirements: QFD

Table 1: QFD

Customer Need	Weight	Engineering Requirement	Electrically Conductive (Y or N)	Mass (slugs)	Principal Dimensions (in)	Working Length (in)	Working Angle (Degrees)	Modulus of Elasticity (lbf/in^2)
1. ESD compliance	0.10		9	0	0	0	0	0
2. Apply axial forces	0.10		0	1	0	3	3	9
3. Six degrees of freedom in movement	0.10		0	0	0	9	9	0
4. Usable 4" - 36" inboard of ring	0.10		0	1	9	9	3	1
5. Transportability	0.07		0	9	9	3	3	0
6. Ease of operation	0.08		3	9	3	9	9	0
7. Durability	0.09		0	3	0	0	0	9
8. Reliability	0.09		0	3	0	0	0	9
9. Adjustable Interfaces	0.10		0	3	0	3	3	0
10. Support 10lbs in locked position	0.10		0	3	0	3	3	9
11. Minimum 3.0 Factor of safety	0.07		0	3	0	0	0	9
Absolute Technical Importance (ATI)			1.14	2.9	1.77	3.63	3.03	4.15
Relative Technical Importance (RTI)			0.27	0.7	0.43	0.87	0.73	1

Schedule & Budget: Budget

Overall budget has been set at $10,000 by Northrop Grumman

Expenses to date: $0

Expected Expenses: ~$8,000 with $2,000 for contingency

Prototyping: ~$1,000

Final Design: ~$7,000

Schedule & Budget: Schedule for Capstone

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Table 2: Gantt Chart

TASK NAME	START DATE	END DATE	DURATION	RESPONSIBLE ENGINEER	PERCENT COMPLETE
Original Design Project					
Team Charter	8/28	9/4	6	Whole Team	100%
System Requirements Review (SRR)	8/28	9/16	14	Client and Team	100%
Presentation 1	8/28	9/18	16	Whole Team	75%
Peer Evaluation 1	9/18	9/20	3	Individually	0%
Presentation 2	9/18	10/9	16	Whole Team	0%
Preliminary Report	9/18	10/16	21	Whole Team	0%
Analyses Team Memo	9/18	10/23	26	Whole Team	0%
Peer Evaluation 2	10/9	10/23	11	Individually	0%
Website Check 1	9/18	10/30	31	Whole Team	0%
Presentation 3	10/9	11/6	21	Whole Team	0%
Final Report	10/16	11/13	21	Whole Team	0%
Peer Evaluation 3	10/9	11/20	31	Individually	0%
Final BOM/CAD	10/16	11/27	31	Whole Team	0%
Prototype Demo	10/16	12/4	36	Whole Team	0%
Website Check 2	10/30	12/4	26	Whole Team	0%
Analytical Reports	10/16	12/11	41	Whole Team	0%
Peer Evaluation 4	11/20	12/11	16	Individually	0%
Preliminary Prototype Demo	10/16	12/4	36	Whole Team	0%
Preliminary Design Review (PDR)	9/16	12/11	63	Client and Team	0%
Critical Design Review (CDR)	9/16	Feb/Mar	N/A	Client and Team	0%

8/26 - 8/30: M T W Th F | 9/2 - 9/6: M T W Th F | 9/9 - 9/13: M T W Th F | M

Schedule & Budget: Schedule for Capstone

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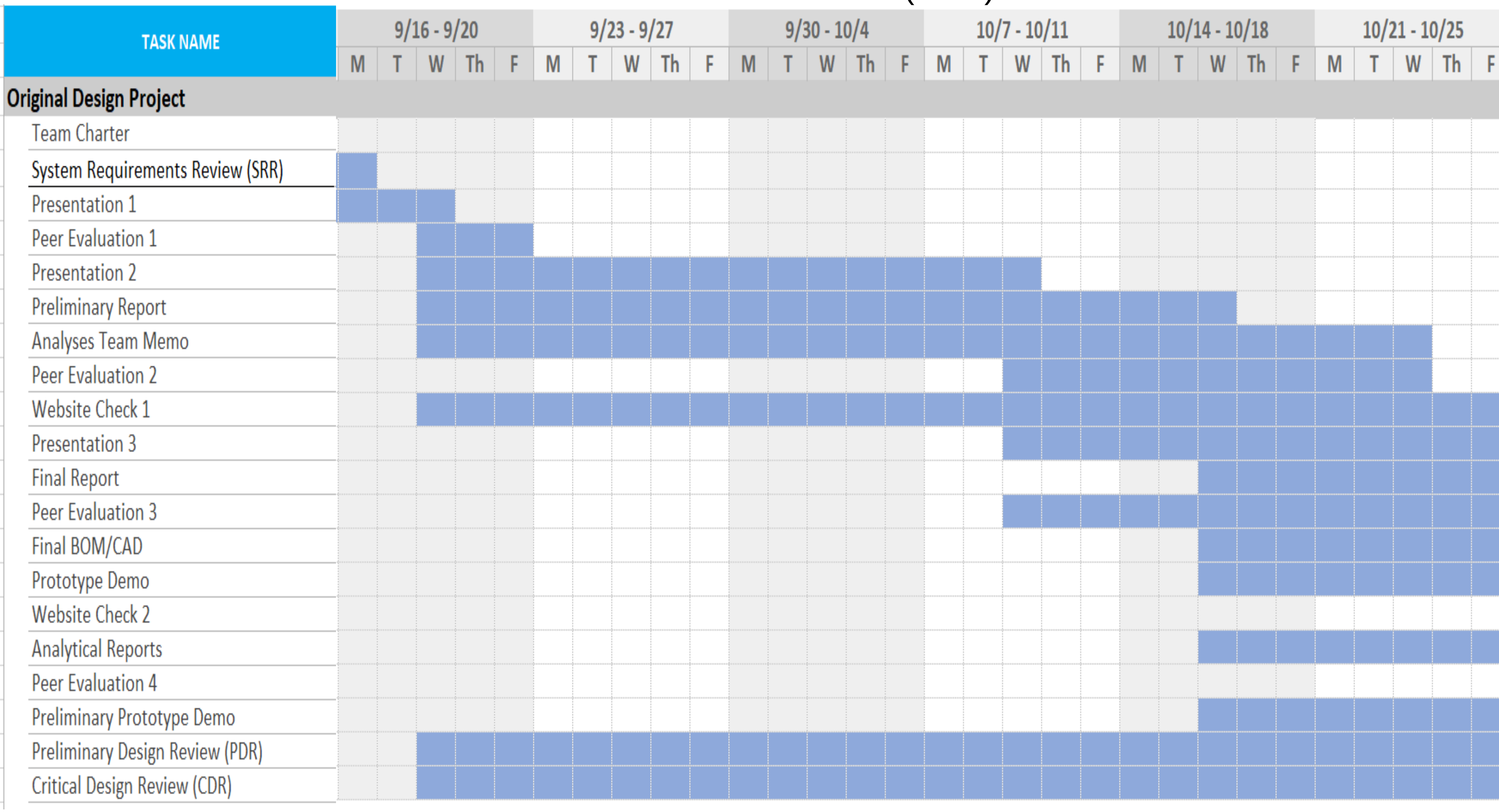
Table 2: Gantt Chart (cont.)



Schedule & Budget: Schedule for Northrop Grumman

System Requirements Review (SRR): Sept 16th - Completed

Preliminary Design Review (PDR): Finals Week Fall Semester

Critical Design Review (CDR): February/March

Northrop Symposium Day : Late April 2020

Northrop Mentor Meetings - Throughout both semesters

References

[1] *Propulsion Products Catalog*, Northrop Grumman, Falls Church, VA, June 2018

[2] "Six degrees of freedom Robot Arm," RobotDigg Equip Makers, [Online]. Available: https://www.robotdigg.com/product/1463/Six-degrees-of-freedom-Robot-Arm?gclid=EAIaIQobChMI5rPC87bZ5AIVsRx9Ch3RxgQZEAQYAyABEgKnYvD_BwE. [Accessed 16 September 2019].

[3] "Kant Twist 515 303 Stainless Steel Clamp," Amazon, [Online]. Available: https://www.amazon.com/Kant-Twist-505-Stainless-Capacity/dp/B00AI7KWW6/ref=s. [Accessed 16 September 2019].

[4] "Dual Arm," HDT Global, [Online]. Available: http://www.hdtglobal.com/product/dual-arm/. [Accessed 16 September 2019].

[5] "The Prevention and Control of Electrostatic Discharge (ESD)", *Minicircuits.com*, 2019. [Online]. Available: https://www.minicircuits.com/app/AN40-005.pdf. [Accessed: 17- Sep- 2019].

[6] D. Kumar B and S. Nayana B, "Design and Structural Analysis of Solid Rocket Motor Casing Hardware used in Aerospace Applications", *Journal of Aeronautics & Aerospace Engineering*, vol. 5, no. 2, 2016. Available: 10.4172/2168-9792.1000166.

[7] O. Olwan, A. Matan, M. Abdullah and J. Abu-Khalaf, "The design and analysis of a six-degree of freedom robotic arm," *2015 10th International Symposium on Mechatronics and its Applications*

[8] V. Sangveraphunsiri and T. Ngamvilaikorn, "A six DOF master-slave human-assisted manipulator arm with relaxation of kinematics similarity," *2002 IEEE International Conference on Industrial Technology, 2002. IEEE ICIT '02.*, Bankok, Thailand, 2002, pp. 388-393 vol.1.

[9] J. Barush, "Selecting an Adhesive for Tensile Adhesion Testing (Pull-Off)", *KTA University*, 2019. [Online]. Available: https://ktauniversity.com/tensile-adhesion-testing-adhesives/. [Accessed: 18- Sep- 2019].

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