

EXPO 2020 OPTIMIZED RIFLESCOPE MOUNT DEVELOPMENT



OBJECTIVE

The primary goal of this project was to investigate, design, and fabricate an optimal design for the Nightforce Ultramount riflescope mount, and provide a reliable simulation method for analyzing future Nightforce products. Optimality of the mount was defined by three major components: being lightweight (<3.69 oz), being as strong or stronger than the current model (must survive 10,000 rounds fired on the mounted rifle), and being relatively cost effective to produce. To pursue the goals laid out by our sponsor, a two-component methodology was pursued. First, a force simulation acting on the mount backed up by live fire data and a comprehensive math model were used to pinpoint high stress regions within the Ultramount and optimize the geometry. This simulation was used to create several designs, which were 3D printed and validated using displacement test methods via hanging weights. Second, an investigation into better materials for Ultramount fabrication was conducted to compliment the new designs. Combining mechanical design, simulation, and material selection aspects, an ideal riflescope mount could be fabricated.

Prototype Validation
Finite Element Analysis
Data Collection
Math Model
Material Design
Client Goal

Plan Of

Action

GOVERNING PRINCIPLES

The objective was to convert acceleration data from gunshots into forces. To do so the gunshots were treated as impacts. By manipulating and simplifying the impulse momentum theorem.

$$F * \Delta t = m * \Delta v$$

We found Newton's Second Law was an accurate model representation.

$$F = m * a$$

To prove Newton's Second Law was the governing principle an impact test stand was built. It consisted of a swinging mass and a stationary bar. The objective was to match the force the swinging mass exerted on the bar with the accelerations experienced by the bar after impact.



Capturing acceleration data with accelerometer on rifle rail.

Impact test stand

FINAL DESIGN

3 prototypes were developed throughout the project

- Prototype 1 focused on reinforcement of original design
- Prototype 2 focused on reducing weight from the original design
- Prototype 3 is a new lightweight design



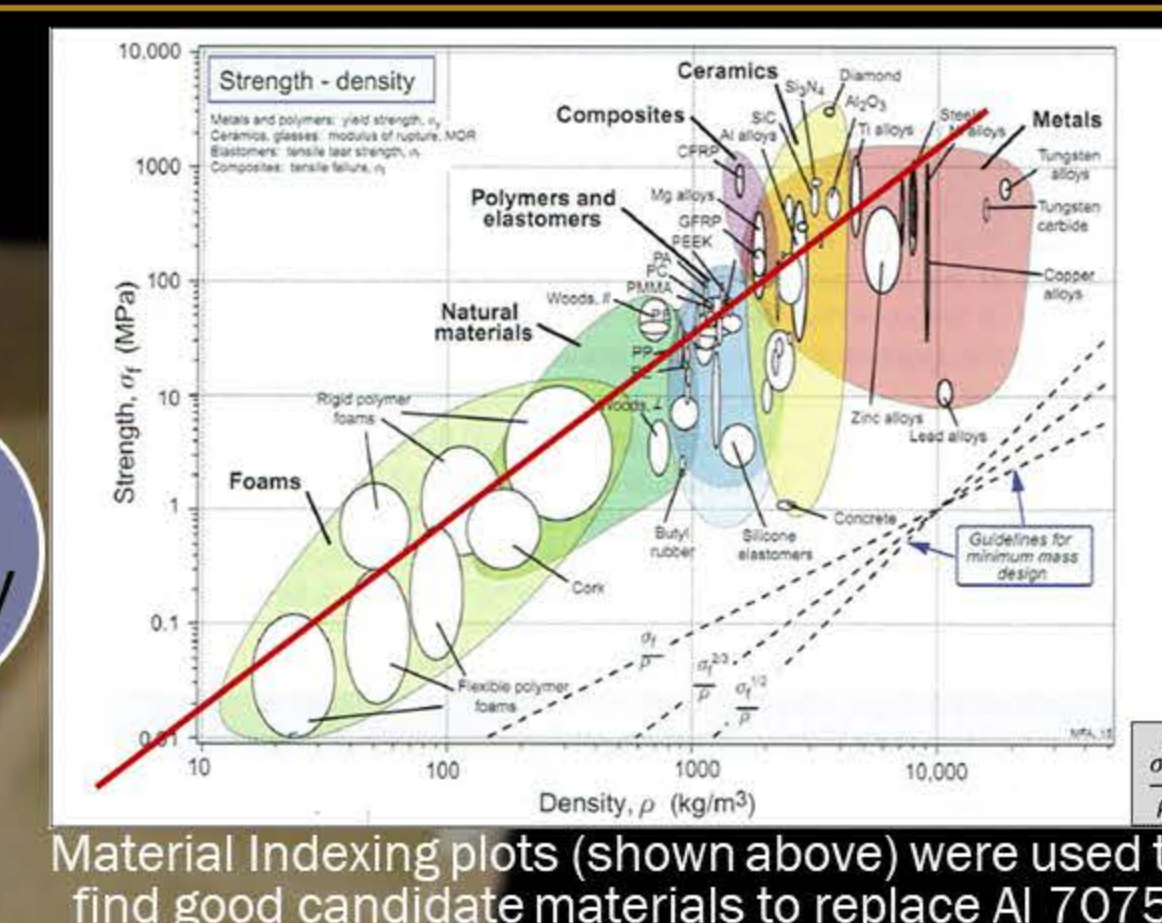
3D Printed Models of our prototypes

Design Stats. Table			
Image	Design #	Mass (oz) / % Reduction	Peak Stress (ksi)*
		3.689 / 0%	33.26
	1	3.5414 / 4%	21.98
	2	3.339 / 9%	24.07
	3	2.609 / 29%	54.79

*Peak stress values are simulation
Solidworks simulation values

MATERIAL DESIGN

- Al-7075 currently used for mount
- Material Indexing conducted to narrow candidate materials
- Corrosion resistance was necessary and was held to the ASTM B1:17 standard (Salt spray test).
- 10 companies were quoted for material pricing
- Coating methods for Mg AZ61A and Al 2024 investigated



Material Indexing plots (shown above) were used to find good candidate materials to replace Al 7075

Candidate Material Unit and Bulk Pricing				
	Al 7075	Mg AZ61A	Al 2024	Al 7068
Unit (\$/lb)	13.82	4.06-42.89	15.35-23.16	19.77
Bulk (\$/lb)	1.13	4.06-11.56	N/A	N/A

Materials Indexing Results*

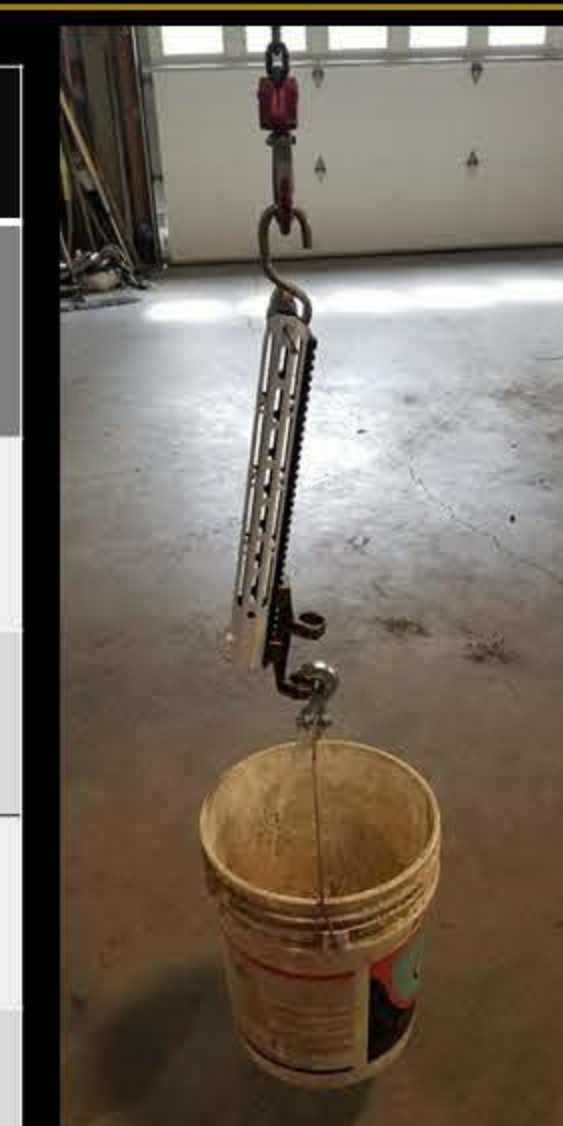
	Al 7075	Mg AZ61A	Al 2024	Al 7068
$E^{1/2}$	999.8	1240.2	1076.5	999.67
ρ				
$\sigma^{2/3}$	171.2	159.5	139.1	188.7
$E^{1/2}$	72.3	152.1	79.3	69.1
C_v				
$\sigma^{2/3}$	12.4	19.57	10.3	13.0
C_v				

*Some materials are excluded from this listing as they were not final candidates

VALIDATION

- 3D prints of designs validated using displacement testing
 - Visijet M3 Black
 - Compared displacement values to simulation values
- Acceleration peak averaging
 - Strain hardening effect in Al 7075 increases yield stress in the impulse time regime

3D Printed Prototype Displacement Results					
(Displacement measured in inches)		Ultramount	Design 1	Design 2	Design 3
Simulation	Displacement (Back Ring)	0.00584	0.007671	0.007763	0.1511
	Displacement (Front Ring)	0.02119	0.02231	0.02721	0.01378
Experimental	Displacement (Back Ring)	0.014	0.01	0.033	0.05
	Displacement (Front Ring)	0.042	0.077	0.09	0.396



Displacement validation setup

CONCLUSION

From start to finish the optimization of the rifle scope was a difficult challenge, that the team met head on. Through live fire testing and research we have found that typical rifle shot accelerations lie at the peak around 150-210 G. To optimize the rifle scope mount our calculations showed that applying 137, 126, 93 pounds force in the X,Y,Z axes created the most accurate simulation. This yielded the peak stresses seen in the final design. In most cases a design team chooses strength or weight. Our team has produced models that stand out in both categories. A detailed analysis of material choices as seen in the material design section were identified as suitable replacements for the current aluminum 7075. To accompany these models a streamlined procedure was developed to repeat this process on any new model of rifle scope mount the client may make in the future.

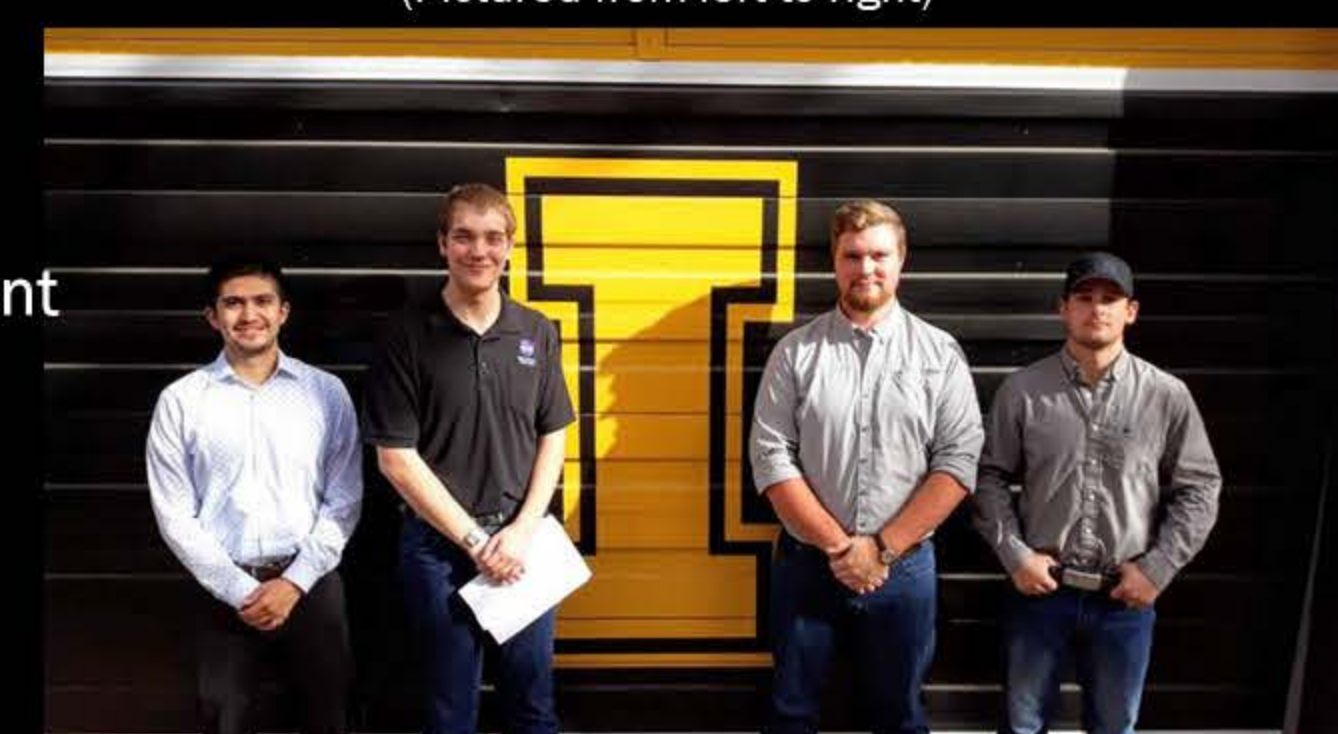
ACKNOWLEDGEMENTS

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THE TEAM

- Hector Magaña - ME
 - Burley, ID
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 - Troy, ID
 - Material Selection and Acquisition
- Jacob Weber - ME
 - Clarkston, WA
 - Prototype Development and Sponsor Contact
- Travis Goehring - ME
 - Grangeville, ID
 - Data Analysis and recorder

(Pictured from left to right)



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