COST ANALYSIS FOR 3D PRINTED COUNTER UNMANNED AERIAL SYSTEM (c-UAS) GUIDED ROCKET PROTOTYPE

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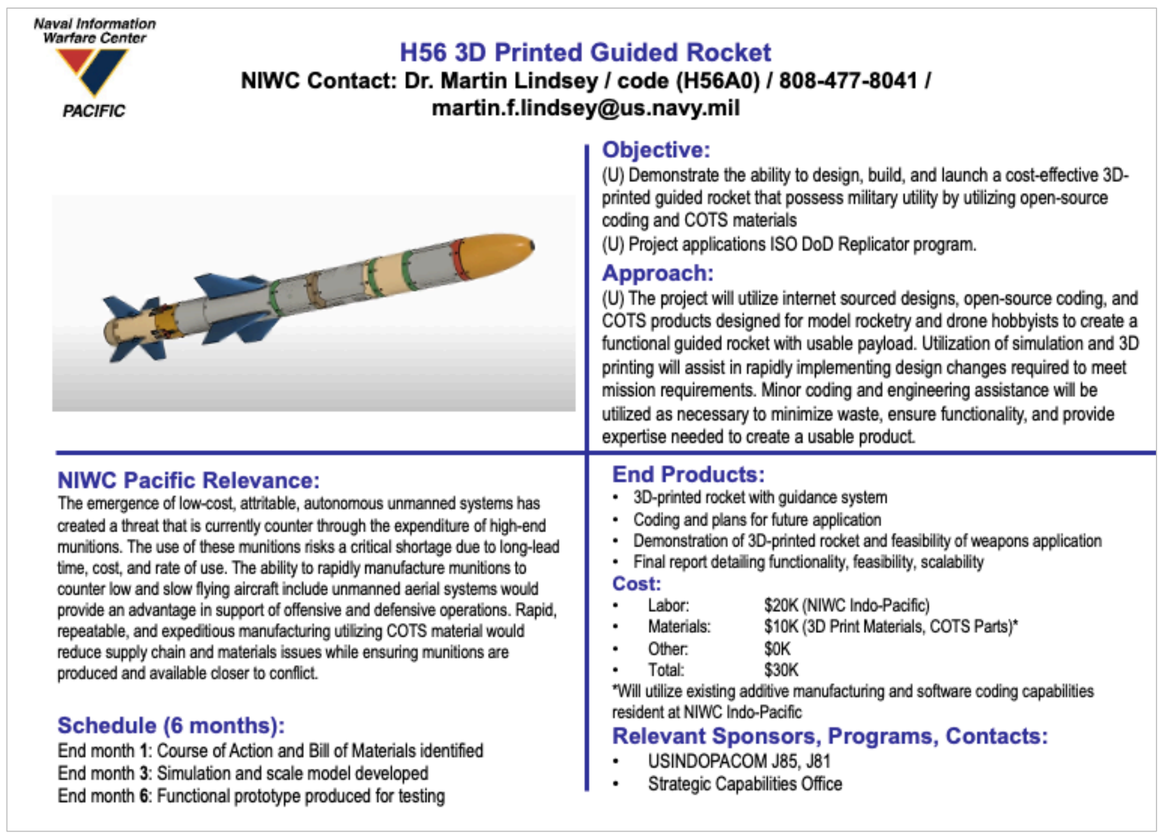
Abstract

Usage of low-cost drones has become prolific in the ongoing conflicts in Ukraine and in the Red Sea. These drones are cheaply made and are readily available to conventional and unconventional forces. The growing usage of inexpensive, unmanned aerial systems (UAS) in military engagements exposes a critical vulnerability of the United States military's typical countermeasures. The United States largely relies on expensive and sophisticated ordnance that have long production lead times. Stockpiles of these munitions are limited and depleting inventories to counter cheaply made threats is unsustainable. This risk is exacerbated by the current pacing threat of China. A potential solution is for the United States is to develop its own low-cost rockets that are capable of successfully engaging and downing UAS. NIWC Pacific and USINDOPACOM J85 are currently working on a viable prototype that leverages off the shelf parts and 3D printed components that could pave the path for viable alternatives. However, a rigorous cost estimate is needed to understand if the prototype offers cost saving advantages over current munitions. This research aims to provide relevant cost information for the prototype rocket with the larger intention of supporting informed strategic decisions for adoption and production of rockets that address the threat created by low-cost UAS.



Naval Information Warfare Center PACIFIC

H56 3D Printed Guided Rocket

NIWC Contact: Dr. Martin Lindsey / code (H56A0) / 808-477-8041 / martin.f.lindsey@us.navy.mil

Objective:
(U) Demonstrate the ability to design, build, and launch a cost-effective 3D-printed guided rocket that possess military utility by utilizing open-source coding and COTS materials
(U) Project applications ISO DoD Replicator program.

Approach:
(U) The project will utilize internet sourced designs, open-source coding, and COTS products designed for model rocketry and drone hobbyists to create a functional guided rocket with usable payload. Utilization of simulation and 3D printing will assist in rapidly implementing design changes required to meet mission requirements. Minor coding and engineering assistance will be utilized as necessary to minimize waste, ensure functionality, and provide expertise needed to create a usable product.

NIWC Pacific Relevance:
The emergence of low-cost, attritable, autonomous unmanned systems has created a threat that is currently counter through the expenditure of high-end munitions. The use of these munitions risks a critical shortage due to long-lead time, cost, and rate of use. The ability to rapidly manufacture munitions to counter low and slow flying aircraft include unmanned aerial systems would provide an advantage in support of offensive and defensive operations. Rapid, repeatable, and expeditious manufacturing utilizing COTS material would reduce supply chain and materials issues while ensuring munitions are produced and available closer to conflict.

Schedule (6 months):
End month **1**: Course of Action and Bill of Materials identified
End month **3**: Simulation and scale model developed
End month **6**: Functional prototype produced for testing

End Products:
- 3D-printed rocket with guidance system
- Coding and plans for future application
- Demonstration of 3D-printed rocket and feasibility of weapons application
- Final report detailing functionality, feasibility, scalability

Cost:
- Labor: $20K (NIWC Indo-Pacific)
- Materials: $10K (3D Print Materials, COTS Parts)*
- Other: $0K
- Total: $30K

*Will utilize existing additive manufacturing and software coding capabilities resident at NIWC Indo-Pacific

Relevant Sponsors, Programs, Contacts:
- USINDOPACOM J85, J81
- Strategic Capabilities Office

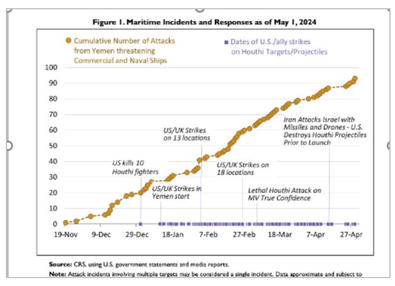
NIWC PACIFIC H56 3D Printed Guided Rocket Proposal

Methods

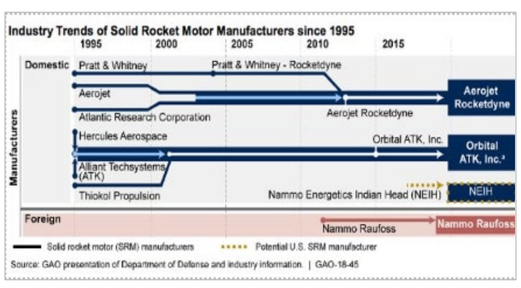
- Used a qualitative analysis to examine how low-cost drone technology is redefining modern warfare.
  - Literature review was conducted from existing research, press releases, and news reports to explore the use of low-cost drones in the ongoing conflicts in Ukraine and the Red Sea.
  - Publicly released reports were collected from various agencies to investigate how the DOD is addressing munition production rates and understand DOD cost estimate shortfalls.
- Used a quantitative analysis to estimated cost for the prototype 3D printed rocket.
  - Used a single and multi-variable regression analyses to examine how two key factors labor hours and range (in meters) effect the overall cost of the rocket prototype.
  - The Ordinary Least Squares (OLS) method was used to estimate the regression coefficients
  - For each model, the R-squared value, F-statistic and its p-value, T-statistic and p-value for the slope coefficient were calculated and interpreted.

Results & Their Impact

- The multiple regression model explains 88.8% of the variation in total cost. The F-statistic evaluates the model's overall validity and .0375 indicates how what the probability is that these events happened at random.
- There is a natural learning curve to building rockets that drives down labor cost per rocket over time but other production costs increase further into the production cycle to achieve greater capabilities.
- The sample size is considerably smaller than is typically needed for a robust statistical analysis which limits statistical inference and predictive modeling capabilities.
- Regressions should be rerun in the future when there is more available data to build a more robust analysis. More data points will naturally refine the cost estimate and help evaluate the variables driving cost.



Maritime Incidents and Responses in the Red Sea



Solid Rocket Motor Manufacturing Trends

Coefficient	Values
β0	2218.35
β1 (Labor Hours)	72.53
β2 (Range)	0.09
ε	1689.21

Multiple Regression Equation

Metric	Threshold	Value
R^2		0.8880
F-Stat p-value	<.1	0.0375
T-stat p-value (Labor Hours)	<.1	0.0171
T-stat p-value (Range)	<.1	0.0556

Multiple Regression Statistical Significance

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