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A Decision Support Tool using Machine Learning Techniques for Strategic Investment Planning

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Purpose & Objective

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- **Purpose:** present in-work doctoral level research
- **Objective:** solicit audience feedback to improve tool's utility for the user
  - Level of interest on topic
  - Clarity of problem description
  - Methodology and approach
  - Ideas to improve utility of final decision support tool
  - Other considerations…

Outline

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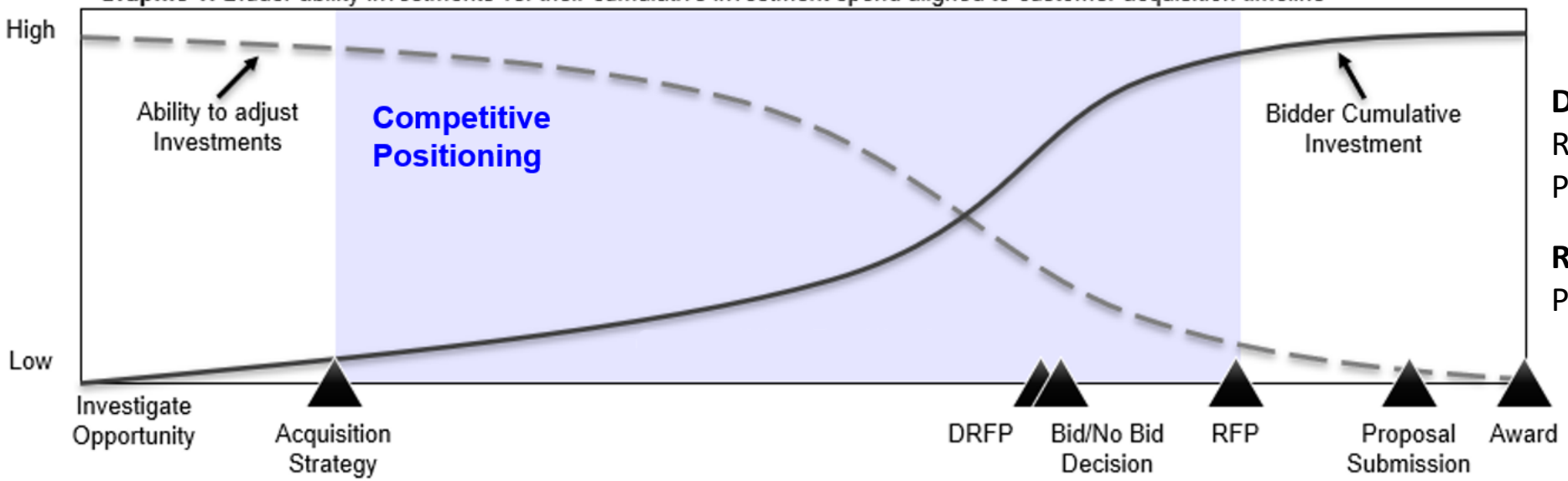
- Introduction
- Research Overview
- Initial Findings
- Path Forward

Problem Description

- Bidders' strategic investments are made to strengthen core competencies in proposed solutions
- Prioritized customer needs are inferred through evaluation criteria in their Request for Proposal

Graphic 1: Bidder ability investments vs. their cumulative investment spend aligned to customer acquisition timeline



DRFP: Draft Request for Proposal

RFP: Request for Proposal

Customer evaluation criteria is not known until majority of strategic investments are incurred

Graphic 1 created from insights from O'Guin, M. (2012). *Winning the big ones: how teams capture large contracts*. Lulu Com.[1]

Current Methods

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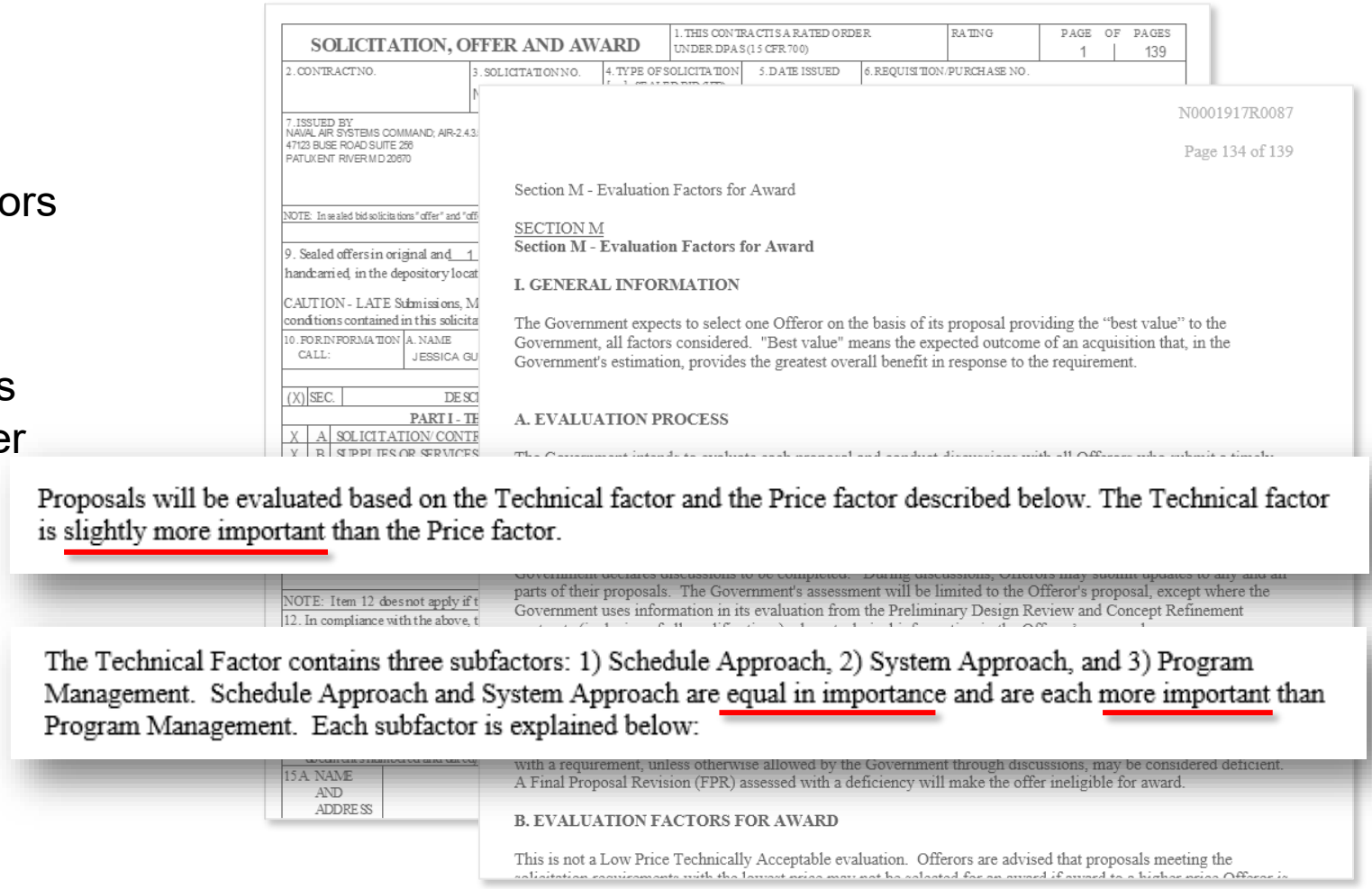
- Evaluation criteria is outlined within RFPs in “Section M”
  - Criteria is stated in factors and subfactors with qualitative relationships
  - Business Strategy analysts leverage small samples of comparable programs to estimate these factors and their order of importance
- Current methods are:
  - Time consuming
  - Expensive
  - Subjective


SOLICITATION, OFFER AND AWARD

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Page 134 of 139

Section M - Evaluation Factors for Award

SECTION M

Section M - Evaluation Factors for Award

I. GENERAL INFORMATION

The Government expects to select one Offeror on the basis of its proposal providing the “best value” to the Government, all factors considered. "Best value" means the expected outcome of an acquisition that, in the Government's estimation, provides the greatest overall benefit in response to the requirement.

A. EVALUATION PROCESS

Proposals will be evaluated based on the Technical factor and the Price factor described below. The Technical factor is slightly more important than the Price factor.

The Technical Factor contains three subfactors: 1) Schedule Approach, 2) System Approach, and 3) Program Management. Schedule Approach and System Approach are equal in importance and are each more important than Program Management. Each subfactor is explained below:

B. EVALUATION FACTORS FOR AWARD

This is not a Low Price Technically Acceptable evaluation. Offerors are advised that proposals meeting the

Example RFP: US Navy MQ-25 Section M [2]

Research Focus

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- **Problem Statement:**
  - A bidder's ability to adjust strategic investments aligned to customer needs decreases by 60% by RFP release, reducing their probability of winning[1].
- **Thesis Statement:**
  - A decision support tool based on machine learning will better enable a bidder's strategic investment planning by forecasting customers' prioritized evaluation criteria.
- **Research Objectives:**
  - Develop a decision support tool to enable strategic investments decisions.
  - Forecast customers' prioritized evaluation criteria for new business opportunity using supervised machine learning.

Machine Learning Algorithm Overview

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ML Algorithm*	Description	Simple to Interpret	Fast Testing	Inexpensive Modeling	Small Dataset	Regression *and* Classifier	Non-Linear Solutions	Analyzes Complex Relationships	Automatic Feature Selection	Minimized Overfitting
Linear Regression	"Best fit" through x and y data Numerical prediction	✓	✓	✓	✓					
Logistic Regression	Estimates probability of category using logistics function	✓	✓	✓	✓	✓				
Support Vector Machine	Identifies classes by hyperplanes in high dimensional space		✓	✓	✓	✓	✓	✓	✓	
Decision Tree	Visual split into decision nodes and leaves (yes/no rules)	✓					✓	✓	✓	
Random Forest	Cumulates predictions of multiple decision trees						✓	✓	✓	✓

*Subset list of supervised Machine Learning algorithms [3-5]

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Decision Tree	Visual split into decision nodes and leaves (yes/no rules)	✓					✓	✓	✓	
Random Forest	Cumulates predictions of multiple decision trees						✓	✓	✓	✓

- **Will provide inexpensive, simple modeling of prioritized criteria with limited dataset**

*Subset list of supervised Machine Learning algorithms [3-5]

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Decision Tree	Visual split into decision nodes and leaves (yes/no rules)	✓					✓	✓	✓	
Random Forest	Cumulates predictions of multiple decision trees						✓	✓	✓	✓

- **Increases accuracy of predictions**
- **Provides classification (grouping) predictions**

*Subset list of supervised Machine Learning algorithms [3-5]

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Logistic Regression	Estimates probability of category using logistics function	✓	✓	✓	✓	✓				
Support Vector Machine	Identifies classes by hyperplanes in high dimensional space		✓	✓	✓	✓	✓	✓	✓	
Decision Tree	Visual split into decision nodes and leaves (yes/no rules)	✓	• **Identifies key features that drive predictions**				✓	✓	✓	
Random Forest	Cumulates predictions of multiple decision trees		• **Analyzes complex relationships of criteria for increased accuracy**				✓	✓	✓	✓

*Subset list of supervised Machine Learning algorithms [3-5]

Research Approach

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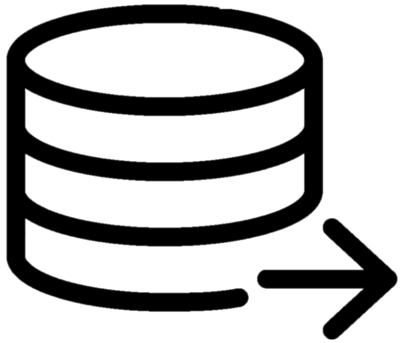
[Phase 1: Model Training]

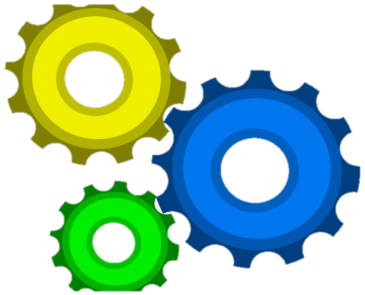


Data Sources

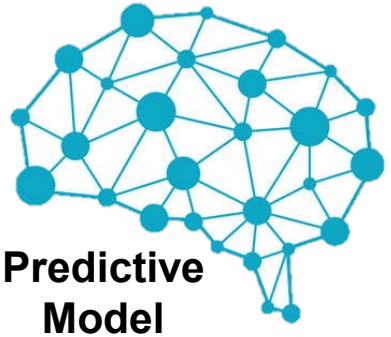
- Sam.Gov
- GovWin
- Defense & Aerospace Competitive Intelligence Service (DACIS)

Training Data

- Customer Organization
- Contract Information
- Prioritized Evaluation Criteria



Applicable Supervised Machine Learning Algorithms

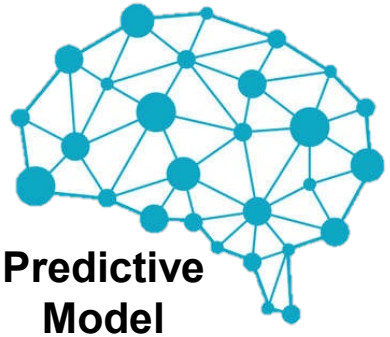


Predictive Model

[Phase 2: Model Testing]

Testing Data

- Customer Organization
- Contract Information



Predictive Model

Outcome

- Evaluation Criteria
- Relationship between criterion
- Criteria prioritization volatility
- Prediction accuracy

Graphics recreated with modifications from Sarker, I. H. (2021). Machine Learning: Algorithms, Real-World Applications and Research Directions. *SN Computer Science*, *2*(3), 1–21.

Research Data Collection

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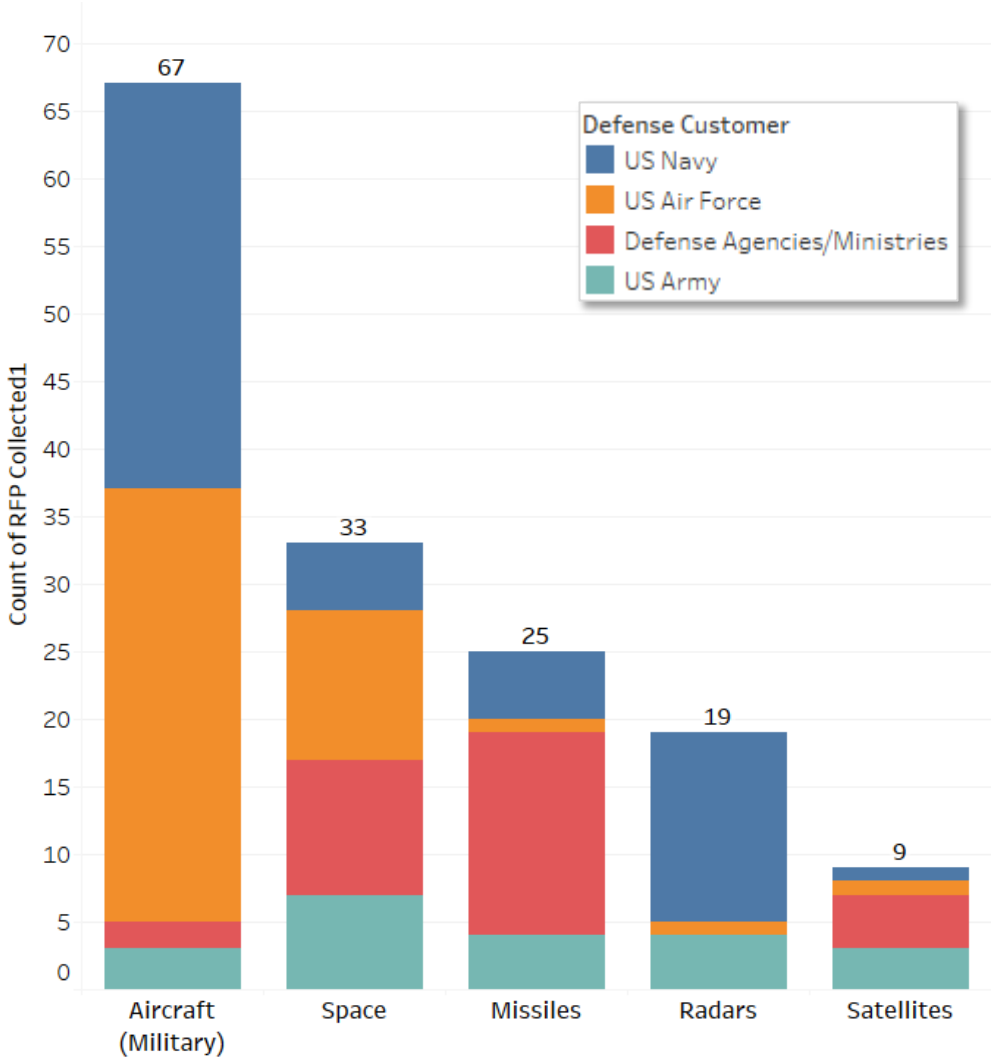
- +150 RFPs reviewed *(research in-work)*
  - 21 – US Army
  - 55 – US Navy
  - 46 – US Air Force
  - 31 – Other
  - 67 – Cost Contracts
  - 70 – Fixed Price Contracts
  - 16 – Other Contract Types
  - 5 – Different market areas
- Data collected:
  - Solicitation Number
  - Contract Number
  - Product Service Code
  - North American Industry Classification System (NAICS) code
  - Customer Organization
  - Contract Type
  - Solicitation Date
  - Period of Performance
  - Award Value
  - Award Date
  - Evaluation Criteria
    - Major factors
    - Subfactors
    - Order of importance



Initial Findings

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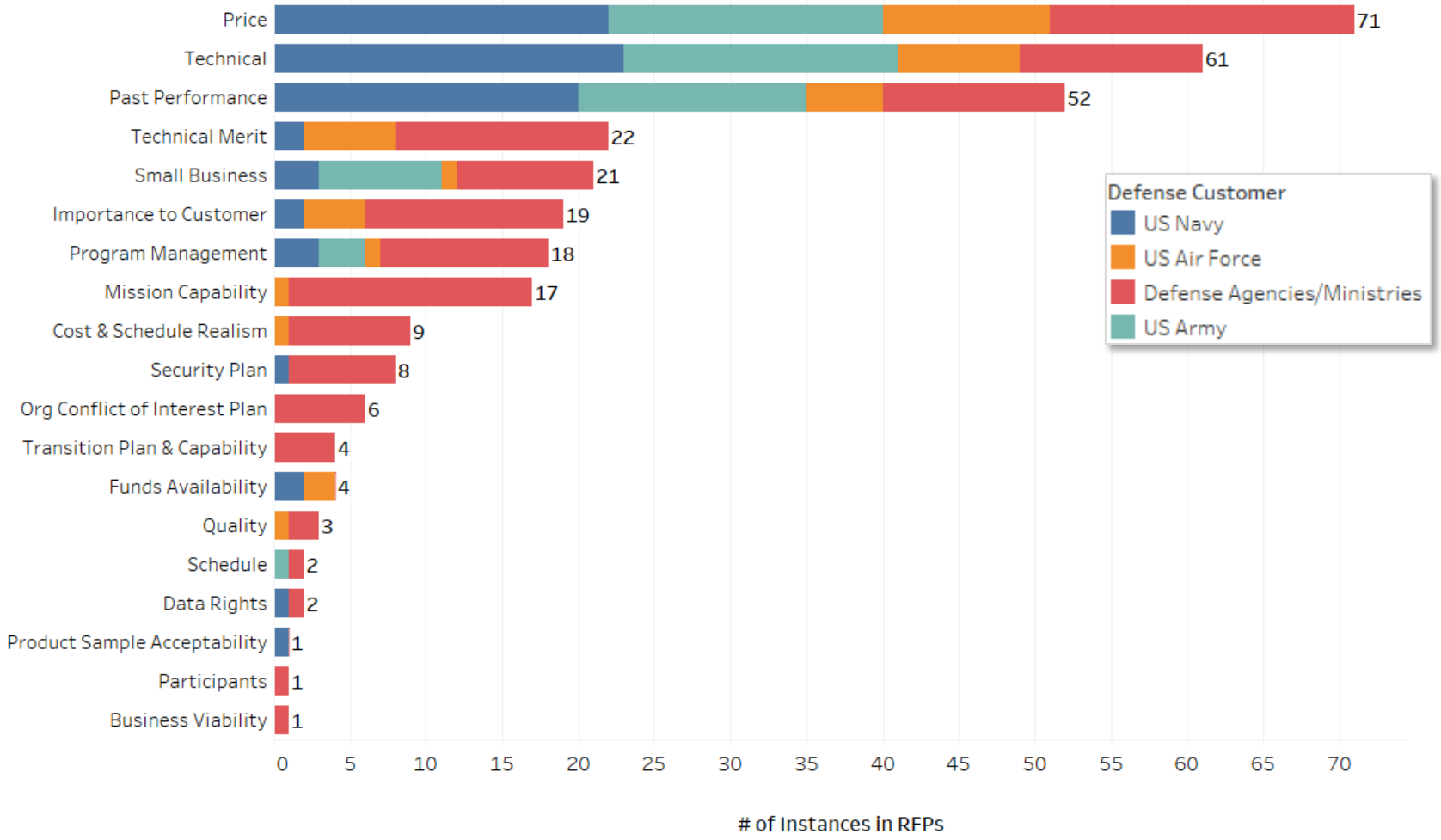
- Major factors are:
  - Technical
  - Price
  - Past Performance
  - Small Business
  - Importance to Customer
  - Program Management
- Additional findings will include ML algorithm prediction accuracy based on experiment progress *(research in-work)*



Major factors vary based on solicitation organization, contract type, and program service code

Path Forward

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- Data collection will expand to 9 different market areas across 10-year timeline
- Initial model development leveraging existing Machine Learning software tools
- Comparison of Machine Learning accuracy measures
- Journal publication containing research findings targeted prior to year-end

Research is ongoing and requesting iterative feedback from other subject matter experts

References

1. O'Guin, M. (2012). *Winning the big ones: how teams capture large contracts*. Lulu Com.
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3. Gianey, H. K., & Choudhary, R. (2018). Comprehensive Review On Supervised Machine Learning Algorithms. *Proceedings - 2017 International Conference on Machine Learning and Data Science, MLDS 2017, 2018-January*, 38–43.
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About the Author

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Wendy Robello brings over 17 years of systems engineering and strategy experience. She is an experienced technical executive within the aerospace and defense industry with leadership roles in strategic analytics, leading competitive positioning for key captures and investment strategy across several portfolios. She has supported numerous platforms across various domains to include space, air, ground, and underwater systems.

Wendy earned a B.S. in Mechanical Engineering from UC, Irvine, an M.S. in Systems Architecture and Engineering from USC, and is currently pursuing a Ph.D. in Systems Engineering from The George Washington University.

LinkedIn Profile

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