PRICE®

Webinar

Rotorcraft Validation Case Study

Estimate with Confidence™

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Cost Analytics


TrueExplorer


TrueFindings


PRICE® Models


TruePlanner


TrueMapper


TrueBOE


TrueXLS

Search & extract data from the PCA Ecosystem	Manage & Analyze Data Sets	Predictive Models	Integration Framework	Customer Data Mapping	Basis-of-Estimate Generator	Access PCA Engine from Excel


Excel


Word


Project


@RISK


ORACLE CRYSTAL BALL


PROPRICER


PHOENIX INTEGRATION


ACEIT

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Today's Presenter

Will Gbelee

Solutions Consultant

- William serves as a technical resource for the United States Air Force, and the United States Army clients
- Supports training, mentoring, and consulting in predictive estimation and data analysis
- Spent 4+ years supporting DoD cost estimating, Budgeting, and Air Force Life Cycle Management Center (AFLCMC)
- William holds a B.S. in Accounting & Finance from Wright State University

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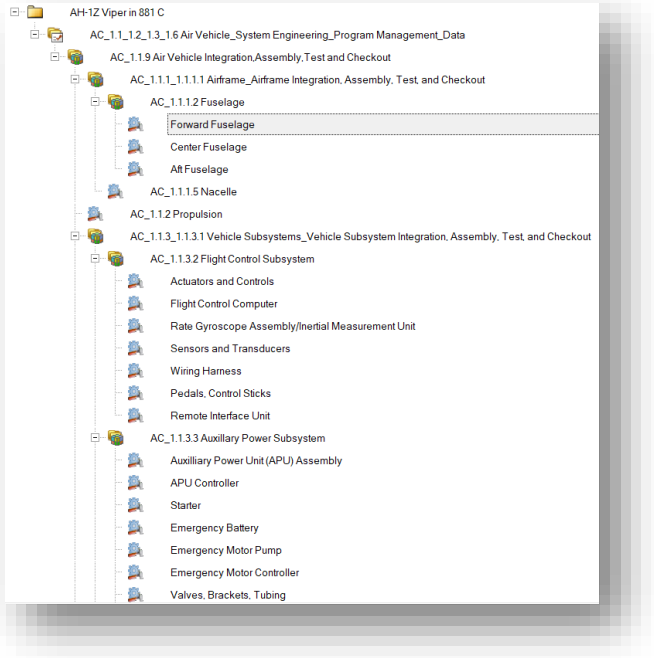
Overview

- Background
- Project Goals
- Ground Rules and Assumptions
- Live Demo
- Results
- Summary



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Background

- The first iteration of Rotorcraft Templates were geared towards top-level production costs
- The work breakdown structure (WBS) of the template and test cases were aligned with MIL-STD-881C structure
- Can the Rotorcraft Templates be refreshed with more advance analysis and to improve traceability, repeatability, and defensibility?

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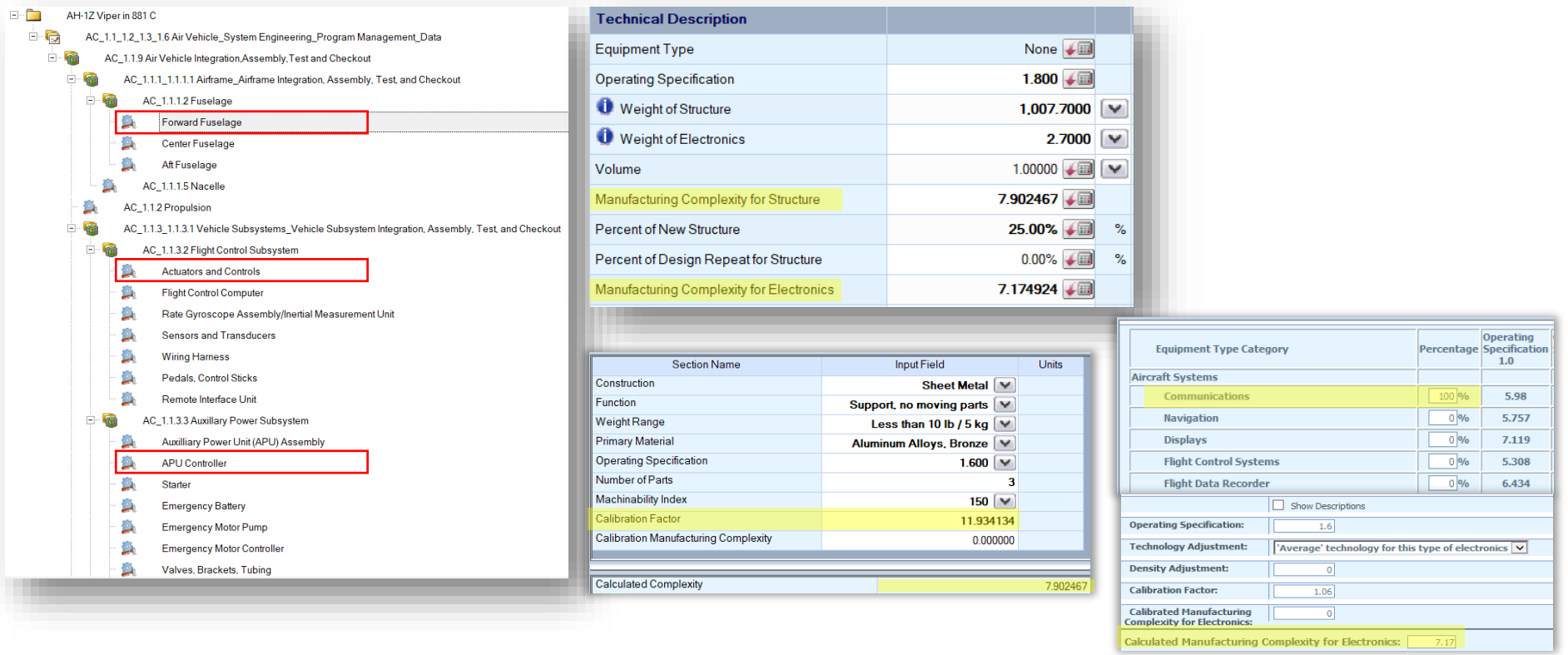
Background continued

Original Test Case PBS:



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Project Goals

- Provide users with a Template and Test cases that can quickly provide rough order-of-magnitude (ROM) cost predictions for amortized unit production cost on existing rotorcrafts
- The template and test cases should provide input traceability and repeatability
- The test cases should be based on open-source data and work breakdown structure should align with the latest MIL-STD-881E

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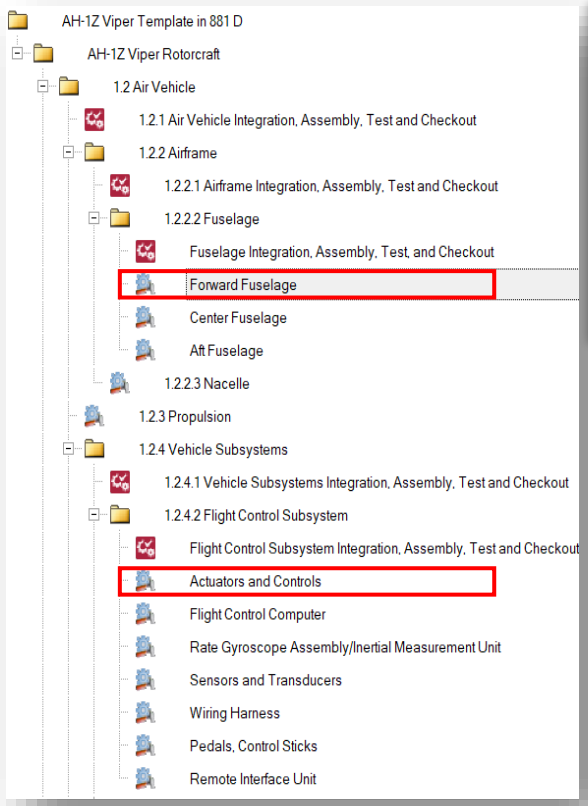
New Test Case Examples

New Test Case PBS:



Technical Description	
Equipment Type	None
Operating Specification	1.800
Weight of Structure	750.5423
Weight of Electronics	0.0000
Volume	1.00000
Manufacturing Complexity for Structure	6.916542
Percent of New Structure	100.00% %
Percent of Design Repeat for Structure	0.00% %
Manufacturing Complexity for Electronics	7.000000

Section Name	Input Field	Units
Construction	Laminated Construction	
Function	Structural frames, supports, bul...	
Weight Range	Over 500 lb / 200 kg	
Primary Material	None	
Operating Specification	1.800	
Number of Parts	500	
Machinability Index	18	
Calibration Factor	0.000000	
Calibration Manufacturing Complexity	0.000000	
Calculated Complexity	6.916542	

Technical Description	
Equipment Type	Flight Control
Operating Specification	1.800
Weight of Structure	410.7614
Weight of Electronics	102.6904
Volume	16.99264
Manufacturing Complexity for Structure	6.363000
Percent of New Structure	100.00% %
Percent of Design Repeat for Structure	0.00% %
Manufacturing Complexity for Electronics	8.865000

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Ground Rules & Assumptions

- Assumptions
  - Cost can be predicted with minor tailoring using a standard template
  - Nominal Production Rates (20% G&A and 12% Fee/Profit)
  - 80/20 Split Between Structure and Electronics for Level 5 WBS Components
  - Manufacturing Country of origin to better capture labor rates
- Parameters
  - Cost, Schedule, and Technical parameters for 21 Rotorcraft systems:
    - *Empty Weight*
    - *EMD & Production Schedule*
    - *Standard complexity sets*
    - *Standard weight allocation based on Tilt Rotor and Baseline Helicopter*

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Weight Allocation Schemes Utilized

Helicopter

Baseline Helicopter (Weight Empty)	Weight %
Fuselage	19.49%
Nacelle	4.27%
Propulsion	12.68%
Flight Control	8.40%
Auxiliary Power	1.49%
Hydraulics	1.09%
Electrical	3.50%
Crew Station	0.63%
Environmental Control	1.82%
Fuel	2.31%
Landing Gear	0.63%
Rotor Group	12.16%
Drive Assembly	14.77%
Communication/ Identification	1.72%
Navigation/ Guidance	0.57%
Mission Computer/ Processing	11.49%
Fire Control	1.15%
Data Display and Controls	1.15%
Survivability	0.67%
Total Weight Empty	**100.00%**

Tilt Rotor

Baseline Tilt-Rotor (Weight Empty)	Weight %
Fuselage	16.67%
Nacelle	2.41%
Propulsion	10.18%
Auxiliary Power	0.98%
Hydraulics	1.01%
Electrical	7.81%
Crew Station	5.56%
Environmental Control	0.94%
Fuel	3.14%
Landing Gear	3.79%
Rotor Group	11.00%
Drive Assembly	15.09%
Communication/ Identification	1.14%
Navigation/ Guidance	0.38%
Mission Computer/ Processing	0.00%
Fire Control	6.59%
Data Display and Controls	0.76%
Survivability	0.56%
Total Weight Empty	**100%**

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Rotorcraft Database

- Number of Rotorcrafts used in this study


AH-1Z Viper


AW-609


CH-53E Super Stallion


Enstrom F28


MH-60R


OH-58 Kiowa Warrior


UH-72 Lakota


AH-64 Apache


Bell 407


CRH


Eurocopter EC1-35


NH-90


Sikorski S-92


V-22 Osprey


AW-139


CH-47 Chinook


Denel Rooivalk


KUH-1 Surion


OH-1 Ninja


UH-60 Black Hawk


V-280 Valor

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PRICE Cost Analytics™ Technology DEMO

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Results: All Rotorcrafts

	** Reference Cost ($M)	** Template Estimate ($M)	% Difference	% Absolute Difference
AH-1Z Viper	$ 29.03	$ 23.53	-18.97%	18.97%
AH-64 Apache	$ 20.69	$ 19.88	-3.94%	3.94%
AW-139	$ 13.46	$ 14.87	10.43%	10.43%
*BELL 407 (Civil)	$ 4.63	$ 4.06	-12.21%	12.21%
CH-47 Chinook	$ 31.89	$ 38.25	19.93%	19.93%
CH-53E Super Stalion	$ 40.06	$ 40.03	-0.07%	0.07%
CRH	$ 48.52	$ 40.08	-17.40%	17.40%
Denel Rooivalk	$ 48.28	$ 37.79	-21.73%	21.73%
*Enstrom F-28 (Civil)	$ 1.90	$ 1.79	-5.90%	5.90%
*Eurocopter EC-135	$ 5.81	$ 5.47	-5.90%	5.90%
KUH-1 Surion	$ 18.50	$ 23.59	27.50%	27.50%
MH-60R	$ 34.09	$ 28.58	-16.16%	16.16%
NH-90	$ 38.10	$ 28.53	-25.10%	25.10%
OH-1 Ninja	$ 26.78	$ 21.15	-21.02%	21.02%
OH-58 Kiowa Warrior	$ 6.41	$ 6.23	-2.86%	2.86%
Sikorski S-92	$ 46.03	$ 46.25	0.49%	0.49%
UH-60 Black Hawk	$ 18.72	$ 18.81	0.48%	0.48%
UH-72 Lakota	$ 8.28	$ 11.53	39.38%	39.38%
V-22 Osprey	$ 89.81	$ 56.58	-37.00%	37.00%
Average				15.08%

* Commercial Rotorcraft Systems

** Normalized to CY2020 Dollars

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Test of Mean Differences

t-Test: Paired Two Sample for Means		
	Reference Cost ($M)	*Template Cost ($M)*
Mean	27.95	24.58
Variance	460.90	241.22
Observations	19	19
Pearson Correlation	0.941728847	
Hypothesized Mean Difference	0	
df	18	
t Stat	1.705564482	
P(T<=t) one-tail	0.052642722	
t Critical one-tail	1.734063607	
P(T<=t) two-tail	0.105285444	
t Critical two-tail	2.10092204	

There is no statistically significant difference between the means of the two trials.

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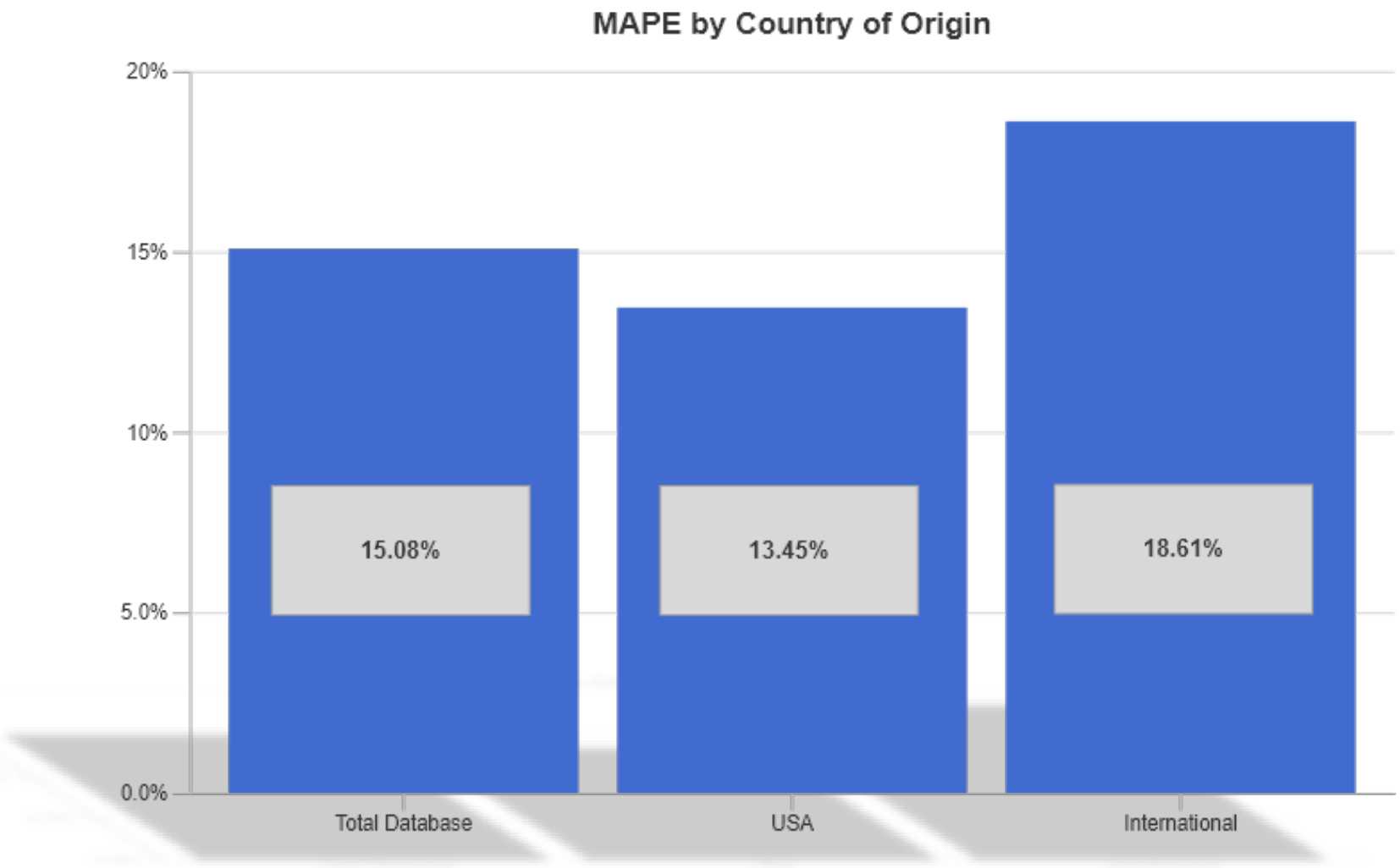
MAPE by Country of Origin



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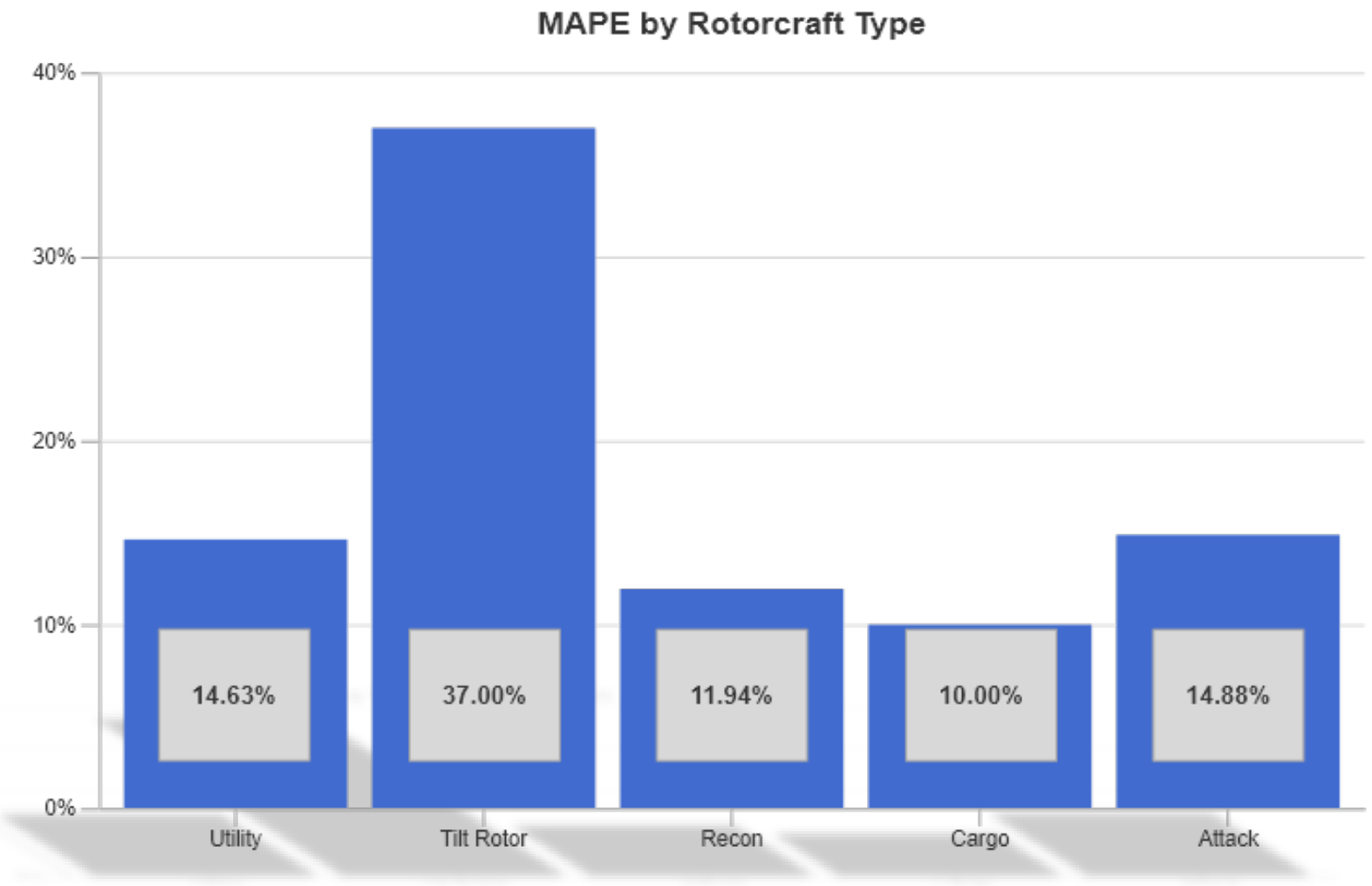
MAPE by Rotorcraft Type



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Dependency Finder- All Rotorcrafts

Name	Rotorcraft Class	Empty Weight	First Flight	MAPE
Enstrom F-28	Utility	1,595	1960	5.90%
CH-47 Chinook	Cargo	23,400	1961	19.93%
OH-58 Kiowa Warrior	Recon	3,829	1966	2.86%
UH-60 Black Hawk	Utility	12,500	1974	0.48%
CH-53E Super Stalion	Cargo	33,226	1974	0.07%
AH-64 Apache	Attack	11,387	1975	3.94%
MH-60R	Utility	14,430	1979	16.16%
V-22 Osprey	Tilt Rotor	33,140	1989	37.00%
Denel Rooivalk	Attack	12,632	1990	21.73%
Eurocopter EC-135	Utility	3,208	1994	5.90%
BELL 407	Utility	2,668	1995	12.21%
NH-90	Utility	14,100	1995	25.10%
OH-1 Ninja	Recon	5,401	1996	21.02%
Sikorski S-92	Utility	15,500	1998	0.49%
AH-1Z Viper	Attack	12,300	2000	18.97%
AW-139	Utility	7,984	2001	10.43%
UH-72 Lakota	Utility	3,951	2006	39.38%
KUH-1 Surion	Utility	10,964	2010	27.50%
CRH	Utility	16,000	2019	17.40%

Statistics

Independent Variable	Dependent Variable	|R Value|
First Flight	Classes	0.469
Classes	First Flight	0.469
First Flight	MAPE	0.458
MAPE	First Flight	0.458
Classes	MAPE	0.273
MAPE	Classes	0.273
Empty Weight	Classes	0.222
Classes	Empty Weight	0.222
Empty Weight	MAPE	0.132
MAPE	Empty Weight	0.132
First Flight	Empty Weight	0.127
Empty Weight	First Flight	0.127

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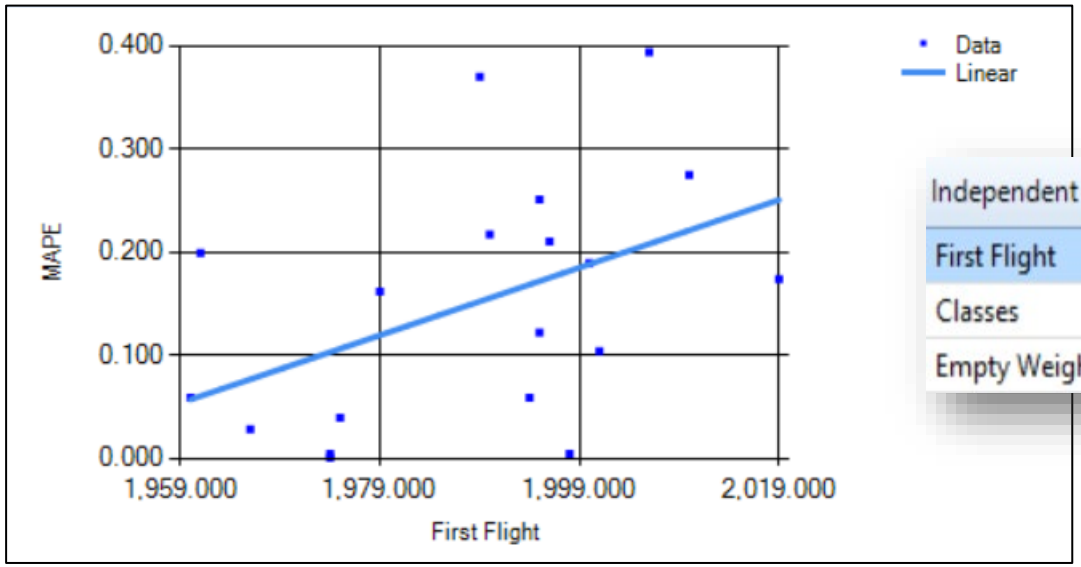
Curve Finder- All Rotorcrafts



Independent Variable	R^2 Value	Trendline
First Flight	0.210	Linear
Classes	0.074	Linear
Empty Weight	0.017	Linear

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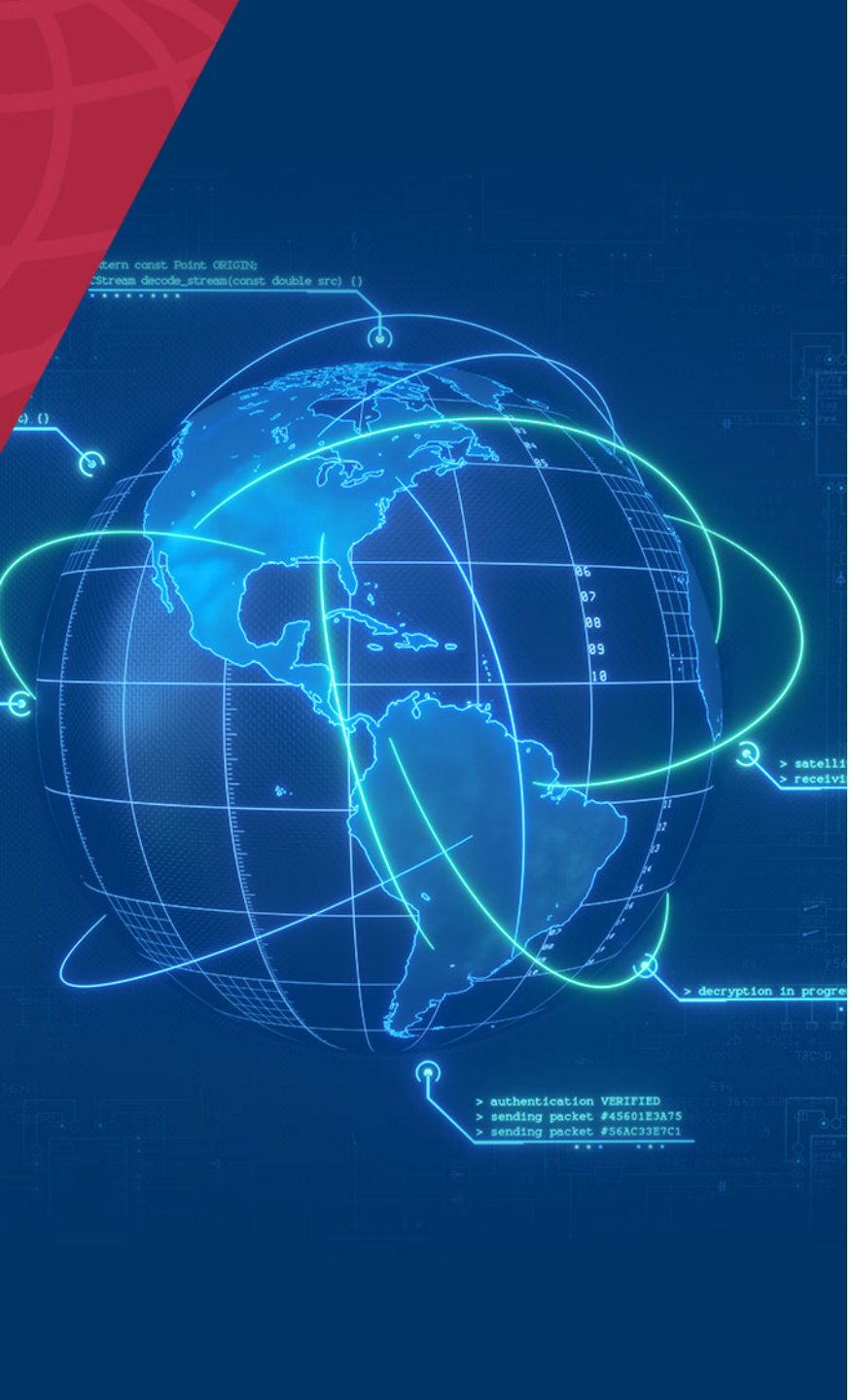

Summary

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Overall Results

- Templates produce mean absolute percent error (MAPE) of 15.08%

- Accuracy was validated by testing for significance
  - Performed paired student's t-Test of mean difference between actuals and template estimates

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Conclusion

- Rotorcraft Templates can accurately estimate historical programs
  - PROVIDES PROOF
- Validates Quality and Reliability of the data behind our models
  - CERs/models can accurately predict Rotorcraft Systems

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Next Steps

- Expand approach to other Aircraft Systems
  - Fighter Aircrafts
  - Bomber Aircrafts
  - Mobility Aircrafts
  - Unmanned Air Vehicles
- Expand approach to Development Phase
- Expand approach to other Weapon Systems

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Questions?

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Backup Slides

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