

NATIONAL RECONNAISSANCE OFFICE

Cost Associated with Acquisition Complexity and Differing Levels of Mission Assurance

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VIGILANCE FROM ABOVE



The NRO CAAG

NRO: National Reconnaissance Office

- Joint Department of Defense/Intelligence Community organization responsible for developing, launching, and operating America's intelligence satellites to meet the national security needs of our nation.

CAAG: Cost and Acquisition Assessment Group

- Independent Cost Estimates / Agency Cost Positions

...“How much will it cost?”

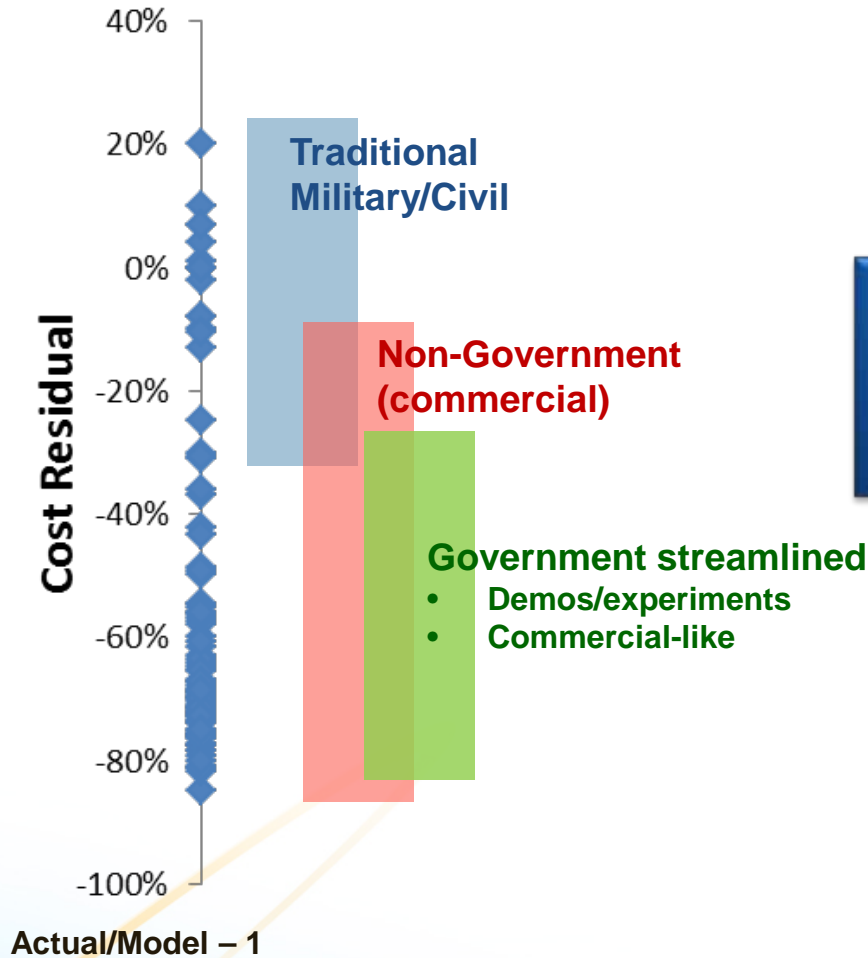
- EVM Center of Excellence

...“Is the baseline executable?”



A Cost Continuum

Our traditional satellite cost model vs.
93 completed programs:



Demos and commercial acquisitions can cost a lot less

- Not a fixed decrement
- Details matter



Study Goals

- Score the mission assurance and acquisition complexity of any satellite program
 - + Demo, commercial-like, traditional
 - + Datasheets for parts, testing, contracting, and oversight
- Show impact on cost
- Identify acquisition practices that align with program complexity



Some Background

- 2008 à NRO CAAG quantifies impact of “acquisition complexity” for commercial-like FFP acquisitions, focusing on communication satellites¹

- 2009 à NRO Director requests wider comparison to include all DoD and NRO systems, focus on mission assurance impact

- 2013 à NRO/CAAG and NRO/Systems Engineering Directorate quantify cost of high-reliability electronic **parts** and environmental **testing** standards²

- 2016 à Improved test-scoring method; unified model presented today

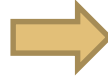
¹ Alvarado, Wilmer, D. Barkmeyer and E. Burgess. Commercial-Like Acquisitions: Practices and Costs. *Journal of Cost Analysis and Parametrics*, Volume 3, Winter/Spring 2010.

² Burgess et al., *Cost of Mission Assurance for Space Programs*, 2013 ICEAA Professional Development and Training Workshop, New Orleans, LA, June 2013.

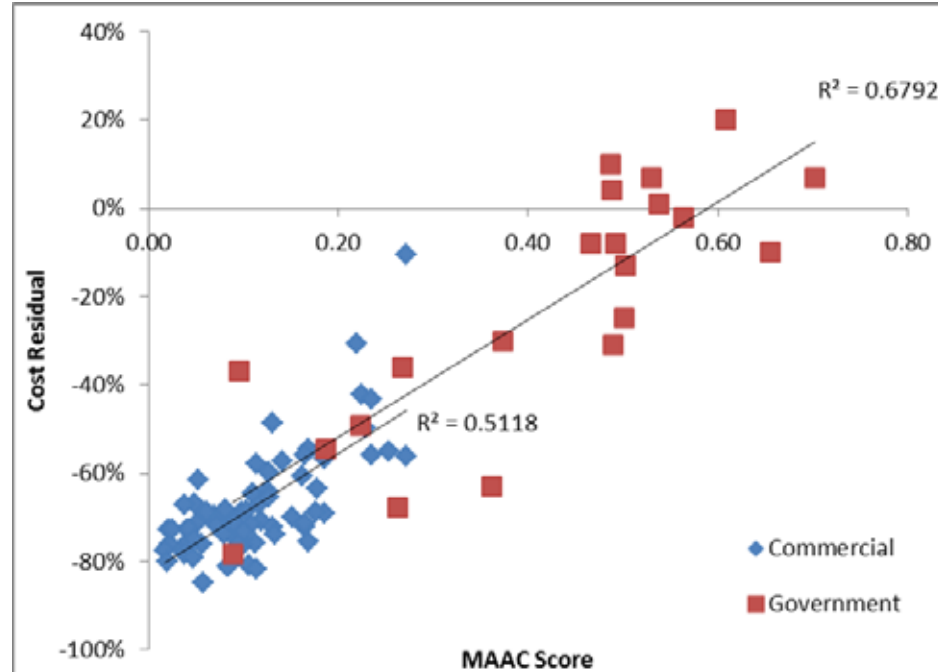
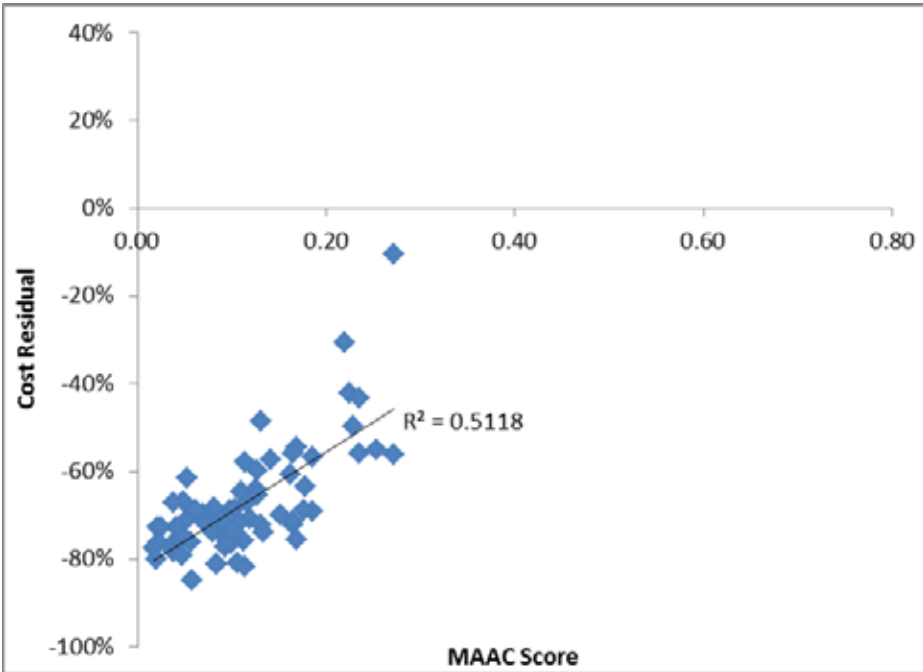


Then and Now

2009: Commercial FFP Study



2016: Extension to All Acquisition Types



2009 Commercial Acquisition Complexity Study has been extended to include all acquisition approaches, with a focus on Mission Assurance



Integrated Model

Incorporate Results from Completed Studies into Single Dataset.

- Add Other Programmatic Drivers (w_i).
- Develop model weighting factors by regression of all data.

$$\begin{aligned} \text{MAAC Score} = & [\text{CAPS Score}] \times a \\ & + [\text{Parts score}] \times b \\ & + [\text{Test score}] \times c \\ & + [\text{contract type: FFP, FPI, CP}] \times d \\ & + \mathring{a} [\text{other programmatics}] \times w_i \end{aligned}$$



Formulating MAAC Score

- A program's rating in any MAAC driver, i , is “normalized” by converting it to a position within the dataset for that aspect (0-1):

$$X_{i_{norm}} = \frac{x_i - x_{i_{min}}}{x_{i_{max}} - x_{i_{min}}}$$

- Overall MAAC Score is a weighted average of each $X_{i_{norm}}$

$$\text{MAAC Score} = \frac{\sum w_i X_{i_{norm}}}{\sum w_i}$$

$X_{1_{norm}}$ = CAPS normalized parameter

$X_{2_{norm}}$ = Testing normalized parameter

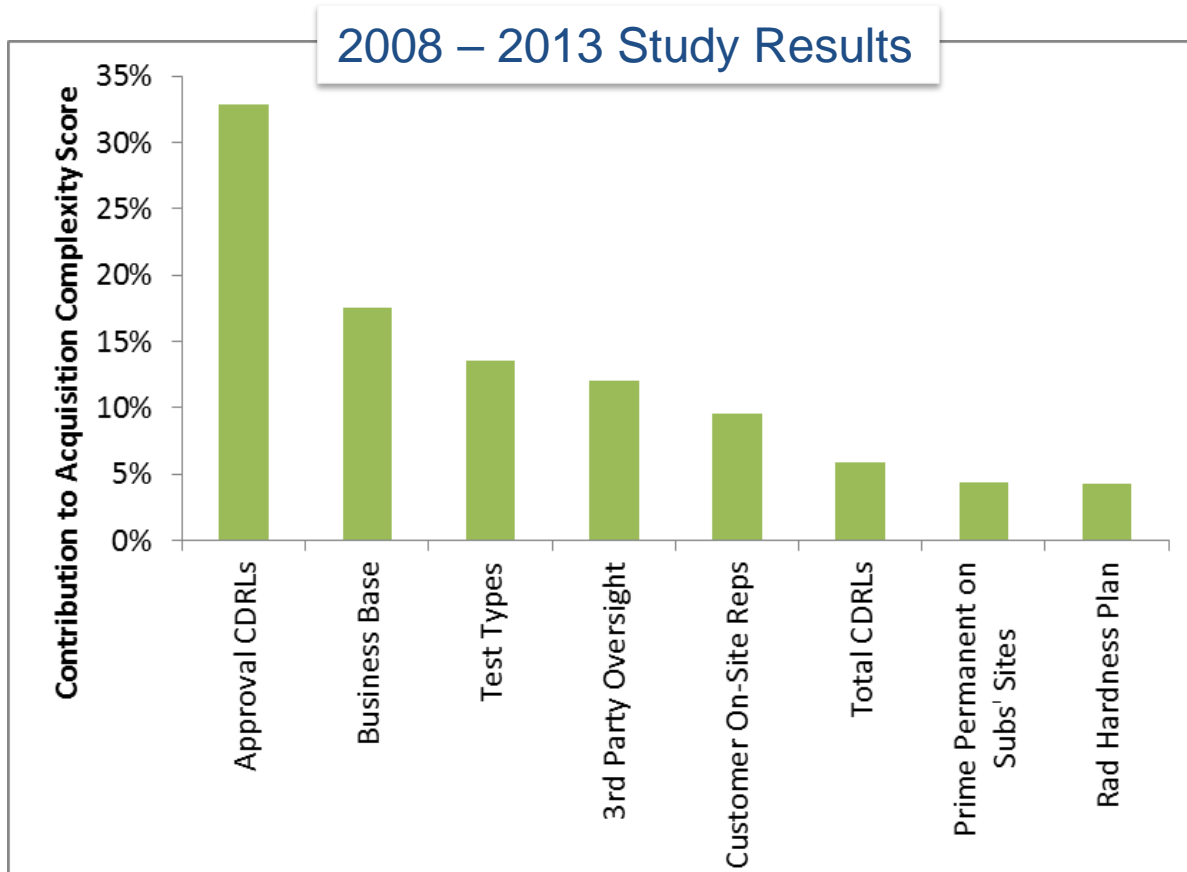
$X_{3_{norm}}$ = Parts oversight normalized parameter

... *etc.*

- Weights, w_i , are estimated by regression



Commercial-Acquisition Program Score (CAPS)



- Combination of parameters gives a “score” that correlates with cost and schedule
- Based on 70 FFP comsats and imagers
- Government and commercial customers



Parts Cost Drivers (1 of 2)

- Procurement, screening, destructive physical analysis, testing, parts engineering costs are driven by practices in 5 areas
 - NRO CAAG collected actual requirements/practices from multiple government and commercial contracts
 - Example “Parts, Materials, and Processes (PMP) data sheet” for NRO gold standard:³

Parts, Materials and Processes	RATING
1. PMP Control Program Scope	Check if applicable
Documented PMP control program?	<input checked="" type="checkbox"/>
Verify vendors/subs meet PMP requirements?	<input checked="" type="checkbox"/>
Please describe methods used for verification.	<input checked="" type="checkbox"/>
Addresses shelf life?	<input checked="" type="checkbox"/>
Addresses reuse?	<input checked="" type="checkbox"/>
Addresses derating?	<input checked="" type="checkbox"/>
Prime flows down derating requirements to vendors/subs?	<input checked="" type="checkbox"/>
Addresses freshness/revalidation process?	<input checked="" type="checkbox"/>
Addresses traceability and lot control?	<input checked="" type="checkbox"/>
New technology review board?	<input type="checkbox"/>
Prime flows down new tech review requirements to vendors/subs?	<input checked="" type="checkbox"/>
Corrosion/contamination prevention and control plan?	<input checked="" type="checkbox"/>
Corrosion/contamination control board separate from PMPCB?	<input type="checkbox"/>
Prime maintains As-Built PMP List?	<input checked="" type="checkbox"/>
ABPMPL traceable to what level?	card/board
As-Built parts tracked electronically?	<input checked="" type="checkbox"/>

Parts, Materials and Processes	RATING
2. Radiation Hardness Requirements	<input checked="" type="checkbox"/>
Radiation hardness assurance control plan?	<input checked="" type="checkbox"/>
Radiation hardness testing subcontracted?	<input type="checkbox"/>
Radiation hardness margin below which lot testing required	10X
ELDRS testing required?	<input checked="" type="checkbox"/>
3. PMP Control Board	
Program has PMP control board?	<input checked="" type="checkbox"/>
Number of organizations represented on prime's PMPCB	2
Subs permitted to run their own PMPCBs?	<input checked="" type="checkbox"/>
Customer represented on suppliers' PMPCB?	<input checked="" type="checkbox"/>
Customer rep on PMPCB has right of approval/disapproval?	<input checked="" type="checkbox"/>
Frequency & duration of PMPCB meetings	none



Parts Cost Drivers (2 of 2)

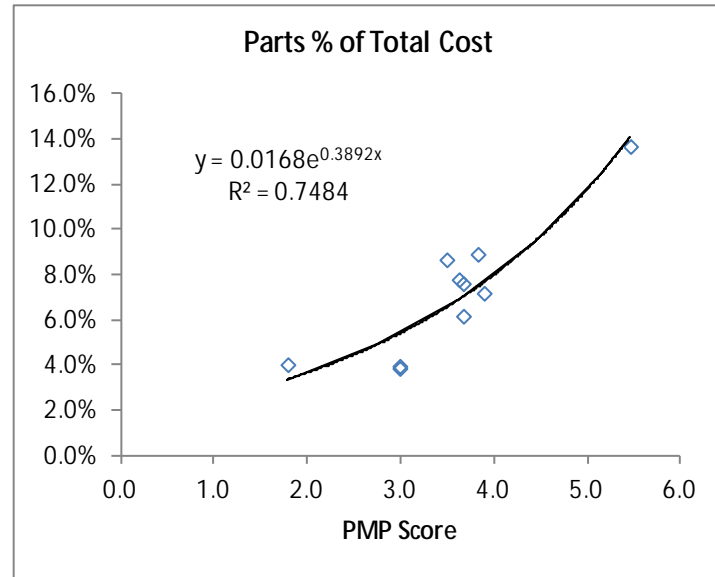
- Example “PMP data sheet” for NRO baseline (continued):

Parts, Materials and Processes	RATING
4. Destructive Physical Analysis	
Percentage of part types requiring DPA	TBD %
Number of units per lot undergoing DPA	5
DPA performed on mil-spec parts?	<input checked="" type="checkbox"/>
Cost threshold beyond which DPA sample size reduced	none
5. Parts Quality Assurance	
Percentage of parts requiring upscreening	TBD%
Percentage of parts considered hi-rel	TBD%
Reuse of parts permitted?	<input checked="" type="checkbox"/>
Time limit beyond which qualification by similarity not permitted	none
Number of PARs & MARs	TBD
PAR required for parts on Space Quality Baseline?	<input checked="" type="checkbox"/>

- Relative importance (costliness) of each section suggested by NRO subject matter experts yields a “PMP Score”



Higher PMP Standards Drive Parts Costs



- PMP score is a weighted average of PMP data-sheet responses
 - Weights based on subject-matter expert guidance
 - Actual costs from completed contracts
- Many other factors affect parts costs, but relationship to PMP standards is clear



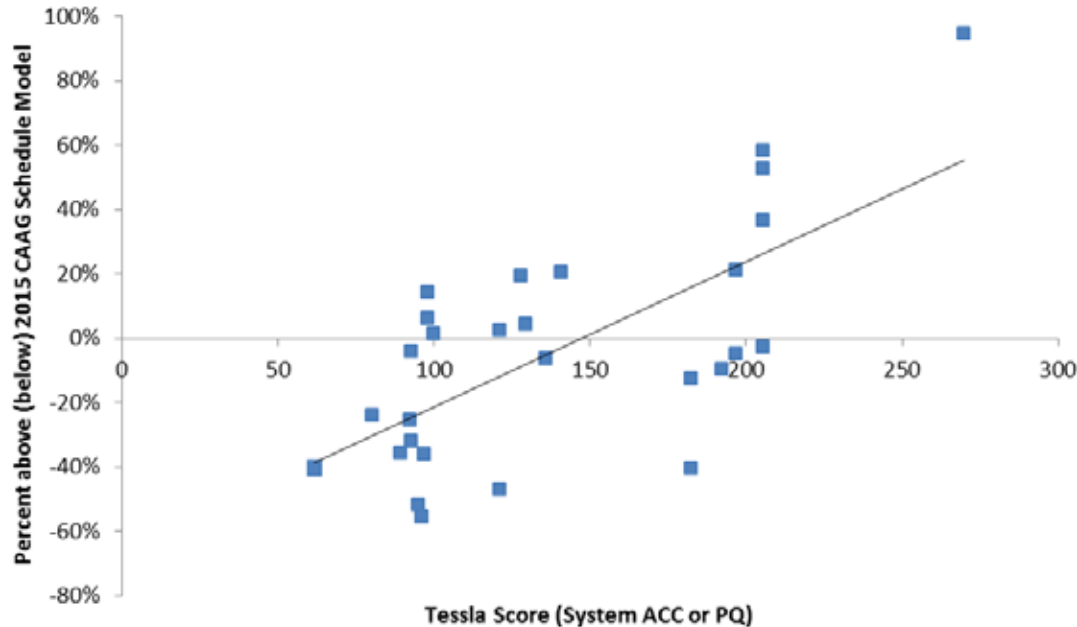
Environmental Testing Model

- NRO/SED developed a new quantitative measure of the level of environmental testing
 - The scoring model (Tesla) is based on MIL-STD 1540E
 - Assesses test compliance, not test quality
 - 1540E used as a standard measure, across acquisition programs that may have been tested to an earlier version of 1540 or to other standards altogether
- Tesla generates 6 “scores” for each program
 - 3 Unit-level scores: Qual, protoqual, acceptance
 - 3 System-level scores: Qual, protoqual, acceptance
- Preliminary results are in:
 - Satellite I&T cost is strongly correlated
 - Satellite testing duration is strongly correlated
 - Differences among NRO programs are clear



Higher system-level score is associated with longer I&T schedule

System Test Duration vs. Tesla Score



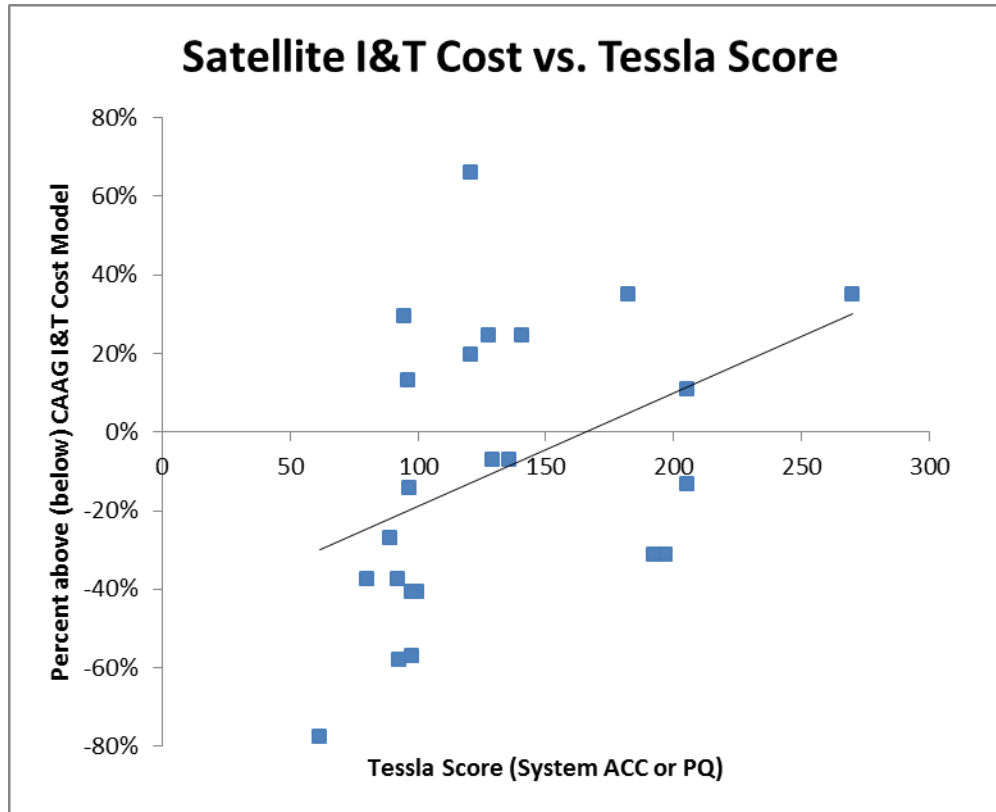
	Correlation	Slope*
Mean	.68	0.45%
Lower 20% confidence	.59	0.37%
Upper 80% confidence	.76	0.53%

*percent test-schedule increase per unit score

- This is a strong association
- Upper and lower bounds can be used for risk analysis



Higher system-level score is associated with greater I&T cost



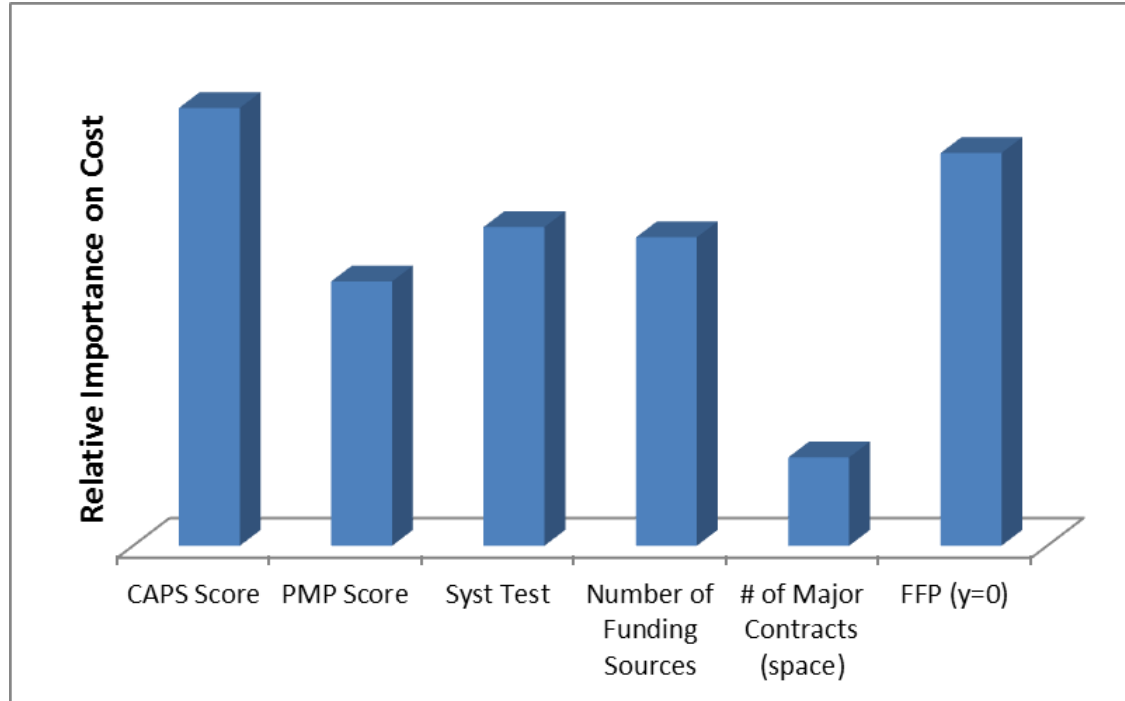
	Correlation	Slope*
Mean	.41	0.29%
Lower 20% confidence	.25	0.18%
Upper 80% confidence	.56	0.40%

*percent I&T cost increase per unit score

- This is a strong association
- Upper and lower bounds can be used for risk analysis



Regression Results: Integrated Model

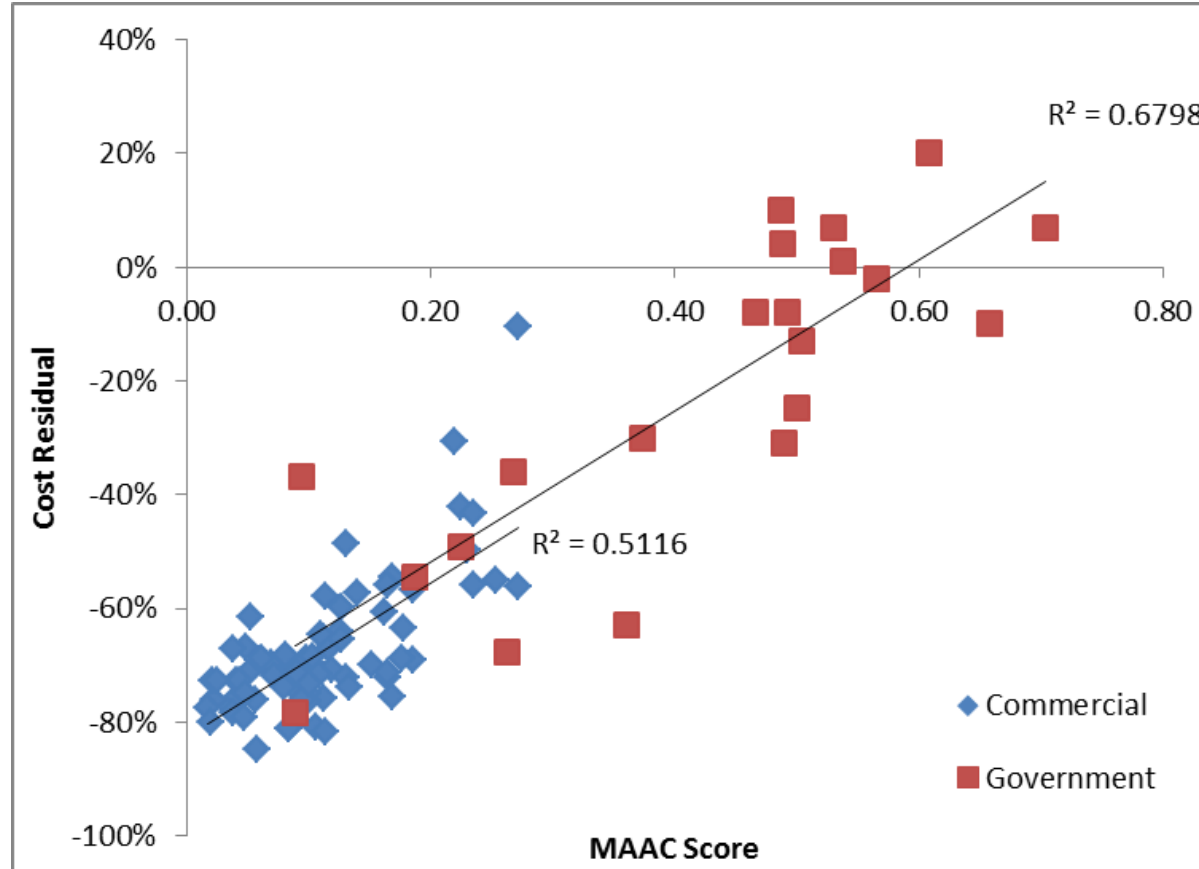


- Aggregate dataset is large
- Regression imputation allows for missing data

count	
93	Cost Data Available
98	CAPS Score
70	PMP Score
75	Syst Test
30	Number of Funding Sources
97	# of Major Contracts (space)
98	FFP (y=0)



Commercial vs. Government



Combined Model Correlates Well for a Wide Range of Commercial and Government Acquisitions



Conclusions

- HOW we buy satellites affects their cost
- New CAAG methods can adjust for these differences among programs
 - A continued focus of our cost research
 - Industry contributions have been valuable
- Modeling approach should translate to other commodities
 - Anything where acquisition practices vary widely