Estimating Commercial-Like Satellite Programs

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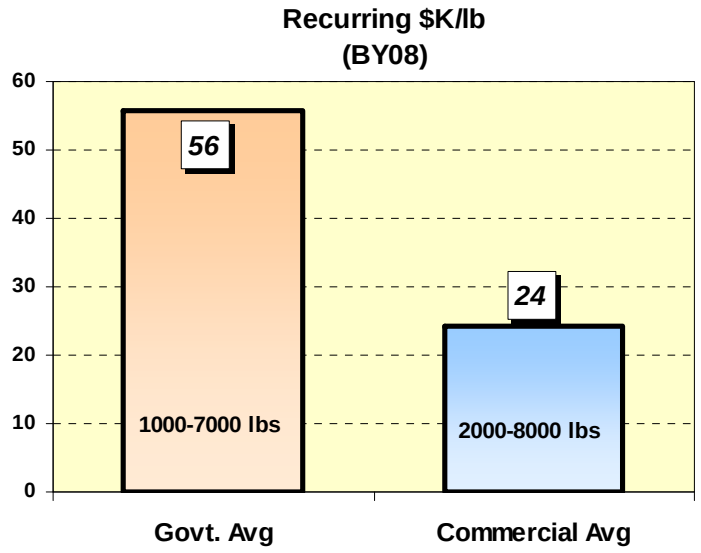
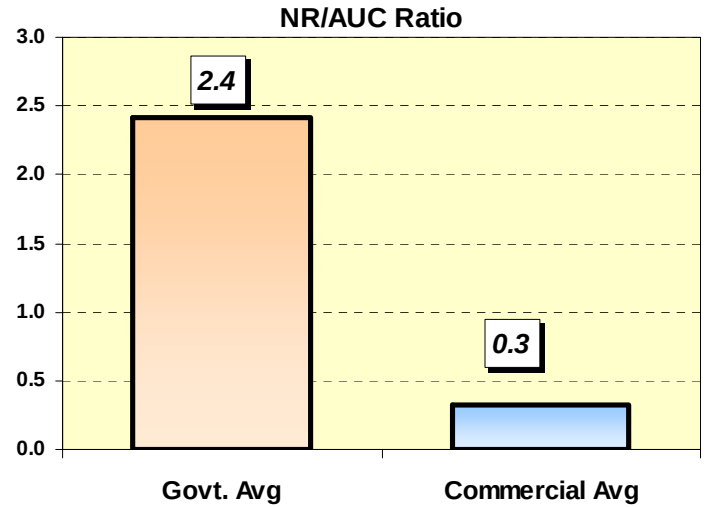
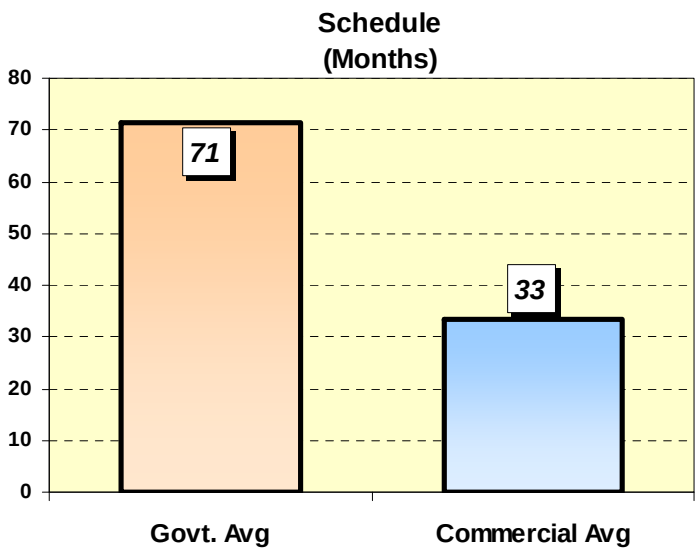
Agenda

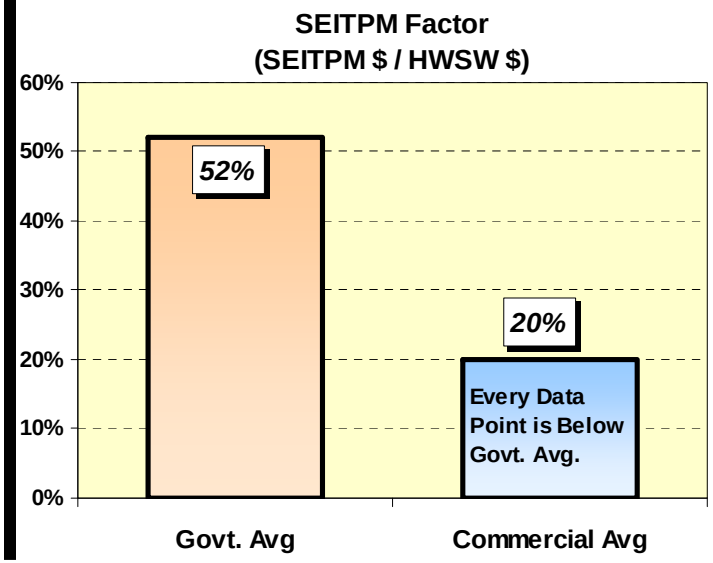
- Commercial-Like Acquisitions
- Developing a Commercial-Like Estimating Model
  - Data collection
  - Analysis and Regression
  - Results

Commercial vs. Government* Comsats









* U.S. DoD, NASA, and NRO Comsats

Commercial-Like Acquisitions

Since 1970s, U.S. commercial space industry hailed as a model of success*

- Lower costs
- Shorter schedules
- Less growth

Government often attempts to imitate

- Use a contractor's product-line bus
- Award a fixed price contract (FAR part 12 or 15)
- Take delivery on orbit

Result is called a "commercial-like" acquisition

- Results have been mixed

* See, for example, GAO report LCD-79-108: "Relative Performance of Defense and Commercial Communications Satellite Programs," August 1979

The Problem

- Government “commercial-like” programs often much more expensive than pure commercial
- Costliness driven by two factors
  - Technical complexity
  - Acquisition complexity

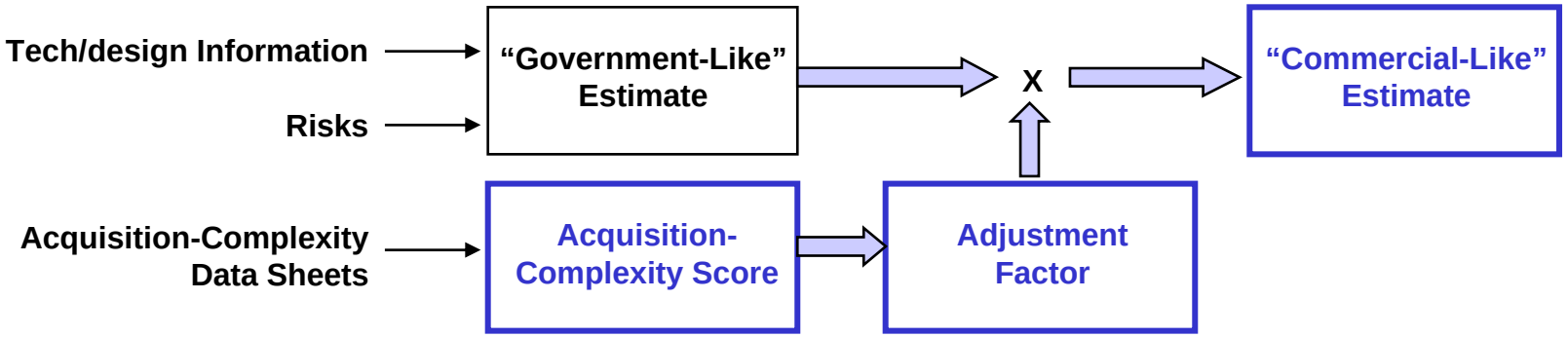
Technical Complexity	Acquisition Complexity
•Performance, SWAP, new technologies, heritage, etc. •Defined, measured, & modeled by existing cost methods	•Oversight, contracting, reporting, etc. •Varies among commercial and Gov’t programs •Need to define, quantify, and incorporate in cost models

NRO Study: Commercial-Like Estimating

- Goal:
  - Defensible basis for estimating commercial-like acquisitions
- Approach:
  - Focus on quantifying **acquisition** complexity
  - Leave **technical** complexity to other studies
- Data collection:
  - Earned access to actual cost (not price), technical, and acquisition complexity data on over 60 comsats & imagers
  - Conducted program reviews with contractor personnel

    (Lockheed Martin, Boeing, Space Systems/Loral, General Dynamics, Orbital Sciences, Ball Aerospace)
- Methods development:
  - Quantify acquisition complexity
  - Show impact on costliness

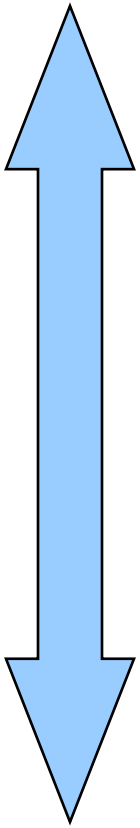
Envisioned Estimating Process



- Leverage substantial experience with traditional government models
- Use acquisition complexity to explain residual errors

Acquisition Complexity

Traditional Government



Hands-Off Commercial

Factors That Drive Acquisition Complexity Up Or Down:

- ❑ Type Of Contract
- ❑ Scope Of Contract (Launch Interface, Ground Interface, Etc.)
- ❑ Industrial Base
- ❑ Technology And Manufacturing Maturity
- ❑ Requirements Stability
- ❑ Amount Of Development Hardware & Obsolescence
- ❑ Vehicle Test Requirements
- ❑ EMI/EMC Requirements
- ❑ Parts, Materials, Processes (PMP)
- ❑ Documentation Delivered (CDRLs)
- ❑ 3rd Party Oversight (Aerospace, SETAs, System Integrators, Etc.)
- ❑ Subcontractor Management/Auditing/Reporting Requirements
- ❑ Program/Design Reviews
- ❑ Number Of Customer On-Site Reps
- ❑ Number Of Customer Personnel Dedicated To Program (Off Site)

Use Data Sheets to Collect Details in Each Area on Each Program

Complexity-Modeling Challenges

- **Combine quantitative and qualitative information, for example:**
  - **Quantitative: Number of CDRLs (15 to 175), number of on-site reps**
  - **Qualitative: Scope of contract, breadth of test program**

- **Large number of factors to consider**
  - **Some may be correlated with each other**
  - **Some may already be modeled by traditional methods (e.g., percent new)**
  - **Some are not known at program inception (e.g., number of requirements changes)**
  - **Easy to "over-fit" the data**

- **No *a priori* assumptions about which factors should dominate**
  - **All factors on data sheets may drive cost**
  - **Our job is to prove it**

Quantifying Complexity Drivers

Evaluate all drivers on data sheets

# of Scope aspects to contract	End users in reviews (yes/no)
Spacecraft TRL	System integration oversight (yes/no)
Spacecraft %New	External consultants hired by customer (yes/no)
# of TVAC test cycles	
# of different tests in testing program	FFRDC oversight (yes/no)
Vendor mgmt program (yes/no)	Customer access to subs (yes/no)
Rad hardness plan (yes/no)	Prime in sub design reviews (yes/no)
PMP control board (yes/no)	Prime permanent on subs' sites (yes/no)
Limited upscreening (yes/no)	PMRs per year
# of CDRLs	# of Reviews
# of one-time submittal CDRLs	# of customer on-site reps
# of approval CDRLs	# of customer off-site reps

Eliminate some:

- **Drivers with many blanks**
- **Drivers with little variation among programs**
- **Percent new and TRL**

Combine some:

- **Scope Breadth: Number of scope aspects on the contract (ground station, launch, O&M, etc.) beyond delivery of spacecraft to the prime**
- **Testing: Number of different types of system-level test**
- **3rd party oversight: Equals 0 if neither FFRDC nor SETA oversight, 1 if either, 2 if both**

Use final list to formulate an "Acquisition Complexity Score" for each program

Formulating AC Score

- **A program's rating in any AC 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 AC Score is a weighted average of each** $X_{i_{norm}}$

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

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

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

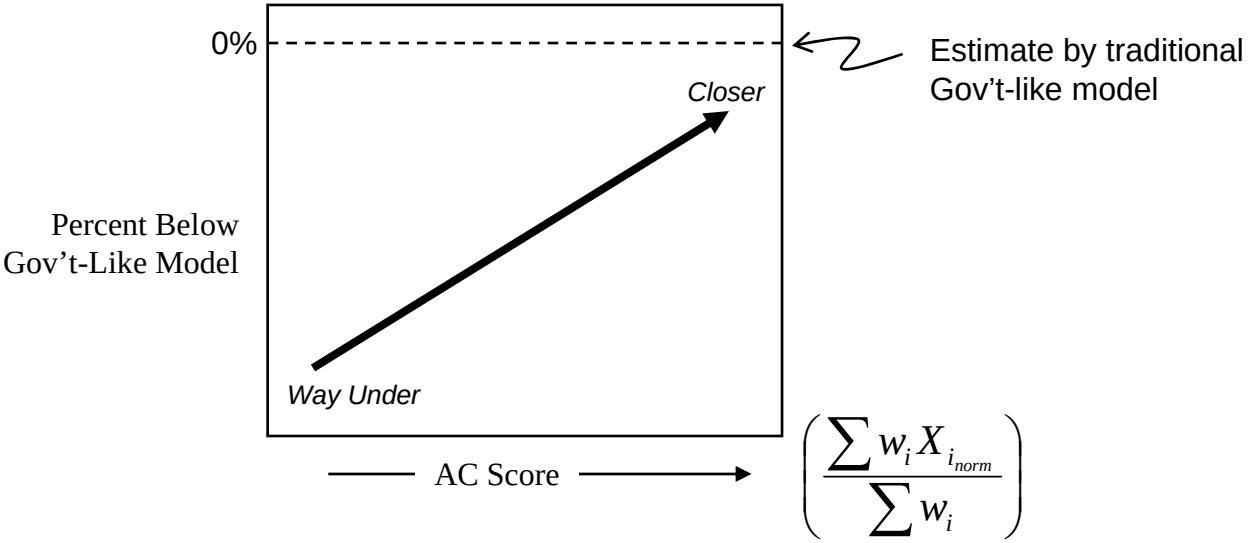
$X_{3_{norm}}$ = 3rd - party oversight normalized parameter

... etc.

- **Weights, w_i, are estimated by regression**

Regression Approach

Theory: **Traditional Gov't-like model* overestimates less for programs with high AC Score**



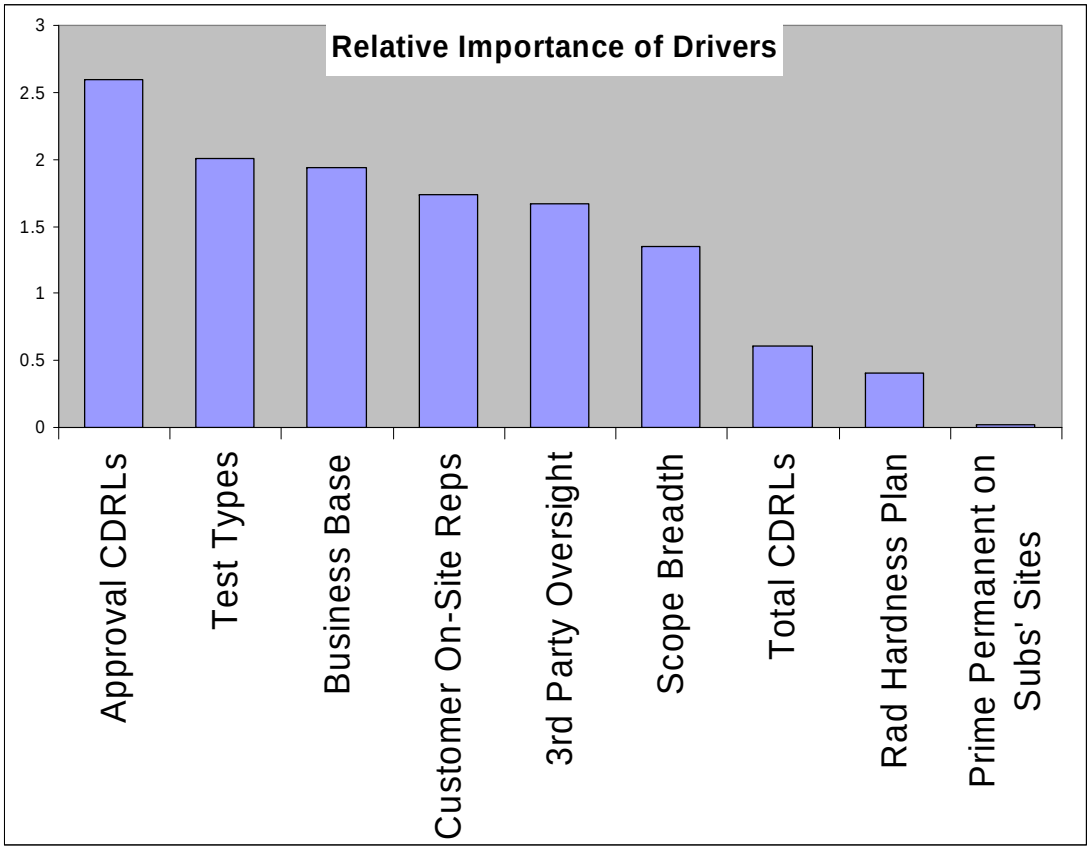
$$\text{Adjustment Factor} = a + b \cdot \{\text{AC Score}\}$$
$$\text{Commercial-like Estimate} = \{\text{Adjustment Factor}\} \cdot \{\text{Gov't-like Estimate}\}$$

Constants a, b, and weights, w_i are estimated by regression

- **Minimize sum of squared percent errors between commercial-like estimates and actuals**
- **Constrain to zero average percent error**

*See 41st Annual DODCAS presentation: "Satellite Subsystem Development Costs," Burgess, E. and Menton, N. February 2008.

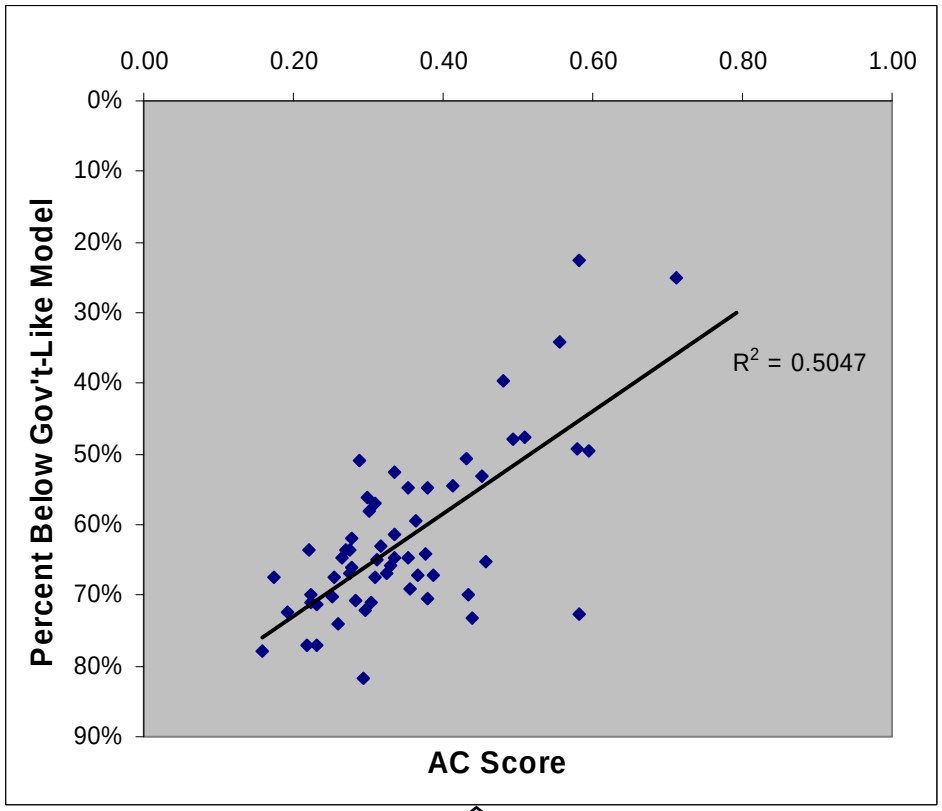
Regression Results

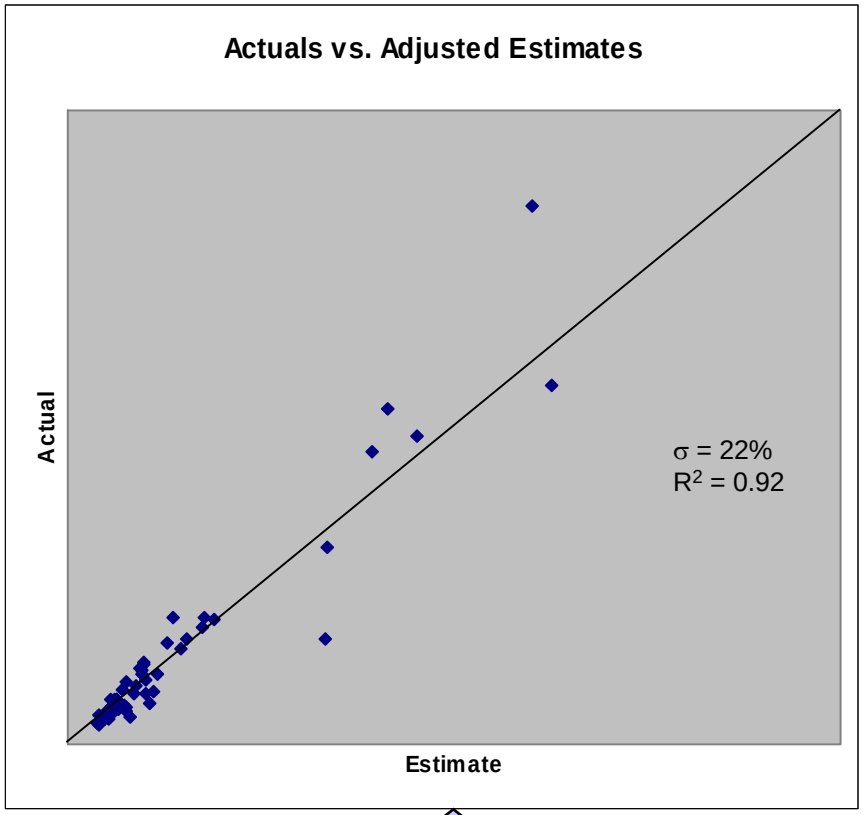


$$\text{Adj. Factor} = 0.129 + 0.719 \times (\text{AC Score})$$

Parameter x_i	Weight (W_i)	x_{min}	x_{max}
# Approval CDRLs	2.59	0	75
Types of Testing	2.00	6	10
Plant Business Base at ATP	1.94	46	3
# Customer On-Site Reps	1.74	0	35
3rd Party Oversight Types	1.67	0	2
Scope Breadth	1.35	0	9
Total # CDRLs	0.61	15	175
Rad Hardness Assurance Plan (y/n)	0.40	0	1
Prime Presence Permanent on Subcontractors' Sites (y/n)	0.02	0	1

Impact on Total-Cost Estimate



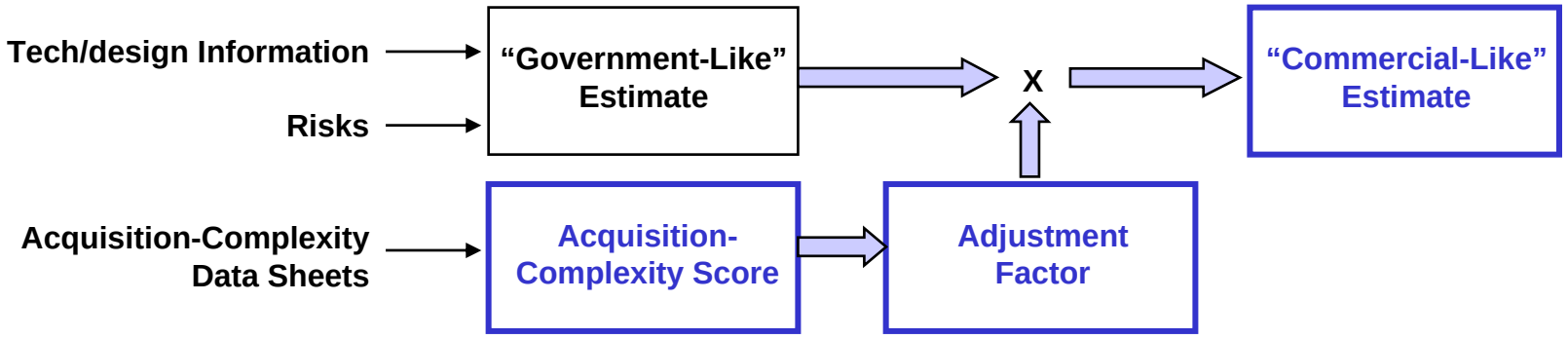


AC Score explains differences between Gov't-model estimate and actual cost.

Actual and estimated costs are in good agreement after applying this model.

Conclusions

- **Acquisition complexity:**
  - **Can be computed**
  - **Helps explain cost differences among commercial and commercial-like programs**
  - **Is being used for NRO estimates**



- **Industry participation in this study was invaluable**
  - **Access to very sensitive data**
  - **Input from experienced program managers, system engineers, and contract/pricing managers**