SYSTEMS PLANNING & ANALYSIS

Cost Estimation: A Psychological Framework for Mitigating Bias

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Overview

- **Challenges in Early Cost Estimation**
  - evolving mission needs
  - uncertainty in solution space
  - stakeholder biases
- **Biases and Influences on Estimates**
  - over-optimistic or unrealistic outcomes
  - fail to reflect system complexity, technology, and risks

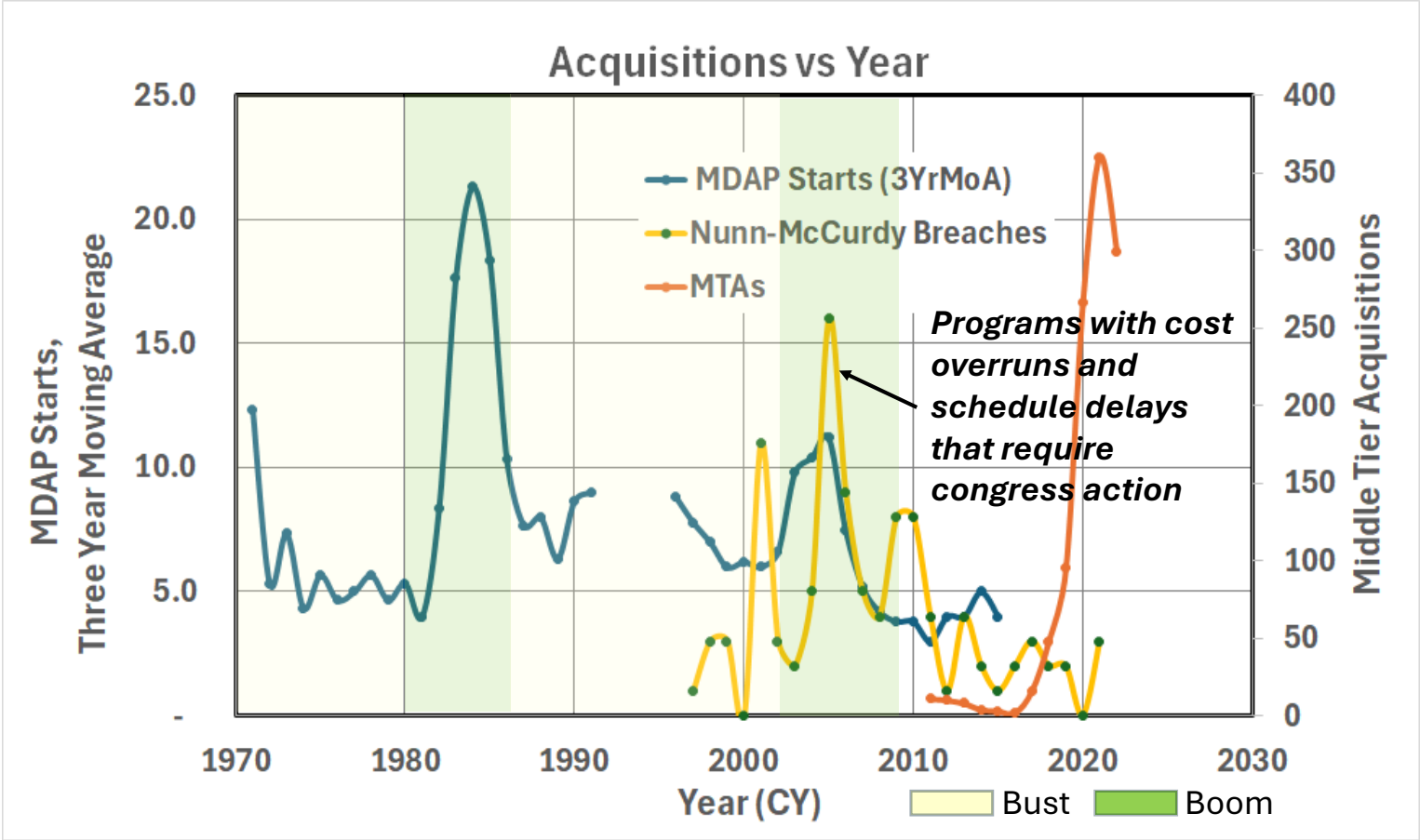
- **Need for Rigorous Estimation Processes**
  - initial point estimates expanded with uncertainties, risks, and probabilistic methods like Monte Carlo simulations
- **Behavioral Models and Decision Biases**
  - “Judge-Advisor System”, “Weight-of-Advice”, Averaging, and Overconfidence can simultaneously influence estimate

The presentation offers methods to identify and correct biases in cost estimates, with examples and tools to improve accuracy and alignment of mission scope, technology, and schedules with cost forecasts

Historical program assessment

- Middle Tier Acquisitions (MTAs) are intended to provide more efficient acquisitions and risk reduction prior to entering an MCA by reducing:
  - qualifications
  - durations
  - milestone reviews

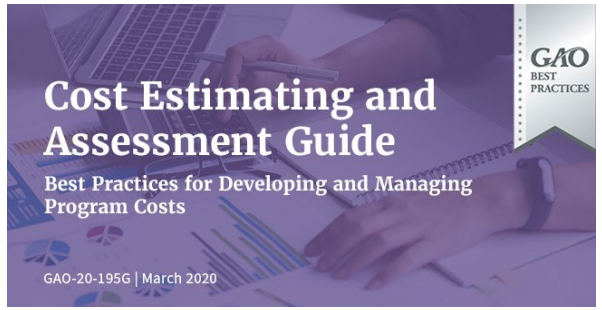
- Regardless of the acquisition format, bias in estimating is still prevalent and needs to be addressed for accurate planning

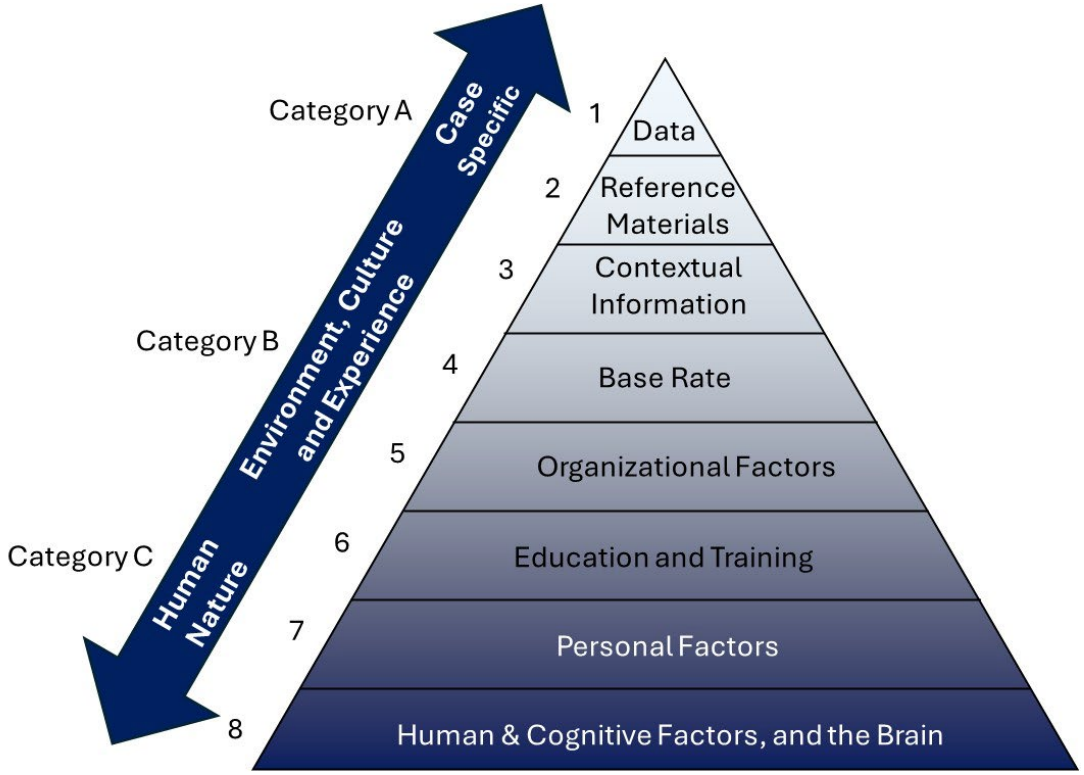


*Nunn-McCurdy breaches require report to Congress when a Major Defense Acquisition Program (MDAP) experiences significant cost overrun

Dror's eight cognitive biases

"Bias can originate from different sources, such as over-optimism, group think, dominating personalities, inexperience, or pressure from management" –GAO-20-195G





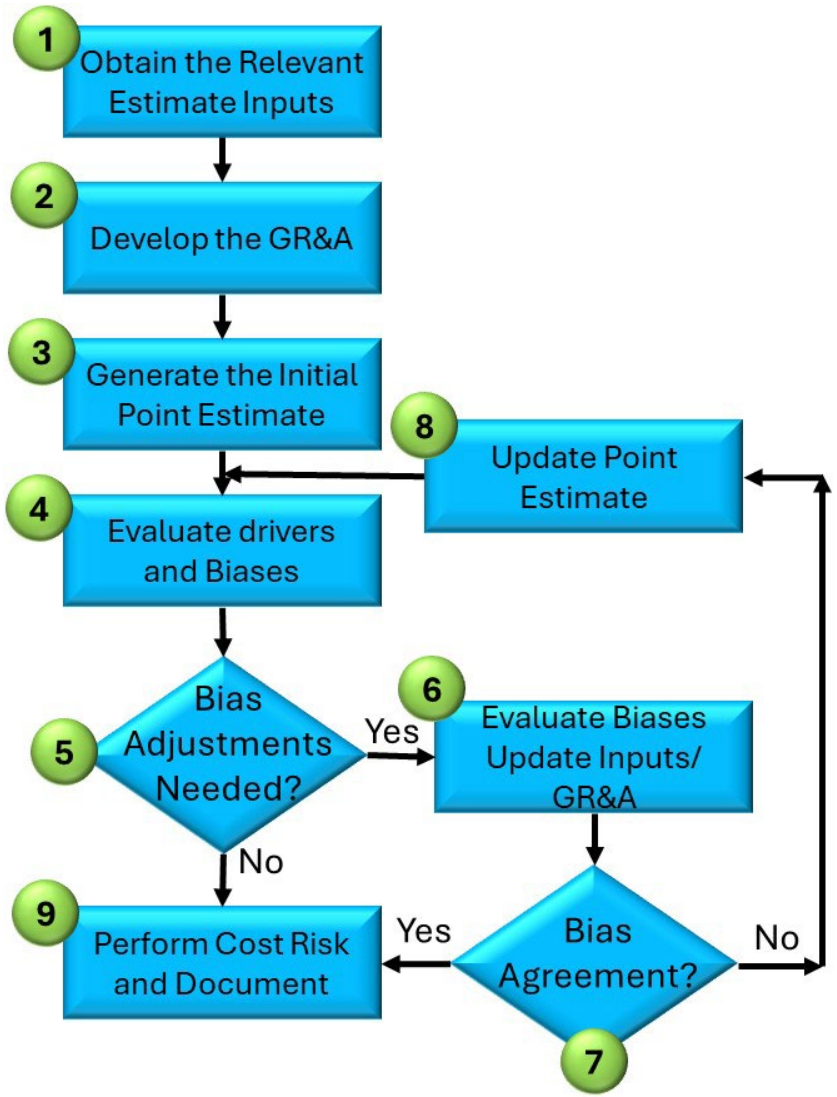
- All of these bias sources may drive cost estimate outcomes
- Understanding where bias within an estimate is can be difficult to identify and mitigate
- Even a risk adjusted estimate may not capture all bias

GAO guidebook bias sources and Dror's eight cognitive biases

- The impacts of bias have strong interactions with each other
- The human interaction of each is interrelated and can influence each other driving cost estimates

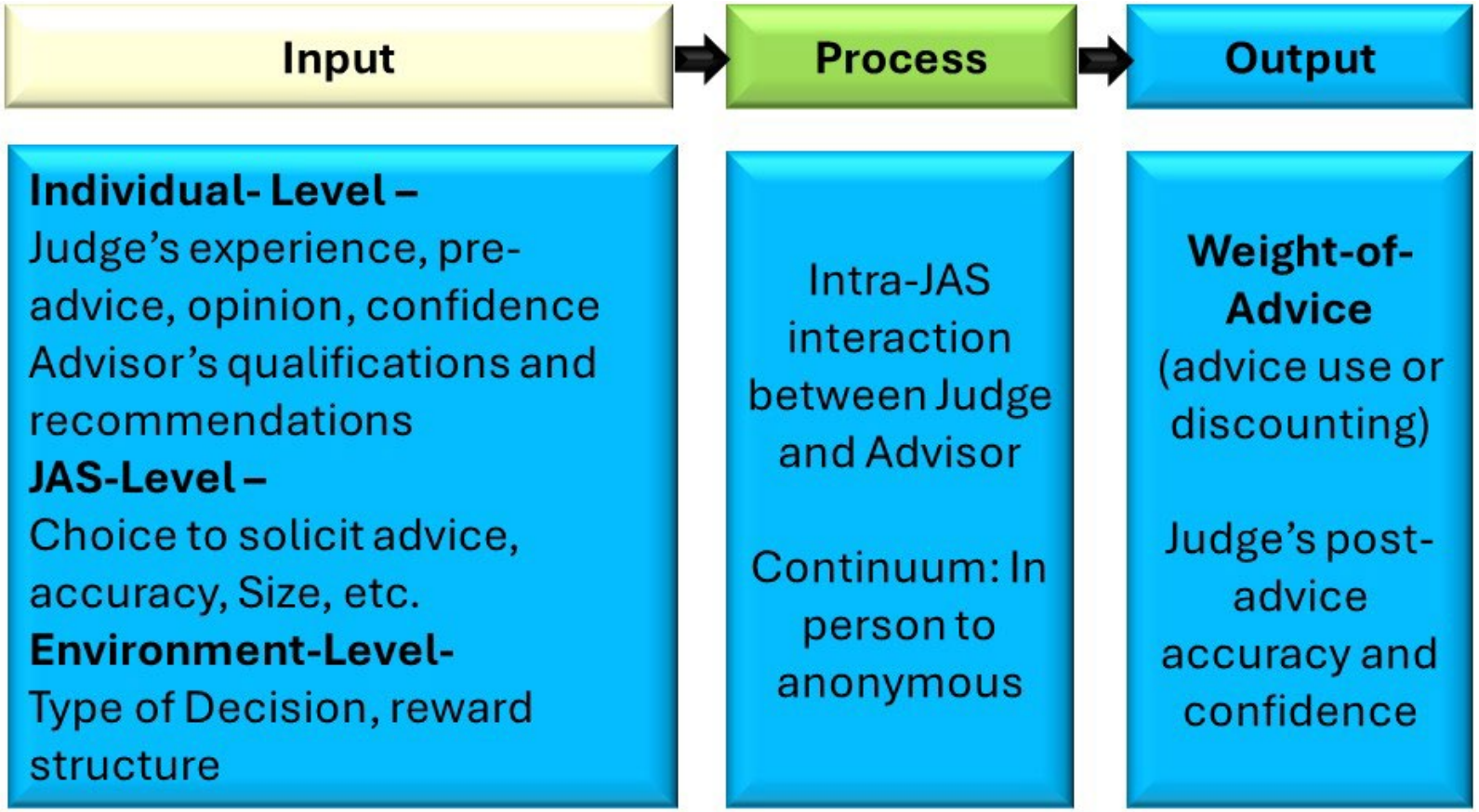
Item	Bias Sources	1. Data	2. Reference Materials	3. Contextual Information	4. Base Rate	5. Organizational Factors	6. Education and Training	7. Personal Factors	8. Human & Cognitive Factors, and the Brain
A	Over-Optimism	◆	◆		◆			◆	
B	Group Think			◆	◆	◆		◆	◆
C	Dominating Personalities							◆	
D	Inexperience		◆				◆		
E	Pressure from Management					◆		◆	
F	Data Bias	◆	◆	◆					

Bias Evaluation Process



- *Recognize Biases:* Understanding them is the first step to mitigating their effects
- *Use Decision-Making Frameworks:* Implement frameworks like SWOT analysis or a decision matrix to systematically evaluate options
- *Seek Diverse Perspectives:* Engage with colleagues, friends, or mentors who may have different viewpoints questioning and challenging ideas is welcomed
- *Base Decisions on Data and Challenge Assumptions:* Verify the facts and look for empirical data behind your assumptions
- *Take Your Time:* Avoid snap decisions. Allow time for reflection to process information more thoroughly
- *Question Your Thought Processes:* Ask yourself whether your thoughts are based on facts or distortions
- *Prioritize Information:* Focus on the most relevant data to avoid being overwhelmed by excessive information that can lead to paralysis by analysis.
- *Avoid Confirmation Bias:* Seek out information that contradicts your views to gain a more balanced perspective.

Judge-Advisor System



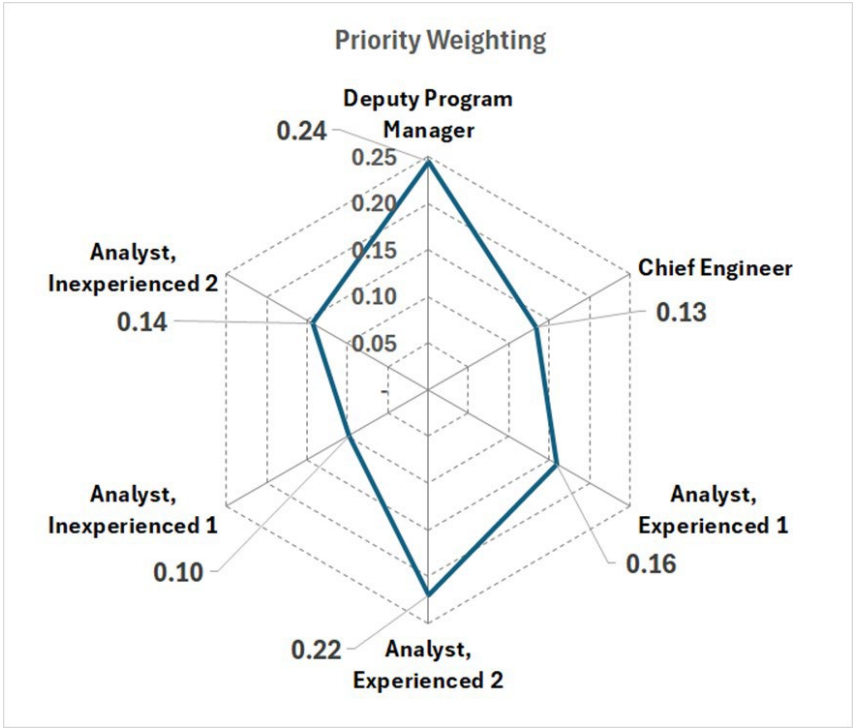
$$\mathbf{WOA} = ((\mathbf{FE} - \mathbf{IE}) / (\mathbf{Advice} - \mathbf{IE})) \quad (1)$$

Where:

IE = Initial Estimate
FE = Final Estimate
Advice = Output from Judge
WOA = Output Weighting Factor

Example

- Group discussed cost inputs to be used on the cost analysis requirements description (CARD) for a new space mission
  - maturity of the system being estimated
  - availability and validity of data for some of the payloads based on historical data and
  - operational concept and space environment
- The system being estimated is a space bus with three payloads
  - Two of the payloads are being modified
  - One is a new design
- Group is comprised of six participants
  - deputy program manager (DPM)
  - chief engineer (CE)
  - four analysts
- Analysts are split with half experienced (AE) and half that are relatively new to the cost and system engineering environment (AN)



Questions

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