Innovative Risk-Driven Contract Pricing Strategy

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Innovative Risk-Driven Contract Pricing Strategy

This paper presents a framework that *quantifies* contract *risk* using a numerical evaluation of the factors that make or break a program or project.

The framework, in turn, is made *operational* by leveraging benchmarks from 40 U.S. naval contracts, enabling data-driven selection of *contract type*, *incentives*, and *share lines* for use in evaluating future contract prices.

Brian Flynn

Robert Nehring

Peter Braxton

Outline

Introduction – the Problem

Consolidation of the Industrial Base

Number of Prime Contractors

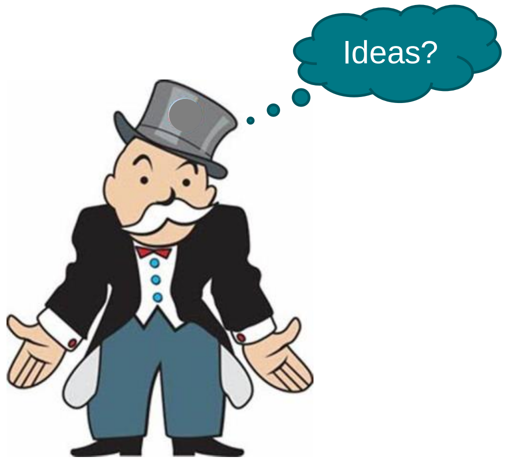
Type of System	1990	2023
Tracked Combat Vehicles	3	1
Ships and Submarines	8	4
Fixed-Wing Aircraft	8	3
Tactical Missiles	13	3
Satellites	8	4

> 50% drop

Less Competition

Oligopoly – at Best

Less Innovation?



Monopoly

Issues for Government & Industry

- Contract Type
- Incentive Packages
- Methods of Payment

Scoring Framework

Illumination of Risk

To produce a win-win

Government: Value for Money

Industry: Return on Sales

Note: Only one U.S. company builds carriers; only one builds amphibs; only two build subs

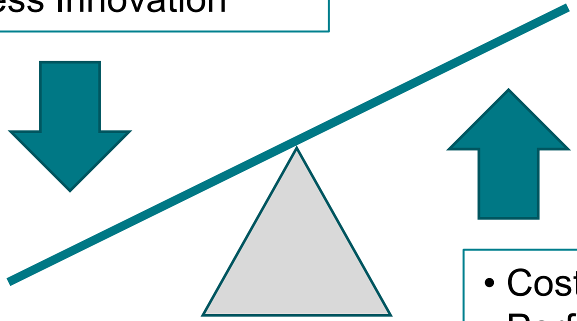
Introduction – the Need

"HIMARS produced sole-source in Camden, Arkansas, in what *used to be literally a* *diaper factory*"

"We need to get **technology** into **production**, **at scale**"

Dr. Bill LaPlante, USD(A&S)

- Less Capacity
- Less Competition
- Less Innovation



- Cost Growth
- Performance Issues

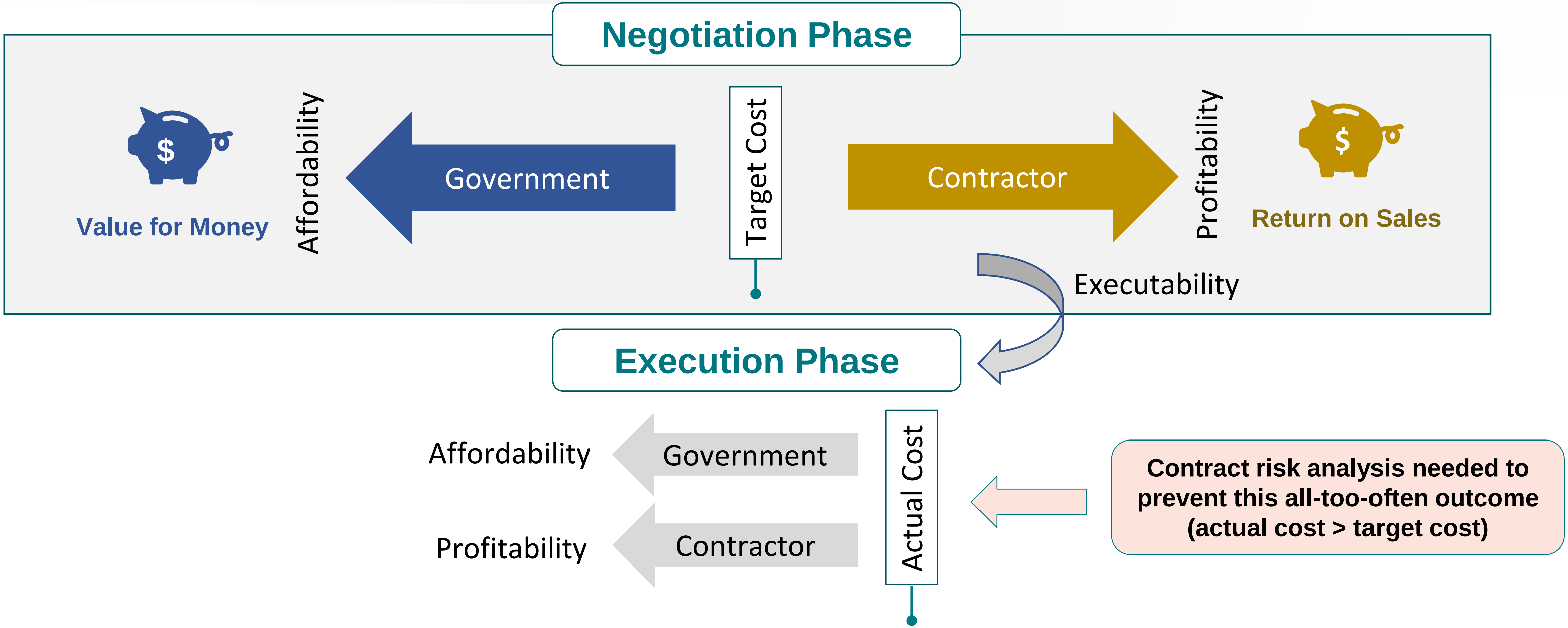
(e.g., JSF, CVN-78)

Joint Strike Fighter:
70% cost growth
(from original baseline)

Electromagnetic Aircraft Launch System:
100% cost growth

Urgency: Better align contract parameters with contract risk to achieve better outcomes

Introduction – the Challenge



Challenge: Set the **Target Cost** & other contract parameters during **negotiation** to align interests during **execution**

Elements of Risk – Program & Contract & CLIN

Stability of Requirements

Rock solid to fluid

Market Structure

Perfect competition to monopoly

Technology Stretch

Current to never-before-built

Contractor Readiness

Experienced to green company/workforce

Price Validation

ICE to ICA to POE to contractor proposal

Schedule

Easy-to-meet to challenging

Sound pricing strategy requires illumination of the risks that influence results

The Model

Overview

The Model uses a *weighted average* of scores for each of the six elements of risk, using *anchored*, *ratio* scales:

$$Total\ Risk = \mu_{w1}Risk_1 + \mu_{w2}Risk_2 + \ldots + \mu_{w6}Risk_6,$$

$$where\ \mu_{wi} = mean\ weight\ for\ Risk_i.$$

In a similar vein, ratio scales are used to assess the risk and uncertainty of individual contracts and CLINs associated with the programs and projects

Anchored Scale: Definitions are provided to assist in the scoring

The Model – Scoring Issues

1 Arrow's impossibility theorem:

- **Nobel Laureate, Economics**

No fair voting scheme exists (unless you like dictators)

Borda Count – imperfect but strong

2 Misuse of ordinal numbers:

- **Common in Economic Analyses & AoAs**

Must distinguish between the number, and what the number is measuring

- Nominal (categorical)
- **Ordinal** (includes rank order)

- **Ordinal** numbers are not **cardinal** numbers
- They're place holders
- Can't do arithmetic on them

Ratio Scales allow +, -, x, and / operations

Note: In 1950 Kenneth Arrow published his "Impossibility Theorem" (Nobel prize for it in 1972). For three or more alternatives and finite number of voters, then the only voting scheme that satisfies Transitivity and Unanimity and Independence of Irrelevant Alternatives is a dictatorship

The Model – Ordinal Numbers

Common Usage – *the numbers are merely shorthand*

❸ represents "Best"; ❷ represents "Second best"; and ❶ represents "Worst"

But Rank Order says nothing about the value of the Score, only the order of the Score

Issue – *meaningless to perform arithmetic on ordinal rankings*

Ordinal in Terms of Authority: E1 < E2 < … < E9 … < W1 … < O1 < O2 … < O10

❶ ≡ E1 ≡ Private

❷ ≡ E2 ≡ PFC ≡ 

❸ ≡ E3 ≡ LCPL ≡ 

$$\sum_{k=1}^{12} Private\ First\ Class_i > \text{Authority of the CMC!}$$

The Model – Modified Borda Count

Element #1	25
Element #2	**50**
Element #3	10
Element #4	15

100 Total Points

Element #2 is judged FIVE times more important or impactful than Element #3

Each scorer allocates a total of **100 points** among the four elements

This allows the scorers to both **rank** the elements in order of preference and to assign a **relative importance** between them

Traditional Rank Ordering [Most to least important]:

Element #2 > Element #1 > Element #4 > Element #3

(Most) *(Least)*

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The Model – the Weights

Stability of Requirements	15
Market Forces	10
Maturity of Technology	20
Contractor Readiness	20
Price Validation	25
Schedule	10

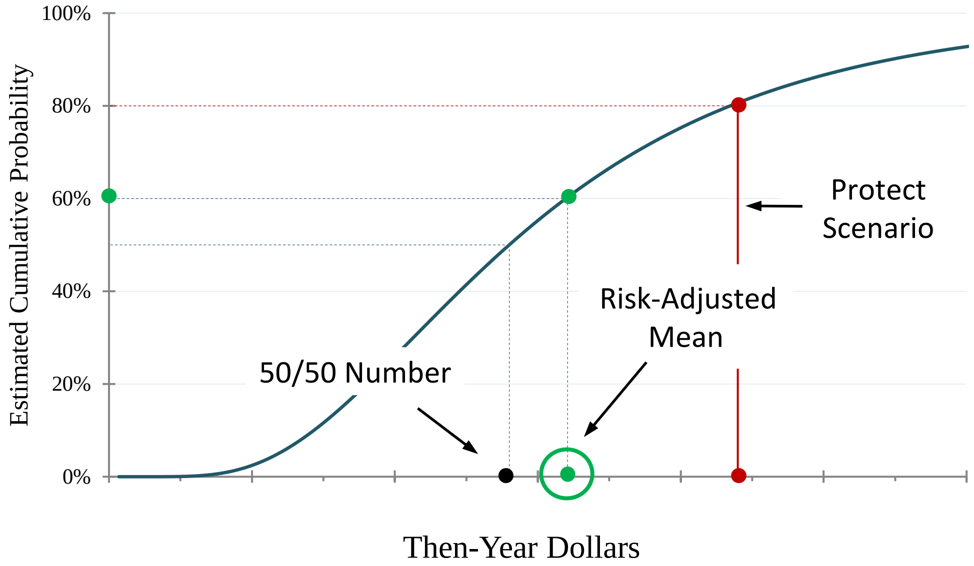
The Team's Scores

100 Total Points

Price Validation

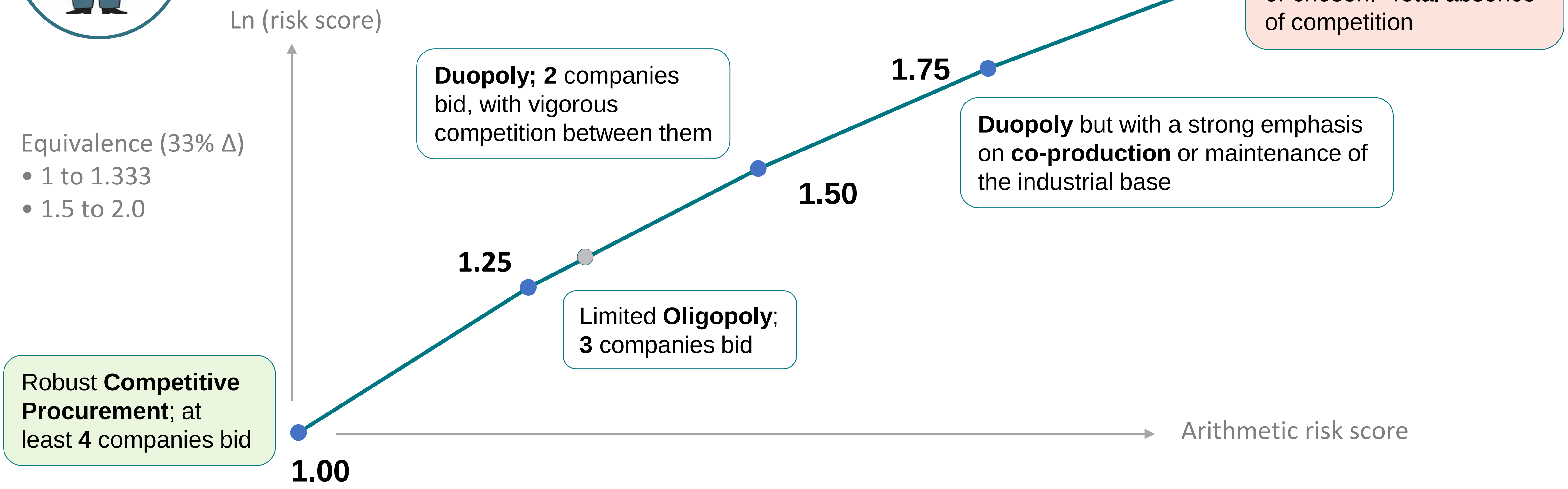
Essential to put the contract on a firm footing

Risk-Informed Independent Cost Estimate



The Model – Risk Profile using Anchored Scale

Market Structure



Anchors: Definitions for key points on the risk curve

Example of Scoring: LPD-17 (Landing Platform Dock)

LPD-17 *San Antonio Class*

Hull	Block	Basis of Payment
LPD-17	I	CPAF → CPIF
LPD-18	I	CPIF
LPD-19	I	CPIF
LPD-20	I	CPIF
LPD-21	I	CPIF
LPD-22	I	FPI Firm Target
LPD-23	I	FPI Firm Target
LPD-24	I	FPI Firm Target
LPD-25	I	FPI Firm Target
LPD-26	I	FPI Firm Target
LPD-27	I	FPI Firm Target
LPD-28	I	FPI Firm Target
LPD-29	I	FPI Firm Target
LPD-30	II	CPFF
LPD-31	II	FPI Mod to CPFF contract

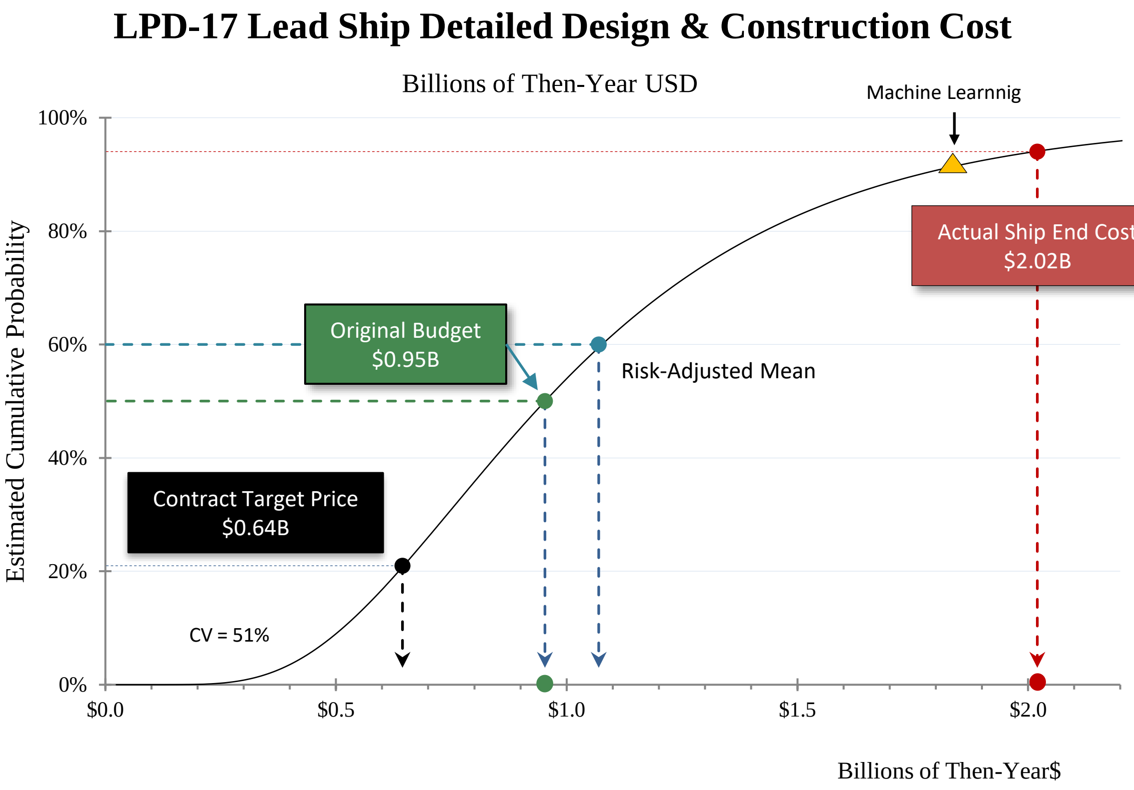
Focus: from **schedule** to **cost**

High Risk as cost & performance problems persist

Risk decreases as technical issues resolved

Risk increases with Block II

Risk decreases



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LPD-17: Lead-Ship Contract Score

Stability of Requirements
- Weight 15%
- Score 1.25 — *Largely unchanged until Block II*

Market Forces
- Weight 10%
- Score 1.50 — *Two yards bid*

Maturity of Technology
- Weight 20%
- Score 1.75 — *Regarded as "… the most highly technical and advanced amphibious ship ever built"*

Lead Ship

$$\sum_{i=1}^{6} Weight_i Score_i = \mathbf{1.7}$$

Contractor Readiness
- Weight 20%
- Score 1.75 — *Blue-collar yard; 3D CAD vendor weak*

Price Validation
- Weight 25%
- Score 2.0 — *NAVSEA bought into the yard's assumption: Lead ship at unit #4 on learning curve!*

Schedule
- Weight 10%
- Score 1.75 — *Challenging*

Risk Assessments - Summary

Average Risk Scores for USN Contracts/CLINs *(n = 40)*

	Stability of Requirements	Market Forces	Maturity of Technology	Contractor Readiness	Price Validation	Schedule	Aggregate Weighted
Average (μ)	1.40	1.70	1.44	1.46	1.46	1.50	**1.47**
Std Dev (σ)	0.22	0.34	0.28	0.27	0.24	0.23	**0.18**
CV (σ/μ)	15.9%	20.0%	19.5%	18.3%	16.7%	15.2%	**12.5%**

Diminished competition of current concern to USD(A&S)

Take-Aways

- Moderate risk, overall (**1.47**). Scores for "green" companies internationally running at 1.70 to 1.75
- Remarkable consistency across risk categories – except for **Market Forces**
- CVs remarkably consistent, too

Axes of Risk – Example of CLIN Details

Scores for CVN-78 and CVN-79

Ship/Ship System & CLIN Type	Stability of Requirements	Market Forces	Maturity of Technology	Contractor Readiness	Price Validation	Schedule	Aggregate Weighted
"CVN-21" Construction Preparation CPIF, CPAF, CPFF	1.50	2.00	1.75	1.50	1.25	1.75	**1.56**
Electromagnetic Aircraft Launch System SDD CPAF	1.50	2.00	2.00	2.00	1.75	1.75	**1.84**
Advanced Arresting Gear (AAG) SDD CPAF	1.50	2.00	1.75	1.75	1.75	1.75	**1.74**
Lead Ship Detailed Design & Construction CPIF, CPAF, CPFF	1.50	2.00	1.60	1.60	1.50	1.50	**1.59**
EMALS and AAG Production for CVN-78 FFP	1.75	2.00	1.50	1.50	1.50	1.50	**1.59**
CVN-79 Construction Preparation CPFF, CPIF	1.30	2.00	1.50	1.50	1.50	1.60	**1.53**
CVN-79 Detailed Design & Construction FPIF	1.20	2.00	1.40	1.30	1.60	1.40	**1.46**
EMALS & AAG Production for CVN-78 & -79 FFP	1.25	2.00	1.40	1.30	1.30	1.40	**1.39**

Take-Aways for CVN-78 & CVN-79

The lead ship, CVN-78 (USS Ford), was ***delivered incomplete****. Shipyard* ***workers*** *and* ***parts*** *on the first follow-on ship, CVN-79 (USS Kennedy), were "****borrowed****" to complete work on the lead ship. Problems with the new technologies continued with the Kennedy – with costs* ***spilling over*** *to the Ford.* Source: GAO

1 Use of multiple Cost-Plus contracts early-on

- Appropriate with new technologies; but, largely **ineffective**
  - 20% cost growth on CVN-78 & -79
  - 100% on EMALS and 80% on AAG
  - Weapons elevators – issues continued into deployment

USS Gerald R. Ford Underway

2 Questionable CLIN parameters

- FPIF for CVN-79 vs CP while risks still high
  - Congressional cost cap *busted*
    - $11.4B TY$ vs current cost of $13.9B
- FFP for EMALS and AAG for production

DoD *tends* to use FPI's after design, with a 50/50 share line. Often results in cost growth

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Pricing Approach: Strategic Challenge

Industry Motivation: Return on Free Cash Flow

Development

5% to 10% of acquisition cost

The big prize is production

In effect, a company gains a "franchise" upon award of the first contract

Production

90%+ of the revenue and profit

Add complexity & capability to systems in design & low-rate production

- JSF and Triton UAS
- *Zumwalt Class* destroyers

Inherent Tension

- **Cost growth**
- **Schedule delays**
- **Losses**

Reach the production stage to maximize shareholder value

- **Higher profits**
- **Better ROI**
- **Sustainment $'s**

*A contractor's **prime motivation** is arguably to **maximize the free-cash-flow** return on invested capital for all contracts across all projects in the portfolio. This profit motive might induce the firm to **trade** short-term losses for future gains, and could easily **swamp the incentives** of development contracts*

Insights

*Each program is a **non-repeatable** experiment. Upfront **flexibility** and **realism** are critical in trying to influence the contractor to better manage costs, schedule, and quality*

1 Difficult to discern effectiveness of pricing approach

Conceptual Design, Development

CPAF, CPFF, CPIF

Typical Progression →

Production

FPI, FFP, with various share lines

An example of evidence – mixed results

LPD-17 Class: CPAF to CPIF to FPI → *Issues eventually resolved; egregious cost growth*

LSD-41 Class: CPAF to CPFF (with ceiling) to FPI → *Largely effective*

Remote Minehunting System (RMS): CP to FPI → *Program cancelled*

Insights

*Although the **reliability** issues became apparent as early as 2005 with the **Remote Multi-Mission Vehicle** (RMMV), the program office did not sufficiently address them before awarding any of the **three** low-rate initial production (**LRIP**) contracts as fixed price.* Source: IDA

❷ Important to eschew rigidity

CPAF, CPFF, CPIF in Development → Expectation → FPI and FFP in Production

Impact of rigidity in the face of challenges

FPI contract CVN-79 (2nd ship in class)	*Cost growth & problems well into deployment*
FPI contracts for RMMV (LRIPs)	*Program cancelled even after $350M plus-up*
FFP for EMALS and AAG production	*Severe technical issues, and cost & schedule growth*

Note: The autonomous Remote Minehunting System (RMS) comprised the submersible Remote Multi-Mission Vehicle (RMMV), the AN/AQS-20A Variable Depth Sonar, and Littoral Combat Ship (LCS) equipment needed to deploy the system

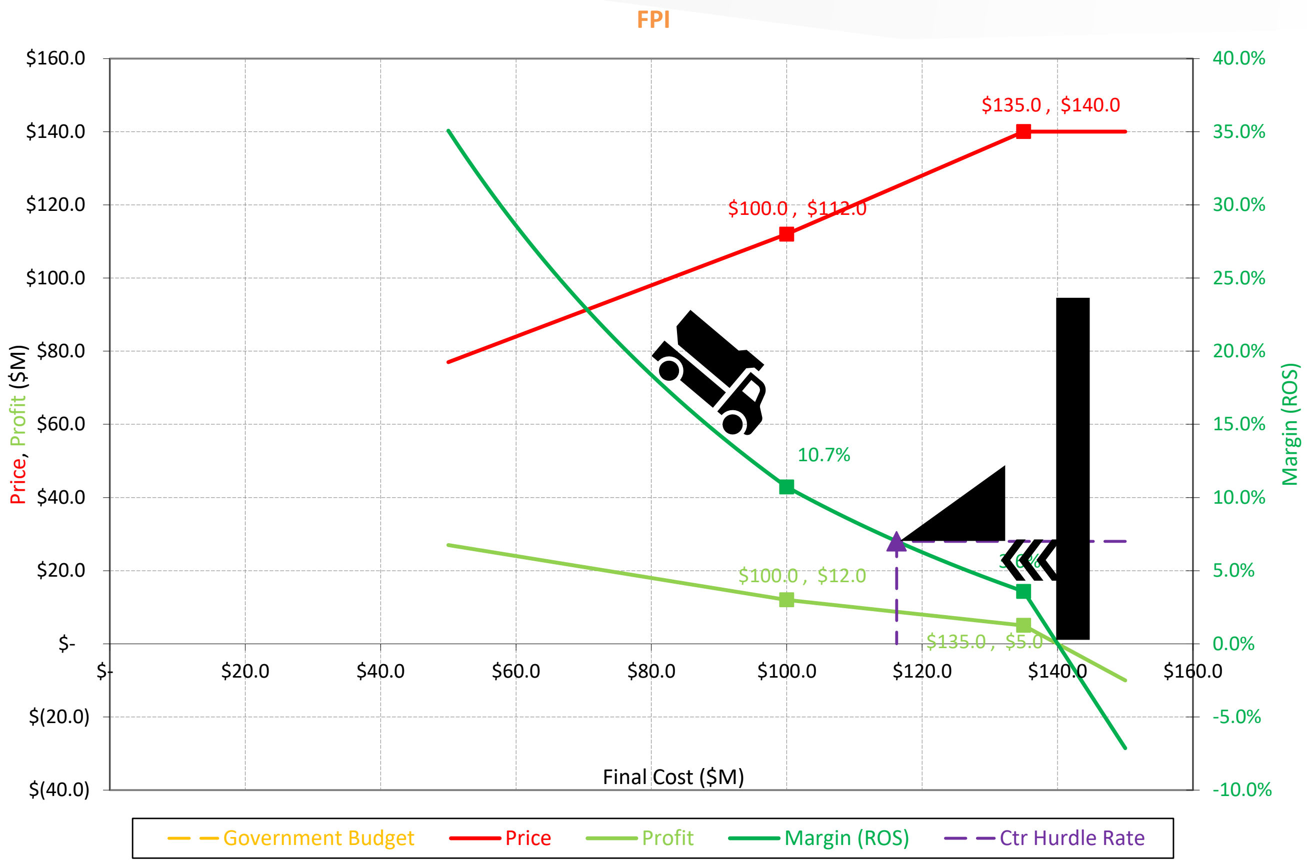
Insights

❸ Essential to analyze contract geometry

Contract Parameters

Contract Type : FPI
Target Cost : $100M
Target Profit : 12%
Contract Ceiling: 140% or $140M
Sharelines : 80/20 over & 70/30 under

Runaway Truck with Safeguards



Mechanisms needed above target cost to encourage cost control. Problems begin with an increase in EAC. But, the **truck stops**

Technomics

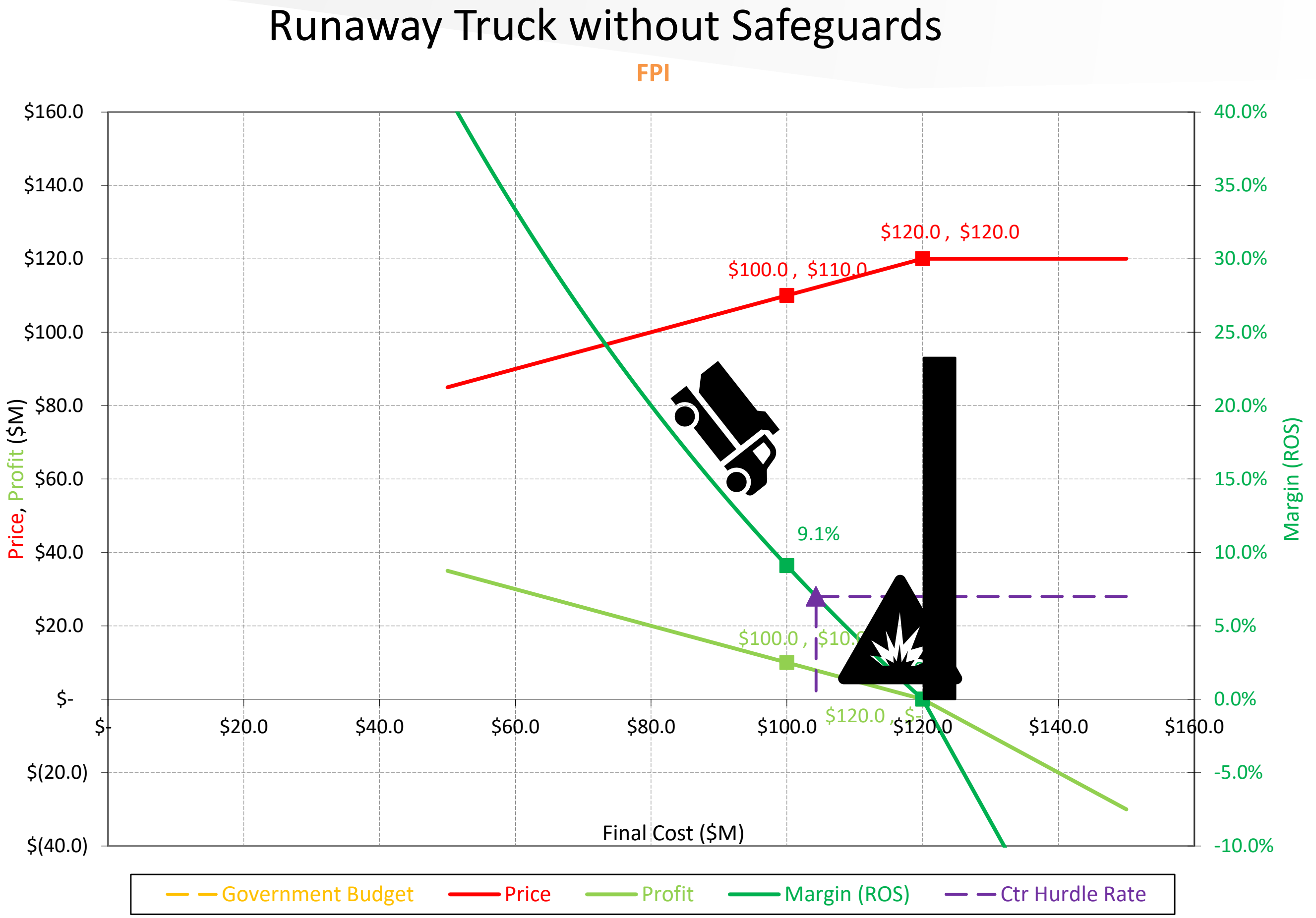
Insights

❸ Essential to analyze contract geometry

Contract Parameters

Contract Type : FPI
Target Cost : $100M
Target Profit : 10%
Contract Ceiling: 120% or $120M
Sharelines : 50/50 over & 50/50 under

Less attractive for the firm
- **Lower ceiling**
- **Less profit**
- **Steeper sharelines**



For a high-risk contract, **steep sharelines**, low **target profit**, and low **ceiling price** make for an unrealistically **narrow range** over which cost-control incentives function. **Truck crashes**

Insights

❹ Important to limit stretch in technology

Reduce risk by incentivizing the contractor to

- Achieve **incremental improvements** to Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs) according to plan
- Invest in **test-beds** during the Engineering and Manufacturing Development (EMD), and certainly before construction
- Experiment with more than one technology as a **contingency measure**

USS Zumwalt Underway

Exquisite Requirements

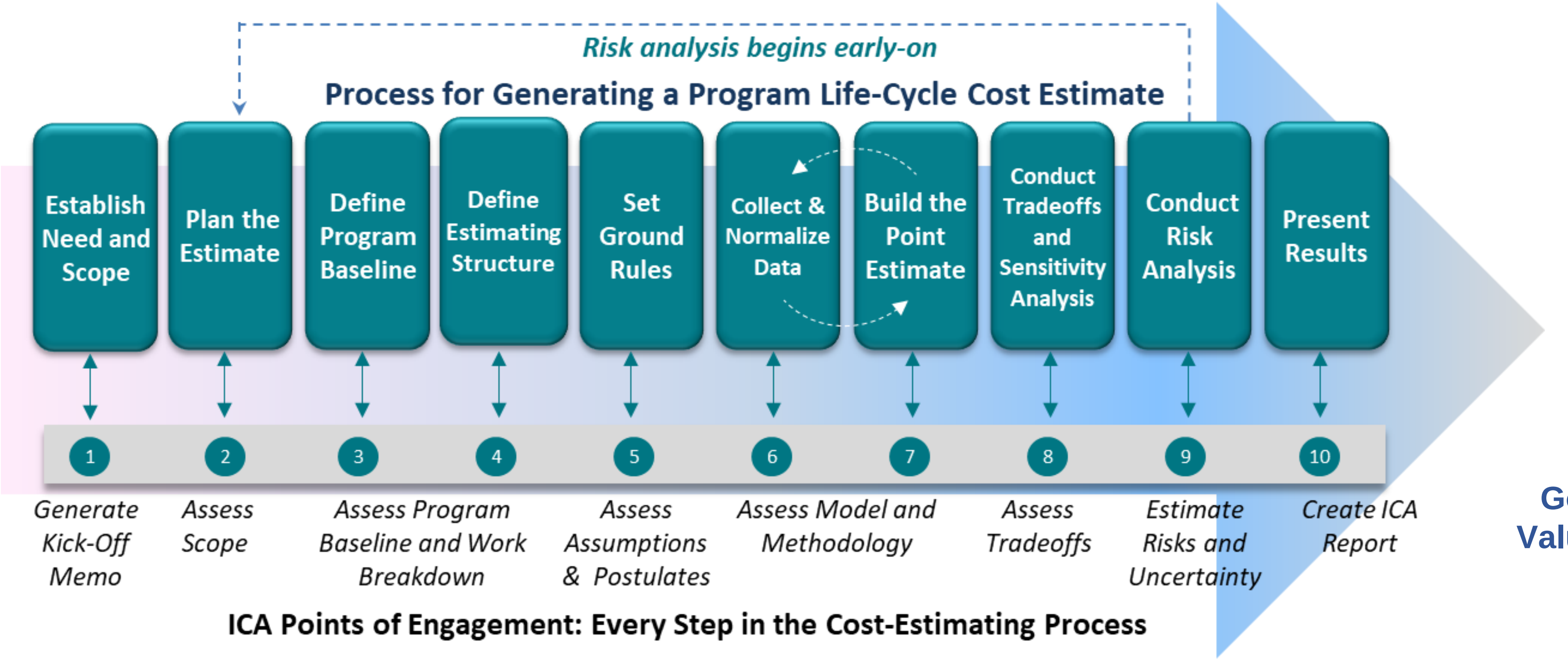
*"They just started putting **all sorts of requirements** on the ship without really understanding the **cost implications**."*
[former U.S. Deputy Secretary of Defense, Robert Work]

*"Cramming a lot of **new technologies** into one platform was **just crazy** - it was **doomed** from the start. Incremental is always the way to go when you're talking about big systems."* [former Secretary of the Navy, John Lehman]

Insights

5 Essential to validate price

ICE: Independent Cost Estimate
ICA: Independent Cost Assessment



Informs selection of contract target cost and target price

To promote a win-win

Government: Value for Money

Industry: Return on Sales

Overruns are likely in the absence of a realistic, accurate, and complete cost baseline

Pricing Approach – Operational Construct

Application of the framework will help engender better-informed decisions related to choices of contract type and incentives – with the ultimate goal of increasing the effectiveness of the pricing approach at acceptable cost and risk to all parties.

❶ Collect Intelligence

- Programmatic information
- Requirements documents
- Past contractor performance
- Historical benchmarks, as presented in the paper

❷ Prep for Scoring Session

- Form team
- Evaluate data
- Discuss prospective risk scores
- Maximize knowledge – ensure a common denominator of understanding

❸ Establish Weights of Each Risk Element

- Compute means & variances across the *k* scorers

$$\mu_{w1} = \sum_{i=1}^{k} w_{1i} = mean\ for\ Risk\ Element\ \#1$$

$$\sigma_1 = standard\ deviation\ of\ the\ k\ scores\ for\ w_1$$

$$CV_1 = coefficient\ of\ variation\ for\ Risk\ Element\#1$$

Compute for all elements of risk (1 to 6)

❹ Score the New Contract

Informs:

Contract Type

$$Total\ Risk = \mu_{w1} \cdot Score_{w1} + \mu_{w2} \cdot Score_{w2} + \cdots + \mu_{w6} \cdot Score_{w6}$$

Contract Incentives

$$Impact\ Factor_i = Category\ Weight_i\ x\ Risk\ Score_i, \ldots, i = 1\ to\ k$$

Pricing Approach – Operational Construct

Ex-Ante Assessment of Contract Risk

Impact Factor = Category Weight x Risk Score

Risk Categories	Stability of Requirements	Market Forces	Maturity of Technology	Contractor Readiness	Price Validation	Schedule Challenge	Aggregate Score
	Notional Scoring of Contract Risk						
Category Weights	μ_{w1}	μ_{w2}	μ_{w3}	μ_{w4}	μ_{w5}	μ_{w6}	
(Means from Scoring)	15%	10%	15%	20%	20%	20%	100%
Evaluation of Upcoming Contract							
Mean Scores	1.50	2.00	1.85	1.80	1.35	1.83	**1.70**
CV	*18%*	*25%*	*19%*	*15%*	*20%*	*15%*	
Impact Factors	0.23	0.20	0.28	0.36	0.27	0.37	**1.70**
Percent of Total	13%	12%	16%	21%	16%	22%	**100%**
U.S. Shipyards							
Means	*1.40*	*1.70*	*1.44*	*1.46*	*1.46*	*1.50*	***1.47***
CV	*16%*	*20%*	*19%*	*18%*	*17%*	*15%*	***12%***

Contractor-Readiness Risk

Little experience with the vessel (50% new)

Sample Incentive:
Increase Headcounts for critical Job Codes

Schedule Risk

Many task & schedule dependencies. High uncertainty of durations. Material not in place

Sample Incentives:
Tie to Critical Events
Tie to Physical Progress

The Impact Factors *drive the focus* of the contract incentives

Pricing Approach – Impact Factors

Raw Scores

- Show **level of risk** but not **relative impact**
- Akin to regression coefficients (partial derivatives)

Impact Factors

- Show **contribution** to **overall** contract risk
- Akin to beta coefficients in regression analysis

Risk Categories	Notional Scoring of Contract Risk						
	Stability of Requirements	Market Forces	Maturity of Technology	Contractor Readiness	Price Validation	Schedule Challenge	Aggregate Score
Impact Factors	0.23	0.20	0.28	0.36	0.27	0.37	1.70
Percent of Total	13%	12%	16%	21%	16%	22%	100%

43% of Total Risk

A beta coefficient compares the strength of the effect of each explanatory variable on the dependent variable. Beta coefficients have standard deviations as their units, enabling a comparison of relative impact.

Pricing Approach – Next Steps

Industry Executive:

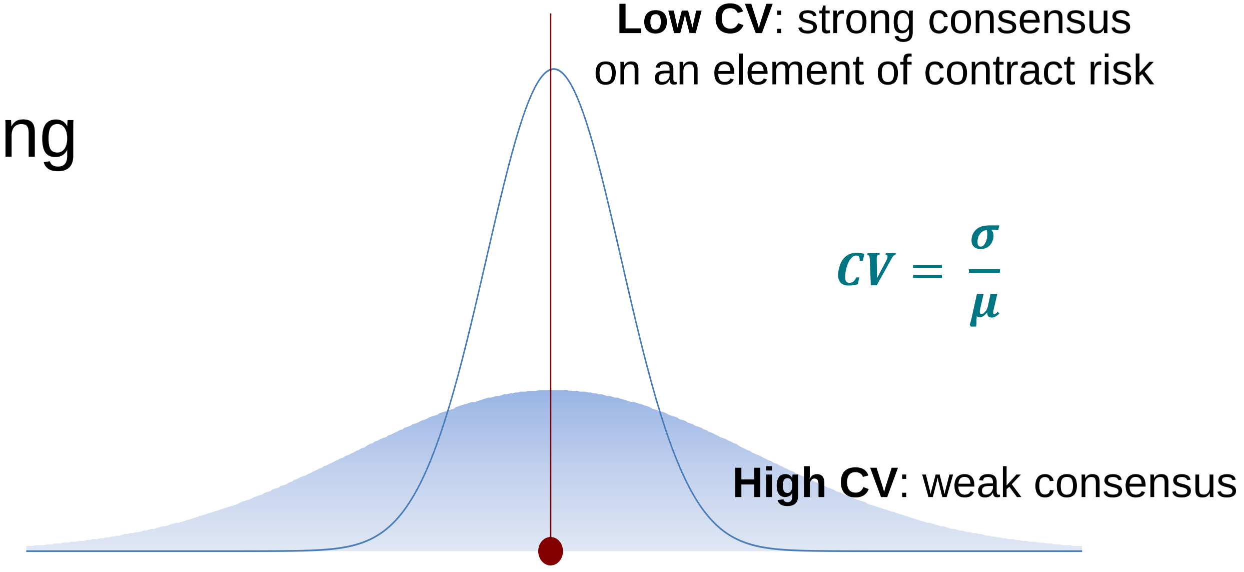
“*You can’t manage your way out of a bad deal*”

Actionable Intelligence – Risk Scores

Preliminary Step – arguably the most important!

Check for consistency in the scoring

- Good metric is the CV
- Historical range: 15% to 25%
- Historical mean: ~ 20%



$$CV = \frac{\sigma}{\mu}$$

Potential Action

- Continue if all CVs are within historical bands or only *slightly* outside
- Re-group if CV ≥ 50% (or double the σ)

High CV itself means high risk – failure of the team to agree on the challenge of the contract!

Re-Group: ❶ Determine the reason for lack of consensus, ❷ obtain more information, and, if necessary, ❸ conduct a scoring Round 2

Actionable Intelligence – Contract Types

Choose contract type

- Historical average contract risk score is 1.5
  - Across all phases of acquisition
  - Higher for design and development and lower for production
  - Remarkable consistency across the six elements of risk

Potential Action

- Use cost-plus early-on then transition to a fixed-price incentive vehicle (per current guidance)
- **But**, base decision on **risk score**
- Heuristic
  - Score > 1.5 ➔ cost plus
  - Otherwise, use a version of fixed price

Flexibility and Constant Review are Essential in the Decision Calculus

- Some CLINs are high risk even in production (e.g., LPD-17, RMS, EMALS, AAR)
- Risk may diminish into production but then rise again with block upgrades (e.g., Triton, JSF)
- Some contracts seemingly never diminish in risk (e.g., Remote Minehunting System)

There's no substitute for continuous engagement and scoring of the program, contract, and CLINs

"A foolish consistency is the hobgoblin of little minds" [Emerson]

Actionable Intelligence – Incentives

Prospective Contract Incentives to Manage Risk

Leverage the Impact Factors and CVs to focus attention on ***what*** *to* incentivize (**bang** for **buck**)

Market Forces
- Degree of competition for Tier 1 vendors
- Magnitude of labor and material escalation

Maturity of Technology
- Achievement of TRLs
- Investment in test beds
- Use of alternative technologies

Contractor Readiness
- % complete for design
- % vacant jobs filled for hard-to-fill trades
- Improvements in manufacturing
- Achievement of MRLs

Price Validation → **Company Cost Controls** →
- Achievement of should-cost goals
- Reduction in overhead & G&A expenses
- Make-versus-buy decisions
- Investments in property, plant, equipment

Schedule
- Calendar dates
- Design milestones such as PDR, CDR
- Production milestones such as IOC

Note: Requirements is usually a government responsibility

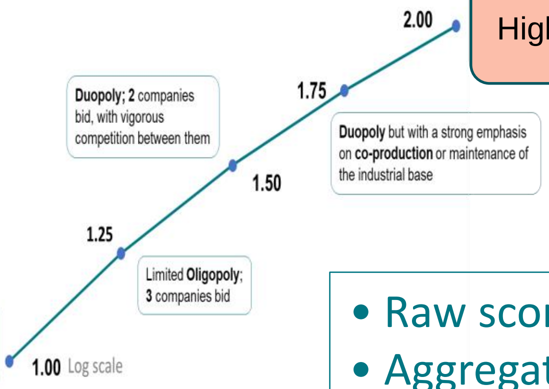
Summary

Data-driven, analytically-based, contract-risk framework

Factor	Points
Stability of Requirements	15
Market Forces	10
Maturity of Technology	20
Contractor Readiness	20
Price Validation	25
Schedule	10

100 Total Points

Low risk



High risk

- Raw scores
- Aggregate Score
- Impact Factors
- CV’s

Illumination of Contract Risk

To produce a win-win

Government: Value for Money

Industry: Return on Sales

Ratio Scales → Anchored → Results → Analysis → Actionable Intelligence

Epilogue

Contract pricing in context

Effective Contract Parameters

↑ *Establishing Incentives Across Likely Ranges*

Realistic Cost Estimates

↑ *Translating Manageable Risk into Possible Outcomes*

Sound Acquisition Strategies