Technomics
Better Decisions Faster

Contractually Speaking

The Story of DoD Contract Vehicles

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Speaking Today

Orly Olbum
Analyst

Orly Olbum is an analyst at Technomics, Inc., with experience in data collection, database management, and statistical analysis. She supports the Air Force Cost Analysis Agency (AFCAA) through data acquisition and training efforts on the Contracts Database project. She graduated from Penn State with a BS in Applied Statistics.

Peter Braxton
Subject Matter Expert

As a Subject Matter Expert, Peter Braxton is responsible for implementing best practices in cost and risk analysis at department- and agency-level defense and intelligence clients. Peter has over 20 years of experience and played a key role in developing the independent risk review process at Northrop Grumman. A long-time ICEAA Board member with a focus on Training and Education, Peter has taught extensively at government, corporate, and society training events throughout North America, Europe, and Australia.

The Problem

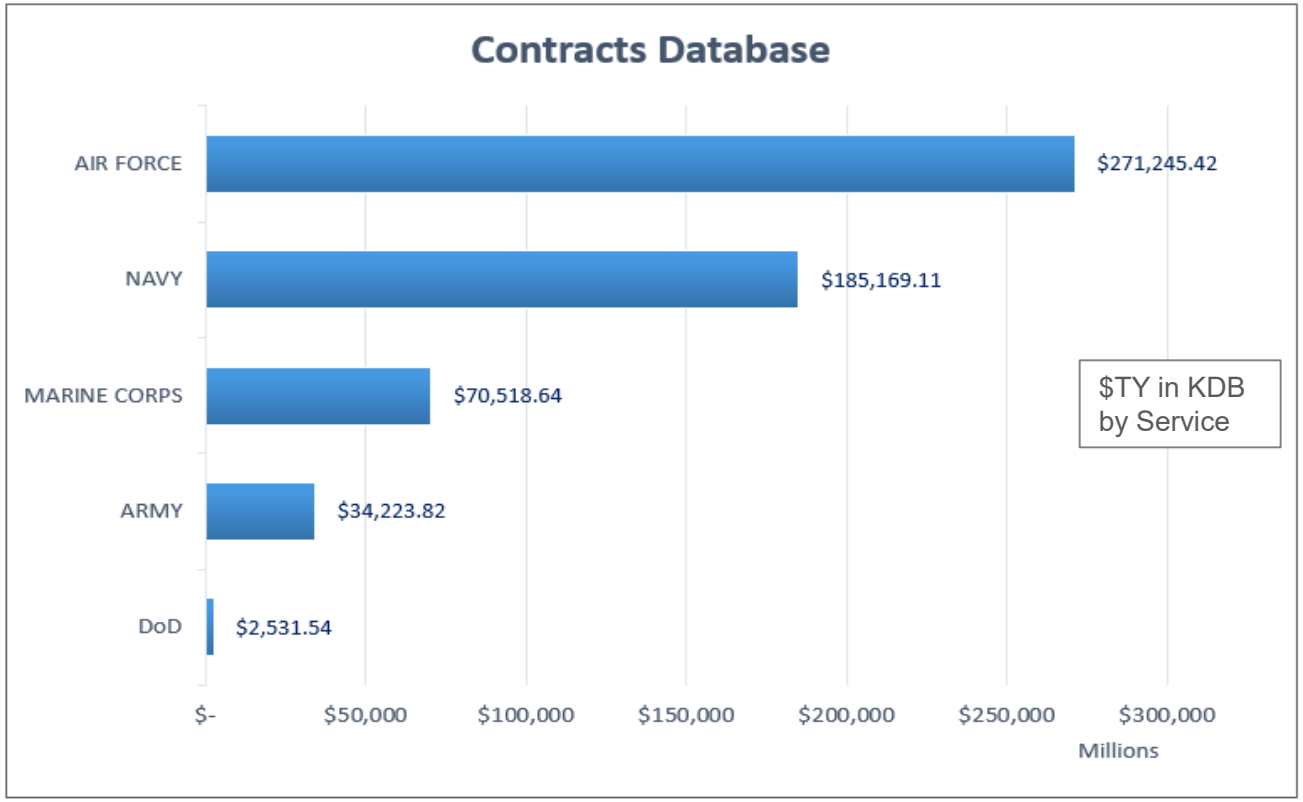
- In 2017, the Department of Defense (DoD) contracted $320 billion of effort and consistently procures more than any other United States government agency. An important part of the procurement process is agreeing on a contract with industry. As the legal document that holds the government and contractor accountable for their responsibilities, the contract can play a significant role in cost, schedule, and other issues that arise. This paper investigates the consequences of the choice of contract vehicle. Is the structure of a contract affecting the ability of a program to receive its final products on time and on budget? Is DoD getting the bang for their buck? This paper utilizes the Contract Price and Schedule Database to inspect different types of contract price growth and where in the lifecycle of a program different contract vehicles and contract types may be contributing to unanticipated price growth.

What is a contract?

- A contract is a legal document holding government and contractors accountable for their responsibilities
- Contracts can play a significant role in cost and schedule issues throughout its lifetime
- Agreeing on a contract with industry is an important part of the contracting process
  - What is the profit determination?
  - Who will bear the risk of unanticipated cost or scope overruns?
  - What method is most accurate for the phase of acquisition?

Contracts Database

- Since 2004, the Air Force Cost Analysis Agency (AFCAA) has sponsored the development and management of the Contracts Price and Schedule Database (KDB)
- KDB is a detailed repository of Department of Defense (DoD) contract information dating back to the 1990s
  - Contract price, including growth in price over time
  - Price growth category
  - Contract type
  - Contract vehicle
  - Etc.



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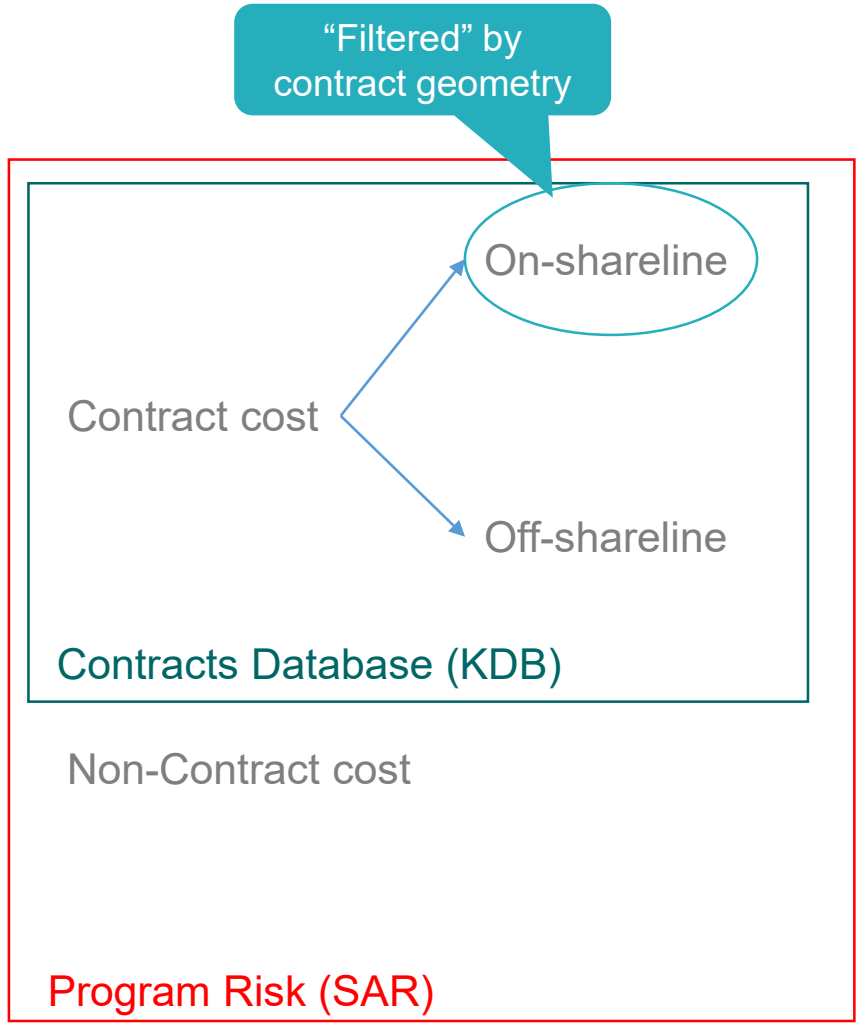
Previous Research

- "Contract Geometry Best Practices for Incentive Contracting" (2017) focused on an initial exploration of the KDB data to determine whether cluster analysis could provide deeper insight into drivers of price growth.
- "Risk-Adjusted Contract Price Methodology (RCPM)" (2018) focused on describing the titular methodology for modeling both on- and off-the-shareline risk on new contracts



Growth Categories

- KDB contract price growth categories:
  - **BASELINE**: Anticipated scope changes that affect the overall contract price, be it options exercised or procurement of items spelled out in the original Statement of Work
  - **TECHNICAL**: Unanticipated scope changes that affect the overall contract price and scope, such as additional spares, storage, labor, etc.
  - **COST**: Overall price changes that do not affect scope, such as cost overrun or underrun, or funding/obligation changes that affect contract price
  - **SCHEDULE**: Schedule changes that directly impact the overall price changes
  - **ADMINISTRATIVE**: Modifications which sum to zero dollars, no effect on overall contract price
  - **FMS**: Any modification whose dollar plurality are for foreign military sales

Contract Vehicles

- Our research explores the following vehicles:

FA0000-00-**C**-0001

  - C: General Contract Vehicle
    - Standard Federal Acquisition Regulation (FAR) Part 16 contract vehicle
    - Initial requirements are definite, schedule relatively established
  - D: Indefinite Delivery, Indefinite Quantity (IDIQ)
    - Initial master contract, Delivery Orders (DOs) issued subsequently as need arises
    - Requirements are fluid, no established schedule
  - G: Basic Ordering Agreements (BOAs)
    - Similar to D – initial contract with following DOs
    - BOAs allow for additional contractors to be added after initial award, while IDIQs do not

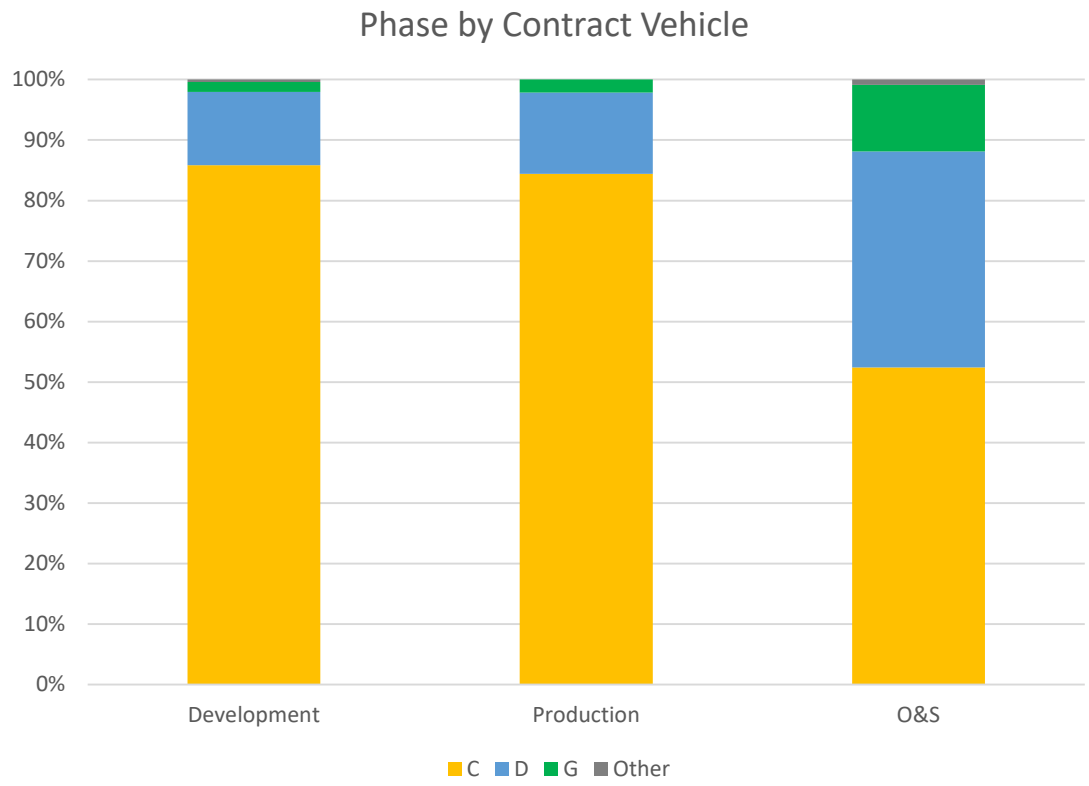
Contract Vehicles in KDB

- Single-award vehicle types – the default C plus the less common F, P, M, and K – represent the majority of the database (766 or 76.7%)
- The remainder are multiple-award vehicle types – D, G, and A, in decreasing order of precedence (233 or 23.3%)
- Because the IDIQ (D type) vehicles average over 30 delivery orders per contract, and BOA (G type) vehicles over 70, the DO-level counts swing strongly in favor of the multiple-award vehicles (9,213 or 92.3%).

Type	S/M	# Vehicles	# DO	Avg. DO/Vehicle
A	multiple	1	15	15.00
C	single	656	656	1.00
D	multiple	180	5515	30.64
F	single	76	76	1.00
G	multiple	52	3683	70.83
K	single	1	1	1.00
M	single	4	4	1.00
P	single	29	29	1.00
		999	**9979**	**9.99**

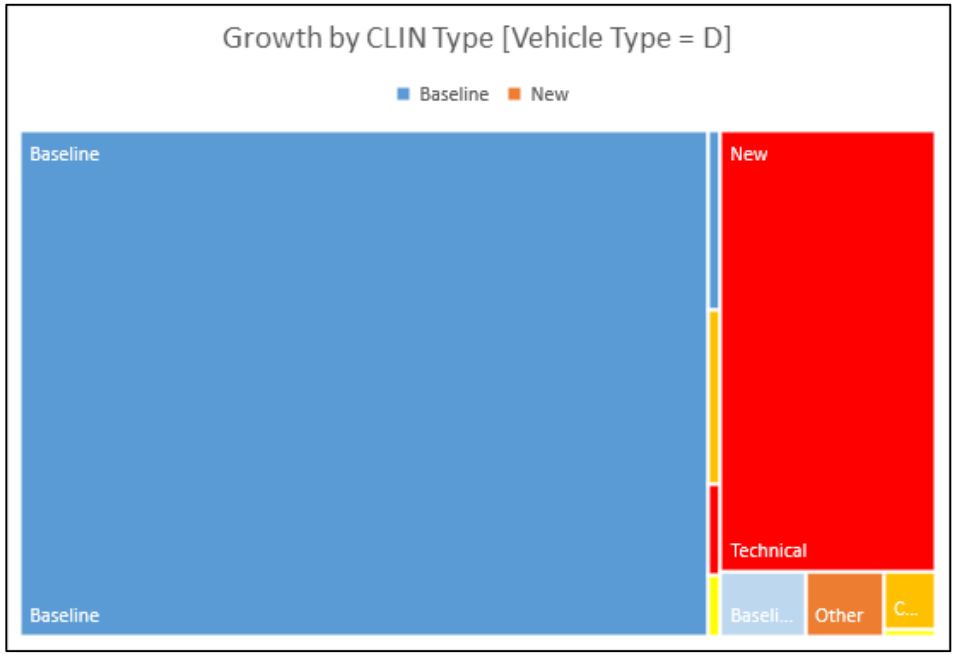
Phase by Contract Vehicle

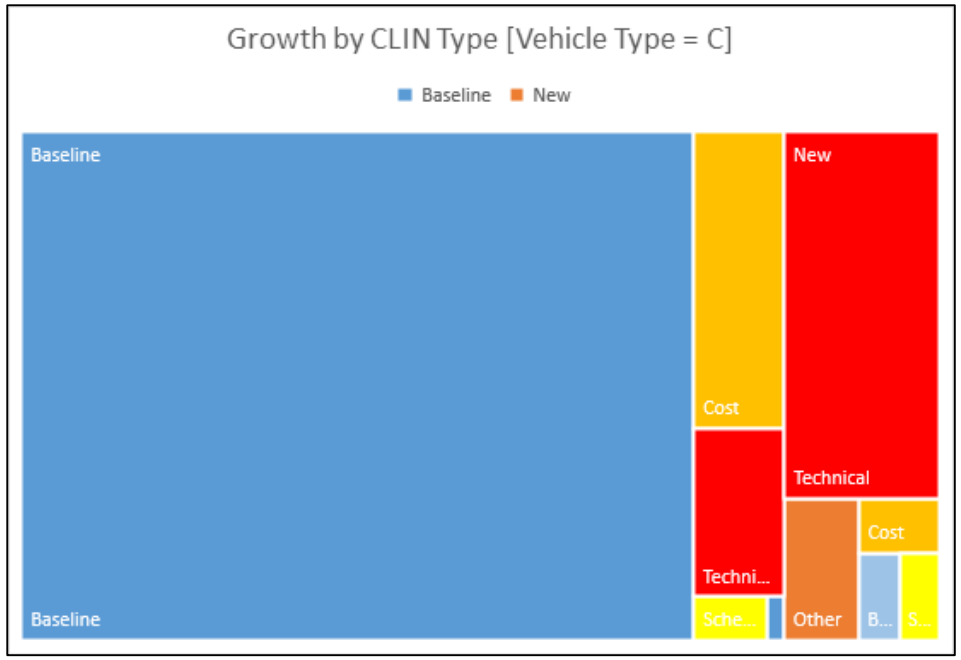
- While most of Development and Production is made up of C-type contracts, they only consist of about half of O&S contracts
- G and D type contracts, with less established requirements, show a lower percentage of $TY in Development and Production than C type contracts
- G (BOA) contracts are close to absent during Production, but they along with D contracts make up almost half of O&S contracts

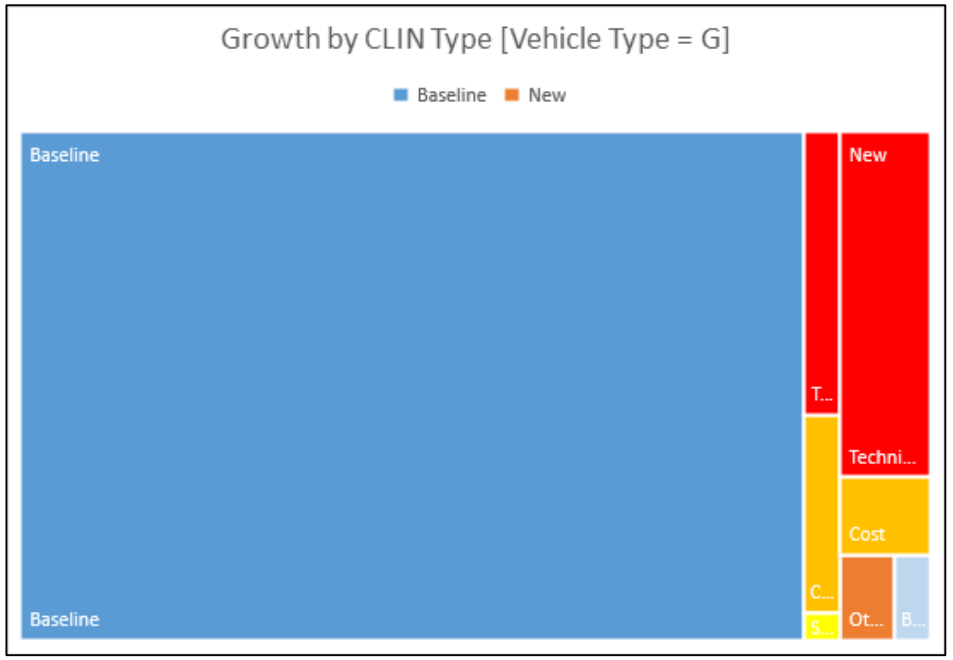


Growth by Contract Vehicle

- C-type: addition of new CLINs accounts for about twice the price change as growth on Baseline CLINs
- D-type: almost no growth on the Baseline CLINs; addition of New CLINs accounts for almost enough to match the total growth of C-type contracts
- G-type: less total growth, concentrated in the addition of new CLINs; not as severely as with D-type







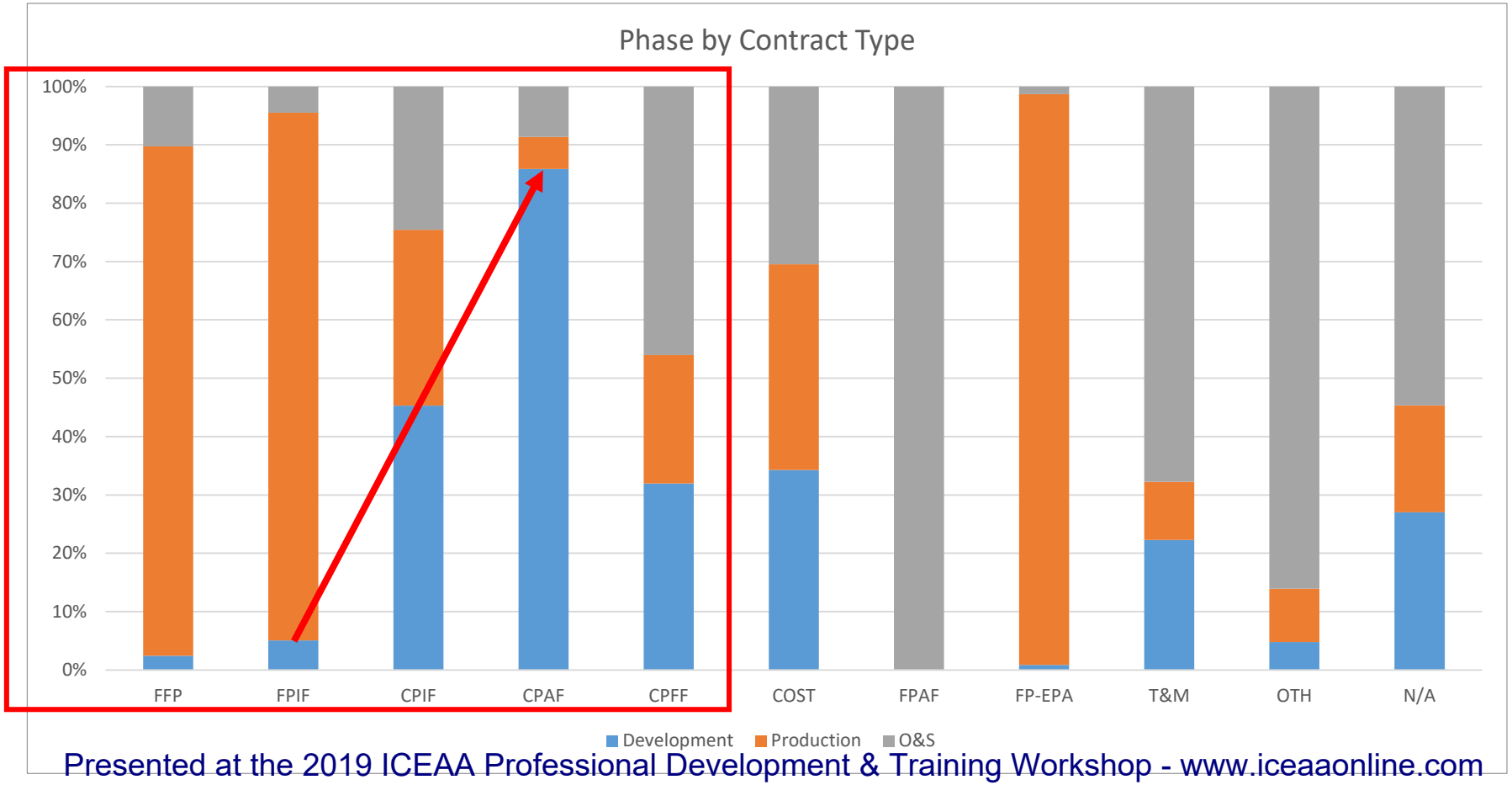
Contract Types

- Fixed Price: the contractor bears the risk, since the price is fixed and the requirements are outlined early on.
- Cost-Reimbursement: the government bears the risk, since the contract requires best efforts of the contractor for the duration of the contract rather than a set group of requirements.

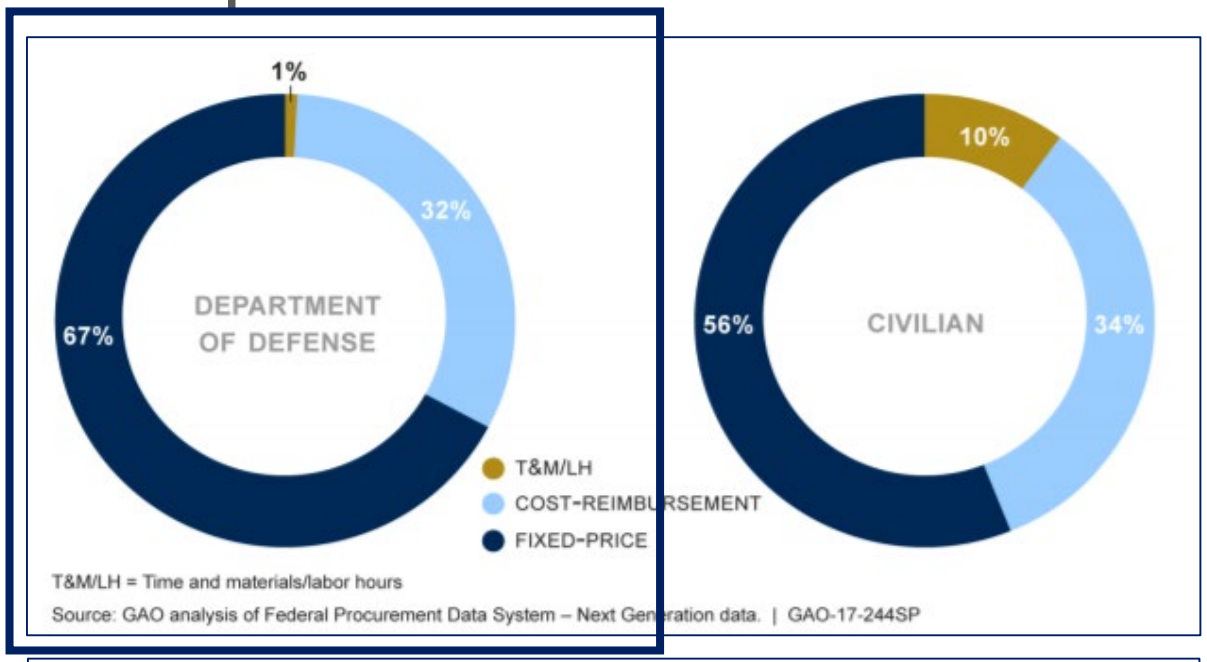
Contract Type	$TY Value	% of Total
FFP	$ 250,895,885,400.35	46.4%
FPIF	$ 82,217,665,963.91	15.2%
CPIF	$ 51,016,220,178.91	9.4%
CPAF	$ 88,453,238,794.47	16.4%
CPFF	$ 48,565,077,818.30	9.0%
Other	$ 42,540,442,840.67	3.6%
Total	**$ 540,674,974,355.01**	**100.0%**

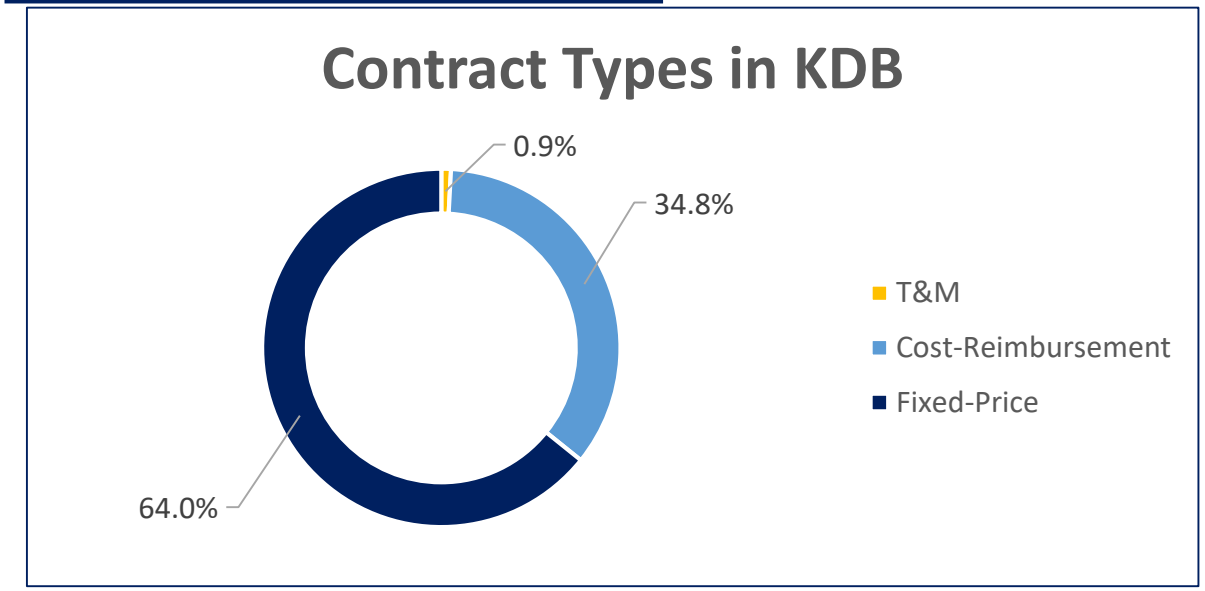
Phase by Contract Type

- Phase by contract type from KDB is broken out below
  - Cost-reimbursement contracts are typically more suitable for R&D
  - Fixed-price contracts are more appropriate for long term production



Contract Type Comparison

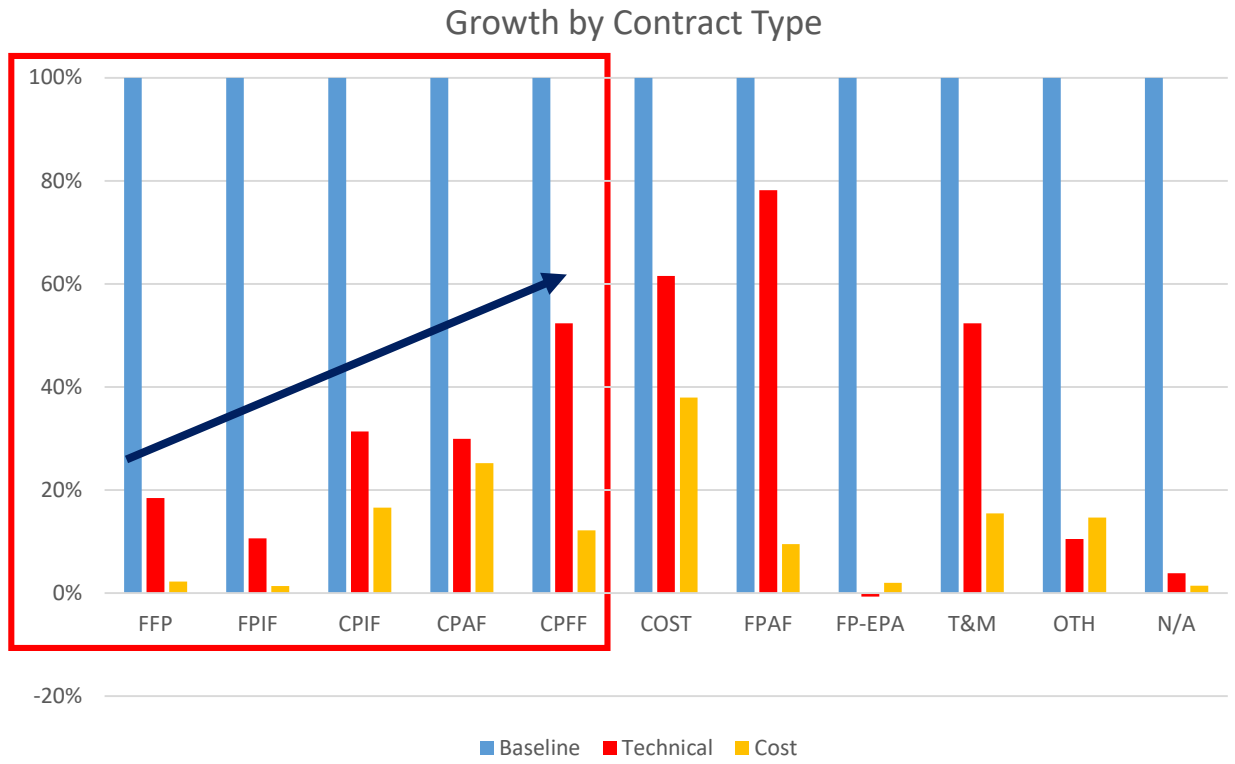




[1]Woods, W. T. (2017). *Contracting Data Analysis: Assessment of Government-Wide Trends.* GAO

Growth by Contract Type

- KDB data corroborates expectations
  - Knowing that fixed-price CLINs have lower risk, we'd expect them to have higher baseline, or anticipated, price growth, and cost-reimbursement CLINs are expected to have higher technical, or unanticipated, price growth
  - Cost-reimbursement CLINs are more likely to have cost price growth



From Aggregate to Estimate-Level Risk

- The summary statistics in the preceding slides show aggregate historical growth across the database by vehicle type, contract type, and life cycle phase
  - These enable a traditional factor approach to estimating potential growth
- Not all contracts, DOs, or CLINs are created equal, so we devised a parametric methodology that allows us to leverage the entirety of a proper subset of the data in applying risk and uncertainty to a new estimate
- This following slides describe this methodology, a significant improvement to the traditional factor approach

MLE Regression Derivation

- MLE Regression extends traditional Ordinary Least Squares (OLS) regression to account for a heteroscedastic error term

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i, \varepsilon_i \sim N(0, \alpha_0 + \alpha_1 X_i)$$

- The Y-values can then be seen as a Normal distribution

$$Y_i \sim N(\beta_0 + \beta_1 X_i, \alpha_0 + \alpha_1 X_i)$$

- The *likelihood function* is the product of the probability densities as a function of the parameters

$$L = \prod_{i=1}^{n} \frac{1}{\sqrt{2\pi\sigma_i^2}} exp\left(-\frac{(Y_i - \mu_i)^2}{2\sigma_i^2}\right), \mu_i = \beta_0 + \beta_1 X_i, \sigma_i^2 = \alpha_0 + \alpha_1 X_i$$

- The *log likelihood function* makes the math a little easier

$$\log L = \sum_{i=1}^{n} \left[\log \frac{1}{\sqrt{2\pi\sigma_i^2}} - \frac{(Y_i - \mu_i)^2}{2\sigma_i^2}\right] = -\frac{1}{2}\sum_{i=1}^{n} \left[\log\left(2\pi\sigma_i^2\right) + \frac{(Y_i - \mu_i)^2}{\sigma_i^2}\right]$$

MLE Regression – Optimization Step

- Maximizing the log likelihood is equivalent to minimizing its opposite

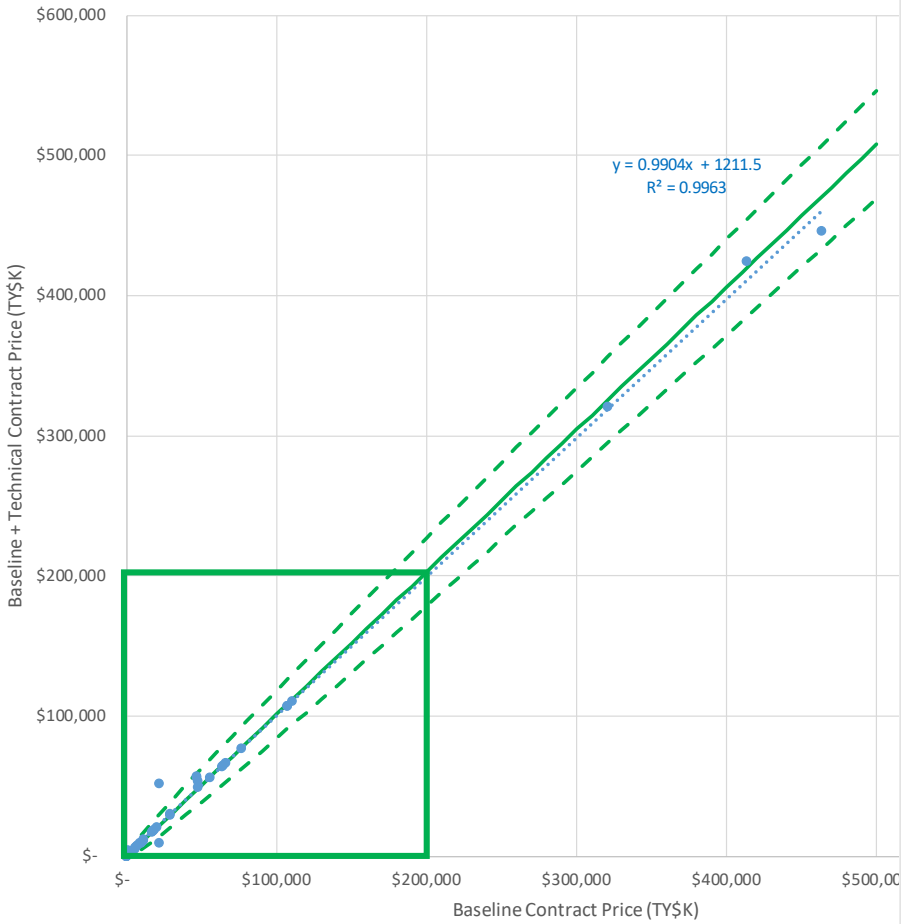
- We can also safely drop extraneous additive and multiplicative constants

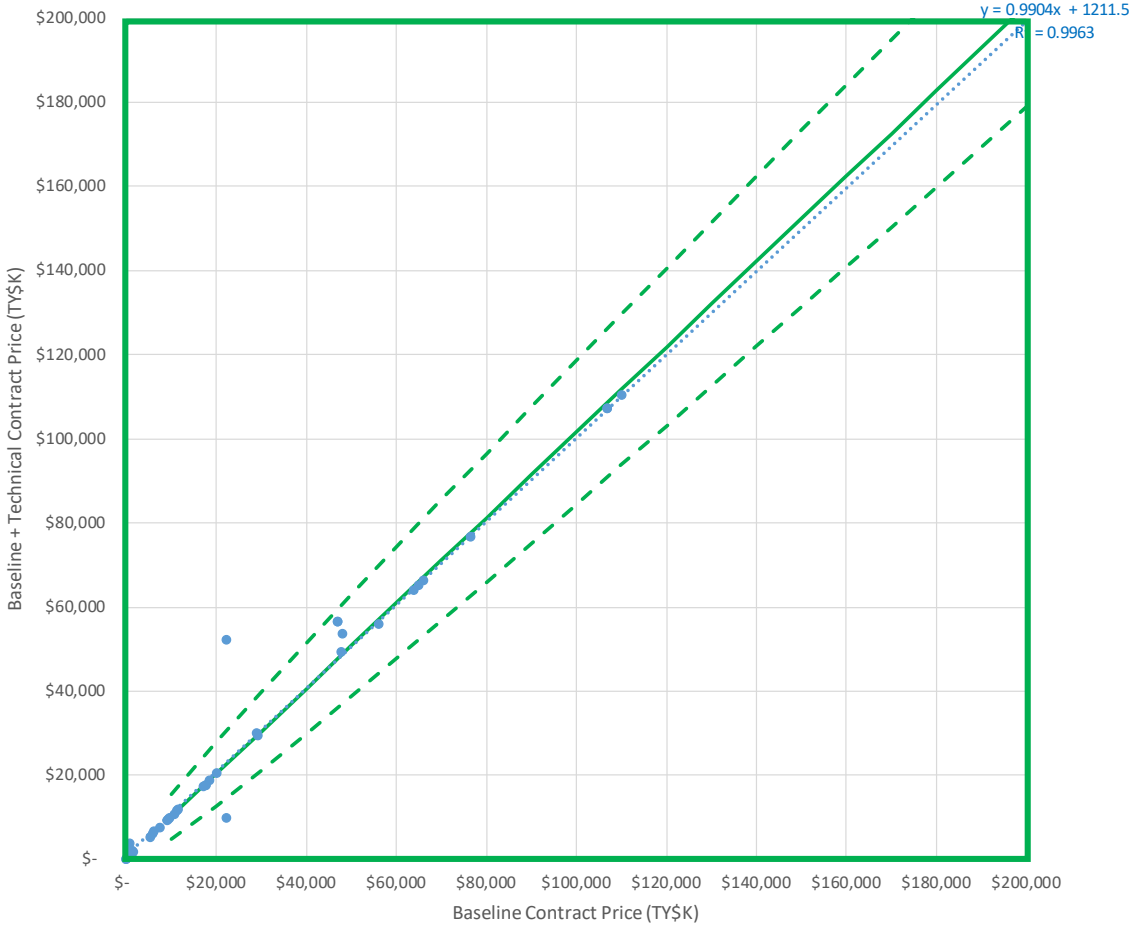
$$\min_{\beta_0;\beta_1;\alpha_0;\alpha_1} \sum_{i=1}^{n} \left[\log\left(\sigma_i^2\right) + \frac{(Y_i - \mu_i)^2}{\sigma_i^2} \right], \mu_i = \beta_0 + \beta_1 X_i, \sigma_i^2 = \alpha_0 + \alpha_1 X_i$$

- The second term looks very similar to a Sum Squared Error (SSE) calculation, but the heteroscedastic variance is factored into both terms

MLE Regression – "CER View"

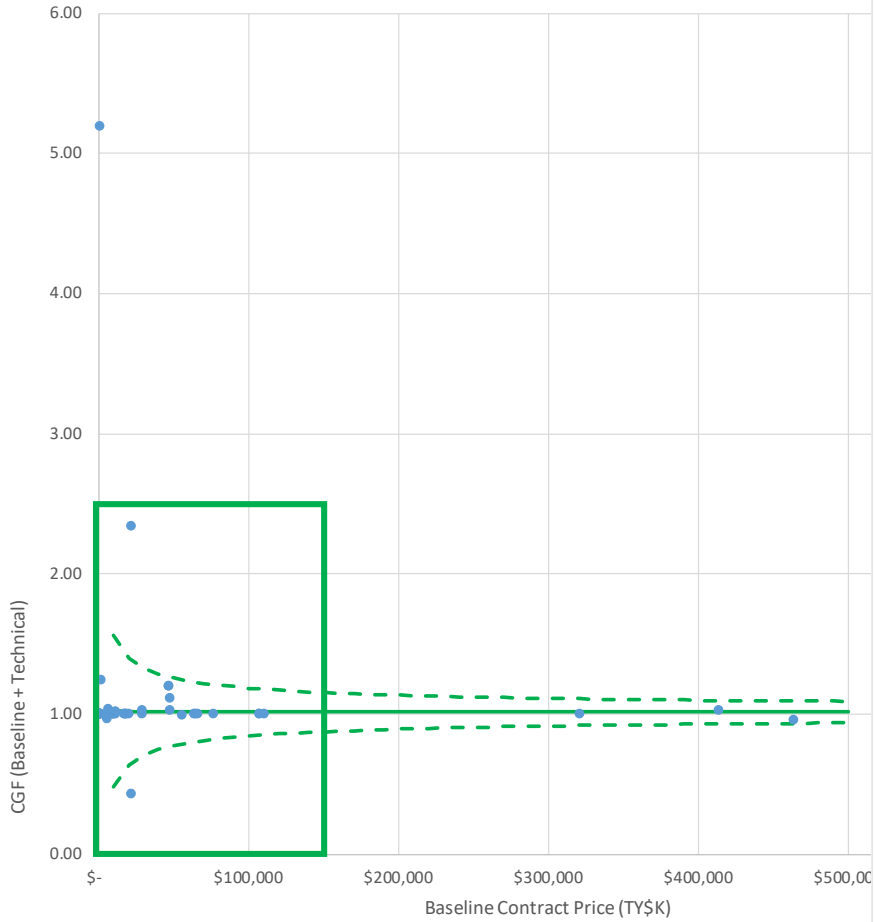
- Graphs show the final price with growth estimated as a function of baseline price

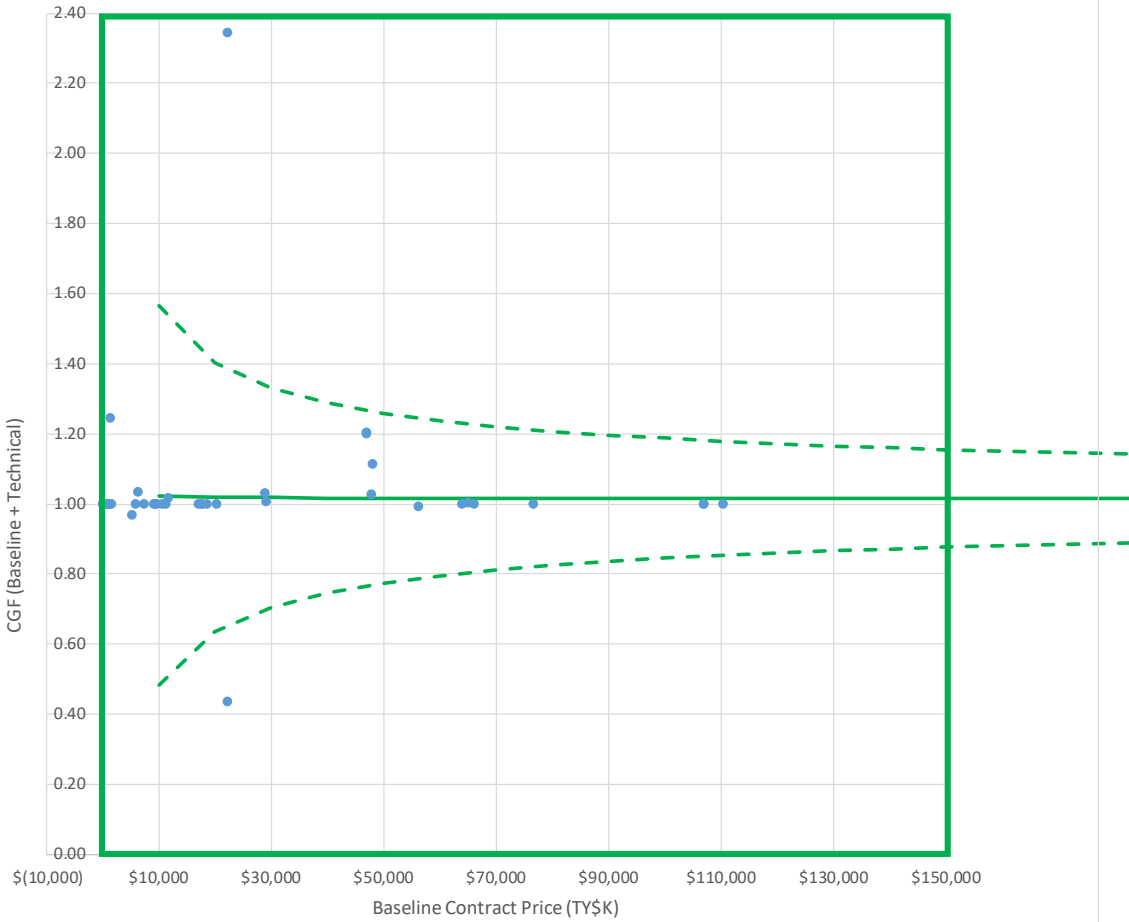




MLE Regression – "CGF View"

- Clearly shows Coefficient of Variation (CV) decreasing with size





Summary

- DoD contracting methods impact how much is spent on products and services
- While looking at a specific program may provide insight into technical contract growth, grouping dollars spent by contract vehicle provides further insight
  - We saw that new CLINs are more frequent on D contracts – Does providing the platform for IDIQ of products/services help, or hurt?
  - We saw higher cost growth on C contracts – Are overruns happening when the PoP or requirements are too rigid?
  - Should CLIN growth be a source for coming up with factors for estimates rather than the contract or program?
- This analysis provides a framework for further investigation into contracting best practices and offers insights into what may be causing unexpected contract growth in the DoD

Future Work

- To better make sense of historical data, it is highly important to assess the appropriateness of contract type for a given scope of work
  - This may require a mix objective guidelines and analyst judgment (e.g., expertise on individual programs)
- To support objective guidelines, we can tag data more precisely – CLINs by Phase, e.g.
  - Technology Maturation and Risk Reduction (TMRR)
  - Engineering and Manufacturing Development (EMD)
  - Low-Rate Initial Production (LRIP) and Full-Rate Production (FRP) lots
- The relationship between Platforms, Programs, and Sub-Programs is also important
  - For example, platforms (e.g., the C-5 Galaxy) may be well into the O&S phase when an associated modernization effort (e.g., C-5 RERP) essentially becomes its own program
  - This effort may have its own Development and Production phases and contracts
- Better tagging of CLINs by work scope (rough WBS) will also help with determination of appropriateness

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Backup

Contract Types – Firm Fixed-Price (FFP)

- FFP arguably has the simplest contract geometry
- Price is fixed, Profit decreases or increases for every dollar with any cost overrun/underrun – essentially a 0/100 shareline

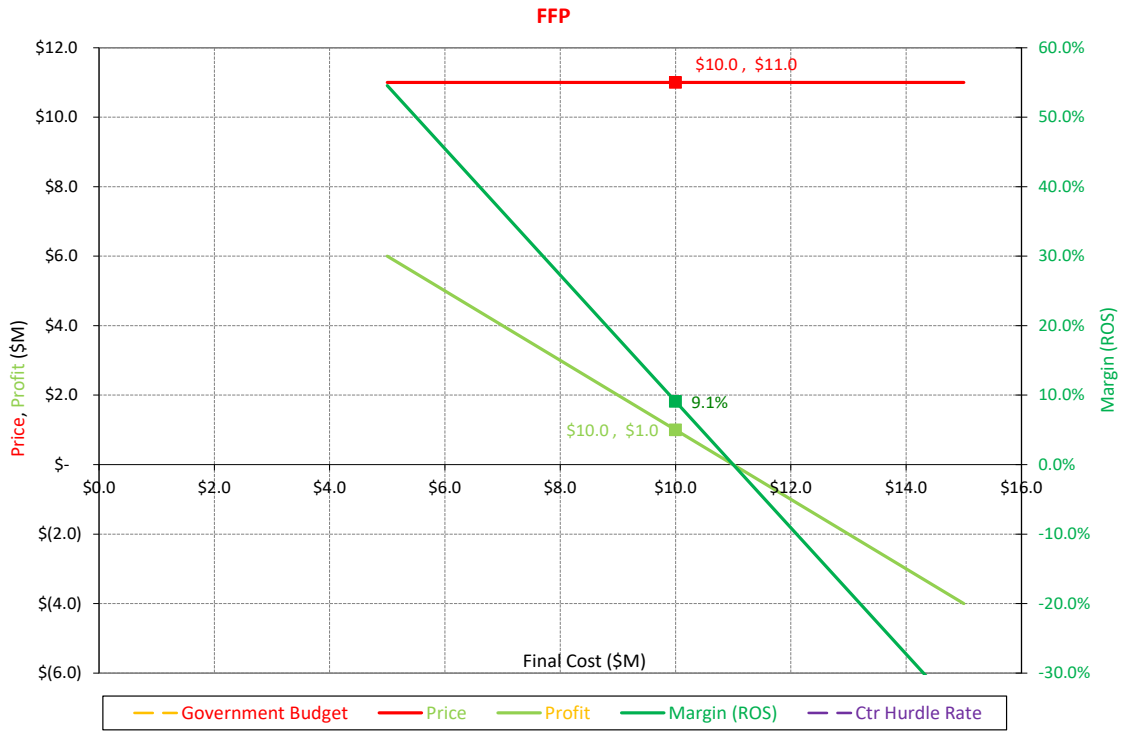

Figure 4. Firm Fixed-Price (FFP) graph from CIIT

Contract Types – Cost Plus Fixed Fee (CPFF)

- CPFF has a simple contract geometry, with Fee being a fixed dollar amount
- Price increases or decreases dollar for dollar with any cost overrun/underrun, respectively – essentially a 100/0 shareline

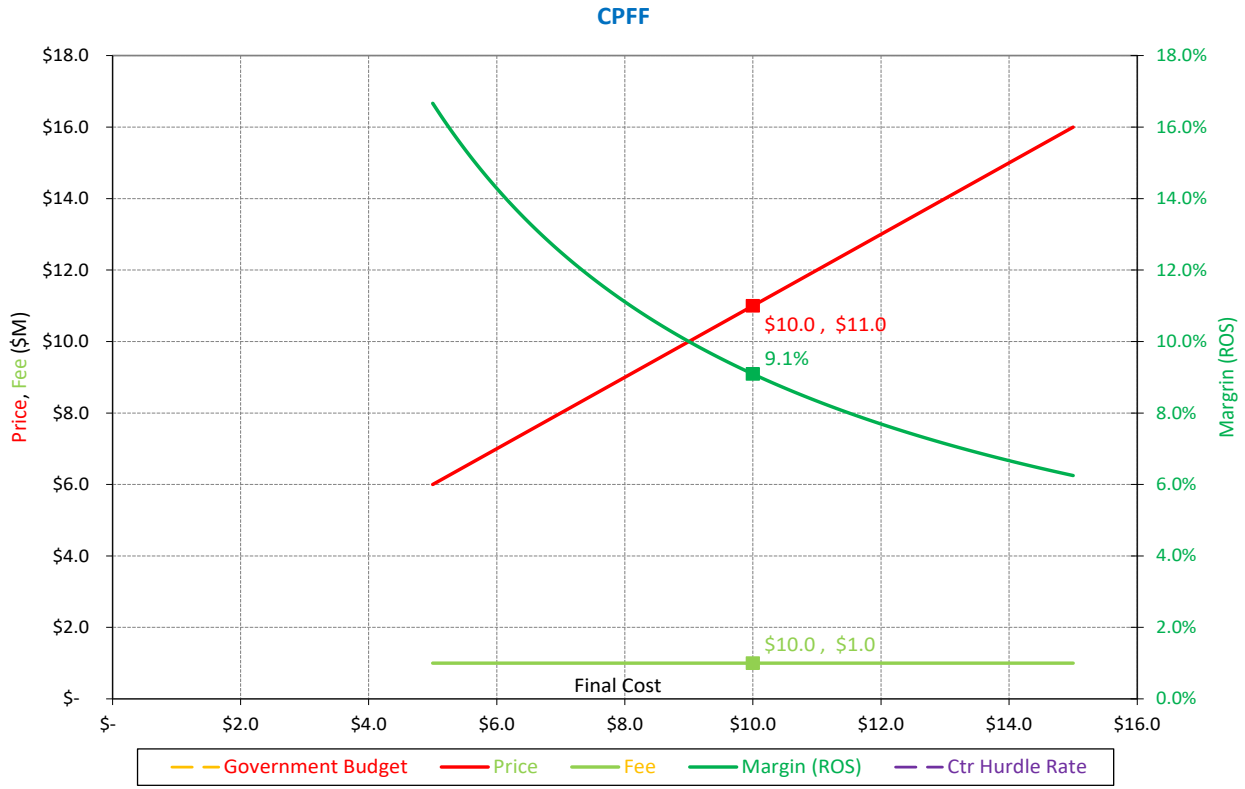

Figure 5. Cost Plus Fixed Fee (CPFF) graph from CIIT

Contract Types – Fixed-Price Incentive (FPI)

- The contract geometry in FPI adds a break point at the Point of Total Assumption (PTA), where the adjusted price reaches the Ceiling Price
- Target Cost is generally a breakpoint as well – we allow different share rations above (overrun) and below (underrun)

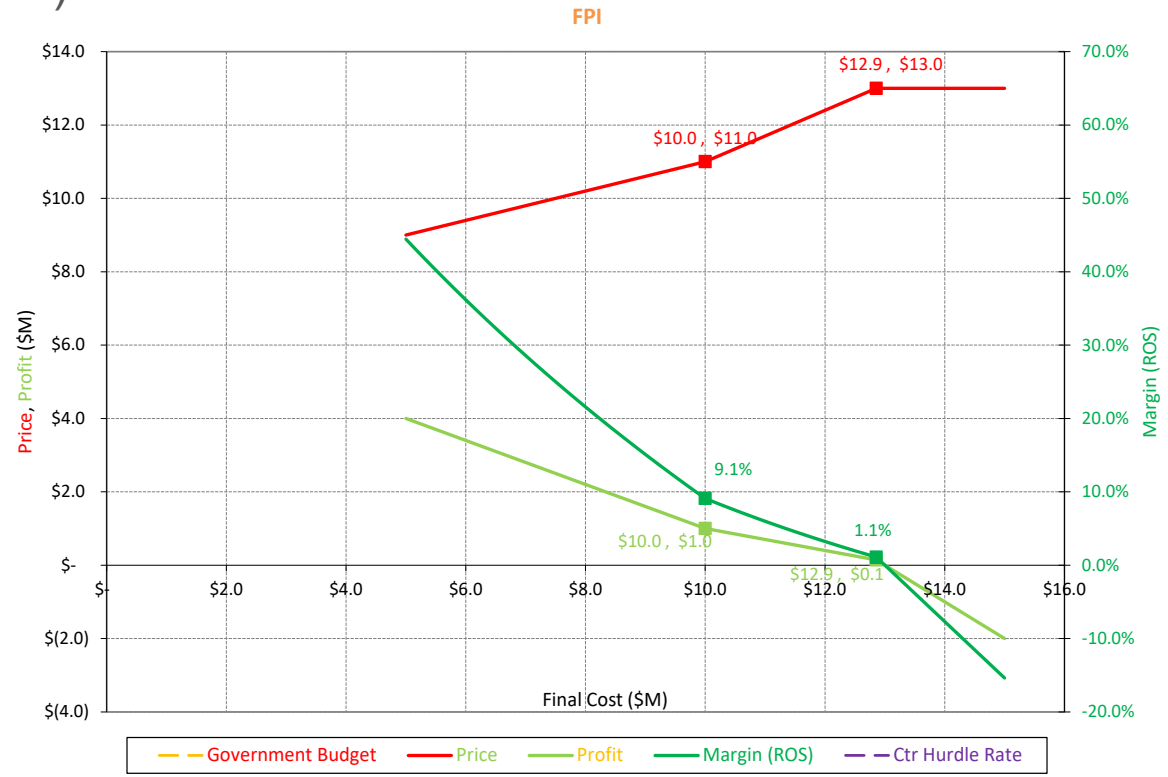

Figure 6. Fixed-Price Incentive (FPI) graph from CIIT

Contract Types – Cost Plus Incentive Fee (CPIF)

- CPIF has three breakpoints: Target Cost, and the left and right endpoints of Range of Incentive Effectiveness (RIE)
- Min and Max Fee are usually specified as a percentage of Total Cost, but become fixed dollar amounts

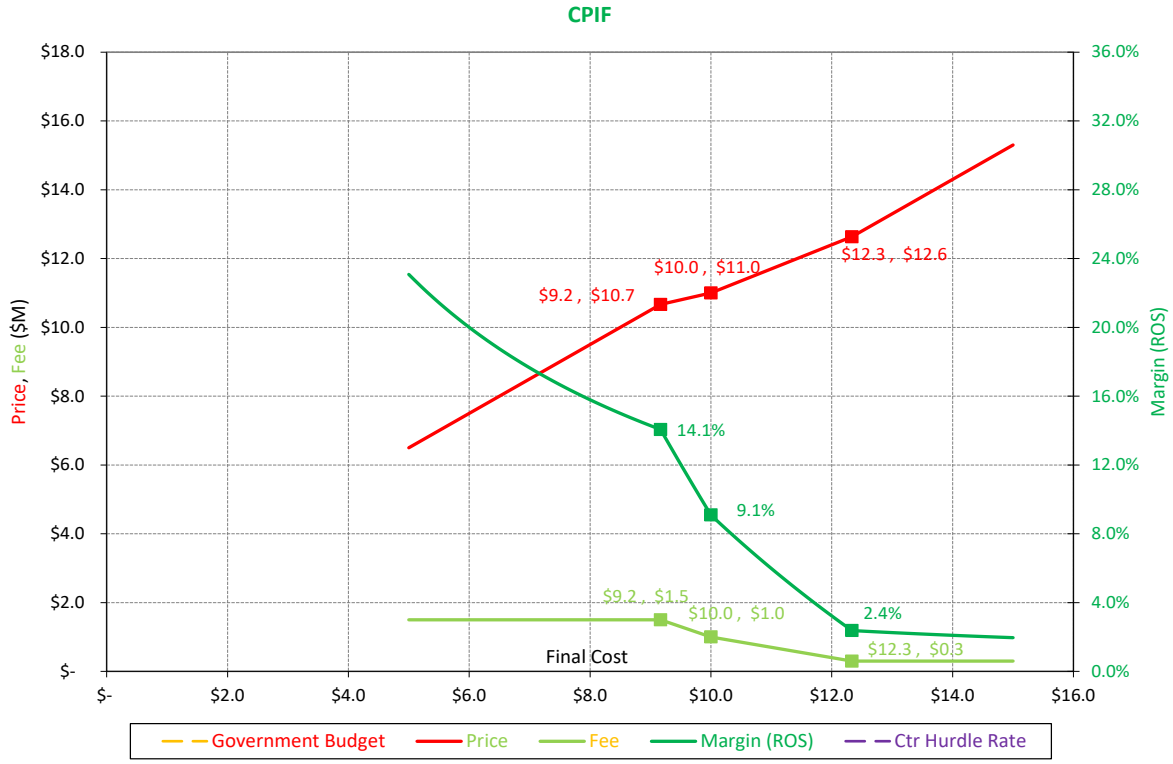

Figure 7. Cost Plus Incentive Fee (CPIF) graph from CIIT

Off-the-Shareline Risk

- Previous distributions assume all variation in cost “hits” the shareline, and thus affects Final Price (CPFF), Final Profit (FFP), or both (FPI, CPIF) according to established contract geometry
- In reality, some variation in final contract cost comes in the form of modifications that are adjusted off the shareline