

## LARGE SPACE HARDWARE SYSTEM DEVELOPMENT UNDER FIRM-FIXED PRICE CONTRACTS ~ SURVEY, NARRATIVE, AND PROGRAMMATIC PERFORMANCE

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## AGENDA

#### Study Phase 1 Framework

- Premise & Scope
- 🗋 Dataset
- Assumptions and Definitions

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#### LFDs: Profiles & Thematic Survey

- Big Commercial Space Family Tree
- Program, Project, & Partner Context
- Commercial Development & Gov Insight/Oversight
- Acquisition Approach & Temporal Analysis

### LFD Performance

- Contract/Agreement (C/A) Cost Growth & Risk Profile
- Differentiation among Types of Cost Growth
- Business Viability & Partner Feedback
- Schedule Growth
- Viral Growth & Growth Correlation

### Epilogue: Study Phase 2 Teaser

- Scope: FFP vs Cost+ / Estimate Accuracy
- Is it the FFP mechanism alone that saves money?-

## **STUDY FRAMEWORK:** PREMISE & SCOPE

## Longstanding Questions

(repeatedly posed internally and by stakeholders)

What are the salient themes and characteristics of Large Space Hardware Systems developed using FFP contracts (LFDs) worthy of focus? How have LFDs performed programmatically? ...and does this uncover any nuances & heuristics useful to analysts & leadership? How does this exploration change the way we understand the nature of cost & schedule growth?

Phase 1 – Now/NCSS

#### Are FFP vehicles 'worth it' vs Cost+?

What are the specific dimensions of tradeoff (culled from real examples within both the Cost+ and LFD universes)?

- Relative Cost savings
- Relative Schedules savings
- Other tradeoffs

■ Which parameters drive these savings/penalties? How can we use these to assess future LFD (aka human space) projects?

How well did the initial estimates

perform vs actuals?

Phase 2 – 2024 thru 🗙

## STUDY FRAMEWORK Dataset

## I 2 Highly Sensitive LFD datapoints (and counting)

- Largest, most diverse (aka not primarily science) dataset of this type studied at NASA
- Includes: Human space, proto-human, science, defense
- Most data points: ATP after 2000
- Sources: Protected programmatic relationships supplemented with sources of every sort

## Despite popular opinion/accusation, these data are very not public

These data are not shareable.



Unique, diverse dataset allows for novel investigation...

...but priority = Protect sensitive data.

## **STUDY FRAMEWORK** ASSUMPTIONS & DEFINITIONS

- '<u>LFD</u>' == Large Space Hardware Systems developed using FFP contracts and/or like agreement
  - 'Large' ~ >\$100M DDTE + complex technically and organizationally... and usually politically salient and (at least) analogous to large human space DDTE
  - $\square$  Average partner contract cost  $\sim$  \$1B-ish
  - ...and often cheaper-option replacement for expiring capability
  - SAAs and OTAs also considered herein as FFP

#### Study is DDTE-focused

- DDTE == Contract ATP thru for IOC cert (sometimes = FOC)
- This study does not directly address per mission or per unit cost performance (though we talk about it some)
- We focus on contract-scope costs that include demonstration and certification flights but not 'services' flights

## Growth' of any type is measure from earliest credible estimate

- ...not @ABC (lots of datapoints didn't even have one)
- Most original schedule estimates crafted circa MCR or` SRR/SDR equivalent
- Original cost 'estimate' == original contract/agreement cost...
- ...aka we are not measuring parametric cost estimate performance. Yet. That's the next study.
- Obvious early sales pitches disregarded
- '==' means 'defined as' & '=' means 'equals'
- Some analyses herein include a small few projects that have not flown yet
  - Growth of DDTE projects midstream... is still growth, so summary stats could be treated as minima

## LFD PROFILES AND THEMATIC SURVEY BIG COMMERCIAL SPACE FAMILY TREE

- FFP history: Specifically not used for DDTE projects, especially big ones — off-the-shelf projects, et al
- EELV: Spiritual godmother to NASA FFP large project dev (LFD) trend – leveraged OTAs (aka SAAs) for dual-rocket dev (Atlas V & Delta 4)
- Irony: EELV not considered fully programmatically successful due to ballooned (+250%) per mission cost
- COTS highly inspired by EELV, especially use of SAAs/OTAs (which are not domain of <u>NASA FAR</u>)
- CCP's success gave NASA license to go all-in on FFP for large DDTEs in human space on the premise that the partner/government cost-sharing mechanism would save the agency's human space budget



## LFD PROFILES AND THEMATIC SURVEY PROGRAM, PROJECT, & PARTNER CONTEXT

- All partners earned significant cost savings vs traditional estimates...
- ...but few established a discernable intention to achieve schedule savings.
- > LFD partners...
  - 50/50 Traditional Cost+ participants 🤤
  - Projects mandated by presidential directive and/or responding to international events
  - Some partners benefitted from cancellation of other projects... a subset were direct 'sequels'

All partners enjoyed a single final award or were part of a pair of <u>independent</u> finals awards

| Incidence | %                |               | <u>Factor</u>                                          | 1     | 2     | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-----------|------------------|---------------|--------------------------------------------------------|-------|-------|---|---|---|---|---|---|---|----|----|----|
| 12        | 100%             | ost<br>tives  | DDTE Cost Savings: Stated<br>Priority (hence FFP)      |       | -ALL- |   |   |   |   |   |   |   |    |    |    |
| 12        | 100%             | ŭ to<br>M     | Actual Cost Savings<br>(vs estimated under Cost+)      | -ALL- |       |   |   |   |   |   |   |   |    |    |    |
| 0         | 0%               | dule<br>tives | DDTE Schedule Savings:<br>Stated Priorty               |       |       |   |   |   |   |   |   |   |    |    |    |
| 2         | 17%              | Sche<br>Mot   | Actual Schedule Savings<br>(vs historical analogues)   |       |       | ↓ | ↓ |   |   |   |   |   | X  | X  |    |
| 8         | <mark>67%</mark> | tical<br>vers | Presidential Directive                                 |       |       | Х | X |   |   | X | X | X | X  | X  | X  |
| 5         | 42%              | Polt<br>Driv  | Response to International<br>Events                    | Х     | Χ     | Χ | X |   |   |   |   | X |    |    |    |
| 6         | 50%              | tner<br>ass   | Traditional Aerospace<br>turned 'Commercial'           |       |       |   | Х | Χ | Х | Х | Х | Х |    |    |    |
| 6         | 50%              | Part<br>Cla   | New Guys On the Block                                  | Х     | Х     | Х |   |   |   |   |   |   | X  | Χ  | X  |
| 3         | 25%              | rial<br>tors  | Scavenger Programs<br>(Cancellation Beneficiaries)     |       |       | Х | Х |   |   |   |   | Х |    |    |    |
| 2         | 17%              | Se<br>Fac     | Shameless Sequel Projects                              |       |       | Χ |   |   |   |   |   | Х |    |    |    |
| 6         | 50%              | oject<br>airs | Sustained Competition:<br>Pair of Independent Partners | Х     | Х     | Х | Х |   |   | Х | Х |   |    |    |    |
| 6         | 50%              | Pro<br>Pa     | Single Final Award                                     |       |       |   |   | Х | Х |   |   | Х | Х  | Х  | Х  |

## LFD PROFILES AND THEMATIC SURVEY PARTNER DYNAMICS: COMMERCIAL DEVELOPMENT & GOV INSIGHT/OVERSIGHT

- Lean government organizations; swift commercial entities...
- ...but challenges tracking LFD partners progress were pervasive and problematic.
- Limited programmatic data deliverables
- No cost information ala CADRe or traditional reporting
- IMSs sometimes not provided regularly & low quality; some partners did not adhere to schedule DRDs
- In three instances, partners said outright: "our accounting systems don't support reporting since we have a flexible workforce"... vague/no WBS-like charging
- FFP cost data DRD CAP initiative underway now

Ask yourself: Does it really make sense that the data a partner manages to really costs that much?

|           |      |                           |        |                                                              | Proje                    | ct #  |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
|-----------|------|---------------------------|--------|--------------------------------------------------------------|--------------------------|-------|-------|-------|-------|-------|-------|--------|--------|---------|---------------------------------------------|--|--|---|---|---|---|--|--|
| Incidence | %    |                           |        | Dimension                                                    | 1                        | 2     | 3     | 4     | 5     | 6     | 10    | 11     | 12     |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% | ed                        | ntages | 'Lean' Gov Program<br>'Footprint'                            |                          |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 0         | 0%   | dvertis<br>mmeri          | P Adva | "On-the-Floor" Imbedded<br>Gov Team @ Partners               | -ALL-                    |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% | ₹ S                       | 8. FFI | 'Commerical' Dev Approach<br>Gets Results                    |                          |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% | ø                         | S      | but IS often so quickly<br>moving it's harder to track       |                          |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% | ical                      | tation | Gov Reports of "Blind Spots" vs<br>Traditional Relationships | -ALL-                    |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% | mmer                      | h Limi | Challenge in Adhering to<br>Agencies' Way of Doing Business  |                          |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% | Com                       | pproac | Partner Owns Design                                          |                          |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 7         | 78%  |                           | ۷      | Significant Departure from<br>7120.5 (or equivilent)         | Х                        | Х     | Х     | Х     |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 0         | 0%   | Deliveries<br>exhaustive) | eries  |                                                              | Actual Costs & Estimates |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 4         | 44%  |                           |        | eries                                                        | eries                    | eries | eries | eries | eries | eries | eries | reries | reries | istive) | Integrated Master<br>Schedule (actual file) |  |  | Х | Χ | Χ | Χ |  |  |
| 9         | 100% |                           | exhau  | Summary Schedules                                            |                          |       |       | -,    | ALL   | -     |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% | Data                      | (not   | Top Risks                                                    | -ALL-                    |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |
| 9         | 100% |                           |        | MELs/PELs (et al)                                            | -ALL-                    |       |       |       |       |       |       |        |        |         |                                             |  |  |   |   |   |   |  |  |

\*Three datapoints had so little insight into these dimensions, we did not include them.

## LFD PROFILES -ACQUISITION APPROACH: TEMPORAL PROFILE

- LFD Projects isolated by downselect paradigm
  - Type I: Final partners were immediately selected first round
- Type D: Projects' part of an umbrella programs' downselect process involving several rounds

#### > Type D split into four frames

- Total, before and after final partners' selection, per N round, and final round
- Some programs did not have 3rd or 4th rounds
- Combined type & NASA HSF history also considered



## LFD PROFILES -ACQUISITION APPROACH: COMPETITION & DOWNSELECT

#### > Typical Competitive Progression

- First: SAA & OTA (aka non-NASA SAA) rounds with tiny \$ and fewer traditional stipulations...
- ...Then: Large \$ FFP Contract/TOs usually corresponding to selection of final partners
- All Type D programs we studied: two final partners
- Some early favorites had big issues, some massive
- Vast majority of the downselect approach DDTE is spent after final partner selection or final round start: (77% of DDTE or 71%)



## LFD PROFILES -ACQUISITION APPROACH: COMPETITION & DOWNSELECT

- LFDs beat HSF on average by 1.4 years...
- ...but HSF beat Type D LFDs by 1.9 years
- 2.6 years spent downselecting
- 5.6-year difference between immediate selection and downselect (10.7 vs 5.1)
- 'Loser Tax' == 5.5% of total DDTE spent on partners not eventually selected as providers
- LFDs's funding streams appear to be backloaded vs traditional Cost+ beta curve
  - Image: ...perhaps to encourage initial investment burden on partners... but puts schedule growth pressure on downstream work (small 23% vs huge 77%)

Downselecting isn't free – time and money cost.



## LFD PERFORMANCE CONTRACT/AGREEMENT (C/A) COST GROWTH

- LFD C/A Growth: So far away from 0%, looks like Cost+
- Most datapoints fall within Mid group: 35% and 70% (50% CL and 92%CL)
- Requirements changes cited (also *Extreme*)... but 'Growth Packing' a possibility
- Design changes, additional testing, realized risks, pervasive optimism (also *Extreme*)
- > Low group projects entail caveats
- Contract/design changes pending
- HIDDEN contract/agreement cost growth due to many funding rounds (discussed in two slides!)
- Yes, cost risk assumed by partner & we imputed (where appropriate) large internal cost growth to companies (from financial statements, interviews, congressional testimony, etc)

#### Common Perception: "FFP contracts shift the majority of the cost risk to the provider..."



...and you thought fixed price meant cost to gov was fixed. Fixed price is in no way fixed when it involves large DDTE projects.

## LFD PERFORMANCE RISK PROFILE

#### > Question 1: Why does cost growth happen?

- Requirements changes, major test or launch failures, acts of the universe....
- ...are just a few of the risk situations that were not adequately captured by the pervasive optimism built into original pitches and plans
- Most providers departed significantly from their original generous heritage assumptions (even the 'sequel' projects)

#### Question 0: Whose fault is it? aka Who is going to pay?

- Growth Packing' => Partners know they are (partially) responsible for growth in FFP agreements so there's a financial incentive to blame the government whenever possible...
- The "FFP Premium" paid due to the additional risk assumed by a partner is hard to quantify... cost growth internal to partner becomes part of the BOE for that premium
- ➢ Government/Partner cost split is 60/40 ≈ near-equal cost partnership...
- ...but if Growth Packing grows into a prominent trend, government advantage afforded by FFP may disintegrate.

| Project # |                   |                            |                                                |       |    |   |   |   |   |    |    |    |
|-----------|-------------------|----------------------------|------------------------------------------------|-------|----|---|---|---|---|----|----|----|
| Incidence | %                 |                            | Dimension                                      | 1     | 2  | 3 | 4 | 5 | 6 | 10 | 11 | 12 |
| 12        | 100%              |                            | Pervasive Optimism (aka<br>Sales Mentality)    | -ALL- |    |   |   |   |   |    |    |    |
| 3         | 25%               | Major Risks                | Major Program<br>Requirements Changes          |       |    |   |   | Х | Х |    | Х  |    |
| 7         | <mark>58</mark> % |                            | Acts of the Universe                           |       |    |   | Х | Х | Х | X  | Х  | X  |
| 3         | 25%               |                            | Launch Provider Schedule<br>Issues             |       |    |   |   |   |   | X  | Х  | X  |
| 4         | 33%               |                            | Major Test/Launch<br>Failures                  |       |    |   | Х |   |   | X  |    |    |
| 11        | 92%               | tage<br>dence              | High Initial Leverage on<br>Hertiage Systems   |       | Х  | Х | Χ | Χ | Х | Х  | Χ  | Х  |
| 11        | <mark>92</mark> % | Heri<br>Depen              | Significant Departure from<br>those Systems    |       | X  | Х | Х | Х | Х | X  | Х  | X  |
| 10        | <mark>83%</mark>  | s                          | Subject of Many Critical GAO<br>and IG Reports | Х     | Х  | Х | Х | Х | Х |    |    | Х  |
| 5         | 42%               | onsequence:<br>litigations | Unplanned Testing & Risk<br>Reduction Added    | Х     | Х  | Х | Х |   |   |    |    |    |
| 4         | 33%               |                            | Business Plan Viability<br>Consequences        | Pr    | Pr |   |   |   |   |    |    |    |
| 12        | 100%              | Risk Co<br>& N             | Cost Growth on FFP<br>Agreements               | -ALL- |    |   |   |   |   |    |    |    |
| 12        | 100%              | -                          | Schedule Growth                                | -ALL- |    |   |   |   |   |    |    |    |

Top priority for programs: Keep requirements stable or tempt a Pandora's Box of growth.



## LFD PERFORMANCE HIDDEN COST GROWTH

- > We can measure contract/agreement cost growth all day....
- Solution when you go with FFP, partners' internal costs and estimates are not reported.
- <u>'Hidden Cost Growth'</u> == Growth in cost of a funding round vs a partner's original, unadvertised cost estimate of it
  - Example: At the beginning of funding Round 1, Partner A secretly estimates \$100 for Round 2, but @ the end of Round 1, it bid \$200
  - A cost growth = 0%, but hidden cost growth = 100%
- The more DDTE funding rounds you have, the more cost growth the partner can HIDE...
- ...and the more that measurable cost growth to contracts/agreements doesn't capture the real story.
- $\succ$  Well, then, what IS the Real Story?  $\rightarrow$



Unless round budgets are fixed, multi-round acquisitions are likely packed with hidden cost growth that NASA pays for regardless.

## LFD PERFORMANCE TOTAL COST GROWTH

#### Real Story → <u>Total Cost Growth</u> ==

Contract/Agreement (C/A) Growth + Internal Partner Growth

...where Internal Partner Growth == In-Round Internal Growth + Hidden Cost Growth

#### Corollary: Contract Growth ≠ Total Cost Growth

...unless partner has maxed Growth Packing, pushing all growth onto government and maxing out government % contribution to project

Current estimates suggest of Gov/Partner contribution ratio heuristic (→) suggests that we haven't yet seen this worst-case scenario...

...but since growth packing is a rational partner act, future partners may be increasingly willing to pass as much growth to government as is plausible

## Contract Growth ≠ Total Cost Growth... ...No matter how much you want it to

- EX: Touting FFP victory, one NASA program achieved a ~10% Contract/Agreement Growth with its LFD partner, but that's not the same as Total Cost Growth...
- ...the same partner's hefty losses captured on its public financial statements (and associated news stories) implied 54% Total Cost Growth, well short of a financial win



Using FFP DDTE contracts means abdicating full measurement of Total Cost Growth.

## LFD PERFORMANCE BUSINESS VIABILITY & PARTNER FEEDBACK

- But who cares about total cost growth if the government only has to cover some of it?
- There is evidence that FFP contracts could be making business cases less attractive for partners
- NASA leadership has keen awareness of this issue and is concerned with partner financial viability of partners current and future
- > Some companies complaining about their experience with FFP
  - One partner openly acknowledged the commercial market they needed to recoup their cost never materialized
  - Another partner stated that they do not intend to pursue or sign any more FFP development contracts
- NASA perception: majority of cost risk on partner...
- ...but story may not be as bad in future if Gov/partner cost split changes in favor of partner



'Advantageous' Gov/partner split may not be attractive to commercial partners.

## LFD PERFORMANCE: SCHEDULE GROWTH

- Cost isn't fixed.... schedule isn't either: LFD schedule growth mean of 90%
- Most datapoints fall within Mid group: 82%@ 42%CL & 130% @ 85%CL
  - Requirements changes cited (also *Extreme*) ... but 'Growth Packing' is relevant
  - Design changes, additional testing, realized risks, pervasive optimism (also *Extreme*)
- > Low group projects entail caveats
  - Contract/design changes pending
  - Unlike cost, schedule growth cannot be HIDDEN, but its drivers can be



So... what exactly is 'fixed' about FFP?

## LFD PERFORMANCE VIRAL GROWTH

- '<u>Viral Growth</u>'== Similarly observed cost or schedule growth amongst codependent or even independent program partners signifying global risks that either identified, undiscovered, or concealed.
- Cost & Schedule growth correlation between LFD program partners (some advertised as completely independent DDTE efforts) is <u>high</u>
- WHY? '<u>Risk Contagions</u>' transmit growth within program regardless of ostensible partner independence ->
- ..."But I am a SRA/JCL practitioner and know that unique, individual project risks drive growth!"
  - Perhaps not as much as program meta-drivers
  - Should our quantitative schedule analyses shift focus from the project/sub-project level (ala SRA/JCL) to the program level?

Viral Growth Drivers may Dominate Partner-Unique Risks,

|                            | C/A Cost Growth<br>Btwn Paired<br>Program Partners | Schedule<br>Growth Btwn | C X S |
|----------------------------|----------------------------------------------------|-------------------------|-------|
| Correlation                | 74%                                                | <b>98%</b>              | -11%  |
| Average Pair<br>Difference | 13%                                                | <b>12%</b>              |       |

\*Incomplete projects omitted



#### RISK CONTAGIONS

- ✓ Common Classes of Acknowledged Global Risks/Dynamics
  - Program budget constraints and funding timelines
  - Common technical or political risks
  - □ Forces of competition (positive contagion ?)
- ✓ <u>Rarely Identified Drivers of Viral Risk</u>
  - Hidden interdependencies, including psychology and expectation
- License to collectively fail (they're late, so I can be too)
- Same PM management and gov-side technical oversight team approach

## LFD PERFORMANCE KUO METRIC: COST AND SCHEDULE GROWTH CORRELATION



#### <u>Fred Kuo Metric</u> == 🌾

#### Why is the Kuo Metric slightly negative for LFDs?

- Preemptive Response #A: No, the correlation matrix is not inconsistent CXS is a different matrix than the first two columns
- Preemptive Response #B: Yes, the expectation from NASA history is that Kuo Metric > 0
- Math interpretation: Cost growth between projects and schedule growth between projects move together for all the reasons (see previous slide)...
- ...but some partners with very high schedule growth demonstrate very low C/A cost growth

|                            | C/A Cost Growth<br>Btwn Paired<br>Program Partners | Schedule<br>Growth Btwn | C X S |
|----------------------------|----------------------------------------------------|-------------------------|-------|
| Correlation                | 74%                                                | <b>98</b> %             | -11%  |
| Average Pair<br>Difference | 13%                                                | 12%                     |       |
|                            | *Incomplete pr                                     | rojects omitted         | Eee   |

- Political Interpretation: Gov/Partner funding contribution split is subject to significant influences – But everyone suffers for schedule growth regardless of source
- Cynical Interpretation: Projects, programs, or partners pick which degree of freedom they want to abuse

#### Hypothesis: The more a partner engages in Growth Packing, the higher the Kuo Metric rises.

Unified Interpretation: There is a "Fungibility Mismatch" between LFD cost and schedule growth.

## **EPILOGUE** Study Phase 2 Teaser: Scope

#### Bored yet? We've just scratched surface.

#### Phase 2 Study: Cost+ -VS- FFP for big development projects



- PRELIMINARY Commercial-Ways-of-Doing-Business (CWODB) discount factor ~ 60% discount when we go with new batch of partners vs traditional militaryindustrial complex
- LDF program manager just last week: "This project was done for 1/2 to 1/3<sup>rd</sup> of what NASA would have cost."
- ...our data confirms this.

#### > Who wins from a performance perspective?

PRELIMINARY findings: Neither. Cost+ cost growth ~ FFP cost growth.

#### Bonus: How did our community's parametric estimates do vs actual LFD cost?

#### Denouement

#### Are FFP vehicles 'worth it' vs Cost+?

What are the specific dimensions of tradeoff culled from real examples within both the Cost+ and LFD universes?

- Relative Cost savings
- Relative Schedules savings
- Other tradeoffs

■ Which parameters drive these savings/penalties? How can we used these to assess future LFD projects?

How well did the initial estimates

perform vs actuals?

Phase 2 -2024 thru 🗙

Phase 2 of this study: Fight between Cost+ & FFP

## **EPILOGUE** STUDY PHASE 2 TEASER: *DOES THE FFP MECHANISM ALONE SAVE MONEY?*

#### Data suggests not.

Does the FFP mechanism itself save the government money? It's all about who bears the burden of cost growth, right?



- If you apply the 60/40 split metric to the contract cost in the dataset to arrive at a total cost...
- ...the figure is STILL an order of magnitude (at minimum) less than traditional HSF Cost+ contracts (even from a \$/lb standpoint).
- FFP's shared-burden environment isn't the driver of significant savings...
- ...compared to the deep discounts modern companies are willing to make on total project cost regardless of contract type.



Could powerful new space realm influences alone (and not FFP) be driving lower cost?

# 

## BACKUP

## FIRM FIXED PRICE STUDY PHASE 1 Abstract

#### LARGE SPACE HARDWARE SYSTEM DEVELOPMENT UNDER FIRM-FIXED PRICE CONTRACTS ~ SURVEY, NARRATIVE, AND PROGRAMMATIC PERFORMANCE

Firm-Fixed Price (FFP) contracts, traditionally reserved for off-the-shelf or build-to-print projects, dominate NASA's recent acquisition strategy for large human space hardware development efforts, including a large portion of the Artemis campaign. Starting with Commercial Orbital Transportation Services (COTS) and inflecting upon the success of second-gen systems, many recent major human space flight projects have followed suit on the premise that lower cost to government is a 'free lunch' that need not be purchased with less predictable programmatic, schedule, and technical outcomes.

We examine the above premise through the lens of the consolidated meta-narrative, including quantitative measurement of cost and schedule performance, associated with a basket of nine (9) large space system FFP development (LFD) acquisitions from NASA and DOD. This study marks the first time this level of breadth and depth of data associated with the most salient LFD cases has been thoroughly compiled and examined as a whole.

Contrary to current agency philosophy, our preliminary findings indicate the nuanced programmatic dynamics entailed by variations on the FFP theme consistently induce cost and schedule performance consequences that call into question the acquisition method's reputation as a 'free lunch' strategy. We explore each dimension of characteristic FFP features within this context, such as specific contract mix, down-select scheme, partner interdependency and notions of 'fly off' targets, and modalities of growth.