COMMERCIAL SPACE FEDERATION

Perfecting Public-Private Partnerships

The Future of Government Space Contracts

February 2026

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Acknowledgments

This study involved interviews with industry stakeholders and the members of the Commercial Space Federation (CSF). Rational Futures thanks the interviewees for their time, as well as CSF leadership for their support.

About the Commercial Space Federation

The Commercial Space Federation (CSF) is the leading trade association representing the commercial space industry. We serve as the industry's voice to policymakers in the U.S. government, international governments and organizations, the media, and the public, advocating for policies that support growth and innovation in the space economy. CSF's members comprise multiple sectors of the commercial space industrial base including launch and reentry, remote sensing, spaceports, in-space research and manufacturing, space communications, commercial space stations, and other new space capabilities. CSF and its members are focused on expanding America's leadership in space by offering innovative and less expensive solutions to U.S. government customers including the National Aeronautics and Space Administration (NASA), the U.S. Space Force, and the intelligence community. In addition, CSF advocates for policies that will provide services to the American public and grow a sustainable space economy. For more information, please visit https://commercialspace.org/.

About Rational Futures

Rational Futures was founded by NASA's former Chief Economist team to build actionable and evidence-based techno-economic analyses for the advanced technology and space sectors. We are led by a team of multidisciplinary experts in space economics, engineering, and commercial operations. With backgrounds at NASA, Voyager Space, RAND, the White House, and academia, we have conducted rigorous assessments of emerging technologies, markets, and policies to inform effective resource allocation and strategic decision making. Our work spans cost-benefit analysis, risk modeling and valuation, market sizing, investment tracking, policy evaluation, and technology assessment, with a track record that includes informing national policy documents, acquiring over $500M in space sector business, and building analytical frameworks used across NASA and the U.S. Government. We combine space technology expertise with world-class economic modeling to deliver reality-grounded insights for clients committed to building a prosperous future. Learn more at www.rationalfutures.com.

Foreword

In 2004, when NASA decided to retire the space shuttle, the agency still needed the capability to transport astronauts, research experiments, and supplies to the International Space Station (ISS) from U.S. soil. At the same time, NASA had its eyes on human exploration beyond low-Earth orbit – the Moon, Mars, and beyond – an expensive proposition. Instead of building a bespoke government-owned transportation system for low-Earth orbit (LEO), NASA implemented an acquisition model in which the government would buy commercial transportation services from industry at a fraction of the cost of developing, owning, and operating its own system. The Commercial Orbital Transportation Services (COTS) program was wildly successful, with the Commercial Resupply Services and Commercial Crew programs now regularly delivering cargo and crew to the ISS. More than 75 U.S. astronauts, international partner astronauts, and private citizens have now ridden to space on a commercial rocket. There have been 55 commercial resupply missions to the ISS. These programs saved the U.S. government billions of dollars, and, by betting on the then-nascent commercial space industry, NASA fueled development of the industry and, in turn, new commercial capabilities for the U.S. government.

NASA has sought to replicate the success of commercial LEO transportation in nearly every new human spaceflight program. When U.S. astronauts return to the Moon for the first time since 1972, it will be on a commercial lunar lander wearing a commercial space suit. Lunar surface transportation, lunar payload and cargo delivery, lunar communications and navigation, and lunar power are all planned as commercial programs. When ISS retires after 2030, NASA plans to move its LEO activities to a commercially developed and operated space station. Even NASA's science mission directorate is leveraging commercial capabilities through programs like the Commercial Lunar Payload Delivery Services (CLPS) program and the Commercial Smallsat Data Acquisition (CSDA) Program. Under these firm-fixed price programs, NASA and the taxpayers are paying for services and results. Industry partnerships are allowing U.S. space programs to do more – explore more – with fewer resources.

Inevitably, not all public private partnerships are created equal. In the years following the COTS program, some government buyers have implemented firm-fixed price contracts but, in practice, managed these contracts like a cost-plus development program. As NASA, the Department of Defense, and other government agencies continue to embrace commercial space solutions, there are a number of factors government buyers should consider as they design and manage commercial acquisitions. The Commercial Space Federation (CSF) commissioned this survey and report to provide government officials with a guidebook on successfully developing and managing commercial space partnerships in a way that provides maximum benefit to the U.S. government and the U.S. commercial space industry.

Sincerely,

Dave Cavossa
President, Commercial Space Federation

Executive Summary

U.S. law and national space policy mandate that federal agencies leverage private sector space capabilities to the maximum extent practicable to meet government needs. To assist in designing and facilitating government engagements with the private space sector and enhancing outcomes in non-traditional procurements, we provide a collection of ideas and recommendations drawn from literature and interviews with stakeholders.

In Section 1, this paper provides a primer on public-private partnerships (PPPs) by first illustrating that risk ownership determines the type of procurement arrangement**. In traditional procurements,** the government retains all key project risks**.** In **PPPs,** government and private entities share key project risks. Lastly, in **commercial development,** the private entity retains all key project risks. Literature shows that there are three main reasons to use PPPs.

- **Risk sharing**: PPPs allocate major risks to the party best able to manage them.
- **Specialization**: Each partner handles the tasks they do best.
- **Incentive bundling**: Aligned incentives across a project encourage better outcomes.

In Section 2, this paper introduces mechanisms to improve outcomes from non-traditional procurement arrangements and facilitate engagements with the private sector. We categorize them into three levels.

Agency-level Mechanisms	Program-level Mechanisms	Contract-level Mechanisms
Build internal capacity	Signal clear demand	Assess appropriate procurement options
Communicate with transparency	Conduct robust market assessment	Commit to requirements
Conduct capability surveys	Support multiple suppliers	Utilize block buys
Establish a control tower		

Section 3 explores a qualitative framework of broad concepts for program design and implementation. This framework accounts for key program characteristics, including a capability's importance to government objectives, the interdependence of technical and organizational components, and the total expected lifecycle cost. It also considers essential market conditions, such as the size of the addressable non-government market, the nature of available private investment, and the prevailing macroeconomic context.

Important Note on Mechanisms

Readers should understand the ideas below *solely* as methods whereby the government can better design partnerships with the commercial space sector. They are not intended to be standalone mechanisms to achieve lower prices of individual systems or any other narrow goal. While cost reduction, for example, is a valuable *outcome* of positive engagement, no single mechanism can achieve this result on its own. These mechanisms are tools that should be applied judiciously on a program-by-program basis and only following careful review of surrounding market conditions.

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Section 1: Primer on Public-Private Partnerships in the Space Industry

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Section 1: Primer on Public-Private Partnerships in the Space Industry

- **Risk ownership determines procurement type**: Public entity retains responsibility for all major risks in traditional procurement, public and private entities share the risks in PPPs, and the private entity retains the risks in commercial development.
- **Three main benefits of PPPs**:
    - Risk sharing: Allocate risks to the party best able to manage them
    - Specialization: Each partner handles tasks they do best
    - Incentive bundling: Aligned incentives encourage better outcomes
- **Procurement arrangement types are not the same as contract types**: PPPs and commercial development describe procurement structures, while Firm Fixed Price (FFP), Cost Plus (CP), and Other Transactional Authority (OTA) are legal mechanisms to execute them.
- **Success requires careful implementation**: Mixed empirical evidence across sectors shows benefits depend on careful planning, involvement of appropriate experts, and understanding of market conditions and program characteristics.

This section describes public-private partnerships (PPPs) and commercial development programs, two types of non-traditional government procurements. It begins with a definition of key terms related to these procurement arrangements. It then describes the benefits of PPPs and concludes with a clarification of the differences between procurement arrangements and contract types, such as firm fixed-price (FFP) contracts, often used interchangeably in industry.

For the purpose of this white paper, the term “commercial development” differs from “commercial market.” The former refers to how the government acquires capabilities, while the latter describes the state of a market.

Definitions

A PPP is a procurement arrangement that describes the inclusion of private contributions in public sector projects. Organizations like the Government Accountability Office, the Department of Transportation, and the Federal Accounting Standards Advisory Board use different definitions of PPPs, but they all share a common characteristic: the allocation of risks between public and private entities (GAO 1999; FASAB 2016; DOT 2025). Because no single definition is universally accepted, this white paper adopts the typological framework from Kim (2023a) to facilitate a discussion of risks specific to the space sector.

The typological framework identifies five core risks in public sector space programs to classify PPPs, alongside traditional procurement and commercial development. The type of procurement arrangement depends on which entity—public or private—owns the risks. The five core risks are financial, construction, technical, operational, and business risks. Table 1 below provides detailed descriptions of each risk.

Table 1. *Understanding the five core risks is necessary to describe the type of procurement arrangements* (Kim 2023).

Core Risks	Description of Risk
Financial	Securing the funding and capital required to successfully complete the design and development phases of a program.
Construction	Cost and schedule performance of system development.
Technical	Whether the system will work due to possible engineering failures.
Operational	Activities in the operations phase that allow the continuation of the service that the system is meant to provide.
Business	Securing the revenue to sustain the operations phase.

Using this framework, we can clearly illustrate the full procurement spectrum concerning the risks shared or transferred between parties, as detailed below and in Figure 1. Numerous combinations of risks can be shared or transferred within PPPs, resulting in various types of PPPs. For this paper, the term PPP represents a general archetype that encompasses all PPPs within the spectrum of procurement arrangements.

Figure 1. *The ownership of risks determines the type of procurement arrangement* (Kim 2023).

- In **traditional procurement**, the public entity retains full responsibility for all five core risks. It owns and operates the system, with access to capabilities typically reserved for its own use.
- **PPPs** facilitate the sharing of core risks with private entities. The private entity typically operates the resulting system and generates revenue by providing services to both public and private sectors.
- In **commercial development**, the private entity assumes responsibility for all five core risks. The public entity may incur costs for the customization of existing systems. The private entity typically earns revenue by offering products and services to both sectors.

Benefits of PPPs

There are three main advantages in using PPPs:

- **Risk sharing**: PPPs can allocate major project risks to the party best able to manage them. The private sector, being closer to production, usually has better information to assess and control these risks (Irwin 2007, 57).
- **Specialization:** Each partner can handle the tasks they do best. PPPs apply this by outsourcing design, production, and operations to private firms that operate more efficiently through competition (Camm 2005, 183).
- **Incentive bundling**: Aligning roles across a project encourages better performance. When the same party builds and operates a system, it can design it to cut long-term costs (Hart 2003; Välilä 2005).

These practical benefits can help improve programmatic performance, foster a market, and enhance national capabilities (World Bank Group, n.d.). For example, by effectively allocating risks, PPPs can enhance risk management and prevent certain cost increases (OECD 2012). When the manufacturer and operator are the same entity, transaction costs associated with transferring operations can be reduced (Hart 2003). Furthermore, private sector participation accelerates technology diffusion, contributing to market development and improving industrial capabilities (Link 1999).

In spite of these benefits, empirical evidence regarding the effectiveness of PPPs across various sectors—including infrastructure, transportation, and health—is mixed. Some studies indicate success in reducing costs and improving quality, while others show the opposite (DOT 2004; Hodge and Greve 2007; IPA 2007; Helby Peterson 2019; Fabre and Straub 2023). The complexities of drafting comprehensive contracts and adequately assessing risks contribute to these varied results. This variation highlights two important insights: 1) if designed and executed correctly, PPPs can provide substantial benefits; and 2) realizing these benefits requires careful planning, involvement of experts, and a robust understanding of both market conditions and program characteristics.

As the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD) increasingly utilize PPPs, the agencies should continue to monitor and refine their understanding of when to employ specific procurement arrangements. Sections 2 and 3 of this paper offer several useful mechanisms for navigating this complex landscape.

Procurement Arrangements and Contract Types

PPPs and commercial development are procurement arrangements defined by which entities own the key program risks. Contracts are the legal means for executing the terms of these strategic arrangements. Broadly, contracts fall into two categories: the Federal Acquisition Regulation (FAR) based contract vehicles, such as firm fixed-price (FFP) and cost-plus (CP) contracts[1], and the non-FAR vehicles known as Other Transaction Authority (OTA) agreements.[2] Table 2 below provides the definition of each contract type.

Table 2. *Legal definitions of the various contract types provide context for their appropriate use.*

Contract Types	Definitions
Firm-Fixed Price Contracts	**FAR 16-202:** A firm-fixed-price contract provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss. It provides maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administrative burden upon the contracting parties.
Cost-Plus Contracts (Cost-reimbursement)	**FAR 16-301:** Cost-reimbursement types of contracts provide for payment of allowable incurred costs, to the extent prescribed in the contract. These contracts establish an estimate of total cost for the purpose of obligating funds and establishing a ceiling that the contractor may not exceed (except at its own risk) without the approval of the contracting officer.

[1] Note that there are various types of FFP and CP contracts such as Fixed Price Incentive Pricing, Cost-Plus-Incentive-Fee, Cost-Plus-Award-Fee, and Cost-Plus-Fixed-Fee contracts. Refer to FAR Subpart 16.204, 16.304, 16.305, and 16.306, respectively, for definitions.

[2] While others exist, such as grants and Federal Assistance instruments, this paper focuses exclusively on FAR-based contracts and OTA-based agreements due to the substantially larger scale of financial commitments they represent.

Other Transaction Authority (OTA)	**Space Act Agreement (SAA) for NASA:** "A broad term for any agreement conducted under the National Aeronautics and Space Act of 1958 to establish a set of legally enforceable commitments between NASA and a partner requiring the obligation of NASA resources" (NASA OIG 2023). SAAs are not typical contracts subject to the FAR or other Federal procurement statutes (NASA OIG 2014). **Other Transaction (OT) Agreements for DoD:** "The Secretary of Defense and the Secretary of each military department may enter into transactions (other than contracts, cooperative agreements, and grants) under the authority of this subsection in carrying out basic, applied, and advanced research projects" (10 U.S. Code § 4021, n.d.).

In a CP contract, the public entity retains most key risks, as CP allows the contractor to recover incurred costs during contract execution (Federal Acquisition Regulation 2025a). As a result, the public entity bears the burden of cost increases typical in large space programs. Government agencies have generally leveraged CP contracts for traditional procurements involving significant technology development risks, uncertainties in government requirements, and limited private sector demand.

FFP contracts place "maximum risk and full responsibility for all costs" on the contractor, requiring the delivery of a product or service at a predetermined price (Federal Acquisition Regulation 2025b). This feature transfers major risks to the private entity, incentivizing efficiency and potentially resulting in substantial cost savings. For instance, a NASA report estimated that developing a launch vehicle under a CP contract could cost about three times as much as an FFP contract (NASA 2011). However, if the predetermined price is inaccurate or if the underlying assumptions change, the program faces an increased risk of financial loss for the private entity, necessitating contract renegotiation. Therefore, FFP contracts are ideal when requirements are well-defined and stable across the contracting period.

OTA agreements provide the legal flexibility to structure agreements outside the statutory governance of the FAR. This allows for the tailoring of incentives according to the risks transferred to the private entity. OTAs can be designed for public and private partners to collaboratively evolve statements of work as technical uncertainties are resolved (DoD 2023). This flexibility mitigates the extensive legal, regulatory, and administrative resources required for FAR contract modifications. However, the absence of FAR boundaries also means less legal protection for stakeholders when issues arise.

Given the traits of FFPs and OTAs, they can align well with the goals of PPPs and commercial development in sharing or transferring core risks to private entities. While this may imply that contract types and procurement arrangements are interchangeable, maintaining distinct definitions is crucial for clarity in partnership formulation. Conflating PPPs with FFP contracts can create misleading expectations of cost-capping, as PPPs can incur increases due to unforeseen risks, changing market conditions, or inadequate implementation.

Section 2: Improving Public-Private Partnership Program Outcomes

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- **Agency-level**: Build internal capacity beyond engineering, communicate transparently, conduct capability surveys, and establish a coordination office
- **Program-level**: Conduct robust market assessments, signal clear, multi-year demand, support multiple suppliers for competition and redundancy
- **Contract-level**: Select appropriate procurement options that align with program characteristics, commit to requirements, and utilize block buys for economies of scale

This section introduces mechanisms to facilitate government engagements with the private sector and enhance outcomes in non-traditional procurements. U.S. space agencies face significant challenges in navigating PPPs and commercial development. Beyond the “Iron Triangle” of cost, schedule, and performance goals (Pollack et al. 2018), they must also cultivate emerging markets in the space economy. Therefore, agencies must strategically focus not only on what to build, but also how to ensure it achieves broader policy objectives. These mechanisms are drawn from a literature review, lessons from past programs, and non-attributional stakeholder interviews. The subsequent section then presents a conceptual framework for applying these mechanisms based on program characteristics and market conditions.

Table 3 lists the mechanisms, categorized into three levels:

- **Agency-level** mechanisms consider the institutional capabilities necessary for effective public-private engagement at scale. This requires top-down commitments, including building internal expertise in finance and economics, and establishing a unified organizational voice.
- **Program-level** mechanisms address the operational and market dynamics of multi-year efforts, emphasizing the management of the industrial base, and market competition.
- **Contract-level** mechanisms address the granular and legally binding aspects of the procurement.

Table 3. *Leveraging the mechanisms at various governance levels allows stakeholders to improve program outcomes.*

Agency-level Mechanisms	Program-level Mechanisms	Contract-level Mechanisms
Build internal capacity	Signal clear, multi-year demand	Assess appropriate procurement options

Communicate with transparency	Conduct robust market assessments	Commit to requirements
Conduct capability surveys	Support multiple suppliers	Utilize block buys
Establish a control tower		

These mechanisms may have limited effect in improving outcomes when applied individually or without adequate consideration of market context. Their effectiveness derives from tailored application, often requiring combinations of multiple mechanisms, rather than a one-size-fits-all approach. Section 3 of this paper describes examples of more tailored approaches using market and program analyses.

Agency-level Mechanisms

Build Internal Capacity

Successful PPPs and commercial development require expertise beyond engineering, including specialists in legal, procurement, and finance practices, as evidenced by NASA's Commercial Orbital Transportation Services (COTS) program (NASA 2014). As public entities become consumers and market facilitators, they must develop internal capacities to meet this evolving landscape. Agencies must promote organizational learning and retain a skilled workforce to sustain specialized knowledge as they shift toward a higher degree of market involvement. This shift also demands a cultural change, moving away from traditional risk management to enhance the capacity to implement and support non-traditional procurement and risk management mechanisms.

Communicate with Transparency

Academic literature on PPPs identify transparency and open communication as critical factors in enhancing performance (Jacobson and Choi 2008; Osei-Kyei and Chan 2015). Transparent communication fosters clarity at all organizational levels, justifying its inclusion at the agency level. Consistently providing a clear long-term strategic direction helps maintain private sector investor confidence. Moreover, effective communication goes beyond merely announcing intentions. Utilizing industry days, requests for information, and stakeholder meetings facilitates two-way dialogue, ensuring the government actively listens to and integrates industry input on technical capabilities and market dynamics for the success of all parties involved (Shelton et al. 2021).

Conduct Capability Surveys

A capabilities survey evaluates available technologies in the private market to inform decision-makers about whether comparable technologies can meet mission needs and if incremental development can effectively close performance gaps. Maintaining these resources at the Agency-level ensures continuity for new programs and mitigates the risk of information being siloed or lost

when a program concludes. Accordingly, United States Space Force (USSF) senior leadership recently spoke about the importance of conducting surveys of what technologies are available and propagating this information throughout the government to enable better decision making (Waterman 2025). As the space industry changes, public entities should institutionalize recurring capability assessments to validate assumptions and align procurement decisions (Yonekura et al. 2022).

Establish a Control Tower

Given the organizational complexity of public space entities, a centralized office for private sector engagements can prevent individual programs from pursuing potentially redundant activities. Adapting an enterprise perspective, rather than focusing on specific systems, can also contribute to the efficiency of an agency (Shelton et al. 2021). By serving as a hub for data and expertise, this office enhances internal coordination and organizational consistency. Externally, it functions as a “front door” for private entities, simplifying navigation through government processes and providing industry partners with a single point of access for planning, designing, and managing their engagements. Recognizing these potential benefits, the USSF established the Space Force Front Door with the Space Systems Command in 2025 (SSC 2025).

Below is a sample list of activities the centralized office could manage, based on the mechanisms discussed in this section:

- **Coordination**: Facilitate rapid and efficient partnership decisions across legal, program, and procurement offices.
- **Strategic Market Assessment**: Conduct independent market assessments during the planning phase to advise programs and agency leadership on market realities.
- **Unified Voice**: Provide a consistent, unified voice for the agency by developing a long-term strategy and signaling demand.
- **Private Sector Capability Assessment**: Develop a comprehensive database of private sector capabilities through industry surveys to inform internal programs and optimize the utilization of the space industrial base.
- **Knowledge and Performance Management**: Document and share the performance of non-traditional procurements and lessons learned to foster organizational learning.

Program-level Mechanisms

Conduct Robust Market Assessments

A robust, accurate, and independent assessment of the private market is essential for structuring and managing non-traditional procurements. NASA’s Office of Inspector General (OIG) reported inaccurate market assessments as a factor that contributed to unfavorable program performance (NASA OIG 2024). Relying on incomplete information to align risks can lead to contractor bankruptcy or vendor dropout due to lower-than-expected business opportunities. Such outcomes can increase government costs, diminish investor confidence, and hinder the private market's development in both speed and scale. Public entities should rigorously verify and validate industry-circulated market estimates with the same scrutiny applied to hardware.

A robust assessment offers multiple benefits: it enhances clarity and transparency for investors, provides public entities with insights into the market's provider capacity, and facilitates more rational down-selection (Rao 2025). This process is crucial for avoiding excessive market concentration and effectively leveraging competition to ensure industrial base management, market stability, and cost reduction.

Signal Clear Demand

Private capital flows from investors to industry based on a program's perceived economic value, which in turn depends on the demand from both the public and private sectors. Since markets in the space industry are typically nascent, space PPPs and commercial development programs are often viewed as high-risk ventures by private investors (Kuhr 2024). This market uncertainty compels investors to seek higher returns through increased equity stakes or interest rates, putting significant pressure on the private entity's business case. Interviewees noted that clear and consistent demand signals help mitigate these uncertainties, directly aiding the private entity in securing the funding necessary to successfully complete the program.

Below are a few examples of ways public entities can signal demand:

- Early contract awards for service provision during the development phase.
- Consistent communication via public channels, affirming that the program will remain a priority for the agency.
- Early down-selection of the most promising providers when multiple competitors are present.
- Detailed scope definitions that specify quantities and types of funded capabilities rather than relying on broad statements of need.
- Avoiding competing against industry by not developing equivalent technologies or capabilities within the government.

Support Multiple Suppliers

When the government plans a non-traditional procurement for a service, selecting multiple providers when feasible promotes competition and reduces risks related to single source dependency. Multiple providers also enhance mission resiliency by offering redundancy in case of vendor failure. Programs such as NASA’s COTS and Commercial Lunar Payload Services (CLPS), and DoD’s Proliferated Warfighter Space Architecture (PWSA) and National Security Space Launch (NSSL), illustrate the importance of supporting multiple providers.

As with all mechanisms presented herein, supporting multiple suppliers alone is not guaranteed to produce positive outcomes. When designing a program, it is critical that the public entity consider how many suppliers the market can sustainably support. While selecting multiple suppliers is beneficial, trade-offs are involved (Rao 2025). Choosing too few limits competition and may raise prices, while selecting too many risks spreading investment too thinly (Triezenberg et al. 2020). Additionally, failing to implement a timely down-selection may prolong investor

uncertainty and slow private capital commitment. This delay exposes potential suppliers to significant financial risk during critical early development phases, causing investors to lose confidence and redirect their capital, ultimately weakening the industrial base and increasing government risk.

Contract-level Mechanisms

Assess Appropriate Procurement Options

Program formulation requires selecting the appropriate procurement arrangement and contract type. This task involves assessing the relationships between market realities, technology maturity, government requirements, and policy goals. When a market has many customers and the technology that meets the government's requirements is mature, commercial development through FFPs is the appropriate approach, as stated in the FAR. Structuring a firm-fixed price procurement incorrectly may impose financial pressure on the private entity, which could incentivize it to exit the contract due to cost overruns and reduced business viability (Eaton 2024).

CP contracts have been the traditional approach when technology needs substantial research and development, and the government is the sole customer during the early market phase before private sector demand emerges. NASA's COTS demonstrated that a PPP via OTA can also be used successfully in these situations. The flexibility of OTAs enables the public entity to share development risks, reducing the financial burden associated with FFPs. Once development is complete, the partnership can transition to commercial development using FFPs for service purchases, as shown by the Commercial Resupply Services (CRS) approach (NASA 2014). When commercial markets already exist, agencies can pursue commercial development to buy services with minimal customization. For example, NASA purchases Earth observation data via the Commercial SmallSat Data Acquisition program from existing service providers, rather than deploying redundant capabilities (Ostrenga and Kaulfus 2024). While simplified for clarity, these examples emphasize that careful assessment and selection of procurement options based on various factors are crucial for program success.

Commit to Requirements

Successful non-traditional procurements allow private entities to serve both public and private sector demands. To facilitate this, contract formulation should focus on "what" (goals) rather than "how" (product specifications). Focusing on goals enhances business viability in the private sector and aids companies in closing their business cases (NASA 2014; 2022; Zapata 2023). Additionally, clear and timely requirement setting enables private entities to secure necessary fundraising and investments early, contributing to the overall financial stability of the program.

Once the contract is signed, the private partner expects fixed, stable requirements over the term of the contracting period, as changes in requirements can disrupt their financial and business models. Additionally, shifts in design or performance can increase costs for the public entity, undermining the intended fiscal benefits (Ames et al. 2024). Multiple interviewees noted that non-traditional procurements in which they have participated have been subject to costly requirements

changes. While committing to initial requirements is ideal, when changes are necessary, their impact should be integrated into the decision-making process through discussions with industry partners.

Utilize Block Buys

Placing larger orders provides certainty for vendors and their investors, potentially reducing overall costs from economies of scale. For products and services needed on a consistent basis, the block-buy approach leverages this effect by committing to a large volume purchase over multiple years under a single contract rather than relying on sporadic, one-off contracts (Dennis et al. 2025). This mechanism offers private entities a reliable demand source, enabling them to negotiate volume discounts on raw materials, stabilize labor and supply chains, and optimize production runs. For the public entity, block buys can lead to overall cost reductions and position it as an anchor customer with strategic purchasing power (Powers et al. 2018; O'Rourke 2025).

It is important to note that improper implementation of block buy contracts could prevent competition from emerging, negating potential positive effects to government buyers. Architecting block buys should consider market context, while incorporating multiple suppliers where possible.

Mechanisms in Practice - Program Examples

The following examines NASA's COTS and CLPS programs to illustrate how the mechanisms described above affect program outcomes and challenges. We selected these programs based on the availability of extensive public documentation.

COTS

NASA's COTS program successfully developed multiple independent commercial cargo systems, establishing a commercial space transportation market that continues to serve NASA and other customers. Four key mechanisms contributed to this success: selecting an appropriate procurement option, supporting multiple suppliers, committing to the initial requirements, and utilizing block buys.

The COTS program facilitated a multi-billion dollar PPP that shared financial risks while allocating other key risks to private partners (Kim 2023). NASA contributed approximately $800 million while private partners contributed an estimated $900 million—based on SpaceX's reported contribution of $450 million and assuming similar investment from Orbital Sciences—for total development costs of approximately $1.7 billion (NASA 2014; Zapata 2017). Full government funding of this amount would have pressured NASA's already constrained budget, forcing tradeoffs with other critical programs, while fully private funding exceeded what partners could raise, as demonstrated when an initial partner failed to secure adequate financing (NASA 2014). At the same time, allocating other key risks to private entities enabled them to retain intellectual property ownership for commercial uses, incentivizing private investment while shifting NASA's role from providing oversight to providing insight.

Cost-sharing also enabled NASA to award multiple contracts and select multiple suppliers, encouraging competition during development and reducing monopoly risk (Lindenmoyer 2012). This portfolio approach required active management and advanced contingency planning. When one partner failed to meet financial and technical milestones early on, NASA moved quickly to terminate the contract and launch a new round of partner selection within a month (NASA 2014). Maintaining the portfolio preserved NASA's access to a critical national capability when another partner later experienced significant schedule delays.

In addition, COTS focused its requirements on what needed to be delivered (e.g., cargo mass to the International Space Station) rather than how to achieve those objectives and committed to this approach throughout the program. This opened opportunities for the private partners to make decisions tailored to their own business models, while avoiding disruption to the development plan with requirement changes (NASA 2014). The flexibility proved essential for developing systems that could serve markets beyond NASA's demand.

Near the completion of the COTS development program, NASA awarded SpaceX $1.6 billion and Orbital Sciences $1.9 billion for a total of 20 CRS deliveries in 2008, followed by the second phase award in 2016 with a maximum value of $14 billion (NASA 2014; NASA 2016). For the private partners, the block buys signaled clear demand from the government, providing demand stability and production optimization. At the same time, NASA benefitted from the economies of scale as evidenced by the annual average cost reduction of 1.9 percent for CRS missions from 2012 to 2022 (Kim 2025).

CLPS

The success of COTS led subsequent NASA programs to adopt non-traditional procurement arrangements that transfer risks to private entities. CLPS applied several mechanisms similar to COTS. While these mechanisms achieved intended outcomes in some cases, the program experienced cost increases and schedule delays that more accurate and consistent implementation could have reduced. This case illustrates that selecting mechanisms alone does not ensure success.

Based on initial market assessments, CLPS structured its procurement arrangement as commercial development, transferring all key risks to private partners (Kim 2023). Accordingly, the program adopted a risk posture focused on accepting more risks compared to traditional risk mitigation approaches (NASA OIG 2024). The program also selected multiple companies as a supplier pool competing for FFP task orders. This portfolio approach ensured competition and redundancy, protecting the program when suppliers faced technical challenges in lunar landing and financial distress.

However, the initial market assessments proved overly optimistic. Based on early surveys and requests for information, CLPS anticipated the suppliers could achieve lunar landings within short development periods and set mission schedules accordingly (NASA OIG 2024). The providers ultimately encountered supply chain disruptions, workforce development challenges, and technical obstacles in lander development, all of which were compounded by macroeconomic challenges resulting from the COVID-19 pandemic. The optimistic assessments led to schedule

goals that provided insufficient margin to absorb these challenges and misaligned with actual supplier capabilities, resulting in schedule delays across task orders (NASA OIG 2024).

NASA's initial hands-off strategy and risk acceptance posture changed as these issues emerged. The program added oversight reviews not included in original task orders, shifting from the intended strategy and leading to cost increases (NASA OIG 2024). Requirement changes also created programmatic challenges. CLPS awarded the task order for delivery of the Volatiles Investigating Polar Exploration Rover (VIPER) over a year before its critical design review; by the time VIPER passed its design review, its mass and other parameters had changed, requiring changes to the CLPS award that led to cost growth (NASA 2020; NASA 2021; NASA OIG 2024).

Section 3: A Conceptual Framework for Consideration of Program Characteristics and Market Conditions for Program Design and Implementation

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Section 3: A Conceptual Framework for Consideration of Program Characteristics and Market Conditions for Program Design and Implementation

Program characteristics to assess:

- Criticality: Importance of the capability to government objectives – these inform the appropriate degree of risk-sharing with the private sector
- Complexity: Technical and organizational programmatic interdependencies – these affect implementation approach and can amplify risk.
- Capital expenditure: Total lifecycle costs – these inform financial risk allocation

Market conditions to evaluate:

- Private sector demand: Size and persistence of non-government markets
- Private capital: Nature and availability of investment sources
- Macroeconomic context: Broader economic factors influencing investment and cost

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The following qualitative framework offers broad concepts that stakeholders should consider when designing and implementing a PPP or commercial development. It also provides considerations for when to use the mechanisms previously discussed. This framework does not provide a prescriptive guide of potential issues and corresponding mitigation actions for non-traditional procurements. Such an approach would hold limited value due to the unique attributes of each program. Public entities can use this framework to define the specific factors, missions, and risk tolerances as they design and implement non-traditional procurement programs.

At the highest level of the framework, two domains exist:

- **Program Characteristics:** These are intrinsic to the organization and its governance of the system being developed. They are largely linked to the nature of the technology and its role in achieving government objectives.
- **Market Conditions:** These influence private sector participation and the long-term business viability of private entities.

The rest of this section provides several factors and illustrative mechanisms in each domain. Table 4 summarizes the discussion. Mechanisms are not fixed to specific factors or domains;

within each factor, all mechanisms can be used to varying degrees to improve public entity engagements with the private sector.

Table 4: *Identifying underlying program characteristics and market conditions within which a program operates can help identify the appropriate mechanisms to navigate them.*

Domain	Factor	Description	Illustrative Mechanisms
Program Characteristics	**Criticality**	Importance of the capability to government objectives	**Assess appropriate procurement options** to ensure alignment of the mission importance and risk transfers. **Support multiple suppliers** for redundancy in highly critical missions.
	Complexity	Degree of technical and organizational interdependence	**Conduct capability surveys** to assess how well existing technologies can meet government needs. **Commit to requirements** to contain and avoid increase in complexity.
	Capital Expenditure	Total cost required to develop and field the capability	**Assess appropriate procurement options** to provide flexibility if further public financial support is needed in high capital expenditure programs. **Commit to requirements** to avoid cost growth and ease budget constraints.
Market Conditions	**Private Sector Demand**	Size and persistence of the non-government demand	**Conduct robust market assessment** to assess the alignment of requirements to expected private sector demand. **Utilize block buys** to provide anchor tenancy in markets that have not developed robust private sector demand.
	Private Capital	Size and type of private investment available to the program	**Build internal capacity** to better understand the dynamics between private entities in a program and their sources of capital. **Signal clear demand** to enhance investor confidence when private capital is hesitant to invest in new technology development.
	Macroeconomic Context	Broader economic environment influencing investment and cost	**Establish a control tower** to assess changing market environments and provide strategic guidance for adaptation. **Communicate with transparency** to ensure consistent and clear long-term goals for reduced uncertainty.

Criticality (program characteristic)

Criticality refers to the importance of a capability in achieving government objectives. Depending on the criticality of the capability, the public entity can determine the degree of risk-sharing with the private sector. High-criticality programs typically exhibit lower risk tolerance, so aligning risk management practices should be an area of particular focus for program designers. Another approach to maintaining access to capabilities in critical missions is redundancy through multiple suppliers or parallel development paths, which reduces program-level vulnerability and fosters competition. For instance, NASA's Commercial Crew Program balanced the high criticality of human spaceflight access with competition among providers to mitigate risk while leveraging private design efficiencies.

Complexity (program characteristic)

Complexity refers to the degree of interdependence among a program's technical and organizational components, where the program's success relies on the effective integration of these elements to achieve its objectives. Complexity can amplify risk, especially when combined with high criticality or significant capital expenditure.

Mechanisms for navigating complexity include conducting capability surveys to determine if using existing private sector technologies or services can serve government needs, as seen in DoD's PWSA and NASA's Communications Services Program (Erwin 2023; Walker and Kearns 2024). This method, if available, has the potential for less complexity compared to designing, developing, and deploying a new government-owned system. If leveraging existing services is not feasible, committing to requirements once a new development program begins helps contain complexity by avoiding changes that could increase programmatic interdependencies, as described above, and scope.

Capital Expenditure (program characteristic)

Capital expenditure refers to the total expected lifecycle cost to develop and deploy a capability. Government and industry cost estimates often diverge due to insufficient data or differing methodologies (CBO 2025). Expertise in interpreting market estimates and private sector assumptions is therefore crucial. Accurate cost estimates are vital for understanding the financial risks shared or transferred to the private sector and for structuring the appropriate procurement arrangements. Additionally, for high capital expenditure programs, committing to stable requirements is essential to mitigate cost growth and ease budgetary constraints.

Private Sector Demand (market condition)

Private sector demand refers to the size and persistence of the addressable non-government market. Capabilities aligned with stable, multi-customer demand have a greater likelihood of achieving self-sustaining success. Conversely, if private sector demand does not materialize, the public entity may need to act as an anchor tenant through mechanisms like DoD's NSSL block buys.

To determine the appropriate level of market support, the public entity should conduct independent market analysis, while engaging with industry early to validate assumptions. This thorough assessment informs the requirements design, enabling the public entity to consider requirements that enhance private sector utilization.

Private Capital (market condition)

Private capital refers to the nature of private investment available to the program through the private partner. This factor is essential for assessing the private entity's financial risk posture and informing government decisions. For instance, high capital availability with a long-term investment horizon allows the public entity to contribute less and transfer a larger share of financial risk. Conversely, if private capital trends toward lower availability and shorter investment horizons, the public entity may need to retain more financial risk and increase its level of funding.

The source of investment also influences the private partner's risk posture. Venture capital (VC), institutional investors, and sovereign investors each have unique risk profiles and time horizons. For example, VCs seek higher returns over shorter time frames compared to other capital types. Thus, a private entity relying on short-horizon venture funding for a long-term, high-capital expenditure system will have a different risk posture than one self-funded by high-net-worth individuals. Developing internal expertise to understand the dynamics between investment sources and private partners can help public entities navigate these complexities more effectively.

Macroeconomic Context (market condition)

Macroeconomic context, such as interest rates, inflation, insurance markets, and global supply chain conditions, directly impact business viability, overall project costs, and the private capital environment. When macroeconomic conditions are unfavorable, the government may need to take a more active role in facilitating program operations to reduce uncertainties. A central office within an agency capable of monitoring inflation, supply chain disruptions, and the financial health of private partners can provide strategic guidance to mitigate negative impacts. Additionally, continuous and open communication of long-term goals and commitments to private sector stakeholders can alleviate the uncertainties that pressure program stability.

Implementing the Framework and Further Work

To operationalize the concepts in this report, public entities can take the following initial steps:

1. **Integrate Market and Program Analysis:** Require each new partnership proposal to identify core risks to be shared or transferred, justifying the chosen procurement arrangement while assessing both program characteristics and market conditions. This ensures procurement design aligns with external market realities prior to solicitation release. Further work may involve empirical analysis on the relationships between program characteristics, market conditions, procurement arrangements, and programmatic performance.

2. **Develop Tools for Smarter Buying:** Build capacities to improve engagements with the private sector, better measure underlying conditions, and deploy appropriate mechanisms. While some factors, like capital expenditure and private sector demand, are readily quantifiable in terms of dollars, assigning a singular numeric value to complex factors like program criticality remains challenging. Regardless, quantifying these factors will enhance understanding of their interrelationships. Further work may involve developing quantitative measurements for qualitative factors in the conceptual framework of this paper.

3. **Sustain Knowledge and Expand Analytical Capacity:** Institutionalize mechanisms for continuously monitoring and validating lessons learned, documenting successful strategies, and establishing interagency databases to track market trends, investor behavior, and program performance. This requires collecting relevant data as programs conclude and converting it into analytical tools. Such tools would help practitioners better understand realized benefits, common issues, pain points, and lessons learned across programs. Further work may involve documenting these elements and developing these tools as a collaborative effort between government and industry.

Successful program design and implementation require substantial planning, coordination, and collaboration among stakeholders throughout the lifecycle. When executed effectively, both the government and industry can benefit.

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