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HANDBOOK TO INFORM MAJOR FIXED PRICE, COMMERCIAL, AND COTS SYSTEM SELECTION, PROCUREMENT, AND INSIGHT

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FOREWORD

This handbook is published by the Goddard Space Flight Center (GSFC) to provide uniform engineering and technical implementation guidance for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

This handbook provides guidance to inform decisions to select fixed price contracts for procurement of major systems as well as the implications during the development, delivery, receiving, and post-delivery stage for systems accordingly procured.

Requests for information, corrections, or additions to this handbook should be submitted via "Contact GTSP" to the Executive Secretary for the GSFC Technical Standards Program on the GSFC Technical Standards website at http://standards.gsfc.nasa.gov.

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TABLE OF CONTENTS

1. SCOPE

1.1 Purpose

This handbook provides guidance to help inform decisions to choose fixed price, commercial, or Commercial-off-the-shelf (COTS) procurements of major systems as well as the implications for development and product delivery phases, whether the product is selected as the only solution to meet a specific need or as an approach to obtain the most reliable product given the constraints of the project. A major system is one at the spacecraft component level or above (e.g. star tracker, power supply, up through a full constellation of spacecraft). For guidance in selecting a standard or COTS product based on its history, refer to Goddard Procedural Requirement (GPR) 8705.4, *Risk Classification and Risk-based SMA for GSFC Payloads and Systems* and GPR 8730.5, *Safety and Mission Assurance Acceptance of Inherited and Built-to-Print Products* or contact the GSFC Standard Components Commodity Risk Assessment Engineer (CRAE) in Code 371.

1.2 Applicability

This handbook applies to procurements for products for ground usage and space flight application, including specific considerations for the range of mission risk classifications. These products may range from components all the way through full spacecraft and constellations of spacecraft.

This handbook may be cited in contracts, program, project, and other Agency documents to provide technical guidance.

The guidance provided in this document is based on extensive GSFC experience and those of its subcontractors.

2. APPLICABLE DOCUMENTS

2.1 General

Documents listed in this section contain provisions that constitute underlying requirements related to the implementation guidance provided in this handbook. When imposed, it is expected that the latest issuances of the cited documents will be used unless otherwise approved by the applicable Technical Authority. The applicable documents are accessible via the NASA Technical Standards System at http://standards.nasa.gov, directly from the Standards Developing Organizations, or from other document distributors.

2.2 Government Documents

GPR 7120.4D	Risk Management
NPR 8705.4	Risk Classification for NASA Payloads
GPR 8705.4	Risk Classification and Risk-based SMA for GSFC Payloads and Systems
300-PG-7120.4.2	Code 300 Risk Management Plan
GPR 8730.5 A	Safety and Mission Assurance Acceptance of Inherited and Built-to-Print Products
EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Derating

2.3 Non-Government Documents

IPC 6012	Qualification and Performance Specification for Rigid Printed Circuit Boards

2.4 Order of Precedence

When applied internally or imposed by contract on a program or project, the technical requirements in NASA and GSFC directives (or other requirements documents) take precedence, in the case of conflict, over implementation guidance provided in this handbook.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms and Abbreviations

COTS	Commercial-off-the-shelf
CPIP	Commercial Procurement Implementation Plan
CRAE	Commodity Risk Assessment Engineer
EEE	Electrical, Electronic, and Electromechanical
GIDEP	Government-Industry Data Exchange Program
GPR	Goddard Procedural Requirement
GSFC	Goddard Space Flight Center
ILPM	Industry Leading Parts Manufacturer
IMU	Inertial Measurement Unit
IPC	Organization formerly known as Institute for Printed Circuits
MIL-SPEC	Military Specification
NESC	NASA Engineering and Safety Center
NPR	NASA Procedural Requirement
RSDO	Rapid Spacecraft Development Office
SMA	Safety & Mission Assurance
SME	Subject Matter Expert

3.2 Definitions

Commercial product	A nondevelopmental product that is manufactured based on the standard practices that a developer uses to make a profit.

COTS	Commercial-off-the-shelf - generally available to the public (often in a catalog or on a website), produced with no government intervention or insight into the manufacturing processes or parts and materials and only obtainable based on a set of specifications pre-determined by the manufacturer
Established Reliability	Demonstrated operation (of a standard product or COTS assembly, component, or spacecraft) over years and production over multiple units by the same vendor, including possible changes due to obsolescence and modernization. May be quantified by risk classification using the Inherited Standard Products row in Table 1 along with Appendix D from GPR 8705.4A.
Fixed-price	A contract where the buyer agrees to pay a set price for a product regardless of the seller's actual costs. Note that in selecting a fixed-price contract, the buyer should have full confidence in the seller delivering the product as required and on time. Any assistance from the buyer would be based on lack of confidence and would unlikely be factored into the fixed price.
Quality	The totality of features and characteristics of a product or service that bear on its ability to satisfy given needs
Reliability	The probability of a system to perform the necessary functions within expected life cycle exposure conditions for a required period
Risk	The combination of 1) the likelihood (qualitative or quantitative) that a project, program, or organization will experience an undesired event such as cost overrun, schedule slippage, or failure to achieve a required outcome, and 2) the worst-case consequence or impact of the undesired event were it to occur.
Risk Assessment	The formulation of one or more statements of risk based on analysis of the supporting data associated with a concern.
Risk Classification	A stakeholder-assigned definition of risk-tolerance for a project. See NASA Procedural Requirement (NPR) 8705.4 and GPR 8705.4.
Safety	A condition of protection against threats to (1) personnel, (2) the public, or (3) collateral damage outside of the ownership of a project or program.

4. COTS BACKGROUND AND DEFINITION

The term *COTS* not only has an extensive number of definitions in use, but also covers an infinite trade space. In this handbook, a COTS product will be defined as a software or hardware item that is generally available to the public (often in a catalog or on a website) produced with no government intervention or insight into the manufacturing processes or parts and materials and that can only be procured based on a set of specifications pre-determined by the manufacturer. However, the emphasis in the handbook guidance is on large scale procurements of high-level assemblies and components through constellations of spacecraft. The aforementioned specifications are generally delineated in a *datasheet* or *product specification*. Traditionally COTS products have been labeled unreliable for a variety of reasons, one being that the government has no control of the internal requirements. Another reason is that historically, COTS products have been used in complex systems where there was no other viable means within resource allocations to produce a component to perform the required function. Such a force-fitted solution brought with it many technical challenges and possibly reliability threats. A less circumstantial reason was that in the middle of the 20th century, there were few industrial areas where manufacturing processes were automated and mature enough to produce items that had sufficient consistency and robustness in designs to provide assured long-term operation. This was an era where repair shops were busy fixing many common household electronics items such as televisions, stereos, computers, etc., often because of electronic part failures. Since many such products were common across thousands or in some cases millions of households, it was reasonable to conclude that parts were often faulty, weak, or simply had wear-out mechanisms. Given the state of manufacturing maturity at the inception of the US Space Program, concerns about COTS products were well-founded. Another reason for the "unreliable" characterization has been the conflation of the term *quality* with r*eliability*. This came about because historically the agency has produced one-of-a-kind systems from piece-parts that only have the possibility to obtain reliability as a side effect of reliable design practices, extensive quality requirements, and extensive testing, rather than obtaining directly through volume, statistical process controls, and field experiences. This conflation is present in many current documents such as EEE-INST-002 where testing and screening requirements levels are denoted "reliability levels," and in use of industry standards such as IPC 6012 where the defined quality levels are purported to align with product reliability requirements, even though there is no correlation between the quality requirements and the actual reliability.

4.1 Drivers for Considering the Use of COTS Products

Over time, industry capabilities have grown and, in many cases, surpassed the government space sector in many areas, which has been reflected in "make-or-buy" assessments. While it has often been recognized that standard products, including in some cases full spacecraft, have been suitably proven to be reliable and a better alternative than a new in-house development, this has not in general led to significant reduction in the piece-part level of controls and oversight in the development of such products. Furthermore, at the piece-part level, COTS parts used as is have been relegated only to the highest of risk-tolerant applications because of the lack of government oversight and controls, and the subsequent assumption that the government involvement and knowledge are necessary to minimize, mitigate, or eliminate risk. However, this links back to (1) the notion that reliability is quality, and that quality is more about the oversight and internal knowledge than it is about the features of the product itself and (2) that organizations outside of NASA are less capable of developing reliable systems than those within the agency. Such notions mischaracterize reliability in terms of the testing approaches of the piece parts inside rather than the probability of the system to perform for the required amount of time, and neglect the fact that reliability is established by volume of usage and established means of quality control (including internal testing, screening, inspection, and statistical process controls) and continuous improvement. Currently the spacecraft industry is mass producing spacecraft using their internal processes and procedures with excellent success. The spacecraft on orbit demonstrated reliability is outstanding for many vendors.[1] Established reliability at the highest possible level of assembly will always provide the most substantive basis for reliability of the mission. There are three top candidates for COTS products in space system development:

1. A product with Established reliability that already has a proven history of success and well-defined datasheet, with past usage enveloping the current mission requirements and environments – This product has the best basis of reliability if nothing is done to try to change or "improve" the product or inserting processes to interfere with the development flow and this would often be the best solution for a critical application.
2. A product with limited history or even undesirable failure history is the only possible, available, or affordable solution. Any such usage should always capture and acknowledge the elevated risk, which often may be present on a Class D or sub-Class-D mission or would require a backup for the function on a Class A-C mission. Attempting to change the COTS item is not likely to reduce risk or improve reliability and, in most cases, it is not possible.
3. A product that is the best price and/or availability to be used in a non-critical application that has insignificant impact of product failure.

Risk classification may be used to guide the selection of a standard product based on successful past usage using Appendix D in GPR 8705.4A. Note that in some cases, there will not be an option to obtain a product that satisfies the classification-based guidelines in 8705.4A, but a standard product would still be the best choice. While such a decision should be documented by the project's chosen method commensurate with the particular development phase (based, e.g., on whether there is a study report, project planning documentation, or other internal project reports), no waiver would be required unless a project were to choose to impose its own requirement internally.

Further consideration for the procurement of a COTS or commercial fixed price bus is the set of services that come with the bus, such as spectrum allocation, security approach, RF compatibility testing, commissioning planning and support, comms and contact management, ground segments, and databases. In some cases, these "extras" might be of equal or greater consideration to that of the spacecraft itself. In addition, there may be many non-recurring engineering elements that have to be developed to accommodate unique instruments and interfaces with other components or systems. It is essential to consider the level of insight or oversight desired to cover the unique elements and to ensure that they are appropriately addressed in the contract. The level of insight or oversight would be defined by the non-inherited sections of the project's Mission Assurance Requirements document. These unique elements have a standard inclusion in Rapid Space Development Office (RSDO) procurements but might not be naturally addressed in other forms of procurements.

[1] See https://smallsatnews.com/. Also based on information from NOAA/NESDIS-funded "Smallsat Reliability Study" performed by Johns Hopkins University Applied Physics Laboratory. For further info, contact NASA GSFC Rapid Spacecraft Development Office.

4.2 Reliability of COTS Products

The reliability of a system is its ability to perform (or the probability to successfully perform) the necessary functions within expected life cycle exposure conditions (i.e., in its intended operating environment) for a required period. A system can be designed using sound practices that factor in wear-out mechanisms relative to the operating environment and that include features that make the system tolerant to the expected disturbances that will act on it. These features can include redundant elements, margins (e.g., via derating of individual parts and components), protection circuits, and various types of barriers of protection such as shielding, to name a few. While these collective practices provide reliability assurance, they do not in and of themselves establish a system as reliable, and none in themselves are necessary or sufficient to guarantee reliability. Given that NASA's historical approach at developing space systems is centered around one-of-a-kind systems, and the fact that in the early days of the US space program, NASA was one of few capable organizations for developing space flight hardware, the term *reliability* was used to represent high quality combined with sound design practices as there were no established reliable systems. Often accelerated testing and associated *reliability prediction* were key accompanying elements. Unfortunately, the growing and successful space community has had little effect on the use of the term, so often reliability has been conflated with quality and there has been a failure to recognize that reliability is established directly by successful history[2] rather than strict implementation of traditional quality requirements. This misunderstanding has also perpetuated the misguided view that standardized and commercialized components that have a proven history (and thus have established reliability) are "unreliable" because they don't follow traditional quality requirements imposed within the agency. In fact, the best means for reliability is through the use of products that have a high[3] volume of production and where the manufacturer has established and proven quality controls, performs 100% electrical testing across product datasheet or product specifications, employs statistical process controls, and has processes in place for continuous improvement with a zero defects policy. The high volume and successful performance attributes determine the proven reliability, while the other attributes represent *quality*, which provides the indicators that the current product is representative of the proven products. Quality itself can be divided into two categories:

1. **The observable (through inspection or testing of the product as a whole) physical attributes**
2. **The paperwork (certifications, certificates of conformance, etc.)**

Item 1 is the actual representation of quality of the item while item 2 is the assurance that internal details of the item (such as raw material composition) are per the design. Elements of each of these two categories should be used to provide assurance of the preceding attributes above. Most assurance artifacts will be based on information from the manufacturer and the remaining artifacts come from external inspection and functional testing for assembled COTS components. An element of trust is required for the use of COTS since verifications cannot in

[2] Note that successful history not only considers the performance of an exact duplicate product, but also the developer's ability to change the product to address needs for continuous improvement, obsolescence management, and supply chain risk mitigation while maintaining consistent, reliable performance.
[3] The term *high* is relative based on the level of assembly. At the piece part level, high volume would imply one million or more delivered, while for major spacecraft components or assemblies, high may imply 10-20.

general be performed internal to such devices. Thus, a relationship with the manufacturer and knowledge of the manufacturer's reputation are essential elements to instill confidence in the product. Notably, these aspects of quality are not in direct control of the customer (i.e., the customer cannot screen quality in or convert a poor-quality standard product into a good quality product) and thus the customer must rely heavily on the quantitative understanding of reliability obtained through performance metrics on a product operating within its design parameters and designed for environment. Such performance metrics would include operating life, availability/down-time, or detailed technical performance of the item such as accuracy, data rate, noise level, etc.

4.3 COTS vs Non-COTS Selection Decision

The use of COTS components requires a different philosophy than that traditionally employed within NASA since the internal constituents cannot be prescribed or controlled. Thus, it is essential that the datasheet covers all necessary performance parameters and that none are violated[4]. The greater the volume and past success history the current version of the product has in the given environment, the greater the reliability. An established COTS product by a reputable manufacturer with high volume of usage, used within its defined bounds, would almost always be more reliable and lower cost than a custom-built product.

Building upon the common drivers for COTS annotated in Section 4.1, any of the following would be valid selection criteria for COTS:

1. Item has been fully established to cover the time, environment, and operation of the current task at hand (lowest risk, most reliable solution) as evidenced by past direct experience, flight data provided by the manufacturer, or records held within the agency such as by the standard components CRAE,
2. Item is the only option available within time and money resources to do the job and would thus be used at elevated risk,
3. Item is the lowest cost option in an application for which failure of the component is acceptable, which includes the special case where the item is experimental and under qualification for applications of greater importance.

A well-known attribute of most COTS products is that elements of them can be changed at any time, as long as the product meets the requirements of its spec sheet or datasheet. Thus, the decision should also consider the manufacturer's past record of how it has maintained product performance and reliability through changes based on, e.g., continuous improvement and obsolescence management for parts and materials within. Since all products change over time due to obsolescence and continuous improvement, a positive history is inherently indicative of how the manufacturer has managed such change. The use of leading and reputable manufacturers, preferably those with a trusted NASA relationship, provide a strong basis for understanding some of the important details. When considering product history and

[4] There will be situations in which the only solution would be to procure a COTS item and use it outside of its bounds, but in that case, the function should not be critical unless there is a backup option or the item would have to be qualified for the extended performance range. In such cases, there is no established reliability, so the associated risk should be assessed and accepted by the project.

manufacturer past record, the procuring organization should also consider whether the manufacturer has recently gone through major changes, such as a buyout or merger. In many cases, such events have had positive effects, but there have been cases historically that have indicated significant changes in product. Due diligence should go into understanding of product status since such an event has occurred. There are many approaches to gain more understanding, such as audits, assessments, supply chain risk assessments, or in some cases informal engagements. The history of the product and any changes should be the drivers for selecting such a contract and a vendor. The comparison of the vendor's practices to GSFC's practices might provide comfort and peace of mind, but assurance of reliability is indicated by results. The addition of non-commercial practices and oversight will in general negate the established reliability of a product by changing it and contradict the premise of choosing a commercial procurement option. If it is deemed that GSFC-specific oversight and practices are required based on sound evidence, then a commercial, fixed-price, or COTS procurement would be the wrong contract choice. Such evidence, for example, would be poor on-orbit performance without GSFC oversight and excellent on-orbit performance with GSFC oversight. If such is discovered after a contract has been let, then it will be necessary to convene a high-level review to determine whether it makes sense to continue under the current contract terms. Historically, attempts to fix such a situation by inserting personnel carrying GSFC's traditional practices have resulted in overruns and in many cases cancellations after extensive expenditure.

The standard components CRAE has the Safety & Mission Assurance (SMA) responsibility for standard spacecraft components (e.g., star trackers, reaction wheels, full spacecraft), under which COTS high-level assemblies would fall, and is the focal point for maintaining product-specific information when past NASA history exists.

4.3.1 Commercial and Fixed-Price Buys

In some cases, there is no catalog item available to do the required job, but a vendor has proven capabilities for producing similar products and/or is willing to encumber some of the risk by offering the product at fixed price. In these cases, the logic for selection turns towards the history of the vendor for delivering similar products and the benefit to the government of entering into such a contract. A commercial contract involves using the vendor's own internal practices without government intervention, notwithstanding any special additions for which the government would choose to pay and encumber extra time. The more special additions added, the less effective such a contract will be. Fixed-price buys involve similar logic in that any type of open-ended government intervention items may only be included per added contract language with the additional cost and time associated. Notably, to accept such items might require the contractor to add large margins into the fixed-price estimate to mitigate the risk. In both such situations, as with a COTS procurement, Subject Matter Experts (SMEs) inputs are required in the initial decision process and their role during development is limited by the specific restrictions and inclusions in the contract.

4.3.2 The Role of Subject Matter Experts

Within GSFC, SMEs have key roles throughout the lifecycle of development, procurement, and testing of products at all levels of assembly. SMEs cover functions such as, but not limited to, EEE parts, materials and processes, radiation, workmanship, quality assurance, reliability, and contamination. The roles are different for fixed price, commercial, and COTS procurements compared to custom, piece-part-based developments in the following ways:

a. Fixed price and commercial: product selection, receiving inspection and testing of final product, and only elements during development that are specified in the contract.
b. COTS: product selection and receiving inspection and testing of the final product.

There is no opportunity to intervene during the development of a COTS product or of other fixed price and commercial products when the specific interventions are not spelled out in the contract.

4.4 Acceptance Process for COTS Items

The acceptance of any COTS product requires a different approach than that historically used for product assurance within NASA. Since in a general sense, the buyer cannot access or change the internal elements of a COTS product, the product must be assured by a combination of the observable aspects of the product, the history of the product or similar products, and knowledge of and relationship with the manufacturer. As part of standard SMA practices at GSFC per GPR 8730.5, historical information will be reviewed to determine if the product is formally an Inherited Item. When the item is a complete spacecraft, the successful inherited item data review should constitute a technical acceptability standard for Commercial Spacecraft Procurements. When levels of assembly lower than a full spacecraft or major spacecraft component are procured, often acceptance testing and, in the case where disposable units can be procured, qualification testing and/or construction analysis may be performed to assure that (1) the product is the same product that was procured, (2) the product meets functional requirements, and (3) the product is free from defects that are likely to prompt unexpected failure mechanisms. It is outside of the scope of this handbook to prescribe the testing approach and levels for any given situation. However, it is important to point out that it is this process itself where significant mistakes are often made. The following recommendations apply:

1. Do not test a product intended for flight use at levels above datasheet rated levels without manufacturer concurrence. Exception: if the product is the only potential solution and the application requires overextended use, then such testing and ultimate usage should entail a risk assessment and a determination that the usage does not cause a concern for safety, collateral damage, or early wear-out.
2. Solicit manufacturer inputs prior to performing (destructive) qualification testing of the product to avoid misleading or overconservative testing results.
3. Take note of any particular sensitivities associated with the product prior to testing, such as relative humidity, atmosphere (e.g., for high voltage items), mechanical or electrical setup, etc.
4. If construction analysis or destructive physical analysis is performed, be sure that results are assessed against a baseline for the specific part from the specific manufacturer and not based on a general standard for the part, as high volume, statistically-process-controlled parts are controlled by parametric performance and reliability, rather than traditional features for a given part type.

Note: In most cases, with a COTS procurement, any risks are accepted at the decision to use the specific COTS item and those risks can be mitigated by proper usage or in some cases, buying more than the number required and selecting the best by qualitative or quantitative judgment, i.e., “cherry-picking.” Thus, assessment of the constituent elements will only be helpful after the fact, upon a failure or anomaly since it is counterproductive (and generally not possible) to try to change parts in a COTS item and generally the manufacturer will not provide a list of internal parts and materials. The exception involves cases where a COTS item is the closest fit but does not quite match the performance or operational requirements, but the plan is to modify the item. Notably in that case, there is no longer a reliability basis, and the elevated risk should be acknowledged in executing the plan. This modified-COTS exception should have no expectations for cost-control or reliability and there are no standard recommendations that would be generally applicable. Unfortunately, this approach has a history of misuse in the agency, which is often couched (in e.g., GSA reports) as “misapplication or misunderstanding of heritage.” In many such cases, products were changed not out of actual necessity for the project but rather a pre-conceived prescriptive requirement. The danger in this is that a proven product that meets the needs of the project is changed to meet prescriptive lower-level requirements (example: prescribing a need for internal drag torque in a motor when the ultimate need is to point an actuator under a particular power limitation), which results in a new and unproven product. This becomes problematic not because the customer is not controlling the piece parts of the product, but rather because attention does not go to the new product design.

It is understandable that the use of items as procured causes discomfort in the subject matter experts who have been tasked with leaving no stone unturned to verify and assure every part, material, and process that have entered NASA systems. It is also difficult to recognize that even the most benign practices to assure outside developments add their own risks and, in many cases, the risks added outweigh those that are inherently associated with some types of products.

4.5 Quality Assurance of COTS Products

As mentioned earlier, the risks associated with the use of COTS products are accepted at the point where they are selected, so there are two mechanisms available for quality assurance: (1) quality and supply chain assessment prior to selection and (2) assessment of the product upon receipt. Under a COTS procurement the typical opportunity does not exist for intervention during production. Problems after delivery can only be addressed through warranty, assuming the product has not been misused. Products used outside of their rated limits or warranty period entail risk that should be assessed for acceptability. One should approach the procurement of a COTS item in the same way they would procure a new automobile, with similar research and similar expectations.

4.6 Alerts Related to COTS Products

Alerts, such as those from the Government-Industry Data Exchange Program (GIDEP) are not restricted to military specification (MIL-SPEC) parts and components, and just as well apply to COTS products. However, the GIDEP and other similar alert systems are dominated by nonconformances, rather than field failures. Since the MIL-SPEC system is centered around quality rules rather than demonstrated field reliability, while limited MIL-SPEC parts options are available for compliance to typical NASA and military requirements, the GIDEP system is key to assure that quality shortfalls are understood and communicated. This contrasts the commercial approach, which is driven by the market and the negative aspects of poor product reliability or field return, rather than internal quality requirements. More commonly, COTS and other standard commercial products would be subject to “safe alerts,” which warn of specific safety concerns that have been identified (an example being that many instances of a broadly used fire egress lighting system were ironically catching fire while in “ready” mode).

4.7 Major Commercial Procurements

As mentioned earlier, commercial procurements should be made based on a careful assessment that the product or service is the best solution for the job because once the decision is made and the contract is in place, there is no reasonable recourse to challenge the internal elements or to assist in the development or service. When a commercial or fixed-price option in general is selected without special language added to the contract that departs from a commercial development approach, the only subject matter expert that comes into play after the item has been selected and is in the development stage is the individual with expertise in the item as a whole, such as the Standard Components CRAE or the subsystem PDL (e.g. Attitude Control System Hardware lead for procurement of a COTS star tracker) since interior constituents are accepted at the time the decision is made to purchase the item. For major commercial or fixed-price contracts that are not instituted under a standard process, such as a RSDO procurement, a commercial procurement implementation plan (CPIP) should be developed prior to drafting the contract to ensure that once the contract is in place, the engagement by GSFC does not follow the traditional oversight, design review, and piece-part approval process, which would be in conflict with both the intent and the defined procurement approach.

The CPIP should cover the following:

1. The solution space considered
2. The basis for the selection of the item and associated commercial procurement
3. Any major risks identified for the selected item
    a. Note that major risks should only apply when there is no other viable solution under resource and performance constraints
    b. The use of commercial practices from a capable vendor does not constitute elevated risk
4. The mitigation plan for aforementioned risks
5. The means for assurance and acceptance of the item or service, consistent with the earlier stipulations of this document.

The RSDO selection and procurement process addresses the intent of the CPIP.

APPENDIX A – Example COTS Procurements

Examples:

A1. Procurement of a COTS Inertial Measurement Unit (IMU)

A small satellite project requires an IMU with demonstrated performance in highly inclined, highly elliptical orbit missions that extend beyond the geosynchronous orbit radius. There are two proven IMUs, both with 100% past success on several missions across solar cycle high and low periods, one with older technology but past piece-part approvals and internal NASA inspections during development and another that has been proven in volume through the newspace community and commercial constellations, with no insight from NASA into the development. The older technology unit slightly exceeds allocations for weight, volume, and power, and thus would require some redesign work to accommodate, while the modern unit leaves extra margin in vehicle commodities and provides excess performance. Both units have similar demonstrated reliability in the target orbit and lifetime. NASA has substantial direct experience with the older unit and minimal experience with the modern component. Both developers have well over 10 years' experience developing similar successful systems for space applications. In this case, while it would be tempting to select the unit that is more aligned with internal practices and NASA's experience base, such features are more about comfort than risk, while the need to redesign the vehicle to accommodate extra resources introduces some amount of risk, while the margins available from the new design would tend to reduce risk. Barring any other substantive information that indicates elevated risk (rather than elevated discomfort with new practices), the modern device would constitute lower risk than the traditional component and would have a stronger basis for selection. The device should be procured as a COTS product without any internal engineering or SMA specifications and should not require or expect any internal inspections or development involvement. The product would be considered an inherited item within GSFC's typical mission assurance requirements and would be the full responsibility of the Standard Components CRAE for SMA acceptance, under the supervision of the project Chief Safety and Mission Assurance Officer.

A2. Procurement of a COTS Spacecraft, Enveloped History

A new mission concept has been formulated around a constellation of spacecraft that have been designed and proven in several commercial constellation missions. Dozens of the spacecraft have flown successfully for between 4 and 10 years with a mission success rates applicable to all classes of mission GSFC implements A-D and below. When choosing a Commercial Spacecraft, the choice should envelope the payload having hosted instruments of the same size or larger with comparable pointing and stability requirements, having similar instrument interfaces to choose from (data and power), and having flown in a comparable environment to the mission in question. With a mission requirement for three years, a COTS procurement of comparable spacecraft would be an appropriate choice. As mentioned in this document, the choice of a COTS spacecraft should be based on a careful assessment of history of the device in a comparable environment, the manufacturer capability, and confidence that the device being procured will be an appropriate duplicate of the previous versions, with any major changes being understood. (Changes of internal parts and materials along with software or hardware logic changes should be expected and the decision to select the item relies on confidence that the manufacturer appropriately qualifies such changes). All of the development risk (if any) is thus accepted at the time the selection of the product is made. Notably, the selection of such a COTS spacecraft coincides with a decision to accept all developer practices and relinquish control of any internal constituents of the product, with the only tool being a final acceptance of the spacecraft as a whole. Thus, the energy for performing risk reduction must go into the selection process and the final acceptance process since there are no controls available in between. Thus, no SMA or engineering requirements may be imposed internal to the product, including internal inspections.

A3. Procurement of a COTS Spacecraft, Limited History

A new Class D mission concept is formed around the flight of a small instrument that is fully developed and waiting for a ride on a host spacecraft. The project office is tasked with finding a host vehicle and has determined that a dedicated vehicle will be required because there are no candidate comparable host spacecraft in the necessary orbit. A draft request for information led to several options:

1. a cost plus award fee at $50M with a vendor that is very experienced and follows all of GSFC's practices and has worked many missions with GSFC and a proposed spacecraft that can accommodate the instrument with large margin,
2. a firm fixed price commercial offer for $40M with a vendor that has a history of producing successful similar spacecraft, but whose practices differ greatly from those of GSFC, and a proposed spacecraft that can accommodate the mission with some margin
3. a first-time COTS spacecraft for $28M fixed price from a company with three past small spacecraft on-orbit but similar practices to GSFC, but with a spacecraft design that does not have significant margin for accommodating the instrument.

The budget for the spacecraft for the mission is $34M. The decision was made to go with selection 3, largely because it was the only option, but with confidence based on the similar practices to GSFC. Six months after contract award, a storm damaged the facility, prompting the manufacturer to move the spacecraft development to a partner facility 1000 miles away, with only one of the key personnel able to move to support development in the new facility. A new set of engineers with similar space development experience, but no experience on this company's practices or any of previous spacecraft that the contracted company had produced.

This is a decision point. $10M had already been paid to the contractor and a launch is planned in less than two years, so the plan is to continue the contract. Over the next few months, progress reports indicate a range of problems from workmanship to minor mishaps, and surprising test failures driven by basic design and test set up errors. With the amount of money already committed and launch in less than two years, the project plans to send some experts out to assist and oversee the contractor. However, it is notable that this was a COTS procurement and by any definition, the COTS item that will result will not be that which was originally procured. At this point, it is time to stop and rethink the contract. The contract terms should be reconsidered, and the contract should either be ended or renegotiated, assuming there appears to be a viable path to completion. GSFC's assistance to the company contrasts with the fixed price COTS buy and will likely result in numerous programmatic and technical problems.