Involving the Extended Value Chain in a Target Costing / Life Cycle Cost Process Model

6 November 2009

The Consortium for Advanced Management – International (CAM-I)
Target Costing Interest Group

Primary Author: James R. Hendricks, Boeing

Interest Group Chairperson: Tami L. Capperauld, Boeing

Contributors: Matthew A. Anderson, Boeing; Andrew Crossley, VEN Group; Shahid Ansari, Babson College; Michael W. Groves, Regence Group; James L. Lorenz, Rockwell Collins; Robyn L. Smith, Boeing; Charlie Stirk, CostVision; Richard L. Trent, IBM.

Table of Contents

Abstract

The CAM-I Target Costing Best Practice Interest Group conducted a study on involving Operations and Support (O&S) suppliers as partners in the product design process when the O&S cost of the product represents a significant component of the product's life cycle cost. A literature search was conducted to discover recent, relevant research on the subject, and a summary of this research is presented. Interviews were conducted with several companies representing a spectrum of industries to explore preliminary identified issues, and to collect related current practices. Four major topic areas were studied: (1) Supplier Involvement and Engagement, (2) Contractual Issues, (3) Setting and Accepting O&S Cost Targets, and (4) Managing Risk and Uncertainty. Key challenges include data unfamiliarity, unavailability, and poor quality; lack of contractual incentives and missing protective terms and conditions; lack of supplier participation in developing cost targets, lack of credibility of the cost targets, lack of attention paid to the importance of the cost target, unwillingness to adhere to the cost target, and organizational impediments; exposure to operational and estimate risk (on operational decisions) in O&S estimates.

Introduction

One of the six principles of target costing[1] is gaining the involvement of value chain members in target costing activities. Involving suppliers/partners, through coordinated and complementary efforts, helps maximize the impact a target costing implementation has on a project. For most organizations, suppliers play a critical role in the value chain, especially from a cost management standpoint. Final end users also play a crucial role, providing input (e.g. requirements, priorities) as the "voice of the customer", and providing price/performance trade-off guidance.

In a previous CAM-I Target Costing Interest Group publication, *Target Costing: the Next Frontier in Strategic Cost Management*, the importance of estimating a product's life cycle cost was addressed:

> *"Life cycle costs are important to consider from both the producer's and customer's perspectives. Cost of operating, repairing, warranty, support, and disposal are some elements that should be part of the initial cost estimate. All of these are part of a customer's cost of ownership. They should be predicted, even if some elements are difficult to predict at the time of product design. Similarly, a producer's cost from R&D [Research & Development] to abandonment must be considered in cost estimates as well."*

However, the extent to which life cycle cost is addressed is commonly limited to offering advice on how product design decisions impact support operations cost. It

[1] Target Costing Key Principles are: (1)Price Led Costing, (2) Focus on Customers, (3) Focus on Design, (4) Cross-Functional Involvement, (5) Life Cycle Orientation, and (6) Value Chain Involvement. See *Target Costing: The Next Frontier in Strategic Cost Management*, A CM-I/CMS Model for Profit Planning and Cost Management; Shahid L. Ansari, Jan E. Bell and the CAM-I Target Cost Core Group.

does not fully describe the potential complexities of negotiating with partners for commitment to after-production logistic support service contracts, which have their own distinct revenue and cost streams apart from the initial product sale, associated risks, performance metrics (e.g. reliability, availability), and related target cost issues (e.g. setting and accepting cost targets).

The purpose of this bulletin is to examine if/how organizations develop linked product and after-sale support strategies through building a collaborative relationship with their suppliers and customers early in the product life cycle. This includes involving suppliers in design-for-support related trade-off studies and decision making. This bulletin also addresses the obstacles and challenges faced by lead systems integrators and suppliers working in this business environment. Potential solutions to overcoming these obstacles and challenges will be offered.

Applicability

The global trend toward outsourcing non-core business functions causes system integrators to increasingly look to their suppliers to provide Operations & Support (O&S) services. This practice is prevalent among lead-system integrators in the defense and aerospace sectors. For example, the prime contractor of a military aircraft program will procure engines from a company that specializes in engines, e.g. General Electric, Pratt & Whitney, etc. The engine supplier provides the development and production of the engine, and the after delivery O&S services, as well.

Such an arrangement is not limited to these industries only. An analogous circumstance exists in the semiconductor manufacturing industry. Companies that build semiconductors (e.g. ON Semi-conductor, Texas Instruments, Intel) invest billions of dollars in equipment to outfit a single production factory. The equipment is sourced from many different equipment suppliers. Each manufacturing tool may cost tens of millions of dollars. Beyond this initial investment, the semiconductor manufacturer will incur significant additional O&S expenses. It may choose to utilize its own staff to perform O&S, but it is also common to outsource the O&S service tasks to the equipment supplier. In this sense, the manufacturing firm functions as a lead system integrator to the factory. It can be expected that the semiconductor manufacturer likely faces O&S challenges similar to the military aircraft manufacturers.

As businesses continue to outsource non-core functions, involving the extended value chain in life cycle target costing becomes a critical issue. Given the widespread use of outsourcing, this issue is of concern to nearly every modern enterprise.

Problem Statement

Gaining supplier involvement in a target costing implementation becomes more challenging when expectations of the supplier include meeting requirements related to logistics, maintenance and support services – beyond the initial product production and delivery. There are several contributing factors as to why suppliers may be reluctant to agree to these requirements and terms. These challenges include:

Supplier Involvement and Engagement

Generally, primes and suppliers collaborate well in design for maintainability activities. However, sometimes price commitments are requested of suppliers too early in the product development cycle.

Challenges regarding sharing data/information exist and can refer to a few different situations:

(1) Suppliers may not be familiar with operational end customer data and how new data requirements being asked of them support this.

(2) Suppliers might not share information because they do not actually have the necessary data to support a support service strategy initiative.

(3) The data could be business proprietary and competition sensitive, so there is a disincentive to sharing the data.

(4) Sharing support data with a supplier may not be legally allowed.

(5) The data may not be worth sharing due to poor quality, or unknown data quality.

Contractual Issues – Appropriate business, financial, and program incentives need to be in place to encourage desirable behavior of the project team. Resource commitments follow when contracts require a supplier to perform specific work functions, for example the requirement to provide regular (e.g. monthly or quarterly) cost estimate updates or product reliability and/or maintainability metrics – e.g. Mean Time Between Failure (MTBF), Mean Time Between Unscheduled Maintenance Action (MTBUMA), Mean Time to Repair (MTTR), etc. Without such incentives, cost-reduction initiatives, opportunity management, estimate updates, and related operating and support cost analysis and management activities will be lacking.

Setting and Accepting O&S Cost Targets – This refers to the method of deriving operating and support cost targets, the subsequent assigning and accepting of the cost targets by integrated product teams (IPTs), and the periodic status providing of current and projected costs relative to the cost target. The primary challenges related to these activities include:

(1) Lack of supplier participation in developing cost targets

(2) Lack of credibility of the cost targets themselves

(3) Lack of attention paid to their importance

(4) Unwillingness to stick to the cost target due to subsequent design change or significant material cost increase

(5) Organizational impediments

Sometimes there are no formal targets at all, just goals requiring best efforts only.

Managing Risk and Uncertainty – Long product life is a source of uncertainty with regard to forecasting anticipated costs against projected incoming revenue streams when performing to a support contract. In addition, product end users or typical product use may change, causing additional uncertainty. For example, a product may experience heavier operational use than it was originally designed for – resulting in it wearing out sooner or requiring more maintenance than anticipated. Or it may be placed in a different (harsher) environment for which it was originally designed, e.g. desert with sandstorms resulting in it wearing out sooner, or a humid tropical climate where condensation can render electronics inoperable. A supplier does not have control of these factors, and as such will shy away from the implied risk of being financially responsible for covering the shifting, underlying operational ground rules and assumptions that differ from their original proposal.

Context /Background

Recent research and investigation has highlighted the need for focus on life cycle costs and supplier estimates, as shown in a recent GAO report[2].

During the period Feb. 2003-Mar. 2004, the United States General Accounting Office (GAO) investigated 27 of the 68 NASA programs and made a more in-depth review of 10 of these 27 programs. Among the May 2004 report findings were:

> Program focus is on meeting annual budget vs. managing total program cost, and was found to be the single greatest factor in project cost growth.
>
> The Space Station program's fiscal year 2002 through fiscal 2006 budget was not credible because of weaknesses in its cost-estimating processes and it did not prepare a full life-cycle cost estimate.
>
> Only three of the ten programs provided a complete breakdown of the work to be performed. Underestimating a program's full life-cycle costs creates a risk that a program could be under-funded and subject to major cost overruns, which would ultimately result in the program being reduced in scope or additional funding being requested and appropriated to ensure the program meets its objectives. Conversely, overestimating life-cycle costs creates the risk that a program will be deemed unaffordable and would, therefore, go unfunded. Without a complete work breakdown structure (WBS), NASA programs cannot ensure that the life-cycle cost estimates have captured all relevant costs, which again can result in under-funding and cost overruns. Further, inconsistent WBS estimates across programs can create problems of double counting or, worse, underestimating costs when using historical program costs as a basis for projecting future costs on similar programs.

[2] United States General Accounting Office Report to the Committee on Science, House of Representatives *NASA Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management*, May 2004.

> Seven of the ten programs also failed to have an independent review of contractors' cost estimates—as required by NASA. Instead, programs established their budgets based on contractor proposals—particularly problematic since many contractors could bid low in order to win the contract. The result is that the supplier's low bid would be included in the final program estimate, but having not been reviewed and validated, it corrupts the credibility of the top level estimate.

With program cost focus changing from Acquisition Cost to Life Cycle Cost and Performance Based Logistics[3] support concepts, the GAO report made a recommendation that the NASA Administrator direct the Chief Financial Officer to "establish a standard framework for developing life-cycle cost estimates." Requirements include that a program "base its cost estimates on a full life cycle for the program—including all direct and indirect costs for operations and maintenance and disposal as well as planning and procurement—and on a work breakdown structure that encompass both in-house and contractor efforts."

Another study found similar cost issues. In June 2005, then Acting Deputy Secretary of Defense Gordon England issued a memorandum citing deep concern about the Department of Defense's (DoD) acquisition process. He indicated that, despite multiple studies over the previous 15 years, many programs continued to increase in cost and schedule. This memo then authorized an integrated acquisition assessment, considering every aspect of acquisition. The Defense Acquisition Performance Assessment Project was subsequently created.

A comprehensive review was undertaken, consisting of: a review of over 1,500 documents of previous acquisition reform recommendations, open meetings and a public web site to obtain public input, presentations from 107 experts, over 170 hours of briefings, a detailed survey and interviews of over 130 government and industry acquisition professionals. This review led to 1,069 observations.

In December 2005, a report was created by the project's panel[4]. One of the major findings of the report was, "DoD elects short-term savings and flexibility at the expense of long-term cost increases." This finding suggests that life-cycle cost impacts are overlooked in favor of short-term cost savings.

Having interviewed companies conducting business in defense and other industries, the authors know that the issues mentioned above are not unique to any one company or industry alone. Given these findings, symptoms and remedies for the symptoms

---

[3] Performance-Based Logistics (PBL) is the preferred Department of Defense product support strategy to improve weapon system readiness by procuring performance, which capitalizes on integrated logistics chains and public/private partnerships. The cornerstone of PBL is the purchase of weapon system sustainment as an affordable, integrated package, based on output measures such as weapon system availability, rather than input measures, such as parts and technical services. PBL Implementation is mandated by DoD Directive 5000.1.

[4] The report can be found at:
https://acc.dau.mil/GetAttachment.aspx?id=32595&pname=file&lang=en-US&aid=6193

may be obvious, but are there fundamental underlying causes which produce this result, and if so, can these causes be identified?

Target Costing and Acquisition

Target costing is a strategic profit and cost management process initiated during the early stages of product development. It applies throughout the product life cycle by actively involving the entire value chain. A goal of target costing is to invest more effort early in the design of the product to avoid expensive and time consuming changes, rework, and modifications later. Typically, the majority of product costs are *committed* in the design program phase, while the majority of costs are *incurred* during the production, and operations and support program phases. Unfortunately, addressing the cost of sustainability of the product tends to get overlooked in the early stages of a program. Instead, program focus is often directed towards meeting technical performance measures, and performing to current (short-term) contract schedule milestones. Note that U.S. Dept. of Defense Evolutionary Acquisition / Spiral Development[5] policy frequently results in multiple sequential short-term contracts (e.g. 1-2 years). This policy may actually be a contributing factor to neglecting design for supportability decision considerations.

Consider, for example, three projects with the following cost characteristics (see Figure 1). Project A has a high acquisition cost and a low Operations & Support (O&S) cost – perhaps a missile or satellite program. Project B has an approximate 50% / 50% split between acquisition and O&S costs. Project B might represent a product such as a car or truck, where depending on the underlying assumptions (e.g. cost of gas, miles driven, re-sale value, etc.), the 50%/50% acquisition/operating &

---

[5] Definitions from April 12, 2002 Department of Defense memo from the Under Secretary of Defense E.C. Aldridge, Jr. http://acquisition.navy.mil/content/download/863/3763/file/041202acq.pdf

Evolutionary Acquisition - An acquisition strategy that defines, develops, produces or acquires, and fields an initial hardware or software increment (or block) of operational capability. It is based on technologies demonstrated in relevant environments, time-phased requirements, and demonstrated manufacturing or software deployment capabilities. These capabilities can be provided in a shorter period of time, followed by subsequent increments of capability over time that accommodate improved technology and allowing for full and adaptable systems over time. Each increment will meet a militarily useful capability specified by the user (i.e., at least the thresholds set by the user for that increment); however, the first increment may represent only 60% to 80% of the desired final capability.

There are two basic approaches to evolutionary acquisition. In one approach the ultimate functionality can be defined at the beginning of the program, with the content of each deployable increment determined by the maturation of key technologies. In the second approach the ultimate functionality cannot be defined at the beginning of the program, and each increment of capability is defined by the maturation of the technologies matched with the evolving needs of the user.

Spiral Development - An iterative process for developing a defined set of capabilities within one increment. This process provides the opportunity for interaction between the user, tester, and developer. In this process, the requirements are refined through experimentation and risk management, there is continuous feedback, and the user is provided the best possible capability within the increment. Each increment may include a number of spirals. Spiral development implements evolutionary acquisition.

support cost split is reached in approximately five to nine years. Project C represents a low acquisition and high O&S cost project – perhaps an aircraft with considerable lifespan longevity, such as the B-52 bomber program, which has been in service since 1955.

Considering these projects with varying cost profiles, it is probably evident who *should* lead the cost management effort. However, in current business practices, the acquisition team dominates the cost decision-making regardless of the project's cost profile.

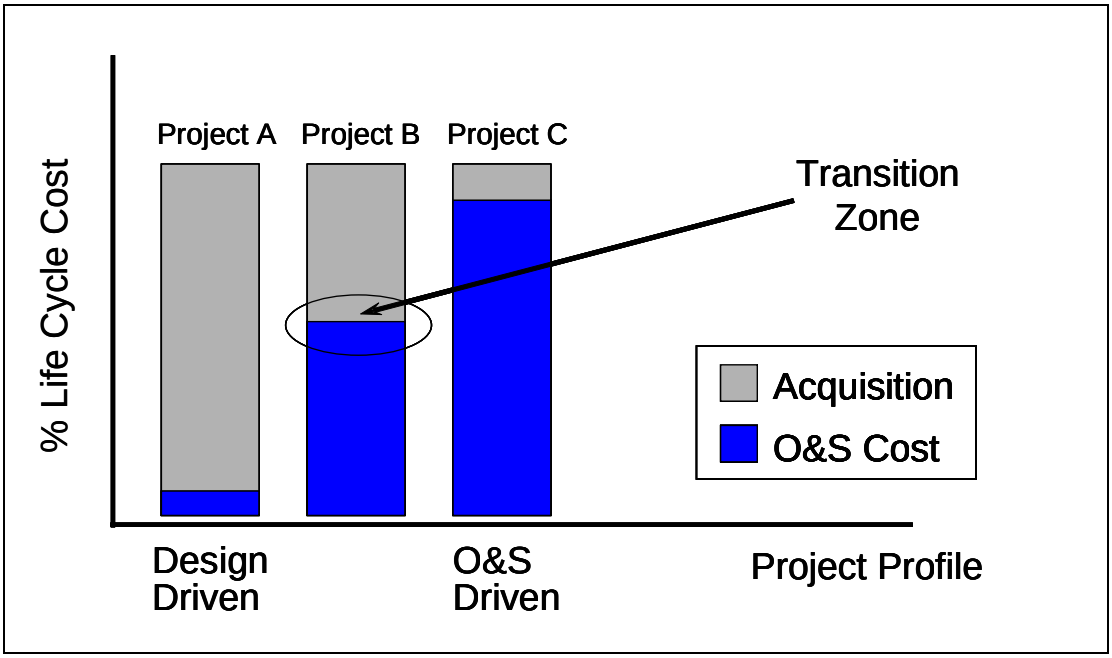

Figure 1: Life Cycle Cost Profile

By considering Life Cycle Cost up front, total cost can be optimized (minimized) through acquisition and O&S cost design trade-offs (see Figure 2). If the O&S cost analysis team is not involved in the design decision-making process during the product development phase, the acquisition team could mistakenly pursue reductions in acquisition cost without knowledge of the potential adverse impact to O&S cost. For example, a product design could have high acquisition cost and low O&S cost as represented on the far left side of the chart. Cost reduction opportunities could exist to reduce acquisition cost, but if the O&S team is not involved in the analysis of the opportunities, pursuing those "opportunities" could actually increase the life cycle cost. The result, therefore, misses its aim of reducing the total cost of the product, and instead increases it. Alternately, a product could have high initial O&S costs and low acquisition costs (right side of chart). Again, if only one of the teams is making decisions in isolation from its counterpart, the second team could see a negative cost impact, instead of what was intended to be a positive one. However, when both teams are simultaneously involved in trade-off studies and design decisions, the resulting end product life-cycle cost is minimized.

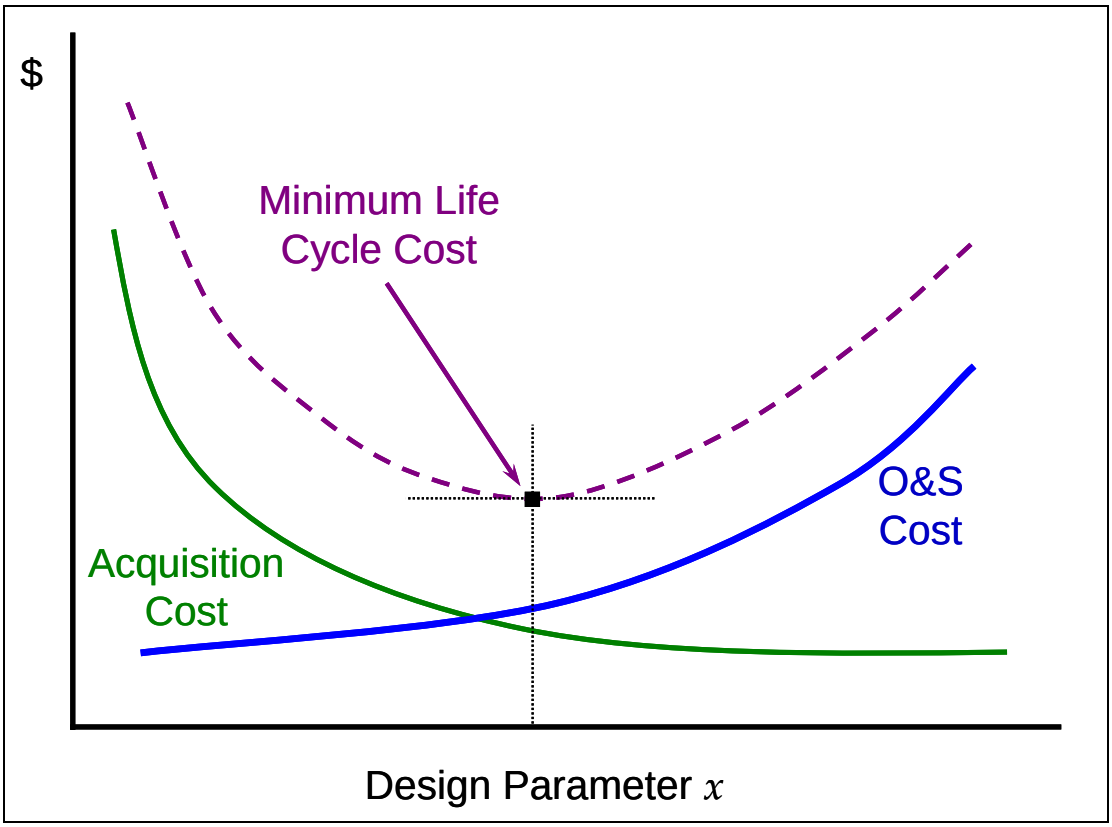

Figure 2 Minimum Life Cycle Cost

This technical bulletin is focused on involving the O&S team in the design phase of the project for decision making, especially when O&S cost is a significant portion of the product's life cycle cost. Life cycle cost encompasses the design, production and sustainability of the product, each with its own distinct revenue and cost stream. Adopting this perspective helps manage the total program cost for both the contractor and customer.

Literature Review

Method

A literature search was conducted to discover recent, relevant research related to the subject of interest. Fifty key word phrases were used to seed the search. Sample search phrases included: Supplier engagement/involvement in high-risk projects, life-cycle cost and supplier incentives, long term supply contracts, logistics support target costing, and engaging suppliers in the logistics chain. For a complete list of search phrases used, see Appendix A: Key Terms for Literature Search.

The databases searched were ScienceDirect[6] and Emerald[7], which enabled access to a large set of technical and management information on-line.

[6] ScienceDirect offers more than a quarter of the world's scientific, medical and technical information online: over 2,000 peer-reviewed journals, hundreds of book series, handbooks and reference works.

Relatively few papers were found that were related to the subject of this bulletin, and none which directly addressed it – specifically outlining the problem and offering solutions. Preliminary interviews conducted also pointed to a need to tackle a number of related issues. These two facts indicated to us that our intended research would be useful to pursue and study, and that the results would be valuable to many who work in this business context.

Related Papers

The following related research papers were found. Each is briefly summarized here to present their basic content and to highlight a few key points. A more comprehensive summary can be found in Appendix B: Related Papers Summaries. The Reference section contains the larger set of papers that were reviewed.

1. Supply Management's Involvement in the Target Costing Process by Lisa M. Ellram

Purpose: Investigates the role of purchasing/supply management in the target costing process.

Key Findings:

Supply management plays a substantial role throughout the target costing process, particularly critical at the initial stages.
External suppliers have a significant impact on a firm's ability to achieve desired target costs.
It is essential to involve all key parties in the target costing process as early as possible.
Several problems occur if suppliers are not involved up front.

Several methods to achieve target costs exist.

2. The Role of Cost Management in Network Relationships by Harri I. Kulmala, Jari Paranko, Erkki Uusi-Rauva

Purpose: Discover what networking relationships challenges are present for cost management.

Key Findings:

A wide gap exists between supplier side quality of cost information and customer side expectations.

A company should know the costs of its own operations, and share part of the cost information with cooperating firms. Only two out of seven suppliers are ready to share cost information

Companies rarely know the full costs of each product.

---

[7] Emerald today is the world's leading publisher of management research, with more than 200 journals, a range of online products, and a collection of series, serials and books in management and social sciences

Coordinating the cost-reduction programs at the firms can help reduce costs in two ways: (1) Identifying ways to make the interface between the firms more efficient. (2) Reduce the manufacturing cost of products.

Improvement efforts are made together, sharing the resulting profit/loss if the costs are below/above the agreed estimate.

3. Total Cost Control: Nissan and its U.K. Supplier Partnerships by Chris Carr and Julia Ng, 1995.

Purpose: Discusses Nissan's approach to total cost control and its strategic approach, as applied to its UK transplant operations.

Key Findings:

80% of major Japanese companies have adopted a strategic approach to target costing, aimed at reducing the *life cycle costs* of new products, while ensuring quality, reliability and other customer requirements.

Profit improvement targets and cost reduction strategy objectives are known by all employees to reinforce the philosophy that cost is the concern of everyone.

Teams focus almost exclusively on controlling supplier costs, as these represent just over 80% of total costs.

Meeting target cost objectives are always clear in terms of how much, by when, by which department, and how. This process is extended to first tier suppliers, with intention to apply to sub-suppliers.

The supplier development team assists suppliers in improving their overall performance. They build close relationships, making them privy to confidential internal statistics. Effort is towards not eroding profit margin, only costs.

Approximately 25% of suppliers provide a complete breakdown of component price. This is one of the purchasing department's performance measures.

Advancement in State of the Art Needed

In summary, the articles reviewed do address topics related to target costing activities, namely:

The value of applying target costing early in the life cycle
Focusing on the complete life cycle cost
Setting cost targets
Using target costing as a business strategy
The value of working closely with suppliers
Sharing cost data
Problems of working with suppliers in a development environment

However, the articles fail to address some essential issues. These issues demand further examination, research and analysis. This missing content forms the basis of

the problem statement of this paper: Gaining supplier involvement in a target costing implementation becomes more challenging when expectations of the supplier include meeting requirements related to logistics, maintenance and support services – beyond the initial product production and delivery.

Interviews

To test whether our beliefs, outlined in the problem statement, are accurate and to try to learn more on the subject, we decided to survey qualifying companies with an interview, based on a questionnaire. There are two questionnaires – one is intended for use in interviewing the prime contractor or lead systems integrator, the second for interviewing the supplier. The two questionnaires appear in Appendix C: Interview Questionnaires. The term "qualifying companies" indicates those companies that answered 'yes' to the following screening questions:

> Are the operations and support service costs of your products a significant portion of the total life-cycle costs?
> Do you have now, or have you had past experience contracting operations and support services?
> Do you have experience coordinating with operations and support service suppliers during the product development phase?
> Would you be interested in participating in our study? If yes, are there any ground rules for your participation?

Thirteen persons from five companies were interviewed, including those involved in the aerospace/defense, semiconductor, truck manufacturing, and communications / electronics industries. The individuals interviewed held positions in their company such as life-cycle cost analyst, cost manager, purchasing agent, engineering manager, and vice president maintenance operations. The companies were interviewed by the CAM-I Target Costing interest group team members. The questionnaire was given in advance to the interviewees, and they were permitted to have the questions in front of them as the interview progressed. This was useful to the interviewees as it enabled them to differentiate between similar sounding questions.

Supplier Involvement and Engagement

In the problem statement, the primary reasons were stated regarding difficulties in supplier engagement and why information isn't shared. The primary reasons are (1) data unfamiliarity / new data requirement (2) lack of available data, (3) the data may be business proprietary, (4) legal reasons prevent sharing the data, or (5) the data is of poor or unknown quality and not worth sharing. In this section, more detail is provided about these circumstances.

Supplier Involvement

Suppliers may collaborate with their prime contractors in several ways to help address operations and support costs. The following list is a sample of common collaborative activities.

Participate in Operating & Support Cost reduction initiative programs
Provide warranties for their products
Design their products to meet reliability, maintainability, repairability, durability and availability thresholds, e.g. mean time between failure (MTBF), part repair cost, etc.
Support early design development of integrated product teams
Participate in logistics support trade-off studies, set serviceability requirements

The following examples from the commercial truck-making industry will help illustrate a couple of the activities listed above.

Design for repairability: The company's customers experienced many deer strikes with their trucks in Wisconsin. This precipitated the need for a design change to simplify the repair process and reduce repair expense. The new design calls for an assembly to be constructed in *more* parts, as fewer less expensive parts need to be replaced when an accident does occur and repair is made.

Design for serviceability, availability: Truck owners consider the cost of down time when evaluating a truck's operational value; money is made only when the truck is actually running. International Truck asks its suppliers to design for a similar maintenance service interval, so that service items can be concurrently addressed at these intervals (e.g. 15k miles). This requirement is included in the design requirements document early in the design process.

Design for durability: The International Truck brand is known for its durability. The customer knows he will be able to recapture his investment through the truck's resale value. Design life of a commercial truck is typically ten years, but it can still be in use up to fifty years later, performing alternate roles. It may be used in a farm application, for example, as opposed to traveling cross country – its intended use. It could serve the farm application as many as another twenty more years.

One facet of supplier engagement that presents a complication involves the situation where the prime is trying to get cost commitment from the supplier when the development design configuration is immature. When a design is incomplete, contractually agreeing to costs does not make good business sense, as future configuration changes can be potentially adverse to established baseline cost estimates. Interviewees mentioned that this occurs.

In addition to the product itself, the definition of the associated maintenance arrangement (to provide maintenance service to a product) can produce a similar situation. Rockwell Collins was asked to provide maintenance cost estimates to support an international, multi-hub maintenance configuration. The number of hubs, and the countries covered were significant cost drivers to the configuration, but they were not fully defined. Different countries have different tax rules, and support cost is very sensitive to the numbers of hubs in the system. In this instance, the uncertainty was mitigated by adding the risk assumptions and thresholds into the contract's terms & conditions.

Data Unfamiliarity / New Data Requirement

An impediment to supplier involvement in the U.S. defense industry is that suppliers are asked to provide data for that which they are unfamiliar, such as providing warranties for their products or guaranteeing availability for performance based logistics contracts. This makes it difficult to accurately and confidently bid, as they do not have full visibility into the operational use data and don't control the costs or mode of use for their product. Historically, suppliers typically design for meeting a technical failure rate threshold, such as Mean Time Between Failure (MTBF), instead of cost. Other measures, such as removal rates, number of maintenance actions, and repair costs, are new data requirements for them.

Lack of Data

Suppliers' business systems may not be mature enough to collect the data needed, or their business process does not call for the collection of the data, as it is not a typical data need required to support their enterprise's daily business operations. Technically, this is not a matter of the *willingness* of whether to share data or not, but a matter of actually *having* the data to share.

The NATO report on "Methods and Models for Life Cycle Costing[8]" emphasizes that because life cycle costing is a data driven process, the quality and value of life cycle cost and life cycle management analyses is highly dependent on the quality of the available data. Thus, the report spends an entire chapter on data collection, and recommends the use of data standards like STEP AP239 Product Life Cycle Support (PLCS), and the U.S. DoD Contractor Cost Data Reporting (CCDR) Manual[9] to ease the collection and normalization of life cycle cost data.

Proprietary Data

This may apply to both the supplier and the prime contractor/lead systems integrator. Trusting each other with sensitive cost data can be tricky given that a current partnering arrangement can easily become a competitive arrangement when the next proposal is let and bid. Teaming arrangements are regularly forming and disbanding as contract pursuit courses through time. Even though proprietary information agreements are routinely in place to prevent disclosure of partner data, competitive knowledge is gained even while honoring the agreement.

Legal Obstacles

The United States Department of Defense (DoD) government regulations require that contractors and suppliers have a sponsoring contract in place to secure access privileges to commonly used O&S databases. These restricted access databases include:

---

[8] The Methods and Models for Life Cycle Costing guide can be accessed at: http://ftp.rta.nato.int/public//PubFullText/RTO/TR/RTO-TR-SAS-054///$$TR-SAS-054-ALL.pdf

[9] The Contractor Cost Data Reporting Manual can be found here: http://www.ncca.navy.mil/resources/dod5000-4-M-1.pdf

1. **Air Force Total Ownership Cost (AFTOC) Management Information System** compiles, stores, and regularly updates data from more than a dozen cost and logistic sources and assigns or allocates the data to systems, bases, and commands in commonly used cost categories. Historical, current, and program year's cost, programmatic, and logistic information are available. The information is available via the internet, but is restricted to approved, registered DoD users and contractors with DoD sponsors.
2. **Navy Visibility and Management of Operating and Support Costs (VAMOSC)** is a management information system that collects and reports U.S. Navy and U.S. Marine Corps historical weapon system O&S costs. Cost analysts use VAMOSC data to develop the O&S portion of life cycle cost (LCC) estimates for future weapon systems. VAMOSC also contributes to the Navy's efforts to reduce the Total Ownership Cost (TOC) of legacy and future weapon systems. VAMOSC is being used to identify significant cost drivers that represent cost reduction opportunities. The Naval VAMOSC database is currently available to U.S. government personnel and government contractors. Government and contractor users have different levels of VAMOSC data access, since the database contains government proprietary information.
3. **Operating and Support Management Information System (OSMIS)** is the U.S. Army's source of historical O&S cost information for more than 1,100 systems deployed in Active, Guard, and Reserve units. OSMIS tracks operating and support information for combat vehicles, tactical vehicles, artillery systems, aircraft, electronic systems, and miscellaneous engineering systems. All contractors must have their government sponsor send a request for user access.

Given that these databases require an existing contractual relationship with DoD and a need-to-know restriction applies, the data are unavailable to suppliers (or primes) not meeting these requirements.

Non-domestic suppliers are subject to International Traffic in Arms Regulations (ITAR) restrictions, making the sharing of such restricted technical data and technology illegal.

Data of poor or unknown quality

Data from end customer

It is often difficult to get good quality O&S data early in a project to create early baseline O&S cost estimates. Data aggregation is one problem. If O&S service is provided by a contractor (e.g. as part of a Contractor Logistics Support agreement), this cost can represent as much as 60% of the total O&S cost but it is aggregated into one cost line item in the Cost Analysis Improvement Group (CAIG) estimate[10]. This disguises any detail which might be useful for allocating the costs, doing further analysis, and making decisions based on the data. Potential O&S cost savings are

[10] The CAIG estimate is the standard report format for DoD O&S costs. For more information, see https://acc.dau.mil/CommunityBrowser.aspx?id=188404

typically discovered through the process of drilling down to lower level costs to finally arrive at its root cause. Data aggregation hinders this. For example, depot level spares costs are affected by production costs as well as the depot repair turnaround time, typically a cycle time of 90 days. However, this can be reduced through overnight shipping or other similar cost saving ideas. Without the supporting detail, potential cost savings ideas will be missed.

Another example of unusable data occurs when O&S data are intermixed, consisting of both war and peace time data. Ordinarily, only peace time data are used for O&S cost estimates. Including war time data will distort the data. For example, cost per flight hour for an aircraft would be lower than otherwise as more flight hours occur during war time and are used in amortizing the cost in the unit metric.

Another cause for poor quality data is that physical items returned for repair are not necessarily representative of typical field operations. Suppliers might see only extreme damage cases. In the field, shop replaceable assemblies (SRA or circuit cards) are often cannibalized from one unit to repair a second unit in the field. This is repeated, eventually resulting in a near empty line replaceable unit (LRU). This empty LRU is what is eventually sent back to be repaired. When the supplier receives the unit, it has the appearance of being a much worse problem than it actually is, since many smaller repairs were aggregated into this one physical piece of evidence. This causes the final repair cost to appear significantly higher but is not truly representative of the typical smaller daily field repairs that are actually experienced.

Data from supplier

When supplier reliability data are provided, they are often not credible, as they are unrealistic (too optimistic). Sometimes, lab results are the basis for their reliability. The field environment is usually much harsher than the lab environment, and consequently, the actual field reliability is much lower than the lab estimate.

Contractual Issues

Incentive Systems

The primary incentive of a company – both prime contractor and suppliers – in early phase program development is to win the initial program proposal, thus increasing revenue and profit. During this period, partner suppliers are properly incentivized to provide the necessary supporting O&S data and cost estimates to the prime contractor. Naturally, they also want to share in the benefits of belonging to the team winning the bid. However, once the program contract has been won, this incentive diminishes greatly. Although customer contracts may require O&S cost data, analysis and estimate updates to be provided, actually meeting the estimated future support costs is not contractually binding, and instead only best efforts (unmeasured) are required. As a result, budget is directed towards pursuing other program milestone priorities, such as technical performance measures and schedule. This situation causes a lack of resources for lower, but still important priority items, such as collecting and updating O&S data and estimates. Even if supplying O&S data *is* part of the supplier contract, it is common that submissions are of low quality due to program resource

constraints which are re-allocated to higher, customer-set priorities rather than ensuring that O&S estimates are current and accurate. To legally satisfy the contract requirement (but falling short of providing high quality data), near identical data, with minor adjustments for rate changes and/or in-house work, are repeatedly re-submitted as quarterly updates. Despite providing sub-standard data and estimates, the risk of program cancellation as a consequence does not seem to be regarded by suppliers as a realistic possibility once the contract has been won.

Other factors also play a role in explaining why incentives fail. In the aerospace defense industry, for example, most suppliers also serve as prime contractors on other projects and wish to expand their support service business. They may wish to retain proprietary cost and technical data to protect future business prospects. Although most individuals interviewed expressed confidence in prime/supplier confidentiality being maintained in their business relationship, there is ultimately no certainty whether confidentiality agreements are upheld. This doubt and the risk of losing a competitive business advantage may outweigh the incentive to share "exposing" data and estimates to a potential future competitor.

Prime contractors, such as Boeing Integrated Defense Systems (IDS), also have an aerospace support business unit (now called Global Services & Support) and could conceivably be reluctant to invite suppliers to get too involved in the O&S function. This situation could be perceived as a threat to winning future O&S contracts if suppliers were to build internal O&S analysis capability and expertise.

These facts point to the need for new and creative contractual incentive clauses to establish a win-win proposition for both parties. One suggested method to positively incentivize partners is to proportionately share the award fee. Suppliers could earn a higher award fee (on a sliding award fee target scale) based on the extent of program cost risk they are willing to accept and share with the prime contractor. This would create the proper long-term financial incentive for the supplier to ensure that the highest quality data, estimates, and analysis were provided. Similar incentives have been used successfully in the construction industry to get positive results between contractors and suppliers. In such an arrangement, project profits and losses are shared according to an agreed to formula established beforehand.

The U.S. Department of Defense (DoD) also recognizes the importance of minimizing Operations and Support costs and the need for proper incentives. A pilot program, called "Reduction in Total Ownership Costs (R-TOC)," was created in May 1999 by then Under Secretary of Defense for Acquisition, Technology and Logistics (USD/AT&L), Jack Gansler. It was initially made applicable to thirty programs across the Army, Navy, Air Force and Joint Program services, with representation across all acquisition phases.

The R-TOC website[11] explains its purpose:

> *"The purpose of the R-TOC program is to achieve readiness improvements in weapon systems by improving the reliability of the systems or the efficiency of the processes used to support them. New Technologies and*

[11] The R-TOC website can be found at: http://ve.ida.org/rtoc/rtoc.html

management practices may provide significant opportunities to improve readiness and reduce ownership costs."

It also acknowledges that there is an opportunity to improve in the area of providing proper incentives to reduce O&S costs:

"…normal DoD budget, requirements, and contracting practices may not provide strong incentives to program managers, contractors, users, or logistics support providers to develop ownership cost reduction measures."

The DoD has issued an Incentives Guide[12], which provides policy guidance on the use of incentives, discusses why they are of interest to the DoD, and describes various types of incentives. Much of the guide is directly relevant to the Reduction of Total Ownership Costs (R-TOC) program. The guide states that:

"Suppliers should be rewarded for adopting business processes and principles designed to reduce costs and cycle time while maintaining schedule, achieving performance expectations, and maximizing efficiency. DoD business strategies should focus on the overarching business considerations related to each acquisition strategy and address the following objectives:

Use incentives tailored to the specific business case to achieve maximum benefit for both parties

Assess the most critical issues related to specific acquisitions and design incentives to ensure optimal results

Design strategies to reflect an understanding of the business case from industry's perspective. Profit, earnings per share, cash flow, and return on investment are important industry considerations in entering into business relationships

Recognize and reward contractors that strategically focus on efficient and effective management practices, thereby reducing unneeded capacity and maximizing overall value to the customer (e.g., lean industry practices and best practices should be recognized and rewarded)

Recognize that a requirement's structure drives business solutions. Match the essential program objectives and potential incentive arrangements early on, and communicate objectives to industry

Agree on incentives and remedies to ensure successful business relationships"

At International Truck, some incentives are employed to encourage suppliers to engage early in product development, control and improve costs, and address product reliability.

Instead of using, for example, multiple suppliers for several parts, one supplier is awarded a "package deal" for design support of all parts in exchange for a quantity discount or similar concession.

[12] Incentives Guide can be found on-line at http://ve.ida.org/rtoc/open/incentivesguide-0201.pdf

Suppliers are chosen from a preferred list, vetted for product quality and financial stability.

Suppliers are asked to agree to year-over-year negotiated material cost reductions.

Suppliers are responsible for support of their products, in addition to production.

The company's warranty system tracks one- and two-year warranty agreements. It tracks failures and warranty expenses. It is used to produce reliability goals for future products (this subsequently feeds the design requirements document).

Suppliers participate in warranty claim analysis and disposition (determining who is responsible for paying the claim)

Fleet data are shared so that customer satisfaction can be addressed in new concept development

Contracts

Incentives and contracts are closely related, both in a positive and negative way. Well written contracts will appropriately incentivize the supplier to produce favorable results. Conversely, where incentive issues arise, the contract is likely a significant contributor to those issues. One instance of incentive problems was described in the section above, regarding absence of clauses specifying legally binding future O&S cost commitments.

A second contributing factor in contract incentive difficulties is that suppliers generally don't participate in O&S related efforts until just before contract award. On a particular Boeing aircraft development program, there was no supplier participation in early support logistics trade-offs. It was thought then that there was not enough configuration detail known at that point to know which suppliers to involve. The program phase was Functional Concept with no hardware yet defined. Trade-off studies included searching for ideas to reduce training cost, repair cost, engine repair, depot repair, etc.

Nevertheless, suppliers should be invited to participate in these trade-offs. Who should be invited? Engineers and Supplier Management generally have good industry knowledge and familiarity with the potential set of suppliers' capabilities. Based on this, they may have inclinations as to which suppliers they will eventually invite to bid on the proposal. These are the suppliers with whom a prime should be exploring ideas and conducting trade-off studies. Learning about the supplier's technology roadmap, their technology and manufacturing readiness levels, the trends of their product reliability, the initiatives that are being pursued to improve in these areas, are all beneficial contributors to formulating a sound O&S estimate.

Another scenario, in which omitting key contract clauses can produce unfavorable future cost impacts, is being experienced by several recent Boeing product upgrade programs. These programs have been structured with reliance on the supplier to invest its own money to develop the new technologies which will be incorporated into the product. This fact is paired with the assumption that the maintenance support

concept for the newly supplied product will be Organization-Original Equipment Manufacturer (O-OEM)[13]. This arrangement will succeed only if the customer is able to obtain a core law waiver, which allows an exception to the requirement that the government maintain core maintenance capability of its hardware. This arrangement would allow the program to save organic logistics infrastructure development costs.

However, if the customer is ultimately unable to obtain such a waiver, the cost to subsequently "stand up" (meaning "setting up the infrastructure for") organic capability must be borne by the program at a later date at a substantially higher cost. If the research and development cost for the technology and equipment has been paid for by the supplier, the supplier owns the technical data. To now obtain this data, for example, to enable the ability to develop test and diagnostic procedures for organic support, the customer will have to pay for it. In this situation, the supplier has much leverage to charge a premium for the needed data, leading to an increased expense.

A lesson learned here is to be clear early in the project, defining who will support the product, and have back-up plans outlined for instances where transfer of support and technical data is required in the future. Contracts should establish, beforehand, what technical data is needed, the format, when it is needed, and at what price it shall be provided. International Truck avoids this type of problem in their business (commercial truck building). Their service parts organization develops separate spare parts contracts. Also, base part costs are factored for ongoing maintenance and incidentals (e.g. shipping).

From a supplier point of view, contractual challenges occur with their prime also. Rockwell Collins reported that sometimes the airline customers want too many liability conditions included in the contract (described in the "terms and conditions"). Negotiations with their customer can be a challenge to limit liability to an acceptable level, e.g. cause of fire. They accept direct cause liability, but negotiation occurs regarding liability for indirect causes.

Not getting all the configuration data from its customer – because the customer doesn't have it –can create obvious difficulties for estimating and committing to maintenance costs. Rockwell Collins described such an instance:

> *"We provide help with root-cause determination for passenger induced damage to their products. For example, an airline may install an In Flight Entertainment (IFE) handset in a seat armrest / console, which is more prone to damage (spills, impact) from the passenger than one installed in the back of the forward seat. Airlines don't always know ahead of time where the IFE will be located, so we don't always know which design configuration will be used."*

Last, service domain contracts can vary widely with regard to how the supplier is paid. Customers may pay by time and material, flight hours, per aircraft/ per month, performance based, fixed price, or fixed costs. The data collection, accounting, and

[13] This maintenance concept implies that the maker of the equipment will be responsible for field maintenance and repair (vs. organic military personnel performing the work).

estimating detail required to support all format varieties is an added business challenge for the supplier.

Setting and Accepting O&S Cost Targets

Regardless of whether referring to the prime or supplier, the ultimate responsible party for meeting cost targets – if cost targets are set, is ordinarily the program manager (or program management team[14]) who has profit and loss responsibility. Sometimes incentive compensation is established to reward successfully meeting the cost targets. Top level cost targets are typically then flowed down to system level IPTs, who are then responsible to work the details to support and meet the cost target.

Regarding the negotiation between primes and suppliers in establishing support cost targets, primes often have a "should cost" value in mind for direct maintenance costs but they don't necessarily share it with the supplier. Instead, they ask the supplier to submit an estimate to them. If the estimate is higher than expected, more detail is requested from the supplier to support the estimate and the gap is subsequently reconciled. The prime's estimate methodology may or may not be shared with the supplier. It depends on the nature of the relationship with the supplier, e.g. whether the supplier is a significant partner in the design of the end product vs. a commodity part producer, or whether the terms of a non-disclosure agreement permits.

The primary challenges related to setting and accepting cost targets, as identified in the initial problem statement, are (1) lack of supplier participation in developing cost targets, (2) lack of credibility of the cost targets themselves, (3) lack of attention paid to their importance, (4) unwillingness to stick to the cost target, and (5) organizational impediments.

Supplier Participation

It is not uncommon that O&S *cost* targets are not established for, nor required of, suppliers to meet. This was reported as true for several of our interviewees. Instead, O&S *performance metric* targets are set, namely reliability and maintainability targets. Although not direct costs measures themselves, these metrics do causally affect O&S costs and are, therefore, included as part of the contract, either the statement of work or request for proposal, depending on the situation. To help suppliers meet these performance metrics, the lead systems integrator (LSI) will flow down important information, e.g. design concepts, maintenance concepts, and other key assumptions – such as whether to plan for Line Replaceable Units (LRUs) or Line Replaceable Modules (LRMs) when providing avionics or equipment. The supplier then uses this information to create projected product reliability and maintainability performance metrics. This is then submitted back to the LSI, who then uses it to produce the O&S cost estimate. The O&S cost estimate is then included as part of the proposal to the end customer.

[14] The program management team can conceivably be composed of individuals representing the prime, supplier, and customer.

Other information that may be required of suppliers by the LSI includes: required support equipment for the provided system, repair cost, spares cost, turn-around-time, service cost, and ease of repair. Having this information helps control the corresponding activity or performance, which drives O&S cost.

For the supplier, sometimes maintenance cost commitment is included in its contract with the prime. Internally, the contracted price then becomes the cost target at the system level. This was Rockwell Collins' experience with Airbus. Airbus was trying to limit and lock down maintenance costs for the A350 – which is common operating procedure for the large aircraft manufacturers.

Credibility

One reason that credibility surrounding established cost targets (or performance metrics) is low is that they may have been set by the LSI early in the design configuration program phase, prior to the selection of suppliers; therefore, suppliers likely have not participated in the development of the target setting methodology and do not buy in to the resulting assigned target.

Another reason suppliers do not trust given O&S targets is that they do not see the underlying operational data which created the targets. Seeing this data is not normally part of their routine business environment[15]. The LSI is the one who sees it. The supplier is unable to imagine how this unseen data produced its resulting performance targets. A causality thread is missing, so there is no foundation upon which to gauge their fairness or unfairness. When credibility is an issue, cost targets indicating a need for cost cuts from suppliers can seem arbitrary to them. It is common to hear a supplier comment about perceived, forced profit margin squeeze.

The LSI estimates may also have limited credibility because they are estimates for costs many years out. Estimate uncertainty increases, of course, as projections for further, future time periods increases. O&S costs time period duration can range from between 20 and 50 years[16].

On the other hand, LSIs tend not to believe the O&S performance metric data provided to them by suppliers. Their estimates are often regarded as being too optimistic. Said one affordability analyst during her interview, "The joke on programs has become, 'half the price and two times the reliability' referring to the supplier's optimistic forecast of its product's cost and reliability performance. The forecast may be accurate under carefully controlled lab conditions, but in the field of operations, the real performance is often significantly different, i.e. significantly worse. A "giggle

[15] As mentioned previously, a sponsoring contract with the government is required to access the commonly used military databases (e.g. Reliability and Maintainability Information System (REMIS)) to retrieve this information. Prime contractors cannot pass on the operational data, for which they do have legitimate access, to their suppliers. Some suppliers of major platform components, for example engines, do have access, but this is an exception. The majority of suppliers do not. There are some alternate options for suppliers to access *some* information, e.g. technical, cost, order history, through IHS Haystack, but this does not have operational data such as MTBF, MMH/FH, etc. Defense Logistics Information Service is another option, but access control to this database has recently become more stringent as well.

[16] Surface ships and ground systems typically have the longer expected service life.

test" is employed as a cross check against the submitted numbers, to test whether they are reasonable or not.

There is also the corollary difficulty in *verifying* that the supplier is actually performing to the cost or performance estimates that it gives, if it did provide them. This is because it cannot be determined until five to ten years into the contract, after actual costs have begun to accumulate, that metrics can then be compared to the originally estimated ones and prove execution to plan has occurred. With such a long feedback loop, many underlying factors and assumptions may have changed during the period, rendering futile any attempt to reconcile the baseline estimate with the actual costs incurred.

Improvements in supplier participation and operational failure root-cause education may help address some of the credibility issues outlined above. Improving database access requires the cooperation of the Armed Forces. They need to be shown how a holistic approach to project management with respect to implementing target costing, and providing the data to do so, benefits all parties involved. Currently, there is some implicit competition between the service's depot maintenance organization and contractors. Although U.S. Code explicitly outlines the conditions for public-private work conversion, human nature suggests management at the depots have personnel which they wish to maintain employment for, so there may be some reluctance to share data which may lead to a competitive bid and loss of work load.

Another way to enable supplier participation is to facilitate supplier access to REMIS. REMIS provides the single, primary Air Force data system for collecting and processing equipment maintenance data, used to provide information on reliability and maintainability, trend analysis, failure prediction and weapon system availability. VAMOSC and AFTOC databases are used to query operational cost data.

Importance

If the contract with the customer does not require a commitment to a target O&S cost, contractors are generally not concerned about it either. If meeting the target isn't part of the scoring value for their performance award fee, focus will be elsewhere. If O&S cost is truly an important aspect to the customer, it should be formalized by including it as part of the award fee and disclosing it as such. Contractors would subsequently be financially motivated to address O&S cost earlier in the product lifecycle.

Regardless of the above discussion related to importance, targets are created by the contractor and provided to the customer as a "best efforts" analysis[17]. Often, the support cost estimate is also intended to represent a positive discriminator of the product offering. Life cycle costs are always compared in program award, and the proposal with the lowest life cycle cost will be ranked higher, all other criteria being equal.

[17] "Best efforts" means that the contractor is providing an estimate which is, to the best of his knowledge, accurate as can be, but the contractor is not ultimately held financially accountable for the eventual incurred costs matching the originally estimated costs.

However, the targets created are of limited use if they are not actually used to proactively manage the program. The cost targets should be used for initiating some cost saving action, or to make a decision. Also, the initial *setting* of targets is not the primary challenge. The challenge resides in accurately updating and providing the status of the targets over the life of the program, and then proactively responding to any adverse trends that may develop.

On the other hand, there may be real and direct financial incentives for focusing on support cost targets. Rockwell Collins' commercial business collects comprehensive reliability & maintainability data (they have fleet-wide visibility) to see if their product is performing to specification. The data are not published, but offered as a subscription service to customers. The benefit to the customer is the ability to monitor and respond to discovered anomalies in maintenance records. For example, if the average failure rate for a given part is 25%, and an airline is experiencing failures at a 45% rate, Rockwell Collins will help the customer understand the cause of the high failure rate and possibly suggest a new maintenance procedure.

Sticking to Cost Target

Suppliers are unwilling to stick to the original assigned cost target if there is a significant material cost increase, or if the design changes. When a design change is needed, it needs to be determined who is responsible for the change (prime, supplier) to decide if the cost target will be modified or not. Needed change could arise from a variety of reasons: lack of good initial planning, competitive response, or management/political decision.

In the case of a material cost increase, the terms and conditions of the contract should specify when, the frequency, and under what circumstances (e.g. define cost bands about the material cost when the contract is originally written) contracts and associated cost target should be re-negotiated. The previously agreed to year-over-year annual material cost reduction schedule may now be obsolete.

Organizational Impediments

It may be the situation – in fact it is common -- that a company's maintenance/service organization is a business entity separate from the product development and production organization. This separateness may include accounting or workplace geography differences which can hinder efficient and effective teamwork related to setting O&S cost targets. The two business entities may be, for practical purposes, behaving as independent businesses and working at "arms length." For example, at International Truck, Navistar Parts & Service dealerships or the customer's own inside service department normally do the maintenance type work. If International Truck does not hold the service contracts, coordinating design for support activities, access to and collection of field data may limit the success of implementing target costing in this environment.

Managing Risk and Uncertainty

Operations

Suppliers do not always know exactly how or where their products will be used when deployed, so they are reluctant to accept this risk when asked to commit to or estimate an O&S cost.

For example, military aircraft are initially sold to one of the domestic armed forces. Later, production aircraft are often sold to international customers. The Boeing F/A-18 has several international customers with wide ranging operational climates. They range from severe cold (Canada, Finland), to dry desert (Kuwait), to hot, humid tropical (Malaysia, Thailand). Each climate has unique support challenges, and perhaps all environments were not fully prepared for when designing to meet the original requirements, simply because they were unknown at that time.

This is known by the prime contractors, so a business courtesy is frequently extended to suppliers by not asking them to commit to cost targets. Prime contractors know that the suppliers would be assuming great risk in committing to a cost for which they may have little control. Responsibility can only be assigned to effects for which suppliers have control, such as technical reliability of their products.

Estimate

Prime contractors are generally more comfortable with their top-level O&S cost estimates and targets than they are with the lower system-level estimates or sub-targets. Also, certain costs are easier to estimate (i.e. have a smaller risk band), such as fuel or personnel costs, for example.

In the case of fuel, propulsion engineers are fairly accurate in their fuel consumption estimates, and there are well established relationships, based on much historical data, between engine thrust and fuel consumption ($/flight hour).

In the case of labor support costs, there can be a wide range of system reliability values that demands nearly the same labor headcount level, hence labor costs. This is because whether something (e.g. equipment) needs a given individual's support rarely or frequently, you still need at least one skilled person on hand to maintain mission capability. The person may be working at 10% capacity or 100% capacity, but headcount doesn't change unless support demand is still higher than this person's capacity.

On the other hand, some details are harder to estimate. Individual spare parts and their associated repair cost is an example. It is difficult to forecast the details of a new individual part, its expected disposition when it is in need of attention (e.g. repair, condemn), and the amount of touch labor required to perform the disposition action. This requires a lot of detailed information and analysis for which a business decision must be made. It needs to be determined whether the value gained in estimate detail and precision is worth the time and expense of data collection and detailed analysis that is required to support this.

Independent of the estimate's level of detail, in all cases the estimate needs to be based on likely achievable affordability initiatives, and not mere wishful thinking. Estimates must be credible. This may seem quite obvious; however, in a competitive proposal environment, competitors are trying to put their best foot forward and, as a result, are often pushing the envelope of what's possible.

But more important than being credible, which one could say is the appearance of being accurate, estimates need to actually *be* accurate, as they are used to make real operations and support related decisions. Wrong operational decisions have negative cost impacts. Inaccurate reliability predictions and unit cost estimates may cause wrong maintenance concept decisions. For example, if a supplied product is estimated to be very low cost and high reliability, the recommended maintenance concept may likely be "discard at failure." If, in fact, these estimates are too optimistic, and in reality the part is high cost and less reliable, the end customer will need to develop the required infrastructure to support the repair of the part. This development expense is significant, and has an obvious, adverse cost impact.

The existence of these challenges does not mean that O&S cost estimating should not be performed. Despite the difficulties of long-range forecasting and related uncertainty of events, some effort should be made to create accurate and "appropriate level of detail" operational cost estimates. Guides exist to help develop operating and support cost estimates using a variety of methods and models. Examples include:

1. Operating and Support Cost Estimating Guide[18]
2. Methods and Models for Life Cycle Costing by The Research and Technology Organisation (RTO) of NATO.

The challenges to create good O&S estimates extend to the armed services themselves. No two customers, among the United States Army, Navy, Air Force, Coast Guard, or Marines define Total Ownership Cost (TOC) the same way. Philosophic differences exist as to what is and isn't included in the estimate. For example, some include development and production cost. Some define it as costs from a given point in time forward. In this latter case, if a program is already in the O&S lifecycle phase, it would leave out development, production and any O&S costs expended up until this time.

The U.S. Navy's approach is to add its cost to the provider's life cycle cost submittal. DoD, by rule, cannot provide its O&S future year[19] program budget, estimates (or input data), but it can provide the methods, factors and models. Ordinarily, the provider would use the Navy's methodology where applicable, and adjust the estimate where sensible to do so. This provides credibility for estimates. Sometimes the methodology is subject to interpretation of the cost handbook.

With recent commodity price volatility, suppliers report material escalation as a significant source of uncertainty in their estimates. Of course, primes experience the result of this volatility as well, as setting cost targets and drawing up terms and

[18] The Operating and Support Cost-Estimating Guide can be found here: https://acc.dau.mil/CommunityBrowser.aspx?id=188404

[19] Historical costs and current year budget values are publicly available.

conditions for contracts with their suppliers is impacted. If done well, inclusion of these terms and conditions limits cost risk exposure for both parties, and as such is beneficial to both.

Other large estimate risks include: replacing obsolete parts / forecasting technology development and adoption, and reliability assumptions.

Recent Developments

In the Context/Background section and other sections in this paper, research was presented showing the audit review results and initiatives conducted over recent years to improve program estimates and provide program cost control. But past reform efforts have obviously been insufficient, as evidenced by the continued need to address similar problems with additional laws and guidance. Near the completion of this bulletin, the following additional information was encountered.

Weapon Systems Acquisition Reform Act of 2009

The Weapon Systems Acquisition Reform Act of 2009[20] was introduced in February 2009 by the Senate Armed Services Committee (Levin, McCain). It was signed into law in May 2009. The law was designed to improve the procedures of DoD for the acquisition of major weapon systems. United States Senator Carl Levin (D-MI) commented:

> *"Without serious steps to bring cost and schedule estimates and performance expectations in line with reality, billions more in taxpayer dollars would have been wasted. The legislation…will require the Department of Defense to take the necessary steps to avoid that continued waste.*
>
> *"By establishing an independent office for cost estimates,…this new law will put major weapons programs on sound footing from the start and help to control future costs overruns, schedule delays and performance shortcomings."*

The law is composed of ten sections. Key sections include:

> **Sec. 101.** Cost Assessment and Program Evaluation
> *"…the Director of Cost Assessment and Program Evaluation … shall review existing systems and methods of the Department of Defense for tracking and assessing operating and support costs on major defense acquisition programs and submit to the Secretary of Defense a report on the findings and recommendations of the Director as a result of the review, including an assessment by the Director of the feasibility and advisability of establishing baselines for operating and support costs…".*

[20] The full text of the Weapon Systems Acquisition Reform Act of 2009 can be seen here: http://www.conferencereport.gpoaccess.gov/SearchCongressionalRecord.aspx?CongressionalRecordId=E7W4jG3Xke4=

Sec. 104. Establishes within DoD a Director of Independent Cost Assessment to advise the Secretary, Under Secretary and Under Secretary of Defense (Comptroller) on cost estimation and analyses for DoD acquisition programs.

Sec. 201. Consideration of trade-offs among cost, schedule and performance in the acquisition of major weapon systems.

Sec. 304. Comptroller General of the United States reports on costs and financial information regarding major defense acquisition programs.

"(a) Review of operating and support costs of major weapon systems.
(1) Not later than one year after the date of the enactment of this Act, the Comptroller General of the United States shall submit to the congressional defense committees a report on growth in operating and support costs for major weapon systems.
(2) In preparing the report required by paragraph (1), the Comptroller General shall, at a minimum—
(A) Identify the original estimates for operating and support costs for major weapon systems selected by the Comptroller General for purposes of the report;
(B) Assess the actual operating and support costs for such major weapon systems;
(C) Analyze the rate of growth for operating and support costs for such major weapon systems;
(D) For such major weapon systems that have experienced the highest rate of growth in operating and support costs, assess the factors contributing to such growth;
(E) Assess measures taken by the Department of Defense to reduce operating and support costs for major weapon systems; and
(F) Make such recommendations as the Comptroller General considers appropriate."

Department of Defense Reliability, Availability, Maintainability and Cost Rationale Report Manual

The Department of Defense Reliability, Availability, Maintainability and Cost Rationale Report Manual[21] is a 78-page manual published in June 2009.

The Foreword is written by Ashton B. Carter, Under Secretary of Defense for Acquisition, Technology and Logistics; Dr. Charles E. McQueary, Director, Operational Test and Evaluation; and LTG Kathleen M. Gainey, USA Director for Logistics J4, The Joint Staff. In the Foreword, the purpose is described:

"The guide was written to help capability document requirements writers and their supporting engineering organizations think through the top level sustainment requirements for RAM-C early in the requirements generation

[21] The Department of Defense Reliability, Availability, Maintainability, and Cost Rationale Report Manual can be viewed here: http://www.acq.osd.mil/sse/docs/DoD-RAM-C-Manual.pdf

and refinement phase of a program to ensure the system is sustainable and affordable throughout its life cycle."

In the Introduction section of the manual, it reads:

> *"The Department and some Services have issued policy letters to increase attention on reliability and maintainability during program acquisition phases. If reliability, maintainability and logistics are not adequately designed into the system, there is risk that programs will breach Acquisition Program Baseline thresholds with significantly higher development or acquisition costs due to resulting corrective action costs; will cost more than anticipated to own and operate; or will fail to provide availability expected by the warfighter.*
>
> *"As a result of these concerns, the Chairman of the Joint Capabilities Integration and Development System (JCIDS) Manual defined three mandatory sustainment requirements to ensure that effective sustainment is addressed and accomplished over the life cycle for all newly developed and fielded systems. These requirements include a Key Performance Parameter (KPP), Availability; and two Key System Attributes (KSA), Reliability and Ownership Cost."*

This published document highlights a key principle that this bulletin has been emphasizing -- that is, focus on sound systems engineering practices early in the product development project phase to ensure affordable life cycle costs later in product life.

Conclusion

It is clear from studying this subject and its history that it has received considerable attention over the years, yet many issues still remain unresolved. Many initiatives and laws have been repeatedly undertaken and forwarded with little impact on correcting the underlying problems. Tools are available in the form of recommendations, guidebooks and manuals to address technical issues and to provide focus on practices that need attention. They need to be implemented to see improvement in program cost performance results.

This paper can be useful to practitioners as a benchmarking device. By examining how others have responded to similar issues in their respective industries, a new idea may be encountered and applied anew to their own situation.

This topic also offers a large problem space, rich for further exploration. This paper has attempted to outline the problem, its sub-issues, with an occasionally suggested solution. Further research could be helpful by defining the supporting details of these solutions as well as creating and testing additional, new solutions.

For example, one area of study might be creative contracts and incentives. Another could be inventing new business processes, e.g. define and develop a phased approach to product development – e.g. a gate by gate approval process whereby a prime or supplier signs up to cost targets with its customer before proceeding to the next phase of the project. One could also examine the pros and cons of this approach.

Appendix A: Key Terms for Literature Search

1. Risk management when uncertainty is great
2. Warranty management
3. Allocate supplier cost targets
4. Performance based logistics and how it is incorporated
5. Contractual negotiations with suppliers
6. Strategic partnerships
7. Supplier engagement/involvement in high-risk projects
8. Post sales support costs
9. Lifecycle cost and supplier incentives
10. Design for affordability
11. Whole life product costing
12. Design for supply and service
13. Opportunity management involving supply chain
14. Contracting for support service
15. Incentivizing suppliers
16. Allocating service cost targets
17. National association of purchasing managers
18. Increasing risk with least return
19. Initial cost and support cost trade-offs
20. Condition based maintenance
21. Target costing in capital intensive products with long lifecycles
22. Design build and operate contracts
23. Supplier ownership data management
24. Sustainment engineering
25. Partnering relationships with suppliers
26. Partnering vs. subcontracting
27. Involving suppliers in risk and opportunity management
28. Service opportunities
29. Keiretsu
30. Partnerships in design cost
31. Design for maintenance
32. Reductions in total ownership costs
33. Long term supply contracts
34. Collaborative costing
35. Logistics support target costing
36. Reliability, availability and maintaintability extras
37. Linked product/service strategy
38. Supplier agreement operator and support cost
39. Cost risk sharing
40. Harvard Business Review
41. Long lead maintenance contracts
42. Product operating, support, maintenance and upgrade costs
43. Full-stream costs to the customer
44. Institute for supply management

45. Target costing in supply chains
46. Forecasting anticipated costs in product development
47. Engaging suppliers in the logistics chain
48. Cost containment
49. Lifecycle cost management
50. Operational and support cost management

Appendix B: Related Papers Summaries

Supply Management's Involvement in the Target Costing Process by Lisa M. Ellram

This article investigates the role of purchasing/supply management in the target costing process. It is based on case studies of eleven firms that use target costing. Some of the key findings are:

> Research results indicate that supply management plays a substantial role throughout the target costing process. Its contribution is particularly critical at the initial stages, when developing component level target costs, and when activities/modifications are occurring to achieve target costs.
>
> Given that external purchases constitute approximately 60% of the cost of sales for most manufacturers and around 25% of the cost of sales for service providers, external suppliers have a significant impact on a firm's ability to achieve desired target costs.
>
> It is essential to involve all key parties in the target costing process as early as possible. Supply management plays the key roles of identifying and qualifying suppliers, facilitating its involvement at the ''concept'' stage.
>
> Problems that occurred if suppliers were not involved up front include:
>
> - no price expectations were established, so no effort was made to manage costs
> - suppliers would be ''pre-selected'' by R&D, then hold the company ''hostage'' for a high price
> - purchasing had no negotiating leverage when brought in during later stages
> - product/service rollout was delayed when purchasing had to qualify ''pre-selected'' suppliers at later stages of the target costing process.
> - unqualified suppliers were selected (in terms of quality, financial viability, size, etc.)
> - R&D personnel had closer working relationships and commitment to the supplier than purchasing
>
> Methods to achieve target costs include:
>
> - Negotiate with supplier based on factual data
> - Work with supplier/supplier development to improve capabilities
> - Change design
> - Change material
> - Change specifications
> - Trade-off features to reduce cost
> - Accept higher start-up cost with firm cost reduction commitment
> - Cancel projects that do not meet target cost
> - Use long-term agreements to get future cost reduction guarantees
> - Share long-term strategies with supplier

The Role of Cost Management in Network Relationships by Harri I. Kulmala, Jari Paranko, Erkki Uusi-Rauva

The aim of the paper is to find out what kinds of challenges networking relationships present for cost management. The results of the study show a wide gap between supplier side quality of cost information and customer side expectations. Networking places a number of demands on cost management:

- A company should know the costs of its own operations.
- A company should share part of the cost information with cooperating firms.
- Part of the information flow should be open to all the companies in the network.

Companies rarely know the full costs of each product. A lot of development work with suppliers' cost accounting systems is needed. A win/win relationship creates a need for open book accounting. Only two out of seven suppliers are ready for this (willing to share cost information). There is also a need to create mutually accepted accounting practices.

For the majority, management accounting practice has limited its scope to the boundaries of the firm. This limitation makes it difficult for the firm to take advantage of any cost-reduction synergies that exist across the supply chain. Such synergies can only be achieved by coordinating the cost reduction activities of multiple firms. The objective of inter-organizational cost management programs is to find lower-cost solutions than would be possible if the firm and its buyers and suppliers attempted to reduce costs independently. Coordinating the cost-reduction programs at the firms can help reduce costs in two ways: First, it can help identify ways to make the interface between the firms more efficient. Second, it can help the firm and its buyers and suppliers find additional ways to reduce the manufacturing cost of products. This coordination requires the firms in the supply chain to extend their cost management programs beyond their organizational boundaries. Little evidence of management across the supply system of businesses as a whole has been found.

If customer and supplier are going to share profit there is a necessity for open book accounting. The need to share information must be two way. For open-book costing to work, however, there needs to be trust between the parties.

One typical feature of partnership is that some of the improvement efforts are made together. If the cost for a project is below the agreed estimate, both parties share the resulting profit, according to a formula. If the costs are above the agreed estimate, they share the loss.

Total Cost Control: Nissan and its U.K. Supplier Partnerships by Chris Carr and Julia Ng, 1995.

This paper discusses Nissan’s approach to total cost control and its strategic approach, as applied to its UK transplant operations.

> Japanese companies, such as Toyota, have adopted a strategic approach to target costing. Target costing is regarded not as a costing system, but an

activity aimed at reducing the *life cycle costs* of new products, while ensuring quality, reliability and other customer requirements, by examining all ideas for cost reduction at the product planning, research and development process. Over 80% of major Japanese companies in assembly-type industries are said to have adopted such an approach.

Profit improvement targets and cost reduction strategy objectives are printed on cards and given to each employee to reinforce the philosophy that cost is the concern of everyone, not just of those in the finance and accounting departments.

Total Cost Achieving Activity (TCAA) teams focus almost exclusively on controlling supplier costs, as these represent just over 80% of total costs.

Meeting target cost objectives are always clear in terms of how much, by when, by which department, and how. This process is extended to first tier suppliers as well, with intention to apply to sub-suppliers. It is a commitment by the customer and supplier, regardless of size, to a long-term relationship to strive for world-class capability and competitiveness.

The supplier development team, located within the purchasing department, assists suppliers in improving their overall performance with respect to quality, productivity and efficiency. They work with suppliers, building close relationships which make them privy to confidential internal statistics. TCAA teams do not receive this confidential information from supplier development teams, except with consent. Effort is towards not eroding profit margin, only their costs.

Approximately 25% of suppliers are open book (complete breakdown of component price) and Nissan aims to increase this to 80% by 1996. This is one of the purchasing department’s performance measures.

Appendix C: Interview Questionnaires

Prime or Lead Systems Integrator

Introductory Questions:

Please describe the type of product you produce and the contracting environment in which you operate.
What is the life cycle of your product?
Are the service requirements fairly uniform and predictable over the life of the product or do they vary considerably with the environment or customer who uses the product?

Theme 1: Supplier Involvement and Engagement

1) At what point in the development cycle do you involve your O&S suppliers, and how are they involved?
2) How do you encourage your O&S suppliers to provide early O&S cost estimates and participate in cost reduction activities?
   a) What are some of the incentives if any?
3) How do you ask suppliers to make early cost or cost driver commitments on product and O&S costs?
4) For a given part or sub-system, do you have a single supplier responsible for both development and O&S, or are these handled by two or more different suppliers?
   a) What motivated the decision?
   b) How do you differentiate in the way you manage product development suppliers and O&S suppliers?
5) Are there any other issues around supplier involvement and engagement you wish to raise?

Theme 2: Contractual Issues

6) What are the specific obstacles you face with regard to obtaining O&S information from your suppliers that are not common to other areas such as target costing?
7) Who has the responsibility for achieving the O&S cost target on the project?
   a) How do hold them accountable?
8) Are there any other issues around supplier contractual challenges you wish to raise?

Theme 3: Setting and Accepting O&S Targets

Setting

9) During the Target Setting stage, how do you communicate the O&S requirements, O&S operational data, and estimating method with your suppliers?
10) Please explain how your customer accounts for the total ownership cost?
11) Prior to having the supplier under contract, how do you obtain sufficient and reliable source data for analysis to support cost targets development?
12) In the early design stage, how do you identify opportunities to achieve O&S target costs?
13) What are the chief impediments to setting and including O&S cost in cost targets?
14) What motivates your choice of methodology for setting targets for product and O&S?

Accepting

15) What are your O&S supplier's primary objections to accepting O&S target costs?
16) What methods do you use to provide an O&S cost estimate?
17) Are there any other issues around setting and accepting O& S cost targets that you wish to raise?

Theme 4: Managing Risk and Uncertainty

18) What are some of the major risks, and their sources, that you face in trying to meet your O&S cost target commitments?
19) How do you deal with these risks?
20) Are there any other issues around managing risk and uncertainty you wish to raise?

Supplier

Words in {} are prompting notes for interviewer only. Please remove these words before you send the interviewee an advanced copy of these questions.

Introductory Questions:

Please describe the type of product you produce and the contracting environment in which you operate.

What is the life cycle of your product?

Are you a part *and* Operations & Support supplier, or Operations & Support only?

During your customer's product development phase, do you have a) decision authority, b) input into the decisions, or c) no input.

Are the service requirements fairly uniform and predictable over the life of the product or do they vary considerably with the environment or customer who uses the product?

Theme 1: Supplier Involvement and Engagement

21) At what point in the development cycle does your customer involve you in O&S decisions? {Concept, functional design, detailed design, process planning, mfg.}

22) How are you encouraged to participate in cost reduction activities as an O&S supplier? {your expectations, shared savings, paid for effort, mandatory to be eligible for later work}

   a) What are some of the incentives, if any {e.g. improved supplier rating, financial, knowledge improvement, etc.}?

23) What are some typical contributions you have made to an affordable design? {What do you do together with your customer: contribute design ideas, trade-off studies, flow-down and influence requirements, discuss constraints; Where: co-location; Who: person on design team; When: continuous, periodic workshops, telecons}

24) Have you been asked by your customer to make early cost or cost driver commitments on product and O&S costs?

25) Are there any other issues around your involvement and engagement, in the early design phase, that you wish to raise?

Theme 2: Contractual Issues

26) What are the specific obstacles you face with regard to sharing O&S information with your customer that are not common to other areas such as target costing? {For example, there is a lot of uncertainty with the estimates because the information is so far out in the future}.

   a) Any contractual challenges?

   b) Does your customer provide all the information you need to reduce your O&S cost?

c) Do you provide all the information that your customer wants? If no, why?
d) Have your customers respected your confidentiality agreements?
e) How do you know? {audit, full or random, post event executive certification}

27) Who within your company has the responsibility for achieving the O& S target cost?
a) How do you ensure they are accountable? {reward or enforce}

28) Are there any other issues around contractual challenges you wish to raise?

Theme 3: Setting and Accepting O&S Targets

Setting

29) During the target setting stage, how does your customer communicate the O&S requirements?

30) Please explain how your customer accounts for the total ownership cost?

31) How do you ensure you have sufficient, reliable source data for analysis to determine if the O&S cost targets are feasible? {How do you determine the quality of information and identify gaps?}

32) What type of O&S operational data do you share with your customer to support target cost development? If you don't share operational data, please explain why not? {Operational data can be reliability & maintainability numbers as well as cost of repairs on similar projects}

33) In the early design stage, how do you identify opportunities to achieve O&S target costs?

Accepting

34) What are the primary objections to accepting the inclusion of O&S cost targets?

35) What methods do you use to provide an O&S price estimate for your customer? {
a) Historical cost of earlier programs;
b) industry surveys;
c) parametrics; and/or,
d) engineering detailed modeling.}

36) Are there any other issues around accepting O&S cost targets that you wish to raise?

Theme 4: Managing Risk and Uncertainty

37) "What are some of the major risks, and their sources, that you experience in trying to meet your O&S cost target commitments? {
a) customer's environment
b) general economic environment
c) project scope change
d) design changes }

38) How do you deal with these risks?

39) Are there any other issues around managing risk and uncertainty you wish to raise?

References

Ansari, Shahid L., Jan E. Bell, and the CAM-I Target Cost Core Group. *Target Costing: The Next Frontier in Strategic Cost Management.* New York: Irwin-McGraw-Hill, 1997.

Baiman, Stanley and M.V. Rajan, "Incentive Issues in Inter-firm Relationships," Accounting Organizations and Society, Elsevier Science Ltd. 2002.

Carr, Chris and Julia Ng, **"**Total Cost Control: Nissan and its U.K. Supplier Partnerships," Management Accounting Research, Academic Press Limited, 1995.

Ellram, Lisa M., **"**Supply Management's Involvement in the Target Costing Process," European Journal of Purchasing & Supply Management, Elsevier Science Ltd., 2002.

Hllikas, Jukka, K. Puumalainen, T. Vesterinen, V. Virolainen, "Risk-based Classification of Supplier Relationships," Science Direct, Oct. 7, 2005.

Hllikas, Jukka, I. Karvonen, U. Pulkkinen, V. Virolainen, M. Tuominen, "Risk Management Processes in Supplier Networks," Science Direct, Feb. 6, 2004.

Kulmala, Harri I., Jari Paranko, Erkki Uusi-Rauva, "The Role of Cost Management in Network Relationships," International Journal of Production Economics, May 15, 2000, Elsevier Science B.V. 2002.

Lee, John Y., and Yasuhiro Monden, "An International Comparison of Manufacturing-Friendly Cost Management Systems," The International Journal of Accounting, 1996.

Supply Management Research Group, Japan, "Japan's Keiretsu as a Strategic Relationship with Suppliers: The value chain of the new Keiretsu in evolution," CAPS: Center for Strategic Supply Research, 2005.

United States General Accounting Office Report to the Committee on Science, House of Representatives, "NASA Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management," May 2004. www.gao.gov/cgi-bin/getrpt?GAO-04-642.

About CAM-I

The Consortium for Advanced Management –International (CAM-I) is a research organization consisting of sponsoring companies and academia who work in collaboration to study and solve management problems and critical business issues common to the group in the areas of cost, process and performance management. More information here: http://www.cam-i.org/