Special Feature

From performance-based contracting for a multitude of services, to award-fee provisions in system support contracts to cost- incentive provisions in materiel contracts, the logistics community is seeing increasing emphasis on incentive contracts. This trend is part of a new sophistication in contracting which can be described as New-Age Contracting.

logistics Challenges

Incentive Contracts—Motivating Performance and Allocating Risk

Nanotechnology: Enabling Future Space Viability

This edition of the Journal presents two featured articles: "Incentive Contracts—Motivating Performance and Allocating Risk" and "Nanotechnology: Enabling Future Space Viability."

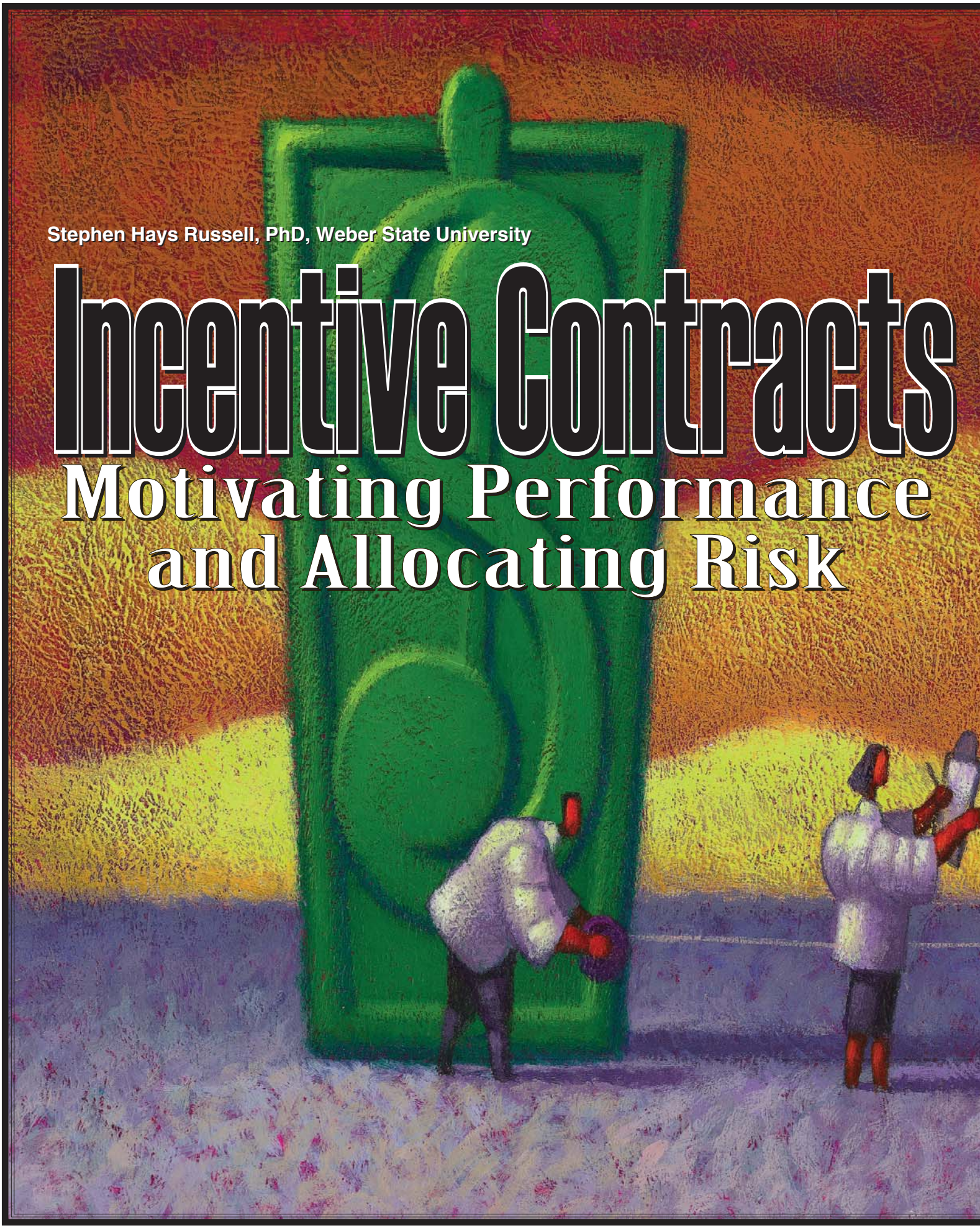
In "Incentive Contracts—Motivating Performance and Allocating Risk," the author examines the various types of incentives that can be introduced into contracts, provides both a mathematical and graphic presentation of various types of incentive contracts, and demonstrates how incentive contracts not only guide contractor performance to the advantage of the buying organization but also allocate risk between the parties. Central to the article is the comparison of classical contracting with New-Age Contracting. In classical contracting, the buying organization seeks the minimum contract price from a wide field of contractors based upon the competitive bid process. Contracts are typically fixed-price and the parties perceive each other as having competing objectives. In New-Age Contracting, world-class contractors with leading-edge technologies are important partners to the buying organization. New Age Contractors assist in defining requirements—collaboration is essential, and long-term relationships are important. Contract terms are negotiated and incentives to motivate performance and allocate risk are typically incorporated.

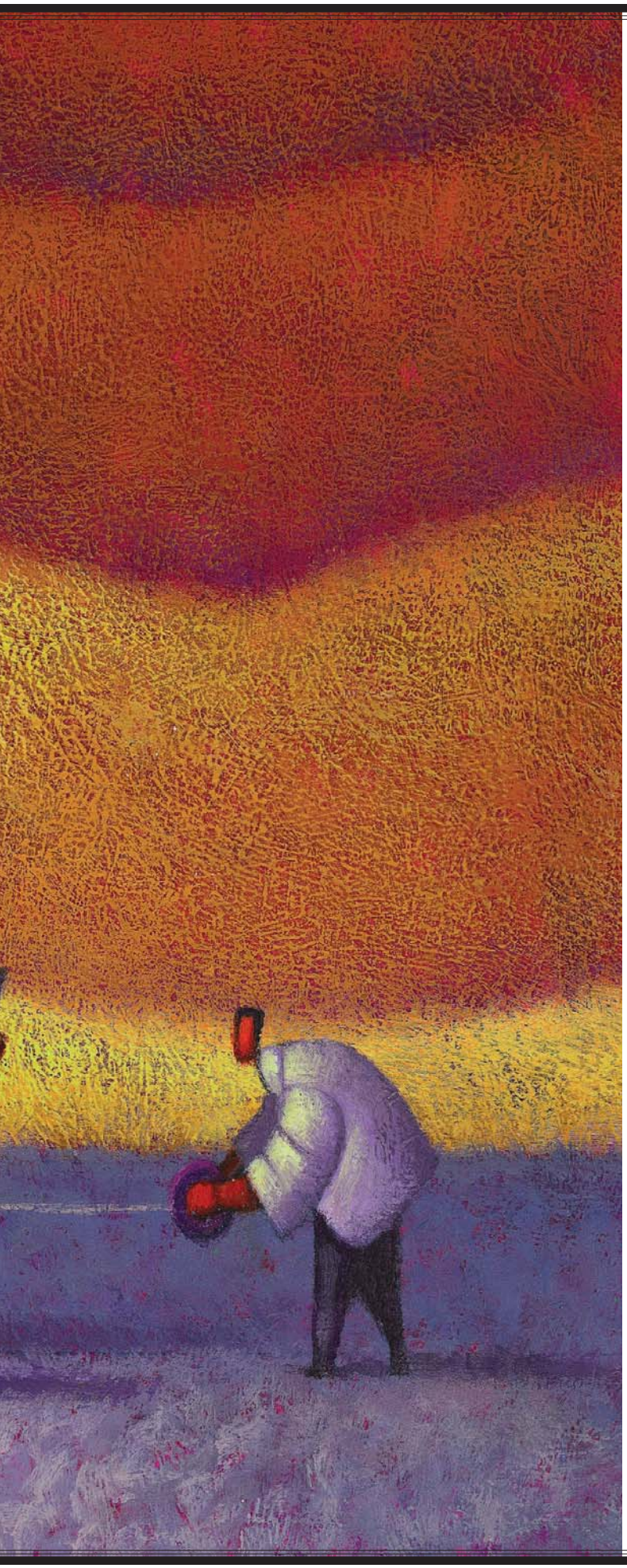
In the second feature Colonel Jenkins contends that aggressive development of nanotechnology-enabled space systems today has the potential to facilitate future space viability and dominance in 2035 and beyond. To support this contention she first explores the importance of space today to the United States (US) and surveys the most obvious US vulnerabilities. Next she examines the landscape of advancing technologies, focusing on the changer—nanotechnology—and its practical space applications, and explores who the leading competitors are in the realm of nanotechnology research and development. She then envisions a future space enabled by nanotechnology by examining real near-term possibilities, surveying long-term predictions, and addressing the impact of nanotechnology-enabled space on future US national security. In the final section of the article future scenarios are presented.

Stephen Hays Russell, PhD, Weber State University

Incentive Contracts

Motivating Performance and Allocating Risk





Introduction

Contracting—an integral part of the logistics process and a formal subdiscipline within the logistics umbrella—is undergoing substantial philosophical and procedural changes. Table 1 on page 4 summarizes the continuing movement from what might be called *classical contracting* to *New-Age Contracting*.[1]

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In classical contracting, the buying organization seeks the minimum contract price from a wide field of contractors based upon the competitive bid process. Contracts are typically fixed-price and the parties perceive each other as having competing objectives. In New-Age Contracting, world-class contractors with leading-edge technologies are important partners to the buying organization. New-Age Contractors assist in defining requirements—collaboration is essential, and long-term relationships are important. Contract terms are negotiated and incentives to motivate performance and allocate risk are typically incorporated.[2]

This article considers various types of incentives that can be introduced into contracts, presents both a mathematical and graphic presentation of various types of incentive contracts, and demonstrates how incentive contracts not only guide contractor performance to the advantage of the buying organization but also allocates risk between the parties.

Key Decisions in Procurement

The critical decisions in procurement are as follows.

- The nature of the specifications
- Contractor selection
- Price
- Contract type
- How to manage contractor performance

Classical contracting focuses primarily on the first three critical decisions. New-Age Contracting, on the other hand, adds emphasis to improving performance with collaborative buyer-contractor relationships and to contract type. Judicious attention to contract type will appropriately allocate risk between the buying organization and the contractor and will motivate performance.

The Issue of Risk in Contracts

Contract risk is of four types.

- Failure to perform
- Cost
- Technical
- Schedule

Failure to perform means the chosen contractor is not capable of meeting his contractual obligation. Cost risk is defined as uncertainty in final costs to the contractor and uncertainty in final

Article Highlights

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In "Incentive Contracts—Motivating Performance and Allocating Risk," Dr Stephen Hays Russell of Weber State University examines the various types of incentives that can be introduced into contracts, presents both a mathematical and graphic presentation of various types of incentive contracts, and demonstrates how incentive contracts not only guide contractor performance

financial obligation of the buying organization. Technical risk relates to quality issues and compliance with the technical specifications of the contract. Schedule risk is whether the deliverables of the contract will meet the required contract time schedule.

Failure to perform is not a significant risk issue when financially stable contractors with solid performance histories are selected. The formidable risk challenges in contracting relate to cost, technical, and schedule issues.

Contract Type and Cost-Risk Allocation

A fixed-price contract allocates all cost risk to the contractor. Regardless of what his actual costs turn out to be, the contractor is obligated to perform the requirements of the contract and will be paid only the fixed contract price. Obviously, the contractor has an incentive to control costs because of the dollar-for-dollar inverse relationship between cost and profit to him.

At the other extreme, a straight cost-reimbursable contract allocates all cost risk to the buying organization. The contractor has no incentive to control costs because he or she gets reimbursed dollar for dollar by his or her customer.

Incorporating Incentives into Contracts

Incentives in contracts will not only motivate performance and award achievement, but incentives also allocate risk between the parties. The important role incentive contracts play in New-Age Contracting was highlighted in a 2007 Office of Management and Budget memorandum, wherein chief acquisition officers throughout the federal government were admonished to give increased attention to the judicious employment of incentive contracts.[3]

Most incentive contracts focus on cost inasmuch as cost is often the biggest element of risk in contracting. Contractors by nature are risk averse. If a contractual effort involves substantial uncertainty in costs to be incurred (because of technology challenges or uncertain material prices, for example), contractors will not agree to a fixed-price contract (with all cost risk on them). As explained in the section that follows, an incentive contract on cost will allocate the risk between the parties and at the same time motivate the contractor to control costs. The literature defines the two general categories of cost-incentive contracts as linear and piece-wise linear contracts.[4, 5]

Linear Risk-Sharing Contracts on Cost

Linear risk-sharing contracts on cost set forth a target cost, a target profit, and a contractor cost-share rate. The share rate, between zero and one, sets the fraction of the difference between target cost and actual cost incurred by the contractor

	Classical Contracting	New-Age Contracting
Contract objective	Compliance at minimum price	Value with emphasis on performance and service
Supplier base	Huge	Circumscribed to world-class contractors
Relationships	Arms length; adversarial	Integrative
Trust	Tentative, personal	Trusted partners
Buyer's view of contractor	Source	Resource
Specifications	Imposed	Jointly developed with contractor input
Loyalty to contractor	Price chasing; frequent contractor switching	Earned loyalty; long-term contracts
Legal approach	Highly legalistic	Adaptive to mutual satisfaction
Pricing and award mechanism	Emphasis on competitive bidding	Emphasis on proposal and negotiation
Service contracts	Detailed statements-of-work	Performance-based specifications
Conflict resolution	Heavy-handed blame assignment; punitive remedies	Contractor-buyer collaborative resolution; emphasis on the continuing relationship
Contract type	Extensive employment of fixed-price contracts	Growing use of incentive contracts

Table 1. Characteristics of New-Age Contracting Compared to Classical Contracting

which is absorbed by the contractor (via decreases or increases in profit), with the balance being absorbed by the buying organization.

Consider Figure 1 on page 6. Cost is plotted on the horizontal axis. Price (the sum of cost plus profit) is plotted on the vertical axis. If actual cost turns out to be the target cost (C_T), then actual price will be the target price (denoted by $\pi_T + C_T$, where π_T is target profit and C_T is target cost). The slope of the diagonal line reflects cost sharing between the contractor and the buying organization when actual cost deviates from target cost. Assume, for example, that the contractor share rate (symbolized by b) is .25 (meaning that for each dollar of cost overrun the contractor absorbs $0.25 by way of reduced profit and the buying organization picks up $0.75 in the form of a higher final price). Then the slope of the diagonal line in Figure 1 is 1 - b, or .75.

A numeric example will illustrate both the allocation of risk and the incentive to control costs in this type of contract. Assume target cost (C_T) is $1,000, target price ($\pi_T + C_T$) is $1,100 (the sum of target cost of $1,000 and target profit of $100). If actual cost turns out to be right on target ($1,000), the buyer-firm pays the contractor the target price ($1,000 for cost and $100 for profit, or $1,100). Instead, if actual cost is $1,200 (reflecting a $200 overrun and depicted as point C_1 in Figure 1, the buyer-firm pays the contractor the target price ($1,100) plus just .75 of the $200 overrun for an actual price of $1,250. The $50 of the cost overrun not paid by the buyer-firm (representing 25 percent of the overrun) becomes a profit penalty to the contractor because his actual profit on this contract is $100 - $50 or $50.) These results are portrayed graphically in Figure 1 with points C_1 and P_1.

Mathematically, a linear risk-sharing contract is shown as follows.

$$P_A = \pi_T + C_A + b(C_T - C_A)$$

where

P_A = actual price (final contract price; what the buying organization pays in total)

C_A = actual contractor cost for the contract effort

π_T = target profit (a negotiated value)

b = contractor cost-share rate, a negotiated value ($0 \leq b \leq 1$)

C_T = target cost (a negotiated value)

Equation 1

In words, Equation 1 states that the actual final price of the contract is the target profit plus the actual cost, but adjusted by the contractor's share of the overrun or underrun. Note in the equation 1 and in Figure 1 that if C_A equals C_T (that is, if the contractor performs right on target cost), actual price equals target price at point $\pi_T + C_T$.

Equation 1 can be rearranged:

$$P_A = \pi_T + bC_T + (1 - b)C_A$$

Equation 2

Article Highlights

to the advantage of the buying organization but also allocate risk between the parties. He concludes with the following five points.

- Incentive contracts both motivate performance and allocate risk.
- Incentives can be applied to the three substantial risk areas in contracting: cost, technical, and schedule performance.
- Incentive contracts on cost are either linear or piece-wise linear. The predominant contracts of this category in the Department of Defense are Cost-Plus-Incentive-Fee contracts and Fixed-Price-Incentive Contracts. Risk is allocated by setting a contractor share ratio for cost overruns and cost underruns. These contracts typically have upper limits in sharing provisions.
- Incentive contracts for technical or schedule performance are objective (formula-type) contracts. For these contracts, performance measurement is quantifiable. When achievement in a performance area is not amenable to specific quantitative measurement, subjective (award-fee) contracts are employed.
- Incentive contracts require a substantial investment of time in administering. However, these contracts are cost-effective promoters of improved cost, technical, and delivery outcomes in all situations where risk is substantial or where risk and cost-benefit analyses demonstrate a clear advantage to an incentive contract.

Article Acronyms

CPIF – Cost-Plus-Incentive-Fee
FPI – Fixed-Price-Incentive
PEB – Performance Evaluation Board

In this form, actual price is seen as a lump sum and a 1 - b share of actual cost. This relationship is depicted graphically in Figure 1 inasmuch as Equation 2 is the equation for the diagonal line. The slope of the actual price equation is 1 - b, which is the buying organization's cost-share rate.

Also note in Figure 1 that before a contractor begins incurring costs in a linear risk-sharing contract on cost, he theoretically has a $\pi_T + bC_T$ amount of profit (all price is profit when costs are zero). As effort on the contract is executed and costs are incurred (illustrated in Figure 1 by rightward movement along the diagonal line), price increases less than cost; hence, profits fall.

The incentive to control cost is obvious. In this example, for every dollar actual costs are below target cost, the contractor keeps $0.25 of the underrun as incentive profit in addition to the target profit. For every dollar actual costs are above target costs, the contractor loses $0.25 of the target profit.

The allocation of cost risk is accomplished by setting b. The higher the contractor share rate, the greater the risk on the contractor.

Piece-Wise Linear Risk-Sharing Contracts on Cost

Piece-wise linear contracts are precisely the linear risk-sharing contracts on cost discussed previously but with upper and lower boundaries on the risk-sharing. Piece-wise linear contracts are such because contract provisions include profit ceilings and floors, or price ceilings, which cause the diagonal sharing line in Figure 1 to kink.

Two piece-wise linear risk-sharing contracts heavily employed in the defense industry are reviewed below.

Cost-Plus-Incentive-Fee (CPIF) Contracts. If the risk-sharing contract specifies upper and lower limits on risk-sharing, a piece-wise linear contract is defined (see Figure 2). Between cost levels C_O and C_P we have a standard linear risk-sharing contract with a contractor cost share of b and a slope of 1 - b. Actual costs above C_T reduce contractor profit; actual costs below C_T reward the contractor with increased profit (as previously presented with Figure 1). But in Figure 2 this risk-sharing arrangement ends at the kinks on the line at cost levels C_O and C_P.[6]

To the left of C_O, the slope of the diagonal sharing line steepens to 1.0, meaning the contractor share rate (b) goes to zero. Every additional dollar of cost underrun to the left of C_O goes to the buying organization in the form of reduced price. This means that by contract provision contractor profit is maximized at C_O.

Similarly, the slope of the diagonal share line steepens to 1.0 at C_P as well. All cost risk beyond this point is on the buying organization (because b—the contractor's cost share—is now zero with slope at 1.0). The entire burden (risk) of more cost overrun beyond this point is on the buying organization because, beyond C_P, every dollar of cost increase is a dollar increase in price paid by the buying organization. Accordingly, the cost level C_P is the point where a minimum profit level is guaranteed to the contractor.

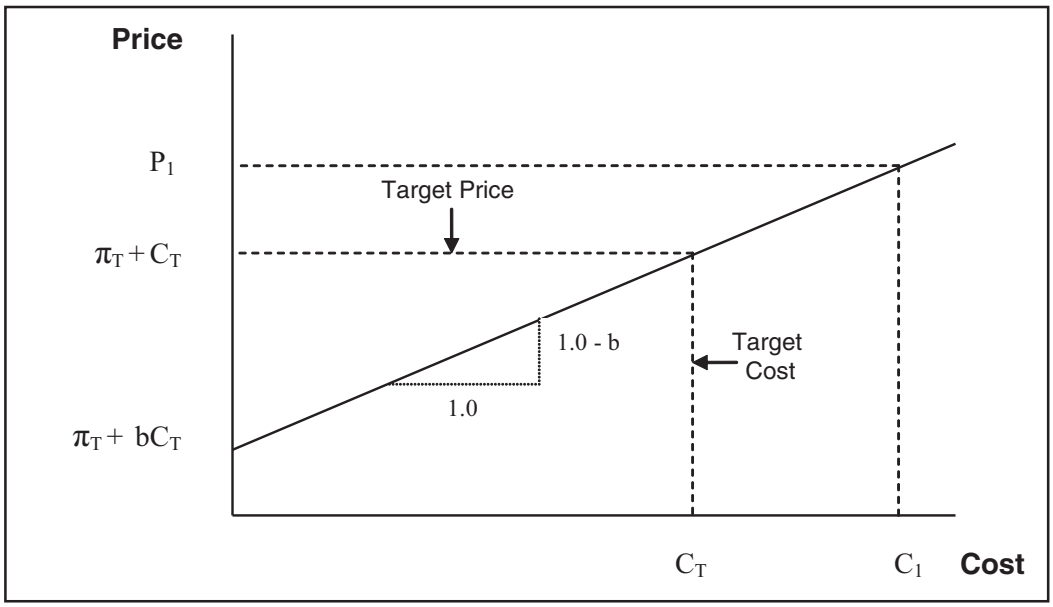

Figure 1. Linear Risk-Sharing Contract on Cost

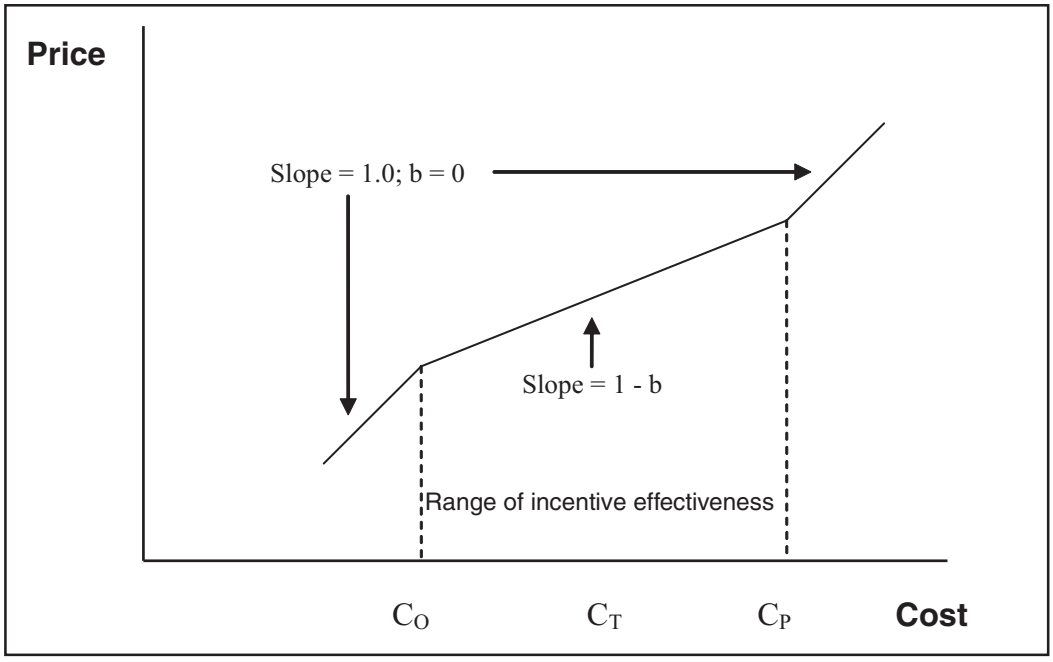

Figure 2. Cost-Plus-Incentive-Fee Contract

With these kinks in a CPIF contract, incentives apply and risk is shared between C_O and C_P. All cost risk is born by the buying organization outside of this range.[7]

Fixed-Price-Incentive (FPI) Contracts. The imposition of minimum and maximum profit levels is not the only manner in which a linear risk-sharing contract on cost becomes piece-wise linear. If the buying organization places a ceiling on actual price in a risk-sharing arrangement, a kink is introduced.

This contract type is illustrated in Figure 3. In this diagram, P_C is the ceiling price, the contractual maximum compensation to be paid to the contractor, regardless of actual cost. Note that cost-sharing ceases where the diagonal share line becomes perfectly horizontal at the ceiling price. Mathematically, given the negotiated target cost, target price, contractor share ratio, and ceiling price, the level of actual cost that brings the contract to the ceiling price is given as follows.

$$Cc = [P_C - P_T]/(1 - b) + C_T$$

where,

C_C = the ceiling cost

P_T = target price ($\pi_T + C_T$)

Equation 3

At point C_C in Figure 3 risk-sharing ceases and all cost risk is now on the contractor (b is now 1.0). Regardless of costs incurred beyond C_C, the compensation to the contractor is maximized (becomes a fixed price) at P_C.

The ceiling cost is sometimes referred to as *the point of total assumption* because the contractor absorbs dollar for dollar all costs beyond C_C.[8]

Objective Risk-Sharing Contracts on Technical or Delivery Performance

Objective risk-sharing contracts on technical or delivery performance allocate risk by making at least a portion of contractor profit a function of contractor performance in such areas as logistics response time (the average time between generation of a requisition and receipt of the material by the customer), inventory accuracy, forecasting accuracy, completion date, defect rates, energy efficiency, or mean time between failure achievement. In this type of contract, a target price and a target achievement level for delivery or technical performance is set. Deviations from the target in actual achievement yield profit bonuses or penalties. Such a scheme motivates performance and allocates some risk to the contractor by putting his realized level of profit at risk.

Figure 4 illustrates this type of contract. Actual price is a negotiated target price adjusted by penalty or bonus as actual achievement deviates from the plan. In Figure 4, the slope of the line represents the penalty or bonus per unit of variance. For example, units of favorable variance along the horizontal axis to point V_1 would move the actual price from the target price to P_1, a price with bonus profit.

An example of this type of contract would be a highway construction contract with a target price of $25M and a bonus (penalty) for early (delayed) completion of $25K per day.

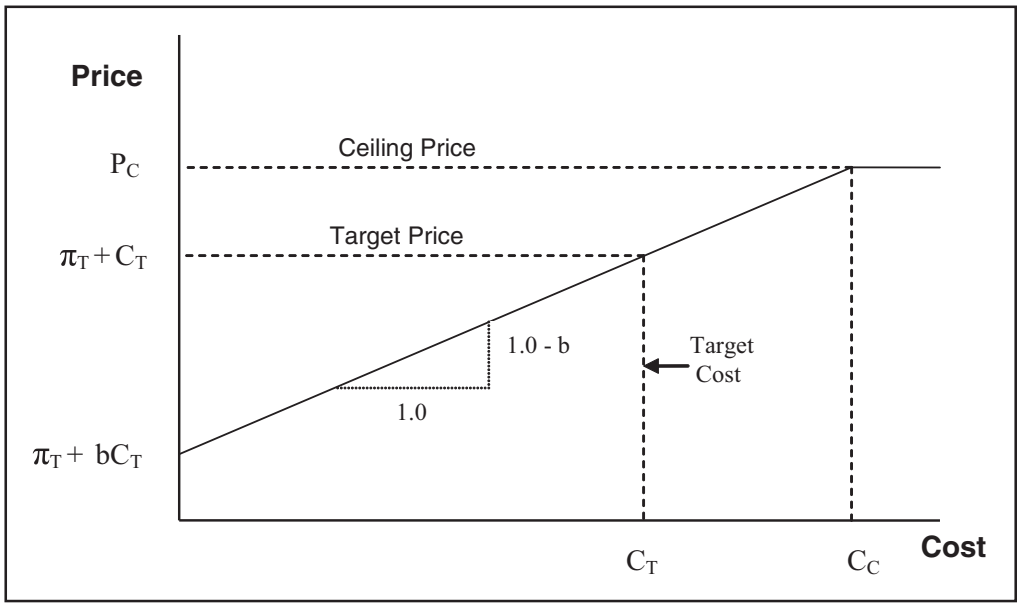

Figure 3. Fixed-Price-Incentive (FPI) Contract

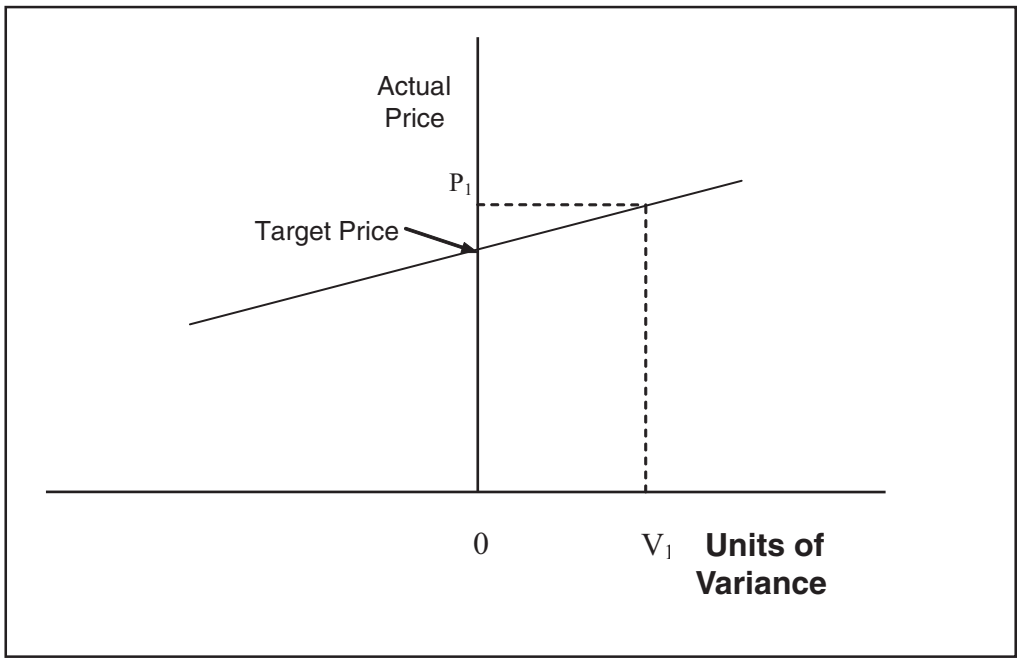

Figure 4. Objective Risk-Sharing Contract Where Actual Price Depends Upon Positive or Negative Units of Variance from Target Objective

Subjective Risk-Sharing Contracts

Subjective risk-sharing contracts are designed to reward contractors for exceptional levels of achievement in areas not amenable to quantifiable or specific measurement (such as value-added services, technical ingenuity, customer satisfaction with services, and problem identification and resolution skills). Evaluations in these areas are judgments by the buying organization, and the earned compensation is called *award fee*.[9]

These contracts (generally called *visible hand* or award fee contracts) are always hybrid contracts in that an award fee provision is always used in conjunction with either an underlying fixed-price or cost-reimbursable provision.[10]

A contract with an award fee provision incorporates an award fee pool, which is a dollar amount of award money that the contractor can potentially earn over the course of the contract. Typically the buying firm will convene a performance evaluation board (PEB) quarterly or semiannually to review contractor performance in the areas specified by the award fee plan of the contract. The PEB makes a subjective judgment as to what percentage of the award fee pool for this period should be awarded the contractor.

Subjective risk-sharing contracts allow the buying organization to change areas of emphasis for award fee in each evaluation period. This way the buying organization can more effectively manage contractor effort by allowing new areas of evaluation to evolve during the course of the contract.

The contractor shares in the risk of performance because the percentage of the fee pool awarded in each evaluation period is tied directly to the buying organization's evaluation of contractor performance. Shortfalls in performance become foregone award fee.

Conclusion

From performance-based contracting for a multitude of services, to award-fee provisions in system support contracts to cost-incentive provisions in materiel contracts, the logistics community is seeing increasing emphasis on incentive contracts. This trend is part of a new sophistication in contracting which can be described as New-Age Contracting.

This article demonstrates with mathematical exposition, graphs, and narrative how incentive contracts both motivate performance and allocate risk.

Incentives can be applied to the three substantial risk areas in contracting: cost, technical, and schedule performance.

Incentive contracts on cost are either linear or piece-wise linear. The predominant contracts of this category in the Department of Defense are CPIF contracts and FPI contracts. Risk is allocated by setting a contractor share ratio for cost overruns and cost underruns. These contracts typically have upper limits in sharing provisions.

Incentive contracts for technical or schedule performance are objective (formula-type) contracts. For these contracts, performance measurement is quantifiable. When achievement in a performance area is not amenable to specific quantitative measurement, subjective (award-fee) contracts are employed.

Incentive contracts require a substantial investment of time in administering. However, these contracts are cost-effective promoters of improved cost, technical, and delivery outcomes in all situations where risk is substantial or where risk and cost-benefit analyses demonstrate a clear advantage to an incentive contract.[11]

Notes

1. For an overview of the differences between classical contracting and New-Age Contracting in the automobile industry, see "Detroit's Demise Stems from Flawed Supplier Relations" by procurement guru David N. Burt, *The Warren Company Current Issues*, November 2008, [Online] Available: www.warrenco.com/html/detroit_s_demise.html, accessed 28 October 2010.
2. A clarification is important: When the buying organization has a need for standard, readily-available materials or services or otherwise has well-defined requirements with price rather than an enduring relationship as the legitimate contract objective, and at least three capable and willing contractors are available, a classical approach is acceptable, even in the era of New-Age Contracting.
3. Executive Office of the President, Office of Management and Budget, Memorandum for Chief Acquisition Officers, Subject: Appropriate Use of Incentive Contracts, 4 December 2007, [Online] Available: http://www.whitehouse.gov/sites/default/files/omb/procurement/memo/incentive_contracts_120407.pdf, accessed 30 October 2010.
4. R. K. Goel, "Choosing the Sharing Rate for Incentive Contracts," *The American Economist*, Volume 39, No 2, 68-72.
5. Joseph Y. Chen and Bruce L. Miller, "On the Relative Performance of Linear vs. Piecewise-Linear-Threshold Intertemporal Incentives," *Management Science*, Volume 55, No 10, October 2009, 1743-1752.
6. Kinks occur in a CPIF contract at end points in a cost range from "optimistic cost estimate" (C_O) to "pessimistic cost estimate" (C_P).
7. The range between C_O and C_P can be referred to as the *range of risk sharing* or the *range of incentive effectiveness*.
8. Note that a CPIF contract has no limit on the financial obligation of the buying organization, whereas the FPI contract caps financial obligation at the ceiling price. Clearly a CPIF contract allocates more risk to the buying organization than does an FPI contract, and is appropriate only when uncertainties in cost are so great that a contractor is unwilling to accept any type of a *fixed* price contract. See the parameters for employing a CPIF contract in the Federal Acquisition Regulation (FAR) Volume I, Subpart 16.3, *Cost Reimbursement Contracts*, March 2005, [Online] Available: https://www.acquisition.gov/far/current/html/Subpart%2016_3.html#wp1077348, accessed 18 November 2010.
9. *National Aeronautics and Space Administration Award Fee Contracting Guide*, 27 June 2001, [Online] Available: http://www.hq.nasa.gov/office/procurement/regs/afguidee.html, accessed 22 September 2010.
10. Code of Federal Regulations–Title48, *Federal Acquisition Regulations System*, Chapter 1, Subchapter C, Part 16, "Types of Contracts," 16.405-2, "Cost-Plus-Award-Fee Contracts," undated, [Online] Available: http://cfr.vlex.com/vid/16-405-2-cost-plus-award-fee-contracts-19870012, accessed 13 November 2010.
11. FAR Volume I, Subpart 16.4, *Incentive Contracts*, March 2005, [Online] Available: https://www.acquisition.gov/far/05-47-1/pdf/FAR.book.pdf, accessed 18 November 2010.

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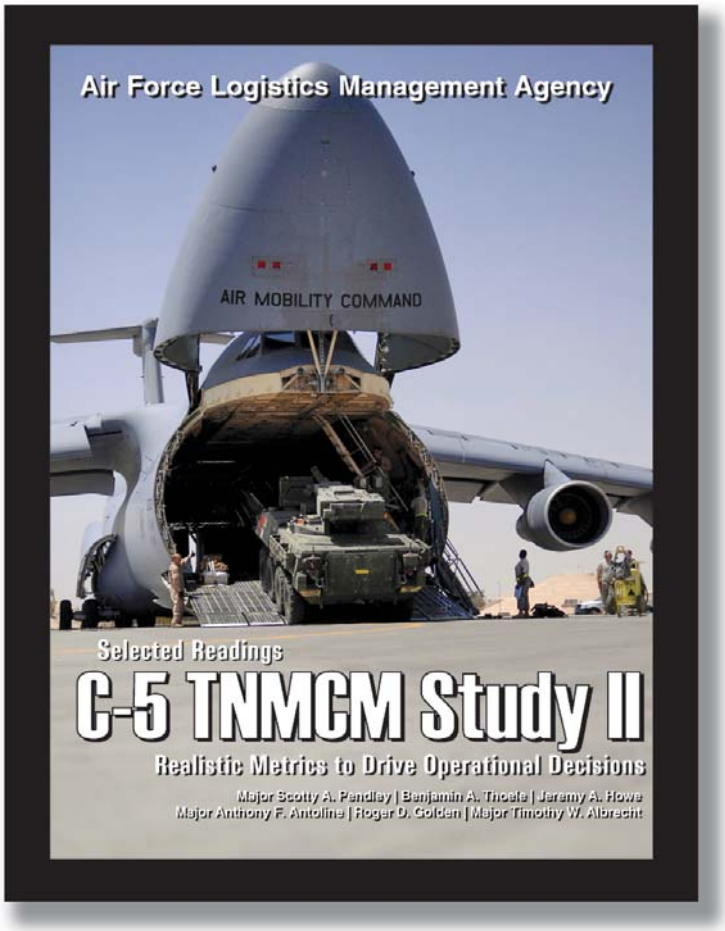

The *C-5 TNMCM Study II* proved to be a stern test of AFLMA's abilities and perseverance. Considering the numerous potential factors that impact TNMCM rates as well as the C-5's historical challenges in the areas of availability and achieving established performance standards, the study team was determined to apply new thinking to an old problem. The research addressed areas of concern including maintaining a historically challenged aircraft, fleet restructuring, shrinking resources, and the need for accurate and useful metrics to drive desired enterprise results. The team applied fresh perspectives, ideas and transformational thinking. As a result, the study team developed a new detailed methodology to attack similar research problems, formulated a new personnel capacity equation that goes beyond the traditional authorized versus assigned method, and analyzed the overall process of setting maintenance metric standards. AFLMA also formed a strategic partnership with the Office of Aerospace Studies at Kirtland AFB in order to accomplish an analysis of the return on investment of previous C-5 modifications and improvement initiatives. A series of articles was produced that describes various portions of the research and accompanying results. Those articles are consolidated in this book.

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