AN ANALYSIS OF MANAGEMENT RESERVE BUDGET ON DEFENSE ACQUISITION CONTRACTS

Author:	David S. Christensen, Ph.D.	Carl Templin, Ph.D.
Mailing address:	College of Business Southern Utah University 351 West Center Street Cedar City, Utah 84720	College of Business Southern Utah University 351 West Center Street Cedar City, Utah 84720
Email:	ChristensenD@suu.edu	Templin@suu.edu
Phone:	(435)865-8058	(435)865-5440
Fax:	(435)586-5493	(435)586-5493

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ABSTRACT

Management Reserve (MR) budget is an amount of the total allocated budget withheld by contractors for management control purposes. More specifically, its purpose is to provide an adequate budget for in-scope but unanticipated work on the contract. As a contract proceeds to completion, and unanticipated, in-scope work is identified, MR budget is allocated to that work. Once allocated, MR budget becomes part of the performance measurement baseline (PMB) used to measure and control cost and schedule performance on the contract. Accordingly, MR budget is an important part of effective planning and control on defense contracts.

Presumably, contracts with greater risk (uncertainty) will have a need for greater MR budget. Using data from the Defense Acquisition Executive Summary (DAES) database, we test this assumption. In addition, this paper provides quarterly descriptive statistics and related graphics on the amount and use of MR budget on hundreds of defense acquisition contracts from 1975 to 1998. Results indicate statistically significant differences in the median MR budget percentage across contract types (cost-reimbursable and price) and the military services managing the contracts (Army, Air Force, Navy), and no significant differences across contract phases (development and production). In addition to providing benchmarks for establishing an appropriate amount of MR budget, these results provide insight into the relative risk across contract types, contract phases, and contracts managed by the services.

I. INTRODUCTION

Terminology Related to Management Reserve Budget

Management Reserve (MR) budget is defined as "the amount of the total allocated budget withheld for management control purposes rather than designated for the accomplishment of a specific task or set of tasks. It is not part of the Performance Measurement Baseline" (DOD 1997:60).

"Management control" is not defined in DOD policy documents. In general, management control implies a process by which managers influence others to achieve the organization's objectives (Anthony and Govindrajan 1995:8). On defense contracts, key objectives include completing the project within cost, schedule and technical parameters set by the government. Management control is implemented by establishing a time-phased budget for all the authorized work on the project. The budget is then used as a baseline against which performance is measured. Significant deviations from the baseline, termed cost and schedule variances, are early warning signals to identify and correct problems before they worsen.

The time-phased budget is known as the performance measurement baseline (PMB). Figure 1 illustrates the PMB and related budgetary terms, including MR budget. The PMB includes budget for all the authorized work on the project. The PMB is defined as

> *the time-phased budget plan against which contract performance is measured. It is formed by the budgets assigned to scheduled control accounts and the applicable indirect budgets. For future effort, not planned to the control account level, the performance measurement baseline also includes budgets assigned to higher level CWBS elements, and undistributed budgets. It equals the total allocated budget less management reserve* (DOD 1997:61).

At the start of the project, the contractor will typically use a product-oriented work breakdown structure to organize the work. Near-term effort is divided into work packages. Far-term effort is divided into planning packages. On a large project, there may be more than 100,000 work packages that must be performed

before the project is completed (National Security Industrial Association (NSIA) 1980:10). As a result, only the near-term work is planned in detail. As the project progresses, the planning packages are systematically divided into work packages and planned in detail. Regardless of the timing of the work, a budget in terms of hours, dollars, or other measurable units is assigned to each work and planning package.

The point at which budgets and actual costs are compared is termed a control account. A control account is the focal point for planning, scheduling, budgeting, cost accumulation, performance measurement, and variance analysis. The person in charge of a control account, called a control account manager, is typically responsible for determining the budget baseline and explaining the variances within the control account.

MR budget is controlled by the contractor program manager. It is distributed to the control account manager only when properly authorized. Using MR budget solely to adjust cost variances is not a legitimate reason for distributing MR budget. Once distributed, the MR budget becomes part of the PMB.

The sum of the performance measurement and MR budgets is termed the contract budget base (CBB). The CBB is formally defined as "the negotiated contract cost plus the estimated cost of authorized unpriced work" (DOD 1997:59). The CBB should reconcile to the total allocated budget at the start of the project. Later, the total allocated budget may exceed the CBB, a condition known as "over-target baseline." This occurs when available budgets are judged to be seriously inadequate to accomplish the remaining work and ensure valid performance measurement. Measuring performance against an unrealistic baseline would impair effective management control and the contractor's ability to manage on-going and future work. Implementing an over-target baseline is a major management decision and should be discussed with the government in advance (DOD 1997:10).

MR is not a budget for contingencies in the literal sense. *Federal Acquisition Regulation* 31.205-7 (US Government 1999) defines "contingency" as "a possible future event or condition arising from presently known or unknown causes, the outcome of which is indeterminable at the present time" (paragraph a), and indicates that costs for contingencies are *generally* not allowable (paragraph b). However, in estimating future costs, there are two kinds of contingencies:

> *(1) Those that may arise from presently known and existing conditions, the effects of which are foreseeable within reasonable limits of accuracy; e.g., anticipated costs of rejects and defective work. Contingencies of this category are to be included in the estimates of future costs so as to provide the best estimate of performance costs.*
> *(2) Those that may arise from presently known or unknown conditions, the effect of which cannot be measured so precisely as to provide equitable results to the contractor and to the Government; e.g., results of pending litigation. Contingencies of this category are to be excluded from cost estimates under the several items of cost, but should be disclosed separately (including the basis upon which the contingency is computed) to facilitate the negotiation of appropriate contractual coverage* (US Government 1999, FAR 31.205-7, paragraph c).

Thus, contingency costs that can be reasonably foreseeable should be estimated and included in the PMB. In contrast, MR budget is not foreseeable, and should not be included in the PMB. In addition, the *Earned Value Management Implementation Guide* indicates that MR budget cannot be eliminated by government contract price negotiations or used to absorb the cost of contract changes:

> *Management reserve is not a contingency which can be eliminated from the contract price during subsequent negotiations or used to absorb the cost of contract changes. The contractor should not be required to use existing MR budget for authorized but undefinitized work, or other modifications to authorized contractual efforts* (DOD 1997:12).

MR budget is not the same as Undistributed Budget (UB). UB is for authorized work that the contractor has not yet allocated to specific WBS elements or control accounts. UB is typically established when project changes occur too late in the month to be distributed. As such, UB is a temporary holding account. Budget in UB should be distributed to WBS elements or control accounts as soon as possible. UB is part of the PMB. MR budget is not part of the PMB.

In general, the use of MR budget is considered a routine management decision. The contractor does not require advance approval from the government to use MR budget. However, its use and the reason for its use should be reported on the monthly cost management report submitted to the government. In addition, when the scope of a contract is increased, an appropriate amount of MR budget may be added to the project.

Purposes for MR Budget

Budgets, including MR budget, have many purposes, including planning, communication, coordination, control, motivation, and performance evaluation. A budget that is optimal for one purpose may not be optimal for another (Barrett and Fraser 1977). For example, for planning and control purposes, budgets should be accurate estimates of future costs. But for other purposes, budgets may be deliberately overstated by a manager to minimize the need for variance reporting, or deliberately understated by a manager's supervisor to reduce possible over-consumption of resources (Merchant 1985, Merchant and Shields1993, Merchant and Manzoni 1989).

Although the purpose of MR budget is probably most related to control, the earned value literature suggests that another purpose of MR budget is motivational: to create a "budget challenge" for cost account managers (e.g., Antolini, et al. 1991:31, Bowman 1993:5; Fleming 1992:49, Gould 1995:29-31). Two relatively new forms of challenge budgeting are target costing and kaizen budgeting. Both were popularized in Japan but are now found worldwide (Tanaka 1993).

Target costing is a process of determining a maximum allowable cost for a product by subtracting a desired profit from the product's market price. Value engineering is then used to design the product to stay within the target cost. Target costing applies primarily to the design phase, where the majority of a product's life cycle costs are determined (Artto 1994). Cost As an Independent Variable (CAIV) is the DOD analogue of target costing. Lacking market prices, the target cost under CAIV comes from an "affordability analysis" by the military services rather than from a market analysis. There is some evidence that CAIV has been effective in controlling the cost of recent defense acquisition projects (e.g., Coleman, et al. 1998).

Kaizen budgeting occurs during the manufacturing stage of a product, and may be viewed as a final step in the target costing process (Blocher, et al. 1999:138). Kaizen budgeting is intended to stimulate innovation and process improvements that lead to cost reduction. "Kaizen" is a Japanese term for continuous improvement. Kaizen budgeting explicitly anticipates continuous improvements in operating processes. Instead of assuming that current practices will continue, a kaizen budget is viewed as a challenge to managers to alter practices in ways that reduce costs without reducing quality.

Kaizen budgeting is not the same as an arbitrary budget cut. If MR budget is determined as a percentage of the total allocated budget without evaluating the uncertainty/risk in each control account, the potential for a challenge budget to stimulate cost savings through process improvement seems doubtful:[1]

> *A decrease in cost in a kaizen budget is a result of doing the same activity more efficiently and with higher quality; it is not a result of arbitrarily eliminating activities or components* (Blocher, et al. 1999:307).

Another purpose for MR budget is to create a reserve for in-scope but unforeseen work:

> *In most projects, particularly developmental activities, there is considerable uncertainty regarding the timing or magnitude of future difficulties. The use of MR provides the project manager with a capability to adjust for these uncertainties* (DOD 1997:12).

[1] Gould (1995) indicates that selectively removing MR budget according to the uncertainty in each control account is rare.

Examples include work created by events that cannot be predicted, such as accidents, planning errors, technical re-directions, or contractor-initiated studies.

Budgets for all authorized work should be included in the PMB. Work without budget or budget without work is inappropriate for performance measurement and control purposes. Work without budget overstates the cost variance. Budget without work understates the cost variance. In either case, effective control via variance analysis is impaired. Accordingly, MR budget is necessarily excluded from the PMB until the unforeseen work is identified.

MR Estimation

Estimating the amount of MR budget may appear to be an oxymoron: How can something that is unforeseen be estimated? However, Antolini et al. (1991:32) report that most contractors can determine MR budget from their own experience with prior contracts. In addition, before contract award, prudent CAMs almost certainly include an unspecified amount of excess budget in their cost estimates. Research suggests that (1) budgetary slack exists in most business organizations, (2) it is in managers' best interests as rational economic individuals to create slack, and (3) it is nearly impossible to prevent (Bart 1988:188, Merchant 1998:219). Although contractor policy may preclude CAMs from padding their budgets, it seems likely that every prudent CAM would do so, knowing that only a fraction would be approved (Fleming 1996:64-65). It is possible that MR budget could be estimated by each CAM and aggregated to the total program level with full visibility. However, based on a review of contractor system descriptions and telephone interviews with industry experts, Gould (1995:38) reports that a "top-down" process is more common, where the contractor program manager withholds a portion of the approved CBB as MR budget.

Surveys of defense contractors (NSIA 1980, Gould 1995) indicate that the amount of MR budget withheld from the CBB depends on many factors, such as risk, management philosophy, the magnitude of the profit/fee, constraints related to time and experience, negotiation skills, and the stability of the contract requirements. In response to Gould's question of what factors influence the determination of MR budget, one expert reports the following:

> *The determination is entirely up to the contractor. In arriving at the proper amount of MR budget, evaluation of the major risks is surely a prime factor. The degree to which the contractor wants motivational or incentivized budgets is another important factor. In assessing the risks, the near-term clearly defined work probably will be less risky than the far-term ill-defined or undefined work. Also, work which is the same or very similar to work which has been done previously will have less uncertainty (and impel less management reserve) than work which is not familiar* (Gould 1995:36).

With these factors in mind, determining the amount of MR budget is probably best described as an iterative process, where all managers affected by MR budget have some role in its determination.

> *Regardless of the detail available, these budgets [MR, PMB, cost account budgets, and functional budgets] should be considered preliminary until functional and operating managers have accepted them. …Managers who disagree with either the statement of work or the budget must make this known to their superiors as well as the project manager. Negotiations should take place* (Slemaker 1985:99-100).

Encouraging managers at all levels to participate in the budget process can improve the accuracy of the budget and management commitment to it (Garrison and Noreen, 2000:382). Survey research shows that most companies use some form of participative budgeting (Horngren, et al. 2000:181).

Some authors suggest that MR budget be identified by uncertainty analysis, where the cost of each WBS element is modeled as a random variable (e.g., Garvey 1995:161; Goldberg and Weber 1998:III-17; Stewart and Wyskida 1987:297-306). Instead of specifying a percentage of the CBB as MR budget, the authors

suggest specifying a probability for the cost of work (e.g., total project, control account) to be less than or equal to its budget, termed the "probability of success" (P(s)) in Goldberg and Weber (1998). Adding MR budget increases P(s). Thus, the amount of MR budget can be identified at any desired P(s) specified by project management.[2]

Several models have been developed to quantify project risk in support of estimating and budgeting. The Risk Analysis and Cost Management Model (RACM) developed by Lockheed Martin is a recent example. In evaluating RACM, Goldberg and Weber (1998:III-6) note that summing budgets that are relatively easy to achieve (P(s) > 0.5) results in a budget for the entire project that is even easier to achieve:

> *The program-wide percentile will exceed the common WBS-element percentile when the latter is greater than .5; the opposite condition holds when the common WBS-element percentile is less than one-half.*

In evaluating kaizen budgeting, Shih (1998:560) provides a similar conclusion:

> *If the chance to attain the y percent cost savings is lower (higher) than 50 percent for units at the bottom level, then the chance to attain the y percent cost savings will be progressively lower (higher) for units at successively higher levels of the hierarchy.*

Shih (1998:562) also notes that if budgeting is from the top-down, the effect on budget achievability (P(s)) is reversed: "if the budgets for the top-level units are hard (easy) to meet, those for units at lower and lower levels are progressively easier (harder) to meet."

Overall, these findings suggest that the achievability of a budget depends on how the budgets are established. Establishing challenge budgets for each control account at a specified P(s) will result in a challenge budget for the project with a different P(s). Likewise, removing MR budget from the CBB at the project level for a specific P(s) will result in a different P(s) for each control account.

Since determining the PMB and MR budget is almost certainly iterative, the ability to specify an appropriate amount of MR budget using such models is unclear. Moreover, implementing probabilistic budgeting requires strong assumptions about the costs of WBS elements (e.g., distribution properties, correlation). For example, Goldberg and Weber (1998:I-7) report that RACM assumes normality, does not fully account for potential correlation among cost elements, and makes assumptions about contractor behavior that are not universally held. Other models make similar assumptions. In their review of RACM and similar models, Goldberg and Weber conclude that "neither RACM nor any other particular tool can be viewed as a silver bullet to remove all risk or prevent all cost overruns on defense programs" (1998:I-10). At best, RACM and similar models are decision support tools that make the treatment of risk more systematic; they do not replace management judgment.

Estimating MR budget is necessarily a subjective process, involving negotiations among managers at various levels in the contractor organization. Moreover, budgets have several overlapping functions, including planning, motivation, and performance evaluation. Although budget theorists suggest that no single budget may be right for all purposes (Barrett and Fraser 1977:141), having a different budget for each purpose is uncommon (Umpathy 1987). MR budget reflects compromises between these purposes and the managers involved with it.

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[2] Based on data gathered from 54 profit center managers in 12 corporations, Merchant (1990) indicates that most profit center managers prefer budgets that are achievable 80 to 90 percent of the time. However, control accounts are cost centers, not profit centers, and it is unknown if control account budgets are planned to be achievable at similar percentiles. Barrett and Fraser (1977:137) suggest that budgets should be highly achievable for motivational purposes, and less than highly achievable for planning and control purposes.

Historical data on the amount of MR budget is available on a large number of completed and on-going defense projects. The remaining sections of this paper describe the amount of MR budget established on defense acquisition contracts over the last two decades. Descriptive statistics may be useful as potential benchmarks for MR budget on new projects. In addition, we test for significant differences across contract phase (development versus production), contract type (cost versus price), and the military services managing the contracts. If MR budget is indeed a function of management philosophy and uncertainty/risk, then differences may exist across these categories. Section II reports the methodology. Section III reports our results. Section IV reports our conclusions.

II. METHODOLOGY

The database

To develop the benchmarks and test for differences, we use data from the Defense Acquisition Executive Summary (DAES) database, maintained by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD (AT&L)). This database contains monthly cost and schedule performance data on over 500 completed and on-going defense contracts since the mid-1970s. The contractor summarizes the monthly cost and schedule status of the project on a Cost Performance Report (CPR) and sends it to the government program office that is managing the project. Program offices summarize data from the CPRs on DAES reports and send them to OUSD(AT&L) for review and incorporation into the DAES database.

The reliability of the CPR is controlled by a requirement for the contractor to comply with Earned Value Management Systems (EVMS) criteria (formerly Cost/Schedule Control Systems Criteria).[3] The government assumes that if the contractor is criteria-compliant, then the CPR is reasonably reliable. Because the DAES database is derived from the CPR via the DAES report, we assume that the DAES database is also reasonably reliable.[4]

Hypotheses

Because one of the stated purposes of MR budget is to adjust for uncertainty related to the timing and magnitude of future difficulties, there should be more MR budget on projects with more uncertainty (risk).[5] Accordingly, the development phase of a contract should have more MR budget than the production phase, because the development phase is more uncertain or riskier. Likewise, price contracts are more risky to the contractor than cost-reimbursement contracts, and should have more MR budget.[6] Hypotheses describing these expectations are as follows:

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[3] EVMS criteria are required on "significant" contracts and subcontracts within all acquisition programs. Significant contracts are defined as DOD development contracts and subcontracts with a value of $70 million of more and production contracts with a value of $300 million or more in FY 1996 constant dollars. These dollar thresholds have increased a few times over the last three decades. Compliance with the criteria is normally not required on contracts that are firm-fixed price, time and material, and on contracts consisting mostly of level-of-effort work (DOD 1997:24).

[4] See Data Item Description DI-MGMT-81466 (OMB Form Number 0707-0188, 19 Oct 1995), for a description of the CPR. See DOD (1997) for a description of the criteria and implementation procedures.

[5] For the remaining sections of this paper we use the terms "risk" and "uncertainty" as synonyms.

[6] The contractor establishes MR budget, not the government. In theory then, MR budget should be more reflective of risk to the contractor than risk to the government.

H1o: Median MR% development ≤ Median MR% production contracts
H1a: Median MR% development contracts > Median MR% production contracts

H2o: Median MR% price contracts ≤ Median MR% cost contracts
H2a: Median MR% price contracts > Median MR% cost contracts

We also test for differences in MR budget across the military services (Army, Air Force, Navy) managing the contracts. MR budget may differ across military services because of potential risk differences in weapon systems procured and used by each service and potential management differences across the contractors that build the systems. The hypothesis for this expectation is as follows:

H3o: Median MR% Army = Median MR% Air Force = Median MR% Navy contracts
H3a: Median MR% Army \≠ Median MR% Air Force \≠ Median MR% Navy contracts

A relative measure of MR budget (MR%) is used to control for differences in contract size, and is defined in equation 1.

MR% = MR budget / Total allocated budget [1]

For hypotheses 1 and 2, we use the non-parametric Mann-Whitney test (Conover 1980:216-227). This test is appropriate when comparing the medians of two independent samples, and the data are at least ordinal (rank-order). When the Mann-Whitney test is significant, it indicates that there is a significant difference between the two sample medians. The more common one-sided t-test for differences in means is inappropriate because MR% is not normally distributed.

For hypothesis 3, we use the non-parametric Kruskal-Wallace test, an extension of the Mann-Whitney test to two or more independent samples (Conover 1980:229-237). When the Kruskal-Wallace test is significant, it indicates a significant difference between at least two of the sample medians. The test does not indicate whether just two or more than two groups differ from each other. If the Kruskal-Wallace test is significant, then the Mann-Whitney test may be used to make the pairwise comparisons (Sheskin (1997: 404-405).

We compute the descriptive statistics on MR budget and test the hypotheses in each of four quarters based on percent complete, computed as shown in equation 2:

Percent Complete = Budgeted Cost of Work Performed / Budget at Completion [2]

The budgeted cost of work performed (BCWP), or earned value, is “the sum of the budgets for completed work and completed portions of open work packages, plus the applicable portion of budgets for level of effort and apportioned effort” (DOD 1997:59). The Budget at Completion (BAC) is the budget for all of the known work on the contract. As such, the BAC excludes MR budget. At contract completion, the BCWP equals the BAC.

The sample

To develop the descriptive statistics and test the hypotheses, we include as many contracts as possible. Not all contracts in the DAES database are used because some lack the necessary data to compute MR% or percent complete. To give all contracts an equal weight, only one MR% from each contract is included in each quarter. Instead of limiting our sample to all contracts with data in each of the four quarters, we include any contract for which we can compute MR% and percent complete in any quarter. This maximizes the sample size in each quarter, but causes the total number of contracts to differ across quarters. The totals differ across quarters because some contracts begin CPR reporting late, and others are terminated or stop reporting before they are 100 percent complete.

III. RESULTS

Descriptive statistics

Tables1 through 3 show quarterly descriptive statistics on the amount of MR budget on the sample of defense acquisition contracts from January 1975 to October 1998. MR budget percent (MR%) and the TAB (in millions of dollars) are shown for the entire sample, and for various categories of the sample (contract phase, contract type, military service). In addition to the usual measures of central tendency and dispersion, the tables include selected percentiles for MR%. Because the distribution of MR% is not symmetrical, confidence intervals around the mean or median are not feasible.

Our intent is to provide benchmarks useful for estimating MR budget on new contracts or for comparing with MR budget on on-going contracts. In this regard, the values in the percentile columns in Tables 1 through 3 should be particularly useful. For example, as shown in Table 1, the amount of MR budget on development contracts in the first quarter is 11 percent at the 95^{th} percentile. This means that the MR budget on 95 percent of the development contracts in the sample is less than or equal to 11 percent. Assuming that the sample is representative of the population, establishing MR budget in excess of 11 percent of the TAB for a new development contract would be very unusual. Similar comparisons can be made with on-going contracts.

We could find only one prior study that reports DOD experience on MR%. In 1980 the National Security Industrial Association surveyed over 100 defense contractors with earned value experience. Seventy-four contractors responded. Results show that "initial reserve levels range from 0-16 percent of total contract value, with 68% of the responses falling into the 5 to 10 percent range" (NSIA 1980:11). The average MR% reported is 6 percent (NSIA 1980:IV-1). Using similar language, our results show that initial reserves range from 0 to 28 percent of total allocated budget, with about 90% of the contracts falling into the 5 to 10 percent range. The average MR% is 4 percent.

The most frequent amount (mode) of MR budget in all quarters and categories was zero. In the first quarter, 10 percent of all contracts in the sample had no budget for unforeseen but in-scope problems. In the remaining quarters, the result is the same, with 10 percent of all contracts having no MR budget.

With respect to non-zero amounts of MR budget in the last quarter, one may be tempted to conclude that most defense contracts do not fully utilize MR budget. This may not be true generally because most contracts stop CPR reporting before the 100 percent completion point. In our sample of 382 contracts in the fourth quarter, only one was 100 percent complete and it had no remaining MR budget. Only 14 contracts were greater than 95 percent complete. Of these, 9 reported no remaining MR budget.

Comparisons

The results of the hypothesis tests were mixed. Figures 2 through 4 show the median quarterly MR percentages across contract phase, contract type, and military services. Table 4 shows quarterly differences in the median MR percentages, and the results of testing the three hypotheses.

Figure 1 compares the quarterly median MR% by contract phase. Although the median MR% on development contracts is greater than the median MR% on production contracts for each quarter, the differences are not significant. Null hypothesis 1 could not be rejected. MR budget is not sensitive to contract phase.

Figure 2 compares the quarterly median MR% by contract type. The median MR% on price contracts is greater than the median MR% on cost-reimbursable contracts for each quarter. The differences are

significant in all quarters (one-tailed $p < .1$). Null hypothesis 2 is rejected. MR budget is sensitive to the type of contract. [7]

Figure 3 compares the quarterly median MR% by military service. Differences in the median MR% across contracts managed by the military services are highly significant (Kruskal-Wallace two-tailed $p < .000$) in each quarter. Most of the pairwise comparisons (Army with Air Force, Army with Navy, and Air Force with Navy) are also significant (Mann-Whitney two-tailed $p < .10$) in each quarter. Null hypothesis 3 is rejected. MR budget is sensitive to the military service managing the contract.

IV. CONCLUSION

MR budget is a management construct with multiple purposes. As a planning tool, it represents the contractor's estimated cost of unforeseen but in-scope work. Determining an accurate amount of MR budget is an important part of risk management on the contract. As a control tool, MR budget is used to adjust the performance measurement baseline. Including budget in the baseline for newly identified but in-scope work makes variance analysis more meaningful. As a motivation tool, MR budget creates incentives for control account managers and others to operate more efficiently.

Given these multiple purposes, determining an appropriate amount of MR budget is necessarily an iterative process that requires input from managers at various levels in the contractor organization. The process depends on many factors, including risk, management philosophy, time constraints, experience, and the bargaining skills of the managers. Risk management models that determine MR budget may make the process more systematic, but they should not replace management judgment.

Experience with MR budget on completed and on-going contracts from 1975-1998 may be useful as benchmarks for determining initial reserve amounts, and for evaluating usage during contract performance. Quarterly descriptive statistics on DOD experience with MR budget are provided in several tables.

In addition to the descriptive statistics, the amount of MR budget is sensitive to contact type (cost versus price), and the managing service. With regard to contract type, the median MR% on price contracts is significantly greater than the median MR% on cost contracts. This is consistent with the expectation that contracts with more risk to the contractor have more MR budget. We do not know why MR budget differs across the three services. Possible explanatory factors include differences in the weapon systems purchased by each service, and the contractors that build the systems.

[7] A comparison of MR budget across specific types of cost contracts (e.g., CPFF, CFAF, CFIF) and specific types of price contracts (e.g., FPIF, FFP) did not show significant differences in each quarter.

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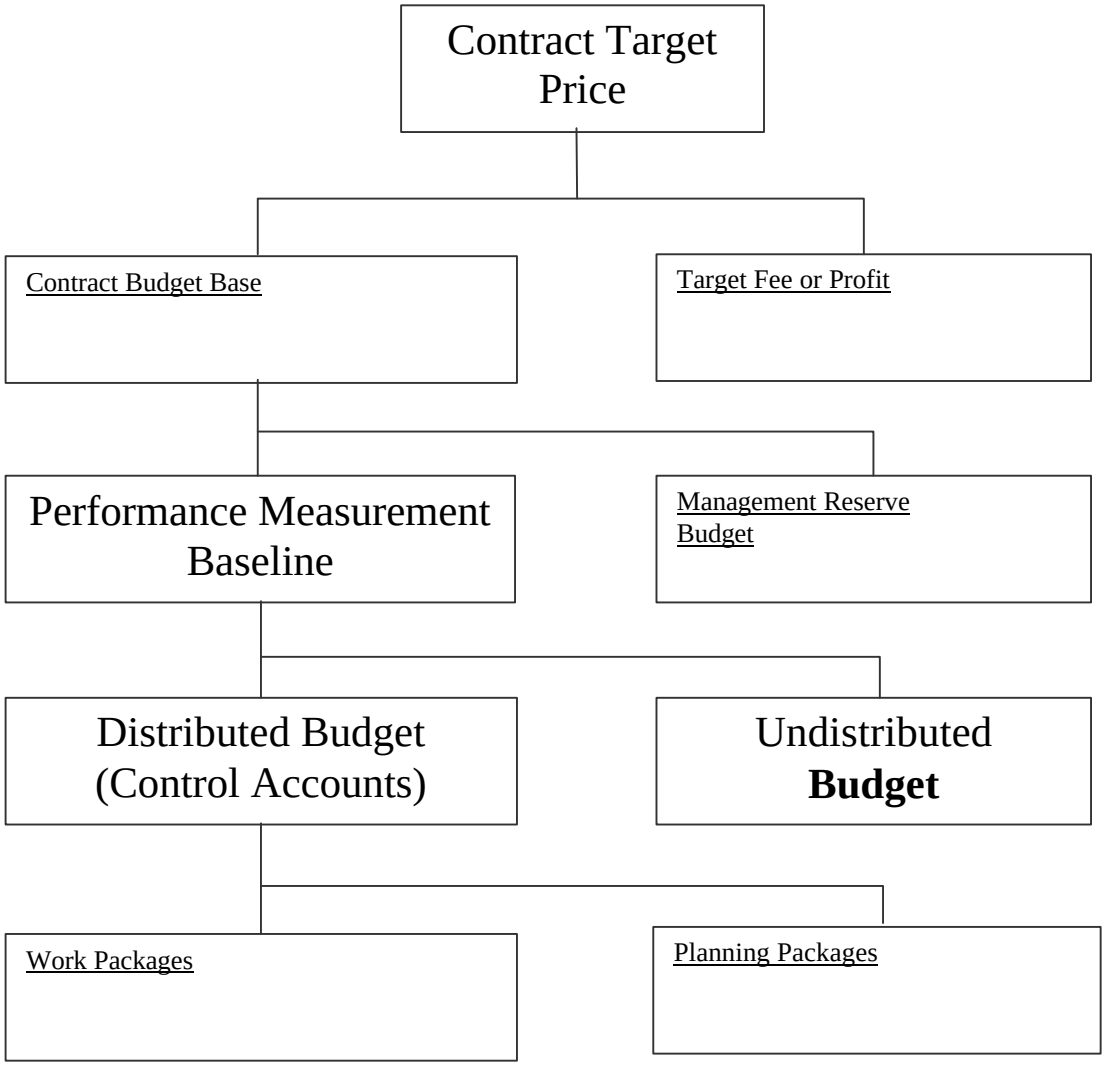

Figure 1. Terminology Related to Management Reserve Budget.

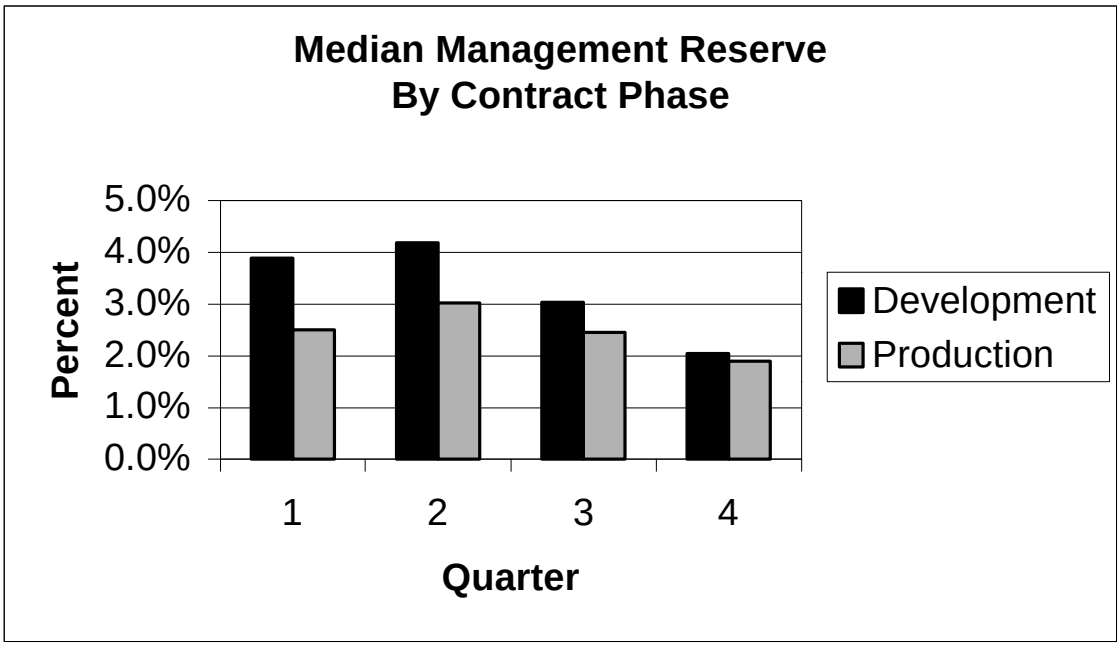

Figure 2. Median Management Reserve Budget by Contract Phase.

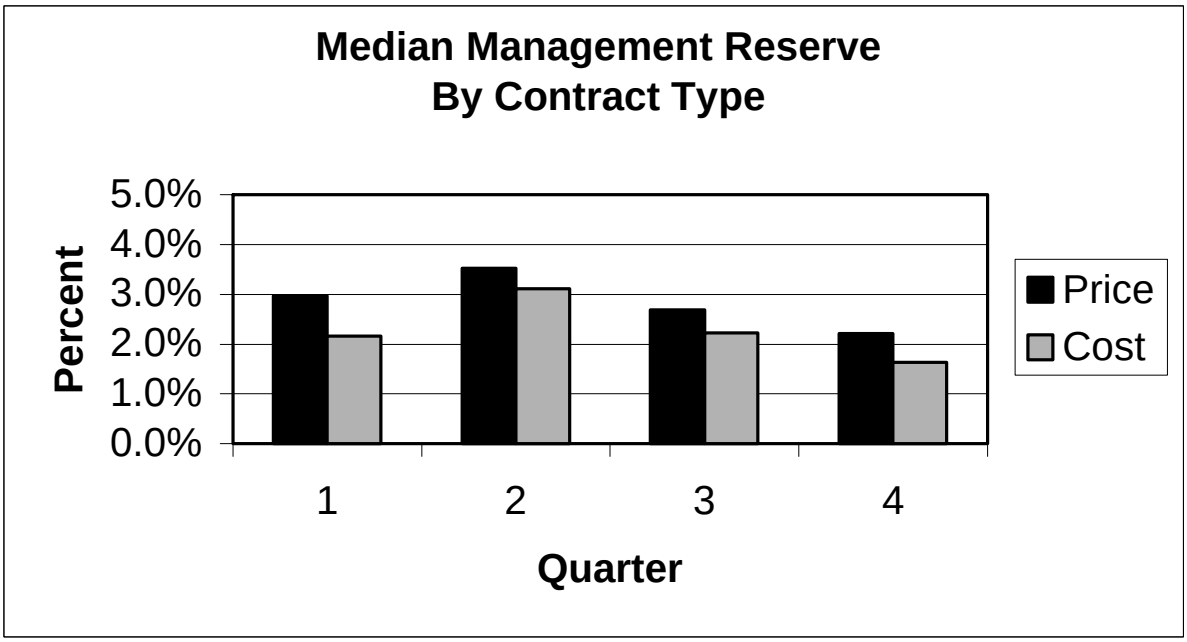

Figure 3. Median Management Reserve Budget by Contract Type.

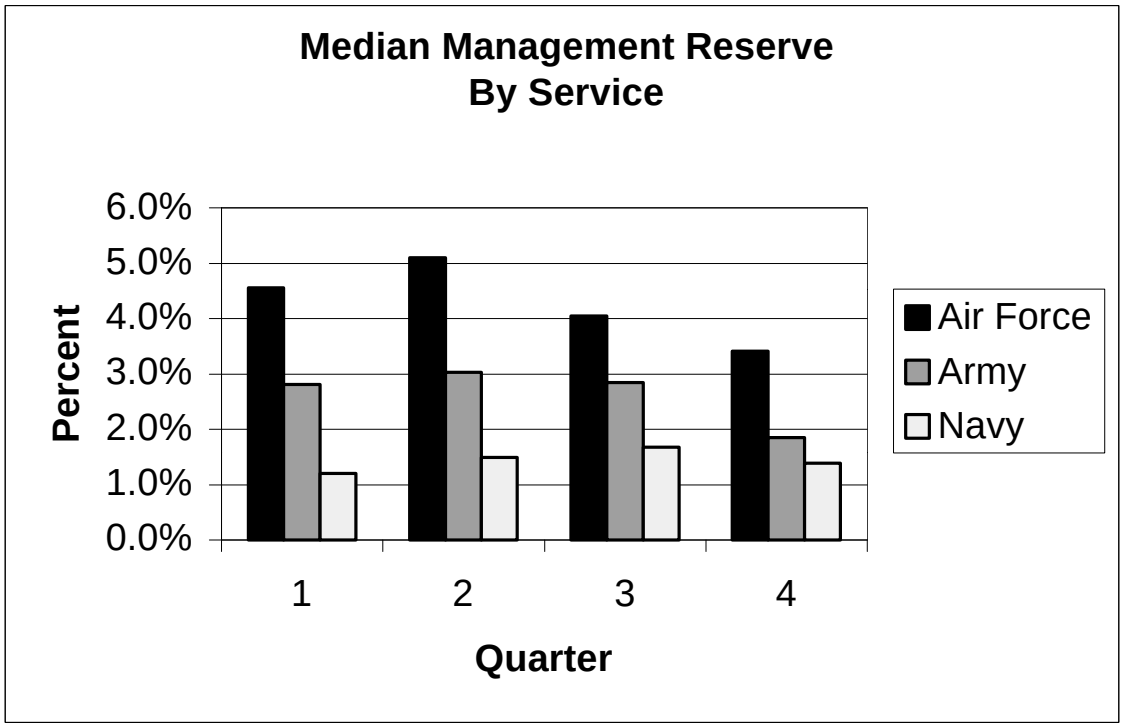

Figure 4. Median Management Reserve Budget by Military Service.

TABLE 1

MANAGEMENT RESERVE BUDGET

		Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($MIL)				
Qtr	Category	n	Mean	Median	Max	Min	Stdev	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max	Min	Stdev
1	Develop	78	4.3	3.9	26.3	0.0	4.8	0.0	0.0	0.0	3.9	6.9	10.4	11.0	208	87	2523	12	326
	Prod	202	3.9	2.5	28.3	0.0	4.3	0.0	0.0	0.3	2.5	6.4	10.0	12.4	317	156	3020	5	413
	Cost	70	3.5	2.2	26.3	0.0	4.5	0.0	0.0	0.0	2.2	5.1	8.1	9.9	255	123	1478	12	295
	Price	210	4.2	3.0	28.3	0.0	4.5	0.0	0.0	0.2	3.0	6.9	10.4	12.4	297	142	3020	5	421
	Army	58	3.9	2.8	15.2	0.0	4.2	0.0	0.0	0.0	2.8	7.1	9.8	12.7	146	87	842	9	174
	Air Force	109	5.3	4.5	16.1	0.0	3.8	0.0	0.0	2.5	4.5	8.3	10.5	12.1	230	107	2823	10	388
	Navy	113	2.9	1.2	28.3	0.0	4.9	0.0	0.0	0.0	1.2	3.3	7.9	12.0	413	307	3020	5	443
	All	280	4.0	2.8	28.3	0.0	4.5	0.0	0.0	0.2	2.8	6.5	10.1	12.2	286	137	3020	5	394
2	Develop	98	4.8	4.2	24.2	0.0	4.6	0.0	0.0	0.6	4.2	7.4	10.9	12.7	209	86	3779	7	433
	Prod	234	4.1	3.0	18.7	0.0	3.9	0.0	0.0	0.9	3.0	6.1	9.6	12.3	345	167	3041	10	436
	Cost	82	3.8	3.1	24.2	0.0	4.2	0.0	0.0	0.5	3.1	5.5	7.8	11.3	228	96	1498	12	290
	Price	250	4.5	3.5	18.7	0.0	4.1	0.0	0.0	0.9	3.5	6.8	10.8	12.4	330	151	3779	7	476
	Army	72	3.8	3.0	12.3	0.0	3.5	0.0	0.0	0.5	3.0	5.9	9.2	11.4	155	93	851	7	174
	Air Force	125	5.8	5.1	16.4	0.0	3.9	0.0	1.3	2.5	5.1	7.9	11.6	13.4	274	112	3779	10	486
	Navy	135	3.2	1.5	24.2	0.0	4.3	0.0	0.0	0.3	1.5	4.6	7.6	12.1	413	218	3041	14	465
	All	332	4.3	3.4	24.2	0.0	4.1	0.0	0.0	0.9	3.4	6.6	10.4	12.4	305	143	3779	7	439
3	Develop	109	4.0	3.0	18.4	0.0	3.5	0.0	0.0	1.2	3.0	6.2	9.0	10.8	260	93	3899	7	560
	Prod	260	3.6	2.5	20.9	0.0	3.5	0.0	0.1	0.8	2.5	5.2	8.8	10.9	347	176	3080	14	430
	Cost	85	3.2	2.2	18.4	0.0	3.3	0.0	0.0	0.9	2.2	4.9	7.2	9.9	260	100	3899	11	479
	Price	284	3.8	2.7	20.9	0.0	3.6	0.0	0.1	1.0	2.7	5.9	9.0	11.0	339	158	3779	7	471
	Army	75	3.9	2.8	18.4	0.0	3.8	0.0	0.0	0.9	2.8	6.3	9.0	11.5	159	105	850	7	180
	Air Force	144	4.6	4.0	15.2	0.0	3.4	0.0	0.5	1.9	4.0	6.7	9.7	11.3	301	135	3779	14	478
	Navy	150	2.7	1.7	20.9	0.0	3.3	0.0	0.0	0.6	1.7	3.7	7.2	8.9	422	202	3899	16	542
	All	369	3.7	2.6	20.9	0.0	3.5	0.0	0.0	1.0	2.6	5.5	8.8	10.8	321.1	149	3899	7	473
4	Develop	106	3.1	2.0	12.7	0.0	2.9	0.0	0.0	1.0	2.0	5.0	7.3	9.0	300	109	3901	7	611
	Prod	276	3.1	1.9	20.2	0.0	3.5	0.0	0.0	0.4	1.9	4.5	8.1	10.1	346	163	6956	4	558
	Cost	93	2.3	1.6	12.7	0.0	2.6	0.0	0.0	0.3	1.6	3.2	5.2	8.8	275	105	3901	4	520
	Price	289	3.3	2.2	20.2	0.0	3.5	0.0	0.0	0.5	2.2	5.3	8.3	9.9	352	161	6956	7	588
	Army	77	2.5	1.8	11.8	0.0	2.7	0.0	0.0	0.2	1.8	3.8	6.5	8.7	160	111	850	4	175
	Air Force	144	4.0	3.4	14.5	0.0	3.4	0.0	0.0	1.0	3.4	6.1	9.1	11.2	358	159	6956	14	707
	Navy	161	2.6	1.4	20.2	0.0	3.3	0.0	0.0	0.4	1.4	3.5	7.1	9.7	394	161	3901	9	548
	All	382	3.1	2.0	20.2	0.0	3.3	0.0	0.0	0.5	2.0	4.5	7.8	9.7	333	150	6956	4	573

TABLE 2

MANAGEMENT RESERVE BUDGET (Contract Phase within Military Service)

		Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($MIL)				
Qtr	Category	n	Mean	Median	Max	Min	Stdev	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max	Min	Stdev
1	Army-Dev	18	3.2	1.5	8.9	0.0	3.5	0.0	0.0	0.0	1.5	6.7	7.8	.	114	73	515	13	117
	Army-Prod	40	4.2	3.2	15.2	0.0	4.5	0.0	0.0	0.0	3.2	7.2	12.0	12.7	160	93	842	9	194
	AF-Dev	39	5.3	5.0	11.3	0.0	3.7	0.0	0.0	2.0	5.0	9.2	10.5	10.9	243	100	2523	12	408
	AF-Prod	70	5.3	4.5	16.1	0.0	3.8	0.0	0.5	2.5	4.5	7.9	10.9	12.9	223	107	2823	10	379
	Navy-Dev	21	3.4	0.1	26.3	0.0	6.9	0.0	0.0	0.0	0.1	3.7	17.1	25.7	222	67	878	21	267
	Navy-Prod	92	2.7	1.2	28.3	0.0	4.4	0.0	0.0	0.0	1.2	3.3	8.0	11.7	456	322	3020	5	464
2	Army-Dev	28	3.5	3.1	11.4	0.0	3.2	0.0	0.0	0.5	3.1	5.4	7.9	10.1	89	62	468	7	93
	Army-Prod	44	4.0	3.0	12.3	0.0	3.7	0.0	0.0	0.7	3.0	6.1	10.3	11.8	196	127	851	12	200
	AF-Dev	46	6.1	5.9	15.8	0.0	4.0	0.0	0.1	3.5	5.9	9.0	11.6	13.1	268	93	3779	15	573
	AF-Prod	79	5.6	4.7	16.4	0.0	3.9	0.6	1.5	2.5	4.7	7.0	11.8	14.0	278	129	2845	10	432
	Navy-Dev	24	4.0	2.0	24.2	0.0	6.2	0.0	0.0	0.0	2.0	4.9	15.3	23.2	234	96	1534	22	339
	Navy-Prod	111	3.0	1.4	18.7	0.0	3.7	0.0	0.0	0.4	1.4	4.2	7.5	10.4	451	302	3041	14	481
3	Army-Dev	30	4.0	2.4	18.4	0.0	4.3	0.0	0.0	1.1	2.4	5.8	9.2	15.4	91	45	629	7	121
	Army-Prod	45	3.8	2.9	11.8	0.0	3.5	0.0	0.0	0.7	2.9	6.7	8.9	11.1	204	150	850	17	200
	AF-Dev	50	4.8	4.6	11.4	0.0	3.2	0.0	0.3	2.2	4.6	7.0	9.3	10.8	285	99	3779	15	564
	AF-Prod	94	4.5	3.8	15.2	0.0	3.5	0.0	0.5	1.8	3.8	6.4	9.9	11.9	309	143	2793	14	427
	Navy-Dev	29	2.5	1.7	11.2	0.0	2.8	0.0	0.0	0.5	1.7	3.2	6.3	9.9	285	99	3779	15	564
	Navy-Prod	121	2.7	1.7	20.9	0.0	3.4	0.0	0.0	0.6	1.7	3.7	7.4	9.1	428	220	3080	21	477
4	Army-Dev	28	2.2	1.8	7.3	0.0	2.0	0.0	0.0	0.4	1.8	3.5	5.5	6.9	114	87	628	7	129
	Army-Prod	49	2.6	1.9	11.8	0.0	3.0	0.0	0.0	0.1	1.9	3.9	7.5	9.3	187	120	850	4	193
	AF-Dev	45	4.2	4.0	12.7	0.0	3.3	0.0	0.0	1.4	4.0	6.7	8.8	10.2	318	146	3775	15	594
	AF-Prod	99	3.8	3.2	14.5	0.0	3.5	0.0	0.0	0.6	3.2	5.7	9.2	11.4	376	161	6956	14	755
	Navy-Dev	33	2.3	1.5	11.1	0.0	2.6	0.0	0.0	0.7	1.5	3.2	6.3	9.3	434	112	3901	16	822
	Navy-Pro	128	2.6	1.3	20.2	0.0	3.5	0.0	0.0	0.4	1.3	3.8	7.2	9.9	383	194	3122	9	456

TABLE 3

MANAGEMENT RESERVE BUDGET (Contract Type within Military Service)

		Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($MIL)				
Qtr	Category	n	Mean	Median	Max	Min	Stdev	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max	Min	Stdev
1	Army-Cost	16	2.9	0.2	8.9	0.0	3.5	0.0	0.0	0.0	0.2	6.8	8.0	.	115	65	515	13	123
	Army-Price	42	4.3	3.2	15.2	0.0	4.4	0.0	0.0	0.0	3.2	7.1	11.6	12.7	157	93	842	9	190
	AF-Cost	20	4.8	4.4	10.5	0.1	2.7	0.2	1.6	3.2	4.4	6.2	9.5	10.5	186	85	647	12	177
	AF-Price	89	5.4	5.3	16.1	0.0	4.0	0.0	0.0	2.0	5.3	8.4	10.9	12.6	240	108	2823	10	421
	Navy-Cost	34	3.0	1.5	26.3	0.0	5.6	0.0	0.0	0.0	1.5	3.4	7.0	21.5	362	281	1478	20	365
	Navy-Price	79	2.8	1.0	28.3	0.0	4.6	0.0	0.0	0.0	1.0	3.3	8.2	11.9	435	309	3020	5	473
2	Army-Cost	27	3.2	2.2	11.4	0.0	3.2	0.0	0.0	0.0	2.2	5.4	8.0	10.2	86	60	468	12	93
	Army-Price	45	4.1	3.0	12.3	0.0	3.6	0.0	0.0	0.9	3.0	6.1	10.2	11.8	196	128	851	7	198
	AF-Cost	19	5.2	4.6	12.6	0.0	2.9	0.0	1.8	3.3	4.6	7.2	8.4	.	183	79	648	21	190
	AF-Price	106	5.9	5.1	16.4	0.0	4.1	0.0	1.2	2.5	5.1	9.0	11.8	13.8	291	121	3779	10	521
	Navy-Cost	36	3.4	1.8	24.2	0.0	5.2	0.0	0.0	0.2	1.8	4.2	8.4	20.6	359	216	1498	22	368
	Navy-Price	99	3.1	1.3	18.7	0.0	3.9	0.0	0.0	0.4	1.3	4.7	7.7	11.9	432	218	3041	14	496
3	Army-Cost	28	4.0	2.4	18.4	0.0	4.3	0.0	0.0	1.1	2.4	5.4	9.3	16.0	91	45	629	11	123
	Army-Price	47	3.9	2.9	11.8	0.0	3.5	0.0	0.0	0.7	2.9	7.0	9.1	11.0	200	150	850	7	197
	AF-Cost	21	4.6	3.9	10.3	0.3	2.6	0.3	1.1	3.1	3.9	6.9	8.5	10.1	194	79	647	21	201
	AF-Price	123	4.6	4.1	15.2	0.0	3.6	0.0	0.4	1.7	4.1	6.7	10.0	11.4	319	143	3779	14	508
	Navy-Cost	36	1.8	1.4	11.2	0.0	2.2	0.0	0.0	0.2	1.4	2.3	5.1	6.6	430	203	3899	16	678
	Navy-Price	114	3.0	1.9	20.9	0.0	3.5	0.0	0.0	0.6	1.9	4.0	7.5	9.6	419	201	3080	21	495
4	Army-Cost	28	1.9	1.8	6.4	0.0	1.8	0.0	0.0	0.0	1.8	3.1	5.0	5.9	103	54	628	4	131
	Army-Price	49	2.8	1.9	11.8	0.0	3.0	0.0	0.0	0.4	1.9	4.6	7.5	9.3	193	135	850	7	190
	AF-Cost	21	3.3	2.5	12.7	0.0	3.3	0.0	0.0	0.9	2.5	4.6	8.9	12.3	193	93	658	23	199
	AF-Price	123	4.1	3.5	14.5	0.0	3.5	0.0	0.0	1.0	3.5	6.2	9.1	11.2	386	164	6956	14	758
	Navy-Cost	44	2.1	1.5	11.1	0.0	2.5	0.0	0.0	0.4	1.5	2.6	4.9	9.7	424	139	3901	16	709
	Navy-Price	117	2.7	1.3	20.2	0.0	3.6	0.0	0.0	0.4	1.3	3.9	7.3	9.8	382	183	3122	9	477

TABLE 4

COMPARIONS OF MEDIAN MANAGEMENT RESERVE BUDGET PERCENT

Qtr	Comparison	Median MR% Difference	Z	Significance	
1	Production – Development	-1.4%	-0.166	0.434	1-tailed
	Cost – Price	-0.8%	-1.434	0.076	1-tailed
	Army – Air Force	-1.7%	-2.509	0.012	2-tailed
	Army – Navy	1.6%	-1.607	0.108	2-tailed
	Air Force – Navy	3.4%	-7.036	0.000	2-tailed
2	Production – Development	-1.2%	-1.168	0.122	1-tailed
	Cost – Price	-0.4%	-1.600	0.055	1-tailed
	Army – Air Force	-2.1%	-3.596	0.000	2-tailed
	Army – Navy	1.5%	-1.753	0.080	2-tailed
	Air Force – Navy	3.6%	-6.468	0.000	2-tailed
3	Production – Development	-0.6%	-1.145	0.126	1-tailed
	Cost – Price	-0.5%	-1.392	0.082	1-tailed
	Army – Air Force	-1.2%	-1.947	0.052	2-tailed
	Army – Navy	1.2%	-2.303	0.021	2-tailed
	Air Force – Navy	2.4%	-5.712	0.000	2-tailed
4	Production – Development	-0.1%	-0.965	0.167	1-tailed
	Cost – Price	-0.6%	-2.106	0.018	1-tailed
	Army – Air Force	-1.6%	-3.175	0.001	2-tailed
	Army – Navy	0.4%	-0.369	0.712	2-tailed
	Air Force – Navy	2.0%	-4.036	0.000	2-tailed

BIOGRAPHIES

Dr. David S. Christensen is an Associate Professor of Accounting at Southern Utah University at Cedar City, Utah. After earning his Ph.D. at the University of Nebraska in 1987, he joined the faculty of the Air Force Institute of Technology, where he taught undergraduate and graduate courses in earned-value for over 10 years. Dr. Christensen is a CMA, CGFM, and CCEA and is active in the Society of Cost Estimating and Analysis (SCEA), the American Accounting Association (AAA), and the Institute of Management Accounting (IMA). Presently, he serves as an Associate Editor of *The Journal of Cost Analysis and Management*. He has published over 50 papers in the area of earned-value management and maintains a comprehensive bibliography of earned value literature on the web at http://www.btc.suu.edu/business/fac/christensend/ev-bib.html.

Dr. Carl Templin is the Dean of the College of Business, Technology and Communication and Associate Professor of Management at Southern Utah University. After earning his Ph.D. at Arizona State University in 1988, he joined the faculty of the Air Force Institute of Technology, where he taught graduate courses in contracting management for seven years and served as Director of the Graduate Contracting Management and Graduate Cost Analysis programs. He also served as Associate Dean and acting Dean of the School of Logistics and Acquisition Management. Dr. Templin is Fellow of the National Contracting Management Association and is a member of the National Association of Purchasing Management. He has published 23 papers in the area of contracting management.