AN ANALYSIS OF MANAGEMENT RESERVE BUDGET ON DEFENSE ACQUISITION CONTRACTS

David Christensen, Ph.D. and Carl Templin, Ph.D.

How should one determine the amount required for a contract's management reserve budget? This study reviews decades of data and provides benchmarks for establishing an appropriate amount for such a budget, as well as insight into the relative risk across contract categories, acquisition phases, and contracts managed by the services.

A management reserve (MR) budget is an amount of the total allocated budget (TAB) 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, an MR budget is allocated to that work. Once allocated, an MR budget becomes part of the performance measurement baseline (PMB) used to measure and control cost and schedule performance on the contract. Accordingly, an 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 a greater MR budget. Using data from the Defense Acquisition Executive Summary (DAES) database, we test this assumption. In addition, we provide quarterly descriptive statistics and related graphics on the amount and use of an 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 categories (cost-reimbursable and fixed-price) and the military services managing the contracts (Army, Air Force, Navy), and no significant differences across acquisition phases (development and production).

Purposes of an MR Budget

Budgets, including MR budgets, 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 Shields, 1993, Merchant and Manzoni, 1989).

Uncertainty

As indicated in Department of Defense (DoD) policy documents, the primary purpose of an MR budget is a reserve for uncertainties related to in-scope but unforeseen work (DoD, 1997, p. 12):

> 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.

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

Budgets for all authorized work should be included in the performance measurement baseline (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.

Motivation

The earned value literature suggests that another purpose of an MR budget is motivational: to create a "budget challenge" for control account managers (e.g., Antolini, et al., 1991, p. 31; Bowman, 1993, p. 5; Fleming, 1992, p. 49; Gould, 1995, pp. 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 lifecycle costs is 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, Chen, and Lin,

1999, p. 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.

Estimating an MR Budget

Estimating the amount of an MR budget may appear to be an oxymoron: How can something that is unforeseen be estimated? However, Antolini et al. (1991, p. 32) report that most contractors can determine an MR budget from their own experience with prior contracts. In addition, before contract award, prudent managers almost certainly include an unspecified amount of excess budget in their cost estimates. Research suggests that:

- Budgetary slack exists in most business organizations.
- It is in managers' best interests as rational economic individuals to create slack.
- It is nearly impossible to prevent (Bart, 1988, p. 188; Merchant, 1998, p. 219).

Although contractor policy may preclude managers from padding their budgets, it seems likely that every prudent manager would do so, knowing that only a fraction would be approved (Fleming, 1996, pp. 64–65). It is possible that an MR budget could be estimated by each manager 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, p. 38) reports that a "top-down" process is more common, where the contractor program manager withholds a portion of the approved contract budget base (CBB) as an MR budget.

Factors affecting an MR budget

Surveys of defense contractors (National Security Industrial Agency [NSIA], 1980; Gould, 1995) indicate that the amount of an MR budget depends on many factors, such as risk, management philosophy, the magnitude of the profit or 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 an MR budget, one expert reports the following (Gould, 1995, p. 36):

> The determination is entirely up to the contractor. In arriving at the proper amount of an 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.

"Kaizen budgeting explicitly anticipates continuous improvements in operating processes."

> 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.

With these factors in mind, determining the amount of an MR budget is probably best described as an iterative process, where all managers affected by an MR budget have some role in its determination (Slemaker, 1985, pp. 99–100).

> 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.

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, p. 382). Survey research shows that most companies use some form of participative budgeting (Horngren, Foster, and Datar, 2000, p. 181).

Uncertainty Analysis

Some authors suggest that an MR budget may be identified by uncertainty analysis, where the cost of each work breakdown structure (WBS) element is modeled as a random variable (e.g., Garvey, 1995, p. 161; Goldberg and Weber, 1998, p. III-17; Stewart and Wyskida, 1987, pp. 297–306). Instead of specifying a percentage of the CBB as the 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 an MR budget can be identified at any desired P(s) specified by project management.

Determining an appropriate level for P(s) is unclear. Based on data gathered from 54 profit center managers in 12 corporations, Merchant (1989) 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. In addition, Barrett and Fraser (1977, p. 137) suggest that budgets should be highly achievable for motivational purposes, and less achievable for planning and control purposes.

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, p. 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.

Overall, this conclusion suggests 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 an 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 the MR budget is almost certainly iterative, the ability to specify an appropriate amount of the 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, p. 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, p. 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 an MR budget is necessarily a subjective process, involving negotiations among managers at various levels in the contractor organization. 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, p. 141), having a different budget for each purpose is uncommon (Umpathy, 1987). An MR budget reflects compromises between these purposes and the managers involved with it.

Historical data on the amount of MR budgets are available on a large number of completed and ongoing defense projects. The remaining sections of this article describe the amount of an MR budget established on defense acquisition contracts over the last two decades. Descriptive statistics may be useful as potential benchmarks for determining MR budget on new projects. In addition, we test for significant differences across acquisition phase (development versus production), contract category (cost-reimbursable versus fixed-price), and the military services managing the contracts. If an MR budget is indeed a function of management philosophy and uncertainty or risk, then differences may exist across these categories.

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METHODOLOGY

HYPOTHESES

Because one of the stated purposes of an MR budget is to adjust for uncertainty related to the timing and magnitude of future difficulties, there should be a larger MR budget on projects with more uncertainty (risk).[1] Accordingly, the development phase of a contract should have a larger 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 a larger MR budget.[2] Hypotheses describing these expectations are as follows:

H_1o: Median MR percent development $\leq$ Median MR percent production contracts

H_1a: Median MR percent development contracts > Median MR percent production contracts

H_2o: Median MR percent price contracts $\leqq$ Median MR percent cost contracts

H_2a: Median MR percent price contracts > Median MR percent cost contracts

We also tested for differences in MR budgets across the military services (Army, Air Force, Navy) managing the contracts. An 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:

H^3o: Median MR percent Army = Median MR percent Air Force = Median MR percent Navy contracts

H_3a: Median MR percent Army $\therefore \neq$ Median MR percent Air Force $\therefore \neq$ Median MR percent Navy contracts

A relative measure of an MR budget (MR percent) was used to control for differences in contract size, and is defined in Equation 1.

$$\text{MR percent} = \text{MR budget} \div \text{Total allocated budget} \quad (1)$$

For hypotheses 1 and 2, we used the nonparametric Mann-Whitney test (Conover, 1980, pp. 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 percent is not normally distributed.

For hypothesis 3, we used the nonparametric Kruskal-Wallace test, an extension of the Mann-Whitney test to two or more independent samples (Conover, 1980, pp. 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, pp. 404–405).

We computed the descriptive statistics on an MR budget and test the hypotheses in each quarter of the contract's life on percent complete, computed as shown in Equation 2.

$$\text{Percent complete} = \text{Budgeted cost of work performed} \div \text{Budget at completion} \quad (2)$$

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, p. 59). The budget at completion (BAC) is the budget for all of the known work on the contract. As such, the BAC excludes the MR budget. At contract completion, the BCWP equals the BAC.

The Database

To develop the benchmarks and test for differences, we used 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 more than 500 completed and ongoing 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). 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.

The Sample

To develop the descriptive statistics and test the hypotheses, we included as many contracts as possible. Not all contracts in the DAES database were used because some lack the necessary data to compute MR percent or percent complete. To give all contracts an equal weight, only one MR percent from each contract was included in each quarter. Instead of limiting our sample to all contracts with data in each of the four quarters, we included any contract for which we can compute MR percent and percent complete in any quarter. This maximized the sample size in each quarter, but causes the total number of contracts to differ across quarters. The totals differ across quarters because some

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contracts begin CPR reporting late, and others are terminated or stop reporting before they are 100 percent complete.

RESULTS

DESCRIPTIVE STATISTICS

Tables 1 through 3 show quarterly descriptive statistics on the amount of MR budgets on the sample of defense acquisition contracts from January 1975 to October 1998. MR budget percent (MR percent) and the TAB (in millions of dollars) are shown for the entire sample, and for various categories of the sample (acquisition phase, contract category, military service). In addition to the usual measures of central tendency and dispersion, the tables include selected percentiles for MR percent. Because the distribution of MR percent is not symmetrical, confidence intervals around the mean or median are not feasible.

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Our intent is to provide benchmarks useful for estimating an MR budget on new contracts or for comparing with an MR budget on ongoing 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 an MR budget on development contracts in the first quarter is 11 percent at the 95th 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 an 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 ongoing contracts.

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

The most frequent amount (mode) of an 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 nonzero amounts of MR budgets in the last quarter, one may be tempted to conclude that most defense contracts do not fully utilize the 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

Table 1. Management Reserve Budget

		Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($ Millions)				
Qtr.	Category	N	Mean	Median	Max	Min.	SD[a]	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max.	Min.	SD[a]
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
	Produce	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
	Produce	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
	Produce	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
	Produce	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

[a] Standard deviation.

Table 2. Management Reserve Budget (Contract Phase within Military Service)

		Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($ Millions)				
Qtr.	Category	N	Mean	Median	Max	Min.	SD[a]	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max.	Min.	SD[a]
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	0.0	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

[a] Standard deviation.

Table 3. Management Reserve Budget (Contract Type within Military Service)

		Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($ Millions)				
Qtr.	Category	N	Mean	Median	Max	Min.	SD[a]	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max.	Min.	SD[a]
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	0.0	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	0.0	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

[a] Standard deviation.

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

budget. Only 14 contracts were greater than 95 percent complete. Of these, nine reported no remaining MR budget.

COMPARISONS

The results of the hypothesis tests were mixed. Figures 1 through 3 show the median quarterly MR percentages across acquisition phase, contract category, 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 percent by acquisition phase. Although the median MR percent on development contracts is greater than the median MR percent on production contracts for each quarter, the differences are not significant. Null hypothesis 1 could not be rejected. The MR budget is not sensitive to acquisition phase.

Figure 2 compares the quarterly median MR percent by contract category. The median MR percent on fixed-price contracts is greater than the median MR percent on cost-reimbursable contracts for each quarter. The differences are significant in

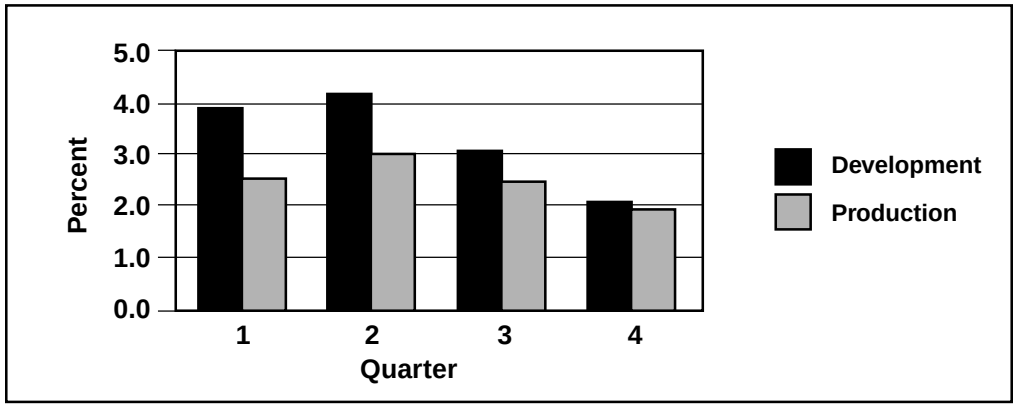

Figure 1. Median Management Reserve Budget by Acquisition Phase

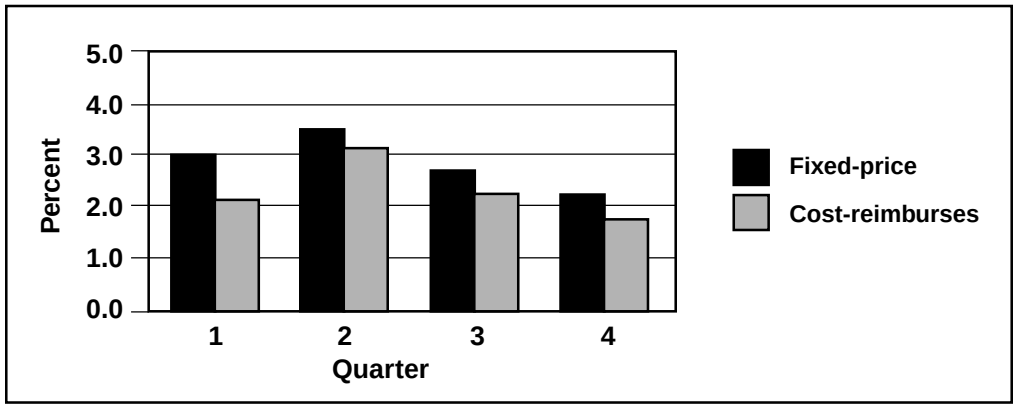

Figure 2. Median Management Reserve Budget by Contract Category

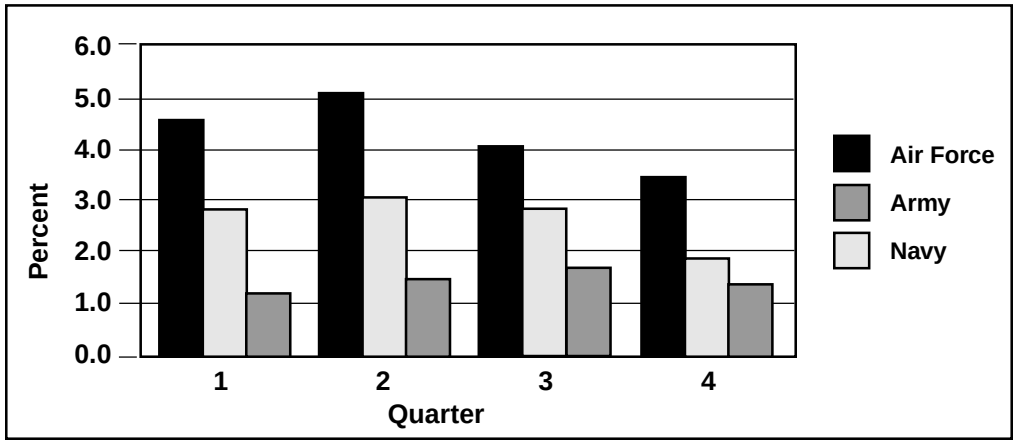

Figure 3. Median Management Reserve Budget by Military Service

all quarters (one-tailed $p < .1$). Null hypothesis 2 is rejected. The MR budget is sensitive to the category of contract.

Figure 3 compares the quarterly median MR percent by military service. Differences in the median MR percent 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 $p < .1$) in each quarter. Null hypothesis 3 is rejected. The MR budget is sensitive to the military service managing the contract.

CONCLUSION

An 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 an MR budget is an important part of risk management on the contract. As a control tool, an 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, an MR budget creates incentives for control account managers and others to operate more efficiently.

Given these multiple purposes, determining an appropriate amount for the 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 the MR budget may make the process more systematic, but they should not replace management judgment.

Experience with MR budgets on completed and ongoing contracts from 1975 to 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 budgets are provided in several tables.

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

ENDNOTES

1. In this article, we use the terms "risk" and "uncertainty" as synonyms.
2. The contractor establishes an MR budget, not the government. In theory, then, an MR budget should be more reflective of risk to the contractor than risk to the government.

Dr. David Christensen is an associate professor of accounting at Southern Utah University at Cedar City, Utah. After earning his Ph.D. degree 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.
(E-mail address: ChristensenD@suu.edu)

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. degree 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. He also served as associate dean and acting dean of the School of Logistics and Acquisition Management. Dr. Templin is a fellow of the National Contract Management Association.
(E-mail address: Templin@suu.edu)

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