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Test and Evaluation Trends and Costs for Aircraft and Guided Weapons

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Summary

T&E is a key step in the development of any military weapon system. It is the primary means of ensuring that the system will actually perform its intended functions in its intended environment.

T&E of a modern weapon system is an involved and often lengthy process that reflects both the complexity of the system under test and the variety of specialized resources and activities its testing requires. T&E consumes a significant portion of the development time and resources for military aircraft and air-launched weapons,¹ which is why the general reexamination of acquisition processes that has taken place over the past decade has included T&E. Looking for efficiencies and cost savings, advocates of acquisition streamlining have questioned the scope, duration, cost, and organizational responsibilities of the traditional T&E process. These questions are even more urgent because most T&E expenditures occur in the later stages of development, when cost overruns and schedule slips from other activities may have become more apparent. As a result, there is often considerable pressure to expedite and/or reduce T&E activities to recoup some of the other overruns.

The T&E process has evolved with the complexity and cost of the systems being developed and with the priorities and practices of defense acquisition management. This evolution and its effects on the development cost of the systems under test are the subject of this monograph.

¹ On average, contractor and government T&E account for approximately 21 percent of development costs for fixed-wing aircraft and 15 percent for guided weapons.

The tasking for this study arose from two concerns. Some program managers have proposed test programs of greatly reduced scope and duration, citing such initiatives as increased use of modeling and simulation to reduce the amount of expensive “open air” testing. Other rationales for reduced test schedules and budgets include using lower-risk designs, combining government and contractor testing, using nondevelopmental item (NDI) and commercial-off-the-shelf (COTS) approaches, and applying total system performance responsibility (TSPR) contracting. Acquisition decisionmakers needed to know whether these approaches can achieve the projected savings.

The second concern was that members of the cost analysis community, particularly those outside of the program offices and test organizations, were not confident that the data and relationships they were using to estimate the costs of testing for a program or to cross check such estimates reflected the current T&E environment. Since some of their tools were based on development programs that were 15 to 30 years old, validation against current and evolving T&E approaches became a priority.

Although the original intention was for this study to focus on fixed-wing aircraft, the Air Force Cost Analysis Agency (AFCAA) asked RAND Corporation to include a cross section of tactical missiles and guided munitions. Because many of the programs of interest were joint Air Force–Navy development efforts and because the Navy cost community had similar requirements, the Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN RDA) agreed and directed the appropriate Navy program executive officers and test activities to support the project.

The project scope involved the following four tasks:

- analyzing the nature of current T&E costs for aircraft, tactical missile, and guided munition systems and the trends likely to affect these costs in the immediate future
- identifying key cost drivers
- collecting, normalizing, and documenting representative data
- developing a set of practical, documented methodologies for making high-level T&E estimates.

To interpret the results of this study correctly, certain limitations and constraints should be kept in mind. First, the study focused on system-level testing associated with development programs funded through research, development, test, and evaluation and categorized as “system T&E.” This therefore excluded postproduction follow-on testing, production acceptance testing, and component-level testing.

Second, the study focused only on what government program offices typically pay for, the items test organizations often refer to as *reimbursable costs*. These could be considered the price the customer pays for test services. These T&E costs are part of each weapon system’s development budget, whether it is the contractor or the program office that directly incurs them.²

Third, we limited our analysis to recent Air Force and Navy fixed-wing aircraft, tactical missile, and guided munition programs. Because the purpose of the study was to examine current test practices, we focused generally on programs that had completed development within the past ten years or, in a few cases, slightly earlier.³ Older data were used for trend analysis and, where appropriate, to augment more-recent data in developing relationships.

Because fewer new development programs are projected for the future, we attempted to include several programs representing major modifications to existing systems for which enough data were available for our analysis. Relevance to both modification and new development programs was also a consideration in selecting parameters for cost relationships.

Since our purpose was to examine the cost of testing as it was being conducted at the time of our research, we did not assess the efficiency and effectiveness of test procedures.

² The government does pay other T&E expenses, such as overhead and construction at test facilities, through specific appropriations. These are not allocated to any weapon system and, therefore, are not included in this study.

³ One of the purposes of the study was to provide more-current cost, technical and programmatic data to the cost community. In a few cases, the data we collected were slightly older than our nominal 10 years but were not always generally available within the cost organizations and thus would be a useful resource.

Cost-Estimating Data, Methodologies, and Trends

To develop cost-estimating methodologies, we collected actual T&E costs, schedules, and programmatic test data from a number of sources, including the contractor cost data reports, system program offices, government cost analysis agencies, government test organizations, and selected contractors (see Acknowledgments). Chapter Four discusses these data, which we treat more fully in a limited-distribution supplement. The appendixes include detailed programmatic data on 16 aircraft and guided-weapon programs for reference.

Chapter Five presents the T&E cost estimating relationships (CERs) we developed from these data. The CERs and the data in the proprietary supplement should allow an estimator to compare estimates for a proposed program with actuals from other programs. Of course, the estimator will have to use expert judgment to take into account any specific, unique aspects of the proposed program. Chapter Five includes CERs for

- overall contractor test costs for aircraft
- contractor ground, flight, and “other” test costs for aircraft
- total contractor and government test costs for guided weapons.

As with most parametric estimating tools, these would be most useful for a Milestone B or earlier cost or test estimate, when fewer details of a proposed program are known. As the system progresses through development and more information becomes available, more-detailed estimating techniques can be used, with these CERs providing a cross-check at an aggregate level.

It was much more difficult to collect and document data on the costs government organizations had incurred than on corresponding contractor costs. We initially did not consider this to be a serious limitation, assuming that, because of acquisition reform, government costs would decrease as contractors took on a greater share of the effort. However, in cases where we were able to obtain government costs for programs, this generally did not prove true. Government T&E costs were substantial and, for guided weapons, generally greater than those of the system contractor. In many cases, contrac-

tors still rely on government test facilities and functional expertise, particularly for high-cost, low-utilization test capabilities. Government personnel normally participate actively in the integrated test teams. Even when the contractor can select any test facility it considers appropriate, that might end up being a government facility—with the government facility then becoming test subcontractor to the system prime contractor. Of course, most open-air testing continues to be conducted on DoD ranges.

Consistent accumulation and reporting of government cost data, to standards similar to those for contractor data, would greatly improve the accuracy of cost estimates for testing. This would ensure that the total program financial picture was available for management in the present and for analysis in the future. This would improve the ability of government test facilities to evaluate the cost and schedule implications of their processes, assess the contributions of all their activities, and focus investment and management attention on the activities most critical to each facility's customer base.

Overall T&E Cost Trends

The overall cost of T&E to the program shows no clear trend upward or downward over the last 20 to 30 years. Although government and industry test personnel have indicated that the increasing use of modeling and simulation, improvements in instrumentation and test processes, reduction of redundant testing, and various acquisition streamlining initiatives have reduced the cost of individual tests, other changes appear to have offset any potential net savings.

Thus, the proportion of development costs dedicated to T&E has remained relatively constant for aircraft and guided weapon systems. Although various explanations for this are possible, the dominant factors are probably the increasing complexity of the systems tested and the increasing content of test programs. (See the Cost Trends section in Chapter Three.)

T&E Issues and Findings

Another principal objective of this study was to identify changes in the practice of T&E and, to the extent possible, their likely effects on the cost of T&E for future aircraft, missiles, and guided munitions.

Overall, we found no cost or schedule data that would allow us to quantify how these practices individually affect current systems, either as upward or downward influences on test costs or schedules. The following paragraphs outline the issues we addressed.

Acquisition Reform

Acquisition reform initiatives are a diverse array of ideas, processes, and practices designed to streamline the DoD acquisition process, reducing either cost or schedule, or improving technology. A previous RAND report (Lorell, 2001) addressed the general effects of acquisition reform on cost estimating.

One of the acquisition reform initiatives that report discusses is TSPR, which transfers certain T&E responsibilities from DoD to the contractors. Although the data to support cost savings tend to be anecdotal, it is apparent that it will shift costs from government activities to contractor activities and must be recognized as such in future cost estimates. Our interviews suggest that TSPR must be well planned to avoid two test-related problems: Test data may not be available to DoD for other, postdevelopment uses, and cross-platform integration might not be adequately coordinated, especially in guided weapon development. DoD must have the foresight to ensure that it can use the system development and demonstration test data to design modifications or to qualify additional platform-and-weapon configurations. In addition, to maintain compatibility, DoD will have to ensure careful coordination of cross-platform integration issues, particularly with guided-weapon development and modification, with other systems.

It is too early to assess the outcome of recent innovative test management approaches that give the contractor broad latitude in developing and executing the developmental test program. Another innovative approach, relying on non-DoD tests and certifications of

nondevelopmental aircraft for DoD applications, was not generally as successful as its promoters had hoped. We found that Federal Aviation Administration certification alone is not sufficient to demonstrate that a particular aircraft meets most military performance specifications. “Best commercial practices” are not an effectively codified set of procedures, like common law or accounting principles. Because they tend to be situational and inconsistent from contractor to contractor, they may be inadequate for responsible acceptance of military systems. (See the Acquisition Reform section in Chapter Three.)

Modeling and Simulation

Virtually all test programs now incorporate modeling and simulation. In many programs, some aspects of the analytical tools have not been mature enough to give enough confidence for waiving live testing. However, in all cases, modeling and simulation at least reduced the risk, and often the duration, of live tests and thus appeared to be a good investment. In addition to directly benefiting T&E, robust modeling and simulation also benefits

- evaluating design excursions during development
- tactics development
- operator training
- evaluating future system enhancements. (See the Modeling and Simulation section in Chapter Three.)

Testing of Software-Intensive Systems

An area of almost universal concern was effective testing of software intensive systems, which are growing in complexity and functionality. Continuing advances in technology have translated into system capabilities unimagined a generation ago. The growth in capability translates into increased test complexity. This area should receive specific attention in any future T&E estimates. (See the Software Intensive Systems section in Chapter Three.)

Combined and Multiservice Testing

There was general agreement that integrated contractor-government test teams were a positive force in optimizing testing. Similarly, combined development and operational test teams have been valuable because they avoid redundant testing and highlight operational effectiveness and suitability issues for early resolution. Some program personnel expressed a desire for even more intensive “early involvement” by the operational test community. The primary constraint appears to be limited staffing of the service operational test organizations. (See the Combined and Multiservice Testing section in Chapter Three.)

Contractor Versus Government Test Facilities

While there was general agreement that the major government test facilities are essential for executing the required test programs and that they generally provide excellent support, some contractor personnel expressed varying levels of frustration in their dealings with the government test organizations. In programs with aggressive affordability goals, there was a concern that some government test range personnel were not as focused on controlling the costs and schedule of the test program as other members of the test team were. Some felt that there were practices at the ranges that were overly conservative and caused unnecessary costs and delays. In other cases, delays resulted from chronic understaffing or procedures with little provision for flexibility. These issues are of increasing importance when contractors are given incentives to perform within what are, in effect, fixed test budgets and schedules. A related contractor concern was that the government ranges tended to be “overfacilitized” but “undermodernized.” (See the Contractor Versus Government Test Facilities section in Chapter Three.)

Live-Fire Testing

Although live-fire testing can be a contentious issue during early planning for system development, our interviews did not highlight major concerns at the program level, as long as the requirements were known in advance and planned for accordingly. Because data were

limited, we could draw no general conclusions about the real cost of live-fire testing. (See the Live-Fire Testing section in Chapter Three.)

Although there is some disagreement over the appropriate level of testing in specific circumstances—live-fire testing, testing for statistically rare events, etc.—we found little controversy in general over the scope of testing. Other studies have concluded that most DoD test programs have already eliminated the majority of unnecessary or redundant testing. Several sources, however, expressed the opinion that thoughtful reevaluation of test procedures could improve the pace and efficiency of the typical test program. (See the Live-Fire Testing and the Contractor Versus Government Facilities sections in Chapter Three.)

Warranties

None of our interviews indicated that warranties significantly changed the T&E process or costs.