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Report to the Subcommittee on Readiness and Management Support, Committee on Armed Services, U.S. Senate

February 2003

BEST PRACTICES

Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs

GAO-03-57

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GAO Accountability • Integrity • Reliability

Highlights

Highlights of GAO-03-57, a report to the Subcommittee on Readiness and Management Support, Committee on Armed Services, U.S. Senate

Why GAO Did This Study

For fiscal year 2003, the Department of Defense (DOD) asked for about $185 billion to develop, procure, operate, and maintain its weapon systems. This request represents an increase of 18 percent since 2001 for the total ownership costs of DOD weapon systems. Often, DOD systems need expensive spare parts and support systems after they are fielded to meet required readiness levels. DOD has been increasingly concerned that the high cost of maintaining systems has limited its ability to modernize and invest in new weapons. This report examines the best practices of leading commercial firms to manage a product's total ownership costs and determines if those practices can be applied to DOD.

What GAO Recommends

GAO recommends DOD (1) revise its guidance for setting requirements to include total ownership cost goals and readiness rates for any major weapons system as performance parameters equal to any others; (2) revise acquisition regulations to require a firm estimate of component and subsystem reliability by the systems integration phase and an estimate of system reliability at the production decision; and (3) structure contracts to ensure proper trade-offs between reliability and performance.

www.gao.gov/cgi-bin/getrpt?GAO-03-57.

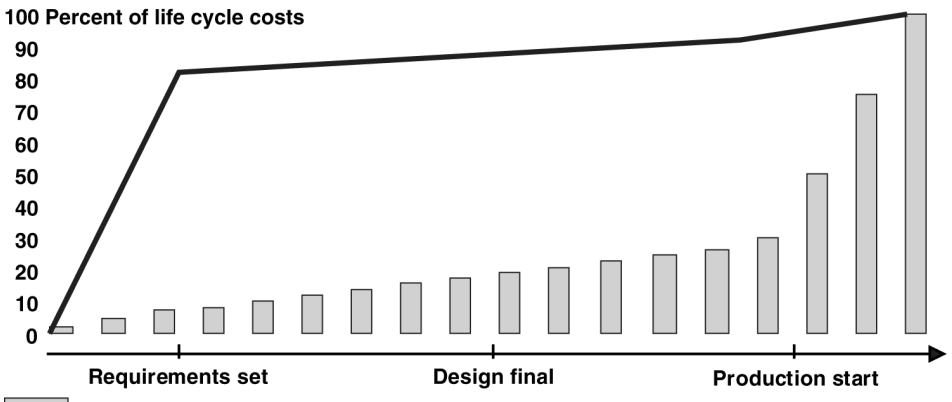
To view the full report, including the scope and methodology, click on the link above. For more information, contact Katherine Schinasi at (202) 512-4841.

What GAO Found

Even though DOD has implemented several initiatives to reduce total ownership costs, some systems, such as the Apache helicopter or the Abrams tank, have experienced costly maintenance problems and low readiness rates, which persisted even after the systems were fielded. We found several reasons for these problems. First, DOD based requirements for weapon systems in product development almost exclusively on technical performance, with little attention to operating and support costs and readiness at the beginning of development when there is the greatest chance of affecting those costs positively. Second, using immature technologies to meet performance goals weakened DOD's ability to design weapon systems with high reliability. Finally, DOD's organizational structure is linear and limits collaboration and feedback among organizations charged with requirements setting, product development, and maintenance.

In contrast, commercial companies that we visited considered operating and support costs to be integral to their new product development decisions. Studies have shown that by the time a product is ready for development, over 90 percent of the operating and support costs have been determined. As a result, these companies required their equipment be easy to maintain, ready when needed, and reliable at a low cost. These requirements were of equal importance to other performance characteristics. After setting requirements, product developers then designed products to meet established reliability rates, using technologies that were proven through past use or testing. At all of the companies we visited, customers and product developers alike, had very collaborative processes and practices that draw extensively on data from past operations to influence the design of new products.

Percent of Life Cycle Costs Determined at Various Points in the Acquisition Process



Source: Defense Acquisition University.

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United States General Accounting Office
Washington, DC 20548

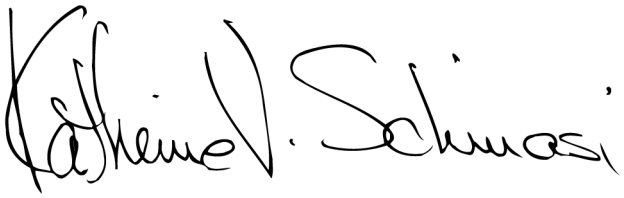
February 11, 2003

The Honorable John Ensign
Chairman
The Honorable Daniel Akaka
Ranking Minority Member
Subcommittee on Readiness and Management Support
Committee on Armed Services
United States Senate

As you requested, this report examines how best practices offer improvements to the way the Department of Defense develops new weapon systems to reduce their total ownership cost, especially the operating and support costs, during design. It examines how the department currently designs for operating and support costs and how best practices could improve outcomes and reduce costs. We make recommendations to the Secretary of Defense for improvements to weapon system requirements policy, including establishing operating and support cost and readiness goals as performance parameters equal to any other performance parameters; revising acquisition policies to require a firm estimate of reliability during product development; and providing contract incentives for product developers to make appropriate trades between reliability and performance before production.

We are sending copies of this report to the Secretary of Defense; the Secretary of the Army; the Secretary of the Navy; the Secretary of the Air Force; the Director of the Office of Management and Budget; the Director, Missile Defense Agency; and interested congressional committees. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you have any questions regarding this report, please call me at (202) 512-4841. Other contacts are listed in appendix II.



Katherine V. Schinasi
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Acquisition and Sourcing Management

Executive Summary

Purpose

For fiscal year 2003, the Department of Defense (DOD) asked for about $184.9 billion to develop, procure, operate, and maintain weapon systems. With this funding, DOD will have received increases totaling about 18 percent since 2001 for what it defines as total ownership costs of its equipment. DOD's budget for operations and maintenance increased by about 5.6 percent during the same period—from about $59 billion to about $62.3 billion. DOD has been increasingly concerned that the high cost of maintaining weapon systems to meet required readiness levels is depleting modernization accounts and denying the department the flexibility to invest in new weapons. In recognition of this concern, DOD has established goals to reduce operating and support costs of weapon systems already in the field as well as those currently in development. In order to provide another perspective on this problem, GAO has continued a body of work to identify best practices used by leading commercial companies to manage new products' total ownership costs to see if these practices can be applied to DOD's weapon system acquisitions.

This report addresses how DOD can use best practices from commercial companies during its acquisition process to reduce total ownership costs of its major weapon systems. It presents a model of the process commercial companies use to incorporate reasonable and manageable operating and support cost into their product development process. In response to a request from the Chairman and Ranking Minority Member, Subcommittee on Readiness and Management Support, Senate Committee on Armed Services, GAO (1) determined the practices, processes and metrics DOD has historically used to manage and control operating and support costs of its major weapon systems; (2) determined the practices, processes and metrics commercial companies use to manage and control operating and support costs; and (3) analyzed the extent to which opportunities exist to apply best practices to reduce operating and support costs during product development.

Background

Readiness is a critical parameter of all DOD's weapon systems. If a system is not ready, its performance characteristics are of no use. Each weapon system has an expected readiness rate, usually expressed in some percentage of available units, that it is expected to maintain for our national security. Readiness can be achieved by building highly reliable weapon systems or, if the systems are not highly reliable, supporting them with an extensive logistics system that can ensure spare parts and other support items are available when needed. In essence, the cost of a product's readiness is the cost to develop, produce, and operate and maintain that system.

DOD recognizes that the total cost of a weapon system includes more than development and procurement costs. Traditionally, development and procurement have accounted for about 28 percent of a weapon's total ownership cost, while costs to operate, maintain, and dispose of the weapon system account for about 72 percent of the total. For a number of years, the department's goal has been to spend less on supporting systems and to devote more funds to development and procurement in order to modernize weapon systems. But, in fact, growth in operating and support costs has limited the department's buying power. DOD officials have cited shortages of spare parts and unreliable equipment as reasons for low mission-capable rates for some weapons. As a result, some modernization has been postponed in order to pay high and unexpected operating and maintenance costs.

GAO has issued a series of reports on best practices that commercial firms use to manage and control the acquisition cost of their products. Commercial firms attain knowledge early in the development process about technology that they plan to incorporate; they make sure the design is mature before production; and they have production processes under control before production begins. The building of knowledge in these areas can also contribute to the reduction of a product's operating costs over its life cycle, thereby reducing a major portion of its total ownership costs. While those reports focused on best practices for reducing the cost and cycle time for acquiring weapon systems, this report will focus on what DOD can do during the acquisition of a weapon system, prior to and during product development, to ensure that products are available when needed, more cost effective to operate and support and more reliable once fielded, thereby reducing their total ownership cost.

Results in Brief

DOD weapons acquisition processes do not consider operations and support costs and readiness as key performance requirements for new weapon systems, and DOD places less emphasis on establishing operations and support cost and readiness as key nontradable goals early in product development. Generally, the department settles for lower reliability in its new weapon systems' designs. In our review of data for five fielded weapon systems, we found none had established operating and support cost or readiness as key requirements. Although recent readiness levels were acceptable to the services for the most part, the five systems had experienced growth in their operating and support cost estimates of between 16 and 48 percent within the last 12 years and problems with reliability once in the field.

We found several reasons for cost growth. DOD's acquisition process is linear, progressing from one organization to the next with little interaction among the groups. Requirements-setting by the war-fighting community focuses on system performance. DOD policy does not require inclusion of readiness or operating and support cost goals as key performance requirements equal in importance to other performance requirements. None of the systems we reviewed had a readiness or an operating and support cost goal as a key requirement. Further, during product development, the use of immature technologies and components to meet performance goals worked against designing weapon systems with high reliability. Using immature technologies also acts as a barrier to manufacturing techniques such as open systems[1] or designing for fewer parts, practices that typically help reduce maintenance costs of the system and increase its reliability. DOD's systems for accumulating data to analyze operating and maintenance actions on weapon systems already in the field do not provide adequate or reliable information, thus making it difficult for DOD to understand the total cost of operations and support. The outcome of these practices at DOD has been an inability to stem the continuous growth in total ownership cost, with actual operating costs continuing to exceed initial estimates. As a result, DOD continues to request more operating and support funding to sustain its systems or to reprogram funds from other accounts to pay the bills.

In contrast, commercial companies consider reasonable operating and support costs and the readiness or availability of their equipment as requirements equal in importance to other performance characteristics, thereby ensuring that the developer places proper emphasis on achieving reliability and operating and support cost goals during product development. Commercial companies have a collaborative process for setting requirements, developing the product, and collecting and sharing data on maintaining and supporting the product once it is delivered. Both the customer and the developer have a voice in the process. During product development, especially during the design process, the maintainer has an active voice and is armed with information about operating and support cost drivers in the previous product. Commercial product developers maintain high standards for reliability, using proven technologies to achieve critical performance requirements. They find an

[1] An open system is one that is designed with interfaces to accept upgrades easily without redesign of the total unit. Replacements in an open system only have to meet interface requirements to be accepted.

evolutionary development process is critical to reducing operating and support costs and achieving high readiness. Emphasis is placed on reducing the number of parts in a design so there is less to maintain, using standardized parts that are readily available in the industrial base and using open systems to maintain competition. Once the product is delivered to the customer, maintainers keep detailed records on its reliability and the cost of its maintenance and support. Importantly, information on the product's performance is communicated back to the developer to be used to improve the product.

DOD has implemented initiatives to reduce the total ownership cost of its weapon systems. It has modified acquisition policies, established programs to reduce operating and maintenance costs in existing systems, and selected several acquisition programs to test different approaches to reduce life-cycle costs during development. However, these steps do not incorporate many of the practices used by commercial companies during requirements determination, product development, and fielding. In comparing DOD's practices to those found at leading commercial firms, we have identified several differences. Because companies operate in an environment where operating costs and readiness are critical to their survival, commercial customers establish low operating and support cost and high readiness requirements when purchasing a product. This forces product developers to design reliable systems that are easy and relatively cheap to operate and maintain. The collaborative relationship between the customer and the product developer is essential to driving down operating and support costs. Further, companies understand that accurate operating and support cost data from current products are also necessary to make good decisions related to the purchase of a product, facilitate cost/performance trade-offs, and provide feedback to the manufacturer for continuous improvement.

GAO is making recommendations to the Secretary of Defense on ways to improve DOD's management of operating and support costs. We are recommending that DOD revise its requirements generation process to include total ownership cost, especially operating and support cost, and weapon system readiness rates as performance parameters equal to any others. We also recommend that any revision of the current policy governing acquisition processes require a firm estimate of the systems' reliability based on demonstrated reliability rates at component and subsystem levels no later than the end of the system integration phase and at the system level no later than the production decision. Finally, we recommend that DOD structure contracts by Milestone B, the start of the system development and demonstration phase, to ensure that proper

trades are made between reliability and performance before the production decision.

Principal Findings

DOD'S Current Practices for Setting Requirements and Developing New Weapon Systems Continue to Yield Higher Total Ownership Costs

DOD is spending more on operating and support costs for its weapon systems than it planned. We found three primary reasons for the high cost of operating and supporting DOD's fielded weapon systems. These were (1) little or no attention to the trade-offs between readiness goals and the cost of achieving them when setting the key parameters for weapon systems;[2] (2) the use of immature technologies during product development and delays in acquiring knowledge about the design and its reliability until late in development, or in some cases, production; and (3) insufficient data on the operations and maintenance costs and actions for fielded systems that would allow improvements in products currently in development. The outcome of these practices in DOD has been an inability to stem continuous growth in total ownership cost, with actual operating costs continuing to exceed initial estimates. As a result, DOD continues to request more operating and support funding to sustain its systems or reprogram funds from other accounts to pay the bills.

Even though operating and support costs are the largest factor in a weapon system's total ownership cost, they do not receive the same attention when requirements are set for a weapon system as other performance characteristics. In our review of data for five fielded weapon systems, we found that none had established an operating and support cost or a readiness goal as a key requirement prior to product development. In fact, operating and support cost estimates were not available in the *Selected Acquisition Reports* until at least 5 years into product development on these programs. Most of the fielded systems we reviewed were near or achieving readiness goals, but had experienced significant cost growth in operations and support cost estimates within the last 12 years to do so. Two of these systems, the Apache and the Abrams, were designated as the Army's most expensive weapons to support. The C-17 reported a cost increase of almost 25 percent, and program officials

[2] A key performance parameter represents a capability that is so significant that failure to meet the minimum value could be a reason for DOD or the services to reevaluate the concept or system or terminate the program.

stated that they would not have a firm estimate of operating and support cost until 2010—more than 25 years after the start of development.

We found practices in three areas—requirements-setting, product development, and operations and maintenance—that contributed to this condition. DOD' s acquisition process is linear and serially involves several organizations whose responsibilities in the process have differing objectives. Communication among the different organizations is fragmented. Requirements focused on the weapon system's performance characteristics. Once the weapon system's requirements were set and the development of the system began, product development focused on achieving the program's acquisition cost, schedule and performance goals, rather than on increasing reliability in order to reduce its total life-cycle costs. We found that the maintainers had limited involvement in making design trades for lower operating and support costs during development and that best practices such as designing for open systems or ease of maintenance were not used by the developer. We also found that once a system is fielded, the services' systems for tracking operating and support costs were suspect, providing inadequate feedback to suppliers and requirements setters.

Commercial Companies Deliberately Manage Ownership Costs through Product Requirements and Design Process

We found that commercial companies that use capital equipment considered operating and support costs integral to their new product development decisions. Companies such as United Airlines, FedEx Express, and Polar Tanker employ practices to maintain the readiness of their fleets at as low an operating cost as possible. Reducing these costs translates into revenues, profits, and market growth. Increases to these costs can mean market failure. As customers, they have established operating and support costs and product readiness as key system requirements before development begins for a new product that are equal in importance to requirements for its performance and the cost to develop and produce the product. For example, United Airlines requires that new aircraft maintain a readiness rate of 98.5 percent or the manufacturer must reimburse it for lost revenue. Polar Tanker established a requirement that its Endeavor Class tanker operate at least 330 days a year at a reduced operating cost per tanker. These dual requirements drove trades during design, sometimes increasing development costs to achieve lower operating costs. Before FedEx Express agreed to a new design for its delivery trucks, it required that the new design last for at least 300,000 miles over a specified number of years and at a specific cost per mile. In gaining agreement with product developers on these requirements prior to product development, these companies sometimes had to trade

performance or spend more in development, but they received more reliable products, reduced total ownership costs, and made those costs more predictable.

To meet their customers' supportability requirements, we found that commercial product developers focused on designing a product that was easy to maintain, would be ready when needed, and reliable at low cost. They used an evolutionary development process. Consequently, they did not allow components or subsystems into a product's design unless the technology had been proven reliable through past use or testing. For example, Boeing told us that it defers use of immature technology to later evolutions of design and makes the reliability ratings of its components available to the airlines before it begins product development. Maytag completed reliability testing on every new product prior to going to production. These companies also emphasized product designs with fewer parts and open systems. Maytag has established a parts reduction program as part of its development process, and Boeing built its 777 so that any of three engines—GE, Pratt & Whitney, or Rolls Royce—would fit. Developers also gained insight into design features their customers valued through regular communication with them. For example, the design for Boeing's latest generation 737—geared toward reducing operating costs—was inspired by the airlines. Boeing emphasized open systems, standardized parts, and reduced parts from one generation to the next to satisfy the airlines' need for reduced operating costs.

All of the companies we visited, customers and product developers alike, had very collaborative processes and practices for drawing extensively on data from past operations to influence the design of new products. This information was used as a baseline for new product designs and was used to estimate the operating costs of new products. United Airlines officials told us that the airlines and the manufacturers both keep meticulous reliability and cost records at all levels of an airplane--components, subsystems, and at the system level. Major operating costs drivers are tracked on a daily basis by the airlines, and the manufacturers usually have personnel residing with the airlines' maintenance crew to help solve problems on the spot and, just as importantly, to feed information back to the manufacturer so that the next product can be improved. FedEx Express and Polar Tanker both emphasized extensive data collection from current operations. In fact, FedEx Express sets annual targets for operating and support cost reductions based on data gathered on the road. Polar Tanker gathered maintenance data from past operations and established a team made up of its own maintenance personnel and outside

consultants to determine areas that could result in higher reliability and lower maintenance costs in designing the new Endeavor Class tanker.

Greater Emphasis on Operating and Support Cost at the Outset and during an Acquisition Program Could Help DOD Reduce Total Ownership Costs

DOD and the commercial companies we visited have policy goals of developing products that will meet customers' needs at the lowest possible cost to build and operate. The difference between them is in how each implements its policies. Leading commercial companies follow an integrated, collaborative process of setting requirements, developing the product, and ensuring that the product can be supported at an acceptable cost. DOD's process is composed of disparate practices carried out by separate organizations with differing objectives and little communication among them about how to support fielded systems. While commercial firms focus on total ownership costs at the outset, DOD focuses mostly on technical performance. One cause of this is that in DOD the accountability and responsibility for total ownership costs are spread across many organizations with separate goals. Another cause lies in motivation for low costs. The commercial companies we visited are driven by the need to be as profitable as possible to survive, and low total ownership costs translate to higher profitability. DOD's environment does not provide such incentives, and the organizations charged with acquiring and operating weapon systems are unconstrained by a need to lower costs since they can request additional operations and maintenance funding to keep systems working.

Some of the practices used by commercial companies to reduce a new product's operating costs during its development may be helpful to DOD. In setting requirements, commercial customers make readiness and operating cost requirements and collaborate directly with the product developer. Product developers establish sound cost estimates early; designs are simplified by using open systems and reducing parts; reliability testing is done early; and a reliability growth curve is established before production begins. Once a product is fielded, operating costs are managed to established targets; operating cost data is collected, analyzed, and used by the developer and the customer to develop more reliable products in the future; and continuous improvements are made to future products. The commercial practice of establishing readiness and operating cost as key requirements for a new product necessitates substantive input from operators and developers before and during product development. The commercial practices used during product development to design reliable systems that are easy and less costly to operate and maintain depend on the use of good product development practices including the use of mature technologies to meet requirements. Commercial firms use

incremental product development processes and depend on a strong relationship between the manufacturer and the customer's operators and maintainers to continue throughout product development.

DOD does not focus on operating and support costs to the degree commercial companies do. In setting requirements, DOD does not make readiness and operating cost key parameters, performance is rarely reduced in favor of reliability or reduced operating cost, and there is no direct relationship between the requirement setters and the product developer. During product development, firm estimates of operating costs are not required, little attention is paid to reliability rates, and open systems or design for manufacturing techniques are rarely used. Once a weapon system is fielded, there is a lack of complete and reliable data available from the field, and there is little collaboration between maintainers and product developers to improve new systems. DOD's acquisitions usually begin with critical technologies that are immature, with unproven reliability. This makes it difficult to implement best practices such as design for manufacturing during product development. Accurate operating and support cost data are not available for helping management make good decisions, facilitating cost/performance trade-off decisions, and providing feedback to the manufacturer for continuous improvement. On the weapon systems we reviewed, we found that the programs had poor initial estimates of operating and support costs for weapon systems, partly because they do not have reliable systems in place to track those costs per weapon system.

DOD has taken some steps to lower its weapon systems' total ownership costs. Those actions include concurring with and implementing recommendations concerning the use of technology readiness levels, indicators of design maturity, and controlled production processes. Further, the department initiated pilot programs with 30 acquisition programs to develop methods for reducing total ownership costs. However, DOD's current environment—both culturally and organizationally—is not presently conducive to applying them. Currently, its acquisition policies do not provide specific guidance for controlling total ownership cost and its requirements-generation policies provide no guidance for establishing readiness or cost goals for weapon systems once they are fielded.

Recommendations for Executive Action

GAO recommends that the Secretary of Defense

- revise the Chairman of the Joint Chiefs of Staff Instruction 3170.01B on the requirements generation process to include total ownership cost, especially operating and support cost, and weapon system readiness rates as performance parameters equal in priority to any other performance parameters for any major weapon system prior to beginning the acquisition program;
- revise the current policy governing the operation of the defense acquisition system (currently under revision) to require that the product developer establish a firm estimate of a weapon system's reliability based on demonstrated reliability rates at the component and subsystem level no later than the end of the system integration phase, coinciding with the system-level critical design review, before proceeding into the system demonstration phase of product development; and at the system level no later than the full-rate production decision; and
- structure DOD contracts for major systems acquisitions so that at Milestone B the product developer has incentives to ensure that proper trades are made between reliability and performance prior to the production decision. One option is to provide specific clauses in the development contract to address reliability growth.

Agency Comments

DOD partially concurred with all of our recommendations but, for the most part, found no further action was needed to lower total ownership cost. We disagree. We believe that if DOD takes no further action in implementing these recommendations, it would ignore significant opportunities to improve readiness by lowering total ownership cost in a budget environment that demands more effort to reduce these costs.

A detailed discussion of DOD's comments appears in Chapter 5 and the full text of DOD's comments is in appendix I.

Chapter 1: Introduction

For fiscal year 2003, DOD asked for $184.9 billion to fund research and development, procurement and direct operations and maintenance costs of its weapon systems. These elements along with disposal costs are defined as the total ownership cost of a weapon system. The budget has increased by about 18 percent for these activities since 2001—with direct cost for operations and maintenance of weapon systems increasing by about 5.6 percent from $59 billion to about $62.3 billion. Since the late 1990's, DOD has been increasingly concerned that the cost of operating and supporting weapon systems to meet required readiness levels is depleting its modernization accounts and denying the department the flexibility to invest in new weapons.

Total Ownership Cost Is the Cost to Ensure Readiness

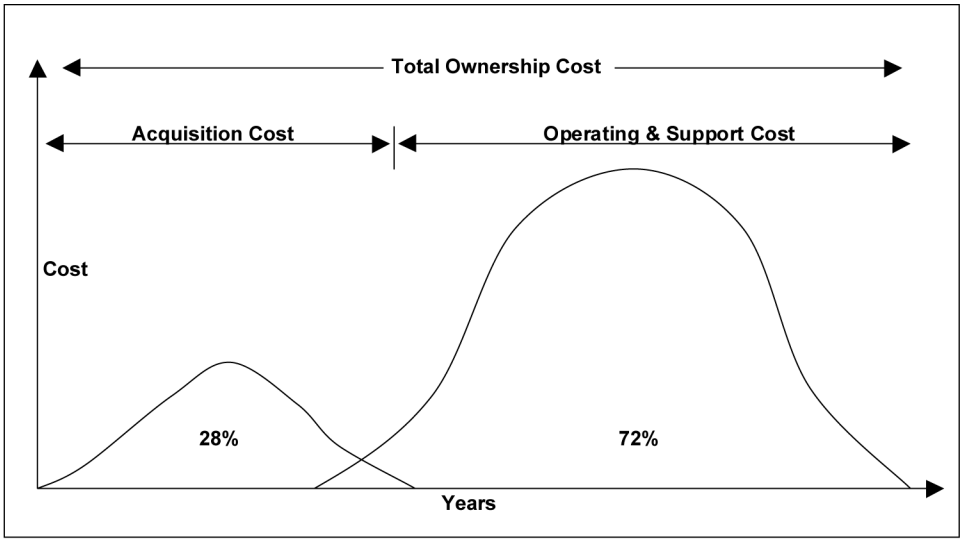
Commercial companies and DOD both use readiness as a key indicator of a product's success. Readiness is usually expressed as the percentage of total units available and capable of performing a mission at any given time. If a weapon system is not ready when it is needed, its performance characteristics are of no use. In general, readiness can be achieved either by building highly reliable weapon systems or, if the systems are not highly reliable, supporting them with an extensive logistics system that can ensure spare parts and other support items are available when needed. In essence, the cost to ensure a product's readiness is the cost to develop, produce, operate, and maintain that product through its life cycle.

The development and production cost of a weapon system, also known as acquisition cost, usually represents about 28 percent of the weapon system's total ownership costs. The acquisition cost is funded through DOD's research, development, test and evaluation, and procurement accounts. These funds are used to mature new technology and design and manufacture new weapon systems. Operating and support costs[1] are typically the highest portion of a weapon system's total ownership cost because they represent the cost to operate the system and keep it ready for action over many years, sometimes more than 30 years. These costs are about 72 percent of the total ownership cost of a weapon system and are funded through DOD's operations and maintenance account. Operating and support costs reflect the purchases of fuel, lubricants, and repair parts

[1] Operations and support of weapons systems is a part of the Operations and Maintenance budget, which also includes amounts for health care, base and facilities support, and other activities for the well-being and operations of the military forces. Costs for operations and support of weapon systems were about 48 percent of the Operations and Maintenance budget in fiscal year 2002.

and their associated maintenance as well as modification kit procurement and installation. Figure 1 depicts the typical distribution of total ownership costs of DOD weapon systems over a 30-year life cycle.

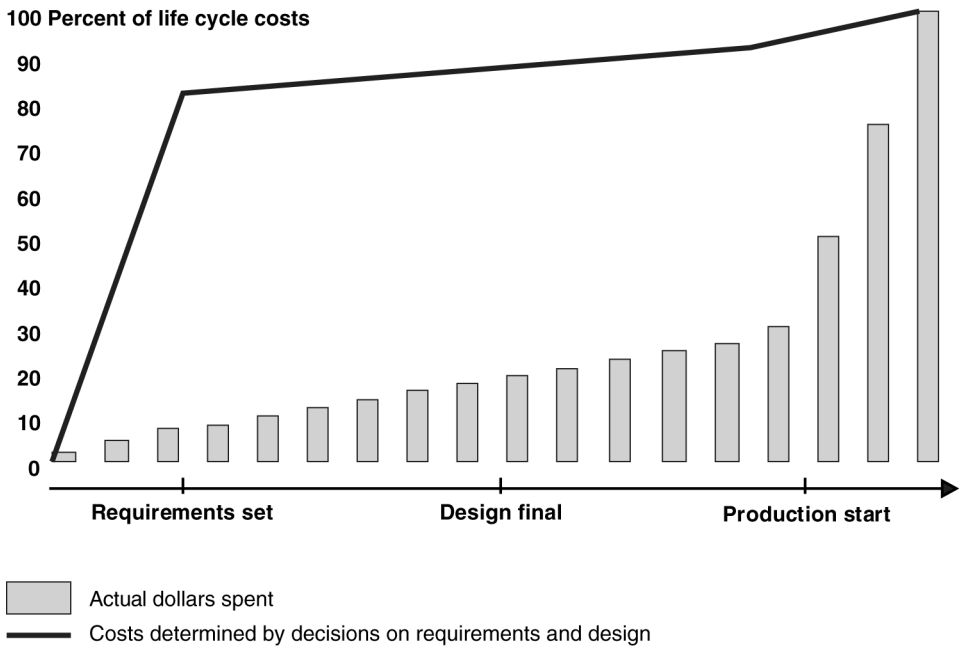
Figure 1: Nominal Life-Cycle Cost of Typical DOD Acquisition Program with a 30-Year Service Life



Source: Defense Systems Management College's Acquisition Guide.

Figure 1 shows that the greater part of a weapon system's total ownership cost is made up of its operating and support cost. While 72 percent of the life-cycle cost of a weapon system is realized only after it is fielded, the decisions made during its acquisition—when its performance requirements are being established and its design is being matured—will dictate operating and support costs very early. In fact, studies show that about 85 percent of the operating and support costs of a weapon system will be determined as soon as requirements are set, while less than 10 percent of the life-cycle cost have been spent. By the time a product is ready for production, over 90 percent of the operating and support costs have been determined, and about 28 percent of the total life-cycle costs have been spent. Figure 2 illustrates this phenomenon.

Figure 2: Percent of Operating and Support Costs Determined at Various Points in the Acquisition Process



Source: Defense Acquisition University.

Because so much of the eventual cost to support and maintain a weapon system is decided very early, it makes sense that more attention should be paid to supportability when the product's requirements are being set and its design is being finalized. World-class commercial companies that either use or develop high-performing products know this and set requirements and designs accordingly.

Commercial Best Practices

GAO has undertaken an extensive body of work that examines DOD's acquisition issues from a different, more cross-cutting perspective—one which draws upon the lessons learned from the best commercial practices to see if they are applicable for DOD's acquisition processes. Previous GAO best practices reports focused on what DOD could do to control product development costs that represent about 28 percent of total ownership costs. This report will focus on best practices for reducing the largest segment of total ownership costs—the operating and support costs. The concepts discussed build on our previous reports that looked at

earlier phases of an acquisition, including matching customer needs with available resources and designing and manufacturing products within cost, schedule, and performance goals. A complete list of best practices reports is at the end of this report

Leading commercial companies expect to obtain high-quality products that meet their expectations in terms of performance, price, and reliability. To ensure they make prudent buying decisions, they use a structured product development process that ensures a high level of knowledge exists about a product at key junctures during its development. Such a knowledge-based process enables decision makers to be reasonably certain that product quality, reliability, and timeliness are assured.

- Knowledge point 1 occurs when a match is made between the customer's needs and the available resources—technology, design, time, and funding. Commercial companies use this knowledge to meet essential product requirements, such as low operating and support costs. To ensure that the knowledge is attained, private companies require the product be demonstrated in its intended environment. In addition, the product developer must complete a preliminary product design, using systems engineering to balance customer desires with available resources.

- Knowledge point 2 occurs when the product's design demonstrates its ability to meet performance requirements. Program officials are confident that the design is stable and will perform acceptably when at least 90 percent of engineering drawings are complete. To obtain this knowledge, commercial companies use simulations and testing to fully understand how the product should be built.

- Knowledge point 3 occurs when the product can be manufactured within cost, schedule, and quality targets and is reliable. Important indicators of this are when critical manufacturing processes are in control and consistently producing items within quality standards and tolerances. Private companies demand these critical manufacturing processes be in control because they could affect the product reliability.

Objectives, Scope, and Methodology

The Chairman and the Ranking Minority Member, Subcommittee on Readiness and Management Support, Senate Committee on Armed Services, requested that we examine best practices for reducing total ownership cost of DOD's weapon systems. This report primarily covers the operating and support cost portion of total ownership costs. Our overall objective was to determine whether commercial best practices for reducing total ownership costs, particularly operating and support costs,

prior to and during the acquisition of weapon systems offer opportunities to improve outcomes in DOD's acquisitions and its efforts to manage and reduce total ownership costs. Specifically, we (1) determined the practices, processes, and metrics DOD uses to manage and control total ownership costs of its major weapon systems; (2) determined the practices, processes, and metrics commercial companies use to manage and control total ownership cost; and (3) analyzed the extent to which opportunities exist for DOD to apply best practices to reduce operating and maintenance costs during product development.

We used case studies of the following six DOD weapons, chosen to reflect all of the services across time, to examine DOD's practices, processes and metrics:

The Advanced Amphibious Assault Vehicle: This vehicle is the U.S. Marine Corps' replacement for its presently fielded amphibious assault vehicle. The new development vehicle is equipped with a 30mm automatic cannon and provides the capability to transport a Marine rifle squad at a speed of 20-25 knots in the water, and cross country with the agility and mobility equal to or greater than that of the M-1 tank. The contract for the Product Definition/Risk Reduction Phase was awarded in 1996. The Marine Corps expects to buy 1,013 of these vehicles. Acquisition costs total $9.6 billion; operating and support costs, $16.0 billion.

The Joint Strike Fighter program: This aircraft is the next-generation aircraft for the Navy, Air Force, Marine Corps, and Allies. There are three variants: a carrier variant will provide the Navy a multi-role, stealthy aircraft to complement the F/A-18E/F. The Air Force variant will be a multi-role aircraft, but primarily used in an air-to-ground role to replace the F-16 and the A-10 and complement the F-22. The Marine Corps variant will be a short-takeoff and vertical-landing aircraft to replace the Sea Harrier and GR-7 for the United Kingdom Royal Navy and Royal Air Force. The program is currently in system development and demonstration. Acquisition costs total $226.5 billion; operating and support costs, $387.6 billion.

The Landing Platform Dock 17 ship program: These ships are used for transporting amphibious assault vehicles and other cargo. They incorporate both a flight deck for helicopters and a well deck to support landing craft. The contract for the detail design, integration and construction of the ship was awarded in 1996. The Navy expects to buy 12 ships to replace 27 older amphibious ships. Acquisition costs total $15.4 billion; operating and support costs, $56.5 billion.

The Apache helicopter program: This Army helicopter's mission is to find tanks and other armored targets and destroy them with its laser-guided Hellfire missiles, its 2.75-inch rockets, or its 30-millimeter gun. Apache development began in 1973 and the helicopter entered production in 1982 and was fielded in 1984. The Longbow Apache is a remanufactured and upgraded version of the Apache, which includes improved radar, engine and Hellfire missiles. The Army currently fields 741 Apache and Longbow Apache helicopters. Acquisition costs total $ 19 billion; operating and support costs for the Longbow Apache are $11.1 billion.[2]

The C-17 cargo aircraft: The C-17 is a multi-engine, cargo aircraft expected to improve Air Force capability to rapidly deploy, reinforce, and sustain combat forces worldwide. The C-17 is capable of carrying outsized cargo over extended distances into unimproved airfields. The C-17 introduces a direct deployment capability that significantly improves airlift responsiveness. Development began in 1982 and the aircraft entered production in 1988 and was fielded in 1993. As of December 2002, the Air Force fielded 96 of 180 aircraft. Acquisition costs total $58.2 billion; operating and support costs, $144.9 billion.

The M-1 series Abrams tank program: This tank is the Army's main battle tank. The M-1's development began in November 1972, entered production in 1979, and was fielded in 1986. The M1A2 is an improved version of the M-1, with improved armor, digital electronics, and an improved commander's weapon station. The Army has fielded over 8,800 M-1 and M1A1 tanks, with about 1,000 upgraded to the M1A2 versions. Acquisition costs total $29 billion; operating and support costs, $16 billion.[3]

For each of the six programs, we interviewed key managers and logistics representatives to discuss how operating and support costs were being managed and controlled during design. For the Joint Strike Fighter program we also visited the prime contractor, Lockheed Martin Aircraft Company, in Ft. Worth, Texas, and interviewed key designers and engineers. We analyzed operating and support cost data contained in *Selected Acquisition Reports* for the Apache Longbow helicopter, the C-17 cargo aircraft, the Abrams tank, the Advanced Amphibious Assault vehicle, Joint Strike Fighter and Landing Platform Dock 17. Information obtained from the *Selected Acquisition Reports* was not always consistent

[2] The operating and support cost for the Apache is not available before 1993.

[3] The operating and support cost for the M-1 series Abram is not available before 1993.

because three of the systems—the Advanced Amphibious Assault Vehicle, Joint Strike Fighter and Landing Platform Dock 17— are still in development. We supplemented information for the development systems with other program cost estimates. We also conducted limited analysis of the B-1, B-2, and F-22 operating and support cost and readiness data, based on information provided by their respective program offices and previous GAO reports.

In addition to the case studies, we reviewed DOD policy, describing the roles and responsibilities of various organizations in the requirements development process. We discussed the implementation of these policies, particularly the role of the logistics community in the requirements determination process, with officials from each of the six program offices listed above, as well as appropriate officials from the

Under Secretary of Defense (Acquisition, Technology, and Logistics);
Air Mobility Command, Scott Air Force Base, Ill.;
437th Airlift Wing, Charleston Air Force Base, S.C.;
Office of the Assistant Secretary of the Army, Washington, D.C.; and
U.S. Army Aviation Center, Ft. Rucker, Ala.

To determine the best practices, processes, and metrics commercial companies use to manage and control operating and support costs, we used a case study methodology by judgmentally selecting companies based upon general literature searches and discussions with experts. On this basis, we identified a number of commercial companies that have a structured and defined process for managing and controlling their operating and support costs. The following are descriptions of the six commercial companies and one quasi-governmental agency we visited:

Boeing Commercial Aircraft designs and manufactures commercial airplanes. In 2001, it reported revenues totaling $58.2 billion. We visited its offices in Seattle, Washington, and discussed the development of the 737, the 767, and the 777 aircraft.

Chicago Transit Authority is a quasi-governmental agency that operates the nation's second largest public transportation system and covers the City of Chicago and 38 surrounding suburbs. In 2002, it reported an operating budget totaling $915 million. We visited its offices in Chicago, Illinois, and discussed the requirements determination process for acquiring buses.

Allison Transmission, a division of General Motors, designs and manufactures transmissions for medium and large vehicles as well as military vehicles. In 2001, General Motors reported sales and revenues totaling $177.3 billion. We visited its offices in Indianapolis, Indiana, and discussed the development process for new transmissions.

FedEx Express delivers packages, freight, and information to its customers worldwide. In 2001, it reported sales and revenues totaling $15.5 billion. We visited its offices in Memphis, Tennessee and discussed their process for setting requirements for a new package delivery vehicle.

Maytag designs and manufactures major home appliances. In 2001, it reported sales and revenues totaling $4.1 billion. We visited its offices in Newton, Iowa, and discussed the development process for new appliances, particularly the Neptune washer and the Wide-By-Side refrigerator.

Polar Tanker, a shipping division of ConocoPhillips Marine, manages the marine transportation of ConocoPhillips' Alaska North Slope crude oil production. In 2001, it reported sales and revenues totaling $26.9 billion. We visited its offices in Avondale, Louisiana, and discussed the development process for the new Endeavor Class tanker, the Polar Endeavor.

United Airlines, a commercial airline division for the UAL Corporation, is a major commercial air transportation company, engaged in the transportation of persons, property, and mail throughout the U.S. and abroad. In 2001, it reported sales and revenues totaling $16.1 billion. We visited its offices in Seattle, Washington; and San Francisco, California; and discussed the product development process and maintenance activities for the Boeing 777 aircraft.

At each of these organizations, we conducted structured interviews with representatives to gather uniform and consistent information about their processes, practices, and metrics for controlling operating and support costs. During these meetings, we obtained a detailed description of the practices and processes they believe are necessary and vital to control and reduce operating and support costs. We met with managers of reliability, maintainability, and new aircraft development; general directors of operations; controllers; directors of configuration and integration; and principal engineers. We did not use examples from Chicago Transit or from Allison Transmissions, but discussions with those firms helped to

refine the commercial model and inform our analysis of commercial best practices.

During the past 5 years, we have also gathered information on operating and support costs from such companies as 3M, Chrysler Corporation, Caterpillar, Bombardier Aerospace, Ford Motor Company, Hughes Space and Communications, and Motorola Corporation. This information enabled us to develop an overall model to describe the general practices, processes, and metrics leading commercial companies take to control operating and support costs.

This report highlights several best practices in controlling operating and support costs based on our fieldwork. As such, they are not intended to describe all practices or suggest that commercial companies are without flaws. Representatives from the commercial companies visited told us that the practices and processes, which we considered best practices, evolved over many years and that the practices continue to be improved based on lessons learned and new ideas and information. They admit that the application and the use of these practices have not always been consistent or without error. However, they strongly suggested that the probability of success in controlling operating and support costs is greatly enhanced by the use of these practices and processes.

We conducted our review between August 2001 and February 2003 in accordance with generally accepted government auditing standards.

Chapter 2: DOD'S Requirements-Setting and Development Practices Yield Higher Total Ownership Costs

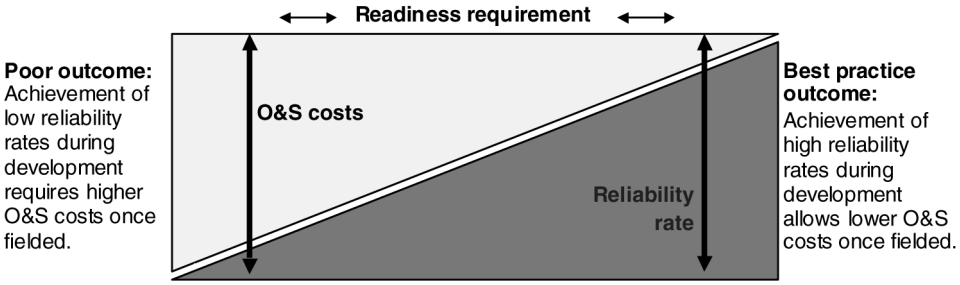
DOD is spending more on operating and support costs for its weapon systems than it planned. We found three primary reasons for the high cost of operating and supporting DOD's fielded weapon systems. These were (1) little or no attention to the trade-offs between readiness goals and the cost of achieving them when setting the key parameters for weapon systems; (2) the use of immature technologies during product development and delays in acquiring knowledge about the design and its reliability until late in development, or in some cases, production; and (3) insufficient data on the operations and maintenance costs and actions for fielded systems that would allow improvements in products currently in development. The outcome of these practices in DOD has been an inability to stem continuous growth in total ownership cost, with actual operating costs continuing to exceed initial estimates. As a result, DOD continues to request more operating and support funding to sustain its systems or reprogram funds from other accounts to pay the bills.

Three key groups are involved in DOD's process to get a weapon system to the war fighter. First, the war fighter's service-based requirements community establishes requirements for a new system. Second, the service-based acquisition organizations design and produce a product. Finally, after the product is developed and produced, it is turned over to the war fighter's operating and maintenance communities, who have the responsibility to operate and maintain it. Decisions made in setting requirements very early in product development have the most impact on the subsequent costs of supporting a system. Trade-offs during the design process can also be significant. In DOD, the focus in the requirements and development process is to establish and meet technical war-fighting performance capabilities, and when trade-offs are made, they are usually to optimize those capabilities. The maintainers often come into this process very late and have little influence. At the end, DOD has no alternative but to pay the operating and support bills that accrue in order to maintain readiness.

DOD's Weapon System Programs Encounter Cost Growth in Achieving Readiness Rates

A weapon system's operating and support cost will depend to a great extent on its performance characteristics, expected readiness rate, and the overall reliability of its design. If a weapon system has a very high expected-readiness rate but its design is not reliable, its operating and support costs will be high and unpredictable. Conversely, if the design has been thoroughly tested for reliability and is robust, the cost to operate and support it will be lower and more predictable. Ideally, there is a balance that customers and product developers can strike between readiness and operating cost. Figure 3 illustrates this balance.

Figure 3: Readiness, Reliability, and Operating and Support Costs



Source: GAO.

A product developer can opt to drive higher reliability into the product during its development by reducing technical requirements, using highly reliable and proven components, or investing more in early testing. Those decisions would increase the product's reliability and consequently improve prospects for readiness and reduce operating costs across the life cycle of the product.

We reviewed five weapon system programs currently in the field and found that most had experienced significant growth in their estimated operating and support cost. We also found that none of the programs established goals for readiness or operating and support cost as key parameters for the weapon system prior to launching the acquisition program. In addition, we found that once fielded, some systems were not achieving the readiness rates that program officials thought were possible during development. Table 1 shows whether systems had specified readiness and operating and support cost goals as key requirements as well as the growth in operating and support costs that the systems have experienced within the last 12 years.

Table 1: Readiness and Operating and Support Costs for Selected Weapons

Weapon	System readiness as a key parameter	Operating and support cost goals as a key parameter	Readiness planned/actual	Percentage growth for operating and support cost
Apache	No	No	62/73 %	48 %
Abrams	No	No	90/93	24
C-17	No	No	92/84	25
B-2	No	No	70/42	35
B-1	No	No	67/64	16

Source: DOD (data), GAO (analysis).

While some systems have maintained their expected readiness rates, they have experienced between 16 and 48 percent growth in estimated operating and support cost. It is reasonable to conclude that the systems have not achieved the reliability rates that were needed to meet their expected readiness goals and, as a result, had to expend more funds on parts and labor in the field than were planned for maintenance. Two of the systems, the Apache and the Abrams, were designated as the Army's most expensive weapons to support. The C-17 has already experienced a cost growth of 25 percent in its operating costs, but program officials stated that they would not have a firm estimate of operating and support costs until 2010—more than 25 years after the start of development.

DOD's Linear Acquisition Approach Makes It Difficult to Control Operations and Support Costs

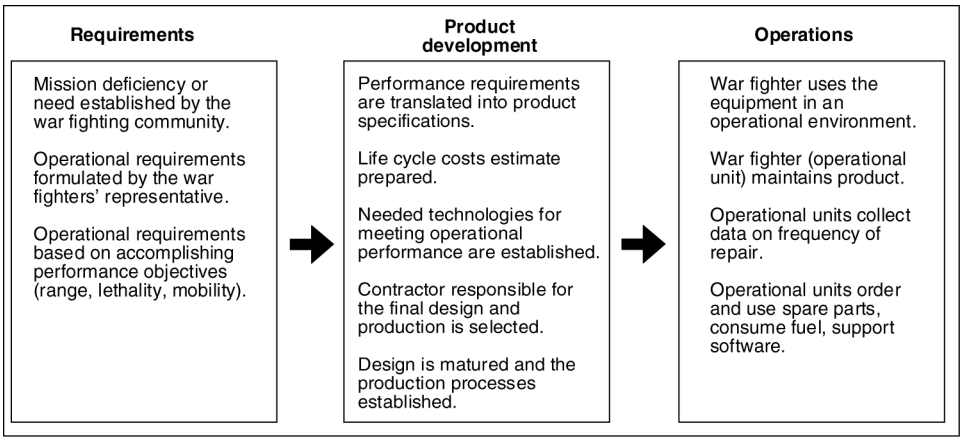
Traditionally, DOD has used a linear approach to setting requirements and developing a product. It focuses attention during product development on achieving revolutionary performance goals while trying to keep acquisition costs for a program as low as possible. Often, it is not until the system is fielded and responsibility shifts to other agencies or the services that the operating and support costs become an overriding concern. By this time, there is no alternative but to pay the bills that accrue to maintain readiness, no matter the cost.

Three key groups are involved in DOD's process to get a weapon system to the war fighter. First, requirements representatives from the war-fighting community establish a need for a new system, and the combat developers formulate a set of operating performance requirements to address the need. Requirements concerning how available the system must be and the cost to operate and support it are not considered key performance parameters. Second, DOD establishes an acquisition program office to begin product development and coordinate design development and production with the defense contractor. Often, the technologies and components needed to achieve tough performance requirements are new

and unreliable; however, the program manager is responsible for developing and producing the weapon system within certain acquisition costs and schedule guidelines. Third, after the product is developed and produced, the war fighter has the responsibility to operate and maintain it. Although decisions made in setting requirements very early in product development have the most impact on the cost to support the system, the personnel who maintain it have less influence on the product development process because the focus is on achieving difficult performance requirements.

Figure 4 briefly describes DOD's process for managing a new weapon system's requirements development, acquisition, and fielding. The most notable aspect of the model is that there is little communication or input from the maintenance community early in the process—during requirement setting and product development—when decisions will be made that will significantly influence the cost to maintain and support the weapon system. The model shows that, traditionally, DOD's processes are separate and independent of each other. First, requirements are set independently of the maintainers and the product developers. Second, once the product development process begins, the focus is on maturing technologies and achieving a producible design that will meet the technical performance requirements for the weapon system. Finally, the operator is tasked to use and maintain the system that has been developed and produced.

Figure 4: DOD's Linear Acquisition Process

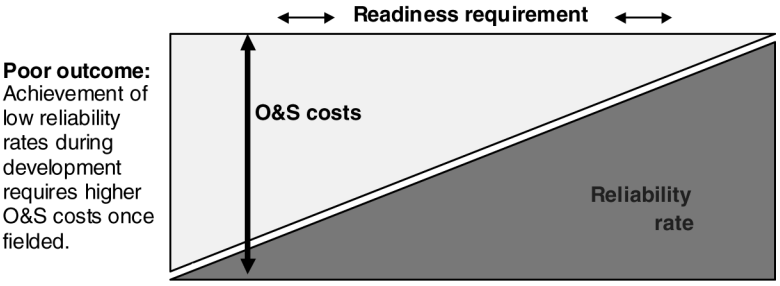


Source: GAO.

The goal of this process is to field a high-performing weapon system that will satisfy the needs of the war fighter better than any other weapon system available. We previously reported that competition for limited funding both within and among the services leads to performance requirements that will make the particular weapon system stand out from existing or alternative systems. [1] Those that provide the greatest leap forward in promised performance stand the best chance of winning the funding. As a result, the design for the weapon system is usually based on undemonstrated components and subsystems that, when integrated into a weapon system, have low reliability and, ultimately, high operating and maintenance costs over their lifetime. Figure 5 illustrates this phenomenon. The demonstrated reliability of the new system is lower, causing an imbalance in the relationship between readiness and operating cost toward the need for higher costs to maintain readiness.

[1] U.S. General Accounting Office, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001).

Figure 5: System Readiness Comes at High Operating and Support Costs When Reliability Is Not Ensured



Source: GAO.

Logistics officials at Air Mobility Command told us that even though they are represented in the requirements determination process for new weapon systems, they view their role as providing input on how the logistics community could support performance requirements of a new system, not on forcing trade-offs that would reduce operating and support costs. The officials also said that the logistics community leads many reliability improvement and cost reduction initiatives once aircraft are fielded. However, this approach is harder and more costly to implement than if reliability and operating and support costs had been considered when requirements were set and product development began. Further, the program must compete against other programs for operating and support funds to implement the upgrades and improvement initiatives.

Operating and Support Cost Estimates Are Provided Later in DOD's Process

Supportability aspects of system performance, such as operating the system at the lowest possible cost and the percentage of time the system has to be available for operations, are not given the same high priority as enhanced performance. Operating and support costs are not estimated until much later in development. For example, the B-2 bomber, Apache helicopter, and Abrams tank programs did not publish an initial estimate for the operating and support costs for those weapon systems in the *Selected Acquisition Reports* until more than 15 years after the start of development. The C-17 program did not publish an estimate until more than 7 years after development began. These estimates were not in the form of goals or key performance parameters. Throughout product development, then, design goals for reliability are not supported by the war fighters' need to meet operating cost and availability goals.

Maturing the Technology Is the Focus of Development

In DOD, requirements for new weapon systems are usually based on the enhanced performance deemed necessary to achieve a certain war-fighting mission with little hesitancy in using new technology or what the cost to support it may be. The user representatives define system performance with limited input from the product developers and maintainers.

A case in point is the B-2 bomber. The low-observable requirement for the B-2 bomber could only be met with technology that was immature at program launch, and this technology continued to cause problems throughout development, production, and fielding. The B-2 program began full-scale development in 1981, and the Air Force began low-rate initial production concurrently with development in November 1987. By 1991, problems with the B-2's low-observable material were still being reported, causing delays in delivery and cost increases because the material was difficult to manufacture. Once fielded, the low-observable materials required very high maintenance. The processes to repair them were time consuming and required an environmentally controlled repair facility. Poor durability and extensive maintenance kept the aircraft from achieving its planned availability. All of these factors are due to decisions to proceed with product development without understanding this technology.

A more recent example is the F-22 fighter. The requirements for the F-22 were very demanding. Performance characteristics included low observability, super cruise speed, and fused avionics. These requirements caused the product design to include many new and unproven technologies. During product development, the program planned to achieve a system-level reliability rate for the F-22 of 3 flying hours mean time between maintenance actions when fully mature. The Air Force had estimated that in late 2001, when the F-22 entered limited production, it should have been able to demonstrate almost 2 flying hours between maintenance actions. However, when the F-22 actually began limited production, it could only fly an average of .44 hours between maintenance actions. In other words, the F-22 is requiring significantly more maintenance actions than planned. To date, the program has identified about 260 types of failures, such as main landing gears wearing out more quickly than planned, fasteners being damaged, and canopy delaminating, all leading to unanticipated operating and support costs.

Product Development in DOD Goes Forward in Spite of Poor Prospects for Reliability

Our previous work identifying best practices during product development concluded that during this phase, the tasks are to ensure the stability of the design and to ensure that the product can be produced.[2] In DOD, the product developer frequently is trying to catch up to design and production tasks because product developments begin with immature technology. Schedule concerns override the need to capture knowledge about the design and production processes, and programs often proceed through development and into production before the reliability of the subsystems and systems has been demonstrated. Design features such as open architectures that allow systems to receive upgrades as technology advances or reductions to the number of parts in a design that reduce the need for spare parts and maintenance time are not given due consideration, even though they could lower operating and support costs of the system.

As the schedule tightens, the lack of knowledge becomes more acceptable, even preferred. Reliability testing is often pushed closer to fielding, resulting in supportability problems being identified during operational testing. The Office of the Director, Operational Test and Evaluation has commented that operational testers identified reliability as a problem in almost every program, because the product developer places more emphasis on performance requirements than suitability. According to the operational testers, many systems enter operational test and evaluation with known, but unresolved reliability problems.

Once a system is fielded, unless the reliability and ease of maintenance have been incorporated into the design already, there are limited opportunities to improve these metrics without costly redesign or retrofit. As the product's design becomes firm and the system is produced and fielded, the opportunities to influence these costs diminish. For example, the Army is currently attempting to reduce operating and support costs on its Apache helicopter and its Abrams tank. These efforts should have a favorable impact on the systems' operating and support costs. However, the Army is retrofitting and replacing components that were identified as problems much earlier in the programs. Examples from the Apache and Abrams development illustrate the problems.

[2] U.S. General Accounting Office, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002).

Figure 6: Apache Helicopter

Source: DOD.

The Apache program focused on acquisition costs, schedule, and performance during product development, even when problems were identified that would impact reliability and maintainability. Today, the Apache helicopter is the Army's most costly system in terms of operating and support costs with those costs rising over the years. For example, the target acquisition and designation system enables the Apache to find

targets and guide its weapons. It is the helicopter's most sophisticated system, involving 26 major electrical, optical and mechanical components. However, the sight requires frequent maintenance, and its complexity reduces its reliability. The pilot's night vision system is also a highly complex system that experienced problems in development. Because its target acquisition and designation system and the pilot's night vision system proved unreliable, the Apache incurred higher than expected costs to maintain the helicopter's availability.

During development, problems identified with the Apache foreshadowed future support problems. These problems included excessive vibration and excessive aircraft weight in addition to difficulty in achieving reliability rates for the aircraft's target acquisition and designation system. During development, problems with the Apache's fault detection system led to questions concerning whether it could operate safely and reliably during operations. Further, Army test and evaluation agencies warned that these problems could cause serious supportability issues since they would result in frequent need for maintenance and repair. By 1990, the majority of the Apache helicopters had been produced and fielded, but Apache could achieve only 50 percent availability rates, well short of their 70 percent goal. Tests showed that the Apache required maintenance actions to correct significant problems every 2.5 flying hours while the Army's goal was 4 hours between failures. Maintenance units were physically unable to handle the repairs required to keep the helicopter flying. Subsequently, the Army added 18 maintainers to the Apache battalion, constructed more contractor repair facilities, and hired more contractors. During Operation Desert Storm, although the system was effective in destroying tanks and other targets, it continued to experience reliability and logistical support problems that grounded some aircraft.

Figure 7: Abrams Tank

Source: DOD.

Likewise, the Army produced the Abrams tank without first resolving reliability problems. The tank provided a major improvement in speed, agility and lethality over the older M-60 tank and was also supposed to decrease the operating and support cost burden. However, during development, the tank experienced serious failures with the track, the engine, fuel filters, the fuel and water separator, and the fuel pump. In particular, the durability and reliability of the Army's turbine engine was a major concern. Tests performed up to the time of the initial production decision showed that the tank generally met its performance requirements. However, frequent breakdowns and component failures raised serious questions about approving the tank's production. In a 1993 operational test report from the Office of the Director, Operational Test and Evaluation, the reviewer concluded that the tank was operationally effective, but not operationally suitable because of its many support problems such as those mentioned above. Today, the Abrams is the second most costly Army system in terms of operating and support costs and accounts for half the repair parts costs by the entire ground combat fleet. The tank engine is a major contributor to the tank's high support costs. In recent years, the operating and support costs for the Abrams have remained steady at about

$2 billion per year, although the Army has reduced the number of tanks to be supported by more than 300.

Data on Operating and Support Costs Is Not Reliable

When estimating operating and support costs for a new weapon system or trying to establish maintenance trends, maintenance data on the current system are an important source of information. However, the three services' operating and support data collection systems do not provide accurate and reliable information about the cost to operate and maintain the systems because they do not collect and maintain data on all elements of the weapon system's operating and support cost. Without reliable information, the services cannot assess trends or identify top cost drivers and take corrective action.

The Army's Operating and Support Management Information System provides historical cost data on Army weapon systems and is the primary source of operating and support data used by the program managers to project costs of new systems, forecast spare parts budgets, and generally manage their programs. The Army uses this data system to develop its operating and support cost budget for weapon systems for consumable items such as repair parts, petroleum, oil, lubricant, fuel, and ammunition as well as for some maintenance. However, the system does not provide a complete and reliable basis for developing and reporting the costs of weapon system support. The data are often incomplete and 12 to 18 months out-of-date. Several important cost elements used to establish the Army's operating and support budget estimates—such as contractor logistics support, supply maintenance and software support—are not included in the database.

The Navy's central tracking system for operating and support costs, like the Army data collection system just described, provides historical cost data on weapon systems. Navy program officials told us that this data is often inaccurate and cannot be relied upon to pinpoint causes of failure or maintenance actions.

Until recently, tracking Air Force operating and support costs was difficult because the cost data were unavailable in a usable format or were of poor quality. Poor cost data weakened operating and support cost estimates. In 1998, the Air Force set up a total ownership cost database, with the objective of providing accurate and reliable data to identify cost drivers and support decision makers in making improvements to fielded aircraft. However, the new system is not available at all aircraft maintenance locations, and therefore data may not be complete. In any case, the Air

Force will need several years of cost data before it can evaluate the effectiveness of the system.

Chapter 3: Commercial Companies Deliberately Manage Ownership Costs through Product Requirements and Design

Leading commercial companies consider the total ownership cost of a new product, including its operating and support costs, integral to their new product development decisions. Companies that use airplanes, trucks, and ships to deliver goods and people such as United Airlines, FedEx Express, and Polar Tanker understand the importance of maintaining the readiness of their fleets at as low an operating cost as possible. Reducing these costs results in increased revenues, profits, and market growth. Increases in these costs, on the other hand, can result in failure. The companies also understand that unless reliability is designed into a product, there are limited opportunities to improve readiness and reduce cost without costly retrofit or redesign. They have been successful in reducing these costs because they developed a collaborative process with companies that develop those products, such as Boeing, for setting the product's requirements, developing the product with operating and support costs in mind, and capturing accurate operations and support data once it is delivered.

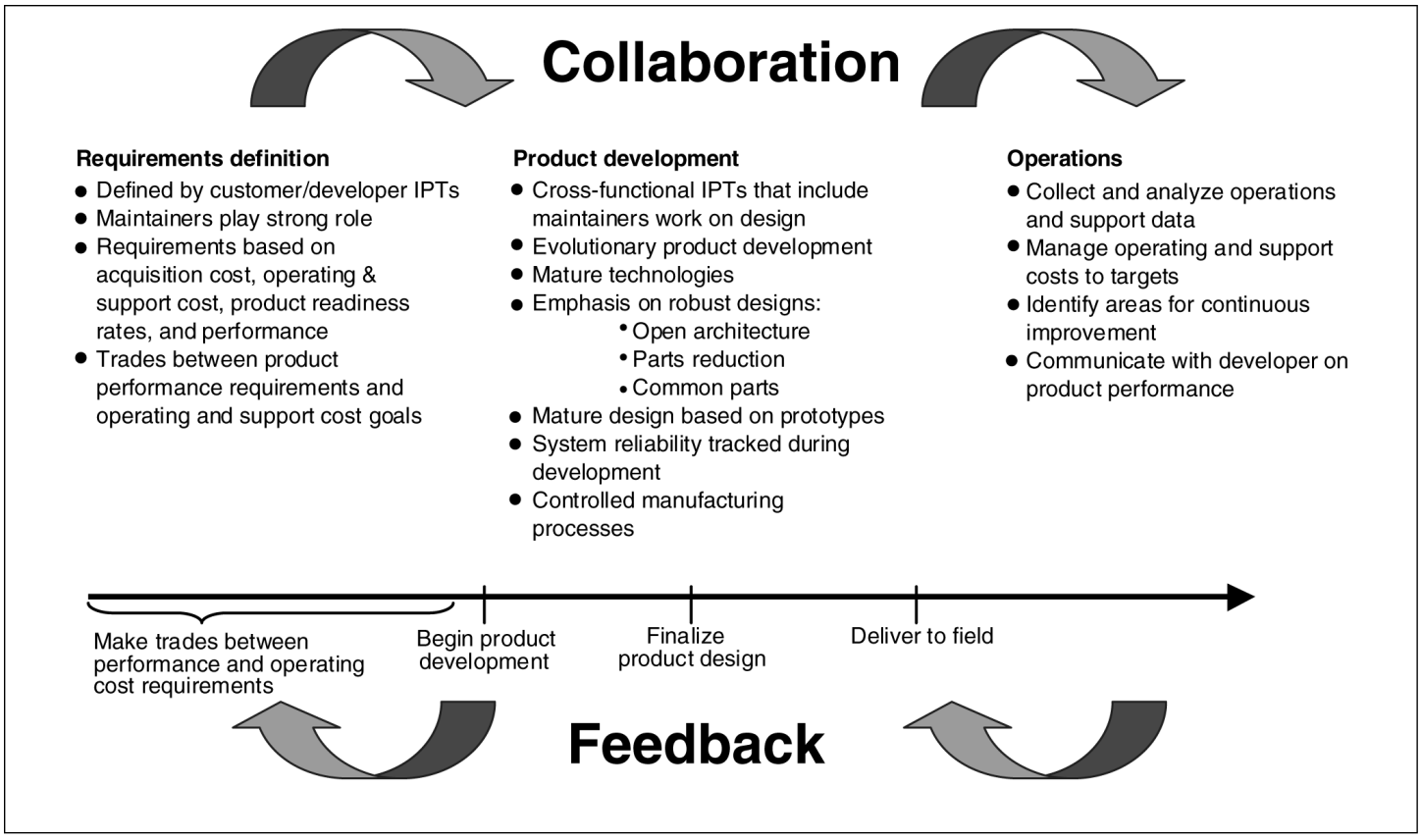
The companies we visited that bought products all established the product's operating cost and its availability as requirements equal to its performance characteristics prior to product development, thereby ensuring that the developer placed priority on those goals during product development. They were amenable to reducing the product's performance features to reduce its operating cost, as long as performance was within acceptable limits for achieving market objectives. They also considered bearing additional cost for the product's design if it resulted in a net benefit from reduced operating costs. Once product development began, maintainers had a strong voice in the product's design and leading product developers set high reliability standards for components they chose, using proven technologies to achieve performance requirements. Companies, such as Boeing and Maytag, chose an evolutionary approach to product development to achieve goals for life-cycle costs, testing extensively and early for reliability. These companies also emphasized other practices to reduce operating costs such as reducing the number of parts in a product's design, using standardized parts, and using open systems to ease maintenance and maintain competition. Once the product is delivered, maintainers keep detailed records on its reliability and maintenance and provide that information to the developer to improve future products.

A Best Practices Model

Figure 8 represents a model of the best practices that were most helpful to the companies we visited in achieving high reliability and reducing a product's operating and support costs. Notably, the most critical events—those that have the most impact on a product's operating and support

costs—take place very early, either prior to product development when the product's key requirements are established, or very early in product development before the design is finalized. Another notable aspect of the model is that each of the activities—requirements-setting, product development, and operations—depend on clear and constant communication and collaboration among the customer, the product developer, and the maintainer from the time a product is conceived until the operator disposes of it.

Figure 8: Commercial Model for Reducing Operating and Support Costs

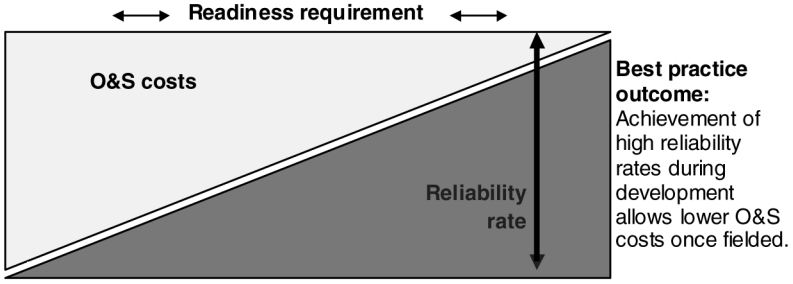


Source: GAO.

The goal of this process is to develop and field a product that will perform in accordance with the customer's needs and will be ready when needed within cost targets. As illustrated above, decisions about the product's performance and cost are finalized prior to beginning the product's

development, and the costs to operate and support the product are key considerations. Once the requirements are set, the product developer can focus as much on achieving a reliable and robust design for the product as on achieving its performance goals. Finally, once the product is fielded, those responsible for its operation and maintenance continue to feed information back to the developer to improve future designs. Figure 9 illustrates what happens when the commercial firms we visited set requirements that force the product developer to consider reliability rates during design. When both operating cost and readiness are key requirements for the product developer, the developer focuses on using as many components and subsystems as possible that have demonstrated reliability rates. The customer, by demanding readiness at a certain cost as a hard requirement upfront has raised the importance of achieving it from the very start.

Figure 9: Benefits of Ensuring High Reliability Rates During Product Development



Source: GAO.

Leading Companies Treat Readiness and Operating and Support Cost as Critical Product Requirements

We visited three companies—Polar Tanker, an operator of large oil tankers; United Airlines; and FedEx Express—to determine their practices for ensuring low operating and support costs from the equipment they purchased from product developers. All three companies believe that understanding and controlling the cost to operate and support a product while it is being designed is essential to driving down the total ownership cost of a product. To do this, they set requirements for a new product's availability and its operating and support costs equal in importance to requirements for its performance and acquisition cost. We found these companies set requirements before development begins that their products be ready almost 100 percent of the time at the lowest operating cost possible. They typically set maintenance goals that drive operating and support cost decisions, such as maintenance cost per mile

over a product's lifetime. The following summaries illustrate the commercial processes.

Figure 10: Polar Tanker's Polar Endeavor

Source: Conoco Phillips Marine.

Polar Tanker

Polar Tanker is a commercial oil-transporting firm that recently decided that a new oil tanker was necessary to haul oil between Prince William Sound and Puget Sound. The company's critical requirements for the new Endeavor tanker, which Polar Tanker believed would reduce the cost of delivering oil, were

- less expensive operations and maintenance over a 30-year life cycle (versus the industry standard of a 20-year life cycle); and
- availability for operations at least 330 days a year.

Polar Tanker teamed its maintenance engineers with industry consultants to ensure these requirements were met. The procurement team relied on its archived maintenance data from previous Alaskan operations to develop its double-hulled tankers. It documented locations, lengths and types of fractures, and stresses in the structures of its existing inventory of ships. This documentation from past operations was used to determine structural changes required to reduce maintenance on the new Endeavor class. As a result of their record keeping and the constant communication with the product developer, Northrop Grumman's Avondale Shipyard,

Polar Tanker's owners were successful in redesigning their ships and meeting their requirements for improved performance, reliability, and lower operations and maintenance costs.

The dual requirement of reduced operating and support cost coupled with high readiness rates drove design trades that increased development costs but improved reliability. For example, once Polar Tanker's procurement team identified ballast tank maintenance as one of the most significant maintenance burdens, it directed Northrop Grumman to use the best and most expensive epoxy coatings and specialized paints to protect the tanks from corrosion. Another design trade—adding additional structure to the ship's hull to reduce the impacts of fatigue cracking—increased the acquisition cost of the tanker but improved reliability and reduced the need for maintenance. Polar Tanker accumulated data from its current fleet and conducted extensive modeling of the hull design to understand where the most critical cracking occurred and to identify operating and support cost drivers. It hired an engineering consulting company to conduct further analysis. As a result, Polar Tanker and Northrop Grumman utilized the most current design tools to optimize the ship's structure. Polar Tanker also developed a list of equipment and suppliers based on reliability analysis and incorporated that list into the design contract with Northrop Grumman. Polar Tanker estimated that these design trades cost about $25 million in additional design costs, but they believe the changes will ensure its tankers will be able to operate more reliably over 30 years.

Polar Tanker's procurement team also required that the new Endeavor Class design use open systems when possible. It worked closely with Northrop Grumman, its contractor, to ensure requirements for an integrated bridge system that consisted of commercial-off-the shelf components with open systems to provide the capability to modernize the system much less expensively as technology improved. For example, systems in the tanker's wheelhouse including the autopilot, marine radars, bridge control console, and satellite communication equipment used the open systems concept. The design also included easily accessible decks to minimize delays and disruption during maintenance. Polar Tanker has already upgraded its electronics since putting its first ship, the Polar Endeavor, into service and experienced minimal disruption in operations.

Figure 11: United Airlines/Boeing 777

Source: United Airlines.

United Airlines

As the launch customer for the new Boeing 777, United Airlines established stringent requirements for aircraft readiness and operating costs, thereby ensuring that reliability would be an important design element. When United and Boeing negotiated the requirements, United stated that it wanted a twin-engine airplane that could fly extended ranges from any airport in the United States. In addition, United required that the 777 be available at the gate for departure within 15 minutes of scheduled departure 98.5 percent of the time. Boeing guaranteed United that the 777 would meet the departure requirement by the third year of operation or Boeing would pay a financial penalty. According to United officials, the 98.5 percent rate was achieved by the third year. United also specified that operating and support costs for the 777 be no higher than on past airplanes. The agreement reached with Boeing was that Boeing would reimburse United for revenues lost as a result of airplanes being unavailable. By setting requirements for operating cost and readiness,

United ensured that Boeing would build reliability into the design of the 777.

Boeing brought together a working group of customers—the leading commercial airlines—to discuss requirements for the new design. Boeing officials told us that during those requirements meetings the participating airlines defined major design initiatives for the Boeing 777 based on estimates of life-cycle costs. Initially there were differences among the airlines as to what exactly was needed on the new aircraft—from wider fuselages to additional electronics—but from the very first meeting, the airlines were all equally concerned with operating and maintenance costs. They were focused on designing an aircraft that would be easy for mechanics to repair. The airlines unanimously agreed that an airline maintenance representative was needed to adequately address operations and maintenance requirements. Boeing named a chief mechanic who had previously worked for United to the working group that was influential in defining the maintenance requirements. Although Boeing provided its customers engineering estimates for the operating cost of its new aircraft in comparison to the older model, United officials said they developed their own estimates based on its historical experience with Boeing aircraft. United officials said that having two perspectives from which to consider its purchase was helpful.

Figure 12: FedEx Express Delivery Van

Source: FedEx Express.

FedEx Express

The FedEx Express mission is to provide global air and ground transportation of high-priority goods and documents that require rapid, time-certain delivery. This mission demands high availability and reliability from its delivery equipment. In purchasing its newly designed fleet of delivery trucks, FedEx Express considered reliability, maintainability, and low operating and support costs to be critical measures of a successful acquisition. For example, improving availability and reliability were the key drivers in its acquisition of the new 700 cubic foot truck. FedEx Express collaborated with a product developer, Freightliner, to set the requirements for a newly designed vehicle with high reliability and endurance to withstand frequent stops, short travel distances between stops, and demanding use of the brakes. During the requirements-setting process, they also established cost and reliability requirements for the new truck that estimated an assumed number of stops per day, a certain number of miles per year at an assumed cost per mile.

To make sure all costs, particularly operating and support costs were considered during product development, FedEx Express had a logistics

manager lead their discussions with Freightliner for the development of the new truck. The FedEx Express logistics managers told us that they are required to reduce the company's operating and support costs, and the company believes that it is essential to give these managers an integral role during these discussions. The new delivery truck has been successful in meeting its reliability and maintenance goals. The truck currently averages 70,000 miles between breakdowns and is operating within the cost per mile of service that was set as a requirement by FedEx Express at the beginning of development.

Knowledge-Based Product Development Is Critical to Achieving Desired Reliability and Managing Operating and Support Costs

To meet the readiness and operating and support requirements that their customers demanded, we found that product developers focused on designing a product that was durable, easy to maintain, ready when needed, and reliable at low cost. They used an evolutionary development process to meet these requirements and did not allow components or subsystems into a product's design unless their reliability had been proven through past use or testing. Boeing told us that it makes the reliability ratings of its components available to the airlines before it begins product development, and Maytag did extensive reliability testing on every new product prior to going to production. The companies also emphasized product designs with fewer parts and used open systems architectures as much as possible. Developers also gained valuable insight into design features their customers valued that drove down operating and support costs. For example, the design for Boeing's latest generation of the 737—geared toward reducing operating costs—was inspired by the airlines' request for more affordable operations and maintenance.

Once defined, the functional and operating and support requirements are tightly managed and controlled to minimize scope increase during product development. Companies work within a common framework to provide management oversight and control. To move a product successfully from concept to operations, the companies we visited used a "gated" product development process and firm criteria to dictate when a product is ready to exit a stage. The design reviews address all operating and support cost requirements of the products. Senior management review teams grant product approval at each gate only after determining that business cases adequately address major drivers of operating and support cost as well as reliability goals.

Boeing

Boeing uses a structured, gated product development process to define, evaluate, and approve projects and to integrate new technology into its

aircraft. This process separates technology development from product development programs. In fact, Boeing keeps immature or untested technologies in a research and development phase until they have been tested for reliability in a realistic environment. The process forces the company to obtain purchase agreements from customers and build a business case that shows the expected profitability of a product line before detailed designs are developed and a large dollar investment is made in manufacturing. In order to get these purchase agreements, Boeing product teams work collaboratively with potential customers to set requirements for readiness, reliability, performance, acquisition costs, and operating and support costs. Because aircraft are large capital investments, customers are working with other developers to make sure that the competitive forces of the market will help them get the best aircraft at the lowest cost.

Boeing officials told us that to remain competitive in this environment, they focus on meeting customer requirements at the highest reliability leading to the lowest operating and support cost possible. For example, when it was designing the new 737, Boeing used maintenance records to prove to the airline that they could redesign the 737 with high reliability and reduced operating and support costs, a key market requirement for that aircraft. According to Boeing officials, they prepared a comparative analysis of the acquisition and operating and support costs for older 737 aircraft with the estimated costs for the 737 Next Generation. This analysis showed that operating and support costs were significantly lower for the proposed next generation 737 and resulted in big savings to the customer. Boeing was able to develop good operating and support cost estimates for potential customers because it used an evolutionary approach for developing new aircraft. This approach allowed Boeing to improve performance and to insert new, reliable, and mature technology.

Once a new product line is approved, Boeing continues to work with its customers to identify improvements that can be made to an aircraft in terms of parts reduction, parts standardization, and ease of maintenance. For example, Boeing formed four airline working groups with representatives from 21 airlines around the world to focus on maintainability, interiors, power plant, auxiliary power units, and common display system issues on the 737. Their objective was to collect feedback from operators on design changes that would reduce maintenance costs. Examples of airline-driven design changes include

- simplifying the wing flaps by eliminating one third of the parts, designing a simpler flap mechanism, and making parts removable with common grip length fasteners;

- reducing engine removal and installation time by increasing the on-wing life of the engine by 40 percent and reducing the predicted change time from 12 hours to 6 hours; and

- improving the reliability and standardizing parts of the fuel system by using a fuel shutoff valve that is common with other aircraft.

To facilitate and improve communication with its customers, Boeing oftentimes collocates customer representatives at its production facilities. Boeing has found that involving the customer in early design decisions improves their ability to design a reliable aircraft that is easy and less costly to maintain. For example, when it began developing the 777 aircraft, airline maintenance workers offered over 5,000 suggestions for changes to the design based upon their experiences with other Boeing aircraft. These suggestions helped reduce parts and improve reliability of the 777, resulting in increased time between maintenance actions. Boeing also utilized the concept of open systems to reduce the total ownership cost of the 777 by allowing customers to choose from three different types of engines—GE, Pratt & Whitney, or Rolls Royce—depending on their needs.

Maytag

Maytag follows a similar product development process. For Maytag, the most critical phase is when design specifications for product reliability and manufacturing feasibility are fully defined and understood. Early in its product development, an integrated product team takes all new product features through rigorous reliability growth analysis to determine what can be expected from the design and whether it will be able to meet the requirements. Maytag uses failure analyses, mock-ups, and other simulation tools to focus testing on the most critical elements of the new design and reduce the number of design/build/test iterations of the product. Even though these analyses require more upfront planning, Maytag officials stated that they still cut testing times in half and yet improved reliability and lower costs.

During this phase, Maytag employs two project leaders, both a marketing manager and technical systems engineer, to conduct cost performance trades and co-chair subsystem design reviews. As a result of this co-leadership, most design issues are resolved immediately, and 80 percent of all reliability testing and cost reductions take place early in

the process. Also, during this phase the project leaders present their strongest business case, fully disclosing feasibility data, product definitions, and estimates of life-cycle costs for team approval. The team uses this information to make the critical product development decision to commit further to product development or kill a product idea. Maytag officials stated that their company has a quality image to uphold and that consumers expect the highest reliability and quality from their products.

Maytag officials were also conservative in their use of new technologies during product development. Decisions to incorporate new technology were made in the earliest phases of product development and were based on assessments of the adaptability and maturity of the technology and associated risks to achieving established reliability targets. Even though its Neptune washer incorporated over 90 percent new technologies in its development, Maytag officials stated that they spent time with suppliers and developers, maturing technologies to an acceptable level of reliability before launching the new development.

Leading Commercial Firms Use Feedback from Operations to Better Understand Customer Needs, Product Deficiencies, and Operating and Support Costs

The collection and analysis of the operating and support costs for delivered products was considered essential by leading commercial companies. Once a product is fielded, leading companies track actual operating cost, reliability of parts, and readiness of the product against what was estimated during product development to make sure the company is getting what it paid for. We found companies are always identifying the top drivers of operating and support cost and working with the manufacturers to reduce these costs. When there are part failures, the companies can quickly identify whether or not they are under warranty and get the part replaced.

All of the companies we visited, customers and product developers alike, had very collaborative processes and practices for drawing extensively on data from current and past operations to improve the reliability of existing products or influence the design of new products. United Airlines officials told us that the airlines and Boeing both keep meticulous reliability and cost records at all levels of the 777: components, subsystems, and the system level. Major operating costs drivers are tracked on a daily basis by the airlines. The manufacturers usually have personnel residing with the airlines' maintenance crews to help solve problems on the spot and, just as importantly, feed information back to the manufacturer so that the next product can be improved. FedEx Express and Polar Tanker both emphasized extensive collection of data from current operations. In fact, FedEx Express sets annual targets for operating and support

cost reductions based on reliability data gathered on the road. Polar Tanker gathered maintenance data from past operations to determine areas that could result in higher reliability and lower maintenance costs in designing the new tanker.

United conducts quarterly meetings for each of its fleets to discuss open issues and short-term and long-term solutions to current problems with operational aircraft. Attendees at the meeting include maintenance mangers, financial representatives, representatives of the manufacturers, and executives with authority to resolve issues. United's practice is to resolve problems as expeditiously as possible, no matter how small. United also monitors flight movements on a real time basis through a computer system that tracks each aircraft by tail number. The monitoring system provides the maintenance history of the aircraft, reports problems on a current flight that require maintenance upon landing, and alerts for other required maintenance based upon the number of flying hours on the aircraft. If a specific part is broken, the system also indicates whether or not it is under warranty. United archives information on parts that break, when they break, and whether they are still under warranties.

Manufacturers like Boeing and other major suppliers like this type of feedback because it provides useful information to them on how to improve the product for future iterations. They also believe that quick responses to customer problems will help them get repeat business. They use this feedback to develop preventive maintenance schedules, better estimate operating and support costs, and refine reliability requirements to be used in preparing budgets and cost estimates for future products. Feedback mechanisms also accumulated operations and maintenance data and "lessons learned" that highlighted reliability problems and other maintenance issues. United officials stated that taking lessons learned from data gathered from current products is an effective tool for improving product reliability and maintainability or developing requirements for new products.

FedEx Express takes any failure to meet its on-time delivery goal very seriously and holds daily failure analysis meetings every morning to analyze and review each delivery failure from the night before. This constant feedback allows them to take immediate corrective action on individual vehicles and to identify trends that may result in larger problems and costlier maintenance requirements. FedEx Express maintained a metric for vehicle miles between road calls and maintenance costs per asset. In addition to tracking these costs per asset, FedEx Express has established a performance goal with its managers to reduce

the overall costs of maintenance each year. FedEx Express managers set their annual targets for reductions in operating and support cost based on reliability data gathered on the road.

Chapter 4: Stressing Operating and Support Cost at the Outset of an Acquisition Could Help DOD Reduce Total Ownership Costs

DOD and the commercial companies we visited have policy goals of developing products that will meet customers' needs at the lowest possible cost to build and operate. The difference between them is in how each implements its policies. Leading commercial companies follow an integrated, collaborative process of setting requirements, developing the product, and ensuring that the product can be supported at an acceptable cost. DOD's process is composed of disparate practices carried out by separate organizations with differing objectives and little communication between them about how to support fielded systems. While commercial firms focus on total ownership costs at the outset, DOD focuses mostly on technical performance. One cause of this is that in DOD the accountability and responsibility for total ownership costs are spread across many organizations with separate goals. Another cause lies in motivation for low costs. The commercial companies we visited are driven by the need to be as profitable as possible to survive, and low total ownership costs translate to higher profitability. DOD's environment does not provide such incentives. The organizations charged with acquiring and operating weapon systems are unconstrained by a need to lower costs since they can request additional operations and maintenance funding to keep systems working.

From time to time, DOD stated the need to lower its total ownership costs in policy documents and in annual budget statements; however, it has not been successful because it does not have an environment that demands collaboration and accountability in setting requirements and developing products with operating costs in mind. DOD has some efforts underway to improve. First, it has rewritten its acquisition and requirements generation policies. Second, a few programs now in development established an early estimate of operating and support costs and are working to gain knowledge of the impacts of requirements and design on those costs. Third, information from pilots on fielded systems, if disseminated throughout the acquisition community, could be used to lower costs. Results are pending.

What DOD's efforts do not do is provide incentives to make investments for more reliable, less-costly-to-maintain systems at the beginning of an acquisition. Instead, DOD provides incentives to field systems with unknown reliability by allowing whatever funding necessary to operate and maintain the systems once they are fielded.

Differences in Practices Explain Different Outcomes for Commercial Companies and DOD in Controlling Total Ownership Costs

In Chapter 3, we discussed our findings that leading commercial companies set specific requirements for readiness and operating and support costs prior to initiating product development that forced developers to design products with a high degree of reliability. In Chapter 2, we noted that DOD, on the other hand, typically focused its requirements on revolutionary performance that often forced developers to mature technologies at the same time they were completing detailed design work. As a consequence, system reliability often suffered, forcing the department to spend a great deal of money to maintain and repair fielded systems in an effort to achieve desired readiness levels. The following table provides a comparison of the specific practices used by commercial companies we visited and DOD programs we reviewed to address operating and support costs early in a new product's life cycle.

Table 2: DOD and Commercial Practices for Controlling Operating and Support Costs

Commercial prevailing practice	DOD prevailing practice
Practices used to set initial product requirements	
Operating and support cost goals as a key requirement.	Operating and support cost goals are not established as key parameters.
Readiness a key requirement.	Readiness is not a key parameter.
Trade performance for reduced operating and support costs, if appropriate; sometimes results in increased costs.	Technical performance is sometimes traded using cost as an independent variable, but cost is usually production cost or development cost, and the trades occur during the design phase.
Direct relationship during requirements-setting between the user and the product developer.	User and product developer separated by user representative and government program office.
Practices used during product development	
Provide detailed operating and support cost estimates early in product development.	Operating and support cost estimates not required until product development launch.
User and developer focus on ways to reduce product parts and standardize parts across product lines.	Product developer has responsibility of focusing on ways to reduce parts counts or use standardized parts with little input from the user (operators or maintainers).
Use open systems architecture approach to improve the cost effectiveness and installation efficiency of future upgrades to the product.	Open systems approach is mandated but implementation is limited.
Set realistic reliability growth goals for the product.	Reliability goals set, but they are tradable or not met.
Conduct reliability testing early.	Reliability testing sporadically performed.
Practices used during operations	
Collect and analyze operations and support data.	Data is often incomplete or unreliable.
Manage operations and support costs to targets.	Do not manage to operations and support targets.
Identify areas for continuous improvement.	Lack of complete and reliable data makes identifying areas for improvement difficult; some areas that are identified are not funded for improvement.
Feedback to developer on product performance.	Limited feedback to the developer. The maintainer does not have a direct relationship with the product developer.

Source: GAO.

Clearly, the practices used by the commercial companies we visited before product development when requirements are set, early in product development when the design is finalized, and during the new product's operating life focus as much on providing a reliable product as on providing a high-performance product. The companies make operating cost and readiness key requirements, they perform extensive reliability testing, and they aim toward continuous improvement once the product is in the field. In DOD, because performance is the overriding concern of the requirement setters, none of these practices are in place.

Several DOD Efforts Underway to Reduce Total Ownership Costs

The changes to policies and the investment in improving systems' reliability are encouraging indicators that DOD has focused its attention on reducing costs to support weapons. DOD has revised acquisition policies, tested new approaches for reducing costs in a few systems, explored differing approaches, and created initiatives to reduce costs of legacy systems. Each of these efforts had some initial success, but most are aimed at reducing costs after fielding when over 90 percent of the costs have been determined.

DOD's Requirements Generation and Acquisition Policies Could Be More Specific in Addressing Supportability Issues

DOD has revised its 5000 series acquisition policies several times over the past 10 years with the intent of defining an acquisition environment that makes DOD a smart and responsive buyer. During this time, the policy has not substantively changed with regard to how acquisition programs can best control total ownership costs. The department is striving for an integrated acquisition and logistics process that is characterized by, among other things, a stronger focus on using supportability as a key design and performance factor. However, rules for total ownership cost goals at the outset of an acquisition program are defined by the Chairman of the Joint Chiefs of Staff's Instruction 3170.01B[1] on requirements generation. This guidance states that cost should be addressed in the operational requirements document for a new weapon system, if an estimate is available at that time. However, policy does not require the services to set requirements for operating and support costs or readiness. Instead, it allows them to identify system capabilities or characteristics they consider essential for successfully completing the mission. It states that the DOD

[1] Chairman of the Joint Chiefs of Staff Instruction, *Requirements Generation System*, (Washington, D.C.: Apr. 15, 2001).

sponsor may make cost a key requirement if it desires and identify the cost it wishes to evaluate.

We previously reported that DOD officials believe they must promise new, revolutionary weapon systems with significantly better performance capabilities than the ones they are replacing in order to obtain funding.[2] Therefore, key parameters are usually focused on performance rather than supportability.

In order to effectively minimize total ownership costs of its systems, the Department of the Navy recently issued its own guidance that establishes specific supportability and affordability thresholds and objectives[3] for all requirements documents. The Navy believes that by establishing readiness and operating and support cost as required parameters, there is assurance that major drivers of total ownership costs will be addressed and minimized throughout the acquisition process. Specifically, the new guidance states that requirements documents must include goals for operating and support costs. It also states that operational availability be included as a key performance parameter, except when logistics delays are not an issue or if the requirements are for a major aircraft or ship platform. In those cases, mission capable rates or full mission capable rates focused on the platform's primary mission areas will be used as key requirements. The Army is discussing a similar change in its guidance.

Three New Acquisition Programs Are Placing Greater Emphasis on Readiness and Operating Cost Goals

We found three DOD programs still in development—the Joint Strike Fighter, the Advanced Amphibious Assault Vehicle, and the Landing Platform Dock 17—that appear to be using good practices to reduce operating and support costs during product development. Each, in its own way, has had a powerful internal incentive to establish more collaborative practices or to focus attention on operating and support costs and product reliability.

[2] GAO-01-288.

[3] A threshold is the minimum acceptable operational combat capability required to meet war-fighter minimum requirements. An objective is the capability desired of the system beyond minimum requirements.

Figure 13: Joint Strike Fighter

Source: DOD.

The Joint Strike Fighter program is intended to produce an affordable next-generation aircraft to replace DOD's aging aircraft inventory. The program is structured to use a common production line to produce three aircraft variants that meet conventional flight requirements for the Air Force, short take-off and vertical landing characteristics for the Marine Corps, and carrier operation suitability needs for the Navy. The program will also provide aircraft to the British Royal Navy and Air Force. A key objective of the acquisition strategy is affordability—reducing the development, production, and operating costs of the program relative to prior fighter aircraft it will replace. The program's latest stated estimate for operating and support cost savings compared to legacy systems is $135 billion, or a 56 percent reduction in cost.

To achieve this affordability objective, the program office has incorporated various DOD and commercial initiatives into the acquisition strategy. For example, two key provisions in its operational requirements document—mission reliability and logistics footprint— will have a direct impact on operating and support costs. Specifically, all variants of the fighter are expected to achieve a mission reliability rate of over 90 percent and meet numeric goals of cargo aircraft or ship space needed to support a 30-day self-sustained deployment. These two requirements, along with

other reliability and maintainability goals, demonstrate DOD's desire to reduce total ownership costs. The product developer currently estimates the Joint Strike Fighter will be able to reduce operating and support cost primarily through efforts to improve

- reliability and durability of materials,
- accessibility of parts or systems that need to be inspected or replaced,
- supportability of low observable materials,
- ability of on-board systems to predict impending flight critical failures, and
- training materials and systems.

For example, DOD expects to save about $39 billion over the life of the fighter through reduced maintenance on low observable materials. The developer estimates that 99 percent of the maintenance actions will require no low observable restoration because they are using high durability materials, parts, or systems that are easier to access and harder to damage. In order to reach this level of savings, the developer spent a great deal of time evaluating previous DOD maintenance experience with the B-2A bomber and the F-117 fighter aircraft and used an evolutionary approach for upgrading these materials. Operating and support costs for the B-2A bomber, for example, were significantly increased by the decision to use an immature technology for low observability.

However, the Joint Strike Fighter program must be careful not to overestimate the total ownership cost savings it can achieve over legacy systems it will be replacing because the program is also depending on new technology for on-board systems to predict failure—prognostics and health management technology—that is not yet ready for product development. In October 2001, GAO reported that this technology was not at an acceptable readiness level for inclusion in product development, but DOD and the contractor decided to include it in order to meet total ownership cost objectives.[4] Program officials stated that about $16 billion—12 percent of the estimated $135 billion in total ownership cost savings—is expected to come from that technology. Since then, the officials have allowed for the possibility that the technology may not be included on initial production lots for the Joint Strike Fighter if it is not ready.

[4] U.S. General Accounting Office, *Joint Strike Fighter Acquisition: Mature Critical Technologies Needed to Reduce Risks*, GAO-02-39 (Washington, D.C.: Oct. 19, 2001).

Figure 14: Advanced Amphibious Assault Vehicle

Source: DOD.

The Advanced Amphibious Assault Vehicle is a Marine Corps program to improve its amphibious landing vehicle. The new development promises faster sea and land speeds, better protection, and more lethality. The development program has focused on maturing technology and paying attention to operating and support costs early in development. The program has used some of the best practices of commercial companies during development. Some of those include collocating the program office at the contractor's facility and making extensive use of Marine Corps war fighters and maintainers to provide a "hands on" assessment of how effective the vehicle would be in operations as well as how supportable it would be during operations. The Marines developed an early estimate of total ownership costs and included a reliability metric as one of its key requirements. The Marines developed three vehicle prototypes to mature the design and have conducted extensive reliability testing. The vehicle will have parts that are common with other weapons such as a gun that will be common with the Landing Platform Dock 17. Advanced Amphibious Assault Vehicle officials estimated that they will save $29 million in operating and support costs.

The Navy program office for the Landing Platform Dock 17 has adopted a total ownership cost approach. The program office established a process for suggesting and evaluating design trades that could reduce operating and support costs. Some of the design changes that the Navy made include enclosing the mast to reduce exposure to weather and salt water, and investing in high performance covering for the deck and well deck to

mitigate corrosion. Other practices include involving users to complete tasks using the virtual software to test special design elements in the ship, making greater use of sensors and automated processes to reduce maintenance and to reduce crew requirements.

Both the Landing Platform Dock -17's and the Advanced Amphibious Assault Vehicle's estimate for operating and support costs have recently increased. The Navy raised its estimate of Landing Platform Dock 17's requirements for spare parts, fuel, and software maintenance. The Advanced Amphibious Assault Vehicle program office attributed its increase in the cost estimate to funding additional prototypes to improve reliability. Information like this allows options for decision makers, while the system is still in development, to accept the costs or re-examine the performance characteristics to see if they can be relaxed in order to improve reliability and, thereby, reduce operating and support costs.

DOD Pilot Programs Attempt to Reduce Total Ownership Costs

In 1999, the Defense Systems Affordability Council implemented a program to explore ways to reduce the total ownership cost of its weapon systems. The Council—chaired by the Undersecretary of Defense, Acquisition, Technology, and Logistics—set a goal of reducing logistics costs for selected fielded weapon systems by 20 percent by fiscal year 2005. The Council also set a goal for selected systems still in development to achieve total ownership costs targets that are 20 percent to 50 percent below historical norms.

DOD selected 30 programs (10 from each military department) to test various approaches for reducing total ownership costs, such as using commercial items or technology to reduce costs of legacy systems and using industry standards when developing systems to make upgrades easier and less costly to complete.

The Air Force's C-17 program is one of the pilot programs. It is a fielded system whose operating and support costs increased by about 25 percent between 1995 and 1999. One C-17 initiative is an engine upgrade to extend the time between removals, reduce unexpected shop visits and spares purchases, and reduce the number of engine overhauls. The Air Force believes the C-17 could avoid $724.5 million in support costs if the upgrade is completed.

The Apache recapitalization program, another of DOD's pilots, integrates a number of selected upgrades that taken together are expected to achieve a 30 percent reduction in operating and support costs by 2010. Most of the

Apache helicopters will be refurbished and modified to the Apache Longbow configuration. The target acquisition and designation system, the top cost driver, is a focus of these improvements along with improvements in the drive train, the rotor, and the propulsion system. The current average cost per flying hour for the Apache fleet is $3,348. The Army's projected cost per flight hour after the modifications is $2,230.

The Abrams tank is also undergoing a major upgrade estimated to cost about $5 billion. The top cost driver on the tank is the power pack, which includes the engine and transmission, followed by the auxiliary automotive system, hull and frame, fire control system, armament, and track. Army officials believe upgrading and replacing the engine is the most effective way to reduce operating and support costs for the tank. The current cost per mile for the Abrams fleet is $181 per mile, including repair parts and fuel but excluding most personnel cost. The recapitalization program's goal is to reduce the cost to $107 per mile and to improve reliability.

Other Initiatives Show Promise, but Implementation Is Slow

We found three other initiatives—the change in acquisition policy toward evolutionary acquisition, an open systems approach for weapon systems and the Commercial Operations and Support Savings Initiative—that could help DOD reduce total ownership cost. However, implementation has been limited in the latter two initiatives because consistent high-level support is lacking.

DOD defines evolutionary acquisition as an approach for delivering capability in increments, recognizing the need for future capability improvements. DOD allows two processes to achieve an evolutionary acquisition, both of which include requirements for collaboration between the user, the tester, and the developer. The first process is referred to as incremental development. In an incremental development process, a desired capability is identified, an end-state requirement is established, and the requirement is met over time by the development of several increments of the product, each dependent on available, mature technology. The second process is referred to as spiral development. In a spiral development process, the end-state requirement is not known, and each increment of the product is based on feedback from the user. Each increment yields the best possible capability for the user. The movement toward evolutionary acquisition and time-phased requirements bodes well for the potential to understand reliability, readiness, and implications for total ownership cost early, because an evolutionary process allows an acquisition program to design a weapon system to requirements based

only on demonstrated technologies. This is very similar to commercial practices.

DOD chartered an open-systems joint task force to implement an open systems approach in weapon systems acquisitions. Open systems can reduce cost through use of widely accepted standard products from multiple suppliers, allowing DOD to benefit from the commercial market place and take advantage of the competitive pressures that motivate commercial companies to improve products and reduce prices. DOD expected open systems to reduce the cost of ownership of weapon systems, delay system obsolescence, and allow fielding superior war-fighting capability more quickly. The DOD Inspector General recently reported that the DOD acquisition community has not fully applied the use of open systems objectives in the acquisition planning and review process.[5] The report recommended DOD enforce the use of an open systems approach as part of the acquisition milestone review process.

Another initiative that showed promise but lacks high level support is the Commercial Operations and Support Savings Initiative introduced to improve weapon system readiness and reduce operating and support costs by inserting existing commercial items or technology into military legacy systems. It emphasizes the rapid development of prototypes and fielding of production items based on current commercial technology. According to a 2001 report by an independent assessment team, the initiative's three objectives of reducing operations and support costs for legacy systems, simplifying prototype development, and attracting commercial firms to the defense marketplace are being met. But, the initiative lacks high-level support. The Under Secretary of Defense (Acquisition, Technology, and Logistics) recently directed that funding for the program be terminated.

[5] Department of Defense, Office of the Inspector General, *Use of An Open Systems Approach for Weapon Systems*, Report No. D-2000-149 (Washington, D.C.: June 14, 2000).

DOD's Current Environment Does Not Provide Incentives to Reduce Total Ownership Cost Early

While initiatives for acquisition programs and potential reductions for the fielded systems are welcomed, the department has not institutionalized the practices used in the initiatives by demanding them on all acquisition programs. As we discussed in Chapter 1, 90 percent of the operating and support costs are determined before fielding, and these initiatives do not attack the causes of higher operating and support costs. Those are: the division of responsibility among the requirements community, the acquisition community, and the maintenance community for controlling costs; the lack of focused attention on reliability early in development; and the lack of accountability for total ownership cost when setting requirements that is caused by the division of responsibilities across these communities.

Companies we visited have incentives to make operating cost and product readiness equal to technical performance when setting requirements for new products because these factors largely determine their profitability and, therefore, survival in the market place. Lower operating costs translate to higher profits and increased sales. Customers cannot afford to have large amounts of capital tied up in extra equipment, spare parts, or personnel to ensure their equipment is ready to perform when needed. They cannot afford to have equipment fail during operations, because failure precludes accomplishment of the company's mission and loss of revenue. These companies are constrained by a finite amount of funding to acquire and operate their equipment, and, therefore, they hold the people setting the product requirements accountable for total ownership cost. Many of the companies we visited use one integrated product team to identify needs, set requirements, and monitor product development. Most importantly, the organization that will be responsible for supporting the equipment in the field sets requirements for new products. There is also a direct relationship between the requirements-setting team and the product developer while the product's requirements are being set, during development, and after products are put into service. Information flows throughout the integrated process, with each new phase in the process being informed by knowledge from the phase just ending.

DOD's current acquisition environment does not provide the same incentives or practices. Traditionally, DOD does not constrain its requirement setters in the same way. Requirement setters in DOD have demanded weapon systems that, due to their performance features, consistently cost more to operate and support than anticipated to achieve necessary readiness levels. This has been accepted because a large logistics organization—separate from the requirement setting organization—is charged with supporting these weapon systems and uses

monies from a different budget to do so. In essence, DOD's environment frees the requirements community to insist on technical requirements that cannot be made into reliable products, are costly to support, and cannot be maintained cost effectively. Accountability for operating and support costs does not rest with the requirement setters, or, for that matter, with the acquisition community. Eventually, maintenance organizations have no choice but to request sufficient funding to keep weapon systems operating once they are fielded. DOD has identified this division of responsibility as a key cause of higher weapon system operating and support costs. In this current environment, there is no incentive for collaboration and accountability in setting requirements and developing products with operating costs in mind. Instead, it provides incentives to field systems with unknown reliability by allowing whatever funding necessary to operate and maintain the systems once they are fielded.

Chapter 5: Conclusions and Recommendations

Acceptable readiness levels are a function of having platforms available when required. Such levels can be achieved by having highly reliable platforms, by spending whatever is necessary on ongoing maintenance, or by having excess capacity. The high cost of maintaining weapon systems to meet required readiness levels is depleting DOD's modernization accounts and denying DOD the flexibility to invest in new weapons. DOD must find ways to reduce total ownership cost while maintaining needed readiness rates. Readiness is a critical component of all DOD weapons systems. If a system is not ready, its performance capabilities are of no use. The decision on whether readiness will be achieved by spending additional funds on operations or by designing high reliability into the weapon system must be made while requirements are being set and early in product development.

DOD's prevailing practices run counter to achieving high reliability. Often, DOD does not make readiness or operating cost performance parameters equal in importance to others when it establishes requirements for weapons systems. Further, reliability growth during product development is hampered by immature technologies and delays in gaining knowledge about the product's design. Finally, DOD does not have sufficient knowledge about its fielded systems to inform its product development process for new systems. DOD is at a crossroad in this regard. It has made positive changes to acquisition policy in order to change its environment. Requiring higher readiness at lower cost will enable DOD to take the next step, ensuring lower total ownership cost.

In contrast, commercial companies that are in the market for new capital equipment understand that they must specify and control the readiness and total ownership cost of a product, especially the operating and support costs early in development. Therefore, they specify how available or ready the products must be in order to carry out the company's mission. Further, they set goals for operating costs when acquiring new equipment; they make sure they understand their own operating costs from data they have collected and analyzed on equipment they are now using. Those two goals—how available the product must be and how much the customer wants to spend per operating unit to support the equipment—are key requirements equal in importance to other performance characteristics that the commercial customer demands from the companies that develop the products. Bounded by the twin requirements of specific operating costs and availability, the product developer sets reliability goals for the components, subsystems, and the full system once it is integrated into a product that will satisfy the customer's requirements. Product developers remain focused on good product development practices with mature

technologies, stable designs, and production processes that are in control. During operations they collect data from their customers on reliability and performance and use that data to predict operating and support costs for subsequent developments or upgrades.

DOD has initiatives underway that partially address the issue of controlling operating and support costs. However, without significant emphasis on providing a better framework for decision-making, these initiatives will not yield sufficient improvements. The department has encouraged the services to include key performance parameters in its newer developments such as the Joint Strike Fighter that indicate how long a system must perform between maintenance actions. It has moved to follow best practices for reducing risk from technology and achieving more stable designs in the Advanced Amphibious Assault Vehicle and the Joint Strike Fighter. However, these programs are early in development and it will take some time to see how reliably they perform. We believe that practices found at the commercial companies we visited to make operating and support costs and product readiness requirements equal in priority to other performance characteristics forces developers to focus on achieving high reliability and that adopting these practices will help DOD achieve high readiness and control total ownership cost.

Recommendations for Executive Action

DOD should take steps to make the cost to operate and support weapon systems at required readiness rates a priority when setting weapon system requirements for an affordable weapon system and finalizing the design of the selected system. To do this, its requirements and acquisition communities must collaborate to fully understand and control the costs to operate and support a weapon system prior to and early in product development, when it is possible to have significant impact on those costs. In establishing requirements for a weapon system, the requirements community should include the costs to operate and support the weapon system over its life cycle and the readiness rate for the weapon system. To establish an affordable design for the weapon system, the acquisition community and acquisition programs should be required to accurately estimate—based on demonstrated component and subsystem reliability testing—that portion of the costs that DOD plans to spend on operations and support of the weapon system throughout its life cycle before the design is finalized.

With this in mind, to ensure that the user's requirements for a weapon system can be met with a reliable design, we recommend that the Secretary of Defense

- revise the Chairman of the Joint Chiefs of Staff Instruction 3170.01B on the requirements generation process to include total ownership cost, especially operating and support cost, and weapon system readiness rates as performance parameters equal in priority to any other performance parameters for any major weapon system before beginning the acquisition program;
- revise the current policy governing the operation of the defense acquisition system (currently under revision) to require that the product developer establish a firm estimate of a weapon system's reliability based on demonstrated reliability rates at the component and subsystem level no later than the end of the system integration phase, coinciding with the system-level critical design review, before proceeding into the system demonstration phase of product development; and at the system level no later than the full-rate production decision; and
- structure its contracts for major systems acquisitions so that at Milestone B the product developer has incentives to ensure that proper trades are made between reliability and performance prior to the production decision. One option is to provide specific clauses in the development contract to address reliability growth.

Agency Comments and Our Response

DOD partially concurred with all of our recommendations; however, for the most part, it found no further action was needed to lower total ownership cost. We disagree. We believe that if DOD takes no further action in implementing these recommendations, it ignores significant opportunities to improve readiness and lower the total ownership cost of its major weapon systems. The current budget environment demands more effort in reducing these costs.

The performance of weapon systems as described in this report is evidence that they demand much more money than planned to remain ready. DOD should consider each of these recommendations as parts of a whole solution for its "death spiral"—that is, the inability to modernize its forces because the cost to operate and maintain unreliable weapon systems at needed readiness rates constantly impinges on its modernization budget. Taken as a whole, our recommendations encourage DOD's requirement setters to demand readiness at an affordable cost as a

part of a system's performance, provide a mechanism to hold the product developer accountable for determining the reliability needed to satisfy DOD's requirements, and provide contractual incentives for the product developer to build reliability into a weapon system very early in its development. The details of DOD's response to each recommendation are summarized below along with our rebuttal.

In a response prepared by the Office of the Joint Chiefs of Staff, DOD partially concurred with our recommendation to include readiness and total ownership cost as performance parameters equal in priority to any others before beginning an acquisition program, commenting that they are currently equal in priority to "non-key performance parameters." We are concerned that DOD does not recognize the importance of requiring targets for a system's readiness and its total ownership cost before beginning product development. These targets are critical to providing a realistic goal for the product developer to deliver reliable, cost-efficient weapon systems.

We examined five deployed weapon systems for this report. None had key requirements for readiness rates or operating costs. All had significant problems with reliability and, therefore, readiness and total ownership cost. We also reviewed several commercial products that were developed with readiness and total ownership cost as critical requirements. In each case, the products were ready to perform when needed at affordable and predictable cost. Unless these requirements are equal in importance to any others, they will not withstand the pressures of an acquisition program. The Joint Chiefs stated that its requirements generation policy is currently under revision and that no decision has been made about the priority readiness and cost should have as requirements. We believe DOD has an excellent opportunity to finally lower the total ownership cost of current and future weapon acquisitions, thereby freeing significant funds for modernization if it implements this recommendation.

In a response prepared by the Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics, DOD partially concurred with our second recommendation to establish estimates of a weapon system's reliability—first, based on demonstrated reliability rates at the component and subsystem level by the end of system integration, coincident with the critical design review and next, at the system level at the time the production decision is made—however, DOD found no need to revise the policy governing the defense acquisition system to achieve this. We disagree. Demonstrating reliability during product development has not received the priority it requires if DOD is to have a realistic opportunity to

reduce the total ownership cost of its weapons while maintaining required readiness levels. The current policy does not provide a mechanism to ensure consistent application of reliability estimates based on demonstrated performance. We believe that the disparity between the actual costs to operate and maintain weapon systems and what DOD had estimated those costs to be during the weapon systems' development, as described in the report, provides strong evidence that product developers do not understand reliability under DOD's current process. Implementation of this recommendation will assist DOD in requiring reliability estimates on a consistent basis.

In a response prepared by Undersecretary of Defense, Acquisition, Technology, and Logistics to our recommendation that DOD structure its development contracts to include requirements to provide incentives for product developers to trade performance for reliability when it makes sense, DOD found no need for additional incentives to contractors beyond giving them total system performance responsibility. We have yet to see evidence that total system performance responsibility has provided an incentive for any product developer to trade performance for reliability in order to reduce total ownership cost. Further, we believe a contractual agreement similar to those we found in commercial cases—such as financial penalties for readiness below certain specified rates—would provide an excellent incentive for product developers to gain the knowledge required to meet reliability rates early in a weapon system's design before committing to production.

DOD provided some technical comments in attachment 2. We have addressed those in the report as necessary. The full text of the department's response to the recommendations is provided in appendix I.

Appendix I: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE

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ACQUISITION,
TECHNOLOGY
AND LOGISTICS

4 DEC 2002

Ms. Katherine V. Schinasi
Director, Acqusition and Sourcing Management
U.S. General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Ms. Schinasi:

This is the Department of Defense (DoD) response to the GAO draft report, "BEST PRACTICES: Setting Requirements for Cost and Readiness Could Reduce Weapon Systems' Total Ownership Costs," dated November 26, 2002 (GAO Code 120092/GAO-03-057). There are two enclosures. The first contains the DoD detailed comments to the recommendations. The second are additional comments on the report. The DoD response to Recommendation 1 was provided by the Joint Chiefs of Staff.

Sincerely,

Spiros G. Pallas
Principal Deputy
Strategic and Tactical Systems

Enclosure(s):
As stated

ENCLOSURE (1)

GAO DRAFT REPORT – DATED NOVEMBER 26, 2002
GAO CODE 120092/GAO-03-057

"BEST PRACTICES: Setting Requirements for Cost and Readiness Could Reduce Weapon Systems' Total Ownership Costs"

DEPARTMENT OF DEFENSE COMMENTS TO THE RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommended that the Secretary of Defense revise the Chairman of the Joint Chiefs of Staff Instruction 3170.01 on the requirements generation process to include total ownership cost, especially operating and support cost, and weapon system readiness rates as performance parameters equal in priority to any other performance parameters for any major weapon system prior to beginning the acquisition program. (p. 66/GAO Draft Report)

DoD RESPONSE: Partially Concur. The Operational Requirements Document currently addresses program affordability, stated in terms of a performance parameter threshold and objective, and system performance parameters, including mission reliability; they are equal in priority to any other "non-KPP" performance parameter. The supporting guidance in CJCSI 3170.01 is currently under revision—the Department has not decided whether to clarify it with a more specific description towards weapon system readiness rates.

RECOMMENDATION 2: The GAO recommended that the Secretary of Defense revise the current policy governing the operation of the defense acquisition system to require that the product developer establish a firm estimate of a weapon system's reliability based on demonstrated reliability rates at the component and subsystem level no later than the end of the system integration phase, coinciding with the system-level critical design review, before proceeding into the system demonstration phase of product development; and at the system level no later than the full-rate production decision. This policy is currently under revision, to be finalized in early 2003. (p. 66/GAO Draft Report)

DoD RESPONSE: Partially Concur: While there is no formal direction to provide a firm estimate of reliability during critical design review, program system performance is reviewed for the final design configuration, including compliance to any reliability requirement or specification included in the contract. Because this is already accomplished, there is no need to further direct the recommendation.

RECOMMENDATION 3: The GAO recommended that the Secretary of Defense structure its contracts for major systems acquisitions at Milestone B to provide incentives for the product developer to ensure that proper trades are made between reliability and performance prior to the production decision. One option is to provide specific clauses in the development contract to address reliability growth. (p. 66/GAO Draft Report)

DoD RESPONSE: Partially Concur: DoD views reliability as part of system performance. Also, DoD already encourages system design trades throughout development. Incentivizing reliability growth is one of many possible approaches already used in some cases. There is no need for additional emphasis by DoD. Other approaches used by DoD include total system support responsibility (TSSR) which automatically incentivizes contractors to provide reliable systems while increasing their profits.

Appendix II: GAO Staff Acknowledgments

Acknowledgments

Cheryl Andrew, Beverly Breen, Belinda LaValle, Carol Mebane, Gary Middleton, Michael Sullivan, Adam Vodraska, and Earl C. Woodard

Related GAO Products

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