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Logistics Engineering Perspective

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Global military operations, rising costs, resource constraints, and a future of strategic uncertainty demand that logistics deliver higher weapon-system availability while simultaneously reducing costs. A logistics engineering approach is the most effective method for enabling logistics transformation and achieving these goals. Logistics engineering brings science to the art of logistics and optimizes difficult, programmatic decisions in a resource-constrained environment throughout a weapon system's entire life cycle.

Weapon-system availability is a key contributor to operational capability. Increased weapons availability also functions as a force multiplier when logistics can achieve and sustain higher system availability in support of increasing operational requirements. America is fighting a global war on terror while executing demanding peace-keeping and humanitarian operations on a global scale. Warfighters must meet these operational commitments in spite of aging weapons platforms, decreasing force structure, rising costs, and resource constraints. A future of strategic uncertainty and competing requirements between readiness and modernization demand that logistics transformation deliver improved availability at lower costs.

The transformation of military logistics has come a long way since the first Gulf War. Significant improve-

ments in logistics capabilities and processes—including total life-cycle systems management, supply chain management, centralized repair, and express delivery—now enable a far more agile military logistics effort to keep pace in an increasingly demanding and jointly focused operational environment. When coupled with enterprise-level data collection and analysis, developments at the cutting edge of technology will make real-time, global, network-centric, knowledge-enabled logistics transformation a reality.

The Department of Defense (DoD) is engaged in continuous logistics transformation that must deliver tangible results to enable a war-winning capability. This logistics transformation requires improvements in speed, agility, dependability, and precision in DoD logistics operations. One primary aspect of logistics transformation is the recognition of supportability as a key design criteria focused on two tenets: (1) increased weapon-systems availability and (2) significant cost savings. Ultimately, improving current operational readiness and engineering more efficient and effective logistics support into the acquisition process will result in the reallocation of scarce resources and recapitalization of vital systems to the combat forces—better enabling warfighters to fight the global war on terror.

Booz Allen's logistics engineering capability brings the analytic rigor and precision needed to support logistics transformation through timeless knowledge-based decision making across the entire weapon-system

life cycle. Our broad, in-depth understanding of the acquisition process and the DoD logistics system, vast experience in the commercial sector, and tremendous organizational resources allow us to bring the required expertise to help each of our clients achieve optimal systems supportability. The foundation of such knowledge-based logistics decision making is *logistics engineering*.

What is Logistics Engineering?

Logistics engineering is a timeless proactive technical discipline that brings science to the art of logistics through the precise application of analytics and tools to facilitate knowledge-based decision making throughout a system's life cycle. Logistics engineering addresses all facets of systems acquisition, including design and development, testing, production, fielding, sustainment, improvement and modification, and disposal. Therefore, logistics engineering is a critical enabling discipline that separates proactive from reactive life cycle management. It is a primary driver that distinguishes organizations that exceed performance and cost expectations from those that do not and who routinely cite insufficient resources (e.g., parts, personnel, money, and training) for their performance shortcomings. The goal of Booz Allen's overall logistics engineering support concept is to design and develop a comprehensive support program that identifies and implements the means for exceptional organizational performance while enabling cost-effective systems management throughout the life cycle.

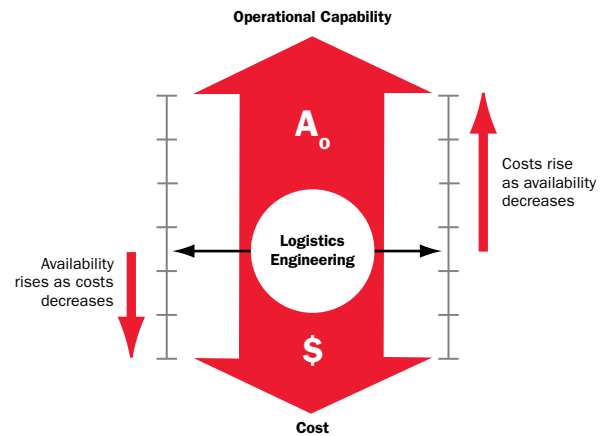
Booz Allen's Logistics Engineering Model

Logistics engineering brings analytic rigor to the field of logistics, and it facilitates knowledge-based decision making throughout the acquisition process. Booz Allen's approach to logistics engineering not only covers the full spectrum of the Defense Acquisition Management Framework but also facilitates Product Support Planning (PSP), Performance-Based Logistics (PBL), and process reengineering methods, such as Lean Six Sigma. In the aggregate, as shown in Figure 1, logistics engineering provides for improved operational availability (A_0), which contributes to increased operational capability at lower costs consistent with the tenets of logistics transformation. In Exhibit 1, the

logistics engineering sphere and the small horizontal arrows between operational availability and cost represent an important variable in the ratio between the two metrics, which is shown by the large vertical blue and green arrow. As the logistics engineering sphere between availability and cost moves downward, the size of the blue area that represents availability increases, while the size of green area representing costs decreases. The availability and cost scales on the sides of the model can measure this relationship.

Exhibit 1

Booz Allen's Logistics Engineering Model



Source: Booz Allen Hamilton

Logistics Engineering and Its Impact on A_0 and Cost

$$A_0 = \frac{MTBM}{MTBM + MDT}$$

Note: In the above operational availability formula, MTBM is Mean-Time-Between-Maintenance, which measures reliability; MDT is Mean-Down-Time, which measures maintainability and supportability.

A_0 is the logistics contribution to overall operational capability. It comprises three variables: reliability, maintainability, and supportability. Logistics engineering seeks to highlight the variables that represent the best opportunity to increase A_0 in a specific scenario. For example, using data from the failure rate of high-value components allows for targeting of engineering improvement efforts. High-value parts last longer, resulting in improved systems availability to the warfighter, reduced parts consumption, and fewer maintenance actions—all of which contribute to lower

costs. Logistics engineers properly target engineering improvement efforts to ensure savings from long-term support are greater than the cost of the engineering effort. This premise is the essence of proactive logistics management.

Using techniques such as analysis of alternatives and pareto analysis principles to identify support drivers, logistics engineering identifies the variables that will provide the greatest leverage in improving A_0 with respect to given cost constraints. Logistics engineering identifies the solutions that are most *effective* in increasing A_0 and most *efficient* in decreasing costs. The optimal situation is to identify solutions that are both effective and efficient. For example, when program managers make effective use of logistics engineering as a core component of their acquisition strategy, the net effect is increased operational availability, which directly contributes to improved operational capability for the warfighter and simultaneously reduces costs. If logistics engineering is not considered or executed properly, the opposite occurs—operational availability decreases and costs increase. For example, when proper logistics engineering techniques are not used to identify the root causes of A_0 problems, symptoms of poor availability (e.g., parts shortages) instead of root causes (e.g., poor design or repair procedures) are addressed. Spending money on symptoms instead of root causes is a recipe for increasing costs over time because the implications of root cause problems tend to worsen as they are not addressed. This scenario drives a downward spiraling requirement for more and more parts and associated increases in maintenance actions in an attempt to reverse decreasing systems availability.

Booz Allen's approach to logistics engineering is a key supportability enabler across the Defense Acquisition Management Framework as well as for PSP and PBL. In addition, logistics engineering is a key reliability and maintainability enabler in process reengineering. The following sections discuss the role of logistics engineering in each of these areas.

Logistics Engineering in the Acquisition Process

The Defense Acquisition Management Framework

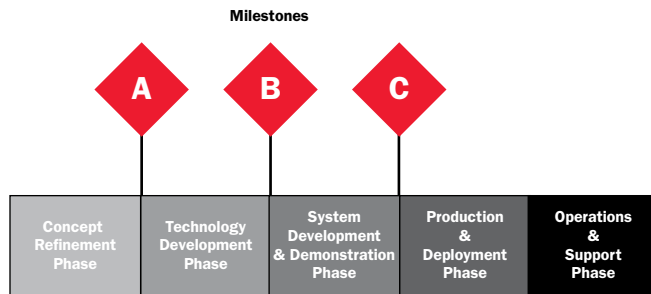
is the core process for weapon-system acquisition. Logistics engineering applies across all phases of this process. It focuses on achieving optimum weapon-system availability at a lower cost throughout the concept refinement, technology development, system development and demonstration, production and deployment, and operations and support phases of the Defense Acquisition Management Framework.

Booz Allen's approach to logistics engineering features analytic rigor and precision in a data-driven process. Ideally, the supporting logistics infrastructure is designed to begin with concept refinement and continue with improvements through the system's planned life cycle. In addition, logistics engineering can be introduced, as needed, at any point in the Defense Acquisition Management Framework. For example, the Global Hawk Intelligence, Surveillance, and Reconnaissance (ISR) weapon system entered the acquisition process at Milestone B. Booz Allen logistics engineering assisted the Air Force with successfully transitioning the program from an Advanced Concept Technology Demonstrator (ACTD) to an operational system two years ahead of schedule.

Without effective logistics engineering, even the most capable weapon systems are vulnerable to fundamental logistics problems. Such problems are often unrelated to the difficulties associated with using emerging technology and can adversely affect both leading-edge and proven technology systems. For example, provisioning based on unrealized component Mean-Time-Between-Failure (MTBF) forecasts can be a major cause of lower mission-capable rates. When components deliver MTBF rates that are lower than expected, the degraded availability can put critical programs at risk. Logistics engineering provides effective analysis of system and component reliability and supportability metrics early in the acquisition process and anticipates the total impact of potential problems before they occur. Logistics engineering enables program managers to make knowledge-based decisions and balance effectiveness and efficiency against the full spectrum of potential consequences throughout the weapon-systems life cycle.

Exhibit 2 shows the Defense Acquisition Management Framework. The following sections describe how Booz Allen applies logistics engineering to each phase of this process.

Exhibit 2
Defense Acquisition Management Framework



Source: Booz Allen Hamilton

Concept Refinement. Logistics engineers work closely with program teams to refine the initial concept and understand supportability objectives. In this phase, logistics engineers support development of the logistics support philosophy, consistent with user requirements as identified in the warfighter's Initial Capabilities Document (ICD). Specifically, logistics engineering seeks to resolve the capability gap in terms of the functional area, relevant range of military operations, and time frame identified in the ICD.

Technology Development. In this phase, logistics engineers work closely with program teams to reduce technology risk and determine the appropriate set of technologies to be integrated into a full system. Logistics engineering supports this process by assessing the viability of technologies while simultaneously refining user requirements (e.g., establishing the initial maintenance concept). Key logistics engineering products include the Failure Modes, Effects, and Criticality Analysis (FMECA) and Level of Repair Analysis (LORA). From the initial maintenance concept, logistics engineers further identify preliminary logistics support requirements and conduct Analysis of Alternatives (AoA) to refine the most cost-effective solution. By

Milestone B, results from logistics engineering efforts have demonstrated the technology for that capability and prepared the system for development in the most efficient and cost-effective manner possible.

System Development and Demonstration. In this phase, logistics engineers work closely with program teams to reduce integration and manufacturing risk; ensure operational supportability while simultaneously engineering methods to reduce the logistics footprint; enable affordability of the system and its associated support structure; and demonstrate system integration, interoperability, safety, and utility. To accomplish this, logistics engineers use modeling and simulation tools and other operations research and systems engineering techniques. Logistics engineering directly contributes to refining and updating preliminary logistics support requirements for the selected alternative, designing the logistics support system, and identifying any interim contractor logistics support required for initial system deployment.

Production and Deployment. At Milestone C, the decision to commit DoD to production is made. Logistics engineers work closely with program teams to verify all Integrated Logistics Support (ILS) elements are in place to ensure concurrent delivery of the system with all required logistics support. Specifically, logistics engineering assesses the need for a preliminary Low Rate Initial Production (LRIP) process or evaluates the option of proceeding directly into Full Rate Production (FRP). If required, LRIP will ensure an adequate and efficient manufacturing capability and will be used to produce the minimum quantity necessary for Initial Operational Test and Evaluation (IOT&E). Logistics engineering serves as an enabler for this entire process.

Operations and Support. This phase has two major efforts: sustainment and disposal. The objective of this phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. Throughout the life cycle of a system, logistics engineers continuously monitor advances in technology and identify and plan for opportunities to insert technology into existing sys-

tems. When the system reaches the end of its useful life, logistics engineers assist in the design and development of the most effective and cost-efficient method for disposal of the system in accordance with all applicable regulations.

Using scientific rigor, analytics, and modeling and simulation tools, logistics engineering ensures program managers can make informed, knowledge-based decisions. Booz Allen's unique approach to logistics engineering recognizes that an effective, knowledge-based decision process is iterative in nature. This approach enables institutionalized learning throughout the acquisition life-cycle framework. Booz Allen logistics engineering provides program managers with a means to design, implement, and manage effective program support strategies, especially for long-term, performance-based contracts where the scientific application of analytically relevant and independently verified data is fundamental to program success.

Logistics Engineering and Product Support Planning

The spirit of DoD 5000.2 emphasizes long-term support planning, which includes planning for maintenance, supply chain management, and technical management. The application of sound logistics engineering techniques is the foundation for proactive PSP. More than 60 percent of the total cost of a system occurs during the operations and support phase of a system's life cycle. Our logistics engineers understand that decisions having the greatest impact on those costs are made early during system design and development. Supportability and cost effectiveness are the key elements in these decisions and must include all 10 elements of ILS.

Optimal weapon-system availability and support can only be achieved through effective integration of the following three components:

- An effective support organization
- Robust planning and support processes
- Effective collection, analysis, and interpretation of logistics data

These three components are often suboptimized, as

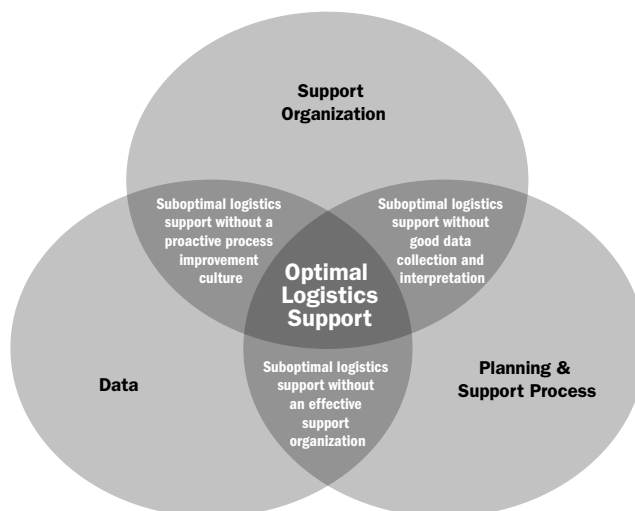
shown in Exhibit 3. The intersection of all three components represents an optimal logistics support environment. The absence of any one of the three elements, represented by the intersection of any two elements, results in suboptimized logistics support. For example, where only the support organization and planning and support process elements intersect, logistics support is suboptimized. This occurs because relevant or accurate data does not exist, or it has not been selected or employed effectively.

To resolve suboptimal logistics support conditions, logistics engineering answers questions such as:

- What spare parts should be bought, and how many?
- What specifically should be repaired, and what should be replaced with new parts?
- How many spare pieces of equipment are needed?
- Where should spare inventory be kept?
- When and how often should equipment undergo routine maintenance?
- How long should repairs take, and where should they be performed?
- How durable should parts be?
- How should one prioritize durability improvement initiatives?

Exhibit 3

The Logistics Support Model



Source: Booz Allen Hamilton

Once these questions have been answered, a PSP process designed and developed by Booz Allen is used to ensure all three logistics support components are realized. The common thread is logistics engineering, which enables complete integration of all three components and enables the optimal solution. Logistics engineering orchestrates all three elements using well-established analytical principles, processes, and tools. As a result, the non-value-added and suboptimized areas of logistics support are eliminated. For example, logistics engineering shows where the most effective trade-offs can be made among reliability, maintainability, and supportability.

The PSP process is iterative and focused on achieving optimal weapon-system availability. Logistics engineering is the engine that drives the process, and it enables knowledge-based logistics support planning. Logistics engineering provides insight into the optimal logistics support planning approach by highlighting which of the three Ao variables (reliability, maintainability, and supportability) will have the greatest leverage in improving Ao within given cost constraints. Logistics engineers then apply this knowledge to develop the logistics support planning approach that will maximize Ao for the weapon system.

Logistics Engineering and Performance-Based Logistics

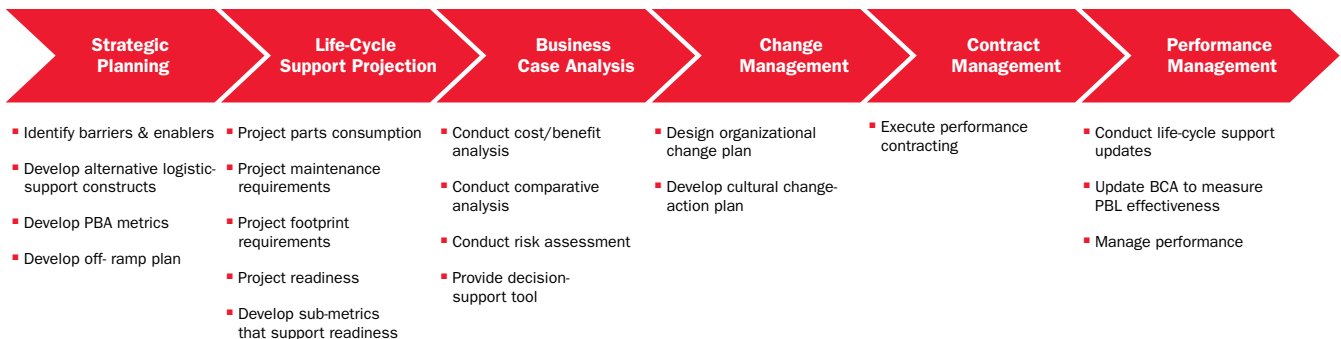
Logistics engineering is also an important enabler in the PBL process. PBL improves weapon-systems availability by optimizing logistics support through the integration of maintenance, inventory management,

and technical management. A well-engineered PBL approach provides a strong incentive for the support organization to establish and maintain good logistic engineering practices. Successful PBL results in proactive management, and the foundation for proactive management is logistics engineering. Well-engineered PBL constructs use sound logistics engineering principles to develop effective metrics that provide the necessary measurement and control of the PBL process. In turn, these well-engineered PBL constructs enable the military to devote more of its scarce resources and personnel to combat and combat-support efforts. At the same time, PBL ensures the continued effectiveness of support, which lends PBL to transition from the armed services to the commercial industrial base.

The essential element that enables the government to effectively measure and control performance management and implement meaningful PBL is the use of actual cost and performance data. Without independently verified and validated cost and performance data, the government cannot effectively hold contractors accountable, establish effective incentives, or manage performance. Logistics engineering employs proven engineering practices, and through the use of applicable analytics and the latest tools, it accomplishes the activities necessary to complete each of the six steps of the Booz Allen PBL Development and Implementation Process outlined in Exhibit 4 below.

Booz Allen logistics engineering is an integral part of PBL development and implementation. It serves as a disciplined, scientific approach that involves searching

Exhibit 4
Booz Allen PBL Development and Implementation Process



Source: Booz Allen Hamilton

out and defining relevant data instead of simply applying readily available data. Through effective application of proven engineering practices, including applicable analytics and the latest modeling and simulation tools, logistics engineering facilitates the shift from transaction management to performance-based management.

Logistics Engineering and Process Reengineering



Logistics engineering is an integral part of process reengineering. Process reengineering (e.g., Lean Six Sigma, Theory of Constraints) is a proven method for realizing improved weapon-system avail-

ability without driving corresponding cost increases. Booz Allen is at the leading edge of Lean Six Sigma, which was originally developed and implemented for the commercial industry. Logistics engineering is a prime enabler of process reengineering techniques. The analytics and tools applied by logistics engineers are ideally suited for deploying process reengineering activities. Specifically, logistics engineering helps identify the processes that will have the greatest leverage in improving Ao within given cost constraints. By applying AoA and pareto analysis principles, logistics engineering ensures the correct processes are reengineered to yield maximum improvement in Ao. Logistics engineering also enables precise selection and design of the metrics necessary for optimum measurement and control of process reengineering activities.

Lean Six Sigma is the primary engine driving the process reengineering efforts of logistics transformation within DoD. It exists at the core of logistics transformation because it is a proven method for increasing effectiveness without increasing corresponding costs. Booz Allen's proven Lean Six Sigma strategic roadmap is well suited to DoD logistics reengineering efforts. When combined with the analytics and tools used in the logistics engineering discipline, the roadmap ensures success. Exhibit 5 illustrates the four components of Booz Allen's Lean Six Sigma roadmap and is followed by a description of the logistics engineering role in each.

- **Strategy.** Logistics engineering methods provide for accurate calculations of operating imperatives.
- **Assess.** Logistics engineering brings science into the assessment process, especially for an organization's

infrastructure readiness, in-project assessments, and selection activities.

- **Design.** Logistics engineering ensures fit-for-purpose processes and the precise incorporation of learning for larger deployments.
- **Implementation and Rollout.** The precision inherent in logistics engineering lays the foundation for effective measurement, which is critical in tracking benefits, ensuring reward and recognition, and achieving cultural change.

Exhibit 5

Booz Allen Lean Six Sigma Roadmap



Source: Booz Allen Hamilton

Logistics engineering ensures verified, validated, and relevant data is appropriately and precisely applied in a given Lean Six Sigma process. In this manner, logistics engineering creates an environment conducive to an effective Lean Six Sigma culture. For example, Booz Allen used logistics engineering methods to help Johnson and Johnson decrease critical clinical trial cycle times by 50 percent and to help Bank of America reduce ATM withdrawal losses by 30 percent.

Logistics Engineering Knowledge and Tools

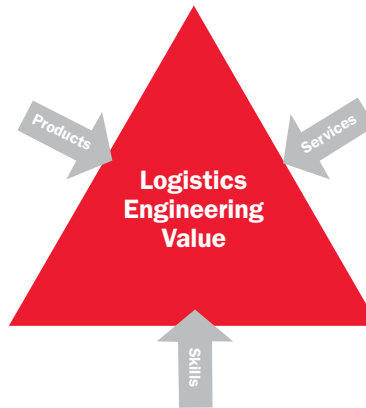
Booz Allen logistics engineering goes beyond the application of analytics and the latest tools. Booz Allen's unique insight and knowledge are based on an extensive portfolio of worldwide commercial and government experience, which provides a global perspective of logistics engineering best practices, knowledge, and experience. To bring this insight together into a comprehensive offering, Booz Allen created the Logistics Engineering Value Model, shown in Exhibit 6, page 8.

$$R = e^{-\lambda t}$$

Furthermore, our extensive knowledge includes the theories behind mathematical models, enabling us to effectively apply, interpret, and deliver results.

Exhibit 6**Booz Allen's Logistics Engineering Value Model****Products:**

- Reliability, Maintainability, & Availability (RMA) Analysis
- Supportability Analysis
- Analysis of Alternatives (AoA)
- Trade Studies
- Level of Repair Analysis (LORA)
- Failure Modes, Effects, and Criticality Analysis (FMECA)
- Reliability Centered Maintenance (RCM) Analysis
- Risk Analysis
- Source of Repair Analyses (SORA)
- Best Value Analyses (BVA)

**Support Services:**

- Metric Design, Development, & Application
- Data Collection, Management, & Analysis
- Parts & Material Selection Analysis
- System Reviews
- Manufacturing Plan Screening
- Cost as an Independent Variable (CAIV) Analysis
- Low-Rate Initial Production & Full-Rate Production Review
- Condition Based Maintenance Analyses
- Analytics/M&S/IT

Skills:

- Systems Engineering
- Operations Research & Applied Math
- Acquisition & Programmatic
- Operational Logistics & Logistics Analysis
- Certifications (e.g., DAWIA, CPL, PMP, etc.)

Source: Booz Allen Hamilton

For example, Reliability, Maintainability, and Availability (RMA) models are based on algorithms. Among Booz Allen's suite of more than 40 analysis tools is the BlockSim model, which uses the Weibull reliability life-data algorithm. Using the BlockSim model, Booz Allen logistics engineers identified three reliability-driving components for a U.S. Navy radar system, which resulted in an expected increase in system availability from 79.5 to 90.5 percent. Our suite of tools includes LORA models, which are based on the equations found in Military Standard 1390D and RMA models. To help compute the cost of future ownership, we use Life Cycle Cost (LCC) models. LORA and LCC are state-of-the-art models, and they ensure optimized performance through the selection and application of verified and validated data.

Logistics Engineering Value-Added Summary

Logistics engineering at Booz Allen is more than a product support and engineering capability. Logistics engineering enhances operational capability and reduces total ownership cost throughout a system's life cycle by adding analytic rigor to acquisition and logistics through the focused application of special-

ized products, skills, and support services that enable knowledge-based decision making. Logistics engineering is a mind-set and framework for institutionalizing a scientific approach that realizes verifiable and validated decision making throughout the defense acquisition process. Moreover, Booz Allen's unique approach takes logistics engineering to a higher level, where it serves as an enabler of critical and timeless logistics transformation processes.

Key points to consider:

- The PSP process is based on logistics engineering principles. Booz Allen has a proven track record of highly effective life-cycle support across the Defense Acquisition Management Framework.
- Logistics engineering employs the appropriate tools and analytics to accomplish the activities needed to complete each of the six steps of the Booz Allen PBL Development and Implementation Process. Logistics engineering will enable the government to hold contractors accountable, establish effective incentives, and manage performance.

- Process reengineering approaches, such as Lean Six Sigma, are at the core of logistics transformation because they are proven methods for increasing weapon-systems availability and effectiveness without driving corresponding increases in cost. Booz Allen's Lean Six Sigma strategic roadmap, when combined with logistics engineering and its associated analytics and tools, is well suited to DoD logistics transformation efforts and will ensure success.

Today, the continuous transformation of logistics includes far more than leveraging leading-edge tech-

nology or improving supply-chain management. In the future, logistics will be based on an entirely new strategic approach to transformation that includes enterprise-level architecture and cultural change. The Booz Allen logistics engineering approach is the new wave and is an ideal instrument for enabling and implementing transformational processes, such as PSP, PBL, process reengineering, and other concepts as they evolve in the future.

What Booz Allen Brings

Booz Allen Hamilton has been at the forefront of management consulting for business and governments for more than 90 years. Integrating the full range of consulting capabilities, Booz Allen is the one firm that helps clients solve their toughest problems, working by their side to help them achieve their missions. Booz Allen is committed to delivering results that endure.

With 18,000 employees on six continents, the firm generates annual that exceed \$3.7 billion. Booz Allen has been recognized as a consultant and an employer

of choice. In 2005 and in 2006, *Fortune* magazine named Booz Allen one of "The 100 Best Companies to Work For," and for the past seven years, *Working Mother* has ranked the firm among its "100 Best Companies for Working Mothers."

To learn more about the firm, visit the Booz Allen Web site at www.boozallen.com. To learn more about the best ideas in business, visit www.strategy-business.com, the Web site for *strategy+business*, a quarterly journal sponsored by Booz Allen.

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