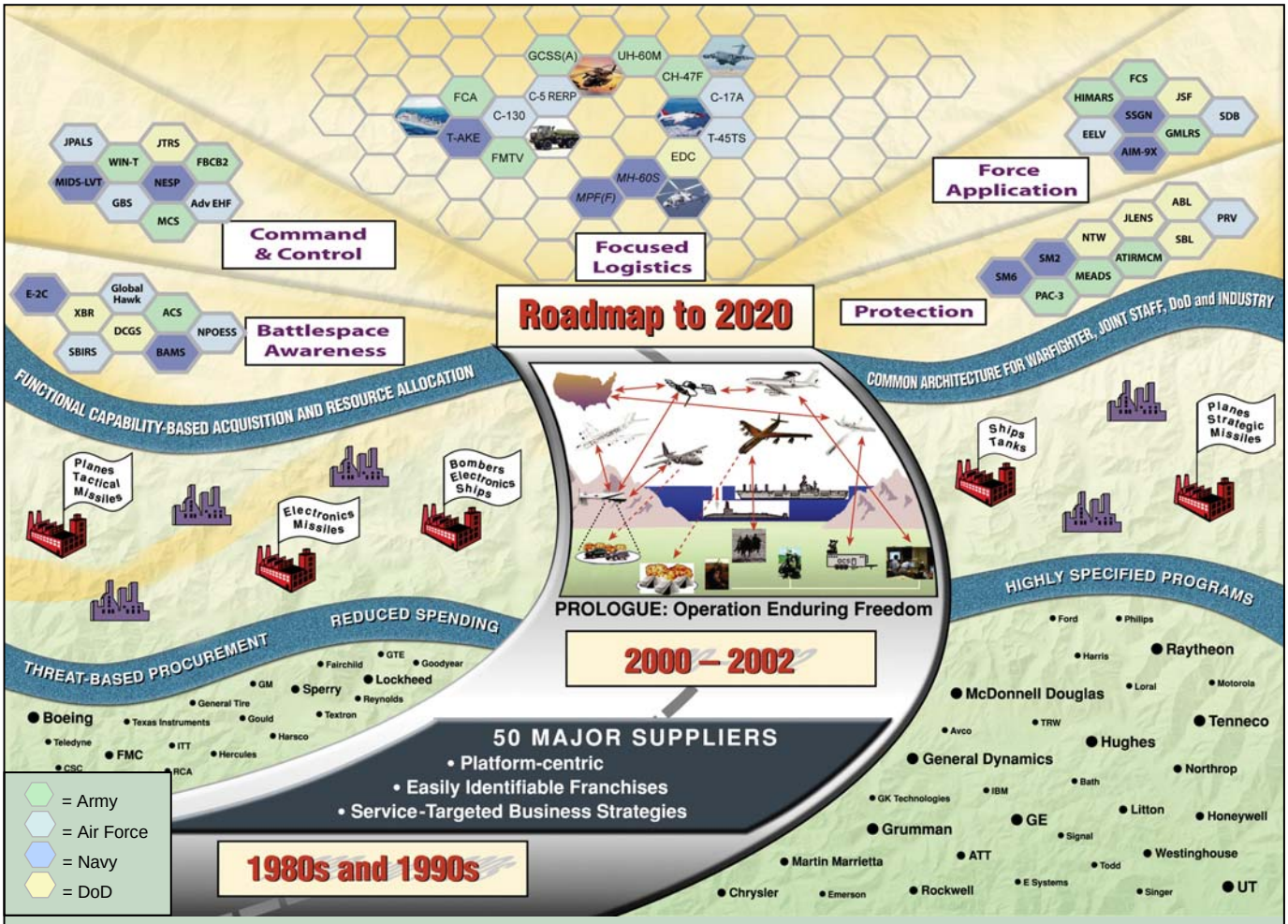

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY: FOCUSED LOGISTICS

JUNE 2005

A version of the cover graphic was used in *Transforming the Defense Industrial Base: A Roadmap* (ODUSD(IP), February 2003). This earlier study concluded that the Secretary's transformation mandate required a different lens for viewing the defense enterprise—one organized around the most essential operational effects that the U.S. warfighter must be able to deliver to be successful. The Joint Staff has now reorganized around new functional concepts. The top of the landscape shows the joint functional concepts where materiel solutions play a major role: Battlespace Awareness, Command and Control, Force Application, Protection, and Focused Logistics, with representative programs indicated for each. The Department is also developing other functional concepts such as Network Centric Operations. These functional concepts, along with related joint operating and integrating concepts, are becoming the central theme for Department decision-making. ODUSD(IP) will continue to adjust its industrial base capability assessments to reflect evolving DoD concepts as appropriate.

This move to capabilities-based decision-making will fundamentally change the defense enterprise. How the Department looks at what it has and what it needs also will affect who participates in the defense industrial base—and likely will cause it to expand. Capabilities-based decision-making provides a common and comprehensive vernacular to the operators, the acquirers, and industry. Clearer communication and an integrated vision should continue to improve the efficiency of planning, decision-making, and execution.

This report and all appendices can be viewed online and downloaded at:

http://www.acq.osd.mil/ip

This report was produced for the Under Secretary of Defense (Acquisition, Technology, & Logistics) by the Deputy Under Secretary of Defense (Industrial Policy) from November 2004 - June 2005. Robert Read led this effort; Dawn Vehmeier, Gary Powell, Dawana Branch, Ronald Genemans, and other Industrial Policy staff also had major roles in the production of this report. Support was provided by Booz Allen Hamilton, Inc. (BAH) and First Equity Development, Inc. Among others, special thanks are due to John Williams, Carmen Alatorre-Martin, and Benjamin Jones of BAH for their important contributions. The team would like to acknowledge the contributions of the Study's Red Teams, consisting of 21 individuals, who reviewed this report. Companies listed or mentioned in this report are representative and not exhaustive. Inclusion or exclusion in the report does not imply future business opportunities with, or endorsement by, the Department.

Inquiries regarding the report should be directed to Mr. Robert Read at (703) 697-0051 or (703) 602-4287. Certain suppliers of which the authors were not aware may possess technologies that mitigate identified industrial base insufficiencies. Such suppliers should contact Mr. Read to document those capabilities for future use.

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY: FOCUSED LOGISTICS

OFFICE OF THE DEPUTY UNDER SECRETARY OF DEFENSE
(INDUSTRIAL POLICY)

JUNE 2005

DEFENSE INDUSTRIAL BASE CAPABILITY STUDY (DIBCS) SERIES STUDY OBJECTIVES
Develop a capabilities-based industrial framework and analytical methodology as a foundation for programmatic and investment decision-making.
Identify technology critical to enabling the new Joint Staff functional warfighter capabilities. Establish a reference database of key industrial base capabilities mapped to warfighting functional capabilities.
Conduct industrial base capability assessments on priority critical technologies to identify deficiencies.
Develop a systematic method to craft industrial base strategies to remedy industrial base deficiencies identified; and encourage proactive, innovative management of the industrial base.

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Findings

Defense industrial base capability assessments must be linked to warfighting capabilities. This report, the fifth and final in the initial Defense Industrial Base Capabilities Study (DIBCS) series, employs a logical, systematic methodology to do this. The primary objective of this study is to identify Focused Logistics (FL) warfighting capabilities and technologies, assess the associated industrial base, and address deficiencies.

Specifically, this study focuses on the FL functional concept as defined in the Joint Staff's Focused Logistics Joint Functional Concept (FLJFC). At its core, FL provides the deployment, redeployment, and sustainment capabilities necessary to project forces anywhere in and above the world for sustained in-theater operations. It includes the traditional mobility functions of airlift, sealift, and spacelift, as well as short-haul (intra-theater and battlefield) transportation. It provides the logistical components essential to operations and sustainment of combat and mobility forces, including logistics Command and Control (C2). FL also includes training the forces, as well as medical capabilities such as health monitoring sensors and battlefield medical gear.

To achieve this goal, sufficient capacity must be built into the U.S. deployment and sustainment pipeline; sufficient control must be exercised over the pipeline from end to end; and a high degree of certainty must be provided to the supported joint force commander that forces, equipment, sustainment, and support will arrive where needed on time. The DIBCS methodology identified 525 warfighting capabilities that directly enable American FLJFC leadership. Supporting these warfighting capabilities, 364 critical technologies qualified as ones in which the United States should maintain leadership. Of these 364 technologies, the study team assessed industrial base sufficiency for 43 priority critical technologies and 15 associated components.

A Note on this Scope of the Study…

Logistics has been an integral part of mission success in all crises that have engaged U.S. armed forces. In doing this assessment, the study team was particularly mindful of current operations and logistics lessons learned from OEF/OIF. This methodology identified many technologies that address current and projected operational logistics concerns: active radio frequency identification (RFID) and sensor-based tagging and tracking for in-transit visibility and total asset visibility; high thrust turbofan engines for airlift; high-speed shallow-draft catamaran hull forms for high-speed sealift; and robotics and ultra lightweight materials for reduced logistics burden. The study team considered the industrial base associated with these technologies, and in most cases found it to be sufficient.

For many other real world logistics concerns, processes, procedures, agreements, and standards—not materiel solutions—are key enablers. Other real world logistics issues may result from resourcing decisions and not industrial base deficiencies. Examples include shortages in strategic lift, as well as for spares and parts. Both categories of issues fall outside the scope of this industrial base assessment.

ODUSD(IP) found:

- With few exceptions, available industrial base capabilities for FLJFC technologies are sufficiently innovative and robust. The study team developed remedial strategies for five technologies where industrial sufficiency requires active implementation of policy measures.

- Production-ready technologies have limited on-ramps to ongoing programs. ODUSD(IP) first addressed these transitional issues when conducting the case studies of 24 emerging defense suppliers in late 2002. The study team re-visited a number of these companies in *DIBCS: Force Application* (*DIBCS FA*) and continues to observe that innovation can be sidelined as a result of many factors: program managers' budgetary constraints; technologies not envisioned in original program requirements; kernels of innovation embedded in losing contract bids; or other technologies not completely aligned with current requirements. The Industrial Base Investment Fund (IBIF) concept, designed to be a Congressionally-funded instrument managed at the most senior acquisition level of the Department, would promote insertion of such producible technologies into programs of record.

- DIBCS assessments already are informing DoD policies and processes related to acquisition strategies, and anti-trust and national security evaluations of proposed business combinations. For example, the *DIBCS: Force Application* assessment identified insufficiency of sources in the GPS-guided Small Diameter Bomb (SDB) program as an industrial base sufficiency issue. The Air Force has since revised its acquisition strategy for the SDB program to plan a competition for the second increment, thereby creating an entry point for potential second sources.

Accounting for the "Ragged Edge"

Over the past two years, the DIBCS methodology has demonstrated its effectiveness in identifying priority critical technologies that will enable the BA/BWA warfighting capabilities for today and tomorrow. However, as with any tool, it has limitations. There are situations where the methodology may not appear to address current warfighters issues—the "ragged edge." First, this technology-based methodology does not address parts obsolescence and other legacy system support issues. There also may be cases where commercial technologies with a sufficient industrial base exist today that can enable the warfighting capabilities, but the Department has not invested in applying those technologies to existing or forward-leaning programs even though the industrial base is sufficient to mature the technology or develop military application. Examples include self-repairing materials technologies that repair early stage structural cracks or halt crack propagation, thereby minimizing structural failures and maintenance; sea-basing applications of commercially available automated guided vehicles; and in-transit visibility applications of satellite-based asset tracking. Finally, many real world logistics issues still result from funding limitations for existing systems such as strategic airlift, spares, and repair parts—not industrial base issues.

Some of the warfighting capabilities identified by this methodology are forward-leaning—to anticipate the Joint Staff's continuing evolution of the joint functional concepts and warfighting capabilities. For some warfighting capabilities, technological solutions are yet to be developed or adapted (or may be classified). Absent technological solutions, industrial base sufficiency cannot be assessed—but will be as the technologies develop. Examples of this are the warfighting capabilities for high speed sealift or heavy vertical lift.

Recommendations

1) The Department should implement remedies in this report to address the five industrial base issues (see summary descriptions on page x) identified in the FL area:

   - Direct Energy Conversion;
   - Advanced Solid Rocket Motors;
   - Fast Reusable Tooling;
   - Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System; and
   - Autonomous Rendezvous and Docking.

2) The Department should continue developing the IBIF to provide better on-ramps for innovative production-ready technologies nominated by emerging suppliers and by company or Department program managers. The Department is in the early stages of conceptualizing the IBIF. Such a fund would leverage and synergize lessons learned from similar funds and transition vehicles available in the Department and in commercial businesses. ODUSD(IP) will continue refining this concept and advocate funding this vehicle by FY07.

3) The Department's acquisition and budgeting decision-making processes should continue to transition to the functional capability lens. In addition, the Department should continue to provide specific oversight on contractual arrangements relating to technologies identified as critical in the DIBCS series. This oversight is necessary to ensure appropriate actions relative to the intended development of these building blocks of the defense industrial base. ODUSD(IP) would accomplish this by reviewing acquisition strategies within the acquisition oversight process and by continuously monitoring DIBCS critical technologies as weapon system programs progress. Finally, ODUSD(IP) should continue to investigate possible changes to the regulatory framework of both the Hart-Scott-Rodino (HSR) and Committee on Foreign Investment in the United States (CFIUS) processes to merge the disparate and sometimes duplicative processes into a single, fused, and comprehensive framework that better addresses Department industrial base equities.

Summary of DIBCS FL Issues

Direct Energy Conversion: technology in which energy from ambient (e.g., solar, gravitational) or human sources is directly converted into another form of energy—usually electricity. It could enable or enhance a variety of military capabilities by replacing heavier and larger power sources, such as batteries.

Advanced Solid Rocket Motors: propellant technology that is in a solid state and is stored and supported within a combustion chamber used in space launchers, intercontinental ballistic missiles, national missile defense interceptors, and a wide array of tactical missiles.

Fast Reusable Tooling: technology where a new class of materials can be reversibly transformed from a liquid-like state to a solid state at room temperature with no change in volume. It can be used to significantly reduce the number of specialized tools required for maintenance and repair of ships, aircraft, and land vehicles—thus reducing specialized asset transport, tracking, and accountability requirements.

Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System: technology for sea-basing applications that integrates robotics, systems controls, and cargo-moving devices (e.g., cranes and elevators) to move, store, and retrieve cargo in bins, pallets, and other packaging containers. It can greatly lower manpower requirements and result in greater efficiency .

Autonomous Rendezvous and Docking: technologies that integrate navigation techniques, sensing devices, collision avoidance systems, avionics, and docking mechanisms to autonomously bring two spacecraft together. It could provide the ability to service on-orbit satellites to increase their lifetimes and expand their missions.

FOREWORD

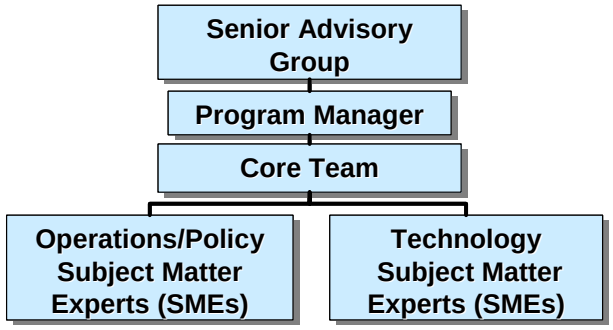
Defense Industrial Base Capabilities Study (DIBCS): Focused Logistics is the fifth and final report in the initial DIBCS series. Two postulates framed this body of work:

(1) the U.S. warfighting ethos dictates that any assessment of defense industrial base capability begins with a detailed understanding of the future warfighting capabilities that senior military leadership desires for the U.S. military; and

(2) good stewardship of the defense industrial base demands in-depth knowledge of the ability of that base to meet those leadership desires.

Armed with these postulates, the Office of the Deputy Under Secretary of Defense (Industrial Policy) (ODUSD(IP)) designed a study methodology that combined the best domain knowledge available on these topics with a rigorous, objective study process to evaluate the spectrum of industrial base capabilities required to support 21st century warfighting.

STRUCTURE OF DIBCS EXECUTION TEAM



Source: Booz Allen Hamilton

The Senior Advisory Group, contracted for in 2003 to oversee this study series, soon was joined by teams of subject matter experts for each Joint Staff Functional Concept. ODUSD(IP) produced each study using data and initial conclusions generated by this DIBCS Execution Team as shown in the graphic opposite. The study methodology also included reviews by a total of 122 Red Team members—outside subject matter experts and senior military and Department leaders. For each study, ODUSD(IP) then convened a final review board consisting of the staff study lead(s) and other ODUSD(IP) personnel to ensure technical rigor, consistency of methodology, and comparability of presentation among these five studies that compose the DIBCS series.

JOINT STAFF'S FIVE ORIGINAL FUNCTIONAL CONCEPTS

Source: ODUSD(IP)

Most importantly, each study is anchored in the Joint Functional Concept for each of the five Functional Capability Areas assessed: Battlespace Awareness, Command and Control, Force Application, Protection, and Focused Logistics. Each study began with Joint Staff discussions to better understand the details of the Functional Concepts.

Now complete, the DIBCS series characterized nearly 5,000 discrete capabilities: 2,881 warfighting capabilities and associated leadership goals; 1,428 critical technologies that enable key warfighting capabilities; and industrial base capabilities for 329 priority critical technologies and components. The DIBCS series also highlights the breadth of the industrial base available to meet functional capability needs: a total of more than 800 companies, laboratories, and universities are involved in the 329 priority critical technologies and components investigated.

These reports are reaching a wide audience. The first four reports have been downloaded nearly 112,000 times from the ODUSD(IP) website. In addition, as summarized in the following tables, ODUSD(IP) is communicating and socializing the DIBCS methodology and findings throughout the Department, other federal agencies, the U.S. Congress, industry, and allied and friendly nations.

ODUSD(IP) SELECTED OUTREACH EFFORTS

	Date	Organization[1]	Purpose
Department	7/24/03	Joint Staff/BA FCB Working Group	DIBCS Briefing
	2/6/04	Joint Staff/C2 FCB Working Group	DIBCS Briefing
	4/16/04	Joint Staff/FA FCB Working Group	DIBCS Briefing
	6/2/04	Program Managers/PEOs for JTRS, FBCB2, MILSATCOM, and GCCS-J programs	C2/NCO PMFCC Offsite Exercise
	7/15/04	Director, Acquisition & Resources Analysis—Dr. Nancy Spruill	PMFCC/ACAR Follow-up
	8/17/04	Mr. Ken Krieg, VADM Szemborski, MG Hunzeker, Col Lawrence	PMFCC/ACAR Socialization
	8/18/04	Joint Forces Command—MajGen Simpson	PMFCC/ACAR Socialization
	8/30/04	AT&L staff—Dr. Nancy Spruill, Raleigh Durham, Robin Quinlan	PMFCC/ACAR Socialization
	9/2/04	MG Hunzeker and staff	PMFCC/ACAR Follow-up
	9/29/04	USD(AT&L)—Mr. Wynne	PMFCC/ACAR Proposal
	10/27/04	General Counsel—Mr. Haynes	HSR/CFIUS Regulatory Changes
	11/3/04	Joint Staff/Protection FCB Working Group	DIBCS Briefing
	12/16/04	DDR&E—Dr. Holland	IBIF Briefing
	2/16/05	Joint Staff/FL FCB Working Group	DIBCS Briefing
	2/22/05	DDR&E—Sue Payton	IBIF Briefing
Interagency/Other	12/4/04	Department of Justice	HSR Regulatory Changes
	12/8/04	American Bar Association General Counsels' Committee	HSR/CFIUS Regulatory Changes
	1/27/05	Senate Armed Services Committee Staffers	IBIF Briefing
	2/23/05	National Security Council	HSR/CFIUS Regulatory Changes
	3/16/05	Senate Staffer (Senator Lieberman, D-CT)	IBIF Briefing
	3/30/05	Department of Homeland Security	HSR/CFIUS Regulatory Changes
	4/6/05	Department of Treasury	CFIUS Regulatory Changes
	5/3/05	Federal Trade Commission	HSR Regulatory Changes
	6/6/05	American Bar Association Strategic Alliance	HSR/CFIUS Regulatory Changes

Source: ODUSD(IP)

[1] Does not include DIBCS Red Teams.

ODUSD(IP) SELECTED OUTREACH EFFORTS (CONTINUED)			
	Date	**Organization**	**Purpose**
International	2/23-25/04	Singapore Defence Officials	DIBCS Methodology/Findings
	3/1-3/04	Japan Ministry of Economy, Trade, and Industry	DIBCS Methodology/Findings
	9/22/04	European Defence Agency Establishment Team	DIBCS Methodology/Findings
	10/21/04	Korean/U.S. Industrial Cooperation Committee	DIBCS Methodology/Findings
	10/26/04	Australian Ministry of Defence	DIBCS Methodology/Findings
	10/27/04	Swedish Foreign Affairs and Defence Officials	DIBCS Methodology/Findings
	1/18/05	German Ambassador and Staff	DIBCS Methodology/Findings
	3/14/05	Deputy Director of European Defence Agency and National Armament Directors/Representatives	Multi-National Defense Planning Workshop
	4/27/05	German Ministry of Defence	DIBCS Methodology/Findings
	6/23-28/05	Turkish Ministry of National Defence, Ministry of Industry, and General Staff	DIBCS Methodology/Findings
	6/29-30/05	Greek Ministry of Defence and Industry	DIBCS Methodology/Findings
Source: ODUSD(IP)			

The stage now is set for the next step: the synchronization of the DIBCS series recommendations and their implementation. First, ODUSD(IP) will further assess the 24 issues of insufficiency and four "Watch List" items[2] to determine whether recommended remedies have been implemented and whether new or classified programs, which the DIBCS series did not assess, have sufficiently strengthened U.S. industrial capabilities.[3] Then, ODUSD(IP) will develop implementation strategies for remaining issues in consultation with other Department leaders. Only when synchronization and implementation is complete will the aims of this initial body of work be accomplished: to provide 21st century warfighters the benefits of industrial base invention and innovation. Long after the study series is complete, the DIBCS framework and findings will continue to inform other federal agency, industry, and allied nation industrial planning processes.

[2] "Watch List" technologies represent unusual technical solutions that could pose challenges to U.S. warfighters if possessed by potential adversaries, or represent *BA/BWA* warfighting capability breakthroughs in which the Unites States is not currently investing.

[3] The DIBCS series utilizes unclassified, open source material to facilitate maximum transparency and distribution.

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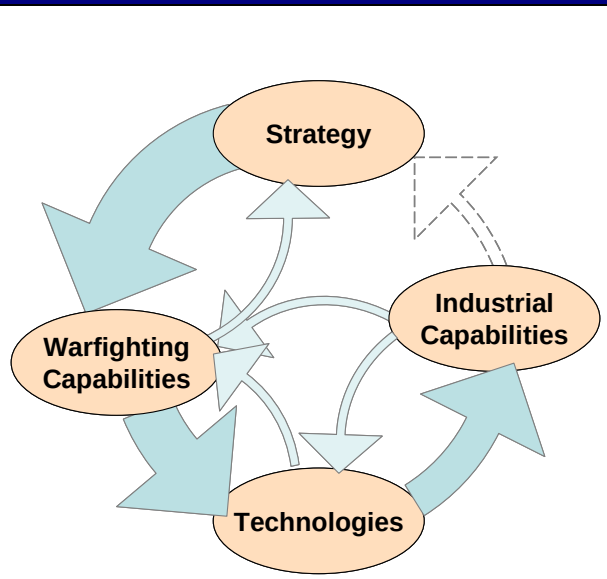
EXECUTIVE SUMMARY

In February 2003, the Office of the Deputy Under Secretary of Defense for Industrial Policy, ODUSD(IP), produced *Transforming the Defense Industrial Base: A Roadmap*. This report identified the need for systematic evaluation of the ability of the defense industrial base to develop and provide functional, operational effects-based warfighting capabilities. The Defense Industrial Base Capabilities Study (DIBCS) series is a systematic assessment of critical technologies needed in the 21st century defense industrial base to meet warfighter capabilities, as framed by the Joint Staff's functional concepts. In addition, the DIBCS series provides the basis for strengthening the industrial base required for 21st century warfighting needs by proposing remedies for issues identified. It also serves as a tool with which companies can assess the relevance of their technologies to the Department's warfighting capability goals. This report addresses the fifth of those initial functional concepts, Focused Logistics (FL). The Department defines FL as the ability to deploy, redeploy, and sustain forces anywhere in and above the world for sustained, in-theater operations.

CAPABILITIES-BASED INFLUENCE CYCLE



The purpose of this process is to explicitly influence the strategy formulation of the Department, recognizing that the formulation of these inputs can be done most completely once all five DIBCS assessments are completed. This tie-in to strategy is also contingent on the synchronization of Department process changes to this new functional capabilities construct.

Source: ODUSD(IP) and Booz Allen Hamilton

The DIBCS methodology associates enabling technologies with warfighting capabilities and assesses the industrial base's ability to develop and produce those technologies. It defines national leadership goals for warfighting capabilities (*Neutral, Equal, Be Ahead, Be Way Ahead*) that establish the degree of innovation desired in the industrial base. A warfighting capability that is ubiquitous—mature and available to all countries—typically has a *Neutral* capability leadership goal. Technologies linked to *Neutral* warfighting capabilities require minimal innovation and can often be sourced from the global marketplace. *Equal* warfighting capabilities are mostly represented by a common technological generation and may also readily be sourced from global suppliers.

In contrast, a warfighting capability that brings key U.S. advantages has a *Be Ahead* (*BA*) or *Be Way Ahead (BWA)* capability leadership goal. Technologies associated with *BA* warfighting capabilities are represented by a technology generation lead or order of magnitude better performance in key

attributes. *BWA* warfighting capabilities must lead by multiple technology generations, must be highly innovative, often require effective competition among suppliers to be sustained, and generally require close strategic alignment with the Department's timing and vision for these capabilities. The graphic on the previous page shows the relationship between the Joint Staff's capabilities-based strategy and the industrial capabilities the DIBCS methodology assesses. The DIBCS series focuses on *critical* technologies—those linked to *BA* and *BWA* warfighting capabilities—and then proactively assesses industrial base sufficiency for a subset of priority critical technologies.

The DIBCS series recognizes that managing priority critical technologies and the associated industrial base capabilities may require policy and process changes. As such, it serves as a forum for implementing policy and process changes necessary to strengthen the industrial base available to the Department.

As part of the challenge of attracting new innovative suppliers to the defense industrial base, ODUSD(IP) also has conceptualized the Industrial Base Investment Fund (IBIF) to address the imperfections of the on-ramps available to companies that have leading-edge, producible technologies relevant to programs of record. The DIBCS study team acknowledges that program managers may be reluctant to inject innovative products, not foreseen at the inception of their program, into their on-going programs real-time due to the potential impact on cost, schedule, and performance against the program's approved Acquisition Program Baseline. Therefore, such technologies often remain on the sidelines of the defense enterprise. Other reasons technologies remain on the sidelines are that they:

- Do not meet programs managers' funding priorities;
- Are not in the program's scope as originally envisioned;
- Are "cutting room floor" technologies from losing bids difficult to assimilate in programs due to intellectual property or acquisition regulation restrictions; or
- Are not completely aligned with current requirements.

The envisioned IBIF would be managed by the office of the Under Secretary of Defense (Acquisition, Technology, and Logistics) (USD(AT&L)) in a manner similar to Chairman Innovation Funds in industrial settings. It would complement other Department initiatives focused on improving innovation, but as a pre-funded vehicle committed to cross-pollinating multi-application innovation; it would insert production-ready technologies across the broadest possible span of impact. Initial funding could be secured in the FY07 budget.

THE ROLE OF FOCUSED LOGISTICS

This study begins with understanding the FL functional concept. At its core, FL provides the deployment, redeployment, and sustainment capabilities necessary to project forces anywhere in and above the world for sustained in-theater operations. It includes the traditional mobility functions of airlift, sealift, and spacelift, as well as short-haul (intra-

theater and battlefield) transportation. It provides the logistical components essential to operations and sustainment of combat and mobility forces, including logistics Command and Control (C2). FL also includes training, equipping, feeding, supplying, and maintaining the forces, as well as medical capabilities.[4] To summarize, the FL warfighting capabilities relate to building sufficient capacity into the U.S. deployment and sustainment pipeline; exercising sufficient control over the pipeline from end to end; and providing a high degree of certainty that forces, equipment, sustainment, and support will arrive where needed on time for the joint force commander.

Focused Logistics warfighting advantages are not just provided by technology; they are driven, in many cases, by practices, processes, and procedures, along with other non-industrial issues identified in the table opposite. These are, however, not within the technology-focused scope of this study. Many of the enabling technologies are commercially available in companies where the Department may not be a dominant customer—which limits the Department's ability to influence the technology development. The Department must continue to refine processes to successfully assess and apply these commercially available technologies for military operations in FL, an issue also identified in the DIBCS work on C2 and Protection for information and medical technologies, respectively.

***Logistics Capabilities Outside the Scope of DIBCS FL**:*

- *Processes, procedures, agreements, standards;*
- *Support functions such as payroll, finance, general counsel, public relations;*
- *Issues related to contractor support and commercial augmentation are not specifically considered—the study focuses on needed capabilities rather than who provides them.*

FOCUSED LOGISTICS RECOMMENDATIONS

This analysis identified 525 specific warfighting capabilities supporting FL. Of these, 271 capabilities were ones in which the United States should maintain a lead of at least one technology generation (*BA/BWA*). These *BA/BWA* warfighting capabilities are enabled by 364 critical technologies. ODUSD(IP) assessed 43 of the most important of these technologies and 15 associated component technologies—for a total of 58 priority critical technologies assessed for industrial base sufficiency.

[4] *DIBCS C2* addressed most logistics command and control capabilities (e.g., data capture and visibility, decision support, communications, etc.); *DIBCS FL* includes only those C2 capabilities fundamental to logistics. *DIBCS: Protection* addressed *BA/BWA* medical capabilities associated with protecting against radiation; disease; biological and chemical weapons; and decontamination from chemical/biological weapons and radiation. *DIBCS FL* includes health monitoring and health care on the battlefield or within the theater of operations, as well as evacuation care.

RECOMMENDATION 1

The Department should implement the remedies in this report to address the five industrial base sufficiency or leadership issues identified in the FL area:

- Direct Energy Conversion;
- Advanced Solid Rocket Motors;
- Fast Reusable Tooling;
- Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System; and
- Autonomous Rendezvous and Docking.

RECOMMENDATION 2

The Department should continue developing the IBIF to provide better on-ramps for innovative production-ready technologies nominated by emerging suppliers and by company or Department program managers. The Department is in the early stages of conceptualizing the IBIF. Such a fund would leverage and synergize lessons learned from similar funds and transition vehicles available in the Department and in commercial businesses. ODUSD(IP) will continue refining this concept and advocate funding this vehicle by FY07.

RECOMMENDATION 3

The Department's acquisition and budgeting decision-making processes should continue to transition to the functional capability lens. In addition, the Department should continue to provide specific oversight on contractual arrangements relating to technologies identified as critical in the DIBCS series. This oversight is necessary to ensure appropriate actions relative to the intended development of these building blocks of the defense industrial base. ODUSD(IP) would accomplish this by reviewing acquisition strategies within the acquisition oversight process and by continuously monitoring DIBCS critical technologies as weapon system programs progress. Finally, ODUSD(IP) should continue to investigate possible changes to the regulatory framework of both the Hart-Scott-Rodino (HSR) and Committee on Foreign Investment in the United States (CFIUS) processes to merge the disparate and sometimes duplicative processes into a single, fused, and comprehensive framework that better addresses Department industrial base equities.

THE LARGER DIBCS EFFORT

Focused Logistics is the fifth and final report in the initial DIBCS series. The DIBCS process provides a rigorous, objective analytical framework to examine industrial base sufficiency issues for the joint functional concepts most dependent on materiel

DIBCS Report	Publication Date
Battlespace Awareness	January 2004
Command & Control	June 2004
Force Application	October 2004
Protection	December 2004
Focused Logistics	June 2005

solutions. The chart opposite summarizes the scope of this body of work. Of the 180 priority critical technologies and 133 key components identified and assessed—supporting over 2,000 *BA/BWA* warfighting capabilities—284 (approximately 91 percent) have a sufficient industrial base.[5]

DIBCS RESULTS FOR ORIGINAL FIVE FUNCTIONAL CONCEPTS

Methodology Execution

List of key *(BA/BWA)* Capabilities

Identify Technology Solutions and Create Technology List

Prioritize Tech List and Down-select Initial Priority Assessment List

Elaborate on Key Components

Assess Industrial Base for Techs and Components

Sector	Total # Capa.	Be Ahead	Be Way Ahead
BA	436	169	188
C2	255	146	43
FA	1036	392	395
Prot	629	323	117
FL	525	254	17
Total	2881	1284	760

Sector	Number Techs
BA	278
C2	293
FA	212
Prot	277
FL	364
Total	1424

Sector	Techs Assessed
BA	31
C2	35
FA	32
Prot	39
FL	43
Total	180

Sector	Components Assessed
BA	41
C2	23
FA	29
Prot	25
FL	15
Total	133

Sector	Techs Sufficient	Potential Issues
BA	69	3
C2	55	3
FA	53	6 + 2WL
Prot	55	7 + 2WL
FL	52	5
Total	284	24 + 4WL

The DIBCS series complements ongoing Department-wide studies by mapping technology and industrial base capabilities to the new functional capabilities construct, providing a comprehensive baseline—and a long forward pass through 2020.

Source: Booz Allen Hamilton and ODUSD(IP)

Across the five functional concepts, U.S. suppliers have no foreign competition for nearly 20 percent of the researched technologies. Most—64 percent—of the researched technologies are either new ways of doing business or breakthrough technologies. The U.S. *Leads* or *Significantly Leads* in over half—55 percent—of the researched technologies, is *Even* in 38 percent, and *Trails* only in seven percent. Battlespace Awareness and Force Application have the highest percentage of *Leads/Significantly Leads* technology areas—approximately 70 percent each. This likely is due to the Department's focus on the breadth of unique technologies necessary to provide U.S. warfighters desired technological advantages in these sectors. The conclusion: the U.S. industrial base is well positioned to develop and apply the critical technologies that will continue to enable the most important 21st century warfighting capabilities.

Now that the initial study series is completed, this framework and its findings will continue to inform other Department, industry, and allied processes related to defense industrial base issues. ODUSD(IP) is currently developing a comprehensive communication and implementation plan of the DIBCS series' findings and

[5] ODUSD(IP) will continue monitoring industrial supplier sufficiency for the already-examined critical technologies, and evaluate additional critical technologies that may be important to current warfighting concerns—resources permitting.

recommendations as part of its continuous review of the industrial base. However, already the individual studies have served to strengthen the industrial base and processes associated with the U.S. and global industrial base. For example, the *DIBCS: Force Application* assessment identified the breakthrough technology used in the GPS-guided Small Diameter Bomb (SDB) program as an industrial base sufficiency issue. The Air Force has since revised its acquisition strategy for the SDB program to plan a competition for the second increment, thereby creating an entry point for potential second sources. In addition, ODUSD(IP) is now using the DIBCS series in developing the Department's positions on merger and acquisition reviews, and for reviews of program acquisition strategies.

While the initial work on the DIBCS series is complete, ODUSD(IP) will continue to utilize the DIBCS methodology as part of its continuous review of the industrial base. The vernacular and methodology it deploys are being echoed in U.S. and global corporations interested in supplying technology for future generations of warfighters. In fact, numerous foreign governments have expressed an interest in adapting our methodology to inform their industrial planning processes. ODUSD(IP) teams recently completed DIBCS series briefings in Australia, Germany, Turkey, and Greece. ODUSD(IP) also hosted a European Defence Agency exercise in March 2005 to assess the utility of this methodology for multi-national industrial base planning.

If disparate industrial base capabilities are to improve warfighting capabilities, sufficiency analyses and the associated industrial base planning must begin with a broad understanding of *warfighting capabilities* required. To base assessments on what is currently available in a given industrial base or on individual constituent interests dooms the warfighter and the industrial base to the status quo. Only by looking to the future can we transform the industrial base to support the operational ethos: warfighting capabilities, and the warfighter, must drive defense demand and the products the Department acquires. The DIBCS series does this for the Department. Long after the study series is complete, the DIBCS framework and findings will continue to inform other federal agency, industry, and allied nation industrial planning processes.

PART I

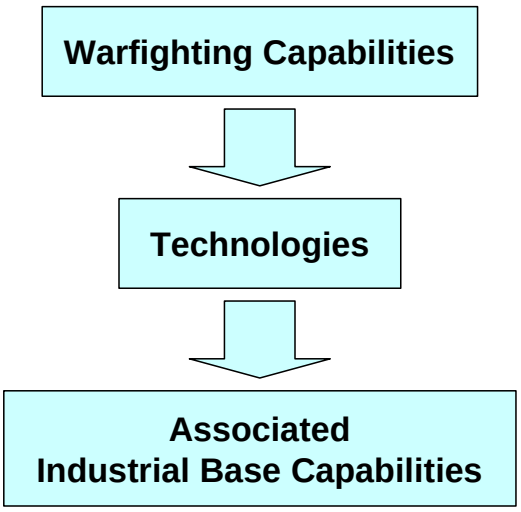
MEETING THE CHALLENGE

The February 2003 report, *Transforming the Defense Industrial Base: A Roadmap*, reflected a revolutionary warfighting doctrine then germinating within the Department. Since then, the Department has organized around functional concepts defined by the Joint Staff that focus the Department's resources on the most essential operating effects that the U.S. warfighter must deliver in order to win. To help the industrial base respond to this new challenge, the Office of the Deputy Under Secretary of Defense for Industrial Policy (ODUSD(IP)) initiated the Defense Industrial Base Capabilities Study (DIBCS) series to communicate these needs and this capabilities-based approach, and to identify and recommend remedies for industrial base issues.

ROADMAP TO THE FUTURE

The DIBCS series represents a structured, top-down analysis and policy framework by which Department decision-makers can harness the full power of competition to address key warfighting capabilities and unleash innovation in academia, industry, and the Government. The DIBCS series identifies warfighting capabilities, the critical enabling technologies that support those warfighting capabilities, and the industrial base capabilities associated with those technologies. The series also highlights and addresses industrial base concerns across lifecycles of programs.

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY TRANSLATION PROCESS



Source: Booz Allen Hamilton and ODUSD(IP)

The Department's move towards capabilities-based planning will fundamentally change the defense enterprise. It is changing the manner in which the Department identifies and prioritizes military capability requirements, focusing its attention on enabling capabilities—often acquired in families- or systems-of-systems. Inherent in this shift are changes in doctrine and the way the Department manages the development and acquisition of these capabilities. How the Department looks at what it has and what it needs will also affect who participates in the defense industrial base—and challenge the Department to make better use of a broader base of suppliers.

The Joint Staff's initial five functional concepts where materiel solutions are most important are: Battlespace Awareness (BA), Command and Control (C2), Force Application (FA), Protection, and Focused Logistics (FL). Translating the industrial base implications of these concepts extends a common and comprehensive vernacular from

the operators to the acquirers and industry. The landscape of the future, as depicted on the cover of this report and illuminated on the flyleaf, is still evolving. Accordingly, ODUSD(IP) continues to modify its industrial capability assessments to reflect the latest evolution of the Department's concepts. This integrated vision will improve the efficiency of resource and operational planning, and associated decision-making and program execution within the Department and industry. Applying these tools with diligence will greatly increase the Department's confidence that critical industrial base capabilities are available when needed to maintain U.S. warfighting superiority. It will be up to the Department leadership to structure programs that effectively draw on industrial base capabilities to meet warfighters' 21st century requirements.

THE DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY METHODOLOGY

The Department's industrial policy challenge is to evaluate the industrial base in this new capabilities-based framework and recommend actions and policies to ensure the industrial base can develop the technologies and produce the systems and weapons required.

JOINT STAFF JOINT FUNCTIONAL CONCEPTS[6]	
Battlespace Awareness Global Hawk, DCGS, NPOESS, SBIRS-High, E-2 Advanced Hawkeye	Capabilities of commanders and force elements to understand their environment and the adversaries they face. Uses a variety of surveillance capabilities to gather information; a harmonized secure netcentric environment to manage this information; and a collection of capabilities to analyze, understand, and predict.
Command and Control[7] FBCB2, AOC-WS, MPS	Capabilities that exercise authority and direction over forces to accomplish a mission. Involves planning, directing, coordinating, and controlling forces and operations. Provides the means to recognize what is needed and ensure that appropriate actions are taken.
Force Application JDAM, MM III, F/A-22, MH-60R, JSF, CVN21, FCS, GMLRS	Capabilities to engage adversaries with lethal and non-lethal methods across the entire spectrum of conflict. Includes all battlefield movement and dual-role offensive and defensive combat capabilities in land, sea, air, space, and information domains.
Protection ATIRCM/CMWS, PAC-3, Chem Demil	Capabilities that defend personnel (combatant and non-combatant), physical assets, and information of the United States, allies, and friends from explosive, chemical, biological, nuclear, radiological, air, missile, and cyber attack.
Focused Logistics C-130, CH-47, GCSS, MPF, T-AKE, C-17, FMTV, MH-60S, C-5 RERP	Capabilities to deploy, redeploy, and sustain forces anywhere in or above the world for sustained, in-theater operations. Includes traditional mobility functions of airlift, sealift, and spacelift,[8] as well as short-haul (intra-theater and battlefield) transportation. Also includes logistics C2, training, equipping, feeding, supplying, maintaining and medical capabilities.
Source: Joint Functional Concepts and ODUSD(IP)	

[6] These definitions do not, in all cases, precisely match current and evolving Joint Staff definitions. In some cases this is because the study series began prior to publication of the joint functional definitions. In other cases, definitions were informed by existing or emerging technology solutions or warfighting capabilities that added important scope to the Joint Staff's more general context. A sampling of major programs is aligned with each functional concept to provide an illustration of that area's scope. Not all of the warfighter capabilities supplied by a program fall into a single sector, however. All acronyms are defined in the Acronym List beginning on page 51.

[7] The Network Centric Operations (NCO) capabilities relevant to that functional concept are included in the *DIBCS C2* report published in June 2004.

[8] Spacelift is considered logistics because it transports material and people (for example, satellites and astronauts) into space.

The DIBCS series assesses the sufficiency of the industrial base for priority critical technologies in each functional capability area, using the same methodology in all functional capability areas.[9] The methodology is consistent with the operational ethos embodied in the U.S. defense industrial base: warfighting capabilities, and the warfighter as the primary constituent, must drive DoD demand and the products the Department acquires.

LEADERSHIP GOALS	
Neutral	Position relative to potential adversaries is immaterial.
Equal	Desire capability at least as good as potential adversaries; systems are likely in a common technological generation.
Be Ahead	Desire a significant capability difference over potential adversaries; systems should likely lead by a technology generation or an order of magnitude better performance in key attributes.
Be Way Ahead	Desire a very significant capability difference over potential adversaries; systems should likely lead by multiple technology generations or orders of magnitude in performance.
Source: Booz Allen Hamilton and ODUSD(IP)	

This methodology categorizes warfighting capabilities according to the advantage they give the United States over potential adversaries. As described in the table opposite, extra attention is focused on those warfighting capabilities where the United States should lead any potential adversary. Less attention is focused where leadership is not possible or not particularly advantageous. Ideally, the Department would wish to have a significant lead in every warfighting capability. Practically, however, the Department cannot do so.

In addition, operational concepts will change over time, and the Department should focus most on those capabilities where leadership will provide the warfighter the greatest advantage. The DIBCS methodology gives added weight to the most important of these technologies. The objective is to concentrate DoD attention and scarce resources on the areas that will have the largest impact on 21st century joint military operations: those warfighting capabilities for which the Department must have *Be Ahead* and *Be Way Ahead (BA/BWA)*[10] leadership goals.

The "Ragged Edge"

As effective as this methodology has proven, there are situations where the methodology may not appear to address current warfighters issues—the "ragged edge." The Department still is defining warfighting capabilities and identifying the technologies that enable these capabilities. DIBCS focuses on technology and materiel solutions.

- *For some warfighting capabilities, technological solutions are yet to be developed or adapted (or may be classified). Absent technological solutions, industrial base sufficiency cannot be assessed—but will be as the technologies develop.*
- *Commercial technologies can enable certain warfighting capabilities. Generally, the commercial industrial base and commercial demand is sufficient to mature the technology. The Department must leverage these technologies and adapt them as necessary for DoD-specific applications.*
- *Many real world logistics issues result from funding limitations for existing systems (e.g., strategic airlift, spares, and repair parts)—not industrial base issues.*
- *Finally, this technology-based methodology does not address parts obsolescence and other legacy system support issues.*

[9] Adapted from the *Space R&D Industrial Base Study*, Booz Allen Hamilton, August 2002.
[10] For clarity, functional capabilities, leadership goals, and policy tools are italicized; Joint Staff operational capabilities are in quotation marks.

Therefore, the methodology focuses on the warfighting capabilities where the Department needs to achieve and maintain the greatest lead; then the study team identifies the priority critical technologies that enable these capabilities and provides assessments of the associated industrial base. When an industrial base deficiency—whether immediate or projected—is identified, the study team examines it in more depth and recommends remedies.[11]

This analytical process, further elaborated below, has three basic steps: identify warfighting capability leadership goals; determine and prioritize associated technologies; and assess the industrial base associated with those technologies.

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY METHODOLOGY[12]

1 Identify U.S. Leadership Goals for Capabilities

DIBCS Focused Logistics Comprehensive Capability Areas	Specific Capability by Leadership Goal			
	Neutral	Equal	Be Ahead	Be Way Ahead
Joint Deployment/Rapid Distribution	42	154	159	12
Agile Sustainment	2	31	27	3
Logistics Information Management	0	3	25	1
Operational Engineering	3	8	12	0
Force Health Protection	0	7	16	0
Training	0	4	15	1

Decompose capabilities and identify functions to determine enabling technologies

2 Determine Enabling Technologies for Be Ahead/Be Way Ahead Capabilities

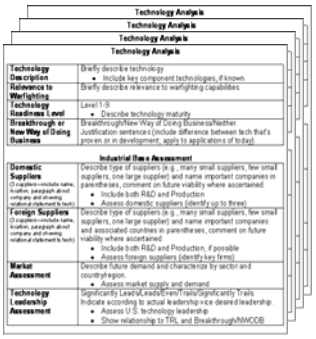
Critical Technology/ Industry List (368)

Airdrop
Cargo Handling
Communications and Networking
Devices
Engineering
Fuel Handling and Storage
Fuels
Maintenance and Repair
Materials
Medical
Power Generation and Storage
Propulsion
.....

Prioritize technologies to focus and scope assessments

- Importance of technology in warfighting
- Importance of capability the technology enables
- Number of capabilities the technology enables

3 Assess Industrial Base Capabilities for Each Critical Technology



Source: Booz Allen Hamilton and ODUSD(IP)

1. Identify U.S. Leadership Goals for Warfighting Capabilities. This industrial base study series uses research and analysis teams of subject matter experts to identify detailed warfighting capabilities derived from other documents such as the Joint Staff's functional concepts and the *Universal Joint Task List.*[13] A DIBCS Senior Advisory Group (SAG), composed of retired senior military and civilian DoD leaders and selected industry experts, guides the subject matter experts. The DIBCS SAG then oversees the selection of the leadership goal for each identified capability based on the advantage it provides the United States in executing joint operations in the 21st century.[14]

[11] For a more detailed discussion of potential policy remedies (portals and levers), see Appendix D.
[12] U.S. leadership goals for warfighting capabilities are characterized by the terms *Neutral, Equal, Be Ahead, Be Way Ahead*. U.S. technology leadership is characterized by the terms *Leads, Even,* and *Trails* as compared to non-U.S. suppliers.
[13] Chairman of the Joint Chiefs of Staff Manual 3500.04C, Universal Joint Task List, July 1, 2002.
[14] See Appendix A for DIBCS Focused Logistics Capability Framework.

2. Determine and Prioritize Critical Technologies for *BA/BWA* Warfighting Capabilities. Once these capability goals have been vetted by the Department, the team identifies the critical enabling technologies for those warfighting capabilities with leadership goals rated *BA/BWA*. The DIBCS SAG oversees a team of subject matter experts to identify and prioritize these technologies, using a variety of sources such as the *Joint Warfighting Science and Technology Plan.*[15] The study team then establishes the priority of a technology using three factors. The first factor is the importance of the technology in enabling warfighting impact in a breakthrough, transformational, or critically essential manner. The second factor is the importance of the specific capability the technology enables. For example, it is more important to enable a *BWA* than a *BA* capability. The third factor is the span of impact of the technology in enabling multiple capabilities.

DIBCS FOCUSED LOGISTICS* SENIOR ADVISORY GROUP** **WITH FORMER RELEVANT POSITIONS AND EXPERTISE NOTED
Gen (Ret) Thomas S. Moorman, Jr. [(a)] *Vice Chief of Staff, USAF*
VADM (Ret) Gordon S. Holder [(a)] *Director of Logistics, J4, Joint Chiefs of Staff* *Commander, Military Sealift Command*
VADM (Ret) Lyle G. Bien [(b)] *Deputy Commander in Chief, USSPACECOM* *Commander, Carrier Battle Group 7, embarked in USS Nimitz*
LTG (Ret) Robert Noonan [(a)] *Deputy Chief of Staff, Intelligence, Army* *Commanding General, U.S. Army Intelligence and Security Command*
RADM (Ret) Robert M. Nutwell [(a)] *Deputy Asst Secretary of Defense for C3I* *Commander Abraham Lincoln Battle Group and Combined Task Force Fifty*
Ms. Renata F. Price [(a)] *Science Advisor, Deputy Chief of Staff, Research, Development and Acquisition, Army Materiel Command*
Dr. Edward L. Warner [(a)] *Asst Secretary of Defense for Strategy and Requirements* *Asst Secretary of Defense for Strategy and Threat Reduction*
Mr. Harry Kingsbery [(a)] *Chief, Space & Nuclear Forces, Air Force XOFS* *Chief, Space Control, HQ Air Force Space Command*
Mr. Cosmo DiMaggio III [(c)] *Industry Expert, Technology Research*
* All Department and military affiliations are former positions; SAG composition varies by functional area. (a) Currently with Booz Allen Hamilton (b) Independent Consultant (c) Currently with the Tauri Group

3. Assess Industrial Base Capabilities for Each Priority Critical Technology. The study team then examines the industrial base capabilities necessary to supply these critical technologies, in priority order. This generally involves identifying the major domestic and foreign suppliers and examining them for sufficiency and suitability. The study team focuses on a limited number of high priority, critical technologies, which are examined in detail. The purpose of the initial assessment is to form a broad understanding of sufficiency and risk in the most important elements of each functional capability area's industrial base. If this assessment identifies a concern, the study notes the deficiency and potential remedies for further investigation. The study team documents the remaining technologies so they can be addressed to the same level of detail later, as resources permit.

Part of this assessment is to compare domestic industrial capabilities with foreign capabilities. To provide the best capability possible to the warfighter, the Department

[15] United States, Director, Defense Research and Engineering, Department of Defense, Joint Warfighting Science and Technology Plan, February 2005.

will look for best value throughout the global industrial base. If the Department uses a foreign supplier to support a *BA/BWA* capability, however, it must manage certain risks this could entail. Broadly, these risks are assurance of supply, technology security, and congruency of strategic interests. Assurance of supply relates to having access to the defense products the Department needs when it needs them. Technology security relates to controlling potential adversary access to the U.S. and non-U.S. industrial base that supplies our warfighters. Congruency of strategic interest describes the desired alignment of corporate interests and strategic planning with U.S. interests and objectives. In assessing whether particular foreign sources represent acceptable risk, the Department must look at numerous factors including the criticality of the technology involved, the status of foreign relations with the other countries involved, and the likely leverage the U.S. can have on the focus of foreign sources**.**

JUST THE BEGINNING

This capabilities-based framework will help decision-makers understand and address industrial base deficiencies. This study completes the first round of DIBCS studies. However, this is just the beginning. The baseline will continue to evolve as the Joint Staff refines and implements the joint functional concepts and as the Department continues to assess the industrial base enabling the warfighting capabilities. The study series should help the whole of the industrial enterprise gain more direct insight into the critical industrial base capabilities required for 21st century warfare. This insight should also help inform individual firm's strategic planning and investment decisions.

The DIBCS series develops a logical, capabilities-based approach to identifying and understanding industrial base sufficiency. It fits naturally into the evolving acquisition and requirements processes. It also provides a firm basis for identifying industrial base deficiencies and potential remedies.

PART II

INDUSTRIAL BASE CAPABILITIES IN FOCUSED LOGISTICS

The DIBCS methodology is a forward-leaning, technology-based assessment. The DIBCS series defines technology and industrial base requirements based on leadership goals for U.S. warfighting capabilities and the defense programs that will deploy them. This study applies the DIBCS methodology to the Focused Logistics (FL) functional capability area, establishing leadership goals for FL warfighting capabilities. Using this warfighting capabilities-based analysis, the study identifies technologies that enable the functional concept and provides an assessment of the industrial base for a prioritized subset of those technologies.

REFINING THE FOCUSED LOGISTICS FUNCTIONAL CAPABILITY AREA

As stated in the Joint Functional Concept (JFC), FL provides for the deployment, redeployment, and sustainment capabilities necessary to project forces anywhere in and above the world for sustained, in-theater operations. It includes airlift, sealift, and spacelift, as well as short haul (intra-theater and battlefield) transportation. It provides the logistical components essential to operations and sustainment of combat and mobility forces, including logistics command and control (C2). FL also includes training, equipping, feeding, supplying, and maintaining the forces, as well as medical capabilities. For the purposes of the DIBCS series, *DIBCS C2* addressed C2 capabilities not fundamentally unique to logistics, such as information fusion, networking, modeling and simulation analysis, and data management. *DIBCS Protection* addressed health protection; chemical, biological, radioactive, nuclear, and explosive (CBRNE) protection; and decontamination capabilities. Thus as defined in the JFC, FL concentrates on building sufficient capacity into the U.S. deployment and sustainment pipeline; exercising sufficient control over the pipeline from end-to-end; and providing a high degree of certainty to the supported joint force commander that forces, equipment, sustainment, and support will arrive where needed on-time.

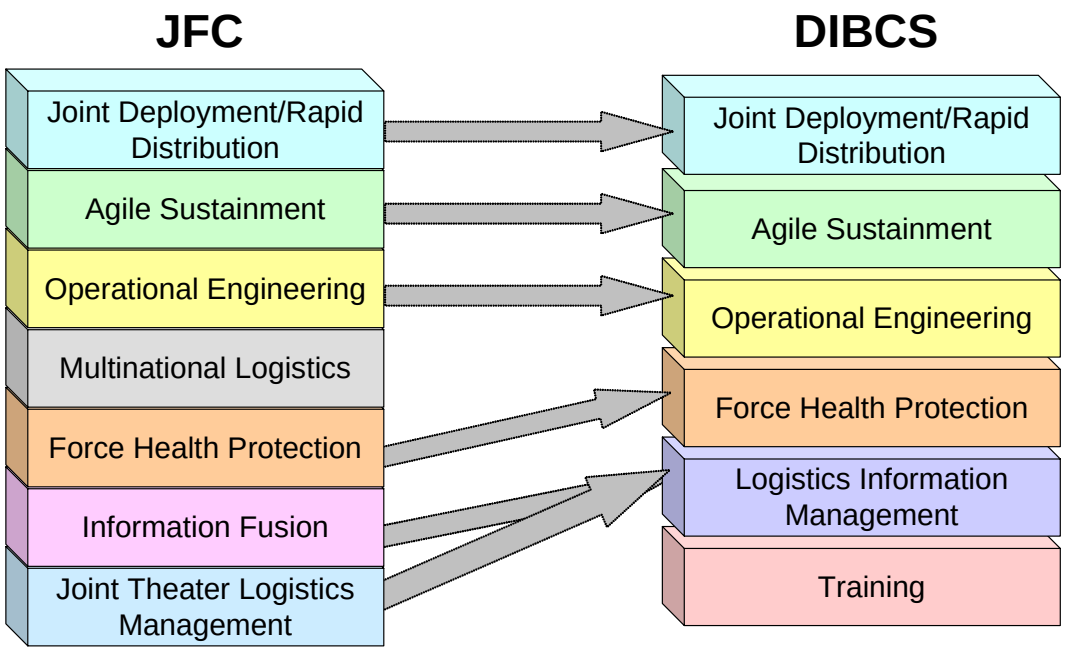
The chart on the following page translates the seven “focused logistics challenges” set forth in the JFC to *DIBCS FL*.

- “Multinational Logistics” was not covered because this challenge area addresses international agreements, standards, and interoperability. Although important to coalition warfare and to improvements in logistics efficiency, this non-materiel area is outside the scope of an industrial base study.

- “Logistics Information Management” combines “Information Fusion” and “Joint Theater Logistics Management” to address logistics information management functions. While “Information Fusion” and “Joint Theater Logistics Management” differ from an operational standpoint, the technologies to address these capabilities are generally in the same broad industrial areas. The *DIBCS C2* study addressed many of these, such as information fusion, networking,

modeling and simulation analysis, and data management. However, in *DIBCS FL* the study team reconsidered some of the technologies assessed for *DIBCS C2* and studied others of particular importance to FL not studied in the C2 sector. Examples of these latter FL-specific "Logistics Information Management" technologies include information visibility and manipulation, and logistics decision support tools.

DIBCS TRANSLATION FROM JOINT FUNCTIONAL CONCEPT



Source: Booz Allen Hamilton and ODUSD(IP)

- "Training" is an area added for consideration in *DIBCS FL* because the joint functional concepts had not been completely designed nor published at the inception of DIBCS. Evolving technology gains are important to the warfighter and their successful training as they move beyond just the "school house" methods to online, on-the-job, and distributed training; training-on-the-move; Mobile Military Operations Urban Terrain (MOUT) training; and simulation and force-on-force training aids.

Evolving Training Beyond the Classroom

The Department has initiated a significant evolution, transforming its old practices and processes for Service-unique training to joint, integrated training that provides a robust, networked, live, virtual and constructive training and mission rehearsal environment. Within a few years, U.S. warfighters deployed around the world will be able to utilize embedded training tools en route to mission objectives to preview and train for the missions down to the last minute detail. The weapon systems of tomorrow will provide a capability for live, simulated, and force-on-force training. The technologies that enable this advantage are mostly commercial. The dramatic warfighting advantage gained by this approach to training will result from adapting commercially available technologies to the Department's practices, procedures, and processes.

To summarize, the *DIBCS FL* capabilities construct is based on several guidelines:

- Processes, procedures, agreements, standards, and the like are outside the scope of an industrial base study.
- Support functions such as payroll, finance, general counsel, public relations, etc. are excluded.
- Contractor support and commercial augmentation are not specifically considered—the study focuses on needed capabilities rather than who provides them (e.g., military, civilian, contractor, etc.).
- *DIBCS: Protection* covered medical capabilities for protecting against disease, biological and chemical weapons, and radiation.
- *DIBCS: Protection* covered decontamination from chemical or biological weapons or radiation.
- *DIBCS C2* addressed most logistics command and control capabilities (e.g. data capture and visibility, decision support, communications, etc.). *DIBCS FL* includes only those C2 capabilities fundamental to logistics.
- *DIBCS: Battlespace Awareness* covered most sensors. *DIBCS FL* covers only those sensors fundamental to logistics.

The table below defines and provides examples of the FLJFC capabilities as translated for *DIBCS FL*.

FOCUSED LOGISTICS MISSION AREAS		
Mission Area	**Definition**	**Examples**
Joint Deployment/ Rapid Distribution	Transportation and distribution of personnel and materiel to a theater, between theaters, or within a theater	• Cargo aircraft • Cargo handling equipment • Airdrop equipment
Agile Sustainment	Capabilities to sustain the operations of personnel, equipment, and infrastructure within the theater of operations	• Food • Fuels • Maintenance and repair equipment
Operational Engineering	Capabilities for assessing and constructing sites within the theater of operations, as well as engineering capabilities required by forces on the move	• Construction machinery • Bridging and earthmoving equipment
Force Health Protection	Health monitoring and health care on the battlefield or within the theater of operations, as well as evacuation care	• Health monitoring sensors • Battlefield medical gear
Logistics Information Management	Capabilities for asset visibility, logistics decision-making, and network operations	• Tagging and tracking, decision support tools
Training	Capabilities for providing warfighter training, including simulation and force-on-force training aids	• Simulators • Games • MOUT facilities and equipment
Source: Booz Allen Hamilton and ODUSD(IP)		

Improvements in FL derive from technology advancements and process, system, and organization transformation. The DIBCS methodology focuses on technology advancements and the extent to which the industrial base supports those advancements. FL-related technologies come in a wide variety: (1) commercial best business practices; (2) designed-in weapon system deployability, reliability, maintainability, supportability, and interoperability; (3) delivery platform improvements; and (4) promising information technology in visibility, collaboration, and decision support capabilities.

Commercial technologies increasingly will enable many FL warfighting advantages. The Department's ability to influence commercial technology development is limited because it will typically be a later and minor customer of these technologies. By adapting these commercial technologies and applying them in creative defense specific ways, the Department can meet *BA/BWA* leadership goals. It will be up to the Department to embrace these commercial technologies and craft relationships with their suppliers that allow the Department to effectively shape a marketplace which is essentially commercial.

LEADERSHIP GOALS FOR FOCUSED LOGISTICS WARFIGHTING CAPABILITIES

The DIBCS series employs a systematic methodology for translating warfighting capabilities to technology and industrial base vernacular in order to assess industrial base sufficiency. Using the Joint Staff's FLJFC as the backdrop, the study team derived capability leadership goals the United States should strive to maintain for each of the 525 FL warfighting capabilities summarized in the chart on the following page.[16]

[16] See process described on page 18.

FOCUSED LOGISTICS WARFIGHTING CAPABILITIES SUMMARY CHART					
Capability Area	**Mission**	**Degrees of Capability Leadership**			
		Neutral	**Equal**	**Be Ahead**	**Be Way Ahead**
Joint Deployment/ Rapid Distribution	Transportation	32	111	129	0
	Distribution	10	43	30	12[17]
Agile Sustainment	Asset Sustainment	0	26	21	3
	Personnel Sustainment (non-medical)	2	5	2	0
	Logistics Demand Reduction	0	0	4	0
Logistics Information Management	Information Capture	0	1	7	0
	Information Visibility and Manipulation	0	1	4	0
	Decision Support	0	1	13	0
	Network Operations	0	0	1	1
Operational Engineering	Site Assessment	0	4	0	0
	Site Establishment	3	1	9	0
	Field Engineering	0	3	3	0
Force Health Protection	Health Care	0	7	14	0
	Health Monitoring	0	0	2	0
Training	Live Training	0	0	4	0
	Simulated Training	0	4	6	0
	Force-on-Force Training	0	0	5	1
525 Total		**47**	**207**	**254**	**17**
Source: Booz Allen Hamilton and ODUSD(IP)					

Of the 525 warfighting capabilities, 271 (52 percent) are *BA/BWA* capabilities. In the previous studies (Battlespace Awareness, Command and Control, Force Application, and Protection), the *BA/BWA* proportions were much higher: on average, 76 percent. The relatively low number and proportion of FL *BWA* warfighting capabilities (17 or three percent of the total) is the primary factor in this relatively low 52 percent *BA/BWA* warfighting capabilities when compared to other sectors. This recognizes that U.S. 21st century warfighting superiority is not dependent on multi-generation leadership over potential adversaries in many FL warfighting capabilities such as trucks, cargo aircraft, warehousing facilities, and asset visibility. In fact, there are few logistics capabilities in which the United States seeks multi-generation technological leadership over potential rivals. This stems from three factors. First, many key logistics technologies are mature and widely available, making multi-generation leadership unrealistic. Second, in the case of lift and other logistics capabilities, dramatic improvement in logistics performance will come from greater quantities of current generation assets rather than

[17] The study team identified 12 Distribution *BWA* warfighting capabilities. The majority of these pertain to refueling of multiple platforms under adverse conditions and precision airdrop of either personnel or cargo in all weather conditions.

more advanced, next-generation assets. Third, the most dramatic improvements in logistics performance are likely to come from greater interoperability among U.S. forces and between U.S. and partner forces; from improved organization, processes, and procedures; and from the adoption of commercial technology (particularly in the realm of information technology). The Department has a successful record of applying commercial technologies to military objectives in the FL area, for example in air cargo, construction, health care, and ground transportation. To successfully deliver FL capabilities, the U.S. military must continue to successfully leverage commercial technologies to the maximum extent possible.

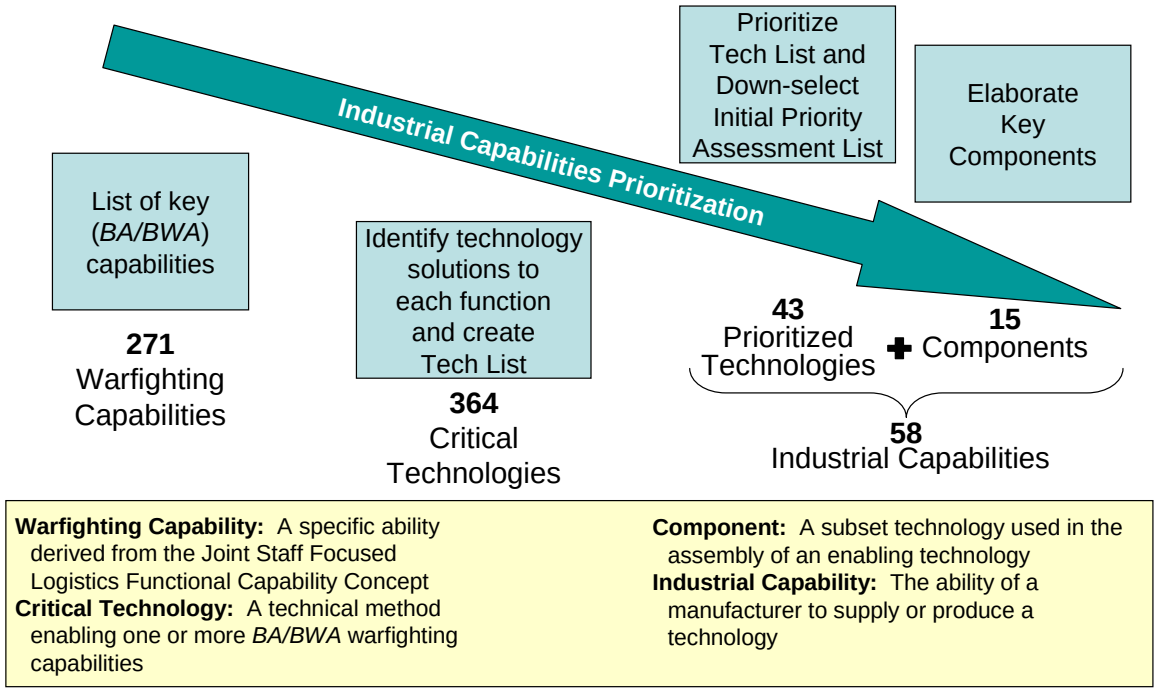
The table below puts FL warfighting capability goals in the broader context of the DIBCS series.

WARFIGHTING CAPABILITY GOALS			
Functional Concept	***BA***	***BWA***	***BA/BWA***
Battlespace Awareness	39%	43%	82%
Force Application	38%	38%	76%
Command & Control	58%	16%	74%
Protection	51%	19%	70%
Focused Logistics	49%	3%	52%
• Joint Deployment/Rapid Distribution	43%	3%	46%
• Agile Sustainment	43%	5%	48%
• Operational Engineering	52%	0%	52%
• Force Health Protection	70%	0%	70%
• Logistics Information Management	86%	3%	89%
• Training	75%	5%	80%

THE TECHNOLOGY PRIORITIZATION & ASSESSMENT PROCESS

The study team then established leadership goals for FL warfighting capabilities and identified critical technologies that enabled *BA/BWA* warfighting capabilities. The DIBCS SAG oversaw a team of subject matter experts that prioritized the critical technologies and associated component technologies according to: 1) the importance of the technology in warfighting, 2) the importance of the capability that the technology enables, and 3) the number of capabilities the technology enables. The illustration on the next page summarizes this process.

FOCUSED LOGISTICS TECHNOLOGY PRIORITIZATION PROCESS



Warfighting Capability: A specific ability derived from the Joint Staff Focused Logistics Functional Capability Concept
Critical Technology: A technical method enabling one or more *BA/BWA* warfighting capabilities
Component: A subset technology used in the assembly of an enabling technology
Industrial Capability: The ability of a manufacturer to supply or produce a technology

Sources: Booz Allen Hamilton and ODUSD(IP)

This study identified a total of 364 critical technologies enabling the 271 *BA/BWA* warfighting capabilities.[18] They are in 19 broad industrial areas, as shown on the following page. The study team evaluated industrial sufficiency for the 43 most pressing critical technologies and 15 associated components.

[18] These warfighting capabilities and critical technologies are discussed in Appendices A and B.

BROAD INDUSTRIAL AREAS FOR FOCUSED LOGISTICS			
Industrial Areas	**Technologies for *BA/BWA* capabilities**	**Priority Critical Technologies Assessed**	
		Technologies	**Components**
Airdrop	16	4	3
Cargo Handling	25	2	4
Command and Control[19]	42	0	0
Communications and Networking	8	2	0
Devices	29	4	2
Engineering	19	2	0
Fuel Handling and Storage	22	3	2
Fuels	5	2	0
Maintenance and Repair	12	2	0
Materials	21	2	0
Medical	26	3	0
Power Generation and Storage	13	1	0
Propulsion	12	2	0
Robotics	6	2	0
Sensors	9	2	4
Software	27	3	0
Space Launch	26	2	0
Structures	43	4	0
Water Generation and Storage	3	1	0
Total	364	43	15
Sources: Booz Allen Hamilton and ODUSD(IP)			

The industrial sufficiency assessment demonstrated the breadth of the industrial base available to meet FL needs. A total of 228 companies, laboratories, government facilities, and universities are involved in the 58 technologies and components assessed. This supplier list is summarized in Appendix C. While the summary does not include every supplier in these industrial areas, it illustrates the overall strength of the U.S. and non-U.S. FL industrial base.

A by-product of this analysis has been the successful application of a methodology that uses the Joint Staff's joint functional concepts as a basis for focusing the industrial base on those technologies likely to continue to assure the U.S. lead in advanced technology weapons systems. The use of the joint functional concepts and the translation of these concepts for DIBCS assessments should help Department policies effectively focus the industrial base on these important *BA/BWA* capabilities. This focus will ensure that the products for the 21st century military operations envisioned in the joint functional concepts are available to the warfighter.

[19] No priority critical technologies identified or assessed because *DIBCS C2* addressed most logistics command and control capabilities (e.g., information fusion; networking; modeling and simulation analysis; data capture, visibility, and management; decision support; and communications).

The 58 specific technologies and associated components evaluated for industrial base sufficiency are listed below.

43 Focused Logistics Technologies and 15 Components Assessed for IB Sufficiency[20]	
1. Autonomous Navigation System - Electromechanical Actuator 2. High Altitude-Low Opening/High Altitude-High Opening Helmet 3. Pneumatic Muscle Soft Landing Actuator 4. Smart Decelerators - Airbags - Cable Retraction 5. Automated Strike Up/Strike Down Machinery - Human Amplification Technology - Automated Stowage and Retrieval System - Linear Electric Drive Transport - Automated Guided Vehicle 6. Modular Medical Evacuation Litters 7. Spectrum-Adaptive Communication System 8. Satellite-Based Asset Tracking 9. Augmented Reality Display 10. Contact Memory Button 11. Externally Blown Flap System 12. High Floatation Landing Gear - Struts - Brakes 13. Lightweight Field Matting 14. Prepackaged Quasi-Fixed Facility System 15. Underway Replenishment System - Hydraulic Winch System - Pump - Padeyes 16. Microprocessor-Controlled Refueling Pods 17. On-Orbit Fuel Transfer System 18. Common Vehicle Fuel (JP-8) 19. Plastics and Biomass Conversion Technology	20. Fast Reusable Tooling 21. Maskless Mesoscale Materials Deposition 22. Mechanical Stabilizing Materials 23. Self-Repairing Materials 24. Focused Ultrasound Technology 25. Nanofiber Bleeding Sensor and Clotting Agent Materials 26. Telerobotic Minimally Invasive Surgery 27. Direct Energy Conversion 28. High Thrust Turbofan Engine 29. Tilt-Rotor Propulsion 30. Heavy-Lift/Positioning Wearable Exoskeletons 31. Human Assisted Walking Machine (Walking Wheelbarrow) 32. Direct Contact Miniature Medical Sensors 33. Embedded Sensors - MEMS - Piezoelectric on Thin Film - Optical Fiber - Miniature Silicon 34. Diagnostic and Prognostic Monitoring Software 35. Dynamic Force Requirements and Transportation Movement Software 36. Wireless Patient Management System 37. Advanced Solid Rocket Motors 38. Autonomous Rendezvous and Docking 39. High-Speed, Shallow-Draft Catamaran Hull Form 40. Inflatable Airbeams 41. Mobile Military Operations in Urban Terrain (MOUT) Facility 42. Ultra-Lightweight Deployable Structures 43. Low-Energy Water Harvesting
Source: Booz Allen Hamilton	

[20] Components associated with the technologies are indented.

CRITICAL INDUSTRIAL AND TECHNOLOGY DEFICIENCIES AND ISSUES

Generally, the industrial base supporting these 43 priority critical technologies and 15 associated components FL is robust, with 53 of the 58 assessed technologies and components as sufficient, as shown in the table below.

53 FOCUSED LOGISTICS TECHNOLOGIES/COMPONENTS WITH SUFFICIENT INDUSTRIAL BASE	
1. Autonomous Navigation System	26. Underway Replenishment System – Padeyes
2. Autonomous Navigation System – Electromechanical Actuator	27. Microprocessor-Controlled Refueling Pods
3. High Altitude-Low Opening/High Altitude-High Opening Helmet	28. On-Orbit Fuel Transfer System
4. Pneumatic Muscle Soft Landing Actuator	29. Common Vehicle Fuel (JP-8)
5. Smart Decelerators	30. Plastics and Biomass Conversion Technology
6. Smart Decelerators – Airbags	31. Maskless Mesoscale Materials Deposition
7. Smart Decelerators – Cable Retraction	32. Mechanical Stabilizing Materials
8. Automated Strike Up/Strike Down Machinery	33. Self-Repairing Materials
9. Automated Strike Up/Strike Down Machinery – Human Amplification Technology	34. Focused Ultrasound Technology
10. Automated Strike Up/Strike Down Machinery – Linear Electric Drive Transport	35. Nanofiber Bleeding Sensor and Clotting Agent Materials
11. Automated Strike Up/Strike Down Machinery – Automated Guided Vehicle	36. Telerobotic Minimally Invasive Surgery
12. Modular Medical Evacuation Litters	37. High Thrust Turbofan Engine
13. Spectrum-Adaptive Communication System	38. Tilt-Rotor Propulsion
14. Satellite-Based Asset Tracking	39. Heavy-Lift/Positioning Wearable Exoskeletons
15. Augmented Reality Display	40. Human Assisted Walking Machine (Walking Wheelbarrow)
16. Contact Memory Button	41. Direct Contact Miniature Medical Sensors
17. Externally Blown Flap System	42. Embedded Sensors
18. High Flotation Landing Gear	43. Embedded Sensors – MEMS
19. High Flotation Landing Gear – Struts	44. Embedded Sensors – Piezoelectric on Thin Film
20. High Flotation Landing Gear—Brakes	45. Embedded Sensors – Optical Fiber
21. Lightweight Field Matting	46. Embedded Sensors – Miniature Silicon
22. Prepackaged Quasi-Fixed Facility Systems	47. Diagnostic and Prognostic Monitoring Software
23. Underway Replenishment System	48. Wireless Patient Management System
24. Underway Replenishment System – Hydraulic Winch System	49. High-Speed, Shallow-Draft Catamaran Hull Form
25. Underway Replenishment System – Pump	50. Inflatable Airbeams
	51. Mobile Military Operations in Urban Terrain (MOUT) Facility
	52. Ultra-Lightweight Deployable Structures
	53. Low-Energy Water Harvesting
Source: Booz Allen Hamilton	

Five technologies and components assessed have an insufficient or potentially insufficient industrial base, and may require remedies:

- Direct Energy Conversion;
- Advanced Solid Rocket Motors;
- Fast Reusable Tooling;
- Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System; and
- Autonomous Rendezvous and Docking.

The table below summarizes the five industrial base sufficiency issues identified in this assessment.

ISSUES IN THE FOCUSED LOGISTICS INDUSTRIAL BASE				
Technology	**Industrial Base Sufficiency Analysis**			**Rationale** (for associated remedies, see page 28)
	Domestic Sources	**Foreign Sources**		
Power Generation and Storage: Direct Energy Conversion - Thin-film photovoltaic - Optical rectenna	>3 1	>3 0		The market for the current generation of this technology is highly competitive with robust, ongoing development driven by numerous U.S. and foreign firms, and dominated by commercial use—for example, the U.S. is *Even* in thin-film photovoltaic technology. However, although the U.S. *Leads* in the development of next generation technology (the optical rectenna), there is only one U.S. developer of this breakthrough next-generation technology. More than one developer may be desirable to ensure continued research.
Space Launch: Advanced Solid Rocket Motors	2	>3		This market has significantly consolidated, leaving only two U.S. suppliers. Without increased demand, the market will not support more suppliers and may not support the existing two. U.S. government attention is focused on this situation, and is monitoring the industrial base closely.
Maintenance and Repair: Fast Reusable Tooling	1	0		An emerging R&D technology. One U.S. supplier and no foreign suppliers are insufficient. It has large potential in military and commercial markets. At present, the United States *Leads* technologically at a TRL 7.[21]
Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System	2	1		Although this completely automated technology is widely used in the commercial market, development for naval application is still developing. Two domestic and one foreign companies are adapting these systems for ship-based use. This ship-based military market is very small; and the United States must lead the way with this technology adaptation.
Space Launch: Autonomous Rendezvous and Docking System	3	>3		A technology leadership issue. Russia has an operational autonomous rendezvous and docking system that has decades of operational history. U.S. must lead because these technologies could revolutionize the global space infrastructure.
Source: Booz Allen Hamilton and ODUSD(IP)				

The discussion below addresses each technology, its link to warfighter capabilities, and the industrial base issues. U.S. leadership goals for warfighting capabilities are characterized by the terms *Neutral, Equal, Be Ahead, Be Way Ahead*; U.S. technology leadership relative to non-U.S. suppliers is characterized by the terms *Leads, Even, and Trails*.

Power Generation and Storage: Direct Energy Conversion. Direct energy conversion is a form of energy harvesting in which energy from ambient (e.g., solar, gravitational) or human sources is directly converted into another form of energy—usually electricity. Photovoltaics (solar cells) are a directed energy conversion technology in which solar energy is converted directly into electricity. This is a proven technology in current use. A new type of direct energy conversion device, commonly called a rectenna, absorbs free-space electromagnetic radions using a broadband, grid antenna array that couples to elliptically-polarized solar radiation or any polarized wave form to generate DC power.

[21] Appendix F defines technology readiness levels.

This is a breakthrough technology. Such extremely small and efficient power sources could enable or enhance a variety of military capabilities by replacing heavier and larger power sources, such as batteries. Additionally, this could turn soldiers into energy collectors by emplacing rectennas on commonly-carried items. Optical rectennas are still being developed and are not yet commercially available. With the current generation of direct energy conversion, the United States is technologically *Even*, with numerous European and Asian nations. The United States *Leads* in the development of optical rectennas. However, there is only one U.S. developer for this TRL 6[22] technology. While the U.S. military has been active in direct solar energy conversion technology development and employment, the potential commercial market dwarfs the potential military market. Given the specificity of military requirements and the constant increase in power requirements in all operational environments, the Department must develop multiple sources of cost-effective capability in this technology.

Space Launch: Advanced Solid Rocket Motors. Space Launch is considered logistics because it transports material and people (for example, satellites and astronauts) into space. Solid rocket motors (SRMs) use a propellant that is in a solid state and is stored and supported within the combustion chamber. The propellant is in the form of a solid shaped block, and the rocket motors work by igniting this propellant block, creating a burn which is directed through the nozzle on the bottom of the engine which then produces thrust. SRMs are not a breakthrough technology nor do they provide a new way of conducting space launch activities. Advancements provide incremental improvement in performance and efficiency. Today, SRMs are used in space launchers, as well as intercontinental ballistic missiles, national missile defense interceptors, and a wide array of tactical missiles.

Two domestic manufacturers dominate the U.S. manufacturing market for advanced SRMs. There are numerous foreign manufacturers and the Unites States is rated technologically *Even*. SRMs are a mature technology that has been available for 50 years. There are over 30 countries capable of producing an SRM. U.S. and non-U.S. companies have made advancements in casing designs and other efficiency areas. U.S. and European manufacturers are the strongest and most advanced in this market, and are generally on par with one another. This technology market is both military and commercial. Most space launch vehicles currently available provide launches for both government and commercial payloads. This industry had five U.S. suppliers in the mid-1990s; however as a result of corporate acquisitions and a mishap (Pratt & Whitney), there are now only two. The Department recently completed a separate assessment of this critical technology and is developing strategies to remedy identified industrial base issues.[23] Implementation of these remedies must be monitored.

Maintenance and Repair: Fast Reusable Tooling. Fast reusable tooling can be rapidly reconfigured, re-formed, and reused. This can significantly reduce the number of specialized tools required for maintenance and repair of ships, aircraft, and land

[22] Appendix F defines technology readiness levels.
[23] ODUSD(IP) *Solid Rocket Motor (SRM) Industrial Base Study*, dated November 2004 (For Official Use Only).

vehicles, thereby reducing specialized asset transport, tracking and accountability. The technology for these tools uses a new class of materials that can be reversibly transformed from a liquid-like state to a solid state at room temperature with no change to volume. Upon completion of one or more manufacturing or repair cycles, the tool can be returned to its liquid-like state and re-formed to create a new tool. At present, this is the only fast tooling technology that is truly re-formable. This technology could enable the rapid repair of a wide variety of items without the necessity of transporting and holding a large array of tools. Prototypes incorporating the technology have been demonstrated in an operational environment.

The United States leads technologically at a TRL 7. There is only one U.S. supplier and no foreign suppliers; however, many companies worldwide offer non-reusable fast tooling technology that could be leveraged to develop reusable tooling. The fast reusable tooling technology has a large potential for the military and commercial markets. Because this technology can be used in vacuum thermoforming, composites repair and manufacture, and in the liquid casting of silicones, urethanes, and other polymer compound, a broader supplier base is indicated.

Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System. This technology uses robotics, systems controls, and cargo-moving devices (such as cranes and elevators) to move, store, and retrieve cargo in bins, pallets, and other packaging containers. It is widely used for commercial material handling and warehousing systems, and several projects are underway to develop demonstrations for naval applications. Strike up/strike down is the term used to describe the process of moving material within a ship to assure it is in the correct location at the correct time. Strike up is the process of moving material from within the ship to the offload point for transit to another ship or to shore. Strike down refers to the process of moving material to its designated storage area on a ship and securing it in place. This technology provides a new way of doing business with a completely automated solution which can greatly reduce the manpower requirements and result in greater efficiency. Cargo restraint, bracing systems, and space constraints are some of the considerations being addressed in the marinization of this technology. There are two domestic companies adapting automated stowage and retrieval systems for ship-based use and one foreign company. Compared to the strong commercial market for the land-based version of this technology, the ship-based military market for this technology is currently very small. The ship-based military market is likely to grow considerably to support arsenal ship concepts and with the advent of sea basing, and needs a sufficiently broad supplier base to ensure competitive pricing.

Space Launch: Autonomous Rendezvous and Docking System. For decades, the approach to rendezvous and docking in space has been to use a human pilot, usually an astronaut, to oversee the maneuver of bringing two spacecraft together while they are in orbit. Autonomous rendezvous and docking system technologies ensure accuracy and stability in the process by using navigation techniques, sensing devices, collision avoidance systems, avionics, and docking mechanisms. Autonomous rendezvous and docking technologies could revolutionize the global space

infrastructure. Although there have been a few cases where human-piloted rendezvous and docking techniques have been used to service or maintain satellites, in most cases once a satellite is launched, it is unavailable for maintenance, repair, or refueling. The ability to autonomously rendezvous and dock two spacecraft is essential to providing capabilities which make more efficient use of on-orbit assets, increasing their lifetimes and expanding their missions. Russia has an operational autonomous rendezvous and docking system that has decades of operational history on the Soyuz and Progress spacecraft to dock with the International Space Station. There are several U.S. companies conducting research and development in this area. Many foreign companies and research organizations are investigating and contributing to autonomous rendezvous and docking technologies. Technology developments in the United States, Europe, and Japan offer the potential to establish global parity. These technologies have a broad range of applications for both military and non-military spacecraft. Easy access to on-orbit assets could have broad impacts on the economics of commercial space and efficiencies of government space. U.S. technology leadership is essential. Part III discusses remedies for issues identified in this section.

PART III

POLICY REMEDIES FOR FOCUSED LOGISTICS INDUSTRIAL BASE ISSUES

The Department has a number of tools with which the Under Secretary of Defense (Acquisition, Technology and Logistics) can develop remedies to support the development, fielding, and continued improvement of the industrial base supporting Focused Logistics. Certain remedies can be taken within the authorities of the Department of Defense: technology innovation investments and optimization of acquisition strategies. Other remedies must be pursued in an interagency environment: actions associated with Hart-Scott-Rodino (HSR) anti-trust and Committee on Foreign Investment in the United States (CFIUS) national security reviews. This assessment of FLJFC priority critical technologies and associated industrial capabilities identified five industrial base sufficiency issues for which remedies are proposed. The DIBCS series assessments will continue to examine industrial base sufficiency and undoubtedly uncover additional issues. Appropriate remedies for those issues will be considered at that time.

ISSUES IN THE FOCUSED LOGISTICS INDUSTRIAL BASE

The industrial base for the five technologies shown in the table on the next page is insufficient. One of the five technologies is still in the R&D phase, providing ample opportunity to make appropriate investments through structured competitions that can strengthen the industrial base. Two are mature commercially-based technologies with follow-on R&D activities. Two are in the production phase. In one of the production phase cases, U.S. leadership is *Even* with foreign suppliers. The remaining technology *Trails* foreign competitors, but there are three identified U.S. suppliers developing this technology. [24]

Power Generation and Storage: Direct Energy Conversion. Direct energy conversion provides in-place power that minimizes transportation of replenishment fuel. The next-generation (TRL 6) form of this technology, optical rectenna, is a breakthrough technology. The study team has assessed that the United States *Leads* this technology. Such extremely small and efficient power sources could enable or enhance a variety of military capabilities by replacing heavier and larger power sources such as batteries.

Directly-converted solar energy has been used to power consumer electronic equipment, water pumps, water heaters, communications equipment, satellites, and phones. It has also been used to supply electricity in remote areas. As oil prices remain high, penetration of both military and commercial markets will further increase.

[24] U.S. technology leadership is characterized by the terms *Leads, Even,* and *Trails* as compared to non-U.S. suppliers.

FOCUSED LOGISTICS INDUSTRIAL BASE REMEDIES							
Technologies	**Industrial Base Sufficiency Analysis**				**Policy Levers**		
	Technology Readiness Level (TRL)	**Domestic Sources**	**Foreign Sources**		**Fund Innovation**	**Optimize PM Structure & Acq Strategy**	**External Corrective Measures**
Power Generation and Storage: Direct Energy Conversion - Thin-film photovoltaic - Optical rectenna	TRL 9 TRL 6	>3 1	>3 0		Invest R&D funds in next generation to broaden U.S. industrial base.	Conduct defense system design competitions for next-generation technological solutions.	Deny teaming arrangements that limit innovation. Monitor export control.
Space Launch: Advanced Solid Rocket Motors[25]	TRL 9	2	>3		Invest R&D funds to maintain engineering design teams.	Structure R&D investments to encourage competition and maintain U.S. industrial base.	Deny teaming arrangements that limit competition that do not provide other benefits to the Department. Monitor export controls.
Maintenance and Repair: Fast Reusable Tooling	TRL 7	1	0		Invest R&D funds to develop new U.S. suppliers and to adapt technology for additional applications.	Conduct competitions to foster the entry of additional sources.	Consider for Militarily Critical Technology List. Deny teaming arrangements that limit innovation.
Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System	TRL 9 (com) TRL 5 (ship-based)	2	1		Invest R&D funds for sea-based applications, develop next generation, and broaden industrial base.	Conduct defense system design competitions for next-generation technological solutions.	Deny teaming arrangements and transactions that limit competition. Monitor export control.
Space Launch: Autonomous Rendezvous and Docking System	TRL 9	3	>3		Invest R&D funds to establish U.S. technology leadership and develop next-generation technology.	Structure R&D investments to encourage competition for next-generation technological solutions.	Deny teaming arrangements and transactions that limit competition. Monitor export controls.
Source: Booz Allen Hamilton and ODUSD(IP)							

Although it is acceptable to be *Even* with the current technology, more than one developer of the breakthrough next-generation technology is desirable. The Department should continue to fund technological innovation and conduct defense system design competitions for next-generation technological solutions. This also will broaden the U.S. industrial base and maintain leadership. As with other critical technologies, the Department should monitor teaming arrangements and corporate acquisition strategies to ensure competition and innovation. Finally, the United States should control U.S. exports and monitor foreign exports.

[25] ODUSD(IP) *Solid Rocket Motor (SRM) Industrial Base Study*, dated November 2004 (For Official Use Only) recommended that the Department intervene to bridge the production gap beginning in 2008 and potentially lasting until 2017. The DIBCS remedies will amplify these recommendations.

Space Launch: Advanced Solid Rocket Motors (SRM). Advanced SRMs provide long storage, variable thrust, high specific impulse, and restartable operations that eliminate the safety and storage requirements associated with volatile and hazardous liquid propellants. This technology has been available for decades and has both military and commercial applications. The study team has assessed the United States as *Even*. There are a number of countries capable of producing an SRM. The United States and European manufacturers are the strongest and most advanced in this market, and generally are on par with one another. Without increased domestic demand, the market will not support more suppliers and may not support the existing two. The Department should continue to fund technological innovation and structure defense system design competitions to maintain engineering design teams. This also will broaden the U.S. industrial base and maintain leadership. The Department should monitor teaming arrangements and corporate acquisition strategies to ensure competition and innovation. Finally, the United States should monitor U.S. exports controls to ensure that they do not impede U.S. competitiveness overseas. These remedies will amplify the recommendations made in ODUSD(IP)'s recently-completed solid rocket motor industrial base assessment.[26]

> ***Solid Rocket Motor Industrial Base Assessment***
>
> *ODUSD (Industrial Policy) conducted an industrial base assessment of the solid rocket motor industrial base and briefed the results to senior Department leadership in November 2004.*
>
> *The assessment had two key findings. The demand for solid rocket motors is declining and, if the current program and funding profiles persist, it will be difficult for this industry to remain profitable and viable. The Department is investigating ways to work with NASA to address the industrial base issues.*

Maintenance and Repair: Fast Reusable Tooling. Fast reusable tooling provides *in situ* recyclable specialized tools for maintenance and repair of ships, aircraft, and land vehicles thereby reducing specialized asset transport, tracking, and accountability. This is a breakthrough technology where the United States *Leads*. Fast reusable tooling is a technology that is re-formable; that is, the materials utilized are reconfigurable and can be reused. Fast reusable tooling technology has a large potential military and commercial market. The study team did not identify any foreign suppliers offering fast reusable tooling technology. However, various foreign companies offer non-reusable fast tooling products. The Department should invest in R&D to develop new U.S. suppliers that broaden the industrial base and adapt this technology for additional applications. The Services should conduct competitions to foster the entry of additional sources. The Department should closely monitor teaming arrangements and corporate acquisition strategies to ensure future competition and innovation. Finally, the Department should consider adding this technology to the Militarily Critical Technology List and should monitor foreign exports.

Automated Strike Up/Strike Down Machinery—Automated Stowage and Retrieval System. Automated strike up/strike down machinery minimizes ship-board personnel

[26] ODUSD (Industrial Policy) *Solid Rocket Motor Industrial Base Study*, dated November 2004 (For Official Use Only).

and handling required for replenishment operations by using automated receipt, sorting, and storage of replenished ammunition, food, and equipment for in-port, at-anchor, and underway ships in all weather conditions and during all sea states. The United States *Leads* in the marinized military market. This technology has been available for many years for commercial land-based applications and is used by a variety of industries throughout the world. However, commercial cargo ships do not have a need to store and retrieve cargo while at sea. Instead, these ships only need to be able to efficiently load and unload cargo in port. As the military continues to pursue this technology for use aboard ship, other applications for military ship-based automated stowage and retrieval systems are likely to emerge. No other militaries appear to be adapting these technologies for military logistics applications. For sea-based logistics, this technology is of importance equivalent to in-flight refueling for tactical aviation. The Department should work through the Navy to fund investments in research and development to expand sea-based applications, develop next-generation technology, and broaden the industrial base through design competitions. The Department needs to closely monitor the development and maintenance of competition within the industrial base and monitor the export of this technology.

Space Launch: Autonomous Rendezvous and Docking System. Autonomous rendezvous and docking eliminates the training and proficiency issues of manual rendezvous, docking, and separation operations for remote servicing and repair of spacecraft. This is a breakthrough technology that could revolutionize U.S. space infrastructure. Autonomous rendezvous and docking system technologies have a broad range of military and commercial applications. The study team assessed that the United States *Trails* in this technology because the Russians have had operational autonomous rendezvous and docking systems for decades on the Soyuz and Progress spacecraft, and the United States has not had the need to produce similar capabilities. Technology developments in the United States, Europe, and Japan offer the potential to establish global parity. By 2020, the United States should require this capability: with the increasing importance of logistics in and from space, this promises to be an important technology for a variety of missions, including satellite life-extension. While the United States lacks an operational system, several firms are in advanced R&D with apparently strong funding, and U.S. technology leadership may result from these efforts. The Department should invest in additional R&D to establish U.S. technology leadership and develop next-generation technology. The Department should structure R&D investments to encourage competition for the next-generation technological solutions. The Department should monitor teaming arrangements and corporate acquisitions to ensure competition and innovation. Finally, the United States should control U.S. exports and the Department should monitor foreign exports.

The Department should continue to evaluate Focused Logistics *BA/BWA* warfighting capabilities, the technologies that enable them, and the associated industrial base. The Department should employ its internal and external policy levers to remedy the five identified industrial base issues. Applying these tools with diligence will greatly increase the likelihood that priority critical technologies and associated industrial base

capabilities are available when needed to maintain U.S. warfighting superiority over any potential adversary.

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PART IV

THE STAGE IS SET

With the completion of *DIBCS FL*, the Department has established a baseline for the industrial base necessary to enable *BA/BWA* warfighting capabilities across all joint functional concepts. The DIBCS body of work will inform future generations of DoD leaders as they make decisions to develop and endorse the warfighting capabilities identified by the Joint Staff as critical for 21st century warfare.

INITIAL DIBCS FINDINGS: HEALTHY, ROBUST INDUSTRIAL BASE

The initial DIBCS series has provided the Department valuable information for industrial analyses, investment decisions, defense program reviews, business combination reviews, and policy formulation. It has also shown that of the 180 priority critical technologies and 133 key components identified and assessed—supporting over 2,000 *BA/BWA* warfighting capabilities—284 (approximately 91 percent) have a sufficient supporting industrial base.[27]

DIBCS RESULTS FOR ORIGINAL FIVE FUNCTIONAL CONCEPTS

Methodology Execution

List of key *(BA/BWA)* Capabilities → Identify Technology Solutions and Create Technology List → Prioritize Tech List and Down-select Initial Priority Assessment List → Elaborate on Key Components → Assess Industrial Base for Techs and Components

Sector	Total # Capa.	Be Ahead	Be Way Ahead
BA	436	169	188
C2	255	146	43
FA	1036	392	395
Prot	629	323	117
FL	525	254	17
Total	2881	1284	760

Sector	Number Techs
BA	278
C2	293
FA	212
Prot	277
FL	364
Total	1424

Sector	Techs Assessed
BA	31
C2	35
FA	32
Prot	39
FL	43
Total	180

Sector	Components Assessed
BA	41
C2	23
FA	29
Prot	25
FL	15
Total	133

Sector	Techs Sufficient	Potential Issues
BA	69	3
C2	55	3
FA	53	6 + 2WL
Prot	55	7 + 2WL
FL	52	5
Total	284	24 + 4WL

The DIBCS series complements ongoing Department-wide studies by mapping technology and industrial base capabilities to the new functional capabilities construct, providing a comprehensive baseline—and a long forward pass through 2020.

Source: Booz Allen Hamilton and ODUSD(IP)

Across the five functional concepts, U.S. suppliers have no foreign competition for nearly 20 percent of the researched technologies. Most—64 percent—represent either new ways of doing business or breakthrough technologies. The U.S. *Leads* or

[27] ODUSD(IP) will continue monitoring industrial supplier sufficiency for the already-examined critical technologies, and evaluate additional critical technologies that may be important to current warfighting concerns—resources permitting.

Significantly Leads in over half—55 percent—of the researched technologies, is *Even* in 38 percent, and *Trails* only in seven percent. Battlespace Awareness and Force Application have the highest percentage of *Leads/Significantly Leads* technology areas—approximately 70 percent each. This likely is due to the many DoD-unique technologies in these sectors necessary to provide U.S. warfighters with technological advantage over adversaries. The conclusion: the U.S. industrial base is well positioned to develop and apply those critical technologies that enable the most important 21st century warfighting capabilities. This series has informed policy formulation and views on assessing industrial base issues. These perspectives are discussed in greater detail in the foreword.

INDUSTRY GLOBALIZATION

Concerns that the Department is acquiring military materiel overseas to the detriment of national security and the U.S. defense industrial base appear misplaced. Certainly the Department is committed to acquiring the best for the warfighter—not just the best from the *American* industrial base or the *defense* industrial base. That said, two Department studies completed in 2004 indicate that the Department employs reliable foreign contractors judiciously and in a manner consistent with national security. The most recent, published by ODUSD(IP) in January 2004, *Study on Impact of Foreign Sourcing of Systems,* concluded that foreign suppliers provide limited amounts of materiel for the systems, and that using those foreign subcontractors does not impact the long-term readiness or the economic viability of the national technology and industrial base. For the systems studied, foreign subcontracts collectively represented about four percent of the total contract value and less than ten percent of the value of all subcontracts.

Foreign Suppliers Are Proven, Reliable Partners

- *Contrary to popular belief at the time, the Swiss government did not halt shipments of a crystal needed for the Joint Direct Attack Munition (JDAM) because of opposition to Operations Iraqi Freedom (OIF). Shipments were delayed because of a misunderstanding on the part of a single Swiss company. The Swiss Government rectified the misunderstanding immediately and instructed the firm to ship. In any event, the U.S. prime contractor immediately found an alternative U.S. supplier. No JDAM shipments were delayed.*
- *Foreign firms helped surge production of the Joint Service Lightweight Integrated Suit Technology (JSLIST) chemical protective suits. The liner fabric which provides the critical protection layer comes from a German firm; and the spherical carbon beads embedded in the liner come from a Japanese firm. A recent GAO report praised both the German and Japanese subcontractors for extraordinary effort and results when the Department surged JSLIST suit production for OIF.*
  - *Prior to OIF, industry was producing 70,000 suits per month with a contracted maximum of 79,000 per month and a surge requirement of 119,000 per month.*
  - *Although DLA did not officially invoke the surge clauses, the U.S. primes (supported by the subcontractors) produced 128,100 per month and sustained that rate until told to return to peacetime production levels.*
- *Firms located in countries that actively opposed OIF nevertheless provided superb support to our military forces in Iraq.*
  - *A French firm, within three weeks of contract award, delivered critical helicopter landing mats to Kuwait to support deploying OIF troops. The mats reduced dust and provided a visual reference for landing, thus reducing hard landings. Our pilots called the mats "phenomenal."*
  - *A German firm, working in advance of receiving a formal contract, produced repair parts for a battle-damaged F-18C on board an aircraft carrier. A U.S. firm quoted two months. The German firm completed and delivered the parts in five days.*

Under ideal circumstances, the Department would prefer U.S. sources for those technologies and industrial capabilities supporting *BA/BWA* warfighting capabilities. When the Department uses a foreign supplier to support a *BA/BWA* capability, it must manage certain risks. As stated in Part I of this report, these risks are assurance of supply,[28] technology security, and congruence of strategic interest. As foreign suppliers perform consistent with the standards of the best U.S. suppliers, the Department's confidence in them should increase—freeing up financial and intellectual capital to work *BA/BWA* warfighting capabilities where the United States must lead.

FOR WANT OF A NAIL…

While the DIBCS methodology focuses attention on critical industrial base capabilities, the Department must also keep in mind that a system can fail for lack of a structural or supporting component that does not directly enable the sought-after warfighter capability. The Department must avoid the predicament of the king in the rhyme who loses his kingdom because his warriors lacked the nails to replace a horseshoe.

On the other hand, it is not feasible for the Department to conduct detailed assessments of every component used in defense systems. Generally, the Department relies on market forces to shape the industrial base. Nevertheless, targeted Department actions within the base sometimes are necessary to develop or maintain competition and innovation. For example, program managers can leverage market forces to increase numbers of competitive sources by emphasizing use of standard components and open system architectures. If an issue does arise, the DIBCS framework links industrial sufficiency and technology to warfighter capabilities. This allows the Department to better understand the impact of industrial base issues on warfighting capabilities, develop potential remedies, and make more informed decisions.

BETTER ON-RAMPS FOR PRODUCIBLE TECHNOLOGIES

An Industrial Base Investment Fund would target:

- *producible technologies;*
- *technologies easily inserted into programs of record; and*
- *multi-function capability-based warfighting applications.*

As first described in *DIBCS FA*, an Industrial Base Investment Fund (IBIF) would pre-fund an investment vehicle to insert innovative, producible technology into programs of record to ensure the broadest possible dissemination of innovation across all warfighting applications.

[28] The Department has negotiated Declaration of Principles (DoP) agreements with its key trading partners. Within these DoP umbrellas, the Department is also negotiating Security of Supply (SoS) arrangements so that non-U.S. suppliers provide preferential delivery for DoD deliveries when necessary. To date, the Department has SoS arrangements with Canada, the United Kingdom, and Sweden. It is negotiating similar arrangements with Italy, Spain, Norway, and the Netherlands; and is contemplating entering negotiations with other nations.

An IBIF would insert mature innovative technology into ongoing programs from the five sources shown to the right, thus acting as a portal for innovation. Other sources may develop over time. However, in order to assure early momentum, program manager nominations may be the primary investments of an IBIF in its initial years of operation. "Watch List"[29] technologies could also provide early investment candidates. An IBIF would serve to help innovative emerging companies develop technologies and transition them into acquisition programs. The Department could use an IBIF to access innovative technologies from firms losing competitions or those without available bidding opportunities.

FIVE INDUSTRIAL BASE INVESTMENT FUND SOURCES	
DoD	• ACTDs and/or Program Manager/Program Executive Officer nominations • "Watch List" technologies
Industry	• Innovative emerging firms • "Cutting room floor" innovative technologies from losing bids • Innovative technologies without available RFPs

Source: ODUSD(IP)

An IBIF, over time, likely will provide innovative emerging firms—and the Department—an important vehicle not available in other vehicles or even through joint ventures with larger, more established defense firms.

CHANGING THE DEPARTMENT'S VIEW OF THE INDUSTRIAL BASE

The DIBCS body of work identifies domestic and foreign suppliers capable of developing and delivering the technologies most critical for 21st century warfighting. It also provides an organizing framework to distinguish critical technologies—those that relate to warfighting capabilities where the U.S. desires leadership by at least one generation—from those that are less important.

It also refocuses the Department's attention on the importance of small companies as sources of innovation. For priority critical technologies assessed, 35-45 percent of the firms with priority solutions have fewer than 100 employees. The DIBCS reports are explicitly written in a manner to allow such companies to map their technologies to 21st century warfighting capabilities. The associated appendices provide further details on these desired warfighting capabilities, critical technologies, and suppliers assessed.

Finally, DIBCS provides a mechanism that enables industry to establish stronger and more effective linkages to the warfighter by explicitly mapping warfighting capabilities to the supporting industrial base. Armed with the detailed technology and industrial base context that this study series provides, companies should be able to craft more effective business and investment strategies focused on DoD's warfighting goals. They also will

[29] "Watch List" technologies represent unusual technical solutions that could pose challenges to U.S. warfighters if possessed by potential adversaries, or represent *BA/BWA* warfighting capability breakthroughs in which the Unites States is not currently investing.

be able to better communicate those strategies to the Department and other suppliers, and become important enablers of a networked, functional capability approach to 21st century warfighting. Companies early to market in this functional context will have substantial competitive advantages.

The DIBCS series is changing the way the Department views the industrial base. It also provides valuable insights that will inform Department and industrial decision-making.

DIBCS DEPARTMENT AND INTERAGENCY APPLICATIONS: PROCESS AND POLICY CHANGES

As the DIBCS series progressed over the course of the last two years, the ODUSD(IP) published the results immediately to allow real-time implementation into processes as detailed below.

DEPARTMENT DECISION-MAKING AND TECHNOLOGY FINDING

Just as the DIBCS series evaluates industrial sufficiency within the functional capability construct, the Department is transitioning its acquisition and budgeting decision-making processes to a functional capabilities lens. As part of the Defense Acquisition Executive Summary (DAES) process, the Department has been reviewing program cost, schedule, and capability issues in the functional capability groupings for well over a year.[30] Over the past year, the Defense Acquisition Board has begun conducting capability area reviews for Integrated Air and Missile Defense, Joint Battle Management Command and Control, and Land Attack Weapons.

Additionally, during the course of the last year, ODUSD(IP) participated in decisions resulting from weapon system program oversight, remedying issues identified in the DIBCS series. For example, the *DIBCS: Force Application* assessment identified the breakthrough technology used in the GPS-guided Small Diameter Bomb (SDB) program as an industrial base sufficiency issue. The Air Force has since revised its acquisition strategy for the SDB program to plan a competition for the second increment, thereby creating an entry point for potential second sources.

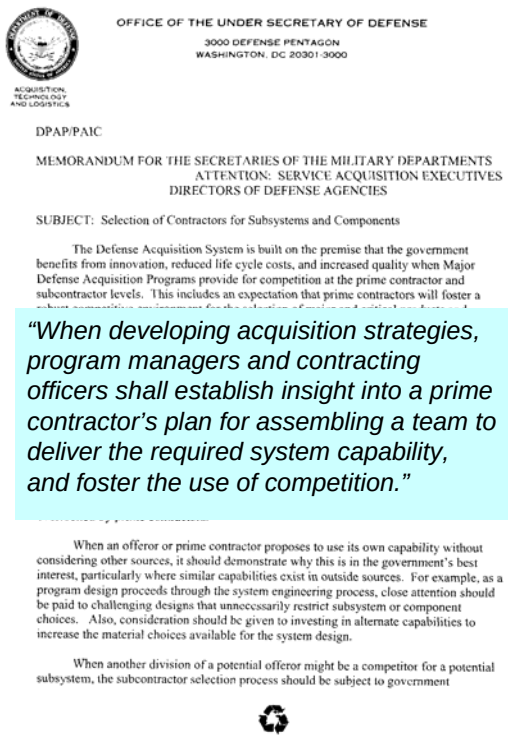
Acquisition Strategy Reports

Consistent with the portals and levers construct introduced in the DIBCS series, the Department is refining its acquisition strategy policies and guidelines. These challenge program managers to develop plans to induce and sustain competition—the key to innovation—throughout a program's lifecycle. Such plans are essential.

[30] Transition initiated on October 15, 2003, and then realigned on August 16, 2004, via memoranda from USD(AT&L).

The Department gains innovation, flexibility, reduced lifecycle costs, and increased quality when major defense acquisition programs provide for competition at the prime contractor and subcontractor levels. Accordingly, as major systems are designed and developed, prime contractors must foster a robust competitive environment for the selection of major and critical products and technologies.

SELECTION OF CONTRACTOR FOR SUBSYSTEMS AND COMPONENTS POLICY GUIDANCE
JULY 2004



OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION, TECHNOLOGY AND LOGISTICS

DPAP/PAIC

MEMORANDUM FOR THE SECRETARIES OF THE MILITARY DEPARTMENTS
ATTENTION: SERVICE ACQUISITION EXECUTIVES
DIRECTORS OF DEFENSE AGENCIES

SUBJECT: Selection of Contractors for Subsystems and Components

The Defense Acquisition System is built on the premise that the government benefits from innovation, reduced life cycle costs, and increased quality when Major Defense Acquisition Programs provide for competition at the prime contractor and subcontractor levels. This includes an expectation that prime contractors will foster a

"When developing acquisition strategies, program managers and contracting officers shall establish insight into a prime contractor's plan for assembling a team to deliver the required system capability, and foster the use of competition."

When an offeror or prime contractor proposes to use its own capability without considering other sources, it should demonstrate why this is in the government's best interest, particularly where similar capabilities exist in outside sources. For example, as a program design proceeds through the system engineering process, close attention should be paid to challenging designs that unnecessarily restrict subsystem or component choices. Also, consideration should be given to investing in alternate capabilities to increase the material choices available for the system design.

When another division of a potential offeror might be a competitor for a potential subsystem, the subcontractor selection process should be subject to government

Source: OUSD(AT&L)

To ensure prime contractors do not favor in-house capabilities or long-term teammate products over more innovative solutions available elsewhere, the then-Acting USD(AT&L) issued policy clarification on July 12, 2004, reiterating that program managers and contracting officers retain both insight into the subcontractor selection process and an ability to influence that selection. For example, when establishing the contract fee structure, program managers and contracting officers are encouraged to give more value to the contractor's effective use of competition throughout the life of the program. In fact, the program manager may require that certain subcontracts be let only after explicit DoD approval, if there is determined to be a potential for bias in subcontractor selection and the potential bias cannot be adequately mitigated.

Defense Acquisition Guidebook

In September 2004, the Department first posted its new Defense Acquisition Guidebook to the Defense Acquisition University website. Section 2.3.16 of the Guidebook ("Business Considerations") notes that "competition is the key to fostering innovation for defense applications" and requires that the program acquisition strategy describe the competition planned for all phases of the program's lifecycle. The Guidebook also notes that "to promote synergies that facilitate competition and innovation, the [program manager] should, where feasible, identify other applications for the technologies in development within the functional capability areas identified by the Joint Staff." This emphasis on synergy is intended to permit the Department to make better use of high-leverage technologies and maximize their span of impact.

The Guidebook provides specific advice to DoD program managers and other DoD acquisition professionals on how to foster a competitive environment by:

- ensuring future competition for defense products,
- building competition into individual acquisition strategies,
- applying competition to acquisition phases, and
- encouraging early industry involvement.

The DIBCS series provides insight into emerging technologies of particular importance to 21st century warfighting capabilities. ODUSD(IP) is using this insight when reviewing acquisition strategies and policies to ensure competition and innovation are maximized.

DEFENSE ACQUISITION GUIDEBOOK SEPTEMBER 2004

DEFENSE
ACQUISITION
DESKBOOK
October 17, 2004

(Formerly the DoD 5000.2-R,
dated April 5, 2002)
(See FOREWORD, next page.)

- *Assess the capacity of the industrial base to support development of key technologies*
- *Induce and sustain competition throughout the program lifecycle*

Source: OUSD(AT&L)

Technology Finding

The focus DIBCS has provided on areas of industrial base insufficiency has, in fact, resulted in "technology finding" among senior Department officials. For example, *DIBCS: Battlespace Awareness* study identified active hyperspectral imagery as an industrial sufficiency issue. Subsequently, ODUSD(IP) representatives identified potentially comparable technologies at Lawrence Livermore Laboratory and in the Australian industrial base. *DIBCS: Command and Control* identified swarming control tools as an industrial base issue, and ODUSD(IP) has identified one additional potential source through a CFIUS transaction.

ANTI-TRUST EVALUATIONS OF MERGERS & ACQUISITIONS

Anti-trust evaluations of mergers and acquisitions are conducted in accordance with the Hart-Scott-Rodino (HSR) Anti-Trust Improvement Act of 1976. The Department's role in merger and acquisition assessments is to examine the implications of a proposed transaction on future competition and innovation. Robust, credible competition is vital to providing the Department with high quality, affordable, and innovative products. The Department must establish, maintain, and strengthen industrial relationships to ensure that the future defense industrial base is both healthy and vital. In doing so, the Department encourages competitive forces for innovation while acknowledging the need of companies to scale up or combine with other firms to create new industrial capabilities essential for future warfare. Such flexibility is essential if the Department is to capitalize on the revolutionary technologies of tomorrow.

DoD merger and acquisition reviews now utilize the DIBCS series to highlight transactions that involve critical technologies, priority critical technologies, or industrial sufficiency issues related to those technologies. The prioritization framework used in the DIBCS methodology provides a deliberative framework to assess the impact of the transaction:

- Are technologies involved in the transaction priority critical technologies? It is generally more important to assure multiple, strategically-aligned sources of technologies supporting *BA/BWA* warfighting capabilities than those supporting *Neutral/Even* warfighting capabilities.
- Will the acquisition of a small, innovative company by a large defense firm precipitate anti-competitive consolidation among other small, innovative firms?
- Finally, if the technologies involved in the transaction are associated with *Neutral* or *Equal* warfighting capabilities, the move to a single source or global sources of supply may not materially harm the Department's warfighting goals, although future pricing may be affected.

COMMITTEE ON FOREIGN INVESTMENT IN THE UNITED STATES (CFIUS) ASSESSMENTS

In assessing foreign acquisitions, the Department's principal objectives are to (1) protect the reliability of supply of goods and services to the Department; (2) minimize the risks of unauthorized transfer of classified information and military and dual use technologies; and (3) assure there is congruence of strategic interests between the acquiring firm and the DoD. Simultaneously, through these reviews, the Department seeks to facilitate the development of an integrated defense industrial base among U.S. allies and trading partners in order to increase interoperability in coalition warfare and reduce DoD acquisition costs.

To assist in achieving these objectives, the Department determines in each foreign investment case whether the firm being acquired possesses critical defense technology or is otherwise important to the defense industrial and technology base. The DIBCS critical technology assessments inform these decisions in a manner analogous to their role in HSR.

Additionally, an ongoing ODUSD(IP) study—to be published in September 2005—is investigating several options to elevate industrial base concerns in the HSR and CFIUS processes.

MILITARILY-CRITICAL TECHNOLOGIES LIST (MCTL) APPLICATIONS

As export control processes continue to be refined, the DIBCS assessment of the over 1,400 critical technologies mapping to warfighting capabilities where the United States must *Lead* could provide valuable perspective and currency to the MCTL and other assessments framing export control deliberations. It is particularly important that export

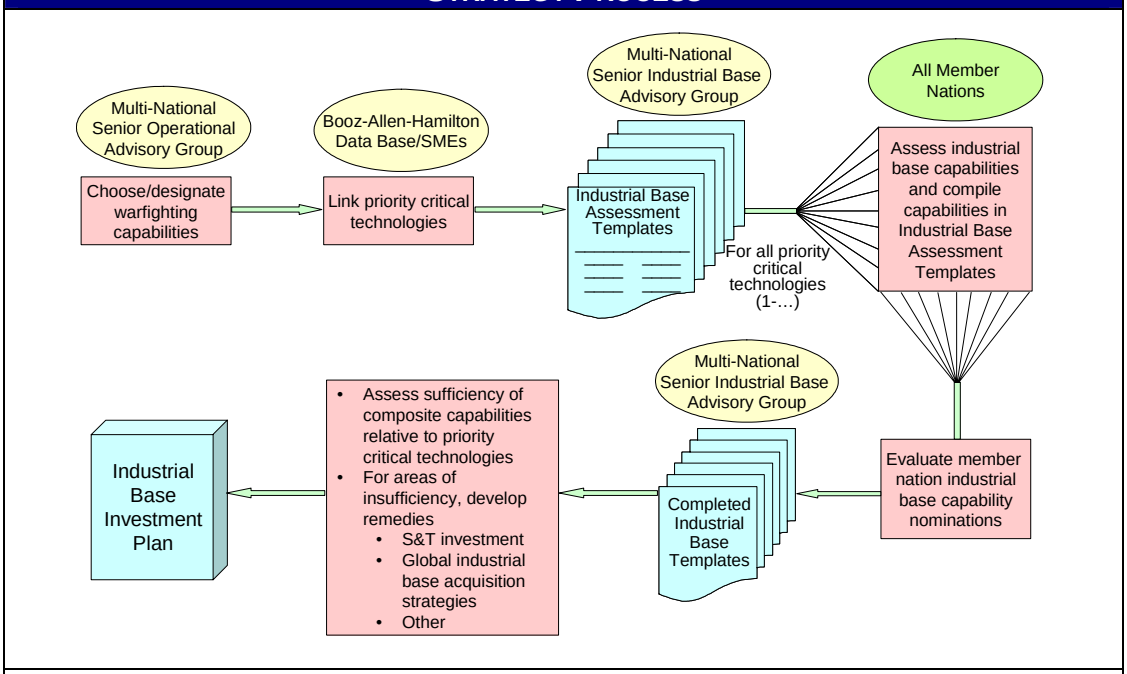
control processes reflect DIBCS guidance relative to these priority critical technologies where sufficiency is at issue. These perspectives will be provided to ODUSD(Policy) as part of the overall DIBCS synchronization and implementation process over the next several months.

DIBCS INTERNATIONAL APPLICATIONS

Of equal importance to the DIBCS applications inside the Department are the demonstrated applications outside the Department. Some allied nations have recognized the benefits gained by implementing the DIBCS methodology and are examining possible reorganizations that reflect a functional capability construct for effective defense industrial base planning. This reorientation suggests adoption of the operational ethos that warfighting capabilities and the warfighter are the primary constituents that must drive defense demand and the products military organizations acquire.

ODUSD(IP) spent considerable time briefing the European Defence Agency and its member nations on the DIBCS assessment tool. Common efforts in this regard are based on the postulate underlying the U.S. efforts: if disparate industrial base capabilities are to improve warfighting capabilities, sufficiency analyses and the associated industrial base planning must begin with a broad understanding of warfighting capabilities required. The European Defence Agency has expressed interest in the DIBCS methodologies and processes in a multi-national setting, as seen in the notional proposed process chart below.

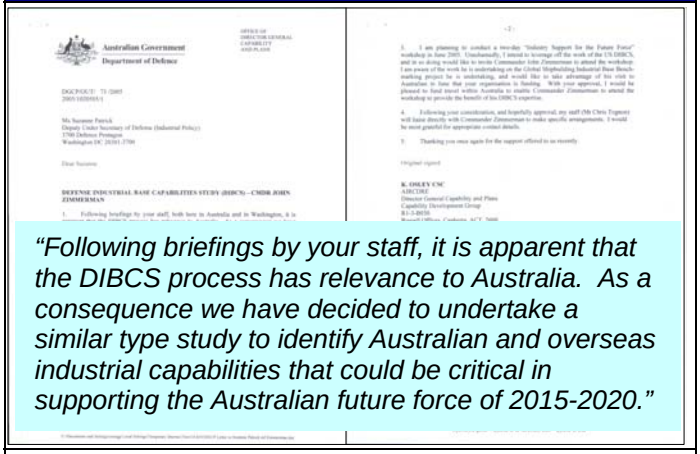
NOTIONAL MULTI-NATIONAL INDUSTRIAL BASE ASSESSMENT AND INVESTMENT STRATEGY PROCESS



Source: ODUSD(IP) and Booz Allen Hamilton

Likewise, Australia has implemented the DIBCS construct in its warfighting capabilities thinking to inform Australian industrial base considerations.

AUSTRALIAN IMPLEMENTATION OF DIBCS



Australian Government
Department of Defence

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY (DIBCS) – CMDR JOHN ZIMMERMAN

"Following briefings by your staff, it is apparent that the DIBCS process has relevance to Australia. As a consequence we have decided to undertake a similar type study to identify Australian and overseas industrial capabilities that could be critical in supporting the Australian future force of 2015-2020."

Source: ODUSD(IP)

Arguably, this construct holds greatest promise for those nations now formulating tools to manage a 21st century defense industrial base: re-militarizing nations such as Korea and Japan; new allies such as Poland and its east European partners; and nations such as Greece and Turkey, now recognizing the importance of a strong defense industrial base.

CONCLUDING THOUGHTS

While the initial work on the DIBCS series is complete, the Department is committed to using the DIBCS framework to refine and enhance the industrial base available to meet 21st century warfighting capabilities. The vernacular and methodology it deploys are already being echoed in U.S. and global corporations interested in supplying technology for future generations of warfighters. In fact, numerous foreign governments have expressed an interest in adapting our methodology to assessments of their respective industrial bases. If disparate industrial base capabilities are to improve warfighting capabilities, sufficiency analyses and the associated industrial base planning must begin with a broad understanding of *warfighting capabilities* required.

In continuing with DIBCS-associated follow-on work, this office will reassess the 24 technology and component issues identified across the initial DIBCS series; investigate non-open source information regarding technology issues and remedies; develop a comprehensive communication and implementation plan of the findings and recommendations; continue to map and synchronize the DIBCS methodology with the evolving joint functional concepts; identify and evaluate additional priority critical technologies that enable warfighting capabilities; and use DIBCS as a tool for the regulatory framework of both the HSR and CFIUS processes, as well as program acquisition strategies.

Additionally, ODUSD(IP) has several other DIBCS-associated efforts ongoing:

- continuing alignment of processes and policies with joint capability areas in accordance with Secretary of Defense direction, using DIBCS where appropriate;
- feeding consolidated DIBCS results back to the Joint Capabilities and Integration Development System (JCIDS) to better inform the requirements process;

- coordinating with the Defense Acquisition University and the Industrial College of the Armed Forces to update courses to reflect the Department's evolving industrial base focus on the Joint Staff's functional capability construct;
- working with the Defense Contract Management Agency to develop an early warning predictive analysis capability to identify possible failures at critical defense industrial base assets;
- leading discussions with the Federal Bureau of Investigation to potentially align counter-intelligence planning with the joint functional concepts; and
- assisting allied nations with their defense industrial base planning in accordance with modified DIBCS methodologies.

To base assessments on what is currently available in a given industrial base or on individual constituent interests dooms the warfighter and the industrial base to the status quo. Only by looking to the future can we transform the industrial base to support the operational ethos: warfighting capabilities, and the warfighter, must drive defense demand and the products the Department acquires. The DIBCS series provides this forward look for the Department. Long after the study series is complete, the DIBCS framework and findings will continue to inform other federal agency, industry, and allied nation's industrial planning processes.

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AFTERWORD

The DIBCS series is designed, *a priori*, to provide an organizing structure for ODUSD(IP) assessments of defense industrial capabilities on a forward-looking, strategic basis. These assessments are necessary to inform Department positions on the health of defense industrial sectors and individual companies, on major program acquisition strategies, on mergers and acquisitions, and on industrial capabilities-related policies.[31] As this body of work developed, however, it became clear that it had numerous other applications.

MULTIPLE APPLICATIONS

Other applications of this body of work include: helping individual companies develop business strategies addressing future warfighting capabilities and enabling technologies, supporting other nations and multi-national organizations assess and manage their respective industrial bases, and informing decisions associated with the Militarily-Critical Technologies List (MCTL) and other framework documents governing export control because it maps critical technologies to future warfighting capabilities.

Many U.S. companies have used the DIBCS series to develop corporate business strategies. Of the nearly 112,000 downloads of these documents to date, 85-90 percent were by U.S. entities and the remaining 10-15 percent were by non-U.S. entities. In fact, the utility of this body of work may be greatest for companies[32] with defense-relevant technology that do not currently participate in defense programs. The DIBCS series should allow these companies to map their technologies to the Department's warfighting goals to better assess relevance and suitability for future Department requirements.[33]

Foreign countries and multi-national organizations may be challenged by employment and social policy considerations in objectively and effectively managing their respective defense industrial bases. However, the Department benefits if the global industrial base available for U.S. and coalition defense operations is as technologically innovative as possible. It is also helpful if all industrial bases which may provide the Department warfighting solutions share a common technology and industrial base vernacular and the same analytical foundation.

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[31] For defense industrial base and acquisition strategy assessments, ODUSD(IP) has been able to implement the DIBCS findings real-time; for complete implementation in the decisions relating to mergers and acquisitions, changes in the interagency regulatory frameworks for Hart-Scott-Rodino and Exon-Florio may be required. A study currently being conducted in ODUSD(IP) is addressing this topic, and is scheduled to publish by September 2005.

[32] Of particular note, the DIBCS series highlighted the importance of small companies as sources of innovation: for priority critical technologies assessed, 35-45 percent of the firms with priority solutions have fewer than 100 employees.

[33] Appendices A and B in this study series provide companies with the technology and industrial base information to craft more effective business and investment strategies focused on DoD's warfighting goals, better communicate those strategies to the Department and other suppliers—hopefully to become important enablers of a networked, functional capability approach to 21st century warfighting.

Australia has, in many ways, taken the international lead in adapting the DIBCS methodology. The Ministries of Defence of the United Kingdom, Sweden, Greece, Turkey, and Poland are considering adapting these principles for their own use. The European Defence Agency is aware of this body of work and understands its relevance for cooperative European industrial base planning.

The 1,428-item critical technologies identified in the DIBCS series may help inform policies. Appropriate export controls are important to the development of a financially robust, innovative defense industrial base. If export controls are unnecessarily stringent, they throttle the competitiveness of U.S. firms in international markets. If too permissive, they endanger the warfighter. Export control policies that effectively balance these objectives will become increasingly important as allies strain to craft appropriate export control policies in emerging markets such as China, and the Department endeavors not to undermine the competitiveness of U.S. companies in major new markets.

OTHER CONCEPTS DEVELOPED

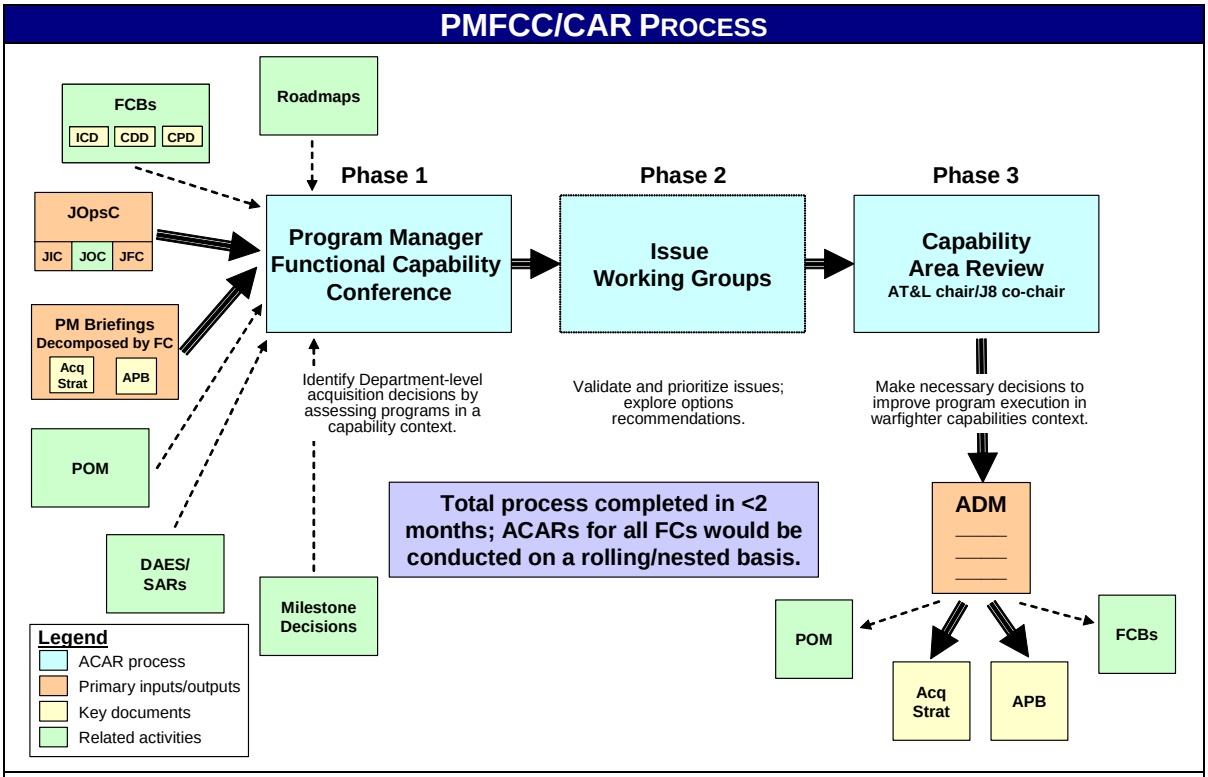
Certain Department processes may be insufficient to stimulate innovation in the defense industrial base, or to insert producible technologies of value into multiple defense programs.

THE PROGRAM MANAGERS' FUNCTIONAL CAPABILITY CONFERENCE AND CAPABILITY AREA REVIEWS

With the publication of *Transforming the Defense Industrial Base: A Roadmap* in February 2003, ODUSD(IP) became an early advocate of fundamental change in the Department's program oversight process. That first study envisioned an oversight process consisting of DAB-like boards that would review entire operational effects sectors instead of individual programs.[34] With the publication of *DIBCS FA,* ODUSD(IP) conceptualized a construct more aligned to the Joint Staff's functional capability concepts.[35] Program Manager's Functional Capability Conferences (PMFCCs) would inform Capability Area Reviews (CARs), which would be conducted annually to continuously re-synchronize capability area programs to overall capability area objectives. They would also serve as fora in which cross-Service and cross-program technology learning could better cross-pollinate high-leverage, high span of impact technologies throughout the defense enterprise. For the time being, some of the nation's most innovative technology resides "in the pockets" of individual programs and neither industry nor program managers have incentives to cost-effectively move this technology to other programs. The PMFCC/CAR process (as illustrated opposite), if implemented, might help attain better visibility into this high leverage technology, and

[34] See *Transforming the Defense Industrial Base: A Roadmap*, February 2003, pages 24-31.
[35] See *DIBCS FA*, October 2004, pages 41-45; and Appendix E of this study for a detailed description of the PMFCC/ACAR process.

assure that the Department's military capability objectives are met by programs intended to accomplish them.



Source: Booz Allen Hamilton and ODUSD(IP)

ODUSD(IP) prototyped a small-scale PMFCC in June 2004 using four multi-Service Command and Control/Net-Centric Operations (C2/NCO) programs. The PMFCC mapped these four C2/NCO programs to the Joint Staff's C2/CNO JFCs to better understand the interrelationships. This exercise provided actionable assessments to meet the requirements for legacy integration methodology and convergence assessments highlighted in the Joint Battle Management Command and Control Roadmap for key C2/NCO programs. By simultaneously evaluating multiple programs against their contribution to accomplishing the JFC capability areas, participants were able to assess common key performance parameters, synergies, disconnects, and interoperability issues; and begin program synchronization. Such assessments could ultimately support programmatic and budgetary decisions to optimize a program's ability to enable C2/NCO functional concepts.

Most participants were convinced of the utility of such a review process and that it could be scaled to PMFCCs conducted over a week or so, followed by a one-day CAR. The resulting Acquisition Decision Memorandum (ADM) would capture in one document all programmatic and budgetary guidance for an entire functional capability area. It is estimated that the entire process could be accomplished in less than two months.

THE INDUSTRIAL BASE INNOVATION FUND (IBIF)

The IBIF is intended to bring production-ready innovation to programs of record using a pre-funded vehicle administered by the Office of the Secretary of Defense. It also would facilitate multi-program application. Its pre-funded feature would assure near real-time incorporation of innovation into weapons systems. While many technology transition programs exist in the Department, none are pre-funded and facilitate multi-program application across all military Services.

FINAL REMARKS

With the publication of *DIBCS FL*, the initial work assessing the ability of the industrial base to support the most important 21st century warfighting capabilities is complete. Over the course of the next year, additional work is necessary to synchronize and implement the conclusions of the initial DIBCS body of work, and to use its framework for ongoing Department industrial assessments. Only by looking to the future can the Department transform the industrial base to support the operational ethos that warfighting capabilities—and the warfighter—must drive defense demand and the products the Department acquires. The DIBCS series furthers this objective. Long after the initial study series is complete, the DIBCS framework and findings will continue to inform other federal agency, industry, and allied nation industrial planning processes.

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ACRONYMS

ACAR	Acquisition Capability Area Review
ACTD	Advanced Concept Technology Demonstration
ADM	Acquisition Decision Memorandum
AF	Air Force
AOC-WS	Air Operations Center – Weapon System
APB	Acquisition Program Baseline
ATIRCM/CMWS	Advanced Threat Infrared Countermeasure/Common Missile Warning System
AT&L	Acquisition, Technology and Logistics
BA	Battlespace Awareness
BA/BWA	Be Ahead and Be Way Ahead
BAH	Booz Allen Hamilton, Inc.
C2	Command and Control
C-5 RERP	C-5 Reliability Enhancement and Re-Engineering Program
C-17	Globemaster III Advanced Cargo Aircraft
C-130	Hercules Cargo Aircraft
C3I	Command, Control, Communications, and Intelligence
CAR	Capability Area Review
CBRNE	Chemical, Biological, Radioactive, Nuclear, and Explosive
CDD	Capability Development Document
CEO	Chief Executive Officer
CFIUS	Committee on Foreign Investment in the United States
CH-47	Cargo Helicopter Upgrade
Chem DeMil	Chemical Demilitarization Program
CJCSI	Chairman of the Joint Chief of Staff's Instruction
CPD	Capability Production Document
CVN 21	21st Century Aircraft Carrier
DAB	Defense Acquisition Board
DAES	Defense Acquisition Executive Summary
DARPA	Defense Advanced Research Projects Agency
DCGS	Distributed Common Ground System
DDR&E	Director, Defense Research & Engineering
DC	Direct Current
DIBCS	Defense Industrial Base Capabilities Study
DIBCS BA	*Defense Industrial Base Capabilities Study: Battlespace Awareness*
DIBCS C2	*Defense Industrial Base Capabilities Study: Command & Control*
DIBCS FA	*Defense Industrial Base Capabilities Study: Force Application*
DIBCS FL	*Defense Industrial Base Capabilities Study: Focused Logistics*
DLA	Defense Logistics Agency
DoD	Department of Defense
DoJ	Department of Justice
DoP	Declaration of Principles
DS	Defense Systems
DUSD	Deputy Under Secretary of Defense

DUSD(IP)	Deputy Under Secretary of Defense (Industrial Policy)
E-2C	Advanced Hawkeye Aircraft
FA	Force Application
F/A-22	Raptor Fighter/Attack Aircraft
FBCB2	Force XXI Battle Command Battalion/Brigade and Below
FC	Functional Capability
FCB	Functional Capability Board
FCS	Future Combat System
FL	Focused Logistics
FLJFC	Focused Logistics Joint Functional Concept
FMTV	Family of Medium Tactical Vehicles
FTC	Federal Trade Commission
FY	Fiscal Year
GAO	Government Accountability Office
GCCS-J	Joint Global Command & Control Systems
GCSS	Global Combat Support System
GMLRS	Guided Multiple Launch Rocket System
GPS	Global Positioning System
HSR	Hart-Scott-Rodino
IB	Industrial Base
IBIF	Industrial Base Investment Fund
ICD	Initial Capability Document
IDA	Institute for Defense Analyses
IHPRPT	Integrated High Payoff Rocket Propulsion Technology
IP	Industrial Policy
JCIDS	Joint Capabilities and Integration Development System
JDAM	Joint Direct Attack Munition
JFC	Joint Functional Concept
JFCOM	Joint Forces Command
JIC	Joint Integrating Concept (subordinate to JOC)
JSLIST	Joint Service Lightweight Integrated Suit Technology
JOC	Joint Operating Concepts (subordinate to JOpsC)
JOpsC	Joint Operations Concepts
JSF	Joint Strike Fighter
JTRS	Joint Tactical Radio System
MCTL	Militarily Critical Technologies List
MEMS	Micro-Electro-Mechanical System
MILSATCOM	Military Satellite Communication
MH-60R	Multi-Mission Helicopter Upgrade
MH-60S	Multi-Mission Naval Helicopter
MM III	Minuteman III
MOUT	Mobile Military Operations Urban Terrain
MPF	Maritime Prepositioning Force
MPS	Mission Planning System
NASA	National Aeronautics and Space Administration
NCO	Net Centric Operations
NPOESS	National Polar-orbiting Operational Environmental Satellite System

ODUSD	Office of the Deputy Under Secretary of Defense
ODUSD(IP)	Office of the Deputy Under Secretary of Defense (Industrial Policy)
OEF	Operation Enduring Freedom
OEF/OIF	Operation Enduring Freedom and Operation Iraqi Freedom
OIF	Operation Iraqi Freedom
OSD	Office of the Secretary of Defense
PAC-3	Patriot Advanced Capability-Phase 3
PEO	Program Executive Officer
PM	Program Manager
PMFCC	Program Manager Functional Capability Conference
POM	Program Objective Memorandum
PRP	Propulsion Replacement Program
R&D	Research and Development
RFID	Radio Frequency Identification
RFP	Request for Proposal
S&T	Science and Technology
SAG	Senior Advisory Group
SASC	Senate Armed Service Committee
SBIRS-High	Space-Based Infrared System – High
SDB	Small Diameter Bomb
SME	Subject Matter Expert
SRM	Solid Rocket Motor
SoS	Security of Supply
T-AKE	Lewis and Clark Class of Auxiliary Dry Cargo Ships
TRL	Technology Readiness Level
TSSS	Technology for the Sustainment of Strategic Systems
U.S.	United States
USAF	United States Air Force
USD(AT&L)	Under Secretary of Defense (Acquisition, Technology, and Logistics)
USN	United States Navy
USS	United States Ship
USSPACECOM	United States Space Command

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APPENDIX A

DIBCS FOCUSED LOGISTICS
CAPABILITY FRAMEWORK

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Joint Deployment/Rapid Distribution

Transportation – Air Neutral
• Transport up to 10 personnel a short range (on order of 100 mi) by air using an established runway
• Transport up to 60 personnel a short range (on order of 100 mi) by air using an established runway
• Transport 60 or more personnel a short range (on order of 100 mi) by air using an established runway
• Transport up to 10 personnel a medium range (on order of 1000 mi) by air using an established runway
• Transport up to 60 personnel a medium range (on order of 1000 mi) by air using an established runway
• Transport 60 or more personnel a medium range (on order of 1000 mi) by air using an established runway
• Transport up to 10 personnel a long range (on order of 2500 mi) by air using an established runway
• Transport up to 60 personnel a long range (on order of 2500 mi) by air using an established runway
• Transport 60 or more personnel a long range (on order of 2500 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air using an established runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of general purpose cargo a medium range (on order of 1000 mi) by air using an established runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a medium range (on order of 1000 mi) by air using an established runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a long range (greater than 1000 mi) by air using an established runway

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Equal
• Transport up to 10 personnel a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport up to 10 personnel a short range (on order of 100 mi) by air and land/take off using an unimproved runway
• Transport up to 10 personnel a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport up to 10 personnel a short range (on order of 100 mi) by air and land/take off vertically
• Transport up to 60 personnel a short range (up to 100 mi) by air and land/take off using a short runway
• Transport up to 60 personnel a short range (up to 100 mi) by air and land/take off using an unimproved runway
• Transport up to 60 personnel a short range (up to 100 mi) by air and land/take off vertically
• Transport up to 60 personnel a short range (up to 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport 60 or more personnel a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport 60 or more personnel a short range (on order of 100 mi) by air and land/take off using an unimproved runway
• Transport up to 10 personnel a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport up to 10 personnel a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport up to 10 personnel a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport up to 10 personnel a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport up to 60 personnel a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport up to 60 personnel a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport up to 60 personnel a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Equal – Cont.
• Transport up to 60 personnel a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport 60 or more personnel a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport 60 or more personnel a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport up to 10 personnel a long range (on order of 2500 mi) by air and land/take off using a short runway
• Transport up to 10 personnel a long range (on order of 2500 mi) by air and land/take off using an unimproved runway
• Transport up to 10 personnel a long range (on order of 2500 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport up to 60 personnel a long range (on order of 2500 mi) by air and land/take off using a short runway
• Transport up to 60 personnel a long range (on order of 2500 mi) by air and land/take off using an unimproved runway
• Transport 60 or more personnel a long range (on order of 2500 mi) by air and land/take off using a short runway
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off using an unimproved runway
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off using an unimproved runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air using an established runway

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Equal – Cont.
• Transport a small amount (up to 5 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport a small amount (up to 5 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport a small amount (up to 5 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a small amount (up to 5 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport a large amount (50 tons or more) of general purpose cargo a medium range (on order of 1000 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of general purpose cargo a long range (greater than 1000 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of general purpose cargo a long range (greater than 1000 mi) by air and land/take off using a short runway
• Transport a small amount (up to 5 tons) of general purpose cargo a long range (greater than 1000 mi) by air and land/take off using an unimproved runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a long range (greater than 1000 mi) by air and land/take off using a short runway
• Transport a medium amount (5 to 50 tons) of general purpose cargo a long range (greater than 1000 mi) by air and land/take off using an unimproved runway
• Transport a large amount (50 tons or more) of general purpose cargo a long range (greater than 1000 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off vertically

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Equal – Cont.
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air using an established runway
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air using an established runway
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air using an established runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off using a short runway
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air using an established runway
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off using a short runway

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Equal – Cont.
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air using an established runway

Transportation – Air Be Ahead
• Transport up to 10 personnel a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport up to 60 personnel a short range (up to 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport 60 or more personnel a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport 60 or more personnel a short range (up to 100 mi) by air and land/take off vertically
• Transport 60 or more personnel a short range (up to 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport up to 10 personnel a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport up to 60 personnel a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport 60 or more personnel a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport 60 or more personnel a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport 60 or more personnel a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Be Ahead – Cont.
• Transport up to 10 personnel a long range (on order of 2500 mi) by air and land/take off vertically
• Transport up to 10 personnel a long range (on order of 2500 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport up to 60 personnel a long range (on order of 2500 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport up to 60 personnel a long range (on order of 2500 mi) by air and land/take off vertically
• Transport up to 60 personnel a long range (on order of 2500 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport 60 or more personnel a long range (on order of 2500 mi) by air and land/take off using an unimproved runway
• Transport 60 or more personnel a long range (on order of 2500 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) using a runway
• Transport 60 or more personnel a long range (on order of 2500 mi) by air and land/take off vertically
• Transport 60 or more personnel a long range (on order of 2500 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air and land/take off using an unimproved runway
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Be Ahead –Cont.
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air and land/take off vertically
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a small amount (up to 5 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a medium amount (5 to 50 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a medium amount (5 to 50 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of general purpose cargo a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a large amount (50 tons or more) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport a large amount (50 tons or more) of general purpose cargo a medium range (on order of 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a large amount (50 tons or more) of general purpose cargo a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport a large amount (50 tons or more) of general purpose cargo a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a small amount (up to 5 tons) of general purpose cargo a long range (greater than 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off vertically
• Transport a small amount (up to 5 tons) of general purpose cargo a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Be Ahead –Cont.
• Transport a medium amount (5 to 50 tons) of general purpose cargo a long range (greater than 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of general purpose cargo a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a large amount (50 tons or more) of general purpose cargo a long range (greater than 1000 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of general purpose cargo a long range (greater than 1000 mi) by air and land/take off using an unimproved runway
• Transport a large amount (50 tons or more) of general purpose cargo a long range (greater than 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air and land/take off vertically
• Transport a large amount (50 tons or more) of general purpose cargo a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off using an unimproved runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off using an unimproved runway

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Be Ahead – Cont.
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off using an unimproved runway
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and land/take off vertically
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range (on order of 100 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Be Ahead – Cont.
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off using an unimproved runway
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and land/take off vertically
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a medium range (on order of 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Be Ahead – Cont.
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off using an unimproved runway
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off vertically
• Transport a small amount (up to 5 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a short range long range (greater than 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off using an unimproved runway
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off vertically
• Transport a medium amount (5 to 50 tons) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off using a short runway
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off using an unimproved runway

Joint Deployment/Rapid Distribution – Cont.

Transportation – Air Be Ahead – Cont.
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and take off/land in adverse weather conditions (high wind, low visibility, rain)
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and land/take off vertically
• Transport a large amount (50 tons or more) of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) a long range (greater than 1000 mi) by air and operate/take off/land in adverse weather conditions (high wind, low visibility, rain) and take off/land vertically

Transportation – Air Be Way Ahead
• None

Transportation – Water-Brown Neutral
• Transport up to 100 personnel by inland or coastal waterway
• Transport more than 100 personnel by inland or coastal waterway
• Transport up to 75 tons of general purpose cargo by inland or coastal waterway
• Transport up to 250 tons of general purpose cargo by inland or coastal waterway
• Transport more than 250 tons of general purpose cargo by inland or coastal waterway
• Transport up to 75 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway
• Transport up to 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway
• Transport more than 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway

Joint Deployment/Rapid Distribution – Cont.

Transportation – Water-Brown Equal
• Transport up to 10 personnel by inland or coastal waterway at high speeds
• Transport up to 10 personnel by coastal waterway through high sea states
• Transport up to 10 personnel by inland or coastal waterway to load/unload/ deploy at shallow draft site
• Transport up to 10 personnel between off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site
• Transport up to 100 personnel by inland or coastal waterway at high speeds
• Transport up to 100 personnel by coastal waterway through high sea states
• Transport more than 100 personnel by inland or coastal waterway at high speeds
• Transport more than 100 personnel by coastal waterway through high sea states
• Transport up to 75 tons of general purpose cargo by inland or coastal waterway at high speeds
• Transport up to 75 tons of general purpose cargo by coastal waterway through high sea states

Transportation – Water-Brown Equal – Cont.
• Transport up to 250 tons of general purpose cargo by inland or coastal waterway at high speeds
• Transport up to 250 tons of general purpose cargo by coastal waterway through high sea states
• Transport more than 250 tons of general purpose cargo by inland or coastal waterway at high speeds
• Transport more than 250 tons of general purpose cargo by coastal waterway through high sea states
• Transport up to 75 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway at high speeds
• Transport up to 75 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by coastal waterway through high sea states
• Transport up to 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway at high speeds
• Transport up to 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by coastal waterway through high sea states

Joint Deployment/Rapid Distribution – Cont.

Transportation – Water-Brown Equal – Cont.
• Transport more than 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway at high speeds
• Transport more than 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by coastal waterway through high sea states

Transportation – Water-Brown Be Ahead
• Transport up to 10 personnel between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site
• Transport up to 100 personnel by inland or coastal waterway to load/unload/deploy at shallow draft site
• Transport up to 100 personnel between off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site
• Transport up to 100 personnel between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site
• Transport more than 100 personnel by inland or coastal waterway to load/unload/deploy at shallow draft site
• Transport more than 100 personnel between off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site
• Transport more than 100 personnel between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site
• Transport up to 250 tons of general purpose cargo by inland or coastal waterway to load/unload/deploy at shallow draft site
• Transport up to 250 tons of general purpose cargo off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site
• Transport up to 250 tons of general purpose cargo between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site
• Transport more than 250 tons of general purpose cargo by inland or coastal waterway to load/unload/deploy at shallow draft site
• Transport more than 250 tons of general purpose cargo off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site

Joint Deployment/Rapid Distribution – Cont.

Transportation – Water-Brown Be Ahead – Cont.
• Transport more than 250 tons of general purpose cargo between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site
• Transport up to 75 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway to load/unload/deploy at shallow draft site
• Transport up to 75 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site
• Transport up to 75 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site
• Transport up to 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway to load/unload/deploy at shallow draft site
• Transport up to 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site
• Transport up to 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site
• Transport more than 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by inland or coastal waterway to load/unload/deploy at shallow draft site
• Transport more than 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) off shore location (up to 10 miles out) and shore to load/unload/deploy at unimproved shallow draft site
• Transport more than 250 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) between "over the horizon" location (up to 75 miles out) and shore at high speeds to load/unload/deploy at unimproved shallow draft site

Transportation – Water-Brown Be Way Ahead
• None

Joint Deployment/Rapid Distribution – Cont.

Transportation – Water-Blue Neutral
• Transport up to 2000 tons of general purpose cargo by sea
• Transport more than 2000 tons of general purpose cargo by sea

Transportation – Water-Blue Equal
• Transport up to 1000 personnel by sea
• Transport more than 1000 personnel by sea
• Transport up to 2000 tons of general purpose cargo by sea at high speeds
• Transport up to 2000 tons of general purpose cargo by sea through adverse weather and sea conditions
• Transport more than 2000 tons of general purpose cargo by sea at high speeds
• Transport more than 2000 tons of general purpose cargo by sea through adverse weather and sea conditions
• Transport more than 2000 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by sea

Transportation – Water-Blue Be Ahead
• Transport up to 1000 personnel by sea at high speeds
• Transport up to 1000 personnel by sea through adverse weather and sea conditions
• Transport more than 1000 personnel by sea at high speeds
• Transport more than 1000 personnel by sea through adverse weather and sea conditions
• Transport up to 2000 tons of general purpose cargo by sea to arrive at shallow draft (15 ft) and rudimentary port facilities
• Transport more than 2000 tons of general purpose cargo by sea to arrive at shallow draft (15 ft) and rudimentary port facilities
• Transport more than 2000 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by sea at high speeds
• Transport more than 2000 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by sea through adverse weather and sea conditions

Joint Deployment/Rapid Distribution – Cont.

Transportation – Water-Blue Be Ahead – Cont.
• Transport more than 2000 tons of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by sea to arrive at shallow draft (15 ft) and rudimentary port facilities

Transportation – Water-Blue Be Way Ahead
• None

Transportation – Ground Neutral
• Transport up to 12 personnel by ground over roadways
• Transport up to 12 personnel by ground over roadways at high speeds
• Transport up to 12 personnel by ground over light terrain
• Transport more than 12 personnel by ground over roadways
• Transport more than 12 personnel by ground over roadways at high speeds
• Transport a small amount of general purpose cargo by ground over roadways
• Transport a small amount of general purpose cargo by ground over roadways at high speeds

Transportation – Ground Equal
• Transport up to 12 personnel by ground over light terrain at high speeds
• Transport up to 12 personnel by ground over rough terrain
• Transport more than 12 personnel by ground over light terrain
• Transport more than 12 personnel by ground over light terrain at high speeds
• Transport a small amount of general purpose cargo by ground over light terrain
• Transport a small amount of general purpose cargo by ground over light terrain at high speeds
• Transport a large amount of general purpose cargo by ground over roadways
• Transport a large amount of general purpose cargo by ground over roadways at high speeds
• Transport a large amount of general purpose cargo by ground over light terrain
• Transport a small amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over roadways

Joint Deployment/Rapid Distribution – Cont.

Transportation – Ground Equal
• Transport a small amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over roadways at high speeds
• Transport a small amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over light terrain
• Transport a large amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over roadways
• Transport a large amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over roadways at high speeds
• Transport a large amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over light terrain

Transportation – Ground Be Ahead
• Transport more than 12 personnel by ground over rough terrain
• Transport a small amount of general purpose cargo by ground over rough terrain
• Transport a large amount of general purpose cargo by ground over light terrain at high speeds
• Transport a large amount of general purpose cargo by ground over rough terrain
• Transport a small amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over light terrain at high speeds
• Transport a small amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over rough terrain
• Transport a large amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over light terrain at high speeds
• Transport a large amount of special purpose cargo (POL, hazardous materials, A&E, WIA, KIA, perishable cargo, outsized cargo, etc.) by ground over rough terrain

Joint Deployment/Rapid Distribution – Cont.

Transportation – Ground Be Way Ahead
• None

Transportation – Space Neutral
• None

Transportation – Space Equal
• Launch a small payload (1000 lbs or less) into low earth orbit
• Launch a medium payload (1000 to 10000 lbs) into low earth orbit
• Launch a heavy payload (10000 lbs or more) into low earth orbit
• Transfer a payload from low earth orbit to medium earth orbit
• Transfer a payload from low earth orbit to geostationary orbit
• Transfer a payload from low earth orbit to highly eliptical orbit

Transportation – Space Be Ahead
• Launch multiple payloads into space from one launch vehicle
• Launch multiple launch vehicles into space within a short period of time (days)

Transportation – Space Be Way Ahead
• None

Distribution – Refueling Neutral
• Refuel ships in port
• Temporary ground storage of small volumes of POL
• Refuel ground vehicles
• Refuel/de-fuel aircraft (fixed wing and rotary) on the ground

Joint Deployment/Rapid Distribution – Cont.

Distribution – Refueling Equal
• Aerial refuel fixed-wing aircraft
• Aerial refuel tilt/rotary aircraft
• Refuel anchored/stopped ships at sea
• Distribute large volumes of POL over extended distances through semi-fixed distribution system
• Distribute large volumes of POL over short distances through semi-fixed distribution system
• Temporary ground storage of large volumes of POL
• Refuel ground vehicles in remote locations with ground-transportable fuel and equipment
• Refuel/de-fuel aircraft (fixed wing and rotary) at sea
• Perform hot-refuel of aircraft (fixed wing and rotary) on the ground
• Perform refueling of aircraft (fixed wing and rotary) on ground in remote locations with ground-transportable fuel and equipment
• Perform hot-refueling of aircraft (fixed wing and rotary) on ground in remote locations with ground-transportable fuel and equipment
• Recharge a battery powered air, land, or sea vehicle

Distribution – Refueling Be Ahead
• Aerial refuel multiple fixed-wing aircraft simultaneously
• Aerial refuel multiple tilt/rotary aircraft simultaneously
• Aerial refuel diverse (both fixed-wing and tilt/rotary) aircraft types in the same refueler sortie
• Refuel anchored/stopped ships at sea, day/night, in adverse weather conditions and rough sea states
• Refuel ships underway at sea
• Refuel ground vehicles in remote locations with air-transportable fuel and equipment
• Perform hot-refuel of aircraft (fixed wing and rotary) at sea
• Perform refueling of aircraft (fixed wing and rotary) on ground in remote locations with air-transportable fuel and equipment
• Perform hot-refueling of aircraft (fixed wing and rotary) on ground in remote locations with air-transportable fuel and equipment
• Recharge a battery powered air, land, or sea vehicle in remote locations

Joint Deployment/Rapid Distribution – Cont.

Distribution – Refueling Be Way Ahead
• Refuel ships underway at sea, day/night, in adverse weather conditions and rough sea states

Distribution – Loading/Off-Loading/Staging Neutral
• Lift and transfer heavy cargo
• Lift and transfer medium cargo using fixed equipment
• Lift and transfer medium cargo on improved surfaces using mobile equipment
• Lift and transfer light cargo on improved surfaces using mobile equipment
• Shuttle containers/trailers on improved surfaces
• Maneuver large aircraft on the ground
• Maneuver large ships into, out of, and within ports

Distribution – Loading/Off-Loading/Staging Equal
• Air drop personnel from low altitudes (day/night)
• Air drop personnel from high altitudes (day/night)
• Load/Off-load personnel from low altitudes (day/night) rotary/tilt aircraft
• Air drop light loads from low altitudes
• Air drop light loads from low altitudes with high precision
• Air drop light loads from high altitudes
• Load/off-load light loads from low altitude rotary/tilt aircraft
• Air drop heavy loads from low altitudes
• Air drop heavy loads from high altitudes
• Transfer cargo between anchored/stopped ships at sea and/or sea bases in calm sea states
• Transfer cargo between ship or sea base and unimproved shore in calm sea states
• Lift and transfer medium cargo on unimproved surfaces/rough terrain using mobile equipment
• Lift and transfer light cargo on unimproved surfaces/rough terrain using mobile equipment
• Shuttle containers/trailers on unimproved surfaces
• Determine appropriate load distribution of cargo for ground vehicles
• Determine appropriate load distribution of cargo transport aircraft

Joint Deployment/Rapid Distribution – Cont.

Distribution – Loading/Off-Loading/Staging Equal – Cont.
• Rapidly load/off-load cargo from large aircraft using roll-on/roll-off capability
• Determine appropriate load distribution of cargo for ships
• Rapidly load/off-load cargo from large naval vessels using roll-on/roll-off capability

Distribution – Loading/Off-Loading/Staging Be Ahead
• Air drop personnel from low altitudes (day/night) with high precision
• Air drop personnel from high altitudes (day/night) with high precision
• Load/Off-load personnel from low altitudes (day/night) rotary/tilt aircraft in adverse weather conditions
• Air drop light loads from low altitudes with high precision under adverse weather conditions
• Air drop light loads from high altitudes with high precision
• Air drop light loads from very low altitudes at low speed
• Load/off-load light loads from low altitude rotary/tilt aircraft in adverse weather conditions
• Air drop heavy loads from low altitudes with high precision
• Air drop heavy loads from high altitudes with high precision
• Air drop heavy loads from very low altitudes at low speed
• Load/off-load heavy loads from low altitude rotary/tilt aircraft
• Transfer cargo between anchored/stopped ships at sea and/or sea bases in adverse weather and rough sea states
• Transfer cargo between ships underway at sea and/or sea bases in calm sea states
• Transfer cargo between ship or sea base and unimproved shore in rough sea states
• Load/off-load outsized cargo (e.g. smaller vessels) at sea using float on/float off capability
• Load/off-load/deploy specialized vehicles (e.g. submersibles) at sea
• Lift and transfer light cargo on unimproved surfaces/rough terrain using deployable, mobile equipment
• Selectively load and off-load cargo from a large aircraft
• Selectively load and off-load cargo from a large naval vessel

Joint Deployment/Rapid Distribution – Cont.

Distribution – Loading/Off-Loading/Staging Be Way Ahead
• Air drop personnel from low altitudes (day/night) with high precision under adverse weather conditions
• Air drop personnel from high altitudes (day/night) with high precision under adverse weather conditions
• Air drop personnel from high altitudes (day/night) with high precision using HALO capability
• Air drop light loads from high altitudes with high precision under adverse weather conditions
• Air drop light loads from high altitudes with high precision using HALO capability
• Air drop light loads from very low altitudes at low speed under adverse weather conditions
• Air drop heavy loads from low altitudes with high precision under adverse weather conditions
• Air drop heavy loads from high altitudes with high precision under adverse weather conditions
• Air drop heavy loads from very low altitudes at low speed under adverse weather conditions
• Load/off-load heavy loads from low altitude rotary/tilt aircraft in adverse weather conditions
• Transfer cargo between ships underway at sea and/or sea bases in adverse weather and rough sea states

Distribution – Containers/Storage Neutral
• None

Joint Deployment/Rapid Distribution – Cont.

Distribution – Containers/Storage Equal
• Facilitate the movement of cargo through intermodal standardized container system
• Refrigerate perishable cargo during transport
• Transport POL in non-specialized vehicles
• Transport hazardous materials in non-specialized vehicles
• Transport ammunition and explosives in non-specialized vehicles
• Safely store large quantities of munitions at forward location
• Safely store large quantities of munitions in theater
• Safely store large quantities of munitions in CONUS
• Safely store nuclear munitions

Distribution – Containers/Storage Be Ahead
• Preposition equipment, weapons, munitions, and supplies in a rapidly usable condition (afloat or ashore)

Distribution – Containers/Storage Be Way Ahead
• None

Distribution – Disposal Neutral
• None

Distribution – Disposal Equal
• Dispose of hazardous materials
• Demilitarize out-of-use weapons systems

Distribution – Disposal Be Ahead
• None

Joint Deployment/Rapid Distribution – Cont.

Distribution – Disposal Be Way Ahead
• None

Agile Sustainment

Asset Sustainment – Weapons Systems Neutral
• None

Asset Sustainment – Weapons Systems Equal
• Test on-board parts for malfunctions at a forward operating base
• Test spare/replacement parts for malfunctions at a forward operating base
• Automatically identify faults in electronic circuits in the field through circuit card screening and replacement at a forward operating base
• Test on-board parts for malfunctions at a rear area location (theater or CONUS)
• Test spare/replacement parts for malfunctions at a rear area location (theater or CONUS)
• Automatically identify faults in electronic circuits in the field through circuit card screening and replacement at a rear area location (theater or CONUS)
• Test and analyze military fuels acquired from a variety of sources for suitability using a mobile laboratory at a rear area location (theater or CONUS)
• Non-destructively test weapon systems for structural defects at a rear area location (theater or CONUS)
• Detect changes in equipment and weapon system condition and anticipate impending failure or remaining operational life
• Conduct minor repairs/maintenance on ground-based weapons systems in austere forward locations
• Conduct minor repairs/maintenance on fixed-wing and tilt/rotary aircraft in austere forward locations
• Conduct minor repairs/maintenance on ships at sea
• Conduct major repairs/maintenance on air-, ground-, and sea-based weapons systems at repair/maintenance facility within theater
• Conduct major battle damage repair on air-, ground-, and sea-based weapons systems at repair/maintenance facility within theater
• Upgrade weapons systems with new components at repair/maintenance facility within theater
• Conduct depot-level maintenance/repair on air-, ground-, and sea-based weapons systems at depot facility within theater or CONUS
• Conduct limited repair/maintenance of munitions in the field
• Conduct major repair/maintenance of munitions at a repair facility within theater/CONUS
• Reconfigure commercial aircraft and ships for military use

Agile Sustainment – Cont.

Asset Sustainment – Weapons Systems Equal – Cont.
• Rapidly arm/rearm aircraft weapons systems with engines off
• Rapidly load/reload major naval weapon system munitions in port
• Rapidly load/reload major ground weapon system munitions in a rear area

Asset Sustainment – Weapons Systems Be Ahead
• Test and analyze military fuels acquired from a variety of sources for suitability using a mobile laboratory at a forward operating base
• Anticipate maintenance requirements for equipment and weapons systems through the use of diagnostic and prognostic sensors
• Anticipate maintenance requirements for equipment and weapons systems through the use of diagnostic and prognostic sensors automatically using automated tools and real-time communication links from the sensors
• Detect changes in equipment and weapon system condition and anticipate impending failure or remaining operational life automatically via capability on the platform, weapon system, or component
• Anticipate maintenance requirements for nuclear weapons systems (propulsion or munitions) through the use of diagnostic and prognostic sensors automatically using automated tools and real-time omm. links from the sensors
• Detect changes in nuclear weapon system (propulsion or munitions) condition and anticipate impending failure or remaining operational life automatically via capability on the platform, weapon system, or component
• Anticipate maintenance requirements for munitions through the use of diagnostic and prognostic sensors automatically using automated tools and real-time omm. links from the sensors
• Detect condition changes in munitions and anticipate impending failure or remaining operational life automatically via capability on the platform, weapon system, or component
• Conduct minor battle damage repair on ground-based weapons systems in austere forward locations
• Conduct minor battle damage repair on fixed-wing and tilt/rotary aircraft in austere forward locations
• Conduct minor battle damage repair on ships at sea
• Conduct maintenance/limited repair of the nuclear reactor on a nuclear-powered vessel at sea
• Conduct major maintenance/repair of the nuclear reactor on a nuclear-powered vessel in port

Agile Sustainment – Cont.

Asset Sustainment – Weapons Systems Be Ahead – Cont.
• Convert "dumb" munitions to precision guided munitions (at sea or ashore)
• Conduct limited repair/maintenance of nuclear munitions in the field
• Conduct major repair/maintenance of nuclear munitions at a repair facility within theater/CONUS
• Rapidly conduct repairs/maintenance on aircraft between sorties without shutting off engines
• Rapidly rearm aircraft weapon systems between sorties without shutting off engines (includes austere locations)
• Reload and rearm naval missile systems at forward facilities
• Rapidly load/reload major ground weapon system munitions in the field

Asset Sustainment – Weapons Systems Be Way Ahead
• Conduct major repairs/maintenance to include battle damage repair on ships at sea
• Conduct major repairs/maintenance to include battle damage repair on submarines at sea
• Remotely service and repair space assets in orbit

Asset Sustainment – Infrastructure Neutral
• None

Asset Sustainment – Infrastructure Equal
• Generate electricity at a forward facility that does not have access to a local power grid (via deployable assets)
• Maintain/repair the utilities grids for a forward facility
• Maintain/repair generators, HVAC systems, water purification systems, fuel storage/distribution, and other equipment at forward facilities
• Provide and sustain services support to forward facilities: lodging, laundry, feeding, mortuary services, etc. (via deployable assets)

Agile Sustainment – Cont.

Asset Sustainment – Infrastructure Be Ahead
• Assess and repair infrastructure battle damage

Asset Sustainment – Infrastructure Be Way Ahead
• None

Personnel Sustainment (non-medical) – Water Neutral
• Purify and store water from local sources in bulk for consumption at a forward facility via deployable asset
• Desalinate sea water and store for consumption at a base or seabase or aboard a naval vessel

Personnel Sustainment (non-medical) – Water Equal
• Enable ground personnel to carry individual water supply conveniently and without encumbrance
• Purify water from local sources for individual consumption by ground personnel on the move

Personnel Sustainment (non-medical) – Water Be Ahead
• None

Personnel Sustainment (non-medical) – Water Be Way Ahead
• None

Agile Sustainment – Cont.

Personnel Sustainment (non-medical) – Food Neutral
• None

Personnel Sustainment (non-medical) – Food Equal
• Enable ground personnel to carry/prepare individual food supply conveniently and without encumbrance
• Provide compact, emergency sustainence to deployed personnel who have depleted normal rations

Personnel Sustainment (non-medical) – Food Be Ahead
• None

Personnel Sustainment (non-medical) – Food Be Way Ahead
• None

Personnel Sustainment (non-medical) – Gear Neutral
• None

Personnel Sustainment (non-medical) – Gear Equal
• Provide rapidly-deployable, easily-carried shelter for ground personnel on the move

Personnel Sustainment (non-medical) – Gear Be Ahead
• Enable foot personnel to carry large, heavy loads over any terrain
• Provide lighter and/or smaller equipment to reduce the load carried by ground personnel

Agile Sustainment – Cont.

Personnel Sustainment (non-medical) – Gear Be Way Ahead
• None

Logistics Demand Reduction Neutral
• None

Logistics Demand Reduction Equal
• None

Logistics Demand Reduction Be Ahead
• Reduce fuel requirements through development of alternative fuels, power sources, and engine technologies
• Reduce logistics burden through development of single fuel for battlefield vehicles
• Reduce lift requirements and/or fuel consumption by reducing the weight of materiel and weapons systems
• Reduce the maintainence needs of weapons systems through reliability and maintainability improvements

Logistics Demand Reduction Be Way Ahead
• None

Logistics Information Management

Information Capture – Logistics Requirements and Status Neutral
• None

Information Capture – Logistics Requirements and Status Equal
• Capture and update status, location, and capabilities of materiel in production at manufacturers

Information Capture – Logistics Requirements and Status Be Ahead
• Capture and continually update status, location, and capabilities of units and personnel worldwide
• Capture and update status, location, and capabilities of contractor, non-DoD governmental employees, and non-governmental personnel and organizations (NGOs) within the theater of operations
• Capture and continually update status, location, and capabilities of materiel worldwide, from acquisition through disposal, including in-process, in-transit, and in-storage
• Capture and update status, location, and capabilities of commercial supplies and capabilities within the theater of operations

Information Capture – Logistics Requirements and Status Be Way Ahead
• None

Information Capture – Logistics Infrastructure Assets Neutral
• None

Information Capture – Logistics Infrastructure Assets Equal
• None

Logistics Information Management – Cont.

Information Capture – Logistics Infrastructure Assets Be Ahead
• Capture and continually update status and capabilities of LOCs, CCPs, and PODs worldwide
• Capture and continually update status, location, and capabilities of transportation assets
• Capture and update status and capabilities of coalition and host country logistics infrastructure

Information Capture – Logistics Infrastructure Assets Be Way Ahead
• None

Information Visibility and Manipulation Neutral
• None

Information Visibility and Manipulation Equal
• Provide web-accessible reporting on expenditure and inventory of consumable materiel, including munitions, sustenance, POL, etc.

Information Visibility and Manipulation Be Ahead
• Integrate and synchronize logistics data from a variety of U.S. sources, including different Services and agencies
• Integrate and synchronize logistics data from coalition partners, host nations, and commercial sources
• Provide visibility and drill-down capabilities to identify status, location, and capabilities of personnel, units, materiel, and infrastructure
• Provide visibility of logistics-relevant planning information, including weather, site surveys, ConOps, multinational arrangements, etc.

Information Visibility and Manipulation Be Way Ahead
• None

Logistics Information Management – Cont.

Decision Support – Visualization Neutral
• None

Decision Support – Visualization Equal
• None

Decision Support – Visualization Be Ahead
• Graphically and dynamically display status, location, capabilities, and trends (e.g. consumption) of personnel, units, and materiel
• Graphically and dynamically display status, location, capabilities, and trends (e.g. availablity) of logistics resources

Decision Support – Visualization Be Way Ahead
• None

Decision Support – Analysis Neutral
• None

Decision Support – Analysis Equal
• Determine the ability of commercial industry to meet warfighters demands in surge situations

Logistics Information Management – Cont.

Decision Support – Analysis Be Ahead
• Project readiness trends for weapon systems and units worldwide based on current readiness posture, projected failures, losses, and asset availability on overall unit readiness
• Dynamically anticipate emerging sustainment requirements and shortfalls worldwide
• Adaptively resolve emerging sustainment requirements and shortfalls worldwide
• Predict and detect global pipeline bottlenecks and recommend alternatives to overcome the bottleneck
• Provide course of action options for fulfilling requirements and averting shortfalls and analyze the logistics implications of each option considered
• Dynamically plan, project and prioritize requirements and shortfalls within each class of supply for alternative courses of actions
• Dynamically build time-phased deployment packages
• Dynamically anticipate emerging sustainment requirements and shortfalls throughout an operation
• Adaptively resolve emerging sustainment requirements and shortfalls throughout an operation
• Monitor, identify, and react to deviations from the selected plan through trigger processes or plan sentinels at key nodes or links in the pipeline (in support of an operation)
• Predict, detect, and recommend alternatives to overcome pipeline bottlenecks (in support of an operation)
• Provide dedicated logistics communications frequencies with no time or volume limit

Decision Support – Analysis Be Way Ahead
• Provide a net-centric, collaborative environment for logistics command and control -- including a robust end-to-end information grid, universal transaction services and distributed environment support

Operational Engineering

Site Assessment Neutral
• None

Site Assessment Equal
• Survey terrain to locate potential sites for the construction of facilities, roads, or other infrastructure
• Evaluate the geological suitability of potential sites for the construction or improvement of facilities, roads, or other infrastructure
• Evaluate the environmental conditions, including weather conditions, at potential sites for the construction or improvement of facilities, roads, or other infrastructure
• Evaluate the structural integrity, weight capacity, and other structural characteristics of existing or newly built infrastructure

Site Assessment Be Ahead
• None

Site Assessment Be Way Ahead
• None

Site Establishment – Bare Base Neutral
• None

Site Establishment – Bare Base Equal
• None

Operational Engineering – Cont.

Site Establishment – Bare Base Be Ahead
• Rapidly establish initial operating capability for a forward operating base in austere locations (facilities, infrastructure, utilities, etc.)
• Rapidly construct shelters for personnel in austere locations using deployable assets
• Rapidly construct shelters for weapons systems storage and maintenance in austere locations using deployable assets
• Rapidly repair or improve an airfield in austere locations
• Rapidly set up airfield operations (air traffic control equipment and towers, aerial port operations, other support equipment) in austere locations
• Rapidly set up sea port operations (sea traffic control equipment, cargo handling, other support equipment) in austere locations

Site Establishment – Bare Base Be Way Ahead
• None

Site Establishment – Construction Neutral
• Clear, level, and excavate terrain and perform other earth-moving operations for the construction of buildings and other infrastructure in austere locations
• Load, transport, and dump payloads of earth, rock, sand, etc. in support of building and infrastructure construction in austere locations
• Level and scrape terrain for the construction or improvement of roads, airfields, and landing zones in austere locations

Site Establishment – Construction Equal
• Construct, improve, or reinforce facilities, utilities, and other key infrastructure in austere locations

Operational Engineering – Cont.

Site Establishment – Construction Be Ahead
• Rapidly construct, improve, or reinforce facilities and other key infrastructure in austere locations using advanced constuction materials
• Rapidly construct airfields in austere locations for fixed wing (includes VSTOL) and rotary aircraft
• Build/establish/disassemble temporary combat support infrastructure for the provision of water, power, and fuel within the theater of operations

Site Establishment – Construction Be Way Ahead
• None

Field Engineering Neutral
• None

Field Engineering Equal
• Provide flexible, mobile earth moving and excavating capabilities to support the offensive and defensive operations of ground forces
• Rapidly repair or improve an established road
• Rapidly establish, repair, or improve a landing zone for vertical lift craft or air drop

Field Engineering Be Ahead
• Rapidly bridge an unprepared narrow land gap (stream, gully, etc.) with self-deploying bridging vehicle
• Rapidly load, launch, establish, and retrieve a modular bridge for wider river
• Rapidly establish a temporary roadway through unimproved terrain

Field Engineering Be Way Ahead
• None

Force Health Protection

Healthcare – Battlefield Medicine Neutral
• None

Healthcare – Battlefield Medicine Equal
• Monitor patient vital signs on the battlefield
• Prepare individual for evacuation
• Provide shelter as needed for patients in field environment

Healthcare – Battlefield Medicine Be Ahead
• Stop bleeding on the battlefield
• Sterilize open wounds on the battlefield
• Provide fluids on the battlefield
• Provide immediate stabilization and trauma care (includes administering drugs, resuscitation, etc.)
• Provide battlefield care in no-light/low-light conditions
• Perform networked and fully-integrated on-site triage to individuals
• Provide rapid, networked, and fully-integrated resuscitative, life- and limb-saving medical/surgical procedures in forward areas, prior to evacuation
• Provide a small, modular, lightweight, deployable, mobile field hospital (capabilities include sterile environment, medical equipment, etc.)

Healthcare – Battlefield Medicine Be Way Ahead
• None

Health Protection – Evacuation Care Neutral
• None

Health Protection – Evacuation Care Equal
• None

Force Health Protection – Cont.

Health Protection – Evacuation Care Be Ahead
• Provide stabilization and emergency care during evacuation from the battlefield
• Provide light-weight, state-of-the-art critical care during evacuation flights out of theater

Health Protection – Evacuation Care Be Way Ahead
• None

Health Protection – In-theater Care Neutral
• None

Health Protection – In-theater Care Equal
• Provide large-scale, quickly established hospital capabilities in rear areas for extended military operations (e.g. set up in existing building)

Health Protection – In-theater Care Be Ahead
• Provide networked and fully-integrated in-theater trauma care to individuals
• Provide a modular, lightweight, deployable self-sufficient theater hospital
• Identify and treat symptoms resulting from exposure to CBRNE
• Provide telemedicine capabilities to leverage emergency/diagnostic expertise from outside theater

Health Protection – In-theater Care Be Way Ahead
• None

Health Protection – General Medical Neutral
• None

Force Health Protection – Cont.

Health Protection – General Medical Equal
• Provide, maintain/store, and distribute blood products for theater-wide medical use
• Provide, maintain/store, and distribute pharmaceuticals for theater-wide medical use
• Provide patient tracking information to C2 systems

Health Protection – General Medical Be Ahead
• None

Health Monitoring Neutral
• None

Health Monitoring Equal
• None

Health Monitoring Be Ahead
• Monitor health status of personnel in real- or near-real-time, including blood pressure, heart rate, body temperature, etc.
• Monitor health status of groups and identify early warning signs of medical threats/trends

Health Monitoring Be Way Ahead
• None

Training

Live Training Neutral
• None

Live Training Equal
• None

Live Training Be Ahead
• Enable live training for sea, air, and ground weapons platforms and systems for individual platform-specific skills training
• Enable live training for sea, air, and ground weapons platforms and systems for individual/unit combat skills training
• Enable live training for a variety of personnel skill sets
• Use technologies to assess and analyze trainee performance in live training
• Simulate the characteristics of sea, air, and ground weapons platforms and systems for platform-specific skills training

Live Training Be Way Ahead
• None

Simulated Training Neutral
• None

Simulated Training Equal
• Simulate environmental effects, including wind, precipitation, terrain, sea state, etc.
• Tailor situations and challenges relevant to a variety of personnel skill sets
• Incorporate user-defined rules of engagement in simulated training scenarios
• Enable distributed, multi-user simulations with human trainees operating collaboratively and in opposition

Training – Cont.

Simulated Training Be Ahead
• Simulate the characteristics of sea, air, and ground weapons platforms and systems for combat skills training
• Simulate and vary the strategies and tactics and behaviors of real-world adversaries (e.g. foreign militaries, terrorists, drug smugglers, etc.)
• Simulate and vary the strategies and tactics and behaviors of real-world blue and allied forces (e.g. other U.S. forces, allies, coalition partners, etc.)
• Simulate behaviors of noncombatants on the battlefield (e.g. neutrals, NGO personnel, journalists, refugees, rioters, looters, etc.)
• Automatically assess and analyze trainee performance in simulations
• Recreate the strategies and tactics and behaviors of real-world adversaries in force-on-force training (e.g. foreign militaries, terrorists, drug smugglers, etc.)

Simulated Training Be Way Ahead
• Recreate a variety of large-scale operational environments for force-on-force training across the full spectrum of warfare

Force-on-Force Training Neutral
• None

Force-on-Force Training Equal
• None

Force-on-Force Training Be Ahead
• Recreate behaviors of noncombatants on the battlefield in force-on-force training (e.g. NGO personnel, journalists, refugees, rioters, looters, etc.)
• Simulate battlefield effects for training purposes
• Enable detailed analysis of training exercises to evaluate trainee performance as well as the effectiveness of new tactics and new equipment
• Provide ability to integrate live and simulated force-on-force training scenarios

Training – Cont.

Force-on-Force Training Be Way Ahead
• None

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APPENDIX B

CRITICAL TECHNOLOGIES FOR FOCUSED LOGISTICS ORGANIZED BY BROAD INDUSTRIAL AREAS

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Airdrop

The ability to deliver passengers and/or cargo at any one time precisely to a given destination by available aircraft.

- Advanced windsonde
- All weather-wind sensing
- Automated computed aerial release point
- Autonomous navigation systems
- Decelerators
- Drogue parachute
- Electromechanical parachute riser actuation
- Gliding (ram air) parachute
- GPS guided steerable parachute
- High Altitude/High Opening/Low Opening (HAHO/HALO) helmet
- Low altitude parachute extraction system
- Motion compensation / mitigation interface system
- Pneumatic muscle soft landing actuator
- Rappelling equipment
- Recovery parachute
- Semi-rigid deployable wing (SRDW)

Cargo handling

The actions taken to package, move, or load goods, equipment, or supplies being conveyed in a ship, aircraft, or vehicle.

- Advanced docking system
- Automated strike up /strike down machinery
- Cargo boom
- Cargo lighters
- Cargo nets
- Deployable, high speed loader
- Dual logistics roller rails
- External cargo hook
- External cargo sling
- External pallet sling
- Floor rollers
- Heavy equipment semi-trailer
- High-tensioned spanwire
- Lightweight blast resistant container for munitions and explosives
- Load handling system
- Modular medical evacuation litters
- Motion compensation / mitigation interface system
- Multipurpose flat racks/pallets
- On-board cargo crane
- On-board rail operated gantry crane
- Ramp to platform interface
- Roll-on roll-off discharge facility (RRDF) platform
- Small cargo UAV
- Underside upward opening door
- Underwater cargo transfer system

Command and Control

The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of a mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

- Adaptive belief engine (ABEL)
- Advanced information technology services (AITS) architecture
- Agent-enhanced decision guide environment software
- All weather flight control systems
- Bayesian variable-resolution modeling
- C2 modeling tools
- Cognitive agent architecture software
- Cognitively congruent decision aiding
- Control of distributed collaborative smart agents
- Course of action (COA) analysis tools
- Data mining
- Data visualization dashboards
- Data warehousing
- Decision-centered visualization
- Distributed interactive collaboration environment (DICE)
- Distributed-agent-based information fusion
- Dynamic 3D model/authoring tool
- Electronic data interchange (EDI)
- Fuel cells
- Geographic information system
- Highly portable, wireless, very small aperture terminal (VSAT)
- Immersive virtual-reality display
- Intelligent information management system
- Laptop mission planning system
- Large scale distributed agent architecture
- Multi-layered, horizontal fusion
- Net-centric web services
- Neural networks
- Next-generation batteries
- Next-generation solar cells
- On-line analytical processing (OLAP)
- Open-architecture standards
- Remote sensing imagery
- Extract, transform, and load (ETL) server
- Secure collaboration software
- Secure web conferencing network
- Synchronous and asynchronous collaboration tools
- Ultra-wide band
- Virtual simulation tools
- Wireless Fidelity (Wi-Fi)
- Wireless Interoperability for Microwave Access (Wi-Max)
- Wireless wide area network

Communications and Networking

These technologies optimize communications channels in terms of their data throughput rates, capacity, security, and mobility. Bandwidth enhancers and bandwidth sharing tools expand the content and detail of the information being exchanged, as well as its update frequency. Wireless technology allows a channel to be established anywhere while robust security measures keep the data on the channel private.

- Cellular micro-radios
- Collaborative scheduling environment
- Connectionless networks
- Dynamic spectrum allocation/ harvesting
- Mobile ad hoc network
- Satellite-based asset tracking
- Telepresence medical workstation
- WiFi networks with 3D user/emitter geopositioning

Devices

A piece of equipment or a mechanism designed to serve a special purpose or perform a special function.

- 2D bar codes
- 3D laser scanners
- Active radio frequency identification (RFID)
- Adjustable height landing gear struts
- Advanced radiolocation tracking technology
- Augmented reality display
- Central tire inflation system
- Contact memory button
- Deployable polarized light
- Electronic system test set
- Externally blown flap system
- Front and rear axle steering
- High flotation landing gear
- Instrumentation and control station for integrated laser engagement system
- Integrated laser engagement system
- Large-area distributed acoustic emission health processor
- LASER range-finder with automated steering
- Load leveling hydraulic suspension
- Local positioning systems
- Magnetic strips
- Optical memory cards
- Passive radio frequency identification (RFID)
- Personnel status monitor
- Photogrammetric camera
- Retractable tailskid
- Sensor-based tagging and tracking
- Smart cards
- Strengthened landing gear
- Wireless vibration energy harvesting system

Engineering

The art and practice of designing and building military works and of building and maintaining lines of military transport and communications.

- Advanced compaction technologies
- Airfield assessment tools
- Autonomous airfield assessment vehicle
- Autonomous GPS-controlled grading and contouring
- Composite tank-/vehicle-carried portable bridges
- Contour crafting
- Deployable weapon storage area planning tools
- Enhanced breakwater construction
- Expedient channel deepening
- Grading and earthmoving equipment
- Inflatable lift bags
- Lightweight field matting
- Prepackaged quasi-fixed facility systems
- Pulverizers
- Rapid pier upgrades
- Rapid soil stabilization
- Remote sensing airfield assessment
- Small, highly mobile basic airfield operations set
- Transportable airfield layout and flight control infrastructure

Fuel Handling and Storage

The ability to move fuel from one place to another for use, distribution, or to hold and protect it for later use.

- “A” frame fueling-at-sea station
- Approved fuel catch containers
- Automatic highline, spanwire and outboard saddle operation
- Ballistic-tolerant bladder
- Buddy-store systems
- Electric fuel pump
- Extended range fuel tanks
- Fuel feed tanks
- Funnel-shaped drogue
- Hose and reel fuel transfer system
- Hot refueling pits
- Inland pipeline distribution system
- Microprocessor controlled refueling pods
- On-orbit fuel transfer system
- Rapid ground refueling hose system
- Receiver aircraft - boom system
- Receiver ship - automatic connect up system
- Self-contained bulk liquid transfer
- Ship rigging winch
- Tanker boom system
- Tanker hose and drogue system
- Wing-mounted tanker pods

Fuels

A material used to produce heat that generates energy to power our military engines.

- Common vehicle fuel (JP-8)
- Fast pyrolysis
- Microbial hydrogen production
- Non-corrosive fuels
- Plastics and biomass conversion technology

Maintenance and Repair

The act of upkeeping property or equipment by restoring it to a sound or healthy state.

- Armament ground safety pins
- Deployable test and repair set
- Fast reusable tooling
- Forward battle-damage repair kits and procedures
- Freeform fab of large tubes
- Fuse and dome covers for missiles
- Inkjet printing
- Machine tool integrated 3D laser scanner
- Mesoscale materials deposition
- Mobile laser engineered shaping
- Mobile multi-task machining equipment
- Rapid laser-based tooling

Materials

Materials are substances, such as metals, ceramics, or plastics, used in building or construction under various conditions.

- Acoustic damping materials
- Carbon-fiber/fiber-reinforced plastic
- Composite matting materials
- Elastic cement
- Elastomer sprayed coating
- Energy dissipating material
- Foam-in-place sandwich panels
- Function-oriented material design
- Hydrolytic cement
- Lattice-block materials (LBM)
- Lightweight, high-stress, composite
- Mechanical stabilizing materials
- Multifunctional structural fabrics
- Rigid polyurethane foam
- Rugged fabric envelope
- Sandwich panel of metal/composite/polymer foams
- Selectively permeable membranes
- Self-repairing materials
- Smart advanced polymer composites
- Transpiration cooling materials
- Ultralightweight materials

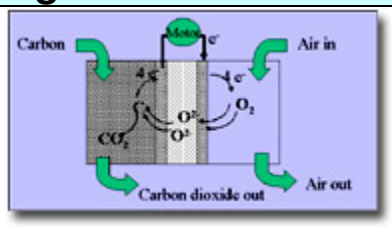
Medical

Technologies associated with physicians or the practice of medicine.

- Advanced hemostatic agents (blood coagulants)
- Antibiotic lavage
- Artificial blood and plasma
- Deployable supply packs
- Enhanced remote triage
- Ferromagnetic nano-particles
- Field life support system
- Fingerlite
- Focused ultrasound technology
- Gene chips
- Hand-held ultrasound devices
- Integrated tourniquets
- Intraosseus infusion device
- Medical personal digital assistants (PDAs)
- Medical trauma pod
- Micro-electro mechanical systems (MEMs)-based transdermal drug delivery system
- Miniature rapid fluid infuser
- Mixed oxidant disinfectant
- Nano-fiber bleeding sensor and clotting agent
- Nano-pore membranes
- Nutrigenomics
- Ocular scanning
- One-handed turniquet
- Quick clotting bandages
- Telerobotic minimally invasive surgery
- Vein viewing filter

Power Generation and Storage

Power in one form or another is what drives all forms of electrical and mechanical tools. Power can be transported in any of several forms including electrical energy in batteries, ranging in size from smaller than a watch battery to larger than a standard car battery, and potential mechanical energy stored in the form of fuel.



- Carbon fuel cell
- Deployable power generation and distribution system
- Direct energy conversion
- Logistics fuel processors
- Mesoscale MEMs-based fuel cells
- Miniature logistic-fuel-powered generator
- On-board recharging system
- Piezoelectric generation
- Tactical photovoltaic recharging system
- Thermoelectric generation
- Vehicle universal battery chargers
- Zinc-silver-polymer matrix rechargeable battery

Propulsion

The propulsion industrial area is very broad. It contains technologies for manned-rate, air-breathing propulsion systems to solid rocket motor technology for missiles and space launch. These propulsion systems power our aircraft, ships, weapons, and even our unmanned platforms. They are capable of moving our weapon systems at a few knots through the water or accelerate a vehicle to velocities that would allow flight to low earth orbit.

- Bearing-less main rotor
- Centrifugal lift fan
- Full rotor ice protection technology
- Gas turbine water jets
- High thrust turbofan engine
- Kevlar sandwich air intake valves
- Thrust wings
- Tilt-rotor propulsion
- Turboprop engines with composite propellers
- Variable pitch propeller
- Vibration absorbing bearings
- Water jet propulsion

Robotics

Robotics is the design, construction, and use of machines (robots) to perform tasks done traditionally by human beings. In the context of Focused Logistics, it includes technologies that enable unmanned or autonomous logistics missions such as sea-based autonomous handling and storage, among other technologies.

- Heavy-lift/positioning wearable exoskeletons
- Human assisted walking machine (walking wheelbarrow)
- Manipulator arm
- Micro-/nano-satellite inspectors
- Modular, self-reconfigurable medical robots
- Robotic transfer arm

Sensors

A device that responds to a physical stimulus such as heat, light, sound, pressure, magnetism, or a particular motion, and transmits a resulting impulse for measurement or operating a control.

- Direct contact miniature medical sensors
- Embedded sensors
- Fiber-optic Bragg gratings
- Guided-wave acousto-ultrasonic sensor
- Linked medical diagnostic sensors
- MEMS ultrasound
- Sensing garments
- Ultrawideband geogridding
- Vital positioning system

Software

Instructions that tell a computer what to do. Software comprises the entire set of programs, procedures, and routines associated with the operation of a computer system.

- Automated engineering monitoring
- Bayesian belief networking (BBN) spares-prioritization engine
- Behavior-based robotics for computer-generated forces
- Casualty effects simulation
- Coalition logistics C2 tools
- Condition-based maintenance prognostics
- Diagnostic and prognostic monitoring software
- Dynamic Flight Simulator
- Dynamic force requirements & transportation movement software
- Embedded diagnostic/prognostic intelligence
- Embedded training software
- Enterprise resource planning systems
- Full envelope adaptive guidance and control
- Integrated vehicle health management tools
- Intelligent instruction agents
- Interactive gaming
- Logistics flow and analysis software
- Maritime tracking architecture
- Medical simulation systems
- Mobile maritime collaboration tools
- Mobility modeling
- Modeling tools for port assessment and selection
- Objective training instrumentation system
- Sensor enabled notification system
- Scalable integration model for objective resource capability evaluations (SIMFORCE) launch vehicle modeling
- Smart agents (“shopping bots”)
- Wireless patient management system

Space Launch

The ability to launch a vehicle into space for the purpose of placing satellites in space or performing space missions.

- Actively cooled structures
- Advanced flow control systems
- Advanced payload fairings
- Advanced rocket engines
- Advanced solid rocket motors
- Air-launched space boosters
- Autonomous rendezvous and docking
- Combined cycle engines (CCE)
- Expendable upper stage
- Fuel transfer points - space
- Grapple and docking mechanisms
- Launch vibration isolation systems
- Liquid rocket engine
- Mobile space launch platform
- Monopropellants
- Multifunctional conformal structures
- Payload dispenser
- Protective coatings and thin films
- Quick turn thermal protection system
- Rapid payload loading/mating tools
- Revolutionary turbine accelerator
- Scramjets
- Secondary payload adapter
- Standardized spacecraft interfaces and protocols
- Turbopumps
- Universal space docking device

Structures

Structures are made up of the traditional material and structures technologies which are the backbone of our weapons platforms. Advanced material and structures will continue to be capability enablers. It includes structural design technologies that add strength while decreasing weight, thereby reducing fuel and airlift requirements.

- Advanced cargo gondola
- Advanced suspension
- Air cushioned skirt
- Bow ramp
- Clamshell cargo doors
- Composite fuselage
- Composite honeycomb fuselage panels
- Configurable air transport bare-base modules
- Configurable fuselage for predesigned cargo modules
- Container-based deployable surgical suite
- Deployable shelter
- Durable integrated hot structures
- Expandable and foldable shelters
- Flat rack cargo bed
- Flexible casualty care modules
- Floating dry dock
- Gas safety shelters
- Hardened vehicle hull
- High-speed large ocean-going passenger vessel
- High-speed, low draft hull form
- High-speed, shallow-draft catamaran hull form
- High-stiffness inflatable wings/empennage
- Hydraulic loading ramp
- Inflatable airbeams
- Integrated quickly deployable medical shelter
- International Organization for Standardization (ISO)-container-based field hospital
- Large cargo door
- Lightweight, transportable, reconfigurable causeway
- Mobile military operations in urban terrain
- (MOUT) facility
- Multifunctional elevator
- Prepackaged personnel facilities
- Rapid deployment modular buildings
- Rapidly erectable hangers
- Re-configurable passenger seating
- Roll-in and roll-out platform
- Sliding cargo doors
- Stern ramp
- Strengthened landing gear
- Strengthened wings
- Submersible cargo elevator
- Sun shades
- Ultra-lightweight deployable structures
- Underside upward opening door

Water Generation and Storage

Technologies that allow the military to obtain drinking water from sources at the mission location that are not usable in their current state to reduce the logistics burden of carrying clean water. These technologies also address the ability to hold and protect the water for later use.

- Low-energy water harvesting
- Medusa bag
- Transportable water harvesting/drilling

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APPENDIX C

COMPENDIUM OF ASSESSED TECHNOLOGY COMPANIES

NOTE: Companies listed are representative; the list is not exhaustive. Inclusion or exclusion does not imply future business opportunities with or endorsement by DoD.

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Airdrop: Autonomous Navigation Systems						
Atair Aerospace, Inc.	2001	New York, NY	N/A	N/A	www.atairaerospace.com	Parachutes and flight navagation systems
AUTOFLUG GmbH	1987	Relligen, Germany	260	$35.3	www.autoflug.com	Manufacture aircraft safety systems and measurement and control systems
CIMSA Ingeniería de Sistemas, S.A	N/A	Madrid, Spain	100	$4.4	www.cimsa.com	Manufacture parachutes
Mist Mobility Integrated System Technology, Inc.	N/A	Ottawa, Canada	N/A	N/A	www.mmist.ca	Precision guided parachute aerial delivery systems
Para-Flite, Inc.	1969	Pennsauken, NJ	115	$15.5	www.paraflite.com	Manufacture ram-air gliding parachutes
Vertigo, Inc.	1986	Lake Elsinore, CA	N/A	N/A	www.vertigoinc.com	Manufacture inflatable structures, unmanned vehicles, and parachutes
Airdrop: Autonomous Navigation Systems - Electromechanical Actuators						
Compañia Española De Sistemas Aeronauticos S.A (CESA)	1989	Getafe, Spain	198	$39.0	www.cesa-sa.com	Manufacture aircraft equipment
Vertigo, Inc.	1986	Lake Elsinore, CA	N/A	N/A	www.vertigoinc.com	Manufacture inflatable structures, unmanned vehicles, and parachutes
Airdrop: HALO/HAHO Helmet						
Atair Aerospace, Inc.	2001	New York, NY	N/A	N/A	www.atairaerospace.com	Parachutes and flight navagation systems
EADS	1998	Amsterdam, Netherlands	109,135	$37,822.3	www.eads.com	Aerospace and defense conglomerate
U.S. Army Natick Soldier Center	1953	Natick, MA	3,914	$1,200.0	www.natick.army.mil	Research and development of soldier support systems
Airdrop: Pneumatic Muscle Soft Landing Actuator						
Festo AG & Co. KG	1925	Esslingen Berkheim, Germany	11,000	$1,773.7	www.festo.com	Automation technology and industrial training
Merlin Systems Corporation Ltd.	1998	Plymouth, United Kingdom	N/A	N/A	www.merlinsystemscorp.com	Research, development, and production of human form robotics and automation
The Shadow Robot Company	1987	London, United Kingdom	N/A	N/A	www.shadow.org.uk	Robotics research and development
University of Louisville	1846	Louisville, KY	5,521	$383.6	www.uky.edu	Research pneumatic muscle actuator
University of Michigan	1817	Ann Arbor, MI	5,600	$3,383.8	www.umich.edu	Research pneumatic muscle actuator
Vertigo, Inc.	1986	Lake Elsinore, CA	N/A	N/A	www.vertigoinc.com	Manufacture inflatable structures, unmanned vehicles, and parachutes
Airdrop: Smart Decelerators						
Atair Aerospace, Inc.	2001	New York, NY	N/A	N/A	www.atairaerospace.com	Parachutes and flight navagation systems
CIMSA Ingeniería de Sistemas, S.A	N/A	Madrid, Spain	100	$4.4	www.cimsa.com	Manufacture parachutes
Dutch Space B.V.	2000	Lieden, The Netherlands	350	$74.8	www.dutchspace.nl	Manufacture solar arrays, launching structures, and control systems for spacecraft
Mist Mobility Integrated System Technology, Inc.	N/A	Ottawa, Canada	N/A	N/A	www.mmist.com	Precision guided parachute aerial delivery systems
Pioneer Aerospace Corporation	1988	South Windsor, CT	350	$33.5	www.pioneeraero.com	Manufacture aerodynamic deceleration systems
Strong Enterprise Co., Ltd.	1961	Orlando, FL	60	$3.1	www.strongparachutes.com	Manufacture parachutes

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Airdrop: Smart Decelerators - Airbags						
Analyticon, Ltd.	1994	Stevenage, England	35	$1.0	www.analyticon.co.uk	Engineering consulting services
CIMSA Ingeniería de Sistemas, S.A	N/A	Madrid, Spain	100	$4.4	www.cimsa.com	Manufacture parachutes
ILC Dover, Inc.	1947	Frederica, DE	450	$54.6	www.ilcdover.com	Manufacture protective masks, space suits, and pharmaceutical containment equipemnt
Vorticity Systems, Inc.	N/A	London, U.K.	N/A	N/A	www.vorticity-systems.com	Manufacture parachutes and aerial landing systems
Warrick and Associates, Inc.	N/A	Prescott, AZ	2	$0.1	www.wamore.com	Mechanical and electromechanical product development
Airdrop: Smart Decelerator - Cable Retraction						
Warrick and Associates, Inc.	N/A	Prescott, AZ	2	$0.1	www.wamore.com	Mechanical and electromechanical product development
Cargo Handling: Automated Strike Up/Strike Down Machinery						
Daifuku Co., Ltd.	1937	Osaka, Japan	3,478	$951.3	www.daifukuworld.com	Automated material handling systems
Fujitec Company, Ltd.	1948	Osaka, Japan	7,276	$434.4	www.fujitec.co.jp	Manufacture elevators, escalators, and vertical mechanized parking equipment
General Dynamics Armament and Technical Products (GDATP)	1996	Charlotte, NC	2,500	$202.6	www.gdatp.com	Manufacture armament systems, composite products for aerospace, and sensor systems
Northrop Grumman Newport News	2001	Newport News, VA	19,500	$6,252.0	www.nn.northropgrumman.com	Shipbuilding and repair
Power Superconductor Applications Corporation (PSA)	1986	New Castle, PA	12	$0.8	www.powersuper.com	Manufacture high-speed linear induction motors and electromagnetic levitation apparatuses
Siemens Automation and Control, AG	N/A	Nuremburg, Germany	N/A	N/A	www.siemens.com	Industrial and building automation
Cargo Handling: Automated Strike Up/Strike Down Machinery - Human Amplification Technology						
Computer Science Corporation, Advanced Marine Center	1976	Washington, DC	N/A	N/A	www.amc.csc.com	Ship systems engineering services
Northrop Grumman Newport News	2001	Newport News, VA	19,500	$6,252.0	www.nn.northropgrumman.com	Shipbuilding and repair
Oak Ridge National Laboratories	1943	Oak Ridge, TN	3,800	$1,000.0	www.ornl.gov	Department of Energy's largest science and energy laboratory
Cargo Handling: Automated Strike Up/Strike Down Machinery - Automated Stowage and Retrieval System						
Benedict Engineering Company	1982	Tallahassee, FL	46	$5.2	www.beceng.com	Engineering consulting services
General Dynamics Armament and Technical Products (GDATP)	1996	Charlotte, NC	2,500	$202.6	www.gdatp.com	Manufacture armament systems, composite products for aerospace, and sensor systems
Siemens Automation and Control, AG	N/A	Nuremburg, Germany	N/A	N/A	www.siemens.com	Industrial and building automation
Cargo Handling: Automated Strike Up/Strike Down Machinery - Linear Electric Drive Transport						
Fujitec Company, Ltd.	1948	Osaka, Japan	7,276	$434.4	www.fujitec.co.jp	Manufacture elevators, escalators, and vertical mechanized parking equipment
General Dynamics Armament and Technical Products (GDATP)	1996	Charlotte, NC	2,500	$202.6	www.gdatp.com	Manufacture armament systems, composite products for aerospace, and sensor systems
Northrop Grumman Newport News	2001	Newport News, VA	19,500	$6,252.0	www.nn.northropgrumman.com	Shipbuilding and repair
Power Superconductor Applications Corporation (PSA)	1986	New Castle, PA	12	$0.8	www.powersuper.com	Manufacture high-speed linear induction motors and electromagnetic levitation apparatuses

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Cargo Handling: Automated Strike Up/Strike Down Machinery - Automated Guided Vehicle						
AGV Products	1988	Charlotte, NC	50	$8.3	www.agvp.com	Automated guided vehicle systems and other material handling automation
Daifuku Co., Ltd.	1937	Osaka, Japan	3,478	$951.3	www.daifukuworld.com	Automated material handling systems
HK Systems, Inc.	1969	New Berlin, WI	N/A	N/A	www.hksystems.com	Automated material handling systems
Nuyts Engineering Systems, GmbH	N/A	Dettenhausen, German	N/A	N/A	www.nuyts.com	Manufacture material handling technologies
Siemens Logistics and Assembly Systems, AG	1991	Grand Rapids, MI	2,145	$1,103.1	www.logistics-assembly.siemens.com	Manufacture material handling automation and electronics assembly systems
Swisslog Management, AG	1986	Buchs, Switzerland	1,850	$536.4	www.swisslog.com	Logistics solutions and distribution systems
Communications and Networking: Spectrum-Adaptive Communication System						
Cambridge Silicon Radio p.l.c.	1999	Cambridge, U.K.	316	$253.1	www.csr.com	Design and manufacture single-chip wireless devices
CREATE-NET International Research Center	2003	Trento, Italy	N/A	N/A	www.create-net.it	Telecommunications research alliance
Freeband Communication	N/A	Enschede, The Netherlands	N/A	N/A	www.freeband.nl	Consortium researching the development spectrum-adaptive communications systems
MITRE Corporation	1958	Bedford, MA	5,600	$870.9	www.mitre.org	Manage three Federally Funded Research and Development Centers (FFRDCs)
Raytheon	1922	Waltham, MA	78,000	$18,109.0	www.raytheon.com	Electronic systems and aircraft
Shared Spectrum Company	2000	Vienna, VA	15	N/A	www.sharedspectrum.com	Manufacture communications products
Communications and Networking: Satellite-Based Asset Tracking						
Eutelsat, S.A.	1985	Paris, France	455	$918.5	www.eutelsat.org	Operate telecommunications satellite
Mobile Satellite Ventures, LP	1996	Reston, VA	110	$27.5	www.msvlp.com	Provide mobile satellite communications services
OuterLink Corporation	2004	Lowell, MA	18	$1.1	www.outerlink.com	Mobile asset tracking and data messaging systems
Satamatics, Ltd.	2001	Tewkesbury, U.K.	25	$2.2	www.satamatics.com	Fleet management, asset tracking, and remote monitoring and control
SkyBitz, Inc.	2003	Dulles, VA	40	$2.9	www.skybitz.com	Satellite asset monitoring and information management
SkyWave Mobile Communications	1997	Ottawa, Canada	N/A	N/A	www.skywave.com	Satellite asset monitoring and information management
Devices: Augmented Reality Display						
Augmented Solutions GmbH	2003	Garching, Germany	N/A	N/A	www.ar-solutions.de	Provides visually interactive systems
InterSense, Inc.	1996	Burlington, MA	23	$3.7	www.isense.com	Develop motion tracking products
LYYN AB	2003	Lund, Sweden	N/A	N/A	www.lyyn.com	Visibility enhancement technology
Microvision, Inc.	1993	Bothel, WA	225	$11.4	www.mvis.com	High-resolution scanned beam display and imaging systems
NEC Corporation	1899	Tokyo, Japan	147,004	$23,920.3	www.nec-design.co.jp	Manufacture information technology, electronic devices, and network technologies
Panoram Technologies, Inc.	1993	Sun Valley, CA	30	$3.0	www.panoramtech.com	Advanced display technology
Devices: Contact Memory Button						
MacSema, Inc.	1989	Bend, OR	N/A	N/A	www.macsema.com	Manufacture automatic identification and data collection systems
Maxim Integrated Products, Inc.	1983	Sunnydale, CA	7,599	$1,439.3	www.maxim-ic.com	Manufacture integrated circuits
Oxley, Inc.	1942	Cumbria, U.K.	250	$21.6	www.oxley.co.uk	Manufacture EMI/RFI filters, data capture devices, night vision products, and LED and lighting systems

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Devices: Externally Blown Flap						
Airbus S.A.S.	1970	Toulouse, France	52,000	$24,225.4	www.airbus.com	Manufacture commercial aircraft
Antonov Aeronautical Scientific/Technical Complex	1946	Kiev, Ukraine	7,400	$44.6	www.antonov.com	Aviation engineering services
Dassault Aviation Group	1971	Saint Cloud, France	11,950	$2,535.9	www.dassault-aviation.com	Manufacture aircraft
Lockheed Martin Corporation	1995	Bethesda, MD	130,000	$35,526.0	www.lockheedmartin.com	Aerospace and defense systems integration
Northrop Grumman Corporation	1994	Los Angeles, CA	125,400	$29.9	www.northropgrumman.com	Manufacture and integrate aerospace and defense systems
The Boeing Company	1916	Chicago, IL	159,000	$43,960.0	www.boeing.com	Manufacture aircraft
Devices: High Flotation Landing Gear						
Goodrich Landing Gear Division	1999	Charlotte, NC	N/A	N/A	www.lgd.goodrich.com	Manufacture landing gear systems
Héroux-Devtek, Inc	2000	Longueuil, Québec	1,100	$213.2	www.herouxdevtek.com	Manufacture and repair landing gear and other aerospace products
Messier-Dowty, Ltd.	1995	Gloucester, U.K.	3,000	$641.2	www.messier-dowty.com	Manufacture landing gear systems
Devices: High Flotation Landing Gear - Struts						
Goodrich Landing Gear Division	1999	Charlotte, NC	N/A	N/A	www.lgd.goodrich.com	Manufacture landing gear systems
Héroux-Devtek, Inc	2000	Longueuil, Québec	1,100	$213.2	www.herouxdevtek.com	Manufacture and repair landing gear and other aerospace products
Messier-Dowty, Ltd.	1995	Gloucester, U.K.	3,000	$641.2	www.messier-dowty.com	Manufacture landing gear systems
High Flotation Landing Gear - Brakes						
Dunlop Aviation Braking Systems	2002	Coventry, UK	900	$150.0	www.dunlop-aerospace.com	Manufacture brakes, braking systems and wheels for aerospace
Goodrich Wheels and Brakes Services	1986	Troy, OH	N/A	N/A	www.wheelsandbrakes.goodrich.com	Manufacture aircraft wheels and brakes
Honeywell Aircraft Landing Systems	1999	South Bend, IN	1,400	N/A	www.honeywellaircraftlandingsystems.com	Manufacture and repair aircraft landing systems, wheels, and brakes
Hydro-Aire Corporation	1943	Burbank, CA	425	$35.4	www.hydroaire.com	Aerospace braking systems and fuel pumps
Messier-Bugatti	1927	Velizy, France	1,330	$416.3	www.messier-bugatti.com	Manufacture braking and landing gear systems
Engineering: Lightweight Field Matting						
GFI, Inc.	N/A	Harrison, AR	8	$0.7	www.gfiinc.us	Manufacture matting system
Rola-Trac, Ltd.	1996	Norfolk, U.K.	14	$1.3	www.rola-trac.co.uk	Manufacture temporary flooring for defense and construction
SOLOCO, LLC	1960	Lafayette, LA	300	$18.1	www.solocollc.com	Manufacture temporary surfaces
Webcore Technologies, Inc.	1991	Dayton, OH	26	$2.3	www.webcoreonline.com	Manufacture fiber reinforced foam cores
Engineering: Prepackaged Quasi-Fixed Facility Systems						
AAR Corporation	1951	Wood Dale, IL	2,300	$652.0	www.aarcorp.com	Aviation parts distribution and aircraft maintenance
Ably Shelters, Ltd.	N/A	Waterlooville, UK	N/A	N/A	www.ably-shelters.co.uk	Relocatable shelters and temporary buildings
Alaska Structures, Inc.	1979	Anchorage, AK	116	$80.0	www.alaskastructures.com	Manufacture fabric structures
Summit Structures	2001	Allentown, PA	20	$3.7	www.summitstructures.com	Manufacture frame-supported tension fabric structures
Uniteam International, A.S.	1993	Oslo, Norway	23	$30.6	www.uniteam.org	Manufacture mobile prefabricated systems and modules
Weatherhaven	1981	Greater Vancouver, Canada	N/A	N/A	www.weatherhaven.com	Manufacture shelters and integrated life support
Fuel handling and storage: Underway Replenishment Systems - Fuel Transfer Pumps						
Imo Pump	1986	Stockholm, Sweden	103	$26.6	www.imo-pump.com	Air and gas compressors
Warren Pumps, Inc.	1889	Warren, MA	100	$11.6	www.warrenpumps.com	Manufacture pumps and pumping equipment

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Fuel handling and storage: Underway Replenishment Systems - Padeyes						
Alstec Defense Systems Ltd.	2000	Leicester , UK	663	$125.7	www.alstec.com	Provides industrial services in logistics, defense systems, airports, nuclear power, and thermal power
Hepburn Engineering, Inc.	N/A	Toronto, Canada	N/A	N/A	www.hepeng.com	Manufacture mining, marine and industrial equipment
The Entwistle Company	1918	Hudson, MA	160	$12.3	www.entwistleco.com	Manufacture capital machinery
Fuel Handling and Storage: Microprocessor Controlled Refueling Pods						
Flight Refueling Ltd.	1934	Dorset, England	900	$160.3	www.flight-refueling.com	Manufacture air refuelling systems
Sargent Fletcher, Inc.	1940	El Monte, CA	159	$14.9	www.sargentfletcher.com	Manufactures aerial refueling systems
Fuel Handling and Storage: On-Orbit Fuel Transfer System						
Alenia Spazio	1990	Turin, Italy	2,497	$371.6	www.alespazio.it	Design and develop complete space systems
Dutch Space B.V.	2000	Lieden, The Netherlands	200	$74.8	www.dutchspace.nl	Manufacture solar arrays, launching structures, and control systems for spacecraft
Orbital Recovery Corporation	N/A	London, England	N/A	N/A	www.orbitalrecovery.com	Provide satellite insurance and risk management services
S.P. Korolev Rocket and Space Corporation Energia	1946	Korolev, Russia	8,916	N/A	www.energia.ru	Manufacture space and rocket technologies
The Boeing Company	1916	Chicago, IL	159,000	$43,960.0	www.boeing.com	Manufacture aircraft
Fuels: Common Vehicle Fuel (JP-8)						
BP, PLC	1909	London, England	102,900	$285,059.0	www.bp.com	Crude petroleum and natural gas
ChevronTexaco Aviation Corporation	N/A	Houston, TX	N/A	N/A	www.chevrontexacoaviation.com	Aviation fuel suppliers
ConocoPhillips Company	2002	Houston, TX	35,800	$136,916.0	www.phillips66aviation.com	Petroleum exploration, production, refining, and distribution
Exxon-Mobile Corporation	1882	Irving, TX	85,900	$298,035.0	www.exxon.com	Petroleum and natural gas exploration, production, refining, and distribution
Shell Aviation Ltd.	1997	London, England	113	$32.3	www.shell.com	Aviation fuel suppliers
TOTAL	1924	Paris, France	110,783	$6,321.2	www.total.com	Petroleum and natural gas exploration, production, refining, and distribution
Fuels: Plastics and Biomass Conversion Technologies						
Biomass Technology Group	1979	Enschede, The Netherlands	50	$13.9	www.btgworld.com	Conversion of biomass into fuel and energy
DNA 2.0, Inc.	2003	Menlo Park, CA	N/A	N/A	www.dnatwopointo.com	Synthetic genes
DynaMotive, Ltd.	1991	Vancouver, Canada	18	$0.0	www.dynamotive.com	Conversion of biomass into liquid fuel
Ensyn Group, Inc. (EGI)	1979	Boston, MA	20	N/A	www.ensyn.com	Conversion of biomass into fuel and energy
Renewable Oil International, LLC	2002	Florence, AL	3	$1.0	www.renewableoil.com	Conversion of biomass into liquid fuel
Maintenance and Repair: Fast Reusable Tooling						
2Phase Technologies	2001	Dayton, NV	14	$1.0	www.2phasetech.com	Reformable tooling systems
Maintenance and Repair: Maskless Mesoscale Materials Deposition						
Optomec, Inc.	1982	Albuquerque, NM	30	$4.0	www.optomec.com	Manufacture laser deposition rapid prototyping technologies
Materials: Mechanical Stabilizing Materials						
Environmental Products and Applications, Inc.	N/A	Palm Desert, CA	22	$1.7	www.envirotac.com	Soil stabilization and dust control
Enviroseal Corporation	1994	Port St. Lucie, FL	7	$3.2	www.enviroseal.com	Soil stabilization and dust control
SoilWorks, LLC	2003	Gilbert AZ	3	$2.0	www.soilworks.com	Manufacture chemical soil stabilzer
Soter, Inc.	N/A	Laval, Canada	N/A	N/A	www.soter.com	Manufacture foam asphalt stabilization products

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Materials: Self-Repairing Materials						
Natural Process Design	N/A	Winona, MN	3	$0.2	www.naturalprocessdesign.com	Research self-repairing materials
Tokai University	1943	Kanagawa, Japan	6,741	$1,164.2	www.u-tokai.ac.jp	Research self-repairing materials
University of Bristol	1876	Bristol, UK	4,700	N/A	www.aer.bris.ac.uk	Research self-repairing materials
University of California-Los Angeles	1919	Los Angeles, CA	3,200	N/A	www.ucla.edu	Research self-repairing materials
University of Illinois	N/A	Urbana-Champaign, IL	35	N/A	www.autonomic.uiuc.edu	Research self-repairing materials
Yokohama National University	1949	Yokohama, Japan	1,025	N/A	www.ynu.ac.jp	Research self-repairing materials
Medical: Focused Ultrasound Technology						
EDAP TMS, S.A.	1994	Lyon, France	80	$14.3	www.edap-hifu.com	Medical devices based on High Intensity Focused Ultrasound (HIFU)
Engineering Acoustics, Inc.	1991	Winter Park, FL	6	$0.3	www.eaiinfo.com	Acoustical engineering and consulting
Haifu Co., Ltd.	N/A	Chongqing, China	N/A	N/A	www.haifu.com.cn	Manufacture therapeutic ultrasound systems
Misonix, Inc.	1959	Farmingdale, NY	201	$39.1	www.misonix.com	Manufacture medical, scientific, and industrial ultrasonic equipment
The Center for Industrial and Medical Ultrasound	2001	Seattle, WA	68	N/A	cimu.apl.wasington.edu	Ultrasound research and development
Ultrazonix DNT, AB	1999	Malmo, Sweden	N/A	N/A	www.ultrazonix.com	Develop ultrasound technology for spinal problems
Medical: Nano-fiber Bleeding Sensor and Clotting Agent Materials						
Intelligent Textiles Team	N/A	Raleigh, NC	20	N/A	www.tx.ncsu.edu/ci/iti	Inteligent textiles research group
Interdepartmental Research Center, University of Pisa	N/A	Pisa, Italy	27	N/A	www.piaggio.ccii.unipi.it	Bioengineering and robotics research
Massachusetts Institute of Technology, Institute for Soldier Nanotechnologies	2002	Cambridge, MA	167	$10.0	web.mit.edu/isn/	Research nanotechnology to improve the survival of soldiers
VivoMetrics, Inc.	1999	Ventura, CA	48	$0.2	www.vivometrics.com	Manufacture healthcare research devices
Medical: Telerobotic Minimally Invasive Surgery						
Center for Surgical Innovation	2003	Cincinnati, OH	12	N/A	surgery.uc.edu/csi/	Develop, assess, and disseminate new technologies in biomedical and surgical care
Center for the Integration of Advanced Medicine and Innovative Technology	2002	Fukuoka, Japan	N/A	N/A	www.camit.org	Manufacture and clinically apply engineering technology
Center of Research in Microengineering	1991	Pisa, Italy	25	N/A	www-crim.sssup.it	Develop microcomponents, microsystems and micromachines medical applications
Intuitive Surgical, Inc.	1995	Sunnyvale, CA	321	$138.8	www.intuitivesurgical.com	Operative surgical robotics
SRI International	1970	Menlo Park, CA	2,800	$320.0	www.sri.com	Research and development
Surgical Technology Research Group	2002	Aachen, Germany	N/A	N/A	www.hia.rwth-aachen.de	Surgical research and development
Power Generation and Storage: Direct Energy Conversion						
BP, PLC	1909	London, England	102,900	$285,059.0	www.bp.com	Crude petroleum and natural gas
Canon, Inc.	1937	Tokyo, Japan	108,257	$33,344.7	www.canon.com	Computer peripheral, cameras, and imaging products
Energy Conversion Devices, Inc.	1960	Rochester Hills, Michigan	721	$66.3	www.ovonic.com	Materials research and advanced product development
ITN Energy Systems, Inc.	1995	Littleton, Colorado	67	$10.7	www.itnes.com	Research and development
Siemens AG	1850	Munich, Germany	430,000	$93,455.0	www.siemens.com	Electrical engineering and electronics
UniSource Energy Corporation	1995	Tucson, AZ	1,208	$1,169.0	www.unisourceenergy.com www.globalsolar.com	Electric utilities

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Sources: SEC Filings, Orbis Bureau van Dijk databases, RDS Business and Industry database, LexisNexis Academic Universe, S&P reports, Hoover's, US Major Companies Database, Yahoo Finance, US Business Directory, Dun & Bradstreet, and First Equity research.

Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Propulsion: High Thrust Turbofan Engine						
General Electric Aircraft Engines	1917	Cincinnati, OH	26,000	$10,970.0	www.geae.com	Manufacture aircraft engines
Pratt & Whitney	1925	East Hartford, CT	650	$68.6	www.pratt-whitney.com	Manufacture aircraft engines and engine parts
Rolls-Royce, PLC	1894	London, United Kingdom	46,600	$9,404.6	www.rolls-royce.com	Manufacture aircraft engines
Snecma Group	1905	Paris, France	34,276	$77.6	www.snecma.com	Manufacture rocket and aircraft engines
The Engine Alliance, LLC	2003	East Hartford, CT and Evendale, OH	20	$1.6	www.enginealliance.com	High-thrust turbofan engine
Propulsion: Tilt-Rotor Propulsion						
Bell Helicopter Textron, Inc.	1960	Fort Worth, TX	7,000	$591.9	www.bellhelicopter.com	Manufacture helicopters
Development of an Advanced Rotor for Tilt-rotor	2002	Europe	N/A	N/A	www.cert.fr.dcsd/tilt-rotor/dart/	Tilt-Rotor research program
Sikorsky	1995	Stratford, CT	8,700	$637.9	www.sikorsky.com	Manufacture helicopters
Robotics: Heavy-Lift / Positioning Wearable Exoskeleton						
Oak Ridge National Laboratories	1943	Oak Ridge, TN	3,800	$1,000.0	www.ornl.gov	Department of Energy's largest science and energy laboratory
Sankai Lab, Tsukuba University	N/A	Tsukuba, Japan	9	N/A	sanlab.kz.tsukuba.ac.jp/HAL/	Develop robotic lower-body exoskeleton
Sarcos Incorporated	1990	Salt Lake City, UT	50	$3.6	www.sarcos.com	Robotics research and development
University of California, Berkeley	N/A	Berkeley, CA	21	N/A	bleex.me.berkeley.edu	Develop robotic exoskeleton
University of Washington	N/A	Seattle, WA	N/A	N/A	brl.ee.washington.edu	Develop robotic exoskeleton
Yobotics, Inc.	2000	Boston, MA	N/A	N/A	www.yobotics.com	Research robotic augmentation of walking
Robotics - Human Assisted Walking Machine (Walking Wheelbarrow)						
University of California, Berkeley	N/A	Berkeley, CA	21	N/A	bleex.me.Berkeley.edu/walkmachine.htm	Develop robotic exoskeleton
Sensors: Direct Contact Miniature Medical Sensors						
Colibrys, S.A.	2000	Neuchâtel, Switzerland	100	$15.7	www.colibrys.com	MEMS components and subsystems
Crossbow Technology, Inc.	1995	San Jose, CA	40	$4.0	www.xbow.com	Inertial sensor systems
Oak Ridge National Laboratories	1943	Oak Ridge, TN	3,800	$1,000.0	www.ornl.gov	Department of Energy's largest science and energy laboratory
Synthetic Blood International, Inc.	1994	Cost Mesa, CA	6	$0.5	www.sybd.com	Biomedical product development company specializing in liquid ventilation, oxygen therapeutics, blood substitutes, and implanted glucose sensing
VivoMetrics, Inc.	1999	Ventura, CA	48	$0.2	www.vivometrics.com	Manufacture healthcare research devices
Sensors: Embedded Sensors						
Coventor, Inc.	1995	Cary, NC	39	$6.8	www.coventor.com	MEMS design software development
Entran Controls, Inc.	1970	Fairfield, NJ	75	$4.7	www.entran.com	Manufacture measurement and control devices
Fiso Technologies, Inc.	1994	Québec, Canada	N/A	$6.2	www.fiso.com	Fiber-optic sensors and signal conditioners
Industrial Monitoring Instrumentation (IMI) Sensors	N/A	Depew, NY	N/A	N/A	www.imi-sensors.com	Manufacture industrial accelerometers, vibration sensors, and transmitters
Innovative Sensor Technology (IST) AG	1991	Wattwil, Switzerland	80	$8.3	www.ist-ag.com	Manufacture thin-film sensors
MEMSCAP S.A.	1997	Bernin, France	147	$8.3	www.memscap.com	Manufacture Micro-electromechanical systems (MEMS) components

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Sensors: Embedded Sensors - MEMS						
Analog Devices Inc.	1965	Norwood, MA	8,900	$2,633.8	www.analog.com	Manufacture analog, mixed-signal, and digital signal processing integrated circuits
Coventor, Inc.	1995	Cary, NC	39	$6.8	www.coventor.com	MEMS design software development
Entran Controls, Inc.	1970	Fairfield, NJ	75	$4.7	www.entran.com	Manufacture measurement and control devices
MEMSCAP S.A.	1997	Bernin, France	147	$8.3	www.memscap.com	Manufacture Micro-electromechanical systems (MEMS) components
Microchemical Systems, S.A.	1998	Corcelles, Switzerland	N/A	N/A	www.microchemical.com	Manufacture gas sensors and measurement devices
Tronic's Microsystems, S.A.	1997	Crolles, France	18	$2.5	www.tronics-mst.com	Manufacture custom MEMS and microsystems
Sensors: Embedded Sensors - Piezoelectric on Thin Film						
Advanced MicroSensors, Inc.	1999	Shrewsbury, MA	82	$10.1	www.advancedmicrosensors.com	Manufacture tape drive heads for data storage devices
Dynasen, Inc.	N/A	Goleta, CA	5	$0.7	www.dynasen.com	Manufacture sensors
Entran Controls, Inc.	1970	Fairfield, NJ	75	$4.7	www.entran.com	Manufacture measurement and control devices
Innovative Sensor Technology (IST) AG	1991	Wattwil, Switzerland	80	$8.3	www.ist-ag.com	Manufacture thin-film sensors
Nanowave Technologies, Inc.	1992	Ontario, Canada	N/A	N/A	www.nanowavetech.com	Develop thin film substrates, radio frequency and electro-optic components and subsystems
Phasis Sarl	2004	Geneva, Switzerland	N/A	N/A	www.phasis.ch	Produce gold substrates and PZT thin-films
Sensors: Embedded Sensors - Optical fiber						
Davidson Instruments, Inc.	1995	Woodlands, TX	10	$0.7	www.davidson-instruments.com	Manufacture fiber optic sensors
Fiso Technologies, Inc.	1994	Québec, Canada	N/A	$6.2	www.fiso.com	Fiber-optic sensors and signal conditioners
Keyence Corporation	1974	Osaka, Japan	1,450	$1,109.5	www.keyence.com	Manufacture sensors and measuring instruments
Opsens, Inc.	N/A	Québec, Canada	N/A	N/A	www.opsens.com	Manufacture fiber optic sensors
Rockwell Scientific LLC	2001	Thousand Oaks, CA	450	$33.7	www.rsc.rockwell.com	Electronics and sensor research and development
Sabeus Sensor Systems	1998	Calabasas, CA	37	$4.6	www.sabeus.com	Manufacture fiber optic sensor systems
Sensors: Embedded Sensors - Miniature Silicon						
Endevco Corporation	1947	San Juan Capistrano, CA	406	$67.0	www.endveco.com	Manufacture vibration and shock measurement devices
First Sensor Technology, GmbH	1999	Berlin, Germany	25	$3.8	www.first-sensor.com	Manufacture pressure sensors
Honeywell Sensotec	1973	Columbus, OH	200	$16.1	www.sensotec.com	Manufacture pressure transducers, load cells, and electronic sensor instrumentation
Silicon Microstructures, Inc.	1991	Milpitas, CA	76	$12.0	www.si-micro.com	Silicon pressure sensors
Silicon Sensing Systems	1999	Hyogo, Japan	60	$14.0	www.spp.co.jp/sssj/comp-e.html	Manufacture gyroscopes and accelerometers
The ABB Group	1988	Zurich, Switzerland	102,500	$20,721.0	www.abb.com	Power and automation technologies

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Software: Diagnostic and Prognostic Monitoring Software						
Brüel & Kjær Vibro, GmbH	N/A	Copenhagen, Denmark	750	$99.5	www.bkvibro.com	Measuring and controlling devices
Cooperative Research Centre for Integrated Engineering Asset Management	N/A	Brisbane, Australia	N/A	N/A	www.cieam.com	Industry-directed R&D, education and commercialisation
Foster-Miller, Inc.	1956	Waltham, MA	360	$121.0	www.foster-miller.com	Engineering and technology development
Impact Technologies LLC	1999	Rochester, NY	51	$5.4	www.impact-tek.com	Engineering consulting and health management system development
MACSEA, Ltd.	1982	Stonington, CT	5	$0.7	www.dexteragents.com	Develop software agents for diagnostic machinery health monitoring software
Mxi Technologies, Ltd.	1996	Ottawa, Canada	N/A	N/A	www.mxi.com	Develop aviation maintenance software
Software: Dynamic Force Requirements and Transportation Movement Software						
Anteon International Corp.	1976	Fairfax, VA	9,000	$1,268.1	www.anteon.com	IT systems engineering and integration
DPRA, Inc.	1961	Knoxville, TN	250	$31.0	www.defensesystemsgroup.com	Environmental, IT, and defense consulting
NATO Consultation, Command & Control Agency	1996	Brussels, Belgium	500	N/A	www.nc3a.nato.int	Developi, procure and implement state of the art C3 capabilities for NATO
SAP Global AG	1972	Walldorf, Germany	32,802	$10,179.1	www.sap.com	Enterprise resource planning software
Tapestry Solutions, Inc.	1993	San Diego, CA	85	$15.4	www.tapestrysolutions.com	Software development
Software: Wireless Patient Management System						
Analytica International Pty, Ltd.	1999	Bangalore, India	N/A	N/A	www.analytica-india.com	RFID and mobile computing software development
eXI Wireless Systems, Inc.	1980	Richmond, Canada	N/A	$8.6	www.exi-rfid.com	Wireless identification, control, and location technologies
Mobile Aspects, Inc.	2001	Pittsburgh, PA	13	$1.0	www.mobileaspects.com	Provide RFID tracking solutions to healthcare industry
Premise Development Corporation	1993	Hartford, CT	6	$0.2	www.premiseusa.com	Healthcare software development
SATO Corporation Europe	1978	Brussels, Belgium	26	$14.6	www.sato-europe.com	Manufacture labeling and printing technologies
ScenPro, Inc.	1993	Richardson, TX	39	$2.2	www.scenpro.com	Healthcare software development
Space Launch: Advanced Solid Rocket Motors						
Aerojet	1944	Sacramento, CA	2,700	$223.0	www.aerojet.com	Manufacture missile and space propulsion systems and armaments
Alliant Techsystems, Inc. (ATK)	1990	Edina, MN	14,000	$2,800.0	www.atk.com	Manufacture advanced weapon and space systems
Avio S.p.A.	1908	Torino, Italy	4,730	$983.9	www.avio.it	Aerospace propulsion systems
Europropulsion	1992	Suresnes, France	55	$207.6	www.snecma.com	Produce solid rocket motors for Ariane 5
Ishikawajima-Harima Heavy Industries (IHI) Aerospace Company, Ltd.	1853	Tokyo, Japan	8,140	$9,914.8	www.ihi.co.jp/index-e/html	Manufacture rocket projectiles and solid rocket motors

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Sources: SEC Filings, Orbis Bureau van Dijk databases, RDS Business and Industry database, LexisNexis Academic Universe, S&P reports, Hoover's, US Major Companies Database, Yahoo Finance, US Business Directory, Dun & Bradstreet, and First Equity research.

Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Space Launch: Autonomous Rendezvous and Docking System						
EADS	1998	Amsterdam, Netherlands	109,135	$37,822.3	www.eads.com	Aerospace and defense conglomerate
Michigan Aerospace Corporation	1996	Ann Arbor, MI	25	$2.7	www.michiganaero.com	Optical, opto-mechanical, and mechanical components and systems for aerospace
Microcosm, Inc.	1984	El Segundo, CA	50	$5.8	www.smad.com	Space launch vehicles and software systems
NEC Toshiba Space Systems, Ltd.	2001	Yokohama, Japan	900	$407.7	www.ntspace.jp	Provide satellites, satellite subsystems, and launch systems
Orbital Sciences Corporation	1982	Dulles, VA	2,450	$675.9	www.orbital.com	Manufacture launch vehicles, satellites, and electronic systems
S.P. Korolev Rocket and Space Corporation Energia	1946	Korolev, Russia	8,916	N/A	www.energia.ru	Manufacture space and rocket technologies
Structures: High-Speed, Shallow-Draft Catamaran Hull Form						
Austal, Ltd.	1987	Henderson, Australia	1,209	$310.1	www.austal.com	Shipbuilding and repair
Bath Iron Works	1884	Bath, Maine	6,500	$1,017.0	www.gdbiw.com	Shipbuilding and repair
Bollinger Shipyards, Inc.	1946	Lockport, Louisiana	1,850	$300.0	www.bollingershipyards.com www.bollinger-incatusa.com	Shipbuilding and repair
Incat, Inc.	1972	Tasmania, Australia	N/A	N/A	www.incat.com.au	Build high-speed passenger and vehicle ferries
Maritime Dynamics, Inc.	1972	Lexington Park, MD	46	$7.0	www.maritimedynamics.com	Marine motion control systems
Umoe Mandal, A.S.	1988	Mandal, Norway	125	$20.9	www.mandal.umoe.no	Shipbuilding and repair
Structures: Inflatable Airbeams						
Airlight S.A.	2003	Biasca, Switzerland	N/A	N/A	www.airlight.biz	Develop lightweight pneumatic structures
Eurovinil S.P.A	1958	Grosseto, Italy	140	$27.2	www.eurovinil.it	Manufacture inflatable structures, decontamination showers, boats, and life-rafts
Federal Fabrics-Fibers, Inc.	1994	Lowell, MA	20	$1.4	www.federalfabrics.com	Develop three dimension fabrics
Fiber Innovations, Inc.	1984	Walpole, MA	50	$10.0	www.fiberinnovations.com	Manufacture artificial cellulose fibers
Survivitec, Ltd.	N/A	Dunmurry, Northern Ireland	N/A	$150.0	www.survivitecgroup.com	Survival technology
Vertigo, Inc.	1986	Lake Elsinore, CA	N/A	N/A	www.vertigoinc.com	Manufacture inflatable structures, unmanned vehicles, and parachutes
Structures: Mobile Military Operations in Urban Terrain (MOUT) Facility						
Anteon International Corp.	1976	Fairfax, VA	9,000	$1,268.1	www.anteon.com	IT systems engineering and integration
BVR Systems, Ltd.	1998	Rosh Ha'ayin, Israel	58	$14.5	www.bvr.co.il	Manufacture simulation and training systems
Cubic Corporation	1951	San Diego, CA	5,950	$722.0	www.cubic.com	Manufacture electronic training systems, communication equipment, and automatic fare collection systems
Information in Place, Inc.	1999	Bloomington, IN	21	$0.4	www.informationinplace.com	Develop context-aware mobile technologies and augmented reality solutions
Oscmar International, Ltd.	1987	Auckland, New Zealand	160	$13.1	www.oscmar.com	Supply training systems to military
Vrcom GmbH	N/A	Darmstadt, Germany	N/A	N/A	www.vrcom-online.de	Manufacture augmented reality systems

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Structures: Ultra-Lightweight Deployable Structures						
Ably Shelters, Ltd.	N/A	Waterlooville, UK	N/A	N/A	www.ably-shelters.co.uk	Relocatable shelters and temporary buildings
DHS Systems, LLC	1984	Orangeburg, New York	185	$20.0	www.drash.com	Manufacture portable and rapidly deployable field sheltering
Foster-Miller, Inc.	1956	Waltham, MA	360	$121.0	www.foster-miller.com	Engineering and technology development
FY-Composites, OY	2000	Nokia, Finland	41	$6.4	www.fy-composites.com	Manufacture composite components and structures
GMA Cover Corporation	1991	Guelph, Canada	150	$30.0	www.gmacover.com	Manufacture camouflaged cover systems
Summit Structures	2001	Allentown, PA	20	$3.7	www.summitstructures.com	Manufacture frame-supported tension fabric structures
Water Generation and Storage: Low-energy Water Harvesting						
Hyflux, Ltd.	1989	Singapore	514	$54.1	www.hyflux.com	Water purification and fluid treatment
LexCarb, LLC	1994	Lexington, KY	6	$1.5	www.lexcarb.com	Produce porous carbon materials for water purification
Munters Corporation	1955	Sollentuna, Sweden	3,064	$686.9	www.munters.com	Provide humidity control products and services
NanoPore, Inc.	1993	Albuquerque, NM	24	$2.1	www.nanopore.com	Develop high-porosity/high-surface area materials
QinetiQ, Ltd.	1991	Hampshire, UK	8,898	$1,485.3	www.qintetiq.com	Defense research and development
Sciperio, Inc.	1996	Stillwater, OK	30	$9.9	www.sciperio.com	Research and development

[1] **Companies listed are representative; the list is not exhaustive. Inclusion or exclusion does not imply future business opportunities with or endorsement by DoD.**

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APPENDIX D

POLICY PORTALS AND LEVERS

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MAJOR INNOVATION PORTALS AND POLICY LEVERS IN THE INDUSTRIAL PROCESS[1]

ODUSD(IP) has developed a policy construct to incentivize innovation in industrial base capabilities and to remedy deficiencies. This policy construct promotes a systematic approach to address industrial base development and avoid deficiencies.

Maintaining the U.S. warfighting advantage requires continuous innovation of critical warfighting capabilities. Key among many factors driving innovation is competition among ideas and the application of those ideas. Ideally, the Department would like more competition for the most critical warfighting capabilities, those facilitating asymmetric advantages. Ideally, as well, the Department would seek to lower risks by choosing and developing domestic suppliers to provide those technologies where the United States wants to have warfighting capabilities superior to those of potential adversaries. Clearly, however, we would not deprive the warfighter when a foreign source has the best solution. By the same token, the Department also seeks to ensure that key technology is protected through export controls and other interagency measures. However, as the criticality of the warfighting capability lessens, the need for competitive U.S. sources to drive innovation of that capability also lessens.

Portals and Levers for Policy Implementation

Management of critical industrial capabilities requires policy implementations. There are three major policy levers that can be used to remedy instances in which required industrial capabilities are insufficient: (1) fund innovation; (2) optimize program management structures and acquisition strategies; and (3) apply external corrective measures where warranted.

These levers are best employed through the five openings or portals into the acquisition process where we believe the most effective influence on the industrial base can be achieved. These key opportunities to innovate the industrial base are: (1) science and technology (S&T); (2) the transition from laboratory to manufacturing; (3) weapon system design; (4) make/buy decisions; and (5) life cycle innovation.

The Department's challenge is to identify, monitor, and act to ensure that the critical technologies and industrial capabilities required to develop and field warfighting capabilities are sufficient in number and have the level of innovation necessary to meet projected DoD requirements. In addition, our assessment that technologies were critical enough to assess on a priority basis was based on the multiple application of these technologies. As a consequence, these recommended actions might also foster applying critical technologies across multi-Service joint applications. By highlighting industrial base deficiencies for critical technologies and implementing appropriate policy

[1] Excerpt taken from *DIBCS BA*, Part III, published January 2004. Therefore, illustrative examples given in this Appendix are primarily BA resources.

initiatives and remedies, the Department will continue to foster the innovative industrial base that is the basis of our warfighting advantage.

How Portals and Levers Work

Our analysis led us to focus on the five primary portals through which the Department can assure sufficiency of sources and innovation—and potentially also tap into particularly innovative technology to pollinate it among other applications. Acquisition policy guidance encourages Department acquisition professionals to appropriately deploy policy levers through these portals as a normal practice throughout the industrial processes that define a program. However, such guidance sometimes is overcome by other programmatic priorities. Particularly in cases where required industrial capabilities are insufficient or have cross-platform utility, remedial action may help optimize outcomes.

Early in responding to an emerging warfighting requirement, critical industrial capabilities may be resident in too few potential suppliers to generate confidence in timely success. For example, when developing or applying a new technology or developing a missing key system or systems enabler, sources may be limited to the incumbent suppliers of the previous generation of that technology, such as in the development of Global Hawk, which is discussed later in this Appendix. The available sources may also not be able to address multiple applications of a given technology. The Department should be prepared to act in such situations.

Later, in concept development or weapon system development and design, the number of potential suppliers may be insufficient to generate innovation or price competition due to industry consolidation, teaming arrangements, waning interest, or other factors. The Navy's Future Destroyer (DDX) program is a good example of an instance in which the Department acted in such a situation to ensure the availability of an innovative, competitive industrial base.

For mature systems or in mature industries, contractors may choose to source commonly available components from the global industrial base for reasons of best performance and cost. Additionally, older systems may be so far removed from the state-of-the-art that domestic suppliers deliberately discontinue producing necessary subsystems and components. While the Department is less concerned as a whole about such situations, it should act in the make-buy decisions and throughout programs' life cycles to induce innovation as much as possible.

In our construct, management decisions and options can be examined systematically using the array of portals and levers, as discussed in this Appendix. Portals generally correspond to program phases. In the case of applying remedies, the phase of the program determines which portals apply. The *science and technology* portal should be open nearly continuously for the more critical technologies since we should evolve these technologies until they reach their scientific limitations. Optimally, the *make/buy decisions* and the *life cycle innovation* portals are also open nearly continuously once a

system is fielded so that technology refresh can be accomplished as necessary. The *transition from lab to manufacturing* and the *weapon systems design* portals represent more limited windows of opportunity. In this construct as illustrated below, once the portal(s) have been determined, the three levers (*fund innovation*, *optimize program management/acquisition strategy*, and *employ external measures*) are systematically considered for how to best influence the desired outcome. The remedy or remedies can then be mapped on the board. This is the construct we will discuss further in the pages that follow: first portals and then levers.

MAJOR INNOVATION PORTALS AND POLICY LEVERS IN THE INDUSTRIAL PROCESS

Portals / Levers	Science & Technology	Lab to Manufacturing	Weapon System Design	Make/Buy Decisions	Life Cycle Innovation
Fund Innovation					
Optimize Program Management/ Acquisition Strategy					
Employ External Measures					

Source: ODUSD (IP)

To illustrate the portals and levers, we use a number of examples. These examples include opportunities taken to use a lever effectively and opportunities lost. While the examples come from a variety of programs, the discussion here is focused on industrial base impacts of the action taken or not taken and are not intended to reflect on the overall status or outcome of the program.

INNOVATION PORTALS

This study's focus on innovation is driven by the need to *Be Ahead* or B*e Way Ahead* in critical technologies. As depicted in the graphic on the previous page, there are five major portals of opportunity where managerial decisions determine the likelihood that critical technologies and associated industrial capabilities are developed and sustained expeditiously and cost-effectively:

- *Science & Technology*. Programmatic and funding decisions by both the government and industry involving technology development significantly impact

the likelihood that there will be sufficient industrial capabilities to incorporate critical technologies in defense systems. A capabilities-based approach like the DIBCS methodology can serve as a guide for shaping these decisions by stimulating investment in critical industrial base capabilities.

- *Laboratory to Manufacturing Transition*. Manufacturing approaches that optimize either for manufacture by the developer or for only one warfighting application often transition new technologies from the laboratory to production with unintended limitations. For critical enabling technologies like those identified earlier, the Department should encourage manufacturing processes that encourage competitive solutions and enable their transition to other applications. Industrial base concerns must, of course, be balanced against delays that preclude the timely delivery of new operational capabilities to the warfighter.

- *Weapon System Design*. Design practices (for example, the effective use of standard software and hardware interfaces) can encourage innovation. On the other hand, government or prime contractor specifications that are too prescriptive can undermine innovation. This often is the case in subsystems or components that optimize designs around single-supplier products, applications, or technologies. This kind of behavior leads to sub-optimized designs and sole sources. The Department's policy on the use of an open systems approach promotes the use of products from multiple suppliers and allows next generation modules to be inserted to upgrade capabilities throughout the life cycle of the weapon system. A key attribute of evolutionary acquisition and spiral development is planning and managing technology insertion to foster opportunities for new warfighting applications from original—and new—manufacturing sources.

- *Make/Buy Decisions*. Contractor make or buy decisions are the front lines of competition and innovation. For critical technologies, the policy levers should be used within this portal to encourage contractors not to favor in-house capabilities or long-term teammate products over more innovative solutions available elsewhere. When warranted, the Department will engage actively to shape make/buy decisions. This is not a new policy but requires advanced planning in the acquisition strategy.[2] Unwarranted favoritism, especially if systemic, discourages innovative suppliers. Warfighters lose when contractors try to satisfy critical capability requirements without choosing the most innovative, best-value suppliers.

- *Life Cycle Innovation*. Under evolutionary acquisition strategies, even more so than in the past, fielded defense systems will continue to undergo further

[2] Government involvement in make/buy decisions is illustrated in explicit subsystem acquisition strategies like the E-10A (see page D-16), Space Based Radar, as well as the consent decrees associated with the Northrop-Grumman/TRW case (see page D-22). Less extreme measures such as make/buy plans and award fee criteria can be applied routinely.

development to improve warfighting capabilities. These innovative improvements offer new opportunities to import emerging technological and industrial capabilities that maintain or expand warfighting superiority. Thus, they should draw from the broadest possible spectrum of the overall industrial base. As a consequence, cost-effective commercial practices and standards and open architectures become particularly important.

Traditionally, these portals have been the provinces of a discrete set of industrial base participants aligned to specific phases within the industrial process as shown below.

TRADITIONAL INNOVATION PORTALS AND INDUSTRIAL PROCESS PARTICIPANTS

Program Phases	Science & Technology	Lab to Manufacturing	Weapon System Design	Make/Buy Decisions	Life Cycle Innovation
Participants	Inventors, Academia, Government Labs and R&D Centers, Domestic And Foreign Industry	Service Labs, Program Offices, Industry, Commercial and Government Centers of Excellence (e.g., NCMS, Fraunhofer Institute)	Industry/ Government Program Office	Industry	Industry/ Government Program Office

Source: ODUSD (IP)

For example, inventors, academia, laboratories, government and industry research and development centers, and industry generally all act in the *science and technology* portal. However, as programs proceed through *weapon system design*, *make/buy decisions*, and *life cycle innovation* portals, the breadth of participants generally narrows to include only industry and government program personnel. This practice is akin to premature down-selection, foreclosing access to the broader defense industrial base and reducing innovation potential. Our first example of the *life cycle innovation* portal (and *acquisition strategy* lever) also is an example of broad industrial base participation to solve a critical need.

ARCI EXAMPLE

- Rapid insertion of technology to enhance system performance, including commercial technology
- Use of maximum breadth of industrial base provides for frequent competitions
- Annual portal for technology refresh and innovation prevents Navy from being captive to a single contractor

The Navy applied the *acquisition strategy* lever to induce innovation and competition in submarines as part of *life cycle innovation* in response to advances in world submarine acoustic technology in the mid-1990s. In 1996, the Navy adopted a revolutionary plan to maintain superiority by applying state-of-the-art signal processing in state-of-the-practice COTS hardware and software. The Acoustic Rapid Commercial off-the-shelf (COTS) Insertion (ARCI) program restored the Navy's submarine acoustic superiority and provided an innovative approach to continued improvement.

In ARCI, the Navy uses standard hardware and software interfaces, and a capabilities-based (versus requirements-based) model to integrate skills from the Navy, academia, and small and large businesses. It developed a rigorous process which rapidly inserts advanced capability into the fleet on a regular basis. By partitioning the sonar system into processing strings, the Navy was able to leverage the strengths of the developers and enable a sequential and incremental capability insertion plan. ARCI prime contractor Lockheed Martin provides system integration and system management. Digital Systems Resources, now part of General Dynamics, developed the towed array. The Applied Research Laboratory at the University of Texas developed the high frequency active array; and John Hopkins University's Applied Physics Laboratory served as the advanced technology test program lead. Members of the advanced development community (Navy laboratories, academia, and industry) continue to provide the new ideas, algorithms, and implementations.

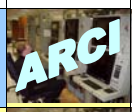
The use of standard hardware and software interfaces is fundamental to ARCI's ability to continue innovation throughout the system life cycle. Selecting standard interfaces commonly used throughout industry removes a significant barrier to supplier participation. Nearly any information technology supplier is familiar with internet protocols as well as common hardware architectures, operating systems, and application program interfaces. It is the adaptation of commonly used standards like these to defense requirements that enables participation by the broadest base of suppliers, including emerging defense suppliers. Standard hardware and software interfaces enable a maximum level of innovation for development and continued improvement of critical warfighter capabilities.

While the ARCI example focuses on the *life cycle innovation* portal, we believe that continuous use of these portals provide the best opportunities to influence the current and future sufficiency of the industrial base. Effective collaboration among all industrial base participants through all program phases makes it possible to access and deploy the best available knowledge and ingenuity. It also makes more certain the Department's ability to identify and employ the appropriate policy levers discussed below to induce and sustain innovation across the breadth of the defense enterprise.

POLICY LEVERS

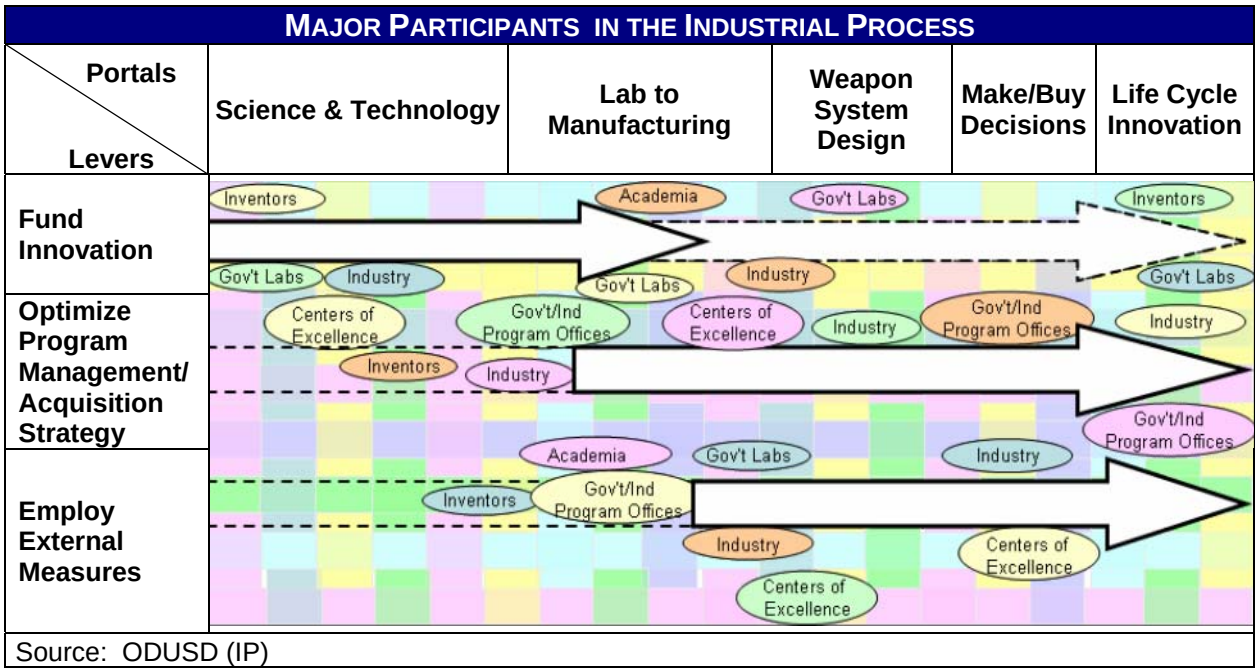
Three major policy levers offer tools with which the Department can develop, sustain, or expand innovation, drawing on the entirety of the industrial base, no matter the phase of the program. Ideally, DoD managers and contractors deploy these levers routinely through the appropriate portals discussed above to develop robust technological solutions to defense problems, insert those technologies, sustain critical industrial capabilities, and leverage those which may have applications elsewhere in the defense enterprise. For those cases where the Department determines that critical technological and industrial capabilities are deficient, it should carefully define the concern and use the appropriate lever to remedy the deficiency. For example, in the ARCI example just cited, the *life cycle innovation* portal was used with the *fund innovation* and *optimize acquisition strategy* levers, as shown in the graphic to the right.

PORTALS AND LEVERS APPLIED TO THE ARCI EXAMPLE

Levers \ Portals	Science & Technology	Lab to Manufacturing	Weapon System Design	Make/Buy Decisions	Life Cycle Innovation
Fund Innovation					
Optimize Program Management/ Acquisition Strategy					
Employ External Measures					

Source: ODUSD (IP)

The three levers we will now discuss are (1) *funding innovation*, (2) *optimizing program management and acquisition strategy*, and (3) *employing external measures* as necessary. Ideally, acquisition managers make use of all participants—laboratories, academia, industry, etc.—through all phases of a program's life cycle to nurture innovation in multiple sources for the purpose of acquiring leading-edge technologies at an affordable price, as shown in the graphic below. A discussion of each of the levers and associated examples follows.



Source: ODUSD (IP)

Fund Innovation

Direct funding of innovation by the government in its science and technology (S&T) accounts and by industry in independent research and development (IRAD) accounts is paramount. During government and industry laboratory development—and the transition from the laboratory to manufacturing and later—funding alternative technologies, as well as multiple applications and suppliers, broadens the industrial base. It also improves what is available to the warfighter, often at less cost.[3] Inadequate funding for innovation can have severe consequences—hence the significance of the Department's efforts to boost science and technology funding as a critical first step to develop multiple innovative sources and technology applications.

> *"Creating market conditions attractive to business will bring you all the capacity and innovation you can use."*
>
> *– Red Team Member*

The role of contracting officers, program managers, and other acquisition professionals in translating the intent of S&T funding to induce maximum innovation is critical. Too often, the intent to develop multi-application, joint capabilities from specific critical technologies is unintentionally undermined by contracting actions made without strategic vision—or by programmatic decisions excessively focused on one program and its requirements. As evolutionary, broader, and

> *"Competitive early development is expensive and thus avoided, but sole source efforts often cost twice original estimate anyway. We lose technologically, and don't gain programmatically."*
>
> *– Red Team Member*

[3] In addition to classic S&T funding, other sources of innovation funding include the Defense Acquisition Challenge Program, Quick Reaction Fund, Defense Technology Transition Initiative, Advanced Concept Technology Demonstrations (ACTDs), Title III Program, Small Business Innovation Research programs, Small Business Technology Transfer programs, and Manufacturing Technology programs.

more flexible acquisition tenets become increasingly important, it will be the challenge of the acquisition universities and other Department curricula to place more emphasis on the innovative paradigms so critical to 21st century warfighting. The functional area architects recommended in this study should also prove an asset to this process by constantly monitoring and comparing each other's portfolios of different capabilities and associated programs for maximum overall effectiveness. Examples that follow discuss use of the three major policy levers to source innovative technology applications.

UAV EXAMPLE

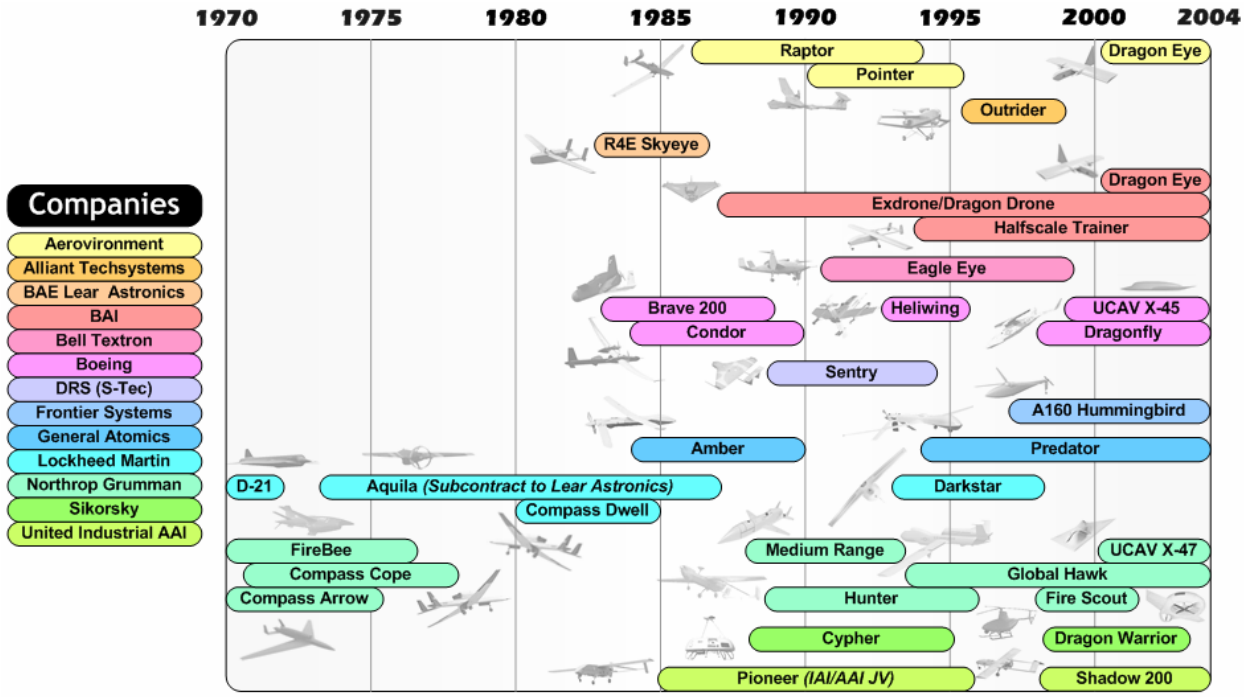
- Acquisition strategy created a single source
- Resulted in increased cost and schedule
- Represented a lost opportunity

The history of UAV development has not benefited from the hallmarks of successful aircraft development: ample funding and number of suppliers. Nor has the Department succeeded in fully migrating this extraordinary manned aircraft technology base to future unmanned applications. Consistent funding and multiple competitions enabled fighter aircraft, whose integrated sensor suites are key components of Battlespace Awareness, to become one of the most dominant warfighting capabilities of the U.S. forces from the period following World War II to the present. The United States now has a capability that assures such complete air dominance that potential adversaries generally don't dare challenge it. The Department achieved such dominance through consistent long-term funding for system innovation and through multiple competitions. In the first few decades after World War II, more than a dozen firms competed to develop and produce military aircraft. Subsequently, some firms left the business and others merged, resulting in eight remaining firms in 1990.[4] The Department nurtured innovation in military aircraft by engaging an ample number of suppliers in aircraft manufacturing over a period of more than 45 years.

Although UAVs are now almost universally identified as a critical technology, the history of their development has been marked by uneven funding due to lack of support by the Services, frequent program cancellations, and few competitions for large production contracts. As a result, no company has had the continuous activity that fosters evolutionary innovation—and the Department's progress in obtaining systems has been marked by fits and starts, impeding the development and diffusion of critical knowledge within the industrial base. The chart below illustrates the uneven nature of UAV development. Many companies over more than three decades have participated in this area—but none have had a long, continuous pattern of involvement in unmanned programs. In addition, many of these companies have exited or been subsumed in the process.

[4] Birkler, John, et. al. *Competition and Innovation in the U.S. Fixed-Wing Military Aircraft Industry*, Rand Corporation, 2003.

UAV DISJOINTED DEVELOPMENT PATTERN[5]



Source: Institute for Defense Analyses

The nature of UAV technology is such that a robust industrial base capability would be characterized as having innovative technologies with myriad applications; multiple suppliers because of low entry costs; and maximum use of COTS components or systems. The consequence of the Department's UAV procurement pattern is few deployed UAVs and a still-nascent capability in spite of the relatively long history of basic technology development. We can only guess where—and over how many applications—unmanned system innovation may have taken the Department had the history been different.

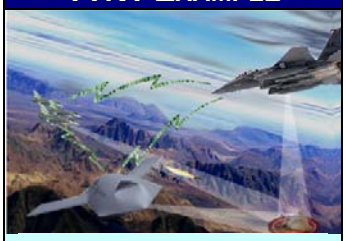
Consider, for example, the development of the Global Hawk UAV, now in high demand because of its demonstrated value in Operations Enduring Freedom and Iraqi Freedom. This is a case where the lever of funding innovation during weapon system design was intended to help maintain a competitive and innovative industrial capability. However, funding constraints led to a change in strategy and the opportunity was not realized. Global Hawk began as an Advanced Concept Technology Demonstration (ACTD) program leveraging Ryan's unmanned technology expertise going back several decades. It was selected in May 1995 from among five competing concepts. DARPA, the Global Hawk program manager, originally planned to fund two contractor teams through initial flight testing. However, budget cuts just prior to selection forced the Department to choose only a single contractor team.

[5] Affiliations in this chart reflect the companies as they exist today and not the heritage companies that may have initiated or contributed to the program.

If, on the other hand, the Department had funded multiple competing teams through initial flight test at a $160 million estimated cost for two, it would have significantly reduced: (1) performance risk because of competitive flight tests; (2) schedule risk arising from single source procurement; (3) super-optimization of one mission application and contractor approach; and (4) future acquisition costs by making available multiple sources for future competitions. This development program represented an early opportunity—not seized—to expand market demand and broaden the supplier base for a critical warfighting capability. The Department is now funding billions of dollars for UAV developments which could have blossomed earlier and at less cost—had the pressure to save $160 million not been so great in 1995.

Conversely, the Tactical Targeting Network Technology (TTNT) program demonstrates application of the *fund innovation* lever through the *weapon system design* portal to develop a robust and innovative supplier base. TTNT, also managed by DARPA, aims to provide the communications infrastructure to support tactical targeting from airborne platforms as part of the Joint Tactical Radio System. In early 2001, DARPA funded four large contractors to work on design requirements and four small contractors to focus on specific component technologies. In June 2002, DARPA chose one systems contractor and three small contractors to further mature TTNT technology and produce articles for testing—thereby continuing to fund multiple approaches. The Department ensured it retained ownership of TTNT intellectual property to facilitate the development of competition for subsequent phases of the program's life cycle.

TTNT EXAMPLE



- Acquisition strategy created innovative environment
- Source selection and management structure institutionalized this environment

From the beginning, the DARPA program manager funded a broader industrial base by soliciting industry responses for two sets of requirements: (1) total system requirements for which larger companies were better suited; and (2) component requirements that small companies with emerging technologies could best satisfy. DARPA funded an industrial base for this program of four system and four component suppliers in the preliminary design phase, reduced it to one system and three component suppliers a year later for the maturation of TTNT technology; and in the future production phase, will be able to attract more suppliers because of the Department's predominant ownership of the intellectual property, thereby allowing for expansion of the defense industrial base—if required.

Optimize Program Management and Acquisition Strategy

Over the years, the Department and its prime contractors have developed and employed a myriad of program management structures and acquisition strategies primarily to optimize program cost, schedule, and performance—sometimes not considering the full impact of such structures and strategies on the industrial base. However, as the following examples illustrate, organizational structures and acquisition strategies can have a significant impact on the Department's ability to acquire multiple

innovative sources to maintain technology leadership. Acquisition programs are at the front lines of shaping the defense industrial base. Tactics at the program-level must be consistent with the Department's strategies to develop sufficient industrial base capabilities, incentivize industry to be innovative, and to seek multi-application solutions.

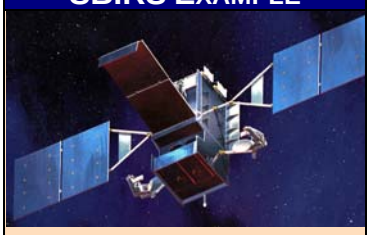
> *"Robust competition to meet challenging performance goals is the most consistent source of innovation."*
>
> *- Red Team Member*

Government and industry program management structures, as well as acquisition strategies, can provide positive or negative impacts on the numbers of suppliers and sources of innovation. For example, government management structures can encourage the development of multiple suppliers. On the other hand, as discussed below, if they allow too narrow a focus on Service-specific applications with the prime contractor and its sub-contractors, they can work to discourage other contractors from contributing competing innovative technologies. Likewise, industry management structures can positively impact innovation. For example, partnering with competitors for contracts in specific program areas where there are few contract awards and limited funding can produce innovative synergies. In some instances, however, partnering can result in monopolistic behavior that works to exclude competitors and squelch innovation. Finally, acquisition strategies may impact innovation either positively or negatively. A strategy where the Department funds multiple sources in early technology development, for example, nourishes the growth of multiple, innovative sources. A strategy where contractors have too much responsibility for program development and inadequate government oversight may foster dependence on current suppliers to the exclusion of other sources of innovative solutions.

Traditional program cost, schedule and performance goals also can defeat program managers trying to apply strategies necessary to obtain the innovative technology the Department requires. The dynamic nature of program development and budget decisions can force changes in acquisition strategies to the detriment of broader industrial base considerations.

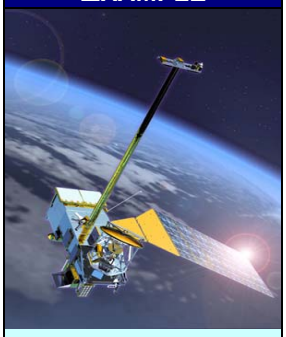
A case of program management structure masking industrial base problems is illustrated in Space-Based Infrared System-High (SBIRS-High). Here is a case where the o*ptimize program management structure and acquisition strategy* lever was not employed during weapon system design. The program office was structured to provide minimum management oversight of the contract using a total systems performance responsibility (TSPR) clause. Major problems of cost, schedule, and performance in SBIRS-High surfaced in late 2001 in part due to the inability of industry to produce key capabilities because of problems related to lack of maturity in the system design.[6] These problems forced both government and contractor program offices to be restructured. The Department's review of the program at that time identified government program office structural issues, government and contractor program management turnover, and the TSPR acquisition strategy collectively as major contributors to the program's problems. The recovery plan is attempting to correct these issues with a restructured contract and management team. This experience reminds the Department of the risks of inadequate program oversight. Lack of attention to the impact of management structure and acquisition strategy on program performance set the stage for program failure, and this program continues to struggle to recover.

SBIRS EXAMPLE



- Government program office structure proved to be inefficient in controlling cost, schedule and performance
- Required restructuring of government and contractor management teams
- Restructured contract to bring performance and technology into line

NPOESS EXAMPLE



- Program merger resulted in consolidation of competitive opportunities
- Acquisition strategy maintained robust competitive environment for innovative industrial capabilities

The combination of the military Defense Meteorological Support Program (DMSP) and the civil Polar-orbiting Operational Environmental Satellites (POES) saved significant money but risked reducing the opportunities for competition in a very innovative set of industrial capabilities. To address these risks, the integrated program office (IPO) for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) addressed this impact to the industrial base through application of the *acquisition strategy* and *fund innovation* levers through the *weapon system design* portal. The merger did not change the number of satellites to be procured but did reduce the number of distinct satellite design opportunities from two to one. The resulting program was estimated to produce sizable cost savings of over $1.6 billion through 2018 by reducing redundancies in U.S. meteorological satellite systems. To avoid reducing the innovation in the industrial base along with the costs, the IPO employed acquisition strategies to create a robust competitive environment by directing competitive subcontracts in the key sensor technologies.

[6] Other causes cited during Nunn-McCurdy breach deliberations included lack of effective requirements and system engineering, and a breakdown in execution management within both Government and contractor teams.

Losers of the sensor design competitions were allowed to team with the winners to leverage their best collaborative design and production capabilities, and stay engaged in one of the few major space-based remote sensing programs.

E-10A EXAMPLE

- Innovative management structure
- Competition-based acquisition strategy
- Results in an innovative industrial base for future competitions

Using the *management structure/acquisition strategy* lever to ensure multiple innovative sources will be even more challenging for future programs. As network-centric warfare demands synergies among defense systems, we are reminded that management structures and acquisition strategies must adapt to ensure the industrial base is properly incentivized to innovate key technologies—across multiple applications or missions. The E-10A Multi-Sensor Command and Control Aircraft program is an example of how the needs to replace several platforms can be met with a distinctive organization and acquisition strategy. The E-10A program employs a cluster of program offices within a lead program office, reinforcing common technologies and systems among the cluster's elements. The program's acquisition strategy is a hybrid as well. It has sole source system integration and platform contractors where the benefits of innovation and competition have already been garnered. However, where innovative technologies can provide critical capabilities, such as in the Battle Management Command and Control System, competition is preserved.

FCS EXAMPLE

- Innovative management structure has potential to generate competitive industrial base environment
- Lack of government oversight and over-reliance on industry as an LSI may have unintended negative consequences

The Future Combat System (FCS) offers an example of an innovative management structure and acquisition strategy approach designed for an extremely complex and massive network-centric program critical to the Department's 21st century warfighting needs. It is using the *management structures/acquisition strategy* lever through the *weapon system design* portal to gain access to system-of-systems and network-centric capabilities found in the larger prime contractors and system engineering houses while retaining full access to the rest of the industrial base to provide critical capabilities in the systems and components that make up FCS. The Army has selected a strategy that establishes a contractor lead system integrator (LSI)—the Boeing/SAIC team—that works closely with the government program office. SAIC and Boeing play a major role in establishing program standards and selecting component contractors. They manage the identification, selection, and procurement of the major FCS systems and subsystems, with the explicit challenge and mandate not to self-deal.

However, while it is too early to know for sure, the FCS LSI approach may not provide the government the necessary in-depth understanding of that program's impact on the industrial base, particularly for the application of innovative technologies developed in

FCS for non-Army applications. Based on its experience with TSPR, the Department has expressed unease with such heavy reliance on a contractor team for key program decisions, especially faced with high Department program office turnover rates. Thus, it is critical that the Department maintain insight into the LSI contractor processes and procedures of this program to ensure that they satisfy industrial base outcomes. In FCS, the contract requirement that the Army Acquisition Executive review all decisions in the *make or buy* portal should help to mitigate this risk.

As these examples have illustrated, deploying the portals and levers in the construct we have developed differs for each situation. Developing a new technology or addressing an industrial base deficiency will require a solution crafted specifically for that deficiency. In making decisions, from resource allocation to acquisition strategies, the Department must ensure that the industrial base and strategies to ensure its sufficiency be considered—particularly in cases involving critical and multi-application technologies.

> *"The ability of acquisition managers to do this effectively depends on whether they continue to manage individual programs, which forces a parochial view, or a capability or technology area, which would cause them to optimize for that broader capability or technology area—a structural issue."*
>
> *– Red Team Member*

The future will demand great finesse in the application of the *program management/ acquisition strategy* lever if the Department is to synergize available industrial base capabilities across broad applications. It is for this reason that we recommend establishing the functional area architect and conducting industrial base assessments for critical capabilities throughout the program life cycle. With the functional architects in all acquisition board meetings to monitor acquisition strategies and elevate industrial base concerns, these reviews will become more effective in maximizing innovation to the benefit of warfighting capabilities—and the defense industrial base.

Changing warfare strategies must erode the familiar platform-centric patterns the Department has long used to structure its thinking, but will only do so in the measure that acquisition professionals view themselves as stewards of warfighting capabilities and not owners of stovepipe platforms. The rest of the Department is adapting to these changes in order to create acquisition processes that recognize the power of synergizing capabilities across Services and platforms. Even our historical platform-based milestone approval process is now undergoing revision to focus on gaps and overlaps in capabilities provided by systems, rather than on the discrete systems themselves. Acquisition strategies are already beginning to bear the imprint of the portals and levers construct to challenge program managers to develop plans for innovation and innovative uses of their technologies—throughout program life cycles.

Employ External Measures

Previously we discussed two levers available to program managers to develop multiple sources of innovative technologies that can potentially be used to enhance multiple warfighting capabilities: *funding innovation* and *optimizing program management*

structures and acquisition strategies. While these tools traditionally may be used to solve cost and technical quality problems, another important purpose is to ensure the development and sustainment of critical and innovative industrial base capabilities.

Now we will discuss measures external to the normal life cycle development of a program that the Department employs on an ongoing basis but also can employ when the first two levers do not secure sufficient innovation for critical capabilities. This third lever includes collaborating with other agencies to apply regulatory remedies in order to prevent undesired foreclosure of competition or innovation.

The graphic below depicts the seven "external" corrective measures available to the Department to remedy or prevent undesired effects on the industrial base. Three of them are external to individual programs, but internal to the Department. While the four on the right side of the chart are external to the Department, the Department has significant influence as to how these tools are employed.

EXTERNAL MEASURES			
DoD		**Interagency**	
Measure	**Purpose**	**Measure**	**Purpose**
Stage competitions to add sources	Induce innovation. Major risk reduction for too few/failing source(s) or lack of performance	Hart-Scott-Rodino Remedies	Maintain sufficient number of competitive sources
Restructure Management Approach	Eliminate excessive self-dealing or narrow focus on specific issues or applications	Exon-Florio Remedies	Maintain technology leadership and security of supply but allow foreign direct investment
Block Teaming Agreement	Discourage fusion of innovation into single source; prevent cartel-like behavior	Balanced Export Controls	Keep military technology from adversaries but allow competition in global markets
		Foreign Cooperative Agreements	Help develop and access foreign sources where appropriate
Source: ODUSD (IP)			

Funding permitting, the Department can stage competitions to add sources in order to induce innovation and improved performance, while reducing risk. When innovation is desired, competitions must avoid contract clauses and acquisition strategies that encourage risk-averse behavior and drive out innovation. The Department also can restructure its management approaches, as was done in the case of the SBIRS-High program discussed earlier, to preclude excessive in-house sourcing or premature narrowing of technology focus. As will be discussed in the case of DD21/DDX, the Department can block teaming arrangements in order to prevent combinations that would result in single sources and thereby restrict the competitive pressures that drive innovation. The Department can, and does, use these tools to ensure program management decisions do not lead to unintended consequences.

The Department also uses interagency processes to influence competition and innovation while protecting national security. Using the deliberative process established

by the Hart-Scott-Rodino Antitrust Improvement Act, the Department works with the Department of Justice (DoJ) and Federal Trade Commission (FTC) to block proposed business combinations when necessary to preserve competition or for other reasons of national security. The Exon-Florio Amendment to the Omnibus Trade and Competitiveness Act authorizes the President to suspend or block foreign acquisitions, mergers, or takeovers of firms located in the United States when they pose credible threats to national security by transferring key industrial capabilities. The Department participates in an interagency committee, chaired by the Department of the Treasury to exercise the Department's leadership prerogative. Similarly, the Department of Defense works with the Department of State on export controls. Export controls should be structured to keep key, critical military technology from our adversaries, yet allow domestic firms to compete in international markets to preserve their global competitiveness.[7] Foreign Cooperative Agreements are agreements between the Department of Defense and foreign governments that allow the Department to develop and access foreign technologies and products that offer unique warfighting benefits.

DoD Measures

The Department has various corrective measures it can apply in order to preserve a robust, innovative industrial base when such action is necessary. First of all, it can take measures to induce innovation by staging competitions to add sources. Over the years, the Department sometimes has been forced to induce innovation within high risk programs or programs that have shown a decline in performance. Techniques range from developing alternative sources, such as in the case of the Navy's ARCI program, to developing technology insertion processes such as practiced today with spiral development planning. The goal always has been to find the best technology and ideas so that program offices can source the broadest array of solutions available.

Another measure the Department sometimes employs is to restructure its management approach. As was discussed earlier, when the SBIRS-High program was experiencing significant problems in late 2001, the Department took action to restructure management oversight to ensure the maturation of innovative technologies inherent in the program, among other corrective measures. The formation of joint program offices within the Department is often used to create a management structure to accelerate the development of innovation and the preservation of competitive sources. Examples of this are the Missile Defense Agency and the recent stand-up of the Joint Unmanned Combat Air Systems program office at DARPA.

A third measure that the Department occasionally employs is to block teaming arrangements. Teaming relationships sometimes can effectively reduce the number of

[7] Northrop Grumman's development of the APG-68(V)9 radar for sale to the United Arab Emirates and Singapore helped bring forward technologies and mitigate risk on 4th generation radars for both the F-22 and JSF programs. The foreign investment helped to lower non-recurring engineering costs and to transfer technology and manufacturing advances to production. This demonstrates how "the international market" benefits the Department.

suppliers in a given market, especially if the two firms teaming are dominant in a particular market sector. On some occasions, it becomes necessary for the Department to interject itself to avoid, or even break up, teaming arrangements between companies in order to sustain competitive conditions and nurture innovation.

One notable example of the Department wielding the *employ external measures* lever occurred in 1998, when the two existing Navy combatant shipbuilders, Ingalls and Bath Iron Works, and the Navy's only large ship combat system supplier/integrator, Lockheed-Martin, announced they would team to bid for the Navy's new DD21 surface combatant ship design and construction program. To motivate continued improvement in key industrial capabilities, the Navy developed and implemented a revised acquisition strategy prohibiting Ingalls/Bath Iron Works and Lockheed-Martin from participating as a team. Thus, for the DDX competition, the two shipyards formed separate teams, promoting the development of distinctive capabilities and alternative sources in a critical industrial sector.

DDX EXAMPLE

- Industry teaming threatened access to innovation
- Acquisition strategy revised to ensure competitive sources

Interagency Measures

There are also measures the Department can employ in collaboration with government regulatory bodies outside the Department. The Hart-Scott-Rodino (H-S-R) legislation provides the basis for the Department's review of the impact of proposed acquisitions or mergers on innovation and competition in the industrial base. Working closely with anti-trust authorities, the DoJ and the FTC, the Department is able to block mergers or, if necessary, secure judgments that force restrictions on the acquiring firm in order to preserve competition in key technologies for critical capabilities. Finally, the Department, in conjunction with the Department of Treasury and the Department of State, can prevent the transfer of critical technologies through Exon-Florio remedies and export control laws, respectively. On the other hand, DoD can also negotiate Foreign Cooperative Agreements to fund and access critical technologies, especially where the source for a critical capability is foreign.

H-S-R Adjudication

The Department's role in Hart-Scott-Rodino (H-S-R) assessments is to look at the implications of a transaction on future competition and innovation. This prospective look is particularly critical as revisiting a merger after the fact is only permitted if the offending issue was not foreseeable at the time of the review.

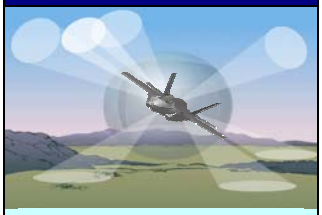
Raytheon's recent acquisition of Solypsis highlights a situation in which the Department proactively worked with the DoJ to preserve competition in technologies critical to its network-centric warfighting plans. The Cooperative Engagement Capability (CEC) will integrate battle force combat systems and sensors into a single, force-wide, distributed combat system in order to counter increasingly capable and less detectable cruise and tactical ballistic missiles.

RAYTHEON – SOLIPSYS EXAMPLE

- Proposed merger of two sensor netting companies
- Transaction allowed with agreement to offer capability to competitors
- Remedy preserved competition for future while enhancing the development of advanced capabilities

Recently, as the CEC Block II competition moved forward, Raytheon decided to acquire Solipsys, a firm with the only other sensor netting product thought to be technically mature enough to represent a viable alternative to the unique CEC hardware and software design: the Tactical Component Network (TCN). Recognizing the implications of this transaction, the Department used the *employ external measures* lever and, with the DoJ, insisted that Raytheon sign a letter of agreement to offer the Solipsys TCN as a merchant supplier to other contractors for future solicitations. By exercising this lever, the Department preserved the possibility of competition for future defense applications. As the example illustrates, the Department works with the antitrust regulatory agencies on a forward-looking basis to ensure a healthy, competitive industrial base for critical capabilities and applications.

LOCKHEED - NORTHROP EXAMPLE



- Proposed merger of two AEW radar providers and platform integrators
- Transaction denied
- Preserved competition in AESA market

The Department also recommended antitrust regulatory actions to preserve innovation and competition in airborne active electronically scanned array (AESA) radar technologies critical to battlespace awareness. One of the defining moments for the airborne AESA industry occurred as a result of Lockheed Martin's attempt to buy Northrop Grumman in 1997. The Department and the DoJ reviewed the merger and filed suit to block it in March 1998, citing potential horizontal and vertical integration issues regarding airborne early warning (AEW) radar along with the loss of competition and innovation in a number of critical systems and components. At the time of the merger, Lockheed and Northrop Grumman were the only two U.S. AEW radar providers. Only two companies (Raytheon and Northrop Grumman) had experience integrating AESA fire control radars in fighter aircraft. After the merger, Lockheed Martin would have had significant vertical AEW and AESA capabilities and could have foreclosed opportunities to potential radar competitors or denied radars to other aircraft competitors. By blocking the merger, the Department and the DoJ preserved competition in the airborne AESA industry, paving the way for its innovation and application to myriad non-airborne applications.

NORTHROP – TRW EXAMPLE

- Proposed merger of satellite prime and subsystem provider
- Transaction allowed with consent decree providing for systems prime impartiality and requirement to provide payloads to competitors
- Department's Compliance Officer to oversee make/buy and merchant supplier provisions
- Remedies preserve competition; competitors not foreclosed from legacy TRW payloads and components

With Northrop Grumman's acquisition of TRW, the Department also took measures to ensure multiple competitive sources in the critical reconnaissance satellite systems sector. After thorough analyses of the effects of the proposed acquisition, the Department communicated its concerns to the DoJ which in turn negotiated a consent decree, forcing Northrop Grumman to select payloads on a competitive and non-discriminatory basis and to provide legacy TRW technology to other competitors.

> *"By requiring Northrop to make its sophisticated satellite payloads available to competitors, along with other provisions, this consent decree enables the U.S. government—the only customer of reconnaissance satellites—to continue to benefit from competitive prices, higher quality, and continued innovation."*
>
> – *R. Hewitt Pate, Acting Assistant Attorney General, Antitrust Division, DoJ, December 11, 2002*

Although discussed earlier as a measure the Department can use internally, blocking teaming relationships also is an action that the Department sometimes takes in conjunction with the DoJ when such teamings have the potential to adversely affect competition and thus negatively impact innovation.

The teaming relationship between DRS Technologies and Raytheon for electro-optical systems using second generation forward looking infrared technology is illustrative of a situation that required the attention of the Department and the DoJ. The Department decided to allow teaming on current contracts since the benefits of competition had already been garnered, given the phase of development of the related acquisition programs. However, the Department indicated that teaming for future programs (e.g., the Advanced Amphibious Assault Vehicle) would be unacceptable because of the negative effect on competition. The regulatory review resulted in both firms modifying their teaming agreement accordingly.

DRS - RAYTHEON EXAMPLE

- Proposed team of the only two second generation FLIR suppliers
- Teaming allowed for existing contracts; not for future competitions
- Modification of teaming agreement retains competition for future while realizing savings on current contracts

When corporate mergers or teaming agreements significantly reduce the competitive pressures which drive innovation, the Department must be prepared to use regulatory powers. In such situations, H-S-R adjudications provide the Department a means to maintain competition and induce innovation for industrial and technological capabilities critical to the warfighter.

<u>Exon-Florio Remedies, Export Control, and Foreign Cooperative Agreements</u>.

The Exon-Florio Amendment to the Omnibus Trade and Competitiveness Act of 1988 amended the Defense Production Act to authorize the President to suspend or block foreign acquisitions, mergers, or takeovers of U.S. firms when credible threats to national security cannot be resolved through other provisions of law. The President has delegated management of the Exon-Florio Amendment to the interagency Committee on Foreign Investment in the United States (CFIUS), chaired by the Department of the

Treasury. Within the CFIUS, the Department of Defense determines if the company or business unit being acquired possesses critical defense technology under development or is otherwise important to the defense industrial and technology base.[8]

Critical technologies and capabilities highlighted by the DIBCS will be important decision aids for the Department in this process. In cases where the Department believes the technologies and capabilities are leading-edge and unavailable to potential adversaries, it may choose not to allow companies with these capabilities to be acquired by foreign companies, or it may develop remedies to reduce the risks of unauthorized technology transfer. In this manner, the Department actively works to safeguard critical defense technologies.

The Department also can advocate export control restrictions to the Department of State when U.S. companies desire to export critical technologies or capabilities abroad. Conversely, where a sole source of a critical capability may be foreign, it may be advisable to engage in cooperative agreements with the company's government to ensure adequate funding to shape the endeavor.

CATALYST II EXAMPLE

- Combined U.K. and U.S. EW systems with U.K. software
- Saved $5-8 million and 2-3 years development time and increased commonality with major ally

In the case of the Catalyst II program, the Department sought more robust electronic warfare (EW) capabilities through the integration of a United Kingdom system, Soothsayer, with a U.S. system, Prophet. Each is an EW system focusing on upgrades to electronic support, electronic attack, and precision location systems. For this new application, the United States also acquired SAGE software from the United Kingdom with a state-of-the-art capability to detect, classify, and locate modern battlefield communications signals. The combined Catalyst II program saved between $5-8 million and two to three years of development time.

In summary, the portals and levers approach is a valuable tool to enhance the health of the defense industrial base. Portals encourage systematic examination of management decisions throughout the technology and program life cycles. Levers provide the means to ensure the innovation and investment that will keep the United States ahead of foreign competition for critical industrial base capabilities. Along with the levers available to programs, external measures within the Department and with the cooperation of regulatory agencies are available to retain innovation and remedy deficiencies. The Department must lead by example in applying new functional capability-based thinking, management practices, and behavior.

[8] For further information on the HSR and CFIUS processes, refer to the ODUSD(IP) *Business Combinations Deskbook* posted at http://www.acq.osd.mil/ip.

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APPENDIX E

PROGRAM MANAGER'S FUNCTIONAL CAPABILITY CONFERENCE (PMFCC)/ CAPABILITY AREA REVIEW (CAR)

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TRANSFORMING DEPARTMENT DECISION-MAKING: CAPABILITIES-BASED PROCESSES

An integrated, capabilities-based approach to the acquisition process will drive changes in Department decision-making and corporate processes, in addition to challenging program managers to function in a capabilities context. By making decisions across functional and operational capability areas, program tradeoffs will be synchronized and prioritized with an increased understanding of relationships among programs by the broader acquisition community. These changes in acquisition oversight processes are at least as important as assuring that program managers' acquisition strategies and management techniques impart the functional capabilities context to individual programs.

Progress To Date

As the Department moves its requirements and acquisition oversight processes toward a capabilities-based paradigm, changes in the current defense program oversight process are anticipated. As shown below, USD(AT&L) has three

HOW AT&L GOALS[1] SYNCHRONIZE WITH SENIOR DEPARTMENT STRATEGY GUIDANCE AND THE 3170[2] CONSTRUCT

AT&L Goal One, Three, and Six deliverables provide complementary elements of end-to-end Department processes to implement JCIDS in Department acquisition oversight processes, system engineering, and industrial base assessments.

	Goal One Lead: Defense Procurement & Acquisition Policy	Goal Three Lead: Defense Systems	Goal Six Lead: Industrial Policy
Objectives	1. **Bring Joint Capabilities perspective to acquisition** 2. Increase accuracy and credibility of cost estimates 3. Shorten acquisition cycle time	1. **Develop systems views of integrated architectures** 2. **Develop integrated plans and/or roadmaps** 3. **Establish broader mission context for DAB reviews** 4. **Foster interoperability, jointness, and coalition capabilities** …	1. **Capabilities-based approach to evaluate industrial base sufficiency** 2. **Organizational cross-feed mechanisms for IB assessments** 3. **Smart IB management by PMs** 4. **Help emerging defense suppliers bring value & innovation to DoD**
Status	✓DAES review in JFC context ✓Prototype of Program Manager Functional Capability Conference (PMFCC) conducted June 2004 • Proof of concept PMFCC/CAR planned for Spring 2005	• Roadmap, investment strategies, and architectures in process for mission areas to support ACARs	• 5-part DIBCS study series underway in JFC context • Until Department processes and organizations reflect JFC paradigm, companies will continue to sub-optimize on current customer-facing investment strategies
Deliverables	JFC / PMFCC / CAR C2/NCO: Mar 05 / Apr 05 Force App: Apr 05 / May 05 Protection: May 05 / Jun 05 FocLog: Jun 05 / Jul 05 BattlAwar: Jul 05 / Aug 05 In context of JFC and available roadmaps	✓AMD roadmap and CAR DAB in May 2004 ✓Land Attack Weapons CAR DAB in May 2004 ✓JBMC2 CAR DAB in August 2004 • EW roadmap and CAR DAB planned for Nov 2004	DIBCS Report / Publication Date ✓Battlespace Awareness: January 2004 ✓ Command & Control: June 2004 ✓ Force Application: October 2004 Protection: December 2004 Focused Logistics: May 2005 Other IB/Process enhancements: • Industrial Base Investment Fund • Shipbuilding Industrial Base Investment Fund
Periodicity	• Annual JFC CAR • Other Department-level reviews as required • Cost/schedule/milestone reviews at Service level to maximum extent possible	Continuous/ongoing	• Initial DIBCS series: Jan 04-May 05 • Less pressing critical technology industrial base assessments as required • Complete update envisioned 2007-08
	← Crossfeeds →		

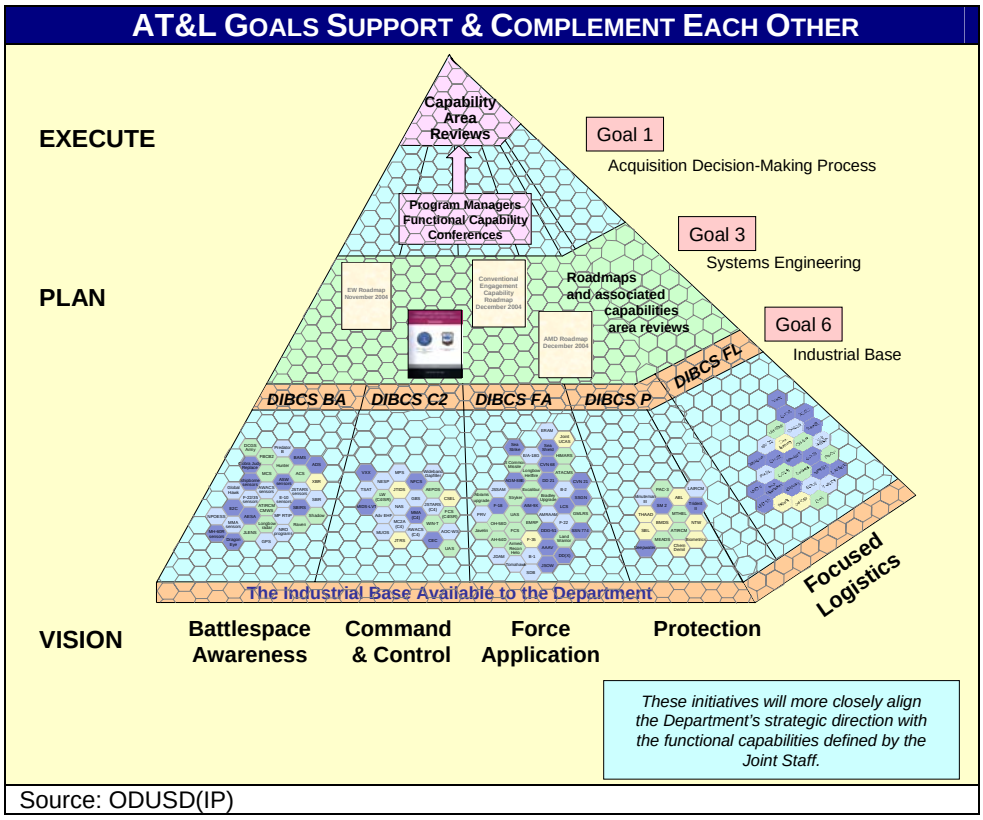
Source: ODUSD(IP)

[1] USD(AT&L) chartered six goals to be worked by his senior staff during the Airlie House Off-Site in June 2003. Goals One, Three, and Six relate to acquisition process and industrial base concerns.

specific goals being worked by senior leadership teams. The goals provide complementary elements that align DoD's acquisition oversight processes, systems engineering, and industrial base assessments with the Joint Capabilities Integration and Development System (JCIDS) and the Secretary's imperative with regard to this capabilities context.

These three goal teams are working collaboratively to provide the foundation required for senior Department acquisition officials to make acquisition oversight decisions in a capabilities context. The Goal One team, chartered to bring a joint capabilities perspective to acquisition, is examining concepts that would scale current DAB reviews beyond single-program and mission capability area reviews to the larger joint functional concepts. The Goal Three team is providing the systems views, roadmaps, and integrated architectures in broader mission contexts that are building blocks for joint functional capability acquisition reviews. These initiatives in combination will foster interoperability, jointness, and coalition capabilities. Finally, the Goal Six team is applying this capabilities-based approach to industrial base assessments—and in so doing, is promulgating this capabilities-based vernacular from the warfighting community to the industrial base and its long-range investment and planning processes.

As shown below, if the industrial base is to effectively deliver the capabilities envisioned, all Department decision processes should be in the same functional



Source: ODUSD(IP)

[2] Chairman of the Joint Chiefs of Staff Instruction 3170.01D, *Joint Capabilities Integration and Development System*, March 12, 2004.

capability vernacular. The proposed Program Manager Functional Capability Conference (PMFCC)/Capability Area Review (CAR) process, being examined by the Goal One team for implementation in 2005, is intended to accomplish this in concert with other Department initiatives and process changes.

The graphic opposite depicts how the DIBCS series has begun this synchronization by mapping warfighter capabilities to the supporting industrial base, enabling industry to establish better links to the warfighter. Armed with these studies, companies should be able to craft more effective business and investment strategies to serve DoD's warfighting goals, better communicate those strategies to the Department and other suppliers, and become important enablers of a networked, functional capability approach to modern warfighting. Companies early to market in this functional context will have substantial competitive advantages. Major defense companies already are reorganizing to respond. As companies improve their fluency in the functional-capabilities language, their ability to shape the DoD's imagination—and requirements—will improve. They will be better positioned to alert DoD program managers to technology and industrial capability connections among disparate defense programs, and better able to connect the dots on technologies with multiple applications than would an individual program manager.

> *"The functional-capability approach substantially broadens the opportunities available to industry well beyond individual programs or an individual military service. At the same time, the clear statement of this [capabilities] vision to industry should boost the flow of ideas and innovation into the department, creating a rich dialogue between industry and warfighter."*
>
> - *Suzanne D. Patrick, Deputy Under Secretary of Defense for Industrial Policy*
> *Defense News—August 30, 2004*

The roadmaps and architectures that are part of Goal Three will inform precepts for the new CARs scaled to the joint functional concepts. They will, in aggregate, help determine the array of programs reviewed. These roadmaps to date have resulted in a series of targeted capability area reviews—Integrated Air and Missile Defense; Joint Battle Management Command and Control; and Land Attack Weapons.

The New Capability Area Review Process Envisioned

The PMFCC/CAR initiatives planned for 2005 will leverage the lessons learned from these targeted capability area reviews in order to put senior Department decisions in an even broader context, more closely aligned to the functional capabilities defined by the Joint Staff.

A preparatory PMFCC would be held several weeks prior to the CAR to map selected acquisition programs to the Joint Staff's Joint Functional Concept (JFCs) and understand the interrelationships between the programs. During the PMFCC, program managers would decompose their programs by the JFC functional capability areas and measure their program capabilities against the defined JFC attributes. In an exercise setting, the PMFCC will simultaneously evaluate multiple programs against their contribution to accomplish JFC capabilities, thereby identifying potential issues to be addressed at the CAR. The intervening time prior to the CAR will be used to validate and further investigate the issues identified at the PMFCC. These assessments will synchronize programs' ability to jointly enable the JFC. Associated decisions will optimize programmatic and budgetary resources for these programs. In turn, these required decisions would provide the basis for the Acquisition Decision Memorandum (ADM), prepared in advance of the CAR. It would then be validated during the CAR—and issued subsequently as programmatic and budgetary direction. DABs would remain program-specific reviews, delegated to the Services wherever practicable.

THE PMFCC/CAR	
Process	**Description**
PMFCC	A preparatory conference to identify Department-level acquisition decisions by assessing programs in a capability context. During the intervening period between the PMFCC and CAR, issue working groups will validate and prioritize issues; explore options; and formulate recommendations.
CAR	A high level review body which makes the necessary decisions to improve program execution in a warfighter capabilities context. The CAR would assess synchronization, synergies, disconnects, and other issues across a large number of programs. DABs would remain program-specific reviews, delegated to the Services wherever practicable.
Source: ODUSD(IP)	

DEPARTMENT PROCESSES THAT INFORM PMFCC/CAR	
Process	**Description**
JOpsC	JOpsC is a unifying framework for developing subordinate concepts and capabilities. It lays out a strategic view of how the future Joint Force will operate and the overarching attributes with which to measure it.
JOCs	JOCs focus on the operational-level and describe how a Joint Force Commander will plan, prepare, deploy, employ, and sustain a joint force given a specific operation or campaign.
JICs	JICs are a further refinement of concepts focused on a specific class of operational missions or threads.
Source: ODUSD(IP)	

A multitude of existing Department processes, some of which are summarized in the chart above, will inform the envisioned PMFCC/CAR process and tie to the Department's strategic planning. The Joint Operations Concepts (JOpsC) provide an operational context for the CAR process based on the JFC description of functional capability areas and attributes. The four Joint Operating Concepts

(JOCs) (i.e., Major Combat Operations, Stability Operations, Homeland Security, and Strategic Deterrence) articulate how the future force will operate within specific segments of the range of military operations. The Joint Integrating Concepts (JICs) (e.g., Joint Forcible Entry Operations, Undersea Superiority, Seabasing) describe critical tasks and associated capabilities needed to support specific missions—i.e., how a Joint Force Commander 10-20 years in the future will integrate capabilities to generate effects and achieve an objective. JICs have the narrowest focus of this family of concepts, and distill JOC and JFC-derived capabilities into fundamental tasks, conditions, and standards, enhancing the foundation required to conduct a CAR assessment.

The envisioned CARs would make decisions to optimize programs' collective ability to provide the functional capabilities required for 21st century warfare. In these high order reviews, the Department would assess synchronization, synergies, disconnects, and other issues across a large number of programs. The ensuing programmatic and budgetary decisions would be documented in an ADM for each functional CAR. As a body of decisions, these ADMs would represent annual, synchronized, and funded capabilities oversight. They would also document oversight guidance responding to—and informing—Strategic Planning Guidance, Joint Programming Guidance, and Functional Capability Boards (FCBs).

> *"If programs were arrayed [across operational effects-based sectors], emerging defense suppliers would be able to ascertain opportunities that cut across individual programs and platforms… Conversely, senior DoD leaders would be better positioned to identify technology 'gaps' affecting both individual and multiple programs."*
>
> *- "Transforming the Defense Industrial Base: A Roadmap," February 2003*

As envisioned, these CARs would be held annually for each of the functional concepts that are directly tied to materiel solutions. In effect, the CARs would continue the process change accomplished by FCBs: programs initiated in functional contexts would be consistently monitored and re-synchronized to these contexts. We learned from our taxonomy work that programs are never static. Hence it is important to continually assure that all programs enabling given functional capabilities remain synchronized to these capability goals—and able to adapt to functional capability changes. An integrated, capabilities-based approach to program acquisition and associated oversight processes will not only improve Department decision-making, but also offers an enterprise-level view of a much broader expanse of the programs that collectively enable the desired warfighting capabilities. With this broader view, it should be possible to more effectively—and efficiently—inject innovation across the defense enterprise using the opportunity presented by the CAR process as an annual series of portals.

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APPENDIX F

TECHNOLOGY READINESS LEVELS (TRLS)

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Overview of Technology Readiness Levels

DoD 5000.2-R establishes technology maturity expressed in Technology Readiness Levels (TRLs).[1] It is important to have a strong grasp of the TRL concept. The tables in this section give the TRL fundamentals in the form of brief descriptions, definitions, and indicators to substantiate the TRLs.

Using TRLs to describe the maturity of technologies considered for use in a new system originated with NASA in the early 1980s. The levels ran from the earliest stages of scientific investigation (level 1) to successful use in a system (level 9), which equates to space flight for NASA. DoD has adopted the NASA definitions—with only minor modifications—for the nine TRLs.

Table F-1 gives the DoD TRL levels, definitions, descriptions, and supporting information. It also describes typical documentation to support a TRL assignment. Table F-2 includes a set of additional definitions that help provide for the uniform interpretation of the levels. The DoD TRL levels, definitions, and descriptions in Table F-1 and the set of additional definitions in Table F-2 have been extracted from DoD 5000.2-R, dated April 5, 2002.[2]

Table F-1. TRL Definitions, Descriptions, and Supporting Information

TRL	Definition	Description	Supporting Information
1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.	Published research that identifies the principles that underlie this technology. References to who, where, when.
2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.	Publications or other references that outline the application being considered and that provide analysis to support the concept.

[1] TRLs are the centerpiece for the Technology Readiness Assessments (TRAs) required for ACAT ID and IAM programs. Other means to accomplish a TRA are allowed but only when approved in advance by the Department. Willoughby charts are a possible alternative. No alternatives to the TRL-based process have been approved thus far. DUSD(S&T) is responsible for TRL guidance for the Department.

[2] Software is likely to be an important element in many TRAs. Since the TRL definitions in Table F-1 reflect a systems approach in which software is treated as a part of a component or system, software TRLs are not spelled out specifically in these definitions.

3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. References to who, where, and when these tests and comparisons were performed.
4	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that they will work together. This is relatively “low fidelity” compared to the eventual system. Examples include integration of “ad hoc” hardware in the laboratory.	System concepts that have been considered and results from testing laboratory-scale breadboard(s). References to who did this work and when. Provide an estimate of how breadboard hardware and test results differ from the expected system goals.
5	Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include “high-fidelity” laboratory integration of components.	Results from testing a laboratory breadboard system are integrated with other supporting elements in a simulated operational environment. How does the “relevant environment” differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered? Was the breadboard system refined to more nearly match expected system goals?

Table F-1. TRL Definitions, Descriptions, and Supporting Information (Continued)

TRL	Definition	Description	Supporting Information
6	System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated operational environment.	Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems encountered before moving to the next level?
7	System prototype demonstration in an operational environment	Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.	Results from testing a prototype system in an operational environment. Who performed the tests? How did the test compare to expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems encountered before moving to the next level?
8	Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Results of testing the system in its final configuration under the expected range of environmental conditions in which it will be expected to operate. Assessment of whether it will meet its operational requirements. What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems encountered before finalizing the design?
9	Actual system proven through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.	Operational Test and Evaluation reports.

Table F-2. Additional Definitions of TRL Descriptive Terms

Term	Definition
Breadboard	Integrated components that provide a representation of a system/subsystem and which can be used to determine concept feasibility and to develop technical data. Typically configured for laboratory use to demonstrate the technical principles of immediate interest. May resemble final system/subsystem in function only.
High Fidelity	Addresses form, fit, and function. High-fidelity laboratory environment would involve testing with equipment that can simulate and validate all system specifications within a laboratory setting..
Low Fidelity	A representative of the component or system that has limited ability to provide anything but first order information about the end product. Low-fidelity assessments are used to provide trend analysis.
Model	A functional form of a system, generally reduced in scale, near or at operational specification. Models will be sufficiently hardened to allow demonstration of the technical and operational capabilities required of the final system.
Operational Environment	Environment that addresses all of the operational requirements and specifications required of the final system to include platform/packaging.
Prototype	A physical or virtual model used to evaluate the technical or manufacturing feasibility or military utility of a particular technology or process, concept, end item, or system.
Relevant Environment	Testing environment that simulates the key aspects of the operational environment.
Simulated Operational Environment	Either (1) a real environment that can simulate all of the operational requirements and specifications required of the final system or (2) a simulated environment that allows for testing of a virtual prototype; used in either case to determine whether a developmental system meets the operational requirements and specifications of the final system.